POLICY RESEARCH WORKING PAPER 1272

The Value of Superfund Cleanups

Evidence from U.S Environmental Protection Agency Decisions

Shreekant Gupta
George Van Houtven
Maureen L. Cropper

The U.S. Environmental Protection Agency (EPA) has considered both cost and permanence in choosing among alternatives for cleaning up contaminated soil. But the EPA is willing to pay large sums to incinerate contaminated soil rather than cap it or put it in a landfill. Are the benefits of incineration worth it?

The World Bank
Environment Department
Pollution and Environmental Economics Division
and
Policy Research Department
Environment, Infrastructure, and Agriculture Division
March 1994

Summary findings

Under the Superfund law, the U.S. Environmental Protection Agency (EPA) is responsible for inspecting hazardous waste sites and for putting those with the most serious contamination problems on a national priorities list. The EPA then oversees the cleanup of these sites, suing potentially responsible parties for the costs of cleanup when possible, and funding the cleanup of "orphaned" sites out of the Superfund, money raised taxing chemical and petroleum products.

The Superfund program is controversial. Cleanups are costly and it is unclear whether the benefits of cleanup, especially the relative benefits of more permanent cleanup, are worth the costs. At many sites, imminent danger of exposure to contaminants can be removed at low cost. What raises the cost of cleanup is the decision to clean up the site for future generations — to incinerate contaminated soil, for example, or to pump and treat an aquifer for 30 years.

To shed light on this debate, the authors infer the EPA's willingness to pay (or have others pay) for more permanent cleanups at Superfund sites. They do so by analyzing cleanup decisions for contaminated soils at 1 Superfund sites.

They find that, other things being equal, the EPA was more likely to choose less expensive cleanup options. But, holding costs constant, the EPA was more likely to select more permanent options, such as incinerating the soil instead of capping it or putting it in a landfill. The EPA was willing to pay at least twice as much for onsite incineration of contaminated soil as it was for capping the soil.

Has the EPA chosen more permanent Superfund cleanups in areas where residents are predominantly white and have high incomes? The authors find no evidence that the percentage of minority residents near site influences the choice of cleanup selected. But offsite treatment was more likely at sites with higher incomes.

This paper — a joint product of the Pollution and Environmental Economics Division, Environment Department, and the Environment, Infrastructure, and Agriculture Division, Policy Research Department — is part of a larger effort in the Bank to promote efficient pollution control in developing countries by examining the U.S. experience with environment regulation. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Anna Maranon, room N5-033, extension 39074 (33 pages). March 1994.

Produced by the Policy Research Dissemination Center

THE VALUE OF SUPERFUND CLEANUPS: EVIDENCE FROM UNITED STATES ENVIRONMENTAL PROTECTION AGENCY DECISIONS

Shreekant Gupta, George Van Houtven and Maureen L. Cropper

*Shreekant Gupta is an economist with ENVPE, George Van Houtven is an assistant professor in the Economics Department at East Carolina University, Greenville, NC and Maureen Cropper is Principal Economist, PRDEI.

THE VALUE OF SUPERFUND CLEANUPS: EVIDENCE FROM UNITED STATES ENVIRONMENTAL PROTECTION AGENCY DECISIONS

Shreekant Gupta, George Van Houtven and Maureen L. Cropper

In the United States, the task of cleaning up hazardous waste that was improperly disposed of in the past falls under the jurisdiction of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), popularly known as the Superfund law. According to the law, the U.S. Environmental Protection Agency (EPA) is responsible for inspecting hazardous waste sites, and for putting those sites that pose the most serious contamination problems on a National Priorities List. EPA then oversees the cleanup of theses sites, suing potentially responsible parties for the costs of cleanup when possible, and funding the cleanup of "orphaned" sites out of the Superfund, money raised by taxing chemical and petroleum products.

The Superfund program is among the most controversial of U.S. environmental programs. Cleanups of individual sites are extremely costly, and questions have been raised on whether the benefits of cleanup are worth the costs. Crucial to this debate is the issue of how permanent cleanups should be. At many sites, imminent danger of exposure to contaminants can be removed at low cost. What raises the cost of cleanup is the decision to clean up the site for future generations--for instance, to incinerate contaminated soil, or to pump and treat an aquifer for 30 years.

In this study we shed light on this debate by estimating how much EPA has been willing to spend (or have others spend) for more permanent cleanups at Superfund sites. We infer this value by analyzing cleanup decisions for contaminated soils at 110 Superfund sites--all wood-preserving sites and all sites with PCB contamination in excess of 10 parts per million. In addition to inferring EPA's willingness to pay for more permanent cleanups, we examine whether more permanent cleanups were selected in urban areas, or at sites with higher baseline risks.

We also examine the controversial topic of risk equity. In the United States it has been alleged that the poor suffer the consequences of pollution much more than the rich. It has also been alleged that EPA has chosen more permanent Superfund cleanups in areas where residents are predominantly white and/or have high incomes. We examine whether this was true for sites studied by looking at the effect of the racial composition and median income of the zip code (postal code) in which the site was located on the cleanup chosen.

The choice of technology to clean up contaminated soils at a Superfund site entails selecting one of three options: capping the soil, treating it _in situ_, or excavating it. If excavation is chosen, EPA must decide whether the soil will be put in a landfill or treated in some way (such as incineration), and whether treatment will occur on or off site. Combining these options yields 6 alternatives: capping, _in situ_ treatment, onsite landfill, offsite landfill, permanent, followed by landfilling of the excavated soil.

For each set of sites (wood-preserving and PCB) we estimated a multinomial logit model to explain the likelihood that EPA would select each of the 6 cleanup options. Two results stand out: Other things equal, EPA was more likely to choose less expensive cleanup options. Costs mattered to the agency in selecting a cleanup strategy. The permanence of the alternative, however, also mattered: Holding costs constant, EPA was more likely to select more permanent options, such as incineration.

The amount EPA was willing to spend for increased permanence was, however, high. The agency was willing to pay at least five times as much for onsite incineration of contaminated soil as it was for capping of the soil. We estimate that, if a site were to contain 10,000 cubic yards of PCB-contaminated soil, EPA would be willing to spend $12 million (1987 dollars) more to incinerate the soil onsite than to cap it. At a PCB site containing 100,000 cubic yards of contaminated soil, the agency would be willing to spend $36,000,000 more to incinerate the soil than to cap it. The figures are similar at wood-preserving sites: given a mean cost of capping of $400,000, EPA would be willing to spend an additional $12 million to incinerate the soil.

Regarding risk equity, we found no evidence that the percentage of minority residents near the site had any influence on the choice of cleanup selected. We did, however, find that offsite treatment was more likely to be chosen at sites with higher incomes than at sites with lower incomes. This may reflect the belief that offsite remedies are more permanent, at least from the viewpoint of residents near the site.

Our findings regarding choice of remedial action suggest that the U.S. Environmental Protection Agency is behaving in accordance with CERCLA: It has considered both cost and permanence in choosing among remedial alternatives, and has made tradeoffs between the two. The tradeoffs it has made, however, indicate that the agency is willing to pay large sums to incinerate contaminated soil rather than capping the soil or putting it in a landfill. These figures raise an important question: Are the benefits of incineration versus capping worth these sums?

THE VALUE OF SUPERFUND CLEANUPS: EVIDENCE FROM EPA DECISIONMAKING

Shreekant Gupta, George Van Houtven and Maureen Cropper

In the U.S. there is currently a heated debate about the amount that should be spent to clean up hazardous waste sites. Businesses, complaining that the cost of such cleanups will put them at a competitive disadvantage, have argued that the current system for cleaning up such sites should be reformed. Experts in risk assessment have argued that many of these sites pose only a small threat to human health and the environment. Indeed, expert rankings of environmental problems (USEPA 1987) place toxic waste sites sixteenth in a list of 31 environmental problems. By contrast, the lay public ranks toxic waste sites as the number one environmental problem in the U.S., ahead of nuclear accidents, pesticide residues and the destruction of the ozone layer (Clymer 1989).

The controversy over hazardous waste sites has in large part been caused by the high cost of cleaning up these sites. A recent study estimates the average cost of cleanup at $27 million per site (USEPA 1990). If there are, indeed, 10,000 such sites the total cost of cleaning them up ($270 billion)--spread over 20 years--would double expenditures on hazardous waste disposal.

What causes the cost of cleanup to be so high is how permanently a site is cleaned up. A typical hazardous waste site consists of contaminated surface area (contaminated soil, a pond into which waste was deposited) and contaminated ground water. At most sites, imminent danger of exposure to contaminants can usually be removed at low cost. Contaminated soil can be fenced off or capped, and an alternate water supply can be provided if ground water is used for drinking. What raises the cost of cleanup is the decision to clean up the site for future generations--for instance, to incinerate contaminated soil, or to pump and treat an aquifer for 30 years to contain a plume of pollution.

Under the Comprehensive Emergency Response, Compensation and Liability Act (CERCLA) it is the U.S. Environmental Protection Agency (EPA) who is responsible for deciding how permanent cleanups at hazardous waste sites will be, at least at those sites which are deemed serious enough to be placed on the National Priorities List (NPL).[1] In choosing how to clean up contaminated soils, EPA must determine both how extensively to clean up the site (i.e., how much soil to excavate), and how permanently to dispose of the soil. The first of these decisions must protect the health of persons currently living near the site regardless of cost.[2] In deciding how permanent the cleanup will be EPA is, however, allowed to trade off permanence against cost.

What we examine in this paper is how EPA has made this tradeoff. By examining EPA's choice of cleanup option at 110 Superfund sites we are able to

---

[1]EPA has developed a Hazard Ranking System which it uses to assess risks at hazardous waste sites. Those sites which receive a sufficiently high Hazard Ranking System (HRS) score are put on the National Priorities List.

[2]It is generally assumed that the risk of an adverse health outcome is directly proportional to the concentration of the pollutant in the soil. The larger the volume of soil addressed, the lower this risk. EPA's guidance states that enough soil must be excavated (or capped) to reduce risk of death to no more than 1 in 10,000.

infer the value that the agency has implicitly attached to more permanent cleanup options, such as incineration of contaminated soil, versus less permanent options, such as capping of soil. Our purpose in doing so is to raise the question: "Is the value that EPA implicitly places on more permanent cleanups the same value society would place on them?"

In addition to estimating the value attached by EPA to more permanent cleanups, we wish to see what factors influence the choice of cleanup technology. It is, for example, reasonable that more permanent cleanups would be selected at sites in more densely populated areas, or that soil would be cleaned up more permanently if ground water contamination were a threat. Has this, in fact, been the case?

Finally, we wish to shed some light on an issue that has received much attention in the last several years, but little careful study--the issue of environmental equity. Environmental and other advocacy groups have charged that minorities and the poor suffer disproportionately from the effects of pollution (United Church of Christ 1987). In the case of hazardous waste cleanups it has been charged (Lavelle and Coyle 1992) that EPA selects less permanent cleanups in areas that have a high percentage of poor and/or minority residents. These allegations are, however, based on simple correlations between variables that fail to hold other factors constant. We wish to see whether, holding other factors constant, EPA has in fact selected less permanent cleanups in areas that have a high percentage of minority residents, or low median household incomes.

To examine these issues we have gathered data on the decisions to clean up 110 Superfund sites--all wood preserving sites and selected sites with PCB (polychlorinated biphenyl) contamination in excess of 10 parts per million. We have used the data to model the decision to clean up contaminated soils at these sites. The next section of the paper provides a brief description of the Superfund program and of the data we collected. Section III presents a discrete choice model of the cleanup decision. Section IV contains empirical results, and section V summarizes our conclusions.

II. A DESCRIPTION OF THE DECISIONS STUDIED

A. An Overview of the Superfund Cleanup Process

The decisions we have studied were made under CERCLA, popularly known as the Superfund law. The law requires EPA to maintain a database of hazardous waste sites,[3] and to investigate each site to determine the seriousness of its waste problems. If required, the site goes through a formal hazard ranking process. This evaluates the site's potential to inflict damage through three pathways--ground water, surface water and air. Sites are scored on the basis of a Hazard Ranking System (HRS), with each site receiving a score between 0 and 100. If the score exceeds 28.5, the site is put on the National Priorities List (NPL).[4]

---

[3]The database, called CERCLIS (Comprehensive Environmental Response, Compensation and Liability Information Service) currently contains over 33,000 sites.

[4]At the end of FY 1992 there were over 1,200 sites on the NPL.

All sites on the NPL are subject to a Remedial Investigation and Feasibility Study (RI/FS). The Remedial Investigation characterizes the wastes at the site and assesses the risks that the site poses to human health and the environment. In the Feasibility Study, remedial alternatives (cleanup options) are developed and screened. After the RI/FS, EPA issues a Record of Decision (ROD) which describes and justifies the cleanup option selected. This is followed by cleanup of the site, after which it is eligible for deletion from the NPL.

At a typical Superfund site the Feasibility Study must address two pollution problems: ground water contamination and surface contamination--contaminated soils or sludge or contaminated ponds. The usual method of treating contaminated ground water is to pump and treat the ground water. The treated water is either reinjected into the aquifer or discharged into a river or stream.[5] Since the choice of cleanup strategy for ground water varies little from one site to another, we focus on the decision to remediate contaminated soils.

There are two parts to the decision to clean up contaminated soils at Superfund sites--the decision as to how extensively to clean up the site, and the choice of what technology to use.

The first decision--how extensively to clean up the site--affects current health risks to residents near the site. Typically this decision is stated in terms of the concentration of contaminants above which all soil is excavated and/or capped.

---

[5]In some cases the use of an alternative water supply may be chosen instead of a pump and treat strategy.

These concentrations are then mapped into a lifetime risk of death from exposure to hazardous substances at the site.

In deciding which technology to employ to clean up the site EPA has three options--capping the soil, treating the soil on-site (in situ treatment) or excavating the soil. Excavated soil can either be put in a landfill (usually after treatment) or more thoroughly treated. For example, soil containing organic waste can be incinerated. The choice of technology is, essentially, a decision about the permanence of cleanup. The least permanent cleanup is not to excavate soil at all, but to cap it. The cleanup, in this case, will last only as long as the life of the cap, and ground water will not be protected from contamination. A more permanent solution is to excavate soil and put it in an approved landfill. This prevents exposure via ground water (and other routes) as long as the landfill liner remains intact. An even more permanent solution (assuming pollutants are organic) is to incinerate the soil.

In selecting target concentrations of pollutants, EPA's choice is restricted in two ways--the concentrations must comply with state and federal environmental standards, and the risk of death that they imply cannot exceed 1 in 10,000. In selecting which technology to use, however, EPA is allowed to balance the cost of cleanup against four other cleanup goals: (1) permanence; (2) short-term effectiveness, (3) reduction of toxicity, mobility or volume of waste through treatment; and (4) implementability.

B. The Scope of the Study

To study cleanup decisions, we were limited to those sites on the National Priorities List for which Records of Decision (RODs)--the document describing the cleanup strategy chosen by EPA--had been signed. Of the 945 sites for which RODs had been signed as of the end of FY 1991, we selected 110: 32 wood preserving sites and 78 sites with PCB contamination.[6] There are a total of 127 RODs for the 110 sites, since a single site may have more than one operable unit, a portion of the site that is treated separately for purposes of cleanup.

Wood preserving sites are wood treatment facilities where pentachlorophenol (PCP) or creosote was used to pressure-treat wood to prevent it from rotting. Soils at these sites are contaminated with polyaromatic hydrocarbons (PAHs)--a constituent of creosote--which are considered a probable human carcinogen. The PCB sites in the sample include landfills, former manufacturing facilities and other sites where PCBs--also considered probable human carcinogens--are found.[7]

These sites were selected for two reasons. Because their principal contaminants are carcinogenic, estimates of health risks from each site are more

---

[6]The 32 wood preserving sites include all wood preserving sites for which RODs had been signed as of FY 1991. The 78 sites with PCB contamination were selected from those sites with PCB contamination in excess of 10 ppm for which RODs had been signed as of FY 1991.

[7]PCBs are a group of toxic chemicals that, prior to being banned in 1979, were used is electrical transformers, hydraulic fluids, adhesives and caulking compounds. They are extremely persistent in the environment because they are stable, non-reactive and highly heat resistant.

likely to be available than for sites whose pollutants are not carcinogenic. Second, because both sets of sites contain organic pollutants, the technological options available for cleanup are similar at both sets of sites.

For each site (more accurately, for each operable unit), data were gathered from the Record of Decision on the set of cleanup alternatives considered and on the characteristics of the site. For each cleanup option considered, we would like to know the cost of the option and the permanence of the option. While data on the cost of each option are available, the permanence of each option is not reported in the Record of Decision; however, we have developed a scheme to characterize the permanence of each cleanup option which is described below.

C. A Classification Scheme for Cleanup Options

Our classification of cleanup options is based on two aspects of each cleanup alternative: whether the alternative involves excavation of contaminated soil, and whether the alternative involves treatment of the contaminated soil. In addition, we distinguish whether remedies that entail excavation are conducted on-site or off-site. Combining these choices yields a total of six categories of remedial alternatives: (1) on-site treatment of soil that has been excavated (on-site treatment); (2) off-site treatment of soil that has been excavated (off-site treatment); (3) disposal of excavated but untreated soil in a landfill on the site (on-site landfill); (4) disposal of excavated but untreated soil in a landfill off the site (off-site landfill); (5) on-site treatment of soil that has not been excavated (in situ treatment)[8]; (6) containment of soil that has been neither excavated or treated (containment).

The six categories are pictured in Figure 1. Table 1 lists, for wood preserving and PCB sites, the number of times each category was considered and selected, and the unit cost of cleanup options within each category.[9] Of the six categories, on-site and off-site treatment correspond to the most permanent cleanups. According to the 1986 amendments to the Superfund Law (the SARA amendments), EPA is supposed to show a preference for treatment, as opposed to non-treatment alternatives. We have also distinguished whether disposal and/or treatment of excavated soil occurred on- or off-site because of the controversy surrounding off-site cleanups. Off-site cleanups are often favored by persons living near a Superfund site, since they are perceived as a permanent solution to the problem. The SARA amendments, however, indicate a preference for on-site, as opposed to off-site remedies. We wish to see whether EPA has, in fact, exhibited such a preference.

Table 1 illustrates the magnitude of the permanence-cost tradeoff facing environmental officials. The average cost of the least permanent options--containment and on-site landfill--is approximately one order of magnitude smaller than the average cost of on-site treatment. Nevertheless, on-site treatment was the

---

[8]This includes flushing of soil to remove contaminants and bioremediation--the use of bacteria to neutralize toxic substances.

[9]All six categories may not be considered at a site, whereas some, such as on-site treatment, may be considered more than once.

most preferred of the six cleanup categories: It was selected 73 percent of the time at wood preserving sites and 62 percent of the time at PCB sites. For this reason on-site treatment has been further broken down into three categories--incineration, innovative treatment and solidification/stabilization.

D. Variables that May Influence the Cleanup Decision

In addition to gathering data on cleanup options, we assembled data on variables that might influence the choice of cleanup option at a site. These are listed in Table 2, together with summary statistics. The variables fall into three categories: characteristics of the site (baseline risk, HRS score, size of the site and where it is located); characteristics of the population living near the site (percent of the population that is non-white, median income of the population) and two miscellaneous variables, the year in which the ROD was signed and Fund Lead.

Since EPA sometimes sets priorities on the basis of baseline risks, we have gathered data on baseline risks at each site. The baseline risk associated with each site measures the lifetime risk of cancer to the "maximally exposed individual" from all exposure pathways, assuming that nothing is done to clean up the site.[10] This may be disaggregated into risk attributable to direct contact with contaminated soil, and risk attributable to exposure to contaminated ground water.

---

[10]The "maximally exposed individual" may be a child who ingests contaminated soils, a person working at a still-active site, or a resident living within the boundaries of the site.

Two features of baseline risk are worth noting. First, the risk of cancer at the sites studied comes primarily from contaminated ground water, rather than from direct contact with contaminated soil. Second, the magnitude of the lifetime cancer risks from these sites--a 1 in 5 chance of contracting cancer from a single site!--reflects the extremely conservative assumptions used to estimate exposure.

While baseline risk is the formal measure of hazards posed by the site prior to cleanup, it is possible that the agency is also influenced by the HRS score, a measure of the relative risk posed by sites, but not a quantitative estimate of risk. It would be ironic if cleanup decisions were influenced by HRS score--a quick-and-dirty estimate of the hazards posed by a site--but not by more careful (and expensive) estimates of baseline risk.[11]

The size of a site may also influence the nature of the cleanup chosen. While the main influence of size should be felt through cost (large sites, being more expensive to clean up, may receive less permanent cleanups) it is possible that size--measured here by the volume of contaminated soil at the site--may exert an independent effect. In particular, if short-term risks associated with cleanup are proportional to the volume of soil excavated, excavation may be less likely to be

[11]Throughout our analysis we use a modified version of the HRS score that combines the surface and ground water components of the score, but eliminates the air score. It is often the case that the air score is not computed for a site if the ground water and/or surface water scores are sufficient to put the site over the threshold for inclusion on the NPL. It is unfortunately impossible to distinguish the case of a zero air score from cases where the air score was never computed, hence we eliminate it from consideration.

chosen the larger the site. Location of a site in an urban area (a proxy for population density) may exert a similar effect.

The two population characteristics--Percent Non-White and Median Income--are included to test the hypothesis that EPA selects less permanent cleanups at sites in poor and/or minority areas. Both variables are measured for the Zip Code in which the site is located, and are based on 1990 Census data.

The year in which the ROD was signed may exert an influence on the type of cleanup chosen if EPA is sensitive to the 1986 amendments to CERCLA (the SARA amendments). As noted above, these call for EPA to give preference to treatment options and to on-site disposal of waste.

The final variable in Table 2, "Fund Lead," indicates who was in charge of conducting the RI/FS at the site. Although the regional EPA administrator is ultimately responsible for selecting a cleanup strategy for a site, the Risk Investigation and Feasibility Study (RI/FS) that precedes the choice of cleanup strategy may be conducted either by the EPA (at a "Fund-lead" site) or by the parties responsible for cleaning up the site (the "potentially responsible parties") at a PRP-lead site. It is sometimes thought that the party responsible for the site investigation can influence the menu of alternatives considered for cleanup, and, hence, the cleanup option selected at the site.

III. A MODEL OF THE CHOICE OF CLEANUP OPTION

At a typical Superfund site, from 3 to 12 cleanup options may be considered in the Feasibility Study, from which the regional EPA administrator must select one. We assume that this decision is made to maximize the net benefits of cleanup, broadly defined. The net benefits of cleanup option i are a function of the risk reduction the option achieves, the permanence of the option and its cost. Unfortunately the risk reduction achieved by each cleanup option is not reported in the RI/FS. We describe the permanence of the option by a vector of dummy variables, **T**, that correspond to the categories in Figure 1.[12] This implies that the net benefits of option i are given by

$$B_i = a + bCost_i + \mathbf{D}\mathbf{T}_i + e_i \qquad (1)$$

where $Cost_i$ is the cost of the cleanup option i and e_i represents the unobserved components of net benefits. We assume e_i is independently and identically distributed for all i with a Type I Extreme Value distribution, so that the choice of cleanup option is described by a multinomial logit model.

If the coefficient of $Cost_i$ is significant and negative, and the coefficient of the on-site treatment dummy is significant and positive, then EPA has indeed balanced cost against permanence in its selection of cleanup option. In this case one

---

[12]In the estimating equation at most 5 of these categories can be used, since a constant terms is included in the equation.

can compute the rate at which EPA was willing to substitute cost for permanence to determine an implicit willingness to pay (or have polluters pay) for increased permanence. Formally, one can ask how much costs may be increased while changing the cleanup option from containment to on-site treatment, and keep net benefits constant. Let $Cost_0$ represent the cost of containing waste at a site, d_0 the coefficient of the containment dummy and d_1 the coefficient of the on-site treatment dummy. W_1, the most EPA would pay for on-site treatment, is defined implicitly by $d_0 + b\ Cost_0 = d_1 + b\ W_1$.

An elaboration of equation (1) is to allow the coefficients of Cost and the technology dummies to depend on site characteristics, implying that site characteristics should be interacted with the independent variables in (1). For example, if, as alleged by Lavelle and Coyle (1992), EPA has a preference for less permanent cleanups in areas with a significant minority population, then the coefficient on the permanence dummies will be a function of Percent Non-White. Likewise, site characteristics (e.g., Median Income, Baseline Risk) may alter the disutility attached to cost.

One final point. In categorizing a remedial alternative according to the scheme presented in Figure 1 we must face the fact that a cleanup option may involve the use of a combination of technologies. It may, for example, call for capping a relatively benign portion of a site while excavating and incinerating the most contaminated soil. In the case of wood preserving sites this is handled by categorizing the remedial alterative according to the primary technology used, i.e., the one applied to the majority of contaminated soil at the operable unit, and then by including a dummy variable to indicate that a secondary treatment was applied to the rest of the unit. At PCB sites the part of the site receiving primary treatment is the only part of the site studied, hence each remedial alternative corresponds to a unique category in Figure 1.

IV. THE CHOICE OF TECHNOLOGY AT SUPERFUND SITES

Separate equations were estimated to explain the remedial alternative selected at wood preserving sites and at PCB sites. In examining these results we focus on three questions: (1) Did costs matter to EPA in its choice of cleanup option? That is, was the agency more likely to select an inexpensive cleanup than an expensive one, other things equal? (2) Did EPA show a preference for more permanent cleanups, and, if so, how much was it willing to pay for them? (3) Did EPA's propensity to select one option rather than another vary with site characteristics?

A. The Choice of Technology at Wood Preserving Sites

Table 3 presents the model for wood preserving sites. Two results stand out. First, in most specifications, EPA is less likely to choose a cleanup option the more costly it is. Costs do matter in determining which technology to use in cleaning up a wood preserving site. Second, EPA has demonstrated a clear preference for on-site excavation and treatment at wood preserving sites.

Both results appear clearly in column 1 of Table 3, which explains the choice of cleanup option solely as a function of cost and of the technology dummies. The logarithm of cost is significant and negative, indicating that the higher the cost of a cleanup option, the less likely it is to be chosen. Of the five technology dummies described above (containment is the omitted category), only on-site excavation and treatment is statistically significant. This implies that EPA was willing to pay significantly more for on-site excavation and treatment, the most permanent technology, as compared to capping; however, it was willing to pay no more for the other four categories in Figure 1 than for capping.

Columns 2 and 3 of the table present, respectively, a more detailed and a less detailed characterization of cleanup options. Column 2 disaggregates on-site excavation and treatment into three categories--incineration, solidification, and innovative treatment. While each of the three categories is statistically significant--EPA is willing to pay a premium for any one of them relative to capping--their coefficients are not significantly different from one another. A comparison of columns 1 and 3 likewise indicates that the coefficients for the two off-site options are not significantly different from one another.

The remainder of the table interacts site characteristics with log cost and with the technology dummies. Secondary treatment (the use of more than one treatment technology) is more likely to be used the higher the percent of minority residents near the site, and costs matter less in remedy selection over time. We emphasize, however, that there is no evidence in Table 3 that EPA selected less permanent remedies in areas with a large minority population, or in low-income areas. All interactions between the permanence dummies and either race or income are insignificant.

The second result--that costs matter less than over time--accords with the spirit of the SARA amendments, i.e., that EPA should give more weight to permanent remedies rather than to costs in choosing a cleanup option. However, a strict test of the amendments--interacting the post-SARA dummy with on-site excavation and treatment--does not yield significant results.

One of the implications of Table 3 and of alternate specifications not reported in the table is that the weight attached to cost and to the technology dummies seems to vary little with site characteristics: EPA's propensity to choose one cleanup option over another was consistent across sites. In particular, it was unaffected by whether the site was located in an urban area, by baseline risk or by risk of ground water contamination.

The Value of More Permanent Cleanup Options

Since costs and permanence are both statistically significant in explaining the cleanup option chosen, one can compute the rate at which EPA was willing to substitute cost for permanence to determine an implicit willingness to pay (or have polluters pay) for increased permanence. Formally, one can ask how much costs can be increased while changing the cleanup option from containment to on-site excavation and treatment, and keep net benefits constant.

Column 1 of Table 3 implies that, at a site where capping would cost $400,000 (1987 dollars), EPA would be willing to spend an additional $11.4 million to incinerate the soil. Its willingness to pay for on-site innovative treatment or stabilization (over the cost of capping) is about half as much ($5 million and $5.7 million, respectively).

It is important to emphasize what these implicit valuations measure. The $11.4 million value attached to incineration in not simply the difference in cost between on-site incineration and capping at sites where incineration was chosen. Indeed, this cost difference, $21.2 million - $0.4 million (see Table 1), is greater than the valuation implied by Table 3. What Table 3 reflects is that EPA sometimes chose not to incinerate soil, even when it was relatively inexpensive to do so. This lowers the implicit valuation of the option below average cost at sites where it was chosen.

B. The Choice of Technology at PCB Sites

Table 4 presents models of the choice of cleanup option at PCB sites. At PCB sites costs clearly play a role in the selection of cleanup technology--in all columns of Table 4 more expensive technologies are less likely to be selected, other things equal. The disutility attached to cost is, however, less at larger sites (up to 15,000 cubic yards) than at smaller sites.[13] This implies, other things equal, that

[13]Interacting volume and cost produces insignificant results at wood preserving sites.

excavation and treatment of waste at two small sites is valued more highly than an excavation and treatment option at a single large site. A possible rationale for this is the belief that more people will benefit from cleanups at two small sites than from a cleanup at a single large site.

Table 4 also suggests that EPA is willing to pay more for more permanent cleanups at PCB sites. Of all the categories in Figure 1, on-site treatment (in practice, on-site incineration) is clearly the most valuable--its coefficient exceeds that of the other technology dummies in all equations.[14] In fact, equation (1) implies that EPA was willing to pay $33.5 million (1987 dollars) more for on-site treatment than it was willing to pay to contain the waste or treat it in situ.[15]

Off-site treatment (in practice, off-site incineration) was nearly as valuable as on-site treatment. It is the second most preferred technology in all equations in the table, and commands a value in equation (1) of $22.3 million, relative to non-excavation cleanups. The fact that off-site treatment is somewhat less valuable than on-site treatment reflects the fact that it was chosen less often than on-site treatment, which accords with the spirit of the SARA amendments.

It is not surprising that EPA is willing to pay more for the two treatment alternatives than for other cleanups--excavation and treatment (usually incineration)

---

[14]This is clearly true by inspection in equations (1) and (2). In equations (3) through (9) it is also true if one evaluates the coefficients of the technology dummies at different volumes of waste.

[15]The excluded category in Table 4 is non-excavation cleanups, which include both containment of waste and in situ treatment. The two categories were combined because in situ treatment is rarely considered at PCB sites.

of contaminated soil is the most permanent method of disposing of PCBs. What is, perhaps, surprising is that disposing of waste in an off-site landfill--a less permanent alternative--is valued about as highly as off-site incineration. The value of an off-site landfill (relative to non-excavation) is $25.3 million in equation (1)--approximately the same value as off-site treatment. Indeed, the hypothesis that the two cleanup options have identical coefficients (compare equations (3) and (4)) cannot be rejected. A plausible explanation for this is that EPA's preferences reflect those of local residents, who view all cleanups that remove waste from the site as equally permanent.

Off-site landfills are clearly valued more highly than on-site landfills. The latter category is valued no more highly than non-excavation cleanups in equations (1) and (2).

<u>The Effect of Site Characteristics on Choice of Technology</u>

In equations (3) through (10) the values attached to treatment and to off-site disposal are allowed to vary with volume of waste at the site. In all cases the value attached to treatment or to a landfill decreases with the size of the site. A possible rationale for this finding is that at large sites excavation of soil will expose more people to short-term hazards than at small sites. Cleanup options involving excavation are therefore less attractive at large sites than at small sites.

When volume of waste is interacted with the technology dummies, on-site treatment still remains the most preferred of the six cleanup technologies at all waste volumes in the sample. Off-site disposal (there is no difference in the value attached to off-site landfills versus off-site treatment) is the second-most preferred option at sites of 50,000 cubic yards or less.

With the exception of volume, the choice of cleanup option at PCB sites is relatively unaffected by site characteristics (see equations (4) - (10)). In particular, the allegation that EPA has selected less permanent cleanups in poor and/or minority areas appears false. Interactions of median income and percent non-white with the technology dummies (see (8) and (9)) are insignificant at conventional levels.[16] The only interaction term that is marginally significant is the product of per capita income and the off-site dummy. This suggests a preference for off-site treatment in neighborhoods with higher per capita incomes.

The only variable that is significant when interacted with the technology dummies is HRS score: EPA was more likely to choose on-site treatment at a site the higher its HRS score. This result may be consistent with conventional economic theory. If more permanent cleanups result in greater reductions in health risks, this result implies that greater risk reductions are being selected at sites with higher baseline risks--a result consistent with the value of life literature (Jones-Lee 1974).

---

[16]In contrast to wood preserving sites, at PCB sites the disutility attached to cost appears to be unaffected by either the racial composition of the population living near the site, by median income or by the SARA amendments (results available from the authors).

The Value of More Permanent Cleanups

Because Table 4 indicates that EPA is willing to pay more for more permanent cleanups, it is interesting to see exactly how large these valuations are. Figure 2 shows the value attached to different cleanup options by size of site, based on column (2) of Table 4. At a 10,000 cubic yard site, EPA would be willing to pay $12.1 million (1987 dollars) to treat waste on-site rather than contain it. For sites with 15,000 or more yards of contaminated waste; however, this figure jumps to $36.5 million.[17] The values attached to off-site treatment (compared to containment) are almost as large--$11.9 million for sites of 10,000 cubic yards and $35.8 million for sites in excess of 15,000 cubic yards.

Off-site disposal of excavated soil is also valued positively by the agency--indeed, the value of transporting waste off-site rather than containing it on-site is $8.25 million at a site of 10,000 cubic yards and $24.8 million at a site containing 25,000 cubic yards of waste. This implies that the agency implicitly valued off-site landfilling of waste more than on-site landfilling (whose coefficient is not significantly different from zero), an interesting result in view of the preference of the SARA Amendments for on-site disposal. The more important question that Figure 2 raises, however, is whether the implicit valuations of more permanent cleanups agree with amounts that society would be willing to pay for these cleanups.

---

[17]Recall that the interaction of cost with log(volume1) implies that the effect of volume stops at volumes of 15,000 cubic yards. That is, the disutility attached to cost at sites of 15,001 cubic yards is the same as the disutility at sites of 50,000 cubic yards.

V. CONCLUSIONS

The answer to the question "How does EPA select cleanup options at Superfund sites?" has several parts. First, at the sites we studied the agency did consider cost in determining how permanently to clean up a site. Other things equal, EPA was less likely to select a remedial alternative the more expensive it was. At PCB sites, however, this aversion to cost decreased as the size of the site increased.

Second, the agency was willing to pay more for excavation and treatment of waste--the most permanent cleanup option--than it was willing to pay to contain (e.g., cap) the waste. Landfilling of waste--a less permanent alternative than treatment--was valued more highly than capping at PCB sites, but not at wood preserving sites. As far as the choice between off-site and on-site disposal is concerned, the agency was willing to pay more at PCB sites (but not at wood preserving sites) to dispose of waste off-site rather than on-site, in spite of the preference the agency is supposed to give to on-site disposal.

In many ways, the most interesting result of the study is a negative one: Despite allegations to the contrary, there is no indication that EPA has a preference for less permanent remedies in areas with a sizable minority population (as measured by percent of the population that is non-white) or in poor areas (as measured by median household income). Neither variable had a significant effect on the permanence of the remedy chosen, although there was a marginally significant tendency for off-site remedies to be chosen more often in areas with higher per capita incomes.

The lack of significance of race and median income in explaining cleanup decisions is mirrored by other site characteristics: Few variables are significantly related to the choice of cleanup option.

The exceptions to this rule are health risks posed by the site and the year in which the ROD was signed. At PCB sites the agency was wiling to spend more and had a preference for more permanent remedies at sites with higher HRS scores. These results agree with Hird (1990) who found that sites on the NPL with high HRS scores had RODs signed sooner than sites with low HRS scores. Moreover, more money was likely to be allocated to a site the higher its HRS score.

The fact that costs mattered less at wood preserving sites over time accords with the spirit of the SARA amendments, i.e., that EPA should give more weight to permanent remedies rather than to costs in choosing a cleanup option. Attaching less weight to costs implicitly raises the value placed on on-site excavation and treatment.

While most of the results reported here suggest that EPA has been fulfilling its mission in selecting Superfund cleanups, at least one aspect of the results is disquieting. The value attached to more permanent cleanup options, such as on-site excavation and treatment of waste, is huge. The premium that the agency is willing to pay for on-site incineration of waste (over and above the cost of capping it) is $12 million (1987 dollars) at small (10,000 cubic year) sites and up to $40 million at large (25,000 cubic yard) sites. What must be asked is whether the benefits of more permanent cleanups--such as those achieved by the incineration of contaminated soil--are worth the amount the agency is willing to pay for them. To answer this question it will first be necessary to define and then value the benefits of alternative waste disposal technologies. In view of the size of the resources devoted to Superfund cleanups, this is research that deserves the very highest priority.

REFERENCES

Chemical Manufacturers Association. 1988. "Impact Analysis of RCRA Corrective Action and CERCLA Remediation Programs." Washington D.C.

Clymer, Adam. 1989. "Polls Show Contrasts in How Public and EPA View Environment." New York Times, May 22, B7.

Hird, John A. 1990. "Superfund Expenditures and Cleanup Priorities: Distributive Politics or the Public Interest?" Journal of Policy Analysis and Management **9**, 455-483.

Jones-Lee, Michael W. 1974. "The Value of Changes in the Probability of Death or Injury," Journal of Political Economy **82**, 835-849.

Lavelle, Marianne and Marcia Coyle. 1992. "Unequal Protection: The Racial Divide in Environmental Law." National Law Journal **15** (September 21, 1992).

United Church of Christ. 1987. Commission for Racial Justice. "Toxic Wastes and Race in the United States, A National Report on the Racial and Socio-Economic Characteristics of Communities with Hazardous Waste Sites." New York.

U.S. Congress, Office of Technology Assessment. 1989. "Coming Clean: Superfund's Problems Can Be Solved." Washington D.C. OTA-ITE-433.

U.S. Environmental Protection Agency. 1987. Unfinished Business.

U.S. Environmental Protection Agency. 1990. "Progress Towards Implementing Superfund, Fiscal Year 1990: Report to Congress." Office of Emergency and Remedial Response, EPA/540/8-91/004.

TABLE 1

CLEANUP OPTIONS CONSIDERED AND SELECTED AND THEIR AVERAGE COST

REMEDIAL OPTIONS CONSIDERED		MEAN COST (a)		WOOD SITES			PCB SITES		
		PER UNIT ($/cub yd)	TOTAL ($ million)	N	MEAN VOLUME (cubic yards)	STD DEV OF VOL.	N	MEAN VOLUME (cubic yards)	STD DEV OF VOL.
EXCAVATION ALTERNATIVES	ONSITE LANDFILL	144	6.1	16	36053	28754	29	45877	59593
	OFFSITE LANDFILL	619	7.9	15	18136	14692	50	77058	224229
	OFFSITE TREATMENT	1428	45.5	19	38351	37896	33	26235	61115
	ONSITE TREATMENT	350	13.1	85	44881	48097	156	55555	
	(i) ONSITE INCINERATION	555	22.0	29	40639	38508	67	53577	110364
	(ii) ONSITE INNOVATIVE	252	9.7	45	42826	38281	58	44535	50326
	(iii) ONSITE S/S (b)	211	3.9	11	20038	21282	31	80450	267022
NON-EXCAVATION ALTERNATIVES	IN SITU TREATMENT	232	11.3	12	42262	38312	11	45810	
	CONTAINMENT	79	3.5	23	46549	46355	36	128850	282599
	TOTAL	**430**	**14.2**	**170**	**41536**	**43030**	**315**	**63042**	
REMEDIAL OPTIONS SELECTED									
EXCAVATION ALTERNATIVES	ONSITE LANDFILL	67	3.4	2	34875	15380	6	42050	69324
	OFFSITE LANDFILL	763	4.8	3	14651	20118	13	9079	10110
	OFFSITE TREATMENT	655	17.5	1	26733	-	4	534	446
	ONSITE TREATMENT	329	10.9	29	36529	45624	54	32905	
	(i) ONSITE INCINERATION	486	21.2	8	39627	34510	22	34298	33103
	(ii) ONSITE INNOVATIVE	267	8.0	16	32127	33628	18	32295	30903
	(iii) ONSITE S/S (b)	279	3.7	5	11924	6598	14	31501	33841
NON-EXCAVATION ALTERNATIVES	IN SITU TREATMENT	142	7.6	2	66150	62013	1	149000	-
	CONTAINMENT	31	0.4	3	35733	42287	9	421222	467160
	TOTAL	**325**	**9.3**	**40**	**36856**	**42920**	**87**	**69993**	**189503**

(a) The cost figures refer to wood preserving sites only and are in 1987 prices.

(b) S/S = Stabilization/Solidification

TABLE 2
VARIABLES THAT MAY INFLUENCE THE CHOICE OF REMEDIAL ALTERNATIVES

Variable	Wood Preserving Sites					PCB Sites				
	N	Mean	Std. Dev.	Min.	Max.	N	Mean	Std. Dev.	Min.	Max.
Baseline Current Risk	33	0.019	0.043	0	0.14	55	0.007	0.020	0	0.12
Baseline Future Groundwater Risk	19	0.360	0.603	2.4E-06	1.6	34	0.208	0.591	1E-05	3.4
Baseline Future Soil Risk	20	0.038	0.062	1E-05	0.1701	30	0.010	0.044	7E-06	0.24
Recalculated HRS Score	40	45.255	10.532	18.61	71.46	87	50.33	13.94	8.85	74.30
Volume of Contamination (cub yds)	40	36856	42920	84.15	211000	87	69993	189503	5	1509000
Urban Setting Dummy Variable	40	0.125	0.335	0	1	87	0.195	0:399	0	1
Percent Non-white	40	19.85	17.878	0.516	69.04	87	0.141	0.233	0	0.935
Median Household Income ($)	40	27493	11874	12210	74620	87	30349	11709	8991	64641
Per Capita Income ($)	40	12814	5837.5	5496	42100	87	13316	4139	6782	28865
Year ROD Signed	40	88.325	1.608	85	91	87	87.99	2.03	83	91
Fund Lead Dummy Variable	40	0.325	0.474	0	1	87	0.609	0.491	0	1

TABLE 3
CHOICE OF REMEDIAL ACTION AT WOOD PRESERVING SITES

VARIABLE	(1)	(2)	(3)	VARIABLE	(4)	VARIABLE	(5)	VARIABLE	(6)
LOG COST (1987 $)	-0.694 (-2.39)	-0.909 (-2.50)	-0.699 (-2.43)		-3.74 (-2.39)		-0.778 (-1.47)		0.001 (0.001)
				LOG COST * TREND	0.497 (2.08)	LOG COST * RACE	-0.002 (-0.11)	LOG COST * INCOME	-2.7E-05 (-0.72)
ONSITE LANDFILL	0.536 (0.51)	0.749 (0.68)	0.537 (0.51)		5.125 (1.27)		2.447 (1.18)		1.531 (0.43)
OFFSITE LANDFILL	1.291 (1.08)	1.701 (1.32)	**1.244 (1.09)**		**5.511 (1.31)**		**-1.045 (-0.48)**		**2.656 (0.62)**
OFFSITE TREATMENT	1.133 (0.77)	1.627 (1.05)							
ONSITE EXCAVATION & TREATMENT	**2.290 (2.48)**		**2.301 (2.50)**		**7.213 (1.73)**		**2.264 (1.31)**		**3.694 (1.06)**
(i) INCINERATION		3.126 (2.48)							
(ii) SOLIDIFICATION/ STABILIZATION		2.523 (2.20)							
(iii) INNOVATIVE TREATMENT		2.419 (2.44)							
IN SITU TREATMENT	1.088 (0.93)	1.306 (1.08)	1.096 (0.94)		5.306 (0.70)		0.527 (0.25)		5.448 (1.24)
SECONDARY TREATMENT	1.380 (1.97)	1.551 (2.11)	1.389 (1.99)		5.445 (1.81)		-0.483 (-0.4)		0.961 (0.48)
				ONSITE LANDFILL * TREND	-1.0 (-0.96)	ONSITE LANDFILL * RACE	-0.315 (-0.95)	ONSITE LANDFILL * INCOME	-2E-05 (-0.22)
				OFFSITE REMEDIES * TREND	-0.72 (-1.11)	OFFSITE REMEDIES * RACE	0.134 (1.32)	OFFSITE REMEDIES * INCOME	-3.4E-05 (-0.25)
				ONSITE EXCAVATION & TREATMENT * TREND	-0.75 (-1.24)	ONSITE EXCAVATION & TREATMENT * RACE	0.014 (0.17)	ONSITE EXCAVATION & TREATMENT * INCOME	-3.4E-05 (-0.30)
				IN SITU TREATMENT * TREND	-0.65 (-0.57)	IN SITU TREATMENT * RACE	0.04 (0.48)	IN SITU TREATMENT * INCOME	-0.0002 (-0.89)
				SECONDARY TREATMENT * TREND	-0.58 (-1.32)	SECONDARY TREATMENT * RACE	0.103 (1.83)	SECONDARY TREATMENT * INCOME	1.2E-05 (0.17)
LOG LIKELIHOOD:	-44.12	-43.56	-44.12		-39.9		-39.48		-42.69

(t-ratios in parentheses)

Coefficients in boldface represent aggregated categories.

TREND: Year ROD signed (1983=1).
RACE: Percent non-white population in the zip code where the site is located.
INCOME: Median household income in the zip code where the site is located.

TABLE 4
CHOICE OF REMEDIAL ACTION AT PCB SITES

VARIABLE	(1)	(2)	(3)	VARIABLE	(4)	(5)	(6)
COST (a)	-0.08	-4.07	-3.49	COST	-3.48	-3.41	-3.50
	(-3.73)	(-3.09)	(-2.18)		(-2.6)	(-2.55)	(-2.62)
COST *		0.42	0.36	COST *	0.36	0.35	0.34
LVOL1 (b)		(3.03)	(2.14)	LVOL1	(2.56)	(2.48)	(2.46)
				COST *		0.93	
				CURRENT SOIL RISK (c)		(1.56)	
				COST *		0.01	
				CURRENT SOIL RISK		(0.17)	
				MISSING DUMMY			
				COST *			0.002
				HRS SCORE (d)			(1.58)
OFFSITE	2.10	2.08	32.71	OFFSITE	32.88	32.30	37.73
LANDFILL	(2.76)	(2.75)	(2.55)		(2.56)	(2.47)	(2.74)
OFFSITE	1.85	2.99	35.76				
TREATMENT	(1.95)	(2.76)	(2.7)				
ONSITE	0.89	0.51	26.54	ONSITE	26.43	26.10	31.64
LANDFILL	(3.73)	(0.68)	(2.02)	LANDFILL	(2.01)	(1.96)	(2.21)
ONSITE	2.78	3.05	25.24	ONSITE	25.09	24.31	29.78
TREATMENT	(3.93)	(4.29)	(2.02)	TREATMENT	(2.01)	(1.91)	(2.24)
OFFSITE LANDFILL			-2.98	OFFSITE	-3.00	-2.94	-3.42
* LOG VOLUME			(-2.51)	* LOG VOLUME	(-2.54)	(-2.44)	(-2.73)
OFFSITE TREATMENT			-3.40				
* LOG VOLUME			(-2.63)				
ONSITE LANDFILL			-2.43	ONSITE LANDFILL	-2.42	-2.38	-2.89
* LOG VOLUME			(-2.01)	* LOG VOLUME	(-2.0)	(-1.94)	(-2.21)
ONSITE TREATMENT			-2.06	ONSITE TREATMENT	-2.05	-1.95	-2.45
* LOG VOLUME			(-1.82)	* LOG VOLUME	(-1.8)	(-1.68)	(-2.05)
LOG LIKELIHOOD:	-79.15	-71.63	-62.88		-63.51	-62.73	-62.11

t-ratios in parentheses

a - millions of 1987 $'s
b - lvol1 = min{ log(volume , log(15,000) }, volume is in cubic yards
c - excess lifetime cancer risk, plausible maximum case
d - Hazard Ranking System score (air route score not included)

TABLE 4 (continued)
CHOICE OF REMEDIAL ACTION AT PCB SITES

VARIABLE	(7)	VARIABLE	(8)	VARIABLE	(9)
COST	-3.44		-4.18		-3.41
	(-2.55)		(-2.66)		(-2.56)
COST *	0.35		0.43		0.35
LVOL1	(2.49)		(2.62)		(2.51)
OFFSITE	40.34		33.88		31.87
	(2.60)		(2.43)		(2.32)
ONSITE	34.42		29.61		27.94
LANDFILL	(2.14)		(2.05)		(1.92)
ONSITE	30.98		26.00		24.48
TREATMENT	(2.07)		(1.90)		(1.84)
OFFSITE	-3.88		-3.09		-3.15
* LOG VOLUME	(-2.61)		(-2.44)		(-2.52)
ONSITE LANDFILL	-3.33		-2.62		-2.48
* LOG VOLUME	(-2.15)		(-2.03)		(-1.98)
ONSITE TREATMENT	-2.90		-2.15		-2.16
* LOG VOLUME	(-2.02)		(-1.76)		(-1.81)
OFFSITE	0.05	OFFSITE *	0.01	OFFSITE *	0.13
* HRS	(0.91)	% NON-WHITE	(0.14)	MEDIAN HH INCOME	(0.49)
ONSITE LANDFILL	0.05	ONSITE LANDFILL *	-0.20	ONSITE LANDFILL *	-0.05
* HRS	(0.75)	% NON-WHITE	(-1.30)	MEDIAN HH INCOME	(-0.15)
ONSITE TREATMENT	0.08	ONSITE TREATMENT *	0.04	ONSITE TREATMENT *	0.10
* HRS	(1.75)	% NON-WHITE	(0.39)	MEDIAN HH INCOME	(0.41)
LOG LIKELIHOOD:	**-61.47**		**-60.85**		**-63.21**

t- ratios in parentheses

FIGURE 1: REMEDIAL ALTERNATIVES FOR SOIL CONTAMINATION

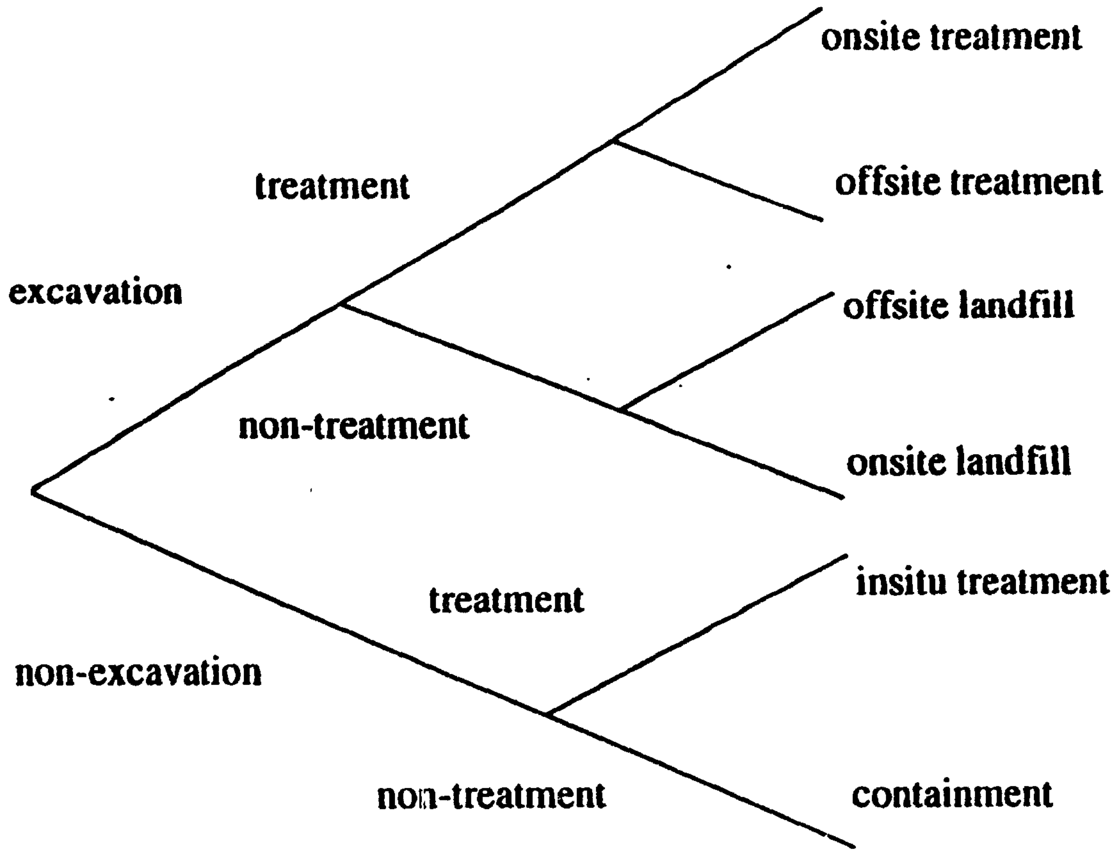
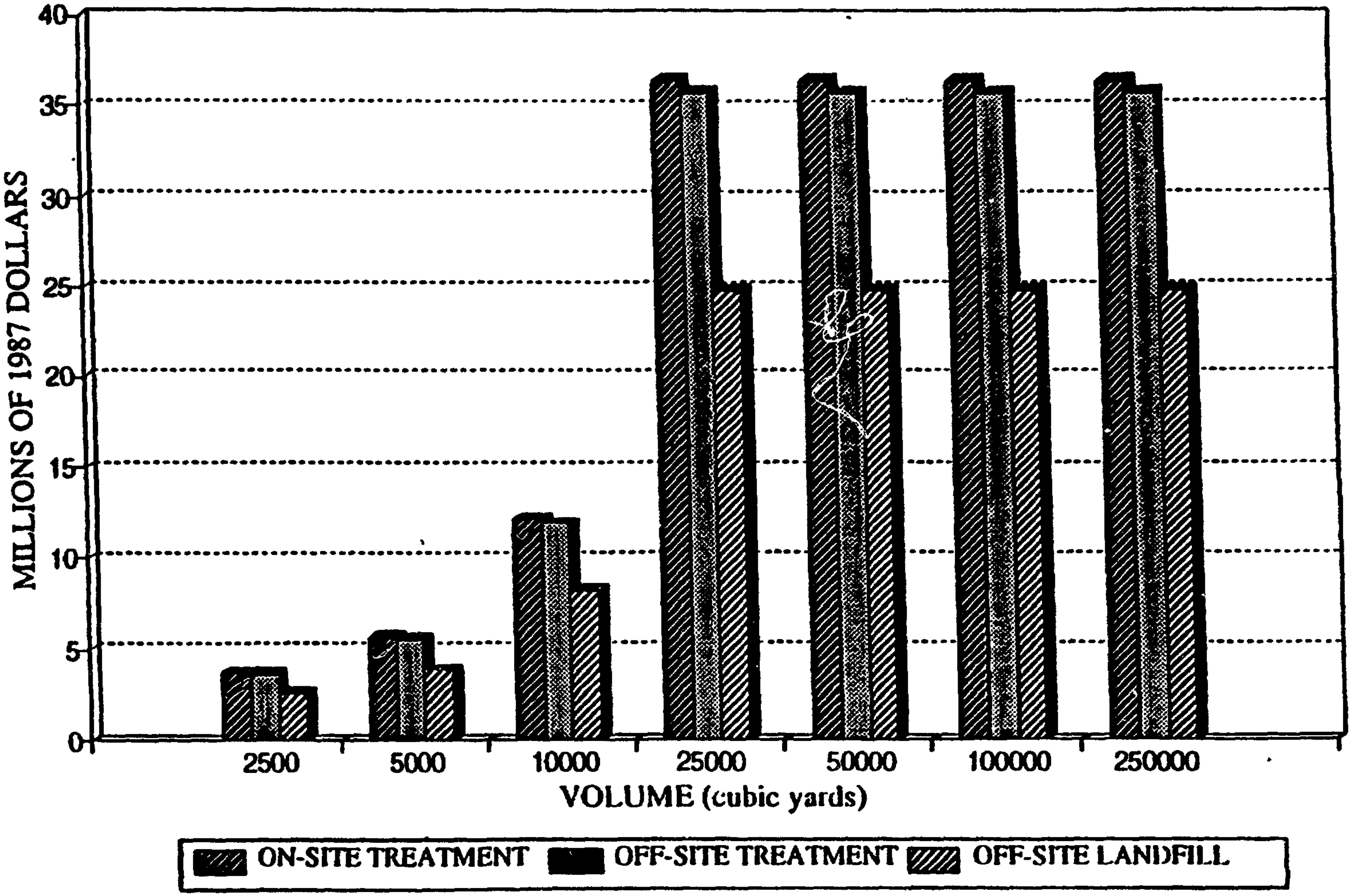


FIGURE 2: IMPLICIT VALUATION OF REMEDIAL OPTIONS WITH RESPECT TO NON-EXCAVATION OPTION

(model specification (2))



Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS1249	Competitiveness and Environmental Standards: Some Exploratory Results	Piritta Sorsa	February 1994	P. Kokila 33716
WPS1250	Explaining Miracles: Growth Regressions Meet the Gang of Four	William Easterly	February 1994	R. Martin 39026
WPS1251	Excise Taxes	John F. Due	February 1994	C. Jones 37699
WPS1252	On the Dangers of Decentralization	Rémy Prud'homme	February 1994	TWUTD 31005
WPS1253	Can Competition Policy Control 301?	J. Michael Finger K. C. Fung	February 1994	M. Patena 37947
WPS1254	What Are OECD Trade Preferences Worth to Sub-Saharan Africa?	Alexander J. Yeats	February 1994	J. Jacobson 33710
WPS1255	Intrahousehold Resource Allocation: An Overview	Lawrence Haddad John Hoddinott Harold Alderman	February 1994	P. Cook 33902
WPS1256	World Fossil Fuel Subsidies and Global Carbon Emissions in a Model with Interfuel Substitution	Bjorn Larsen	February 1994	C. Jones 37699
WPS1257	Old-Age Security in Transitional Economies	Louise Fox	February 1994	E. Vincent 82350
WPS1258	Decentralizing Infrastructure: For Good or for Ill?	Richard Bird	February 1994	WDR 31393
WPS1259	The Reform of Fiscal Systems in Developing and Emerging Market Economies: A Federalism Perspective	Robin Boadway Sandra Roberts Anwar Shah	February 1994	C. Jones 37754
WPS1260	When Is a Life Too Costly to Save? Evidence from U.S. Environmental Regulations	George L. Van Houtven Maureen L. Cropper	February 1994	A. Maranon 39074
WPS1261	A Political-Economy Analysis of Free Trade Areas and Customs Unions	Arvind Panagariya Ronald Findlay	March 1994	N. Artis 37947
WPS1262	Flexibility in Sri Lanka's Labor Market	Martin Rama	March 1994	P. Cook 33902
WPS1263	The Effects of Barriers on Equity Investment in Developing Countries	Stijn Claessens Moon-Whoan Rhee	March 1994	F. Hatab 35835

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS1264	A Rock and a Hard Place: The Two Faces of U.S. Trade Policy Toward Korea	J. Michael Finger	March 1994	M. Pateña 37947
WPS1265	Parallel Exchar.ge Rates in Developing Countries: Lessons from Eight Case Studies	Miguel A. Kiguel Stephen A. O'Connell	Maıch 1994	R. Luz 34303
WPS1266	An Efficient Frontier for International Portfolios with Commodity Assets	Sudhakar Satyanarayan Panos Varangis	March 1994	D. Gustafson 33732
WPS1267	The Tax Base in Transition: The Case of Bulgaria	Zeljko Bogetic Arye L. Hillman	March 1994	F. Smith 36072
WPS1268	The Reform of Mechanisms for Foreign Exchange Allocation: Theory and Lessons from Sub-Saharan Africa	Eliana La Ferrara Gabriel Castillo John Nash	March 1994	N. Artis 38010
WPS1269	Union-Nonunion Wage Differentials in the Developing World: A Case Study of Mexico	Alexis Panagides Harry Anthony Patrinos	March 1994	I. Conachy 33669
WPS1270	How Land-Based Targeting Affects Rural Poverty	Martin Ravallion Binayak Sen	March 1994	P. Cook 33902
WPS1271	Measuring the Effect of External Shocks and the Policy Response to Them: Empirical Methodology Applied to the Philippines	F. Desmond McCarthy J. Peter Neary Giovanni Zanalda	March 1994	M. Divino 33739
WPS1272	The Value of Superfund Cleanups: Evidence from U.S. Environmental Protection Agency Decisions	Shreekant Gupta George Van Houtven Maureen L. Cropper	March 1994	A. Maranon 39074