

Final Report

Final Project Report

ASSESSMENT OF RACER™
COST MODELS AND DATABASE PROJECT

U.S. ARMY CORPS OF ENGINEERS
Hazardous Toxic and Radioactive Waste-Center of Expertise

Denver, Colorado

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Revision History

Date	Version	Description	Author
November 15, 2004	1.0	Project Draft Final Report	Booz Allen Hamilton
November 30, 2004	2.0	Project Draft Final Report	Booz Allen Hamilton
December 27, 2004	3.0	Project Draft Final Report	Booz Allen Hamilton
January 24, 2005	4.0	Project Final Report	Booz Allen Hamilton

Executive Summary

Booz Allen Hamilton (Booz Allen) was awarded a contract order (DACA45-03-F-0010) under Contract GS-10F-0090J on September 26, 2003, to “perform a comprehensive assessment of the Remedial Action Cost Engineering and Requirement System (RACER™ –hereafter referred to as RACER) cost models and underlying databases.” The contract directed Booz Allen to “evaluate cost models in the RACER system that are representative of the most commonly used technologies found when reviewing the historical cost information... The models shall be evaluated for cost reasonableness, current cost methodologies, and general functionality.”

The clients for this project include the United States Army Corp of Engineers Hazardous Toxic and Radioactive Waste–Center of Expertise (USACE HTRW/CX), the United States Army Environmental Center (USAEC), and the Air Force Civil Engineering Support Agency (AFCEA). In support of the contract scope requirements, the Booz Allen team worked with the client to develop a process and protocol for data collection, analysis, and data management during the project.

RACER 2004, Version 6.0, was the most current available version of the software when the project was initiated. Although Version 6.0.1 was released later in the project schedule, Version 6.0 was retained as a consistent benchmark for the RACER evaluation.

A significant benefit of this project was the collection of historical cost data from 211 environmental remediation projects completed by the Department of Defense (DoD). The data was collected during 10 separate visits to USACE district offices, the Air Force Center for Environmental Excellence (AFCEE), and through Internet research. The collection of this historical data resulted in the selection of 131 projects for further analysis and simulation in RACER 2004. The opportunity to compare actual field data with RACER cost estimates represents a best practice in the development of parametric models and will allow continued enhancement of RACER as a calibration tool.

Although we have identified numerous opportunities for improving and enhancing the RACER product, our analysis indicates the foremost issue that affects the ability to produce reliable environmental remediation cost estimates is the RACER default secondary parameters. Default secondary parameters do not characterize the site or planned remedial actions adequately to produce an estimate that is accurate for future project reviews. In order to properly modify secondary parameters, sufficient data must be available to the user to modify RACER parameters and generate planning estimates that are reflective of the physical characteristics and work conditions at the remedial site. Further, the user must be trained in the use of RACER to allow for modification of important parameters and cost assemblies that affect the total estimate.

Our team experience in remedial actions and detailed knowledge of cost estimating in RACER allowed us to produce replicable cost estimates in comparison with historical

remediation projects – *when* we modified important parameters and cost assemblies in RACER. This was dependent upon sufficient data being available to modify the RACER estimates properly to reflect historical project conditions and site characteristics. As stated previously, we collected data on 211 projects that appeared to have sufficient data to replicate in RACER estimates. However, upon close examination and evaluation, only 131 projects were actually replicated in RACER. This is a clear indicator of the difficulty in obtaining sufficient site data to generate cost estimates for remediation projects. Nonetheless, our analysis shows that RACER estimates can be compared to historical project data and the product can be improved with the application of actual field experience derived from DoD environmental remediation programs.

In preparing for this project, the Booz Allen team and the clients discussed the basis for selecting historical projects to be compared with RACER estimates. It was determined that data collection would focus mainly on remedial actions, but other phases of remediation would be included when available, including remedial investigations, operations and maintenance, monitoring, and closure. Additionally, data collection would be directed toward projects completed between 1995 and 2004 in order to minimize distortions due to old technology or the evolution of best practices in environmental remediation.

To make valid comparisons between historical data and RACER estimates, it was necessary to normalize historical project data to base year 2004 using RACER escalation factors that would allow comparison with a current RACER estimate. Every effort was made to normalize the historical data so that actual cost data was strictly tied to specific technologies appearing in the RACER model. During several meetings with the client, the topic of a “direct cost” comparison (no overhead and profit) versus a “fully burdened cost” comparison was discussed. Although direct costs were identified and tracked where possible during this project, it was determined that much of the historical data did not have adequate cost breakdown for a direct cost comparison. A direct cost comparison would have been highly desirable in order to more specifically segregate important cost discrepancies related to technology or productivity impacts but was not possible for all the collected data. Instead, the comparisons shown in this report are made using fully burdened costs. It was then necessary to assign the general overhead burdens and profit in the historical project data to the RACER estimates for an “apples to apples” comparison.

Two weeks prior to each location visit, a packet was sent to the USACE District Office Government Point of Contact (POC). Prior to arriving on site, the team obtained a list of potential historical projects from the USACE Formerly Used Defense Sites Management Information Systems (FUDS MIS) database and the USAEC Army Environmental Database–Restoration (AEDB-R) in order to identify projects by technology and scope of work. This step became more important as the project progressed and gaps in our data collection for important technologies were identified. It was then possible to search for projects with these technologies during the location

visit. The team visiting usually included two Booz Allen personnel and at least one government representative.

The cost data analysis is based on a three-phase process: 1) deconstruct historical cost, 2) cross-walk key data parameters into RACER, and 3) generate a series of project cost estimates for comparison to actual project costs.

Under Phase 3, there is a four-step approach to developing cost estimates in RACER utilizing historical project data. By utilizing this four-step iterative approach, modifications to RACER primary and secondary parameters can be isolated and analyzed. These four steps are referred to as “scenarios” in this report. In general, the scenarios represent an increased level of interaction with the RACER models. In Scenario 1, the default parameters of the model are used; this is typical when planning data is very limited. Scenarios 2 and 3 allow the user to modify important data related to site characteristics and remedial activities. Scenario 4 is a test case using the “96-City Average” location multiplier in comparison with the area cost factor (site-specific location multiplier) used in Scenario 3. This approach of using one of four scenarios enables the analysis to show how greater levels of specificity improve the RACER estimate. Section 2.0 provides more detail on the process and approach used in this analysis.

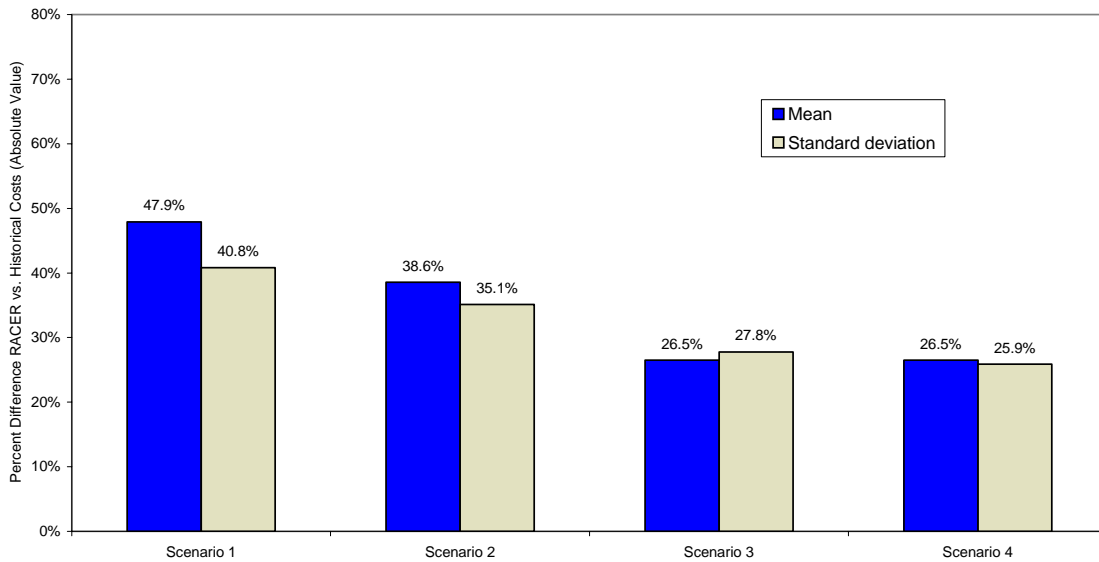


Figure 1 – Absolute Value of Mean Cost Difference Between RACER Estimate and Historical Project Cost by Scenario

Figure 1 depicts a summary of results from all eleven location visits plus additional Internet data research (i.e., 12 locations) for the projects selected for RACER analysis. The chart shows the difference in cost between RACER estimates and actual project cost data for each scenario. The difference in cost between historical data and RACER

estimates in this figure was computed using the absolute value of the differential (expressed as a percent of the actual project cost) and applied to all projects, resulting in a cumulative mean difference in cost for each scenario.

Also presented in Figure 1 is the standard deviation for each scenario. The standard deviation is a measure of the dispersion of the data from the mean cost difference. A smaller standard deviation value (expressed as a percentage) indicates less variation in the results around the mean.

As Figure 1 illustrates, the analysis depicts a step-wise progression in improved estimates beginning with Scenario 1 and continuing through Scenario 3. This outcome is logical as the user is able to provide more project-specific data for the estimate under Scenarios 2 and 3. In Scenario 1, the absolute value of mean cost difference between RACER estimates and historical cost is 47.9% with a standard deviation of 40.8%. In Scenario 2, by modifying important secondary parameters in the model, the absolute value of mean cost difference is reduced to 38.6% with a standard deviation of 35.1%. In Scenario 3, the advanced user can modify specific assemblies that form the basis for the cost estimate, and the absolute value of mean cost difference is reduced to 26.5% with a standard deviation of 27.8%. In Scenario 4, the mean cost difference is also 26.5%, and the standard deviation is 25.9%.

A more detailed discussion of our statistical analysis is found in Section 5.0. A number of statistical measures have been developed to better understand the performance of RACER relative to historical project data.

Summary of Findings

- The historical data collection project was a success in developing a benchmark for comparing RACER performance with actual field experience. The sample population was of sufficient size and diversity to adequately portray the performance of RACER relative to actual DoD remediation experience. The collection of historical data for completed remediation projects provides an important benchmark for evaluating and improving the RACER parametric model.
- RACER functions best when project data is available to modify secondary parameters or assemblies. Depending on the use of RACER in support of program planning or independent government estimates, it is clear that sufficient project data must be available to produce an accurate estimate. In our project analysis, the use of RACER default values under Scenario 1 produced highly variable results. See Section 5.0 for further details.
- In order for RACER users to produce consistent and accurate estimates, it is required that they undergo formal and continued training in the product. Analogous to the previous finding, in order to make adequate use of project-specific data under Scenarios 2 and 3 (modifying parameters), the user must be advanced in the use of RACER in order to produce accurate and acceptable environmental liability estimates. See Section 5.0 for further details.

- RACER models can benefit from access to historical project data to ensure consistency with actual field experience. Our research and analysis clearly identified a large number of potential improvements to RACER based on technology evolution and the environmental remediation process. These potential improvements include:
 - Existing Models Requiring Enhancements – 32
 - Default Secondary Parameters Requiring Enhancement – 26
 - Technology Assemblies Requiring Enhancement – 7
 - Proposed New Models – 12
 - Proposed New Assemblies – 31
 - Software Bug Fixes – 7

Section 5.3 of this report and Appendix C of this report provide increasing detail on our proposed improvements to RACER.

- Our review of records for completed DoD remediation projects did not provide consistent documentation to evaluate and defend initial project estimates or closeout costs. The eleven location visits we conducted demonstrated to us that record management is highly variable in terms of a) the record keeping process, b) the level of documentation available, and c) the format in which data is found. It proved difficult and time consuming to gather historical project documentation and to deconstruct the specifics of each project to understand cost performance. See Section 3.0 of this report for more details.
- There is no clear statistical evidence that RACER consistently produces higher or lower estimates in comparison to historical benchmark costs. There is also no clear statistical evidence that RACER produces better estimates for “high cost” or “low cost” projects, defined as greater or less than \$500,000 total project cost. See Section 5.0 for further details.

A more detailed explanation of these findings can be found in Section 6.0 of this report.

1.0 Objectives

The bullet point references below are objectives taken from the contract scope of work:

- This Task Order is to perform a critical review of the RACER program, models, assemblies, and unit costs to determine if any models need to be updated to reflect best practices in environmental restoration, if assemblies need to be changed or updated, to identify which default parameters need to be changed, or to identify if new models need to be developed. This review shall also provide the Government with a better understanding of when default parameters are best used and when they should be customized.
- The Government will use this information to understand how, or if, RACER needs to be modified to ensure RACER cost estimates are auditable and defensible and will provide a sound basis for developing estimated costs used to report Defense Environmental Restoration Program (DERP) environmental liabilities.
- The Contractor shall perform a comprehensive assessment of the RACER [2004], Version 6.0, cost models and underlying databases. The Contractor shall evaluate cost models in the RACER system that are representative of the most commonly used technologies found when reviewing the historical cost information. The models shall be evaluated for cost reasonableness, current cost methodologies (i.e., does a model reflect the most current best practices) and general functionality in accordance with the Scope of Work dated August 21, 2003.
- Historical project data will be collected and used for comparison with RACER [2004], Version 6.0, under this project, as well as be used as a resource to analyze other parametric systems in the future. Historical project data was collected on 211 projects that appeared to have sufficient data to replicate in RACER estimates. Upon close examination and evaluations, 131 projects were actually replicated in RACER. The project data not used in the RACER analysis were still reviewed and filed for delivery to the Government. This data could potentially be sufficient for other uses in the future.

2.0 Project Process

2.1 GENERAL ASSUMPTIONS FOR RACER MODELING

The following list details general assumptions used in the comparison of RACER estimates with historical costs. These assumptions define the general process and approach that guides the estimating process. Some specific instances required the team to slightly modify RACER defaults to better reflect the reality of a given project. These have been noted in Appendix A – Model Analysis Report. Unless otherwise noted, these assumptions were following throughout the estimating process.

1. All estimates were generated using RACER 2004 (Version 6.0).
2. RACER default values were used in all cases for which more specific information was not available. The following list describes and defines items considered defaults for this process:
 - **Markup Calculation** – RACER uses markup templates to calculate general conditions, overhead, risk¹, owner cost, and prime and sub contractor profit as a percentage of direct costs. A user-defined RACER markup template was used for all projects, which zeroed out the “owner cost”². All other markups were left as default in the template.
 - **Safety Levels** – RACER assumes a default safety level of “D” in all models except Remedial Design and Professional Labor Management, which use a default of level “E”. These safety levels were used in all estimates unless project documentation specified otherwise.
 - **Cost Database** – The default RACER 2004, Version 6.0, cost database was used to define the costs associated with each assembly in the estimates for all scenarios. Although no new assemblies were created and added to the database, changes to the default assemblies within a technology were conducted within Scenario 3 (Subtask C – Historical Data Analysis, should be referenced for a better understanding of these estimating scenarios). Changes to the assemblies could range from deleting/adding assemblies or changing the default assembly quantity. The default material, labor, and equipment costs were never modified for the assemblies. All assembly modifications were based on information

¹ The default template includes a “risk” of 0%.

² The default template includes an “owner cost” percentage of 5%, which is added to the total after Prime Contractor profit and overhead. For this project the owner cost percentage was set at zero in the user defined markup template. This cost in the default template pertains to management costs and oversight activities incurred by the “owner.” For the purposes of this project, the owner is the Government, and this 5% markup pertains to government costs that are not included in the contractor’s cost and thus should not be included in the comparison of RACER to historical costs for this project.

specified in the historical project documentation but are not included within the default RACER estimate.

- **Escalation Factors**³ - Standard RACER escalation factors were used to “normalize” data so that it could be compared to FY 2004 dollars. USACE HTRW/CX in Omaha, Nebraska, provided the escalation index data that are included in RACER 2004. The indices correspond to the Building Cost Index (BCI) published and updated by the Engineering News-Record (ENR): <http://enr.construction.com/features/conEco/costIndexes/bldIndexHist.asp>
- **Location Modifiers (Area Cost Factors)**⁴ - The system location modifiers found in RACER 2004 were used when estimating Scenarios 1, 2, and 3 (Section 3.2, Subtask C - Historical Data Analysis, should be referenced for a better understanding of these estimating scenarios). These system location modifiers were selected based on the location of the project.
- **Professional Labor Rates** - The direct professional labor rates found in the default RACER cost database were used in all cases. The labor types were switched out when actual historical data was available for specific technologies. Any changes to the assemblies are documented in Appendix A - Model Analysis Report.
- **Professional Labor Management** - The “Professional Labor Model” was applied to each remedial action or interim remedial action phase within each project to ensure that a valid comparison could be made for historical projects burdened with professional labor.

³“DRAFT - Update to Escalation Index Values for RACER™ 2004,” Earth Tech, Inc., November 2003

⁴“DRAFT - Update to Area Cost Factors for RACER™ 2004,” Earth Tech, Inc., November 2003

2.2 PROTOCOL FOR HISTORICAL DATA COLLECTION AND ANALYSIS

During visits to ten USACE District Offices, one AFCEE location, and Internet searches, the data collection team followed the protocol called out in the Project Work Plan. Figure 2.1 below displays an overview of the step-by-step approach that Booz Allen followed in accomplishing each subtask for the data collection, processing, and analysis portions of the project.

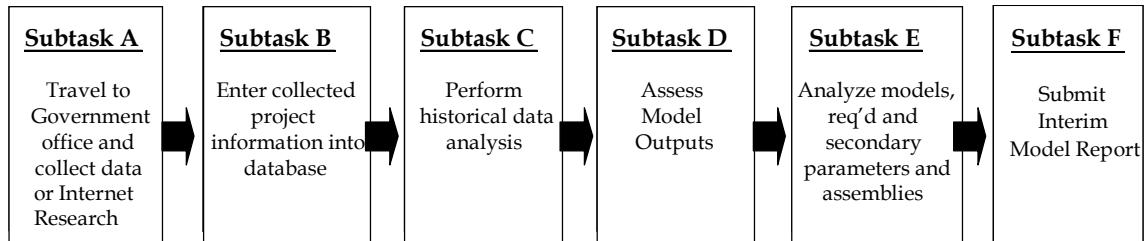


Figure 2.1 – RACER Assessment Project Tasks

The protocol used for each of these subtasks follows:

Subtask A – Travel To Government Office and Collect Data or Internet Research

The Booz Allen team followed a consistent and systematic approach for the data collection task at each location to ensure that the data would be appropriate for decomposition to support the RACER modeling approach.

The following is a list of protocol steps followed during the site visit:

1. USACE contacted the District Office to coordinate the location visit and identify participating district project managers with relevant historical project data.
2. USACE sent out a pre-site visit information packet to the District Office to inform the office of the purpose of the visit, the types of data needed, and the level of participation requested by the data collection team.
3. USAEC and USACE provided a preliminary list of proposed projects to the Booz Allen team prior to the location visit. The initial list was gathered from a query of the FUDS MIS and AEDB-R databases. Booz Allen assisted the Government in evaluating the information results of the query.
4. Upon arrival at the District Office, the data collection team conducted a project in-brief to discuss the overall objectives of the site visit and to begin to narrow down the initial project list. Location of project files, copiers, and other logistics were discussed during this meeting.
5. The data collection team next conducted interviews with the program managers from each District Office.

6. Once relevant projects were targeted and files located, the data collection team copied the supporting cost documentation and then returned the files. The team organized the copied documents and transported them to the Booz Allen office in Denver, Colorado, for processing.

Booz Allen conducted a focused search of Internet resources over a period of several weeks. The goals of this effort were to gather projects that could be re-created in RACER and then conduct cost and engineering analysis against the historical data. The following steps were taken for collecting the Internet projects.

1. Several Web sites were initially reviewed for this analysis. These were found by conducting key word searches using a web browser or search engine and based on our knowledge of the environmental arena. These sites were found to be unsatisfactory because they did not contain the required project information. After receiving guidance from the USACE HTRW/CX, the Federal Remediation Technologies Roundtable Web site (<http://www.frtr.gov>) was identified and selected as the project documentation source.
2. The key information that was required of each project was historical cost and technology best practices. In addition to creating and analyzing RACER estimates, a goal of this project was to determine if the RACER program accurately reflects the most current and accepted industry standards.
3. Project data had to be discrete and substantiated to be usable. The historical cost data needed to be broken down to the technology level so that technology analysis could occur. The technologies that each project contained had to have enough supporting documentation to quantify the RACER technology parameters.

Subtask B - Deconstruct Data and Enter into RACER Assessment Database (RAD)

Upon completion of the data collection, all documents were shipped to the Booz Allen Denver office for data deconstruction, entry into the RACER Assessment Database (RAD), and indexing and filing. The same process was also used for the deconstruction of the Internet projects.

The following steps were applied to deconstruct historical data:

Step 1 - The project documents were thoroughly read and verified for completeness. Section 4.0 provides more information on how data completeness was determined for each historical project collected.

Step 2 - Historical project documentation was organized and inserted into individual project file by documentation type. Documents collected but not used within the RACER analysis are marked and inserted into the back of the project file. Project parameter data was identified within the historical project documentation, highlighted

and tabbed for ease in locating specific data within the documents during the Quality Assurance/Quality Control (QA/QC) process.

Step 3 – Data decomposition templates were created for installation, project, site, phase, and technology level information. Historical cost data and parameter information at each of these levels was recorded within the data decomposition templates for entry into the four RACER estimating scenarios outlined in Subtask C below and the RAD. A technology data decomposition template is available for each of the technology models included in the historical project analysis. Examples of such completed data decomposition templates are provided for the Eagle Army Airfield – Soil and Groundwater Sampling project within Appendix B-1 of this report. Every parameter value recorded within the data decomposition templates must be referenced within the historical project documentation.

Step 4 – The completed project decomposition templates were attached to each of the project source files and filed at the Booz Allen Denver office for QA/QC and entry into RAD. Each file was given a file index based on the site location where the data was collected, the installation name, the project name, and contract number. An example file index is given below:

*Sacramento: Eagle Army Airfield – Soil and Groundwater Sampling –
DACA05-99-D-0014*

Step 5 – The deconstructed historical cost data and parameter information were entered into RAD, along with references to the historical project documentation. An example and the steps followed for the Eagle Army Airfield – Soil and Groundwater Contamination project entry into RAD can be referenced within Appendix B-2 of this report.

Step 6 – All historical project source files will be delivered to the client following the end of the project. They will be delivered via numerous boxes and separated by site location.

Subtask C – Historical Data Analysis

To analyze the RACER program, the deconstructed elements and costs obtained from the historical project documentation were compared against the RACER outputs under the same four scenarios. Actual parameters found in project documentation were entered into the RACER program using the required parameters as defined in Scenario 1 below. Running three additional scenarios facilitated identification of possible causes of cost differences between historical project cost and RACER estimates. Subsequent estimates were generated by copying the baseline estimate (Scenario 1) and following the protocol as defined in the scenarios found in Table 2.1 below.

Scenario Number	Description	Purpose
1	Scenario 1 consisted of entering required parameters into RACER based on project documentation. No secondary parameters or assembly information was changed from the RACER default values. The location factor was dependent upon the information obtained from the historical project data.	This scenario was used to isolate and identify any issues with the RACER models' primary parameters as well as to create a basis for Scenario 2.
2	Scenario 2 consisted of copying Scenario 1 and then changing the RACER default secondary parameters to specific project values derived from the historical project documentation. Assembly information was not changed from the RACER default.	This scenario was used to identify any issues with the RACER models' secondary parameters and compare it with Scenario 3 to determine outstanding issues with RACER model assemblies. This scenario helped to understand if a new cost model is required or if existing cost models require modification.
3	Scenario 3 consisted of copying Scenario 2 and making changes to the assemblies found within the RACER technologies. Changes to the assemblies could range from deleting/adding assemblies or changing the default assembly quantity. The default material, labor, and equipment costs were never modified for the assemblies. No new assemblies were added to the RACER database. Only the default assemblies contained in the RACER 2004, Version 6.0, database were added. All assembly modifications were based on information specified in the historical project documentation but are not included within the default RACER estimate.	This scenario was used to isolate and identify any issues with the RACER model assemblies. These can include the assembly itself, as well as quantities being calculated by the model algorithms.
4	Scenario 4 consisted of copying Scenario 3 and changing the location factor to the US 96 City average.	This scenario was used as the baseline estimate to determine how location factors for each project affect the project costs. Its purpose was to identify any significant problems with an estimate that involve a location factor modification.

Table 2.1 - Scenario Description Table

Subtask D - Assess Model Outputs

Based on the level of detail found in the historical cost documentation, analyses were performed at both the phase level and at the technology level. Once model data was run through the four different scenarios for each project, the percent difference in cost

between the RACER estimates and historical project costs was analyzed to determine how the models performed based on the following criteria:

- *Cost Reasonableness*

The phases and technologies were reviewed for cost reasonableness. The statistical analysis of cost differentials between historical project cost and RACER estimates were performed at both the project and technology levels. In the cumulative analysis, once a sufficient number of project estimates were completed, the difference in cost was analyzed statistically to evaluate the standard deviation between predicted and historical project cost at the phase and technology level.

- *Default Parameter Reasonableness and Accuracy*

This review was conducted by comparing cost differentials between Scenarios 1 and 2. The greater the difference, the greater the likelihood that the default parameters do not accurately reflect actual field conditions. For example, if Scenario 1 had a mean cost difference of 50% between RACER estimates and historical costs, and by changing default secondary parameters (Scenario 2) the mean cost difference was reduced to 15%, then it can be concluded that the default parameters do not adequately reflect actual historic project costs.

- *Best Environmental Engineering Practices*

In cases where the difference in cost was high, the model or phase was evaluated to determine the reason. This was accomplished by reviewing the assembly information to determine if the assemblies used coincided with current best environmental engineering practices.

Subtask E - Analyze Models

The team evaluated each project's RACER estimates against historical project cost by first calculating the percentage cost difference $[(\text{RACER Estimate} - \text{Historical Cost}) / (\text{historical costs})]$. These cost differences were then averaged across all projects for each of the four scenarios.

The team then aggregated model outputs in appropriate data sets to accumulate comparable data for statistical analysis. Initially, model outputs for each scenario were aggregated by project and compared with other projects from previous site visits to evaluate the average variance for each scenario. This activity confirmed the utility of the modified scenario approach used to identify and isolate cost drivers. Technologies with a greater number of occurrences (larger sample size) can be assessed statistically with a greater level of confidence than those with lower frequency. Based on technology occurrences over the life of the project, specific projects with technologies desired for analysis were targeted at future location visits.

3.0 Summary of Location Visits

The data collection team visited 11 locations and performed Internet research to gather historical data for completed environmental remediation projects. Most of these 11 locations were USACE district offices with the exception of the Air Force Center for Environmental Excellence (AFCEE) in San Antonio, TX.

The information below lists locations, dates of visits, and project counts for analysis in RACER.

Location: Omaha, NE (USACE)

Date: December 1–5, 2003

- 19 projects were collected.
- 11 projects were selected for analysis with RACER.

Location: San Antonio, TX (AFCEE)

Date: January 6–10, 2004

- 21 projects were collected.
- 13 projects were selected for analysis with RACER.

Location: Sacramento, CA (USACE)

Date: February 2–6, 2004

- 21 projects were collected.
- 19 projects were selected for analysis with RACER.

Location: Louisville, KY (USACE)

Date: March 8–March 12, 2004

- 17 projects were collected.
- 9 projects were selected for analysis with RACER.

Location: Seattle, WA (USACE)

Date: March 29–April 2, 2004

- 23 projects were collected.
- 16 projects were selected for analysis with RACER.

Location: Mobile, AL (USACE)

Date: June 14–June 18, 2004

- 3 projects were collected.
- 2 projects were selected for analysis with RACER.

Location: Kansas City, MO (USACE)

Date: July 13–July 16, 2004

- 12 projects were collected.
- 7 projects were selected for analysis with RACER.

Location: Baltimore, MD (USACE)

Date: July 27–July 31, 2004

- 24 projects were collected.
- 12 projects were selected for analysis with RACER

Location: Savannah, GA (USACE)

Date: August 9–August 13, 2004

- 19 projects were collected.
- 12 projects were selected for analysis with RACER.

Location: Concord, MA (USACE)

Date: August 17–August 20, 2004

- 13 projects were collected.
- 9 projects were selected for analysis with RACER.

Location: Tulsa, OK (USACE)

Date: August 23–26, 2004

- 27 projects were collected.
- 10 projects were selected for analysis with RACER.

Location: Internet Research

- 11 projects were selected for analysis with RACER.

Lessons Learned From Data Collection and Site

- Proper preparation through advance communication with the USACE District Office is essential to successful location visits. In one case, the team delayed a location visit until site personnel were ready to provide support. Two other location visits might have been similarly postponed, but a limited schedule prevented further delays. Careful scheduling was important in order to gain access to key personnel and allow time for records to be assembled.
- The level of data completeness as it pertains to project cost reporting and scope of work is variable between district offices and affects the ability to consistently examine historical cost performance for environmental remediation. Project templates were developed to ensure that all necessary project parameters were identified and interpreted consistently.

- Ensure that environmental records are readily accessible. Access to formal contract documentation is critical to understanding the project history and performance, and varying archiving and filing practices made obtaining some records difficult.
- Schedule time to interview project managers to capture key information related to cost, schedule, and technical performance issues. These individuals provided valuable insight into the project history and know what is important to consider in evaluating cost performance.
- The support of government representatives was critical to arranging successful location visits providing access to knowledgeable personnel and to overcome data deficiencies. We would like to acknowledge the important support and technical contribution of the USACE, USAEC, and AFCEA personnel who participated in the oversight and execution of this project.
- Projects identified during the Internet research proved to contain sufficient data to conduct all four of the analysis scenarios. For eight of the Internet projects, enough project information was available to run comprehensive estimates that encompassed the entire scope of the project. Additionally, the information that is present in the projects is comparative to what RACER users would have when creating parametric estimates. The Internet projects proved to be a good baseline comparison for high-level cost analysis with the RACER system. This is especially true since the Internet projects included final project cost information.

4.0 Data Collection Summary

The following list is indicative of the types of historical project documents collected:

Scope of Work (SOW) – Produced by the government before the project is started, this document provides a detailed description of the work to be performed at the site.

Contractor’s Technical Proposal – A detailed description of the work to be performed at the site, produced by the contractor and submitted to the government for review as a response to a request for proposal. Typically, this document provides a detailed discussion of how the contractor proposes to accomplish the work, and in some cases, a corresponding cost estimate is attached.

Contractor’s Estimate (at the time of award) – An estimate, proposal, or price from an independent contractor stating the charge to accomplish the work detailed in the SOW. Typically this is the estimate, which was used to accomplish the work, (the winning proposal).

Independent Government Estimate (IGE) – An independent detailed estimate by the government or a government representative used to evaluate the winning proposal and used as a basis for negotiations.

Construction Completion Report – The final document compiled and submitted by the contractor performing the work on a project to the government. Typically, the document summarizes the work performed during the construction phase of a project.

Invoice – The document submitted to the government during or at the end of a project summarizing the work performed for payment of work completed.

In some cases, the documentation collected was insufficient for the purpose of assessing the RACER models against the historical costs. For example, the data collection team may have located a contractor’s estimate and the original scope of work, but neither document provided a description detailed enough to complete a RACER estimate.

Table 4.1 below describes the level of data completeness for collected projects and the minimum types of documentation required to meet each level. Projects that fall within either the high or medium categories were selected to be included in the data analysis. Projects that fall within the low category were not selected for data analysis, but the source data was retained for possible future analysis and reference.

Level of Data Completeness At Project Level		
Information Type	Document Types	
High (Selected)	Scope, design, and detailed cost information available from the time of award to the project closeout stage, including scope or design modifications made during the life of the project.	<ul style="list-style-type: none"> • Scope of Work • Contractor’s estimate at time of award • Contractor’s Technical Proposal • Construction and Completion Report • Final Invoice/Cost Breakdown • Project Modification Details • Contract Execution Summary
Medium (Selected)	Scope, design, and cost information available at the time of award, or final project closeout information including cost and scope was available.	<ul style="list-style-type: none"> • Scope of Work • Contractor’s Technical Proposal • Contractor’s Estimate at time of award <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • Construction and Completion Report • Final Invoice/Cost Breakdown
Low (Not Selected)	Scope, design, and partial cost information available for the project, no final project information found, and incomplete/no project data.	<ul style="list-style-type: none"> • Scope of Work • Partial Technical Proposal • Partial Contractor’s Estimate • Various Reports • Independent Government Estimates (IGEs)

Table 4.1 - Project Data Completeness Levels

Appendix A-1 provides selected project summary information from each of the 11 location visits and Internet research. A total of 211 total projects were collected, with 131 projects selected for RACER modeling and analyses.

Geographic diversity of project locations was sought for cost comparisons of RACER estimates to historical projects in order to eliminate regional bias. Figure 4.1 below depicts the geographical distribution of all projects selected from location visits. The project sites are symbolically depicted by USACE district office or AFCEE.

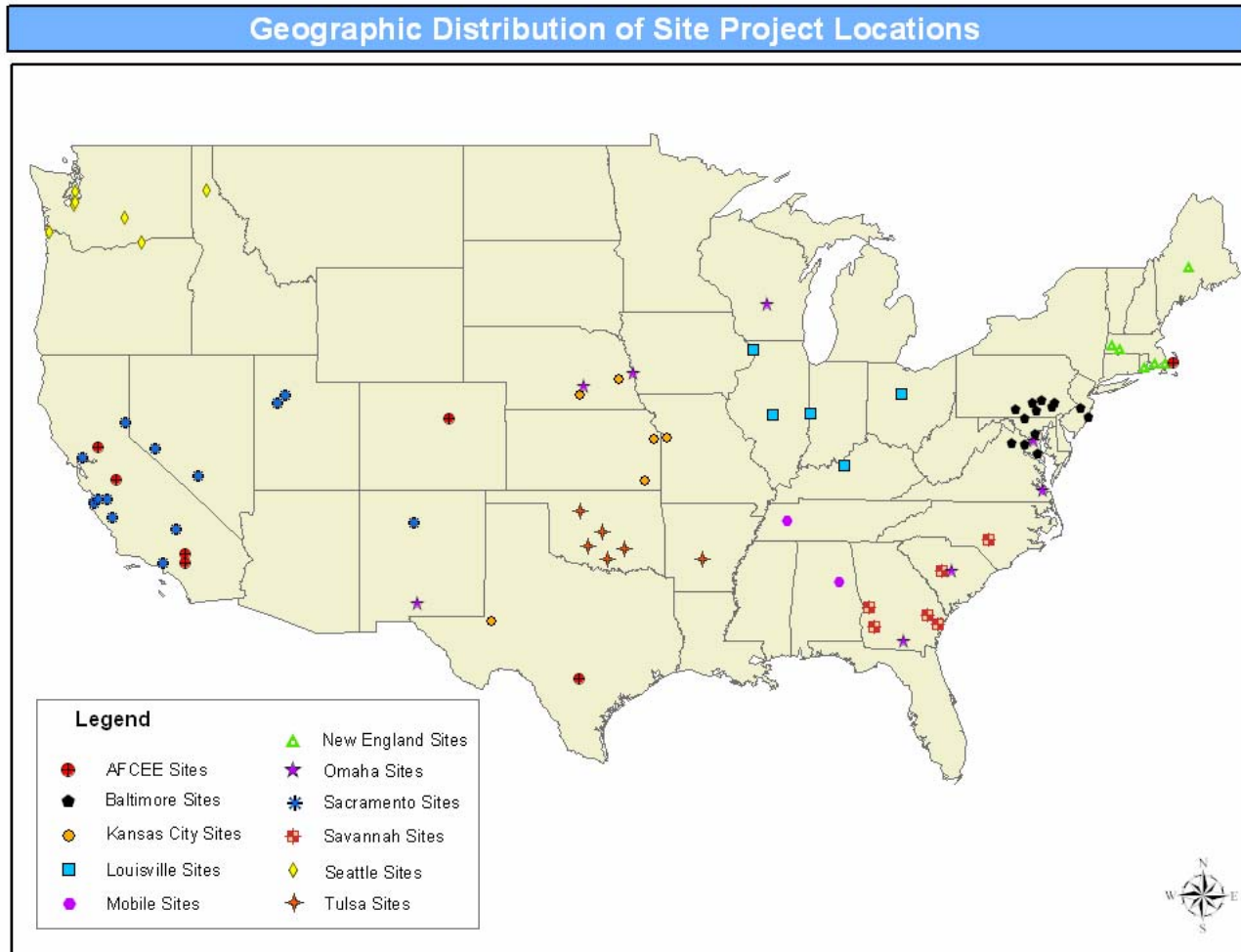


Figure 4.1 - Geographical Distribution of All Selected Projects

In addition to geographical diversity, multiple program category and contract award types were goals when collecting historical project data. Figure 4.2 below depicts the number of selected projects by DoD environmental program category.

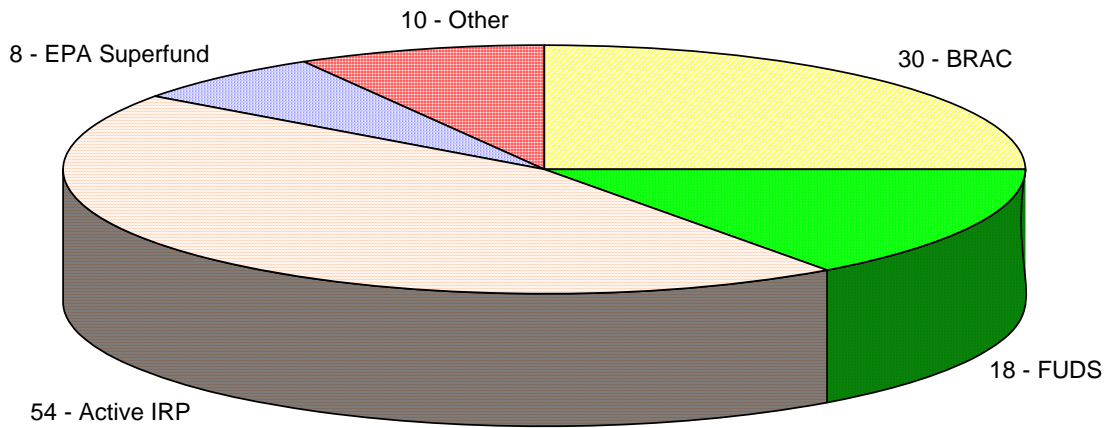


Figure 4.2 - Selected Projects by Program Category⁵

This program data was useful to ensure an adequate crosscut of DoD environmental remediation programs. The majority of selected projects were garnered from the Installation Restoration Program.

Figure 4.3 below depicts the number of projects selected for analysis by contract award type. This was an important factor in eliminating potential bias in evaluating RACER estimates relative to historical project costs. The percentage results show that the majority of contract award types were firm fixed price.

⁵ It should be noted that the total number of projects given in Figure 4.2 does not equal the 131 projects selected for the RACER modeling and analysis. Due to the fact that the projects collected on the Internet do not provide Program Category information, they were not included in the figure.

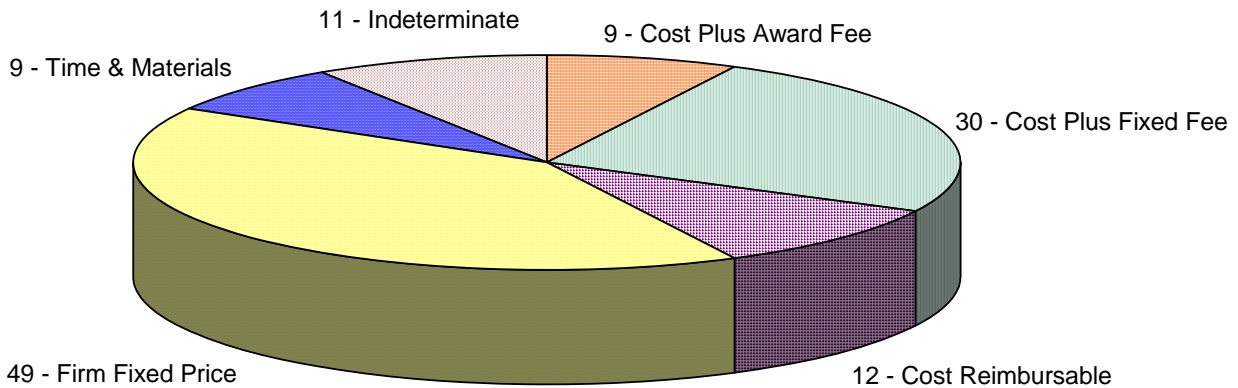


Figure 4.3 – Selected Projects by Contract Award Type⁶

4.1 TECHNOLOGY INFORMATION

During the historical data deconstruction process, phases and associated technologies were identified specific to each of the projects selected and reviewed. Parameters associated with each technology were extracted from the historical project documentation and then ultimately entered into the associated RACER (technology) models. The estimated project costs produced by RACER were then compared with historical cost data for each project using the scenario approach described in Section 2. When possible, line items and quantities from the historical project cost were compared against the RACER assemblies and quantities from the RACER model.

Seventy-four RACER models were utilized when completing the RACER estimates using historical project costs. There were 699 total technology occurrences within the selected projects based on the number of times a technology may have been used at different sites. The list of technologies that were utilized and the number of instances of each are presented in Table 4.2 below.

⁶ It should be noted that the total number of projects shown in Figure 4.3 does not equal the 131 projects selected for RACER modeling and analysis. Due to the fact that the projects collected on the Internet do not provide Contract Award Type information, they are not included in the figure.

Technology Category	RACER Technology Model	Number of Instances
Study	Corrective Measures Study	2
Study	D&D-Final Status Survey	1
Study	D&D-Site Characterization Survey	1
Study	Feasibility Study	4
Study	RCRA Facility Investigation	1
Study	Remedial Investigation	7
Study	Site Inspection	2
Site Work	Access Roads	7
Site Work	Clean-up and Landscaping	27
Site Work	Clear and Grub	17
Site Work	Decontamination Facility	8
Site Work	Demo, Catch Basins/Manholes	2
Site Work	Demolition, Buildings	5
Site Work	Demolition, Curbs	1
Site Work	Demolition, Fencing	5
Site Work	Demolition, Pavements	9
Site Work	Demolition, Sidewalks	1
Site Work	Demolition, Underground Pipes	5
Site Work	Overhead Electrical Distribution	2
Site Work	Parking Lots	1
Site Work	Resurfacing Roadways/Parking Lots	1
Remedial Design	Remedial Design	4
Remedial Action/Study	Groundwater Monitoring Well	21
Remedial Action/Study	Load and Haul	18
Remedial Action/Study	Monitoring	63
Remedial Action/Study	Off-site Transportation and Waste Disposal	76
Remedial Action/Study	Professional Labor Management	121
Remedial Action/Study	Residual Waste Management	8
Remedial Action	Air Sparging	8
Remedial Action	Air Stripping	8
Remedial Action	Asbestos Abatement	1
Remedial Action	Bioslurping	5
Remedial Action	Bulk Material Storage	1
Remedial Action	Capping	18
Remedial Action	Carbon Absorption (Gas)	4
Remedial Action	Carbon Absorption (Liquid)	10
Remedial Action	D&D, Surface Decontamination	1
Remedial Action	Ex Situ Land Farming	7
Remedial Action	Ex Situ Solidification/ Stabilization	9
Remedial Action	Excavation	55
Remedial Action	Fencing	14
Remedial Action	Free Product Removal	4
Remedial Action	Groundwater Extraction Wells	10
Remedial Action	In Situ Biodegradation	2
Remedial Action	Injection Wells	7
Remedial Action	Media Filtration	2
Remedial Action	Miscellaneous Field Installation	3
Remedial Action	Off-site Transportation and Thermal Treatment	3
Remedial Action	Oil/Water Separation	1
Remedial Action	On-site Low Temp. Thermal Desorption	3
Remedial Action	Permeable Barriers	2
Remedial Action	Phytoremediation	1
Remedial Action	Site Close-Out Documentation	3
Remedial Action	Slurry Wall	1
Remedial Action	Soil Vapor Extraction	11
Remedial Action	Storage Tank Installation	1
Remedial Action	Thermal & Catalytic Oxidation	1
Remedial Action	Trenching/Piping	7
Remedial Action	Underground Storage Tank Closure/Removal	30

Table 4.2 - Number of Instances of Each RACER Technology (All Locations)

Technology Category	RACER Technology Model	Number of Instances
Operations and Maintenance	Air Sparging	2
Operations and Maintenance	Air Stripping	4
Operations and Maintenance	Bioslurping	1
Operations and Maintenance	Bioventing	2
Operations and Maintenance	Capping	2
Operations and Maintenance	Carbon Adsorption (Gas)	1
Operations and Maintenance	Carbon Adsorption (Liquid)	13
Operations and Maintenance	Free Product Removal	6
Operations and Maintenance	Groundwater Extraction Wells	5
Operations and Maintenance	Infiltration Gallery	3
Operations and Maintenance	In Situ Biodegradation	1
Operations and Maintenance	Injection Wells	1
Operations and Maintenance	Oil/Water Separation	1
Operations and Maintenance	Soil Vapor Extraction	3
Operations and Maintenance	Thermal & Catalytic Oxidation	1
	Total Number of Technology Instances	699
	Total Number of Technologies Collected	74

Table 4.2 - Number of Instances of Each RACER Technology (All Locations) - Continued

4.2 PROJECT IDENTIFICATION

This section provides specific project detail that was gathered during location visits and is the basis for the organizing and accessing the historical data collected.

Installation Name – The installation under which the project was completed. The installation name corresponds to the folder level within the RACER estimate.

Federal Facility Identification Number – The Federal Facility Identification Data Standard provides a consistent means of identifying facilities that are owned or operated by the federal government. The data standard consists of data elements and their permissible values that indicate a facility (or the land it occupies) is owned or operated by the federal government. Also included is information about the federal agency or organization that is responsible for the facility or land. The role or management relationship of the responsible party to the facility or land may also be specified.

Project Name – The project name is the name defined in the historical data collected. Note that in some cases this is different from the name found in the client database systems. This is the Level 1 name entered into RACER.

Project ID – The project ID is the contract and task order number defined in the historical data collected. Note that in some cases this is different from the ID found in the database systems. This is the Level 1 ID entered into RACER.

Project Date – The project date is the date of project execution found on the project documentation from which the data was derived. This date may not be the same as when the project was actually completed or called out in the client database systems.

Location – The project location is the city or state where the work was performed. This location parameter may differ from the location where the data was collected or the project was managed.

Documents Collected – This includes all project documentation collected during the data collection effort.

Technologies Used – This includes all technologies found within the project documentation.

5.0 Cumulative Analysis of Data and Cost Differentials

For this section of the report, historical cost data and RACER estimates were evaluated to determine relevant differences under each scenario. Data from 12 locations (11 location visits plus Internet research from the Federal Remediation Technologies Roundtable Web site) are presented as a percent difference (ratio) between the RACER estimates and identifiable historical project costs. This assessment pertains to the 131 selected projects⁷ (for all locations) and demonstrates clearly the cost differential trends (costs tightening from Scenarios 1 to 3) and data fit between identifiable historical data and RACER estimates.

Although there are a total of 131 selected projects, the number of projects analyzed for each scenario varies. To prevent mean analyses from giving misleading descriptions of the central tendencies of the data for each scenario analysis, sample projects with differences between RACER estimates and identified historical costs greater than 200% were omitted as outliers⁸. Scenario 1 has 13 outliers, Scenario 2 has 10 outliers, Scenario 3 has 6 outliers, and Scenario 4 has no outliers. Omitting the outliers brings the number of selected projects analyzed for each scenario to:

- Scenario 1 – 118 projects
- Scenario 2 – 121 projects
- Scenario 3 – 125 projects
- Scenario 4 – 131 projects

The analysis consists of an evaluation of the difference between the RACER estimates and the identified historical project costs. An example of sample project cost data and how cost differences were calculated for each scenario are shown in Table 5.0.

Scenario	Historical Project Cost (1)	RACER Estimated Project Cost (Marked-Up) (2)	Difference (\$) (3)=(2)-(1)	Percent Difference (4)=(3)/(1)
Scenario 1	\$ 427,063	\$ 722,388	\$ 295,325	69%
Scenario 2	\$ 427,063	\$ 375,378	(51,685)	-12%
Scenario 3	\$ 427,063	\$ 386,437	(40,626)	-10%
Scenario 4	\$ 427,063	\$ 394,121	(32,942)	-8%

Table 5.0 Sample Project Cost Difference

⁷A selected project only uses historical project information that can be cross-walked into a RACER estimate.

⁸It was determined that sample projects with cost differences greater than 200% were not understood well enough to explain the considerable difference between the RACER estimate and historical project cost. Thus, these projects were omitted from the sample analysis for that scenario.

Five measures of the percent difference are used for analyses:

- Absolute value of mean cost difference
- True mean cost difference
- Standard deviation of each mean cost difference
- Correlation coefficient
- Regression analysis

The absolute value of mean cost difference is computed using the following formula:

$$(1) \text{ ABS}(\mu) = \frac{1}{M} \sum_{i=1}^M \left| \left(\frac{\text{RACER} - \text{Historical}}{\text{Historical}} \right)_i \right|$$

Where: RACER = RACER cost estimate,

Historical = Identified historical project cost, and

M = Total number of projects for each scenario (excluding outliers).

Using the absolute value of mean cost difference provides a meaningful comparison between scenarios. The absolute value of mean cost difference converts the negative difference values between RACER estimates and historical project costs into positive values. Thus, this measure only evaluates the positive percent difference between RACER estimates and historical project costs. This provides a comparative basis to evaluate the relative accuracy of the RACER tool at different levels of use (default, secondary, and assembly levels).

The true mean cost difference provides a metric to evaluate the accuracy of RACER on a program-wide basis to predict average project cost. The true mean difference in cost evaluates both the positive and negative values as they pertain to the RACER estimate difference relative to the historical project cost. So the true mean value can be closer to zero as the positive and negative values cancel out. The true mean cost difference is computed using the following formula:

$$(2) \mu = \frac{1}{M} \sum_{i=1}^M \left(\frac{\text{RACER} - \text{Historical}}{\text{Historical}} \right)_i$$

Where: RACER = RACER cost estimate,

Historical = Identified historical project cost, and

M = Total number of projects for each scenario (excluding outliers).

The third cost difference measure evaluated is the standard deviation of each mean cost difference. The standard deviations for both absolute value of mean cost difference and true mean cost difference are computed using the following formulas respectively.

$$(3) \text{ ABS}(\sigma_{\text{PercentDifference}}) = \sqrt{\frac{1}{M} \sum_{i=1}^M \left[\left| \left(\frac{\text{RACER} - \text{Historical}}{\text{Historical}} \right)_i - \text{ABS}(\mu_{\text{PercentDifference}}) \right|^2 \right]}$$

$$(4) \sigma_{\text{PercentDifference}} = \sqrt{\frac{1}{M} \sum_{i=1}^M \left[\left(\frac{\text{RACER} - \text{Historical}}{\text{Historical}} \right)_i - \mu_{\text{PercentDifference}} \right]^2}$$

Where: RACER = RACER cost estimate,

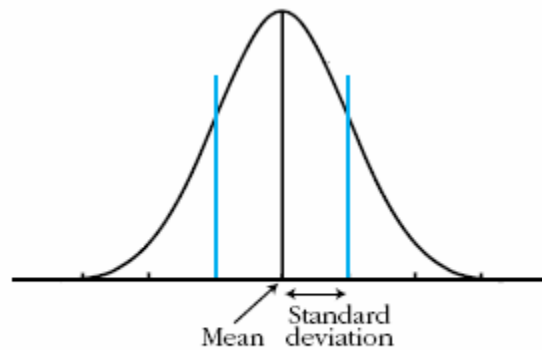
Historical = Identified historical project cost, and

M = Total number of projects for each scenario (excluding outliers).

ABS ($\mu_{\text{Percent Difference}}$) = Absolute value of the mean, and

$\mu_{\text{Percent Difference}}$ = True mean.

The standard deviation is a measure of the dispersion of the data from the mean. A smaller standard deviation indicates less variation in the difference between RACER estimates and identified historical project costs from the mean. Figure 5.0 (a) below illustrates the concept of the standard deviation of a normal distribution. Standard deviation values are an important factor in considering how well RACER produces cost estimates in comparison with historical projects. Hypothetically, a mean of 50% with a standard deviation of 50% across all selected projects would imply that RACER could produce estimates within a range of +/- 100% of the average expected cost.



Visualizing the Standard Deviation

Figure 5.0(a) Normal Curve Distribution and Standard Deviation

The correlation coefficient is also used to analyze the percent difference between RACER estimates and identified historical costs. The correlation coefficient measures

the linear relationship between the RACER estimates and the identified historical project costs on a scale from -1 to 1. If the identified historical project cost is high and the correlation coefficient is close to 1, the RACER estimate will also be high. Thus, the correlation coefficient provides a predictive value of the RACER estimate based on the identified historical project cost. The correlation coefficient is computed using the following formula:

$$(5) \rho = \frac{\text{cov}(\text{Historical}, \text{RACER})}{\sigma_{\text{Historical}} \sigma_{\text{RACER}}}$$

Where: $\text{cov}(\text{Historical}, \text{RACER}) = E(\text{Historical}, \text{RACER}) - E(\text{Historical})E(\text{RACER})$,
 E is the expected value of the particular function of Historical and RACER,
 $\sigma_{\text{Historical}}$ = Standard deviation of the identified historical costs,
 σ_{RACER} = Standard deviation of the RACER estimate costs,
 Racer = RACER estimate cost, and
 Historical = Identified historical project cost.

The final measure used to evaluate cost differentials is a regression analysis between the RACER estimates and identified historical costs. The regression analysis is computed using the following equation:

$$(6) \text{RACER estimate} = \alpha + \beta(\text{identified historical cost}) + \varepsilon$$

Where: α = Intercept parameter,
 β = Slope parameter, and
 ε = Standard error parameter.

The R^2 value from the regression analysis provides a measure of fit for the RACER estimate from the identified historical cost on a scale from 0 to 1. The closer the R^2 value is to 1, the closer the RACER estimate will be to the identified historical cost. Hypothetically, if the R^2 value were 1, then the RACER estimate would be the *same* as the identified historical cost.

5.1 STATISTICAL COST ANALYSIS AT THE PROJECT LEVEL

Mean Cost Differential

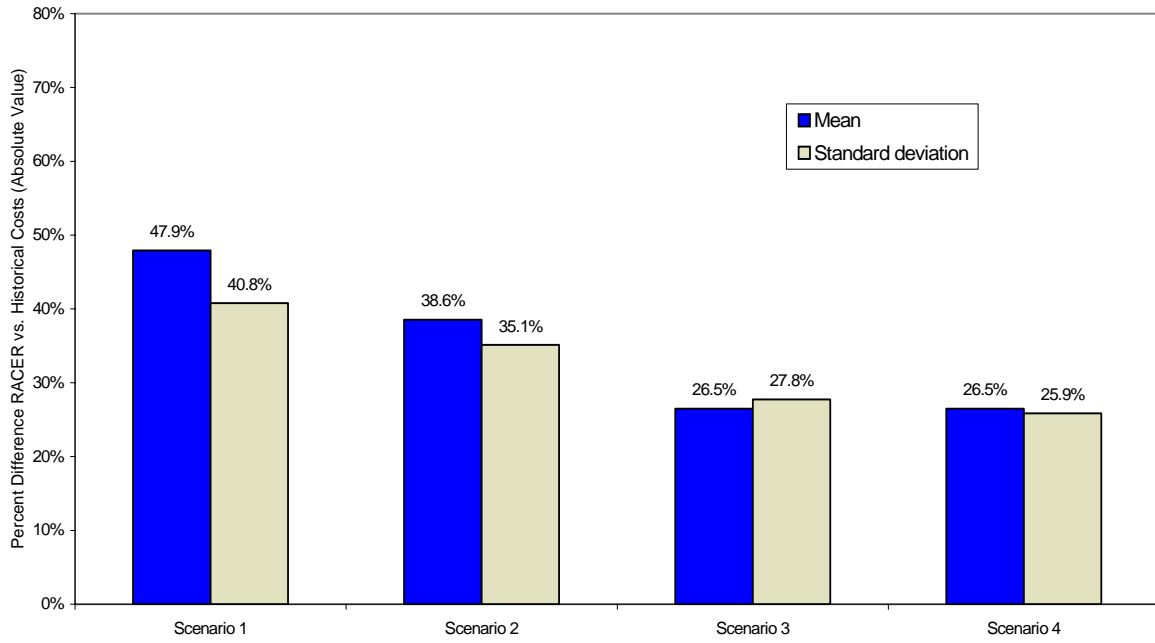


Figure 5.1 – Absolute Value of Mean Cost Difference in RACER Estimate and Historical Project Cost by Scenario

Figure 5.1 presents the absolute value of mean cost difference between RACER estimates and historical project cost for each scenario. The results include data for all 11 location visits and Internet research for the selected projects, excluding outliers. The absolute value of mean cost difference between historical cost and RACER estimates was computed for each scenario (1-4) using Equation 1, while the standard deviation was calculated using Equation 3.

As shown in Figure 5.1, the analysis depicts a step-wise progression in improved estimates beginning with Scenario 1 and continuing through Scenario 3. This outcome is logical as the user is able to provide more project-specific information for the estimate under Scenarios 2 and 3. In Scenario 1, the absolute value of mean cost difference between RACER estimates and historical cost is 47.9% with a standard deviation of 40.8%. In Scenario 2, by modifying important secondary parameters in the model, the absolute value of mean cost difference is reduced to 38.6% with a standard deviation of 35.1%. The analysis of the absolute value of mean cost difference presented in Figure 5.1 reveals a considerable difference between historical costs and RACER estimates under Scenarios 1 and 2. This difference in mean cost under Scenario 1 is exacerbated by large standard deviations that depict broad distribution from the absolute value of mean cost difference.

In Scenario 3, the advanced user can modify specific assemblies that form the basis for the cost estimate, and the absolute value of mean cost difference is reduced to 26.5% with a standard deviation of 27.8%. In Scenario 4, the mean cost difference is also 26.5%, and the standard deviation is 25.9%. Scenario 4 compares the same RACER estimate as Scenario 3 using the 96 city-average location modifier, which sets labor, equipment, and material location modifiers equal to "1". The labor, equipment, and material modifiers are varied up or down by the different location modifiers for each specific location. When the location modifiers were set to "1", as in Scenario 4, the analysis yielded no considerable difference when comparing Scenario 4 to Scenario 3.

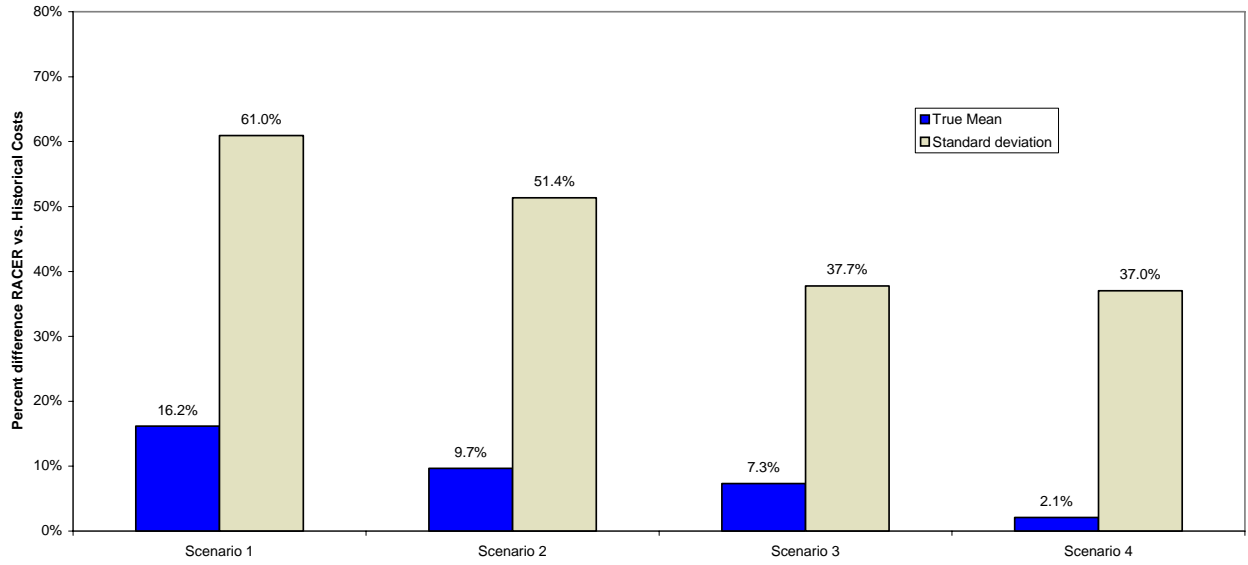


Figure 5.2 True Mean Cost Difference by Scenario

Figure 5.2 shows that the true mean cost difference is much lower than the absolute value of mean cost difference presented in Figure 5.1 for each scenario. This is due to the inclusion of both positive and negative cost differences that tend to cancel each other out. However, the standard deviation is much higher for the true mean cost difference because the data dispersion considers both sides of the expected zero mean.

The true mean cost difference provides insight on the overall effect (program wide) of using RACER for multiple project estimates. A closer look at the dispersion (standard deviation) from the true mean cost difference also provides information on the expected range of outcomes for the RACER estimate relative to the historical costs. The standard deviations for Scenarios 1–4 in Figure 5.2 show relatively high levels of uncertainty in the accuracy and predictability of any given RACER estimate when compared to the historical project cost.

A scatter plot of the cost difference data points provides greater insight into how well RACER estimates cost in comparison with the historical project cost. In Figure 5.3, the cost difference between the RACER estimate and the corresponding identified historical project cost for Scenario 3 (the most detailed comparison) is shown. The percent cost difference in positive and negative terms for 125 projects are displayed. As shown in Figure 5.0 (a), the scatter plot begins to resemble the normal distribution with the true mean cost difference at approximately 0%. The difference in cost generally falls within the 50% cost differential range for most projects. Based on identified historical project cost data, there appears to be no clear trend whether RACER estimates are “low” or “high” for remediation projects, and that the data collected from the 11 site visits and Internet research resemble a normal distribution.

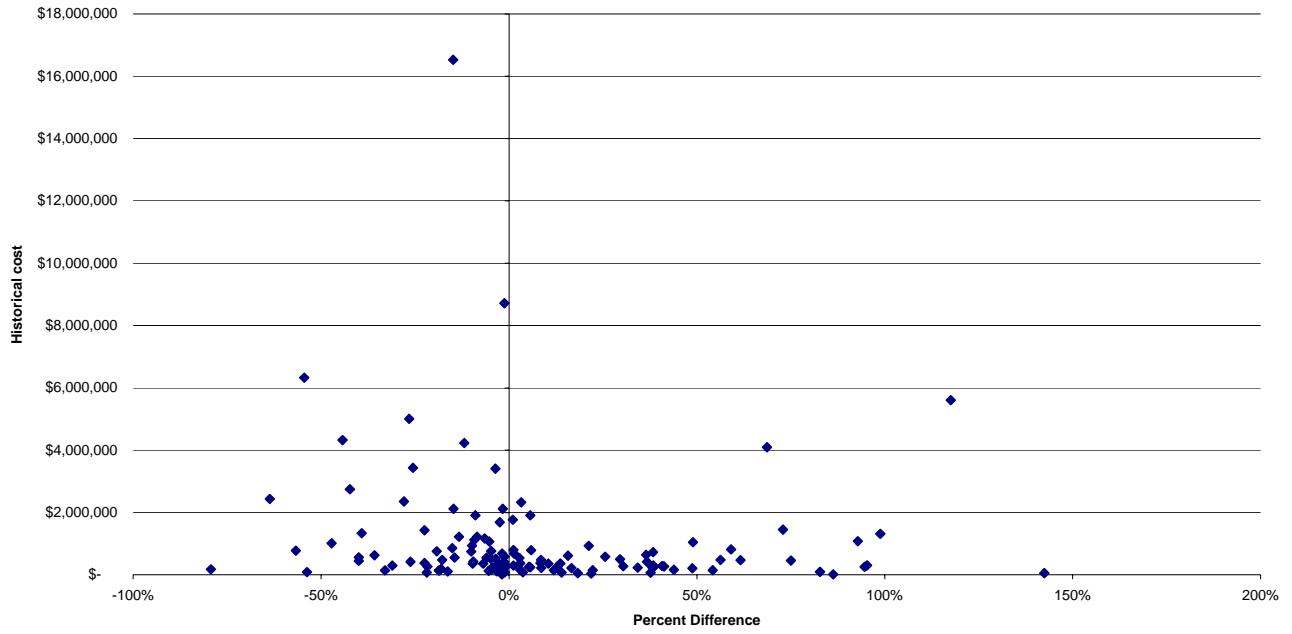


Figure 5.3 – Scatter Plot of Percent Cost Difference Between RACER Estimate and Historical Cost

Correlation Index

The next statistical measure pertains to the correlation of the RACER estimate to the historical cost data. As shown in Table 5.1, the correlation of the RACER estimates and historical cost data improves significantly from Scenarios 1 through 3. These are relatively high correlation values (approaching “1”).

Correlation Coefficient between Historical Project Cost and RACER estimate (All Locations)	
Scenario 1	83%
Scenario 2	87%
Scenario 3	91%
Scenario 4	90%

Table 5.1 - Correlation of RACER Estimate to Historical Cost, by Scenario

Regression Analysis

The least-squares regression analysis result is presented in Figure 5.4.

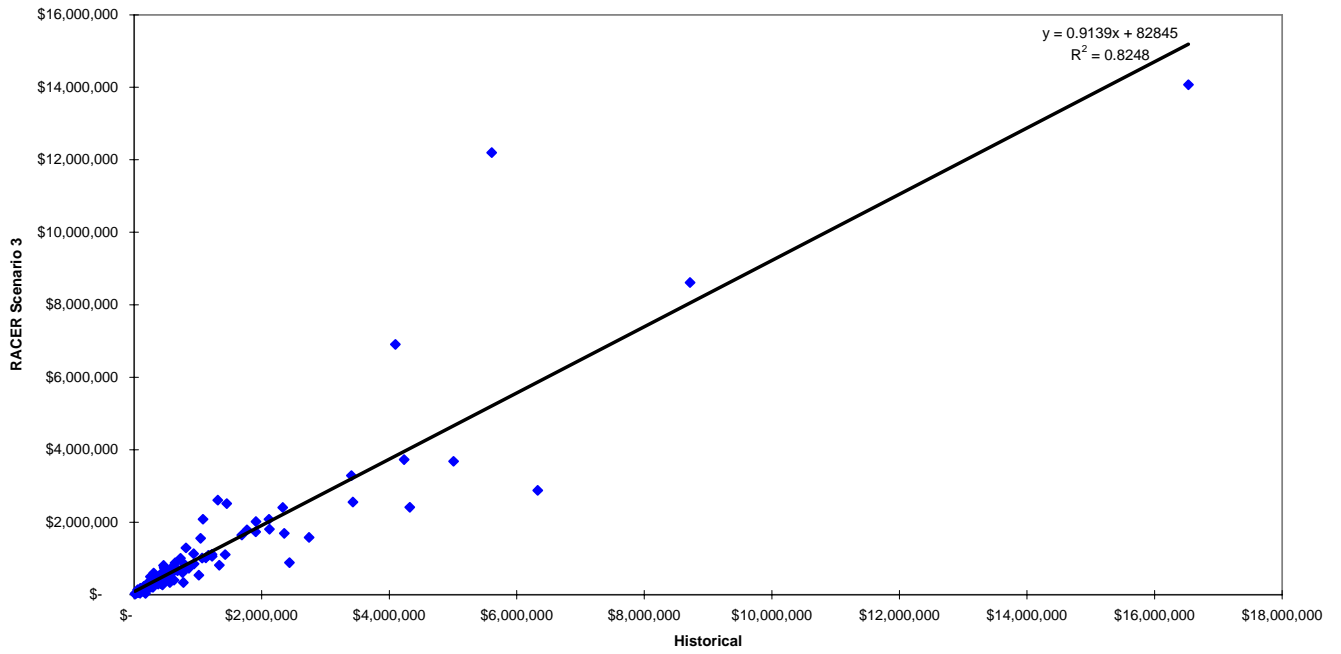


Figure 5.4 - Linear Regression Analysis Scatter Plot, Scenario 3, Locations 1-12

The value of R^2 is most useful as a relative measure across similar data sets, and although a fit above 0.9 usually indicates a “good fit”, this qualitative assessment varies significantly depending on the application. In this analysis, a fit of 0.82 still represents a good R^2 for Scenario 3, particularly in comparison to Scenario 1, which provides a much lower fit value of 0.69.

The slope of the least-squares regression trend line (Scenario 3) is .91. A 1:1 slope (slope of 1.0) would describe a 45-degree line and indicate that the best fit trend (straight line) tracks consistently from low- to high-cost projects. The reported value of .91 is a good fit under Scenario 3.

Table 5.2 below presents conclusive narrowing of the “fit” from Scenarios 1 to 3. The slopes of the best-fit lines also move toward 1.0 across Scenarios 1–4, indicating that the RACER model predictive capability improves across these scenarios, confirming the stepwise improvement in cost estimates.

R-Squared Historical Cost vs. RACER	
Scenario 1	0.70
Scenario 2	0.76
Scenario 3	0.82
Scenario 4	0.81

Table 5.2 - R^2 Results by Scenario (All Locations)

Low- Versus High-Cost Project Analysis

The team performed additional regression analyses, separating the 131 projects into two data sets: historical projects with a cost less than \$500,000 and those with a cost greater than \$500,000 (roughly splitting the total number of projects into two data sets).

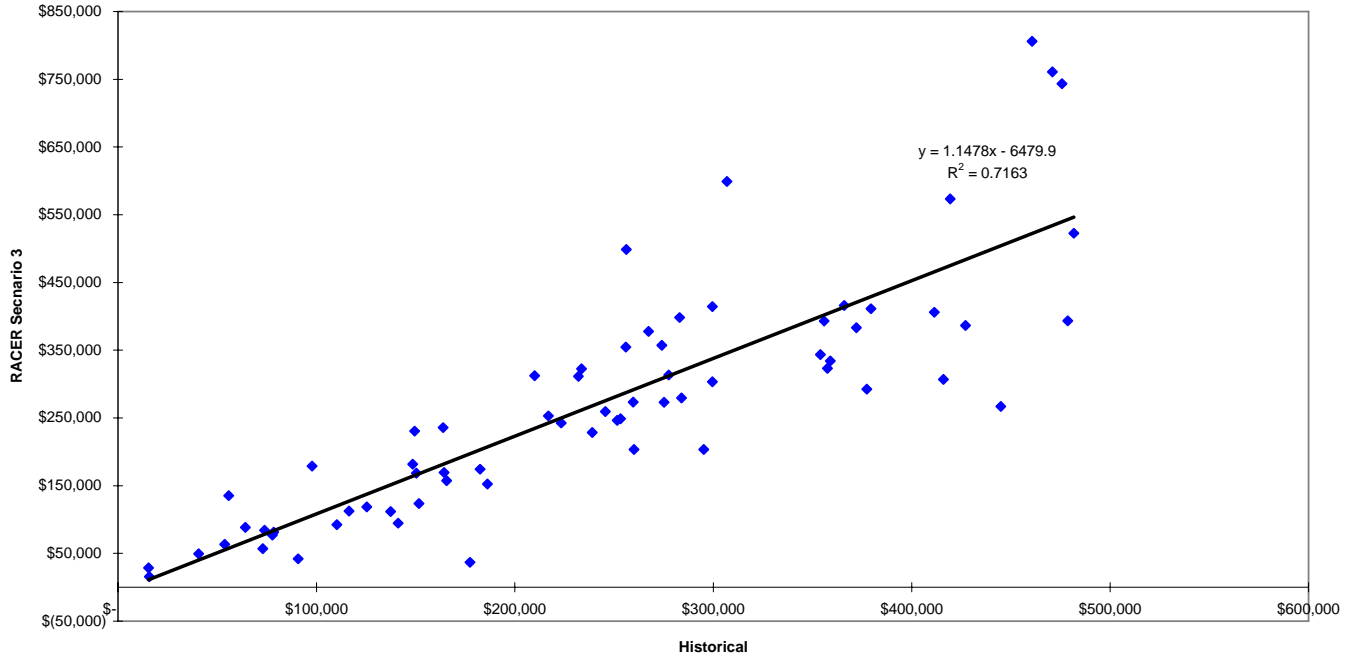


Figure 5.5 - Regression Analysis Scenario 3 Scatter Plot, Projects < \$500,000 (historical cost), Locations 1-12

Results of this analysis for locations 1-12, displayed in Figures 5.5 and 5.6, indicate that with this data set there are no significant statistical differences in the predictability of RACER for low- versus high-cost projects. The R^2 (0.72 for projects less than \$500K, 0.79 for projects greater than \$500K) indicates a slightly greater predictive power for the high-cost projects' regression, and the line slopes (1.15 for <\$500K, .91 for >\$500K) also indicate a slightly tighter fit (closer to 1:1) for the high-cost projects' regression model.

Nonetheless, the analysis presents findings that indicate no comparative advantage to RACER project cost-estimating capability for either low- or high-cost (\$500K threshold) projects.

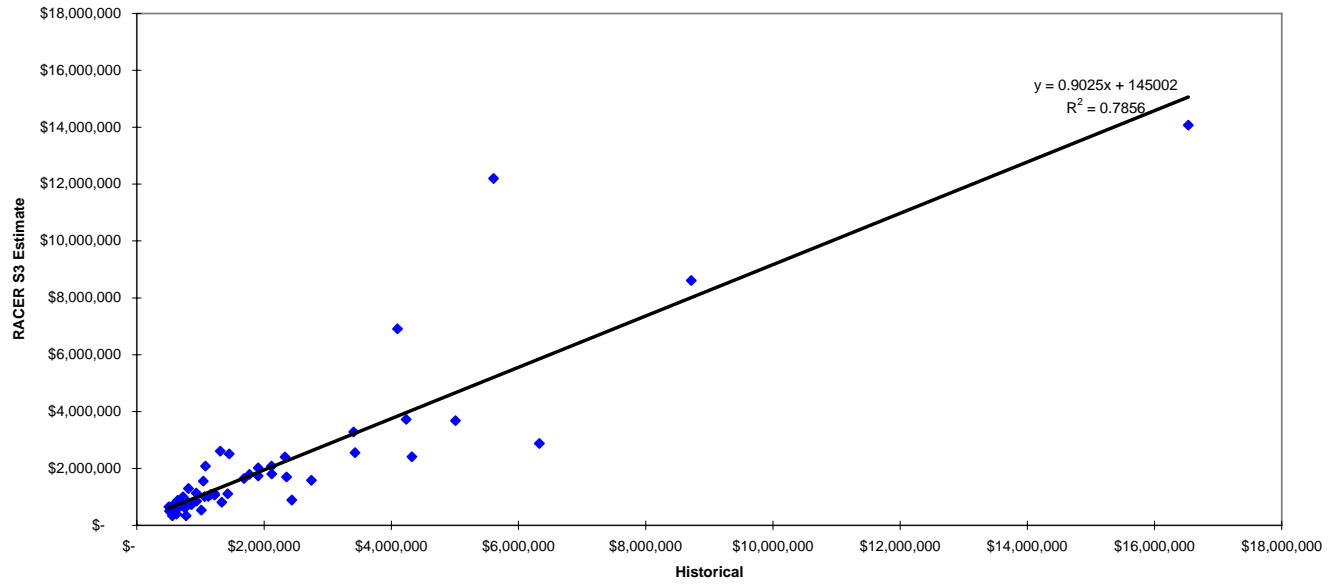


Figure 5.6 -Regression Analysis, Scenario 3, Projects > \$500,000 (historical cost), Locations 1-12

5.2 STATISTICAL ANALYSIS OF TECHNOLOGIES

An approach was developed for evaluating technologies in RACER models based on two major factors:

- Technologies most frequently used in DoD program experience
- Most frequently occurring technologies within the historical project database

In combination, these two factors effectively identified the most important technologies for evaluation. Seventy-four technologies were applied as RACER models in the 131 historical projects. These 74 technologies were applied as RACER models in 699 instances. Table 4.2 describes these technologies and frequency of use in RACER cost estimating during this project

Figure 5.7 below depicts the Top 25 technologies that were identified during this project. The basis for the “Top 25” is RACER models that were most frequently encountered in comparison with selected historical projects. To experienced RACER users, the “Top 25 ” technologies also represent models that are frequently applied to environmental remediation projects based on program experience. As such, these RACER models are typical components of an environmental remediation cost estimate.

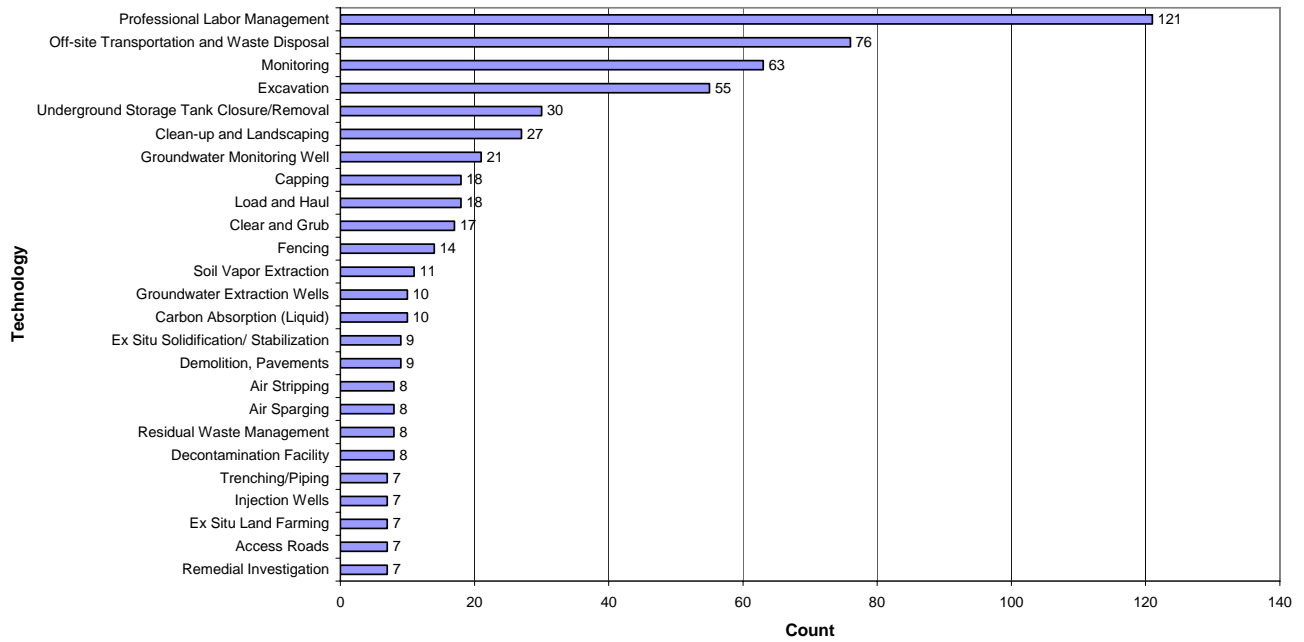


Figure 5.7 - "Top 25" Technologies Identified in Historical Projects

In an effort to develop a viable benchmark for comparison, the USAEC provided a list of the Top 25 technologies based on their user community and program experience. This comparison provides credibility to the top 25 technologies identified during this analysis. Figure 5.8 depicts the USAEC “Top 21” technologies and their frequency of use in comparison with historical projects. The reader should note that 4 of the 25 most common technologies identified by USAEC are ordnance and explosive (OE) models OE Institutional Controls, OE Monitoring, OE Removal Action and OE Site Characterization and Removal Assessment that were not covered by this project.

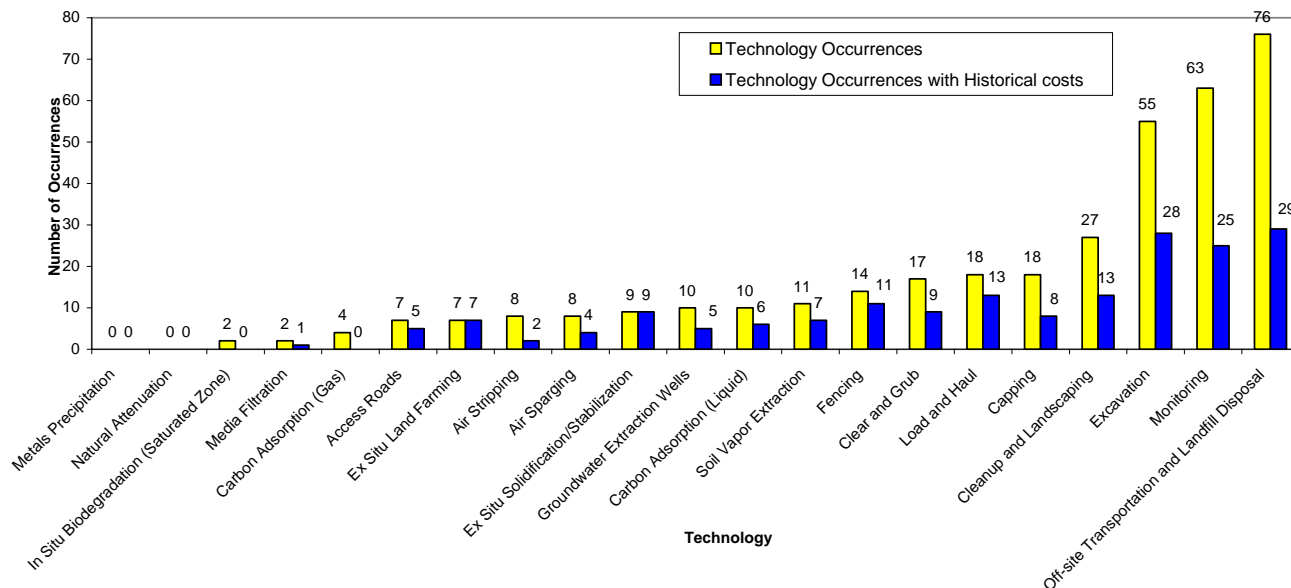


Figure 5.8 – The 21 Most Commonly Used Technologies by USAEC⁹

⁹ Technology Occurrences count the number of technologies identified in the historical projects that could be cross-walked into a RACER estimate. The technology occurrences with historical costs are the number of technologies identified in the historical projects with specific technology costs that could be cross-walked into a RACER estimate.

Analysis of Ten Most Frequently Occurring Technologies

This section evaluates the performance of a subset of the “Top 25” technologies most frequently occurring within the historical cost database. The subset of the ten most frequently occurring technologies are evaluated using the same statistical cost differentials presented in the project-level discussion under Section 5.1. This analysis provides a more specific cost differential evaluation between RACER estimates and historical cost at the technology level. This is especially relevant as the cost difference at the project level is the result of multiple technologies being employed. The examination of the cost difference at the technology level reveals how well, specific and frequently used, RACER models are performing. The reader should note that Section 5.3 of this report identifies key observations for ten technologies. The overlap between the ten technologies most frequently occurring and the ten technologies discussed in Section 5.3 are coincidental and should not confuse the reader.

Figures 5.9–5.12 depict the cost differentials of the ten most frequently occurring technologies under each scenario. These technologies identify relative trends in cost performance and identify outliers. The technologies are arrayed from low to high frequency of identified historical cost occurrence per technology beginning with “Capping” and ending with “Professional Labor Management.”

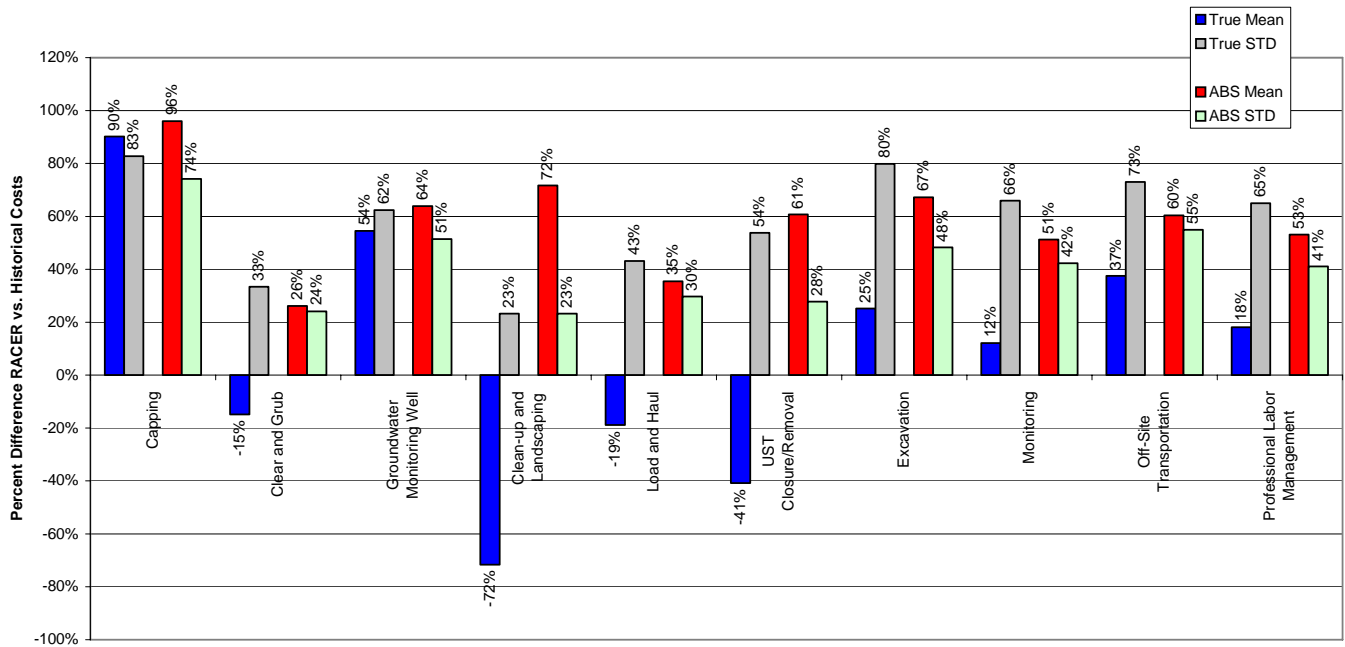


Figure 5.9 – Ten Most Frequently Occurring Technologies – Scenario 1 Percent Difference in Cost¹⁰

¹⁰ Scenario 1: Capping has 8 historical occurrences, but 3 were omitted as outliers.
 Clear and Grub has 9 historical occurrences, but 2 were omitted as outliers.
 Groundwater Monitoring Well has 10 historical occurrences with no outliers.
 UST closure/removal has 13 historical occurrences, but 1 was omitted as an outlier.
 Cleanup and landscaping has 13 historical occurrences with no outliers.
 Load and haul has 13 historical occurrences with no outliers.
 Monitoring has 25 historical occurrences, but 3 were omitted as outliers.
 Excavation has 28 historical occurrences, but 8 were omitted as outliers.
 Off-site transportation has 29 historical occurrences, but 12 were omitted as outliers.
 Professional labor management has 55 historical occurrences, but 6 were omitted as outliers.

Figure 5.9 depicts the ten most frequently occurring technologies for Scenario 1. The absolute value of mean cost difference and true mean cost difference and standard deviations are shown for each technology. Under Scenario 1, technologies that occur less often appear to have a larger mean difference in cost. This can be explained in part due to the smaller sample size, but there are other observations that may prove useful. Capping, Excavation, and UST Closure/Removal are all earthmoving operations with relatively high mean differences in cost. Section 5.3 of this report will address issues identified for these technologies. Professional Labor Management with the largest sample size of 121 instances is a chronically high variance RACER model across all selected projects. Cleanup and Landscaping has a considerably negative true mean cost difference that may reflect the difficulty in modeling these costs. Many of the projects with this technology had unique landscaping requirements tailored to the specific requirements of a particular remedial solution.

Figure 5.10 depicts the ten most frequently occurring technologies for Scenario 2. The absolute value of mean cost difference and true mean cost difference and standard deviations are shown for each technology. The mean difference in cost is reduced across all technologies with the modification of secondary parameters. The standard deviation is also improved for these ten technologies. The pattern of mean difference in cost is consistent with Scenario 1 between technologies.

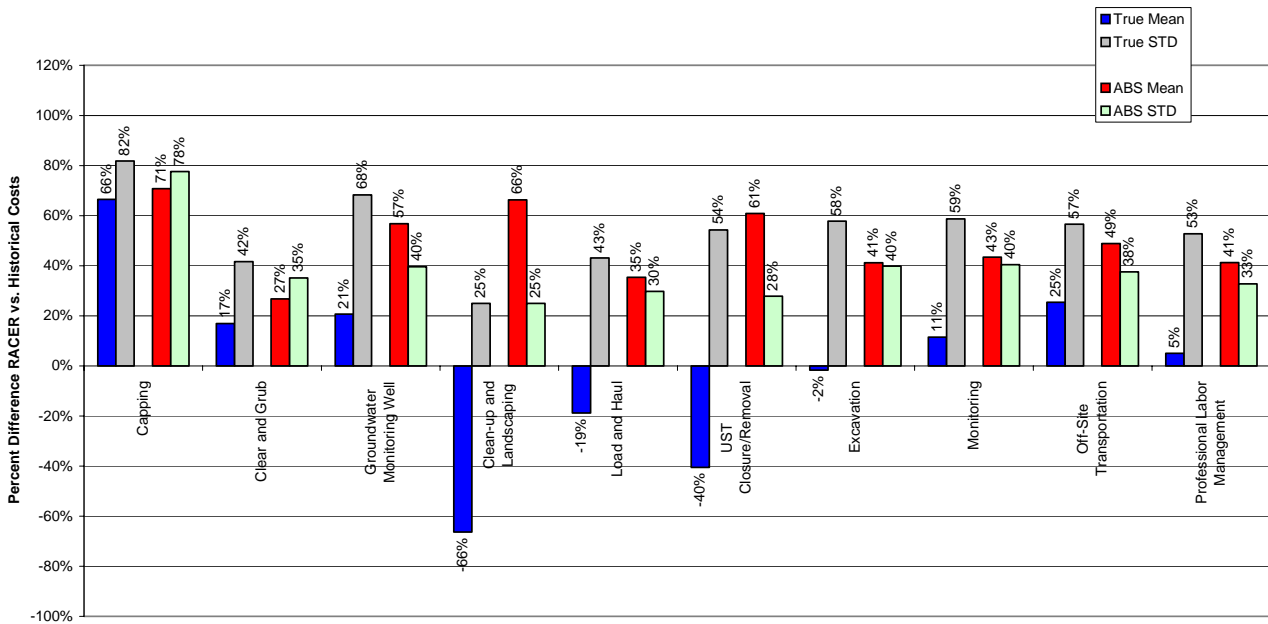


Figure 5.10 – Ten Most Frequently Occurring Technologies – Scenario 2 Percent Difference in Cost¹¹

¹¹ **Scenario 2:** Capping has 8 historical occurrences with no outliers.
 Clear and Grub has 9 historical occurrences, but 2 were omitted as outliers.
 Groundwater Monitoring Well has 10 historical occurrences with no outliers.
 UST closure/removal has 10 historical occurrences, but 1 was omitted as an outlier.
 Cleanup and landscaping has 13 historical occurrences with no outliers.
 Load and haul has 13 historical occurrences with no outliers.
 Monitoring has 24 historical occurrences, but 3 were omitted as outliers.
 Excavation has 27 historical occurrences, but 3 were omitted as outliers.
 Off-site transportation has 27 historical occurrences, but 2 were omitted as outliers.
 Professional labor management has 48 historical occurrences, but 3 were omitted as outliers.

Figure 5.11 depicts the ten most frequently occurring technologies for Scenario 3. The absolute value of mean cost difference and true mean cost difference and standard deviations are shown for each technology. The mean difference in cost is more consistently shown to fall within the 25-50% category with the user's ability to specifically modify parameters and model assemblies.

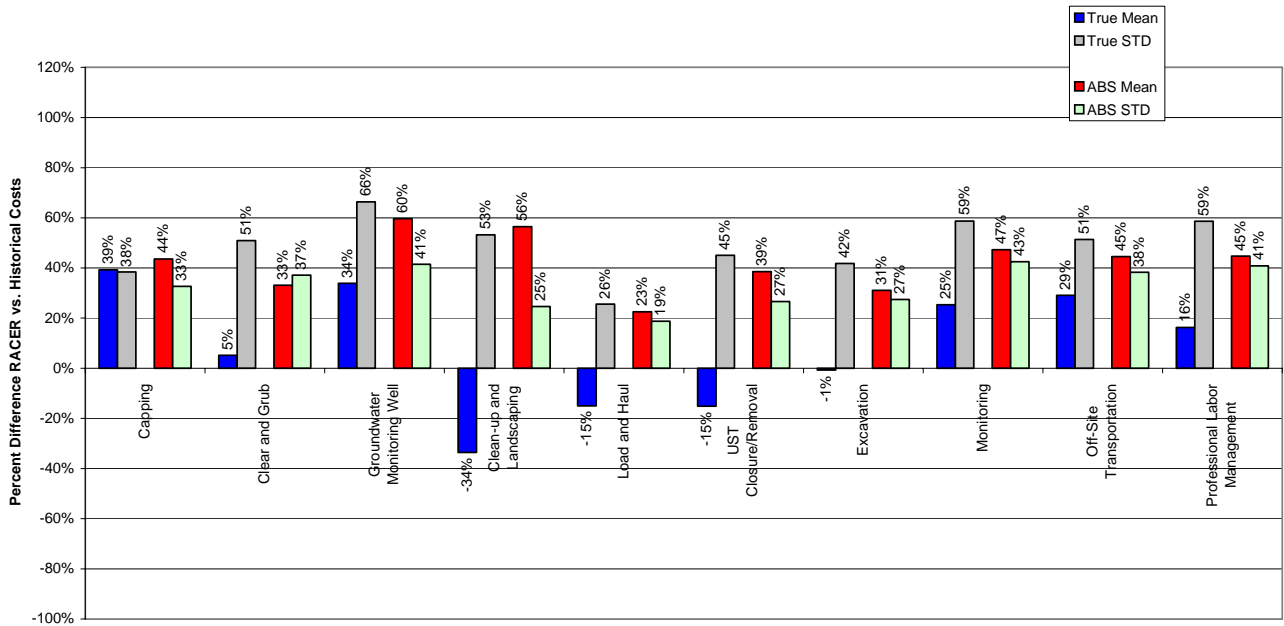


Figure 5.11 – Ten Most Frequently Occurring Technologies – Scenario 3 Mean Difference in Cost¹²

¹² Scenario 3: Capping has 8 historical occurrences with no outliers.
 Clear and Grub has 9 historical occurrences, but 1 was omitted as an outlier.
 Groundwater Monitoring Well has 10 historical occurrences with no outliers.
 UST closure/removal has 13 historical occurrences, but 1 was omitted as an outlier.
 Cleanup and landscaping has 13 historical occurrences with no outliers.
 Load and haul has 13 historical occurrences with no outliers.
 Monitoring has 25 historical occurrences, but 1 was omitted as an outlier.
 Excavation has 28 historical occurrences, but 1 was omitted as an outlier.
 Off-site transportation has 29 historical occurrences, but 1 was omitted as an outlier.
 Professional labor management has 55 historical occurrences, but 2 were omitted as outliers.

Figure 5.12 depicts the ten most frequently occurring technologies for Scenario 4. The absolute value of mean cost difference and true mean cost difference and standard deviations are shown for each technology. Consistent with the analysis of Scenario 4 at the project level in Section 5.1, it does not appear that a considerable difference in the accuracy of estimates is occurring with the use of either area cost factors (Scenario 3) or the 96-City Average (Scenario 4).

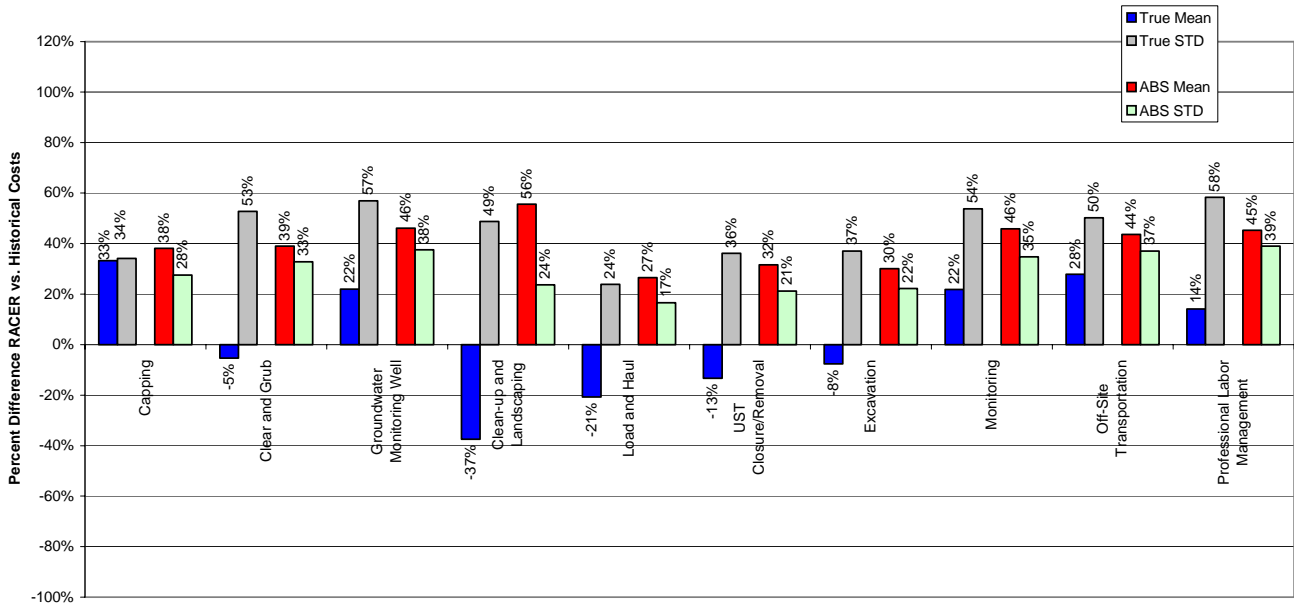


Figure 5.12 - Ten Most Frequently Occurring Technologies - Scenario 4 Mean Difference in Cost¹³

¹³ **Scenario 4:** Capping has 8 historical occurrences with no outliers.
 Clear and Grub has 9 historical occurrences, but 1 was omitted as an outlier.
 Groundwater Monitoring Well has 10 historical occurrences with no outliers.
 UST closure/removal has 13 historical occurrences, but 1 was omitted as an outlier.
 Cleanup and landscaping has 13 historical occurrences with no outliers.
 Load and haul has 13 historical occurrences with no outliers.
 Monitoring has 25 historical occurrences, but 1 was omitted as an outlier.
 Excavation has 28 historical occurrences, but 1 was omitted as an outlier.
 Off-site transportation has 29 historical occurrences, but 1 was omitted as an outlier.
 Professional labor management has 55 historical occurrences, but 3 were omitted as outliers.

5.3 MODEL ENGINEERING ANALYSIS

This section discusses the engineering analysis of the RACER models as it pertains to the list of projects deconstructed for all 11 site locations and Internet research. As part of the critical review of the RACER program, models, assemblies, and unit costs were analyzed to determine if they reflected best practices in environmental restoration. The assemblies were reviewed to see if they needed to be changed or updated, if default parameters needed to be changed, and to identify if new models needed to be developed. This section will assist the Government in gaining a better understanding of the current performance of RACER as well as provide suggestions on how to best update the program.

The following observations were gathered during the deconstruction and development of the four RACER scenarios used for comparison against the historical project costs. During the analysis, the models were reviewed for Cost Reasonableness, Current Technology Methodology, and General Model Functionality. The complete list of RACER observations and recommendations are presented in Appendix C.

The RACER software is based on engineering logic for environmental restoration treatment trains, which are continuously changed and updated. Because environmental technologies are continuously evolving, the RACER software must be assessed and updated as well. Therefore, it is suggested that annual RACER training be implemented for estimators to maintain their proficiency.

Summary of Technology Observations

The following is a summary of observations from all of the 11 locations visited and the Internet research. A more detailed description of the observations is described in Appendix C.

- Existing Models Requiring Enhancements = 32
- Default Secondary Parameters Requiring Enhancement = 26
- Technology Assemblies Requiring Enhancement = 7
- Proposed New Models = 12
- Proposed New Assemblies 31
- Software Bugs = 7

Ten Technologies Most Frequently Observed

The following is a list of the ten most frequently observed, as described in Appendices A and C. The list is ordered by frequency of occurrence in Appendix C. A detailed explanation of suggested solutions is found in the “Recommendations” column of Appendix C. The associated lines in Appendix C are referenced to the right of each technology).

1. UST Closure/Removal (Appendix C, lines 175–197)

2. Excavation (Appendix C, lines 61–78)
3. Monitoring (Appendix C, lines 108–123)
4. Off-Site Transportation and Waste Disposal (Appendix C, lines 133–140)
5. Capping (Appendix C, lines 21–28)
6. General Comment (Markups – Mobilization/Demobilization Costs) (Appendix C, line 84, also on lines 26, 33, 44, 78, 102, 108, and 115)
7. Cleanup & Landscaping (Appendix C, lines 32–35)
8. Professional Labor Management (Appendix C, lines 79, 124, 132, 150, 162, 163)
9. Fencing (Appendix C, lines 80–83)
10. Injection Wells (Appendix C, lines 98–100)

Suggested Improvements to the Most Frequently Observed Technologies

The following is a suggested approach to addressing issues observed in the project observations in Appendix A of the Interim Model Reports from the 11 location visits and the Internet research.

- **UST Closure/Removal Technology**

Throughout the 11 locations visits and Internet research, this technology had 49 observations called out in Appendices A and C. The most frequent observations and with suggested solutions are listed below.

- General Tab (Figure 5.3.1)
 - The following issues are related to the Existing and Replacement Cover parameter sections.
 - Issue: Currently the Existing and Replacement Cover parameter selections are located on the first tab and are considered required parameters. It was observed in several historical projects where different types of replacement covers were needed.
 - Solution: Move the Existing and Replacement Cover parameter selections to the Tank Grp tab(s). This would allow for selection of the tank fields that have varying site conditions.
 - Issue: There were several instances where “Seeding” and/or “Sodding” options for the replacement cover were needed.
 - Solution: Add “Seeding” and “Sodding” to the list of replacement cover types.

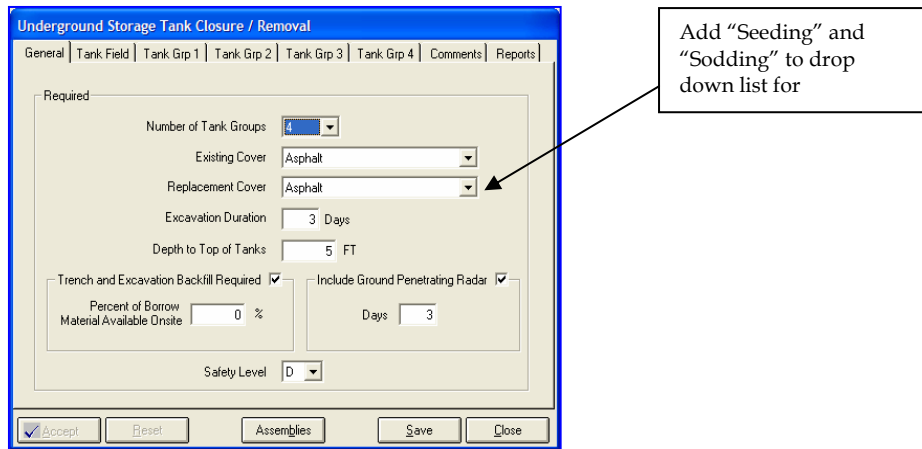


Figure 5.3.1

- **Issue:** There is currently no way to estimate the cost of above ground storage tank removal.
- **Solution:** A new model for above ground storage tank removal could be developed and added to the RACER system. A better suggestion is to consolidate it into the existing UST model and call it “Storage Tank Closure and Removal.”

- **Issue:** The existing UST Closure/Removal model does not include the disposal of the contaminated soil or UST removed from the site. Currently there is no indication to the estimator how to account for the disposal of the tanks being removed from the site.
- **Solution:** There are two possible solutions for these observations. First, change the help system by adding a reminder to the estimator to dispose of the USTs and to add assemblies for disposal in the assemblies section. This would require adding new assemblies for tank disposal to the database and a search option for assemblies in the technology area. The second suggested solution is to modify the graphical user interface (GUI) of this technology to include tank disposal in the technology calculations. This would require adding new assemblies for tank disposal as well as a change to the GUI.

For either suggested solution, the tank disposal assemblies will need to be added to the technology algorithms.

- Tank Field Tab (Figure 5.3.2)
 - **Issue:** Currently the Type of Closure parameter, e.g., “close in place” or “removal,” is located on the Tank Field tab. It was observed in several historical projects where different types of closures were needed at the site.
 - **Solution:** Move the Type of Closure parameter selection to the Tank Grp tab(s). This would allow for selection of the varying types of closures at the site.

- **Issue:** Currently there is no way to estimate the cost for removal of feed lines that are constructed above ground.
- **Solution:** Change the Number of Field Line Trenches and the Total Length of Feed Line Trenches parameters to allow for the possibility of above ground piping.

- **Issue:** As per observations in the historical data, the number of analytical templates for soil and water need to be increased to allow selection of at least two each.
- **Solution:** Add a selection of at least 2 analytical templates for both the water and soil medias. The two templates for each media type need to be defaulted based on selection of the primary and secondary contaminants at the phase level (level 3).

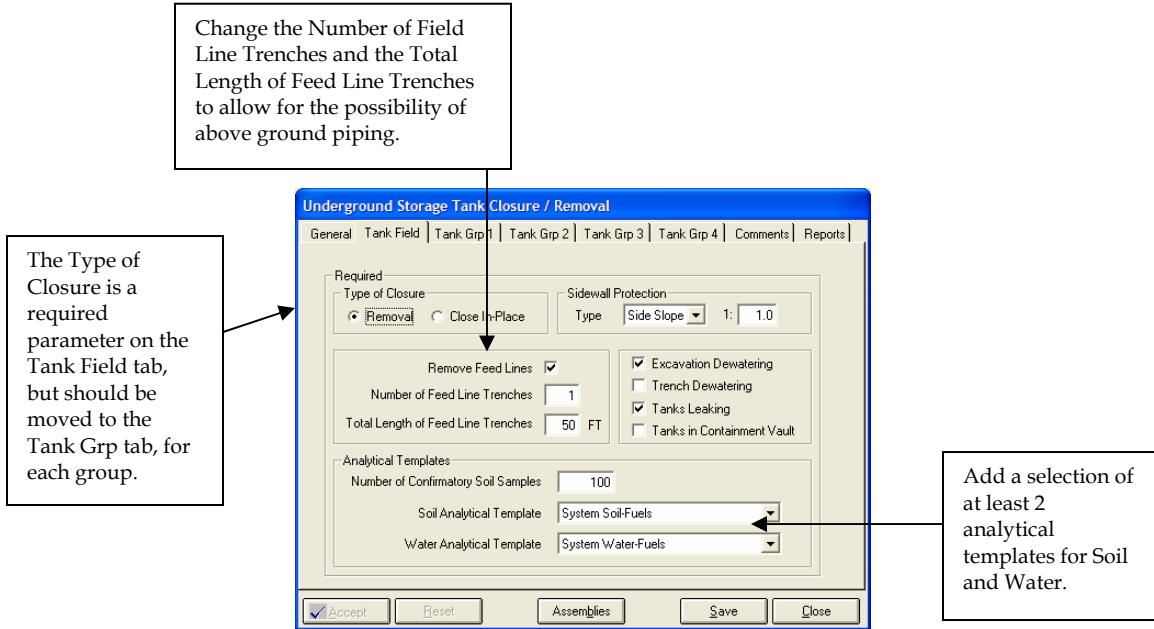


Figure 5.3.2

- Tank Group Tab (Figure 5.3.3)
 - **Issue:** During the project, it was found that there were multiple types of closures at a site, which could not be estimated easily.
 - **Solution:** Move "Type of Closure" to this tab to allow the estimator to choose the type of closure for each particular tank group at the site.

 - **Issue:** Historical project data showed that the valid range for tank volumes needs to be changed.

- **Solution:** For the Carbon Steel tank type, the upper limit needs to be changed to 150,000 gallons. The lower valid range for this field should be changed to 100 gallons.
- **Issue:** Although decontamination of the tank after its removal is estimated within the model, destruction of the tank is not currently included.
- **Solution:** Place a check box on the GUI of this tab to allow the estimator to estimate the cost of destruction of the tank before transportation and disposal off site. This check box might be defaulted on tanks larger than 30,000 gallons for all tank types. An assembly(s) would have to be added to the database to accommodate this change.

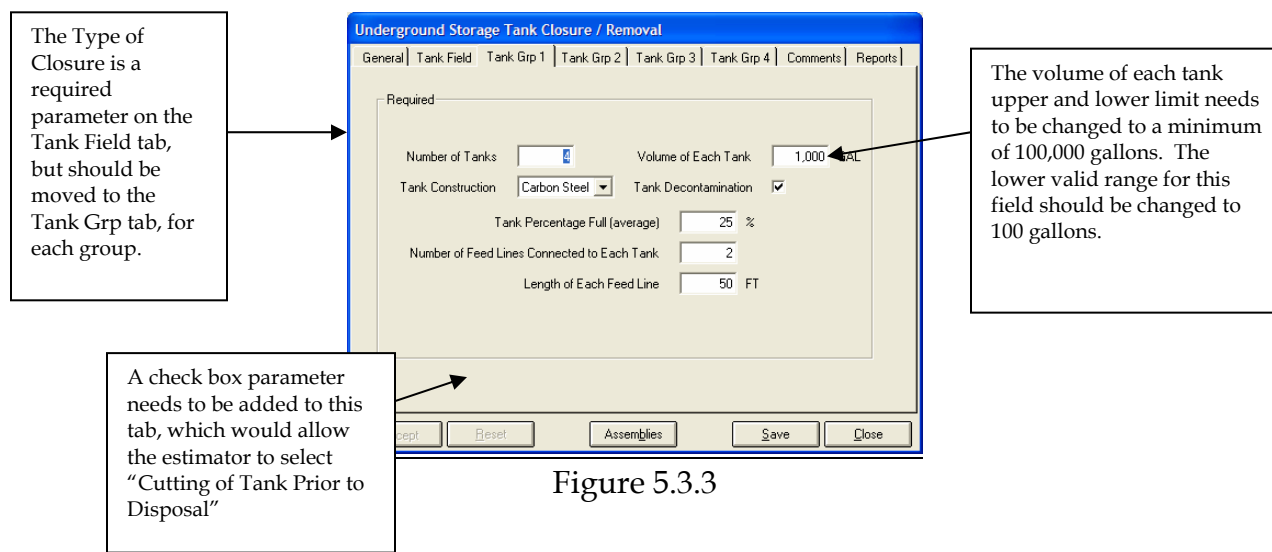


Figure 5.3.3

- Assemblies (Figure 5.3.4)
 - **Issue:** The assemblies for this technology need to have more detail. For instance, the removal of USTs do not allow the estimator to determine if a crane is included or if transportation off site is included in the cost of the assembly. The help system for this technology is vague and does not give any detail on this issue.
 - **Solution:** The assemblies for this technology should be reviewed and line item detail should be provided where applicable or the help system should be updated so that the estimator understands exactly what is being included within the estimate for this technology.

The assemblies in this technology need to have additional detail.

Assembly	Description	Qty	UOM	Material	Labor	Equipment	Extended Cost
17020201	Demolish Bituminous Road with	117.9	CY	0.00	20.02	6.09	3,078.82
17020610	Minor site demolition, pipe,	1625	LF	0.00	8.37	0.74	14,803.26
279	4 CY, Crawler-mounted, Hydraulic	1278.37	CY	0.00	1.02	2.19	4,097.56
423	Unclassified Fill, 6" Lits, D/H-Site,	1778.82	CY	5.91	2.02	1.92	17,516.93
002	2" Diameter Contractor's Trash	3	DAY	39.62	13.09	0.00	158.14
301	Asphalt Pavement - 10"	707.39	SY	5.39	1.87	1.08	5,896.66
303	Organic Vapor Analyzer Rental,	3	DAY	114.31	0.00	0.00	342.93
401	Disposable Materials per Sample	101	EA	8.30	0.00	0.00	838.79
102	Testing, moisture content (209a)	100	EA	23.20	0.00	0.00	2,320.02
33021603	Testing, dissolved solids	2	EA	11.76	0.00	0.00	23.53
33021604	Testing, suspended solids	2	EA	10.33	0.00	0.00	20.66
33021694	Total Petroleum Hydrocarbons	2	EA	76.21	0.00	0.00	152.42
33021722	Polynuclear Aromatic	100	EA	120.03	0.00	0.00	12,002.61
33021732	Testing, soil & sediment analysis,	100	EA	54.32	0.00	0.00	5,431.66
33021776	BTEX/MTBE/TVPH (EPA)	100	EA	76.21	0.00	0.00	7,621.07

Sort Assemblies By: Assembly Description

Delete Assemblies Add Assemblies View Line Items Marked-up Cost Reset Costs Close Total: \$140,484.55

Figure 5.3.4

- **Excavation Technology**

Throughout the 11 location visits and Internet research, the excavation technology had 33 observations called out in Appendices A and C. The most frequent observations and suggested solutions are listed below.

- System Definition Tab (Figure 5.3.5)

- **Issue:** Due to historical data deconstruction, there were problems with the ability to estimate an excavation with a width of two feet.
- **Solution:** Change the lower valid range for the width field to two feet.
- **Issue:** There were instances found in the deconstruction of the historical data, where there was a need to estimate up to 300 confirmatory samples, and this was not possible in RACER.
- **Solution:** Change the upper limit for the number of Confirmatory Samples to 300.
- **Issue:** There were numerous instances where it would have been helpful to be able to choose multiple analytical templates in the estimate.
- **Solution:** As per observations in the historical data, the number of analytical templates for soil needs to be increased to allow selection of at least two. The two templates need to be defaulted based on the selection of the primary and secondary contaminants at the phase level (level 3).
- **Issue:** There were instances where it would have been helpful to understand exactly how the Excavation technology calculates the area to be excavated so that the estimator could determine the quantity of soil to be removed and/or replaced.

- **Solution:** Add a detailed explanation of excavation calculations to the help system. Currently, it is not apparent to the estimator that the bottom of the excavation is used as the perimeter of the excavation (versus the top). This is presented in the help file, but is not readily apparent to the average user. This is important to understand if the estimator is using side slope for excavation protection below five feet.
- **Issue:** A bug exists in this technology that causes the model to continue to calculate a side slope protection even if the "None" option is selected.
- **Solution:** Check the code used with the Side Slope parameter.
- **Issue:** During the deconstruction portion of the projects there were numerous instances found for Silt Fence or other type of erosion control.
- **Solution:** Include an option box for Silt Fence or other erosion control options.

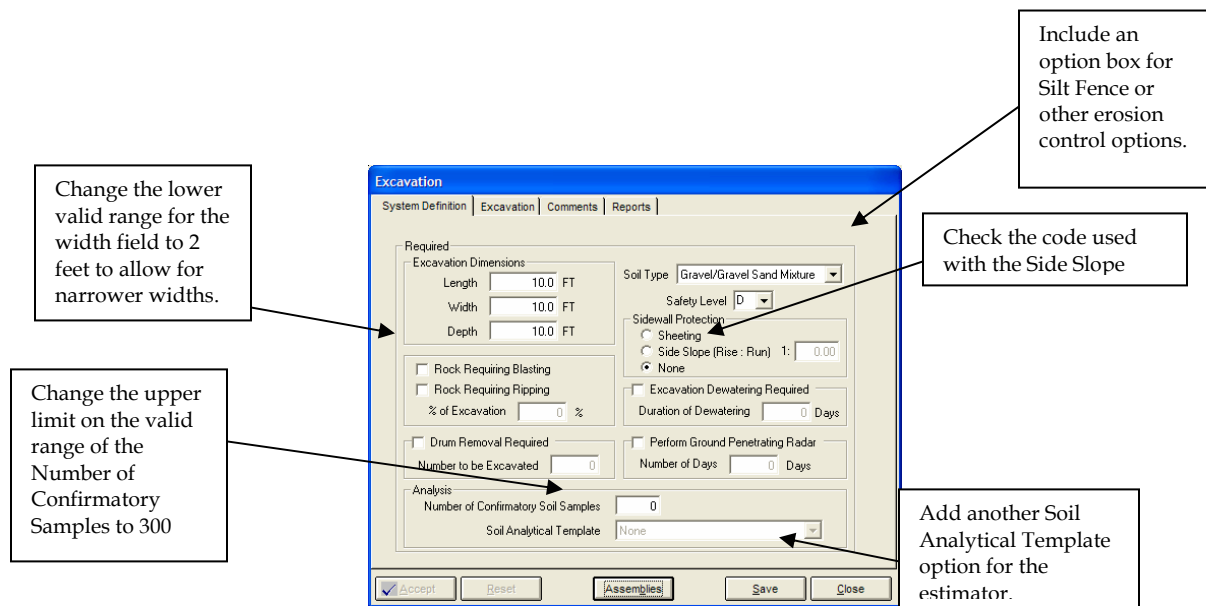


Figure 5.3.5

- Excavation Tab (Figure 5.3.6)
 - **Issue:** This technology defaults Asphalt as the existing and replacement cover. The reason appears to be because Asphalt is the first option in the drop down list. It was found that this parameter has a great impact on the cost of the estimate.
 - **Solution:** One solution would be to change this field to be blank so that the user has to select an existing and replacement cover.

Another solution is to make this parameter selection a required parameter on the Excavation technology's system definition tab. This ensures that the estimator must choose a parameter value in order to save the technology.

- **Issue:** There was a need in an estimate where the replacement cover was seeded.
- **Solution:** As noted previously, add "Seeding" and "Sodding" options to the Replacement Cover drop-down list.

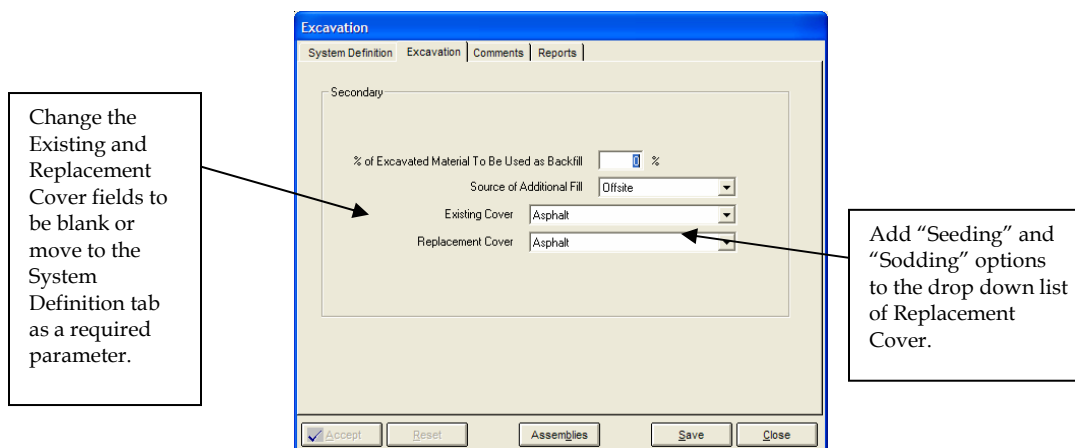


Figure 5.3.6

• Monitoring Technology

Throughout the 11 location visits and Internet research, this technology had 35 observations called out in Appendices A and C. The most frequent observations along with suggested solutions are listed below.

○ System Definition Tab (Figure 5.3.7)

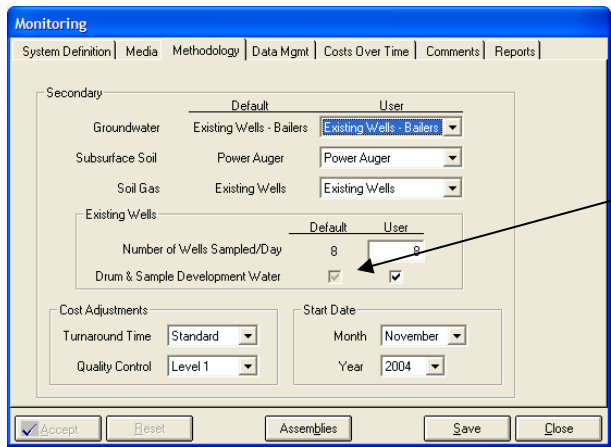
- **Issue:** There were 14 observations sited where the estimator needed to select multiple types of analytical suites but was not able to due to the current architecture of this technology.
- **Solution:** Add a selection of at least 2 analytical templates for both the water and soil medias. The two templates for each media type need to be defaulted based on selection of the primary and secondary contaminants at the phase level (level 3).

The screenshot shows the 'Monitoring' application window with the 'Media' tab selected. The 'Required' section contains a 'Crew Size' dropdown menu set to '2 Field Technicians' and a 'Site Distance' input field set to '50 MI (One-way)'. Below this are three sections for 'Analytical - Water', 'Analytical - Soil/Sediment', and 'Analytical - Air/Soil Gas'. Each section has checkboxes for 'Groundwater', 'Surface Water', 'Subsurface Soil', and 'Sediment', and a dropdown for 'Analytical Template' set to 'System Water-Fuels', 'System Soil-Fuels', and 'System Air-Fuels' respectively. At the bottom, there are checkboxes for 'Include QA/QC Samples', 'Include Data Mgmt/Reporting', and a 'Safety Level' dropdown set to 'D'. Buttons for 'Accept', 'Reset', 'Assemblies', 'Save', and 'Close' are at the bottom.

Figure 5.3.7

- Methodology Tab (Figure 5.3.8)
 - **Issue:** There was an instance where the estimator could not estimate the cost for monitoring/sampling field equipment used during the screening.
 - **Solution:** Add another parameter selection called “Field Screening Equipment”. Options are: None, PID Meter, FID Meter, x-ray fluorescence (XRF), portable gas chromatography (GC), immunoassay test kits (IA), and gas chromatography/mass spectrometry (GC/MS). Currently, only the PID meter exists in the RACER database.
 - **Issue:** There was an observation found where the cost was lowered by de-selecting the “Drum & Sample Development Water” option. This is automatically selected for the user and a warning note is displayed. It was found that this parameter impacts the cost dramatically.
 - **Solution:** Change the “Drum & Sample Development Water” to a Required Parameter. If the user accepts the defaults the cost is almost doubled.

Add another parameter called "Field Screening Equipment". Options are: None, PID Meter, FID Meter, x-ray fluorescence (XRF), portable gas chromatography (GC), immunoassay test kits (IA), and gas chromatography/mass spectrometry (GC/MS).



Change the "Drum & Sample Development Water" to a Required Parameter.

Figure 5.3.8

- o Assemblies (Figure 5.3.9)
 - Issue: There were multiple instances found in the historical data deconstruction where the costs in RACER did not match the costs from the historical costs for analytical tests.
 - Solution: Analytical costs need to be reviewed/researched to obtain accurate and current costs for these assemblies.
 - Issue: The estimator was not able to view the costs beyond the first year in the assemblies area. It would have been helpful to be able to view out-year costs to understand what the total cost of certain assemblies was going to be.
 - Solution: Add an "Element" called "Out Year Costs" which will allow the estimator to view the out year assembly costs. Currently there is no way to view the costs associated with the out years at the assembly level.

Add an "Element" called "Out Year Costs" which will allow the estimator to view the out year assembly costs.

Assembly	Description	Qty	UM	Material	Labor	Equipment	Extended Cost
33020401	Disposable Materials per Sample	3	EA	8.30	0.00	0.00	24.91
33020402	Decontamination Materials per	3	EA	7.40	0.00	0.00	22.19
33021509	Monitor well sampling equipment,	1	WK	232.54	0.00	0.00	232.54
33021603	Testing, dissolved solids	3	EA	11.76	0.00	0.00	35.29
33021604	Testing, suspended solids	3	EA	10.33	0.00	0.00	30.99
33021694	Total Petroleum Hydrocarbons	3	EA	76.21	0.00	0.00	228.63
33022134	Testing, PAH	3	EA	187.77	0.00	0.00	563.30
33022140	Testing, ethylene dibromide (EDB)	3	EA	78.10	0.00	0.00	234.29
33022150	BTEX/MTBE/TVPH (EPA)	3	EA	120.03	0.00	0.00	360.08
33231186	Well Development Equipment	1	WK	430.65	65.46	0.00	496.11
33231189	DOT steel drums, 55 gal., open,	1	EA	81.77	0.00	0.00	81.77
33232407	PVC bailers, disposable	1	EA	5.99	0.00	0.00	5.99

Analytical costs need to be reviewed/researched to obtain accurate and current costs.

Figure 5.3.9

- **Off-Site Transportation and Waste Disposal Technology**

Throughout the 11 data locations and Internet research, this technology had 14 observations called out in Appendices A and C. The most frequent observations and suggested solutions are listed below.

- Transportation Tab (Figure 5.3.10)

- **Issue:** It has been observed repeatedly when running the RACER Off-Site Transportation and Waste Disposal model for non-hazardous solid waste that the incorrect assemblies are being used for the waste disposal and transportation.
- **Solution:** Review the algorithms and code related to the use of the following assemblies when disposing of non-hazardous waste.

- Assembly 33190210 - "Dump Truck Transportation Hazardous Waste 200-299 miles"
- Assembly 33190102 - "Bulk Solid Hazardous Waste Loading into Truck"
- Assembly 33190209 - "Dump Truck Transportation Hazardous Waste Minimum Charge"

Figure 5.3.10

- Disposal Fees Tab (Figure 5.3.11)

- **Issue:** The Average Disposal Fee is a defaulted value, dependent on the type and condition of waste.
- **Solution:** Change the Average Disposal Fee to a required parameter in which the user must enter a location specific disposal fee value.

Figure 5.3.11

- **Capping Technology**

Throughout the 11 location visits and Internet research, this technology had 13 observations called out in Appendices A and C. The most frequent observations and suggested solutions are listed below.

- System Definition (Figure 5.3.12)
 - Issue: There were general observations about how this technology was not able to estimate a smaller, simpler cap. This technology is currently designed using RCRA requirements for cap development.
 - Solution: Add more cap options through a drop-down list, or add a blank field that allows the user to input a more customized cap.

Some of the types of caps found in the historical project data were:

- Simple clay cap composed of 18" relatively impermeable soil and 6" topsoil, no liner is used. (Woodridge Research Facility - Operable Units 1 and 3, DACA31-96-D-0026 - SOW pg. 1 and Detailed Cost Estimate pg. D-24)
- 12" semi-compacted cap from on-site borrow material, no liners. (Sacramento IMR - Tonopah Army Airfield; DACA05-99-D-0014 T.O. CM14 - SOW pg. 3 and RAR pg. 4-14)
- Geotextile cap (20 mil PVC impervious liner), with 2"-3" stone cover. (New Cumberland Army Depot, Construction and O&M of Dual Phase SVE System, DACA31-99-D-0021 - Proposal pg. 7)
- Geosynthetic/Composite cap that contains a gas collection layer, geosynthetic clay liner, geo-composite drainage layer, geotextile fabric, and off-site borrow soil cover. (Mt. Zion Landfill Cap, DACW31-97-B-0011 - Mod P0008, pg 4, and Bid Proposal pg 10-6)

- Composite cap that contains a geotextile liner, LLDPE (Linear Low-Density Polyethylene) liner, gas vents, drainage layer, and soil cover. (Sacramento IMR - Fort Hunter Liggett; DACA05-99-D-0014, D.O.#CM08 - Project Work Plan, pg. 11 and SOW pg. 2)
 - Simple 2' compacted soil layer with 6" topsoil cover. (Newport Chemical Depot, SOW pg. 5)
 - 2" asphalt cap with liner and 4" aggregate base. (Sacramento IMR - Tooele Army Depot, SOW pg. 9)
 - New Cumberland Army Depot, Construction and O&M of Dual Phase SVE System: See Item #4
 - Caps consisted of either a 6" or 24" Hydroseeded soil cover. (Langley AFB, Draft RA Completion Report pg. 3-3)
- **Issue:** There was an instance where it was not possible to estimate the use of a Gas Probe during the construction of the cap. It was possible to add it in the assemblies.
 - **Solution:** Add a "Gas Probe" option to the System Definition tab. Depending on the size of the cap, the algorithm will call assembly 33020308 – Soil Gas Probe.

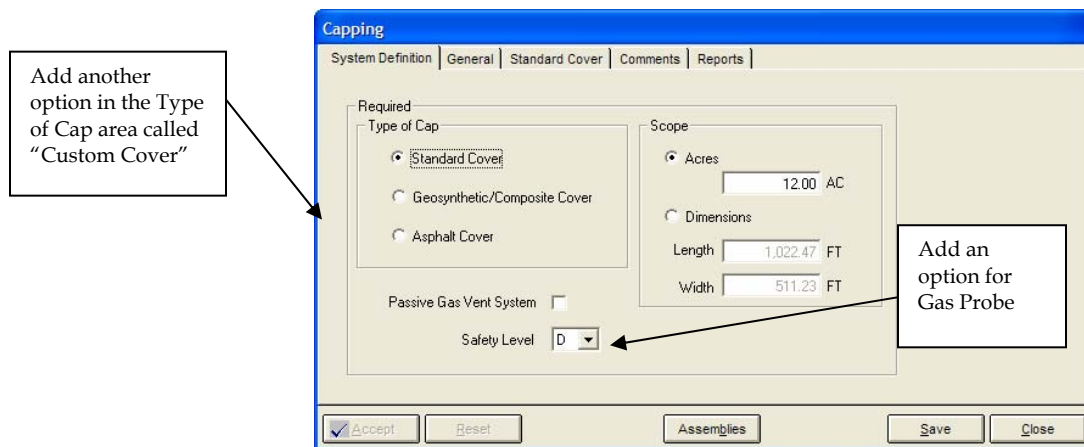


Figure 5.3.12

- Asphalt Cover Tab (Figure 5.3.13)
 - **Issue:** As stated above there were instances where a smaller type of cap was needed but was not able to be estimated in RACER.
 - **Solution:** The Top Cover – Hydraulic Asphalt Concrete Depth field, lower limit of the valid range needs to be lowered to allow a minimum of two inches.
 - **Issue:** Again, it was not possible to estimate a smaller Base Rock Depth.

- **Solution:** The Base Rock Depth field lower limit of the valid range needs to be lowered to allow for a minimum of 6 inches.

Figure 5.3.13

- **Cleanup and Landscaping Technology**

Throughout the 11 location visits and Internet research, this technology had 8 observations called out in Appendices A and C. The most frequent observations and suggested solutions are listed below.

- **Issue:** The technology was found to estimate low most of the time. There are a number of reasons for this, such as:
 - RACER did not include hand raking, grading, or applying mulch for erosion control.
 - RACER was not able to estimate projects involving re-vegetation of large areas. There was no way to estimate the actual number of plants which were used in the re-vegetation task – RACER requires the user to use the number of acres; Several materials that were purchased and used during this project in large quantities could not be accounted for in the RACER estimate - wood fiber mulch, soil organic amendment, polymer-based tacktifier, weed control, aerial application of materials, mobilization and demobilization of aerial equipment, and tacktifier; The technology requires the user to select either seeding or sodding, and if neither activity is performed, then RACER estimates a cost of zero for that technology; Re-vegetation of large areas through the aerial application of materials (fertilizer, mulch, seed, etc) cannot be accurately estimated via this technology.
 - There is no easy way to accurately estimate debris removal involving sites with unusual topography.

- System Definition Tab (Figure 5.3.14)

- **Issue:** Based on historical project data additional selections for landscaping/re-vegetation options are needed within the Cleanup and Landscaping model to accurately estimate this process. Based on the historical data required additions include wood fiber mulch, soil organic amendment, potted plants, decorative boulders, and tacktifier. Currently these assemblies are not available within the RACER database or the Cleanup and Landscaping model.
 - **Solution:** An additional required parameter or tab could be added if the Type of Site Preparation parameter is selected as landscaping or re-vegetation. The additional tab would allow the user to select a series of radio buttons, selecting each applicable type of material as needed. In addition the wood fiber mulch, soil organic amendment, potted plants, decorative boulders, and tacktifier assemblies would be required additions to the RACER database for use in this technology.
- **Issue:** There was no way to estimate the cost for replacement trees and/or shrubs easily in the technology.
 - **Solution:** An additional required parameter or tab could be added if the Type of Site Preparation parameter is selected as landscaping or re-vegetation. The additional tab would allow the user to select a series of radio buttons including replacement trees and shrubs as needed.
- **Issue:** There was no easy way to capture the cost for erosion control during cleanup and landscaping.
 - **Solution:** Add an option parameter for Erosion Control during the cleanup and/or landscaping.

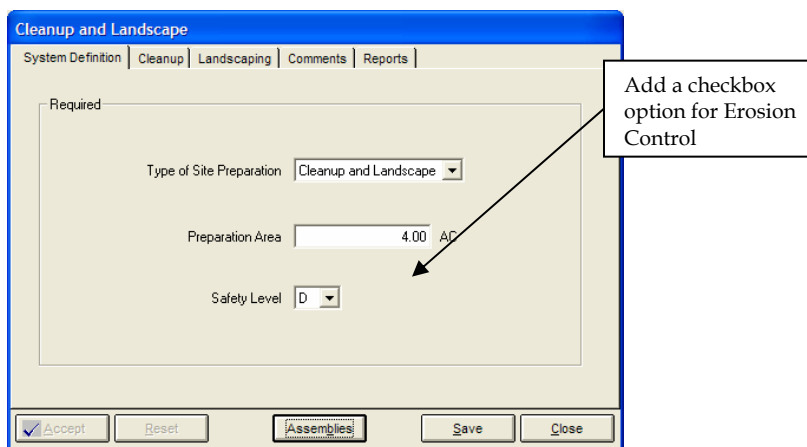


Figure 5.3.14

- **Professional Labor Management Technology**

When running the Professional Labor Management (PLM) Technology in the four scenarios, it was assumed that the deconstruction team would use the percentage method and a level of complexity of low.

Throughout the 11 location visits and Internet research, this technology had 6 observations called out in Appendices A and C. The most frequent observations and suggested solutions are listed below.

- System Definition Tab (Figure 5.3.15 a&b)
 - Issue: This technology continuously estimated the professional labor rates high, even when using the “Low” RA Complexity.
 - Solution: Need to perform a detailed review of this technology and the methodology used in calculating the professional labor rates. One approach that could be applied is to modify the PLM model, or create a fourth methodology that is more parametric in nature. It would have parameters that help to define the level of complexity of the project, such as how often reporting is done, what is the contracting method, and how many different contractors are used. This approach will require in-depth research.
 - Issue: Originally when this technology was created it was used for the Interim Action (IA) and Remedial Action (RA) phase cost models, which typically did not have professional labor assemblies. Recently, the Studies phase technologies can be used in the Interim Action and Remedial Action phases. These technologies are almost entirely professional labor assemblies. If they are used in conjunction with Remedial Action phase technologies along with the Professional Labor Management technology, there would be double calculating of the professional labor in some areas.
 - Solution: One solution to the use of Professional Labor Management on the studies models in the IA and RA phases would be to “turn off” professional labor on these models.
 - Issue: Currently the RACER mark-up template is being applied to the Professional Labor Management technology.
 - Solution: Professional Labor Management should be set to not allow any markups on it in any phase.

Professional Labor Management

System Definition | Percentage Default | Comments | Reports

Required

RA Complexity: Low

Percentage Method

Task Percent Template

User Defined Labor Hour Estimate

Labor Hours Template

Buttons: Accept, Reset, Assemblies, Save, Close

Figure 5.3.15a

Professional Labor Management

System Definition | Percentage Default | Comments | Reports

Secondary

Total Direct RA Construction Cost: \$14,803,770.00

Professional Labor Task	Percent	Weighted Dollar Amount
Project Management	1.25%	\$185,047.15
Planning Documents	1.20%	\$177,645.26
Construction Oversight	2.10%	\$310,879.21
Reporting	0.25%	\$37,009.43
As-Built Drawings	0.25%	\$37,009.43
Public Notice	0.02%	\$2,220.57
Site Closure Activities	0.00%	\$0.00
Permitting	0.50%	\$74,018.86
Responsible Party Costs	0.00%	\$0.00
Total:		\$823,829.90

Buttons: Accept, Reset, Assemblies, Save, Close

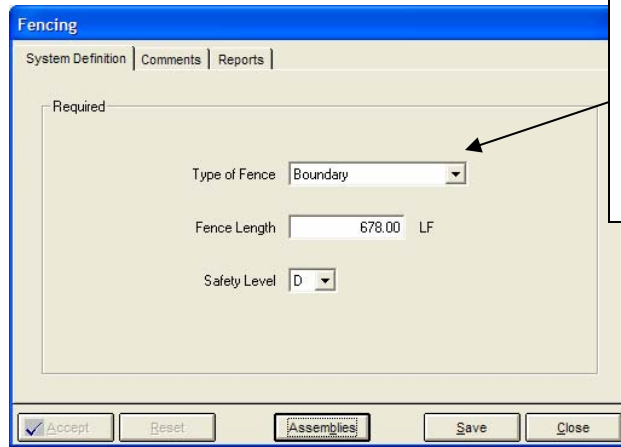
Figure 5.3.15b

• Fencing Technology

Throughout the 11 location visits and Internet research, this technology had 6 observations called out in Appendices A and C. The most frequent observations and suggested solutions are listed below.

○ System Definition (Figure 5.3.16)

- **Issue:** Assembly 18040105 = "Boundary Fence, 5' Galvanized" did not have detailed line item information. No detail is given as to what the posts are composed of, how many are used, or how they are set (concrete, driven, temporary, or free standing).
- **Solution:** Need to either provide more detailed information in the line items of this assembly or provide information in the help system explaining the type and number of poles used.
- **Issue:** The current parameters within the fencing technology do not allow an accurate estimate within RACER for the fencing task.
- **Solution:** Add additional required parameters that would be more specific to the fencing required for the site. Examples of types of parameters needed based on historical project data are as follows:
 - Height of fence
 - Type of fence (chain link, plastic, etc)
 - Number and types of gates for entry
 - Post type and spacing
 - Permanent or Temporary Fencing



Additional fencing parameters needed on this GUI would be:

- Height of fence
- Type of fence (chain link, plastic, etc)
- Number and Type of gates for entry
- Permanent or Temporary fencing?

Figure 5.3.16

- **Injection Wells Technology**

Throughout the 11 location visits and Internet research, this technology had 4 observations called out in Appendices A and C. The most frequent observations and suggested solutions are listed below.

- System Definition Tab (Figure 5.3.17)

- Issue: There were observations where the need for a 175 GPM was required which is beyond the current 50 GPM allowed in the Injection Rate Per Well field.

Solution: Increase the upper valid range of the Injection Rate per Well field to 175 GPM.

Increase the upper valid range of the Injection Rate per Well field to 175 GPM

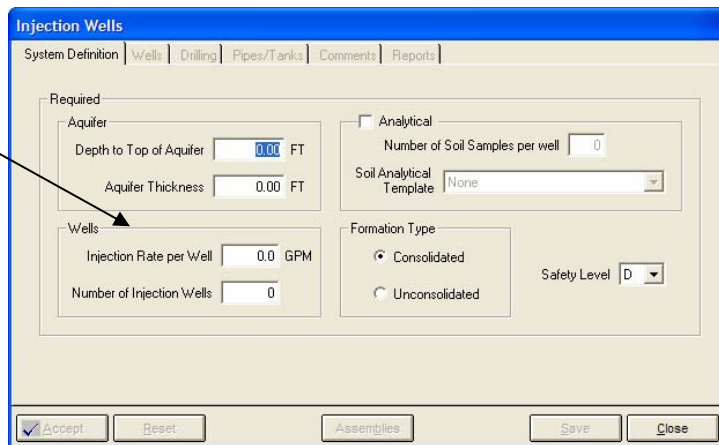


Figure 5.3.17

- **Global Suggested Improvements**

- **Markups Template /(Mobilization/Demobilization)**

Throughout the 11 location visits and Internet research, mobilization and demobilization issues had 18 observations called out in Appendices A and C. The most frequent observations and suggested solutions are listed below.

Issue: It is not clear whether mobilization and demobilization costs are covered within the markup templates. The template methodology needs to be researched in detail. The help system states that mobilization and demobilization costs are covered in the markup template. It is assumed that this is for job project trailers and some of the crew mobilization. Basically, the way RACER addresses the mobilization and demobilization needs to be consistent throughout the software.

Solution: The following are two possible solutions to account for mobilization and demobilization in the technologies:

- First solution would be to assume that all of the mobilization and demobilization costs are covered in the markups. In this case, a search through all of the technologies to remove any assemblies associated with mobilization and demobilization would need to be removed. The help system would need to explain this in the markup templates as well as in each of the technologies using heavy equipment.
- Second solution would be to assume that mobilization and demobilization of heavy equipment is not covered in the markups. In this case, all of the technologies in RACER would need to be reviewed to add assemblies for mobilization and demobilization costs if they do not have them, for example assembly 33231180 – “Mobilization/Demobilization, Drill Equipment or Trencher Crew” within the Capping model would be a required addition within the Capping technology.

The help system will need to be updated to explain this reasoning in the markups template and in each of the technologies where mobilization and demobilization has been added or currently exists.

Suggested New RACER Technologies

During the course of the deconstruction and RACER historical cost comparisons, there were a number of projects or portions of projects that could not be accurately estimated within RACER because an equivalent technology was not available within the RACER program. In some cases, it was apparent that these were independent cases and not representative of other projects. In other cases, the need for a particular technology appeared numerous times.

Suggested new RACER technologies are noted below; all are detailed in Appendix C with line locations noted.

1. Well Abandonment (Line 131)
2. Surveying (Lines 130-131)
3. Erosion Control (Lines, 32, 35, 53, 71, 78, 83, 102)
4. Oxygen Release Compound Remediation (Line 61)
5. Lagoon Closure (Line 127)
6. Wetlands Mitigation (Line 132)
7. Railroad Demolition/Construction (Line 128)
8. Windrow Composting (Line 56)
9. Economies of Scale Wizard (Lines 31, 44)

Suggested new RACER assemblies are noted below; all are detailed in Appendix C with line locations noted.

- Steel Canopy Removal & Replacement (Lines 126, 179)
- Surveying (Line 130)
- Guar & Slurry - Permeable Reactive Barrier Walls (Lines 160-161)
- Vapor Monitoring Wells (Line 171)
- Steel Trench Box - for side wall protection (Line 174)
- UST/AST Transport for Off-Site Disposal (Line 175)
- AST Removal (several sizes) (Lines 175, 189)
- UST/AST On-Site Cutting for Disposal (Lines 131, 191)
- VX (O-Ethyl S-Disopropylaminomethyl Methylphosphonothiolate (Line 112)
- EPA Method TO-10a (Line 121)
- Calciment (for stabilization) (Line 58)
- Assemblies associated with Oxygen Release Compound Remediation (Line 61)
- Assemblies associated with UST Disposal (Lines 175-197)
- Wood Fiber Mulch (Line 35)
- Organic Soil Amendment (Line 35)
- Potted Plants (Line 35)
- Decorative Boulders (Line 35)
- Tackifier (Line 35)

Software "Bugs"

Defining "bugs" as logical or programming errors that cause technology performance problems, a number of "bugs" became apparent while performing the RACER estimates for this project. The following list of "bugs" were found during this project; all are detailed in Appendix C with line locations noted.

- Bioslurping (Appendix C: line 19)
 - Tab notes do not work in this technology.
- Clear & Grub (Appendix C: line 36)

- There is an error in the logic associated with tree and stump removal. Currently, “light” removal is used for trees with a 12”-24” diameter. “Medium” removal is used for trees with a 6”-12” diameter. “Heavy” removal is used for trees with a diameter of less than 6”. Clearly, the logic for “light” and “heavy” diameters should be reversed. In addition, selecting “None” defaults to a 24”-36” diameter tree and stump size, instead of reflecting *no tree or stump removal*.
- Demolition, Building (Appendix C: line 46)
 - The RACER system does not allow the Demolition, Building technology to be copied. The parameters for this technology default to zero when a project is copied and pasted. Due to this bug, the team had to reconstruct the Demolition, Building technology for each scenario.
- Ex-Situ Land Farming (Appendix C: line 54)
 - A RACER error prohibits a proper calculation of this technology. For the secondary parameter, the cell area and the depth of contaminated soil are linked together. It is not possible to enter the cell area as well as the depth; RACER prevents the user from entering the latter.
- Excavation (Appendix C: line 75)
 - The excavation technology system definition tab contains a bug. Originally the estimate was run using sidewall protection, with a side slope of 1-0.67. While testing the program to see if the slope was correctly being applied, the “none” sidewall radio button was selected, while still having the side slope ratio in place. The technology shows that no sidewall is active, but RACER still calculates and includes the increased excavation for Assembly 17030278 – “3 CY, Crawler-Mounted, Hydraulic Excavator.”
- Operations and Maintenance (O&M) (Appendix C: lines 143, 145, 149, 151, 152, 154, 157)
 - There seems to be a problem with the maximum value specified for the gas flow rate parameter of the O&M wizard. For one of the historical projects, the gas flow rate for the gas carbon adsorption technology was 13,368 CFM. RACER is programmed to pass the calculated gas flow rate from model to model and from model to the O&M wizard. When the RACER O&M wizard was run for the Propellant Burning Ground Site project remedial action, the O&M parameter for the air process stream flow rate passed the correct value of 13,368 CFM as the gas flow rate, and this value was shown within the O&M airflow field. When the default was accepted, a RACER error message appeared explaining that the flow rate must be 1-1000 CFM. The user is forced to change the flow rate to a value within this range in order to move to the next wizard screen.

- Assembly 99020110 – “Annual Maintenance Materials and Labor” with a quantity of one lump sum is automatically calculated and included within the RACER estimate for O&M, but no costs are associated with the line item. Upon further investigation, it was observed that there are no unit costs entered for this line item for the equipment, labor, or material costs.
- The F5 & F6 Tab Notes feature is not available in the O&M wizard as they are in other technologies.
- Permeable Reactive Barriers (PRBs)(Appendix C: line 161)
 - The PRB technology in RACER allows the user to choose either a “Treatment Wall Only,” a “Gate with Sheet Piling,” or “Gate with Slurry Wall” PRB type. With each of these three PRB types, assembly 33061011 – “Temporary Medium Wall Sheet Piling” is included within the technology estimate and accounts for a majority of the PRB costs. Due to the significance of the costs for the temporary sheet piling assembly it is recommended that the assembly pricing be reviewed.

6.0 Findings

This section describes our overall findings based on the historical project cost benchmarks used to analyze RACER model performance.

- 1) The historical data collection effort was a success in developing a benchmark for comparing RACER performance with actual field experience.

Eleven district offices were visited and Internet data were obtained, resulting in data on 211 historical projects. Of these, 131 projects were selected for RACER modeling. Seventy-four RACER technology models were applied to these projects. The 74 applied technology models were used 699 times to build project estimates. There are approximately 117 RACER models available to the user. This means that approximately 60% of the available RACER models were used in this benchmark analysis. The resulting data analyses have produced meaningful insights into the reliability of RACER in cost estimating and the need for improvements in selected RACER technology models.

- 2) RACER functions best when project data is available to modify secondary parameters or assemblies. Based on the data provided below, it is clear that the modification of secondary parameters is required in order to produce RACER estimates with acceptable levels of accuracy.

A review of the RACER modeling performance for all selected projects clearly demonstrates a significant improvement in the difference between historical cost and the RACER estimate when secondary parameters are modified. In Scenario 1, using default primary parameters the absolute mean difference is approximately 49%. In Scenario 2, using modified primary and secondary parameters, the absolute mean difference is approximately 38%. The standard deviation is reduced from 41% in Scenario 1 to 35% in Scenario 2. This finding is based on over 100 historical projects, and their corresponding RACER estimates clearly demonstrate the need for project-specific data to better prepare environmental liability estimates.

- 3) RACER users must have formal and continued training to produce consistent and accurate estimates.

Consistent with the second finding, the ability to apply more detailed project data to an estimate depends on the user's ability to modify secondary parameters correctly in selected RACER models. Further, the ability to modify specific assembly data as the underlying foundation for RACER models will improve the cost estimate. A significant improvement in the difference between historical cost and the RACER estimate occurs between Scenarios 2 and 3. In Scenario 3, the absolute mean cost difference is approximately 25% for the projects sampled when assemblies are modified. The standard deviation in Scenario 3 is reduced to 27%. There is sufficient evidence to state that if user training and sufficient project data is available, RACER will produce reliable and defensible estimates for project planning purposes.

An important finding of our analysis relates to the need for developing a consistent approach within RACER for project markups and indirect costs, especially as it pertains to costs associated with professional labor management, mobilization, and demobilization. Users must be trained properly to handle these cost factors in RACER.

- 4) There is no clear statistical evidence that RACER estimates high-value projects (>\$500,000) better than low-value projects, or that it generates an estimate consistently higher or lower than historical project benchmarks.
- 5) RACER models can benefit from access to historical project data to ensure consistency with actual field experience. Based on our review of RACER models in the context of completed projects, we suggest a number of RACER model enhancements including:
 - a. No. of Existing models requiring enhancement - 32
 - b. No. of Default and secondary parameters requiring modification - 26
 - c. No. of Model Assemblies requiring modification - 7
 - d. No. of Proposed new models - 13
 - e. No. of Proposed new assemblies - 32
- 6) DoD remediation projects do not produce consistent documentation to defend project estimates and site closeout costs.

The ability to produce reliable and defensible estimates for calculating environmental liability is dependent upon access to accurate and complete data and information on historical projects. This includes planned and completed scopes of work, records of specific site conditions and areas of concern. This information together with the planned or completed environmental remedies allows independent or outside reviewers to gain confidence in the basis for the environmental liability estimate. Our review found that historical project information was not uniformly accessible or consistent across the 11 district offices we visited in terms of

- record location
- level of detail
- format
- or source

Although it was possible for our team to study and deconstruct historical data records to produce new estimates using RACER, it required one to two days to complete this process for each project reviewed. In most cases it was necessary to augment available project data with interviews and follow-up phone calls to understand and interpret project records.

List of Acronyms

AAP	Army Ammunition Plant
ABS	Absolute
ACF	Area Cost Factor
AEDB-R	Army Environmental Database - Restoration
AFCEE	Air Force Center for Environmental Excellence
AFCESA	Air Force Civil Engineering Support Agency
BCI	Building Cost Index
BRAC	Base Realignment and Closure
CY	Cubic Yard
D&D	Decontamination and Decommissioning
DOE	U.S. Department of Energy
DERP	Defense Environmental Restoration Program
ELM	Environmental Location Modifier
ENR	Engineering News-Record
EPA	U.S. Environmental Protection Agency
EPA - OPA	U.S. Environmental Protection Agency – Oil Pollution Act
ERP	Environmental Restoration Program
FFID	Federal Facility Identification
FS	Feasibility Study
FUDS	Formerly Used Defense Sites
FUDS MIS	Formerly Used Defense Sites Management Information System
FY	Fiscal Year
GAO	General Accounting Office
GUI	Graphical User Interface
ID	Identification
IGE	Independent Government Estimate
IMR	Interim Model Report
IPR	Interim Progress Review
IRA	Interim Removal Action

IRP	Installation Restoration Program
LF	Linear Feet
LLDPE	Linear Low-Density Polyethylene
NAD	Navel Ammunition Depot
NOP	Nebraska Ordnance Plant
MTBE	Methyl Tertiary Butyl Ether
NECOU	Northeast Corner Operable Unit
O&M	Operations & Maintenance
OE	Ordnance and Explosives
OU	Operable Unit
POC	Point of Contact
PRB	Permeable Reactive Barrier
PVC	Polyvinyl Chloride
RA	Remedial Action
RACER	Remedial Action Cost Engineering and Requirements System
RAD	RACER Assessment Database
RAMP	Remedial Action Management Plan
RCRA	Resource Conservation and Recovery Act
SME	Subject Matter Expert
SOW	Scope of Work
SVE	Soil Vapor Extraction
SW	Solid Waste
SWMU	Solid Waste Management Unit
TOC	Total Organic Carbon
TSS	Total Suspended Solid
USACE	United States Army Corps of Engineers
USACE HTRW/CX	United States Army Corps of Engineers, Hazardous Toxic and Radioactive Waste – Center of Expertise
USAEC	United States Army Environmental Center
UXO	Unexploded Ordnance
VOC	Volatile Organic Compound

WAD

Work Authorization Directive

Appendix A-1 - List of All Projects Selected for Analysis

Appendix A-2 - Model Analysis Report

Appendix B-1 - Data Decomposition Templates

Appendix B-2 - RACER Assessment Database Entry Examples

Appendix C - Cumulative List of RACER Observations

Appendix D - Core Personnel Bios

Allan Engebretson

Project Manager

- BA, International Economics, George Washington University
- Certified Cost Consultant, Association for the Advancement of Cost Engineering 1994

We assigned one of our most seasoned Program Managers, Mr. Allan Engebretson, who is based in our Denver office, to oversee this assignment and to coordinate the activities of the Booz Allen team. Mr. Engebretson has over twenty years of experience in cost estimating and cost analysis consulting to federal clients and has worked for over 15 years in the environmental cost

engineering discipline. His work includes major roles in the DOE Environmental Management Program and EPA facility remediation projects with responsibilities for program life cycle costs and performance measurement. He led the team to develop a cost baseline for remediation and facility decommissioning at the Oak Ridge site. Mr. Engebretson has over seven years experience conducting independent program assessments. He has briefed senior executives in government, including the Edison Electric Institute, as well as the Energy and Commerce Departments on cost-related subjects as diverse as site-selection criteria for geologic repositories, nuclear nonproliferation, and export development assistance. His work on DOE economic impact to local communities was reviewed and referenced by the General Accounting Office (GAO) in their report to Congress. Most recently, he briefed the Colorado Legislative Audit Committee on findings concerning the capital development of high-speed digital infrastructure in the state. Mr. Engebretson was certified by the American Association of Cost Engineers (AACE) in 1994 and has presented at numerous professional conferences including the Institute of Business Forecasting and AACE.

Steven R. Ferries

Deputy Project Manager

- B.S., Geology, University?
- RACER™ Certified Trainer

We assigned Mr. Steven Ferries of the San Antonio office as the Deputy Project Manager. His responsibilities were to manage project operations by ensuring that the overall project quality was maintained for each project task, deliverables met the project scope, and deliverable deadlines were met. In addition,

Mr. Ferries will be involved in segregating the project into its phases and technologies, generating RACER estimates, and evaluating model outputs. From 1999–2002, Mr. Ferries taught over a hundred RACER software classes for United States Army Corps of Engineers (USACE) – Formerly Used Defense Sites (FUDS), Army Environmental Center (AEC), Department of Energy (DOE), Air Force Center of Environmental Excellence (AFCEE), and the Navy. He also managed the RACER product as well as developed numerous RACER cost models, associated algorithms, assemblies, and developed and managed the software testing plans for the overall program and individual cost models. Mr. Ferries also performed hundreds of RACER budgetary estimates for the FUDS program.

While at Booz Allen, Mr. Ferries has developed the Military Munitions Response Program (MMRP) RACER Estimating Guidance Document for AFCEE, a document that is now being used by bases for the RACER budgetary estimating process. He also developed specialized RACER MMRP estimating templates and a help system to assist the bases in their budgetary estimating process.

Mr. Ferries developed the former Chanute AFB's budgetary estimates for the FY04 budget, and he was responsible for Landfills 3 & 4 cost estimates. He assisted in the quality control/quality assurance of the other estimates for the project, and he also developed RACER cost estimating guidance for Chanute to maintain consistency of estimates as well as auditability.

Andrew Haggard
Statistical Analysis and Cost Database
Design Lead

- M.B.A., Tuck School of Business, Dartmouth College, financial management concentration
- Experience: Lead for multiple business case analyses, remediation cost estimation experience, financial and statistical analyses, advanced financial modeling

Mr. Andrew Haggard, has seven years of professional experience in business case analyses, cost benefit analyses, litigation support, and major IT outsourcing initiatives. Mr. Haggard was previously employed by Booz Allen for three years before leaving to complete his MBA in June of 2003. Previously, at Booz Allen, Mr. Haggard led high-profile studies for a number of civilian and defense agencies including: the Business Case Analysis for the DoD's Navy Marine Corps

Intranet (NMIC) seat management contract, a market study for the U.S. Foreign & Commercial Service, an ERP cost benefit analysis for the Department of Health and Human Services, and an international demand analysis for the DoD's Advanced Amphibious Assault Vehicle. He has led all phases of high-profile engagements, including financial and technical data collection efforts, investment analyses, advanced modeling, final report development and presentation to senior management and oversight entities. Mr. Haggard has also done environmental cost studies, including a remediation cost estimate for the EPA's Research Triangle facility and litigation support for the DOE's Parks Township remediation efforts. In the summer of 2002, Mr. Haggard was selected as one of 25 consultants for the National Park Service's Business Plan Initiative and was assigned to Grand Canyon National Park. The business plan covered a complete analysis of all park operations, funding sources, and an activity-based analysis of park requirements. Other professional experience includes a staff position in the U.S. Senate in the office of former Senate Majority Leader George Mitchell and three years as a policy analyst at the Committee for Economic Development, a business-led economic think tank in Washington, D.C.

Colleen Miller
Western Region Data Collection
Team Lead

- B.S., Chemical Engineering, Colorado State University
- RACER™ Certified Trainer
- Experience: Developed hundreds of RACER cost estimates for the USACE FUDS sites; involved in the development and testing of numerous RACER cost models

Ms. Colleen Miller of the Denver office was assigned as the Western Region Data Collection Team Lead. In this role, Ms. Miller was responsible for leading the on-site data collection effort for the Western region, which included conducting on-site project management interviews and ensuring consistent and thorough data gathering at district sites. Ms. Miller deconstructed and analyzed project data, generated RACER estimates, and evaluated model outputs.

In her previous position, she acted as the technical point of contact for the RACER user population, assisting users in utilizing RACER to complete environmental remediation and restoration project estimates. Ms. Miller has completed hundreds of RACER cost estimates for the United States Army Corps of Engineers (USACE) Formerly Used Defense Sites. She has assisted in the development and testing of numerous RACER cost models, associated algorithms, and assemblies. Ms. Miller is a certified RACER trainer and has provided basic and advanced training to over 200 trainees within the Army Environmental Center, U. S. Air Force, and USACE.

Kevin Nelson

- B.S., Civil Engineering/ B.S., Economics, Minor Environmental Science, Colorado School of Mines
- PACES™ Certified Trainer
- Experience: Developed dozens of PACES facility models

For this project, Mr. Kevin Nelson conducted on-site project management interviews and collected data from location visits. He also was responsible for deconstruction and analysis of project data, generating RACER estimates, and evaluating model outputs.

Mr. Nelson has five years experience as a rig engineer, cost engineer, trainer, and parametric cost model designer. He has conducted condition assessments and contributed to the development of condition assessment

programs. Mr. Nelson is familiar with the RACER system from his prior experience with the PACES program. PACES provides cost estimates for facility construction but shares the same assembly database and numerous technologies. Previously, Mr. Nelson was the product line manager for PACES. He has been involved with the development of 52 facility and site work models and has trained 120 government employees on use the PACES program.

Katharine Hastie

- M.S., Environmental Systems Engineering, Clemson University; B.S., Physics, University of the South.
- Experience: Conducting interviews for data gathering, environmental file reviews, report writing, environmental statistics

Ms. Katherine Hastie conducted on-site project management interviews and collected data from location visits. Ms. Hastie also deconstructed and analyzed project data, generated RACER estimates, and evaluated model outputs. Ms. Hastie has seven years experience in the environmental field. She has conducted facility investigations and environmental sampling at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource

Conservation and Recovery Act (RCRA) sites. She has gathered data and estimated the cost-to-complete environmental cleanups at various DoD facilities. She has provided technical assistance and conducted training seminars on topics such as Hazardous Waste Site Sampling and Data Quality Assessment, for local, state, and other federal agencies involved in environmental field investigations.