Cleaning up Superfund

W. KIP VISCUSI & JAMES T. HAMILTON

THE cleanup of hazardous wastes is the number one environmental concern of the American people. The government's response: the Environmental Protection Agency (EPA) launched its Superfund program, which was established by Congress in 1980 and reformed in 1986.

But, though not even two decades old, the Superfund effort is now a major target of Congress in its regulatory reform efforts. There are two main sources of dissatisfaction. First, cleanups of hazardous wastes are expensive, averaging $25.7 million per site. Superfund expenditures increased from under $400 million in 1985 to over $1.4 billion in 1995 and continue to be above the $1 billion mark even after recent budgetary cutbacks. Estimates of the total cleanup costs incurred since the program's inception range from $20 billion to $30 billion, about half of which has been borne by private parties. Second, there is a general sense that these cleanup expenditures have not delivered much reduction in risk. Are we devoting our resources to eliminating truly substantial hazards or does Superfund squander society's resources on trivial risks?

Three reform principles

In his 1993 book *Breaking the Vicious Circle*, Stephen Breyer, a Clinton appointee to the U.S. Supreme Court, recounted how cleanup efforts, by design, achieve very little:

> Let me provide some examples. The first comes from a case in my own court, *United States v. Ottati & Goss*, arising out of a ten-year effort to force cleanup of a toxic waste dump in southern New Hampshire. The site was mostly cleaned up. All but one of the private parties had settled. The remaining private party litigated the cost of cleaning up the last little bit, a cost of about $9.3 million to remove a small amount of highly diluted PCBs and "volatile organic compounds" (benzene and gasoline components) by incinerating the dirt. How much extra safety did this $9.3 million buy? The forty-thousand-page record of this ten-year effort indicated (and all the parties seemed to agree) that, without the extra expenditure, the waste dump was clean enough for children playing on the site to eat small amounts of dirt daily for 70 days each year without significant harm. Burning the soil would have made it clean enough for the children to eat small amounts daily for 245 days per year without significant harm. But there were no dirt-eating children playing in the area, for it was a swamp. Nor were dirt-eating children likely to appear there, for future building seemed unlikely. The parties also agreed that at least half of the volatile organic chemicals would likely evaporate by the year 2000. To spend $9.3 million to protect non-existent dirt-eating children is what I mean by the problem of "the last 10 percent."

Such misallocation is commonplace. Indeed, elements present in Breyer's example are embedded in the entire EPA approach. In answering the question—how clean is clean?—EPA should follow three principles: assess risks accurately, determine the extent of the population exposed to the risk, and strive for an appropriate balance between benefits and costs.

Although these principles may seem obvious and unobjectionable, none of the three is reflected in the current approach. Establishing them is essential even if financial reforms to relieve some firms of liability are implemented. For relieving some private parties of Superfund costs does not eliminate the need for targeting public expenditures wisely.

Moreover, a sensible targeting of resources will also eliminate needless cost expenditures and produce more immediate and real risk reductions than the current effort.

Assess risks accurately

EPA does not target its cleanup efforts randomly.[1] Each hazardous waste site is subjected to a comprehensive assessment of the risks and cleanup costs, which is then used to select which sites to clean up and what actions to take.

To understand the reasons for the current policy performance, it is helpful to review current risk-assessment practices. A primary impetus for hazardous waste cleanups is the potential cancer risk from chemical exposures. For the different mechanisms of exposure, EPA assesses the potential risk that would be present if a person was exposed to the chemical. This individual risk probability is a principal policy trigger for cleanup actions.

The assessed individual cancer risk is the risk that an individual would experience over a lifetime from 30 years of exposure. If the cancer risk is greater than 10^{-4}, then the site must be cleaned up; if the risk is between 10^{-4} and 10^{-6}, then cleanup is at the discretion of regional officials; and if the estimated risk is less than 10^{-6}, cleanup is not generally warranted, though this prohibition can be overridden.

This numerical precision of estimated cancer risks, replete with multiple digits of zeros to capture fine gradations of risk, is, however, misleading; for the EPA does not, in fact, assess the real risks associated with Superfund sites. Rather, the analyses focus on worst-case outcomes. In assessing the risks from ground-water contamination, for example, the agency often uses upper bound, or 95th percentile, values for several different components of its risk calculation—the ingestion rate for ground water, the frequency of exposure to contaminated ground water, the duration of such exposure, the concentration of hazardous chemicals, and the potential toxicity of these

[1] Our analysis is concerned with remediation action and does not address emergency removals, which are treated differently. The emergency removals are undertaken to address immediate hazards identified at sites. Cleanup goals for remediations can also be driven by other factors, such as noncancer risks and other state and federal environmental standards.

chemicals. For each of these parameters, a conservative estimate is used, usually one that will occur 5 percent or less of the time.

The combined influence of these conservative factors is that the calculated risks greatly overstate the expected risks from these sites. If each parameter is gauged conservatively, the net conservatism regarding the risk estimate is much greater. Our estimates, using EPA estimates of the mean values of the various parameters, indicate that the true risks will be below the assessed risks more than 99 percent of the time.

Recognizing this conservative bias influences how one interprets the true significance of EPA's policy criteria. Officially, these criteria are linked to lifetime cancer-risk critical values of between 10^{-4} and 10^{-6}. Taking into account the period of exposure and the conservative bias, these policy cutoff values actually pertain to annual cancer risks that are over 100 times smaller. Thus, after correcting for biases in risk assessment, the EPA guideline requires cleanup whenever the actual annual cancer risk is at least 10^{-6}, and permits discretionary cleanup for risks between 10^{-6} and 10^{-8}, and disallows cleanup for risks smaller than 10^{-8}.

Should such seemingly small probabilities alone serve as the trigger for expensive government cleanup efforts? The one-in-a-million threshold for required cleanup is, in fact, quite comparable to many of the risks that we encounter in our daily lives, e.g., eating 40 tablespoons of peanut butter or traveling 10 miles by bicycle. Yet we do not abandon such pursuits simply because of a minuscule hazard.

The existence of a small risk of cancer, if exposed to hazardous wastes alone, is not a sufficient basis for policy. We also care about how many people are exposed, to what extent, and what the cost-benefit tradeoff is to eliminate the risk. But, at present, these components do not enter the EPA risk assessments.

How many at risk?

The Superfund risk estimates are for a hypothetical individual who might be exposed to the risk. Two features of this assessment are noteworthy. First, it is not necessary that anybody actually be exposed to the risk for it to be calculated. Second, the extent of the population exposed to the risk is not considered by the EPA.

Potential risks to an exposed individual are of two types. A current risk arises if current land use could lead to a risk to an exposed individual either now or in the future. A second category of risks are designated "future risks." These risks are those that might arise from a *potential* future land use that is a change from current land use. Conversion of a swamp into a residential area, as in Breyer's example, would be such a change in land use.

The great preponderance of risks at Superfund sites are of the latter type, future risks to populations not now exposed to the hazard. Overall, 68 percent of the ways in which cancer risks could arise—called "cancer pathways"—are actually *future* risk pathways. Moreover, most of the sources of large risks at sites involve hypothetical future risks. After weighting the different risk pathways for the magnitude of the risk level, we found that 94 percent of the cancer-pathway risks pertain to future risks.

Somewhat surprisingly, the most prevalent type of exposure that drives EPA analyses, both in terms of its frequency as well as the magnitude of the risk, is the risk to future on-site residents. Risk analysts hypothesize, in other words, that in future years people will not avoid Superfund sites. Rather, they will choose to live in residential areas on Superfund sites, even though these sites have been put on the EPA's National Priorities List and targeted for cleanup.

This hypothetical enthusiasm for living on Superfund sites is implausible in light of the fact that hazardous waste sites rank number one on the public's list of environmental fears. In a free market, living on a Superfund site is a choice most consumers are not likely to make. Moreover, it is a choice that policy makers can prevent through limited policy actions that fall short of complete cleanup, such as deed restrictions and other institutional controls that prevent residential areas from being located on hazardous waste sites. It is not necessary to remove all hazardous waste from a site to prevent future residents from being exposed to it—simply prohibit them from living there.

A missing element from EPA analyses—the extent of the population exposed to the risk—can be determined by matching Census Bureau population data to the risks at particular Superfund sites. Focusing on 99 sites for which information of the mean risk (rather than simply of the upper bound) values is available, we estimated the total lifetime cases of cancer prevented at these sites to be 204.5. However, the distribution of this risk varies considerably. In our sample, a single site, the Westinghouse PCB site near Sunnyvale, California, accounted for 202 of the 204.5 expected cases of cancer. Yet the true risk for this site is likely to be much less. One of the most contaminated areas at the site has been paved over. Consequently, the likelihood that a large number of residents will come into contact with this contaminated soil is low.

At most sites, the cancer risk is negligible. Overall, out of this sample of 99 sites, one site has one or more expected cases of cancer associated with it, 3 sites have between 0.1 and 1 expected cases of cancer, and 73 sites have fewer than 0.01 expected cases of cancer. A total risk of 0.01 expected cases of cancer to a large population involves a small risk for any particular individual. If there are 10,000 people exposed to the risk, then 0.01 lifetime expected cancers for a site implies an individual cancer risk of one in one million based on a lifetime of exposure.

Evaluating where the exposed populations are, and how many are at risk, is essential to deciding which sites to clean up and how much to clean them. Because real risks and hypothetical future risks are treated with the same urgency, present policies miss many important opportunities for saving lives. But the EPA can easily eliminate these biases by incorporating population exposures into its analysis.

How much bang for the buck?

Even if the risks posed by hazardous waste sites are small, it nevertheless may be sensible to eliminate them if this can be done cheaply. The chief measure for assessing the cost effectiveness of expenditures is the cost per expected life saved or, in this case, the cost per expected case of cancer avoided. These measures tell us how much we are getting for our safety dollar.

Unfortunately, these numbers suggest a fairly low return on the dollar (using mean risk assessments and 3 percent discounting). At 67 of the 99 sites analyzed, the cost per expected case of cancer prevented is in excess of $1 billion. The cost per case of cancer prevented is between $100 million and $1 billion for 18 sites, above $5 million and below $100 million at six sites, and under $5 million at one site. At two sites, there are no cases of cancer prevented at all, so the cost per case of cancer is infinite. The mean cost per case of cancer prevented across these sites is $374 billion, and the median cost per case of cancer prevented is $3.6 billion.

To put these staggering numbers in perspective, the implicit value of saving a statistical life based on the wage tradeoffs made by workers in hazardous jobs and in other private risky choices is between $3 million and $7 million, with a midpoint of around $5 million. But the U.S. Department of Transportation refuses to pursue any policy, such as improved guardrails on highways, that costs more than $3 million per statistical life saved. Only truly exceptional Superfund sites would pass a cost-benefit test using such cutoffs.

Even if one were not wed to a cost-benefit approach, the advantages of targeting cleanup expenditures are considerable. Risk analysts hypothesize that there is a 90:10 phenomenon that often characterizes risk regulation contexts. Society may spend 90 percent of its resources to achieve the last 10 percent of the risk-reduction benefits. If we look across Superfund sites, we can see how, as we spend more on cleanup, the benefits derived lessen.

For example, for the most effective 5 percent of its expenditures, EPA eliminates 99.46 percent of the risk addressed by its remediation efforts. For the most effective 25 percent of its expenditures, EPA eliminates 99.86 percent of the risk. Once 45 percent of the expenditures are made, 99.95 percent of the cancer cases are eliminated. Put somewhat differently, 55 percent of the expenditures are made to eliminate under 0.1 percent of the risk.

Although EPA reaps virtually all the cancer-reduction gains with the initial group of expenditures, this result alone does not imply that additional expenditures are not worthwhile. It could be, for example, that the initial expenditures are extremely productive, but subsequent expenditures would still be desirable as well. To make this assessment, we need to consider the marginal cost per case of cancer averted at different levels of expenditure.

These costs per case of cancer suggest that the policies fall below a reasonable cost-effectiveness cutoff very quickly. On average, the spending per case of cancer over the most effective 5 percent of cost allocations is in the desirable range, as it is only $389,000. Thus the initial Superfund expenditures are clearly worthwhile. However, once we get beyond these initial allocations, the cost per case of cancer averted rises quite steeply. More than 95 percent of EPA's expenditures on Superfund will entail a cost per case of cancer in excess of $100 million per case. This is clearly unreasonable.

Particularly striking is the last 10 percent of expenditures, where the EPA spends more than $100 billion per case of cancer prevented. That is to say, the last 10 percent of expenditures have virtually no cancer-risk reduction whatsoever. If our objective is risk reduction, clearly society can do better.

In these situations, in which there are wide disparities in efficacy, the benefits of targeting are enormous. By picking the targets where there are real risks and exposed populations, rather than spreading resources uniformly irrespective of these concerns, we can achieve virtually all the gains from Superfund at a fraction of the present costs.

Wise reform

The Superfund program has not been a model for effective government policy making. Public fears of hazardous waste sites, fueled by the specter of Love Canal, led the government to launch an ambitious cleanup effort. The failure to make a significant dent in the hazardous-waste problem, and the often substantial cost of the cleanups that have been undertaken, has created pressures for financial relief.

Reform efforts in Congress and at EPA, however, need to be more fundamental than simply reallocating the cost. The key question is the set of procedures used to decide which sites to cleanup and how clean to make them. Current risk policies miss the mark by failing to assess risks accurately, by ignoring the extent of the populations at risk, and by failing to ensure that the policy achieves reasonable risk-reduction benefits for the monies expended. By adopting the three simple principles for policy reform which we have outlined here, Congress can create a more effective and efficient Superfund.