



Designation: **E2137–17** **E2137 – 22**

Standard Guide for Estimating Monetary Costs and Liabilities for Environmental Matters¹

This standard is issued under the fixed designation E2137; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope

1.1 *Purpose*—The purpose of this document is to provide a standard guide for good commercial and customary practice in estimating *costs and liabilities* for environmental matters.² Many possible uses for estimates of *costs and liabilities* for environmental matters exist, including but not limited to business decision making and portfolio optimization, due diligence and communications involving acquisitions and divestitures, regulatory requirements, third-party lawsuits, insurance premium calculation and claim settlement, change of property use, revitalization, compliance planning, construction and project control, analysis of remedial alternatives, budgeting, strategic planning, audit defense, financing, and investment analysis by shareholders. The use of estimated *costs and liabilities* developed in accordance with this standard may be subject to other standards applicable to the matter involved. For example, it is not intended to supersede accounting and actuarial standards. This standard does not address the establishment of reserves or disclosure requirements.

1.2 *Objectives*—The objective of this standard is to provide guidance on approaches for estimating *costs and liabilities* for environmental matters.

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents^{3,4}

2.1 ASTM Standards:

- [E1527 Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process](#)
- [E1739 Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites](#)
- [E2081 Guide for Risk-Based Corrective Action](#)
- [E2091 Guide for Use of Activity and Use Limitations, Including Institutional and Engineering Controls](#)
- [E2107 Practice for Environmental Regulatory Compliance Audits](#)
- [E2150 Classification for Life-Cycle Environmental Work Elements—Environmental Cost Element Structure](#)
- [E2173 Guide for Disclosure of Environmental Liabilities](#)
- [E2205 Guide for Risk-Based Corrective Action for Protection of Ecological Resources](#)

¹ This guide is under the jurisdiction of ASTM Committee E50 on Environmental Assessment, Risk Management and Corrective Action and is the direct responsibility of Subcommittee E50.05 on Environmental Risk Management.

Current edition approved March 1, 2017. Published April 2017. Originally approved in 2001. Last previous edition approved in 2011 as E2137–06E2137 – 17, (2011). DOI: 10.1520/E2137-17.10.1520/E2137-22.

² For the purposes of this standard, costs and values are defined as monetary estimates.

³ Appendix XI includes citations for additional relevant documents and requirements from other organizations including FASB, GASB, PCAOB, FASAB, IASB, and SEC.

⁴ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

- [E2247 Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process for Forestland or Rural Property](#)
[E2637 Guide for Utilizing the Environmental Cost Element Structure Presented by Classification](#)
[E2718 Guide for Financial Disclosures Attributed to Climate Change](#)
[E3123 Guide for Recognition and Derecognition of Environmental Liabilities](#)
[E3228 Guide for Environmental Knowledge Management](#)

3. Terminology

3.1 Definitions:

3.1.1 *accretion*—an increase to the present value of a *liability* solely due to the passage of time, normally a year; also known as “unwinding the discount.”

3.1.2 *activity and use limitations (AULs)*—legal or physical restrictions or limitations on the use of, or access to, a site or facility to eliminate or minimize potential exposures to chemicals of concern, or to prevent activities that could interfere with the effectiveness of a response action, to ensure maintenance of a condition of “acceptable risk” or “no significant risk” to human health and the environment. These legal or physical restrictions are intended to prevent adverse impacts to individuals or populations that may be exposed to chemicals of concern.

3.1.3 *allocation or allocated share*—the portion of *cost or liability* for which a party is responsible for payment or reimbursement.

3.1.4 *asset retirement obligation (ARO)*—*legal or constructive obligations* associated with the retirement of a tangible long-lived asset that result from the acquisition, construction, development, or normal operation of a tangible long-lived asset. Activities include (but are not limited to) demolition, decommissioning, decontamination, reclamation, restoration and abandonment.⁵

3.1.5 *constructive obligation*—the concept that past practice creates a valid expectation on the part of a third party. An example of this is a company policy to excavate underground storage tanks once removed from service. Also known as promissory estoppel.

3.1.6 *costs and liabilities*—economic expenses, accrued liabilities, *asset retirement obligations*, and loss contingencies.

3.1.7 *dutyholder*—party responsible for the *costs and liabilities*.

3.1.8 *environmental compliance*—operations, permits, equipment, facilities, products, records, documentation, reports, training, procedures, inspections, certifications, monitoring, controls, or other conditions or activities that must conform to environmental statutes including, but not limited to, CAA, CWA, OPA, RCRA, CERCLA, TSCA, FIFRA, SDWA, and state and local laws, as well as any international jurisdictional requirements.

3.1.9 *estimator*—an individual or entity that prepares and analyzes *costs and liabilities*.

3.1.10 *event*—a condition or incident which occurred, or may occur, with respect to an environmental condition and/or *environmental compliance* issue, that affects or leads to potential *costs and liabilities*. Examples of events include: a new requirement for air emission controls (for example, NO_x), a hazardous waste site that requires remediation, a claim for personal injury related to an alleged environmental incident, or the need to comply with NPDES standards as a result of a process change.

3.1.11 *fair value—value measurement*—an estimate of the price that could be received for an asset or paid to settle a *liability* in a current transaction between marketplace participants that are unrelated, knowledgeable about factors relevant to the *liability* and the transaction, able, and willing to transact in the reference market for the *liability*.⁶

3.1.12 *legal obligation*—duty to carry out what the law or a contract states.

3.1.13 *liability*—an actual or potential obligation that may or may not be accrued. This includes *legal obligations* as well as *constructive obligations* (promissory estoppel), and may also be in the form of commitments, guarantees or contingencies.

⁵ See FASB ASC 410-20 and GASB 18 references in [Appendix X1](#).

⁶ See FASB ASC 820, GASB 72, and IFRS 13 references in [Appendix X1](#).

3.1.14 *obligating event*—a past outcome which confirmed a financially recognizable obligation.⁷

3.1.15 *orphan share—liability* assigned to a *PRP* that cannot be located or that is insolvent, or the *liability* associated with pollutants which cannot be attributed to a *PRP*.

3.1.16 *potentially responsible party (PRP)*—any individual, legal entity, or government—including owners, operators, transporters, or generators—potentially responsible for, or contributing to, the environmental impacts at an *event*.

3.1.17 *recognition benchmark*—stages in the assessment and remediation process which create the expectation of a more comprehensive or robust estimate.⁸

3.1.18 *studies*—investigations such as regulatory interpretations and applicability studies, compliance analysis, environmental regulatory compliance audits, operating scenarios study, engineering design and analysis, cost estimation, process hazard analysis, modeling, communication plans, preliminary investigation, sampling and analysis, site assessment, site characterization, Phase I and II studies, remedial action plan, remedial investigation, contamination assessment report, feasibility study, risk assessment, treatability study, ecological impact assessment, environmental impact report, work plans, ASTM Risk-Based Corrective Action (RBCA) analysis, RCRA facility investigation, RCRA facility assessment, report of waste discharge, corrective measures study, corrective action report, health and safety plan, quality assurance plan, and other studies.

3.2 Acronyms:

3.2.1 *AICPA*—American Institute of Certified Public Accountants.

3.2.2 *ASC*—Accounting Standards Codification

3.2.3 *AULs*—Activity and Use Limitations.

3.2.4 *CAA*—Clean Air Act.

3.2.5 *CERCLA*—Comprehensive Environmental Response, Compensation and Liability Act of 1980 (as amended, 42 USC Section 9601 et seq.).

3.2.6 *CWA*—Clean Water Act.

3.2.7 *EPA*—United States Environmental Protection Agency.

3.2.8 *EV*—expected value; an estimate of the weighted mean value of an unknown quantity that represents a probability-weighted average over the range of all possible values.

3.2.9 *FAF*—Financial Accounting Foundation.

3.2.10 *FASAB*—Federal Accounting Standards Advisory Board

3.2.11 *FASB*—Financial Accounting Standards Board, a part of FAF.

3.2.12 *FIFRA*—Federal Insecticide, Fungicide and Rodenticide Act.

3.2.13 *GAAP*—Generally accepted accounting principles.

3.2.14 *GASB*—Government Accounting Standards Board, a part of FAF.

⁷ See GASB 49:11 references in [Appendix X1](#).

⁸ See GASB 49:12-13 and ASC 410-30-25-15 references in [Appendix X1](#).

3.2.15 *MLV*—most likely value.

3.2.16 *NPDES*—national pollutant discharge elimination system.

3.2.17 *OPA*—Oil Pollution Act.

3.2.18 *PCAOB*—Public Company Accounting Oversight Board.

3.2.19 *PRP*—potentially responsible party.

3.2.20 *RBCA*—Risk-based corrective action.

3.2.21 *RCRA*—Resource Conservation and Recovery Act (as amended 42 USC Section 6901 et seq.).

3.2.22 *SDWA*—Safe Drinking Water Act.

3.2.23 *SEC*—Securities and Exchange Commission.

3.2.24 *TSCA*—Toxic Substances Control Act.

4. Significance and Use

4.1 *Use*—The standard is intended for use on a voluntary basis by an *estimator of costs and liabilities* for environmental matters. The user may elect to apply this standard for any or all uses outlined in the Purpose. Application of this standard for one use does not compel application of the standard for all or any other use.

4.2 *Principles*—The following principles are an integral part of this standard and should be used to resolve ambiguity or dispute regarding the interpretation of estimated *costs and liabilities* for environmental matters.

4.2.1 *Framing the Estimate*—It is important to understand and document/disclose the framework in which the estimate is being made, including identification of the requestor, estimator and relevant qualifications, purpose of the estimate, audience/user of the estimate, limitations, assumptions, and a description of what constitutes a reliable estimate.

4.2.2 *Caution When Repurposing Estimates*—The *estimator* should exercise care when repurposing an estimate generated for one objective and audience. For example, an *estimator* may use the expected value approach on a given *cost and liability*, and find that the “financial assurance estimate” uses unique financial assumptions (inflation, discount rate, time horizon) specified by a state regulator, while a “project controls” or “reserve” forecast – for the very same *cost and liability* -- will use differing financial factors.

4.2.3 *Uncertainty Not Eliminated*—Even though an estimate of *costs and liabilities* for environmental matters is prepared in accordance with this standard, uncertainty remains with regard to, among other things, the resolution of contractual, technological, regulatory, legislative, and judicial issues, which could affect the *costs and liabilities*. However, inherent uncertainty in estimates should not prevent an estimate from being made.

4.2.4 *Periodic Review of Assumptions and Estimates*—Assumptions underlying estimates should be reviewed, documented and periodically analyzed for the purpose of incorporating new information. There is a preference for current information over historical assumptions if the current information is comprehensive and comparable. Subsequent improvements in estimates should be made as more information becomes available, or as *recognition benchmarks* or *obligating events* occur. For example, for remediation of an individual site, such assumptions include changes to the conceptual site model; contaminant concentration data found in soil, groundwater, air and sediments; the selection of different remedial technologies; the indication of a preferred alternative by the governing agency; the weighting of alternatives; the probability of failure of a remedial technology to achieve the desired outcome in the time anticipated; the probability of accelerated or delayed enforcement; the probability of a compressed remedial construction timetable; the explicit or implied value of impacted drinking water, wetlands, and other natural resources; changes to the default values of fines and penalties and their associated tax consequences; and the ability to pay of *PRPs* or other counterparties. Changes in available information such as contaminant data, market prices, regulatory requirements, precedential

court findings, technology, counterparty ability to pay, *dutyholder* ability to pay, property use, inflation and discount rates, or other issues may affect the basis for the estimates, therefore necessitating revisions. (See ⁹Appendix X4 for examples of aggregation of portfolio-wide assumptions and metrics.)

4.2.5 Comparison with Subsequent Estimates—Subsequent estimates based on additional information should not be construed as indicating the prior estimates of *costs and liabilities* for environmental matters were unreasonable at the time they were made. Estimates should be evaluated on the reasonableness of analyses and judgments made at the time and under the circumstances in which they were made. Subsequent improved estimates should not be considered valid standards on which to measure the reasonableness of a prior estimate based on hindsight, new information, use of developing analytical techniques, or other factors. However, information on trends in estimates over time may be of value to a user of the *cost and liability* estimates. Any comparison should recognize the reasons the estimates were performed, whether they were accomplished under the standard and any differences in technique in the application of the standard.

4.2.6 Not Exhaustive—Estimation of *costs and liabilities* for environmental matters does not necessarily require an exhaustive evaluation of all possible outcomes. A point exists at which the cost of obtaining information or the time required to gather it outweighs improvement in the quality of the estimate.

4.2.7 Assessment of Risk—The actual or potential risk to human health and the environment should be considered in assessing environmental matters. The degree of risk should be a factor in developing the *cost and liability* estimates associated with those matters.

4.2.8 Estimator Selection—An appropriate *estimator* or group of *estimators* will consist of those individuals or groups who possess sufficient knowledge, training, and experience to develop appropriate estimates for the *costs and liabilities* being estimated. It is the responsibility of the entity sponsoring the *cost and liability* estimates to select an *estimator* with the appropriate level of knowledge, training, and experience for the parts of the estimation effort for which that *estimator* is responsible. The *estimator* should be free of conflicts of interest to provide an objective and reliable estimate.

TABLE 1 Examples of Environmental Costs and Liabilities^A

	Entity's Internal Costs	Costs Paid to an Affected Party	Costs Paid to a Vendor
Project management	✓	✓	✓
Procurement and contracting	✓	...	✓
Studies and environmental assessments	✓	✓	✓
Response actions (including but not limited to soil, groundwater, surface water, and sediments)	✓	✓	✓
Environmental compliance	✓	✓	✓
Plug/abandon pipelines	✓	✓	✓
Demolition	✓	✓	✓
Permitting and reporting expenses	✓	✓	✓
Regulatory oversight reimbursement	...	✓	...
Public comment/involvement	✓	✓	✓
Fines and penalties	...	✓	...
Natural resource damages and ecological damages	...	✓	...
Property damages	✓	✓	...
Compensatory restoration	...	✓	✓
Business interruption	✓	✓	...
Toxic tort, bodily injury, nuisance, negligence, and other damages claims	...	✓	...
Legal defense and litigation	✓	✓	✓
Insurance premiums	✓
Parent-subsidiary guarantees	✓
Financial assurance: self-bonding	✓
Financial assurance: third-party bond	✓
Counterparty risk	✓	✓	✓
Guarantee to perform response work	...	✓	...
Commitment to buy back impacted property	...	✓	...

^A Over the life cycle of a *cost and liability*, multiple types of expenses (for example, internal and external expenses) may occur for the same type of activity. See also Classification E2150 and Guide E2637.

⁹ See Guide E3228 for examples of environmental knowledge management and Guide E2173 for examples of aggregation of portfolio-wide assumptions and metrics.

5. Procedures for Estimating Costs and Liabilities for Environmental Matters

5.1 *Determination of Relevant Information and Types of Costs and Liabilities*—There are many types of *costs and liabilities* for environmental matters, including, but not limited to:

5.1.1 An entity’s internal costs, paid by the *dutyholder* responsible (see examples in [Table 1](#)).

5.1.2 Costs paid to an affected party by the *dutyholder* responsible (See examples in [Table 1](#)).

5.1.3 Costs paid to vendors by the *dutyholder* responsible (See examples in [Table 1](#)).

5.1.4 After identifying the types of potential *costs and liabilities* for environmental matters, existing relevant information should be considered to estimate *costs and liabilities* identified in [5.1.1](#), [5.1.2](#), and [5.1.3](#), ~~including, but~~ which may include, but is not limited to:

5.1.4.1 *Event* type (for example, new air emission control or other compliance requirements, leaking landfill, site *PRP* notice, worker exposure, site decommissioning, compliance audit findings,¹⁰ notice of violation, filing of a lawsuit, and *recognition benchmarks* and *obligating events*~~events~~.(see¹¹ [Appendix X7](#))).

5.1.4.2 Number and location of affected operations/facilities,

5.1.4.3 Use of surrounding property, including but not limited to sewer systems, groundwater and surface waters,

5.1.4.4 Past, current, and potential future site uses, and constraints imposed upon those future uses by AULs, including institutional controls and/or engineering controls,

5.1.4.5 Findings from environmental and other relevant *studies*,

5.1.4.6 Environmental risks posed by the *event*,¹²

5.1.4.7 Bodily injury or other claims related to the *event*,

5.1.4.8 Relevant federal, state, tribal, local, or other regulatory requirements and alternatives,

5.1.4.9 Federal, state, tribal, local, or other agency involvement, including the preferred alternatives and preferred remedies of governing agencies,

5.1.4.10 Public involvement,

5.1.4.11 Planned or completed remedial activities,

5.1.4.12 Decision documents (for example, Records of Decision),

5.1.4.13 Litigation activities related to the *event* (for example, claims, suits, actions, demands, requests for payment, notices),

5.1.4.14 Resources, tasks, and deadlines,

5.1.4.15 Available technologies and designs,

5.1.4.16 Type and extent of contamination,

5.1.4.17 Number of operable units (CERCLA) or solid waste management units (RCRA),

5.1.4.18 Involvement of various parties at the *event*,~~and~~

¹⁰ See Practice [E2107](#).

¹¹ See Guide [E3123](#).

¹² See Practice [E1527](#); Guide [E1739](#); Guide [E2081](#), Guide [E2091](#), Guide [E2205](#), and Practice [E2247](#).

5.1.4.19 Information on prior experience with similar ~~events~~events,

5.1.4.20 Experience with and expectations of enforcement actions by regulatory authorities,

5.1.4.21 Timeline to implementation of a given *liability*, through, for example, a remediation program, compliance program, asset retirement plan, capital expenditure project, claim adjudication, toxic tort investigation, arbitration proceeding, or litigation,

5.1.4.22 Impacts to natural resources and ecological assets, and the interests of relevant natural resource trustees,¹³

5.1.4.23 Ecological assets and environmental projects used to offset assessment or remediation costs (This may include supplemental environmental projects.),

5.1.4.24 Relevant tax ~~consequences~~consequences, and

5.1.4.25 Climate change considerations, some examples of which may be impacts of sea level rise or flood potential on wastewater discharges and related infrastructure, security of waste sites and/or exterior material and product storage, modification of the designation of certain activities as "green," impacts of reduction of carbon emission allowances on production capacity.

5.1.5 The organization and application of the foregoing information may be further subject to corporate, accounting, or regulatory policy decisions. The user will need to determine what these policy decisions are, and assess their effect on the cost estimate. Examples of such policy decisions include, but are not limited to:

5.1.5.1 Changes to ~~GAAP~~US GAAP, non-US accounting rules and principles, ASTM Standard Practices and Guides and associated training,

5.1.5.2 Changes to requirements of external financial auditors,

5.1.5.3 Changes to entity policies to comply with ~~GAAP~~and accounting and disclosure standards and auditor requirements,

5.1.5.4 New or modified environmental laws and regulations (for example, critical habitat regulations may change over time),

5.1.5.5 Policy decisions or interpretations to be made by regulatory ~~agencies~~agencies (for example, changes to maximum allowable concentrations of residual contaminants in an environmental medium and consideration of emerging contaminants),

5.1.5.6 Compliance assurance procedures or policies adopted by the *dutyholder*,

5.1.5.7 Acceptable levels of risk (for example, business risk, human health risk, ecological risk),

5.1.5.8 The degree to which societal or external costs and benefits are considered,

5.1.5.9 The duration of the forecast for *costs and liabilities*, and whether or not life cycle costs are considered,

5.1.5.10 The degree to which sustainability/sustainable development are considered,

5.1.5.11 Local environmental management system criteria, including trade-off of emissions across environmental media, alternative methods and permitting options, auditability, and performance oriented metrics,

5.1.5.12 Level of non-governmental organization involvement and scrutiny,

5.1.5.13 The degree of communication with and cooperation of the public.

5.1.5.14 The risks and impacts associated with climate change, including but not limited to, material availability and use, energy and water sourcing, waste releases to all media, infrastructure security, and the continued credibility of public commitments.

5.1.6 In the absence or insufficiency of such information, an assessment should be made of the applicable regulatory and industry

¹³ For natural resources damages, guidance on deriving estimates of losses can be found at 43 CFR 11 and 15 CFR 990.

standard requirements, and a determination made as to whether based on these requirements, significant *costs and liabilities* for environmental matters may be incurred that would indicate the need for further data collection and analysis in the future. This assessment should be documented, as discussed in 5.10.

5.2 *Selection of Estimation Approaches*—A decision framework for estimating *costs and liabilities* for environmental matters is required. For purposes of naming various estimating methods, the following terminology is used, ranked in level of robustness/comprehensiveness from highest to lowest as shown in Fig. 1.

- Arms-Length Market Price/Fixed Contract Price
- Quoted Price
- Expected Value (EV)
- Most Likely Value (MLV)
- Range of Values
- Known Minimum Value

5.2.1 Selection of the estimation approach is dependent on a number of factors, such as the availability of information, the purpose of the estimate, the estimate (including consideration of the specific needs of the user(s) of the estimate), the time and expertise available, and others. The decision to use one or more of these approach(es) for a particular purpose is not arbitrary. The informational value of the estimate supplied by any one approach is not equivalent to the others. When the uncertainties are great (for example, when an *event* is first identified) it may not be possible to make a highly reliable cost estimate. The reliability of estimates should continue to improve as those estimates are periodically updated over the life of a *liability* (see 4.2.34.2.4), including through the course of implementing response actions to extinguish the *liability*. In general, the estimator should prepare a robust/comprehensive estimate most appropriate to the need or purpose of the estimate.

5.2.2 The robustness and comprehensiveness of an estimate and the quantification of uncertainty about the estimate, given adequate information, generally decreases moving from top to bottom of this list of approaches, corresponding with the depth of analysis and use of available information to prepare an estimate. (See Fig. 1.) Depending on availability of information and circumstances, the level of effort required to prepare estimates at the top of the list is typically greater than the bottom of the list. However, any given *event* may have concurrent approaches and estimates underway simultaneously. Given the principles cited in Section 4, it is not necessarily true that the “best” estimate for a given set of circumstances will always be the expected value higher estimation approach on the comprehensiveness/robustness hierarchy depending on the purpose of the estimate, availability of information, and level of rigor applied to the estimate. The quality of an estimate is determined both by accurate implementation of the estimation approach, as discussed below, and by the quality of the inputs to the estimate. The user should consider these elements when selecting the estimation approach.

5.2.3 It is possible that a cost estimate may become fixed for a particular purpose at a particular point in time. For example, a judicial court may determine a cost estimate in a litigation proceeding or bankruptcy judgment, a regulator may determine a cost

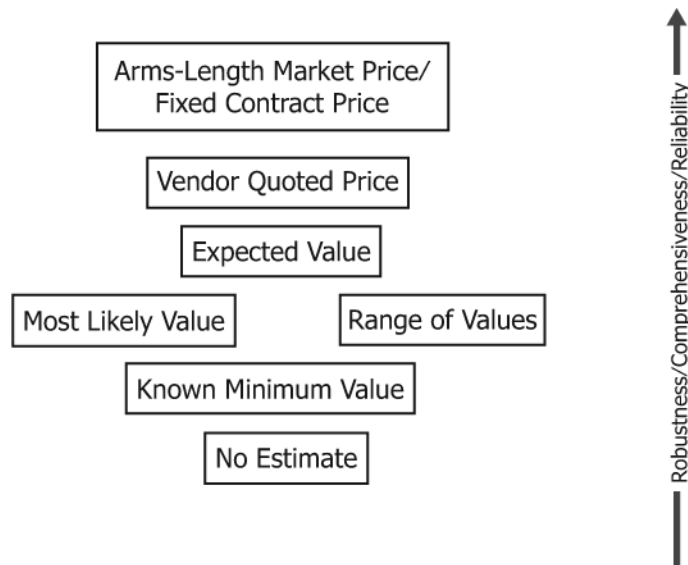


FIG. 1 Hierarchy of Approaches for Estimating *Costs and Liabilities* for Environmental Matters (see descriptions in 5.4)

for financial assurance or a consent decree, and a contractually-agreed upon fixed price may be set in a merger/acquisition or other transaction. A user of these fixed estimates should carefully evaluate the original purpose of such estimates and any applicability to estimates at other times and/or for other purposes. Issues to examine include (but are not limited to) whether the fixed estimate covered all relevant cost components and time periods (for example, are there exclusions, cost caps, limited coverage periods, or penalties), whether new information should be included to derive an updated estimate, and whether other values were incorporated in the fixed estimate (for example, unrelated merger efficiencies and penalties). The estimator should determine whether prior fixed estimates are relevant for other purposes, and whether prior fixed estimates require updating, adjustments, or re-evaluations for other purposes.

5.2.4 The *estimator* should take into account the number of *events* and quality of the information available or obtainable when selecting the *cost and liability* estimation approach to be used. (These may include the *recognition benchmarks* and *obligating events* listed in [Guide E3123](#) see also the parameters listed in [Appendix X7X5](#).) *Estimators* should consider whether it is useful to employ the same estimation approach for a portfolio of matters that are similar (for example, similar in nature or similar in magnitude) to improve comparability.

5.3 *Sources of Uncertainty in Estimation:* There are many sources of uncertainty in estimation that may affect the selection of the cost estimation approach and that should be considered in preparing estimates. These sources include, but are not limited to:

5.3.1 Decisions: an entity may complete a capital expenditure project, increase operating expenses, accelerate or defer site assessment, remediation and monitoring work for reasons unrelated to strict compliance with environmental laws and regulations. For example, a mine operator may elect to close an operation before its mineral lease expires because the operation is not expected to be profitable before the lease ends; consequently, by compressing the delay before eventual reclamation work, the *asset retirement obligation* increases to a higher present value.

5.3.2 Shared decisions/negotiations: a *dutyholder* may negotiate a compliance program with an environmental regulator to reduce or eliminate an environmental risk. The resulting mix of operating changes, monitoring, remediation, fines/penalties, compensatory restoration and/or capital expenditures may be lower cost and better aligned with the intent of environmental laws and regulations.

5.3.3 Market pricing: the market for environmental consulting and legal expertise, landfill space, trucking services, demolition explosives, construction equipment and other inputs are subject to supply and demand. Regional and nationwide price pressure and deflation can occur anywhere, at any time.

5.3.4 Safety: an unstaffed industrial or commercial property can be an attractive nuisance where trespassers may be exposed not only to chemicals of concern but also to hazards ranging from confined spaces and airborne pathogens to waterborne bacteria and criminal activity.

5.3.5 Media properties: different types of soil, in combination with rock, sand, silt and clay, have different “bulking factors,” meaning that when excavated and transported, the soils expand to a predictable and larger volume. In addition, contamination migrates within and between different media at differing rates. Also, to prevent slope failure, the angle of side slopes are limited to less-than-vertical angles, meaning that over-excavation of clean soil to reach contaminated soil is likely.

5.3.6 Mobility, toxicity and volume: Environmental regulations often focus on the mobility, toxicity and volume of contamination to be addressed. Robust and comprehensive estimates may depend on an understanding of the movement of these compounds through various media, such as a given site’s unique soil structure to a fluctuating groundwater table, and then laterally toward a surface water body or downward to deeper aquifers. Predicting how multiple chemical compounds will interact with each other over time and then respond to different remedial technologies is a complex undertaking. An *estimator* should regularly assess the value of incremental data and periodically state a need for additional data to prepare more reliable estimates of *costs and liabilities*, even if existing data may be sufficient for regulatory purposes. For example, a regulator may only require five soil samples to determine the presence or absence of contamination, but an *estimator* may need twenty soil samples to determine a more precise volume of contaminated soil and to rule out some remedial technologies as technically impractical.

5.3.7 Financial condition of *PRPs* sharing costs: in multi-party *liability* and contractual indemnification situations, one party may be invested in the financial survival of another. For example, bankruptcy or dissolution of one party may transfer costs to the surviving party. These two paths, bankruptcy and dissolution, represent two forms of non-performance risk (that is, counterparty default, or environmental counterparty risk).

5.3.8 Availability of timely insurance coverage: while certain assessment and remediation expenses may be theoretically

recoverable from insurers, the limitations of insurance should be understood by an *estimator*, including the costs to prepare a claim, the time for an insurer to process a claim, the ratio of claims to allowed expenses, and the probability of litigation to properly assert an insurance claim.

5.3.9 **Timing:** a regulator or property owner may decide to accelerate or defer future phases of assessment, cleanup or decommissioning work, and thereby increase or decrease the environmental *cost or liability* (in present value terms); this uncertain outcome can be caused by such *events* as environmental assessment findings, negative press attention, community complaints, the hiring of additional regulatory staff, a change in zoning/property use, or a natural disaster.

5.3.10 Duration of a series of costs, such as operational, monitoring, maintenance and compliance costs may be uncertain. Care should be taken to capture realistic expectations for the longevity of costs rather than using simplistic default assumptions (such as estimating costs for a duration of only 30 years when they are expected to continue after that point; See Note X1.7 in Appendix X1.)

5.3.11 Fraud and malfeasance: an entity may intentionally avoid any valuation of costs or liabilities, often in order to achieve other results, with the unsustainable outcome of defrauding investors or creditors.

5.3.12 Cost engineering deficiencies: an entity may choose historical spending, an abbreviated work breakdown structure, or vendors wishing to perform the quoted work as the sole data source for reliable estimates.

5.3.13 There are software and other cost estimation tools available that may be useful in framing and estimating costs and liabilities. The user of these tools should be cautious when employing these tools to make sure they understand the underlying assumptions in these tools and whether they are appropriate to the estimation matter.

5.3.14 ~~Other Uncertainties:~~Uncertainties: The user should be aware that there may be numerous other uncertainties to be investigated and ~~evaluated.~~evaluated for inclusion in the estimate(s). The quality of an estimate is determined both by accurate implementation of the estimation approach, as discussed below, and by the quality of the inputs to the estimate.

5.4 Detailed Description of Approaches for Estimation

5.4.1 Arms-Length Market Price/Fixed Contract Price—When possible, market information should be used to determine an arms-length market price and/or fixed contract price for an identical *cost and liability* in an active market.

5.4.2 Vendor Quoted Price—~~When possible, market information should be used to determine a fair value measurement. A quoted price for an identical cost and liability in an active market provides a reliable estimate and should be used when available. If a quoted~~If a price for an identical *cost and liability* is not available, quoted vendor prices for similar *costs and liabilities* in active markets may be used after adjustment for differences in cash flows or other relevant factors.¹⁴

5.4.3 Expected Value: The expected value is also known as a weighted arithmetic mean or weighted average. The approach, whether described through a written event tree or complex spreadsheet model, involves the following common steps:

5.4.3.1 Identifying the key issues contributing to the magnitude, sequencing and pace of *event costs and liabilities*. This may involve identifying which issues are decisions, negotiations, or random outcomes.

5.4.3.2 Sequencing the decisions, negotiations and random outcomes, often into an event tree (see example in [Appendix X2](#)) or a computer simulation.

5.4.3.3 Assigning probabilities and cash flows to each node in the event tree or for each issue in the computer simulation. Assign correlations to issues which have a strong relationship to one another, such as soil contaminant levels and offsite disposal costs. The *estimator* should consider whether nodes in the event tree are dependent. For example, if the regulators choose a particular remedy for one portion of the site, this may affect the likelihoods of remedies at other portions of the site.

5.4.3.4 Calculate the expected value, or probability-weighted value (See example in [Appendix X2](#)).

¹⁴ May meet the definition of *fair value measurement* ~~measurement~~ “level 2” under GASB 72, IFRS13, and ASC820.

NOTE 1—If required under FASB Concepts Statement 8, determine if the results are relevant, sufficient and reliable.¹⁵ If not, repeat most or all of the preceding steps while using measurements such as rank correlation and sensitivity analysis to determine how to convey information about uncertainty, as described in 5.8.

5.4.3.5 The *estimator* should test and confirm the robustness and comprehensiveness of the calculations by reviewing the sensitivity of the expected value to reasonable changes in underlying probabilities, dependencies, outliers, and other factors (such as those described in 5.3.)

5.4.3.6 The *estimator* should be careful to include realistic outcomes with statistically significant probabilities to avoid shifting the expected value through the addition of extreme outcomes with insignificant probabilities of occurrence. Statistical significance will vary depending on the quality of data, the magnitudes of the outcomes, and the presence of outliers.

5.4.3.7 An alternative method for performing an expected value calculation is to assemble cost data from comparable *events*. This actuarial approach may be useful when the data are truly sufficient (a sufficient sample size) and comparable (similar to the *event* being estimated). When using this actuarial approach, care should be taken to screen and confirm that the sample population is representative of the *event(s)* being evaluated. For example, data from sites with similar nature of operations, environmental setting, and regulatory framework should be used where available and the variation within the sample population should be assessed and documented. Care should also be taken when using historical data to assess the effects of changes such as technology enhancements, modified laws and/or regulatory policy, the changing application of presumptive remedies, and the application of risk-based corrective action approaches that could significantly alter current and future costs. Adjustments should be made to population cost data to normalize for regional pricing differences and to bring costs from different time frames to a consistent dollar basis. Where there are a large number of *events*, statistical approaches to estimating the expected value may be particularly appropriate. It is important to realize statistical approaches can be predictive of aggregate *costs and liabilities*, even if expected values for individual *events* are at variance from the actual results. Consideration should be given to the potential loss of relevant information through use of statistical means or averages which may not convey information concerning uncertainty.

5.4.3.8 These approaches can be used in combination or concurrently, or both, as appropriate.

5.4.3.9 Other approaches to estimating an expected value may include Monte Carlo simulation or Markov Chain Monte Carlo simulation, with the possibility of capturing simulation complexities such as underlying unit cost distributions or complex interdependencies.¹⁶ Care should be taken to appropriately select and justify the underlying distributions selected for such modeling, and these assumptions should be clearly documented as discussed in 5.10.

5.4.4 *Most Likely Value (MLV)*—When an expected value approach is not practical or appropriate, a Most Likely Value could be developed. This MLV captures the cost of the scenario believed to be most likely to occur (for example, a stated preferred remedy). Typically, the exercises *a priori* judgments (based on experience) about the ranking of likely outcomes, but because of cost or other considerations does not develop a full range of possible outcomes to support an expected value estimate. Care should be exercised in preparing an MLV estimate. For example, the MLV is typically not the mid-point between the high and low cost estimates. The MLV should represent a technical and regulatory scenario that is most likely to occur. The MLV may represent a grouping or cluster of scenarios where the cost outcomes are close in magnitude and the combined probability of the grouping or cluster exceeds the probability of other possible scenarios. The MLV is not useful if no scenario, grouping or cluster of outcomes has a probability of occurrence that is significantly greater than others. For the MLV approach, it is recommended that a Range of Values also be developed to convey a minimum level of information about uncertainty.

5.4.5 *Range of Values*—When an expected value approach is not practical or appropriate, a range of values (without probabilities) may be developed instead. This approach may also be used in addition to the MLV approach to provide additional information, or instead of the MLV approach if probabilities or rankings for various outcomes cannot be determined. The range of values should cover costs from a low cost estimate to a high cost estimate, based on reasonable assumptions. If some outcomes within the range are more probable than others, this standard recommends the additional estimation of a most likely value or an expected value, when possible.

5.4.6 *Known Minimum Value*—In the unusual event that the outcome and cost uncertainties are so great that it is premature to estimate a range of values or a most likely value, then a minimum value including component costs (for example, contracts entered, initial *studies*) that are reasonably certain to be incurred should be estimated.

¹⁵ FASB Concepts Statement 8.

¹⁶ For additional information, see for example J. Mun, *Modeling Risk: Applying Monte Carlo Risk Simulation, Strategic Real Options, Stochastic Forecasting, and Portfolio Optimization*, 2010