THE GREAT ENVIRONMENTAL RESTORATION COST ESTIMATING SHOOTOUT: A BLIND TEST OF THREE DOE COST ESTIMATING GROUPS

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ABSTRACT

The cost of the Department of Energy's (DOE) Environmental Restoration (ER) Program has increased steadily over the last three years and, in the process, has drawn increasing scrutiny from Congress, the public, and government agencies such as the Office of Management and Budget and the General Accounting Office. Programmatic costs have been reviewed by many groups from within the DOE as well as from outside agencies. While cost may appear to be a universally applicable barometer of project conditions, it is actually a single dimensional manifestation of a complex set of conditions. As such, variations in cost estimates can be caused by a variety of underlying factors such as changes in scope, schedule, performing organization, economic conditions, or regulatory environment. This paper will examine the subject of cost estimates by evaluating three different cost estimates prepared for a single project including two estimates prepared by project proponents and another estimate prepared by a review team. The paper identifies the reasons for cost growth as measured by the different estimates and evaluates the ability of review estimates to measure the validity of costs. The comparative technique used to test the three cost estimates will identify the reasons for changes in the estimated cost, over time, and evaluate the ability of an independent review to correctly identify the reasons for cost growth and evaluate the reasonableness of the cost proposed by the project proponents. Recommendations are made for improved cost estimates and improved cost estimate reviews. Conclusions are reached regarding the differences in estimate results that can be attributed to differences in estimating techniques, the implications of these differences for decision makers, and circumstances that are unique to environmental cost estimating.

INTRODUCTION

The cost of the Department of Energy's (DOE) Environmental Restoration (ER) Program has increased steadily over the last three years and, in the process, has drawn increasing scrutiny from Congress, the public, and government agencies such as the Office of Management and Budget and the General Accounting Office. This attention demonstrates the importance of cost estimate credibility for large, publicly funded programs particularly when the costs of these programs increase rapidly. Programmatic costs have been reviewed by many groups from within the DOE as well as from outside agencies. This paper will examine the subject of cost estimates by evaluating three different cost estimates prepared for a single project including two estimates prepared by project proponents and another estimate prepared by a review team. The objective of this evaluation is to identify the reasons for cost growth as measured by the different estimates and the ability of review estimates to measure the validity of costs. The comparative technique used to test the three cost estimates will identify the reasons for changes in the estimated cost, over time, and evaluate the ability of an independent review to correctly identify the reasons for cost growth and evaluate the reasonableness of the cost proposed by the project proponents. Recommendations will be made for improved cost estimates and improved cost estimate reviews. Conclusions will be reached regarding the differences in estimate results that can be attributed to differences in estimating techniques, the implications of these differences for decision makers, and circumstances that are unique to environmental cost estimating.

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THE PLANNING ESTIMATE

The first cost estimate was prepared before environmental site investigations were completed and, as a result, the scope of work includes many assumptions. While these assumptions were reasonable, when made, many could not be supported by project specific information. As such, while these assumptions are reasonable, in the technical sense, many of them will ultimately prove not applicable to this project as site characterization and the regulatory process proceed.

Examples of key scope assumptions included:

- cap materials can be purchased in sufficient quantity and at the required quality levels, to support the project,
- the project schedule is correct, and
- no support facilities are required to accomplish the remediation.

Unit prices used for cost estimating were based on a limited amount of historical data. In addition, the preliminary nature of project scope definition resulted in a lack of detailed information on the design of engineered systems such as impermeable caps. As a result, the planning estimate relied on aggregated unit costs. The cost of an impermeable cover, for example, is based on the average cost per cubic yard for a RCRA compliant cover. In making this cost estimating assumption, implicit assumptions were also made concerning the design of the RCRA cap. A similar assumption concerned the unit price for treatment of hazardous leachate. The

estimate assumes that the leachate will be treated in the existing waste water treatment plant and the effluent discharged under the existing NPDES permit. However, a lack of sufficient information concerning the presence of hazardous constituents in the leachate, including the presence of radiologic constituents, leaves some doubt as to the best unit price for this application. Examples of the unit prices that were available to the estimator included:

- Granular Activated Carbon (GAC) Treatment: $0.22-$0.55 per gallon
- Air Stripping: $0.04-$0.17 per gallon.

Air stripping would be appropriate only if the contaminants were limited to volatile organic compounds such as those found in gasoline (benzene, toluene, xylene) while GAC would be appropriate if less volatile compounds were present. In some cases, the two processes could be used in series. The presence of radiological contaminants in the leachate such as tritium would also have an impact because of the need to treat concentrated residues or effluent streams as low level waste.

The planning estimate was also based on an assumption concerning the regulatory environment. In particular, the time required for review and comment on regulatory deliverables was based on the existing regulatory structure at a local level, and DOE's programmatic requirements for internal review. Changes in regulation influenced not only the overall duration of the project, but also increased the cost because the labor requirements (and cost) for staff support during the review and comment period were increased.

CONCEPTUAL ESTIMATE

The conceptual cost estimate was prepared on the basis of more complete information and shows a number of significant changes from the planning estimate. The first change is in the scope of the estimate. While the planning level estimate includes design, management, and execution of the remedial action, the conceptual estimate has expanded to include the assessment scope of work. Although this is easily understood when a work breakdown structure is used to summarize cost, it would not be apparent to the casual reader of a summary cost number for the entire project (Table I*).

The cleanup scope of work has also changed by the time that the conceptual estimate was prepared to include the following elements of support facilities:

- relocation of utilities that transect the site
- development of a quarry for cap materials including a haul road to the site
- development of waste handling facilities including a transfer facility for hazardous leachate,
- an interim storage facility for material removed form the site during site preparation for capping, and
- an equipment decontamination facility.

None of these items were explicitly included in the scope of the original estimate. Some elements, such as the need to relocate existing utilities were simply overlooked, while others such as the development of a quarry reflect a decision to invest in infrastructure to support remedial actions at the site in return for a lower and less volatile overall unit price. The decision to build an interim storage facility for contaminated material produced as the result of leveling the site represents a more conservative interpretation of hazardous waste regulations and can be attributed to increased experience dealing with the regulators.

Specific costs associated with changes in project conditions for the remedial action portion of the project occurring between planning and conceptual estimates are:

- SARA/OSHA training for field personnel: $1,850,000
- Health Physics (radiological) protection: $4,752,000
- Safety compliance (inspection/supervision): $810,000

These factors amount to a cost increase of almost 57%. The design concept also changed with regard to site capping. The planning estimate assumed that one large cap would be used to cover the entire site while the planning estimate assumes a design based on a number of smaller but thicker caps. The cost also increased by an additional $9.4 million dollars because of the need to grout abandoned wells, a scope change that contributed another 73% to cost growth.

TABLE I

Summary of Cost Estimate Elements

Element	Planning Estimate	Conceptual Estimate	Review Estimate
Assessment	0	9,957,800	0
Remedial Design	2,544,527	24,851,300	6,243,695
Project Management	1,966,000	13,614,735	5,932,400
Remedial Action	12,818,885	30,002,695	48,100,566
Supporting Facilities	0	19,609,700	54,213,425
Surveillance and Maintenance	9,495,851	16,074,945	0
Contingency	9,399,342	46,785,581	22,898,017
Total	$36,254,605	$160,896,755	$131,768,103

* The cost estimates in this table have been reformatted to facilitate comparison. The planning and conceptual estimates were both classified as "draft" by their preparers in recognition of the incomplete nature of project definition at the time of preparation. However, these estimates are representative of the knowledge that existed at the time that the estimate was prepared.

The average contingency increased from approximately 35% to 41% reflecting a combination of factors. The first is the inclusion of more out year scope in the conceptual estimate. Greater uncertainty is associated with activities farther in the future. In addition, the contingency may have increased because of an enhanced understanding of the risks associated with environmental projects.

THE REVIEW ESTIMATE

A review of the cost estimate for this project was conducted to "validate" the budget request. The validation was directed at the FY 1994 budget request although the entire cost estimate was reviewed. The focus on a single year's budget request resulted in the review team holding a perspective that differed from that of the project management team. For example, the review's focus on a single year's funding is inconsistent with the objective of project management and, as a result, the review team tended to oversimplify the project. The project management team had directed their efforts toward developing a cost estimate and schedule for the entire project and found it difficult to discuss the FY 1994 scope without discussing the entire project. In order to evaluate the reasonableness of a single year's funding, the review team was compelled to evaluate the total estimated cost and the schedule and revised their review effort accordingly.

The method used to prepare the review estimate also differed from the normal cost estimating process and appears to have influenced the results. The review estimate was prepared by two teams. The first met at the job-site with members of the project management team to discuss the project. The results of these interviews, which consisted mainly of transcribed quantities of material and labor, were recorded on data sheets. Areas such as project management or engineering support were not determined independently by the review team but were simply recorded as levels of effort using the project team's staffing plan. In most cases, this had the effect of narrowing the scope of the review to the cost of a full time equivalent rather than a confirmation of the reasonableness of the overall cost based on an independent "validation" of the project.

The review team did exercise judgement in some areas of the project such as occupational safety and health requirements, health physics support to field operations, and unit prices for construction labor and equipment. However, these areas led to differences between the review team and the project team and were subsequently resolved in most cases by revising the review estimate to agree more closely with the project estimate. This again points out the limited utility of a review focused on "pure cost" that neglects the broader issues facing the project.

The review estimate used the overhead and indirect rates that were in place at the site for incumbent contractors. The schedule and method of performance were also unchallenged by a review team.

CONCLUSIONS

While the cost of this project changed considerably over the period covered by these three estimates, differences in scope and design assumptions overwhelmed changes in unit cost. Yet the review team accepted the scope of work and limited their review to the unit cost alone thereby overlooking the greatest area of uncertainty. In addition, the lack of a standard WBS or framework to facilitate comparison creates the illusion of problems where there are none and masks problem areas where they exist. Increased standardization of cost estimate format is necessary to facilitate project cost comparisons and if cost estimate are to be relied upon in the decision making process. Otherwise,the management process will not be able to use cost estimate data for important decisions. Environmental cost estimates are subject to many influences not ordinarily found on construction projects and the management of environmental projects must accommodate these differences. Many of the unique features of environmental projects are manifested in changes in the cost estimate. Both managers and reviewers must understand these conditions to correctly interpret changes in cost estimates.

Cost growth occurring between the planning estimate and the conceptual estimate initially appears significant, but closer analysis reveals that changes in scope or changes in scope definition are actually the cause of most of the cost growth. This must be understood if project and program managers are to take appropriate corrective action because true cost growth (more cost for the same work) is a different situation than "more cost for more work". On the other hand, the cost associated with health physics protection is significant and, if the overall cost is to be verified, the review team must have the expertise to evaluate technical requirements and deduce appropriate resource requirements. This necessitates an understanding and appreciation of how the work is actually performed.

Considerable uncertainty exists with regard to unit prices and the level of detail available in the early stages of project definition is often insufficient to allow the estimator to select the correct price. Uncertainty concerning the presence of radioactive material in the waste can render unit prices for non-radioactive waste treatment invalid and assumptions in this regard should be carefully documented and explained to any reviewer. The following unit costs were used for estimating the cost of treating hazardous waste leachate:

- Planning Estimate: $54.00 per thousand gallons
- Conceptual Estimate: $150.00 per thousand gallons
- Review Estimate: $100.00 per thousand gallons

The review team's use of average unit costs from a privately owned treatment works is an example of a reviewer's reliance on a potentially invalid data source. It is recommended that the estimator document the source and basis of the unit process used in these circumstances so that follow-on estimates can differentiate between changes in unit price and changes in treatment processes (scope).

Finally, it is recommended that reviews of environmental restoration projects be conducted in a coordinated and streamlined manner if the reviews are to contribute to increased confidence in the accuracy of cost estimates. Otherwise, the review estimate, which is conducted in a limited amount of time and by personnel not familiar with project details, will decrease confidence rather that "validate" the project estimate. Coordination should begin with review planning and include agreement on central elements as the purpose of the review and the use of appropriate references or standard for the review. An understanding of the purpose of the review is essential for the project team if they are to explain their project effectively to the reviewers. While it would be best if the review teams used personnel knowledgeable

concerning environmental projects and the special circumstances surrounding nuclear related operations, this is not always the case. Therefore, the volume and type of background and supporting data required of the project management team must be tailored to fit each circumstance. Agreement on the scope of the review will allow the project management team to provide the review team with all relevant information needed to prepare an estimate including the scope of work, the schedule, descriptions of job conditions, and assumptions. At the conclusion of the review, a reconciliation should be held between the review team and the project team. The result of this reconciliation will be a consensus that contributes to increased management support for the project rather than giving the illusion of disagreement where none may exist.