Chapter 4

Strategies for **Setting Cleanup Goals**

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INTRODUCTION

Establishing goals for cleanup by Superfund, the States, and private parties will depend on scientific, technical, economic, and legal analyses. Ultimately, however, the answer to "How clean is clean?" will be a major policy judgment that must strike a delicate balance among certain and uncertain health and environmental risks, available resources, technological capabilities, and public concerns. OTA's analysis does not produce a simple answer to this key question. However, one approach has emerged that offers a way to choose among several processes for determining cleanup goals; it is based on a classification of sites according to their present and future use.

When a site has been identified as a potential source of dangerous chemical releases, decisions are made on how to respond.[1] Removal actions are short-term responses to immediate threats. Remedial actions are long-term responses designed to provide permanent remedies and are the focus of this chapter. A critical component of the Superfund program is determining the extent of cleanup that is required at sites, i.e., defining the residual level of contamination or exposure that is acceptable. Unfortunately, it is possible to know that a site poses significant threats, but not know *precisely* what those threats are or what constitutes a safe level of cleanup.

While certain criteria, such as the necessity of fund balancing and use of cost-effective remedies, are present in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP), they do not actually prescribe a course of action. This lack of clear direction has led to problems.

The current methods for determining the extent of cleanup at Superfund sites may not meet statutory goals of public protection. Current actions appear to be ad hoc and inconsistent; no national goal on the extent of cleanup has been defined. Without specific cleanup goals [with which to confirm cleanup), the selection, use, and evaluation of cleanup technologies will be difficult and contentious. Moreover, goals can help determine whether a technology is technically feasible and guide the development of new technologies.

The chapter begins by examining the current institutional framework within which goals are now structured, It then discusses six factors to evaluate alternative approaches to establishing cleanup goals and outlines seven alternative approaches. Finally, the chapter the cleanup goals issue might be resolved.

[1]Uncontrolled release of chemicals from Superfund sites presents the potential for various types of damage. Some releases can harm people directly, others primarily affect the environment. Some damage may be immediately observable while other harm may manifest itself only after years of exposure; .

CURRENT INSTITUTIONAL FRAMEWORK

CERCLA: Summary of Key Provisions

CERCLA, or Superfund, was enacted to address the problem of uncontrolled releases of hazardous substances into the environment. Removal actions are short-term responses to prevent or mitigate immediate threats. Remedial actions (the focus of this chapter) are longer term responses designed to provide permanent remedies, The statute does not provide explicit guidance on how to decide on the extent of a cleanup. The statute does, however, impose constraints on the choice of removal and remedial actions. Removal actions are limited to $1 million or 6 months unless certain statutory conditions are met,

Remedial actions are restricted by *fund-balancing* and *cost-effective* requirements. The fund-balancing requirement limits the selection of a remedial action to one that provides a balance between the need to protect public health and welfare and the environment at that site and the availability of Superfund money for response to other sites. The NCP is directed to require that remedial actions be cost effective over the period of potential exposure to the hazardous substances or contaminated materials. It is commonly accepted that cost effectiveness pertains to a fixed goal that different approaches may meet.

National Contingency Plan: Summary of Key Provisions

The NCP establishes the process for determining appropriate removal and remedial actions at Superfund sites. The NCP can be revised periodically, which was last done on July 16, 1982. EPA proposed revisions to the NCP on January 28, 1985, pursuant to a settlement agreement reached in *Environmental Defense Fund and the State of New Jersey v. EPA.*

The existing NCP authorizes two types of removal actions: immediate and planned. EPA is empowered to conduct immediate removal actions when it determines such actions are necessary to prevent or mitigate an immediate and significant risk to human life or health or to the environment. There is no explicit provision establishing the required extent of cleanup. Immediate removal actions are considered "complete" when there is no longer an immediate and significant risk to human life or health or to the environment, and the contaminated waste materials have been treated or disposed of properly offsite.

Planned removals are authorized when the Environmental Protection Agency (EPA) determines that continuing an immediate removal action will result in a substantial cost savings or that the public or the environment will be at risk if response is delayed at a site not on the National Priorities List (NPL). *As with immediate removals, there is no explicit provision establishing the extent of cleanup for planned removals.* They are "terminated" when the risk to the public health or the environment has been abated.

The current NCP provides extensive guidance for choosing an appropriate remedial action plan. There is a process EPA uses to evaluate the nature and extent of contamination at a site; propose and evaluate possible remedial alternatives; and select a remedial action plan, As with removal actions, *the NCP does not provide explicit guidance on what degree of cleanup must be achieved by a remedial action.* The appropriate extent of remedy is determined by selecting the most cost-effective remedial alternative (i. e., the lowest cost alternative that is technologically feasible and reliable and which effectively minimizes damage to and provides adequate protection of public health, welfare, and the environment). As with CERCLA, the NCP requires that the need to respond to other releases with Fund monies be considered in determining the appropriate extent of remedy,

Applicability of Other Laws to Determining Extent of Cleanup at Superfund Sites

The proposed draft revisions to the NCP incorporate EPA's policy on CERCLA compliance with the requirements of other environmental statutes. For removal actions, EPA proposes to meet applicable or relevant standards of other Federal environmental and public health laws to the maximum extent practicable, considering the exigencies of the situation.

For remedial actions, EPA proposes to comply with applicable and relevant standards of other Federal public health and environmental laws, with limited waivers. Specifically, the draft revisions would require that the appropriate extent of remedy be determined by selecting a cost-effective remedial action that effectively mitigates and minimizes threats to and provides adequate protection of public health and welfare and the environment. In particular, the remedy must, at a minimum, attain or exceed applicable or relevant existing Federal public health or environmental standards. *Applicable* standards are those standards that would be legally applicable if the actions were not taken pursuant to Section 104 or 106 of CERCLA. Relevant standards are those that are based on scientific or technological considerations that are similar to conditions at the site.

Where two or more alternatives achieve comparable levels of protection of public health and welfare and the environment, the most cost-effective alternative will be selected; one which provides the most favorable balance between cost and protection. Selection can consider the reliability of the remedy, available technology, administrative concerns, and other relevant factors. According to EPA, an alternative that does not meet applicable or relevant standards may be selected for one of the following reasons:

- fund-balancing;
- the selected alternative is not the final reined y;
- technological infeasibility;
- unacceptable environmental impacts; or
- overriding public health concerns,

Thus, it is not clear that EPA's approach necessarily leads to a cleanup decision consistent with the level of protection originally intended for a site.

Use of Hazard Ranking System

Sites that are included on the NPL are ranked by the Hazard Ranking System (HRS). The score assigned to each site is intended to reflect the relative potential of the hazardous substances present to cause damage, the rapidity with which the damage will occur, and the magnitude of the impact. Three scores are combined to produce the final rank. These scores reflect the potential for harm by chemicals that have migrated away from the facility and are found in the groundwater, surface water, or air. If the final priority score is equal to or above 28.5, the site is placed on the NPL and is eligible for remedial action.

The HRS addresses the possibility that a site will cause harm. Since it neglects actual exposures and effects, however, it does not provide a qualitative assessment of the risk presented by the site. Moreover, sites where data are lacking may have lower scores than appropriate because zero is generally assigned for any specific points lacking data (see chapter 5).

Some of the factors used in the HRS model indicate the types of concerns that should be addressed in determining cleanup goals. The model estimates hazard based on limited data and can lead to scores which other information could increase or decrease. For example, an increasing number of points are given for decreasing distance to surface water, buildings, or local populations. The *current model* cannot incorporate additional knowledge that would substantially affect the danger posed by the site, e.g., whether the geologic conditions are likely to allow the chemicals to contaminate the surface water, whether the buildings are occupied, or whether the activities of the local population cause frequent contact with the site. The presence of an observed release, an unusual smell, or a large number of drums or tanks increase the score in the model. Thus, some parts of the current model address issues of concern for determining extent of cleanup, but not all important issues are considered. The model was not designed to and is not used to determine extent of cleanup and, as currently structured, is inadequate for this purpose. But a *revised, improved model* could be used to determine, at least partially, the extent of response, even if only the *initial* response (see chapter 2).

Use of Cleanup Goals

At the four sites OTA examined closely, all the remedial strategies were based primarily on waste containment and groundwater *treat*ment, rather than waste removal and treatment. Several factors seemed to influence these decisions. Costs required for complete site cleanup appeared to be important factors at the Love Canal and Seymour sites. At Stringfellow, incorrect assumptions regarding the permeability of underlying bedrock formed the basis for remedial action decisions that have proven ineffective. Little consideration was given to the long-term effectiveness of containment, continually increasing operating and maintenance costs, possibilities of containment failure and continuing groundwater contamination, and practical problems resulting from the very long times (hundreds or thousands of years) required to manage these hazardous waste sites.

At three of the sites (Seymour, Stringfellow, Love Canal), initial actions were required prior to remediation. These actions were short-term solutions to immediate problems, and in some cases may have actually worsened the problem. At these sites, there was also a lack of specific cleanup goals specifying acceptable residual levels of contamination.

The Sylvester site was the only one where environmental goals were set prior to remedial action. The specific cleanup goals involved a hundred-fold reduction in the offsite release of contaminants in groundwater, compliance with EPA water quality standards at Lowell drinking water intakes, and compliance with certain EPA air quality criteria at a nearby trailer park. In particular, the goals were aimed at meeting standards for several contaminants in water and chloroform in air emissions. The cleanup goals did not consider other sources of toxic chemicals entering the water supply.

APPROACHES TO ESTABLISHING CLEANUP GOALS OR STANDARDS

This section will evaluate some alternative approaches to establishing the extent of clean-up at Superfund sites. No attempt has been made to consider all possible approaches. The approaches selected were those that appear most reasonable given current knowledge and past experience with remedial actions at Superfund sites.

The analysis of each approach will consider six major factors that define the nature and extent of cleanup that is possible at Superfund sites: 1) inherent hazard of the chemical wastes found at the sites; 2) site-specific considerations and exposure; 3) assessment of risks to human health, environmental biota, and natural resources; 4) available technologies and remedial action alternatives; 5) resource limitations; and 6) institutional constraints. While *many of these factors involve scientific and technical issues, it is important to recognize that the choice of a cleanup goal or standard is ultimately a policy decision.*

Factors for Evaluating Alternatives

Inherent Hazard of Chemical Wastes Found at Superfund Sites

The inherent hazard of the chemicals present at a site determines their potential to cause harm to human health or the environment. When inherent hazard is combined with potential exposure, the potential risk (i.e., the possibility of an adverse effect) for harm to human health or the environment can be assessed. Inherent hazard of chemicals can be evaluated by the type of damage they cause, the amount present as compared to existing standards and acceptable levels, the extent of reliable knowledge about them, and the mixture of hazardous substances present at the site.

Several types of hazard can occur from the release of chemicals into the environment. For example, some chemicals are likely to ignite or explode, causing both the danger of physical damage and the potential for the chemicals to be spread over a large area. The corrosive properties of chemicals can directly damage human health or the environment and can affect the stability of the site by causing a breach of natural or engineered barriers, The chemicals can also present a toxicological risk to people or local flora and fauna.

Each chemical can present one or several types of toxicological hazards. The compound can be acutely toxic, i.e., exposure for minutes or hours can produce an effect that is generally observed within a very short period of time. Somewhat longer exposures may also produce adverse effects, either a more severe consequence or an entirely different effect, including cancer. Certain more sensitive populations may be affected by lower levels of exposure than the general population, For instance, some chemicals are most toxic to developing fetuses *in utero* but cause little harm to the pregnant woman, Still other effects may be observed in young children or the elderly,

Adverse health effects range from reversible effects, e.g., skin or eye irritation, to irreversible damage, e.g., malfunction or cancer of vital organs. A chemical may cause predominantly one effect or may cause several diverse toxic reactions. Moreover, each chemical can produce a variety of effects depending on the level of exposure. *While all chemicals can produce an adverse effect at some level of exposure, the level of exposure will determine both the type of damage and the severity of the harm.* Thus, low levels of some chemicals will produce dizziness or headaches while higher levels may cause unconsciousness or death. Similarly, a dilute acid may cause skin irritation while a more concentrated solution will burn the skin. Knowledge of both the inherent toxicity of the chemicals present at the site and levels of potential exposure is, therefore, necessary to determine what hazard exists.

Standards or levels that have been deemed acceptable exist for some of the chemicals found at Superfund sites. Some standards, which have had some peer and public review, and other established levels (e. g., judicially established action levels) can be used to evaluate inherent hazard. Care must be taken to ensure that the standard or other acceptable level is appropriate for the Superfund site. *Standards are usually developed for one medium and one route of exposure.* For example, a standard of 1 part per billion of dioxin in soil has been set for Superfund sites, but not for water or air. A standard developed for one medium is frequently inappropriate for another since the medium may determine the extent and route of exposure. The severity and type of toxicity of a chemical can also vary with route of exposure. Furthermore, some standards are for acute (short-term) exposures while others are for chronic (long-term] exposures. Occupational standards for exposure assume a limited time exposure for healthy adults. Other standards may be partially based on cost or available technology and should not be considered a measure of inherent toxicity.

Although the inherent toxicity of several chemicals has been studied in depth, a recent study by the National Academy of Sciences concluded that most chemicals have not been adequately examined for all potential toxic effects.[2] Based on an examination of randomly selected compounds, the report estimates that no toxicity information is available on 76 to 82 percent of chemicals in commerce included on the Toxic Substances Control Act Inventory, 38 percent of pesticides and inert ingredients of pesticides formulations, 56 percent of cosmetic ingredients, 25 percent of drugs and excipients used in drug formulations, and 46 percent of food additives. Less than 18 percent of the chemicals in these categories were estimated to have a sufficient data base to provide a complete health hazard assessment. The lack of data is a particular concern for chemical wastes, i.e., chemicals that are unwanted byproducts of chemical synthesis or other manufacturing process. Until recently, there has been little economic incentive to study the potential toxic effects of such chemicals. Moreover, there have been few studies on health ef-

[2]National Research Council, *Toxicity Testing, Strategies to Determine Needs and Priorities* (Washington, DC: National Academy Press, 1984).

fects associated with actual uncontrolled sites, and those completed have generally posed significant scientific uncertainties.

Finally, few waste sites contain only one chemical; thus, chemical and toxicological interactions need to be considered. Chemical reactions can result in new compounds whose physical, chemical, and toxicological properties differ significantly from those originally at the Superfund site, Chemical reactions can also cause fire or explosions. The potential of toxicological interactions is poorly understood. While some chemicals have been shown to enhance or interfere with the toxicological effects of another (e.g., synergism or antagonism), only a few such mixtures have been examined. In *the absence of knowledge, the hazards of combinations of chemicals is generally ignored and may present a large uncertainty* in the assess*ment of the site.*

Site-Specific Considerations and Exposure

For chemicals to pose a hazard to health and the environment, people, flora, and fauna must be exposed to them. Geology, geography, and weather conditions are some of the factors that will affect the routes and levels of exposure. Thus, *site-specific factors will affect which media are contaminated and the routes and extent of potential exposure.*

Site-specific factors will determine the probability that chemicals will leach into groundwater, drain into rivers, or evaporate into the air. For example, soil with high organic content will tend to retain hydrophobic chemicals such as polychlorinated biphenyls (PCBs) while soils with less organic content will tend to release these chemicals into the groundwater or air. Soil composition and permeability will influence the rate at which contaminants leach from the site, which in turn can affect the rate and extent of exposures, e.g., via drinking water wells or via contamination of nearby surface water. Weather, including temperature, amount and type of precipitation, and wind strength or direction can affect the movement of chemicals and their transfer among media. Conditions that affect the route of exposure, e.g., exposure to contaminated soil via dermal contact versus inhalation of dust particles, can affect the amount absorbed into the body and, thus, the extent of exposure.

Models can be used to predict environmental fate and potential levels of exposure by various routes. Confirmation of the accuracy of environmental fate models is limited by the paucity of data on the actions and reactions of chemicals in the environment. For example, predictions of a chemicals's movement for several decades is often based on data collected over several months. Small errors in initial measurements or in assumptions can be compounded for long-term predictions.

Modeling potential exposure will also depend on the ability of the assessor to estimate human activity. Route and level of exposure will depend on the activities of the local population, e.g., digging in soil, swimming in or drinking of water. Inhalation exposure levels will vary with breathing rate which, in turn, depends on factors such as age and level of activity. The average exposure for a population can differ significantly from the exposure of a person whose habits or occupation cause more or less contact with the site. Exposure models also make assumptions about the extent to which an individual's activities will change over a lifetime and the likelihood that people will remain in their current residence and/or occupation.

The size and sensitivity of the local population and the nature of the flora and fauna will determine the extent of the effects of exposure to the chemicals. The size of the local population and its proximity to the site will determine the number of people potentially exposed. The presence or absence of particularly sensitive populations (e.g., children, the elderly) needs to be known to adequately assess the level of exposure that will produce an adverse effect, Knowledge of activities on or near a site will indicate potential routes of exposure and allow reasonable estimations of durations of exposure, e.g., children at Love Canal faced potentially high exposure because of the location of their school and playground.

A Superfund site should not be examined in a vacuum, Other factors in the surrounding environment can affect the nature and extent of remedial action at a site. Naturally occurring chemicals can present a hazard when combined with residual levels from a cleaned site. Even *if a Superfund site is cleaned to a level that is acceptable by itself, the background level of some toxic chemicals, such as heavy metals, may be sufficiently high that exposure to the background levels combined with the residual contamination can raise exposure to an unacceptable level.* Local sources of pollution need to be considered when determining the potential risk to an exposed population. Some of these other sources may cause concomitant exposures, especially if they contaminate the same resource, e.g., the same aquifer. Other sources may cause exposure to the same chemicals but by different routes, for instance, organic solvents may be in the drinking water or in the air.

Assessment of Risks to Human Health, Environmental Biota, and Natural Resources

An assessment of a site's potential health and environmental risks is based on the inherent hazard of the chemicals present and the routes and levels of potential exposure. Risk assessment is the use of available data to estimate the potential effects of exposure to particular hazardous materials or situations on an individual, species, or populations. Results of risk assessments are frequently expressed as the probability of the occurrence of a particular effect under specific conditions. The National Academy of Sciences has identified four processes that comprise a risk assess ment:[3]

- *Hazard identification:* The determination of whether a particular chemical is or is not casually linked to particular health effects,
- *Dose-response assessment:* The determination of the relation between the magnitude of exposure and the probability of occurrence of the health effects in question.
- *Exposure assessment..* The determination of the extent of human exposure before or after application of regulatory controls.
- *Risk characterization:* The description of the nature and often the magnitude of human risk, including attendant uncertainty.

The first three issues were discussed during considerations of inherent hazard and site-specific conditions. Risk characterization is discussed below.

Risk assessments should explicitly consider the uncertainties in knowledge about the inherent hazard of the chemicals at the site and the routes and levels of exposure. Thus, if the toxicological data limitations were greatest for chemicals that would be expected to volatilize easily and if the greatest exposure were expected to be by inhalation, a greater uncertainty factor might be incorporated into the risk assessment to account for these compounds' potential toxicity, Similarly, if the toxicity of the compound that poses the most significant risk at the site were estimated from incomplete data or from experiments that were inadequately performed, a greater uncertainty factor would be included in the risk assessment or, alternatively, the next most toxic chemical might be used for the evaluation,

A site-specific risk assessment is comprised of a series of such assessments: for each route of exposure, for each duration of exposure (i.e., acute, short-term, or chronic), and for various adverse effects (e. g., cancer or organ toxicity) for each organism (e.g., human, animal, or plant) potentially affected. Usually the exposures producing the highest risks based on preliminary assessments for the populations of concern are more carefully evaluated.

In addition to uncertainties associated with conditions at a site, *the process of risk assessment itself has inherent uncertainties.* For example, toxicological risk assessments are based on current knowledge and assumptions about biological processes use models that have been developed to describe them, Often the models are designed to overestimate rather than underestimate risk. While such prudence is reasonable given the limitations of toxicological

[3]Ibid

knowledge, it must be recognized that such decisions are based on considerations other than those provided by science alone. This is one example of the difference between risk assessment and risk management.

Risk *assessment* is defined as the calculation of the probability of adverse outcomes such as injury, disease, or death. *Risk management* incorporates other considerations such as acceptability of risk, costs and benefits, and policy into a determination of a course of action. Although theoretically distinct parts of the decisionmaking process, risk assessment and risk management are too often interwoven. In the case cited above, deciding which risk extrapolation model to use is a risk management decision, Evaluating and selecting data to be used in the extrapolation model, as well as the extrapolation process, are elements of risk assessment. Decisions about what actions to take based on the extrapolated risk are risk management judgments. When elements of risk management are imbedded in risk assessment processes, confusion about the "scientific" or "objective" content of policies and decisions can result.

Site-specific risk can be compared with risk levels that are considered to be acceptable. Non-chronic toxic effects are thought to have a threshold of exposure below which no toxicity will occur. Acceptable exposure levels for these compounds are frequently based on a no-observed-adverse-effect level which is lowered by uncertainty factors that consider concerns such as variation in individual susceptibility and extrapolation of results from animals to man. The resultant levels are often called acceptable daily intakes or ADIs. EPA has published draft guidance on the use of ADIs for assessment of the risk to human health from nonchronic effects. *

Acceptable exposure levels for carcinogens are usually based on the estimated increase in an individual's probability of contracting cancer. In the past, EPA has regulated carcinogens at individual risk levels in the range of 10^{4}(1 in 10,000) to 10^{8}(1 in 100,000,000). The breadth of this range is caused by many factors including cost-benefit analysis (when applicable under the appropriate legislation), availability of substitute chemicals (e.g., for regulating pesticides), or feasibility (e. g., ability to remove chemicals from groundwater). In general, EPA recommends that residual risk levels for carcinogens at Superfund sites be in the range of 10^{4} to 10^{8} before consideration of site-specific factors,[5] with a risk of 10^{8} (1 in 1,000,000) as the point of departure for an acceptable level.

Available Technologies and Remedial Action Alternatives

The ability to detect the identity and levels of contaminating chemicals and achieve cleanup goals depends on currently available technology. Although technology continues to advance, it has limitations that cannot be exceeded regardless of situation or intentions; there can be no *a priori* assurance that even a proven technology will work for each particular situation. Technological limitations affect several aspects of cleanup goals and procedures.

The state of the art of sampling technology limits the extent to which the identity and levels of chemicals contaminating a site can be determined. Sampling can represent the most difficult problem at large sites with diverse chemical contaminants and geologic conditions.

Analytical procedures do not exist for the unambiguous identification of all chemicals that may be encountered at Superfund sites. Procedures have been developed for some chemicals, but they only detect that compound above a certain level, As analytical procedures limit knowledge of the presence of chemicals, they also limit the extent to which cleanup can be achieved with certainty. After a remedial cleanup, the presence or absence of a compound can at best be determined to be at or below the lim-

[4] U.S. Environmental Protection Agency, *Guidance and Methods for the Use of Acceptable Daily intakes in Health Risk Assessment,* 1984,

[5] U.S. Environmental Protection Agency, Memorandum by Lee M. Thomas on International Paper ACL Demonstration, Nov. 19, 1984.

its of detection. These may be above or below levels of concern for threats to health or environment.

Cleanup technologies are similarly limited. Public expectations usually ignore the limitations of even the best technology to eliminate exposure to a waste once it is released into the environment, particularly groundwater, or to completely prevent future releases. Current options for handling waste chemicals include destruction (e.g., incineration), blocking movement (e. g., slurry walls), or removal (e. g., offsite disposal). Many prospective cleanup technologies are in the R&D or the pilot plant stages of development (see chapter 6).

The unintended consequences of the use of any remedial technology may include transfer of toxicants among media, transfer or risks among populations, and residual pollution resulting from the technology. Transfers of toxicants among media may involve the same chemicals (e. g., when chemicals are stripped from water by aeration) or chemical byproducts of processing the orginal contaminants (e.g., transfer of combustion products of solids or liquids into air pollutants by incineration), Although such processes can remove the contaminants from the Superfund site, the residual risks posed by the chemicals or their byproducts in new media need to be considered.

Remedial technologies can also involve the transfer of risks among populations. Offsite disposal of waste chemicals will potentially expose additional populations during transit, treatment, or disposal of the waste chemicals. Risks to new and previously unexposed populations should be considered when evaluating the effectiveness of any remedial action.

Most technologies will leave some level of residual contamination, either at the original site, in aquifers distant from the site, or at the ultimate site of treatment or redisposal. Some residual contamination results from the inability of any process to completely eliminate a chemical. Risks posed by this residual contamination should be considered when cleanup goals are established. Other remedial processes produce new wastes (e.g., contaminated carbon from filtration systems), While not always immediately obvious, generation of such wastes must be considered in establishing cleanup procedures and goals.

Resource Limitations

A number of resource limitations significantly affect the nature and extent of remedial actions. First, there is a finite amount of public and private money that can be devoted to the cleanup of Superfund sites. In addition to financial limitations, other resources such *as* the number of trained personnel, laboratories for sampling and analysis, and equipment to achieve the desired cleanup response are also limited and may not be available even if money were (see chapter 7). Similarly, decisions to use offsite hazardous waste management facilities assume that these facilities have sufficient capacity,

Dividing the total available resources among all NPL sites involves difficult decisions based on limited data and can result in inconsistencies in the extent of cleanup among sites. Whatever the allocation of resources for any site, the cleanup should obtain the highest level of cleanup for resources spent. But this still begs the issue of cleanup goals. It is becoming increasingly clear that at this time the potential number of Superfund sites is not accurately known, nor is it known what resources will be needed for remedial actions at those sites. Consequently, the resources made available for any single site must be carefully considered. Without such consideration, several intractable sites could significantly deplete the available funds and necessitate less extensive cleanup at serious sites that are discovered or investigated later (see chapters 2 and 3).

Institutional Constraints

As discussed, CERCLA and the NCP as currently drafted provide little guidance about how to determine the extent of cleanup required at Superfund sites. Draft revisions to the NCP would require that in most cases, cleanups must attain or exceed relevant and applicable Federal standards. It is not clear that this requirement would really resolve the issue of extent of cleanup, especially in light of the exceptions incorporated in the draft provision,

The extent to which other laws and regulations may define the extent of cleanup and the manner in which the cleanup is achieved also lacks clarity. For example, it is obvious that material removed from a Superfund site for offsite disposal must be handled in compliance with the provisions of the Resource Conservation and Recovery Act (RCRA), (However, see chapter 5 for a discussion of the problems with RCRA facilities.) Less clear is the impact of the provisions of RCRA if the material is to be disposed, stored, or contained on site. Does the site become a *de facto* RCRA facility that must comply with all RCRA requirements? The resolution of these issues could substantially affect the nature of remedial actions.

Other laws such as the Safe Drinking Water Act (SDWA), Clean Water Act (CWA), and Clean Air Act (CAA) regulate contaminants in the environment, Current provisions of these acts are insufficient to define the extent of cleanup under CERCLA. The number of chemicals regulated under each act is small compared with the number of compounds already identified at Superfund sites, The standards developed under these laws consider one medium and/or route of exposure: SDWA, drinking water (ingestion); CWA, surface water; CAA, air (inhalation). SDWA health advisories only consider short-term effects (1 day to 2 years) and do not, therefore, consider carcinogenic effects. While none of these existing standards are alone sufficient to determine the extent of cleanup, they may provide guidance for a particular medium or route of exposure.

Hazardous waste sites have generated considerable public, political, and media interest. These concerns have focused attention on the problem in general, and decisions about actions at Superfund sites are being examined with increased intensity, While the high level of interest may increase the probability that all alternatives are examined and that appropriate action is ultimately taken, this interest can also present problems. The issues involved in determining the extent of cleanup at any site are technically complex and contain large uncertainties. Oversimplification of the issues can lead to an overstatement or understatement of the risk that, in turn, can lead to unnecessary concern or complacency. Public, political, or media pressure may cause cleanup based on notoriety rather than hazard. When the method or extent of cleanup is well-publicized at one site, public perception of fairness may require that the same method or extent of cleanup be used at another site, even if site-specific considerations would suggest a different action.

Actions of the local population, media, or elected officials can be based on calculated, potential adverse effects or on their perception of risks that may not exist, Studies of *real* versus *perceived risk* have clearly demonstrated that the risk perceived by the public may differ significantly from the calculated risk, not that calculated risk is necessarily a complete indicator of actual risk, b Both perceived and actual risks may have to be addressed in the remedial action program, perhaps through more effective public participation in decisionmaking (see chapter 8).

One factor influencing public perception of risk will be actions taken at other sites where remedies have been instituted, Public reaction may be adverse if actions that are perceived to be less stringent are implemented at one site as compared with another, Because of site-specific factors affecting the design of remedial action programs, comparison of one cleanup plan with another will be difficult and in many cases unfair. *What is ultimately important and realistically achievable is consistency in the process of determining what the cleanup of sites should be, rather than necessarily making all cleanups the same.*

Discussion of Alternative Approaches

This section analyzes seven alternative approaches for determining the extent of cleanup

[8]V. T. Covello, W.G. Flare m, J.V. Rod ricks, and R.G. Tard iff, The *Analysis of Actual Versus Perceived Risks* (New York: Plenum Press, 1983).

at Superfund sites. The primary focus of four of the approaches is to establish cleanup goals based primarily on current scientific and technical considerations: *site-specific risk assessments, national levels of residual contamination, background or pristine levels of chemicals, or best available technology.* The fifth approach, the use of *cost-benefit analysis,* balances the extent of cleanup at each site against cost, with or without a site-specific resource limitation, A potential-use driven approach is designed around *a classification system based on present and future use of sites.* Also discussed is a continuation of the current ad hoc practices,

Continued Use of Current Ad Hoc Practices

Description of Approach.—In general, the present reliance on ad hoc practices has not provided a consistent explicit process for determining goals. Nor is it likely that the remedial actions thus far have resulted in consistent levels of cleanup among sites posing similar threats. A review of remedial actions at various Superfund sites indicates that the inherent toxicity of the chemicals present has, in part, determined the chosen remedy. Site-specific factors, especially as they affect feasibility, have also been considered. Risk assessments of the potential for sites to harm human health or the environment have rarely been explicitly included in the decision process.

Availability and *presumed effectiveness* of best available remedial technologies have been driving factors in determining the extent of cleanup. This may be due, in part, to the comparative ease of analyzing the cost, feasibility, and reliability of existing technologies contrasted with the difficulty of making such judgments regarding health and environmental risks. There has been some sensitivity to the concerns of the local population, elected officials, and the media.

Analysis of Approach.—Continuation of current practices, possibly with additional guidance, would provide an increased opportunity to evaluate remedial actions. One might then have a stronger basis for deciding on the preferred approach to establishing cleanup goals. On the other hand, CERCLA was enacted over 4 years ago; considerable resources have been expended and continue to be spent with mixed results, Now may be the time to resolve an issue which is critical to the remedial action program.

Site-Specific Risk Assessment

Description of Approach.—One alternative approach to determining cleanup goals involves the *explicit use of risk assessment coupled with a site-specific or national determination of acceptable risk levels.* Uniform procedures and methodologies would also need to be used. Risk assessment would involve determining the potential hazards of the chemicals at each site, characterizing exposures based on site-specific considerations, and calculating risks based on the inherent toxicity of chemicals at the site and potential exposures to humans and the environment.

Various models can be used to determine site-specific risk. One model illustrates some of the issues that need to be resolved in site-specific risk assessment.[7] In this model, the individual chemicals to be used in the risk assessment are selected by a ranking scheme that evaluates each chemical's potential for toxicity (based on ADI and/or carcinogenic potency) and exposure (based on quantity present and physical-chemical properties). For each selected chemical, potential exposure is estimated by all appropriate routes, for each remedial action plan considered. The risk for each chemical for each route is calculated and compared with the predetermined acceptable level for the toxic effect. Remedial actions are compared, and the appropriate response is selected to achieve the maximum difference between the residual and acceptable level of risk at the lowest cost.

For the sake of consistency and defensibility, uniform procedures and methodologies should be used in risk assessment; therefore, a num-

[7] J.V. Rodricks, "Risk Assessment at Hazardous Waste Disposal Sites," *Hazardous Waste,* vol. 1, 1984, pp. 333-362.

ber of choices must be made. A site-specific risk assessment of human health effects can be expressed in terms of individual or population risk. Individual risks estimate the risk of any person exposed under the conditions stated in the estimate and are independent of the size of the population exposed. Population risks are derived by multiplying the individual risk by the number of people exposed by that route of exposure. *If individual risks are used for setting the standards for extent of cleanup, cleanups will be consistent throughout the country regardless of the size of the potentially exposed population. If population risks are used, Superfund sites in sparsely settled locations may have higher residual individual risk than those in more populated areas.*

Since most Superfund sites contain many chemicals, the risk assessor, for a variety of reasons, including cost and expediency, may choose to determine the risk on the basis of a few indicator substances. If the selection of indicator chemicals is based on their relative abundance at the site, the most toxic chemicals may be overlooked. If the selection is based on inherent toxicity, compounds that have been extensively studied may be favored since knowledge about lack of toxicity is not always distinguished from lack of knowledge about toxicity. Clearly making such a choice without doing assessments for the alternatives could lead to results that are not indicative of the site's greatest risks.

Similarly, choices must be made for predicting potential exposure. These choices are often between the use of models to predict exposures and collecting more extensive data on actual exposure. After the site has been generally characterized for factors such as geology, weather, and local population, models can provide an estimate of exposure, albeit with some uncertainty. Gathering more data can reduce this uncertainty, but can delay action, cause more exposure to the pollutants, and be quite expensive.

Analysis of Approach.—By definition, a cleanup goal determined by risk assessment must give appropriate consideration to the inherent hazard of the chemicals present at a site, the site-specific factors affecting exposure, and the potential risks to human health, environmental biota, and natural resources. All of the previously discussed uncertainties and concerns associated with these factors would still apply, It is possible to structure conservative risk assessments through a "worst-case" perspective, or to consider "average" or "likely" risks.

This approach's sensitivity to technology and resource limitations depends to a large extent on whether the cleanup would need to achieve a national or site-specific standard (perhaps within a nationally established range of acceptable residual risk). For example, an inflexible risk goal for a chemical or for the total site may not be achievable for technical reasons. The goal may be below the limits of detection with current analytical procedures. Technologies may not exist to remove low levels of specified chemicals from air, water, or soil. Alternatively, the technologies may exist but may require resources disproportionate to the incremental reduction of risk. TO *attempt to achieve a national risk goal might allow a few sites to virtually bankrupt the system, unless considerable resources were provided.* A site-specific standard would be more sensitive to the particular circumstances of a site and the resources and technologies that are available to effect cleanup, but does not assure national consistency for protection at similarly contaminated sites,

In any event, performing a risk assessment is a costly, time-consuming process that requires highly trained technical specialists in a number of disciplines. Thus, a critical issue is how to choose *when* to use risk assessment,

A risk assessment approach to establishing cleanup goals is not inconsistent with CERCLA, Because of the uncertainties that are likely to be associated with a particular site and the uncertainties in the risk assessment process itself, public acceptance of the outcome of risk assessment is likely to be mixed. This would be especially true when the "real" risk is quite different from the "perceived" risk, Considerable effort to educate and inform the public would need to accompany this approach, The choice of a national or site-specific standard of acceptable risk (i. e., a probability) would have a significant impact on public reaction, A single, minimal national standard for acceptable risk, if perceived to provide adequate protection, would be easy to explain and would result, at least in theory, in consistent cleanups. A site-specific standard (even within a range of acceptable risk) would probably result in inconsistent cleanups and cause more public concern.

National Goals for Residual Contamination

Description of Approach.—This approach would involve *setting new residual levels and using available ones for all chemicals or classes of chemicals found at Superfund sites.* These levels would be the same for all sites and not consider site-specific conditions. A major issue that would need to be resolved in the use of this approach is what factors to consider in establishing new levels, i.e., inherent hazard, cost and/or available technology, or some combination of them.

Existing standards, criteria, and guidelines will be of limited utility in establishing national goals. They currently exist for only a small number of chemicals found at Superfund sites. Most were designed for a specific environmental medium and none suit all possible routes of exposure that may exist at Superfund sites. Many were developed for exposures that are not compatible with those at Superfund sites. For example, a standard developed for an occupational exposure (the calculated risk would be for a group of healthy adults for a daily duration of 8 hours, 5 days per week) would not match the conditions of exposure of most Superfund sites,

This is not to say that existing standards, criteria, and guidelines cannot be used, only that one needs to be careful in doing so. In fact, as discussed previously, draft revisions to the NCP would require remedial actions in most cases to comply, at a minimum with “applicable” and “relevant” Federal standards. Under this approach to establishing cleanup goals, for those chemicals for which there are no existing applicable or relevant standards, new ones would need to be developed, or perhaps some other approach to setting cleanup goals used. *Hence, what at first appears to be an expeditious approach may be just the opposite.*

Analysis of Approach.—Establishing national goals for residual contamination would certainly consider, to some extent, the inherent hazard of the chemical wastes. As discussed, there currently exists limited knowledge of the inherent hazardous properties of chemicals at Superfund sites. Consequently, the establishment of standards for all hazardous substances or classes at Superfund sites would be hampered by a limited data base and would involve extrapolation of current knowledge beyond limits of verification.

This approach would not consider site-specific conditions, and the extent to which risk assessment is considered would depend on how the standards were established. For example, if the standards were established in a way so that, under any conditions of exposure, the resulting risks would be acceptable, then a site-specific risk assessment would be of no additional value.

Resource and technological limitations could be addressed in the development of the goals. For example, the cost and/or availability of cleanup technology could be the determining factor in establishing a goal for particular chemicals. Such a standard might not achieve an acceptable level of risk. On the other hand, goals established solely on the basis of inherent hazard may be only theoretical benchmarks if the resources and technologies are not available to attain them.

Establishing national goals is certainly consistent with the direction that EPA is moving in the draft revisions to the NCP and would satisfy the need for national consistency. But if this approach was based on a commitment to develop standards for all or most chemicals and conditions, the system would be slow to initiate and the costs would be substantial, If the goals are set at levels generally perceived to protect health and the environment, public concern would focus almost exclusively on the effective implementation of those goals. On the other hand, if the driving force behind the goals is perceived to be resource limitations, public confidence could quickly erode.

Clean to Background or "Pristine" Levels

Description of Approach.—This approach for establishing the extent of cleanup would require that the cleanup continue *until the levels of all contaminants were indistinguishable from those of the surrounding background.* A variation of this approach would require that the cleanup continue until the site were "pristine, " i.e., as if the pollution had never occurred.

The first issue that would need to be resolved with this approach is how to determine background or pristine levels. Historical background levels are not usually available for most sites, for a diversity of chemicals and media. Frequently, background is determined by sampling nearby locations and can include pollution from other sources. In most cases, pristine would be a cleaner level than background, especially if the site is in an industrial area.

Analysis of Approach.—Cleaning to background or pristine levels does not explicitly consider the inherent hazard of the chemical wastes on site. *Only the environmental context of the site is considered in determining the levels of cleanup.* This approach includes an implicit risk assessment, i.e., it assumes that any level above background or pristine is an unacceptable risk and levels at or below background or pristine are acceptable. These assumptions may not be true. For example, certain industrial contaminants do not exist naturally in the environment and the pristine levels for these chemicals would be zero, Putting aside the financial or technical capability of reaching a zero level of residual contamination, it is hard to imagine that such a result would be necessary from a public health or environmental perspective. Further, "background" levels might not necessarily provide the desired level of protection, especially in heavily industrialized areas with multiple sources of industrial contamination.

This approach to establishing a cleanup goal is not particularly sensitive to resource limitations or available technologies. In general, this approach would be expensive and difficult to implement.

Because this would likely be the most expensive approach, its successful implementation would be significantly constrained by the fund balancing provision of Superfund. Public acceptance of this approach could be expected to be mixed. *There would be inconsistencies among cleanup of sites with similar wastes depending on where they are located.* Moreover, because this is a costly approach, fewer sites could be expected to be cleaned up at any one time.

Technology-Based Standard: Best Available Technology or Best Engineering Judgment

Description of Approach.—This approach would involve examining all available remedial technologies that address the chemical contamination at a Superfund site, A remedial action plan would be developed that used the best available technology to minimize exposure to the waste chemicals at the site.

Analysis of Approach.—A detailed analysis of the inherent hazard of the chemical wastes found at a site would not be an integral part of this approach, However, it might be important to at least identify the wastes of major health and environmental concern at a site as a guide to the designers of remedial action. Site-specific factors would be critical. Knowledge of the quantity and identity of wastes present; of the geology and geography of the area; of the identification of potentially affected natural resources and local populations; and of the routes and levels of exposures would be essential to reach a best engineering judgment as to what remedial measures to take,

A risk assessment would not need to be performed. Implicit in this approach would be the assumption that, by using the best available technology, the risks from the site would be reduced to the lowest level that is technically feasible. (It may be suggested that technical feasibility is a practical limitation of any approach to establishing cleanup goals for remedial action, However, delaying cleanup or taking other risk management actions can be considered also.)

A technology-driven approach would be sensitive to the strength and weaknesses of currently available remedial procedures, The less confidence there is in existing technologies, the less satisfactory is this alternative, Since risk assessment is not an integral part of this approach, concerns about the transfer of risks among populations and the risks associated with residual pollution from the disposal technology would not be central to the decision-making process.

Unless limits were imposed on cleanup costs, this approach could be perceived as providing a blank check for those in the cleanup business. The designers of the remedial action program should employ a cost-effective use of resources. But can this be done without pre-established cleanup goals? Without some assessment of the risks, significant resources could be spent on a site that posed little or no risk. Unproven technologies might be used with little protection obtained, The incremental public health or environmental protection provided by a technology that is substantially more expensive than the second choice might be insignificant, but this could not be evaluated without a risk assessment. How would one know exactly what constituted a complete cleanup, or when to cease operations such as groundwater treatment? Moreover, advances in technology could raise the possibility of subsequent expensive retrofits to achieve higher levels of protection.

This approach would make it difficult to make informed decisions under the fund-balancing provision of CERCLA. Public reaction is likely to be mixed. A policy that Superfund sites will be cleaned up using the best available technology is initially appealing and appears to offer the best that can be provided. Realistically, limited resources are available to devote to cleaning up uncontrolled hazardous waste sites. This approach might create enormous pressure to be among the first sites where resources are spent, without attention to the uncertainties of cleanup effectiveness and the benefits of waiting for different technology or specific goals more related to exposures. Compromises would need to be made that would likely result in inconsistent cleanups.

Cost-Benefit Approach

Description of Approach.—A quantitative cost-benefit approach to establishing cleanup goals would require that the costs of any initial or incremental remedial measures be compared with the benefits (reduction of potential adverse effects to health and the environment) to be derived from such expenditures. Only if the (total or incremental) benefits are greater than the (total or incremental) costs would the expenditures be made. All this assumes that the benefits are measurable and the unit of measurement is comparable to costs. Benefits and cleanup goals are variables weighed against available funds. A less formal cost-benefit analysis based on articulation rather than quantification also could be used,

Analysis of Approach .—This approach requires an understanding of the benefits to be derived from remedial measures at a site, i.e., the reduction in risk to public health or the environment that those measures are likely to produce, To determine this, an analysis of the inherent hazard of the chemical wastes on site, a consideration of site-specific factors, and a risk assessment would be required. All of the uncertainties about the hazards of the materials of concern, the site-specific conditions, and the process of risk assessment would need to be recognized in a quantitative approach, especially when *uncertain additional health or environmental protection would be compared with certain expenditure of resources.* The more uncertain the benefits, the more dubious the results of the analysis. An assessment of risk and reduction of risks would need to be determined on a site-specific basis, This approach would not use national standards for residual risks, If there were national goals for residual risk levels, a cost-benefit analysis would be superfluous.

Calculating the benefits of a reduced risk is difficult, In the first place, regulatory decisionmakers are generally unwilling to assign dollar values to human lives, additional cases of cancer, or even the value of natural resources.

The evaluation of costs would need to be done carefully. Not only should the initial costs associated with a remedial measure be included but its impermanence and long-term (often uncertain) costs associated with the monitoring and maintenance of the technology need to be included in the calculation as well.

This approach would certainly be consistent with the fund-balancing provisions of CERCLA. However, public reaction is likely to be mixed, Attractive in theory, this approach would cause decisionmakers at individual sites to be tested publicly, especially when the uncertainties and value judgments implicit in this approach became apparent. Inconsistent levels of cleanup among sites could result unless very specific national procedures and policies were used.

Site Classification: Determining Cleanup Levels by Present and Future Use of a Site

Description of Approach.—To date, little attention has been given to what will happen to a site after it is cleaned. Under this approach, the extent *of cleanup would be based on the present and future use of a site and its surrounding area,* as determined by local government and communities. How a particular site is classified as to its present or future use (i. e., restoration, rehabitation, and reuse) would be the driving force in the selection of a remedial plan. Classes could be established early in the program, for example, when a site is placed on the NPL. For purposes of classification, the site would include any land or waters already or likely to be contaminated.

A classification system based on current and potential use has been recommended as part of EPA's groundwater protection strategy.[8] In establishing this strategy, EPA considered its inability to protect all groundwater from contamination, its fundamental purpose of protecting human health and the environment, and the cost and difficulty of monitoring and cleaning groundwater. These same considerations apply to NPL sites. In EPA's groundwater protection strategy, three classes of groundwater are recommended. Class I includes special groundwater, so designated because it represents irreplaceable sources of drinking water or ecologically vital areas, e.g., contamination would destroy a unique habitat. Class II includes current and potential sources of drinking water. Class III includes groundwaters that are not a potential source of drinking water and are of limited beneficial use, e.g., with total dissolved solids over 10,000 mg/l or already so contaminated that they cannot be cleaned by methods reasonably employed in public water treatment.

Analysis of Approach.—Implicit in the development of such a classification system is the policy decision that the extent of and the initiation of cleanup would differ among sites. Consequently, *some of the cleanup approaches previously described could be used with such a system,* For example, certain sites might be classified as so valuable as present or future resources that the goal would be developed through use of a site risk assessment. Other sites might not require any cleanup. Based on a cost-benefit analysis, the provision of an alternative water supply or the relocation of nearby residents might comprise the remedial (risk management) response.

For sites where only minimal remedial measures are taken because of limited future use (e.g., a site "paved over" and used for an airport runway or a large parking lot), methods such as deed restrictions must be used to communicate these decisions to future generations so that these contaminated resources are not unknowingly used for unforeseen purposes. The uncertainties in future land use must be weighed against the costs of more extensive cleanup. Transfer of liability to future land users or developers might be effective in enforcing land use restrictions.

[8]U.S. Environmental Protection Agency, *A Groundwater Protection Strategy for the Environmental Protection Agency*, August 1984.

The development of a classification system would be consistent with the fund-balancing provision of CERCLA. *In many ways, it would be the most nationally cost-effective approach discussed in this chapter.* Public reaction would be mixed depending on the classification system developed, the proposed response at individual sites, and the degree of local participation in deciding on land use.

CONCLUSION

On the basis of its analysis OTA finds that:

- There is a need to raise the cleanup goals issue to the highest levels of policymaking and to have open, public debate on it. The effectiveness of the Superfund program and private and State cleanups depend on an equitable and technically sound resolution of this issue.
- What is ultimately important and realistically achievable is consistency in the *process* of determining what the cleanup of sites should be, rather than necessarily making all cleanups the same.
- In setting cleanup levels, it is necessary to examine whether the remedial technologies under consideration can lead to unintended consequences, including transfer of toxicants among media, transfer of risks among populations, and residual pollution.
- It is no longer acceptable to continue cleanups under the current ad hoc approach. As a large number of sites enter the program, dealing with each site as a unique case is inefficient and there is increasing likelihood that sites with similar problems will not be cleaned to comparable levels of environmental protection,
- Pursuing a strategy of establishing cleanup levels on the basis of background or pristine chemical levels does not make environmental, technical, or economic sense, This approach does not assure protection of health and the environment, in many cases is not possible to achieve, and it would cost excessive sums.
- Although seemingly attractive and extensively used, best available technology or best engineering judgment do not offer environmental protection comparable to the likely high costs of implementation. This approach does not directly address actual or potential exposures threatening health and the environment.
- Although the use of existing standards, risk assessment, and cost-benefit analysis approaches pose considerable problems and have substantial limitations, they could be used.

The most important conclusion is that a cleanup strategy based on site classification could be the most beneficial approach to pursue. The present and future use of an uncontrolled site is now sometimes considered prior to cleanup decisions. What this approach would do is to explicitly and uniformly incorporate a decision about site use as the key element of a policy framework. To do this, however, means that a decision about land use must be made. Such a decision would generally need to be made at the local level. This is crucial to proceeding with this approach. It is consistent with the need to have public participation in cleanup decisionmaking (see chapter 8).

Developing a classification based on site use also presents an opportunity to have a hierarchy for establishing priorities for site response. It can provide a policy framework that objectively decides what process is used to set cleanup levels for a site on the basis of the most important site-specific consideration—how the site is or will be used and, hence, what exposures must be considered to determine health and environmental effects.

An illustration of how this approach might be used is given in table 4-I, Under this classification, the most technically sophisticated but

Table 4-1.— Illustration of a Site Classification System for Selecting Cleanup Goals

Classes of NPL sites (established when site placed on NPL)	Cleanup goals for remedial cleanup set by	Likely course of action	For comparison purposes, EPA classes of ground water[a]
I. Known or likely exposures to people or sensitive ecological elements requiring restoration of site (for possible rehabilitation or reuse), including cleanup of contaminated groundwater if technically feasible,	Site risk assessment.	1. High-priority initial response to recontrol site using HRS[b] information, 2. Obtain necessary data and perform risk assessment. 3. High-priority full-scale permanent cleanup when technology available to meet cleanup goals.	I. Special groundwaters vulnerable to contamination *and:* **a)** irreplaceable source of drinking water to substantial populations, *or* **b)** ecologically vital,
II. Known or likely exposures exist, but limited number of people and sensitive environments. Clear alternatives to site cleanup such as relocation and use of alternative water supply; site restoration or reuse not critical,	Cost-benefit analysis.	1. Initial response. 2. After cost-benefit analysis choose risk management option.	II. Current and potential sources of drinking water or have other uses.
III. Site not likely to lead to exposures to people and not situated near sensitive environment. No site restoration or reuse anticipated,	Applicable and relevant environmental standards,	1. Low-priority initial response. 2. Reevaluation every 5 years to assess need for remedial cleanup.	III. Not potential source of drinking water and of limited use,

[a]U S Environmental protection Agency, *Ground-Water Protection Strategy,* August 1984
[b]Assume an Improved Hazard Ranking System

SOURCE Office of Technology Assessment, except as noted

expensive process of risk assessment is used for the highest priority sites. These sites unequivocally require a remedial cleanup, the extent of which depends on the exact nature of the site's use. The next category of sites are those where site use suggests risk management options that would allow delay of a remedial cleanup, or a less complete cleanup, or conceivably no cleanup. For example, the risk management options could be relocation of residents, supplying alternate water, and creating an area where all use is prohibited. For this category, therefore, it is reasonable to use a cost-benefit process to establish cleanup levels in a context that allows comparison to non-cleanup alternatives.

Lastly, the third category of sites are those where exposures and damages are minimal. For this category, existing standards might be used to set cleanup levels; indeed, it might be unlawful or unacceptable to do otherwise. However, cleanup may not be necessary or it may be delayed. Also shown in the table, for comparison, are the analogous categories established by EPA in its groundwater protection strategy, However, it must be emphasized that cleanups of uncontrolled sites often involve much more than dealing with contaminated groundwater.

The table also shows site management decisions other than cleanup that could be associated with the site categories. For example, decisions concerning initial responses and timing of cleanups could be consistent with the hierarchy based on site use,

This discussion pertains to remedial cleanups that are expected to be effective in the long term, There is also a parallel question concerning actions known in the current program as immediate removals (comparable to initial responses in OTA's suggested two-part strategy). These actions are acknowledged to be temporary. Such actions must proceed quickly on the basis of limited information. Hence, a practical approach might be to establish generic standards to direct actions based on: 1) reducing the immediate threats to health and the environment by blocking or preventing releases of hazardous substances into the environment; and 2) assuring that the site, exposed to known environmental conditions, would not deteriorate further over a substantial period of time, perhaps some years before it could receive remedial cleanup. Such standards would not imply that the site is cleaned, but rather that it is isolated, stabilized, and decontrolled. A generic standard could also require continued monitoring and/or inspection consistent with the nature of the site and the likely exposures.

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