1. Introduction

Valuation of environmental liability at industrial sites is required under many circumstances, including for acquisition/divestiture transactions, establishment of environmental reserves, procurement of insurance, and to support environmental litigation claims. The approach and level of effort to quantify the environmental liability at industrial sites can vary widely depending upon the business objectives driving the need for the evaluation, the regulatory requirements, and the quantity and quality of available site information. This paper provides a brief overview of alternative cost estimating approaches and key factors to be considered in the valuation of environmental liability at industrial sites. Useful references for those involved in preparing or reviewing the valuation cost estimates are provided at the end of the paper.

2. Valuation Approaches

Roux Associates has successfully used the following three approaches for valuation of environmental liabilities:

- Site-Specific;
- Site Portfolio Metrics; and
- Published Cost Data for Categories of Sites.

While the site-specific approach is used most frequently, it requires the most information to produce meaningful results. In absence of sufficient site-specific information and/or the time and resources to develop such information, use of a site-specific valuation approach may imply a degree of accuracy or understanding that does not exist. In such cases it may be more appropriate to use one of the other valuation approaches. Each of these three approaches is discussed in further detail in the subsections that follow.

2.1 Site-Specific Estimates

Site-specific estimates are most appropriate when sufficient information and/or data are available. A site-specific estimate can include: relying upon existing cost estimates that are reviewed and determined to be credible; development of independent cost estimates based upon evaluation of the data; or a combination of these methods (i.e., a cost estimate may exist for closure/capping of an onsite landfill, but not for groundwater remediation).
The ASTM “Standard Guide for Estimating Monetary Costs and Liabilities for Environmental Matters” (ASTM E2173-06) provides important guidance on procedures for valuation of liabilities that is accepted in the industry and commonly used by environmental professionals. The guidance outlines five methodologies for estimating costs and liabilities for environmental matters. In addition, where insufficient data and information exist, then a “no estimate” scenario is also considered:

<table>
<thead>
<tr>
<th>ASTM E2137-06 Cost Estimating Methodologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Quoted Price;</td>
</tr>
<tr>
<td>• Expected Value;</td>
</tr>
<tr>
<td>• Most Likely Value;</td>
</tr>
<tr>
<td>• Range of Values;</td>
</tr>
<tr>
<td>• Known Minimum Value; and</td>
</tr>
<tr>
<td>• No Estimate.</td>
</tr>
</tbody>
</table>

A **Quoted Price** is sometimes available where an entity has provided a firm cost to conduct a specified response action. A Quoted Price is considered by ASTM E 2137-06 to be “a fair value market price” that provides “a reliable estimate and should be used when available.” A Quoted Price is typically only possible when a site or liability has been very well characterized, and there is little environmental and regulatory uncertainty.

The next cost estimate in the ASTM hierarchy is the **Expected Value**, which is a cost that is derived using a decision tree or simulation model of potential event outcomes based upon a weighted-probability analysis of various scenarios and the estimated costs associated with each scenario. A **Most Likely Value** is a cost developed to represent the scenario considered most likely to occur (i.e., typically a preferred remedy/closure approach, or selected technology). A **Range of Values** consists of a low estimate and a high estimate based on a range of reasonable assumptions. This approach is appropriate when the probabilities or ranking of various scenarios (required for Expected Value and Most Likely Value, respectively) cannot be determined; and, to provide an assessment of the uncertainty associated with the Most Likely Value. In some instances, it may be appropriate to develop a **Known Minimum Value** because “the outcome and cost uncertainties are so great that it is premature to estimate a Range of Values or a Most Likely Value” (ASTM E2137-01).

Use of one of the methods noted above is dependent upon the available information and data for the site and the level of uncertainty associated with the information, the purpose of the cost estimate (including an understanding of the degree of accuracy required or desired), and level of effort/cost allocated for preparation of the cost estimate. Theoretically, other than a firm Quoted Price, the Expected Value approach should generate the most robust estimate and provide the greatest amount
of information regarding potential uncertainty associated with the estimate. However, Roux Associates’ analysis of multiple portfolios of sites has shown that Expected Value does not necessarily represent the best estimate for any given site; and the actual cost may vary greatly from an Expected Value. Moreover, it is possible to bias an Expected Value toward the desired cost range by manipulation of the probabilities assigned to the variables/scenarios.

2.2 Site Portfolio Metrics Estimates

When developing cost estimates for a portfolio of sites, it is not uncommon for there to be some sites with insufficient data to develop site-specific cost elements. In such circumstances, Roux Associates has used cost ranges developed from similar site types within the same portfolio. For example, when evaluating environmental liability for a portfolio of wood treating sites, there was no site-specific information or environmental data available for a small percentage of the sites. The valuation of the liability for the sites with no information was completed based upon analysis and comparison to the sites for which there was sufficient data. The sites with sufficient information to develop estimates were placed into three categories based upon scale and complexity of remedial actions required. The present value cost ranges associated with these three categories were then applied to the wood treatment sites for which site-specific estimates could not be developed.

2.3 Published Cost Data for Similar Types of Sites

Where neither site-specific nor site portfolio metric costs are suitable, it may be possible to assess potential environmental liability by relying upon published cost data for similar types of sites. Roux Associates has relied upon cost element information provided in a report submitted to Congress by Resources for the Future entitled, “Superfund’s Future: What Will it Cost: A Report to Congress” (herein referred to as the “RFF Study”). The RFF Study was commissioned by Congress in 2000 to address questions related to whether there was enough money in the Hazardous Substance Superfund (Trust Fund) to support the long-term funding needs of the Superfund program. More specifically, Congress asked RFF to conduct an independent study to estimate how much money would be needed by the United States Environmental Protection Agency (USEPA) to implement the Superfund program from FY 2000 through FY 2009. Future costs of the Superfund program were then projected, based on actual historical USEPA expenditures, for various phases of the response action process.

The RFF Study presented industry-specific, operable unit level “unit costs” for key phases of various response actions at sites on the National Priorities List (NPL) including:

- Remedial Investigation / Feasibility Studies;
- Remedial Design; and
- Remedial Action.
According to the RFF, at the end of FY 1999, there were 1,245 nonfederal sites on the NPL (and 52 proposed for listing) including 1,055 final NPL and 190 deleted NPL sites. The 1,245 nonfederal sites comprise approximately 2,200 operable units, with approximately 40% of the sites having more than one operable unit. To facilitate the RFF Study, individual NPL sites were grouped into several categories. The major division that classified sites was based on overall response action costs. Sites with response action costs of $50 million or more, referred to as mega sites, were distinguished from sites with response action costs of less than $50 million or non-mega sites. The non-mega sites were further delineated into 11 site types, as shown in the table that follows.

<table>
<thead>
<tr>
<th>Site Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mega Sites</td>
<td>Site Response Actions Greater Than $50 Million</td>
</tr>
<tr>
<td>Non-Mega Sites</td>
<td>Site Response Actions Less Than $50 Million</td>
</tr>
<tr>
<td>Chemical Manufacturing</td>
<td>Includes chemical plants; chemical distribution, storage, disposal, and packing centers; and pesticide and fertilizer manufacturing plants.</td>
</tr>
<tr>
<td>Oil refining</td>
<td>Includes oil refineries and mud drilling operations.</td>
</tr>
<tr>
<td>Mining</td>
<td>Includes mines and mine tailings, radium contamination, recovery plants, asbestos mills, precious metal mills, phosphate processors, and smelting facilities.</td>
</tr>
<tr>
<td>Wood Preserving</td>
<td>Includes wood preserving facilities, wood treatment facilities, and utility pole treatment facilities.</td>
</tr>
<tr>
<td>Coal Gasification and Other Industrial</td>
<td>Includes coal gasification plants, utility plants, coal coking facilities, manufacturing plants, printing operations, tanneries, paper mills, asbestos manufacturing, foundries, and industrial parks, complexes, developments, and other properties and operations.</td>
</tr>
<tr>
<td>Recycling</td>
<td>Includes abandoned battery recycling facilities, former drum reconditioning facilities, waste oil recycling facilities, and all other recycling facilities.</td>
</tr>
<tr>
<td>Captive Waste Handling and Disposal</td>
<td>Captive facilities may accept industrial and hazardous waste. Includes captive industrial landfills and captive industrial waste management facilities.</td>
</tr>
<tr>
<td>Noncaptive Waste Handling and Disposal</td>
<td>Noncaptive facilities may accept municipal, industrial, or hazardous waste. Includes municipal and commercial landfills and municipal and commercial waste management facilities.</td>
</tr>
<tr>
<td>Transportation</td>
<td>Includes airports, cleaning operations, railroads, repair facilities, and trucking operations.</td>
</tr>
</tbody>
</table>
### Breakdown of Site Types in the RFF Study Database

<table>
<thead>
<tr>
<th>Site Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contaminated Areas</td>
<td>Includes fields and roadsides where illegal dumping has taken place, residential areas, wells, groundwater basins, and waterways.</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Sites that do not fit into the other 10 categories. Includes agricultural facilities, dry-cleaning facilities, military facilities, multiple-operation facilities, schools and universities, and warehouses.</td>
</tr>
</tbody>
</table>


Roux Associates has found that in the absence of detailed site-specific information, published cost information such as RFF Study can be useful in the valuation of potential environmental liability.

3. **Key Factors to be Considered**

Some of the key factors to be considered in the valuation process include:

- The business or regulatory driver for preparing the estimate;
- The categories of cost to be included;
- Accounting for uncertainty;
- Present value analysis; and
- Apportionment of the liability between parties.

A brief discussion of each of the above factors is provided below.

3.1 **Business or Regulatory Drivers**

There are several business and regulatory drivers that can trigger the need for estimating costs of environmental liabilities. These include, but are not limited to:

- Financial reporting;
- Insurance claims;
- Mergers and acquisition / liability transfer;
- Strategic planning / Site prioritization / Budgeting;
• Evaluating remedial alternatives; and
• Litigation.

Understanding the driver is important because this will dictate the approach to be utilized, the types of liabilities that should be included, the accuracy required, and the level of scrutiny the estimate will likely receive. Importantly, the majority of the drivers noted above result in review of the cost estimate by third parties that often have divergent interests from those of the company. Thus, the valuation of liability at industrial sites is a frequent subject of potential dispute, thereby underscoring the importance of following accepted costing methodology to prepare defensible estimates.

3.2 Cost Categories

There are various categories of response actions in which costs are incurred to assess, plan and conduct cleanup actions. These include:

1. Site assessment, engineering, and reporting costs;
2. Capital costs;
3. Operation, Maintenance and Monitoring (“OM&M”) costs;
4. Project oversight costs (client, government and/or other third parties); and
5. Costs for reimbursement of Natural Resource Damages.

A brief description of each category is provided below.

3.2.1 Site Assessment, Engineering, and Reporting Costs

Site assessment, engineering, and reporting costs include costs to evaluate the nature and extent of contamination, identify potential human and ecological risks, determine feasible alternatives, and to design and implement a remedy to achieve site closure. These activities include:

1. Remedial Investigation activities and reporting;
2. Risk Assessment evaluations (human health and ecological risk);
3. Feasibility Study activities and reporting;
4. Remedial Design activities and reporting;
5. Remedial Action planning and reporting;
6. Construction/engineering of remedy and reporting;
7. OM&M and reporting;
8. Post remediation monitoring; and
9. Closure and systems decommissioning.

3.2.2 Capital Costs
Capital costs are expenditures required to build or install the remedial action or closure system. The majority of these costs are incurred through physical construction activities and do not include costs required to operate, maintain, or monitor the remedial action (OM&M costs). The United States Army Corps of Engineers (USACE) defines capital costs to include “all labor, equipment, and material costs, including contractor markups such as overhead and profit, associated with construction activities [and]... expenditures for professional/technical services that are necessary to support construction of the [remedial action].”

3.2.3 Operation, Maintenance and Monitoring Costs
OM&M costs include both short-term and long-term post-construction expenditures necessary to ensure continued effectiveness of a remedial action. According to USACE, examples of Operation and Maintenance (“O&M”) costs include “all labor, equipment, and material costs, including contractor markups such as overhead and profit, associated with O&M activities. O&M costs can also include expenditures for professional/technical services necessary to support O&M activities.” The following figure shows the relationship of OM&M costs (and capital costs discussed in the previous section) to the various phases of the Superfund Pipeline. In addition to O&M, treatment system and groundwater monitoring also occurs during the long-term post-construction (Operation, Maintenance and Monitoring, “OM&M”).
Relationship of Capital and OM&M Costs to Superfund Pipeline Phases

As part of OM&M costs, it is important to consider the need for replacing major treatment system components that would typically be required for large scale systems operating over prolonged time periods (i.e., decades to perpetuity). According to the Chemical Engineer’s Handbook (the “Handbook”), “maintenance costs are not constant over the life of the plant but will increase during later years.” Therefore, estimates of future maintenance costs should increase over the life of the treatment system, or alternatively, a fixed annual amount should be included such that sufficient funds would accrue when future large system component replacement is required. The Handbook recommends that a minimum of 4% per year of the capital cost for the treatment system be included for maintenance.

3.2.4 Oversight Costs

The potential for labor costs associated with oversight of work performed by various entities including USEPA and/or state agencies should be included when such costs are likely.

3.2.5 Costs for Natural Resource Damages

Recovery of damages for injury to natural resources is authorized under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which defines natural resources as “land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources...” The scope of natural resource liability encompasses “damages for, injury to, destruction of, or loss of natural resources, including the reasonable costs of assessing such injury, destruction or loss …”

3.2.6 Litigation Costs

In addition to the response action categories discussed above, costs for litigation are sometimes incurred during or after site cleanup actions. Examples of litigation costs include activities related to environmental enforcement, general negotiations with state and federal agencies, actual or threatened environmental claims (e.g., toxic tort and property damage claims), and litigation with other potentially responsible parties (PRPs) to obtain contribution. These costs can include fees for attorneys, environmental consultants, sample collection and analysis, and expert witnesses. In our experience, it is not customary to include potential litigation costs in developing cost estimates. However, in the absence of doing so, it should be recognized that the estimates are potentially understated.

3.3 Accounting for Uncertainty

The inherent uncertainty associated, to some degree, with all phases of an environmental response action must be recognized and accounted for to produce a useful and relevant total cost estimate. As discussed in Section __, use of the Expected Value cost estimating approach can generate a quantitative measure of the uncertainty associated with a cost estimate. However, this relies upon the estimating the probability of occurrence of various (and potentially numerous) project outcomes and scenarios. It is critical that there be a sound basis for these estimates of probability. In the absence of sufficient supporting information, the quantitative measure of uncertainty can be of little value and/or potentially misleading. In such cases it would likely be more informative to utilize a Most Likely Value in combination with a Range of Values approach to illustrate the uncertainty associated with valuation of a liability.

An important concept used in the accounting for uncertainty is use of “contingencies” in the cost estimating process. Contingency adjustments are added to correct for costs that are undefined at the time of the estimate, but which can reasonably be expected to be incurred. These contingencies are then incorporated into the total project costs to provide a more accurate estimate.

More specifically, ASTM E-2137 states that,

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5.5 Contingencies—Contingency adjustments may be added to correct for costs that are undefined at the time of the estimate, but that is expected to be incurred. Therefore, care should be taken, when adding contingencies to base unit cost estimates, that the contingencies are reasonable and expected to be incurred.

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3 ASTM E-2137-06 and ASTM E-2137-01
In general, allowances for contingencies decrease as project information and details become better defined. In other words, contingencies vary as a function of the available site/project information and site-specific information. Generally, contingencies are highest during the initial planning level or early design phases of a project when less information is available and decrease as the project progresses, more information becomes available, and/or phases of the response action are completed. The following figure, adapted from USACE/USEPA, demonstrates how the accuracy of the cost estimate increases (i.e., contingency decreases) as a project progresses through the Superfund pipeline (and, similarly, through environmental response actions from assessment through remediation and site closure activities).

**Expected Cost Estimate Accuracy Along the Superfund Pipeline**


5 Adapted from: US Army Corps of Engineers and USEPA (2000) “A Guide to Developing and Documenting Cost Estimates During the Feasibility Study”, EPA 540-R-00-002, OSWER 9355.0-75, and Exhibit 2-3. “The accuracy range curves shown in Exhibit 2-3, representing both construction and operation costs, are for illustrative purposes only. The specific percentages correlate with generally accepted rules of thumb for cost estimating accuracy and are not meant to imply that these goals will be precisely achieved.” (Footnote 3, p. 2-3).
**Contingency Guidelines**

A number of the documents included in the reference list provide recommended/expected contingency ranges based on the phase of the remedial action. For example, the US Department of Energy divides environmental restoration projects into two main categories:

(a) assessment and
(b) remediation/cleanup. Contingency ranges are provided for activities within each category, as illustrated in the table that follows:

<table>
<thead>
<tr>
<th>Activity and Estimate Type</th>
<th>Expected Contingency Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary Assessment/Site Investigation</td>
<td>Up to 100%</td>
</tr>
<tr>
<td>Planning Estimate for All Assessment Activities</td>
<td></td>
</tr>
<tr>
<td>Preliminary Estimate for All Assessment Activities</td>
<td>30% to 70%</td>
</tr>
<tr>
<td>Remedial Investigation/Feasibility Study</td>
<td>15% to 55%</td>
</tr>
<tr>
<td>Detailed Estimate for All Assessment Activities</td>
<td></td>
</tr>
<tr>
<td>Planning Estimate for All Cleanup Phase Activities</td>
<td>20 to 100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contingency Guidelines for Remediation/Cleanup Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Design</td>
</tr>
<tr>
<td>Preliminary Estimate for All Remediation/Cleanup Phase Activities</td>
</tr>
<tr>
<td>Remedial Design and Action</td>
</tr>
<tr>
<td>Detailed Estimate for All Remediation/Cleanup Phase Activities</td>
</tr>
</tbody>
</table>

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3.4 Present Value Analysis

An important adjustment to environmental liability valuation estimates is to account for the time value of money, commonly referred to as net present value (NPV) analysis. This is performed after the cost estimates have been developed using current dollars (i.e., the “undiscounted” cost). The NPV for a future cost can be determined using the following formula:

\[ PV = \frac{1}{(1+i)^{t-0.5}} \times X_t \]

where:
- \( i \) = Discount Rate
- \( t \) = Number of years beyond current year
- \( X_t \) = Undiscounted cost for year \( t \)

Based upon the above, the primary variables that must be considered to adjust a cost estimate for NPV analysis are:

- The number of years until the expenses associated with the liability will be incurred; and
- The discount rate to account for the time value of money.

The effect of differing discount rates and time on NPV estimates are illustrated by the graph below for a hypothetical $1,000,000 liability.
3.5 Apportionment of Costs

Environmental matters often involve multiple parties. In such cases, it may be necessary to apportion these costs among the parties. As outlined ASTM E 2137-06, there are a variety of methods and/or considerations in the apportionment of costs. With respect to hazardous waste site clean-ups, CERCLA section 113 (f)(1) allows parties who have borne more than their “fair share” of response costs to see contribution from other responsible parties. In resolving contribution claims, CERCLA grants the courts discretion to use “such equitable factors as the court determines are appropriate.” The common factors used by courts in cost allocation are referred to as the “Gore Factors” (named for then-congressman Albert Gore who proposed them in an unsuccessful amendment to the CERCLA in 1980). The six Gore Factors are:

1. The ability of the parties to demonstrate that their contribution to a discharge, release, or disposal of a hazardous waste can be distinguished;

2. The amount of hazardous waste involved;

3. The degree of toxicity of the hazardous waste involved;

4. The degree of involvement by the parties in the generation, transportation, treatment, storage, or disposal of the hazardous waste;

5. The degree of care exercised by the parties with respect to the hazardous waste concerned, taking into account the characteristics of such hazardous waste; and

6. The degree of cooperation by the parties with federal, state, or local officials to prevent any harm to the public health or environment.

4. References

Additional information regarding valuation of environmental liabilities at industrial sites can be found in the following references:


- USACE and USEPA (2000) “A Guide to Developing and Documenting Cost Estimates During the Feasibility Study” EPA 540-R-00-002, OSWER 9355.0-75;


