RAND

Private-Sector Cleanup Expenditures and Transaction Costs at 18 Superfund Sites

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Preface

The research reported here was sponsored by the Office of Policy Analysis, Office of Policy Planning and Evaluation at the United States Environmental Projection Agency, and by RAND with its own funds. The work was done within the Environment and Natural Resources Program at RAND. The Environment and Natural Resources Program is actively involved in research to better inform public policy on hazardous waste, water, and air pollution issues.

This report should be of interest to those evaluating Superfund's liability-based approach to cleaning up the thousands of abandoned or inactive sites across the nation that are contaminated with hazardous substances.

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Summary

Congress took a novel approach to cleaning up the nation's worst inactive hazardous waste sites when it enacted the Superfund program in 1980.[1] Instead of funding the cleanups with public moneys, it adopted a liability-based program. The program allows the government either to clean up a site and recover its cost from the potentially responsible parties (PRPs)[2] or to require the PRPs to undertake the cleanup themselves.

There is great concern that the liability approach is generating more litigation than cleanup. However, there is little empirical evidence to substantiate this concern. The purpose of this study is to provide estimates of the magnitude of private-sector expenditures and transaction-cost share[3] at Superfund sites.

A previous RAND study reported that transaction costs were 19 percent of outlays for five very large industrial firms at 49 sites on the National Priorities List (NPL)[4] between 1984 and 1989.[5] These firms all had annual revenues in excess of $20 billion, and we felt that further research was necessary to determine if their experiences are representative of smaller firms. In this study, we present information on the expenditures of 108 firms with annual revenues less than $20 billion between 1981 and 1991 at 18 sites on the NPL. We randomly selected the study sites from a set of sites where we had reason to believe that there had been substantial private-sector expenditures through 1991. We present our key findings below.

[1]The Superfund program was established by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980.

[2]A PRP can be any party connected with the hazardous substances found at the site. PRPs include the generator of the hazardous substance, the party who transported the substance, the party who arranged for the transport or disposal of the substance, or the owner or operator of the site.

[3]Transaction-cost share is the ratio of transaction costs to the sum of transaction cost and investigation and remediation costs. In general, transaction costs are expenditures incurred in assigning liability among parties involved at a site.

[4]The NPL is the list of sites that the U.S. Environmental Protection Agency (EPA) has chosen to target with Superfund's remedial program.

[5]Acton and Dixon, 1992. The 15 percent transaction-cost share reported for NPL sites in Table 22 of Acton and Dixon, 1992, is increased by four percentage points to account for unattributed costs (see p. 45 of that report).

Individual Firm Expenditures and Transaction-Cost Shares

Expenditures and transaction-cost share vary enormously across the 108 firms at the 18 study sites.

- Approximately one-third of the firms sampled had expenditures less than $1000, and 7 percent of the firms accounted for 77 percent of the total expenditures.
- Transaction-cost share exceeded 60 percent for over 50 percent of the firms with expenditures greater than $1000. Large outlays with low transaction costs by a minority of firms brought the share of transaction costs in total expenditures down to 21 percent for the sample.

Expenditures and transaction-cost share vary enormously by firm size.

- Transaction-cost share averaged 60 percent for firms with annual revenues less than $15 million and between $15 million and $100 million, 15 percent for firms with annual revenues between $100 million and $1 billion, and 19 percent for firms with annual revenues between $1 billion and $20 billion.
- Average expenditures per firm rose dramatically with firm size.

The transaction-cost shares for the larger firms are consistent with findings for the very large industrial firms in the previous RAND report.

While transaction-cost share is related to firm size, we found firm size is not particularly important in explaining firm expenditures and transaction-cost share when other site and firm characteristics are taken into consideration. Of key importance is a firm's share of the waste at a site. We found that as volumetric share rises, transaction-cost share falls. Larger firms tend to have larger volumetric shares, and it appears to be this relationship, not firm size in and of itself, that induces the correlation between firm size and transaction-cost share.

Composition of Firm Expenditures and Interaction with Insurers

Our analysis suggests that most investigation and remediation (IR) expenditures are for remedial design and remedial action and that most transaction costs are for legal work.

- Approximately one-half of the IR costs that we were able to categorize were for remedial design and remedial action. The remainder were split between remedial investigation and feasibility studies (RI/FS) and payments to the government. We were unable to categorize 24 percent of IR costs.
- Sixty-five percent of transaction costs were for legal work. Only a small proportion paid for duplicative technical work used to contest remedy selection or liability. The remaining transaction costs paid for nonlegal staff and outside consultants that negotiate with PRPs, EPA, or insurers over liability.

Many firms spend money on coverage disputes with their insurers, but few receive reimbursement.

- Approximately one-third of the firms with expenditures over $1000 spent money on coverage disputes, but the total amount spent was only about 1 percent of overall expenditures.
- Twelve percent of firms with expenditures over $1000 received reimbursement. The reimbursements were over six times the firm expenditures on coverage disputes. Overall, insurers reimbursed PRPs for approximately 8 percent of their expenditures.

Variation of Expenditures and Transaction-Cost Share Across Sites

Site characteristics appear to have an important influence on firm expenditures and transaction-cost share, although the limited base of 18 sites makes these findings somewhat tentative.

- Firm expenditures on both IR and transaction costs are higher at sites with higher estimated total cleanup costs, but transaction costs do not increase as rapidly; hence, transaction-cost share is lower at more expensive sites.
- Evidence on whether an individual firm's transaction-cost share is lower at sites with fewer PRPs is mixed when other factors are held constant. Even if a firm's transaction-cost share is not lower at a site with fewer PRPs when other factors are held constant, it may still be that the share for the expenditures of all PRPs at a site with fewer PRPs is lower. This is because as the number of firms decreases, the volumetric share of some firms must rise, and these firms will have lower transaction-cost shares. Further work is necessary to quantify how transaction-cost share varies with the number of PRPs at a site.

We generally found that transaction costs are less sensitive to variation in site and firm characteristics than are IR costs. This suggests that transaction costs have a fixed component and a component that varies somewhat with site and firm characteristics.

Private-Sector PRP Expenditures and Transaction-Cost Share at the Study Sites

Since we oversampled firms with higher volumetric shares and the combined volumetric share of the sampled firms varied by site, the transaction-cost share for the firms we sampled may not be representative of that for all private-sector PRP expenditures at the study sites. We developed a model of firm expenditures to estimate overall PRP expenditures at the study sites. We also used these estimates to project transaction-cost share when cleanup is complete at the 18 sites.

Expenditures Between 1981 and 1991

We estimate that private-sector PRPs spent an average of $32 million per site ($583 million overall) at the 18 study sites between 1981 and 1991 and that the transaction-cost share was 32 percent. As might be expected given the small size of the sample relative to the number of PRPs at the sites, there is considerable uncertainty in these estimates. Ninety-percent confidence intervals are $24 million to $46 million for expenditures and 20 to 44 percent for transaction-cost share. These confidence intervals depend on assumptions required by our statistical procedures. We have some evidence that our data violate some of these assumptions, so these confidence intervals themselves are subject to uncertainty.

We also found that transaction-cost share varies by the cleanup phase during which expenditures occur. We estimate that transaction costs were 51 percent of expenditures from site discovery to start of the first RI/FS, 39 percent from start of the RI/FS to start of the remedial action, and 20 percent after start of the remedial action. Again the confidence intervals on the estimates are sizable. For example, the confidence interval is 7 to 35 percent for expenditures after start of remedial action.

Expenditures and Transaction-Cost Share at Completion

Of primary importance in evaluating the amount of transaction costs produced by Superfund's liability approach are the final transaction costs and transaction-cost share when cleanup is complete. Our finding that the share is lower in later cleanup phases suggests that transaction-cost share to date will overestimate the cumulative transaction-cost share when cleanup is complete. Because construction of the cleanup remedy is complete at only 2 of the 18 study sites, however, it is difficult to predict what transaction costs will ultimately be.

To give some idea of what transaction-cost share for PRP expenditures at completion might be, we project final transaction-cost share under three different scenarios. In the first scenario, we assume that final phase transaction-cost shares will remain at the levels observed through 1991 and estimate final expenditures in each phase based on costs through 1991 and the expected total cleanup cost estimated by the EPA regional project manager (RPM). This results in a final transaction-cost share of 27 percent. There is considerable uncertainty in this estimate. Simply using the upper and lower bounds for the 90-percent confidence intervals for the estimated phase transaction-cost shares through 1991 causes the projected transaction-cost share at completion to vary between 13 and 41 percent.

The assumption that final site IR costs will equal the RPM estimate may not be very accurate. In the second scenario, we assume that IR costs at completion will be 50 percent higher than currently expected. Under this assumption, the final transaction-cost share drops to 25 percent and the range to 12 to 40 percent. Even though the transaction-cost share falls, cost growth causes the total amount of transaction costs at completion to rise.

The assumption that transaction-cost share in each cleanup phase will remain at its 1991 level may not be very accurate either. It is possible that the shares may fall, if transaction costs are front-loaded in each phase of the cleanup process. It is conceivable, however, that the share in the final cleanup phase may rise if PRPs wait until the end of the cleanup process to initiate litigation to recover costs from their insurers, other PRPs, or the government.

Preliminary investigation of the transaction-cost share after start of the first remedial action at the 18 study sites and 21 supplemental sites resulted in mixed evidence on whether, so far, the share after the start of the first remedial action has fallen over time. Nevertheless, we think this is a reasonable speculation and, in the third scenario, give a lower bound for the ultimate transaction-cost share at the study sites assuming no cost growth in IR. Under this scenario, we assume that there will be no more transaction costs after 1991 and no cost overruns. This results in a final transaction-cost share of 19 percent with a range of 15 to 24 percent. We have no basis for projecting an upper bound for final transaction-cost share, however.

The wide spread in estimated transaction-cost share at completion reflects our lack of understanding of how the Superfund process will unfold at the 18 study sites.

Overall Transaction Costs Induced by Superfund's Liability Approach

Given our small sample size, we think further analysis is necessary before we can extrapolate total PRP expenditures to date at all NPL sites from our data. We believe, however, that our estimate of transaction-cost share to date at our 18 study sites, 32 percent, is also a reasonable point estimate for the transaction-cost share through 1991 for all sites with Records of Decision (RODs). The best available measure of uncertainty in this estimate is again the 20 to 44 percent range obtained from our statistical analysis of the 18 study sites. This range may be inaccurate to the extent that our data violate the assumptions implicit in our statistical procedures or that the 18 study sites are not representative of all sites with RODs. However, two pieces of evidence suggest that the 18 sites are reasonably representative. First, their characteristics are roughly similar to those of a larger group of sites where we had reason to believe that there were substantial PRP expenditures. Second, the findings for the large firms at the 18 sites studied here are consistent with those of the very large firms at a much larger number of sites in our previous study.

Preliminary calculations suggest that including sites without RODs would raise the transaction-cost share to date from 32 to 35 percent.

A full accounting of the transaction costs generated by Superfund's liability approach must include outlays by private-sector insurers. In our previous study, we estimated that as of 1989 insurers were spending on the order of $150 million a year at NPL sites and that 88 percent of their outlays were transactional in nature. Due to the high transaction-cost share for insurer outlays, the transaction-cost share for PRP and insurer outlays combined will almost certainly be higher than that for PRP expenditures alone. However, how much higher the combined share will be is unknown.

To private-sector costs, we must also add outlays by EPA and state and local governments. EPA currently spends about $1.5 billion a year on the Superfund program,[6] but there is currently little information on how much state and local governments spend on NPL sites. We also do not know what part of government expenditures is transactional in nature. Approximately 15 percent of EPA's Superfund outlays go toward enforcement, a transaction cost in our classification of costs, but we have not attempted to categorize the remaining 85 percent.

[6]These are obligations of EPA. Actual outlays may be lower. See Acton, 1989.

Acknowledgments

This report would not have been possible without the cooperation of the firms that participated in the study. They devoted substantial time and resources to reconstruct their expenditures at Superfund sites—expenditures that often date back 10 years. We cannot name the study participants because we guaranteed their anonymity, but we would like to thank them for their contribution.

Many individuals at EPA aided this study. Tom Gillis was the project officer, and both he and Harriet Tregoning contributed to the original study formulation and facilitated our requests for information from EPA regions. Regional Project Managers in various EPA regions provided essential information on National Priorities List sites under their supervision. Richard Morgenstern, Bruce Diamond, and Bill White of EPA were members of an EPA project advisory committee that provided useful input in designing the project.

Sandy Geschwind and Lisa Ross at RAND made substantial contributions to the project both in study design and data collection. John Adams and Naihua Duan advised us on the proper use of bootstrapping and smearing estimates in our statistical analysis.

The report benefited greatly from comments made on its various drafts. The three formal reviewers were Bob Bell and Steve Garber at RAND and Perry Beider at the Congressional Budget Office. We would like to thank Perry Beider in particular for his detailed and constructive comments on many drafts. Richard Morgenstern at EPA commented on behalf of the project advisory committee, and Tom Gillis also provided useful comments. In addition, we received helpful comments from John Arlington at American Insurance Association, Warren Azano at Aetna, Linda Greer at Natural Resources Defense Council, Kevin McCarthy at RAND, John Phillips at Ford Motor Company, David Rubenson at RAND, Katherine Probst at Resources for the Future, and Jay Starling at RAND. We thank them for the time and effort they put into their comments.

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Finally, we thank Jan Paul Acton for his comments on the drafts and for his key role in initiating this project.

While we have benefited from the input of many individuals, the interpretations and conclusions in this report belong to the authors, and we remain responsible for any errors.

List of Acronyms and Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CGL	Comprehensive general liability
EPA	United States Environmental Protection Agency
FS	Feasibility study
GAO	United States Government Accounting Office
GDP	Gross Domestic Product
GOCO	Government-owned, contractor-operated facilities
IR	Investigation and remediation
NPL	National Priorities List
OLS	Ordinary least squares
PRP	Potentially responsible party
RA	Remedial action
RD	Remedial design
RI	Remedial investigation
ROD	Record of Decision
RPM	Regional project manager
SARA	Superfund Amendments and Reauthorization Act
SETS	Site Enforcement Tracking System
SIC	Standard Industrial Classification

1. Introduction

There is great concern that the federal Superfund program to clean up the nation's inactive hazardous-waste sites generates more litigation than cleanup. However, there has been little empirical evidence to substantiate this concern. The purpose of this study is to provide empirical information about the private-sector transaction costs generated by Superfund's liability approach to policymakers and the public.

A previous RAND study reported on the size and composition of cleanup expenditures for four insurers and five very large industrial firms.[1] It estimated that 88 percent of insurer outlays between 1986 and 1989 were transactional in nature.[2] It found that transaction costs for very large industrial firms were 19 percent of the total expenditures between 1984 and 1989 at 49 sites on the National Priorities List (NPL).[3]

The industrial firms in the previous study all had annual revenues in excess of $20 billion, and we felt that further research was necessary to determine if the experiences of these very large firms are representative of smaller firms. In this study, we present information on 1981–1991 expenditures at 18 NPL sites of 108 firms each with annual revenues less than $20 billion. We examine how expenditures and transaction-cost share vary across sites and firms. We compare expenditures and transaction-cost shares of these firms with those of the very large industrial firms in the previous study. We extrapolate from our sample to overall private-sector expenditures through 1991 at the 18 study sites and also project what the transaction-cost share will be when cleanup is complete at all 18 sites. Before we present our findings, we provide a brief background on the Superfund program and the issues under debate.

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[1]Acton and Dixon, 1992.

[2]Transaction costs were 88 percent of payments on all claims whether they remained open or had been closed as of 1989. The transaction-cost share for closed claims was 69 percent.

[3]NPL is the list of sites that the U.S. Environmental Protection Agency (EPA) has chosen to target with Superfund's remedial program. The 15 percent transaction-cost share reported for NPL sites in Table 22 of Acton and Dixon, 1992, is increased by four percentage points to account for unattributed costs (see p. 45 of that report).

Program Background

Congress enacted the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) to clean up inactive sites contaminated with hazardous substances. CERCLA, commonly known as Superfund, was amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA), was extended as part of the Budget Reconciliation Act of 1990, and is scheduled for reauthorization in 1994. Many states have adopted laws similar to the federal statute and have set up their own superfund-like programs.

Liability-Based Approach

Congress took a novel approach to cleaning up the nation's hazardous waste sites. Instead of funding the cleanups with public moneys, it adopted a liability-based program. The program allows the government either to clean up a site and recover its costs from the parties responsible for the waste or to require the potentially responsible parties (PRPs) to undertake cleanup themselves. Liability is strict, joint and several, and retroactive:

- **Strict liability** means that a PRP is liable for cleanup costs even when there was no negligence. Indeed, in many instances, parties may have been in compliance with contemporary regulations and standards and even been acting with an explicit license or permit from a governmental agency at the time the original disposal took place.
- **Joint and several liability** means that even if several parties contributed to the waste at a site, any one party can be forced to bear the full cost of the remedy. That party may seek contribution to its costs from other parties through separate legal action.
- **Retroactive liability** means that the provisions apply to actions that took place before CERCLA was passed.

A PRP is almost any party connected with the hazardous substances found at a site. The PRP could be a generator of the hazardous substance, a party who transported the substance, a party who arranged for the transport or disposal of the substance, or the owner or operator of the site.

Progress Through 1991

By the end of 1991, there were approximately 36,000 sites in EPA's inventory of hazardous waste sites that might require cleanup.[4] EPA determined potential harm to human health and the environment was not high enough at 58 percent of these sites to warrant federal action, leaving roughly 14,000 sites across the nation for possible inclusion in the federal program.[5] By the end of 1991, EPA had put 1275 sites on the NPL, of which 127 are federal facilities.[6,7] The cost of cleaning up NPL sites is substantial. EPA estimates it will cost $31 million on average to clean up sites currently in process,[8] and that this number may increase as more complex sites are addressed. Excluding federal facilities, a University of Tennessee study estimates average costs of $35 million to $101 million, depending on the level of cleanup.[9] These estimates are difficult to compare, however, because of differences in discounting procedures. Multiplying by the 1148 nonfederal NPL sites, this range translates into cleanup costs of between $30 billion and $120 billion, and this does not include the transaction costs that are incurred in the process.

EPA has spent a considerable amount on the Superfund program. Since 1988, annual obligations have been approximately $1.5 billion per year, and cumulative obligations were approximately $9.1 billion through 1991.[10,11] Only a small minority of NPL sites were cleaned up during the first 11 years of the program. Of the 1275 sites put on the NPL, work was considered complete at 80 sites by the end of 1991.[12,13]

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[4]EPA, 1992b, p. I-3.

[5]EPA, 1992b, p. I-3. States may clean up sites that do not qualify for the federal program.

[6]Most federal facilities are the responsibility of the Department of Defense or Department of Energy.

[7]EPA, 1992b.

[8]Includes cost of remedial investigation and feasibility study, remedial design, and remedial action. Excludes operation and maintenance costs. Coverted to 1991 dollars using Gross Domestic Product (GDP) deflator. Federal Register, p. 34022, June 23, 1993.

[9]Colglazier, Cox, and Davis, 1991, pp. 64–65.

[10]Obligations are commitments by EPA for future payment.

[11]EPA, 1992b, p. 37, and Acton, 1989, p. 31.

[12]EPA, 1992b, p. I-5. In addition to the long-term cleanup under the remedial program, EPA conducts removal actions in response to the release or threat of release of a hazardous substance that poses a near-term threat to human health or the environment. This part of the Superfund program is widely thought to be very successful. Through 1991, removal actions were started at 2294 sites. EPA, 1992b, p. I-9.

[13]The data we collected for this study go through 1991. We therefore report program statistics through 1991. Since 1991, the pace of cleanup appears to have accelerated. As of April 1993, construction was complete at 161 NPL sites; EPA, 1993, p. I-3.

The Sources of Transaction Costs

The principal actors in the Superfund program are EPA, PRPs, and insurers. Each generates transaction costs. Transaction costs are defined in more detail in Section 2, but loosely speaking, they are expenditures incurred in assigning liability among the parties involved at a site. Below, we first describe the sources of transaction costs for PRPs.[14,15]

There are five main sources of transaction costs for a PRP: (1) searches for other PRPs, (2) negotiations and litigation with other PRPs over apportioning costs, (3) defense against cost recovery by EPA and cost recovery litigation between PRPs, (4) negotiations and litigation with EPA over remedy selection and cleanup implementation, and (5) negotiations and litigation with insurers for reimbursements of costs.

Searches for other PRPs. When there are multiple PRPs at a site, EPA may identify only a subset of the firms involved. It may then leave it to these firms to identify and locate the other firms.[16]

Negotiations with other PRPs. EPA generally attempts to negotiate with groups of PRPs. However, the PRPs at a site typically have very heterogeneous interests, and agreement on a common position is difficult. There are usually differences among PRPs in the type and quantity of waste sent to the site, firm size, insurance coverage, whether they have been named by EPA, and their general attitude toward Superfund. There are many sources of contention. Cost allocation is up to the PRPs themselves and this often involves protracted disagreement and negotiation. This is exacerbated by very poor waste-in records at many sites and the lack of a standard method to cost different types of waste. EPA settlements with subsets of the PRPs are also frequently contentious. For example, EPA can negotiate a *de minimis* settlement with firms that are responsible for a minor proportion of the waste at a site and a minimal share of the overall cleanup cost. The remaining PRPs may feel that the settlement is not equitable and dispute the settlement or be obstinate in ongoing negotiations.

Cost recovery. PRPs can incur substantial legal costs in contesting EPA attempts to recover the costs of EPA-financed cleanups. In the case of PRP-financed cleanups, some firms may not participate in the cleanup. This is often the case for firms that have not been named by EPA. It is then up to the participating

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[14]We omit a discussion of EPA transaction costs since our focus is on the private sector.

[15]For a detailed description of the Superfund remedial process, see Acton (1989) and Lucero et al. (1989).

[16]In recent years, EPA has done this less often.

firms to recover costs from the nonparticipants. This can be a lengthy process and generate substantial transaction costs for both the participants and nonparticipants.

Negotiation with EPA over remedy selection and cleanup implementation. The remedy selected for a site has a major impact on site cleanup costs. PRPs often oppose the remedy selected by EPA and occasionally conduct their own site studies to contest the EPA remedy. Although these duplicate site studies and the time spent bargaining over the remedy may contribute to the understanding or cleanup of the site, they are directed mainly toward reducing the liability of the PRPs, and we classify them as transaction costs. Disagreements over details of the remedy once cleanup is underway can also generate transaction costs. The work statement in a cleanup agreement often leaves a number of issues unresolved about the implementation of the remedy. PRPs can spend substantial time and effort negotiating with EPA to resolve them.

Negotiation with insurers for cost reimbursement. PRPs often turn to their insurers for reimbursement of legal and cleanup costs. These claims are typically brought under comprehensive general liability (CGL) policies, but the applicability of CGL policies to such claims is hotly contested. Insurers hold that CGL polices do not cover claims related to inactive hazardous waste sites while PRPs hold that they do. PRPs spend resources contesting or litigating this issue with their insurers.

Prior Research on Transaction Costs

Many claim that transaction costs are a large proportion of expenditures related to cleaning up Superfund sites, but little empirical evidence is available. As discussed above, RAND reported that the transaction cost share was 88 percent from 1986 to 1989 for four medium-sized and large insurers and 19 percent for five very large industrial firms at 49 NPL sites between 1984 and 1989. In 1990 the U.S. General Accounting Office (GAO) conducted a survey of insurers to determine costs related to hazardous waste claims.[17] Information on various types of costs were reported, but certain categories were omitted, and the data were not categorized so as to allow the calculation of the share of transaction costs.

In December 1991, the National Paint and Coatings Association, Inc., surveyed its 550 members on their expenditures at Superfund sites. For the 103 members that

[17]GAO, 1991.

responded, transaction costs were 35 percent of total expenditures to date at sites where the firms had resolved their liability;[18] the average transaction-cost share across firms for all expenditures to date was 72 percent. This is not the percentage of expenditures to date that were transaction costs, however. Rather, it is the average when each firm is weighted equally irrespective of its total outlays. As we see below, a large proportion of firms may have high transaction-cost shares, but large outlays by a few firms with low transaction-cost shares may cause the share of transaction costs in overall outlays to be much lower than the average transaction-cost share across firms. Thus, the actual share of transaction costs in expenditures to date for all the firms sampled is probably much lower. Some caution should be taken in using the National Paint and Coating Association's numbers because the survey instrument did not contain a definition of transaction costs, and therefore each respondent used his or her own interpretation.

Issues Not Addressed by This Study

There are many potential advantages and disadvantages of using a liability-based approach to clean up the nation's hazardous waste sites. High transaction costs are just one possible disadvantage. A full evaluation must compare all the advantages and disadvantages of the liability approach with those of other approaches, but this is beyond the scope of this study. However, to put this research on transaction costs in perspective, we catalogue some of the advantages and other disadvantages of the liability approach.[19] Potential advantages may include the following:

- **Low government expenditures.** Raising taxes to pay for a program fully funded by the government may be very difficult.
- **Equity.** The parties that generated or handled the wastes are responsible for cleaning them up.
- **More site discovery.** Fear of liability may induce more thorough investigation of land and facilities during property transfers and the loan-approval process.
- **More careful handling and disposal of hazardous substances.** Since firms may be held responsible for future cleanups, Superfund's strong liability provisions may encourage reductions in the generation of hazardous

[18]National Paint and Coatings Association, Inc., 1992.

[19]For a more in-depth discussion, see Probst and Portney, 1992.

substances, greater recycling, and more careful disposal. Note, however, that these responses would be encouraged by prospective liability, and do not require retroactive liability.

- **Voluntary cleanups.** Firms may clean up a site without any direct government intervention in order to avoid the Superfund process.
- **More efficient cleanups.** The private parties paying for a cleanup have a strong incentive to make the cleanup as cost-effective as possible. This may result in the use of more innovative technologies or more efficient implementation than would be the case if only the government were responsible.

In addition to transaction costs, other disadvantages of the liability approach may include the following:

- **Delay.** The litigation between parties may slow the cleanup process and adversely affect human health and the environment.[20]
- **Inequity.** Firms are held liable for cleanup even when they followed accepted practices when they originally disposed of the waste. Also, because of joint-and-several liability, a firm may have to pay cleanup costs out of proportion to its waste contribution.
- **More costly site investigations.** In order to prepare a legal case, EPA and PRPs may investigate a site more thoroughly than they would otherwise. They may also spend more on careful laboratory analyses that can be used in court.[21]
- **Impaired redevelopment of industrial land.** Potential liability may make investors wary of redeveloping any site where there is some possibility of contamination. This may spur growth on "greenfields," or previously unused land.

Overview of This Report

Section 2 briefly discusses the study methods. It describes our survey approach, how we categorize costs, and the characteristics of the sample. Section 3 presents our findings on the expenditures of the firms in our sample and the breakdown

[20]While delay is cited by many critics of Superfund, we are aware of no studies quantifying delay caused by the liability approach.

[21]These added costs can be considered transaction costs related to apportioning liability. We list them separately because they are very difficult to measure and are not included in transaction costs in this report.

of these expenditures into cleanup and transaction costs. Section 4 examines how firm and site characteristics influence firm expenditures and transaction-cost shares. In Section 5 we present estimates of all private-sector expenditures between 1981 and 1991 at the study sites. We also project what transaction-cost share will be when cleanup is complete at the study sites. Section 6 summarizes the findings. Four appendices provide methodological detail.

2. Study Methods

We selected 18 NPL sites spread across five EPA regions and seven states and then interviewed representatives of 108 firms that were involved at these sites. We collected information from these firms on their investigation and remediation (IR) and transaction costs, the history of involvement at the site, firm size, and type of business. In this section we first describe how we categorized costs and then describe our survey approach, sample selection, response rates, and the characteristics of the sample.

Measuring Expenditures

We measured both a firm's internal and external costs. Internal costs cover the time spent by firm staff attending PRP committee meetings, negotiating with EPA or other PRPs, collecting information about the firm's involvement, and in some cases, overseeing or conducting cleanup activities. We asked the firms to provide costs of internal staff time attributable to a specified Superfund site, including the value of fringe benefits. Some firms did this directly, others gave us the number of full-time equivalent staff by year and the average salaries of the different categories of personnel, from which we calculated internal costs. Internal costs are broken down into legal and nonlegal costs and then further broken down into the categories presented in Figure 2.1.

External costs refer to all payments to parties outside the firm. We first asked firms to break down their costs by the destination of the payment—whether to government, to a PRP committee, or directly to an outside firm. PRP committee payments and payments to outside firms are in turn broken down into the same categories as used for internal costs (see Figure 2.2).

Defining Transaction Costs

Transaction costs, unlike investigation and remediation costs, do not contribute directly to the cleanup process; instead, they are incurred in the process of assigning financial liability. It is sometimes difficult to separate expenditures into IR and transaction costs. Legal costs are generally transaction costs, but nonlegal costs can be either. For example, engineering studies to characterize the waste at a site are transactional if their purpose is to assist in the search for

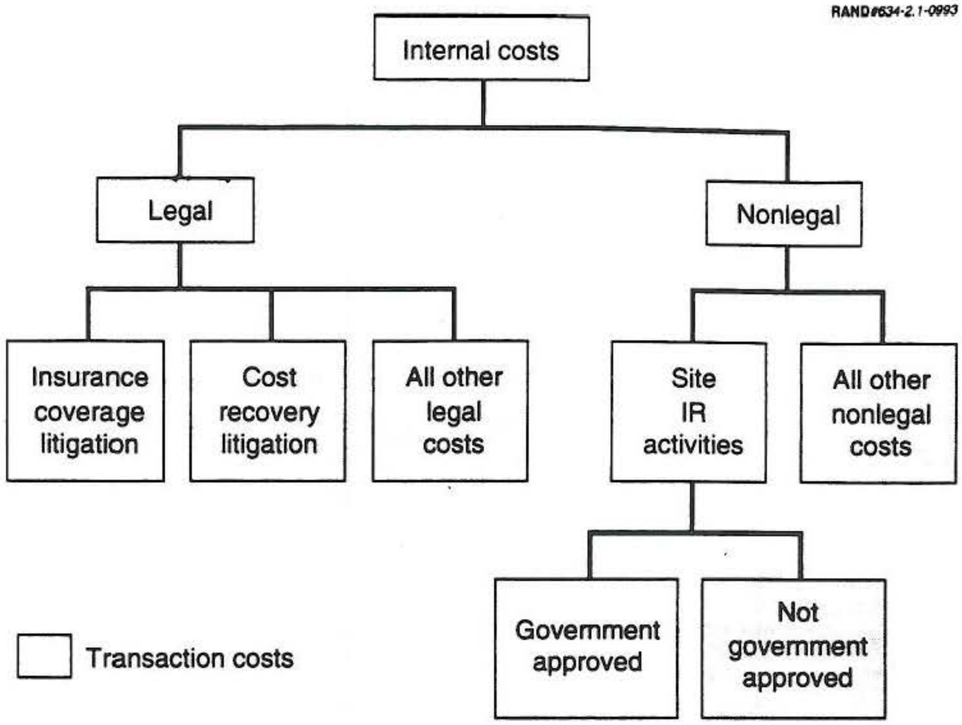

Figure 2.1—Categorization of Internal PRP Costs

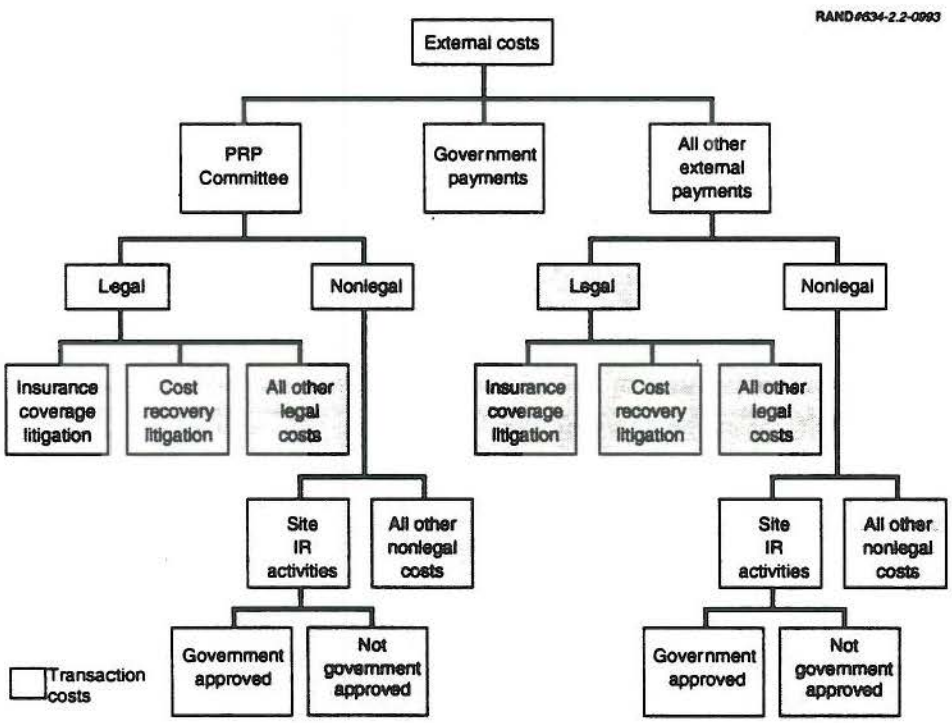

Figure 2.2—Categorization of External PRP Costs

another PRP or to contest a remedy chosen by EPA (e.g., a duplicate Remedial Investigation and Feasibility Study [RI/FS]). On the other hand, engineering studies are IR if they contribute to a better understanding of how to clean up the site.

Figures 2.1 and 2.2 illustrate how we broke down internal payments, external direct payments, and payments to PRP committees into IR and transaction costs. We classified nonlegal expenses as transaction costs if the activity did not have some sort of government approval. This might be by a consent decree, an administrative order, or some other type of agreement. Activities done without an agreement are likely to duplicate government efforts. In such situations, one of the two activities is not necessary to the cleanup process, and we arbitrarily classified the PRP payments in such cases as transaction costs.

We classify payments made directly to the government as IR costs, although it is not known whether the government spends the money on IR or transaction costs. From the perspective of PRPs, these payments represent settlements for some or all of their cleanup liability and are not transaction costs. To determine the total societal resources spent on transaction costs, government transaction costs must be included; however, this is beyond the scope of this study.

The share of transaction costs in total expenditures is defined as

$$\text{Transaction-cost share} = \frac{\text{Transaction costs}}{\text{Transaction costs} + \text{IR costs}}.$$

We exclude from our analysis expenditures related to lawsuits brought by residents or landowners living near a Superfund site for bodily injury or property damage. Although the costs related to these lawsuits are potentially substantial, they are not directly related to site cleanup and could have occurred under federal and state tort law in the absence of Superfund. Consequently, we do not treat them as resulting from Superfund's liability-based approach.[1]

Survey Design

We developed a combination telephone/in-person survey. Firms were initially contacted by telephone and then either interviewed over the phone or in person, depending on the size of their expenditures at a specified NPL site. The survey protocol is described in Appendix A. All data were collected under conditions of

[1]We did collect information on these lawsuits from the PRPs in the study and found that they amount to less than 5 percent of overall outlays.

strict confidentiality; consequently, we identify neither the firms nor sites in the study.

We stratified our PRP sample by site. To do this we first chose a sample of sites, assembled PRP lists for those sites, and then selected a sample of firms at each site. Another approach would have been to randomly select firms from a list of all PRPs across the nation, but no such list exists.[2] In the following paragraphs we first discuss how we selected sites for the study and then how we selected PRPs at those sites.

Site Selection

We chose 18 sites spread across five EPA regions and seven states. We first chose five EPA regions and then chose seven states in those regions. The 18 sites were drawn from a list of eligible sites in the states. We limited our study sites to seven states because this reduced travel costs since the sites were clustered geographically. Limiting our attention to 5 of the 10 EPA regions also reduced costs because it required establishing contacts with fewer regional Superfund branches. These cost reductions allowed us to include more sites and firms in our sample given our fixed budget.

We chose the five regions to ensure both geographic diversity and possible variation in EPA implementation approach.[3] The regions selected are on the West Coast (region 9), in the North and Midwest (region 5), on the East Coast (regions 2 and 3), and in the South and Southwest (region 6). A map of the EPA regions is included as Figure 2.3.

We randomly selected states from the five regions subject to several requirements. First, since we wanted the state to have a sufficient number of sites to pass the screening process described below, we restricted our attention to states with more than 15 NPL sites. This reduced the number of eligible states in the five regions from 22 to 14. Second, since we could choose only a few states and most states have an active state cleanup program, we chose only states with active cleanup programs.[4] This further reduced the number of eligible states to 13.

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[2]EPA's Site Enforcement Tracking System (SETS) database contains a partial list of PRPs.

[3]Church et al., 1991, have suggested that EPA implementation varies across regions.

[4]In 1989, 23 states (46 percent) had more than 15 sites on the NPL. We considered a state to have an active cleanup program if it had fund and enforcement capabilities, a cooperative agreement with EPA, and more than 10 employees in the cleanup program. In 1989, 37 states had fund and enforcement capabilities, 44 had cooperative agreements with EPA, and 38 had more than 10 employees in the cleanup program (EPA, 1989). Overall, 32 states have active cleanup programs. In our sample of five regions, 16 of the 22 states (73 percent) had active cleanup programs.

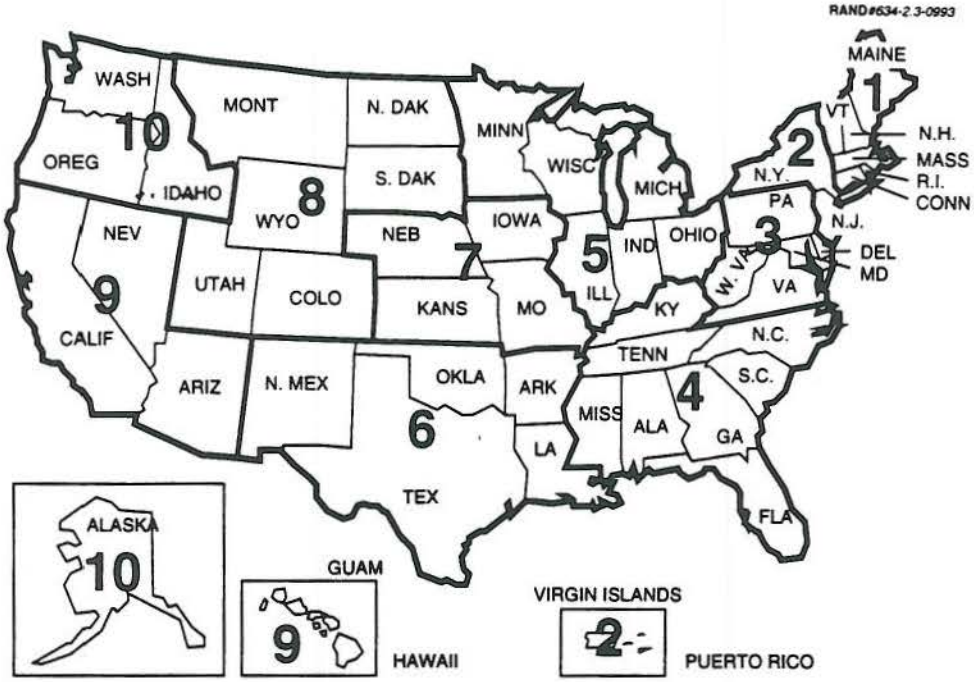

Figure 2.3—EPA Regions

There are 331 NPL sites in the seven selected states. Balancing cost and diversity led us to choose 18 of these sites. Increasing the number of sites increases diversity but also increases study costs (or lowers the number of firms we can sample with a fixed overall budget) because a list of PRPs and volumetric shares must be assembled at each site. Also, increasing the number of sites will likely increase the geographic dispersion of the PRPs and increase travel costs.

Because we were interested in overall private-sector expenditures, we attempted to avoid sites with minimal private-sector PRP expenditures. We therefore randomly selected the 18 sites from the sites that

- Were not federal facilities. These are predominately Department of Defense and Department of Energy sites that have no or limited private-sector involvement.
- Were listed as final on the NPL and had a Record of Decision (ROD) for at least one operable unit by September 1990.[5] This excludes sites that have not

[5]The ROD details the choice of cleanup technology and cleanup plan and certifies that the selection process followed relevant statutory and regulatory guidelines.

progressed very far through the cleanup process and thus are unlikely to have large private-sector expenditures.

- Were not solely government financed. The government may later attempt to recover its costs at such sites from the PRPs but so far has infrequently done so.
- Had total estimated cleanup costs greater than $2 million (not including transaction costs). PRP expenditures at smaller sites are unlikely to make up a large proportion of overall PRP costs.
- Did not contain more than 90 percent municipal waste. This excludes sites where all or almost all of the waste was generated by municipalities. The private-sector costs at these sites are also expected to be low.

Since we could choose only a limited number of sites, we also excluded types of sites that were unrepresentative of most sites on the NPL:

- Notorious sites.
- Extremely diffuse groundwater basins.
- Sites where universities or GOCOs (contractors at government-owned, contractor-operated facilities) generated more than 90 percent of the waste.

We also excluded sites primarily contaminated with asbestos because these sites are complicated by ongoing asbestos litigation.

Forty-six of the 331 sites remained after the screens were applied.[6] The federal facility, NPL final listing, ROD, and government financing criteria eliminated the largest number of sites (240 of 331). The number of sites eliminated by each criterion is detailed in Appendix A. The 18 study sites were then randomly selected from the 46 eligible sites.

Tables 2.1 and 2.2 characterize the study sites. Table 2.1 compares characteristics of the study sites with the eligible sites. Sites are characterized by the number of PRPs that sent waste to the site, current financing, cleanup stage, estimated total cleanup cost, and origin of waste. While the study sites resemble the eligible sites in the seven states, they do not necessarily reflect the characteristics of all sites in the seven states nor of all sites on the NPL. This is because we have excluded sites we have reason to believe have low private-sector costs to date.

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[6]We assembled the information necessary for this screening process from EPA's Comprehensive Environmental Response, Compensation, and Liability Information System (EPA, 1991b) and telephone interviews with EPA regional project managers.

Table 2.1

Characteristics of Study and Eligible Sites

Characteristic	Study Sites		Eligible Sites	
	Sites	Percent	Sites	Percent
Total	18	100	46	100
Number of PRPs				
One	1	6	5	11
Two to 50	8	44	25	54
More than 50	9	50	16	35
Current financing				
Mixed[a]	2	11	11	24
PRP only	16	89	35	76
Current cleanup stage				
Remedy selected	0	0	7	15
Remedy design	6	33	13	28
Cleanup ongoing	10	56	23	50
Construction complete	2	11	3	7
Estimated total cleanup cost[b]				
Less than $50 million	15	83	38	83
$50 million or greater	3	17	8	17
Origin of waste				
Off-site[c]	9	50	NA	—
On-site	9	50	NA	—

[a]Sites currently financed by both the government and PRPs.

[b]Does not include transaction costs.

[c]The waste was not generated at the site. Examples are municipal and industrial landfills.

NA = not available.

Table 2.2

Study Sites Classified by Type of Facility

Type of Facility	Sites	Percent
Industrial	6	33
Waste management	7	39
Recycling	3	17
Nonfacility	2	11
Total	18	100

As an illustration, preliminary findings of a study at Resources for the Future characterizing the NPL indicate that approximately 15 percent of all NPL sites have more than 50 PRPs.[7] In contrast, 50 percent of our study sites and 35 percent of the eligible sites have more than 50 PRPs. This discrepancy may be explained, for example, by our exclusion of sites with expected cleanup costs less than $2 million—it seems likely that these sites do not have large numbers of PRPs. Our study sites are selected to be representative of those that have generated the bulk of private sector costs to date, not all sites on the NPL.

Table 2.2 classifies sites by type of facility. We adopt the classification used in on-going work at Resources for the Future: industrial facilities, waste management facilities, recycling facilities, and nonfacilities.[8] Industrial facilities are sites where contamination resulted from industrial activity on the site. Examples include wood processing and pesticide production. Waste management facilities include commercial waste management sites, municipal landfills, and co-disposal landfills where municipal and industrial wastes were disposed of together. Examples of recycling facilities are lead battery recyclers and oil recyclers. Finally, sites that do not fit into any of the preceding categories are classified as nonfacilities. These include sites where waste was illegally disposed, airports, and railroad yards.

The distribution in Table 2.2 is similar to that found by Resources for the Future at all NPL sites. Their preliminary findings are that 37 percent of NPL sites are industrial facilities, 36 percent are waste management facilities, 8 percent are recycling facilities, and 19 percent are nonfacilities.[9]

PRP Selection

EPA regional project managers provided us with the agency's most recent listing of the PRPs at each study site and, when available, the volumetric share of each PRP. We used this information to select a sample of PRPs for the study. Since we had already collected data from firms with annual revenues of over $20 billion in our previous study, we excluded very large firms from this study. We excluded firms on the *Fortune 100* list of industrial firms and firms that we were able to determine had annual sales greater than $3 billion.[10] Since our focus is

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[7]Probst, 1993, p. 5. Percentage based on the sites for which the number of PRPs could be determined.

[8]Probst, 1993, p. 3.

[9]Probst, 1993, p. 3.

[10]Annual sales are approximately $3 billion for the smallest firm on the *Fortune 100* list.

private-sector expenditures, we also excluded federal, state, and local government agencies.

We then selected 251 firms from the approximately 3600 PRPs at these sites.[11] In some cases we did not know a firm's sales until well into the data collection process. Several such firms had annual revenues between $3 billion and $20 billion, and we kept them in the analysis; however, very large firms remain underrepresented in our sample.

We wanted to capture a large share of the overall PRP expenditures at a site, and initial conversations with the EPA regional project managers (RPMs) and PRPs indicated that the smallest volume contributors at a site frequently have few or no expenditures. Therefore, we oversampled firms with larger volumetric shares. The particulars of our sampling approach are detailed in Appendix A.

Response Rate

Twenty-one of the 251 sampled firms (8 percent) could not be located, were out of business, or said they were not involved at the site. One-hundred-eight (108) of the remaining firms participated in the study, resulting in a response rate of 47 percent. Firms declined to participate for various reasons. The most common reason given was the time and cost necessary to assemble information about activities that went back up to 10 years. Some firms also declined to participate because of the sensitive nature of the data. (See Appendix A for a tabulation of the reasons firms declined to participate.)

The possible biases introduced by this relatively low response rate are many. For example, many firms indicated that they were taking the time to participate because of frustration with the expense, inefficiency, and pace of the Superfund program. Thus, we might expect participating firms to have higher transaction costs and transaction-cost shares than nonparticipating firms, other things being equal. This would cause our estimate of the combined transaction costs and transaction-cost share of sampled and nonsampled firms to be too high. Conversely, a number of firms decided not to participate because they were involved in particularly contentious litigation and were concerned about confidentiality. This might cause participating firms to have lower transaction costs and transaction-cost shares than nonparticipating firms, other things being equal. Our estimates of the level and share of transaction cost would then be too

[11] Some firms were at several of the study sites. We collected information on the site for which they were drawn and, if the firm was willing, at the other study sites where it was involved. These additional observations are included in the sample.

low. Finally, the amount of time required to participate in the study for firms with little or no expenditures was minimal. Thus, these firms may be more likely to participate than firms with large outlays. This would cause our estimates of firm expenditures to be too low. Later we will see that firms with larger expenditures tend to have lower transaction-cost shares; so it may be that an overrepresentation of firms with low expenditures may cause our estimate of transaction-cost share to be too high.

Given these conflicting factors, the size, and even the sign, of the bias introduced by the relatively low response rate is uncertain.

Characteristics of Participating Firms

Firms of different sizes are represented in the sample. Table 2.3 reports the number of firms in the sample and the number of firms with total expenditures of over $1000 categorized by 1991 annual sales revenues.

The industries represented by our sample are shown in Table 2.4.[12] Sixty-nine percent of the firms are in manufacturing, concentrated in the chemical and metal products industries. Other industries represented are building and heavy construction, wholesale trade, and utilities.

Table 2.3

Size and Volumetric Shares of Sampled Firms

1991 Annual Revenues (millions of dollars)	Number of Firms	Number of Firms with Expenditures > $1,000
Less than $15	53	24
$15–100	19	14
$100–1,000	13	10
$1,000–20,000	23	20
Total	108	68

[12]Firms are classified by two-digit Standard Industrial Classification (SIC) code.

Table 2.4

Industrial Classification of Sampled Firms with Expenditures Greater than $1000

Industry	Number of Firms	Percent of Total
Construction	3	4
Wholesale trade	6	9
Manufacturing	47	69
Chemicals and allied products	15	22
Primary and fabricated metal products	12	18
Electronic and other electric equipment	7	10
Other manufacturing	13	19
Electric, gas, and sanitary services	4	6
Other and unknown	8	12
Total	68	100

NOTE: Based on two-digit SIC codes.

3. Size and Composition of Firm Expenditures

This section presents our findings on the expenditures of firms and the breakdown of these expenditures into IR and transaction costs. We report how the ratio of transaction costs to total costs, or transaction-cost share, varies with firm size and compare the findings with our previous work. We also examine the composition of IR and transaction costs and report on the interaction of the firms with their insurers.

Size and Composition of Expenditures at Sampled Firms

The 108 firms in our sample spent $134.1 million between 1981 and 1991 at the 18 study sites.[1] As reported in Table 3.1, transaction costs amount to 21 percent of the total with the remainder for site IR.

IR expenditures jumped dramatically in 1986 because of large remedial payments at several sites, and fell thereafter (see Figure 3.1 and Table 3.2). Transaction costs rose through 1987 and then leveled off. The result was that after hitting a low of 9 percent in 1986, annual transaction-cost share generally rose through 1991 to 34 percent (see Figure 3.2).

Table 3.1

IR Costs, Transaction Costs, and Transaction-Cost Share Between 1981 and 1991

	(millions of dollars)	Share of Total (percent)
Transaction Costs	27.7	21
IR Costs	106.4	79
Total	134.1	100

[1] Includes both external outlays and the salary and benefit costs of firm employees. Throughout this report, all expenditures have been converted to 1991 dollars using the GDP deflator.

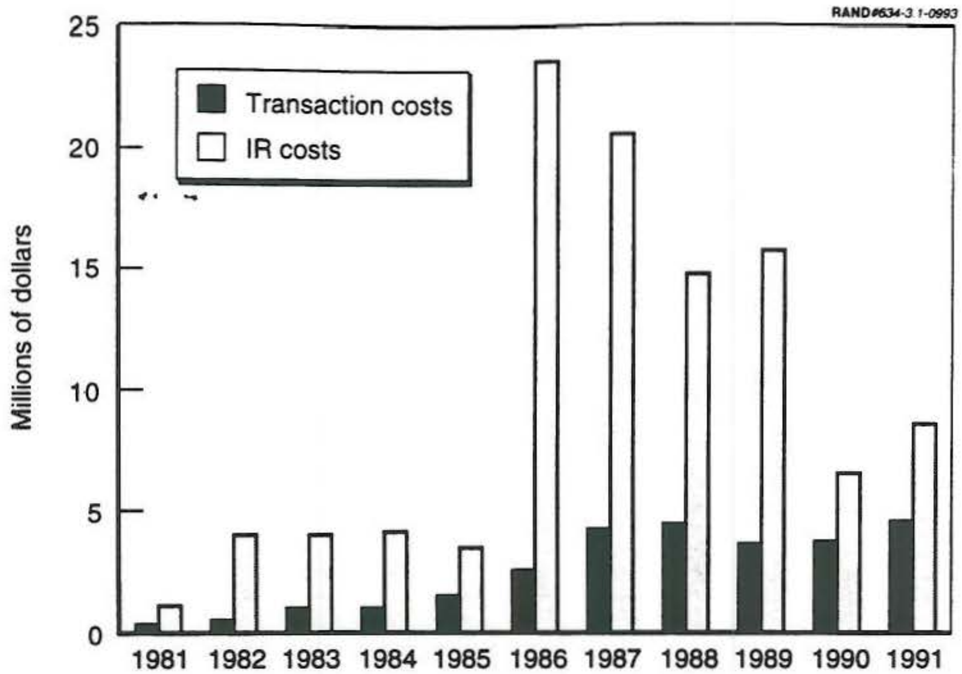

Figure 3.1—Annual IR Costs Compared with Transaction Costs

Table 3.2

Annual Expenditures and Transaction-Cost Shares

Year	Transaction Costs (thousands of dollars)	IR (thousands of dollars)	Total (thousands of dollars)	Transaction-Cost Share (percent)
1981	419	1,098	1,517	28
1982	474	4,135	4,609	10
1983	843	3,995	4,838	17
1984	1,023	4,154	5,176	20
1985	1,610	3,513	5,123	31
1986	2,455	23,709	26,164	9
1987	4,155	20,631	24,786	17
1988	4,529	14,989	19,518	23
1989	3,901	15,372	19,273	20
1990	3,821	6,319	10,140	38
1991	4,429	8,513	12,943	34
Total	27,659	106,428	134,087	21

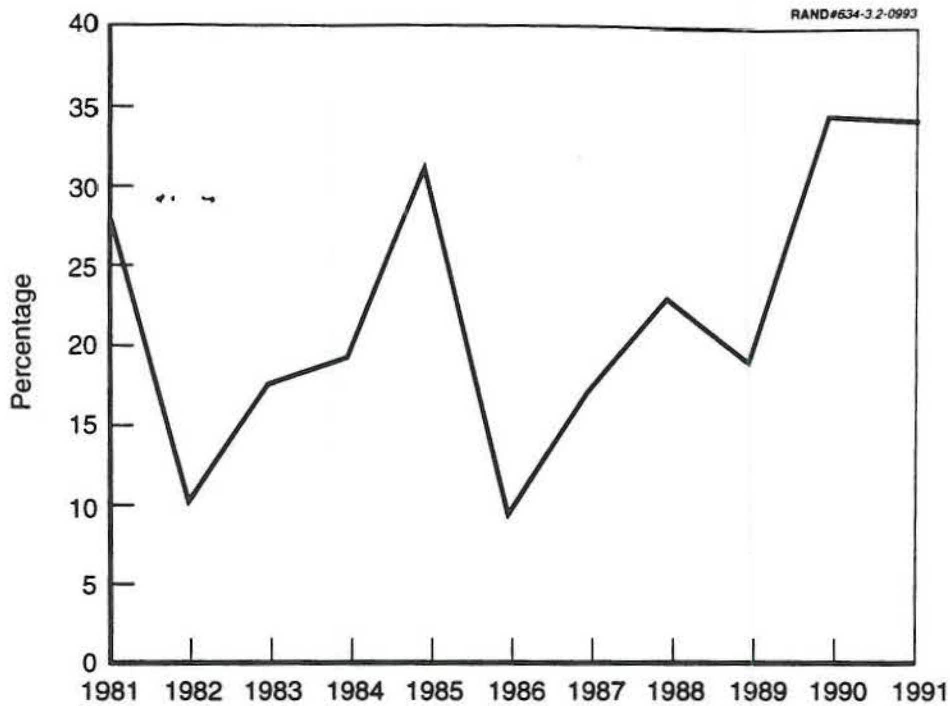

Figure 3.2—Annual Transaction-Cost Share

Both expenditures and transaction-cost shares vary a great deal across firms. A sizable proportion of the firms spent very little. As can be seen by comparing the entries in the last line of Table 2.3, 40 firms (31 percent) spent less than $1000 each.[2] At the other extreme, 7 firms averaged $14.7 million in expenditures and account for 77 percent of total expenditures. The share of transaction costs in total costs varies across the sampled firms from less than 5 percent to 100 percent. A high proportion of the firms have very high transaction-cost shares—over 50 percent of the firms with expenditures over $1000 have transaction-cost shares greater than 60 percent (see Figure 3.3). But while transaction costs exceed IR costs for over half of the firms in our sample, large IR payments by a few firms cause the share of transaction costs in overall expenditures to be much lower (21 percent).

[2]These firms are treated as though they had zero expenditures in our analysis. The maximum the expenditures of these firms could be is $31,000, which is negligible compared with the $135.2 million spent overall.

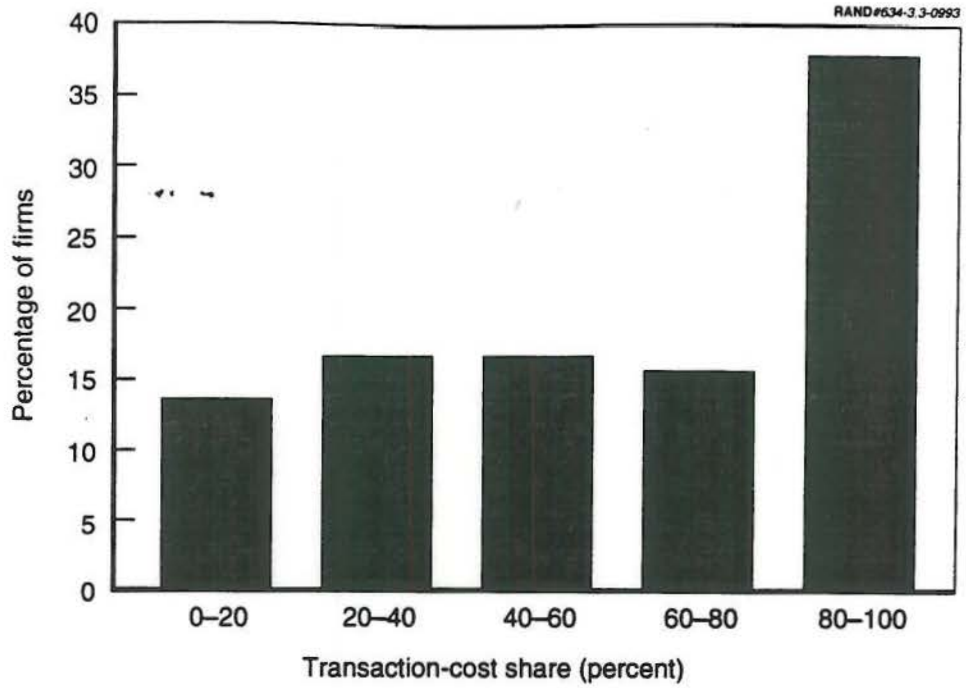

Figure 3.3—Distribution of Transaction-Cost Share for Firms with Expenditures Greater than $1000

Variation in the Size and Composition of Outlays by Firm Size

The size and composition of outlays varies a great deal by firm size. As shown in Table 3.3, average outlay per firm increases with firm size, as measured by 1991 gross revenues. In contrast, transaction-cost shares are substantially lower for larger firms. Transaction-cost share is 60 percent for firms with revenues less than $100 million, 15 percent for firms with revenues between $100 million and

Table 3.3

Average Outlays and Transaction-Cost Shares by Firm Size

1991 Annual Revenues (millions of dollars)	Number of Firms	(thousand of dollars) IR Costs	Transaction Costs	Total	Transaction-Cost Share[a] (percent)
Less than $15[b]	53	19	29	48	60
$15–100	18	96	148	245	60
$100–1,000	14	1,905	347	2,252	15
$1,000–20,000	23	3,349	809	4,158	19
All firms	108	985	256	1,241	21

[a]Dollar-weighted transaction-cost share.

[b]$15 million was chosen as cutoff for the smallest firm-size category because this is the figure used by the Small Business Administration to define a small business.

$1 billion, and 19 percent for firms with revenues between $1 billion and $20 billion. While the transaction-cost shares of the smaller firms are quite high, they do not account for a large proportion of the overall expenditures in our sample.

The transaction-cost shares for firms with annual revenues over $100 million are similar to those we reported in our previous study for very large industrial firms. In the earlier study, we found that the transaction-cost share for five firms with annual revenues over $20 billion averaged 19 percent at 49 NPL sites between 1984 and 1989.[3]

The differences in transaction-cost share across firms may not be due to firm size. Rather, they may be caused by other factors, such as the firm's volumetric share at the site, that are correlated with firm size. In Section 4, we will investigate what explains the large variation in expenditures and transaction-cost share across firms.

Composition of IR Costs

Table 3.4 breaks down IR costs into RI/FS, remedial design and remedial actions (RD/RA), government payments, and those that could not be classified.[4] Of the nongovernment payments in our sample we are able to categorize, expenditures on RD/RA were approximately twice as large as those on RI/FS.

Government payments account for approximately 20 percent of overall IR costs, or almost 25 percent of the costs we are able to categorize. These are not

Table 3.4

Composition of IR Costs

Type of IR Cost	(millions of dollars)	Share of Total (percent)
RI/FS costs	20.0	19
RD/RA costs	40.2	38
Government payments	20.3	19
Unknown	25.9	24
Total	106.4	100

[3]As noted in Section 1, the 19 percent transaction-cost share includes costs attributed to sites as well as an adjustment for unattributed costs.

[4]An example of expenditures that could not be classified is a PRP settlement payment to a trust fund that could have been used either for an RI/FS or RD/RA.

transaction costs from the point of view of the firms, but the government may spend some of these revenues on enforcement or other transaction costs. EPA currently spends about 15 percent of its $1.5 billion Superfund budget on enforcement—a transaction cost in our classification of costs,[5] but there are no good estimates of the overall share of transaction costs in EPA outlays or those of state and local governments. A full accounting of the transaction costs generated by the Superfund program must include government transaction costs, but this is beyond the scope of this study.

Composition of Transaction Costs

As shown in Table 3.5, almost two-thirds of transaction costs are for legal services. These represent the cost of in-house attorneys and legal staff and payments made to law firms. One-third of the transaction costs pay for nonlegal staff and outside consultants who negotiate with other PRPs, EPA, or insurers over liability (labeled "All other nonlegal" in Table 3.5 and Figures 2.1 and 2.2). Firms did not perform much duplicative RI/FS or similar technical work. Only 2 percent of transaction costs fell in this category.

Both the high proportion of transaction costs that are legal and the low proportion for duplicative site studies are consistent with our findings for the very large industrial firms. For those firms, we found that three-quarters of transaction costs were legal costs. We were only able to put an upper bound on the proportion that went to duplicative site studies (25 percent), but we conjectured that the actual figure was much lower.[6]

Table 3.5

Composition of Transaction Costs

Type of Transaction Cost	(millions of dollars)	Share of Total (percent)
Legal	17.9	65
All other nonlegal	9.2	33
Duplicative site studies	0.5	2
Total	27.6	100

[5]EPA, 1992b, p. IV-2.

[6]Acton and Dixon, 1992, p. 42.

Insurance Litigation and Receipts from Insurers

PRPs can file claims with their insurance carriers for reimbursement of legal and IR costs. However, as discussed in Section 1, insurers dispute whether their policies cover these claims. Somewhat over one-third of the firms with expenditures over $1000 had spent money on coverage disputes, with expenditures totaling $1.7 million (see Table 3.6). While this comes to an average of $68,000 per firm engaged in disputes, it represents only slightly more than 1 percent of the overall expenditures of the firms in our sample.[7]

Few firms had received reimbursements from insurers. Twelve percent of the firms in our sample had received reimbursement, either for IR costs or legal costs. While few in number, the total reimbursements were over six times as large as the total outlays for coverage disputes. Total reimbursements come to $10.6 million or about 7.8 percent of total outlays.[8]

Table 3.6

Insurance Coverage Disputes and Insurer Reimbursement for Firms with Expenditures over $1000

	Share of Firms Incurring Costs or Receiving Reimbursements (percent)	Total Costs or Reimbursements (thousands of dollars)
Insurance coverage disputes	37	1,704
Insurer reimbursement	12	10,548

Variation in Coverage Dispute Costs and Reimbursements by Firm Size

It appears that larger firms are more likely to incur costs on coverage disputes than smaller firms are (see Table 3.7). This may be either because larger firms are more likely to have insurance policies or because larger firms are more likely to pursue reimbursement given that they have policies. Expenditures per firm on coverage disputes also appear to rise with firm size. Firms with annual revenues

[7]In our previous study we found that insurers spent $184,000 per coverage dispute between 1986 and 1989 (Acton and Dixon, 1992, p. 25).

[8]Insurers are often directly billed by law firms for legal costs on behalf of the insureds. These costs are usually unknown to the insureds and are not included here. Consequently, the overall proportion of private sector expenditures at the study sites borne by insurers will be greater than 7.8 percent.

Table 3.7

Share of Firms with Coverage Disputes and Average Cost per Firm for Firms with Expenditures over $1000

1991 Annual Revenues (millions of dollars)	Share of Firms (percent)	Average Costs per Firm (thousands of dollars)
Less than $15	25	1
$15–100	29	11
$100–1,000	50	17
$1,000–20,000	50	67

between $1 billion and $20 billion spend an average of $67,000 on coverage disputes while those with revenues less than $15 million spend $1000 on average.

Larger firms were also more likely to receive insurer reimbursements than smaller firms. As seen in Table 3.8, the percent of firms receiving reimbursement was 8 and 7 percent for the smaller firm-size categories and 20 and 15 percent for the larger categories. Likewise, receipts per firm rise with firm size. We do not find a monotonic correlation between firm-size and the percent of overall outlays reimbursed by insurers. Reimbursements are 15 percent of outlays for firms with annual revenues less than $15 million, fall to 1 or 2 percent for firms with revenues between $15 million and $1 billion, and rise to 11 percent for firms with revenues over $1 billion.

Table 3.8

Share of Firms Receiving Insurer Reimbursement and Average Reimbursement for Firms with Expenditures over $1000

1991 Annual Revenues (millions of dollars)	Share of Firms (percent)	Average Receipts per Firm (thousands of dollars)	Total Outlays (percent)
Less than $15	8	16	15
$15–100	7	6	2
$100–1,000	20	41	1
$1,000–20,000	15	483	11

4. Variation in Transaction Costs Across Sites and Firms

In this section, we investigate how firm expenditures and transaction-cost shares vary with site and firm characteristics. In particular, we are interested in whether expenditures and transaction-cost share vary with firm size when other site and firm characteristics are held constant.[1] We are particularly interested in how the level and composition of expenditures vary with cleanup phase. In addition, we investigate how expenditures and transaction-cost share vary with a firm's volumetric share, expected site cleanup costs, the number of PRPs at the site, whether or not there is municipal involvement, and whether or not the sites have been partially government financed. We first describe the characteristics used in the analysis, discuss the methodology, and then present our findings.

Characteristics Used in the Analysis

Table 4.1 reports the number of site-firm pairs, the number of sites represented, and the average expenditures per pair broken down by the site and firm characteristics used in the analysis. It also reports these statistics by the cleanup phase. The characteristics used in the analysis will be described shortly.

Each site-firm pair represents the expenditures of a firm at a particular site. Note that at 112, the number of site-firm pairs is larger than the number of firms in our sample (108) because a few firms have expenditures at more than one of the study sites. We report both the dollar-weighted transaction-cost share and the simple average transaction-cost share. The dollar-weighted transaction cost share is the ratio of the total transaction costs in a particular category to total outlays in that category. It indicates what portion of the total resources spent in a particular category go to transaction costs. The simple average transaction-cost share weights the transaction-cost share of each observation equally. It is most appropriate in predicting what the transaction-cost share will be for an observation drawn at random from a category. Note that the average firm

[1] The tabulation of transaction-cost share by firm size in Table 3.3 does not hold constant other firm and site characteristics; consequently, the differences in transaction-cost share reported there may be partly due to variation in characteristics that are correlated with firm size.

Table 4.1

Expenditures and Transaction-Cost Share of Sampled Firms by Site and Firm Characteristics

Characteristic	Number of Site-Firm Pairs[a]	Number of Site-Firm Pairs with Expenditures > $1000	Number of Sites Represented	Average Expenditures per Site-Firm Pair (thousands of dollars)[b]	Transaction-Cost Share (percent)	
					Dollar-Weighted	Simple Average[c]
All site-firm pairs	112	72	18	1,197	21	62
Site characteristics						
Expected IR cost						
< $20 million	65	35	12	508	22	70
$20–75 million	29	22	3	1,570	27	55
> $75 million	18	15	3	3,086	14	44
Number of PRPs						
< 16	11	8	6	6,341	11	38
16–100	21	14	4	2,118	28	68
> 100	80	50	8	249	37	62
Municipal involvement						
Yes	37	30	4	489	32	48
No	75	42	14	1,547	19	69
Financing						
PRP/fund	81	52	13	913	17	60
PRP only	31	20	5	1,940	25	61

Table 4.1—continued

Characteristic	Number of Site-Firm Pairs[a]	Number of Site-Firm Pairs with Expenditures > $1000	Number of Sites Represented	Average Expenditures per Site-Firm Pair (thousands of dollars)[b]	Transaction-Cost Share (percent) Dollar-Weighted	Simple Average[c]
Firm characteristics						
Firm revenues						
< $15 million	53	24	14	48	60	74
$15–100 million	18	14	7	245	60	69
$100–1,000 million	15	11	8	2,102	15	42
$1–20 billion	26	23	14	3,680	19	49
Volumetric Share						
≤ 1 percent	82	48	14	136	55	64
1–20 percent	23	17	10	817	45	65
> 20 percent	7	7	6	14,888	13	27
Cleanup phase[d]						
Phase 1	105	18	18	23	48	76
Phase 2	112	71	18	733	26	65
Phase 3	42	23	9	1,180	11	41

[a] A few of the 108 firms in our sample are involved at more than one study site. This brings the total number of site-firm pairs to 112.

[b] Based on all site-firm pairs.

[c] Based only on site-firm pairs with expenditures greater than $1000.

[d] Since sites may have gone through several phases, the number of site-firm pairs under cleanup phase need not sum to 112.

transaction-cost share for the firms in our sample is 61 percent. The dramatic difference between this number and the dollar-weighted transaction-cost share (21 percent) again illustrates the fact that large IR expenditures by a few firms drive the overall transaction cost number.[2] We now describe the characteristics used in the analysis.

Site Characteristics

Expected Site IR Cost. We categorize sites according to the expected total of RI/FS and RD/RA costs for all operable units[3] as estimated by the EPA RPM for the site. It is likely that these costs are based on RODs when they exist and on preliminary site assessments and studies when they do not.[4] These estimates do not include transaction costs. Because in most cases these are only rough estimates, we grouped sites into three categories: those with expected cleanup costs less than $20 million, those with costs between $20 million and $75 million, and those with costs over $75 million. We chose these categories based on break points in the data. While we are not very confident in the point estimates of site expected cleanup costs in many cases, we have greater confidence that actual costs will fall in the relevant ranges. As reported in Table 4.1, we have 65 site-firm pairs at sites with expected cleanup costs less than $20 million, 29 at sites with expected cleanup costs between $20 million and $75 million, and 18 observations at sites with expected costs greater than $75 million.

Number of PRPs. This is the number of PRPs that may potentially be held liable for cleaning up the site. These firms may be generators, transporters, owners, or operators at the site. PRPs are included whether or not they are viable and whether or not they have been notified of their involvement either by the government or other PRPs. This number is based on discussion with the RPM and PRPs involved at the site. Again, because of uncertainty about the exact number of PRPs at a site, we report only three distinct categories.

Based on the distribution of the number of PRPs at the 18 study sites, we break sites into three categories: those with 15 or fewer, those with 16 to 100, and those with more than 100.

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[2]This is consistent with our findings on the variation of transaction-cost shares across sites for very large industrial firms (Acton and Dixon, 1992).

[3]Operable units designate particular areas of the site or one component of the remedy when EPA chooses to proceed with the cleanup in stages.

[4]These estimates are probably in current dollars (1991) and do not include discount factors for the real rate of interest.

Municipal Involvement. Thirty-seven of the 112 site-firm pairs were firms at sites where municipalities were involved but accounted for less than 90 percent of the waste sent to the site (recall that our sample excludes sites with more than 90-percent municipal waste). The municipality may have been a generator, transporter, owner, or operator.

Financing. We classify sites according to whether or not the government has funded any site work, either RI/FS or RD/RA. Sites where cleanup has been financed both by the government and the PRPs are called PRP/Fund-financed; those financed only by the PRPs, PRP-financed.[5]

Firm Characteristics

Firm Size. As discussed in Section 2, we classify firms according to their 1991 gross revenues.

Volumetric Share. The amount of waste sent to a particular site usually varies significantly across the PRPs involved at the site. We categorize the PRPs according to the percent of waste (volumetric share) each contributed to the site: those with volumetric share less than or equal to 1 percent, those with shares greater than 1 and less than or equal to 20 percent, and those few firms with volumetric shares greater than 20 percent.[6] We chose 1 percent as a breakpoint because it often is used by EPA to determine which PRPs qualify for *de minimis* settlements.

Cleanup Phase

We divide the cleanup process at a site into three phases using EPA's Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database.[7] Phase 1 covers the period from site discovery to the first start of an RI/FS at any operable unit. Phase 2 covers the period from the start of the first RI/FS to the start of the first RA. All subsequent time falls in Phase 3. The phase definitions are summarized in Table 4.2.

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[5]The government can also entirely finance the cleanup at a site and then recover costs from the PRPs later. As explained in Section 2, since relatively few such sites have begun cost recovery, we expect few PRP expenditures at such sites and excluded them in site selection.

[6]For owners, operators, and transporters, volumetric share is not well defined. Our experience indicates that these parties often do not have large expenditures because they can no longer be found or have limited assets. We classified the few owners, operators, and transporters in our sample according to the share of the cleanup costs they will likely bear based on interviews with PRPs at the site.

[7]EPA, 1991b.

Table 4.2

Phase Definitions

Phase	Starts When	Ends When
Phase 1	Site discovered	First RI/FS begins
Phase 2	First RI/FS begins	First remedial action begins
Phase 3	First remedial action begins	—

All the sites in our study have at least entered or passed through Phase 2; thus we have 112 site-firm observations in Phase 2. The RI/FS at two sites in our sample started in 1981, the first year for which we collected costs. Consequently, we have no Phase 1 observations for these sites, and the total number of site-firms pairs with expenditures in Phase 1 is 105 rather than 112. Likewise, because remedial action has not started at some sites, according to the EPA database, we have only 42 observations in Phase 3 (see Table 4.1). Observations on the same site-firm pair during multiple cleanup phases result in 259 overall site-firm-phase observations.

We found that a few firms undertook some cleanup even before the first RI/FS began at the site. For example, one firm cleaned up contaminated soil on its property that was contributing to pollution of the underlying aquifer. Consequently, we report some IR expenditures in Phase 1, even though the total is small (average firm expenditures are $23,000 in Phase 1 and the transaction-cost share is 48 percent). We also report sizable IR costs in Phase 2. These expenditures include RI/FS costs, but also include some RA payments. There are several reasons for this. First, Phase 2 expenditures include some cleanup expenditures begun in Phase 1. Second, we found a few cases where firms were pushing EPA to proceed more rapidly and started RA work before the RD was officially complete. This occurred at sites where there were few PRPs. Finally, we suspect that there are some delays in updating and errors in the EPA database and consequently that some of the sites in our study are actually in Phase 3 even though EPA reports that they have not finished Phase 2. We used this database because we wanted a consistent determination of phase across sites.[8]

[8] If, in the future, we attempt to extropolate our estimates to sites not in the sample, we would also need to use the EPA database.

Methods

We model IR and transaction costs by a firm at a site during a given phase as a function of the firm's total expected liability at the site, as a function of the phase, and as a function of the remaining site and firm characteristics included in Table 4.1. The firm's expected liability at the site is not entered directly in the model. Rather, it enters indirectly by including both site expected total cost and the firm's volumetric share. The product of volumetric share and expected site total costs is probably a good first cut at the overall IR costs that the firm might expect to pay.

The remaining firm and site characteristics introduce other factors that are possibly important in determining the firm's outlays. The number of PRPs at the site may influence time spent on negotiations and therefore transaction costs. As will be discussed in more detail below, municipal involvement may complicate the allocation of liability and affect both IR and transaction costs. A government decision to fund part of the remedy will also likely reduce firm expenditures to date, but this may be offset by cost recovery in the future. Firm size may affect firm outlays, holding other factors constant. For example, smaller firms may fight more vigorously to avoid large IR payments than large firms.

This model may not contain all the variables that would affect the firms' expenditures at a site. For example, the distribution of volumetric share across the firms at a site may also be important as perhaps might be the number of other sites at which a firm is involved. However, we think that this model does include the most important site and firm characteristics. Note that our model assumes that the effects of site and firm characteristics are the same across phases; this may introduce another source of error.

We statistically estimate separate relationships for IR and transaction costs. In the case of IR costs, we first estimate the probability that a firm will have positive IR expenditures during a given phase and then estimate the level of expenditures given that the firm has expenditures. The product of these two parts is the expected expenditure of the firm for one phase. Transaction costs are treated similarly. Collectively, we call the two two-part models the four-part model. Appendix B presents a technical explanation of these models and statistical estimates of the parameters and their standard errors.

The 259 site-firm phase observations used to estimate the four-part model are drawn from 18 sites and 108 firms. We assume that the errors in each part of the four-part model are uncorrelated within sites and firms, but statistical tests suggest this may not be the case. Correlation would tend to cause the estimated standard errors in each equation to understate their true values, but how it would affect predictions from the two-part models or the four-part model is unclear. Consequently, the findings of statistical significance and insignificance discussed below must be regarded as somewhat tentative—particularly those regarding the effects of site characteristics. In Appendix B, we discuss this issue in more detail and present correction factors that can be applied to the standard errors in each individual equation.

Findings on the Relation Between Transaction Costs and Site and Firm Attributes

Table 4.3 reports how a firm's IR cost, transaction cost, and transaction-cost share *per phase*[9] vary when one characteristic is changed and all other characteristics are held constant at a set of reference values.[10,11] We discuss the impact of each characteristic in turn.

Expected Site IR Cost and Firm Volumetric Share

Firms often pay IR costs at a site in proportion to their volumetric share; so taken together, a firm's volumetric share and expected cleanup cost suggest the firm's overall liability. As reported in Table 4.3, we find that IR expenditures during a given phase are much higher for firms with higher volumetric shares, when other factors are held constant. IR expenditures are over $14 million higher for a firm whose volumetric share exceeds 20 percent than for a firm whose share is less than or equal to 1 percent. As expected, IR costs also rise with total site cost. The differences from the reference category for both volumetric share and expected site cost are all statistically significant. We thus find that IR increases as a firm's expected liability increases.

We also expect transaction costs to rise with expected site cost and firm volumetric cost—the stakes and thus the expected return from contesting liability are higher. We do find that transaction costs rise as volumetric share and site expected total cost increase (see Table 4.3), but the increases are not as dramatic

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[9]In Section 5 we will present estimates that combine expenditures during all three cleanup phases.

[10]The site and firm characteristics we chose for reference values are arbitrary; they do not necessarily represent the "average" site or the "typical" firm. Expenditures in the reference category will vary with the particular set of reference values chosen.

[11]Because we have a highly nonlinear model, the differences between any two categories will depend on the reference category chosen. However, the sign of the difference between any two categories (positive or negative) will not be affected by what reference category is chosen.

Table 4.3

Predicted IR Costs, Transaction Costs, and Transaction-Cost Shares When One Attribute Is Varied and Others Are Held Constant

	Predicted IR Costs per Phase (in thousands of dollars)	Predicted Transaction Costs per Phase (in thousands of dollars)	Predicted Transaction-Cost Share (percent)
Site characteristics			
Expected IR cost			
< \$20 million	2[a]	3[a]	55[a]
\$20–75 million	11[a]	10	47
> \$75 million[c]	48	19	29
Number of PRPs			
1–15	344[a]	155[a]	31
16–100	502[a]	182[a]	27
> 100[c]	48	19	29
Municipal involvement			
Yes[c]	48	19	29
No	2[a]	5[a]	66[b]
Financing			
PRP/Fund	13[b]	18	57
PRP only[c]	48	19	29
Firm characteristics			
Firm revenues			
< \$15 million	5[a]	4[a]	46
\$15–100 million[c]	48	19	29
\$100–1,000 million	23	7	23
\$1–20 billion	43	28	39
Volumetric share			
≤ 1 percent[c]	48	19	29
1–20 percent	290[a]	96[a]	25
> 20 percent	14,399[a]	365[a]	3[a]
Cleanup phase			
Phase 1[c]	48	19	29
Phase 2	871[a]	226[a]	21
Phase 3	1,317[a]	122[a]	9

[a]Significantly different from reference at 5 percent. (Ninety percent confidence intervals are presented in Table B.3.)

[b]Significantly different from reference at 10 percent.

[c]Reference category.

as for IR costs. The difference between transaction cost per phase at sites with expected cleanup costs between \$20 and \$75 million and those with expected cleanup costs greater than \$75 million is smaller than for IR and no longer statistically significant.

The combined effect of the change in IR and transaction costs is that transaction-cost share drops when either expected site cost or firm volumetric share rise, other factors held constant. The share is 26 points lower for firms with volumetric share greater than 20 percent than for firms with shares less than or equal to 1 percent, and the difference is statistically significant. The estimated drop in transaction-cost share as site expected cost rises is also substantial, falling from 55 percent for sites with expected costs less than $20 million to 29 percent for sites with expected total costs greater than $75 million.

In the analysis that follows, we generally find that the level of transaction costs is less sensitive to variation in firm and site characteristics than IR costs. This suggests that transaction costs have a fixed component and a component that varies somewhat with site and firm characteristics. For example, a firm might want to more vigorously contest liability at a site where the stakes are higher, but the additional legal costs may not be that large. Changes in IR costs will thus generally more than offset the corresponding changes in transaction costs. As is the case for volumetric share, large IR payments dilute transaction costs and cause transaction-cost share to drop.

Cleanup Phase

IR costs, transaction costs, and transaction-cost share also appear to depend on the phase of the cleanup process. This has important implications for extrapolations of what the transaction-cost share will be when cleanup is complete at all the study sites.

IR costs rise in each successive phase of the cleanup process. IR costs are higher during Phase 2, which begins with the first RI/FS, than in Phase 1, and much higher still in Phase 3, which begins with RA at the first operable unit. This seems reasonable. The RA is the most expensive part of the cleanup process, and IR expenditures should be highest when remedial activity is under way. Transaction costs, on the other hand, peak in Phase 2 and drop in Phase 3. This suggests that, so far, PRPs have done most of their haggling over liability issues before RA has started.

The combination of these two patterns causes transaction-cost share to decrease as a site moves through the cleanup process. Relative to Phase 1, transaction-cost share is 8 percentage points lower in Phase 2, and 20 percentage points lower in Phase 3, although the differences are not statistically significant.[12]

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[12]There is a great deal of uncertainty in our estimates of transaction-cost share. This is in part because the four-part model does not capture possible correlation in the errors between the IR cost and transaction cost models.

These results suggest that the share of transaction costs in total costs to date is not a good estimate of what the transaction-cost share will be when cleanup is complete. We will explore these issues in Section 5.

Number of PRPs

We find that IR costs are higher for a firm at a site with fewer than 100 PRPs than at a site with more than 100 PRPs. We are unable to detect a difference between sites with fewer than 16 PRPs and between 16 and 100 PRPs. IR expenditures are higher at sites with fewer than 100 PRPs because both the probability that a firm has positive expenditures and the amount of expenditures conditional on positive expenditures are higher (see Table B.1). The probability may be higher because it may be harder for a firm to avoid participating at the site (sometimes referred to as "lying in the weeds") when there are fewer PRPs. The conditional level may be higher because the firms that end up participating may be forced to pay for the entire cleanup because of joint and several liability. This relationship may later be reversed by PRP cost recovery actions against nonsettlers, but so far, there have not been many such actions.

Transaction costs are also higher at sites with fewer than 100 PRPs than sites with more than 100 PRPs, holding other site and firm characteristics constant. Conflicting factors make the expected relation between the number of PRPs at a site and a firm's transaction costs at the site ambiguous. On the one hand, the smaller number of negotiating parties at a site with fewer PRPs would tend to reduce each firm's transaction costs, other things being equal. On the other hand, as the number of PRPs falls, we have seen that IR costs rise, presumably inducing PRPs to contest liability more fiercely. In addition, with fewer PRPs, there are fewer parties over which to spread shared costs, such as those for common legal counsel. The factors that cause transaction costs to rise as the number of PRPs fall appear to dominate.

We find no relationship between the number of PRPs and a firm's transaction-cost share. The share changes very little with the number of PRPs and the differences are not statistically significant. This does not mean that the share of transaction cost in the combined expenditures of all firms at a site is independent of the number of PRPs. This result, rather, refers to the expenditures of one firm with a particular set of characteristics. To compare transaction-cost shares at two sites with different numbers of PRPs, one would have to assemble the group of PRPs at each site and sum the predicted expenditures of all firms at each site. These two groups would have different numbers of PRPs, and, by necessity, different distributions of volumetric shares. For example, there would likely be firms with large volumetric shares and consequently low transaction-cost shares at sites with few PRPs.[13] Such an exercise is beyond the scope of this study.

Other findings suggest that sites with fewer PRPs have lower transaction-cost shares than sites with more PRPs. In addition to using the four-part model, we directly modeled the relation between transaction-cost share and site and firm characteristics for firms with positive expenditures.[14] This approach and the results are presented in Appendix B. Using this approach, we find a strong relationship between the number of PRPs and individual firm transaction-cost shares. This is consistent with the findings using a similar approach in our previous study.[15] While this result suggests that transaction-cost share is lower at sites with fewer PRPs, it does not allow us to predict the overall transaction-share for combined firm expenditures at a site. This is because the model predicts transaction-cost share for a firm but does not weight it by the expenditures of the firm at the site. The four-part model is needed to do that.

Firm Size

We did not find a strong relationship between firm size and either expenditures or transaction-cost share. As shown in Table 4.3, the relationship between firm size and expenditures is not monotonic, and there is no statistically significant difference in expenditures between a firm with between $15 million and $100 million in annual revenues and one with either $100 million to $1 billion or $1 billion to $20 billion in annual revenues. The results do suggest that firms with revenues less than $15 million do spend less on IR and transaction costs than larger firms, holding other factors constant. The magnitude of the difference, however, is much smaller than those found for phase, volumetric share, and number of PRPs.

We also do not find a strong relationship between firm size and transaction-cost share. There is again no monotonic relation between share and firm size (see final column of Table 4.3), and the differences between the reference and the other firm size categories are not statistically significant. The transaction-cost share for a firm with annual revenues less than $15 million may be higher, but these estimates are insufficiently precise to show a statistically significant difference.

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[13]For example, the volumetric shares might be 50 percent for each firm at a 2-party site, but 5 percent each at a 20-party site.

[14]Transaction-cost share is not defined for firms with zero expenditures.

[15]Acton and Dixon, 1992, p. 52.

To test whether the expenditures of the very large industrial firms studied in our previous report differed from those reported here, we reran the models including those firms. (The very large industrial firms all have annual revenues over $20 billion.) We have data on the very large firms only through 1989; so we restrict our attention to the expenditures through 1989. Also, to ensure comparability, we include only the expenditures of the very large firms at the 18 study sites.[16]

Again there is no monotonic relation between firm size and either IR or transaction costs (see Table 4.4). IR expenditures for a firm with annual revenues

Table 4.4

Predicted IR Costs, Transaction Costs, and Transaction-Cost Shares for Expenditures Through 1989, Including Very Large Industrial Firms

	Predicted IR Costs per Phase (thousands of dollars)	Predicted Transaction Costs per Phase (thousands of dollars)	Predicted Transaction-Cost Share (percent)
Site characteristics			
Expected IR cost			
< $20 million	9[a]	8[b]	45
$20–75 million	29	38	56
> $75 million[c]	66	22	25
Number of PRPs			
1–15	138	226[a]	62
16–100	532[a]	284[a]	35
> 100[c]	66	22	25
Municipal involvement			
Yes[c]	66	22	25
No	3[a]	3[a]	52
Financing			
PRP/Fund	11[a]	12	53
PRP only[c]	66	22	25
Firm characteristics			
Firm revenues			
< $15 million	5[a]	5[a]	51
$15–100 million[c]	66	22	25
$100–1,000 million	21	6[b]	22
$1–20 billion	17	15	46
> $20 billion	81	22	21
Volumetric share			
≤ 1 percent[c]	66	22	25
1–20 percent	530[a]	109[a]	17
> 20 percent	15,123[a]	557[a]	4[a]
Cleanup phase			
Phase 1[c]	66	22	25
Phase 2	1,098[a]	91[a]	8
Phase 3	3,682[a]	110[b]	3[a]

[a]Significantly different from reference at 5 percent.
[b]Significantly different from reference at 10 percent.
[c]Reference category.

[16]The very large firms provided data on a much larger set of sites through 1989. See Acton and Dixon, 1992, p. 44.

over $20 billion are not statistically different from those of a firm with revenues between $15 million and $100 million. The same is true for transaction cost. We also do not find a strong relation between transaction-cost share and firm size. Again, the smallest firms may have lower expenditures and perhaps higher transaction-cost shares than the other firms.

In summary, our results suggest that there is no clear relation between either expenditures and transaction-cost share and firm size for firms with annual revenues over $15 million. Our results do suggest that the smallest firms (those with revenues less than $15 million) have lower expenditures and higher transaction-cost shares than larger firms, but in the case of transaction-cost share, the difference is not statistically significant. The differences for either expenditures or transaction-cost shares are not nearly as large as those across some of the other characteristics.

These results are in stark contrast to the large differences in transaction-cost shares between large and small firms reported in Table 3.3 and illustrate the pitfalls of univariate analyses. What would appear from the univariate analysis to be associated with firm size is more accurately attributed to other factors associated with firm size. For example, larger firms have higher volumetric shares than smaller firms (see Table 4.5), and as discussed above, firms with higher volumetric share have lower transaction-cost shares. When volumetric share is held constant in the multivariate analysis, firm size does not have a strong impact.

The level of expenditures for small firms may be lower because EPA may concentrate enforcement on larger firms or offer more generous settlements to the smallest firms. It may also be lower because small firms have more limited resources to spend on either transaction cost or IR cost. Transaction-cost shares

Table 4.5

Distribution of Volumetric Share by Firm Size Category (percent of site-firm pairs)

	Volumetric Share			
Annual Firm Sales	≤ 1 percent	1 to 20 percent	> 20 percent	Total
< $15 million	79	21	0	100
$15–100 million	83	17	0	100
$100–1000 million	63	19	19	100
$1–20 billion	39	30	31	100

may be higher because the small firms are more risk averse than larger firms and willing to spend proportionately more on transaction costs to limit their liability.[17]

Municipal Involvement

Many suspect that municipal involvement at an NPL site creates additional obstacles in the cleanup process. First, the technical cleanup issues are usually more complicated. These sites are often municipal landfills to which a large number of generators sent very different types of waste and where hazardous substances are comingled with large amounts of nonhazardous wastes. The increased complexity of the material at the site is likely to complicate the remedy selection process and increase cleanup costs. Second, municipal liability is unsettled and a source of litigation between PRPs. Municipalities have contested liability, and even where municipalities have participated in the cleanup process, there is much conflict over how to assign volumetric share or cost share to a party that is often responsible for the bulk of the waste at the site but a much smaller percentage of the hazardous substances. Thus, municipal involvement will likely increase transaction costs.

We find that a PRP would spend $48,000 more in IR costs per phase at sites where municipalities are involved than at those where they are not. This happens even when other factors, including expected site cleanup cost and volumetric share, are held constant. One possible explanation is that private-sector PRPs have to cover some or all of the volumetric share of the municipality at the site. Another is that costs are allocated on the share of hazardous waste, rather than total waste, sent to the site. Thus, while a PRP's volumetric share may be low, its share of the overall cleanup cost may be much higher. As expected, sites with municipal involvement have higher transaction costs than other sites, but contrary to expectation, the transaction-cost shares at these sites are substantially lower. While transaction costs are higher, they do not increase as much as IR costs. Thus, while we do find that municipal involvement appears to increase costs of the private PRPs and generate more contention, it also appears to result in lower private-sector transaction-cost shares.

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[17]It is also possible that we observe these results because we have only a crude measure of volumetric share, and it is not fully controlled for.

Financing

A firm can expect to spend less on IR per phase at a site that has been partly financed by the government, other site and firm characteristics held constant, although this may partly be because EPA has not pursued cost recovery yet. As shown in Table 4.3, we find that a PRP at a PRP/Fund-financed site will spend less on IR than at a PRP-financed only site, other factors equal.

Financing does not affect transaction costs with the result that transaction-cost share is higher for a site with government funding, although the difference is not statistically significant. This finding is consistent with our previous work. It is important to remember that these results reflect costs only through 1991 and that they may change if EPA succeeds in recovering large IR costs from the PRPs.[18]

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[18]Through the end of FY 1991 EPA had a large accounts receivable from PRPs at NPL sites—approximately $340 million. EPA, 1992b, pp. III–4, 5.

5. Estimating Private-Sector PRP Expenditures at the Study Sites

In this section we first estimate total private-sector PRP expenditures between 1981 and 1991 at the sites in our study and the share of transaction costs in total expenditures. To do this, we extrapolate the expenditures of the firms in our sample to all private-sector PRPs involved at the study sites. Because we have a relatively small proportion of the PRPs at the study sites in our sample, there is a good deal of uncertainty in our estimates.

In the second part of this section we project what transaction-cost share will be when cleanup is complete at all of the study sites under three different scenarios. While the ultimate transaction-cost share is of central policy importance, there is considerable uncertainty in our prediction of what that share will be.

Private-Sector PRP Expenditures at the Study Sites Through 1991

In Section 3, we reported that the transaction-cost share was 21 percent for the combined expenditures between 1981 and 1991 of all of the firms in our sample. However, this may not be a good estimate of the share of transaction costs in the overall expenditures of the thousands of firms involved at the study sites. This is partly because we oversampled firms with larger volumetric shares, and as seen in the preceding section, these firms appear to have lower transaction-cost shares than other firms. Also, the combined volumetric shares of the sampled firms varied across sites, which may cause expenditures at some sites to be overrepresented in the sample.

Methods

We determined the number of PRPs in the three volumetric share categories discussed in Section 3 at each of the study sites.[1] Overall, there are 3650 private-sector firm-site pairs at the 18 study sites, of which 112 are in the sample. We then predict IR and transaction costs for each PRP not in the sample by

[1]This was based on information provided by EPA RPMs and on information we collected from the sampled firms.

substituting the firm and site characteristics into the four-part model. Predictions for the nonsampled PRPs are summed and added to the expenditures of the PRPs in the sample. We use bootstrapping techniques to generate a statistical distribution of estimates.[2] Our estimate is the mean of the distribution, and the confidence interval describes the spread of the distribution. This approach is detailed in Appendix C.

For prediction, we estimate the four-part model of expenditures through 1991 without the firm-size variables. We do this because we have no information on the size of the firms that are not in the sample. Very large firms are underrepresented in our sample, so our projections may be biased since we cannot adjust for firm size. Based on the results in Section 4, this may cause our projections for IR and transaction costs to be somewhat low and our projection of transaction-cost share to be somewhat high, but this is not likely to be a serious problem. Firm size does not appear to be nearly as important in explaining IR and transaction costs as other factors, such as volumetric share, number of PRPs, and phase. Nor is there a strong relationship between firm size and transaction-cost share.

Estimate of Total Private-Sector Expenditures at Study Sites

We estimate that private-sector PRPs spent an average of $32 million per site (or $583 million overall) at the 18 study sites between 1981 and 1991 (see Table 5.1). We estimate that PRPs spent $22 million at the study sites on IR costs and $10 million in transaction costs. Thus, we estimate that transaction costs accounted for 32 percent of total expenditures. The transaction-cost share rose to 32 percent from the 21 percent reported in Section 3 both because our sample captures a larger proportion of firm expenditures at sites with lower transaction-cost shares than at sites with higher shares and because we oversample firms with higher volumetric shares.

There is significant uncertainty in the estimates of expenditures and transaction-cost share. For example, the bootstrap analysis produces a 90-percent confidence interval of 20 to 44 percent (see Table 5.1).[3] Unfortunately, this interval is also subject to uncertainty. As noted in Section 4, it does not take into account the apparent correlation of equation errors. How this correlation affects the confidence intervals in Tables 5.1 and 5.2, however, is unknown. The

[2]Bootstrapping techniques make repeated draws from the error distribution in the model to generate a distribution of the estimated model parameters.

[3]Ninety-percent of the bootstrap replicates fall in this interval, which captures variation due to estimated model coefficients and the equation errors.

Table 5.1

Average PRP Outlays per Study Site from 1981 to 1991

	Estimate	90% Confidence Interval
Outlays (millions of dollars/site)		
IR costs	22	14–36
Transaction costs	10	8–14
Total costs	32	24–46
Transaction-cost share (percent)	32	20–44

bootstrap analysis also assumes that the four equations are correctly specified, that the sampled firms are representative of other firms in their volumetric share category, and that we correctly allocated PRPs to the volumetric share categories. Violations of these assumptions may introduce additional errors into our point estimates and confidence intervals.

Table 5.2 reports projected outlays per site and transaction-cost shares by phase for all PRPs at the 18 study sites. We estimate that between 1981 and 1991, outlays were $1 million per site in Phase 1, $21 million in Phase 2, and $10 million in Phase 3. The remedial action is usually the most expensive part of the cleanup process, so one expects cost to be highest in Phase 3. However, only half of the 18 sites have begun Phase 3 and the bulk of expected IR costs have not yet occurred at many of the others; so the average across all 18 sites is still low relative to Phase 2. Average Phase 3 expenditures should rise over time.

Table 5.2

Average Estimated Outlays per Study Site and Transaction-Cost Share from 1981 to 1991 by Cleanup Phase

	Phase 1	Phase 2	Phase 3
Outlays (millions of dollars per site)			
Estimate	1	21	10
90% confidence interval	0.6–3	16–29	6–20
Cumulative outlays (millions of dollars per site)			
Estimate	1	22	32
90% confidence interval	0.6–3	16–30	24–46
Transaction-cost share (percent)			
Estimate	51	39	20
90% confidence interval	19–80	25–50	7–35
Cumulative transaction-cost share (percent)			
Estimate	51	39	20
90% confidence interval	19–80	26–51	7–35

The projected share of transaction costs in total PRP outlays between 1981 and 1991 also varies by phase. As shown in Table 5.2, we estimate that transaction costs were 51 percent of expenditures during Phase 1, 39 percent in Phase 2, and 20 percent in Phase 3. This causes the share of transaction costs in cumulative outlays to fall as cleanup advances. Note that the 90-percent confidence intervals on the transaction-cost shares is large—particularly for Phase 1.

Extrapolating to the Entire NPL

Neither the $32 million per site estimate of private-sector PRP expenditures between 1981 and 1991 nor the 32 percent estimate of transaction-cost share can be directly extrapolated to the 1148 nonfederal sites on the NPL. This is because the study sites exclude several types of sites. First, sites that did not have RODs by the end of 1991 are excluded, and about 42 percent of the NPL sites did not have a ROD by that time. These sites would likely have lower expenditures and higher transaction-cost shares on average through 1991 than the sites in the sample since they are not as far through the cleanup process. Second, sites with total expected cleanup costs less than $2 million are excluded. Expected cleanup costs were less than $2 million in 22 percent of the sites with RODs for the seven states we investigated (see Section 2). Third, sites where there have been little or no PRP expenditures through 1991 are excluded. EPA RPMs estimated that there were very little or no PRP expenditures through 1991 at approximately 30 percent of sites with RODs in the seven states in the study (primarily fund-financed sites with no cost recovery as of 1991). Including sites with expected cleanup costs less than $2 million and sites with few PRP expenditures would cause average private-sector expenditures between 1981 and 1991 across the NPL to be lower than the $32 million reported here.[4] However, since they probably account for a small proportion of PRP expenditures, including them would probably have little effect on overall transaction-cost share.

Resources permitted us to select only 18 sites in seven states. Even if we can account for the subgroups of NPL sites just mentioned, we think it premature to project total private-sector expenditures and transaction-cost share through 1991 at all NPL sites using our sample. More information is needed on the characteristics of the sites on the NPL. To use our models to project total private-sector expenditures, we require information on the number of PRPs, expected total cleanup costs, municipal involvement, government financing, and the

[4]We have also excluded federal facilities. There should be no private-sector expenditures at the 10 percent of NPL sites that are federal facilities.

distribution of volumetric share (or some approximation) at each site on the NPL. This information is not currently available, but it may be available soon.[5]

While we are not prepared to extrapolate the level of private-sector costs at all NPL sites through 1991, we believe that 32 percent is a reasonable point estimate for all sites with RODs. The best available measure of uncertainty in this estimate is the 20- to 44-percent range obtained from our bootstrap analysis of the 18 study sites. Again, this range is subject to uncertainty. In addition to the factors that introduced uncertainty into our estimate of the 90 percent confidence interval for costs at the study sites through 1991, this interval does not reflect the additional issue of how well these sites represent the larger universe of NPL sites with RODs.

Two pieces of evidence suggest that the 18 study sites may well be fairly representative of all sites with RODs, however. First, the 18 study sites are at least roughly representative of the eligible sites from which they were drawn, taking together all four criteria in Table 2.1. The eligible sites were those sites in the selected states that we felt likely to be typical of all sites with RODs and where we had reason to believe there were nontrivial private-sector expenditures. Second, the consistency of the transaction-cost share for the very large firms at 49 NPL sites reported in our previous study (19 percent between 1984 and 1989[6]) and those for the larger firms in this study (16 and 19 percent for firms with between $100 million and $1 billion and $1 billion and $20 billion in annual sales, respectively), suggests that the 18 study sites are representative of the larger set of 49 sites.[7]

At the end of 1991, 481 of the 1148 nonfederal NPL sites did not have RODs, and an RI/FS had not yet begun at 372 of these. We used the IR and transaction costs during Phase 1 and Phase 2 at the study sites to develop a rough idea of how including these sites would affect the private-sector transaction-cost share. The results suggest that including sites without RODs might raise the share at all NPL sites through 1991 from 32 percent to perhaps 35 percent.

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[5]EPA is currently surveying RPMs to collect data on all NPL sites.

[6]Expenditures between 1984 and 1989 are 82 percent of total expenditures between 1981 and 1991 for the 108 firms sampled in this study.

[7]Since there is some overlap of the two sets of sites, figures on the shares are not completely independent. Six of the 18 study sites overlap with the 49 sites in the earlier study.

Private-Sector PRP Transaction-Cost Share at Completion

Costs to date give only a partial picture of the Superfund program. In evaluating the size of legal and other transaction costs generated by Superfund's liability approach, of fundamental importance is what IR and transaction costs will be when cleanup is complete. Because cleanup is close to complete at only a few of the 18 study sites, costs through 1991 are only a fraction of what they will be when cleanup is complete at all sites, and the share of transaction costs in costs to date is unlikely to be representative of what it will be in the end. Indeed, we expect transaction-cost share to fall over time if transaction costs occur primarily at the beginning of the process and are diluted over time by large IR payments.

There is a great deal of uncertainty in what the final transaction-cost share will be at the 18 study sites. To give some idea of what the share may ultimately be, we project transaction-cost share for the 18 study sites at completion under three different scenarios. In each scenario, we project both the transaction-cost share and the percent of overall site expenditures in each phase at completion. The final transaction-cost share is then the weighted average of the phase transaction-cost shares with the proportion of overall site expenditures in each phase serving as weights. In the first scenario, we use the transaction-cost shares through 1991 in each cleanup phase and estimate the ultimate proportion of expenditures in each phase based on observed expenditures to date and expected total cleanup costs as reported by EPA RPMs. In the second scenario, we use the same phase transaction costs but assume that cost overruns cause IR costs to be 50 percent higher at completion than currently expected. In the third scenario, we assume that transaction costs are front-loaded in each phase and that no more transaction costs will be incurred at the study sites.

Scenario 1: Extrapolation Based on Expenditures to Date

To project the proportion of ultimate site expenditures in each phase, we first estimate what IR expenditures will be in each phase at completion. All the study sites have completed Phase 1, so IR costs at completion in Phase 1 remain at their current values. Nine of the 18 sites have completed Phase 2, so for these sites Phase 2 IR costs at completion are set to current values. For the nine sites still in Phase 2, we assume that the ratio of Phase 2 to Phase 1 IR expenditures will be either the same as that for the nine sites that have already completed Phase 2 or the current ratio of Phase 2 to Phase 1 expenditures, whichever is larger. For four of the nine sites still in Phase 2, it turns out that the current ratio is larger: Thus, we estimate that they will incur no further Phase 2 expenditures.

For sites that have already begun Phase 3, ultimate IR expenditures in Phase 3 are estimated using the difference between estimated Phase 2 IR costs to date and expected total cleanup costs (as reported by the EPA RPMs). For sites that are still in Phase 2, ultimate Phase 3 expenditures are estimated by subtracting estimated final expenditures during Phase 2 from expected total cleanup costs.[8] At four of the study sites, IR costs through 1991 exceed expected total cleanup costs; consequently, we project that there will be no further IR costs at these sites. At two of the study sites this seems reasonable since construction is complete at all operable units, but at the other two sites, cost overruns seem inevitable. This issue is addressed in Scenario 2. The calculations allocating IR at completion to phases are described in more detail in Appendix C.

We assume that transaction-cost shares at completion will be the same in each phase as the shares at the study sites estimated through 1991 (see Table 5.2). We then determine the implied transaction costs in each phase and calculate the ultimate share of total expenditures (IR plus transaction costs) in each phase.

The first rows in Table 5.3 report the resulting transaction-cost shares and proportion of expenditures ("weight") by phase. We estimate that at completion, 66 percent of expenditures will occur in Phase 3, 32 percent in Phase 2, and 2 percent in Phase 1. This results in an overall transaction-cost share of 27 percent at completion. In dollar terms, we estimate that total private-sector IR expenditures will average $51 million per site at the 18 study sites at completion, that transaction costs will average $20 million, and that total expenditures will average $71 million.

The uncertainty in our estimates of transaction-cost share by phase through 1991 implies considerable uncertainty in the estimate of transaction-cost share at completion. The last column of Table 5.3 reports the projection when each of the phase transaction-cost shares are first at the lower and then at the upper bound of their 90-percent confidence intervals (see Table 5.2). The resulting range is 13 to 41 percent, which illustrates that, based on information available to date, we have only a very sketchy idea of what transaction-cost share will be when cleanup is complete.

Scenario 2: 50-Percent Cost Growth

The assumption in Scenario 1 that final site IR costs will equal the current RPM estimate may not be very accurate. As discussed above, this results in no

[8]Phase 1 costs are not included in expected cleanup costs.

Table 5.3

Projected Transaction-Cost Share When Cleanup Is Complete at the Study Sites Under Various Scenarios (in percent)

				Overall Transaction-Cost Share	
	Phase 1	Phase 2	Phase 3	Point Estimate	Range from Sensitivity Analysis
Scenario 1					
Transaction-cost share	51	39	20	27	13–41
Weight	2	32	66	100	—
Scenario 2					
Transaction-cost share	51	39	20	25	12–40
Weight	1	23	75	100	—
Scenario 3					
Transaction-cost share	51	36	6	19	15–24
Weight	2	39	59	100	—

additional IR costs for two sites where construction was not complete at the end of 1991. One of these sites has not finished Phase 2, which implies there will be no Phase 3 expenditures. This is evidence that cleanup costs will exceed expected cleanup costs at the 18 study sites as of 1991, and cost growth is probably common at other NPL sites as well. In its internal NPL cost projection, EPA currently assumes that actual cost will exceed the expected cost in the ROD by 50 percent.[9] Since overruns probably occur mainly during Phase 3, they are likely to cause the final transaction-cost share to be lower than it would be otherwise. To illustrate how cost overruns might affect transaction-cost share at completion, we assume in Scenario 2 that IR costs at completion will be 50 percent higher than currently expected, and that these costs will be incurred during Phase 3.[10] As a result, the proportion of overall expenditures at completion in Phase 3 rises from 66 percent in Scenario 1 to 75 percent (see Table 5.3). The share of transaction costs in overall expenditures at completion drops to 25 percent, and the range falls to 12 to 40 percent. Note, however, that even though this cost overrun causes the final transaction-cost share to fall, it causes the final amount of transaction costs to rise.

[9]Personal communication with EPA, August 1993.

[10]We continue to assume that phase transaction-cost shares at completion remain at the values observed through 1991.

Scenario 3: No More Transaction Costs

Phase transaction-cost shares through 1991 may not be a good estimate of what they will ultimately be when cleanup is complete. In particular, it is possible that transaction costs are loaded toward the front of Phase 3 and thus that the 20 percent share estimated for Phase 3 through 1991 will overestimate the ultimate transaction-cost share in that phase. Conversely, the final share in Phase 3 could conceivably be even higher than 20 percent if PRPs wait until the end of the cleanup process when costs are known to initiate litigation to recover costs from their insurers, other PRPs, or the government.

Data available on the time pattern of transaction costs within Phase 3 are available at only a handful of sites. These data suggest that front-loading may occur at some sites and not at others.[11] We thus think it premature to estimate how Phase 3 transaction-cost shares at the 18 study sites will change over time. We think it is reasonable to speculate that Phase 3 transaction-cost shares will fall. To provide a lower bound on how far overall transaction-cost shares at the 18 sites could fall at completion given no cost growth, we assume in Scenario 3 that there will be no more transaction costs after 1991. We assume that IR costs per phase at completion are the same as in Scenario 1 and determine final transaction-cost share for each phase by taking the ratio of transaction costs to date to total final phase expenditures. Note that this implies that sites still in Phase 2 as of 1991 will have no transaction costs in Phase 3. The last rows of Table 5.3 show that the resulting transaction-cost share is 6 percent in Phase 3 and that the final overall share drops to 19 percent. Using the upper and lower bounds of the 90-percent confidence interval for transaction costs (see Table 5.1) causes the final transaction-cost share to range from 15 to 24 percent in Scenario 3.[12]

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[11]Construction of the remedies for all operable units is complete at two of the 18 study sites. At these two sites, transaction-cost share was 8 percent from when construction had started at all operable units to the completion of construction at all operable units and 10 percent in the postconstruction period.

We also have data on 21 additional sites selected by the PRPs in this study. PRPs typically chose their most expensive or difficult sites. RA had started at four of these nonrandomly selected sites. In these four cases, transaction-cost share fell from 64 percent during the period between the start of RA at the first operable unit and the start of RA at all operable units to 34 percent afterward (none of the four sites had completed construction at all operable units). See Appendix D for more detail.

[12]The range for the sensitivity analysis for Scenario 3 is smaller than for Scenarios 1 and 2, first, because the Scenario 1 and 2 sensitivity ranges compound the upper and lower bound in the confidence interval in each Phase (see Appendix C). Second, we use separate confidence intervals for each phase transaction-cost share in Scenarios 1 and 2 versus the confidence interval for overall transaction-costs through 1991 in Scenario 3. It is not surprising that the confidence intervals for the phase shares are relatively larger. First, they are based on both IR-cost and transaction-cost projections, and second, since they are components of an overall share, measurement error may be relatively larger.

These scenarios illustrate our substantial uncertainty regarding the ultimate transaction-cost share at the 18 study sites. Just based on the uncertainty in phase transaction-cost shares through 1991, the projected share at completion in Scenario 1 varies from 13 to 41 percent. Scenarios 2 and 3 demonstrate the sensitivity of the prediction to cost overruns and changes in the phase transaction-cost shares over time. The cost overruns in Scenario 2 did not cause predicted final transaction-cost share to change much, but the effect would be greater if the Phase 3 transaction-cost share were lower. While a reasonable speculation, we have only weak evidence so far that Phase 3 transaction cost will decline over time. Scenario 3 gives a lower bound for final transaction-cost share at the 18 study sites, assuming no cost overruns and our estimates of transaction costs through 1991. We, however, have no basis for projecting an upper bound for final transaction-cost share. It seems unlikely that back-end litigation will cause the Phase 3 transaction-cost share to rise above the 20 percent observed through 1991, although it is a possibility.

Finally, note that all these projections are based on the extrapolation of past results. Changes in the Superfund law or program implementation could increase or decrease final transaction-cost shares.

6. Summary and Conclusions

This report examined the expenditures of 108 private-sector firms between 1981 and 1991 with annual revenues less than $20 billion at 18 NPL sites. We evaluated the variation in expenditures and transaction-cost share across firms and sites, the composition of IR and transaction costs, and the interaction of PRPs with their insurers. We compared the expenditures and transaction costs of these firms with those reported in a previous RAND study on firms with annual revenues over $20 billion.[1] We used the sample to estimate total private-sector PRP transaction costs, IR costs, and transaction-cost share at the study sites through 1991. We also projected what PRP expenditures and transaction-cost share at the study sites will be when cleanup is complete under several different scenarios. Below we summarize our findings.

Individual Firm Expenditures and Transaction-Cost Shares

Expenditures and transaction-cost share vary enormously across the 108 firms at the 18 study sites.

- Approximately one-third of the firms sampled had expenditures less than $1000, and 7 percent accounted for 77 percent of the total expenditures.
- Transaction-cost share exceeded 60 percent for over 50 percent of the firms with expenditures greater than $1000. Large outlays with low transaction costs by a minority of firms brought the share of transaction costs in total expenditures in the sample down to 21 percent. This explains how transaction costs can exceed IR costs for the "average" firm, but the overall share of transaction costs across all firms can be much lower.

Expenditures and transaction-cost share vary enormously by firm size.

- Transaction-cost share averaged 60 percent for firms with annual revenues less than $15 million and between $15 million and $100 million, 15 percent

[1] Acton and Dixon, 1992.

for firms with annual revenues between $100 million and $1 billion, and 19 percent for firms with annual revenues between $1 billion and $20 billion.

- Average expenditures per firm rose dramatically with firm size.

These findings on transaction-cost share are consistent with our previous findings on transaction-cost shares for firms with annual revenues over $20 billion.[2] We found that the transaction-cost share of those very large industrial firms averaged 19 percent at 49 NPL sites between 1984 and 1989.

While transaction-cost share is related to firm size, we found firm size is not particularly important in explaining firm expenditures and transaction-cost share once other site and firm characteristics are taken into consideration. Of key importance is a firm's volumetric share at a site. We found that as volumetric share rises, transaction costs rise more slowly than IR costs and transaction-cost share falls. Larger firms tend to have larger volumetric shares, and it appears to be this, not firm size itself, that induces the correlation between firm size and transaction-cost share. When other factors are held constant, our results do suggest that firms with annual revenues less than $15 million spend less and have higher transaction-cost shares than larger firms, but the differences are not large and, in the case of transaction-cost share, not statistically significant.

We generally found that transaction costs are less sensitive to variation in firm and site characteristics than are IR costs. This suggests that transaction costs have a fixed component and a component that varies somewhat with site and firm characteristics. For example, the decline of transaction-cost share when volumetric share rises suggests that some costs of contesting liability are not extremely sensitive to a firm's stake at the site.

Composition of Firm Expenditures and Interaction with Insurers

Our analysis suggests that most IR expenditures are for RD/RA and most transaction costs are for legal work.

- Approximately one-half of the IR costs that we were able to categorize were for RD/RA. The remainder were split between RI/FS and payments to the government.

[2]Acton and Dixon, 1992.

- Sixty-five percent of transaction costs were legal in nature and only a small proportion paid for duplicative technical work used to contest remedy selection or liability.

Many firms spend money on coverage disputes with their insurers, but few receive reimbursement.

- Approximately one-third of the firms with expenditures over $1000 spent money on coverage disputes, but the total amount spent was only about 1 percent of overall expenditures.
- Twelve percent of firms with expenditures over $1000 received reimbursement. The reimbursements were over six times the firm expenditures on coverage disputes. Overall, insurers reimbursed PRPs for approximately 8 percent of their expenditures.

Variation of Expenditures and Transaction-Cost Share Across Sites

Site characteristics have an important influence on firm expenditures and transaction-cost shares, although the limited base of 18 sites included in our analysis makes these findings somewhat tentative.

- Firm expenditures on both IR and transaction costs are higher at sites with higher estimated total cleanup costs, but transaction costs do not increase as rapidly; hence, transaction-cost share is lower at more expensive sites.
- Evidence on whether an individual firm's transaction-cost share is lower at sites with fewer PRPs when other factors are held constant is mixed. One model of transaction-cost share showed such a relationship while a second did not. Even if the latter result holds true, it may still be that the overall transaction-cost share for all firms at a site with fewer PRPs is lower. This is because as the number of firms decreases, the volumetric share of some firms must rise, and these firms will have lower transaction-cost shares. Further work is needed to quantify how transaction-cost share varies with the number of PRPs at a site.
- Sites with municipal involvement are more burdensome to private-sector PRPs. Expenditures on both IR and transaction costs were higher at sites with municipal involvement, other factors held constant, while the share of transaction costs was lower.

We generally found that transaction costs are less sensitive to variation in site and firm characteristics than IR costs. This suggests that transaction costs have a fixed component and a component that varies somewhat with site and firm characteristics.

Overall Private-Sector PRP Expenditures and Transaction-Cost Share at the Study Sites

Since we oversampled firms with higher volumetric shares and the total volumetric share of sampled firms varied by site, the transaction-cost share for the firms we sampled may not be representative of that for all private-sector PRP expenditures at the study sites. We developed a model of firm expenditures to estimate overall PRP expenditures at the study sites. We also used these estimates to project transaction-cost share when cleanup is complete at the 18 sites.

Expenditures Between 1981 and 1991

We estimate that private-sector PRPs spent an average of $32 million per site ($583 million overall) at the 18 study sites between 1981 and 1991 and that the transaction-cost share was 32 percent. As might be expected given the small size of the sample relative to the number of PRPs at the sites, there is considerable uncertainty in these estimates. The 90-percent confidence interval derived from our statistical procedures is $24 million to $46 million for expenditures and 20 to 44 percent for transaction-cost share. These confidence intervals depend on assumptions required by our statistical procedures. They are themselves subject to uncertainty, reflecting possible violations of these assumptions.

We also found that transaction-cost share varies by the cleanup phase during which expenditures occur. We estimate that transaction costs were 51 percent of expenditures from site discovery to start of the first RI/FS, 39 percent from start of the RI/FS to start of the RA, and 20 percent after start of the RA. Again the confidence intervals on the estimates are sizable. For example, the confidence interval is 7 to 35 percent for expenditures after start of RA.

Expenditures and Transaction-Cost Share at Completion

Of primary importance in evaluating Superfund's liability approach are what transaction costs and transaction-cost share will be when cleanup is complete. Given that transaction-cost share appears to be lower in later cleanup phases, it is likely that the share of transaction costs in expenditures through 1991 will overstate what transaction-cost share will be when cleanup is complete at the 18 study sites. Because construction of the cleanup remedy is complete at only 2 of the 18 study sites, however, it is difficult to predict what the transaction-cost share will ultimately be.

To give some idea of what transaction-cost share for PRP expenditures at completion might be, we first assumed that final phase transaction-cost shares will remain at the levels observed through 1991 and estimated final expenditures in each phase using estimated PRP expeditures through 1991 and the expected total cleanup cost estimated by the EPA RPM. This resulted in a final transaction-cost share of 27 percent. Even given the assumptions on phase expenditures, there was considerable uncertainty in this estimate. Simply using the upper and lower bounds of the 90-percent confidence intervals for the estimated phase transaction-cost shares through 1991 caused the projected transaction-cost share at completion to vary between 13 and 41 percent.

This projection depends on many assumptions, and to illustrate the sensitivity of the projection to two of the most important, we projected final transaction-cost share at the 18 study sites under two additional scenarios. Growth in IR costs may cause the proportion of Phase 3 expenditures at completion to be higher than we projected in the first scenario. When we assumed that final IR costs would be 50 percent higher than expected, transaction-cost share at completion fell to 20 percent with a range of 7 to 35 percent.

Phase transaction-cost shares through 1991 may not be a very good estimate of what they will ultimately be when cleanup is complete. It seems likely that Phase 3 transaction-cost share will fall from the 20 percent estimated through 1991 over time, but it is also possible that litigation at the end of the cleanup process will keep the Phase 3 share from falling and may even cause it to rise. Preliminary investigation of transaction-cost shares during Phase 3 at the 18 study sites and 21 supplemental sites resulted in mixed evidence on whether transaction-cost shares have fallen in Phase 3 so far. Nevertheless, we think it reasonable to speculate that Phase 3 transaction-cost share will fall over time, and, to provide a lower bound on the share of transaction costs in overall costs at the 18 study sites at completion given no cost growth, we assumed that there would be no additional transaction costs after 1991. This caused final transaction-cost share to fall from 27 percent in the first scenario to 19 percent, with a range of 15 to 24 percent.

The wide spread in estimated transaction-cost share at completion reflects our lack of understanding of how the Superfund process will unfold at the 18 study sites. There is evidence of cost growth at many Superfund sites, as well as at some of the 18 study sites.[3] There is little information on which to predict how phase transaction costs will change over time. Analyses of expenditures through time at more sites that have progressed far through the cleanup process would help, but even at sites where construction is complete, there may be more transaction costs and, if the remedy fails, more IR costs.[4]

Overall Transaction Costs Induced by Superfund's Liability Approach

Combined with the findings for very large firms in our previous study, the information presented here has improved our understanding of the transaction costs induced by Superfund's liability approach. Given our sample sizes, we think further analysis is necessary before we can extrapolate total PRP expenditures to date at all NPL sites from our data. We believe, however, that 32 percent is a reasonable point estimate for the transaction-cost share through 1991 for all sites with RODs. The best available measure of uncertainty in this estimate is again the 20 to 44 percent range obtained from our statistical analysis of the 18 study sites. In addition to possible violation of the same assumptions used to calculate our uncertainty in cost to date at the 18 study sites, this interval may also be inaccurate to the extent that the 18 study sites are not representative of sites with RODs. Encouragingly, however, two pieces of evidence suggest the 18 sites are reasonably representative. First, the characteristics of the 18 study sites are roughly similar to those of a larger group of sites where we had reason to believe that there were substantial private-sector expenditures. Second, the findings for the large firms at the sites studied here are consistent with those for the very large firms at a much larger number of sites in our previous study.

We used the IR and transaction costs during Phases 1 and 2 at the study sites to develop a rough idea of how much including sites without RODs would affect the private-sector transaction-cost share through 1991. Preliminary calculations suggest that including sites without RODs would raise the transaction-cost share from 32 to 35 percent.

A full accounting of the transaction costs generated by Superfund's liability approach must include outlays by private-sector insurers. In our previous study, we estimated that as of 1989 insurers were spending on the order of $150 million

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[3]It is important to note, however, that while cost growth may reduce the ultimate transaction-cost share, it by no means reduces the overall level of transaction costs.

[4]In most circumstances, PRP liability never ends. Thus, if a remedy fails, the PRPs can be required to finance the investigation and implementation of a new one.

a year at NPL sites[5] and that 88 percent of their outlays were transactional in nature. Due to the high transaction-cost share for insurer outlays, the transaction-cost share for PRP and insurer expenditures combined will almost certainly be higher than for PRP expenditures alone. However, how much higher the combined share will be is unknown.

To private sector costs, we must also add outlays by EPA and state and local governments. EPA currently spends about $1.5 billion a year on the Superfund program,[6] but there currently is little information on how much state and local governments spend on nonfederal NPL sites. We also do not know what part of government expenditures are transactional in nature. We know that approximately 15 percent of EPA's Superfund outlays go for enforcement, a transaction cost in our classification of costs, but we cannot categorize the remaining 85 percent.

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[5]We estimated that insurers spent $470 million in 1989 on claims related to inactive hazardous waste sites. We also estimated that NPL sites accounted for 40 percent of total expenditures and bodily injury/property damage (BI/PD) suits accounted for 21 percent of total expenditures. Assuming that BI/PD suits are distributed among NPL and non-NPL sites in equal proportions implies that insurer expenditures pertaining to remediating NPL sites were $470 million $\times$ 0.40 $\times$ 0.79 = $149 million.

[6]These are obligations of EPA. Actual outlays may be lower. See Acton, 1989.

Appendix

A. Interview Protocol, Sample Selection, and Response Rates

Interview Protocol

We developed a combination telephone/in-person survey to collect information on PRP expenditures at selected Superfund sites. PRPs were initially contacted by telephone and asked to consider participating in the study. If they consented, a letter of introduction was sent to the appropriate individual in the firm explaining the purpose of the study and describing the type of information required. In addition, a confidentiality agreement was provided for the prospective participant's review. In most cases the firms participating in the study wanted to execute a written confidentiality agreement. Follow-up phone calls began one week later to confirm participation. If the respondent declined to participate, the reasons for refusal were recorded.

If a firm had less than $1000 in expenditures attributable to a specified study site, we requested information on their annual sales only (for characterization of firm size). Forty of the 108 firms participating in the study fell into this category. Firms with expenditures between $1000 and $5000 (three firms) were interviewed over the telephone. PRPs were interviewed in-person at their place of business if their total expenditures at the study site were greater than $5000 (65 firms).

In-person interviews were typically scheduled within four weeks of the follow-up phone call.

We developed a list of questions for interviewing the PRPs. The questionnaire was designed to provide both quantitative information on PRP costs related to the Superfund program and qualitative information for understanding the basis of these costs. We asked PRPs to specify the activities for which costs were incurred.

Sample Selection and Characteristics

Characteristics of Regions

Representativeness of the five EPA regions chosen for the study was evaluated along two dimensions: (1) the percentage of Superfund sites that are financed by PRPs as opposed to the government, and (2) the progress of cleanup at Superfund sites within each region. Table A.1 compares the statistics for each region with the national values.

Site Selection

Table A.2 lists the screens applied to the 331 NPL sites in the seven selected states and the number of sites excluded by each screen. The screens are sequential. Thus, for example, it is not the case that 19 of the 331 sites have expected cleanup costs less than $2 million, but that 19 of the 126 sites that have passed the previous screens have expected cleanup costs less than $2 million.

PRP Selection

Initial information from our telephone conversations with smaller volume contributors indicated that they had little or no expenses to date, so we oversampled firms with larger volumetric shares. To do this, we ranked the PRPs according to volumetric share and then summed the volumetric shares,

Table A.1

Financing and Cleanup Stages of Superfund Sites in Sampled Regions (in percent)

	Region					Nation		
	2	3	5	6	9		Min	Max[a]
Financing								
PRP financed	56	68	59	57	65	63	56	77
Cleanup stage								
Site studies	52	58	57	37	64	58	37	74
Remedy selected	6	6	5	3	9	5	3	9
Remedial design	17	9	15	24	9	13	8	24
Cleanup ongoing	22	20	17	29	12	18	10	35
Cleanup complete	1	1	5	4	2	3	1	5

SOURCE: EPA, 1989.

[a]National percentages are based on totals across all 10 regions in the country; national minima and maxima are the lowest and highest regional percentages in the country.

Table A.2

Screens Sequentially Applied to NPL Sites

Reason for Exclusion from Sample	Sites Excluded	Sites Remaining
Total		331
Federal facility	37	294
Not final on NPL	38	256
No ROD	129	127
No-action ROD	1	126
Cleanup cost < $2 million	19	107
Fund financed, no cost recovery	36	71
Only very large PRPs	9	62
Notorious	3	59
Municipality with > 90% share	4	55
Other[a]	9	46

[a]Includes sites where asbestos is the primary contaminant, very diffuse groundwater basin sites, and sites where universities and government contractors are responsible for over 90 percent of the waste.

starting with the largest waste contributor, until 90 percent of the waste was cumulatively accounted for. Our goal was to collect data from 5 to 10 of the PRPs in this group. If there were fewer than 5 PRPs in this group our goal was to collect data from all. After excluding firms on the *Fortune 100* list, we randomly selected 5 to 10 firms out of the firms with the largest volumetric shares that accounted for 90 percent of the waste at each site and attempted to survey them. If the elimination of very large firms, public-sector PRPs, and firms that refused to participate left fewer than 5 firms, we drew supplemental random samples until the desired number of firms had agreed to participate or until there were no more firms. At several sites all the PRPs in this group were contacted.

For those firms accounting for the bottom 10 percent of waste by volume, our target was to collect data from two. We followed a similar procedure as for the larger-volumetric share firms to select firms for the sample.

In some sites, there was no volumetric share information and we sampled all PRPs with equal probability.

Response Rates

Firms cited a number of reasons for declining to participate in the study. As shown in Table A.3, the most common reason given was the time and cost involved in obtaining information about activities that occurred up to 10 years ago (12 percent of eligibles). A small number of firms declined to participate because of concerns about confidentiality (6 percent of eligibles). While this

Table A.3

PRP Response Summary

	Number of Firms	Percent
Total Sample	251	100
Ineligible to participate	21	8
Eligible to participate	230	92
Ineligible to participate	21	100
Could not locate	15	71
Dissolving or out of business	6	29
Eligible to participate	230	100
Refused	64	28
Time/cost burden	27	12
Confidentiality	13	6
General policy	8	3
Unknown reason	16	7
Initial interest but broke off contact	24	10
Unable to contact appropriate person	34	15
Survey completed	108	47

reason for refusal represents a potential source of downward bias in the transaction costs estimates (if firms involved in extensive litigation are less likely to participate), it should also be noted that many firms indicated they were participating because of their frustration with the expense, inefficiency, and pace of the Superfund program.

The overall response rate obtained was 47 percent of eligibles. This low value reflects the difficulty of contacting the appropriate person and the inability of the interviewer to obtain either a commitment to participate or a refusal. In general, we found that it was surprisingly difficult to initiate and maintain contact with prospective participants. Very few of those contacted returned telephone messages, and a persistent and time-consuming effort to locate and speak with the appropriate person was necessary. In addition, we found that breakoffs (initial interest, subsequent lack of response) were more frequent than typical for most sample surveys, a tendency that may be a special characteristic of small business surveys[1] as well as the burden of recovering so many data.

In a relatively large number of cases, the appropriate person was located, but was inaccessible. Interviewers would attempt to contact the potential respondent and, in most cases, would leave messages two to three times a week for a period of two to four weeks. These messages were rarely returned, and after six to ten

[1] See Cox et al., 1989.

attempts, the interviewer would discontinue attempting to establish contact. In some cases, a first contact would be made, and the informational package would be sent. Later attempts to confirm participation would not be successful, however. These two types of unresponsiveness account for 25 percent of the eligibles.

B. Statistical Methodology for Analyzing Firm Expenditures

Four-Part Model of Firm Expenditures

The observed distribution of expenditures by a firm at a site during a given phase has point mass at zero and, relative to a normal distribution, excessive weight in the right tail. To model these expenditures we use a two-part model that first models the firm's decision to make any expenditures at a site during a phase and then models the log of expenditures given positive expenditures.[1] We develop separate two-part models for IR and transaction costs. We refer to these models jointly as the four-part model of firm expenditures. Below, we present the two-part model for IR expenditures. We use a similar model for transaction costs.

We assume that there is an underlying latent response variable, I^{*}_{ijp}, that determines whether firm i has positive IR expenditures at site j during phase p. It is assumed to be determined by:

$$I^{*}_{ijp} = X_{ijp}\alpha + \varepsilon_{ijp}$$

where X_{ijp} is a vector of site characteristics, firm characteristics, and cleanup phase, and α is the vector of parameters to be determined. The cumulative distribution function of ε_{ijp} is assumed to be independent identically distributed (i.i.d.) logistic.

If

$$\begin{Bmatrix} I^{*}_{ijp} > 0 \\ I^{*}_{ijp} \le 0 \end{Bmatrix},$$

then

$$\begin{Bmatrix} y_{ijp} > 0 \\ y_{ijp} = 0 \end{Bmatrix}$$

where y_{ijp} is the IR expenditures of firm i at site j during phase p.

---

[1]A tobit model was rejected because it constrains the coefficients in each part of the two-part model to be equal. See Amemiya, 1984 for a survey of tobit models. Our approach has been used in the health economics literature (Duan et al., 1987) and accident compensation literature (Hammitt, 1985) where data have similar distributions.

We model the log of expenditures conditional on positive expenditures because the log transformation handles the heavy right tail better than the untransformed expenditures do:

$$\log\left(y_{ijp} \middle| y_{ijp} > 0, X_{ijp}\right) = X_{ijp}\beta + \eta_{ijp}$$

where β is a vector of parameters to be determined and η_{ijp} is i.i.d. with mean zero.

Conditional on the model, the expected value of y_{ijp} given X_{ijp} is

$$E\left(y_{ijp} \middle| X_{ijp}\right) = Pr\left(y_{ijp} > 0 \middle| X_{ijp}\right) \cdot E\left(y_{ijp} \middle| y_{ijp} > 0, X_{ijp}\right)$$

where

$$Pr(y_{ijp} > 0 | X_{ijp}) = \frac{\exp(X_{ijp}\alpha)}{1 + \exp(X_{ijp}\alpha)},$$

$$E\left(y_{ijp} \middle| y_{ijp} > 0, X_{ijp}\right) = \exp\left(X_{ijp}\beta\right)\gamma, \text{ and}$$

$$\gamma = E(\exp(\eta_{ijp})).$$

We calculate the corresponding transaction-cost share as the ratio of expected transaction costs to the sum of expected transaction costs and expected IR costs:

$$tshare_{ijp} = \frac{E(TC_{ijp})}{E(TC_{ijp}) + E(IR_{ijp})}$$

Variable Specification

For both the logistic and logarithmic parts of the model, we use a model that includes firm characteristics, site characteristics, and cleanup phase. Each characteristic is broken down into C_k categories. One category is chosen as a reference for each characteristic and omitted from the regression. The others are specified as

$$X_{ijp}\beta = \beta_0 + \sum_{k=1}^{K_f} \sum_{c=1}^{C_f - 1} \beta_{kc}^f d_{kc}^f + \sum_{k=1}^{K_s} \sum_{c=1}^{C_k - 1} \beta_{kc}^s d_{kc}^s + \sum_{c=1}^{C_l - 1} \beta_c^l d_c^l$$

where

$$d_c = \begin{cases} 1 \text{ if firm, site, or phase characteristic falls in category c} \\ 0 \text{ otherwise} \end{cases}$$

The superscript *f* indexes firm characteristics. Firm size and volumetric share are the firm characteristics included in the model. The letter *s* indexes site characteristics. The site characteristics are expected site IR costs, number of

PRPs, whether or not there is municipal involvement, and who finances the cleanup. Finally, l indexes the cleanup phase. We use a similar specification for the logistic part of the model, replacing β with α.

Estimation

Let N be the total number of observations and N_1 be the number of observations with positive IR expenditures. We estimate the first part of the model using logistic regression on all N observations and the second part on N_1 observations using ordinary least squares (OLS). We use a nonparametric estimate of γ, the smearing estimate:[2]

$$\hat{\gamma} = \frac{1}{N_1} \sum_{ijp} \exp\left(\hat{\eta}_{ijp}\right)$$

where $\hat{\eta}$ is the residual from the ordinary least squares regression used to estimate the second part of the model. We checked to see if different smearing factors for different levels of the right-hand-side variables were warranted (caused possibly by heteroscedasticity), but we found no statistically significant differences.

Estimates for the two-part model for IR expenditures are presented in Table B.1. Estimates for transaction costs are in Table B.2.

Comparative Statics

To calculate the effect of changing a site or firm characteristic on IR costs, transaction costs, and transaction-cost share, we compare the expected value when all characteristics are set to reference values with that with one characteristic changed. For IR and transaction costs, we calculate

$$\Delta = \hat{E}\left(y_{ijp} \middle| X^{*}_{ijp}\right) - \hat{E}\left(y_{ijp} \middle| \bar{X}_{ijp}\right)$$

where

$$\hat{E}\left(y_{ijp} \middle| Z_{ijp}\right) = \frac{\exp\left(Z_{ijp}\hat{\alpha}\right)}{1 + \exp\left(Z_{ijp}\hat{\alpha}\right)} \exp\left(Z_{ijp}\hat{\beta}\right)\hat{\gamma} \quad .$$

[2]See Duan et al., 1982, and Duan, 1983.

Table B.1

Two-Part Model of IR Costs

	Logit for Positive Expenditures		OLS on Log of Expenditures	
	Coeff.	Std. Error	Coeff.	Std. Error
Constant	−3.271[a]	0.957	8.479[a]	0.730
Firm revenues				
< $15 million	(reference)			
$15–100 million	1.500[a]	0.551	0.868[b]	0.476
$100–1,000 million	1.054[b]	0.599	0.527	0.493
$1–20 billion	1.761[a]	0.598	0.567	0.468
Expected IR cost				
< $20 million	−2.022[a]	0.631	−1.245[a]	0.421
$20–75 million	−0.314[b]	0.589	−1.228[a]	0.454
> $75 million	(reference)			
Number of PRPs				
< 16	1.363[b]	0.800	1.087	0.950
16–100	0.381	0.608	2.066[a]	0.441
> 100	(reference)			
Municipal involvement				
Yes	0.428	0.537	2.579[a]	0.457
No	(reference)			
Financing				
Fund/PRP	−0.420	0.547	−0.922[a]	0.456
PRP only	(reference)			
Volumetric share				
≤ 1 percent	(reference)			
1–20 percent	0.728	0.509	1.278[a]	0.363
> 20 percent	1.117	0.935	4.949[a]	0.856
Cleanup phase				
Phase 1	(reference)			
Phase 2	2.909[a]	0.503	1.520[a]	0.481
Phase 3	2.770[a]	0.600	1.959[a]	0.590
N	259		71	
R-square	—		0.819	
Root MSE	—		1.095	
Dep. Mean[c]	—		11.757	
−2LogL	190.5		—	

[a]Significantly different from zero at 5 percent.
[b]Significantly different from zero at 10 percent.
[c]Dependent variable mean.

$\tilde{X}_{ijp}$ sets d_c to zero, and X^{*}_{ijp} sets d_c to one for the appropriate effect, leaving the other values at zero. Transaction-cost shares are calculated by taking the ratio of expected transaction costs to expected transaction costs plus expected IR costs in the various scenarios. The differences between each scenario and the reference are calculated.

Table B.2

Two-Part Model of Transaction Costs

	Logit for Positive Expenditures		OLS for Log of Expenditures	
	Coeff.	Std. Error	Coeff.	Std. Error
Constant	–2.701[a]	0.866	9.118[a]	0.713
Firm revenues				
< $15 million	(reference)			
$15–100 million	1.268[a]	0.482	0.331	0.425
$100–1,000 million	0.416	0.532	0.052	0.482
$1–20 billion	1.182[a]	0.545	0.759[b]	0.444
Expected IR cost				
< $20 million	–1.244[a]	0.589	–0.870[a]	0.418
$20–75 million	0.230	0.575	–0.887[b]	0.455
> $75 million	(reference)			
Number of PRPs				
< 16	1.110	0.677	1.291[a]	0.580
16–100	0.440	0.547	1.902[a]	0.415
> 100	(reference)			
Municipal involvement				
Yes	–0.063	0.455	1.412[a]	0.370
No	(reference)			
Financing				
Fund/PRP	–0.434	0.501	–0.413	0.442
PRP only	(reference)			
Volumetric share				
≤ 1 percent	(reference)			
1–20 percent	0.841[a]	0.434	0.977[a]	0.348
> 20 percent	1.113	0.907	2.146[a]	0.646
Cleanup phase				
Phase 1	(reference)			
Phase 2	2.822[a]	0.406	1.000[a]	0.419
Phase 3	2.026[a]	0.483	0.613	0.515
N	259		109	
R-square	—		0.551	
Root MSE	—		1.346	
Dep. Mean	—		10.790	
-2LogL	246.1		—	

[a]Significantly different from zero at 5 percent.
[b]Significantly different from zero at 10 percent.

Confidence Intervals

To calculate standard errors for differences in expected values of IR and transaction costs from the reference level, we rely on bootstrapping techniques.[3]

[3]See Efron, 1982. For another application of this technique see Hosek, Goldman, Dixon, and Sloss (1993).

To do this we construct a sequence of differences $\Delta^{(1)}, \Delta^{(2)} \cdots \Delta^{(1000)}$. We sort this sequence into ascending order and use $\Delta^{(50)}$ and $\Delta^{(951)}$ as the lower and upper bounds of the 90 percent confidence interval. Below we describe the procedure we use to generate $\Delta^{(t)}$ for IR expenditures. An analogous procedure is used for transaction costs. Given the relatively small size of the data set, we decided to bootstrap on residuals rather than on entire observations.[4] Thus the confidence intervals derived below should be interpreted as being conditional on the set of site and firm characteristics that we observed (i.e., conditional on X).

1. We construct the fitted probability that firm i will have positive IR expenditures at site j during phase p:

$$\hat{Pr}\left(y_{ijp} > 0 \middle| X_{ijp}\right) = \frac{\exp(x_{ijp}\hat{\alpha})}{1 + \exp(x_{ijp}\hat{\alpha})} \quad .$$

   For each site-firm-phase triplet, we then draw from a uniform [0,1] distribution. Denote the draw in bootstrap iteration t as $u_{ijp}^{(t)}$. We then construct

$$I_{ijp}^{(t)} = \begin{cases} 1 & \text{if } u_{ijp}^{(t)} < \dfrac{\exp(X_{ijp}\hat{\alpha})}{1 + \exp(X_{ijp}\hat{\alpha})} \\ 0 & \text{otherwise} \end{cases} .$$

   We use the sequence $\left\{I^{(t)}\right\}$ as the dependent variable to reestimate the logit regression generating $\hat{\alpha}^{(t)}$.

2. We use the OLS estimate of the log of IR expenditures conditional on positive IR expenditures to generate

$$e_{ijp} = \log(y_{ijp}) - X_{ijp}\hat{\beta}$$

   for the N_1 observations with positive IR expenditures.

   Let

$$N_1^{(t)} = \sum_{ijp} I_{ijp}^{(t)}$$

   be the number of observations in iteration t for which positive IR expenditures are predicted in iteration t, $I_{ijp}^{(t)} > 0$, and let $k(t)$ index these observations. Note that $N_1^{(t)}$ need not equal N_1. We assign equal probability

[4]Had we bootstrapped observations, the $X'X$ matrix would likely have been singular for some replicates.

to each of the N_1 residuals e_{ijp} and draw $N_1^{(t)}$ times with replacement to generate a new sequence of residuals $\{e^{(t)}\}$. A new simulated sequence of IR expenditures,

$$\log(y_{k(t)}^{(t)}) = X_{k(t)}\hat{\beta} + e^{(t)},$$

is generated, and we then regress $\log(y_{k(t)}^{(t)})$ on $X_{k(t)}$ to generate $\hat{\beta}^{(t)}$ and $\hat{\gamma}^{(t)}$.

3. Finally, we compute $\Delta^{(t)} = \hat{E}^{(t)}\left(y_{ijp}\middle|X_{ijp}^{*}\right) - \hat{E}^{(t)}\left(y_{ijp}\middle|\tilde{X}_{ijp}\right)$.
4. Steps 1–3 are repeated 1000 times to generate the bootstrap distribution of differences $\Delta^{(1)}, \Delta^{(2)} \cdots \Delta^{(1000)}$. The difference is statistically significant at 5 percent if $\left[\Delta^{(25)}, \Delta^{(976)}\right]$ does not contain zero and significant at 10 percent if $\left[\Delta^{(50)}, \Delta^{(951)}\right]$ does not contain zero.

Table B.3 contains the 90-percent confidence intervals for the differences reported in Table 4.3.

Effect of Error Correlation on Confidence Intervals

The confidence intervals have been estimated assuming that the errors in each equation are uncorrelated across observations. However, there may be correlation within sites and within firms. If the errors are correlated, the estimated standard errors in Tables B.1 and B.2 would tend to understate the true values. Since in almost every case a firm appears at only one site, it is difficult to separately estimate the size of site effects and firm effects. Instead, we first checked for evidence of within-site correlation and then for within-firm correlation. To do this, we included a complete set of dummy variables first by site and then by firm in the four-part model and did an F-test on the sum of squared residuals. As shown in Table B.4, we rejected the hypothesis of no correlation at the 5 percent level for three out of the four regressions for both site correlation and firm correlation.

We use a procedure described in Scott and Holt, 1982, to determine the correction factors for the standard errors in each equation. These are reported in the last two columns of Table B.4. For site variables, the standard errors should be multiplied by a factor between 1.28 and 1.95. For firm variables, the corrections vary from 1.05 to 1.11. The corrections for site variables are larger than those for firm variables because the site clusters are larger than the firm clusters.

Table B.3

90-Percent Confidence Interval for Predicted Changes in IR Costs, Transaction Costs, and Transaction-Cost Share When One Attribute Is Varied and Others Are Held Constant

	Change in IR Costs (in thousands of dollars)	Change in Transaction Costs (in thousands of dollars)	Change in Transaction-Cost Share (percentage points)
Site characteristics			
Expected IR cost			
< $20 million	[−201, −5]	[−61, −2]	[−7, 56]
$20–75 million	[−185, −2]	[−48, 2]	[−14, 42]
> $75 million	(reference)	(reference)	(reference)
Number of PRPs			
1–15	[18, 1251]	[14, 539]	[−35, 37]
16–100	[42, 1825]	[21, 556]	[−28, 26]
> 100	(reference)	(reference)	(reference)
Municipal involvement			
Yes	(reference)	(reference)	(reference)
No	[−194, −5]	[−53, −1]	[2, 56]
Financing			
Fund/mixed	[−176, −1]	[−34, 14]	[−5, 51]
PRP	(reference)	(reference)	(reference)
Firm characteristics			
Firm revenues			
< $15 million	[−180, −4]	[−58, −1]	[−13, 43]
$15–100 million	(reference)	(reference)	(reference)
$100–1,000 million	[−130, −8]	[−48, 1]	[−33, 25]
$1–20 billion	[−94, 44]	[−18, 46]	[−17, 37]
Firm-site characteristics			
Volumetric share			
≤ 1 percent	(reference)	(reference)	(reference)
1–20 percent	[23, 1138]	[8, 291]	[−26, 16]
> 20 percent	[907, 8347]	[24, 2016]	[−65, −2]
Cleanup phase			
Phase 1	(reference)	(reference)	(reference)
Phase 2	[257, 1991]	[60, 531]	[−44, 14]
Phase 3	[344, 3523]	[19, 322]	[−61, 1]

There is no straightforward way to determine the correction factors for the expected level of transaction costs or IR costs (each the product of two equations) or transaction-cost share (a nonlinear function of all four equations). The correction factors may be higher or lower than those of the component equations. Further work on this issue may be warranted.

Table B.4

Test of Hypothesis of No Correlation in Errors by Site and by Firm and Correction Factors for Standard Errors

	Test of Hypothesis of No Error Correlation[a]		Correction Factors for Standard Errors of	
Equation	Site Correlation	Firm Correlation	Site Variables	Firm Variables
Prob(IR costs > 0)	rejected	rejected	1.28	1.08
Log(IR costs) | IR costs > 0	rejected	not rejected	1.52	1.06
Prob(transaction costs > 0)	not rejected	rejected	1.33	1.11
Log(transaction costs) | transaction costs > 0	rejected	rejected	1.95	1.05

[a]F-test done at 5 percent significance level.

Single-Equation Model of Transaction-Cost Share

As an alternative, we directly estimate the relation between transaction-cost share and site and firm characteristics and cleanup phase *conditional on positive firm expenditures*. That is, we estimate

$$E\left(tshare_{ijp} \middle| tot_{ijp} > 0, X_{ijp}\right) = \beta_0 + \sum_{k=1}^{K_f} \sum_{c=1}^{C_f - 1} \beta_{kc}^f d_{kc}^f$$
$$+ \sum_{k=1}^{K_s} \sum_{c=1}^{C_k - 1} \beta_{kc}^s d_{kc}^s + \sum_{c=1}^{C_l - 1} \beta_c^l d_c^l$$

where tot_{ijp} is the total expenditures by firm i at site j during phase p.

Table B.5 reports both the untransformed OLS regression of transaction-cost share on site and firm characteristics and cleanup phase and a transformed regression. A variance-stabilizing transformation that is often suggested for proportion data is used for the transformed regression

$$f(tshare_{ijp}) = 2 * \arcsin\left(\sqrt{tshare_{ijp}}\right)$$

The signs and statistical significance of the coefficients in the two regressions are identical. In contrast to the results from the four-part model, there is a strong relationship between the number of PRPs at the site and transaction-cost share. We find no statistically significant relation between transaction-cost share and firm size. The results do suggest, however, that shares for smaller firms are higher. This is consistent with the results of the four-part model.

Table B.5

Regression of Transaction-Cost Share on Site and Firm Characteristics

	Dependent Variable: tshare		Dependent Variable: f(tshare)	
	Coeff.	Std. Error	Coeff.	Std. Error
Constant	0.772[a]	0.144	2.370[a]	0.409
Firm revenues				
< $15 million	0.092	0.089	0.293	0.254
$15–100 million	(reference)			
$100–1,000 million	–0.064	0.102	–0.160	0.291
$1–20 billion	–0.053	0.083	–0.178	0.237
Expected IR cost				
< $20 million	0.169[b]	0.082	0.497[a]	0.250
$20–75 million	0.100	0.096	0.273	0.272
> $75 million	(reference)			
Number of PRPs				
1–15	–0.319[a]	0.116	–0.926[a]	0.330
16–100	–0.057	0.087	–0.189	0.249
> 100	(reference)			
Municipal involvement				
Yes	–0.284[a]	0.078	–0.757[a]	0.222
No	(reference)			
Financing				
Fund/PRP	0.119	0.093	0.386	0.264
PRP only	(reference)			
Volumetric share				
≤ 1 percent	(reference)			
1 to 20 percent	–0.043	0.073	–0.073	0.208
> 20 percent	–0.212	0.132	–0.456	0.374
Cleanup phase				
Phase 1	(reference)			
Phase 2	–0.130	0.088	–0.413	0.249
Phase 3	–0.332[a]	0.106	–0.948[a]	0.300
N	110		110	
R-square	0.451		0.432	
Root MSE	0.284		0.806	

[a]Significantly different from zero at 5 percent.

[b]Significantly different from zero at 10 percent.

C. Prediction of Total Private-Sector PRP Expenditures at the Study Sites

Private-Sector PRP Expenditures at the Study Sites

To estimate total PRP expenditures at the study sites, we first estimate the four-part model without firm size. We omit firm size because we do not have information on firm size for the firms not in our sample. Tables C.1 and C.2 report estimates of the IR costs and transaction costs models without firm size. The coefficient estimates for these models are broadly consistent with those for the models with firm-size variables (Tables B.1 and B.2). We then construct a set of right-hand-side variables, Z_{ijp}, for each of the 3538 firms at the study sites that are not included in the sample and use the four-part model to estimate their IR and transaction costs. We sum these estimates and add in the IR and transaction costs for the firms in the sample to generate an estimate of overall PRP expenditures at the study sites. The process is repeated 1000 times using bootstrapping techniques as described in Appendix B to generate a distribution for the estimate of firm expenditures. Our point estimate is the mean of this distribution, and the 90-percent confidence interval runs from the 5th to the 95th percentile. Below we describe the procedure we use to generate the sequence of estimates of IR expenditures. Note that the confidence interval captures variation due to both the estimated model coefficients and the equation errors.

1. For each firm not in the sample with characteristics, Z_{ijp}, draw from a uniform [0,1] distribution. Denote draw t as $v_{ijp}^{(t)}$. Then construct

$$\tilde{I}_{ijp}^{(t)} = \begin{cases} 1 & \text{if } v_{ijp}^{(t)} < \dfrac{\exp(Z_{ijp}\hat{\alpha}^{(t)})}{1+\exp(Z_{ijp}\hat{\alpha}^{(t)})} \\ 0 & \text{otherwise} \end{cases}$$

   where $\hat{\alpha}^{(t)}$ is the parameter estimate from bootstrap iteration t estimated using the methods in Appendix B. Note that $\hat{\alpha}^{(t)}$ does not have the same dimension or value as in Appendix B because the model has changed.

2. Assign equal probability to each of the N_1 residuals from the original OLS regression of log(IR costs), $\{e_{ijp}\}$, and draw N_{NS} times with replacement to generate a sequence of residuals $\{\xi_{ijp}^{(t)}\}$ where N_{NS} is the number of firms at

Table C.1

Two-Part Model of IR Costs Excluding Firm Size

	Logit for Positive Expenditures		OLS on Log of Expenditures	
	Coeff.	Std. Error	Coeff.	Std. Error
Constant	−1.974[a]	0.825	8.982[a]	0.615
Expected IR cost				
< \$20 million	−2.223[a]	0.598	−1.296[a]	0.387
\$20–75 million	−0.195	0.560	−1.053[a]	0.422
> \$75 million	(reference)			
Number of PRPs				
< 16	0.719	0.759	0.951	0.950
16–100	0.471	0.596	2.034[a]	0.440
> 100	(reference)			
Municipal involvement				
Yes	0.661	0.509	2.419[a]	0.443
No	(reference)			
Initial financing				
Fund/mixed	−0.963[b]	0.503	−0.950[a]	0.438
PRP	(reference)			
Volumetric share				
≤ 1 percent	(reference)			
1–20 percent	0.955[a]	0.476	1.317[a]	0.346
> 20 percent	2.506[a]	0.806	5.116[a]	0.834
Cleanup phase				
Phase 1	(reference)			
Phase 2	2.783[a]	0.493	1.587[a]	0.437
Phase 3	2.720[a]	0.590	1.982[a]	0.538
N	259		71	
R-square	—		0.808	
Root MSE	—		1.098	
Dep. Mean	—		11.757	
−2LogL	202.0		—	

[a]Significantly different from zero at 5 percent.
[b]Significantly different from zero at 10 percent.

the study sites that are not in the sample. Then estimate expenditures for each firm not sampled using

$$\tilde{y}_{ijp}^{(t)} = \tilde{I}_{ijp}^{(t)} \exp(Z_{ijp}\hat{\beta}^{(t)} + \xi_{ijp}^{(t)})$$

where $\hat{\beta}^{(t)}$ is the estimate from bootstrap iteration t.

3. Total IR expenditures of private-sector PRPs at the study sites during phase p are then

$$\tilde{y}_{p}^{(t)} = \sum_{ij} \tilde{y}_{ijp}^{(t)} + IR_p$$

Table C.2

Two-Part Model of Transaction Costs Excluding Firm Size

	Logit for Positive Expenditures		OLS for Log of Expenditures	
	Coeff.	Std. Error	Coeff.	Std. Error
Constant	−1.859[a]	0.756	9.502[a]	0.617
Expected IR cost				
< \$20 million	−1.389[a]	0.561	−0.899[a]	0.390
\$20–75 million	0.382	0.596	−0.809[b]	0.445
> \$75 million	(reference)			
Number of PRPs				
< 16	0.710	0.653	1.211[a]	0.580
16–100	0.572	0.537	1.951[a]	0.410
> 100	(reference)			
Municipal involvement				
Yes	0.062	0.440	1.448[a]	0.369
No	(reference)			
Initial financing				
Fund/mixed	0.043	0.456	−0.716[b]	0.404
PRP	(reference)			
Volumetric share				
≤ 1 percent	(reference)			
1–20 percent	0.956[a]	0.404	1.104[a]	0.337
> 20 percent	2.011[a]	0.799	2.627[a]	0.578
Cleanup phase				
Phase 1	(reference)			
Phase 2	2.702[a]	0.389	1.047[a]	0.420
Phase 3	2.040[a]	0.474	0.686	0.514
N	259		108	
R-square	—		0.532	
Root MSE	—		1.351	
Dep. Mean	—		10.790	
-2LogL	255.0		—	

[a]Significantly different from zero at 5 percent.

where IR_p is the observed IR expenditures for the sampled firms during phase p. Total PRP expenditures to date are

$$\tilde{y}^{(t)} = \sum_p \tilde{y}_p^{(t)} + \sum_p IR_p$$

4. Repeat steps 1–3 1000 times. The point estimate of total PRP expenditures is the mean of the sequence, and the 90-percent confidence interval is $\left[\tilde{y}^{(50)}, \tilde{y}^{(951)}\right]$.

Transaction-Cost Share at Completion for Scenario 1

In this subsection we describe the calculations used in Scenario 1 to determine transaction-cost share at completion for the 18 study sites. Transaction-cost share at completion is estimated as a weighted average of the transaction-cost shares in each phase, where the weights correspond to the estimated proportion of total expenditures (at site completion) by phase. This estimate assumes that the expected transaction-cost shares in each phase are common across sites and are independent of the distribution of total costs across phases.

Weights are derived as follows:

1. For each site, IR costs in Phase 1 are estimated using observed costs for the sampled firms and the two-part model to estimate costs for the nonsampled firms.
2. For sites that have completed Phase 2, Phase 2 IR costs are estimated using observed costs for sampled firms, and estimated costs (from the two-part model) for nonsampled firms. For the nine sites that have not completed Phase 2, IR costs are estimated as the maximum of (a) a multiple of Phase 1 IR costs, where the multiple (18.2) is equal to the dollar-weighted ratio of Phase 2 to Phase 1 IR costs for the nine sites that have completed Phase 2, and (b) Phase 2 IR expenditures to date (observed for sampled firms, estimated by the two-part model for nonsampled firms). The two estimates are about equal for four sites; the observed-cost estimate is substantially larger for four sites, and the multiple-based estimate is substantially larger for one site.
3. For all sites, Phase 3 IR costs are estimated as the maximum of (a) the expected total cleanup cost less estimated Phase 2 expenditures and (b) Phase 3 costs to date (observed for sampled firms, estimated from the two-part model for nonsampled firms). The first estimate is used at fourteen sites, the second at four sites. Of the four sites where estimated Phase 2 costs to date exceed expected total cleanup cost, two have not yet completed Phase 2, so estimated Phase 3 costs are zero.
4. Total (IR plus transaction) expenditures in each phase are estimated using estimated IR expenditures and transaction-cost shares:

$$tot_p = ir_p \left(\frac{tshare_p}{1 - tshare_p} + 1 \right)$$

where tot_p is total PRP expenditures through completion in phase p, ir_p is IR expenditures in phase p, and $tshare_p$ is the transaction cost share in phase p.

5. Final weights are derived by dividing estimated total expenditure in each phase by the sum of estimated total expenditures across phases. The resulting weights are: Phase 1, 0.02; Phase 2, 0.32; Phase 3, 0.66.

Transaction-cost share at site completion is the weighted average of the estimated transaction-cost shares in each phase, 27 percent. A confidence interval can be obtained by substituting upper and lower bounds for the 90-percent confidence intervals for transaction-cost share in each phase.

Using upper or lower bounds simultaneously yields a range for the share at completion of 13 percent to 41 percent. The interpretation of this interval depends on assumptions about the relationship between estimated mean (across site) transaction-cost shares in subsequent phases. If these are perfectly correlated (because of model misspecification, for example), the range is a 90-percent confidence interval; alternatively, if estimated mean shares by phase are independent, the range represents a 99-percent confidence interval (conditional on the model specification and weights). Because of uncertainties concerning model specification, calculation of weights, and other factors that are not adequately quantified, interpreting this range as even a 90-percent interval overstates our confidence in transaction-cost share at site completion.

D. Evidence of Front-Loading of Transaction Costs

To investigate whether there is any evidence of front-loading of transaction costs, we first separate Phase 3 expenditures at the 18 study sites and a set of supplemental sites (discussed below) into 3 separate subphases and then examine how transaction-cost share changes as sites move through Phase 3.

We break Phase 3 down into Phases 3A, 3B, and 3C. As shown in Table D.1, Phase 3A begins when RA starts at one operable unit at the site and ends when RA has begun at all operable units. (Sites with only one operable unit skip Phase 3A). Phase 3B starts when RA has begun at all operable units and ends when construction is complete at all operable units. Finally, Phase 3C covers time subsequent to the completion of construction at all operable units.

Table D.2 presents transaction-cost shares for the 108 firms in our sample categorized by site cleanup phase as of 1991. These are not the transaction-cost shares for all firms at the sites, rather they are only the observed shares for the sampled firms. Breaking sites down into so many categories results in cases where there are only a few sites in each category.[1] This breakdown, however, allows us to look for some preliminary evidence of front-loading of transaction costs.

There is no evidence so far that transaction costs are front-loaded in Phase 3 at the study sites. For the two sites currently in Phase 3C, transaction-cost share

Table D.1

Definition of Components of Phase 3

Phase	Starts When	Ends When
Phase 3A	RA begins at one operable unit, but not at all	RA has begun at all operable units
Phase 3B	RA has begun at all operable units	Construction complete at all operable units
Phase 3C	Construction is complete at all operable units	—

[1] We collapsed Phases 3A, 3B, and 3C in the four-part model of firm expenditures because there were insufficient data to statistically estimate separate effects.

Table D.2

Transaction-Cost Share by Site Cleanup Phase in 1991

		Transaction-Cost Share (percentage)[a]					
1991 Cleanup Phase	Number of Sites	Phase 1	Phase 2	Phase 3A	Phase 3B	Phase 3C	All Phases
Phase 2	9	79	29	—	—	—	29
Phase 3A	5	22[b]	17	13	—	—	14
Phase 3B	2	100	21	—[c]	4	—	14
Phase 3C	2	100	17	4[d]	8	10	10
All sites	18	48	26	12	5	10	21
(Number of sites)		(16)	(18)	(6)	(4)	(2)	(18)

[a]Dollar-weighted transaction-cost share.

[b]Based on three sites because two sites skipped Phase 1.

[c]Both sites currently in Phase 3B have only one operable unit and thus skipped Phase 3A.

[d]Based on one site.

actually rises from 4 percent in Phase 3A to 8 percent in Phase 3B and 10 percent in Phase 3C.[2]

In addition to the study sites, we asked the firms participating in the study to report their expenditures at any other NPL sites where they had incurred significant costs. The choice of the supplemental sites was made by the PRPs, but typically they chose the most expensive or difficult sites. The firms provided information on 21 supplemental sites. The supplemental sites were similar to the 18 study sites in terms of the percentage with mixed financing and estimated total cleanup cost greater than $50 million. In contrast, a lower percentage of the supplemental sites had more than 50 PRPs, and on the whole, they had not progressed as far through the cleanup process.[3]

Table D.3 reports the phase transaction-cost shares for the supplemental sites classified by cleanup stage in 1991. Here there is some evidence that Phase 3 transaction costs are front-loaded: The share is 64 percent in Phase 3A versus 34 percent in Phase 3B for four sites in Phase 3B as of 1991.

[2]We can also look for front-loading by comparing phase transaction cost shares for sites that have finished a particular phase and those that have not (down columns in Table D.2). However, these differences may be due to differences across sites and not to front-loading of transaction-costs. For example, the low transaction-cost shares for sites currently in Phase 3C in Phases 2 and 3A suggest that sites currently furthest through the process may be the sites that will have the lowest transaction-cost shares when construction is complete at all sites.

[3]We did not use these nonrandomly selected sites in our main analysis, but we include them here because of the paucity of data and because it seems unlikely that the change in transaction-cost share over time at a given site would correlate with whether a firm selected the site.

Table D.3

Transaction-Cost Share by Site Cleanup Phase in 1991 for 21 Supplemental Sites

		Transaction-Cost Share (percentage)[a]					
1991 Cleanup Phase	Number of Sites	Phase 1	Phase 2	Phase 3A	Phase 3B	Phase 3C	All Phases
Phase 2	11	55	32	—	—	—	37
Phase 3A	6	36	32	22	—	—	24
Phase 3B	4	—[b]	70	64	34	—	50
Phase 3C	0	—	—	—	—	—	—
All sites	21	54	34	36	34	—	37
(Number of sites)		(17)	(21)	(10)	(4)		(21)

[a] Dollar-weighted transaction-cost share.

[b] Sites currently in Phase 3B skipped Phase 1.

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