Short Changing Short-Term Risk: A Study of Superfund Remedy Selection

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Unlike most environmental statutes, CERCLA requires a lengthy period of labor-intensive activity to achieve its clean-up goals. This aspect of the Superfund program does not receive sufficient attention in policy and legal analyses of CERCLA, nor during site-specific remedy selection decisionmaking. The risks of the remediation period—to workers, to site neighbors, and to the natural environment—are substantial, as this Article illustrates. However, the confusing and sometimes dismissive treatment of remediation risk in the EPA's detailed guidance for Superfund decisionmakers invites the neglect of the short-term effectiveness criterion in the remedy selection process. A study of remedy selection documents in one EPA region suggests that this invitation has been understood and accepted by EPA officials. Remediation risk appears to play a very minor role in the site-specific decisions examined in this Article; indeed, in some cases the relevant managers seemed not to understand that remediation risk had any role to play at all. Since a more thorough consideration of remediation risk would probably suggest a different outcome in at least some site-specific remedy selection decisions, the EPA should implement administrative reforms to ensure the consistent and adequate inclusion of remediation risk criteria in the Superfund remedy selection process.

Introduction .................................................................................................................. 270

I. The Problem of Remediation Risk ........................................................................... 274
   A. The Life Cycle of a Superfund Site .................................................................. 275
   B. The Physical Effects of Remediation................................................................. 277
      1. Decontamination, Decommissioning, Demolition ....................................... 280
      2. Hazardous Materials .................................................................................... 282
      3. Handling Contaminated Media ..................................................................... 284
      4. Waste Treatment .......................................................................................... 288
      5. Transportation ............................................................................................. 290
      6. Federal Facilities .......................................................................................... 293
      7. Summary ....................................................................................................... 296

II. The Legal Framework for Remedy Selection ......................................................... 297
   A. The Statutory Language .................................................................................... 299

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Introduction

A Superfund project is major surgery on the environment. Superfund, which is shorthand for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA),\(^1\) requires the clean-up of hazardous waste sites that release or threaten to release pollutants into the environment. However, despite beneficent intentions, skillful execution, and salutary results, the remedy itself is by no means a benign process. Superfund projects are heavy construction sites and present, in addition to the hazardous substances that are being cleaned up, all of the hazards normally associated with such activities. Construction and transportation accidents; pollution of the air and water by disturbing contaminated soil and sediment; destruction of ecosystems by stripping off soil and excavating wetlands; and exposure to hazardous substances during treatment, transportation, or disposal operations are just some of the physical effects that these activities have on project workers, neighboring populations, and the surrounding natural environment. The Superfund remedy, in short, poses its own serious risks, which the surgeon fails to consider at the patient’s peril.

The present study of the decisionmaking process at Superfund sites demonstrates, however, that remediation risks are routinely marginalized and frequently ignored in the remedy selection process for Superfund sites. The remediation risks from construction and transportation activities are
Short Changing Short-Term Risk

substantial and very real—insurers, for example, predict them with profitable accuracy. Hundreds of people die in construction and truck and train transportation accidents every year, and thousands more are injured. The toxic properties of Superfund sites, on the other hand, by and large pose significant but not dramatic risks. Moreover, the toxic risks tend to be statistically calculated rather than experientially determined. So, in the extreme case, the short-term risks of remediation could swamp the long-term risks of the underlying environmental contamination. There is an actuarial and historical certainty that individuals (most likely remediation workers) will be killed and seriously injured in the process of reducing the long-term risks posed by hazardous waste sites. It is therefore melodramatic but not inaccurate to regard the remediation decision as a life-and-death issue. At a minimum, the risks of fatality associated with remediation should be carefully considered in selecting the remedy for a Superfund site, because different remedial techniques have very different risk consequences.

The phenomenon of ignoring remediation risks can be traced to a general tendency in environmental statutes (and probably in most regulatory statutes)

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2. See infra Section I.B.
4. See Joshua T. Cohen et al., Life Years Lost at Hazardous Waste Sites, 17 Risk Analysis 419, 422 (1997); see also Michael B. Gerrard & Deborah Goldberg, Facilities in Hazardous Waste Cleanup, 214 N.Y. L.J. 1, 3 (1995) (noting the difference between actuarial accident data and conservative risk assessments). Gerrard and Goldberg also found many newspaper reports of occupational and construction injuries associated with active and inactive Superfund hazardous waste sites. See id.

It is not, however, the purpose of this Article to undertake a quantitative comparison between baseline and remediation risks or to generalize about what such a comparison would show. The remediation risks are very different from the baseline risks with which the regulation of hazardous wastes usually concerns itself. As a result, the formal, quantitative comparison of baseline and remediation risks is an exceptionally difficult and controversial problem in its own right and thus beyond the scope of this Article. See infra note 16 and accompanying text; cf. John S. Applegate, When the Cure Is Worse Than the Disease, Presentation at the Symposium on Risk, Science, and Law, Society for Risk Analysis Annual Meeting (Dec. 10, 1996) (transcript on file with the author) (describing Superfund remediation risk as a problem in comparative risk analysis).
to envision only two states of the world: the pre-regulation or baseline state, which is the condition that the statute seeks to remedy; and the post-regulation or target state, in which the problem has been resolved to the legislature’s satisfaction. Legislation typically specifies in detail the characteristics of the target state, such as the residual level of risk that ought to be tolerated in air emissions, water discharges, or solid waste disposal. However, far less thought goes into the desired characteristics of the transition period during which the world moves from the baseline to the target condition. Under the federal air, water, and solid waste statutes, the transition period may involve installing pollution control devices or reconfiguring a process to prevent the pollution before it begins. For these traditional pollution problems, the principal transition issues are the cost and duration of the transition in relation to the magnitude of the baseline hazard and the targeted improvement. Despite the fact that pollution-control techniques can pose their own risks, these remain a relatively minor aspect of pollution control decisions.

At first glance, CERCLA seems to differ in this respect from the traditional pollution control statutes. Since CERCLA operates retrospectively, requiring the clean-up of past pollution to which humans and the environment remain exposed, the clean-up of Superfund sites has a distinctive temporal element that ought to make the remediation period difficult to ignore. It is pictured in Figure 1.


7. See Viscusi & Zeckhauser, supra note 5, at 19, 38 (attributing this phenomenon to the long-term risk-reducing motivation for the creation of the short-term risks).

8. These risks have aroused growing interest. See generally Stephen Breyer, Breaking The Vicious Circle (1993); Risk Versus Risk, supra note 5; W. Kip Viscusi, Fatal Trade-Offs (1992); Cross, supra note 5. The problem was described nearly two decades ago in Lester Lave, The Strategy of Social Regulation 15-16 (1981), wherein Lave advocated the use of “risk-risk” analysis.

The baseline risks are those that Superfund was originally designed to fix, with Love Canal as the archetype: chemically contaminated soil and groundwater in basements, backyards, and schools.\(^{10}\) The target state is defined by compliance with other environmental standards and the achievement of a low but greater-than-zero level of residual risk. The residual risks tend to be lesser versions of the baseline risks. That is, they are the baseline risks as ameliorated by treatment, removal, or isolation of the original contamination.\(^{11}\) The remediation activities occur in the intervening transition period and may last years (even decades at more complex sites), costing many millions of dollars, and employing hundreds of remediation workers.

Nevertheless, CERCLA imitates its pollution control counterparts' sketchy treatment of the remediation activities themselves. The existence of remediation risks has been pointed out by several commentators,\(^{12}\) and the EPA's failure to consider the risks seriously in site-specific remedy selection decisions has not gone unnoticed.\(^{13}\) However, evidence of their existence is haphazard, and evidence of the failure of decisionmakers to consider them remains entirely anecdotal and impressionistic. This Article seeks to fill these gaps with a systematic analysis of the types of hazards created by remediation activities, the approximate magnitude of the risks they pose, and the extent to which the EPA uses (or fails to use) remediation risk data in remedy selection.

Part I of the Article sets out in detail the many physical impacts of remediation. Even though only very tentative estimates of the quantitative

\(^{10}\) The EPA requires a "baseline risk assessment" to measure these threats to human health and the environment. 40 C.F.R. § 300.430(d)(1) (1997) (emphasis added).

\(^{11}\) Consistent with the usual emphasis on the baseline and target, two major empirical studies of CERCLA remedy selection in the legal literature have focused on the sources of baseline and target risks and the relative costs of achieving different target risk levels. See James T. Hamilton & W. Kip Viscusi, The Benefits and Costs of Regulatory Reforms for Superfund, 16 STAN. ENVTL. L.J. 159, 186 (1997) [hereinafter Benefits and Costs] (concluding that the great majority of the cost of remediation is associated with the last few increments of risk reduction); Human Health Risk, supra note 3, at 608 (concluding that most of the risk considered in RODs was from the long-term exposure scenarios).

\(^{12}\) See John S. Applegate, A Beginning and Not an End in Itself: The Role of Risk Assessment in Environmental Decision-Making, 63 U. CIN. L. REV. 1643, 1653-54 (1995); see also supra note 5 and accompanying text.

\(^{13}\) See infra Section II.C.
magnitude of these risks are possible, the existing data reveal a distinctive and serious risk profile resulting from exposure to hazardous substances, construction work, transportation, and environmental contamination. Risks to remediation workers are emphasized because workers bear the brunt of remediation risks and because worker risks are almost entirely ignored in the public consideration of CERCLA remedy selection.14

Part II reviews the legal framework for remedy selection generally and for the consideration of remediation risks in particular. While CERCLA and the EPA's interpretations in the National Contingency Plan (NCP)15 and guidance documents nominally take full account of remediation risk (which the EPA confusingly calls "short-term effectiveness"), they nonetheless relegate remediation risk to a subordinate role in site-specific remedy selection decisions. In Part II we also address the appropriateness of incorporating voluntarily undertaken worker risk in the remedy selection process.

In Part III, we describe a study of the role of remediation risk in the remedy selection records of decision (RODs) for Superfund sites in the industrial Midwest. Our review of the RODs confirms our hypothesis that remediation risks do not weigh heavily in remedy selection decisions. Indeed, we find that the RODs rarely even consider all of the elements of remediation risk that are identified by the EPA's guidance documents as relevant to remedy selection, and that the RODs often betray a fundamental misapprehension of the role of remediation risk in the EPA's analysis.

Part IV discusses the significance of these findings and recommends changes in the administration of the Superfund program to address them. While comparing different types of risk is difficult and fraught with uncertainty, the consideration of remediation risks should have a significant impact on the choice among remedial actions. The failure to consider remediation risks means that remedy selection decisions are being made and reviewed without full information concerning the consequences of the decision. While the statutory machinery is in place to repair this problem, we recommend that greater internal legal and managerial attention be paid to this issue, and that appropriate revisions be made in the regulatory framework that governs remedy selection.

I. The Problem of Remediation Risk

The thesis of this Article is that the EPA's remedy selection decisions for Superfund sites, as reflected in its RODs, fail to give adequate consideration

14. See Hoskin et al., supra note 5, at 1011.
15. The National Contingency Plan is the administrative blueprint for CERCLA. The remedy selection procedures and standards are set out at 40 C.F.R. §§ 300.400-435 (1997).
to remediation risks. As a first step, we describe the nature of remediation risk with two goals in mind. First, we want to establish that remediation risks are significant, that is, that they are sizable enough to warrant serious attention in the EPA’s remedy selection decisions. Precise quantification of remediation risks would be ideal, but quantification is in fact an extremely uncertain enterprise and is not necessary for present purposes. Second, we want to identify the sources, types, and receptors of remediation risks in order to support the argument that the thorough consideration of remediation risk would make a significant difference in remedy selection decisions in the long run.

A. The Life Cycle of a Superfund Site

We must begin with some terminology because, as will become clear, one reason for the lack of consideration of remediation risk is the EPA’s use of confusing terms to describe it. Consideration of the entire life cycle of a Superfund site expands on the baseline-target chart set out in Figure 1:

FIGURE 2
Site Life Cycle

<table>
<thead>
<tr>
<th>Uncontrolled Past</th>
<th>Polluted Present</th>
<th>Remediation Period</th>
<th>Foreseeable Future</th>
<th>Long-Term Stewardship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>Transition</td>
<td>Target or Residual</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The uncontrolled past includes the activities that led to hazardous materials being released into the environment. The polluted present—the baseline condition—is the state of affairs that needs to be corrected. The target state is the foreseeable future of the site, as defined by risk-based standards and the requirements of other environmental statutes. The target risk level is the

16. While identifying the sources and receptors of remediation risks is a fairly straightforward process, quantifying those risks is currently difficult. The paucity of data on remediation risk is itself some of the best evidence of the scant attention that remediation risk receives in Superfund remedy selection. See Hoskin et al., supra note 5, at 1012. Moreover, the terms in which most remediation risks are measured differ from the metrics used for long-term risks. For the latter, the EPA uses the familiar excess individual cancer risk, as expressed in the regulatory risk range, $1 \times 10^{-6}$ to $1 \times 10^{-4}$. See 40 C.F.R. § 300.430(e)(2)(A)(2) (1997). For the former, the Occupational Safety and Health Administration (OSHA) and other agencies use total actual deaths and injuries, injuries per mile or per person-hour, and other measures. Thus, quantitative statements about the magnitude of various remediation risks, to say nothing of comparisons with other risks, must be made cautiously.

17. See infra Part IV.

18. The “release,” CERCLA § 101(22), 42 U.S.C. § 9601(22) (1994), of a “hazardous substance,” § 101(14), into the “environment,” § 101(8), is the trigger for CERCLA remedial action, see § 104, and liability, see § 107(a).
residual risk after clean-up activities are substantially complete. Finally, long-term stewardship is required to minimize further exposure to hazardous materials that remain in place, either as residual contamination or as deliberate disposal, after achievement of the target state. "Stewardship" in this context refers to the activities required to maintain the effectiveness of the selected remedy. They range from routine maintenance of containment structures, to documenting the remaining hazards for future generations, to land use restrictions in deeds or ordinances. The remediation period bridges the two past and two present periods. It effectuates the transition from the baseline condition to the target, cleaned-up state.

The target (or residual) risk is easily determined in theory, as it is the legal standard that the EPA must meet. As interpreted in the EPA's regulations, it is a range spanning two orders of magnitude from $1 \times 10^{-4}$ to $1 \times 10^{-6}$ excess lifetime risk of cancer. On the other hand, baseline risks are more variable since they depend on the particular conditions at each site. Ideally, any risk greater than the target would be eligible for clean-up, but studies of Superfund sites that have been willing to generalize have found that the baseline risks are relatively low and that they may even overlap the target levels. The context in which remediation risk must be considered, therefore, is the difference between the baseline and target risks. In other words, the remediation risk is one of the "costs" of purchasing the improvement in public health represented by the increment between the baseline and the target risks. The ultimate normative question for Superfund is whether that is a worthwhile

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19. See generally Alex S. Karlin, How Long Is Clean? The Temporal Dimension to Protecting Human Health Under Superfund, NAT. RESOURCES & ENV'T, Summer 1994, at 6, 48 (distinguishing between the foreseeable future use of a site and its indefinite long-term use and arguing that the remedy selection should focus on the former and not the latter).

20. See 40 C.F.R. § 300.430(e)(2)(i)(A)(2) (1997). One study notes, however, that the EPA has tolerated maximum cancer risks up to $1 \times 10^{-2}$ at a substantial proportion of sites. See Katherine D. Walker et al., Confronting Superfund Mythology: The Case of Risk Assessment and Management, in ANALYZING SUPERFUND 25, 31 (Richard L. Revesz & Richard B. Stewart eds., 1995). Obviously, the higher the target risk, the smaller the difference between it and the baseline risk.

21. The National Research Council, for example, was unwilling to do so. See NATIONAL RESEARCH COUNCIL, ENVIRONMENTAL EPIDEMIOLOGY 19 (1991).

22. See GERRARD, supra note 3, at 176-78; Human Health Risk, supra note 3, at 608-10; Gerrard & Goldberg, supra note 4, at 2. Hamilton and Viscusi emphasized that the substantial risks of Superfund sites arise from long-term uncontrolled exposures rather than current conditions. See Human Health Risk, supra note 3, at 608.

The EPA's risk comparison exercises, while not strictly quantitative, consistently ranked Superfund sites low in risk relative to other environmental problems. See SCIENCE ADVISORY BD., U.S. ENVTL. PROTECTION AGENCY, REDUCING RISK: SETTING PRIORITIES AND STRATEGIES FOR ENVIRONMENTAL PROTECTION 50, 57 (1990); I U.S. ENVTL. PROTECTION AGENCY, UNFINISHED BUSINESS: A COMPARATIVE ASSESSMENT OF ENVIRONMENTAL PROBLEMS 30, 42, 49, 55, 75 (1987).

23. In their hypothetical case study, Cohen et al. use $3 \times 10^{-4}$ as the lifetime risk of cancer from exposure to site contamination. See Cohen et al., supra note 4, at 420. This figure is derived from their review of Superfund baseline risk assessments. See id.
Short Changing Short-Term Risk

bargain at a given site. However, this Article does not directly address the normative question. The discussion here is limited to whether remediation risks are adequately considered in the remedy selection process.

B. *The Physical Effects of Remediation*

Remediation risk can be and has been largely ignored in the selection of remedies for most Superfund sites. This is in part an artifact of the baseline-target orientation of regulatory statutes. It is also undoubtedly due in part to the familiar and voluntary nature of the risks assumed by the remediation workers. Fundamentally, a Superfund clean-up site is a heavy industrial or construction facility, and such activities are not typically of great public interest. For whatever reason, the remediation risks seem minor by comparison to the hazards of the polluted present and are thus often overlooked. We now turn to a discussion of the types of remediation risk commonly present at Superfund sites. This section concludes with a description of the remediation risks posed by federal facilities, since they combine remediation risks in a particularly dramatic manner.

Superfund sites pose a wide variety of remediation risks. Remediation risks are not a monolithic entity or a single number that can be plugged into remedy selection calculations. Clean-up sites subsume many risk-creating activities. The activities create the danger of different kinds of undesirable effects, and those effects can befall different victims, human and otherwise. To present a systematic account of remediation risks, therefore, it is essential to distinguish among categories of sources, types, and receptors of risk.

First, the clearest way to understand the sources of the physical effects of remediation is to see a clean-up project for what it is—a construction site and industrial operation. Construction and transportation risks account for the great majority of the fatalities suffered by remediation workers. Cleaning up Superfund sites also requires some or all of the following kinds of operations:

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24. Superfund sites consistently rank higher in the lay public’s perception of risks than in the EPA’s evaluation of the risks that the sites pose. See BREYER, supra note 8, at 21 tbl.4, 33, 34 tbl.6.

25. See Hoskin et al., supra note 5, at 1015. For the remainder of this part, we will cite specific sources for particular points. However, on the more general discussion of the identity and sources of remediation risks, we have relied generally on our review of the RODs themselves and on the following: CONSORTIUM FOR ENVTL. RISK EVAL., HEALTH AND ECOLOGICAL RISKS AT THE U.S. DEPARTMENT OF ENERGY’S NUCLEAR WEAPONS COMPLEX 3-2 (1995) [hereinafter CERE]; NATIONAL INST. FOR OCCUPATIONAL SAFETY AND HEALTH ET AL., U.S. DEP’T OF HEALTH AND HUMAN SERVS., OCCUPATIONAL SAFETY AND HEALTH GUIDANCE MANUAL FOR HAZARDOUS WASTE SITE ACTIVITIES (1985) [hereinafter OCCUPATIONAL SAFETY GUIDANCE]; OFFICE OF TECH. ASSESSMENT, HAZARDS AHEAD: MANAGING CLEANUP WORKER HEALTH AND SAFETY AT THE NUCLEAR WEAPONS COMPLEX (1993) [hereinafter OTA]; WORKER PROTECTION DURING HAZARDOUS WASTE REMEDIATION (Lori P. Andrews ed., 1990); Hoskin et al., supra note 5, at 1012-14; Curtis C. Travis et al., Evaluation of Remediation Worker Risk at Radioactively Contaminated Work Sites, 35 J. HAZARDOUS MATERIALS 387

277
1) restricting site access and imposing institutional controls to limit post-remediation land use;
2) decontaminating, decommissioning (shutting down), and demolishing buildings and other structures;
3) handling hazardous materials in tanks, ponds, pits, drums, and other containers;
4) managing contaminated media such as soil, sediment, surface water, and groundwater;
5) treating wastes or contaminated media to stabilize, compact, or neutralize it; and
6) transporting hazardous materials away from a site and transporting construction and treatment equipment and materials to it.26

This section’s description of remediation risks is organized around these activities.

Second, remediation risks consist of both (i) the toxic and unfamiliar risks associated with the hazard that triggered the clean-up in the first place, and (ii) the mechanical or accident-related risks associated with the physical demands of construction and transportation work.27 We call these two risk subsets materials risks—which are typically toxic but can also be radiologic, flammable, or corrosive—and conventional risks, respectively.28 For a variety of reasons, it is common in environmental law to treat these types of hazards very differently. For our purposes, however, familiar accident risks are an integral part of the analysis.29 These risks can be large or small depending on the level of exposure.30

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26. See OTA, supra note 25, at 2 (listing operations that remediation workers must perform). Hamilton and Viscusi break down the remedies for soil as follows: institutional controls, containment, removal, treatment, and containment with removal. See Benefits and Costs, supra note 11, at 198 tbl.6. They break down the remedies for groundwater into institutional controls and treatment. See id. OTA adds the risks to workers engaged in emergency response. See OTA, supra note 25, at 2, 41-43.

27. This distinction is drawn, for example, in Travis et al., supra note 25, at 388. The EPA’s Risk Assessment Guidance for Superfund distinguishes three types of risks: (i) exposure to hazardous substances during on-site remedial activities; (ii) injury due to physical hazards such as explosions, heat stress, and precarious work environments; and (iii) exposure to hazardous substances during emergency response activities. See U.S. ENVTL. PROTECTION AGENCY, RISK ASSESSMENT GUIDANCE FOR SUPERFUND: HUMAN HEALTH EVALUATION MANUAL, PART C, RISK EVALUATION OF REMEDIAL ALTERNATIVES 22 (1991) [hereinafter RAGS].


29. Stated in terms of familiar and unfamiliar, the phenomenon of ignoring remediation risks
Third, it is important to distinguish between different receptors of risks. After all, a hazard is not a risk until someone or something is exposed to the hazard. The primary receptors of remedial risks are (i) project workers, including both those regularly employed at the site and transportation workers; (ii) the general public, including immediate neighbors, affected area population, and residents of transportation corridors; and (iii) the natural world, especially sensitive ecosystems like wetlands in and around the site. Each receptor is potentially exposed both to materials and conventional risks.

The relationships among these variables is summarized in Table 1.

### TABLE 1
Risk Sources and Receptors

<table>
<thead>
<tr>
<th>REMEDIATION RISK SOURCES</th>
<th>REMEDIATION RISK RECEPTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M = materials risk, C = conventional risk</td>
</tr>
<tr>
<td></td>
<td>CAPITALS = relatively larger risk</td>
</tr>
<tr>
<td></td>
<td>lower case = relatively smaller risk</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Worker</th>
<th>Public</th>
<th>Ecosystem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access Controls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D, D &amp; D</td>
<td>M,C</td>
<td>m</td>
</tr>
<tr>
<td>Hazardous Materials</td>
<td>M,c</td>
<td>m</td>
</tr>
<tr>
<td>Contaminated Media</td>
<td>M,C</td>
<td>M</td>
</tr>
<tr>
<td>Treatment &amp; Disposal</td>
<td>M,c</td>
<td>m</td>
</tr>
<tr>
<td>Transportation</td>
<td>M,C</td>
<td>M,C</td>
</tr>
</tbody>
</table>

As Table 1 indicates and the following text describes, remediation activities often include both materials and conventional risks and always have
implications for two or more groups of receptors. The exceptions are access restrictions (fences and the like) and long-term institutional controls (deed restrictions and the like), both of which are designed to isolate the site and its contamination from types of intrusion or occupation that would result in exposure to hazardous materials. Fences and deeds pose no real remediation risks, but they are of debatable efficacy except as temporary removal actions pending a permanent remedy.

1. Decontamination, Decommissioning, Demolition

The first step at many Superfund sites is the management of existing structures. They must be decontaminated before it is safe to demolish, reuse, or mothball them. The contamination may involve only a few "hot spots" that must be removed, or it may be ubiquitous. Likewise, the contamination may consist of a relatively small amount of a hazardous substance on or in building materials, or it may require the removal of the building materials themselves, as in the case of asbestos. Decommissioning or shutting down a building involves additional efforts to leave it in a safe configuration. Pipes and tanks must be purged of water and other (often hazardous) liquids; ventilation and heating systems must be cleaned of hazardous residues; electrical connections must be severed; structurally unsound areas must be shored up; and the building must be secured against infestation by birds and rodents. Demolition techniques range from piece-by-piece dismantlement to implosion, each with its own risks and benefits.
Decontamination and demolition activities, such as implosions or the pressure-removal of lead paint, pose materials risks to site neighbors. For example, at the South Bay Asbestos Site in Alviso, California, the EPA advised neighbors to wet-mop the interiors and to spray down the exteriors of their houses. \(^{38}\) Residents were concerned that they had not been further warned to stay inside or to keep their windows closed. \(^{39}\) Access restrictions and dust suppression measures certainly exist to minimize these hazards, but the EPA’s advice to South Bay residents confirms that the hazards cannot be eliminated.

Decontamination and demolition hazards are dominated, however, by conventional risks, which fall overwhelmingly on remediation workers. An inter-agency manual for worker protection at hazardous waste sites lists a wide range of safety hazards—typical of construction and industrial sites generally—that are found at Superfund sites. \(^{40}\) Basic safety hazards include holes and ditches, precariously positioned objects, sharp edges, slippery surfaces, steep grades, uneven terrain, and unstable surfaces. Since the structures at Superfund sites are often old and dilapidated, the last is a very substantial concern. \(^{41}\) Heavy equipment adds additional safety risks, and, ironically, the use of protective equipment can impair a worker’s vision, hearing, and mobility, increasing the chance of accidents. Electrical hazards may arise due to the use of electrical equipment and to contact with overhead power lines, downed electrical cables, and buried cables severed during remediation. Heat stress from the use of personal protective equipment is another recurrent problem, and outdoor work in the winter creates a danger of overexposure.

These conventional, even mundane, hazards must figure prominently in any comprehensive evaluation of remediation risks. The typical risks of construction activities—falls, being struck by something, being caught in or between objects, and electrical shock—account for 90% of construction fatalities. \(^{42}\) Firm data on rates of conventional injuries are fairly difficult to obtain because different agencies use different categories (e.g., construction risks are the closest general category to conventional remediation risks. See Hoskin et al., *supra* note 5, at 1015; Viscusi, *supra* note 8, at 12.

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39. *See id.*


41. *See, e.g., CERE, supra* note 25, at 3-6 (describing difficulties of remediating Manhattan Project-era sites).

industry versus construction trades) and different metrics (e.g., per worker versus per person-hour). However, construction is dangerous work by any standard. The Bureau of Labor Statistics (BLS) indicated in its census of fatal injuries for 1995 that there were 916 fatalities that year, for a combined rate of 63 fatalities per 100,000 workers in the construction industry. BLS also reported that about one-sixth of all fatal workplace injuries occurred in construction work. While the consideration of fatalities (usually from cancer) is typical in the regulation of toxic and hazardous substances, this is an extremely incomplete measure of conventional risks, many of which may be devastatingly debilitating without being fatal. The Department of Energy (DOE) has used industry rates of 13 illnesses and injuries per 200,000 hours of work and 2.5 fatalities per 10,000 workers per year. For the clean-up of a contaminated fly ash dump at its Fernald site, the DOE used Department of Labor data indicating risks of $3.4 \times 10^{-5}$ injuries per person-hour and $5.0 \times 10^{-7}$ fatalities per person-hour. At these rates, a lengthy clean-up process would almost assuredly result in injuries and fatalities.

2. Hazardous Materials

The signature risks ofremediating tanks, ponds, and other containments—staples of Superfund clean-ups—are materials risks. Liquids must be drained; solids must be collected (no small task if they are in powder


44. See Bureau of Labor Statistics, U.S. Dep't of Labor, National Census of Fatal Occupational Injuries, 1995 (last modified Mar. 6, 1998) <http://stats.bls.gov/oshhome.htm> [hereinafter BLS]; see also Hoskin et al., supra note 5, at 1015 (using a rate of 33 per 100,000 for laborers, but noting that other estimates are much higher and that some are lower).

45. See BLS, supra note 44. Both BLS and OSHA believe that their data are incomplete and therefore underestimate the magnitude of the problem. See id.; OSHA DATA BASE, supra note 42, at 51-54.

46. See Hoskin et al., supra note 5, at 1016; Viscusi & Zeckhauser, supra note 5, at 30, 37 (explaining that non-fatals injuries are "vastly more frequent" than fatal ones).

47. See OFFICE OF ENVTL. MGMT., U.S. DEP'T OF ENERGY, RISKS AND THE RISK DEBATE: SEARCHING FOR COMMON GROUND 50-53 (1995) [hereinafter DOE RISKS]; see also Travis et al., supra note 25, at 393 (using 2.45 per 10,000). The Travis statistic is approximately half the BLS estimate if one combines both construction trades and laborers. See BLS, supra note 44. We cannot account for this discrepancy.


49. See, e.g., Laskin/Poplar Oil, Jefferson, Ohio, EPA ID OHD061722211 (June 29, 1989), available in WL, Database EDR-ROD.
Short Changing Short-Term Risk

form); and gases must be contained\(^5\) for subsequent treatment\(^5\) (e.g., neutralization), destruction\(^5\) (e.g., incineration), or disposal\(^5\) (e.g., landfilling). Each of these activities presents dangers which correspond to the characteristics of hazardous waste (e.g., ignitability, corrosivity, reactivity, toxicity, infectiousness, and radioactivity\(^5\)). The actual handlers are at greatest risk.\(^5\) For example, the DOE's draft environmental impact statement for the remediation of high-level tank wastes calculated both the conventional risks of construction activities and the radiological exposure risks of working in close proximity to radioactive sources.\(^5\) Ionizing radiation can cause everything from burns to debilitating injury and death. Workers are informed of possible risks and are closely monitored. Yet despite these warnings, the DOE estimated that there would be up to four latent cancer fatalities from radiological exposure.\(^5\)

The inter-agency guidelines identify several other types of materials risks.\(^5\) The chemical hazards at a site are varied and potentially severe. Sites may contain hundreds of different chemicals in gaseous, liquid, or solid form, all of which must be handled with great care.\(^6\) Exposure can occur in several

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50. See, e.g., Midstate Disposal Landfill, Cleveland Township, Wis., EPA ID WID980823082 (Sept. 30, 1988), available in WL, Database EDR-ROD (requiring soil/clay caps, sludge stabilization, and alternate water supply).

51. See, e.g., Cardington Rd. Landfill, Dayton, Ohio, EPA ID OHD93895787 (Sept. 27, 1993), available in WL, Database EDR-ROD (requiring active landfill gas collection and treatment, low permeability cap, and landfill closure actions).

52. See, e.g., Reilly Tar & Chem., Indianapolis, Ind., EPA ID IND1000289722 (Sept. 30, 1993), available in WL, Database EDR-ROD (requiring excavation of soil and treatment by thermal desorption; disposal of condensate from treatment; treatment of sludge by in situ solidification; placement of soil cover over landfill; and area monitoring).

53. See, e.g., Cross Bros. Pail Recycling, Pembroke Township, Ill., EPA ID ILD980792303 (Sept. 28, 1989), available in WL, Database EDR-ROD (requiring excavation of PCB soil and incineration, installation of on-site groundwater treatment facility, installation of vegetative cover, fencing, and deed restrictions).

54. See, e.g., Bofors Nobel Inc., Muskegon, Mich., EPA ID MID006030373 (Sept. 17, 1990), available in WL, Database EDR-ROD (requiring excavation and treatment of highly contaminated sludge via on-site thermal treatment, disposal of less contaminated sludge in on-site RCRA landfill, and upgrading of existing groundwater pumping and treatment).


56. Neighbors, too, may be at risk, as alleged in a recent lawsuit concerning the removal of buried vats of coal tar. See Tara Burghart, Families Allege Coal Tar Cleanup Caused Children’s Cancer, WASH. POST, Dec. 26, 1997, at A4. As in that case, however, the routes and levels of neighbors' exposure are less direct and certain. See also Michael B. Gerrard, Demons and Angels in Hazardous Waste Regulation: Are Justice, Efficiency, and Democracy Reconcilable?, 92 Nw. U. L. Rev. 706, 740 n.177 (1998) (book review) (collecting examples of local citizens opposing proposed remedies).


58. See id. at S-34 to S-35.

59. See OCCUPATIONAL SAFETY GUIDANCE, supra note 25, at 2-1 to 2-3.

60. See Thomas C. Marshall et al., A Risk Assessment of a Former Pesticide Production Facility,
different ways—routes of entry include inhalation, direct contact, ingestion, and injection—and this compounds the difficulty of effectively protecting workers. Moreover, chemical and other toxic materials pose risks both from acute, high-dose and chronic, low-dose exposures. Hazardous materials also may be the sources of explosion and fire from chemical reactions, ignition of explosive or flammable chemicals, ignition of materials due to oxygen enrichment, agitation of sensitive compounds, and the sudden release of materials under pressure.

The decontamination and demolition of structures also requires the handling of hazardous materials. The hazards to asbestos and lead removal workers are the now-familiar basis of the allegation that the statistical risks to the workers are substantially higher than the baseline risks to the occupants of the buildings being remediated. Whether or not this means that asbestos and lead removal requirements are misguided, there can be no question that the workers are exposed to vastly greater quantities of the contaminants in the course of these kinds of clean-up activities than the occupants are ever likely to be in the course of their daily activities.

The inter-agency guidelines note that explosions and fires not only cause immediate hazards to on-site workers but also may result in the transport of toxic chemicals into surrounding communities. Exposure to these chemicals creates a risk of chronic, long-latency illness. Other remediation activities use transportation routes through surrounding communities. The DOE’s Fernald site evaluated the effects of excavating and placing in an engineered facility many tons of uranium-contaminated fly ash from the facility’s power plant. It estimated a risk to the neighboring community of $2.0 \times 10^{-6}$ fatalities from airborne particulates (dust) produced during the excavation process.

3. Handling Contaminated Media

The management of contaminated media such as soil, sediments, surface water, and groundwater is also typical of Superfund sites. Widespread soil or sediment contamination, as opposed to concentrated “hot spots,” results from

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62. While workers are exposed for a shorter period of time at any given location, asbestos or lead removal specialists spend every workday with the toxic material.


64. See FERNALD OU2 FS, *supra* note 48, at § 5.4.2.5; see also Susan M. Brett et al., *Assessment of the Public Health Risks Associated with the Proposed Excavation of a Hazardous Waste Site*, in THE RISK ASSESSMENT OF ENVIRONMENTAL AND HUMAN HEALTH HAZARDS 427, 447 (Dennis J. Paustenbach ed., 1989) (finding that the inhalation of vapors generated by excavation activities at a hazardous waste site posed a cancer risk of $3 \times 10^{-5}$ to local residents).
the deposition of contaminants from air or water into solid media. Thus, large volumes of soil or sediment must be excavated with heavy equipment and isolated somewhere, either temporarily or permanently. Contaminated surface water must be collected, and groundwater must be pumped up. One of the more difficult technical problems at Superfund sites is the removal of contaminated sediments under rivers, harbors, and other bodies of water, which sediments are not only hazards in themselves but continue to recontaminate the superjacent waters.

Putting aside situations in which urgent action must be taken to address an imminent risk, the typical Superfund site has reached a sort of stability that is necessarily disturbed by the handling of waste or contaminated media. Removing radiologically contaminated lake sediments, for example, exposes remediation workers to radiation that would otherwise be largely isolated. Likewise, disturbing and exposing chemically contaminated soil can result in abnormally high airborne exposures to workers from the inhalation of volatilized or particulate matter. Nevertheless, contaminated media present a relatively low materials risk for workers because the concentration of the hazardous constituents of these media is comparatively light. The total volume of material is often correspondingly high, however, which means that the risks of conventional injuries associated with excavation and the use of heavy equipment are substantial. The Bureau of Labor Statistics reported

65. See, e.g., Springfield Township Dump, Springfield Township, Mich., EPA ID MID980499966 (Sept. 29, 1990), available in WL Database EDR-ROD (requiring excavation and thermal destruction of soil; solidification of incinerator ash; solidification of metal-contaminated soil; redeposition of soil and ash on-site; in situ vacuum extraction system; and groundwater extraction and treatment by a carbon absorption unit).

66. See Mar et al., supra note 5, at 130-31 (describing the clean-up of arsenic contamination from the ASARCO smelter in Ruston, Washington).


68. See, e.g., New Brighton/Arden Hills, Arden Hills, Minn., EPA ID MN7213920908 (Sept. 30, 1993), available in WL Database EDR-ROD (requiring pumping and treating groundwater in a granular activated carbon facility, an alternative water supply, and monitoring).

69. See, e.g., Moss-American Kerr-McGee Oil Co., Milwaukee, Wis., EPA ID WID039052626 (Sept. 27, 1990), available in WL Database EDR-ROD (requiring removal and treatment of soil; river rerouting; treatment of groundwater; and on-site disposal of residue from treatment of soil).

70. CERCLA provides specially for such situations; they are addressed by "removal" or abatement actions. CERCLA § 101(23), 42 U.S.C. § 9601(23) (1994). Removal and abatement actions are governed by different legal criteria than long-term "remedial actions," § 101(24), and they are accordingly outside of the scope of this Article.

71. See Stephen Dycus, National Defense and the Environment 112-13 (1996) (suggesting that it might prove better not to clean up the cesium-137 contaminated sediments found in a lake at the DOE Savannah River site).

72. For example, conventional risks far exceed materials risks for low-level radioactive and mixed waste, but not for high-level radioactive and transuranic waste. Compare WMPEIS, supra note 25, at 46, 57 (LLW and MLW), with id. at 67, 75 (HLW and TRU).
fatalities in 1995 among heavy moving equipment operators, or 15 per 100,000 workers.\textsuperscript{73}

The remediation of contaminated media poses hazards to the surrounding community as well. The disturbance of contaminated soil or sediment within a clean-up site can result in either resuspension of contamination in the air or erosion of exposed contamination, both of which transport the material beyond site boundaries.\textsuperscript{74} This was the source of the public health hazard from the Fernald fly ash pile.\textsuperscript{75} A published risk assessment of the excavation of hazardous waste lagoons adjacent to a residential area reported an excess carcinogen risk of $3 \times 10^{-3}$, as well as a risk of several non-cancer illnesses.\textsuperscript{76} In another clean-up, residents complained that a proposed groundwater remedy for contamination of an aquifer would draw the chemical of concern from the contaminated shallow aquifer to the clean deeper one.\textsuperscript{77}

The public health concern can also involve contamination within the community itself.\textsuperscript{78} At the Montclair/West Orange radium site in New Jersey, residents were temporarily relocated while their yards were dug up to remove contaminated soil. Residents who were not relocated were concerned about noise and dust from the heavy machinery. At the California Gulch Superfund site in Leadville, Colorado—an old mining town with severe mining waste problems and high lead levels in the soil—one of the operable units encompasses the residential areas that are contaminated with lead. Remedies for the contaminated soil included sediment drainage controls, revegetation, capping, reshaping, and removal. Residents of Leadville strongly opposed clean-up, claiming that they were not suffering any adverse effects from lead and therefore did not want to be subject to the risks and inconveniences of having their yards excavated. The EPA responded to these complaints by abandoning some aspects of the clean-up and changing the lead standard by which they determine if clean-up is necessary for a particular piece of property.\textsuperscript{79}

\textsuperscript{73} See BLS, \textit{supra} note 44.


\textsuperscript{75} See \textit{Fernald OU2 FS}, \textit{supra} note 46, at § 5.4.2.5.

\textsuperscript{76} See Brett et al., \textit{supra} note 64, at 447.

\textsuperscript{77} See United States v. Princeton Gamma-Tech, Inc., 31 F.3d 138, 141 (3d Cir. 1994). The court's holding that such a challenge could be maintained was overruled by \textit{Clinton County Comm'rs v. EPA}, 116 F.3d 1018 (3d Cir. 1997) (en banc).

\textsuperscript{78} This was the case in the area around the ASARCO smelter described in Mar et al., \textit{supra} note 5, at 130-31.

The harm to the natural environment from excavating large volumes of soil and sediment is even more pronounced. Large areas of land can be contaminated by airborne deposition of hazardous materials, such as particulate matter emitted by a smokestack. It turned out, for example, that the most effective technique for handling the contamination of Belarussian forests after the Chernobyl accident was “organic layer removal,” which means stripping out all of the organic material on the ground. However, this technique results in the resuspension of radiological contaminants and large volumes of waste material. At the Idaho National Engineering Laboratory, the accumulation of wind-blown dust on plants affected birds and animals that fed on the plants. Also, without subsequent remediation of the remediation, so to speak, a moonscape results. For instance, at the Fernald site, soil cleanup will involve scraping away at least several hundred acres of the soil surface, including wetlands. The resulting surface will be unusable unless new top soil is brought in (thus denuding some other location), and any flora or fauna residing in the soil during remediation will be destroyed. Wetland habitats are destroyed by such excavation activities as well as by the dredging of contaminated sediments. A DOE report noted that many of its sites have become habitats for threatened and endangered species and that habitat destruction or disruption from similar remediation activities would place such species at risk. More prosaic activities can be equally destructive. The clean-up of Prince William Sound after the Exxon Valdez oil spill resulted in the destruction of many shoreline organisms from both the heated water used to wash the beaches and from the trampling feet of an army of remediation workers.

The measurement of ecological effects is difficult, and balancing them with health effects is even more so. There are no common metrics for...
ecological harm and human health, so one must rely on the common-sense inference that, without vigorous restoration efforts, the kind of excavation activities involved in remediating contaminated media is likely to devastate the natural environment. For contamination in industrial areas, the net effect could be minimal, but for contamination in rural or greenspace areas, this should be a major concern.

4. Waste Treatment

As we shall see in Part II, CERCLA contains a preference for "treatment which permanently and significantly reduces the volume, toxicity, or mobility" of the hazardous substances found at Superfund sites.90 Therefore, much of the hazardous material found at these sites is destined for some form of treatment to neutralize it,91 to solidify it,92 to burn it,93 to reduce its volume,94 to wash it,95 to separate its components,96 or to dilute it.97 Treatment residues and untreated materials are typically disposed of in hazardous waste landfills.98 Treatment and disposal can occur either on the site itself99 or elsewhere,100 often at a substantial distance.

91. See, e.g., MIDCO I Site, Gary, Ind., EPA ID IND980615421 (June 30, 1989), available in WL, Database EDR-ROD (requiring on-site treatment of contaminated soil by a combination of vapor extraction and solidification/stabilization followed by on-site deposition of the solidified material).
92. See, e.g., Reilly Tar & Chemical, Indianapolis, Ind., EPA ID IND1000289722 (Sept. 30, 1993), available in WL, Database EDR-ROD.
93. See, e.g., LaSalle Elec. Utils., LaSalle, Ill., EPA ID ILD980794333 (Mar. 30, 1988), available in WL, Database EDR-ROD (requiring excavation and on-site incineration of affected soil and sediment; and collection and on-site treatment of groundwater by phase separation, filtration, and air stripping).
94. See, e.g., Hunts Disposal, Caledonia, Wis., EPA ID WID980511919 (Sept. 29, 1990), available in WL, Database EDR-ROD (requiring fencing, consolidation of contaminated soil, construction of cap and slurry wall, monitoring, and institutional controls).
95. See, e.g., Tri-State Plating, Columbus, Ind., EPA ID INDD006038764 (Mar. 30, 1990), available in WL, Database EDR-ROD (requiring monitoring of groundwater and institutional controls).
96. See, e.g., Adams Plating, Lansing, Mich., EPA ID MIDD006522791 (Sept. 29, 1993), available in WL, Database EDR-ROD (requiring excavation and off-site disposal of contaminated soil; collection and treatment of water; replacement of excavated soil; land use restrictions; and groundwater monitoring).
97. See, e.g., Dakhue Sanitary Landfill, Hampton, Minn., EPA ID MND9811191570 (June 30, 1993), available in WL, Database EDR-ROD (requiring institutional controls and groundwater monitoring).
98. See, e.g., Bofors Nobel Inc., Muskegon, Mich., EPA ID MID9806030373 (Sept. 17, 1990), available in WL, Database EDR-ROD (requiring excavation and treatment of highly contaminated sludge via on-site thermal treatment, disposal of less contaminated sludge in on-site RCRA landfill, and upgrading of existing groundwater pumping and treatment).
99. See, e.g., MIDCO I Site, Gary, Ind., EPA ID IND980615421 (June 30, 1989), available in WL, Database EDR-ROD (requiring on-site treatment of contaminated soil by a combination of vapor extraction and solidification/stabilization followed by on-site deposition of the solidified material).
100. See, e.g., Republic Steel Quarry, Elyria, Ohio, EPA ID OHD980903447 (Sept. 30, 1988),
Short Changing Short-Term Risk

The draft environmental impact statement (EIS) for the Tank Waste Remediation System at the DOE's Hanford site exemplifies the hazards for remediation workers from the disposal and management of radioactive, hazardous, and mixed wastes. Both conventional occupational accidents and materials exposures during operations and waste transportation are implicated. Based on a "labor year" analysis, the DOE determined that the number of occupational fatalities would range between one and three over the course of the project. Community risk derives from radiological and chemical accidents, and from transportation accidents involving deliveries of materials and supplies to the site. Exposures could occur through accidents such as spray release during the transfer of waste in the cross-site transfer line, a breakdown of the air filtration system, or transportation accidents during the off-site shipment of high-level waste. Taking into account the probability of occurrence, the DOE concluded that up to three deaths would occur from radiological and chemical accidents. Finally, the remediation would have adverse effects on the surrounding shrub-steppe habitat, such as displacing sensitive wildlife. The EIS estimated that up to 250 acres of habitat would be destroyed by new remediation facilities and by earth-moving activities.

Similarly, at the Oak Ridge facility, habitat destruction for small mammals was caused by capping waste sites, which required clearing trees and removing topsoil.

By far the most common waste treatment of concern is incineration, which is frequently selected because it promises to eliminate the hazardous substances almost entirely. Nearby residents often oppose incineration because they fear adverse health effects caused by combustion products and the dispersion of incompletely consumed chemicals through the incinerator's exhaust. CERCLA broadly precludes judicial review of the EPA's remedy selection until the EPA actually imposes costs on a private party, so review usually occurs only after the remedy has been implemented. Since this

available in WL, Database EDR-ROD (requiring removal and off-site disposal of contaminated soil).

101. See HANFORD DEIS, supra note 57, at S-1, S-22 to S-24. The waste includes 56 million gallons of waste stored or to be stored in underground storage tanks at the site. See id. Additionally, cesium and strontium contained in 1930 capsules is in need of disposal. See id.

102. The long-term management and minimal retrieval alternatives would disturb between 25 and 100 acres. See id. at S-24. The more extensive retrieval alternatives would disturb between 180 and 250 acres. See id.

103. See CERE, supra note 25, at 4-28.

104. See, e.g., GAO, supra note 38, at 14, 57 (reporting on the Texarkana Wood Preserving Company site, Texarkana, Texas, and the Brio Refining, Inc. site, Harris County, Texas). When the waste being incinerated is nerve gas, the danger from incomplete destruction is severe. See DYCUS, supra note 71, at 66-67.

provision has been interpreted broadly, \(^{106}\) relatively few preemptive challenges are even attempted. What nevertheless seems to encourage such attempts, notwithstanding the unlikelihood of prevailing, is the fear of incineration of dioxins, PCBs, and other hazardous materials in contaminated soil. \(^{107}\) None of the challenges has been successful, but it is clear that the risks of incineration are of serious importance to affected communities.

5. Transportation

The risks of transportation associated with remediation activities are the most substantial remediation risks, both because there is a great deal of movement of waste and other materials in and out of Superfund sites and because transportation is statistically quite hazardous. \(^{108}\) Transportation risks are also the best defined remediation risks because transportation risks are generally well-documented. The paradigm case is the transportation of contaminated soil for distant treatment or disposal. As we have seen, the soil contains the contaminants in relatively low concentrations, but the overall volume is very high, requiring many truck- or train-miles to move it. A study of the transportation risks of removing arsenic-contaminated soil from residential areas around a smelter found that the number of deaths and injuries from accidents was comparable to the expected incidence of cancer from the arsenic. \(^{109}\) Similarly, transportation accidents are the only substantial risks to

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\(^{107}\) See Clinton County, 116 F.3d at 1021; Arkansas Peace Ctr. v. Arkansas Dep't of Pollution Control and Ecology, 999 F.2d 1212 (8th Cir. 1993); Schalk v. Reilly, 900 F.2d 1091, 1095-96 (7th Cir. 1990); Alabama v. EPA, 871 F.2d 1548, 1557-58 (11th Cir. 1989). Reviewing these cases, Healy identifies two kinds of health-based claims: (i) The clean-up will be inadequate under CERCLA or an ARAR, and (ii) the clean-up itself will be too dangerous. See Effectiveness and Fairness, supra note 105, at 271-72. Healy is critical of the absolute preclusion of health-based claims and certainly of those claims alleging the danger of the clean-up, noting that the site can be stabilized while the dangers or inadequacy of the remediation is litigated. See id. at 301-07, 313-14, 341-44; Judicial Review, supra note 105, at 36-43, 48-51.

The Times Beach saga has produced its own series of cases challenging the incineration remedy for the dioxin-contaminated dirt in that town. See Missouri v. Independent Petrochemical Corp., 104 F.3d 159 (8th Cir. 1997); United States v. Bliss, 133 F.R.D. 559 (E.D. Mo. 1990); United States v. Bliss, 132 F.R.D. 58 (E.D. Mo. 1990). None of the challenges was successful.

\(^{108}\) See, e.g., Adams Plating, Lansing, Mich., EDR ID 1000303229 (Sept. 29, 1993), available in WL Database EDR-ROD (requiring excavation and off-site disposal of contaminated soil; collection and treatment of water; replacement of excavated soil; land use restrictions; and groundwater monitoring).

\(^{109}\) See Mar et al., supra note 5, at 132. Mar and his colleagues estimated that at the highest levels of transportation (necessitated by the lowest levels of residual risk), one would expect 0.67 fatalities and 24.19 injuries (3.62 of them disabling) from truck traffic, as compared to the EPA's
Short Changing Short-Term Risk

the general public predicted in association with the Waste Isolation Pilot Plant for defense radioactive waste. The public radiation risk is swamped by both worker and transportation accident risk. Acting on the basis of transportation risk information, a citizens group at the Fernald facility formally recommended to the DOE that it utilize on-site waste disposal in order to avoid additional shipments from Ohio to Utah or Nevada.

Like the other remediation activities, transportation risk has both materials and conventional aspects. The materials risks, however, are swamped by the conventional, mechanical risks of accidents, which have nothing to do with the nature of the material being transported, but rather result from the frequency of rail and truck accidents. Thus, the Hanford DEIS found that for every scenario requiring waste transportation, the expected fatalities from transportation accidents significantly exceeded those expected from radiation exposure during transportation. Railroad accident statistics also reveal a large differential between accidental fatalities and fatalities from exposure to hazardous materials during transportation.

The most visible transportation concern is the movement of hazardous substances or contaminated media from the clean-up site to another location for treatment or disposal. The prospect of such materials rolling through towns and cities, on road or rail, is a matter of real concern to those who inhabit the transportation corridors and the immediate vicinity of the site. At the Ewan Property Dump in New Jersey, for example, residents were concerned about the impact of a fleet of trucks on rural traffic and the safety of children who lived close to the site access road. Transportation is a two-way street,

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111. See FERNALD CITIZENS TASK FORCE, RECOMMENDATIONS ON REMEDIATION LEVELS, WASTE DISPOSITION, PRIORITIES, AND FUTURE USE 39 (1995). The DOE had estimated between 7 and 11 transportation-related deaths and between 37 and 115 injuries. See id. at 18 app. E.

112. See NEVADA RISK ASSESSMENT/MANAGEMENT PROGRAM, PRELIMINARY RISK ASSESSMENT OF DOE SITES IN NEVADA 72 (1996) [hereinafter NRAMP] (identifying routine radiation and chemical releases, exhaust fumes, accidental exposures, and accidents as the types of transportation risk).

113. See Travis, supra note 25, at 401.

114. HANFORD DEIS, supra note 57, at S-22 to S-23, S-34.

115. The Association of American Railroads reported that there was only one hazardous materials fatality from rail traffic and 118 from truck traffic between 1985 and 1996. See On Track?, ENV’T, Jan.-Feb. 1997, at 24. In 1995 alone, there were 918 fatal motor vehicle operator accidents, or about 24 per 100,000 workers.

116. GAO, supra note 38, at 29. Similarly, centralized management of chemical weapons and nuclear waste is often opposed on the grounds of transportation risks. See DYCUS, supra note 71, at 66-67.
however. Superfund sites also require \textit{inbound} transportation of construction materials, treatment chemicals, and other equipment for building and operating, for example, treatment facilities and disposal cells, or for restoring the grade where soil and sediment have been removed. While such materials are naturally less hazardous than the outbound traffic, in terms of conventional risks such as accidents it makes no real difference that these materials are \textquotedblleft clean.\textquotedblright

Conventional risks have two potential receptors, namely transportation workers and the general public, with the latter generally exposed to similar or greater risks than the former.\textsuperscript{117} Transportation incidents are, by a factor of two, the largest cause of worker fatalities (including fatalities at construction sites).\textsuperscript{118} Moreover, transportation literally delivers conventional risk to the public, and in far greater magnitude than any of the materials risks from contaminated media or waste treatment and disposal.\textsuperscript{119} It is common for Superfund sites to require the transportation of waste materials over long distances,\textsuperscript{120} which should not be surprising given the difficulty of siting hazardous waste disposal facilities.\textsuperscript{121} The DOE's study of transuranic waste

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\textsuperscript{117} See \textit{Carlsbad Area Office}, \textit{supra} note 110, at S-71.

\textsuperscript{118} There were about 2500 such fatalities in 1995. Bizarrely, homicides are the next most frequent cause of death, followed closely by being struck by or caught in between objects. See BLS, \textit{supra} note 44; \textit{see also} Hoskin et al., \textit{supra} note 5, at 1015.

The Fernald feasibility study figures, drawn from various federal sources and normalized by the authors into a single unit, give some sense of relative accident rates.

\textsuperscript{119} See \textit{NRAMP}, \textit{supra} note 112, at 235 ("[T]ransportation is the dominant source of public risk and . . . treatment and disposal are dominant for worker risks.").

\textsuperscript{120} See Cohen et al., \textit{supra} note 4, at 420; Hoskin et al., \textit{supra} note 5, at 1014; Gerrard & Goldberg, \textit{supra} note 4, at 3.

\textsuperscript{121} See \textit{generally} Gerrard, \textit{supra} note 3 (discussing the difficulty of siting hazardous waste
Short Changing Short-Term Risk

disposal scenarios that require transportation to a centralized location shows that transportation risk dominates the overall risk profile.\textsuperscript{122} For low-level waste, centralized disposal options ranged from 35 to 38 expected truck accident deaths while regional options ranged from 1 to 10—all of which are far higher than predicted occupational fatalities.\textsuperscript{123} Moreover, the DOE estimated that the risk of fatalities from truck accidents was slightly lower per mile than the risk of death from the vehicles’ exhaust.\textsuperscript{124}

6. Federal Facilities

Federal facilities provide a particularly dramatic way to explore remediation risks. The slighting of remediation risks, while common at Superfund sites where the clean-up period is relatively brief, is simply not possible for the clean-up of environmentally contaminated military facilities, especially the former nuclear weapons production facilities of the DOE. The types of waste and contamination are so exotically hazardous; the scale of the problems is so vast; and the cost is so extraordinary that the DOE’s remediation phase demands attention to a degree that private sites do not.\textsuperscript{125} In this sense, federal facilities are the apotheosis of remediation risk, exhibiting virtually all of the elements associated with ordinary sites and expanding them to new dimensions.

Several of the materials at issue—unlike hazardous materials such as asbestos, dioxin-contaminated waste, and PCB-contaminated waste—pose a real risk of immediate, catastrophic effects.\textsuperscript{126} For example, unexploded ordnance and chemical weapons must be handled with great caution. Less dangerous materials, but equally capable of imposing immediate harm, include the extremely radioactive wastes from plutonium extraction at the DOE’s Hanford and Savannah River sites and the toxic constituents of defoliant production at the Defense Department’s Rocky Mountain Arsenal. One example of these hazards is the radium-bearing wastes at the DOE’s Femald facility in southwestern Ohio. Extraordinary precautions must be taken even in the basic process of removing the wastes from their storage silos both to shield workers from intense direct radiation and to prevent the release of large quantities of radon gas generated by the radioactive decay of

\begin{itemize}
\item \textsuperscript{122} See \textbf{CARLSBAD AREA OFFICE}, \textit{supra} note 110, at S-44 (estimating five fatalities in association with the preferred alternative, which involved shipping to a central facility).
\item \textsuperscript{123} See \textbf{WMPEIS}, \textit{supra} note 25, at 57.
\item \textsuperscript{124} See id. app. at E-117 (finding that accident risk was $1.53 \times 10^5$/mile, while exhaust ($SO_2$ and particulates) risk was $1.6 \times 10^7$/mile).
\item \textsuperscript{125} For an excellent and thorough overview of the occupational hazards posed by the remediation of DOE facilities, see \textbf{OTA}, \textit{supra} note 25.
\item \textsuperscript{126} See \textbf{DYCUS}, \textit{supra} note 71, at 66-67, 99-100.
\end{itemize}
radium. The retrieval of all of the unexploded ordnance from the Jefferson Proving Ground in Indiana will also entail the ecologically disastrous "stripmining" of the 51,700-acre site. Mismanagement of any of the foregoing materials could have lethal effects.

Military waste poses unusually serious dangers. A highly-charged debate continues over the best way to neutralize and destroy chemical weapons. The Army's method of choice, incineration, could conceivably release the unconsumed agents into the air, as well as create dioxins and other incineration by-products. Radioactive wastes, whose millenia-long half-lives mean that they will remain dangerous far into the future, raise the spectre of exposing future generations to high levels of radiation through the breakdown of repositories or inadvertent intrusions into them. The life cycle of plutonium, used primarily as the fuel for nuclear weapons, exemplifies the problem. Plutonium is radioactive and extremely toxic, especially when inhaled. Its production entails the creation of large quantities of highly radioactive liquid waste. Plutonium itself oxidizes rapidly into an extremely fine powder that is easily inhaled. Moreover, in some circumstances it will burn spontaneously when exposed to the air. Non-nuclear explosions of the components of weapons have left the floor of an entire Nevada valley littered with plutonium, and ventilation systems at the Rocky Flats plant near Denver are coated with plutonium dust. Furthermore, plutonium must be carefully safeguarded to prevent its use in a terrorist bomb, the health and environmental effects of which would be unspeakable.

Even for the more conventional risks that federal facilities present, the number of those facilities and the expected duration of the remediation projects tend to concentrate the mind on remediation risk. Contaminated sites can be found at about 1722 Department of Defense installations, and the DOE has over 10,000 separate contaminated locations at 137 facilities.

131. See CERE, supra note 25, at 4-3.
132. NRAMP, supra note 112, at 131-34, 144. The area is now aptly named "Plutonium Valley."
134. See CONGRESSIONAL BUDGET OFFICE, CLEANING UP DEFENSE INSTALLATIONS: ISSUES AND OPTIONS 7 (1995). The problems include both conventional contaminants, such as petroleum and industrial solvents, and unconventional items such as unexploded ordnance. See id. at 10-11.
Despite an aggressive plan to accelerate the pace of clean-up, the DOE’s remediation activities will not be entirely complete for decades, at a cost of up to $265 billion. Over the course of decades and with hundreds of thousands of person-years of work involved, fatalities, serious injuries to workers, and harm to the public and environment are likely to occur (as they already have).

In sum, the types and scale of hazards at defense facilities make cleaning them up a unique and perilous undertaking. It is in this context that the problem of remediation risk is most dramatically illustrated, but the underlying problem is ubiquitous. The remediation risks of federal facilities are in many ways simply the extreme case of a problem that can be found throughout the Superfund program. For the purposes of this study, federal facilities are also important because their remediation risks, especially as they relate to workers, have not been ignored, and precisely because they are so long-lived and exotic. Studies of DOE facilities in particular, and regulatory submissions by the DOE for its facilities, have considered the problem in detail and thus provide an invaluable source of data on the components and scale of remediation risks. Moreover, since one of the DOE’s major clean-up operations, the Fernald Environmental Management Project, is in EPA Region V (the source of the RODs in this study), its regulatory consideration of short-term risk provides a control against which less thorough consideration of remediation risk can be evaluated.

Environment Management Report 3-13 (1996). Several smaller sites have subsequently been transferred to the U.S. Army Corps of Engineers.

136. See id. at 4-1 (1996). The terms “complete” and “clean-up” are somewhat euphemistic in this context. Current plans aspire to finish the bulk of the clean-up in ten years and at a substantially lower life-cycle cost of $117 billion, but a number of significant projects, such as the tanks at Hanford, will take longer. Residual groundwater treatment and environmental monitoring will continue long after the completion of even those projects. See Office of Envtl. Mgmt., U.S. Dep’t of Energy, Accelerating Cleanup: Focus on 2006, at 4-7 to 4-12 (1997) [hereinafter Accelerating Cleanup]. Moreover, an area that is “clean” should not necessarily be released to the public; for the many sites at which some contamination remains (either in situ or in a disposal facility), long-term stewardship activities must continue indefinitely. See id. at 1-4 to 1-5; Office of Envtl. Mgmt., supra note 135, at 3-8 to 3-18, 6-1 to 6-13.


138. See DOE Risks, supra note 47, at 51-52; CERE, supra note 25, at 3-8 to 3-9; Travis et al., supra note 25, at 396-400.

139. The Femald RODs post-date our sample and therefore are not included in our study. In the interests of full disclosure, it should be noted that one of us (Applegate) has been heavily involved in the remedy selection at Femald, as chair of the Femald Citizens Task Force, the citizens’ advisory board of that site.
7. **Summary**

Our review of remediation risks supports the two points made at the beginning of this discussion. First, remediation risks are significant in the sense that they warrant serious attention in the EPA’s remedy selection decisions. Translating the known risk levels from person-hours and miles to actual expected deaths, one would multiply the rates by several orders of magnitude, resulting in positive numbers of predicted fatalities in many cases, and certainly in the overall Superfund program. The DOE’s overall risk estimates suggest that several fatalities will occur over the course of the clean-up program, and the Hanford and Nevada site studies both expect several remediation fatalities from various causes. Viscusi has estimated a low of 720 and a high of 6000 fatalities over the life of the Superfund program, but his methodology requires some comment. The figures are derived from a calculation of the mortality effects of loss of income (the poorer one is, the higher one’s mortality rate), and loss of income is viewed as a function of the cost of the Superfund program. Similarly, Viscusi and Zeckhauser calculated remediation risks from general statistics on the risk component of industrial output. These are, to say the least, indirect measures of remediation risk. Viscusi may have been driven to use such measures by the lack of good direct data, but his figures should be used with extreme caution.

Second, different remediation activities pose different types of hazards to different risk receptors. Therefore, remedy selection decisions inevitably, though not explicitly, determine how many injuries and fatalities will occur, what will cause them, and who will be the victims. Moreover, the underlying decision to take remedial action allocates risk among different time periods, which also means among different populations. It increases total risk in the near term to decrease it in the long-term, as Figure 3 indicates.

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140. See DOE RISKS, supra note 47, at 27, 50 (estimating 2.5 construction fatalities per 10,000 workers per year, not including chemical and radiological risks).

141. See HANFORD DEIS, supra note 57, at S-22 to S-23, S-34 to S-35; NRAMP, supra note 112, at 235, 237.

142. See Viscusi, supra note 5, at 12-13.

143. See Viscusi & Zeckhauser, supra note 5, at 22-24.

144. See supra note 16 and accompanying text.

145. See supra p. 279 tbl.1.

146. The figure superimposes a graph adapted from CERE, supra note 25, at 3-15, on the time line used in this Article. The CERE graph relates to plutonium stabilization, but its general trend is consistent with that of Superfund site risk. The near-term increases in risk are documented in this Article. The long-term increase of the uncontrolled risk has been documented elsewhere. See Human Health Risk, supra note 3, at 587 (concluding that a major source of risk at Superfund sites is the anticipated future use of the site). The flatness of the remedial action line is a result of the remedial action itself, the main purpose of which is to stabilize the physical situation (and hence the residual risk) over the long term.
Any regulatory decision, the effect of which is to choose who and how many people will be injured or killed as a consequence, should report that prediction and make it an indispensable (though not necessarily determinative) element of the decisionmaking process.

II. The Legal Framework for Remedy Selection

CERCLA has two distinct parts. The liability provisions identify those persons responsible for the potentially enormous clean-up costs.\textsuperscript{147} The remedy selection provisions, on the other hand, define the actions that must be taken to clean up Superfund sites.\textsuperscript{148} Remediation risk receives limited attention in the remedy selection process. Even detailed descriptions of the remedy selection criteria and process mention it only in passing.\textsuperscript{149} While the remedy selection process establishes the costs allocated by the liability provisions, it receives considerably less legal attention. This is presumably due in part to CERCLA's preclusion of judicial review of the remedy selection process.\textsuperscript{150} It is also due to the fact that liability allocation decisions are the most proximate, and thus most obvious, cause of costs being imposed.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
Uncontrolled & Polluted & Remediation & Foresceable & Long-Term \\
Past & Present & Period & Future & Stewardship \\
\hline
\end{tabular}
\end{table}

\textsuperscript{147} See, e.g., CERCLA §§ 107, 111, 113, 122(a), 42 U.S.C. §§ 9607, 9611, 9613, 9622(a) (1994).
\textsuperscript{148} See, e.g., §§ 104, 105, 121(a).
\textsuperscript{150} See supra notes 105-107 and accompanying text.
on CERCLA defendants. Moreover, lawyers tend to be more comfortable with the familiar issues of legal responsibility than with the technical problems of remediation. The remedy selection provisions of CERCLA are our present focus, and we shall see that they follow a pattern of focusing on baseline and target conditions, with the effect of minimizing consideration of the transition period.

As is typical in federal administration, the applicable legal rules are found not only in the statute, but also in the regulations and guidance documents. The regulations in this case are found in the so-called National Contingency Plan (NCP)—the name reflects CERCLA's ancestry in the oil spill response legislation—which sets out the formal and rather elaborate process of making remedy selection decisions. The process begins with the site investigation (SI) and preliminary assessment (PA) of places showing the effects of an environmentally uncontrolled past. If warranted, the site is placed on the National Priorities List for remedial action. Serious evaluation of the site's condition and needs is undertaken in the remedial investigation (RI) and feasibility study (FS), which are usually combined into a single document called the RI/FS. The consideration and comparison of alternative remedies in the feasibility study leads to the development of a proposed plan (PP) that, after public comment and revision, is memorialized in the record of decision (ROD). The decisionmaker for all practical purposes is the EPA's remedial project manager (RPM). According to The RPM Primer, the EPA's introductory description of the job, RPMs are responsible for the overall management of the clean-up project. They oversee the gathering and analysis of information, the implementation of interim and final remedies, and the initial selection of a remedy. Like any bureaucratic decisionmaker, the manager is subject to both legal and programmatic supervision. Formal approval of the ROD is made by the Regional Administrator, but the uniqueness and complexity of each situation, as well as the limited time of supervisory personnel, obviously make intensive oversight impractical.

Detailed planning of remediation activities occurs in the remedial design/remedial action (RD/RA) phase, after which the physical clean-up

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153. See id. at 18-19. The RPM, according to The RPM Primer, makes all of the initial decisions, including interim actions, remediation targets, writing the PP, and drafting the ROD. Indeed, design work on the selected remedy begins before the ROD is formally approved. See id. at 4-5, 14-15, 17-19.
154. See Benefits and Costs, supra note 11, at 184 ("[T]he diversity of remedies that have been selected... demonstrates that site managers do enjoy some discretion."); see also Ferris & Rees, supra note 149, at 839-44 (describing the RPMs' discretion as "uncontrolled").
must begin promptly. The remedy selected in the ROD is designed to achieve a target condition that meets the residual risk levels specified by CERCLA and the NCP. Finally, the NCP provides for operation, maintenance, and eventual completion of the site. The remedy selection process can be mapped onto the time line:

**FIGURE 4**
**RI/FS Process**

<table>
<thead>
<tr>
<th>Uncontrolled Past</th>
<th>Polluted Present</th>
<th>Remediation Period</th>
<th>Foreseeable Future</th>
<th>Long-Term Stewardship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>Transition</td>
<td>Target or Residual</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The SI, PA, and RI/FS documents define the polluted present of the site; the PP, ROD, and RD/RA documents determine what the remediation period will look like.

Remediation risks come into play only at the feasibility study stage, and they are incorporated into the remedy selection analysis in the proposed plan and ROD under the rubric of “short-term effectiveness,” as detailed below. While remediation risks play no part in site identification, they could conceivably be the basis of a no-action decision in the ROD.

**A. The Statutory Language**

Remedy selection is directed primarily by section 121 of CERCLA. It divides the issue into two subsections: the selection of a particular remedial action or actions and the degree of clean-up, defined as the permissible level of residual risk. The distinction itself is logical enough, but the barrier between technique and degree often breaks down in practice. Many technologies have limited capabilities. For example, soil washing can remove most but not all of the contamination, and in some cases the “clean” fraction remains a hazardous waste. Conversely, the choice of certain clean-up parameters, such as solidification or destruction, will effectively mandate a particular technology to accomplish it. The two subsections have overlapping provisions. Therefore, it is most realistic to consider choice and degree of

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156. See § 121(b), (d).
remedy together as aspects of a single set of factors, priorities, and preferences for remedy selection. It is common, even de rigeur, to criticize CERCLA as a badly drafted statute passed in haste at the end of the Carter presidency. The 1986 Superfund Amendment and Reauthorization Act (SARA) resolved many interpretive problems of CERCLA, but the new section 121, while a jumble of disparate Congressional concerns, is also unusually specific about the criteria that the EPA is to consider in remedy selection and the priorities and preferences among them.

A careful reading of two subsections of section 121 suggests a fairly coherent hierarchy of values in remedy selection decisions. The ultimate standard to be achieved is a cost-effective remedy that "is protective of" or "assures protection of" human health and the environment. A number of preferences are also stated. Permanent solutions are preferred over temporary ones, and treatments to reduce toxicity and mobility are preferred over disposal (i.e., some form of containment). Congress created incentives for on-site management of wastes by discouraging transportation and by applying the stringent hazardous waste standards to off-site disposal. Congress also wanted to assure uniformity with other hazardous waste situations, so it required that Superfund sites follow all "applicable or relevant and appropriate" requirements (ARAR) of federal and state law, though this can be waived in stated circumstances. Finally, section 121 identifies a number of other considerations that the EPA is to take into account in its remedy selection decisions: long-term effectiveness, long-term uncertainties, Resource Conservation and Recovery Act (RCRA) on-site requirements, risk (toxicity and exposure), short- and long-term health effects, long-term maintenance costs, potential future remediation costs, the dangers of remediation activities, experience elsewhere, and the support vel non of interested parties.

158. CERCLA § 121(b)(1).
159. § 121(d)(1).
160. See § 121(b)(1). The cost-effectiveness criterion can also be found in § 105(a)(7).
161. The EPA is required specifically to justify any departure from statutory preferences. See § 121(b)(2).
162. See § 121(b)(1).
163. See id.
165. See CERCLA § 121(d)(2), (3).
166. See § 121(d)(4).
167. See § 121(b)(1)(A)-(G), (b)(2).
There are two points of particular importance in this litany of factors. First, Congress was clearly aware of the issue of remediation risk and directly addressed it. In addition to the general instruction to consider the short-term potential for adverse health effects, it specifically identified dangerous remediation activities as “the potential threat to human health and the environment associated with excavation, transportation and redisposal, or containment.” While treatment risks are not mentioned in this subparagraph, they are largely covered by RCRA. Together, these provisions encompass virtually all of the remediation risks discussed above. In addition, SARA permits a waiver from the ARAR requirements when “compliance ... will result in greater risk to human health and the environment than alternative options.”

Second, this attention to remediation risks is overshadowed by the statute’s aggressive favoring of permanent remedies. This is expressed both in the number of criteria that point in that direction and their place in the statutory hierarchy. Both permanence and treatment (which is a more permanent solution than mere containment) are accorded explicit preference status. Long-term effectiveness is not called a preference, but the EPA is directed “specifically [to] address” this factor. The stated concerns for long-term uncertainties, persistence of a hazardous substance, long-term adverse effects, long-term maintenance costs, and future remediation needs all reinforce this emphasis on the target condition of the site, that is, the foreseeable future and beyond.

The preference for long-term solutions is also strong because it is an eminently sensible position for Congress to take. Detailed policy analysis is not required to see the desirability (all other things being equal) of permanent solutions in terms of human and environmental health, total cost, and administrative convenience. Conversely, it is reasonable for Congress to downplay remediation risk to the extent that it would interfere with its long-

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168. See § 121(b)(1)(D).
169. § 121(b)(1)(G).
171. CERCLA § 121(d)(4)(B).
172. See § 121(b)(1).
173. Id.
174. All other things are not equal, of course, and current proposals for legislative reform seek to eliminate the treatment, permanence, and ARAR requirements as unrealistic and, in some cases, counterproductive. Indeed, Superfund reform legislation would allow consideration of future land use controls as ways to protect the public. See Superfund: House Democrats Circulate Draft Proposal on Remedy Selection, Community Grants, 28 Env’t Rep. (BNA) 717 (1997); see also Benefits and Costs, supra note 11, at 184-85 (describing the high cost of the preference for permanent remedies). It seems unlikely, however, that the general preference for long-term solutions will disappear, though it may become less dominant.
term preference. Our point in this Article, therefore, is not that CERCLA is wrong-headed in its lack of emphasis on remediation risk, but rather that the EPA’s site-specific decisions de-emphasize it to the vanishing point. It is one thing to override remediation risk in favor of other concerns; it is quite another to ignore it. Moreover, as the foregoing analysis shows, ignoring or virtually ignoring remediation risk is inconsistent with the statutory language.

B. Regulatory Translation

If one thinks of section 121 as an unassembled jigsaw puzzle of relevant factors, then it was the EPA’s job, in developing the NCP, to piece it together into a coherent, manageable structure for remedy selection decisions. For the most part, the EPA did its job exceptionally well. It derived from the text of section 121 nine remedy selection criteria, which it further arranged into a hierarchy of three categories that indicate the weight to be accorded each criterion. It is a logical, serviceable framework for decisionmaking.

The most important group of factors is called the threshold criteria, which constitute minimum standards that must be met in every case (unless waived). The first criterion, “overall protection of human health and the environment,” draws on several other criteria (including long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs) and demands that a selected remedy eliminate, reduce, or control the baseline site hazards to a certain level. A risk-based standard, it requires the target condition of the site to meet a residual individual risk level between $1 \times 10^{-4}$ and $1 \times 10^{-6}$ excess cancers. The second threshold criterion, “compliance with ARARs,” requires that the selected remedy meet the federal and state requirements that would otherwise apply to the site. The most important ARARs are quantitative or numerical standards drawn from water, air quality, and hazardous waste regulations.

175. The NCP is the basic regulatory framework for the EPA’s clean-up activities. Its creation (actually, revision—the NCP was originally developed for oil spills pursuant to the Clean Water Act, 33 U.S.C. § 1321 (1994)) is required by CERCLA § 105.


179. Id. § 6.2.3.1.


181. ARARs are subdivided into chemical-specific, action-specific, and location-specific ARARs. See RI/FS Guidance, supra note 178, § 6.2.3.2. CERCLA specifically mentions the Safe Drinking Water Act and Clean Water Act standards. See CERCLA § 121(d)(2), 42 U.S.C. § 9621(d)(2)
At the other end of the spectrum, the so-called “modifying criteria” include “state acceptance,” which refers to technical or administrative issues raised by state regulators, and “community acceptance,” or public concerns. The modifying criteria are intended at most to adjust a remedy that already has been identified as the “preferred alternative,” and they have been criticized for that reason.\(^{183}\)

In the middle are the “primary balancing criteria,” by which the EPA attempts to fine-tune the remedy selection.\(^{184}\) While the threshold criteria tend to require quantitative levels of achievement, the balancing criteria specify other important characteristics of the remedy selection. The first of these criteria, “long-term effectiveness and permanence,” addresses the residual risks after remedial action is complete.\(^{185}\) “Reduction of toxicity, mobility, or volume” reflects the statutory preference for the use of treatment technologies that provide permanent solutions.\(^{186}\) “Short-term effectiveness” refers to remediation risks, and it includes risks to the community, workers, and environment during remediation, as well as the elapsed time to completion.\(^{187}\) “Implementability” means the administrative and technical feasibility of implementing a remedial alternative, including the availability of necessary services and materials.\(^{188}\) And “cost” subsumes the capital and operating costs of the remedy.\(^{189}\)

The threshold-balancing-modifying framework is one way in which the NCP channels consideration of the statutory criteria. The framework also gives explicit guidance for performing the comparisons and making the necessary trade-offs among the criteria.\(^{190}\) It reemphasizes the primacy of the protectiveness and ARAR thresholds; it further defines cost-effectiveness; and it restates the preferences for permanent solutions and treatment. The NCP concludes:

The balancing [of the primary balancing criteria] shall emphasize long-term effectiveness and reduction of toxicity, mobility, or volume through treatment. The balancing shall also consider the preference for treatment as a principal element and the bias against off-site land

\(^{185}\) See RI/FS GUIDANCE, supra note 178, § 6.2.3.3.
disposal of untreated waste. In making the determination under this paragraph, the modifying criteria . . . shall also be considered.\(^{191}\)

These directions for the actual balancing operation mention every one of the nine criteria, including the lowly modifying criteria, except those having to do with the remedial activities themselves, that is, implementability and short-term effectiveness.\(^{192}\) If this is merely an oversight, it is surely Freudian.

The EPA has not been entirely silent on the meaning of “short-term effectiveness,” however. The NCP states that the determination of short-term effectiveness for a given remedy should focus on the effects of the implementation of the remedy on the community, workers, and the natural environment during the period of remediation activity. The components of such an evaluation, accordingly, are:

1) short-term risks that might be posed to the community during the implementation of an alternative;
2) potential impacts on workers during remedial action and the effectiveness and reliability of protective measures;
3) potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation; and
4) time until protection is achieved.\(^{193}\)

The NCP therefore clearly uses the term “short-term effectiveness” to refer to the remediation or transition period,\(^{194}\) whereas “long-term” refers to everything after that—both the foreseeable future and long-term stewardship.\(^{195}\)


\(^{192}\) One might detect a concern for remedial risks in the bias against transportation even though there are other reasons for that directive.


\(^{194}\) Id.

Furthermore, short-term effectiveness, as described by the EPA, measures the risks caused by the implementation of the remedy and incurred by the community, workers, and the environment during that period. Short-term effectiveness does not measure the achievement of clean-up goals or the reduction of the baseline risk in the near future. The continuing effects of contaminants already present on the site are not part of the analysis, as the EPA's original explanation of these provisions confirms.

Thus, like section 121, the NCP includes a potentially adequate consideration of remediation risks. The receptors (if not the sources) of the risks are all identified, and the duration problem (i.e., the longer the project, the more effort, the more risk) is flagged. However, several aspects of the NCP distinctly weaken the role of remediation risk. First, the name “short-term effectiveness” is poorly chosen. By speaking of “effectiveness” instead of “risk,” it implies that the real issue is early reductions in the baseline risk. That is not an implausible concern, so the terminology invites

196. This makes good sense; the short-term risks of the contamination are to be managed through removal and abatement actions. See CERCLA § 101(23)-(24), 42 U.S.C. § 9601(23)-(24) (1994) (defining temporary and permanent remedial actions); § 104(a)(2) (requiring that temporary actions be consistent with subsequent permanent ones).

The Risk Assessment Guidance confuses matters somewhat by asserting that “[s]hort-term health risks generally include any current baseline risks plus any new risks that would occur while implementing the remedy.” RAGS, supra note 27, at 18. However, the “current baseline risks plus any new risks” measurement is not mentioned elsewhere in RAGS and directly contradicts the NCP and R/FS Guidance.

197. The preamble to the NCP identified short-term effectiveness as the criterion used to address the effects of the remedial alternative “during the construction and implementation phase” until the site objectives are accomplished. Examples of factors that affect short-term effectiveness are the dust caused by excavation, the risk involved in the transportation of hazardous materials, or the negative impact on air quality that could occur through a stripping tower operation. Additionally, the assessment is intended to “consider who may be exposed during the remedial action, what risks those populations may face, how those risks can be mitigated, and what risks cannot be readily controlled.” National Oil and Hazardous Substances Pollution Contingency Plan, 55 Fed. Reg. 8721 (1990). Potential adverse impacts on the environment due to construction and implementation of an alternative should be assessed, and an evaluation should be undertaken of the reliability of the available mitigation measures in preventing or reducing potential impacts. See id. at 8721-22.
misinterpretation. Second, short-term effectiveness obscures the statute's specific mention of excavation and other sources of remediation risk in its general description of receptors, reducing the attention that Congress paid to it. Third, remediation risk ends up as a single criterion out of nine in the NCP, whereas section 121 mentioned it three times. Fourth, the NCP marginalizes worker risk in its overall analysis by its assumption that workers are adequately protected by occupational standards, making further consideration of risks to them unnecessary. Finally, the elevation of the easily measurable, quantitative ARARs to threshold status and the reemphasis on the balancing instructions of long-term effectiveness and treatment implicitly relegate other considerations to a lesser role. None of these changes to the statutory structure would be decisive in itself, perhaps, but together they send a clear signal in the NCP that remediation risks are to be considered only briefly, if at all. Since RPMs have considerable discretion in choosing a remedy, such signals can have a major impact on actual decisions. Indeed, The RPM Primer describes the criteria that RPMs and the Regional Administrator must use in developing and approving the remedy selection at a clean-up site, yet it does not even mention "short-term effectiveness" or any aspect of remediation risk.

The EPA's RI/FS Guidance adds relatively little descriptive material to the NCP on this issue. The Superfund Risk Assessment Guidance, however, is more helpful. Evaluation of short-term human health risks during the initial development and screening of alternatives in the FS is very brief and intended merely to identify alternatives with clearly unacceptable short-term risks. Risk evaluation during the FS's detailed analysis of alternatives is much more complex. The main near-term focus is the risk of each alternative remedy for the community and workers during implementation, so that they can be compared with other alternatives. The first step in the risk evaluation is to decide whether a quantitative or qualitative risk evaluation is necessary, based on the importance of relative short-term effectiveness in a particular alternative and the degree of "perceived risk" associated with the alternative. Several factors can lead to a higher "perceived risk," such as the close proximity of populations, the presence of highly or acutely toxic chemicals,


199. See Ferris & Rees, supra note 149, at 839-44.

200. See RPM PRIMER, supra note 152, at 15-17, 19 (discussing the FS and ROD approval).

201. See RAGS, supra note 27, at 8-9.  

202. See id. at 12.  

203. See id. at 7, 15-21.
technologies with a high release potential, and releases that occur over long periods of time.\textsuperscript{204} The actual evaluation of short-term human health risks\textsuperscript{205} considers exposure,\textsuperscript{206} toxicity values that are relevant to risks from shorter exposures,\textsuperscript{207} and characterization of short-term risks to the community and to workers. This process is similar to the baseline risk assessment, but the analysis is to be qualitative instead of more rigorously quantitative.\textsuperscript{208}

To summarize, the various parts of the legal framework for remedy selection under CERCLA display a consistent view of short-term or remediation risk. The statute, the NCP, and EPA guidance all provide a clear direction to consider remediation risk in site remedy selection decisions. However, to varying degrees they all clearly subordinate remediation risks to other considerations, notably baseline risk reduction and the permanent achievement of low target risks.

C. Worker Risk

Before proceeding to the analysis of RODs, a few words are needed concerning the relevance of worker or occupational risk to Superfund remedy selection. Worker risk is, as we have seen, a major component of remediation risk. Without worker risk, the problem of ignoring remediation risk would still be significant, though perhaps less compelling. At one level, it is worth asking whether RODs adequately consider worker risk as part of remediation risk, because if they do not, then the law is not being followed. More fundamentally, our interest in worker risk implicitly assumes that worker risk \textit{should} be part of Superfund remedy selection. That is, while in this Article we do not prescribe the particular weight to be given to worker or remediation risk as against other risk and nonrisk factors, we do assert that worker risk should be given \textit{some} weight.

It should be clear that worker risk stands on somewhat different ground than risk to the general public. At least to some extent, workers voluntarily assume the risks of their work, which their pay should reflect. In addition, they generally have a greater degree of control over the extent of the risks, as

\textsuperscript{204} See \textit{id.} at 16. Other factors that affect perceived risk include a high uncertainty in the nature of the release that may characterize innovative technologies, multiple contaminants and/or exposure pathways affecting the same individual, multiple releases occurring simultaneously, or multiple releases occurring from remedial actions at several operable units in close proximity. See \textit{id.}.

\textsuperscript{205} See \textit{id.} at 17-21.

\textsuperscript{206} This includes release sources, receiving media, fate and transport, exposure points, exposure routes, and receptors associated with a particular remedial alternative.

\textsuperscript{207} Exposure that lasts minutes, hours, or a full day is a "single exposure element." Exposure that lasts for up to two weeks is "very short-term" exposure. Exposure that lasts two weeks to seven years is "short-term" exposure. See RAGS, \textit{supra} note 27, at 20.

\textsuperscript{208} See \textit{id.} at 19-20.
they are both risk creators and risk receptors. There are two principal objections, flowing from these facts, to considering worker risk at all in remedy selection. We address each briefly, in turn.

The first objection argues that because workers have voluntarily assumed the risk, the regulatory system has no further role to play. They argue that their wages, at least in theory, include a “risk premium” to compensate for the extra hazard to life and limb. The asserted voluntariness of occupational risks depends both on the psychological assumption that workers are more risk preferring and on the idea of a risk premium that compensates workers through higher wages for engaging in hazardous activities. The psychological element has been debated extensively, and those who deny that the workers’ assumption of risk is voluntary usually point to the lack of adequate understanding of the risks and to social and economic pressures that undermine the idea of consent. Even those who believe that voluntary assumption of risk is possible concede that market failures such as inadequate information would undermine voluntariness. In principle, risk premiums ought to be susceptible to verification or refutation, but efforts to do so have proven quite difficult. Kip Viscusi claims to have developed clear evidence of a wage premium for hazardous jobs, but others have challenged his conclusions. In the absence of a clear demonstration that worker risk is voluntarily assumed as a matter of informed preference or higher compensation, we do not believe that it is appropriate to exclude it from the remedy selection analysis.

The second objection is that occupational risks that do not rise above the risks ordinarily encountered in construction and transportation (i.e., mechanical risks) should not be counted, because in all likelihood the workers would be doing the same work for other employers. Therefore, the argument

209. This argument is strengthened by the applicability of OSHA regulations, noted above, that require the elimination of most egregious hazards in the workplace.
211. See MICHAEL J. MOORE & W. KIP VISCUSI, COMPENSATION MECHANISMS FOR JOB RISKS: WAGES, WORKERS’ COMPENSATION, AND PRODUCT LIABILITY 13-14 (1990); VISCUSI, supra note 210, at 38-45 (detailing the risk premium argument).
213. See W. Kip Viscusi, Structuring an Effective Occupational Disease Policy: Victim Compensation and Risk Regulation, 2 Yale J. on Reg. 53, 56-60 (1984); VISCUSI, supra note 8, at 44.
214. See VISCUSI, supra note 210, at 38-45.
215. See generally McGarity & Shapiro, supra note 212; McGarity & Shapiro, supra note 212; Schroeder & Shapiro, supra note 212.
Short Changing Short-Term Risk

goesthere is no net increase in risk to the workers. The principal difficulty
with this argument is that it is speculative. We do not really know what an
individual would be doing if not the work at this particular site. The
alternative might be more or less safe. Indeed, the no-net-increase argument
proves too much. If we were to count only net increases in risk for all
purposes, we could never determine the risk of any activity. We would always
have to reduce it by the risks of whatever the person might otherwise be
doing. The actual activity before us creates a focal point for our weighting
of risks, and the risks of alternative activities do not change the character of
the one under consideration.

The foregoing objections to the consideration of worker risk have
undeniable force, but they are more properly considered in assigning weight to
worker risk rather than its admissibility. The precise relative weight to be
given to worker risk and to remediation risk generally is a difficult, value-
laden question. It is probably not susceptible to general rules and is certainly
beyond the scope of this Article. But no decision based on the life cycle of
Superfund risks would be complete without consideration of worker risk.

III. Analysis of Records of Decision

The observation that prompted this study and that became our working
hypothesis was that remediation risks receive only perfunctory analysis in
RODs and have little or no discernible impact on the selection of the remedy.
This observation is something of a truism among persons familiar with the
Superfund remedy selection process in practice. They generally believe that
remediation risk is either ignored or takes a back seat to other
factors. The hypothesis receives implicit confirmation from published descriptions of the
remedy selection process that simply pass over remediation risk, often without
any apparent awareness of the omission, as did the EPA materials described

216. To take an extreme example, parachuting would not be considered very dangerous at all
since the parachutist might otherwise be skiing or driving or performing some other dangerous activity. Similarly, exposure to benzene in a rubber factory would not be risky since the worker might alternatively be exposed to cotton dust in a mill. In other words, “alternative risks” are at best inchoate. But see Risk Versus Risk, supra note 5, at 21-22 (arguing for examining the “first, nearest and biggest” alternatives).

217. See OTA, supra note 25, at 19-20, 22-23 (reporting that Superfund practitioners believe that remediation risk takes a back seat to other NCP criteria); Cross, supra note 5, at 901 n.260 (quoting Alan Krupnick of Resources for the Future as remarking that RODs often do not even mention the dangers to remediation workers); Viscusi & Zeckhauser, supra note 5, at 19 (“Created risks tend to be ignored completely when new expenditures are principally designed for risk reduction, as with... the cleanup of Superfund sites.”); Gerrard & Goldberg, supra note 4, at 3. This was further confirmed by our own conversations with present and former EPA Superfund officials.

218. See Mar et al., supra note 5, at 131. For examples of risk assessments that omit remediation risk, see Brett et al., supra note 64, passim (omitting conventional risks while studying materials risks);
above. Like most truisms, however, this observation has not been systematically tested. A study based on characterizations like "perfunctory" and "discernible impact" resists quantification. Nevertheless, we have sought to devise a methodology that will yield useful, replicable results and that will confirm or reject our hypothesis.

A. Methodology

In the remedy selection process, as we have seen, the ROD documents the remedy finally selected for a particular site as well as the reasons for the choice. The ROD identifies and compares the remedial alternatives that were analyzed in the FS; it summarizes the facts, analyses, and policies that were considered; and it explains how the nine evaluation criteria were used in the selection of the remedy.219 Thus, RODs are, in theory at least, the ideal resources through which to investigate actual remedy selection practices, since they encapsulate the entire process. Moreover, they are readily available from a number of sources.

Reviewing RODs is not a perfect way to study Superfund practices, however. RODs are summaries and as such sacrifice detail. They are also the principal medium for communicating the remedy selection decision to the public,220 so there may be a tendency to sacrifice completeness for readability. Others who have used RODs to study Superfund have expressed similar misgivings,221 and other studies have relied instead on detailed case studies of a few sites.222 For the purpose of uncovering a general tendency in remedy selection, however, detailed site data are not critical and review of a few cases would be inadequate. The RI/FS documents clearly would have provided more complete information, but our analysis did not require detailed risk data, and we had no reason to suspect that the RODs do not faithfully reflect at least the topics covered in the RI/FS analysis.223


223. OTA noted that RI/FSs do not, in fact, provide much data on occupational risk. See OTA,
We obtained the text of the RODs from the Westlaw RODs database.\textsuperscript{224} To minimize selection bias, we reviewed all of the available RODs from EPA Region V, which includes Ohio, Indiana, Illinois, Michigan, Wisconsin, and Minnesota. While this encompasses only a portion of the country, these states are the heart of the industrial Midwest (less flatteringly, the Rust Belt) and a rich source of Superfund sites and experience. We are, admittedly, extrapolating from the results in a single administrative region, and the EPA's regions have a tradition of independence.\textsuperscript{225} The corroboration of our hypothesis by the literature described above, however, leads us to believe that a regional study is sufficient to test the hypothesis.

We also limited our review to RODs from 1988 and later. The EPA's RI/FS Guidance was released in 1988 and for the first time singled out the short-term effectiveness criterion in its current form. Therefore, findings of dismissive treatment before the Guidance would be difficult to interpret. They could be merely evidence of the failure of the immature Superfund program to focus on this issue. After the 1988 Guidance, which clearly identified remediation risk issues, this possibility has been largely ruled out.\textsuperscript{226} As of September 3, 1997, the Westlaw database contained 124 Region V RODs from this period. Of these, sixteen were unusable either because the ROD did not compare any alternatives or because the comparison was sketchy.\textsuperscript{227} Separate analyses were made for multiple operable units within a single ROD. The net result is that a total of 113 separate analyses were made.

The analysis entailed reading the ROD for the following features relating to the thoroughness of the consideration of short-term and occupational risk:

1) \textit{How much weight was given to the short-term effectiveness criterion?} (This was determined by examining whether the remedy selected was the same as the remedy with the greatest short-term effectiveness or otherwise appeared to be influenced by short-term effects.)

\textsuperscript{supra} note 25, at 22-23.

\textsuperscript{224} See generally WL, Database EDR-ROD.


\textsuperscript{226} In addition, the current version of the NCP itself was formally proposed on December 21, 1988, though it was adopted a year and a half later. See National Oil and Hazardous Substances Pollution Contingency Plan, 53 Fed. Reg. 51,394 (1988). The proposed rule defined short-term effectiveness as "impacts of the [remedial] alternatives—i.e., impacts during implementation—on the neighboring community, the workers, or the surrounding environment, including threats to human health and the environment associated with excavation, treatment, and transportation of hazardous substances." \textit{Id.} at 51,428 (1988). The idea of short-term effectiveness thus seems to have been in general circulation by 1988.

\textsuperscript{227} We also discounted a few of these RODs because they made extensive use of charts that were not available through Westlaw.
2) Did the ROD identify and discuss all four subcategories of short-term effectiveness? (In particular, the ROD was examined for whether it considered risk to workers, the community, the environment, and the time to completion.)

3) Was worker risk taken seriously or treated dismissively? (This was identified, for example, through the use of boilerplate language\textsuperscript{228} about the effectiveness of personal protective gear, instead of a site-specific analysis.)

Obviously, these are not quantitative evaluations like cost or risk data and thus are not susceptible to clearly objective measurement. We therefore looked elsewhere for informal standards against which RODs could be measured. The Fernald RODs provided one control, as noted above. The EPA's RI/FS Guidance, while it adds little substance to the current NCP, provides a list of questions that need to be addressed during the analysis of short-term effectiveness. The Guidance shows exactly how the EPA expects RPMs to analyze short-term effectiveness. It particularly looks for the following:

\begin{itemize}
  \item Protection of community during remedial actions
    \begin{itemize}
      \item What are the risks to the community during remedial actions that must be addressed?
      \item How will the risks to the community be addressed and mitigated?
      \item What risks remain to the community that cannot be readily controlled?
    \end{itemize}
  \item Protection of workers during remedial actions
    \begin{itemize}
      \item What are the risks to the workers that must be addressed?
      \item What risks remain to the workers that cannot be readily controlled?
      \item How will the risks to the workers be addressed and mitigated?
    \end{itemize}
  \item Environmental impacts
    \begin{itemize}
      \item What environmental impacts are expected with the construction and implementation of the alternative?
      \item What are the available mitigation measures to be used and what is their reliability to minimize potential impacts?
    \end{itemize}
\end{itemize}

\textsuperscript{228} "Boilerplate" is conventionally defined as "language which is used commonly in documents having a definite meaning in the same context without variation." BLACK'S LAW DICTIONARY 175 (6th ed. 1990). As is described in more detail below, we take the use of boilerplate as an indication that little individualized analysis has gone into the ROD. See infra Subsection III.B.4. Of course, there are only a limited number of verbal ways to express that worker risk has been accounted for, so the use of boilerplate language does not in itself prove that worker risk received minimal attention. However, it is consistent with such an interpretation in the context of the rest of each ROD, and it is consistent with the other evidence assembled from other RODs.
Short Changing Short-Term Risk

- What are the impacts that cannot be avoided should the alternative be implemented?

* Time until remedial response objectives are achieved
  - How long until protection against the threats being addressed by the specific action is achieved?
  - How long until any remaining site threats will be addressed?
  - How long until remedial response objectives are achieved?229

A thorough ROD ought to answer these questions, and we used the Guidance as the "gold standard" for the purposes of the second and third features of thoroughness.

A ROD is a summary, however, and may appropriately be more terse than the RI/FS Guidance questions suggest. To account for this, we regarded far less verbiage than included in an RI/FS to be a reasonably thorough analysis of remediation risks in the ROD. The following excerpt from one of the RODs that we reviewed reflects what we viewed as a moderately complete analysis:

[1] With respect to protection of the community, alternatives 1 through 5 will not pose risks to the local community, though there may be temporary inconveniences. Alternatives 4 and 5 which involve excavation may result in increased dust generation but this can be controlled through conventional dust suppression techniques.

[2] Risks to workers during remedial action in alternatives 1 through 5 can be controlled with safe working practices. Alternatives 4 and 5 may expose workers to VOCs from excavated soils but the levels should be within applicable PELs and TLVs.

[3] With respect to environmental impacts, ... alternatives 3, 4, and 5 will result in a temporary change in groundwater flow from extraction and pit dewatering and a temporary increase in the flow rate in the bayou from the discharged groundwater. Alternatives 4 and 5 could result in the release of low levels of VOC to the air from the soil excavation.

[4] Evaluation of the time until protection is achieved reveals the following estimates: alternative 2 should take a few weeks to a few months, alternative 4 should take 5-6 months, and

229. RI/FS GUIDANCE, supra note 178, at tbl.6-3.
alternatives 3 and 5 should take 4-5 years. Alternatives 1 and 6 will not achieve protection.230

With these guidelines in mind, we now turn to the results.

B. Findings

1. Weight Accorded to Short-Term Effectiveness

The first step in determining the weight accorded to short-term effectiveness in the remedy selection decision was to see what the ROD said about it. When that failed or was inconclusive, which was usually the case, we compared the apparent ranking of the selected remedy in terms of both short- and long-term effectiveness on a scale of high, moderate, or low, relative to the alternatives that were considered. This determination was necessarily subjective since the RODs themselves rarely ranked the effectiveness of remedies in this way.231 This was also only a rough indicator of weight, because seven other criteria also influence remedy selection; however, we judged that any such attempt, absent a multiple regression analysis, would have this limitation. In fact, the failure to provide this kind of ranking in the RODs is in itself troubling. It hampers not only retrospective analysis but, more importantly, contemporaneous technical and public review, thereby effectively obscuring the trade-offs between short- and long-term risk and among different short-term risks.

Of the 85 selected remedies compared to alternatives, 40 remedies ranked higher in long-term effectiveness than short-term effectiveness, 35 remedies ranked equally in long- and short-term effectiveness, and only 10 remedies obtained a higher ranking in short-term effectiveness than long-term effectiveness. That is, only 10 cases gave a clear indication that short-term effectiveness had strongly influenced the outcome. This is actually a relatively high percentage (12%) in light of our expectations, though some of the apparent preference for short-term effectiveness may well be a preference for on-site management, implementability, or another criterion. Review of the RODs for this characteristic, therefore, did not contradict our hypothesis, but was inconclusive of its validity.

231. Only a very few RODs employ this technique. See Reilly Tar & Chem., Indianapolis, Ind., EPA ID IND1000289722 (Sept. 30, 1993), available in WL, Database EDR-ROD. More commonly, the ROD lists each alternative and gives a reason why it may cause short-term risks, without making a definitive comparison. See Fisher Calo Chem, Kingsbury, Ind., EPA ID IND074315896 (Aug. 7, 1990), available in WL, Database EDR-ROD.
2. Completeness of Analysis

Our most quantitative analysis measured whether the ROD separately discussed and analyzed all four subcategories of short-term effectiveness. This was a rarity. Only 33 of the 113 analyzed remedies (29% of the examined RODs) actually mentioned all four subcategories. Conversely, 71% discussed three or fewer subcategories, in clear contravention of the NCP and EPA Guidance. The norm among RODs is to look at short-term risk in general, as opposed to relating risk respectively to workers, the community, and the environment. While this approach may be adequate for some situations, it certainly is not appropriate where the risk implications for these receptors differ, as they frequently do. RODs often separately estimate the “time for completion of the remedy” criterion, but usually without the other three. These findings clearly support the hypothesis that remediation risks are inadequately considered. They suggest that when presented with conflicting signals, RPMs are following the tone or spirit of the NCP and Guidance (which marginalize remediation risk) rather than their letter.

3. Misapplication of Short-Term Effectiveness

A disturbing and quite unexpected finding was that RPMs not only underapply short-term risk analysis, but that they often misapply it as well. As we have discussed previously, the term “short-term effectiveness” seems to invite the incorrect interpretation that it is an analysis of the near-term effects of the baseline contamination, rather than of the risks of implementation. Of the 113 selected remedies, 25 (22%) misstated or misapplied short-term effectiveness. For instance, one ROD described the “no action” alternative for...

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232. The Hedblum ROD, used above as an example on this point, was one of the exceptions. See Hedblum Indus., Oscoda, Mich., EPA ID MID980794408 (Sept. 29, 1989), available in WL, Database EDR-ROD.

233. The United Scrap Lead ROD analyzed short-term effectiveness in the following manner: "In all alternatives (except no action) there will be a slight increase in dust due to construction activities. Good construction practices should minimize this. Protection will be achieved in the shortest period of time (17 months) in alternative 1 and take the longest - in alternative 4 (48 months)." United Scrap Lead, Troy, Ohio, EPA ID OHD18392928 (Sept. 30, 1988), available in WL, Database EDR-ROD. Such a description of short-term effectiveness does not adequately explain how the hazards relate to different groups. See also Republic Steel Quarry, Elyria, Ohio, EPA ID OHD980903447 (Sept. 30, 1988), available in WL, Database EDR-ROD ("All alternatives considered to address the on-site surface soil contamination, with the exception of alternative 1 (no action) are effective in the short term.").

234. See supra p. 279 tbl.1.


a site as not being effective in the short-term since groundwater would still pose an unacceptable risk at the site. This is an improper interpretation of short-term effectiveness, the analysis of which should address the risks of an alternative during the construction and implementation stage of a remedial action. If there is no remedial action then there is no construction or implementation, and short-term effectiveness would be at its highest (and short-term risk at its lowest). Without implementation of a remedy, it is impossible for workers, the community, or the environment to experience risks from that remedy.

Some RODs misapplied short-term effectiveness only when they described the “no action” alternative and applied it correctly for the other remedial alternatives. For example, one ROD stated that “[a]lternative 1 [no action] would not be effective in addressing contamination from the site,” but then analyzed other alternatives as causing short-term impacts such as noise and dust from the construction of a cap. Another ROD incorrectly applied short-term effectiveness to the no action alternative and to other alternatives, but then applied it correctly to a different alternative. Yet another simply stated that “[a]ll action alternatives are more effective in reducing risks to the local community and the environment than the no action alternative.”

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237. See Perham Arsenic, Perham, Minn., EPA ID MND980609572 (Mar. 31, 1994), available in WL Database, EDR-ROD.

238. See Coshocton City, Coshocton, Ohio, EPA ID OHD980509830 (June 17, 1988), available in WL, Database EDR-ROD.

239. In its discussion of short-term effectiveness the Midstate Disposal Landfill ROD states: Alternative 1 is not effective in protecting the public health and the environment because there is no reduction of risk. Remedial objectives in the FS will not be obtained and, in addition, water quality criteria will not be met. Alternatives 2 and 3 greatly reduce future risk. Risk to community and workers during implementation is limited. Alternatives 4 through 7 may cause odors during stabilization and may involve some risk to workers. Alternatives 5 through 7 provide further protection by reducing leachate production by at least 75%.

Midstate Disposal Landfill, Cleveland Township, Wis., EPA ID WID980823082 (Sept. 30, 1988), available in WL, Database EDR-ROD.

The Waite Park Wells ROD analyzes short-term risk in the following manner:
Both of the protective alternatives, alternatives IIIA and IIIB, will provide a good degree of short-term effectiveness since control of both shallow and deep aquifers can be implemented quickly and treatment of the contaminated water will occur simultaneously with essentially no adverse impact from implementation of the remedy. The other alternatives, since they do not address the deep aquifer, the shallow aquifer, or both, do not have adequate short-term effectiveness.

Waite Park Wells, Waite Park, Minn., EPA ID MND981002249 (Sept. 28, 1989), available in WL, Database EDR-ROD; see also Naval Indus. Reserve Ordnance Plant, Fridley, Minn., EPA ID MN3170022914 (Sept. 28, 1990), available in WL, Database EDR-ROD (applying a similar analysis of short-term effectiveness); Schmalz Dump, Harrison, Wis., EPA ID WID980820096 (Sept. 30, 1987), available in WL, Database EDR-ROD (analyzing short-term effectiveness both correctly and incorrectly).

240. Ninth Ave. Dump, Gary, Ind., EPA ID IND980794432 (Sept. 20, 1988), available in WL,
Short Changing Short-Term Risk

It is astonishing that nearly one quarter of RODs demonstrate that the RPMs who authored them misunderstood one of the criteria that they are required to apply. The best explanation of this is undoubtedly the infelicitous choice of "effectiveness" to describe this criterion, implying that remediation should reduce risk in the near term. Since virtually all remedies increase risk in the near term, the idea of risk reduction as a measure of remediation activities is incoherent. The proper measure is the minimization of additional risks, which the term "effectiveness" does not convey. The effect of this misunderstanding is that remedies can be easily chosen without regard to minimizing remedial risks, to the detriment of remedial workers, neighboring communities, and the surrounding natural environment.

4. Treatment of Occupational Risks

Occupational risks are usually treated dismissively, if they are discussed at all. The analysis of short-term effectiveness is supposed to include "protection of workers during remedial actions," according to both the regulations and the Guidance, but 53 of the remedies analyzed (47%) discussed occupational risks using boilerplate language and 42 RODs (37%) did not discuss it at all. The boilerplate statements assumed that workers would be protected from risk by the use of "personal protective equipment," or that risks would be reduced through "health and safety plans." Even putting aside the fact that these assumptions do not reflect reality, neither of

Database EDR-ROD. This ROD went on correctly to analyze the rest of the remedial alternatives. See id.; see also New Brighton/Arden Hills, Arden Hills, Minn., EPA ID MN7213820908 (Aug. 11, 1989), available in WL, Database EDR-ROD (“Except for the no-action alternative, the remaining alternatives would effectively alleviate the contamination problem at site D on the short-term basis.”).

241. See Perham Arsenic, Perham, Minn., EPA ID MND980609572 (Mar. 31, 1994), available in WL, Database EDR-ROD (“[I]mpacts to site workers during remediation will be controlled with the use of the appropriate personal protective equipment (PPE), and by ensuring that site workers have the appropriate training.”); Auto Ion Chems., Inc., Kalamazoo, Mich., EPA ID MID980794382 (Sept. 27, 1989), available in WL, Database EDR-ROD (“These risks can be controlled by use of... personnel protective equipment for controlling exposures for site workers.”); Wausau Groundwater Contamination, Wausau, Wis., EPA ID WID980993521 (Dec. 23, 1988), available in WL, Database EDR-ROD (“[S]ite workers can be protected by personal protection equipment.”); Ninth Ave. Dump, Gary, Ind., EPA ID IND980794432 (Sept. 20, 1988), available in WL, Database EDR-ROD (“[C]onventional personnel protection measures will be adequate to protect on-site workers.”).

242. See South Andover Salvage Yards, Andover, Minn., EPA ID MND980609614 (May 31, 1994), available in WL, Database EDR-ROD (“[H]ealth and safety plans would require that all workers be adequately protected during work.”); Adams County Quincy Landfill, Quincy, Ill., EPA ID ILD980607055 (Sept. 30, 1993), available in WL, Database EDR-ROD (“Worker health and safety practices will be instituted.”); Metamora Landfill, Metamora, Mich., EPA ID MID980506562 (Sept. 28, 1990), available in WL, Database EDR-ROD, (“Standard health and safety measures shall be followed by the workers.”); Hedblum Indus., Oscoda, Mich., EPA ID MID980794408 (Sept. 29, 1989), available in WL, Database EDR-ROD (“Risks to workers... can be controlled with safe working practices.”).

243. See OTA, supra note 25, at 27-43 (finding that, for many reasons, protections for hazardous

317
these boilerplate statements adequately examines the risks posed to workers on a site-specific basis, as anticipated by the EPA Guidance. If only 16% of RODs seriously discuss occupational risk, one must conclude that the occupational risk of remedies does not play an important role in remedy selection.

Even when a ROD mentions worker risk, the analysis almost never \(^{244}\) reaches the level of detail specified by the Risk Assessment Guidance. \(^{245}\) While this information is required only in the RI/FS and not in the ROD, the ROD should nonetheless summarize the information from the detailed analysis. Instead, the ROD usually just notes that a particular action will not result in any unacceptable short-term risks to workers, \(^{246}\) or it briefly states that one particular remedy will increase short-term risk to workers. \(^{247}\) This also may be attributable to the NCP’s permitting the EPA to assume full compliance with Occupational Safety and Health Administration (OSHA) hazardous waste regulations, even though such regulations purport neither to eliminate all worker risk nor to guarantee full compliance. \(^{248}\) In any event, the end result is that very few RODs adequately analyze short-term effectiveness in relation to occupational risk.

We singled out occupational risk in our original methodology because we expected it to be a bellwether for the adequacy of consideration of remediation risk, since workers are the most obvious and most threatened remediation risk receptor. If occupational risk is ignored or treated perfunctorily, it is unlikely that other remediation risks will be considered more carefully. This proved to be the case. Our hypothesis, that short-term risk would receive perfunctory analysis and have little discernible impact on the ultimate remedy selection decision, was confirmed with few exceptions. Remediation risk did not appear to weigh heavily in decisions. Rarely were all four subparts of short-term risk...
considered, and when they were they were often treated superficially. Most strikingly, RODs often mischaracterized short-term risk as the risks posed by the polluted present.

IV. Remedy Selection

A. The Significance of Remediation Risk

The fundamental reason to consider remediation risk in remedy selection is the magnitude of the risk. All aggressive remedies (i.e., excluding access restrictions and institutional controls on future land use) have real-life, near-term effects on remediation workers, site neighbors, and the surrounding environment. Whether or not they compare favorably with the baseline risks, serious risk consequences flow from the choice of a CERCLA remedy. Just as rational regulation cannot be indifferent to feasibility and cost, neither can it be indifferent to its health and safety consequences, even (or especially) if they are unintended.

The post hoc review of a particular ROD does not, of course, permit a credible inference that full consideration of remediation risks would have changed the remedy selection in a particular case in a particular way. Even with more information (like the FS documents), any assertion that the decisionmakers at the time would have chosen differently would be largely speculative. Nevertheless, there is every reason to believe that full consideration of remediation risks would affect remedy selection in the long run because, as we have seen, different remedies differ substantially in (i) the degree of remediation, and (ii) the receptors of that risk. If the decisionmakers are not simply indifferent to remediation risk, then over the course of many remedy selections some decisions could be expected to change, as in fact they have in some of the very few cases in which the ROD did fully consider remediation risk.

1. Degree of Remediation

The degree of clean-up (or level of residual risk) affects short-term risk because a higher clean-up standard (lower residual risk) normally requires greater clean-up efforts. This is most obvious in the case of soil excavation, which is a labor-intensive activity requiring the use of heavy machinery. The concentration of contamination at a site is rarely uniform, but is rather a gradient that decreases as it moves away from the source or sources of the

249. See Cass R. Sunstein, After the Rights Revolution: Reconceiving the Regulation State 90 (1990) ("No sensible regulatory program... can be indifferent to cost.").
250. See supra p. 279 tbl.1.
In physical terms, then, the decision to achieve a lower residual risk level means that more contaminated soil at lower concentrations must be removed. A higher residual risk would allow the removal of only the more contaminated fraction. The incremental materials risk associated with removing the less contaminated soil decreases with the reduction in contamination concentration, though at a slower rate than the decrease in concentration because the excavation process can be expected to create dust and to volatilize chemicals, both of which increase exposure to the contaminants. The Region V RODs noted a number of these effects. The incremental conventional risks associated with digging and hauling remain the same, however. Figure 6 illustrates the relationship between marginal risk per unit of remediation activity and concentration of contaminants in soil.

251. For example, if the source is a spill, the contamination would radiate down in a half-sphere or column. If it is airborne deposition, the gradient would be horizontal with lower levels of soil having less contamination than levels closer to the surface.

252. See Brett et al., supra note 64, passim (assessing the risks of excavating waste lagoons).

253. See, e.g., St. Louis River, Duluth, Minn., EPA ID MND039045430 (Sept. 28, 1990), available in WL, Database EDR-ROD (air emissions); Fisher Calo Chem, Kingsbury, Ind., EPA ID IND074315896 (Aug. 7, 1990), available in WL, Database EDR-ROD (contaminated material in general); Wayne Waste Oil, Columbia City, Ind., EPA ID IND048989479 (Mar. 30, 1990), available in WL, Database EDR-ROD (worker exposure to volatile chemicals); Hedblum Indus., Oscoda, Mich., EPA ID MID980794408 (Sept. 29, 1989), available in WL, Database EDR-ROD (other air contaminants); Auto Ion Chems., Inc., Kalamazoo, Mich., EPA ID MID980794382 (Sept. 27, 1989), available in WL, Database EDR-ROD (uncovering and disturbing waste); Pristine, Inc., Reading, Ohio, EPA ID OHD076773712 (Dec. 31, 1987), available in WL, Database EDR-ROD (increase in dust generation).

254. The construction and transportation risk data reported in Part I do not show any distinctions among rates of conventional risk based on differences in the hazardousness of the material. The per-mile injury and fatality rates for transportation, for example, remain constant. See supra Subsections I.B.1, 3, 5.

255. Marginal risk, of course, is to be distinguished from total risk. The marginal risk reflects the value of each increment only; therefore, total risk increases additively even though the marginal risk does not.
The more dirt that is moved, in other words, and the more time that is spent moving it, the higher the total conventional risk will be. Moreover, as we have seen, the conventional remediation risks tend to exceed the materials risks, so the dominant effect of increased risk reduction will be increased conventional remedial risk. The Hanford DEIS, for example, reasoned that (i) conventional risks occur at predictable rates related to the type of construction activity and the number of labor hours spent on that particular activity, and (ii) construction activities have the highest accident rates. Therefore, remedial alternatives with a high number of construction labor hours would have a high number of injuries and fatalities. Some RODs note the benefit of reducing the amount of soil excavated, and they occasionally remove the excavation component from a selected remedy altogether or reduce its scope. There

256. This was the basis of the plaintiffs' unsuccessful challenge in United States v. NL Indus., 936 F. Supp. 545, 554-56 (S.D. Ill. 1996). The choice of a 500 parts per million (ppm) residual lead level in soil instead of a 1000 ppm level would result in the generation of much greater quantities of waste material that would have to be transported from the site. The city and the potentially responsible parties were arguing for the higher lead (and higher risk) level.

257. See HANFORD DEIS, supra note 57, at S-22 to S-23; Hoskin et al., supra note 5, at 1013-15.

258. See Kummer Sanitary Landfill, Northern Township, Minn., EPA ID MND980904049 (Sept. 30, 1988), available in WL, Database EDR-ROD (disturbing only minimal volumes of in-place waste during construction activities); Allied Chem. & Ironon Coke, Ironon, Ohio, EPA ID OHDO43730217 (Sept. 29, 1988), available in WL, Database EDR-ROD (disturbing hazardous waste as little as possible).

259. See Kentwood Landfill, Kentwood, Mich., EPA ID MID000260281 (Mar. 29, 1991), available in WL, Database EDR-ROD (eliminating one remedy due to excavation of landfill waste which would increase the potential for exposure to hazardous constituents by contact and inhalation); Hagen Farm, Stoughton, Wis., EPA ID WID980610059 (Sept. 17, 1990), available in WL, Database EDR-ROD (posing minimal risks due to the fact that the waste would not be excavated); Hedblum
was a similar result in Usaviex, where a RCRA cap was not selected due to the increase in risk from excavation and exposure to contaminated soil. Another Region V ROD, Lakeland Disposal Services Inc., was confronted with the same choice between a landfill cap and a RCRA cap. A landfill cap was selected, but the ROD stated that the differences between a landfill cap and a RCRA cap would not affect short-term risk. This is difficult to understand when the RCRA cap remedy obviously takes longer and requires more construction activity than the landfill cap. Some remediation activities may not follow this pattern, but any remedy with sustained construction or transportation activity necessarily does. Even pumping and treating groundwater, which involves only start-up construction risks, can have a continuing detrimental effect on neighboring aquifers, which is an environmental short-term risk.

The method of remediation also affects the magnitude of short-term risk. On the one hand, access restrictions and institutional land-use controls have almost no remedial risks. Off-site treatment and disposal, on the other hand, increase the amount of transportation, which is a major risk item. Since the risks of transportation are dominated by conventional (viz., accident) risks, the total risk increases at a constant rate as the volume of material being moved increases, as Figure 6 suggests. The more miles that are driven, the more accidents will occur and the more people are potentially exposed to contaminated material, a fact noted in several of the Region V RODs. Thus, the choice of a transportation-reliant remedy is the choice of substantial remediation risks to project workers and the public.

Indus., Oscoda, Mich., EPA ID MID980794408 (Sept. 29, 1989), available in WL, Database EDR-ROD (avoiding excavation in the selected remedy which would have increased dust generation and exposed workers to VOCs).

260. For example, the installation of a multilayer cap designed for hazardous waste sites takes longer and requires more extensive construction activities than the installation of an ordinary landfill cap. The ROD for one Ohio site therefore selected the less elaborate solid waste landfill cap, noting that it provided less long-term effectiveness but greater short-term effectiveness. See Buckeye Reclamation, St. Clairsville, Ohio, EPA ID OHD980509657 (Aug. 19, 1991), available in WL, Database EDR-ROD. The difference was 1.3 million cubic yards versus 11 million cubic yards of earth to be moved. See id.

261. Usaviex, Niles, Mich., EPA ID MID980794556 (Sept. 7, 1988), available in WL, Database EDR-ROD.


263. See Hoskin et al., supra note 5, at 1012-15.

264. See Mar et al., supra note 5, at 133-34.

265. See City Disposal Sanitary Landfill, Dunn, Wis., EPA ID WID980610646 (Sept. 29, 1992), available in WL, Database EDR-ROD; Carter Indus. Site, Detroit, Mich., EPA ID MID980274179 (Sept. 18, 1991), available in WL, Database EDR-ROD; St. Louis River, Duluth, Minn., EPA ID MND039045430 (Sept. 28, 1990), available in WL, Database EDR-ROD; Oak Grove Landfill, Oak Grove Township, Minn., EPA ID MND980904056 (Sept. 30, 1988), available in WL, Database EDR-ROD.
The EPA’s nearly universal preference for depth over breadth (that is, going after fewer sources, but demanding more of each of them)\textsuperscript{266} may need to be reconsidered at sites where remediation risks are high. In the extreme case, a thorough consideration of the risks of the remedy could encourage the abandonment of substantial remediation efforts in favor of access restrictions only. These will be rare cases,\textsuperscript{267} but it must be an active option where remediation risks are uncontrollable. For the vast majority of cases, a full understanding of remediation risks is simply a means of ensuring informed decisionmaking, and that will lead in the long run to different choices being made.

2. Risk Receptors

The selected remedy also has a profound effect on who (or what) is subjected to remediation risks. Incineration as a method of treatment, for example, tends to have similar materials risk effects on workers and the neighboring population as a result of exposure to air emissions\textsuperscript{268} or particulate dispersion,\textsuperscript{269} whereas excavation imposes far greater conventional risks on workers and ecosystems. It is not inappropriate to think of these choices of remedy (and therefore of receptors) as transfers of risk among subpopulations.\textsuperscript{270} The question here is who will bear the risks of remediation.\textsuperscript{271} To take a previous example, organic layer removal of forest soil is the most effective way to protect the local public from Chernobyl fallout. It imposes few remediation risks on the public (a forest is sparsely populated, so dust is not a problem), but it has huge excavation,

\textsuperscript{266} See Applegate, supra note 12, at 1672-73 (discussing depth versus breadth in the context of the Clean Air Act); Cross, supra note 5, at 912-13; Viscusi & Zeckhauser, supra note 5, at 37 (noting that U.S. regulation heavily emphasizes prevention of fatalities over nonfatal injuries and illnesses).

\textsuperscript{267} See, e.g., DYCUS, supra note 71, at 112 (describing the cesium-137 contamination of lake sediments at the DOE’s Savannah River site).

\textsuperscript{268} See Pristine, Inc., Reading, Ohio, EPA ID OHD076773712 (Mar. 30, 1990), available in WL, Database EDR-ROD.

\textsuperscript{269} See Usaviex, Niles, Mich., EPA ID MID980794556 (Sept. 7, 1988), available in WL, Database EDR-ROD.

\textsuperscript{270} For more information on risk transfers, see generally RISK VERSUS RISK, supra note 5; Viscusi, supra note 5. The general problem in environmental law of transferring risk from the public at large to workers has been noted in several contexts. See, e.g., BREYER, supra note 8, at 12-13 (discussing risks to asbestos abatement workers); RISK VERSUS RISK, supra note 5, at 22-25 (classifying the types of risk trade-offs); Cross, supra note 5, at 872 (discussing risks to workers from pesticides); Inhaber, supra note 28, at 720-21 (comparing worker and public risks from different energy production technologies).

\textsuperscript{271} Of course, the decision to undertake active remediation at all involves some burden-shifting from the neighboring public to remediation workers. In terms of “life years lost,” as opposed to simple fatalities, the transfer is dramatic. As Cohen et al. demonstrate in their hypothetical case study, the types of injury and age of the victim result in much higher numbers of life years lost per worker than per neighbor. See Cohen et al., supra note 4, at 422.
transportation, and ecological consequences.\textsuperscript{272} The transportation of large waste volumes affects the neighboring public, but it also spreads the per-mile risk across a broader area.

It should go without saying that basic choices regarding who will be subjected to how much risk should not be ignored, made inadvertently, chosen in ignorance, or hidden.\textsuperscript{273} For example, even if worker risk is heavily discounted as the result of a judgment that such risk is counterbalanced by voluntariness or the risks of alternative employment, such normative principles do not obviate the utility and necessity of an evaluation of the factual effects of our judgments.\textsuperscript{274} At some point, voluntariness and alternative risks may no longer outweigh a rising tide of worker injury. Putting aside the malignant effect of selective knowledge on the decisionmaking process, the failure to take adequate account of remediation risk effectively shields the selection of high-risk remedies from review by the public, who are entitled to comment on the proposed plan,\textsuperscript{275} and by the courts, whose review is limited in time and in scope but to which aggrieved citizens have a right to turn.

B. Directions for Change

If the 105th Congress succeeds where its immediate predecessors have failed in reauthorizing and revising CERCLA, there will shortly be an opportunity to reform the NCP to take better account of remediation risk and to require a better accounting of remediation risk from RPMs. CERCLA itself does not require substantial reworking in terms of remediation risk. As we have seen, it contains ample authority for considering remediation risk. To the extent that it expresses a preference for long-term risk reduction, that is a policy choice which our study does not challenge. The proposals in Superfund reform bills to eliminate ARAR compliance and the preference for treatment\textsuperscript{276} would probably have the beneficial but indirect effect of raising the status of remediation risk. However, the implications (many of them negative) of such major changes go far beyond the problem that we have

\begin{itemize}
\item \textsuperscript{272} See Linkov et al., \textit{supra} note 81, at 69.
\item \textsuperscript{273} For example, the kind of detailed analysis that Suter et al. advocate for ecological risk is impossible if the data are not developed in the first place. See Suter et al., \textit{supra} note 85, at 228-29; see also Viscusi & Zeckhauser, \textit{supra} note 5, at 20-21, 38.
\item \textsuperscript{274} Cf. Linda Ross Meyer, \textit{Just the Facts?}, 106 \textit{Yale L.J.} 1269, 1311 (1997) (book review) (explaining the need to consider the costs and collateral consequences of tort rules, even if the theoretical underpinnings of the rules do not recognize such facts as determinative).
\item \textsuperscript{275} See CERCLA § 117(a), 42 U.S.C. § 9617(a) (1994); 40 C.F.R. § 300.430(f)(3) (1997).
\item \textsuperscript{276} See Special Report: Commerce Panel GOP Floats Draft Remedy, NRD Plans in Bipartisan Talks, \textit{Inside EPA's Superfund Rep.}, July 21, 1997, at 1 (newsletter on file with the authors) (reprinting draft committee language on remedy selection revisions).
\end{itemize}
sought to identify. There is no need to exclude criteria such as ARARs in order to do a better job of including the criterion of remediation risk.

The NCP and associated guidance, on the other hand, are in large part responsible for the EPA’s failure to consider remediation risk in remedy selection. As Part II of this Article demonstrated, the NCP greatly strengthens the statutory preference for long-term and permanent remedies in a number of ways. Therefore, one goal of the post-reauthorization revision of the NCP should be the restoration of the statutory balance between short- and long-term concerns. A first step toward this goal is the renaming of the criterion to “remediation risk reduction” or “implementation risk reduction.” The level of confusion regarding the meaning of “short-term effectiveness” among the EPA’s own employees is embarrassingly high, and it needs to addressed.

As a first step, RPMs need more explicit guidance on remediation risk. To ignore it altogether, as The RPM Primer does, sends a clear message that it is utterly unimportant in clean-up decisions. The EPA should also remove or revise the directions for the actual balancing process that emphasize long-term risk and permanence within the balancing criteria category while not even mentioning remediation risks. This goes beyond simply sending mixed signals on remediation risk. It is a virtual directive to ignore remediation risk, and our study shows that this part of the NCP has been understood and followed as such.

A second goal of reform should be to require full disclosure of remediation risks on equal terms with other data, so that they can be fully considered by the EPA and the public. Textually, one could add more comprehensive and clearer descriptions of the meaning of remediation risk and require more thorough discussion of the issue in the proposed plan. Full disclosure in the proposed plan is especially important in view of the limitations on judicial review, as it may be the only meaningful opportunity to change the decision.

We do not yet advocate the further step of a general requirement for quantitative risk-risk analysis. The idea of requiring risk comparisons to ensure that environmental remedies do not make the situation worse is not new. But the difficulties of comparing risks, quantitatively or otherwise, are numerous and extremely controversial. As the comparative risk literature points out, comparative risk assessment poses both methodological

278. For discussions of the need for risk-risk analysis, see Risk Versus Risk, supra note 5, at 246-60; Cross, supra note 5, at 920-24; and Viscusi, supra note 5, at 5-6.
279. See Inhaber, supra note 28, at 18; Chauncey Starr & Chris Whipple, Risks of Risk Decisions, 208 SCIENCE 1114 (1980).
280. See generally Applegate, supra note 12, at 1658-60; John S. Applegate, Comparative Risk Assessment and Environmental Priorities Projects, 25 N. KY. L. REV. 71 (1998); Adam Finkel,
difficulties, such as identifying a feasible common unit of measurement and obtaining the large amounts of data required, and normative difficulties, such as the appropriateness of the common metric and the relative weight to be given to various risks and risk receptors. The present study has not addressed these issues, though we hope that it provides an empirical basis for such work. 281

There are, in any event, limits to what one can realistically expect to accomplish through revisions of statutes and regulations. In any plausible version of the revised statute, CERCLA will require the weighing of several disparate factors to come up with remedy selections in particular cases. Superfund sites are simply too diverse and too complex to admit of one- or two-dimensional rules of decision. Consequently, remedy selection will always be to a large extent discretionary and case-specific. Beyond full disclosure of relevant data and the clear, consistent articulation of factors and preferences, there is little that additional directive language can accomplish. This seems particularly true in light of our findings that misunderstandings and a failure to follow the requirements of the NCP are commonplace in remedy selection. These shortcomings are the result of internal communication failures and of problems in legal and program supervision. Therefore, these are the areas in which the most immediately effective opportunities for reform lie.

Conclusion

One of the distinctive features of CERCLA among environmental protection statutes is its lengthy, labor-intensive, and relatively dangerous remediation phase. This transition period cannot be ignored by those who are directly involved in the clean-up of a Superfund facility, and it should not be ignored by site-specific remedy selectors or national policymakers. Yet, from all indications, remediation risks are consistently undervalued and even dismissed in the remedy selection process, both as a matter of implied policy and of common practice. Our review of 113 remedial actions from EPA Region V confirmed these indications and revealed a further troubling fact—many EPA decisionmakers seem not to understand fully how remediation risk fits into the remedy selection process.

Solving the remedy selection problem is not an easy task. The relevant statutory language, while not a model of clarity, already adequately conveys


281. See Applegate, supra note 5.
the importance of remediation risk. The NCP does require attention, and we have suggested some key changes. The most pressing need, therefore, is for better compliance with the existing regulatory directions governing the consideration of remediation risk. While entrenched patterns of agency behavior are not easily changed, a vigorous program of communication and supervision would result in a Superfund remedy selection process that is better informed and more sensitive to its effects on remediation workers, surrounding populations, and ecosystems.