Cleanup Goals Appropriate for DNAPL Source Zones

Introduction

Notice: It is very important to note that this paper has been prepared by EPA's Ground Water Task Force for informational purposes only. This paper does contain some discussion summarizing EPA's statutory authorities and regulations. However, this paper does not constitute an EPA statute or regulation and does not substitute for such authorities. In addition, the statements in this paper do not constitute official statements of EPA's views and are not binding on EPA or any party.

This options paper is being developed by EPA's Ground Water Task Force, a workgroup established under the "One Cleanup Program Initiative" of the Office of Solid Waste and Emergency Response (OSWER).[1] This Task Force is comprised of EPA and State regulatory officials, and was formed to:

- serve as the main technical / policy / communication / networking resource for OSWER on groundwater issues;
- promote cross-program coordination and communication on technical and policy issues related to the cleanup of contaminated groundwater;
- identify and prioritize and work to solve and/or provide guidance on groundwater issues and projects that will benefit multiple programs; and
- assign subgroups to work on priority issues, and/or making recommendations to EPA senior management on the best course of actions for such issues.

In carrying out its purpose, Ground Water Task Force representatives discussed with Senior EPA and State program managers a variety of implementation challenges cleanup programs face with respect to setting ground water cleanup goals.[2] One of those challenges, which was identified as a priority issue, is differing perspectives on what cleanup goals are appropriate for that portion of the contaminant plume where dense nonaqueous phase liquids (DNAPLs) are present in the subsurface (the DNAPL source zone). The purpose of this paper is to promote dialogue on this issue. It provides a brief background on DNAPLs as a source of contamination, differing stakeholder points of view (based on written or anecdotal input) with respect to challenges posed by DNAPLs, and potential options for addressing these problems. Stakeholders include Federal and State regulatory officials, and members of the regulated community, as well as environmental and public interest groups.

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[1] For more information concerning the EPA's One Cleanup Program, refer http://www.epa.gov/swerrims/onecleanupprogram/index.htm. For more information concerning the One Cleanup Program Ground Water Task Force, refer to http://gwtf.cluin.org/.

[2] Oral presentation and discussion on March 4, 2003 before the Cleanup Programs Council, an advisory group for the OSWER One Cleanup Program initiative.

The Groundwater Task Force recognizes that other problems and options may exist, and no decisions have been made at this point with respect to which option(s) the Agency may pursue. Readers are encouraged to provide their comments on the paper and to suggest solutions they believe the Agency should consider to address the problems stated in this paper and/or other problems not mentioned herein. As conveyed in this document, any additional option submitted should describe the particular problem(s) it would address, as well as its associated advantages and disadvantages. These comments will be used in planning future activities of the Task Force and in developing recommendations for EPA senior managers on a course of action to address the issues raised in this paper.

Questions or comments concerning this paper should be directed to Kenneth Lovelace and sent via email to gwtf@emsus.com by July 31, 2004. Copies of this paper can be obtained from the Ground Water Task Force web site: http://gwtf.cluin.org/.

EPA recognizes that some stakeholders are concerned that raising issues addressed in this paper may generate pressures to change existing approaches, promote debates that slow down cleanup decisions, and ultimately affect the ability of regulatory programs to impose and achieve cleanup goals. However, the Task Force believes that avoiding these issues would not be responsive to other concerns raised during stakeholder meetings held by the Agency in 2003 concerning the goals of the One Cleanup Program initiative. Additional stakeholder meetings are planned specifically for this and other options papers developed by the Task Force. By including States on the Task Force and promoting public dialogue on these ground water issues, the agency is attempting to fairly balance all of these concerns.

Issue Background

DNAPLs as a Source of Contamination

A nonaqueous phase liquid (NAPL) is a chemical or mixture of chemicals that do not readily mix with water. In water, NAPLs form a separate liquid phase and do not readily dissolve. Dense NAPLs (DNAPLs) sink while light NAPLs (LNAPLs) float. DNAPLs include chemical compounds and mixtures with a wide range of chemical properties, including chlorinated solvents, creosote, coal tar, and polychlorinated biphenyls (PCBs). After a spill, DNAPLs migrate into the subsurface resulting in disconnected blobs of liquid referred to as "residual DNAPL," and continuous distributions of DNAPL sometimes referred to as "pools." Residual and pooled DNAPL occupy pore spaces within granular media (e.g., soil) or fractures in bedrock. DNAPL pools can be mobile or potentially mobile.

The "DNAPL source zone" is that portion of the subsurface containing residual and/or pooled DNAPL. Ground water flowing through the source zone dissolves some of the DNAPL, giving rise to aqueous phase plumes of contamination hydraulically down-gradient of the source zone. A plume may also result from precipitation infiltrating through residual DNAPLs (or LNAPLs) located in the unsaturated zone (above the water table). Since DNAPLs are only slightly soluble in water, DNAPL source zones can persist for many decades and, in some cases for the foreseeable future. Volatile constituents within the DNAPL may continue to release vapor phase contamination to the unsaturated zone or the surrounding ground water. Thus, the nature of the contamination problem at DNAPL sites has two components: 1) the DNAPL source zone, and 2) the aqueous phase plume (and may also include vapor phase contamination in the unsaturated zone).

Some DNAPLs, such as chlorinated solvents, are much denser than water and very mobile in the subsurface. A large DNAPL spill can sink below the water table, spreading laterally as it encounters finer grained layers, and may extend to the base of an aquifer. Pooled DNAPL can migrate due to gravity along the top of down-ward sloping geologic layers or along fractures, and the flow path can be in a direction different from the ground water flow. Pooled DNAPL can also penetrate into deeper aquifers by migrating along fractures in confining layers. For these reasons, delineating the subsurface extent of the DNAPL source zone can be a substantial undertaking. At many sites, DNAPLs are suspected but have not been observed in the subsurface. For other sites, DNAPLs have been observed at some locations but the extent of the DNAPL source zone has not been distinguished from the overall plume.

The number of CERCLA[3] (i.e., Superfund) sites or RCRA[4] Corrective Action facilities with DNAPL source zones is uncertain. However, in the early 1990s, the Superfund program reviewed existing site investigation data from a sample of 712 sites in order to estimate the extent of the DNAPL problem. Results were presented in a 1993 report, which concluded that "*...approximately 60% of all NPL sites exhibit a medium to high likelihood of having DNAPLs present as a source of subsurface contamination"* (EPA,1993a; page x).

EPA Cleanup Goals

The goal for ground water remediation at Superfund sites and RCRA Corrective Action facilities is to protect human health and the environment, typically using a combination of short-term measures (e.g., providing alternative water supplies) and long-term measures intended to return contaminated ground water to quality consistent with its designated beneficial uses. In general, ground waters have been designated by States as current or future sources of drinking water, although a number of states are looking at other approaches in designating ground water based on use, value, and vulnerability. (See Task Force options paper: “Ground Water Use, Value and Vulnerability as Factors in Setting Cleanup Goals.”) For ground waters designated as current or future sources of drinking water, long-term (i.e., final) cleanup goals typically include returning contaminated ground water to drinking water standards (e.g, Federal maximum contaminant levels (MCLs) or State MCLs).[5] For Superfund sites and RCRA Corrective Action facilities

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[3] The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) was enacted in 1980, and amended in 1986.

[4] The Resource Conservation and Recovery Act (RCRA) was enacted in 1976, and amended in 1984.

[5] Federal Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (enacted in 1974, amended in 1996), and related information are available online at: http://www.epa.gov/OGWDW/mcl.html

where returning the plume to MCLs is a cleanup goal, MCLs are typically to be attained within the contaminated aquifer and "throughout the plume." Thus, long-term cleanup goals at most Superfund sites and RCRA Corrective Action facilities include attainment of drinking water standards "throughout the plume"of contaminated ground water, which may include the DNAPL source zone (if present) as well as the aqueous contaminant plume.

Long-term cleanup goals for Superfund sites and RCRA Corrective Action facilities do not always include attaining MCLs "throughout the plume." For ground waters that are not designated by States as current or future sources of drinking water, drinking water standards are generally not used as cleanup levels and alternative cleanup goals are typically established, such as control of sources and containment of the plume. Also, where the remedy calls for on-site management of waste materials (such as a landfill), cleanup levels generally do not need to be attained in ground water beneath the waste management area. In such cases, attaining MCLs "throughout the plume" applies only to that portion of the plume outside the waste management area. Furthermore, both the Superfund and RCRA Corrective Action programs generally allow alternative cleanup goals to be established at sites where attaining MCLs "throughout the plume" is determined to be technically impracticable (TI). Both of these EPA cleanup programs also establish alternate cleanup limits (ACLs) in lieu of MCLs, under appropriate circumstances. However, ACLs defined under CERCLA are somewhat different from those in RCRA Corrective Action.[6] Some State cleanup programs have provisions for establishing contaminated ground water containment or management zones. Within such a zone, active cleanup of contaminated ground water may be deferred or may not be required. The specifics of how containment or management zones are defined, and what alternative cleanup goals are applied, differ from State to State.

Cleanup Technologies

For the reasons discussed above, sites where DNAPLs are present in the subsurface are very difficult to clean up to drinking water standards. Cleanup technologies applicable to these sites often include individual approaches or various combinations of approaches intended to control migration of contaminants (containment), remove contaminants from the subsurface (extraction), or treat contaminants in place (in situ treatment). Each of these technology types have been used (with varying degrees of success) on DNAPLs in the source zone or on dissolved contaminants in the plume.

Over the past two decades, significant advancement has been made in the development of these technologies, especially those intended to remove or treat DNAPLs in the source zone. However, site owners and cleanup managers have been reluctant to implement these technologies. Potential reasons for the limited application of source-zone depletion technologies include uncertainties with respect to: 1) actual extent of the DNAPL source-zone, 2) whether MCLs can be attained in the source zone, 3) predicting benefits and adverse impacts of DNAPL

[6] ACLs used in the Superfund program are defined in CERCLA 121(d)(2)(B)(ii). Guidance for use of ACLs in RCRA is provided in EPA, 1987.

depletion where MCLs are not likely to be attained, and 4) the acceptability of cleanup goals other than MCLs (EPA, 2003).

Potential Benefits and Impacts of DNAPL Mass Reduction

Reducing the quantity of DNAPL mass in the source zone can have several potential benefits, regardless of whether MCLs can be attained in the source zone. A recent national panel report specifically addresses cleanup of DNAPL source zones. This panel, convened by EPA's Office of Research and Development, completed a report titled: The DNAPL Remediation Challenge: Is There A Case For Source Depletion? The Executive Summary of this report provides the following conclusions regarding the potential benefits of DNAPL mass depletion (EPA, 2003; page xi):

> Regardless of the site owner, there is a range of benefits, from a risk management perspective, that may result from DNAPL source-zone depletion. These include explicit benefits such as: 1) mitigating the future potential for human contact and exposure through long-term reduction of volume, toxicity, and mobility of the DNAPL, 2) mitigating the future potential for unacceptable ecological impacts, 3) reducing the duration and cost of other technologies employed in conjunction with the source removal technology, and 4) reducing the life-cycle cost of site cleanup. These benefits can be achieved if the source depletion option can result in the following outcomes: 1) reduction of DNAPL mobility, if mobile DNAPL is present, 2) reduction in environmental risk to receptors; 3) reduced longevity of groundwater remediation, and 4) reduction of the rate of mass discharged from the DNAPL source zone. These outcomes could then lead to enhanced efficiency of complimentary technologies used for groundwater remediation as well as potential reduction in life-cycle costs. Implicit benefits of DNAPL source-zone depletion include: 1) minimizing risks of failure of long-term containment strategies, 2) mitigating public stakeholders' concerns, 3) enhancing a company's "green image" as stewards of the environment, and 4) minimizing future uncertain transaction costs associated with management of the site.

The 2003 national panel report also summarized the potential adverse impacts of DNAPL mass depletion as follows (EPA, 2003, page xi):

> Adverse impacts of DNAPL source depletion could include: 1) expansion of the DNAPL source zone due to mobilization of the residual DNAPL, 2) undesirable changes in the DNAPL distribution (i.e., DNAPL architecture), and 3) undesirable changes in the physical, geochemical and microbial conditions that may cause long-term aquifer degradation, and/or may adversely impact subsequent remediation technologies. All of these adverse impacts could increase life-cycle costs of site cleanup.
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> Quantitative predictions of these potential benefits and adverse impacts to aid decision making on whether to implement DNAPL source depletion actions are highly uncertain. These uncertainties remain as significant barriers to more widespread use of source depletion options.

Need for Alternative Cleanup Goals

Several national advisory panels have studied the difficulties associated with cleanup of contaminated ground water, including the particular problems posed by DNAPLs, and have issued summary reports of their findings. In 1994, the National Research Council (NRC)[7] completed the report: Alternatives for Ground Water Cleanup. This report recommended that sites be categorized according to the “Relative Ease of Cleaning Up Contaminated Aquifers as a Function of Contaminant Chemistry and Hydrogeology” and gave an example of such a categorization scheme (Table ES-1), which clearly indicates that DNAPLs are the most difficult type of contaminant problem to clean up (NRC, 1994; page 5). Among other findings, this report included the following findings regarding "Setting Cleanup Goals" (NRC, 1994; page 18) (bold text is from original):

> **Conclusion. Existing procedures for setting ground water cleanup goals do not adequately account for the diversity of contaminated sites and the technical complexity of ground water cleanup.** Whether goals established under existing procedures adequately protect public health and the environment, or whether they are overprotective or underprotective, is uncertain, as are the costs to society when these goals cannot be achieved.
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> **Recommendation 1. Although the committee recognizes that different agencies must operate under different authorities, all regulatory agencies should recognize that ground water restoration to health-based goals is impracticable with existing technologies at a large number of sites.**

The Executive Summary of 2003 national panel report provides the following conclusions regarding "Appropriate Metrics For Performance Assessment” (EPA, 2003; page xi):

> The Panel assessed the technical basis for using drinking water standards, such as Maximum Contaminant Levels (MCLs), as the single performance goal for successful DNAPL source-zone remediation and the use of chemical analyses in groundwater samples from monitoring wells as the primary metric by which to judge performance of groundwater remediation systems. Although an MCL goal may be consistent with prevailing state and federal laws for all groundwater considered a potential source of drinking water and is a goal that is easily comprehended by the public, this goal is not likely to be achieved within a reasonable time frame in source zones at the vast majority of DNAPL sites. Thus, the exclusive reliance on this goal inhibits the application of source depletion technologies because achieving MCLs in the source zone is beyond the capabilities of currently available in-situ technologies in most geologic settings.

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[7] The National Research Council (NRC) is the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering. More information about the NRC can be obtained from: http://www.nationalacademies.org/nrc/

Problem Statements

For the purpose of this options paper, the Ground Water Task Force developed generalized problem statements based on written and anecdotal information. However, the problem statements listed below do not necessarily represent the position of EPA. Rather, these problem statements attempt to capture the perspectives of various stakeholders such as Federal and State regulatory officials, and members of the regulated community, as well as environmental and public interest groups. Also, individual opinions can vary as much within these respective groups as between them. Furthermore, these problem statements are not listed in any order of importance or priority, and do not represent all possible points of view associated with remediation of a DNAPL source zone.

1. **Site owners[8] say that cleanup to drinking water standards (e.g., MCLs) is not a realistic goal for DNAPL source zones, yet they are rarely allowed to use alternative goals.** Federal and State site managers continue to set such stringent goals within the DNAPL source zone, even though most technical experts agree that attaining MCLs within the DNAPL source zone is not possible with currently available technologies at most DNAPL sites. Site managers are not utilizing program flexibilities for setting alternative cleanup goals for this portion of the plume (e.g., technical impracticability decisions, containment zones, or similar).

2. **Technology developers say that continued adherence to overly stringent cleanup goals for DNAPL source zones inhibits the potential use of existing technologies and is detrimental to development of new methods.** Currently available in-situ treatment methods, such as thermal and oxidation technologies, can remove significant quantities of DNAPL from the source zone. However, site owners are reluctant to consider using such technologies in remedies because they feel that attaining MCLs in the source zone is not likely to be achieved, even with the most promising technologies.

3. **Federal and State site managers say that alternative cleanup goals often cannot be applied because the DNAPL source zone has not been distinguished from the overall plume.** For many sites, the DNAPL source zone has not been delineated. Regulatory officials are reluctant to use program flexibilities (e.g., technical impracticability decisions, containment zones, or similar) in these cases, because there is no basis for defining the portions of the plume where alternative goals are to be applied. Site managers say that site owners are not interested in delineating the DNAPL zone and typically want alternative goals to be applied to the entire plume, which would mean that none of the plume (neither source zones nor aqueous phase plumes) would be cleaned up. Continued adherence to stringent cleanup goals is the best way to make sure that DNAPL sites get cleaned up.

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[8] In this paper the term "site owners" is used to refer to those parties responsible or potentially responsible for the release of contaminants to the environment, and therefore, for paying cleanup costs.

4. **Federal and State site managers are concerned that alternative cleanup goals have uncertain reliability and long-term costs.** Alternative cleanup goals, such as containment or exposure control, will require that ground water monitoring and site controls be maintained throughout the foreseeable future. The long-term reliability of containment systems and exposure controls is uncertain. Also the effectiveness of such system and controls often is not well documented. Containment systems have high capital costs, and hydraulic (i.e., pumping) containment systems also have high operating costs. Components used in containment systems have a finite operating life (e.g., pumps, wells, piping, flow barriers), and replacement costs are not typically considered during remedy selection. Institutional controls (e.g., deed covenants or well drilling restrictions) also have long-term costs associated with monitoring and enforcement. Long-term custodial care[9] of sites with DNAPL source zones cannot be maintained if site owners go out of business; or if Federal and State governments decide to eliminate funding for "orphan sites" at some time in the future. For sites where cleanup to MCLs can be achieved in the DNAPL source zone and throughout the plume, uncertainties, long-term costs and other disadvantages associated with long-term custodial care can be avoided.

5. **Federal and State site managers say that although source depletion is sometimes a cleanup goal, there is currently no accepted performance measures to determine the effectiveness of DNAPL mass removal.** There is no agreement among technical experts on what performance measures should be used to indicate that DNAPL mass has been removed to the extent practicable from the DNAPL source zone. A 1996 EPA guidance says that long-term objectives for the DNAPL source zone are to (EPA, 1996; page 14):

> ... control further migration of contaminants from subsurface DNAPLs to the surrounding ground water and reduce the quantity of DNAPL to the extent practicable.

Although total DNAPL mass removed by recovery systems is relatively easy to measure, estimates of total mass present in the subsurface are highly uncertain and are typically underestimated. This means there is no good way to estimate the fraction of DNAPL mass removed from the subsurface with an acceptable level of confidence. In some cases, a sharp decline and "leveling off" of mass recovery over time has been used to indicate that DNAPL has been removed to the extent practicable. However, there is no standardized method for determining when the mass recovery has "leveled off." Also, "leveling off" of mass recovery can result from a poorly designed recovery system.

6. **Site owners say that source depletion should not be a cleanup goal because the potential benefits of DNAPL mass removal are outweighed by disadvantages.** Some site owners believe that such efforts are unlikely to remove all of the DNAPL from the

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[9] Long-term custodial care includes all activities needed to ensure the protectiveness of a remedy into the foreseeable future, which will likely include multiple generations. These activities include site monitoring; maintenance of remedy components, replacement of remedy components as needed; and monitoring and enforcement of institutional controls.

source zone, which means that a plume of contaminated ground water will persist and remedies to contain or otherwise manage the plume will still be required. Site owners also say that mass removal from the source zone is unnecessary as long as the entire plume is contained and institutional controls are established. Also, attempts to remove DNAPL mass could have detrimental effects, such as causing further migration of the DNAPL. Site owners say that containment of the plume, including the DNAPL source zone, is protective and consistent with EPA guidance (e.g., the 1993 TI guidance).

7. **Managers of Federal and State cleanup programs say that flexibility in setting appropriate cleanup goals for DNAPL source zones is also a concern when revisiting operating remedies.** Improved decision making approaches will be helpful when selecting the initial remedy and also when revisiting operating remedies. Many DNAPL sites have remedies that were selected several years ago, when the state of knowledge concerning problems posed by DNAPLs was less advanced. Reasons for revisiting cleanup goals during the operating phase of a remedy could include:

- desire to reduce annual operating costs,

- desire to change to a more cost effective cleanup technology,
- lack of progress toward existing cleanup goals,
- new or previously unrecognized contamination problems, and/or
- changes in land use.

Those who are paying remedy costs (site owners, Federal and State cleanup programs) generally want to reduce long-term remedy costs. Since annual maintenance costs are higher for operating systems (e.g., pump and treat, in-situ treatment systems), site owners and cleanup programs would like to turn off these components of the remedy sooner rather than later.

8. **Federal and State site managers say that they should be able to revisit technical impracticability (TI) decisions.** If a TI decision is made for DNAPL source zones (or for other site conditions), Federal and State site managers want to be able to revisit the TI decision at some time in the future when new cleanup technologies become available. Cleanup of the site is preferable to long-term custodial care for the reasons discussed above. EPA's 1993 "Guidance for Evaluating the Technical Impracticability of Ground-water Restoration" states that TI decisions *"...will be subject to future review by EPA"* (EPA, 1993b; page 25). However, this guidance also indicates that TI decisions can be permanent for Superfund sites if the remedy continues to be "protective." In contrast, the 1993 guidance indicates that TI decisions are not permanent for RCRA facilities (EPA, 1993b; page 25).

EPA DNAPL-Related Projects

The projects listed below are technology demonstration projects and multi-year research efforts intended to address one or more of the problems identified above. All of these projects were recommended in the findings of a recent national panel report: titled: The DNAPL Remediation Challenge: Is There A Case For Source Depletion? (EPA, 2003). EPA's ability to continue and/or initiate these DNAPL-related projects is dependent upon resources and their relative priority compared to research needs for other issues.

Project A - A review of existing data from sites where sufficient documentation is available to assess the performance of DNAPL source depletion efforts, including long-term impacts on the plume (EPA, 2003; Section 5.2, No. 4).

Project B - Develop guidelines for data that should be collected to document field demonstrations of source depletion technologies, prior to initiation of DNAPL removal, during operation and after completion of DNAPL removal (EPA, 2003; Section 5.2, No. 3).

Project C - Develop and validate technologies for measurement of mass flux from DNAPL source zones, and other measures for evaluating the effectiveness of DNAPL mass removal (EPA, 2003; Section 5.2, No. 5).

Project D - Continue research and demonstration projects to develop, test, and validate the most promising technologies for DNAPL source zone characterization and mass depletion. Much of this work is being undertaken in partnership with other Federal and State agencies, and with industry groups (EPA, 2003; Section 5.2, No. 2).

Options for Addressing Problems

The options listed below are intended to address one or more of the problems identified above. They are listed in approximate order of increasing complexity and time to complete. For instance, the longer-term projects require the collection of additional supporting data. It is assumed that the statutory and regulatory framework for EPA cleanup programs will not change in the near future, so all options fall within the current framework for these programs. It is also assumed that training and outreach activities are an essential component of each option. A brief discussion of advantages and disadvantages is included for each option. A matrix table showing the problems addressed by each option is included as Table 1.

Option 1 - Develop a fact sheet describing the potential benefits of DNAPL mass removal from the source zone, as well as the potential disadvantages.

> **Advantages:** No additional studies would be needed to develop such a fact sheet. The potential benefits of DNAPL source removal are often overlooked. This may encourage greater consideration and use of DNAPL recovery and/or treatment technologies for site remedies. May encourage delineation of the DNAPL source zone.

Disadvantages: Simply listing potential benefits and disadvantages, without guidance on the types of sites where source depletion should (or should not) be included as a remediation goal (Option 6) will not be very helpful. Also, since there are currently no accepted performance measures to determine the effectiveness of DNAPL mass removal, it may be difficult to determine whether benefits have been realized at a particular site.

Option 2 - Develop a fact sheet describing program flexibilities and alternative cleanup goals that may be applied to the DNAPL source zone other than attainment of MCLs. Program flexibilities (e.g., technical impracticability decisions, containment zones, or similar) would be those that may be allowed under Federal or State cleanup programs. The alternative goals would typically apply only to the DNAPL source zone rather than the entire plume, in accordance with existing policy.

Advantages: No additional studies would be needed to develop such a fact sheet. May encourage site managers to make greater use of program flexibilities currently available from Federal and State programs for the DNAPL source zone. TI decisions as well as other flexibilities would be discussed (e.g., containment zones, or similar designations). May encourage delineation of the DNAPL source zone.

Disadvantages: Would only apply to sites where DNAPL source zone has been delineated, which may be a small minority of sites. May not increase use of program flexibilities. If examples of program flexibilities are described but not mandated, this fact sheet may not be very helpful.

Option 3 - Develop a supplemental EPA guidance on technical impracticability (TI) which clarifies some or all of the following questions for Superfund and other EPA cleanup programs:

- circumstances that would warrant revisiting a TI decision;
- what a TI evaluation report should look like;
- how the TI decision process can be used to encourage delineation of DNAPL source zones;
- can a simplified (or streamlined) TI decision process be applied to operating remedies; and
- how the TI decision process can be used to encourage use of innovative source removal technologies.

Advantages: No additional studies would be needed to develop such a guidance. Clarification of when a TI decision can be revisited may especially help the Superfund program (Problem 8). TI determinations are currently an option in both the Superfund and RCRA Corrective Action programs. Current guidance would be updated. This guidance could address several questions or concerns regarding the TI decision process, such as the examples given above. Such a guidance could resolve questions that are currently discouraging TI determinations.

Disadvantages: Some Federal and State cleanup programs may prefer to use program flexibilities other than TI for DNAPL source zones. For these programs, a supplemental TI guidance would have limited usefulness. Providing guidance on the TI decision process, without guidance on the types of sites where source depletion should (or should not) be included as a remediation goal (Option 6) may not be very helpful in determining when DNAPL source reduction should (or should not) be attempted.

Option 4 - Develop a policy memorandum re-emphasizing existing EPA policy that program flexibilities are to be used for DNAPL source zones, as a means of setting cleanup goals that are achievable in a reasonable time frame. Such program flexibilities may include TI determinations, containment zones, groundwater classification exemptions, or similar flexibilities that are available at a particular site from either the Federal or State cleanup program overseeing the cleanup at that site. The memorandum would reiterate EPA's current policy that cleanup goals for DNAPL source zones should **not** include restoration of groundwater to drinking water standards, if this goal cannot be achieved in a "reasonable time frame" based on site conditions.

Advantages: No additional studies would be needed to develop such a policy. This is not a policy change because EPA's cleanup expectations (as stated in the regulations for Superfund) are to: *"... return usable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site"* (Federal Register, 1990; §300.430 (a)(1)(F)). This memorandum would clarify EPA's national policy on cleanup expectations for DNAPL source zones, clarify that cleanup goals should be scientifically defensible, and apply only to sites where DNAPL source zones have been delineated.

Disadvantages: Such a policy memorandum would be similar to a policy issued by OSWER in 1995 (EPA, 1995) which has had little discernable effect on remedy decisions. No guidance would be provided on the types of sites where source depletion should (or should not) be included as a remediation goal, and therefore, would not provide much useful guidance to decision makers. This policy would only apply to sites where the DNAPL source zone has been delineated, which may be a small minority of sites. It is not clear whether such a policy memorandum would provide an incentive to delineate such source zones. Providing guidance on "reasonable time frame" may be difficult. This option does not address any of the concerns regarding TI determinations (Problem 8). Since there is currently insufficient guidance regarding what a "reasonable time frame" is for attaining cleanup goals, this policy may not be helpful unless this question is also addressed.

Option 5 - Develop guidance on recommended methods and approaches for delineating the extent of the DNAPL source zone.

Advantages: This guidance would explain which characterization methods, including newly developed and conventional tools, are most helpful in delineating the spatial extent of the DNAPL zone. This would update existing guidance. This may encourage more site managers to characterize the DNAPL zone.

Disadvantages: There may not be a clear consensus on which characterization methods are most helpful. If there is no such consensus, then additional research and demonstration projects will need to be completed before such a guidance can be initiated (Project D). To be useful this document will need to do more than simply describe field methods. It will also need to address how field data should be evaluated, level of detail needed to for delineation of the DNAPL source zone as a function of the types of remedies being considered, value to be placed on direct versus indirect indicators of DNAPL, and other considerations.

Option 6 - Develop guidance providing a qualitative approach for determining when source depletion technologies should be implemented, or should not be implemented. This guidance would attempt to identify types of site conditions where:

- MCLs are potentially achievable in the DNAPL source zone;
- MCLs are not likely to be achieved;
- benefits of source depletion efforts tend to outweigh disadvantages; and
- types of sites where source depletion should be included as a remediation goal (regardless of whether or not MCLs are likely to be achieved within the DNAPL source zone).

Advantages: This would provide a useful decision making tool. No such guidance currently exists. This project was included in recommendations of a recent national panel report (EPA, 2003). May encourage delineation of the DNAPL source zone.

Disadvantages: There is currently a lack of well documented case studies, and therefore, a lack of scientific consensus on these topics. Therefore, this project may not be feasible at present. A separate project to evaluate existing data from sites where DNAPL source depletion efforts were undertaken (Project A) would need to be completed before such a decision making approach could be developed. Also, results of this data evaluation (Project A) may be inconclusive. If results of Project A are inconclusive, then additional research and demonstration projects will need to be completed before such a guidance can be initiated Project D).

Option 7 - Develop guidance on performance measures for the effectiveness of DNAPL mass removal, and on how to determine when active DNAPL removal efforts should be discontinued. Such measures could include trend analysis for mass removal rates, mass flux data, or other parameters for gauging remedy performance.

Advantages: Currently there is no EPA guidance on this topic. This guidance may encourage more site managers to include DNAPL depletion as a cleanup goal for the source zone, and may encourage wider use of technologies designed to attain this goal. May encourage delineation of the DNAPL source zone.

Disadvantages: There may not be a clear consensus on which performance measures are most helpful. Additional research and field testing of technologies for measurement of mass flux and other potential performance measures (Project C) are needed before these methods can be included in such a guidance.

Option 8 - Develop guidance describing improved methods for comparing long-term remedies, which would allow a more realistic accounting of the costs and other disadvantages of long-term custodial care. This would include long-term costs of maintaining containment systems, equipment replacement, monitoring and enforcing institutional controls, and site monitoring.

Advantages: Currently there is no EPA guidance on this topic. This guidance would allow EPA to start fresh with new ideas for 1) utilizing the latest technologies; 2) being responsive to a wide spectrum of stakeholders, including State and local governments, environmental groups and the general public; 3) comparing costs and reliability issues associated with long-term custodial care.

Disadvantages: Currently there is no consensus on how to do such a comparison. Therefore, this project may not be feasible at present. No research activities are currently planned to develop or test potential improved methods for comparing long-term remedies.

References Cited

EPA, 1987. "Alternate Concentration Limit Guidance," Office of Solid Waste and Emergency Response (OSWER), Publication EPA/530/SW-87/017, July 1987. Available at: http://www.epa.gov/correctiveaction/resource/guidance/gw/acl.htm

EPA, 1993a. "Evaluation of the Likelihood of DNAPL Presence at NPL Sites, National Results," Office of Solid Waste and Emergency Response (OSWER), Publication 9355.4-13, EPA/540-R-93-073, September 1993. Available at: http://www.epa.gov/superfund/resources/gwdocs/non_aqu.htm

EPA, 1993b. "Guidance for Evaluating the Technical Impracticability of Ground-water Restoration," Office of Solid Waste and Emergency Response (OSWER), Directive 9234.2-25, EPA/540-R-93-080, September 1993. Available at: http://www.epa.gov/superfund/resources/gwdocs/techimp.htm

EPA, 1995. "Superfund Groundwater RODS: Implementing Change This Fiscal Year," Office of Solid Waste and Emergency Response (OSWER), Memorandum, Elliott P. Laws to Regional Administrators and Waste Management Division Directors, OSWER Publication 9335.5-03P, EPA/540-F-99-005, July 31, 1995. Description available at: http://www.epa.gov/superfund/resources/gwdocs/non_aqu.htm

EPA, 1996. "Presumptive Response Strategy and Ex-situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites," Final Guidance, Office of Solid Waste and Emergency Response (OSWER), Directive 9283.1-12, EPA/540-R-96-023, October 1996. Available at: http://www.epa.gov/superfund/resources/gwguide/index.htm

EPA, 2003. "The DNAPL Remediation Challenge: Is There A Case For Source Depletion?,"Report Prepared by an Expert Panel to the Environmental Protection Agency, Office of Research and Development, Publication EPA/600/R-03/143, dated December 2003. Available at: http://www.epa.gov/ada/pubs/reports.html).

Federal Register, 1990. Volume 55, No. 46, March 8, 1990; 40 CFR Part 300, "National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule" (NCP). Available at: http://www.epa.gov/superfund/action/guidance/remedy/regenfor.htm

National Research Council, 1994. "Alternatives for Ground Water Cleanup," National Academy Press, Washington, DC. Available at: http://books.nap.edu/catalog/2311.html

Table 1: Cleanup Goals Appropriate for DNAPL Source Zones:
Matrix Summary of Problems Addressed by Each Option

Problem Statements	Options (primary focus)*							
	1 p	2 p	3 p	4 p	5 t	6 t	7 t	8 t
1. Cleanup to MCLs not a realistic goal for DNAPL zones, yet alternative goals are rarely used.	1**	2	2	2	1	2	2	2
2. Overly stringent cleanup goals inhibits use of existing technologies.	1	2	2	2	1	2	2	2
3. Alternative goals often can't be applied because DNAPL zone has not been distinguished from overall plume.	1	2	1	1	3	1	2	
4. Alternative goals have uncertain reliability and long-term costs.							3	3
5. No accepted performance measures for effectiveness of DNAPL mass removal.							3	2
6. Potential benefits of DNAPL mass removal outweighed by disadvantages.	1					2	1	1
7. Setting appropriate cleanup goals for DNAPL zones is also a concern when revisiting operating remedies.	1	2	2	2	1	2	3	3
8. Should be able to revisit TI decisions.			3	2		1		

NOTES:

* Initial/primary focus of option: **p** = policy; **t** = technical and/or research study

** **3** = Option provides significant contribution to resolution of problem.
2 = Option provides some help to resolution of problem.
1 = Option may provide help to address problem.