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ALLOCATING FINANCIAL RESPONSIBILITY UNDER CERCLA: AN EMPIRICAL MODEL

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ABSTRACT

The purpose of this article is to suggest a cost allocation method to allocate financial responsibility under CERCLA that is efficient, equitable, and logical. This study focuses on the use of CERCLA's comprehensive liability scheme and its impact on the allocation process. The proposed allocation method relies on the formation of cooperative coalitions and the use of existing cooperative game theory methods in order to allocate Superfund costs.

INTRODUCTION

The Comprehensive Environmental Response and Compensation Liability Act (CERCLA), or Superfund, was enacted in 1980 in the wake of widely publicized concerns over toxic spills and hazardous waste problems at sites throughout the country. In order to facilitate the cleanup of hazardous waste sites considered to be a threat to human health and the environment, Congress authorized the Environmental Protection Agency (EPA) to develop a "national priorities list" (NPL) of the nation's worst hazardous waste sites. The EPA received $1.6 billion to respond to and administer the cleanup at 400 such sites. In 1986, Congress amended CERCLA by enacting the Superfund Amendments and Reauthorization Act (SARA), which reauthorized CERCLA for an additional five years and increased the Superfund to $8.5 billion to deal with an enlarged NPL [1].

In 1991, a University of Tennessee study placed the average cleanup cost for a NPL site at $50 million [2, p. 65]. A more recent study estimates the average cleanup costs to be $29.1 million for each site. The study took into account higher site study costs and the present value of operation and maintenance activities that would be incurred in the thirty-year post-closure-care period following the site cleanup [3, p. 20]. In a 1994 report, the Congressional Budget Office (CBO) estimated the total cost of cleaning up the current and future NPL to be between $106 and $463 billion [3, p. 18].

The problem facing Congress in 1980 was how to ensure the cleanup of contaminated sites without placing a strain on general revenues or raising taxes. During the floor debate over CERCLA's passage in 1980, a strong notion emerged that past polluters should be required to pay for the cleanup of such hazardous waste sites, either directly or by reimbursing the government for any response actions that may have occurred [4]. As a result, CERCLA promoted two basic goals: 1) that the polluter pay for site cleanups, and 2) that cleanup be completed in a timely fashion. Congress hoped that forcing potentially responsible parties (PRPs) to internalize the costs of haphazard waste disposal would be an effective method of penalizing PRPs as well as deterring such behavior [1, 5]. The act authorized the EPA to utilize CERCLA's comprehensive liability standard in order to compel voluntary or involuntary private party cleanups. In instances where there was an immediate threat to the health and environment, the agency was authorized to use Superfund monies for cleanup, after which the EPA may pursue private parties for contribution costs using the liability standard established by CERCLA.

The liability standard under CERCLA has resulted in numerous law suits, adding to the excessive time and cost already associated with site remediation. Because liability under CERCLA is strict and joint and several, the courts have ruled that the government does not need to do the following: 1) prove a nexus between the PRP's waste disposed at the site and the subsequent release or threatened release that initiated the response action, or 2) join all the PRPs at the site. With so many parties attempting to limit their share of liability, the costs of devising a cleanup strategy and deciding financial responsibility often threatens to exceed the actual cleanup costs [6].

Due to the use of such a comprehensive liability scheme, a cleanup can be significantly delayed and overall cleanup costs can increase dramatically while the involved parties continue to debate their relative contributions. As a result, some transaction costs are inevitable, especially when considering the number of parties and amount of time spent debating relative contributions. Therefore, the process is generally considered to be an inefficient and inequitable attempt at allocating financial responsibility [3, 6-10].

The purpose of this article is to suggest a cost allocation method to allocate financial responsibility under CERCLA that is efficient, equitable, and logical. This study focuses on the use of CERCLA's comprehensive liability scheme and its impact on the allocation process. The proposed allocation method relies on the formation of cooperative coalitions and the use of existing cooperative game theory methods in order to allocate Superfund costs. The discussions in the article begin with a review of cost allocation principles as they relate to allocating financial responsibility under CERCLA. This review serves as a guide for understanding some of the problems that have been encountered when allocating financial responsibility for the comprehensive liability standard provided by the Superfund. The discussions then turn to the problem of cost allocation and model selection. The usefulness of the selected method is illustrated by developing a case study that uses data based loosely on PRP involvement at an existing Superfund site. The last section of the article presents a set of conclusions concerning the article's principle findings.

LITERATURE REVIEW

The Superfund process includes the use of a comprehensive liability standard that was intended to facilitate the cleanup of hazardous waste sites. However, due to the litigious nature of such a strict liability standard, the Superfund process has been plagued by numerous delays and excessive transaction costs. The purpose of this section is to provide an overview of the liability standard adopted by CERCLA. This overview includes the statutory framework of CERCLA, the economic efficiency of CERCLA's comprehensive liability standard, and the use of current allocation methods.

The Statutory Framework of CERCLA

The severity of the Superfund liability scheme may be understood from the following: 1) it is imposed without any showing of fault or knowledge; 2) it is retroactive for actions and practices that were legal, normal, and considered proper at the time; 3) it is not related to whether the wastes treated or disposed of caused the conditions requiring the cleanup; and 4) the standard is joint and several, which means that any PRP can be required to pay the total cost of cleanup at a site regardless of the number of existing PRPs [5, p. 36]. Such an expansive liability scheme only reiterates the Congressional intent regarding who should pay for the site cleanups.

The liability standard provides that certain "persons" be held responsible for response costs associated with cleanup activities. Section 107 of CERCLA defines certain "persons" to include the following: 1) present owners or operators of the facility, 2) any past owners or operators during whose tenure the substances were disposed, 3) generators who arranged to have their wastes deposited, and 4) any party involved in the transportation of the substances for treatment of disposal [1, 10, 11].

All four classes of PRPs may be held liable for response costs, damages to natural resources, and the cost of conducting studies on the health effects of the hazardous substances present at a site [1]. There are only three limited defenses available to the potentially responsible parties: that the release or threatened release resulted from 1) any act of God, 2) an act of war, or 3) the act of a third party not in any contractual relationship with the PRP [1, 11].

Because liability is joint and several, the courts have ruled that the government need not join all PRPs at a site. The legislative history of SARA indicates that Congress sought to ease the burden of joint and several liability by allowing a cause of action for contribution. Congress hoped that this provision would stimulate quicker cleanups by encouraging PRPs to undertake voluntary actions [10, 12]. Therefore, section 113(f)(1) of SARA allows a party who has incurred response costs to seek contribution from any person who is liable or potentially liable under section 107. The right of contribution enables a joined party to sue fellow parties in order to recover the amount it paid in excess of its fair share [10, 11]. In cases where an original PRP seeks a claim for contribution from a fellow PRP, the third-party PRP is liable only for its "fair share" of the harm [1]. Therefore, PRPs found jointly and severally liable at the outset are prevented from discharging the full liability to a third-party PRP through the contribution process.

CERCLA failed to provide the agency or PRPs with any explicit guidelines for negotiating a settlement agreement [1, pp. 86-87]. Therefore, the SARA amendments explicitly authorized the use of the following mechanisms: 1) preparation of nonbinding allocations of responsibilities (NBARs), in which the EPA could proactively make an initial allocation of financial responsibility among the parties; 2) the use of mixed funding settlements, which enable PRPs to perform various cleanup activities with the help of Superfund monies and the EPA; 3) the use of *de minimis* buyouts, which allows an eligible party to buy out its financial obligation (when contribution constitutes less than 1 percent of the expected cost); and 4) the issuance of covenants not to sue, providing a waiver from future liability [10-13]. Whenever a negotiation would facilitate a settlement with PRPs, the government must notify all such parties. Section 122 requires that the notice must contain the following information: the names and addresses of PRPs, the volume and nature of the waste contributed by each PRP, and a ranking by volume of the waste found at the site [11, 14].

Although the intent of these settlement alternatives is to promote prompt cleanups and utilize Superfund monies more effectively, delays and high transaction costs continue to plague the Superfund process. Of about 1,300 sites on the NPL, the EPA has entered into only 125 *de minimis* settlements at seventy-five locations [15, p. 12]. As of September 1993, the EPA (under the mixed fund alternative) had negotiated only four mixed work agreements, twelve preauthorizations, and an uncertain number of cashouts [10, p. 1,503]. Furthermore, there is little evidence that NBARs are being implemented at all [10, 13].

The Enforcement Process

The Superfund process begins when the EPA becomes aware of a site. Under section 104, the government is authorized to investigate and cleanup a release or threatened release of any hazardous substance, pollutant, or containment that may present an imminent and substantial danger to the human health of the environment. The agency will then perform a series of preliminary assessments and inspections in order to determine if a threat exists. There are two different actions that can take place at Superfund sites: 1) a removal action, and 2) a remedial action [16, p. 2,962]. The EPA must perform any response action within the existing framework of CERCLA and the National Contingency Plan (NCP) [16]. The agency will then begin the formal process of assigning a hazard-ranking score (HRS) to the site. The site will be included on the NPL if its score is greater than 28.5 [16, 17]. Once a site has been included on the NPL, a formal study of the site conditions is conducted in order to determine the possible remedial actions.

The enforcement process begins after the site is proposed for listing on the NPL. Following such a proposal, the EPA begins searching for PRPs who may be potentially liable for the contamination at the given site. Identified PRPs are given a general notice letter and become involved in an information exchange with the EPA. The information includes site conditions, PRP connections to the site, and identification of other PRPs [12, 16]. The EPA examines the information gathered and makes a determination of which PRPs to pursue.

The EPA may then proceed with either a fund-lead or an enforcement-lead cleanup action. Under a fund-lead cleanup action (section 107), the EPA spends Superfund monies on remediation at the outset and then may enter into a cost recovery action against PRPs at a later stage of the cleanup action. Under an enforcement-lead cleanup action, the agency attempts to compel PRPs to take voluntary action and finance the cleanup from the outset [13, 16]. (Note that under section 106, the government may seek an injunction directing a responsible party to initiate a response action. If the party does not respond, the EPA may bring an action to enforce compliance. Finally, if the government undertakes a response action, it may initiate a cost recovery action under section 107 [10, 11].)

The agency uses considerable discretion when determining the number of PRPs named at a Superfund site. The EPA typically names several responsible parties, but, in general, fewer than the total number involved [13]. The EPA's failure to identify all or at least a majority of the PRPs at a site may ultimately delay the cleanup of the site. The potential effect is to force a PRP to pay for the full cleanup costs of a site, despite the presence of other parties. Aside from being potentially unfair to small contributors, such costs provide an incentive for PRPs to delay cleanup through litigation [6]. The named PRPs will not want to agree to a settlement until they are confident of the number of parties that should contribute to the final cleanup costs. In contrast, nonresponding PRPs have a strong incentive to avoid being named as PRPs at the site. As a result, the named PRPs are often burdened with substantial transaction costs due to the costly process of gathering information relevant to identifying other potential responsible parties for contribution [12].

The Economic Efficiency of CERCLA Liability

The "polluter-pays" principle is generally effective in environmental regulation because it allows externality costs to be "internalized" by the individual discharger, thereby leading to socially responsible decisions [7]. Generally, the polluter-pays principle works closely with the goal of economic efficiency. In order for economic efficiency to occur, firms and consumers must be forced to bear all the costs associated with the products that they produce or consume [3, 7]. The polluter-pays principle can be interpreted as an attempt to invoke the benefits-received principle, whereby the cost of remediation should be paid by those who benefited from the less restrictive waste disposal practices of the past [6]. However, the method of allocating direct cleanup costs to responsible parties through the imposition of joint and several liability may be difficult to support under a benefits-received criterion for allocating costs.

Pollution engendered torts may possess several unique characteristics that undercut the use of conventional liability rules, such as multiple parties, multiple wastes, and high transaction costs [18-20]. Therefore, the use of direct regulation under CERCLA requires that the government promote a site remediation program based on a broad liability standard, enforce the liability standard, and arrange for the cleanup of the site in cases where responsible parties are unwilling to initiate the cleanup [21]. Because the courts have interpreted CERCLA to maintain such a powerful standard of liability, it is very difficult to achieve economic efficiency. Such an enforcement approach results in significant delays, high transaction costs, and the allocation of substantial cleanup costs.

Transaction costs represent a major expenditure that occurs throughout the Superfund process. These costs are measurable in terms of dollars spent and cleanup costs. Virtually all transaction costs relate to the search for parties that may contribute to site cleanup costs, debating relative contributions, agreeing to a remediation plan, and developing a suitable allocation process [10]. As a result, transaction costs typically increase in proportion to the time spent in negotiating these items.

The number of PRPs at a site has a direct impact on transaction costs, even when other factors are constant. Due to the number of parties involved in the process, the cost of devising a cleanup strategy and deciding financial responsibility for a cleanup often threatens to exceed the actual cleanup costs [6]. The transaction cost share is 34 percentage points lower at a single PRP site than at a multiple PRP site with the same characteristics. This suggests that transaction costs are significantly higher at multiple party sites than at single party sites.

Therefore, the costs of communication and negotiation are expected to rise as the number of PRPs grows [13].

Allocation Methods

Apportioning liability at a Superfund site is a difficult, controversial, costly, and time-consuming process. It is the doctrine of joint and several liability that ensures that a PRP's actual contribution to a site will most likely not play a significant role in the allocation of its financial responsibilities [6]. The inability or failure to determine the waste contributions made by each party often results in the inequitable distribution of cleanup costs. Compounding the problem is the fact that CERCLA did not establish an explicit method for allocating financial responsibility in a given case. Therefore, both the courts and the agency have developed methods for allocating responsibility among PRPs.

There are four basic cost allocation methods used in Superfund situations. These methods allocate costs on the basis of volume, relative toxicity, a combination of volume or toxicity and other equitable factors, or stand-alone costs [22]. In most cases volume is the primary factor taken into consideration by the courts, the EPA, and private negotiators in apportioning liability. However, the courts have recognized that where a purely volume-based allocation would be inequitable because one party's waste is significantly different than another party's, other factors must be considered. As a result, allocation methods are increasingly focusing on whose waste stream is responsible for which associated costs [10].

Allocations based on relative volume are simple, understandable, and cost effective, given the right circumstances. Volumetric apportionment requires the use of "waste-in" lists. The waste-in lists are comprised of information relative to the quantity and type of waste present at a site. This information is normally gathered during the general information search under section 104(e) and is therefore collected regardless of whether a waste-in list is performed [10, p. 1,497]. The information is obtained from records maintained by site operators, transporters, generators, state records, and on-site inventories. Apportionment is made on the basis of relative volumes shipped by each PRP or on the proportionate volume disposed of at the site by each PRP [10, 11, 22].

One major factor that complicates allocations using the volumetric approach is incomplete or missing data. Many Superfund sites are abandoned ones; therefore, companies will have little or no data on the amount of waste shipped to or disposed of at the site. The inability to obtain reliable data often results in the need for arbitrary decisions to be made in order to complete the waste-in list [11].

Even if a reliable waste-in list can be prepared, the use of the volumetric approach is plagued by other inherent problems. The approach violates the cost causation principle by allocating volumes without regard to directly attributable costs. Furthermore, some key assumptions must be made in order to implement the volumetric approach. Wastes must be considered to be homogeneous; as a result, the approach does not distinguish between hazardous and nonhazardous wastes or the different cleanup costs associated with each [22, p. 10,139).

Use of the relative toxicity approach generally requires that wastes to be cleaned up or treated be placed into groups of wastes with similar toxicity. A toxicity score is then developed for each group. The volume of each waste is then multiplied by its toxicity score in order to obtain a toxic equivalent volume. Finally, the ratio of each PRP's toxic equivalent volume to the total toxic equivalent volume of all the representative wastes at the site constitutes its cost allocation share. Therefore, this approach does not account for the higher cost shares associated with highly toxic wastes and the lower cost shares associated with less-toxic wastes, all things remaining constant [22].

Once again, this is a process that requires a substantial amount of information and data; therefore, an arbitrary decision may need to be made in order to facilitate the final allocation. Due to the heterogeneity of the wastes contributed by each party (specifically generators), individual parties may need to provide detailed information on the composition and quantity of wastes sent to the site [22]. Therefore, the inherent lack of valid information common to many Superfund sites remains a logistical problem.

Allocations can also be made on the basis of stand-alone costs (SAC). The SAC method is an approach that has historically been used in the distribution of costs for water resource projects. The method is based on the idea that fairness requires members of a multipurpose project to pay in proportion to the benefits they may receive [22, p. 10,141]. The stand-alone cost (SAC) method begins by allocating any identifiable direct cleanup costs to the responsible parties. Following this initial allocation, the common costs would be allocated according to the relative costs of cleaning up each PRP's contribution as if it was the only waste at the site.

This approach can be mathematically expressed by the following.

$$\sum_{i=1}^{N} \mathrm{SAC}_i \qquad (1)$$

where:

SAC_i = the stand-alone cost for PRP_i (or PRP group i).

This calculated share of the common costs is multiplied by the total common costs associated with the cleanup effort to arrive at the share of common costs allocated to each PRP or PRP group [22, p. 10,141].

Allocating Superfund remediation costs based on the SAC method derives from the concept of economies of scope. The economies of scope at a Superfund site occur when the cost per cubic yard to treat a large volume of waste is less than the cost per cubic yard to treat a small volume of waste [22, p. 10,142]. Theoretically a party would realize significant savings by participating in a joint cleanup effort rather than acting alone. One disadvantage of the SAC method is that the cost of implementing the approach increases as the number of PRP groups increases due to the additional number of SAC options that must be calculated [22, p. 10,143].

COST ALLOCATION AND MODEL SELECTION

In general, an apportionment problem arises whenever a set of similar, indivisible objects must be distributed among a group of claimants in proportion to their claims [23, p. 43]. Traditionally, joint cost allocations have been based on information regarding either 1) physical proxies for benefits received from joint factors, or 2) the ability to pay. These physical proxies may include units of production, volumes, lengths, weights, and heat contents [24, p. 11]. Historically, joint cost settings occur when production costs are a nonseparable function of the outputs of two or more products. In some instances, physical proxies such as volume and toxicity may be an inadequate basis for allocating financial responsibility under CERCLA. Disputes often arise between parties concerning their relative contributions and their associated cleanup costs. As a result of these pitfalls, there has been some discussion on the appropriate rules for allocating joint costs under Superfund.

Discussions on the appropriate rules for allocating cleanup costs under Superfund have led to several conclusions. First, a party or class of parties should bear only those costs that can be directly attributed to them. In Superfund cost allocations, it is viewed as equitable and economically efficient that costs that can be directly traced to the actions of a specific party should be paid by that party [22, p. 10,138]. Second, any costs that cannot be directly traced to a party or class of parties should not be borne by that party or class based on cost causation (cause and effect) [22, p. 10,138]. These costs are considered to be a nonseparable function of the outputs of two or more products or, in the case of Superfund, two or more parties. Such costs cannot be logically apportioned to any single party [22, 24].

The nonseparability of the cost function and the joint production of the products reflect cost savings or economies of scope. Economies of scope arise when it is less costly to jointly produce a set of products. (That is to say, when the cost of producing two products in combination is less than the total cost of producing each product separately, the condition is called "economies of scope." Economies of scope are generally defined as a less than proportionate increase in costs for a proportionate increase in outputs.) The costs associated with jointly producing a product are known as "common costs." Common costs apply to a setting in which the production costs are based on a single service that is used by two or more users [24, pp. 4-5]. In the context of Superfund, common costs are the nonseparable costs that cannot be allocated to any single party on the basis of cost causation (cause and effect). The presence of common costs generally results in the use of joint and several liability. Under CERCLA, the doctrine of joint and several liability does not require the government to establish a nexus (cause and effect relationship) between a PRP's waste and the release that initiated the response action [25]. Therefore, the cost of cleaning up "nonseparable" wastes can be allocated entirely to one party without any regard to the party's actual contribution.

Generally, joint cost allocations emphasize output decision incentives, whereas common cost allocations emphasize incentives to potential users to participate in the common provision of a product or service [24, p. 5]. It follows that common production is undertaken in order to realize the cost savings related to economies of scope. However, these cost savings will not be realized unless parties agree to voluntarily participate in a coalition [24, p. 16]. Therefore, a party must choose between acting independently and participating in a joint project, and such a decision should be made by comparing the cost of each.

The Formation of Cooperative Coalitions

The decision to participate in a coalition will be made only if a party's cost as a member of the coalition is lower than the cost of acting independently [26, p. 966]. The decision to participate can be "systematically analyzed by applying cooperative game theory" principles [27, p. 1,387]. When allocating costs among a group of parties, some sense of fairness must exist in order for there to be agreement among the project members. Concepts from cooperative game theory are often used to apportion costs among project participants in a fair manner [28, p. 87]. Cooperative game theory analyzes a joint cost project as a game with *N* players, each of whom can choose among the following: 1) acting independently, 2) joining the grand coalition of all *N* players, or 3) forming a coalition with only a subset (*S*) of the *N* players [27, p. 1,387].

Games in which a coalition seeks to minimize costs are known as "cost games." Cost games can be converted to savings games by measuring savings relative to the costs of not participating in a coalition [29]. Cost games are subadditive; that is:

$$c(s) + c(\mathrm{T}) \geq c(S \cup \mathrm{T}) \text{ for } S \cap \mathrm{T} = \Phi \qquad S, T \subset N \tag{2}$$

where Φ is the empty set and (*S*) and (*T*) are any two subsets of *N*. Satisfaction of subadditivity is a requirement for voluntary cooperation. If it is not met, then at least one coalition exists for which costs would be lower if the members did not form the coalition. However, this is not possible if the least-cost solution has been found for each coalition. At worst, no lower cost would occur when the coalition forms; such a condition is said to be "inessential" [29, p. 477]. (The idea of economies of scope is described as "subadditive of costs" where subadditivity is sufficient to produce common cost savings.)

Game theorists have established three general axioms that a fair solution to a cost game should satisfy. First, the cost assigned to the i^{th} group, *x(i)*, should be less than or equal to its cost of acting independently:

$$x(i) \leq c(i) \qquad \supset i \,\varepsilon\, \mathrm{N}. \tag{3}$$

Second, the total cost, *c(N)*, must be allocated among the groups:

$$\sum_{i \varepsilon N} x(i) = c(N). \tag{4}$$

Finally, the cost allocated to the members of any sub-group (*S*) should be less than or equal to the costs that the subgroup will incur by acting independently from the other members of the grand coalition *N*;

$$\sum_{i \varepsilon N} x(i) \leq c(S) \qquad \supset \mathrm{S} \subset \mathrm{N} \tag{5}$$

[29, p. 478; 27, p. 1,388]. Any solution(s) satisfying the first two criteria are referred to as "imputations." Any solution(s) satisfying all three criteria will constitute the core of the game. (For subadditive games, the set of imputations is nonempty but the core may be empty. See [29, p. 478].) A cost game has a convex core if:

$$c(S) + c(T) \geq \mathrm{c}(\mathrm{S} \cup T) + c(S \cap T)\; S \cap T \not\equiv \Phi \qquad S, T \subset N. \tag{6}$$

Therefore, an allocation is in the core of the cost-sharing game if no participant or group of participants pays more than its cost of acting alone [23, p. 85]. As a result, the more attractive (less costly) the game, the more likely that the core is convex. On the other hand, the less attractive (more costly) the game, the more likely the core is empty [29, p. 478].

If these conditions are not met, there will be an incentive for some participants to leave the grand coalition in order to act independently or carry out their own joint project [27, p. 1,388]. Therefore, if the cost allocation results in a charge that is more than the avoided or stand-alone cost (SAC) of any participant, the party or parties that are charged more will go at it alone and the economic efficiency of a joint cleanup effort will be lost [22, p. 10,143]. The importance of these issues lies in the fact that if the cost is too high there will be disincentives to participate, while if charges are too low, the total costs will not be covered [28].

Concepts from cooperative game theory provide a logical and straightforward approach to the allocation of nonseparable costs among PRP groups. Cooperative game theory considers problems of fairness and equity in allocating costs among members of a group who voluntarily agree to cooperate; the focus is on ensuring the parties' cooperation [24, p. 16]. In order to ensure that a coalition or sub-coalition is formed, it is necessary to ensure the following: 1) identification and allocation of each party's separable costs, 2) incentives for participation, and

3) the division of the prospective participants into PRP classes that are manageable. Once these conditions have been met, the allocation committee or entity can identify coalitions or subcoalitions and begin the process of implementing the proposed allocation method.

Identifying Each PRP's Separable Costs

"Separable costs" are defined as the difference between the cost of the coalition project and the cost of the project with the coalition omitted. They include direct costs and the incremental costs of changing the size of the coalition's cost elements. Calculating the separable costs for each PRP provides the following information: 1) it provides the allocation committee or entity with the necessary information for identifying each party's directly attributable cleanup cost, and 2) it helps each party determine the feasibility of acting independently vs. participating in the coalition. Separable costs can be expressed mathematically by:

$$sc(i) = c(N) - c[(N) - \{i\}] \qquad \supset i \in N \qquad (7)$$

where:

$sc(i)$ = separable cost to PRP_i (or PRP group i),
$c(N)$ = total cost for the grand coalition of n groups, and
$c[(N) - \{i\}]$ = total cost for the grand coalition with PRP_i (or PRP group i) excluded.

Assuming that each group has been allocated its separable costs, the remaining costs to be assigned are called "nonseparable costs" (NSC) [29, p. 477]. By allocating directly attributable cleanup costs, any attempt to allocate project costs based on cost causation is avoided.

Incentives for Joining a Coalition

Due to the nature of Superfund liability and the pitfalls of current allocation methods, there are significant incentives for the various parties to undertake a joint cleanup effort. Most significant among these incentives is the economic efficiency that can be attained because of economies of scope or commonality of interests [27, p. 1,387]. (This line of reasoning follows from the methods used in allocating costs for multiagency water resource projects. See, for example [27-29].) The obvious incentive is the aversion of joint and several liability and the possibility of bearing the full cost of the cleanup. Whether a party will respond favorably to these incentives and choose to participate in a joint cleanup effort will depend on its anticipated savings.

A PRP would presumably compare the expected benefits and costs of acting independently with those of participating in a coalition or subcoalition if the expected cost of participating is greater than the expected cost of taking an independent action. This decision would be based on the calculated costs generated from equations (3) and (5). Therefore, it is important for the entity performing the allocation (preferably a neutral third party) to quickly identify each party's separable cost and establish an estimated cleanup cost. This cost will serve as the baseline for comparing the cost savings among a party's possible alternatives.

The incentives for participating in a coalition should be obvious to a PRP. Under the doctrine of joint and several liability, a PRP could risk bearing the full cost of cleaning up a site if the decision is made to litigate the matter or if they choose not to respond. In most cases, the size and financial assets of a PRP are likely to influence a firm's decision to litigate or negotiate a settlement with the EPA or fellow PRPs. Generally, a negotiated settlement will result in a total cost that is substantially less than any settlement that may be obtained in court [3, 13]. Moreover, the opportunity to join a coalition would generally offer the PRP a reduction in overall costs.

Dividing Coalition Participants into Discernible Classes

The presence of multiple PRPs generally creates heterogeneity among PRPs. Differences usually exist between PRPs in the type and quantity of waste contributed at the site, whether they have been named by the EPA, their financial viability, and their general attitude toward the Superfund process. Any apportionment of responsibility involves allocation not only among the various classes of PRPs, but also within each of those classes [30, p. 203]. Therefore, in most cases it is beneficial to group PRPs into similar classes based on the information gathered during the initial investigation. These groups or classes are generally comprised of generator or transporter status PRPs based on their involvement at the site. This classification system serves three important functions: 1) it divides the PRPs into manageable and well-defined units, 2) it provides a quick and easy way to determine directly attributable share, and 3) it ensures that similar parties are allocated similar costs.

The Role of the Minimum Cost Remaining Savings (MCRS) Method

The proposed model is based on the minimization of costs through cooperative participation. The proposed allocation method incorporates the use of the minimum costs remaining savings (MCRS) method as a means of apportioning cleanup costs among a coalition of PRPs. The MCRS cost allocation method provides incentives for participating in a coalition by minimizing individual cost and maximizing individual savings [29].

The overall idea is to delineate the boundaries of the core. Using a game theory approach, the boundaries of the core are delimited. Then the minimum and maximum feasible costs for each participant are calculated. The minimum feasible costs correspond to the separable costs, while the remaining costs are prorated based on the difference between the participant's feasible maximum and minimum costs and the total difference [29, p. 481]. Therefore, for games with a core, the upper and lower bounds on each *x(i)* can be found by solving the following linear program.

$$\begin{aligned}
&\text{max or min: } x(i) \\
&\text{subject to: } x(i) \le c(i) && \supset i \ \varepsilon N \\
&\sum_{i\varepsilon N} x(i) \le c(s) && \supset x \ \varepsilon N \\
&\sum_{i\varepsilon N} x(i) = c(N) \\
&x(i) \text{ unrestricted} && \supset i \ \varepsilon N
\end{aligned} \tag{8}$$

If a game does not have a core, the solution to the linear program will be infeasible. An empty core indicates that no stable solution exists. Generally, this occurs when the additional savings for forming the coalition are relatively small. In such a case, the values of the characteristic functions for the S-member coalitions are relaxed until a core develops. The linear programming solution for this problem is:

$$\begin{aligned}
&\text{minimize: } \theta \\
&\text{subject to: } x(i) \le c(i) && \supset i \ \varepsilon N \\
&\sum_{i\varepsilon s} x(i) - \theta\, c(S) \le c(S) && \supset S \subset N \\
&\sum_{i\varepsilon N} x(i) = c(N) \\
&x(i) \text{ unrestricted} && \supset \iota \ \varepsilon N
\end{aligned} \tag{9}$$

Therefore, the optimal solution is the minimum value θ, which results in the formation of a core [29, p. 480].

In summary, the minimum costs remaining savings (MCRS) solution procedure includes the following steps.

Step 1. Find the minimum [$x(i)_{\min}$] and maximum [$x(i)_{\max}$] costs that satisfy the core conditions graphically or by solving linear programs where a core exists (8) or where no core exists (9).

Step 2. Prorate the nonseparable cost (NSC) using:

$$\beta(i) = \frac{\left[x(i)_{\max} - x(i)_{\min}\right]}{\sum_{i \varepsilon n} \left[x(i)_{\max} - x(i)_{\min}\right]} \qquad \supset i \ \varepsilon \ N \qquad (10)$$

$$\text{NSC} = c(N) - \sum_{i \varepsilon N} x(i)_{\min} .$$

Step 3. Find the fair solution for each PRP or PRP group using:

$$x(i) = x(i)_{\min} + \beta(i) \quad (\text{NSC}) \qquad (11)$$

[29, p. 481]. Using the MCRS solution method, even the most complicated cost allocation problems can be solved by satisfying the core conditions either graphically or by solving linear programs. However, additional work is required when a core does not exist (equation 9). Therefore, decision makers may decide to abandon the coalition if the cost allocation problem appears to be too complicated in comparison to the small amount of cost savings that will result [29, p. 480].

THE EMPIRICAL MODEL: METHOD AND RESULTS

The use of the minimum costs remaining savings (MCRS) method as a means of apportioning cleanup costs among a coalition of PRPs is demonstrated in this section. First, an overview of the case study site is presented, followed by a discussion of the procedures used to implement the MCRS method. The results of implementing this method are then discussed.

The Selected History of the Case Study Site

The Royal N. Hardage industrial waste site is located approximately thirty-five miles south-southwest of Oklahoma City, fifteen miles southwest of Norman, and one-half mile west of Criner in McClain County, Oklahoma. The disposal site is located on a 160-acre tract of the Hardage family ranch. The site consists of a number of permanent and temporary impoundments into which a variety of liquid, sludge, and solid wastes were disposed and mixed [31].

On September 15, 1972, the Oklahoma State Department of Health (OSDH) granted Royal N. Hardage a license to construct, operate, and maintain a hazardous waste disposal facility for industrial and hazardous waste. From 1972 to 1980, over twenty million gallons of waste were transported to the site for storage and/or disposal by approximately 400 companies and state and federal government agencies. Until June 1979, the Hardage-Criner site was the only permitted hazardous waste facility in Oklahoma [31, p. 1]. In 1979, the site had reached its permitted capacity, resulting in the use of unpermitted pits, improper maintenance and closure of existing pits, failure to retain runoff, and improper storage of wastes at the site. These activities resulted in a series of investigations by both state and federal agencies. The State of Oklahoma found that disposal activities at the site were in violation of the permitting requirements, and administrative proceedings were initiated to revoke Hardage's permit.

Subsequent EPA investigations determined that disposal practices at the site had resulted in various degrees of contamination to the surface water, groundwater, and surface soil [31]. In September of 1980 the EPA sued Royal N. Hardage for site investigation costs and ordered him to remediate the site. Mr. Hardage closed the site in late 1980. Mr. Hardage filed bankruptcy in 1985 and was discharged from liability [31, p. 1].

In 1984, the EPA notified companies that had legally disposed of wastes at the Hardage-Criner site that they were potentially responsible for cleanup at the site under CERCLA. Following this notification, more than 100 of the PRPs organized themselves into the Hardage Steering Committee (HSC) in order to coordinate the cleanup of the site. The EPA continued with numerous site investigations and divided the site into two operable units: (1) source control and (2) management of migration. The HSC contested the EPA's evaluation of the site conditions and their decision to divide the site into source control and management of migration operable units. As a result, the HSC initiated their own evaluation of the site conditions and proposed an alternative remedy [31, p. 1].

In 1986, the EPA sued Hardage and thirty-six of the PRPs in order to recover costs and to implement the agency's selected remedy. Disputes between the EPA and the PRPs over the selection of an appropriate remedy continued for the next four years. A remedy trial was held in December 1989. In August 1990, the Western District Court of Oklahoma ordered the parties to implement the proposed HSC remedy with certain modifications. The court-ordered remedy required the pumping and removal of waste, groundwater treatment, and containment of remaining wastes on-site [31, p. 2].

As early as 1986, the HSC began conducting remedial measures to prevent any possible adverse environmental impacts from the site. The HSC repaired and stabilized various disposal units, installed security fencing, established a field office, and employed a full-time site supervisor. Additional measures included providing an alternative water supply to residents dependent upon domestic wells and the buy-out of existing grazing leases on the site in order to stop ongoing grazing. In addition, the HSC has acquired the acreage necessary to implement the institutional control portion of the remedy, provided routine site maintenance, and conducted ongoing site inspections [31, p. 2].

The HSC has incurred substantial costs as a result of meeting the conditions set forth in the court-ordered remedy [Table 1]. As a result, the HSC has sought contribution from a number of parties involved at the site. On March 25, 1991, the HSC, comprised of fifty-eight parties, entered into a settlement agreement with approximately twenty-two other parties. This study is, to some extent, based on the data provided by this settlement agreement. However, in order to avoid

Table 1. Summary of Costs Associated with the Remedial Measures Ordered by the Court in August 1990

	Remedy Including Court Order Additions
Vertical Liquid Recovery Well System	
Equipment, Installation/Evaluation	$ 2,412,000
	6,458,000
NAPL/Water Treatment/Destruction	792,000
	570,000
Well System	956,000
Permanent Site Facilities	33,000
Treatment Plant	4,120,000
Monitoring Wells	6,230,000
Composite Cap	1,000,000
V-Shaped Interceptor Trench	214,000
Land Purchase	577,000
Site Restoration	366,000
Temporary Construction Facilities and Monitoring	460,000
	315,000
Closure of Existing Facilities	
System Startup	$24,503,000
Community Relations Program	
	$ 4,900,600
CONSTRUCTION SUBTOTAL	
	$29,403,600
Bid and Scope Contingency	
	$ 2,057,896
TOTAL CONSTRUCTION COSTS	2,057,896
	1,028,948
*Engineering and Design	882,384
*Construction Management	$ 1,470,640
*EPA Oversight	
*General Liability Insurance/Performance Bond	$36,901,564
*Legal Services	$15,262,000
	7,379,913
TOTAL ONSITE COSTS	
	$59,543,500
O&M Costs/Routine Equipment Replacement	
Major Remedy Repl. Contingency	
TOTAL PRESENT WORTH COST	

*Transaction costs: $7,497,764

Source: [32] (slightly modified).

potential conflict, the HSC members and various third parties are not referred to by company name.

Methods

Due to the fact that these parties were in no way aware of their role in this study, certain assumptions were made involving their participation. This project assumes that each participant has been allocated its separable costs. Therefore, the costs attributed to each participant represent the nonseparable costs (NSC) to be allocated to each party (see Tables 2 and 3). A hypothetical incentive is also provided in order to accommodate the study. As a result, the formation of each coalition is based on its calculated share of the total transaction costs associated with the settlement agreement. However, data on the transaction costs associated with the settlement were not provided. Therefore, in order to derive each coalition's calculated share, the data provided is used to extrapolate an estimated total of the transaction costs attributable to the settlement agreement. The extrapolation is based on the following steps.

Step 1. Identify the total transaction costs (T) associated with the total project costs (P). In this case, \$7,497,764 (see Table 2).

Step 2. Identify the percentage share (S) of the total HSC settlement agreement costs (H) in comparison to the total project costs (P) where

$$S = \frac{H}{P} \text{ or } \frac{\$15{,}000{,}000}{\$59{,}543{,}500} \tag{12}$$

$$= .25\%$$

Step 3. Identify the transaction costs attributable to the HSC settlement agreement (T_1) where

$$\begin{aligned} T_1 &= ST \text{ or } (.25)\ (\$7{,}497{,}764) \\ &= \$1{,}874{,}441 \end{aligned} \tag{13}$$

Step 4. Identify each coalition's share (c_i) of T_1 where

$$\begin{aligned} c_i &= \sum_{i \in N} c_i (T_1) \\ &= (.0058) + (.0497)\ (\$1{,}874{,}441) \\ &= (.0555)\ (\$1{,}874{,}441) \\ &= \$104{,}031 \end{aligned} \tag{14}$$

and c_i = each coalition member's settlement percentage (see Tables 3 and 4).

Table 2. Cash Amounts and Percentages for the HSC Settlement Agreement at $15,000,000

PRP	Volume	*c(i)*	% Share	*PA*	Net Payment
1	32,692	.0058	$ 87,156	$ 1,125	$ 86,031
2	486,890	.0497	$ 745,604	$247,102	$ 498,502
3	1,400,000	.1429	$2,143,906	$ 78,116	$2,065,789
4	376,740	.0384	$ 576,925	$ 78,391	$ 498,534

Source: [32] (slightly modified).

Table 3. Cash Amounts and Percentages for the HSC Settlement Agreement at $16,874,441

PRP	Volume	*c(i)*	% Share	*PA*	Net Payment
1	32,692	.0058	$ 97,872	$ 1,125	$ 96,747
2	486,890	.0497	$ 838,660	$247,102	$ 591,558
3	1,400,000	.1429	$2,411,358	$ 78,116	$2,333,242
4	376,740	.0384	$ 647,979	$ 78,391	$ 569,588

Source: [32] (slightly modified).

Table 4. Total Cost to be Allocated to Each Coalition

Coalition	Total Cost
1	$96,747
2	$591,558
3	$233,242
4	$569,588
12	$584,274
13	$2,151,260
14	$583,485
23	$2,563,783
24	$996,008
34	$2,562,994
123	$2,649,658
124	$1,081,883
134	$2,648,869
234	$3,061,692
1234	$3,147,267

The original HSC settlement agreement cost figures are detailed in Table 2, while the extrapolated cost figures are detailed in Table 3. The new project cost (H_1) was derived in the following way.

$$H_1 = H + T_1$$
$$= \$15{,}000{,}000 + \$1{,}874{,}441 \qquad (15)$$
$$= \$16{,}874{,}441$$

where:

PA = credit for 50 percent of past assessments.

Therefore, the new cost figures presented in Table 3 are the cost figures utilized in this particular study. For the purpose of this study, these cost figures also represent each PRP's nonseparable cost share of the HSC settlement agreement. As a result, it is assumed that each party has been allocated its separable costs.

The four parties selected for this study were selected on the basis of their PRP status at the site. Of the twenty-two parties involved in the HSC settlement agreement, the PRPs represented constituted the transporter status PRPs. These four parties were grouped into a discernible class based on their transporter status. It was assumed that these parties would agree to participate in a joint cleanup effort.

The following examples are for PRP 1 for coalition [12]. For games with a core, the upper and lower bounds for each participant can be found by solving the following linear program represented by equation (8).

max or min: $x(1)$
subject to: $x(1) \leq 96{,}747$
$x(2) \leq 591{,}558$
$X(1) + x(2) = 584{,}274$

The upper and lower bounds for each coalition are summarized in Table 5. These bounds identify the maximum and minimum payment of each party in the coalition and are essential to performing the MCRS solution procedure. In summary, the minimum costs remaining savings (MCRS) solution procedure includes the following steps.

Step 1. Find the minimum [$x(i)_{\min}$] and maximum [$x(i)_{\max}$] costs that satisfy the core conditions graphically or by solving linear programs where a core exists (8) or where no core exists (9).

Step 2. Prorate the nonseparable cost (NSC), using equation (10):

Table 5. Lower and Upper Bounds on Costs for Four-Party Cost Game

Coalition	Party Bounds: L = Lower, U = Upper ($)			
	PRP 1	PRP 2	PRP 3	PRP 4
	L–U	L–U	L–U	L–U
12	0 – 96,747	487,527 – 584,274	—	—
13	0 – 96,747	—	2,054,513 – 2,151,260	—
14	13,897 – 96,747	—	—	486,738 – 569,588
23	—	230,541 – 591,558	1,972,225 – 2,333,242	—
24	—	426,420 – 591,558	—	404,450 – 569,588
34	—	—	1,993,406 – 2,333,242	229,752 – 569,588
123	85,875 – 85,876	498,398 – 498,399	2,065,384 – 2,065,385	—
124	85,875 – 85,876	498,398 – 498,399	—	497,609 – 497,610
134	85,875 – 85,876	—	2,065,384 – 2,065,385	497,609 – 497,610
234	—	498,398 – 498,399	2,065,384 – 2,065,385	497,609 – 497,610
1234	85,875 – 85,876	498,398 – 498,399	2,065,384 – 2,065,385	497,609 – 497,610

$$\beta(1) = \frac{96{,}747 - 0}{(96{,}747 - 0) + (584{,}274 - 487{,}527)}$$

$$= \frac{96{,}747}{193{,}494}$$

$$= 0.5$$

$$\text{NSC} = 584{,}274 - 0 - 487{,}527$$

$$= 96{,}747$$

Step 3. Find the fair solution for each PRP or PRP group using equation (11):

$$x(1) = 0 + (0.5)\ (96{,}747)$$

$$= 48{,}373.5$$

This process is repeated for PRP 2 and the individual members of each coalition. The cost figures presented in Table 4 will be used for calculating the maximum and minimum costs for each coalition structure. These costs are generated by solving the linear programming solution represented in equation (8). These bounds are then used to calculate the MCRS solution for each coalition structure. Table 6 represents the last-cost solution for each coalition structure, as well as each coalition member's minimum cost.

Table 6. Cost Allocations for Optimal Solution and Intermediate Solutions

Coalition Structure for Least-Cost Solution	Least-Cost Solution	MCRS Cost Allocation ($)			
		PRP 1	PRP 2	PRP 3	PRP 4
1, 2, 3, 4	$3,591,324	96,747.00	591,558.00	2,333,242.00	569,588.00
12, 34	$3,147,268	48,373.50	535,900.50	2,163,324.00	399,670.00
13, 24	$3,147,268	48,373.50	508,989.00	2,102,886.50	487,019.00
14, 23	$3,147,268	55,322.00	411,049.50	2,152,733.50	528,163.00
123, 4	$3,219,246	85,875.33	498,398.33	2,065,384.33	569,588.00
124, 3	$3,415,125	85,875.33	498,398.33	2,333,242.00	497,609.33
134, 2	$3,240,427	85,875.33	591,558.00	2,065,384.33	497,609.33
234, 1	$3,158,139	96,747.00	498,398.33	2,065,384.33	497,609.33
1234	$3,147,267	85,875.25	498,398.25	2,065,384.25	497,609.25

Results

The following conditions were satisfied for each coalition: 1) the cost assigned to each PRP was less than or equal to its cost of acting independently, 2) the total cost was allocated, and 3) the cost assigned to any subcoalition (*S*) was less than or equal to the cost that the subcoalition would have received by acting independently from the grand coalition (*N*). The coalitions formed in this study were all feasible coalitions and fell within the core of the game. No participant or group of participants was charged more than its cost of acting alone (see Table 6).

The success of this study can be measured by: 1) the realized savings or economies of scope, and 2) the fact that the total cost attributable to each coalition structure was allocated. First, the savings (economies of scope) realized from the formation of these cooperative coalitions can be expressed in terms of both individual savings (see Table 6) and coalition structure savings (see Table 7). These savings are significant when compared with the avoided or stand-alone costs (SAC). Secondly, the costs assigned to each coalition structure were completely allocated (see Tables 4 and 8).

The decision to participate in a particular coalition may be based on the following factors (but is not limited to): 1) overall cost savings, 2) negotiations with other participants, or 3) an existing agreement between all participants. In the absence of a pre-existing agreement, each party will inevitably select the solution that minimizes cost and maximizes savings. For example, comparing the assigned cost for [12], [34] coalition structure versus the [1234] coalition structure, PRPs 1 and 4 would prefer the two-party coalition structures. However, PRPs 2 and 3 are the big losers if the two-party coalition structure is selected (see Table 6). Similar comparisons could be made between all the coalition structures.

Table 7. Total Savings Realized by Each Coalition Structure

Coalition	Total
12, 34	$444,056
13, 24	$444,056
14, 23	$444,056
123, 4	$372,078
124, 3	$176,199
134, 2	$350,897
234, 1	$433,185
1234	$444,057

Table 8. Total MCRS Cost Allocation for Each Coalition

Coalition	Total Cost Allocated to Each Coalition	MCRS Cost Allocation ($)			
		PRP 1	PRP 2	PRP 3	PRP 4
1, 2, 3, 4	$3,591,324	96,747.00	591,558.00	2,333,242.00	569,588.00
12	$584,274	48,373.50	535,900.50	—	—
13	$2,151,260	48,373.50	—	2,102,886.50	—
14	$583,485	55,322.00	—	—	528,163.00
23	$2,563,783	—	411,049.50	2,152,733.50	—
24	$996,008	—	508,989.00	—	487,019.00
34	$2,562,994	—	—	2,163,324.00	399,670.00
123	$2,649,658	85,875.33	498,398.33	2,065,384.33	—
124	$1,081,883	85,875.33	498,398.33	—	497,609.33
134	$2,648,869	85,875.33	—	2,065,384.33	497,609.33
234	$3,158,139	—	498,398.25	2,065,384.33	497,609.33
1234	$3,147,267	85,875.25	498.398.25	2,065,384.25	497,609.25

A closer examination of Table 6 indicates that the two-party coalition structures offer significantly different individual savings when compared to the three-party coalition structures. Presumably the members of the two-party coalition structures would be inclined to base their decisions to participate in a particular coalition on their individual cost savings. Therefore, any subsequent decision would be the result of continued negotiation among the various two-party coalition members. Similarly, the members of the three-party coalition structures would be more inclined to participate in the grand coalition due to the slight increase in individual cost savings.

In terms of total cost savings, the least-cost solution is represented by the coalition structure [1234]. When compared with the total cost of each party acting independently, the [1234] coalition structure offers a total savings of $444,057 (see Table 7). Therefore, in this particular case the allocation entity would presumably select the least-cost solution represented by the coalition structure [1234]. Furthermore, some consideration may be given to each of the cost solutions represented by each of the two-party coalition structures. However, if the selection of the allocating entity results in a charge that is greater than that of any subcoalitions charge, there will be an incentive for those participants to leave the grand coalition and go at it alone. Therefore, in order to avoid any continued negotiations or delays, the allocating entity may choose to arrange a nonbinding allocation of responsibility (NBAR) based on the solution that represents the least-cost when compared to the avoided or SAC totals (preferably a binding allocation of responsibility).

The fact that these parties did not voluntarily agree to participate in this study did not in any way compromise the results. However, the fact that the allocation itself was based on extrapolated data (due to the need to provide a hypothetical incentive) could have affected the results of the study. The linear programming equations generated some very similar cost figures. These cost figures were particularly similar among the three-party coalitions, while the two-party coalitions were better scaled (see Table 5). Furthermore, the MCRS equations generated very similar results among the three-party coalitions. As a result, the cost allocations for each member remained constant, regardless of the member's coalition affiliation (see Table 6).

These similarities could be attributed to the close scaling of the linear programming results. The similarities could also be attributed to the fact that the cost allocations were based on extrapolated data rather than data generated from the outset of the HSC settlement. In short, the lack of specific and meaningful data relating to individual transaction costs could have generated the similarities. Some of the coalition structures (namely the three-party coalition structures) are not very "attractive" solutions; this is a reflection of the numbers. However, the overall results generated from the MCRS solution procedure indicate that such a method could produce significant cost savings for each coalition.

CONCLUSIONS

Having established an understanding of the decision criteria and methods that can be utilized in the allocation process, the next step is to develop a formal allocation process. It is clear that each Superfund case will present its own unique set of circumstances, such as missing data, orphan shares, and PRPs who choose not to participate in the process. In many circumstances, applying volumetric or toxicity-based methods would be an arbitrary attempt at allocating cost share among multiple PRPs. Therefore, it is important to realize that no one allocation method will apply in all cases. Equitable factors, technical complexities, and site-specific conditions require that each allocation method address the unique circumstances of each case. Even if the process is formalized, the allocators must continue to use highly selective and unique allocation methods.

Traditional allocation methods fail to consider economies of scope, and they attempt to establish causation where no causation can be established due to the presence of common costs. Public utility regulators spent years searching for a nonarbitrary method of allocating the common costs associated with providing public utility services before realizing that such a method was impossible due to economies of scope. For the environmental community to travel down that same path would be a wasted effort [22].

Therefore, the success of an allocation process will depend on a commitment of the involved parties to achieving as fair a solution as the facts of the case and the tools at their disposal will allow. As a result, the allocation model presented in this study attempts to address the presence of economies of scope, the allocation of common costs, and the cooperative participation of multiple parties. The model picks up where the traditional allocation methods leave off, providing a systematic approach for allocating the common or nonseparable costs that remain after the apportionment of any direct or separable costs using traditional approaches. The method also ensures the cooperative participation of the involved parties by providing significant incentives for participating in a joint cleanup effort.

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