DIRTY WORDS: INTERPRETING AND USING EPA DATA IN AN ACTUARIAL ANALYSIS OF AN INSURER'S SUPERFUND-RELATED CLAIM COSTS

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Abstract

A significant amount of liability exposure for many insurers stems from pollution-related claims. Many of these pollution-related claims, in turn, stem from the implementation of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, also known as Superfund. This paper discusses adjustments necessary to properly use the EPA's records of decision (RoDs) and Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) data in actuarial analyses of Superfund costs. Background on the Superfund process and an approach to using the data in an exposure-type analysis suitable to insurers with significant potential exposure to environmental losses are also presented. The paper also discusses the difficulties typically facing an actuary in non-Superfund site cleanup cost evaluations, and concludes with some comments on environmental liability discounting considerations.

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This paper should be read with the understanding that the opinions expressed herein represent the views of the author, and do not necessarily represent the views of the Casualty Actuarial Society, Ernst & Young LLP, or anyone else.

1. FROM THE GROUND UP: AN INTRODUCTION

A significant amount of liability exposure for many insurers stems from pollution-related claims. Many of these pollution-related claims, in turn, stem from the implementation of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, also known as Superfund.

Currently, there are two primary sources of Superfund cost-related information available for use in an environmental analysis: Records of Decision (RoDs) published by the Environmental Protection Agency (EPA), and the Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS). While data from these sources is readily available from the EPA,[1] information on the appropriate use of that data is not as easily found. Given the importance of reasonably estimating these liabilities in connection with acquisitions, commutations and financial reporting, a thorough understanding of the data underlying many of these analyses is vital. This paper is an attempt to fill the gap in CAS literature relating to environmental cost data and its use in environmental analyses.

2. DIGGING IN: AN OVERVIEW OF THE SUPERFUND PROCESS

The Superfund process begins with the discovery of a location which represents *either a current or potential future* health

[1]Most readily through *WWW.EPA.GOV/Superfund/*, which is the EPA's Superfund web site. In addition to the EPA, the Agency of Toxic Substances and Disease Registry (ATSDR) also maintains a database accessible through the Internet at *http://atsdr1.atsdr.cdc.gov:8080/hazdat.html* with information on public health hazard levels (discussed in Appendix C).

hazard. The potential for future hazard is generally based on (1) the potential for current contamination levels to spread at a particular site, (2) plausible future uses of that site, and (3) plausible estimates of the future size of the population at and adjacent to that site. If this discovery is reported to the EPA, information on that "site" is put into the CERCLIS database.

An off-site preliminary assessment is then performed to characterize the site as a potentially imminent, serious, or non-serious threat. Imminent threats are addressed through emergency removal actions, designed to reduce the threat to a serious or non-serious level. Serious (but not imminent) threats are addressed through site inspections, which include on-site evaluations to better characterize whether or not the site requires further EPA attention (including an emergency removal action not already initiated, due to insufficient information at the preliminary assessment phase). A site determined to pose no serious threat receives no further attention by the EPA.

The EPA then uses a hazard ranking system (HRS) to prioritize those sites that still pose a potentially serious threat. The HRS is a quantitative assessment, on a scale of 1 to 100, of the level of hazard to human health via several "exposure pathways." These pathways represent different ways that a hazard can expose human beings to a health risk—for example, through ground and surface water, the soil and the air. If the HRS is high enough (currently, 28.5[2] or greater), the EPA "proposes" that the site be included in the National Priorities List (NPL), representing those sites which, in the EPA's estimation, represent the greatest potential hazard to human health, past, present

[2]The 28.5 threshold score was derived "because it would yield an initial NPL of at least 400 sites as suggested by CERCLA, not because of any determination that it represented a threshold in the significance of risks presented by sites." [1] This apparent need to initially list at least 400 sites on the NPL may somewhat mitigate the argument that the hazard level of the average site listed early in the program exceeds the hazard level of the average site listed more recently. This is discussed further later in this paper, as well as in Appendix B.

or future.[3] Community discussions are then held, and after some additional work, these sites may be listed on the "final" NPL.[4] It is worth noting some of the events that have impacted past, and may impact future, site listings:

- As noted earlier, CERCLA appeared to suggest that at least four hundred sites should be listed on the initial NPL in 1983.
- Federal facilities started showing up with some regularity in 1987, after the Superfund Amendments and Reauthorization Act of 1986 (SARA) gave the EPA a level of control over remedy selection at Federal facilities.
- Between the mid-1980s and early to mid-1990s, the capabilities of the states' individual Superfund programs grew, perhaps leading to a shift in emphasis from Federal to State enforcement.
- In December of 1990, the HRS was revised, leading to fewer annual NPL site listings per year.
- "Governor's Concurrence" legislation enacted in July of 1995 required the EPA to seek approval from a state before listing a site located there on the NPL. Since then, more than 30 sites were not listed, at the request of the relevant states' governors.

It is also worth noting two additional means by which a site may be listed on the NPL. First, each state is entitled to select a single site and include it on the NPL, regardless of that site's HRS score, if the state feels that the site represents a significant

[3]The preliminary nature of the data used to derive the HRS is believed to be useful for determining whether or not a site represents a potentially significant hazard, but it is not necessarily useful for ranking the relative hazard levels of those sites which exceed the HRS threshold. In addition, if the HRS reaches this threshold before all pathways are scored, the remaining pathways might not be scored. For these reasons, the author recommends not using the HRS to estimate the relative hazard levels of Superfund sites.

[4]There are actually two NPLs—one for Federal sites (i.e., federally owned), and one for non-Federal sites. Only the non-Federal sites are usually considered relevant to estimating an insurer's potential environmental liabilities. Information on whether a particular site is a Federal facility is available in CERCLIS.

danger to public health. Second, a site may be listed if all of the following conditions (taken from [2]) are met:

- The Agency for Toxic Substances and Disease Registry (ATSDR) of the U.S. Public Health Service has issued a health advisory that recommends dissociation of individuals from the site.
- EPA determines that the site poses a significant threat to public health.
- EPA anticipates that it will be more cost-effective to use its remedial authority (available only at NPL sites) than to use its removal authority to respond to the site.[5]

Sites that were reviewed and subsequently not listed on the NPL remained in the CERCLIS database for many years, leaving them with a stigma stemming from the belief that there was a strong possibility they might still become NPL sites at some later date. To alleviate this concern, the EPA created a new database in March of 1995 which would store these "archived" sites. The database was called NFRAP, which stands for "No Further Remedial Action Planned," and, by September 30, 1996, it contained 25,000–30,000 sites no longer being considered for NPL status. However, these sites remain within the purview of the state and local governments, who may require further action.

How to Remedy a Bad Situation: An Introduction to Records of Decision

For sites listed on the NPL, the next step is to determine what actions would constitute an appropriate remedy. The EPA publishes the details relating to these "remedial actions" (RAs), addressing the potential contamination at a particular location in a "record of decision" (RoD). These RoDs typically include a

[5] A removal action is a mechanism whereby the EPA can take immediate action to "remove" hazardous substances posing an immediate threat to public health and the environment, rather than allowing the threat to linger until that site is listed on the NPL, making it eligible for a more extensive (but likely less timely) cleanup effort.

description of the problem that is being addressed, the remedy selected to address the problem, and the expected cost associated with the selected remedy.

There are two types of costs usually addressed in the RoDs—those related to the construction of the selected remedy (capital costs) and those related to the implementation, operation and on-going maintenance of the selected remedy over time (operation and maintenance, or O&M costs). Once issued, RoD cost estimates are not typically updated to reflect new information, except in the event of a fundamental change in the approach required or technology to be used.

There are three types of RoDs issued: interim RoDs, which address either a partial remedy or a "quick fix" to prevent the further spread of contamination that will be addressed in a later RoD; final RoDs, which represent either the complete remedy at a particular location or the completion of a remedy begun earlier in an interim RoD; and amendment RoDs, which supplant previous RoDs due to a change in scope, cost or both. These amendment RoDs can be either interim amendment RoDs or final amendment RoDs, though interim amendment RoDs are rare.

A single RoD need not address the remedy required for an entire site. Sometimes, multiple RoDs are issued. This is done because an NPL site may have several problems needing to be addressed, such as groundwater and soil contamination. These problems may be addressed as two separate "operable units" (OUs) of that site, in different RoDs. It is worth noting that these RoDs are not necessarily issued at the same time—the EPA (or any other party responsible for site cleanup) may address the groundwater issue at a site (which might soon contaminate an adjacent town's drinking water if unchecked), but forego cleanup efforts relating to the soil contamination. This might happen if the contaminated soil is felt to be a less immediate risk to human health than exists currently at another site. In this case, the EPA might divert its resources toward that other site, and return to the first site later. It is also worth noting that multiple OUs at a site typically relate to different contaminated media at that site (e.g., groundwater and soil), which may or may not be present at different locations of the site. In other words, two OUs at a site should not automatically imply two geographic areas requiring attention at that site. Similarly—and adding to the confusion—a RoD may also address a single OU comprised of multiple contaminated media (e.g., groundwater and soil together). Also, remember that a single OU may be addressed through multiple RoDs (i.e., an interim, a final and/or an amendment RoD).

Digging Deeper: Remedial Design Costs

As technical as they might appear to be, RoDs only address the *general* approach to be used in implementing the selected remedy. After the RoD is issued, the "remedial design" (RD) phase provides the *specific* approach to be used in implementing the general remedy outlined in the RoD. The RD cost estimate and the costs included in the RoD are intended to represent the same items (i.e., capital and O&M costs); since the approach is more detailed in the RD phase, however, the RD cost estimates are expected to be more refined. EPA guidance indicates that the actual costs incurred for cleanup activities should be between 70% and 150% of the RoD cost estimate, but only between 95% and 115% of the RD cost estimate.[6]

It is possible that the cost or approach of the RA selected in the RD phase may be significantly different from the cost or approach of the RA as outlined in the RoD, perhaps as a result of unforeseen conditions encountered at a given site. If these significant differences do not result in a fundamental change to the general remedy selected in the RoD, the EPA would typically issue an "Explanation of Significant Differences" memorandum (ESD), outlining the nature and cause of the differences. This

[6]The RD documentation relating to each RA is generally made available for public viewing near the area to be remediated. To the best of this author's knowledge, the RD documents are not consolidated in a single, publicly-available database.

differs from an amendment RoD, which results from significant differences in the approach of the RA that *do* result in fundamental changes to the general remedy selected in the RoD.

Once remedial construction activities have been completed, a site or OU can be labeled "construction complete." This does not mean that the selected remedy has been put into operation yet; only that the necessary construction required to do so has been completed. Additionally, significant O&M activities may be required after the remedy is enacted.

After all necessary construction is completed, the selected remedy is instituted and O&M activities (if any) are concluded, that site, OU or particular formerly contaminated media may be "deleted" from the NPL, indicating that no further action is deemed necessary. *Not all deleted sites represent completed cleanups, however*. Resource Conservation and Recovery Act (RCRA) sites may be deleted from the NPL before cleanup activities have been completed "if the site is being, or will be, adequately addressed under the RCRA corrective action program under an existing permit or order." [3] A short introduction to RCRA, for those not familiar with it, is included in Appendix D.

It's a Dirty Job, but Someone's Gotta Do It: Cleanup Cost Liability Allocation

At any point along the way in the Superfund process, the EPA may uncover leads on people and companies they believe to be potentially responsible for a given site's polluted status. A list of these potentially responsible parties (PRPs), which has previously been available through the EPA's SETS database (Site Enforcement Tracking System), is now included in CERCLIS. Allocation of liability among PRPs at any given site is considered by many as the single most difficult aspect of estimating Superfund liability. The count of PRPs at a given site changes over time. In addition, a PRP's share of liability might not correlate well with the number of PRPs potentially sharing the cleanup cost at that site (in part because the group of PRPs connected by the EPA to many sites can be characterized as a small number of large polluters and a large number of smaller ones, skewing the proportions).

To help distinguish the possibly responsible from the probably responsible, the actuary should consider looking at other types of communications between the EPA and parties that may be liable at NPL sites. The following is a list that, in the author's opinion, might be used to form a "Superfund Liability Pyramid," in the sense that the items in the list are ordered from least to most likely responsible for activities at a Superfund site:

- *general notice letter recipients*—the EPA sends this letter to parties to inform them of their potential responsibility for site cleanup-related activities.
- *special notice letter recipients*—the EPA sends this letter to parties to inform them of their right to offer to conduct the cleanup efforts at a site.
- *unilateral administrative order (UAO) recipients*—the EPA uses UAOs to "unilaterally order" parties to undertake activities at a site.
- *parties to an administrative order on consent (AoCs) or consent decree*—these documents formalize agreements reached between the EPA and other parties relating to Superfund-related actions those parties have agreed to undertake.

Once in communication with the EPA, an entity involved in a cleanup effort may seek out additional parties to share the responsibility for cleanup-related costs, in addition to those other parties already in communication with the EPA. These additional parties—sued for cooperation not by the EPA, but by those already responsible for cleanup-related costs—are called "collateral suit defendants." Since the EPA is unconnected to the search for these additional PRPs, they would not be included in the EPA's data when and if they are found. To this author's knowledge, there are no good publicly-available data sources for information on collateral suit defendants.

Superfund Action Figures: EPA Expenditure Data

While RoDs contain estimated prospective remedial action costs, EPA's actual costs incurred to date relating to remedial and pre-remedial activities can be found in the CERCLIS and NFRAP databases. The information contained in them is identical, except that NFRAP contains information on sites where no further EPA activity is planned, and CERCLIS contains information on all other sites reported to the EPA. Throughout this paper, reference to CERCLIS should be understood to include NFRAP.

Users of CERCLIS information must be cautious since *only* those costs incurred to date directly by the EPA (referred to as "fund-financed" costs) are included in CERCLIS.[7] As a result, the cost information in CERCLIS is only potentially complete and up to date for activities with a fund-financed cleanup effort.[8] In other situations (i.e., a PRP-financed activity), CERCLIS only includes costs relating to the EPA's oversight of that activity—the cost of *performing* that activity must still be quantified, perhaps based on the average cost of similar, fund-financed activities.

In evaluating how the costs of PRP-financed activities may relate to corresponding, historical fund-financed activities, the reader should note that the General Accounting Office (GAO) had the following to say about the EPA's cost controls [5]:

> "…our recent review found that in spite of the [EPA's] actions, several problems persist: (1) EPA's regions are

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[7]Note that no O&M costs are to be incurred by the EPA under Superfund. These costs are intended to be the responsibility of either the states or PRPs. However, since the definition of O&M activities differs between CERCLIS and the RoDs (as will be discussed later), some O&M costs arguably are fund-financed.

[8]Even these fund-financed efforts require that some of the capital costs be borne by the states, implying that CERCLIS might not have complete cost information on even these sites. For example, "The President shall not provide any remedial actions pursuant to this section unless…the state will pay or assure payment of (i) 10 per centum of the costs of the remedial action, including all future maintenance…" [3]

> still too dependent upon the contractors' own cost proposals to establish the price of cost-reimbursable work, (2) EPA continues to pay its contractors a high percentage of total contract costs to cover administrative expenses rather than ensuring the maximum amount of available moneys is going toward the actual cleanup work, and (3) little progress has been made in improving the timeliness of audits to verify the accuracy of billions of dollars in Superfund contract charges."

Working with the cost information in CERCLIS is not straightforward. Even for fund-financed activities, the costs cannot always simply be added up to derive a given activity's total incurred cost. For example, some activities are funded by the Superfund program but overseen by a state instead of the EPA. For some of these "state-led" activities, the state is responsible for its own share of the cost from the outset, which would not be included in CERCLIS. A detailed schematic of the cost data included in CERCLIS is shown in Exhibit 1. Exhibit 2 compares and contrasts the data contained in CERCLIS and RoDs.

3. GETTING DOWN AND DIRTY: WHAT ARE SUPERFUND'S COSTS?

Litigation and other transaction costs aside, what are the costs incurred under the Superfund program? Exhibit 3 displays a list of the activities that have typically been included in the EPA's review of an NPL site, with estimates of the average duration and cost for each type of action.

Intent on improving the process, the EPA introduced the Superfund Accelerated Cleanup Model (SACM), designed to streamline the process by (1) combining the preliminary assessment and site inspection steps into a single step (Site Screening and Assessment), eliminating much duplication of assessment-related effort, (2) instituting consistent remedy selections for similar sites rather than assuming site-specific remedies were always required, yielding more efficient and cost-effective cleanups, and (3) creating regional decision teams to more effectively prioritize the cleanup efforts of Superfund sites in each region. The EPA's consistent remedy selection strategy, as well as another recent initiative—increased remedy selection updating through RoD amendments—will be revisited later.

4. MUDDYING THE WATERS: "BROAD" VS. "NARROW" REMEDIAL ACTIONS

Before beginning a discussion on cleanup costs, a note about terminology is in order. The term "remedial action" as used so far has referred to the costs associated with all aspects of the cleanup process (capital costs plus all O&M costs), as is typically done when discussing cleanup (remedial) vs. other-than-cleanup (non- or pre-remedial) actions. Within the context of discussing cleanup costs only, however, the phrase "remedial action" has two different meanings. When used in a RoD or other engineering costing study, it typically relates to those costs incurred only to *construct* the remedy (i.e., the *capital costs*)—the actual *implementation* of the remedy and any other O&M-related activities would be considered when estimating O&M costs. Alternatively, to determine which costs are eligible for Superfund funding, the EPA considers RA costs as those which must be incurred to safeguard the environment from the contamination at an environmentally-impaired site—clearly, a broader definition, incorporating both the *construction* and (at least partial) *implementation* of the remedy. Therefore, the capital costs displayed in the RoDs (usually representing construction costs only) typically should not be compared to the RA costs in the EPA's CERCLIS database without first adjusting for the percentage of total RA costs included in CERCLIS (see Exhibit 1) and the addition of a portion of the RoD's O&M costs. The appropriate portion of the RoD's O&M costs to include in this comparison is up to ten years when groundwater or surface water restoration is included, and up to one year in other cases.

5. SPARE THE ROD: WHAT IS (AND IS NOT) INCLUDED IN A RECORD OF DECISION

RoD costs typically represent the sum of undiscounted capital costs (relating to remedial actions) and discounted O&M costs, yielding a total which is neither fully discounted nor undiscounted. Unwinding the discount in the O&M estimate requires three items: an estimate of O&M expenditures by year, the discount rate used and the expected duration of O&M activities in years. There are three issues relating to these items:

- Annual O&M costs do not represent estimates of O&M expenditures by year since they do not include a provision for inflation. As an example of the magnitude of this issue, an annual inflation rate of only 3% over an eighteen year period (an estimate of the average duration of O&M activities where no groundwater issues are present [6]) increases the total O&M cost estimate by approximately one-third. Over a thirty-year period (the maximum duration included in RoD O&M cost estimates), the estimated total O&M cost would increase by approximately 60%.[9]

- The discount rate used to calculate the present value of total O&M costs is not always included in the RoDs. Exhibit 4 provides a list of the discount rates likely applicable to this calculation, according to RoD-related guidance and other documentation in effect during each period. Note that the inflationary impact excluded from the annual O&M costs above is included here as a reduction to the nominal discount rate selected—hence the term "pre-tax, after inflation" discount rate, as shown in Exhibit 4. The reader should be aware, however, that this discount rate is reduced by the overall inflation level of the economy. It may be possible that these O&M-

[9]The increase of 32% can be calculated as the summation of $j = 1$ to 18 over the expression $(1.03)^{(j-0.5)}/18$. The increase of 61% can be calculated similarly, using a summation of $j = 1$ to 30, and dividing by 30.

related costs, which are largely construction and labor-related, are subject to a different degree of inflation than the average inflationary level of the economy as a whole.

An example should help to clarify the issues above and simultaneously explain how the O&M cost information in RoDs has frequently been misinterpreted. Assume, for example, an inflation rate of 3%, a nominal discount rate of 10%, and an expected first O&M payment (as indicated in the RoD) of $1,000, with O&M activities expected to continue for 30 years. The present value of the first O&M payment—assuming it is expected to occur during the second year of cleanup activities—might be calculated either as $\$1{,}000 * (1.03)/(1.10)$, or as $1,000/1.07 (where 1.07 is the rounded result of $1.10/1.03 = 1.067$). Similarly, the present value of the second payment would be either $\$1{,}000 * (1.03)^2/(1.10)^2$, or simply $\$1{,}000/(1.07)^2$. It should be clear from these examples that it is easier and faster to simply work with the 7% "after inflation" discount rate and the constant $1,000 starting value than to use both the inflation rate of 3% and the nominal, pre-inflation discount rate of 10%. Unfortunately, the fact that the first year's payment is frequently referred to as the "annual" O&M cost, has led to the traditional approach of estimating undiscounted O&M costs as this allegedly "annual" O&M cost, multiplied by the number of years of O&M activities—in this case, yielding $30,000 (= 30 years ∗ $1,000 per year). However, applying the 3% inflation and 30 year duration assumptions to the $1,000 first year O&M cost yields an undiscounted cost estimate of $49,003—more than 60% greater than the $30,000 estimate. In addition, if it is believed that O&M cost inflation is 5% per year, rather than the 3% general inflation rate, the undiscounted O&M cost estimate becomes $69,761—more than double the $30,000 estimate typically derived. This is especially important in evaluating the extent to which RoD cost estimates have historically over- or understated actual costs incurred. If the actual O&M costs incurred for this RoD's O&M activities were between $50,000 and $70,000, the traditional approach would indicate that the actual O&M costs are in the neighborhood of 67%–133% greater than the expected costs. In reality, however, we can see that correct estimation of the undiscounted O&M cost would imply that our estimate was right on target, assuming a 3%–5% inflation rate over the thirty-year period applied.

- 1EPA guidance documents [7] note that for the purpose of estimating the total O&M discounted cost, the maximum duration of O&M activities permitted is thirty years. This is because the EPA is only concerned with providing a discounted estimate of O&M costs, and the EPA believes that there is little gained on that basis by continuing beyond thirty years.[10] As a practical matter, many of the cleanup efforts requiring thirty-year O&M costs are actually expected to continue forever.[11]

In addition to the above, two additional considerations regarding RoD cost adjustments are noteworthy:

- Although the focus of the above was primarily on O&M costs, for construction efforts expected to require more than a year to complete, there may be some level of capital cost inflation as well.

[10]Readers of [8] may recall the comment that "there was a clear pattern of 30 years as the standard duration (of O&M costs)," (p. A-10) consistent with the EPA's maximum allowable O&M duration for RoD costing purposes.

[11]From [9], the following is offered with regard to O&M activity durations: "The federal government, states, and responsible parties must perform some long-term operations and maintenance at almost two-thirds, or 173, of the 275 sites we reviewed that were formerly or are currently on the National Priorities List and where the cleanup remedy has been constructed. These activities—which include controlling the erosion of landfill covers, treating contaminated groundwater, or implementing and enforcing restrictions on the use of land or water on or adjacent to the sites—will continue for decades, and, in some cases, indefinitely." Also, from the EPA's own documentation [7], "Remedial action alternatives requiring perpetual care should not be costed beyond thirty years, for the purpose of feasibility analysis. The present worth of costs beyond this period become negligible and have little impact on the total present worth alternative."

- When included in the RoDs, both capital and annual O&M costs are typically stated in "current dollars," where "current" refers to the year in which the RoD was written—not necessarily the year either construction or O&M activities are expected to begin.

Appendix A includes a sample RoD Summary taken from the EPA's web site, and an approach which can be used to calculate the undiscounted cleanup cost estimate implied by information included in that sample RoD, adjusting for the above issues. (Note the assumption that the duration of O&M activities will not extend beyond thirty years, which may not be reasonable.) Row 16 of Appendix A, Exhibit 1 displays the undiscounted total cost estimate for this RoD ($81,178,343). This amount is between two and three times greater than the estimate of present worth total costs actually displayed in the RoD ($30,720,300, from Row 1). The magnitude of this difference emphasizes the importance of properly interpreting the RoD data prior to its use in actuarial analyses.

6. SUM IN-SITE: ESTIMATING INDIVIDUAL SITE COSTS BY ADDING ROD COST ESTIMATES

There are several issues which hamper the use of RoD data for estimating individual undiscounted Superfund site cost estimates, including the following:

- There are many sites for which no RoDs have been issued.
- The most recently issued RoDs may not yet be readily available.
- A site may have two or more OUs, but currently only one RoD addressing only one of them.
- A RoD need not address the final remediation for an OU (or combination of OUs). As noted above, interim RoDs may be stop-gap measures designed merely to contain the spread of contamination, rather than reduce or eliminate it. A subsequent

RoD would address the completion of the clean-up effort at that OU.

- RoDs represent up-front estimates of long-term costs. As a result, it may be necessary to include an average Superfund RoD cost redundancy/deficiency factor in the actuary's analysis.[12]
- Some RoDs relate to remedies which may continue indefinitely, yielding an infinite ultimate cost on an undiscounted basis. However, information provided in the RoD usually shows activities limited to a specified duration (typically, up to thirty years for O&M). In the remainder of this paper, the phrase "*adjusted* RoD cost" will be used to represent the undiscounted RoD cost derived using the information provided in the RoD. We avoid using the phrase "*undiscounted* RoD cost," since it may be infinite, as noted above.

The model described in the following sections is an attempt to address at least some of the above issues by modeling RoD costs directly, rather than site costs. It is not proposed as "the" environmental model, but one of several different frameworks which are available to the actuary for modeling Superfund liabilities. Additionally, the reader should note that, as much as possible, the author has assumed that little if any data from the insurer is available to assist in performing this analysis. Clearly, the actuary should consider all data that may be available from an insurer in performing this type of study. However, to the extent that different insurers may have different levels of Superfund data available for this type of study, the author felt that this assumption would hopefully provide a model useful to the widest possible audience.

[12]From a practical perspective, this may be impossible. First, capital costs in the RoDs and CERCLIS may have differing definitions, as noted earlier. Second, the EPA cannot collect O&M expenditure information from the PRPs, so actual O&M costs incurred are not available publicly. Therefore, no true "actual to expected" total RoD cost comparisons may be made for RoDs calling for O&M activities, short of independently gathering large quantities of proprietary data from numerous sources.

7. SACM (A SUPERFUND *ACTUARIAL* CLEANUP MODEL): INCORPORATING RODS IN AN ANALYSIS OF THE TOTAL, SUPERFUND-RELATED COSTS OF AN INSURER

First, we define a claim in this model as an insured's cost relating to a single site[13], subject to the applicable coverage terms, policy periods, and insurer defenses against incurring environmental liability. The model described here estimates an insurer's total Superfund liability as the sum of the liability stemming from claims at current NPL sites and the liability stemming from claims at future NPL sites. Each of these aspects is addressed separately below, followed by an introduction to the concept of policy buybacks and known site settlements.

The general approach used in this model to estimate the liability at current NPL sites is as follows:

1. Estimate the cleanup cost on each current NPL site. For each site, this includes three components: actual, historical costs from (or perhaps based on data in) CERCLIS; previously-estimated future costs, from current RoDs; and not-yet-estimated future costs, if any, from future RoDs. The first two items have already been discussed; we address the third item in the next section of this paper.
2. Estimate each insured's share of liability at each relevant NPL site. An introduction to this topic was discussed earlier in Section 2 (*It's a Dirty Job, but Someone's Gotta Do It: Cleanup Cost Liability Allocation*).
3. Multiply items (1) and (2) together for each insured with a current NPL-based claim to estimate that insured's share of the relevant NPL site cost.
4. Apply any relevant cost add-on factors, such as for allocated loss adjustment expenses (ALAE), to the insured's share of the relevant NPL site cost.

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[13]Adjustments to this assumption may be made by the actuary as appropriate. For example, some insureds may attempt to aggregate all Superfund sites into a single claim to mitigate the impact of multiple, large retentions.

5. Apply the relevant coverage factors (e.g., attachment point, limit, share of layer), coverage triggers, cost allocation scheme (e.g., pro-rated over several years using total limits by year), and other claim-specific factor adjustments (such as the probability of successfully denying coverage for the claim) to derive the estimated cost to the insurer of that particular claim.[14]

6. Sum the estimated costs to the insurer of the current claims on current NPL sites (based on the application of steps 1–5 above).

7. Adjust this total to include a provision for future claims on current NPL sites.

The primary focus of this paper is on those items which relate to the use of EPA data in an exposure analysis. Therefore, items (4) and (5) above—though unquestionably important concepts—will not be addressed in this paper.

The Hole is Greater than the Sum of its Parts: Estimating Record of Decision and Relevant Operable Unit Counts by Site

So how can RoDs be used to estimate the total cost of a Superfund site? This model divides that task into three components:

1. estimating the number of RoDs per OU at the site,
2. estimating the number of OUs per site, and
3. estimating the cost indicated in each current and future RoD at that site.

An analysis of the estimated number of RoDs per OU at a site is included in Exhibit 5. Many OUs do not and will not have RoDs associated with them, and therefore will not be considered in this remedial action cost analysis. These OUs represent among

[14]Note that, depending on the terms of the insurance agreement, Steps 4 and 5 may need to be reversed. For example, if ALAE is covered in proportion to the amount of loss covered, Step 5 would need to be performed prior to Step 4.

other things, site-wide preliminary assessments (typically, OU 00) and emergency removal actions. There are costs associated with these removal action OUs, which are discussed later. However, at this point, we only want to consider those OUs which do (or will) have RoDs. To accomplish this, we can develop the ratio of the number of RoDs issued to date to the number of OUs with at least one RoD issued to date, by NPL site listing year, as displayed in Exhibit 5.[15]

An analysis of the estimated number of OUs per site is included in Exhibit 6. Once again, we circumvent the issue of OUs which will not have RoDs by developing the ratio of operable units with at least one RoD to NPL sites with at least one RoD. While there is variation in the results, note that the ultimate expected number of OUs per site for the 1987–1994 years is 1.47, almost identical to the estimate of 1.48 OUs per site from [8, p. 48]. Although potentially reasonable based on this comparison, however, research into approaches to estimate the tail factor for this type of analysis is left open as a topic for future study.

The specific approach used by the actuary to incorporate future RoDs at current NPL sites is at his or her discretion; the important point is that some form of development is necessary. Even on known sites, there may be future OUs planned. And, even on known OUs, there may be future RoDs planned (or not planned, but which will later be required). At the very least, an OU with an interim remedy RoD issued will likely require a follow-up RoD, describing any subsequently required cleanup efforts.

Note that this approach estimates RoDs per OU and OUs per site separately, rather than estimating RoDs per site directly. This is because a RoD cost typically relates to a given OU, rather than to the total site. Once we estimate the number of additional

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[15]Note that an amendment RoD should not automatically be counted as an additional RoD for a given OU, since it can supplant, rather than just supplement the original. “No action remedy” RoDs with no (or minimal) associated costs should also be removed, unless the analysis’ average RoD cost(s) reflect them.

RoDs required at a current OU (using the ultimate RoD/OU ratio determined above), we can estimate the cost of these future RoDs by looking at the costs of RoDs relating to OUs with similar characteristics (i.e., similar types of contaminated media) at other sites. Similarly, when we estimate the number of future OUs at a given site (using the ratio of OUs with RoDs to sites with RoDs, also discussed above), we can estimate the characteristics of these additional OUs by looking at the characteristics of other OUs at similar sites (e.g., chemical plants, manufacturing plants, etc.). Then, once the characteristics of these future OUs have been determined, estimating the future RoD counts and costs on those future OUs is similar to estimating the future RoD counts and costs on current OUs.

The estimations referred to above are achieved in this model through simulation, based on the expected values derived previously. Simulation is also used to estimate the cost of future RoDs, which is addressed in the next section of this paper. The idea of simulating costs is especially important when estimating the cost for excess policy limits. As an example, suppose a particular site cleanup will cost either \$500,000 or \$1.5 million, depending on which of two equally-likely cleanup alternatives outlined in the relevant RoD is selected. The expected cost of this cleanup would be \$1 million ($= 50\% * \$500,000 + 50\% * \$1.5$ million). If you are a reinsurer covering losses in excess of \$1 million, you might not establish a reserve for this claim, since its expected cost only reaches, but does not pierce, the attachment point. However, there is a 50% chance that the reinsurer may be asked for \$500,000 (since there is a 50% chance that the cost will be \$1.5 million), and a 50% chance that the reinsurer may not be asked for any reinsurance recovery (if the cost is only \$500,000). Under this scenario, then, a reasonable reserve for the reinsurer might be \$250,000 ($= 50\% * \$500,000 + 50\% * \$0$), rather than the \$0 reserve that might be established using the expected value method. From the primary insurance company viewpoint, an insurer protected by this reinsurance coverage would have booked

$1 million using the expected cost approach, but only $750,000 (= $1 million total expected cost, less the $250,000 ceded to the reinsurer) by incorporating variability into the site cost estimates.

No Clean Break from the Past: Estimating Future RoD Costs Using Environmental Characteristics

At this point, we have simulated the number and characteristics of future OUs at current sites, and simulated the number of future RoDs on those OUs. We now turn our attention to estimating the costs to be included in these future RoDs. First, we must differentiate between interim and final RoDs. This is infrequently discussed, but can be vitally important. *An "average RoD cost" multiplied by the current average number of RoDs per site yields a biased-low estimate of the average cleanup cost per site, if any of the sites contain interim RoDs for which the final RoDs have not yet been issued.* As a simple example, suppose only one Superfund site exists, with one operable unit and one (interim) RoD issued to address it. The average cost to clean that site using this approach would be the cost of that interim RoD, despite the fact that a final RoD will follow at some point in the future.

But even this level of detail—where interim and final RoDs are separately reviewed—can be further refined by selecting a set of *environmental characteristics* that best subdivides both the interim and final remedial action costs into even more homogeneous categories. The author believes that the more important, readily quantifiable characteristics are the remedy selected (for example, treatment vs. containment of the contamination), presence or absence of groundwater issues, and the process lead (i.e., whether the EPA or PRP was responsible to create the RoD). Additional characteristics based on the EPA's decision to promote consistency in remedy selections (discussed shortly) may also be considered. Other characteristics, such as the size and accessibility of the contaminated area, as well as current "policy" regarding preferred remedies are also highly relevant—but can be difficult to ascertain consistently and objectively via the RoDs.

Once the groundwater status and selected remedy values for a RoD are determined, they are fixed from that point forward for the remedial action relating to that RoD. The process lead, however, may change over time, as the EPA may turn over the responsibility for a site's cleanup to other parties during the remediation efforts. To the extent that the actuary believes that an EPA-led effort and non-EPA-led effort may differ in cost, some analyses of the past and future likelihood and timing of these (potential) changeovers is appropriate. Alternatively, one might try modeling based on an assumed frequency of changeovers for EPA-led activities at Superfund sites.

Another possibly relevant and measurable characteristic is the year the RoD was issued. These might be segregated into four groups:

1. *1986 and prior.* These RoDs were written in the program's infancy and addressed some of the most hazardous sites addressed through the Superfund program. The worst of these sites represents the most volatile and variable costs in recorded, historical RoDs.
2. *1987–1989.* The Superfund Amendments and Reauthorization Act of 1986 (SARA) directed the EPA to ensure that cleanups would be adequately protective of human health and the environment through the selection of more permanent remedies (i.e., emphasizing treatment, rather than containment).
3. *1990–1994.* An "enforcement first" policy, issued in 1989, led to a strong shift from EPA-led to PRP-led cleanup efforts.
4. *1995–Present.* The EPA begins phasing in new administrative reforms, intended to speed up cleanup efforts, improve cost-effectiveness and cut down on litigation. Costs included in RoDs issued since 1995 will likely be based on these initiatives, and should therefore be grouped accordingly.

The above should be considered in addition to the previously mentioned characteristics (plus any others the actuary feels are appropriate) with respect to the ever-present credibility trade-off: increasing the homogeneity of the data by breaking it up into additional pieces may simultaneously decrease the credibility of the data, since each piece would have less data included in it.[16]

We have now established the level of detail to be incorporated in this model to estimate the cost of a claim at a current Superfund site. The current RoD costs can be taken directly from the data in the Adjusted RoD Cost Database established earlier. The number of future RoDs required has also been determined. The characteristics of the additional RoDs required for a given OU can be simulated, based on the characteristics of RoDs relating to other OUs with similar OU characteristics. Once each future RoD's characteristics are simulated, the future RoD costs can be simulated based on the average and variance of costs in similar, current RoDs.

Several considerations relating to the simulation of these future RoD costs are noteworthy. First, which RoDs should be used, and why? The actuary may be able to allow for future legal, social and technological changes in future RoD cost estimates by only using the mean and variance of costs from similar RoDs issued during the most recent years. Two specific EPA initiatives prompt this suggestion. First, the EPA expects to reduce future costs by approximately $500 million based on its review and updates to more than 90 previously issued RoDs from the early years of the program.[17] In other words, the past will be

[16]In addition to helping quantify the cost of Superfund sites, environmental characteristics are also useful in helping an insurer's claim department evaluate the reasonableness of the insured's requested amount. For example, suppose a claim submitted by a policyholder relates to a site with contaminated soil being addressed by a containment remedy. The cleanup cost underlying the insured's claim can be benchmarked using the cost from RoDs that address contaminated soil through containment remedies at other sites.

[17]The reform guidance relating to these cost reductions was issued September 27, 1996. A significant portion of this savings is a result of three RoD cost adjustments: the Western Processing Site in Washington, the Norwood PCB Site in Massachusetts, and Metamora Site in Michigan have seen RoD cost reductions of $82 million, $47 million, and $28 million, respectively.

adjusted to look more like the present. Second, the EPA has set in place "presumptive remedies" for certain types of sites. According to Carol M. Browner, Administrator of the EPA:

> "Presumptive remedies are based on scientific and engineering analyses performed at similar Superfund sites and are used to eliminate duplication of effort, facilitate site characterization, and simplify analysis of cleanup options. EPA issued presumptive remedy guidances for the following: municipal landfill sites; sites with volatile organic compounds in the soil; wood treater sites; and a groundwater presumptive response strategy." [10]

In other words, the future will also be adjusted to look more like the present and the (adjusted) past. Therefore, limiting the data used to only the most recent data (which is not currently being adjusted) may reasonably address this issue. Then, after the average and variance of each combination of RoD characteristics is calculated using the most recent data, future RoD costs may be simulated.

Why use only recent RoDs to predict future RoDs on current sites? Exhibit 7 displays a graph of the history of RoD remedy selections from 1982 to the present. Note that from 1982 to 1986, containment-only remedies were the most prevalent. From 1987 to 1991, consistent with SARA's expressed preference for permanent remedies, treatment-oriented remedies predominated. From 1992 to the present, however, there is a slow but steady increase in "other" remedies. This grouping includes no-action remedies, site monitoring, site access restriction, and other such non-containment or treatment-based approaches. On average, these remedies cost less than containment or treatment remedies, and have yielded a decreasing average RoD cost in recent years. However, the majority of RoDs issued in recent years actually relate to sites listed on the NPL in the earlier years of the program, which have already had their more serious threats addressed in previous RoDs. It may be reasonable, therefore, to estimate the cost of future RoDs relating to these "mature" current sites using recent RoDs (which also likely relate to other "mature" sites).

However, many recently-listed (and some not-so-recently-listed) Superfund sites have not yet had their most serious threats addressed by any RoD. For these sites, using this overall current average RoD cost (relating primarily to mature sites) may not be appropriate. The author recommends instead simulating initial RoDs at these sites using the average cost of similar, initial RoDs recently issued at other sites. If it is necessary to simulate additional RoDs on these sites, the approach described in the previous paragraph may be appropriate.

A second consideration relating to the simulation of future RoD costs is that not all current sites should have the need for future RoDs randomly determined. It may be reasonable to expect that no additional RoDs will be required on sites which have either been deleted from the NPL or labeled construction-complete.

Third, an additional adjustment might be made to the data reflecting those few sites whose total costs are a multiple of the overall average. These sites are frequently referred to by actuaries as "megasites."[18] Insurers should be aware of their insureds with claims relating to these sites (which include, for example, Love Canal and Stringfellow), and should separate their potential liability at these sites from any analysis of their potential liability at the more "standard" Superfund sites, the same way that an actuary would typically segregate large losses from development triangles.[19] The actuary should remain alert to the possibility of new megasites, however, like the General Electric

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[18]Interestingly enough, according to the RCRA/Superfund Hotline (1-800-424-9346), the EPA's original use of the term "megasite" did not refer to sites with high cleanup costs, but to sites with high remedial investigation and feasibility study (RI/FS) costs (in excess of $3 million).

[19]The presence of these megasites may invalidate the use of unadjusted average Superfund site cost estimates in an actuarial analysis. Since megasites would be included in an estimate of the average Superfund site cleanup cost, an insurer (or insured) not potentially

Pittsfield, Massachusetts Plant/Housatonic River site, currently estimated to cost more than $200 million and require more than ten years to clean—and only proposed for inclusion on the NPL in September of 1997!

Finally, we must account for the variability between a given effort's expected and actual cost, in addition to the variability of a given effort's expected cost alone. As noted earlier, according to the EPA, the actual cost of remediation should be between 70% and 150% of the RoD's expected cost. If the actuary considers the RoD cost as a "best estimate" with, say, a 95% probability that the actual cost will be between 70% and 150% of that best estimate, then the actual cost associated with each RoD could be simulated based on the expected cost and other relevant parameters.[20]

Now that we can estimate the cost of current claims on current NPL sites, we turn our attention to estimating the number of future claims on current NPL sites. The number of current claims on current NPL sites is readily available to the insurer; the estimate of future claims on current NPL sites requires some additional work, as described in the following section.

The Fly in the Ointment: Estimating Future Claims on Current Sites

One way to estimate the number of future claims on current NPL sites is to estimate the ultimate number of claims relating

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liable at these megasites should likely use a lower estimate. Conversely, for an insurer (or insured) with liability at one or more megasites, the overall average is likely too low to apply. In those cases where the insurer doesn't know if an insured is or will become linked to a megasite, the actuary might decide in those cases that the overall average may be appropriate. Conversely, given the time that has elapsed since these megasites have been listed, the actuary may decide that, if the insured hasn't notified the insurer by now, there is likely no link present, and the average excluding the megasites may be used. This is, of course, at the discretion of each individual actuary's judgment.

[20]There is a question as to whether it is the nominal or discounted actual cost that should be between 70% and 150% of the expected RoD cost. In the case of a site requiring perpetual care, however, a range of 70%–150% of the expected undiscounted cost is almost meaningless. As a result, the actuary may want to adjust the model to reflect the likelihood that the costs fall within 70%–150% of the discounted RoD cost.

to current NPL sites, and subtract out the number of claims reported to date on those sites. Estimating the ultimate claim count for current sites can be done using a variation on the standard, actuarial triangle format and (ideally) internal company data. In the approach outlined in this paper, each row represents a different NPL listing year (i.e., sites listed on the NPL in 1983, sites listed on the NPL in 1984, etc.) and each column represents the amount of time (in years) between when a site was listed on the NPL and when a claim relating to that site was reported to the insurer (or reinsurer). This approach allows us to develop to ultimate the number of claims which will be presented to an insurer/reinsurer relating to sites listed on the NPL in each site listing year. Unlike typical development approaches, however, many PRPs will have reported claims to their insurers prior to the year a given site achieved NPL status. This is not a problem, since the triangle need not and should not have a "0" or "1" as its first column heading. Under this approach, the left-most column should be a negative number representing the greatest time lag between when an insured first notified its insurer of its PRP status at a site and when that site was subsequently listed on the NPL. The goal here is to develop to ultimate the number of claims relating to current Superfund sites.

If company data at this level of detail is not available (and usually it is not), an alternative is to use the EPA's data on PRP counts and notification dates (formerly in SETS, currently in CERCLIS) and NPL site listing dates (in CERCLIS) to estimate the ultimate number of PRPs linked to current NPL sites. As an example of how this approach would work, the reader is referred to Appendix B.

The resulting PRP notification pattern can then be lagged to reflect the expected average additional time between the EPA notifying a PRP of its potential liability at a site, and the PRP notifying its insurer.[21] To estimate this additional time lag, the

[21] This lag should also consider an adjustment for notification to reinsurers (and excess carriers) if appropriate, as well as collateral suit defendants, who by definition cannot

actuary should consider differences in the manner in which data has historically been reported to the insurance company. In the early days of pollution coverage disputes, many insureds reported multiple claims all at once, as part of declaratory judgment ("DJ") actions. These simultaneous, multiple reportings stemmed from the sudden recognition of possible insurance coverage availability. If the policyholder subsequently received notice of its potential liability at other sites, however, these additional claims would usually be reported to the insurer even in the midst of DJ proceedings to avoid possible late notice issues on those new claims. As a result, an insurer reviewing its data may notice an initial "flood" of claims from its insureds (during which there was likely no relationship between PRP and insurer notification dates), followed by a more stable relationship between PRP and insurer notifications. Since a new "flood" of initial claim reportings from an insurer's policyholders is unlikely to occur in the future, the author suggests that the time lag between PRP and insurer notifications relevant to future claim reportings may be estimated using PRP notification and corresponding claim report dates, excluding the policyholders' initial, multiple-claim reportings from the late 1980s to the early 1990s. Multiple claim reportings by insureds after this time period may either be included or excluded, depending on the actuary's judgment as to whether they should be considered part of future expectations or aberrational.

The actuary may also want to separately review policyholders according to their relative likelihood of liability for Superfund-related costs. (See the "Superfund Liability Pyramid" discussion in *It's a Dirty Job, but Someone's Gotta Do It: Cleanup Cost Liability Allocation* in Section 2.) These splits were not included in this paper, as it would complicate the description of the approach. Also, it is possible that a single policyholder linked to a

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notify their insurers until after another PRP seeks them out. Estimating these time lags—which will no doubt differ for insurers and reinsurers—may be a very worthwhile area for future research.

single site may yield claims in multiple policy years. Adjustments to reflect this issue, if any are desired, may be made based on a review of insurance company claims data and discussions with legal counsel.

Other factors possibly impacting the time lag between NPL site listing date and insurer notification include CERCLA-related legislative or administrative changes, major coverage-related court decisions and insurer settlement procedures. While these are significant issues, the author believes that they may only have a modest impact with regard to this particular time lag issue. First, the author is not aware of any recent CERCLA legislation that might have significantly impacted this time lag. In addition, litigation over the question of whether or not insurance coverage is applicable to Superfund-related cleanup costs has slowed, with recent decisions in the environmental area focusing more on the allocation of costs among the insured and insurers (where applicable) than the determination of coverage. As a result, focusing on the more recent development factors in the parallelogram (and possibly any trends in those factors) may diminish any potential concern regarding these issues. Finally, though insurer reserving and settlement practices may significantly impact the data used to estimate an insurer's expected cost, the author does not expect that they will significantly impact the time lag between NPL site listing and insurer notification.

We have now completed the discussion on estimating an insurer's potential Superfund-related liability at current NPL sites. The following section addresses how an actuary might estimate an insurer's potential liability stemming from future NPL sites.

Incurred but not Remediated: Estimating the Cost of Future Sites

To estimate an insurer's liability stemming from future Superfund sites, the model assumes that an estimate of the total, ultimate number of NPL sites is available to the actuary. For reference, some estimates of the total number of NPL sites from different sources have been compiled in [11]. Then, the number of future sites can be calculated directly as the estimated, total Superfund site count, less the number of current NPL sites.

While there are several approaches to estimating true IBNR, one approach the author has seen is to multiply the total estimated cost to the insurer of current sites by the ratio of IBNR sites to current sites. This approach assumes that the percentage of current Superfund sites with no currently identified PRPs (referred to as "orphan sites") is similar to the percentage of future Superfund sites with no PRPs. It also assumes—among other things—a relatively stable average NPL site cost over time. On a present value basis, the shift over time from relatively expensive, shorter-term remedies (i.e., treatment) to relatively less expensive, longer term remedies (like containment and the more recent, "other" remedies) yields an overall downward cost trend. But does the duration of a typical, thirty-year (or longer) containment remedy applied against relatively low—but inflating—annual costs outweigh the high, up-front cost of treatment on an *undiscounted* basis? This would be a good area for future research.

The author's preferred approach is to estimate the total claim cost on future sites using a four step procedure:

1. estimate the percentage distribution of future sites by site type (e.g., chemical plants, landfills, etc.) based on recently listed sites and sites currently proposed for listing on the NPL,

2. estimate the future number of sites for each site type by applying the percentage distribution above to the up-front estimate of the total number of future Superfund sites,

3. multiply the future site counts for each site type calculated above by its respective future average site cost (which might be based on the cost of recently-listed, similar types of NPL sites), and

4. assume the insurer's percentage of future site costs for each site type is proportional to the insurer's percentage of current site costs for that site type.

Clearly, actuarial judgment may be applied at any step along the way, as desired.

Finally, some comments on the theory of "barrel scraping" are in order. According to [12], barrel scraping is "the theory that a disproportionate number of the worst problems were discovered and listed in the early years because of their obviousness, and that the (Superfund) program will increasingly be 'scraping the bottom of the barrel' as additional sites are listed." However, when evaluating how the average cleanup cost for NPL sites has changed (and will change) over time, the actuary should consider four additional items:

1. In addition to the few, ultra-costly "megasites," many more sites listed in the early to mid-1980s were subsequently de-listed with minimal if any remedial activities necessary. (The smaller costs associated with these non-remediated sites may have stemmed from short-term removal actions, RI/FS activities, monitoring costs, etc.) Like the megasites, these "microsites" were predominantly listed on the NPL between 1983 and 1986, and contributed to the average cleanup cost for sites listed during those years. As a result, the average cleanup cost of sites listed on the NPL from 1983 to 1986 is lower than it would otherwise be, were it not for the presence of these microsites.

2. Improved site-screening technology over time, as well as a revised hazard ranking scoring approach (discussed earlier in this paper), has led to a significant reduction in (and possible elimination of) the number of microsites listed on the NPL during the late 1980s to mid-1990s. The removal of low-cost sites from the list of potential

NPL sites yields an average site cost for this time period that is higher than it would otherwise be, were it not for the changes in site-screening technology and the HRS scoring approach.

3. During the mid-1990s, the EPA initiated an effort to take advantage of more cost-effective technology by issuing RoD amendments that superceded the more costly remedies selected in earlier RoDs (in those instances where the remedies had not yet been implemented). As a result, the improvements in the cost-effectiveness of cleanup efforts that are expected to benefit currently listed sites are also benefiting previously listed sites (in the form of these RoD amendments). The impact of these RoD amendments, therefore, is to bring the average cost of currently and previously listed sites closer together than they would otherwise be, were it not for these RoD amendments promoting currently available technology on older Superfund sites.

4. Governors' Concurrence legislation enacted in 1995 (as noted earlier in this paper) required the EPA to receive approval from a state before listing a site located there on the NPL. As of this writing, it remains the EPA's policy to determine a state's position on the listing of a particular site before proposing it for inclusion on the NPL. This is important because, according to a GAO study [13], "Officials of 26 (60 percent) of the 44 states (surveyed) told us that they are more likely to support listing sites with cleanup costs that are very high compared to those for other types of sites." This implies that the cost reduction benefits discussed in the previous item may actually result in fewer future site listings, since the majority of states would be looking to list sites with higher cleanup costs. It would also likely result in an increase in the average cost of future Superfund sites, relative to the average future site cost that would otherwise have

been expected (since the sites *not* listed would be those that are less costly).

Another consideration that might imply a possible *downward* shift in historical site costs over time is the shift from EPA-led efforts to PRP-led efforts. The theory is that a PRP spending its own money may have greater incentive for cost control than the EPA, which may be spending money it hopes to collect later from PRPs. In conjunction with item 4 above, however, the author believes that the expected impact of this issue is more of a decrease in the number of future Superfund sites than a change in the average cost of future Superfund sites, since these future sites where the costs could be lowered might no longer be listed.

In summary, based on all of the above, it is the author's opinion that the average undiscounted Superfund site cleanup cost may not have changed very much over time, and that the average cleanup cost of future Superfund sites might, in fact, be larger than the average cost of currently listed sites (depending on the extent of the impact of item 4 above)—or at the very least, not necessarily be lower than the average cost of currently listed sites, as is implied by the barrel scraping theory.[22]

Does the barrel scraping theory apply to non-NPL sites? The author's opinion about this is similar to his opinion about barrel scraping at NPL sites, though for different reasons:

- The GAO survey noted above implies that the majority of states favor supporting the most costly sites for NPL listing

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[22]It would be interesting to test the impact of the barrel scraping theory on sites listed to date using actual cost data (or at least estimated costs from RoDs). However, as of this writing, less than half the sites listed since January of 1991 (after the change in the HRS approach) appear to have had even a single RoD issued for them, per CERCLIS. For sites listed since January of 1995 (the year Governors' Concurrence legislation and some of the SACM initiatives were introduced), less than one-third of the sites listed appear to have had any RoDs issued so far. Further complicating this study is the fact that estimating the number and cost of future RoDs needed on these sites (both where some RoDs have been issued as well as where none have yet been issued) requires assumptions about what the number and costs of those RoDs will likely be—which in a sense puts the cart before the horse, requiring one to answer the barrel scraping question by first assuming it to be true or false.

on a going-forward basis. Shifting the other potential NPL sites into state Superfund programs (which, as will be discussed further later in this paper, are generally considered to have a lower average cleanup cost) will tend to raise the average cleanup cost of non-NPL sites in recent years and into the future. And, while there may be some administrative cost reductions stemming from the "transplanting" of NPL sites from the EPA to the states' jurisdictions, the author believes it unlikely that this jurisdictional shift alone would bring the cost of an otherwise Superfund-worthy site down from the average NPL site level to the average non-NPL site level.

- With the EPA's introduction of the Brownfields initiative in the mid-1990s (which promotes cleanup efforts through financial rewards, rather than enforcement-related penalties), many potential hazardous waste sites that might have otherwise been addressed through state or federal enforcement are now being addressed with the voluntary cooperation of the responsible parties. Many states have since instituted similar programs.

A potentially responsible party's decision whether or not to voluntarily clean a site under these programs is likely based on that site's expected cleanup cost, relative to the benefits derived from performing the cleanup (e.g., tax benefits, improved public perception). The author believes that the non-NPL sites cleaned under these initiatives are likely the less costly ones, since the other sites' cleanup costs may be more likely to outweigh the benefits of performing those cleanups (which may partially explain why few if any expensive Superfund site cleanup efforts are voluntary). As a result, if it is believed that *voluntary* cleanup efforts are not likely subject to insurance recoveries, then the removal of these smaller, less costly sites from the potentially insurable universe of non-NPL sites also yields an increase in the average non-NPL site cleanup cost relevant to insurers.

Based on the above, the author believes that increased state Superfund capacity for larger cleanup and enforcement-related efforts over time, in conjunction with more recent federal and state initiatives centered on achieving voluntary cooperation from responsible parties for the smaller cleanup efforts, may have resulted in an increase in the average non-NPL site cleanup cost over time *for those sites potentially relevant to insurers*—or at the very least, not necessarily a decrease, as would be implied by the barrel scraping theory.

In summary, then, the author believes that the future average cost for both NPL and non-NPL sites may be larger than historical levels. In the case of Superfund, this is due largely to a reduction in the number of expected future sites with smaller associated costs. In the case of non-NPL sites, this is due to an increase in the number of higher cost sites (e.g., the "dropping down" of some otherwise Superfund-worthy sites) in addition to the removal of some of the less costly sites (e.g., the voluntary cleanups).

It is important to stress that many of the reasons the author questions the barrel scraping theory stem from political changes (e.g., the Brownfields initiative, Governors' Concurrence legislation) and technological changes (e.g., improvements in site-screening technology) that—in the author's opinion—mitigate (if not eliminate) the likely impact of the barrel scraping theory. Were it not for these issues, the author would probably support the barrel scraping theory as well.

8. RUMMAGE SALE: KNOWN SITE SETTLEMENTS AND POLICY BUYBACKS

A policy buyback represents an agreement between an insurer and an insured whereby the insurer pays money to the insured in exchange for which the insured provides a full or partial release from any future liability relating to a policy or set of policies. In the event of a full policy buyback, the insurer is relieved of all responsibility for both case reserves and IBNR. In the event of a partial policy buyback, the insurer is typically relieved of responsibility for both case reserves and IBNR relating to specific causes of loss only.

A known site settlement represents an agreement between an insurer and an insured whereby the insurer pays money to the insured in exchange for which the insured provides a release from any future liability relating to known sites only. This relieves the insurer of responsibility for case reserves on the claims relating to those sites. However, the insurer may remain potentially liable for claims relating to other current sites, if claims relating to them were not included in the settlement. Also, since the insurer remains potentially liable for that insured's claims relating to future sites, a known site settlement does not eliminate IBNR.

While these are significant issues, a detailed discussion of them is outside the scope of this paper. In general, however, the reader should note the following:

1. Adjustments for historical policy buybacks can be made by running the model excluding them, and then adding to the model results the costs paid by the insurer to achieve them.
2. Adjustments for historical known site settlements can be made in the same way as described for policy buybacks. Alternatively, adjustments for these site settlements may be made by subtracting from the model's results the difference between the estimated and actual amount relating to settled claims. For example, if a ten claim site settlement was estimated to cost a total of \$5 million in the model but actually settled for \$3 million, then \$2 million should be subtracted from the model's results.[23]

[23]The reader should note that a likely reason for the \$2 million difference is the timing of the insurer's payments. The \$5 million output from the model assumes that the insurer may be liable for costs as the policyholder incurs them over a long period of time. If the insurer settles the claim when the insured still has future payments to make (as is

Determining which of these two approaches to use may depend on whether or not the actuary finds it easier to search for and remove linkages between insureds and sites up-front (i.e., before running the model), or to review the model's results and adjust for any relevant linkages it identified (i.e., after running the model).

3. Adjustments to reflect future site settlements and policy buybacks may be made by reviewing trends in historical site settlement and buyback activity. Relevant issues include trends in the number, timing and average cost of buybacks and known site settlements.

4. When estimating known site settlement and policy buyback adjustments, the actuary should be mindful of the possibility that they could yield increases in the results, rather than reductions. This typically occurs in connection with policy buybacks where the policyholders—each linked to a large number of sites—have policies with high attachment points. In these cases, insurers are sometimes willing to buy their way out of possible future coverage, even though the expectation is that none of those insureds' claims would penetrate the covered layers. While this is a legitimate thing for an insurer to do, the result is still a situation where the actual cost may be greater than the expected.

9. GARBAGE IN, GARBAGE OUT: REMOVAL ACTION COSTS

As Exhibit 3 shows, removal actions are typically restricted to a one-year duration and a $2 million cost limit. There have been many instances where removal costs have exceeded this figure significantly, however, like the Summitville Mine site in

frequently the case), the insurer will presumably only pay the costs incurred by the insured to date plus the present value of the insured's expected future costs at the time of that settlement (though the discount rate used would likely also reflect the transfer of uncertainty from the insurer back to the insured).

Colorado, where more than $70 million has been obligated for removal actions alone. These costs are not included in the RoDs, and may produce enough variability in severity to have a material impact on the total cost at a particular site. To the extent that an insured (or insurer) may become liable for these removal costs, it may be worthwhile to consider modeling both remedial and removal costs. In addition, the actuary should try to stay abreast of the continuing stream of environmental liability-related rulings over time, to determine if any other environmental activities (beyond removal and remedial actions) may need to be included in this type of analysis.

10. CONSTRUCTION COMPLETE? (A FEW THOUGHTS ON NON-NPL SITE CLEANUP COSTS)

There are several important differences between Superfund and non-Superfund sites that should be considered when adapting this Superfund-based approach to non-Superfund sites, including the following:

- RoDs are only issued for Superfund sites. RoD-like cost information is not readily available for non-Superfund sites, though it has been generally accepted that cleaning an average (less hazardous) non-NPL site will be significantly less costly than cleaning the average (more hazardous) NPL site. However, within the context of comparing particular types of NPL and non-NPL sites (e.g., landfills listed on the NPL vs. landfills being addressed through state enforcement activities), this is a debatable point. Many actuaries have postulated that the level of hazard and cost at a particular site are directly related,[24] but it is more likely that the EPA's selected remedy for a site based on its relative hazard level (i.e., treat the worst sites and contain the rest) drives the cost. This is important, because for non-NPL sites—where the EPA may not be

[24] The author's negative view of this argument—and the rationale for it—are detailed in Appendix C.

involved—if a particular state does not share the EPA's philosophy, the possible relationship between hazard and cost might not hold. Three more arguments in favor of higher than expected non-NPL site enforcement-based cleanup costs include: (1) some states may not have reported to the EPA all of their hazardous waste sites—many of which may be Superfund-worthy—simply to avoid the perceived delays in cleanups, (2) many states in the past have not considered as many alternative remedies as the EPA prior to determining the selected remedy, which may have caused more cost-effective and equally viable remedies to be excluded from the non-NPL site cleanup alternatives, (3) non-NPL sites requiring no cleanup actions will not produce claims, and sites requiring small-scale efforts will likely be dealt with through voluntary cleanup programs, which might not be considered insurable. Clearly, the removal of these smaller claims from the insurable non-NPL universe will tend to raise the relevant average non-NPL enforcement-based cleanup cost.

- While an estimate of the ultimate number of Superfund sites may be based on the current number of sites already on the NPL and those still in CERCLIS awaiting their NPL-status determination, there is no single, generally accepted estimate of either the current or total number of non-NPL sites that will require cleanup through enforcement (non-voluntary program) actions.

- Estimating an insured's potential liability at a Superfund site frequently includes an estimate based on the number and names of other PRPs at that site. Neither the number nor the names of potentially responsible parties is readily available at most non-NPL sites, however, though it is generally accepted that non-NPL sites have far fewer PRPs than NPL sites (frequently as few as one!). And, similar to NPL sites, even if the number and names of all PRPs for a given non-NPL site were available, a PRP's share of liability might not correlate well with the number of PRPs potentially sharing the cleanup cost at that site. An additional problem is that not all states apply "retroactive, strict, and joint and several" liability standards. As noted earlier, estimating a given PRP's expected liability share is one of the most difficult aspects of estimating an insurer's environmental liabilities.

- Relevant characteristics applicable to non-Superfund sites may differ from those of Superfund sites, even if RoD-like cost data were available, due to (among other things) differences in state-by-state cleanup requirements and the types of site in each category. For example, Superfund will rarely include leaking underground storage tank (LUST) sites, since these are almost always filled with petroleum—not a substance to which Superfund moneys are intended to respond. (These are addressed under RCRA; see Appendix D.) As a result, when LUST cleanup efforts are required, they will almost always be addressed as non-NPL sites. Small fuel leaks and drycleaner sites will also typically be addressed as non-NPL sites, usually too small and not hazardous enough to warrant NPL listing. It is worth noting that the types of non-NPL sites discussed here (i.e., small fuel leaks, drycleaner sites and LUSTs) tend to be less costly on average than the types of sites typically found on the NPL (e.g., manufacturing and chemical plants) resulting in a lower overall average cost for non-NPL sites than for NPL sites. However, for sites that appear both on and off the NPL (such as landfills), comparisons between NPL and non-NPL site costs may be reasonable.

11. DISCOUNTING THE PROBLEM: WHAT'S IT WORTH TO YOU?

While this topic is clearly deserving of a paper in its own right, a brief introduction to some relevant concepts is included here. In most discounting analyses, three items are required: an estimate of undiscounted total cost, a payout pattern and a discount rate. To discount Superfund liabilities, three additional values are useful: a Superfund cost incurral pattern (indicating the timing of costs incurred by those actually cleaning up the Superfund site, regardless of any cost-sharing agreements or future reimbursements which may apply), a probability of payment (based on the idea that the insurer may or may not be successful in denying liability for the claim altogether), and an estimate of the insured's share of liability for site cleanup costs.

The Superfund cost incurral pattern is necessary because the insurer's potential cost burden relates to future costs associated with Superfund cleanup in addition to those previously incurred. In a car collision claim, an insurer's payment is typically made after the car is repaired and the cost to fix the car is known. In Superfund liability claims, however, cleanup costs are incurred before, during and after an insurer may be found liable for site cleanup costs. Once found liable, an insurer may reimburse the insured for past costs incurred to date in connection with that site's cleanup efforts, but may be reluctant to pre-pay future annual cleanup costs which the insured will incur over the next several years at that site. As a result, the payout pattern for an insurer found liable for site cleanup costs at a given site would be comprised of (1) a first payment, based on cleanup costs incurred to date by its insureds at that site, and (2) annual payments beginning the following year, equal to the cleanup costs to be incurred by the insureds in each subsequent year in which cleanup efforts are required.[25] If the insurer is attempting to deny liability for this claim, however, an additional lag may be necessary to reflect the time between when the insured first notified the insurer of the cleanup claim and when the determination is later

[25] In practice, once liability has been determined, the insurer may instead offer to simply reimburse the insured's past costs and offer the insured the net present value of the future costs to be incurred in connection with the site's cleanup efforts. This present value concept should not be confused with the idea of discounting reserves for statutory reporting purposes. As an example, suppose that in three years, an insurer will extinguish its liabilities to an insured for a particular site by paying the present value (at that time) of costs to be incurred after that date. For simplicity's sake, also assume that the insured will have spent nothing on site cleanup up to that point, and that the payment amount will be $133,100. This $133,100 represents the insurer's current, undiscounted liability to that insured at that site. Assuming, for example, a discount rate of 10% applies, the discounted value of that claim would be calculated as $\$133,100/(1.10)^3$, or $100,000.

made regarding whether or not coverage applies. If it is felt that a determination of liability would take three more years, for example, item (1) above would be the sum of the incurred to date costs, plus the next three years of annual payments, and would be presumed payable (pending determination of liability) three years from today. Item (2) would, therefore, begin with the fourth year of annual payments, and would be assumed to begin one year thereafter. This translation of the Superfund incurral pattern to the insurer's payout pattern is referred to in this paper as the "litigation lag." The litigation lag may be estimated from numerous sources, including the information underlying the selection of the probability of payment at a particular site, and allocated loss adjustment expense (ALAE) development (if there is sufficient history to produce a reasonable and reliable pattern).

The probability of payment represents the fact that, unlike more traditional claims, there is a chance that the insurer will not become obligated to pay for site cleanup costs. This value should differ at least by state, based on relevant court decisions in each state. Similarly, the estimated share of liability reflects the fact that an insured might be held responsible only for a portion of the total cleanup costs at a site, limiting the insurer's liability at that site to its insured's share of liability at that site. This is an important consideration, which, as noted above, is beyond the scope of this paper.

With these issues in mind, one approach that might be used to estimate the discounted Superfund liabilities of an insurer is to (1) estimate the amount and timing of the Superfund cleanup costs incurred at each site (regardless of who will ultimately bear liability for them) using site costs and site cost incurral patterns based on the adjusted RoD costs described earlier in this paper, (2) multiply each of the annual cleanup costs by the estimated share of responsibility borne by the insured, (3) reallocate the insured's Superfund site costs at each point in time based on each site's estimated litigation lag, (4) remove from the litigation lag-adjusted cost incurral pattern the costs incurred before the attachment point is reached and the costs incurred after the policy limit is exhausted, (5) multiply each of the remaining annual cleanup costs by the probability that coverage applies, (6) add together the reallocated costs for all Superfund sites within each calendar year to estimate the costs to be paid by the insurer relating to all Superfund claims in that year, and then (7) discount the Superfund claim payment stream using the selected discount rate.

An additional issue, of course, is the discount rate that should be applied. One approach might be to tie the discount rate in some way to the U. S. Treasury Bond rate in effect at the appropriate point in time (e.g., year-end for statutory reporting purposes), with a duration closest to the estimated RoD cleanup duration for the OU(s) in question. Alternatively (and depending upon the reason for discounting the costs), an insurer could consider the discount rate underlying previous coverage buybacks. The author suggests consulting [14] prior to selecting a discount rate.

12. A PRELIMINARY ASSESSMENT: SOME CONCLUDING THOUGHTS

The author hopes that this paper will serve as a stepping stone for future research into several areas noted throughout this paper, as well as other areas of environmental liability analyses. There is certainly enough that still needs to be done, including:

- research into non-NPL site counts and costs (including what drives them, and how they differ from NPL site cost and count drivers),
- research into other current and future environmental liability issues that should have an impact on our environmental analyses,
- development of alternate environmental liability models, and

- development of environmental (Superfund and non-Superfund) reserve discounting models (with an eye toward acceptability to regulators).

What might be said of the Superfund program in recent years could also apply to actuaries estimating its costs—much has been done, but plenty of work still remains.

REFERENCES

[1] Federal Register, Part VII, Environmental Protection Agency, *Final and Proposed Amendments to National Oil and Hazardous Substances Contingency Plan; National Priorities List*, 8, September 1983, p. 40659.

[2] Federal Register, Part V, Environmental Protection Agency, *National Priorities List for Uncontrolled Hazardous Waste Sites; Rule*, 25, April 1995, p. 20331.

[3] Federal Register, Environmental Protection Agency, *The National Priorities List for Uncontrolled Hazardous Waste Sites; Deletion Policy for Resource Conservation and Recovery Act Facilities*, 20, March 1995, p. 14642.

[4] United States Code, Title 42, Chapter 103, Section 9604(c) (3).

[5] United States General Accounting Office, *Superfund Program Management*, GAO/HR-97-14, February 1997, pp. 9–10.

[6] United States Environmental Protection Agency, *Estimated O&M Costs for RODs: Historical Trends and Projected Costs Through Fiscal Year 2040*, CH2M Hill, 31, May 1995, pp. 3–5.

[7] United States Environmental Protection Agency, *Remedial Action Costing Procedures Manual*, EPA/600/8-87/049, October 1987, pp. 3–21.

[8] Russell, Milton, and Kimberly L. Davis with Ingrid Koehler, *Resource Requirements for NPL Sites*, University of Tennessee, Joint Institute for Energy and Environment, Knoxville, TN, 1996, Appendix A, p. A-10.

[9] United States General Accounting Office, *Superfund: Operations and Maintenance Activities Will Require Billions of Dollars*, GAO/RCED-95-259, September 1995, pp. 1–2.

[10] United States Environmental Protection Agency, *Statement of Carol M. Browner, Administrator, U.S. Environmental Protection Agency Before the Committee on Environment and Public Works—U.S. Senate*, 5, March 1997.

[11] American Academy of Actuaries, *Costs Under Superfund: A Summary of Recent Studies and Comments on Reform*, Public Policy Monograph, August 1995, p. 3.

[12] Congressional Budget Office, *The Total Costs of Cleaning Up Nonfederal Superfund Sites*, January 1994, p. 20.

[13] United States General Accounting Office, *Hazardous Waste: Unaddressed Risks at Many Potential Superfund Sites*, GAO/RCED-99-8, November 1998, p. 26.

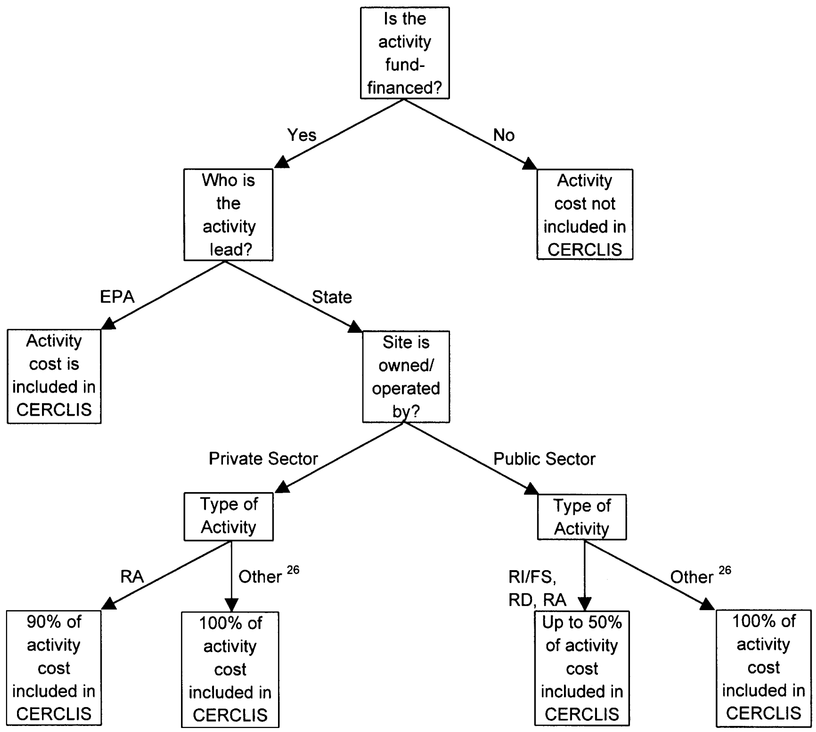
[14] Actuarial Standards Board, Actuarial Standard of Practice No. 20, "Discounting of Property and Casualty Loss and Loss Adjustment Expense Reserves," April 1992.

[15] United States Environmental Protection Agency, Office of Solid Waste, *Draft Regulatory Impact Analysis for the Final Rulemaking on Corrective Action for Solid Waste Management Units Proposed Methodology for Analysis*, March 1993.

[16] United States General Accounting Office, *Hazardous Waste: Remediation Waste Requirements Can Increase the Time and Cost of Cleanups*, GAO/RCED-98-4, October 1997.

EXHIBIT 1

INTERPRETING CERCLIS COST DATA



[26] Excluding those O&M costs not considered eligible for Superfund funding.

EXHIBIT 2

CERCLIS DATA VS. ROD DATA

	CERCLIS	RoDs	Comments
Timeframe	Contains actual, historical incurred to date costs	Contain estimated, prospective costs	CERCLIS also includes information on planned activities
Whose Expenditures are Included?	EPA only	Anyone who will be required to perform the relevant activities	If EPA partially funds an activity, adjustments must be made to derive the total cost from CERCLIS. (See Exhibit 1.)
Cost of Remedy Construction	Included in Remedial Action	Included in Capital Cost	
Cost of Remedy Implementation	At Least Partially Included in Remedial Action	Included in O&M Cost	Percentage of cost included in CERCLIS varies by site ownership, activity lead (i.e., EPA, state, or PRP) and type of activity
Cost of Performing O&M Activities	Not Included in CERCLIS	Included in O&M Cost	
Oversight of Remedial Action, Where Necessary	Included in Remedial Action Cost	Not Included in RoDs	
Oversight of O&M Activities, Where Necessary	Included in O&M Cost	Not Included in RoDs	
Cost Level of Dollar Values	Nominal (Undiscounted)	Discounted	

EXHIBIT 3

Steps in The Process of Listing a Site on the NPL

Activity	Estimated Average Duration[27]	Estimated Average Site Cost[27]	Comments
Site Discovery			Not all potentially hazardous waste sites are reported to the EPA to be included in CERCLIS; many non-NPL sites have never been on CERCLIS.
Preliminary Assessment (PA)			Characterizes threat based on off-site analysis of readily available data: is it imminent (removal action needed), serious (site inspection needed) or not serious (archive the site)?
Removal Action	Up to 1 Year	Up to $2,000,000	Generally targets immediate threats only; remaining serious threats dealt with in Site Inspection (SI) phase. Time and spending limits may be increased if immediate risk to public health or the environment remains.
Site Inspection (SI)			Preliminary and cursory on-site qualitative evaluation of hazard posed
Hazard Ranking			Numerical quantification of the degree of hazard posed at the site based on data collected during PA and SI phases
Proposed for Placement on NPL			Proposal to NPL of sites with Hazard Ranking Scores of 28.5 or greater, State Priority Sites and sites to be listed at the ATSDR's request.

Final Placement on NPL			
Remedial Investigation/Feasibility Study (RI/FS)[28]	18–30 Months	$1,250,000	Actual cleanup cost should be between 50% and 200% of the RI estimate, and then 70% and 150% of the Feasibility Study (RoD) estimate
Remedial Design (RD)	12–18 Months	$1,260,000	Actual cleanup cost should be between 95% and 115% of the RD estimate
Remedial Action (RA)	12–36 Months	$22,500,000	Remedy-related construction and implementation activities. Average duration displayed is per RA; average cost per site.
Construction Completion			Occurs when no further physical construction is required, whether or not remedy has been implemented (i.e., may be before RA completion).
Ongoing Operations & Maintenance (O&M)	22 Years	$5,360,000 on a PV Basis; $20,795,000 Undiscounted[29]	EPA guidance limits duration to 30 years for costing purposes, regardless of actual expectations. Average duration displayed relates to O&M activities for a single RoD; average cost displayed is per site.
Deletion from NPL			Typically occurs when EPA determines that no further response is required to protect human health or the environment.

[27] Duration and cost information from various sources, including [2], [4], CERCLIS and conversations with the EPA.

[28] This results in the issuance of a Record of Decision (RoD) which details the problem, the selected remedy, and its expected costs. The scope at this phase is still based more on assumptions than hard data.

[29] Undiscounted cost assumes $400,000 first year O&M costs are expended, and a 30 year duration, per Federal Register. Also assumes annual inflation of 3%, with O&M activities beginning 3 years after RoD issuance. Discounted cost assumes no inflation and a 5.8% discount rate, which was applied against the first year of O&M costs, as well as each year thereafter.

EXHIBIT 4

Discount Rate Guidance

Publication Date	Publication Title	Discount Rate[30]
Jun-93	Revisions to OMB Circular A-94 on Guidelines and Discount Rates for Benefit-Cost Analysis (OSWER Directive 9355.3-20)[31]	7%
Oct-88	Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA	5%
Mar-84	Remedial Action Costing Procedures Manual	10%

[30]Since the annual O&M costs included in RoDs are not increased for inflation over time, the discount rate used to calculate their present value also excludes a provision for inflation. For this reason, the discount rates shown here reflect pre-tax, after inflation discount rates.

[31]The referenced OMB circular is available through the internet, at http://www.whitehouse.gov/WH/EOP/OMB/html/circulars/a094/a094.html#7

EXHIBIT 5

Records of Decision (RoDs) Per Operable Unit (OU) with at Least One RoD

Year Listed on NPL	Cumulative Records of Decision/Cumulative OUs with at Least One Record of Decision Issued by Number of Years Since NPL Listing: 1	2	3	4	5	6	7	8	9	10	11	12	13	14
83	1.05	1.02	1.02	1.03	1.03	1.03	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.05
84	1.00	1.00	1.00	1.03	1.03	1.03	1.03	1.03	1.05	1.05	1.05	1.05	1.06	
85	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
86	1.00	1.00	1.00	1.01	1.02	1.04	1.04	1.05	1.05	1.06	1.06			
87		1.00	1.00	1.00	1.00	1.00	1.02	1.02	1.03	1.03				
88														
89	1.00	1.00	1.00	1.01	1.01	1.01	1.04	1.04						
90	1.10	1.04	1.02	1.02	1.01	1.02	1.03							
91	1.00	1.00	1.00	1.00	1.00	1.00								
92	1.00	1.00	1.00	1.00	1.08									
93														
94	1.00	1.00	1.00											
95	1.00	1.00												
96	1.00													

EXHIBIT 5

Records of Decision (RoDs) Per Operable Unit (OU) with at Least One RoD

(Continued)

	Age to Age Factors													
	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	
83	0.972	0.999	1.016	0.997	1.002	1.005	0.997	1.001	1.002	1.001	0.999	1.006	1.004	
84	1.000	1.000	1.026	1.007	0.992	1.004	1.004	1.012	1.003	1.004	0.998	1.004		
85	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000			
86	1.000	1.000	1.011	1.014	1.016	1.002	1.006	0.996	1.012	1.003				
87		1.000	1.000	1.000	1.000	1.018	0.997	1.012	0.998					
88														
89	1.000	1.000	1.010	1.005	0.998	1.027	1.003							
90	0.942	0.987	0.994	0.997	1.008	1.007								
91	1.000	1.000	1.000	1.000	1.000									
92	1.000	1.000	1.000	1.083										
93														
94	1.000	1.000												
95	1.000													
Age-to-Age	1.000	1.000	1.000	1.021	1.004	1.009	1.001	1.004	1.003	1.002	0.999	1.005	1.004	
Age-to-Ultimate	1.075	1.075	1.075	1.075	1.053	1.048	1.039	1.038	1.033	1.030	1.028	1.029	1.024	1.020
RoDs/OU	1.00	1.00	1.00		1.08	1.00	1.03	1.04		1.03	1.06	1.00	1.06	1.05
Ult RoD/OU Ratio	1.08	1.08	1.08		**1.08**	1.05	1.07	1.08		1.06	1.09	1.03	1.08	1.07

Overall Average RoDs/OU =	1.07
Average, 1983–1986 =	1.07
Average, 1987–1996 =	1.07

Notes: The value of this ratio for the most recent years and the overall average is a consistent 1.07.

The value for the most recent diagonal for site listing year 1992 represents 7 RoDs issued on 7 OUs through calendar year-end 1995, and 6 more RoDs issued on 5 more OUs during calendar year 1996, yielding 13 RoDs on 12 OUs, and the 1.0833 ratio. Due to the limited number of RoDs and OUs for this year, the average of the most recent three years' results was used for this value.

Approaches to estimating the tail factor for this type of analysis is left as a subject of further research.

EXHIBIT 6

Operable Units (OUs) with at Least One RoD Per Site with at Least One RoD

Year Listed on NPL	Cumulative OUs with at Least One RoD Issued/Cumulative Sites with at Least One RoD Issued, by Number of Years Since NPL Listing: 1	2	3	4	5	6	7	8	9	10	11	12	13	14
83	1.06	1.06	1.15	1.15	1.19	1.27	1.32	1.36	1.40	1.41	1.44	1.48	1.51	1.54
84	1.00	1.00	1.05	1.06	1.12	1.15	1.15	1.22	1.26	1.33	1.33	1.38	1.41	
85	1.00	2.00	2.00	2.00	1.33	2.00	2.00	2.00	2.00	2.00	2.00	2.00		
86	1.00	1.05	1.14	1.19	1.28	1.28	1.34	1.39	1.40	1.42	1.45			
87		1.00	1.00	1.05	1.06	1.07	1.17	1.18	1.21	1.21				
88														
89	1.11	1.17	1.26	1.24	1.25	1.26	1.28	1.30						
90	1.00	1.08	1.07	1.08	1.11	1.13	1.17							
91	1.00	1.00	1.00	1.00	1.00	1.00								
92	1.00	1.00	1.00	1.00	1.09									
93														
94	2.50	2.00	1.44											
95	1.33	1.40												
96	1.00													

EXHIBIT 6

Operable Units (OUs) with at Least One RoD Per Site with at Least One RoD

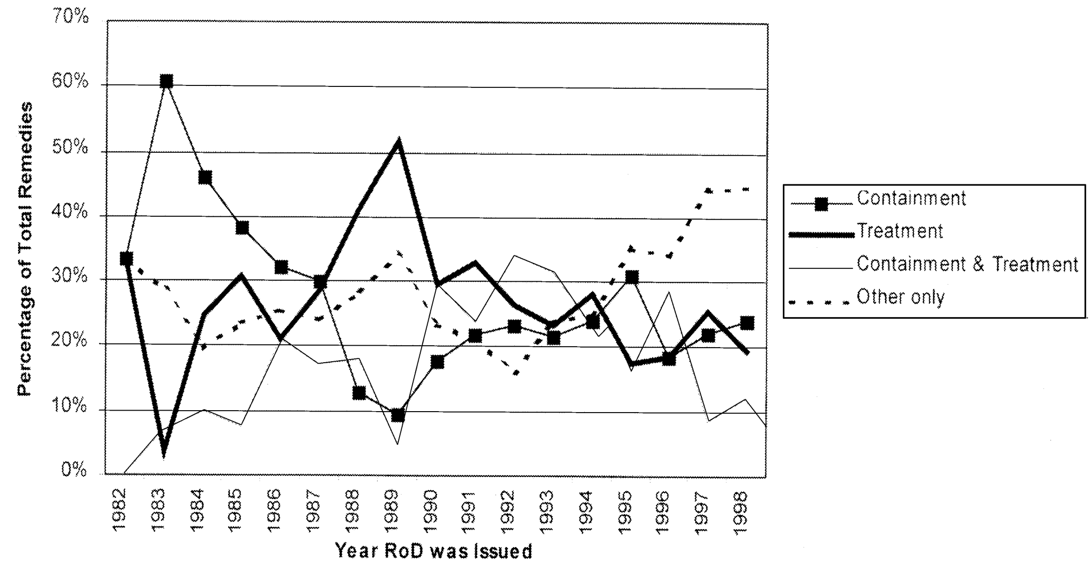
(Continued)

	Age to Age Factors													
	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	
83	1.00	1.08	1.00	1.04	1.06	1.04	1.03	1.03	1.01	1.02	1.02	1.02	1.02	
84	1.00	1.05	1.01	1.06	1.03	1.00	1.06	1.03	1.06	1.00	1.03	1.03		
85	2.00	1.00	1.00	0.67	1.50	1.00	1.00	1.00	1.00	1.00	1.00			
86	1.05	1.08	1.04	1.08	1.01	1.04	1.04	1.01	1.01	1.02				
87		1.00	1.05	1.01	1.01	1.09	1.01	1.02	1.00					
88														
89	1.06	1.07	0.99	1.01	1.01	1.01	1.02							
90	1.08	0.99	1.01	1.02	1.02	1.04								
91	1.00	1.00	1.00	1.00	1.00									
92	1.00	1.00	1.00	1.09										
93														
94	0.80	0.72												
95	1.05													
Age-to-Age	1.04	1.02	1.00	1.03	1.01	1.05	1.03	1.02	1.02	1.01	1.02	1.02	1.02	
Age-to-Ultimate	1.40	1.35	1.32	1.31	1.27	1.26	1.20	1.17	1.15	1.13	1.12	1.10	1.07	1.05
OUs/Site	1.00	1.40	1.44	—	1.09	1.00	1.17	1.30	—	1.21	1.45	2.00	1.41	1.54
Ult OUs/Site Ratio	1.40	1.89	1.90	—	1.38	1.26	1.41	1.53	—	1.37	1.62	2.20	1.52	1.62

Overall Average OUS/Site =	1.59
Average, 1982–1986 =	1.66
Average, 1987–1996 =	1.52
Average, 1987–1994 =	1.47

EXHIBIT 7

NON-FEDERAL SUPERFUND SITE REMEDY SELECTION TRENDS



Notes: This data relates to the remedies for each of the more than 2,800 contaminated media addressed in approximately 1,400 RoDs.
"Containment" includes both containment-only remedies, and RoDs where both "Containment" and "Other" remedies were selected.
"Treatment" includes both treatment-only remedies, and RoDs where both "Treatment" and "Other" remedies were selected.
"Other" includes RoDs where only "Other" remedies were selected.

APPENDIX A

SAMPLE RECORD OF DECISION (RoD) ABSTRACT

General Site Information

Site Name: MOTOR WHEEL
EPA ID: MID980702989 EPA Region: 05
Metro Statistical Area: 4040
Street: 2401 N HIGH ST (REAR)
City: LANSING TWP State: MI Zip: 48909
Congressional District: 08
County Code: 065 County Name: INGHAM
National Priority List (NPL) Status: F
Proposed NPL Update Number: Final NPL Update Number:
Ownership Indicator: OH
Federal Facility Flag: N Federal Facility Docket: F
Latitude: 4245390 Longitude: 08432060
LL Source: E LL Accuracy:
Incident Type: Incident Category: P
Resource and Recovery Act Facility: FMS SS ID: 05S5
Dioxin Tier: USGS Hydro Unit: 04050004
Site Description:

Remediation Information (Records of Decision)

Site Name: MOTOR WHEEL
EPA ID: MID980702989
Operable Unit:
ROD ID: EPA/ROD/R05-91/172 ROD Date: 09/30/91
Contaminant: VOCS
BENZENE
PCE
TCE
TOLUENE
XYLENES
ORGANICS
PAHS

PCBS
PESTICIDES
METALS
ARSENIC
CHROMIUM
LEAD
O&M Costs: Estimated Costs:
Keys: NONE

Abstract:

THE 24-ACRE MOTOR WHEEL SITE IS AN INACTIVE INDUSTRIAL WASTE DISPOSAL SITE IN LANSING, INGHAM COUNTY, MICHIGAN. LAND USE IN THE AREA IS PREDOMINANTLY INDUSTRIAL. THE SITE OVERLIES A GLACIAL TILL AND A GLACIAL AQUIFER. FROM 1938 TO 1978, THE MOTOR WHEEL CORPORATION USED THE SITE FOR THE DISPOSAL OF SOLID AND LIQUID INDUSTRIAL WASTES INCLUDING PAINTS, SOLVENTS, LIQUID ACIDS AND CAUSTICS, AND SLUDGE. WASTES WERE DISPOSED OF IN TANKS, BARRELS, SEEPAGE PONDS, AND OPEN FILL OPERATIONS. AN ESTIMATED 210,000 CUBIC YARDS OF WASTE FILL IS IN PLACE ONSITE. AS A RESULT OF DISPOSAL PRACTICES, CONTAMINANTS HAVE LEACHED THROUGH THE SOIL AND INTO THE UNDERLYING GLACIAL AQUIFER AND PERCHED ZONE. BETWEEN 1970 AND 1982, AT LEAST THREE ONSITE CLEAN-UP ACTIONS WERE INITIATED. IN 1970, THE STATE REQUIRED THE REMOVAL AND OFFSITE DISPOSAL OF SOLID WASTES, PAINT SLUDGE, AND OILS FROM SEEPAGE PONDS AND BACKFILLING OF EXCAVATED POND AREAS. IN 1978, INDUSTRIAL WASTES AND DEGRADED SOIL WERE EXCAVATED AND STOCKPILED ONSITE UNDER A CLAY COVER.

IN 1982, THE SITE OWNERS REMOVED THREE 10,000-GALLON TANKS, THEIR CONTENTS, AND SURROUND-

ING CONTAMINATED SOIL, ALONG WITH CONTAMINATED FILL MATERIAL CONTAINING AN UNKNOWN QUANTITY OF DRUMS. THIS RECORD OF DECISION (ROD) ADDRESSES THE WASTE MASS AND GROUND WATER CONTAMINATION IN THE PERCHED ZONE AND THE GLACIAL AQUIFER. THE PRIMARY CONTAMINANTS OF CONCERN AFFECTING THE SOIL, DEBRIS, AND GROUND WATER ARE VOCS INCLUDING BENZENE, PCE, TCE, TOLUENE, AND XYLENES; ORGANICS INCLUDING PAHS, PCBS, AND PESTICIDES; AND METALS INCLUDING ARSENIC, CHROMIUM, AND LEAD.

THE SELECTED REMEDIAL ACTION FOR THIS SITE INCLUDES BACKFILLING THE NORTHERN PORTION OF THE FILL AREA WITH 125,000 CUBIC YARDS OF FILL; CAPPING THE DISPOSAL AREA WITH A 14.9-ACRE MULTI-MEDIA CAP; INSTALLING A SLURRY WALL AT THE WESTERN AND SOUTHERN BOUNDARY OF THE DISPOSAL AREA; INSTALLING GROUND WATER RECOVERY WELLS OR TRENCHES DOWNGRADIENT, AND A COLLECTION TRANSFER SYSTEM TO DELIVER WATER TO AN ONSITE TREATMENT FACILITY; PRETREATING GROUND WATER ONSITE TO REMOVE IRON AND MANGANESE USING AERATION, CLARIFICATION, AND FILTRATION IF NEEDED, FOLLOWED BY ONSITE TREATMENT USING AIR STRIPPING AND CARBON ADSORPTION; USING ACTIVATED ALUMINA TO REMOVE FLUORIDE FROM GROUND WATER, FOLLOWED BY OFFSITE DISCHARGE OF THE TREATED WATER TO A PUBLICLY OWNED TREATMENT WORKS (POTW); MONITORING GROUND WATER; AND IMPLEMENTING INSTITUTIONAL CONTROLS INCLUDING DEED AND GROUND WATER USE RESTRICTIONS, AND SITE ACCESS RESTRICTIONS SUCH AS FENCING. THE ESTIMATED PRESENT WORTH COST FOR THIS REMEDIAL ACTION IS $30,720,300, WHICH INCLUDES A CAPITAL COST OF

$11,083,300 AND AN ANNUAL O&M COST OF $1,277,400 FOR 30 YEARS. PERFORMANCE STANDARDS OR GOALS; GROUND WATER CLEAN-UP GOALS ARE BASED ON STATE HEALTH-BASED STANDARDS OR METHOD DETECTION LIMITS (MDL), WHICHEVER IS HIGHER. CHEMICAL-SPECIFIC GOALS INCLUDE BENZENE 1 UG/L (STATE), PCE 1 UG/L (MDL), TCE 3 UG/L (STATE), TOLUENE 800 UG/L (STATE), XYLENES 300 UG/L (STATE), AND LEAD 5 UG/L (STATE).

Remedy:

THIS OPERABLE UNIT ADDRESSES REMEDIATION OF GROUNDWATER AND SOURCE CONTROL BY REDUCING THE POTENTIAL FOR CONTINUING GROUNDWATER CONTAMINATION FROM THE ON-SITE WASTE MASS AND REDUCING THE THREAT FROM CONTAMINATED GROUNDWATER THROUGH TREATMENT. THE MAJOR ELEMENTS OF THE SELECTED REMEDY INCLUDE;

* INSTALLATION OF AN APPROXIMATELY 11.3 ACRE MICHIGAN ACT 64 CAP OVER THE DISPOSAL AREA;

* BACK-FILLING TO COVER EXPOSED FILL AREAS AND TO ESTABLISH AN ACCEPTABLE SLOPE IN THE EXCAVATED AREA OF THE SITE FOR EXTENSION OF THE CAP;

* EXTRACTION OF CONTAMINATED GROUNDWATER FROM THE PERCHED ZONE AND THE GLACIAL AQUIFER AND TREATMENT OF THE GROUNDWATER BY AIR STRIPPING, GRANULAR ACTIVATED CARBON, AND ALUMINA REACTION ON-SITE AND TREATMENT OF THE OFF GASES;

* SITE DEED RESTRICTIONS TO LIMIT DEVELOPMENT AND LAND USE AND TO PREVENT INSTALLATION OF DRINKING WATER WELLS OR OTHER INTRUSIVE ACTIVITY AT THE SITE; AND

* GROUNDWATER MONITORING TO ASSESS THE STATE OF THE REMEDIATION.

* A SLURRY WALL WILL BE INSTALLED TO FACILITATE THE DEWATERING OF THE PERCHED ZONE AQUIFER.

APPENDIX A

Exhibit 1

Deriving an Undiscounted Estimate of Remediation Costs Using RoD Data

		Amount	Source
(1)	Total Present Value	30,720,300	RoD
(2)	Total Capital Costs	11,083,300	RoD
(3)	Implied Present Value of O&M Costs	19,637,000	(1)–(2)
(4)	Annual O&M Cost	1,277,400	RoD
(5)	Years of O&M Cost	30	RoD
(6)	Assumed Discount Rate	5%	Assumption based on RoD date and Exhibit 4
(7)	Calculated O&M Present Value	19,636,769	Present value of (4) per year for (5) years discounted at a rate of (6).[32]
(8)	Assumed Inflation Rate	3.0%	Selected by actuary
(9)	Initial Estimate of Undiscounted O&M Cost	60,772,836	Future value of (4) per year for (5) years compounded at a rate of (8).[33]
(10)	Assumed Delay from RoD Issuance to Start of Cleanup Effort (in Years)	1.5	Selected by actuary[34]
(11)	Lag-Adjusted Capital Costs	11,585,771	(2)∗[1+(8)]^(10)
(12)	Assumed Duration of Construction Effort (in Years)	2.0	Selected by actuary[34]
(13)	Lag and Duration-Adjusted Capital Costs	11,759,557	(11)/2+(11)/2∗[1+(8)][35]
(14)	Assumed Delay from Construction Completion to O&M Start-up (in Years)	1.0	Selected by actuary[34]
(15)	Lag-Adjusted O&M Costs	69,418,786	(9)∗[1+(8)]^[(10)+(12)+(14)]
(16)	Total Estimated Undiscounted RoD Cost	81,178,343	(13)+(15)
(17)	Ratio: Total Estimated Undiscounted RoD Cost to Present Value Estimate in RoD	264%	(16)/(1)

[32]Note the similarity to the implied O&M cost from item (3).
[33]This is approximately 60% greater than the value derived by simply multiplying the annual O&M cost by the number of years applicable.
[34]Information useful to help estimate this lag may be obtained from CERCLIS.
[35]Assumes that, inflation aside, the two year total cost in current dollars is equally allocable between the two years of construction activities. It may be more realistic to assume a larger percentage applies to the first year, during which some large initial costs are incurred (i.e., equipment), as opposed to subsequent years, which may require predominantly materials and labor.

APPENDIX B

DIGGING UP MORE DIRT: AN APPROACH TO ESTIMATING FUTURE PRP COUNTS ON CURRENT SUPERFUND SITES

This appendix documents the approach outlined in the accompanying exhibits. Note that although this data has received a limited "scrubbing," due to various data quality issues outside the scope of this paper, *the reader should not rely on its quality or accuracy for use in analyses.* One adjustment made to the data is the removal of those PRPs that may relate to sites that are either still under review (i.e., they may eventually, but have not yet become Superfund sites) or sites that have been removed from CERCLIS and placed on NFRAP (i.e., they are expected to receive no further attention from the EPA). In addition, exact duplicate PRP entries at a given site were also removed, though in some cases, due to differences in the name for that PRP (e.g., General Electric Co. vs. GE), they may remain in the data.

Exhibit 1 of Appendix B displays PRP counts by year of NPL site listing and PRP notification, based on CERCLIS and PRP data at year-end 1995. The reader can see that, for sites listed on the NPL in 1983, 1,632 PRPs received notification of their potential liability at that site in 1982. In addition, 2,096 more PRPs received notification of their potential liability in 1983 on these sites.

Exhibit 2 restates the information on Exhibit 1 in "parallelogram" format. The column headings now reflect the difference in time between a PRP's notification of potential liability at a site and that site's placement on the NPL. On Page 2 of Exhibit 2, we can see that, for sites listed on the NPL in 1983, there were 1,632 PRPs notified of their potential liability at those sites one year earlier (in 1982). Another 2,096 PRPs were notified of their potential liability at sites listed in 1983 during 1983, and yet another 1,097 PRPs were notified of their potential links to sites listed in 1983 one year after those sites were listed (in 1984).

Exhibit 3 restates the incremental information in Exhibit 2 on a cumulative basis. Continuing our example, Page 2 of Exhibit 3 shows us that 1,742 PRPs received notice of potential liability at NPL sites listed in 1983 by the end of the year before those sites were listed (1982), and 3,838 PRPs were notified of their potential liability at those sites by the end of the year those sites were listed (1983). At the end of the year after these sites were listed (1984), 4,935 PRPs had been notified of potential links to those sites.

Exhibit 4 is simply "parallelogram" age-to-age factors, based on Exhibit 3. Page 2 shows us a development factor indicating that, for NPL sites listed in 1983, the growth in the number of PRPs notified of their potential liability at those sites between one and two years after those sites were listed is 33.6% $(6,592/4,935 = 1.336)$. Pages 2 and 3 also include the selection of age-to-age factors, as shown below the diagonal line. (It is worth repeating here that the development factors selections included here are for explanatory purposes only, and should not be relied on as "industry PRP development factors." Many additional adjustments to the PRP data should be made prior to evaluating the factors for that purpose.)

Exhibit 5 displays the age-to-ultimate factors corresponding to the age-to-age factors in Exhibit 4. Using our example, the selected factors imply a belief that, for sites listed on the NPL in 1983, no additional PRP notifications will be sent out (i.e., the age-to-ultimate development factor is 1.000). For sites listed in 1995, however, the expected number of PRPs yet to be notified of their links to these sites is expected to be 63.2% of the number of PRPs already linked to those sites (since the age-to-ultimate factor selected is 1.632). The author stresses again that the tail factor of 1.000 is displayed here for explanatory purposes only. It may be too early to truly expect no additional PRP development. Considerations and approaches which may be used to estimate PRP development tail factors may be a worthwhile area of future research.

Exhibit 6 summarizes our results and completes this explanation. The exhibit implies that, under the assumptions used here, 91.1% of PRPs have already been notified of their potential liability at current Superfund sites by year-end 1995. As a result, an estimate of the total number of claims relating to Superfund sites listed on the NPL as of year-end 1995 might be estimated by multiplying the current claim count on current Superfund sites by 1.10 (= 1/91.1%), further adjusted as necessary for any applicable collateral suit defendant and claim report lags. Then, subtracting the number of claims reported to date from the total number of expected claims yields an estimate of the number of future claims on current sites.

APPENDIX B

Exhibit 1

Page 1

PRP Data At Year-End 1995 (Quasi-Scrubbed)
Raw Data Format: Incremental Counts

Year Listed	Year PRP Received Notice of Potential Liability at Site							
on NPL	1980	1981	1982	1983	1984	1985	1986	1987
1982	0	0	0	0	0	0	0	0
1983	0	110	1,632	2,096	1,097	1,657	1,690	306
1984	0	0	19	123	29	497	32	48
1985	0	0	0	0	0	0	0	0
1986	0	0	0	2	59	147	289	587
1987	0	0	0	5	4	0	99	88
1988	0	0	0	0	0	0	0	0
1989	0	0	0	18	25	27	71	551
1990	0	0	0	0	0	2	8	61
1991	0	0	0	0	0	1	3	0
1992	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	8
1995	0	0	0	0	0	0	0	0

APPENDIX B

EXHIBIT 1

PAGE 2

PRP DATA AT YEAR-END 1995 (QUASI-SCRUBBED) RAW DATA FORMAT: INCREMENTAL COUNTS

Year Listed	Year PRP Received Notice of Potential Liability at Site							
on NPL	1988	1989	1990	1991	1992	1993	1994	1995
1982	0	0	0	0	0	0	0	0
1983	673	854	1,306	430	1,916	110	98	3
1984	105	79	919	203	31	298	332	1
1985	0	0	0	0	0	0	0	0
1986	315	398	580	490	778	393	9	0
1987	18	90	132	327	243	32	6	0
1988	0	0	0	0	0	0	0	0
1989	131	1,100	385	493	278	108	470	2
1990	383	300	301	238	190	28	31	2
1991	6	19	0	10	5	0	0	0
1992	1	3	1	0	558	17	3	1
1993	0	0	0	0	0	0	0	0
1994	4	646	1	98	73	57	10	0
1995	0	0	0	0	11	2	14	7

APPENDIX B

Exhibit 2

Page 1

PRP Data At Year-End 1995 (Quasi-Scrubbed) ''Parallelogram'' Data Format: Incremental Counts

Year Listed	Year PRP Received Notice of Potential Liability at Site, Relative to NPL Listing Year							
on NPL	−12	−11	−10	−9	−8	−7	−6	−5
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989							18	25
1990								2
1991							1	3
1992								
1993								
1994						8	4	646
1995								

APPENDIX B

Exhibit 2

Page 2

PRP Data At Year-End 1995 (Quasi-Scrubbed) "Parallelogram" Data Format: Incremental Counts

Year Listed	Year PRP Received Notice of Potential Liability at Site, Relative to NPL Listing Year								
on NPL	−4	−3	−2	−1	0	1	2	3	4
1982									
1983			110	1,632	2,096	1,097	1,657	1,690	306
1984			19	123	29	497	32	48	105
1985									
1986		2	59	147	289	587	315	398	580
1987	5	4	0	99	88	18	90	132	327
1988									
1989	27	71	551	131	1,100	385	493	278	108
1990	8	61	383	300	301	238	190	28	31
1991	0	6	19	0	10	5	0	0	0
1992	1	3	1	0	558	17	3	1	
1993									
1994	1	98	73	57	10	0			
1995		11	2	14	7				

APPENDIX B

EXHIBIT 2

PAGE 3

PRP DATA AT YEAR-END 1995 (QUASI-SCRUBBED) ''PARALLELOGRAM'' DATA FORMAT: INCREMENTAL COUNTS

Year Listed	Year PRP Received Notice of Potential Liability at Site, Relative to NPL Listing Year							
on NPL	5	6	7	8	9	10	11	12
1982								
1983	673	854	1,306	430	1,916	110	98	3
1984	79	919	203	31	298	332	1	
1985								
1986	490	778	393	9	0			
1987	243	32	6	0				
1988								
1989	470	2						
1990	2							
1991								
1992								
1993								
1994								
1995								

APPENDIX B

EXHIBIT 3

PAGE 1

PRP DATA AT YEAR-END 1995 (QUASI-SCRUBBED) ''PARALLELOGRAM'' DATA FORMAT: CUMULATIVE COUNTS

Year Listed	Year PRP Received Notice of Potential Liability at Site, Relative to NPL Listing Year							
on NPL	−12	−11	−10	−9	−8	−7	−6	−5
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989							18	43
1990								2
1991							1	4
1992								
1993								
1994						8	12	658
1995								

APPENDIX B

EXHIBIT 3

PAGE 2

PRP DATA AT YEAR-END 1995 (QUASI-SCRUBBED) ''PARALLELOGRAM'' DATA FORMAT: CUMULATIVE COUNTS

Year Listed	Year PRP Received Notice of Potential Liability at Site, Relative to NPL Listing Year								
on NPL	−4	−3	−2	−1	0	1	2	3	4
1982									
1983			110	1,742	3,838	4,935	6,592	8,282	8,588
1984			19	142	171	668	700	748	853
1985									
1986		2	61	208	497	1,084	1,399	1,797	2,377
1987	5	9	9	108	196	214	304	436	763
1988									
1989	70	141	692	823	1,923	2,308	2,801	3,079	3,187
1990	10	71	454	754	1,055	1,293	1,483	1,511	1,542
1991	4	10	29	29	39	44	44	44	44
1992	1	4	5	5	563	580	583	584	
1993									
1994	659	757	830	887	897	897			
1995		11	13	27	34				

APPENDIX B

EXHIBIT 3

PAGE 3

PRP DATA AT YEAR-END 1995 (QUASI-SCRUBBED) ''PARALLELOGRAM'' DATA FORMAT: CUMULATIVE COUNTS

Year Listed	Year PRP Received Notice of Potential Liability at Site, Relative to NPL Listing Year							
on NPL	5	6	7	8	9	10	11	12
1982								
1983	9,261	10,115	11,421	11,851	13,767	13,877	13,975	13,978
1984	932	1,851	2,054	2,085	2,383	2,715	2,716	
1985								
1986	2,867	3,645	4,038	4,047	4,047			
1987	1,006	1,038	1,044	1,044				
1988								
1989	3,657	3,659						
1990	1,544							
1991								
1992								
1993								
1994								
1995								

APPENDIX B

EXHIBIT 4

PAGE 1

PRP DATA AT YEAR-END 1995 (QUASI-SCRUBBED)
''PARALLELOGRAM'' DATA FORMAT: AGE-TO-AGE DEVELOPMENT FACTORS

Year Listed	Development Based on PRP Notification Year, Relative to NPL Listing Year							
on NPL	−12 to −11	−11 to −10	−10 to −9	−9 to −8	−8 to −7	−7 to −6	−6 to −5	−5 to −4
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989							2.389	1.628
1990								5.000
1991							4.000	1.000
1992								
1993								
1994						1.500	54.833	1.002
1995								

APPENDIX B

EXHIBIT 4

PAGE 2

PRP DATA AT YEAR-END 1995 (QUASI-SCRUBBED)
''PARALLELOGRAM'' DATA FORMAT: AGE-TO-AGE DEVELOPMENT FACTORS

Year Listed	Development Based on PRP Notification Year, Relative to NPL Listing Year								
on NPL	−4 to −3	−3 to −2	−2 to −1	−1 to 0	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5
1982									
1983					1.286	1.336	1.256	1.037	1.078
1984				1.204	3.906	1.048	1.069	1.140	1.093
1985									
1986		30.500	3.410	2.389	2.181	1.291	1.284	1.323	1.206
1987	1.800	1.000	12.000	1.815	1.092	1.421	1.434	1.750	1.318
1988									
1989	2.014	4.908	1.189	2.337	1.200	1.214	1.099	1.035	1.147
1990	7.100	6.394	1.661	1.399	1.226	1.147	1.019	1.021	1.001
1991	2.500	2.900	1.000	1.345	1.128	1.000	1.000	1.000	1.050
1992	4.000	1.250	1.000	112.600	1.030	1.005	1.002	1.014	1.050
1993							1.007	1.014	1.050
1994	1.149	1.096	1.069	1.011	1.000	1.051	1.007	1.014	1.050
1995		1.182	2.077	1.259	1.053	1.051	1.007	1.014	1.050

APPENDIX B

EXHIBIT 4

PAGE 3

PRP DATA AT YEAR-END 1995 (QUASI-SCRUBBED)
''PARALLELOGRAM'' DATA FORMAT: AGE-TO-AGE DEVELOPMENT FACTORS

Year Listed	Development Based on PRP Notification Year, Relative to NPL Listing Year							
on NPL	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	11 to 12	Tail Factor
1982								
1983	1.092	1.129	1.038	1.162	1.008	1.007	1.000	1.000
1984	1.986	1.110	1.015	1.143	1.139	1.000	1.000	1.000
1985						1.003	1.000	1.000
1986	1.271	1.108	1.002	1.000	1.074	1.003	1.000	1.000
1987	1.032	1.006	1.000	1.076	1.074	1.003	1.000	1.000
1988			1.006	1.076	1.074	1.003	1.000	1.000
1989	1.001	1.074	1.006	1.076	1.074	1.003	1.000	1.000
1990	1.099	1.074	1.006	1.076	1.074	1.003	1.000	1.000
1991	1.099	1.074	1.006	1.076	1.074	1.003	1.000	1.000
1992	1.099	1.074	1.006	1.076	1.074	1.003	1.000	1.000
1993	1.099	1.074	1.006	1.076	1.074	1.003	1.000	1.000
1994	1.099	1.074	1.006	1.076	1.074	1.003	1.000	1.000
1995	1.099	1.074	1.006	1.076	1.074	1.003	1.000	1.000

APPENDIX B

EXHIBIT 5

PAGE 1

PRP DATA AT YEAR-END 1995 (QUASI-SCRUBBED)
''PARALLELOGRAM'' DATA FORMAT: AGE-TO-ULTIMATE DEVELOPMENT FACTORS

Year Listed	Development Based on PRP Notification Year, Relative to NPL Listing Year							
on NPL	−12 to ult	−11 to ult	−10 to ult	−9 to ult	−8 to ult	−7 to ult	−6 to ult	−5 to ult
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989							254.521	106.544
1990								1,062.289
1991							63.574	15.893
1992								
1993								
1994						173.769	115.846	2.113
1995								

APPENDIX B

EXHIBIT 5

PAGE 2

PRP DATA AT YEAR-END 1995 (QUASI-SCRUBBED)
"PARALLELOGRAM" DATA FORMAT: AGE-TO-ULTIMATE DEVELOPMENT FACTORS

Year Listed	Development Based on PRP Notification Year, Relative to NPL Listing Year								
on NPL	−4 to ult	−3 to ult	−2 to ult	−1 to ult	0 to ult	1 to ult	2 to ult	3 to ult	4 to ult
1980									
1981									
1982									
1983									
1984				19.131	15.886	4.067	3.881	3.632	3.185
1985									
1986		2,178.656	71.431	20.949	8.767	4.020	3.115	2.425	1.833
1987	241.929	134.405	134.405	11.200	6.172	5.653	3.979	2.774	1.585
1988									
1989	65.448	32.492	6.620	5.567	2.382	1.985	1.636	1.488	1.438
1990	212.458	29.924	4.680	2.818	2.014	1.643	1.433	1.406	1.378
1991	15.893	6.357	2.192	2.192	1.630	1.445	1.445	1.445	1.445
1992	855.522	213.880	171.104	171.104	1.520	1.475	1.467	1.465	1.445
1993							1.475	1.465	1.445
1994	2.109	1.836	1.675	1.567	1.550	1.550	1.475	1.465	1.445
1995		5.043	4.267	2.055	1.632	1.550	1.475	1.465	1.445

APPENDIX B

EXHIBIT 5

PAGE 3

PRP DATA AT YEAR-END 1995 (QUASI-SCRUBBED)
''PARALLELOGRAM'' DATA FORMAT: AGE-TO-ULTIMATE DEVELOPMENT FACTORS

Year Listed	Development Based on Year Listed on NPL Relative to PRP Notification Year							
on NPL	5 to ult	6 to ult	7 to ult	8 to ult	9 to ult	10 to ult	11 to ult	12–ult
1980								
1981								
1982								
1983								1.000
1984	2.915	1.468	1.323	1.303	1.140	1.001	1.000	1.000
1985						1.003	1.000	1.000
1986	1.520	1.195	1.079	1.077	1.077	1.003	1.000	1.000
1987	1.202	1.165	1.159	1.159	1.077	1.003	1.000	1.000
1988			1.165	1.159	1.077	1.003	1.000	1.000
1989	1.253	1.252	1.165	1.159	1.077	1.003	1.000	1.000
1990	1.376	1.252	1.165	1.159	1.077	1.003	1.000	1.000
1991	1.376	1.252	1.165	1.159	1.077	1.003	1.000	1.000
1992	1.376	1.252	1.165	1.159	1.077	1.003	1.000	1.000
1993	1.376	1.252	1.165	1.159	1.077	1.003	1.000	1.000
1994	1.376	1.252	1.165	1.159	1.077	1.003	1.000	1.000
1995	1.376	1.252	1.165	1.159	1.077	1.003	1.000	1.000

APPENDIX B

EXHIBIT 6

DATA AT YEAR-END 1995 (QUASI-SCRUBBED)
DEVELOPMENT ANALYSIS SUMMARY

Year Listed on NPL	(1) Selected PRP Dvlpmnt Factor	(2) 1/(1) Probability: Current PRP on Current NPL Site	(3) 1–(2) Probability: Future PRP on Current NPL Site	(4) Count of Current PRPs on Current NPL Sites	(5) (1)∗(4) Estimate of Ultimate PRPs on Current NPL Sites
1983	1.000	100.0%	0.0%	13,978	13,978
1984	1.000	100.0%	0.0%	2,716	2,717
1985	1.003	99.7%	0.3%	0	0
1986	1.077	92.9%	7.1%	4,047	4,357
1987	1.159	86.3%	13.7%	1,044	1,210
1988	1.165	85.8%	14.2%	0	0
1989	1.252	79.9%	20.1%	3,659	4,581
1990	1.376	72.7%	27.3%	1,544	2,125
1991	1.445	69.2%	30.8%	44	64
1992	1.465	68.3%	31.7%	584	856
1993	1.475	67.8%	32.2%	0	0
1994	1.550	64.5%	35.5%	897	1,390
1995	1.632	61.3%	38.7%	34	55
				28,547	31,332

Estimated Probability of Current PRP on Current Site:
Total(4)/Total(5) = 91.1%

Estimated Probability of Future PRP on Current Site:
[Total(5) − Total(4)]/Total(5) = 8.9%

Estimated PRP Development, All Years Combined:
Total(5)/Total(4) = 1.10

APPENDIX C

COMING CLEAN: THE RELATIONSHIP BETWEEN HAZARD, TIME AND COST

Similar to the note preceding the main text, the author would like to emphasize that the opinions expressed in this Appendix represent the views of the author, and do not necessarily represent the views of the Casualty Actuarial Society, Ernst & Young LLP, or anyone else.

Many have stipulated a relationship among these three quantities, based on the following argument:

- The Superfund was created to address the country's super-hazardous inactive waste sites; as a result, the most hazardous of Superfund sites would have been those first put on the national priorities list (NPL).
- These super-hazardous sites will also tend to be the largest, most complex sites, making them also the most costly.
- If the earliest, most hazardous sites tend to be the most costly, it follows that the later sites, which should be less hazardous, would be less costly.

A test of this hypothesis is displayed in Exhibits 1 and 2 of Appendix C, which test the specific relationship between the year a site was listed on the NPL and the site's Public Health Hazard Category (PHH) by the Agency of Toxic Substances and Disease Registry (ATSDR). These exhibits imply that the average site posted to the NPL in the most recent years is, if anything, more hazardous than the average site posted to the NPL in the program's earliest years.

Before discussing the possible reasons behind this, a few notes about the exhibits are in order. The ATSDR ranking was used in lieu of the Environmental Protection Agency's (EPA's) hazard ranking system (HRS) score for at least five reasons:

1. The EPA only uses the HRS score to separate potential NPL sites from non-NPL sites; it is not the primary tool used to subsequently prioritize which NPL sites are the most hazardous and require the earliest attention. Thus, the EPA itself does not consider the HRS sufficient for differentiating the degree of differences in hazard among NPL sites. The PHH, however, is designed to differentiate hazard levels at any location (NPL or otherwise).

2. As noted in the main text, since the HRS score only needs to reach a value of 28.5 for possible proposal to the NPL, once sufficient exposure pathways have been scored to achieve this, the remainder might not be scored at all, further diminishing the usefulness of the HRS score as a measure of each NPL site's relative hazard level. Again, this shortcut would not present a problem for the EPA's prioritizing of Superfund sites, since the HRS score is not the primary tool used for that purpose.

3. Part of the HRS scoring approach considers the size of the population near the site being scored. As a result, two sites with identical problems and required remedies may have different HRS scores. This does not imply that such differentiation is improper; only that the EPA's HRS score is really a measure of both hazard and the extent of population exposure to that hazard. The PHH, by contrast, does not consider the extent of population exposure, only whether or not there is *any* potential population exposure.

4. While the potential for future spreading of current contamination at a site is clearly considered by both the HRS and the PHH, the HRS score may be more conservative in that the PHH tries to consider the "likely" future spread of contamination, while the EPA's HRS score has historically considered a broader definition.

This is analogous to estimating "likely" vs. "conservative" IBNR amounts.

5. The HRS was updated in December of 1990, which might limit its usefulness as a consistent estimator of hazard over time. In contrast, the PHHs have been relatively consistent since inception.

Despite the above, however, there are some drawbacks to using the ATSDR data as well, including the following:

1. There are seven PHH categories in the ATSDR scoring system: 1 (urgent public health hazard), 2 (public health hazard), 3 (indeterminate public health hazard), 4 (no apparent public health hazard), 5 (no public health hazard), 6 (no hazard conclusion required) and 12 (posed public health hazard only in the past). Since the rankings of the ATSDR are not actually relative (e.g., a ranking of a 5 is not one-fifth as hazardous as a ranking of 1), the average PHH category for a given site listing year is not meaningful. As a result, the median value was used here, as displayed in Exhibit 1 of Appendix C. The percentage of sites posted to the NPL in each year that represent public hazards as evaluated by the ATSDR is also displayed, in Exhibit 2 of Appendix C.

2. There has been a preponderance of sites with a PHH of 3 (indeterminate hazard), largely because the ATSDR felt that the necessary data to reasonably evaluate the "likely" hazard level at many sites was not available. This analysis focused on differentiating the higher hazard levels (PHH categories 1 and 2) from the lower hazard levels (PHH categories 4 and 5) by excluding sites with a PHH of 3 from the review (Scenario 1 of Appendix C, Exhibits 1 and 2). For sensitivity testing purposes, Scenario 2 in these exhibits includes sites with a PHH of 3, and scenarios 3–8 display the impact that these PHH Level 3 sites

would have had on Scenario 1 if they could all have been allocated among the higher and lower hazard levels (1, 2, 4 and 5). For example, Scenario 3 assumes that 25% of the sites with a PHH of 3 are really higher hazard level sites (i.e., would have been a 1 or 2 if sufficient data were available), and 75% are really lower hazard level sites (i.e., would have been a 4 or 5). Scenario 8 assumes all of these sites would have been categorized as higher hazard level sites, and scenarios 4–7 run other scenarios between those two extremes. The author believes that Scenario 4, displaying a 60%/40% split between low and high hazard levels, respectively, is the most likely. This is because, consistent with a conservative tendency stemming from the EPA's need to protect human health, the last thing an EPA site evaluator would want to do is to remove a site from consideration for the NPL, only to later find out that the site was, in fact, Superfund-worthy. As a result, sites with an indeterminate hazard, though plausibly hazardous, are likely not.[36]

3. Some sites have been categorized and recategorized, though only one category should be used per site for this type of analysis. The selected category used here for a given site was determined by first removing all PHHs of 6 and 12 from the data. Then, the site's ranking was selected as either (1) the most recent PHH determined, if no remedial actions (RAs) have begun at that site yet, or (2) the most recent PHH determined prior to the onset

[36]As possible support for (though far from proof of) this, the author reviewed the 109 non-Federal, non-RCRA sites deleted from the NPL which have received PHHs as outlined earlier in this section. Of the 35 sites with a 4 or 5 PHH categorization (likely not hazardous), 80% were deleted with no need for remedial actions (RAs). In contrast, only three of the seven sites with a PHH of 1 or 2 (i.e., 43% of the likely hazardous sites) were deleted with no RAs required. Of the 67 deleted sites with a PHH of 3 (indeterminate hazard), 50 of them (75%) were deleted with no RAs required—which is much closer to 80% (PHHs 4 and 5) than 43% (PHHs 1 and 2). If we can assume that in general, the more hazardous NPL sites tended to require RAs, then the hazard level of sites with a PHH of 3 is more similar on average to the hazard level of sites with a PHH of 4 or 5 than to sites with a PHH of 1 or 2.

of RA activities which have begun at that site (since any cleanup efforts underway hopefully reduce the hazard level at a site by the time the ATSDR begins its review there). Sites with a PHH of 3 were then pulled out of the data for Scenario 1, included in the data for Scenario 2, and redistributed to the other four categories for Scenarios 3–8, as described in the previous item. Sites with no PHHs at all (there were 21 of these), or PHHs completed only after the onset of RA activities (there were 90 of these) were excluded altogether.

Despite these adjustments, however, Exhibit 1 of Appendix C implies that the recent years' median site hazard levels may be greater than those in the earliest years—or, at the very least, not any less hazardous than those in the earliest years. Exhibit 2 of Appendix C also shows a generally greater percentage of higher hazard level sites in the more recent years than in the early years of the program. The data underlying these exhibits is also included, in Exhibit 3 of Appendix C.

The Fallacy of (De)composition: Possible Explanations for the Apparent Non-decreasing Average Hazard over Time

One possible explanation for this somewhat unlikely result is that, although some ultra-hazardous sites were posted to the NPL early in the Superfund program, that doesn't necessarily mean that all sites posted to the NPL early in the Superfund program were ultra-hazardous. There is some intuitive appeal to this idea as well—it is generally accepted that there were approximately 10–20 "megasites" (i.e., sites which are extremely hazardous and costly) posted to the Superfund in the earliest years of the program. However, this is possibly 20 sites out of more than 400 posted to the Superfund in 1983 alone.

It is also possible that in the early years of the program, political pressure might have been exerted to include on the NPL some sites which would have been addressed through state

Superfund programs, if they existed at the time. With almost all states currently having some form of state Superfund program, these potentially less-hazardous sites might now be addressed as non-NPL sites, leaving only the more hazardous ones to be listed on the NPL currently and into the future. Ironically, political pressure is currently being applied in this, the opposite direction, with the states pressing for a more active role in the Superfund cleanup process.

A third possible explanation stems from the fact that, during the program's infancy, there must have been almost by definition a lack of experience in dealing with Superfund site cleanups. Guidance documents useful to assist in determining what is and is not Superfund-worthy take time and experience to develop—neither of which was likely present by 1983, the year the first 400 Superfund sites were listed. This lack of experience stemming from the newness of the program, in conjunction with a possible conservative desire of the EPA to address plausible (rather than just likely) future public health hazards may have led to some sites with undeterminable or even minimal hazard levels being placed on the NPL as a precautionary measure. However, fifteen or more years of experience with the Superfund program, coupled with the issuance and revisions of guidance documents, a revised HRS score and improved technology no doubt helped to decrease the percentage of sites listed on Superfund with an indeterminate hazard level (as shown in the last column in Exhibit 3 of Appendix C). These same factors may help explain the percentage decrease in sites listed with a PHH of 4 or 5 in the more recent years.

In summary then, the author believes that the average hazard level of Superfund sites has actually *increased* over time, rather than decreased, due to the fact that the sites presenting lower level hazards—which may have been included on the NPL in the past—are perhaps being more effectively screened out during the site review process now, leaving only the most hazardous of sites to be included on the NPL.

"Four Score" and Seven Years Ago: Why the Sudden Drop in NPL Site Listings and Lower Hazard Level Scores between 1990 and 1991?

It is noteworthy that in the most recent seven years, there has been a decrease in the average number of sites posted to the NPL per year, as well as a marked decrease in the percentage of those sites with a 4 or 5 PHH value. This is likely due to the revamping of the HRS score in December of 1990. It is also possible (though purely speculative) that this dramatic decrease in additional NPL postings is partially due to the EPA's desire to complete the cleanup process for those sites already in the Superfund pipeline before starting on new sites, rather than to take every site through the Superfund process simultaneously, one step at a time.[37] Adding more sites to the NPL might only increase the number of Superfund sites which will need to wait for attention, possibly reducing the desire to add sites currently to the NPL. As a result, as current cleanup efforts near completion (and many have been completed in the most recent 2–3 years), a significant increase in the number of sites being posted to the NPL annually may be possible in the near future, depending upon (among other things) the probability that a cap is placed on the number of sites permitted on the NPL (explicitly or implicitly).

Breaking New Ground: A New Theory on the (Non-) Relationship of Hazard and Cost

So what does this imply about the hazard/cost relationship? If it exists, it may imply that current Superfund sites could end up on average more costly than those listed in the earlier years. However, this potential cost increase would be offset by the EPA's recent initiatives discussed in the paper, improved tech-

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[37] This actually presents a catch-22 situation. Under the first approach, some sites are cleaned, but many others are forced to wait until any actions can be taken. Under the second approach, all sites are addressed immediately (eliminating the problem using the first approach), but no cleanups would be completed (or perhaps even begun) for many years.

nology, and the experience gained with this type of remediation work over the past fifteen years, which may result in a current average site cost not very different from the average cost of previously listed sites.

The author believes that cost is more likely a function of the selected remedy than the indicated hazard. This is an important distinction, because although the remedy is somewhat dependent on the hazard, it is also dependent on the stringency of cleanup requirements in effect at the onset of remediation activities (i.e., the degree of the preference for treatment over containment) and technology available to implement the selected remedy at the time. This is one reason why it is important to consider records of decision (RoDs) for cost analysis purposes. Over the past couple of years, the EPA has been issuing many new RoDs which supplant remedies selected in the original RoDs for many of the sites posted to the NPL early in the Superfund program, based on new technologies and changes in cleanup requirements. Using this recent RoD information allows these aspects of cleanup costs to be effectively captured in actuarial analyses.

The hazard *is* an important consideration—especially for those sites involving groundwater issues—but it is far from the only consideration. And, as indicated in the main text of the paper, the author also believes the party leading the effort (i.e., the PRP, EPA, or other governmental agency) may also be a significant factor.

APPENDIX C

EXHIBIT 1

An Analysis of the Relationship Between NPL Listing Date and Site Hazard Using The Agency of Toxic Substances and Disease Registry's Public Health Hazard (PHH) Rankings

NPL Listing Year	Scenario 1 Median PHH	Scenario 2 Median PHH	Scenario 3 Median PHH	Scenario 4 Median PHH	Scenario 5 Median PHH	Scenario 6 Median PHH	Scenario 7 Median PHH	Scenario 8 Median PHH
1983	2.0	3.0	4.0	4.0	2.0	2.0	2.0	2.0
1984	2.0	3.0	4.0	4.0	2.0	2.0	2.0	2.0
1985	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1986	2.0	3.0	4.0	4.0	2.0	2.0	2.0	2.0
1987	2.0	3.0	4.0	4.0	2.0	2.0	2.0	2.0
1988								
1989	2.5	3.0	4.0	4.0	2.0	2.0	2.0	2.0
1990	2.0	3.0	4.0	2.0	2.0	2.0	2.0	2.0
1991	2.0	2.5	2.0	2.0	2.0	2.0	2.0	2.0
1992	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1993								
1994	2.0	3.0	3.0	2.0	2.0	2.0	2.0	2.0
1995	2.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0
1996	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	2.0	3.0	4.0	4.0	2.0	2.0	2.0	2.0

Public Health Hazard Category Code—

1 = Urgent Public Health Hazard
2 = Public Health Hazard
3 = Indeterminate Public Health Hazard
4 = No Apparent Public Health Hazard
5 = No Public Health Hazard

Scenario Descriptions:

1. Excludes sites with PHH of 3
2. Includes sites with PHH of 3

Scenarios 3–8 include PHHs of 3, reallocated to PHHs 2 and 4 in the following proportions:

3. 25% to Level 2/75% to Level 4
4. 40% to Level 2/60% to Level 4
5. 50% to Level 2/50% to Level 4
6. 60% to Level 2/40% to Level 4
7. 75% to Level 2/25% to Level 4
8. 100% to Level 2/0% to Level 4

APPENDIX C

EXHIBIT 2

AN ANALYSIS OF THE RELATIONSHIP BETWEEN NPL LISTING DATE AND SITE HAZARD USING THE AGENCY OF TOXIC SUBSTANCES AND DISEASE REGISTRY'S PUBLIC HEALTH HAZARD (PHH) RANKINGS

PERCENTAGE OF SITES WITH DETECTED PUBLIC HEALTH HAZARD LEVELS, BY SCENARIO[38]

NPL Listing Year	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
1983	52.7%	17.6%	34.3%	44.2%	50.9%	57.6%	67.5%	84.2%
1984	60.5%	19.5%	36.4%	46.6%	53.4%	60.2%	70.3%	87.3%
1985	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1986	63.3%	23.8%	39.4%	48.8%	55.0%	61.3%	70.6%	86.3%
1987	63.6%	20.9%	37.7%	47.8%	54.5%	61.2%	71.3%	88.1%
1988								
1989	50.0%	15.6%	32.8%	43.1%	50.0%	56.9%	67.2%	84.4%
1990	67.3%	26.7%	41.8%	50.8%	56.9%	62.9%	71.9%	87.0%
1991	100.0%	50.0%	62.5%	70.0%	75.0%	80.0%	87.5%	100.0%
1992	88.9%	61.5%	69.2%	73.8%	76.9%	80.0%	84.6%	92.3%
1993								
1994	64.7%	35.5%	46.8%	53.5%	58.1%	62.6%	69.4%	80.6%
1995	80.0%	44.4%	55.6%	62.2%	66.7%	71.1%	77.8%	88.9%
1996	85.7%	66.7%	72.2%	75.6%	77.8%	80.0%	83.3%	88.9%
	61.1%	22.4%	38.2%	47.7%	54.1%	60.4%	69.9%	85.8%

Public Health Hazard Category Code—

1 = Urgent Public Health Hazard
2 = Public Health Hazard
3 = Indeterminate Public Health Hazard
4 = No Apparent Public Health Hazard
5 = No Public Health Hazard

[38] Calculated as the sum of sites with a PHH of either 1 or 2, divided by all sites included in that scenario. The scenario descriptions are as follows:

1. Excludes sites with PHH of 3
2. Includes sites with PHH of 3

Scenarios 3–8 include PHHs of 3, reallocated to PHHs 2 and 4 in the following proportions:

3. 25% to Level 2/75% to Level 4
4. 40% to Level 2/60% to Level 4
5. 50% to Level 2/50% to Level 4
6. 60% to Level 2/40% to Level 4
7. 75% to Level 2/25% to Level 4
8. 100% to Level 2/0% to Level 4

APPENDIX C

EXHIBIT 3

An Analysis of the Relationship Between NPL Listing Date and Site Hazard Using the Agency of Toxic Substances and Disease Registry's Public Health Hazard (PHH) Rankings
Underlying Data

NPL Listing Year	Public Health Hazard (PHH) Category 1	2	3	4	5	Total	PHH 3, as Pct of Total
1983	6	53	223	38	15	335	66.6%
1984	0	23	80	11	4	118	67.8%
1985	2	1	0	0	0	3	0.0%
1986	1	37	100	11	11	160	62.5%
1987	0	14	45	4	4	67	67.2%
1988	0	0	0	0	0	0	
1989	3	24	119	23	4	173	68.8%
1990	0	35	79	14	3	131	60.3%
1991	1	2	3	0	0	6	50.0%
1992	2	14	8	2	0	26	30.8%
1993	0	0	0	0	0	0	
1994	1	10	14	4	2	31	45.2%
1995	1	3	4	1	0	9	44.4%
1996	0	6	2	1	0	9	22.2%
	17	222	677	109	43	1,068	63.4%

21	w/no PHHs 1–5 at site
90	w/PHH completed after onset of RA activities
1	Delisted, then relisted
1,180	Total on NPL

Public Health Hazard Category Code—

1 = Urgent Public Health Hazard
2 = Public Health Hazard
3 = Indeterminate Public Health Hazard
4 = No Apparent Public Health Hazard
5 = No Public Health Hazard
6 = No hazard conclusion (often applies to brief addenda)
12 = Posed Public Health Hazard Only in the Past

Each site may have multiple PHHs. The following approach was used to select one:

PHH values 6 and 12 were excluded from this analysis altogether (2 sites).
If no RAs have begun at that site by 12/31/96, the most recent PHH available was selected.
Otherwise, the most recent PHH prior to onset of RA activities at that site was selected.
21 sites were excluded due to lack of a PHH.
90 sites were excluded because the first PHH review was completed after the onset of RA activities there.

APPENDIX D

WASTE NOT, WANT NOT: REDUCING AND ELIMINATING HAZARDOUS WASTE THROUGH RCRA

Federal solid waste regulation began in 1965 with the Solid Waste Disposal Act, with an emphasis on research and development (R&D) of solid waste disposal practices. This act was amended in 1970 by the Resource Recovery Act, which changed the emphasis from R&D to recycling and waste reduction. The Resource Conservation and Recovery Act (RCRA) was enacted in 1976, and contained regulations on waste management and the prohibition of open dumps. It also required that anyone seeking to operate a hazardous waste Treatment, Storage and Disposal Facility (TSDF) must first receive a permit from the Environmental Protection Agency (EPA) to do so. The Hazardous and Solid Waste Amendments of 1984 significantly expanded the scope of RCRA, adding land disposal restrictions and corrective action requirements addressing the need to clean previous releases of hazardous waste prior to receiving a RCRA permit (under RCRA Subtitle C).

While the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) is overseen by the EPA, RCRA is predominantly state-run (though there are certain minimum Federal requirements). In addition, there is no RCRA-equivalent to CERCLA's Superfund, which the EPA can use to pay for site cleanups if there are no potentially responsible parties (PRPs). RCRA doesn't focus on the concept of PRPs (i.e., on a broad spectrum of possible sources for any necessary corrective action funding), but instead focuses its authority on the current owner/operator of the TSDF. As a result, the cost sharing typically found at National Priorities List (NPL) sites among their many PRPs might not be as prevalent under RCRA. Therefore, even though the average RCRA site cleanup cost is expected to be approximately $15 million [15]—which is less than the frequently-quoted estimates of the average NPL site cleanup cost—there may be a greater financial burden to the entity responsible for corrective action at a RCRA site than to the entity paying only a fraction of the cleanup cost at an NPL site.

Underground storage tanks (USTs) are typically addressed under RCRA, rather than Superfund. This is because most USTs are filled with petroleum, which is not one of the contaminants identified for response actions under the Superfund program.

Despite their differences, RCRA and CERCLA both share the common goal of protecting human health and the environment from adverse contact with hazardous waste. In general, CERCLA approaches this goal retroactively, by requiring clean up of *inactive* hazardous waste sites, while RCRA attempts to address the issue prospectively, through establishment of standards for *active* hazardous waste sites. RCRA standards require tracking hazardous waste from its creation to its ultimate disposition ("cradle-to-grave" monitoring).

CERCLA and RCRA also interact. For example, RCRA cleanup standards may be applied to Superfund cleanups, since CERCLA doesn't actually dictate specific cleanup standards. RCRA sites may become listed on the NPL if a facility requiring cleanup is owned by a bankrupt entity, or an entity who has shown an unwillingness to clean up a particular RCRA site. In this case, the site is eligible for Superfund moneys—and the possibility of response actions by other PRPs, if they can be found. Conversely, Superfund sites may be deferred to the RCRA program under certain circumstances as well, allowing the EPA to focus its efforts (and funding) on other, Superfund-worthy sites.

A recent General Accounting Office (GAO) Study [16] indicated that the cost of cleaning RCRA sites may be higher than it needs to be in several cases, because of three key RCRA requirements:

1. *Land Disposal Restrictions.* According to the GAO Study, the same stringent standards are frequently applied to

both high-risk and relatively low-risk waste targeted for land disposal.

2. *Minimum Technological Requirements.* The GAO study also notes that the same stringent technological requirements may apply to facilities that manage both high-risk waste and facilities managing low-risk waste.

3. *Permit Requirements.* From [16, pp. 8–9], "the administrative cost of obtaining a RCRA permit can range from $80,000 for an on-site treatment unit, such as a tank, to $400,000 for an on-site incinerator, and up to $1 million for a landfill, according to EPA's estimates. In addition to these costs, a party may incur other costs for tasks needed to obtain a permit, such as assessing a site's conditions in order to design a groundwater monitoring system or conducting emissions testing and trial burns from an incinerator. The time required to obtain a permit can also be extensive…getting a permit can take 7 to 9 months for a simple treatment unit, such as a tank, and an additional 5 to 6 years for a more complicated unit, such as a landfill."

The study also discusses how the EPA has attempted to address these issues, and the policy and regulatory alternatives available to entities responsible for RCRA cleanups. However, the report also notes that, both the EPA and GAO believe that "(comprehensive) reform, while necessary, may take some time to implement." [16, p. 18]

Finally, it is worth noting that, due to the significant differences between CERCLA and RCRA noted here, equally significant insurance coverage-related issued may apply. A discussion of these and other coverage-related issues represents yet another potentially fruitful area for additional research.