Cost Estimates for the Decontamination and Decommissioning of Eight ORNL Buildings

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ABSTRACT

The U.S. Department of Energy's Oak Ridge National Laboratory (ORNL) contains a number of buildings that are antiquated and no longer used. These buildings historically were used for the production of atomic weapons and often remain contaminated with radioactive materials. Certain costs and risks are associated with the long-term stewardship of the buildings. One way to reduce these liabilities is to eliminate the buildings that are no longer in use and are not expected to be used in the future.

Some of these buildings at ORNL are located in an area known as "Isotope Circle." From this area, eight buildings that are expected to be decontaminated and decommissioned (D&D) in the next five to ten years were chosen to have cost estimates completed. The specific facilities are Buildings 3030, 3031, 3118, 3032, 3033, 3033 Annex, 3034, and 3093.

There are many challenges for estimating the costs to D&D buildings potentially contaminated with radionuclides. Each building is unique, has various types and levels of contamination, and (as in this case) often lacks up-to-date information. Because of these limitations, order-of- magnitude cost estimates for each of the eight ORNL buildings were completed using parametric cost modeling software known as RACER™ (Remedial Action Cost Engineering and Requirements System). This type of cost estimate is useful for screening technical concepts and is used for budgetary planning.

For the eight buildings evaluated in this study, the total cost to D&D was estimated to be nearly $6M. This value includes the direct cost of approximately $3.5M to complete D&D and $2.5M in cost markups. Also, assuming the actual project does not begin until the year 2010, this total cost is escalated to almost $6.7M, which accounts for expected inflation.

Although the cost estimates in this study were expected to have a wide range in accuracy, there are various factors that could impact these estimates in a negative or positive fashion. For instance, a cost estimate for each building was completed separately and independently from the other buildings. One approach that has the potential to reduce the total cost to complete the D&D work is economies of scale. If there was coordination at the ORNL site to D&D all of the eight buildings one after another, then cost savings due to such items as elimination of multiple mobilization and demobilization could be realized. On the other hand, there may very well be unexpected challenges that occur during the D&D process, which would drive the costs higher.

SITE HISTORY

Many of the U.S. Department of Energy (DOE) sites contain buildings that were initially established to design and produce atomic weapons during WWII. One such site, the Oak Ridge National Laboratory (ORNL), is an 1,100-acre campus located in Oak Ridge, Tennessee [1]. This site was originally known as the Oak Ridge Reservation when it was developed during WWII in early 1942. Several large buildings

were constructed on site primarily for the extraction of uranium-235 to be used for producing the first atomic bomb. Other processes were also developed at ORNL in support of developing atomic weapons.

Over time, these buildings were converted and used for other developments such as nuclear medicine, nuclear energy, and a variety of other technological advancements. However, many of these buildings are antiquated and no longer in use and therefore have been slated for demolition. ORNL has a series of buildings in an area known as "Isotope Circle" that fall into this category. Although nuclear products have not been developed or produced in some of these buildings for many years, they still contain high levels of radioactive materials that complicate the demolition process.

PROJECT OBJECTIVES

In addition to the complications associated with the actual decontamination and decommissioning (D&D) of a nuclear facility, the process of estimating the costs associated with completing this work is also challenging. Before actually beginning the work involved with cleaning up a site (whether a government facility or commercial nuclear plant), a budgetary or feasibility estimate to complete the work is typically necessary. This often requires the estimator to assemble an order-of-magnitude cost estimate with a minimal amount of information.

The purpose of completing an order-of-magnitude cost estimate is to provide a basis for financial planning for future budget cycles. This allows the organization an approximation of the amount of funds that will be required to complete the D&D tasks in the future. This method of estimating is not useful for projects that need to be completed in the near term, as these require a more detailed bid estimate. As the time to complete the D&D project gets nearer, a budgetary estimate must be further refined to provide a more accurate picture of costs associated with the process.

ORNL currently has a number of surplus buildings that require surveillance and maintenance on an ongoing basis. These buildings that require active management contain a wide range of radioactive materials as a result of historical operations. Although radioactive fuel sources have been removed and most of these buildings have not been operational for a number of years, many are still highly contaminated.

As part of a cost savings measure associated with the elimination of surveillance and maintenance, these surplus buildings are scheduled for D&D in the next five to ten years. In addition to the cost savings, another benefit of D&D to these buildings is the reduction of risk to employees, the public, and environment due to the removal of radioactive contaminants. Another benefit is the possibility of putting the land to better use rather than it being occupied by a vacant building.

To assist the DOE with its risk reduction initiative, MSE Technology Applications, Inc. (MSE) provided support in determining estimated costs to complete the D&D of a group of surplus buildings at ORNL. The cost estimates provided in this report are for eight buildings located in an area commonly referred to as "Isotope Circle." These buildings were primarily used to initially support the development of atomic weapons and ultimately nuclear medicines.

Subject to the availability of data, levels of contaminants, and other conditions related to safety and health, order-of-magnitude cost estimates were completed for the buildings using a variety of sources. Initially data were obtained from information provided through ORNL personnel, literature searches, and material takeoffs from facility drawings. From these data, cost estimates for program funding purposes to D&D these particular buildings were completed using parametric cost modeling software known as RACER™.

APPROACH TO COMPLETING THE PROJECT

Project kickoff began with a meeting organized by personnel involved at the ORNL complex. At this time, a tour of the site and the buildings scheduled for D&D was completed. Some of the facilities were not toured due either to the hazards associated with a structurally unsound building or high levels of contaminants. The purpose of this tour was to provide MSE with an overview of the physical properties and conditions of the buildings targeted for D&D. In addition to this tour, MSE also examined historical files and drawings archived in a document library. It was determined from dates shown on these files that this information was a minimum of 40 years old and not available electronically. Based on what was observed at this time and the availability of up-to-date information being available, MSE determined a method of approach for completing this project.

Once the specific buildings for which cost estimates to D&D were identified, the next step was to determine what information would be required. MSE requested drawings containing (at a minimum) the floor plan and elevation for each facility. MSE also requested that more detailed drawings containing piping, electrical, and mechanical systems be provided where available. Other information such as building descriptions and contaminant characterizations were also obtained from ORNL and from Internet literature searches.

In addition to the drawings being dated, they were not in an electronic format. Therefore, the drawings available had to be copied from the microfilm on which they were stored. This process took a considerable amount of time to complete, and the quality of the copies was sometimes poor as the images contained on the microfilm were not of good quality. While most of the drawings could be used for completing material takeoffs, in some cases "best estimates" were made by obtaining data from drawings of similar buildings or other sources. It was also assumed the drawings available had been updated to incorporate the extensive modifications made over the years.

Once the material takeoffs from facility drawings were complete and other available information was summarized, order-of-magnitude cost estimates were developed. To complete these estimates, parametric cost modeling software known as RACER™ was used. This software was originally developed as a cost-estimating tool by the U.S. Air Force and is now licensed through Earth Tech. Over the years, RACER™ has been revised and updated using a combination of government and private industry funding and inputs. This software is commonly used for providing cost estimates for all phases of environmental remediation projects. Although RACER™ contains a range of technologies for completing the remediation of sites containing various contaminants, in this particular case, the only technologies used within the RACER™ model were to D&D buildings contaminated with radioactive materials.

The primary phases used to complete the cost estimate were site characterization, remedial design, and remedial action. The specific technologies used to complete each necessary task associated with building D&D are contained within each of these three primary phases. Data appropriate for each technology was entered into the model as required. In some cases, user inputs are required while others contain default values based on historical data. Once appropriate data for a building is entered into the model, the technology is run to calculate its total costs. This is completed for each of the required technologies within the primary phases associated with building D&D. An outline of data and information required to complete the RACER™ cost modeling is published in the original report.

Once all of the technologies were run for each phase, a total cost both with and without markups was calculated for each specific building. Markups (or indirect costs) include costs associated with general conditions, overhead, owner costs, and contractor profit. After completing cost estimates to D&D each of the various facilities and associated equipment at ORNL, the final product is a cost summary report containing budgetary cost estimates to D&D all of the specified buildings. In addition to a total cost

estimate to D&D each of the facilities, a breakdown of major cost elements for each is also produced. The purpose of these estimates is to provide a basis for program funding requests for the ORNL complex.

FACILITIES DETAIL

There are eight buildings at ORNL for which cost estimates to D&D were completed, and these include Buildings 3030, 3031, 3118, 3032, 3033, 3033 Annex, 3034, and 3093. These buildings are primarily associated with an area at ORNL referred to as "Isotope Circle." Each of these buildings is similar in construction but contain different types and amounts of equipment. Fig.1 shows a plan view of the "Isotope Circle" location with the specific buildings being considered in this study highlighted in red.

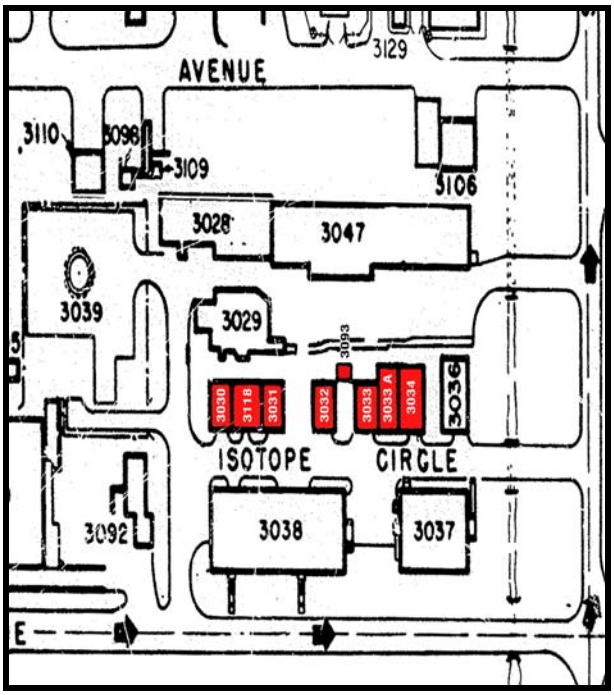

Fig. 1. Plan view of ORNL's isotope circle

Fig. 2 shows the exterior and Fig. 3 shows the interior of a typical building along "Isotope Circle." These buildings are predominantly concrete and steel-frame structures with aluminum skins on both the inside and outside and with tar and gravel roofing material. These photos also show the typical ducting for each building and the limited amount of equipment contained within. Fig. 4 provides a general view of the ORNL site.

Fig. 2. Exterior of a typical building along "Isotope Circle"

Fig. 3. Interior of a typical building along "Isotope Circle"

Fig. 4. General view of the ORNL site

An example of a general description of each building based on various documents, observations made by MSE personnel, and ORNL drawings is provided in Table I. For each building, there are sections containing a summary of the building, information obtained from building drawings, and contaminant characterization data. This information provides a basis from which the RACER™ cost estimates were made. A general description of all of the buildings contained in this study is published in the original report (*Cost Estimates for the Decontamination and Decommissioning of Eight ORNL Buildings*, MSE, September 2005).

Table I. Summary of Building Descriptions

Facility	Information Summary Of Buildings For The D&D Project At Oak Ridge's Isotope Circle
Summary	**Isotope Circle - Buildings 3030, 3031, 3118, 3032, 3033, 3033 Annex, 3034, and 3093**
	All buildings about same construction – concrete, structural steel, tar & gravel roofing material, little to no interior walls/rooms, corrugated metal or transite (asbestos) walls (although most seem to be sheet metal rather than transite), each has own exterior ventilation ductwork w/HEPA filter system that all feed to LGWO. However, only the ~12' X 12' tritium processing room within building 3033 actively ventilated. All other buildings not ventilating to exterior HEPA and LGWO.
Building 3030	**Radioisotope Production Laboratory C**
	Single story, steel frame, corrugated aluminum siding, 825 sq ft, contains 1 manipulator-type hot cell, 2 lab hoods, and 1 glovebox. Hot cell has 2-ft concrete walls with 4" of lead brick on two sides.
	From drawings:
	27'W X 32'L X 11'H (roof), 7' parapet
	Foundation - 10" thick concrete
	Walls - 16 ga. aluminum skin, 2 5/16" Stran steel studs, Celotex insulation (asbestos), corrugated aluminum exterior siding, 8" C-channel @11.5 lbs/ft with 8" flange (Medium).
	Roof - 12W45 structural, Robertson FKX 18-18 Q-Decking, 3" poured gypsum decking, mineral wool insulation, 4-ply roof membrane, flashing, wood, celotex sealant (possible asbestos).
	Piping, equipment, and ductwork - drawings did not contain details for these items. Assume the same as for Building 3031, which did have more detailed drawings.
	Characterization data:
	Contaminants - small quantities of Ni-63 and Pd-103 present, although not noted in ORNL Hazard Screening.
	Release data - NA
	Location - some areas of the building are contaminated, but not noted specifically where.
	Ni-63 has 100.1 yr half-life & releases beta radiation. Pd-103 has 17 day half-life & releases gamma radiation.

The building summary section provides a description of each facility based on information contained in ORNL documents and observations made by MSE. Information from drawings was obtained by completing material takeoffs of drawings provided by ORNL. The characterization data provides the contaminants available and their location for each building. This information was taken from the document *Site Descriptions of Environmental Restoration Units at Oak Ridge National Laboratory, Oak Ridge, Tennessee* [2] and is believed to be the most current characterization data available.

LIMITATIONS AND ASSUMPTIONS

Limitations

There are several limitations to the RACER™ model including the inability to estimate the cost to D&D hot cells, which many of the ORNL buildings contain. Due to the unavailability of cost data and technical approaches to D&D hot cells, the Specialty Process Equipment technology in the RACER™ model was used. This option requires an estimate of the total weight of the cell as an input, which was determined from the materials takeoff from the available drawings.

Another limitation for this cost modeling was the lack of detailed information for each of the buildings. In addition, most of the data was obtained from old facility drawings that had not been updated. Consequently, in completing these estimates, various assumptions had to be made regarding inputs for the model and the technical specifications of the buildings. The following section contains the general assumptions made for this cost-estimating project. For assumptions specific to each individual facility contained in this study, see the original report (*Cost Estimates for the Decontamination and Decommissioning of Eight ORNL Buildings*, MSE, September 2005).

General Assumptions

- Utilities are deenergized, disconnected, and abandon in place prior to the building D&D. The costs associated with this are not included in the estimates.
- Each building has been deactivated such that any nuclear source materials have been removed.
- None of the equipment or materials is salvaged or recycled.
- Each building will require a full facility characterization.
- Asbestos (such as for fire-proofed ceilings or insulated pipe) is removed prior to demolition.
- Structures are taken down just below grade level using an excavator.
- Items that may be present below grade level (e.g., pipelines, concrete footings, substructures, and contaminated soil) are left in place.
- The bulk of waste from demolition meets the waste acceptance criteria (WAC) for disposal in ORNL's Comprehensive Environmental Response, Compensation, and Liability Act designated on-site landfill.
- A small amount of waste (such as for the hot cells) is expected to possibly not meet the WAC and require shipment and disposal at the Envirocare facility.
- The one-way distance from ORNL to the Envirocare facility is 2,000 miles.
- Hot cells have already been stabilized with a fixant and coated with a covering such as Instacoat.
- D&D of hot cells is accomplished using a hydraulic shear after the structure surrounding them has been taken down.
- On average, cured concrete weight is 3,600 pounds per cubic yard.
- The weight of lead is 19,115 pounds per cubic yard.
- A final status survey is not required because each building will be totally demolished.

COST ESTIMATES

Using the required inputs and technical assumptions for each of the buildings, order-of-magnitude cost estimates were then completed for each of the eight buildings. Order of magnitude cost estimates typically are in an accuracy range of –30% to +50% because they are prepared from limited information and data [3]. Due to this wide range of accuracy, these estimates are to be used only for conceptual screening and high-level budgetary purposes.

The cost estimates ranged from approximately $150,000 to remove the exterior ductwork for all of the buildings included in this study to $1.3M to D&D Building 3033. The total cost to D&D all eight of the ORNL buildings is estimated to be approximately $6M. A summary of the estimated costs to D&D each of the buildings included in this study is contained in Table II.

Table II. Estimated Costs to D&D ORNL Buildings

Description	Building									TOTAL
	3030	3031	3118	3032	3033	3033 A	3034	3093	Ext Duct	
Site Characterization Survey	$159,229	$223,085	$220,746	$ 295,699	$ 173,468	$232,027	$165,071	$139,103	-	$1,608,428
Remedial Design	$ 56,736	$ 55,345	$ 31,137	$ 60,834	$ 71,947	$ 25,361	$ 24,987	$ 6,525	$ 14,713	$ 347,585
Remedial Action	$651,991	$636,033	$323,546	$ 693,200	$1,024,060	$264,997	$259,787	$ 53,133	$134,274	$4,041,021
TOTAL	$867,956	$914,463	$575,429	$1,049,733	$1,269,475	$522,385	$449,845	$198,761	$148,987	$5,997,034

The estimated costs to D&D each building included in Table II is the direct cost to complete the work plus any associated markups. Cost markups (or indirect costs) were calculated based on a percentage of direct cost for each of the tasks associated with the site characterization survey and remedial action. These markups take into account the costs associated with general conditions, overhead, prime contractor profit, and owner costs. General conditions include labor supervision, temporary facilities, personal protective gear, required travel, and other miscellaneous costs such as insurance and permits. Overhead includes common items such as employee fringe benefits and office costs along with general and administrative expenses. Markups for subcontracts are also included when applicable. The remedial design cost element does not include markups.

The percent markup values are based on remediation and general construction industry data. In this particular case, the total direct cost to D&D all of the buildings is estimated at approximately $3.5M. Based on this amount, the markup is calculated to be approximately $2.5M for a total cost of nearly $6M. Detailed information is shown in Table III.

These costs do not contain an escalation factor to adjust for the fact that the D&D work is not expected to begin within a year after the completion of this cost estimate. Based on information from ORNL, it was assumed that the schedule to D&D these facilities would not begin until the year 2010. For the purposes of this model, it was assumed the site characterization study for each building would begin in October 2010, followed by the remedial design in April 2011 and remedial action in October 2011. Assuming this schedule is used, this cost estimate would require escalation to inflate the current dollars to the time when actual costs will be incurred.

The indices used to escalate the costs are based on the Office of Management and Budget's inflation rates. For these specific buildings and schedule, the additional cost to adjust for inflation by making the total cost dollars current is approximately $662,000. This raises the total estimated cost to D&D all of these facilities starting in the year 2010 to approximately $6.66M.

Table III. Site Cost Summary Report (with Markups)

Folder:	ORNL Facilities D&D			
Site				
Name:	ORNL Facilities D&D			
ID:	Phase 1			
Location:	OAK RIDGE, ENV, TENNESSEE			
Modifiers:	**Material**	0.92		
	Labor	0.92		
	Equipment	0.92		
Category:	None			
Report Option:	Calendar Year			
Description:	Cost estimates to D&D facilities at the ORNL.			
Phase		**Direct Cost**	**Markups**	**Total Cost**
Study		$991,608	$616,819	$1,608,427
Design		$197,557	$150,028	$347,585
Remedial Action (Capital)		$2,292,621	$1,748,400	$4,041,021
Total Site Cost		$3,481,786	$2,515,248	$5,997,034
			Escalation	$662,213
			Escalated Site Cost	$6,659,247

The cost estimates ranged from approximately $150,000 to remove the exterior ductwork for all of the buildings included in this study to $1.3M to D&D Building 3033. On the low end of this range is the cost to D&D the exterior ductwork running across the roof of each building and then down to the ground where local filters are contained. Because the data necessary to include this in the estimates were not available for each specific building, a general estimate was made using the minimal information available, which is why the ductwork was treated as a separate cost estimate from the buildings.

Most of the buildings were similar and therefore had similar total costs to D&D. Buildings 3030, 3031, and 3032 are very similar in size and materials and therefore have similar costs. Although Buildings 3030 and 3031 contain similar equipment, 3031 has a slightly higher cost to D&D because of the potential to contain alpha emitter contamination along with the beta/gamma. Building 3032 has the highest cost to D&D in this group because it contains five hoods and also has potential for containing alpha-emitting isotopes.

Although lower in cost relative to Buildings 3030 and 3031, Buildings 3118, 3033 Annex, and 3034 are also similar in total cost. Building 3118 has a higher cost due to the extra steps necessary to remove asbestos, while Building 3034 is the lowest cost in this group because it is expected to be clean and not contain equipment used for handling radioactive materials. Building 3033 is the most expensive to D&D because it contains a significant amount of transite (asbestos-bearing) ducting that requires removal prior to demolition. Further adding to this cost is the large krypton cell constructed of concrete, steel, and lead. The lowest cost facility is Building 3093, which is really not a building but a concrete enclosure without a roof and contains four stainless steel cylinders.

For each building, there is a breakout of the direct cost and marked up cost for the major cost categories referred to in the RACER™ model as technologies. For this D&D cost estimating study, the technologies used include remedial design; D&D site characterization survey; professional labor management; D&D specialty process equipment; D&D radiation contaminated building; asbestos removal; residual waste management; and D&D conduit, pipe, and ductwork. All of these technologies (except for the remedial design and the D&D characterization survey) are collectively referred to as the remedial action phase.

Within each of these technology cost categories, there are comments provided by the estimator that give the logic for the inputs used and the related assumptions made during the cost estimating process. For each building in the cost summary report, all of the costs associated with each of the technologies contained within a phase are rolled up as subtotals. The last entries for each building contains the total direct cost and total marked up cost for each facility in this study. Cost summary reports for the rest of the facilities in this study are shown in the original report (*Cost Estimates for the Decontamination and Decommissioning of Eight ORNL Buildings*, MSE, September 2005).

SUMMARY

An order-of-magnitude cost estimate to D&D buildings along "Isotope Circle" at ORNL completed using the RACER™ model resulted in a total cost of nearly $6M. This amount is in today's dollars and assumes the work to D&D will be completed within one year. However, because the estimated timeframe for this work to begin is approximately five years out, the total cost including escalation is estimated to be nearly $6.7M. This cost figure is valid for conceptual estimates or high-level budget feasibility studies. As the time to begin the D&D task draws nearer, the project needs to be more accurately defined and the cost estimates for each building further refined.

These cost estimates include the major cost elements of remedial design, site characterization survey, and remedial action. In addition, the costs to D&D the exterior ductwork for all of these eight buildings is also included. The advantages to D&D these buildings include a reduction in surveillance and maintenance costs, the elimination of risk to various stakeholders, and potentially a better use for the land on which these buildings are situated.

As with all cost estimates, there is a certain amount of risk associated with the accuracy of the estimate. Because these estimates were completed with dated and limited data and information, they are expected to have wide variances. In addition, there are a number of factors that could significantly impact the total cost to D&D these buildings. A reduction in cost may be seen if D&D were done to all of the eight buildings about the same time due to a one-time mobilization and demobilization. Other variables that may negatively impact the total cost are such items as discovering unexpectedly high contaminant levels or a requirement that all waste be shipped to an off-site disposal facility. However, the estimates in this study should provide reasonable dollar values from which future budgetary planning can be completed to D&D these specific buildings at ORNL.

ACKNOWLEDGEMENTS

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