Decommissioning Cost Estimate
For
Fansteel, Inc.
Muskogee, OK

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1.0 Introduction

This independent cost estimate for decommissioning the Fansteel Incorporated's Muskogee, OK facility has been prepared in accordance with guidance developed by the U.S. Nuclear Regulatory Commission (NRC) for the development of Decommissioning Funding Plans. The cost estimate prepared is for decontamination and unrestricted release of all areas within Fansteel's facility that are subject to licensing under NRC radioactive material license Number SMB-911.[1]

This decommissioning cost estimate includes:

- Overview of Scenarios Modeled and Results;
- Overview of Cost Estimating Methodology;
- Summary of Site Characterization;
- Key Assumptions for the Unrestricted Release Scenario;
- Derivation of Unit Costs; and
- Listing of Reference Documentation.

2.0 Overview of Scenario Modeled and Results

This cost estimate models costs for decommissioning associated with an unrestricted release scenario at the Fansteel site in Muskogee, OK. In this scenario, contamination is removed from buildings through scabbling or chemical cleaning, contaminated equipment is decontaminated and disposed as low-level radioactive waste (LLW), contaminated vegetation is removed from the site, pond residues and contaminated soil are removed and disposed as LLW, and groundwater is treated. The decommissioning activities are designed to remove all contamination above the unrestricted release criteria listed in Fansteel's license.

Exhibit 1 lists the criteria to be used for soil, surface water and sediments, pond residue, and groundwater at the Fansteel site. Exhibit 2 lists the total, removable, and maximum radioactivity limits for equipment and structures as contained in Fansteel's NRC license for thorium and uranium. The license indicates that for surfaces of equipment and structures contaminated with natural thorium, the thorium release limits should be used, and that for surfaces contaminated with natural uranium and thorium that cannot be cleaned to the thorium release limit, the sum of uranium and thorium activity fractions may not exceed one. In evaluating the sampling data for surfaces, the use of a *removable* release limit would be more conservative, however no samples were collected to identify areas with *removable* surface contamination. In the absence of radioactivity data for *removable* contamination, ICF evaluated the survey data of the buildings against the *total* alpha and beta-gamma radiation release limits established in Fansteel's NRC license for thorium. These limits are indicated in shaded cells in Table 2.

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[1] A portion of the Fansteel property, known as the Northwest Property, was previously decontaminated and released for unrestricted use. This cost estimate does not include any costs for the Northwest Property.

Exhibit 1. Radiological Limits for Soil, Surface Water and Sediment, Pond Residue, and Groundwater at the Fansteel Site

Nuclide	Soil, Sediment, and Pond Residue Activity (pCi/g)	Groundwater and Surface Water Limit (pCi/L)
Gross Alpha (Excluding Ra-226, and U)	NA	15
Gross Beta	NA	50
Uranium (U-238, U-235, U-234)	NA	30
Uranium and Thorium	10	NA

NA = Not applicable

Exhibit 2. Radiological Limits for Equipment and Structures at the Fansteel Site

Nuclide	Total Radioactivity (dpm/100 cm^2)	Removable Radioactivity (dpm/100 cm^2)	Maximum Radioactivity Over 100 cm^2 (dpm/100 cm^2)
Thorium Alpha	1,000	200	3,000
Beta-gamma	5,000	1,000	15,000
Uranium Alpha	5,000	1,000	15,000
Beta-gamma	5,000	1,000	15,000

Because disposal of LLW is the major cost driver in this scenario, this cost estimate used three LLW disposal rates to bound the cost (\$5/ft^3, \$11/ft^3, and \$17/ft^3), assuming the waste will be disposed at Waste Control Specialist (WCS) facility in Andrews County, TX as LLW. Mixed waste is considered to be approximately three times the cost of disposal of LLW and is assumed to be disposed at Envirocare's facility in Clive, UT. The disposal cost range for LLW and the increase for mixed waste corresponds to data provided by a Department of Energy (DOE) web site that describes the range of disposal costs for DOE and commercial sites, as well as direct input from NRC staff. Section 6.8 provides more information on the derivation of these unit costs. Exhibit 3 presents three sets of costs associated with this unrestricted release scenario, assuming a disposal cost estimate of \$5/ft^3, \$11/ft^3, and \$17/ft^3 for LLW.

Exhibit 3. Unrestricted Release Costs Estimates for Fansteel

DISPOSAL COST =	$5/ft³	$11/ft³	$17/ft³
Buildings			
Scabbling	$ 141,473	$ 141,473	$ 141,473
Chemical Cleaning - Equipment	$ 4,590,485	$ 4,590,485	$ 4,590,485
Chemical Cleaning - Building Surfaces	$ 174,660	$ 174,660	$ 174,660
Excavate and Backfill Soil	$ 4,650,447	$ 4,650,447	$ 4,650,447
Drying	$ 264,432	$ 264,432	$ 264,432
Clear Vegetation	$ 4,575	$ 4,575	$ 4,575
Groundwater Treatment	$ 7,000,000	$ 7,000,000	$ 7,000,000
Packaging, Containers, and Shipping			
Envirocare	$ 9,189,998	$ 9,189,998	$ 9,189,998
WCS	$ 8,706,509	$ 8,706,509	$ 8,706,509
Disposal			
Envirocare	$ 5,901,015	$ 12,364,582	$ 18,828,148
Envirocare Mixed Waste	$ 1,324,844	$ 2,775,957	$ 4,227,069
WCS	$ 27,920,662	$ 60,929,786	$ 93,938,910
Subtotal	$ 69,869,100	$ 110,792,903	$ 151,716,707
Planning & Preparation	$ 10,480,365	$ 16,618,936	$ 22,757,506
Final Radiation Survey	$ 4,890,837	$ 7,755,503	$ 10,620,169
Contingency	$ 21,310,076	$ 33,791,836	$ 46,273,596
Total	**$106,550,378**	**$168,959,178**	**$231,367,978**

3.0 Overview of Cost Estimating Methodology

Developing the independent cost estimate for Fansteel involved the following six steps:

1) Review site documentation and conduct a site visit to become familiar with the site;

2) Evaluate the prior characterization of the site to date, to define the nature and extent of contamination;

3) Evaluate the existing cost estimates;

4) Develop assumptions for appropriate methods to adequately remediate the site;

5) Gather necessary unit cost estimates; and

6) Calculate cost results.

Steps one, two, and three were performed under other subtasks within this Task Order. A summary of the results of the site characterization review is provided in section 4.0. The remainder of this document outlines the assumptions used (section 5) and explains the derivation of unit costs (section 6).

4.0 Summary of Site Characterization

This section provides a summary of the major findings from the site characterization document prepared by ICF entitled *Review and Evaluation of Characterization Data Provided for Fansteel Corporation, Muskogee, OK.* A more complete description of characterization efforts conducted at the Fansteel facility can be found in that report.

4.1 Buildings

The Fansteel site currently includes 15 buildings. Eight of these buildings were surveyed by Earth sciences in 1993.[2] However, waste reprocessing activities were conducted between 1999 and 2002 in six buildings: Chemical A Building, Chemical C Building, R & D Building, White House, Themite Building and Sodium Reduction Building. The remaining buildings are used for storage and facility maintenance.

As noted above, the characterization conducted for Earth Sciences 1993 *Remediation Assessment* did not include removable concentrations. In the absence of radioactivity data for *removable* contamination, ICF evaluated the survey data of the buildings against the *total* alpha and beta-gamma radiation release limits established in Fansteel's NRC license for thorium. Of the seven buildings with sampling data, four had contamination above these limits. Exhibit 4 shows the percentages of grids contaminated above the release limits.

[2] Earth Sciences surveyed other buildings in 1993 that have subsequently been torn down and thus were not considered in the cost modeling.

Exhibit 4. Summary of Building Contamination

BLDG NAME (Number)	Total Grids Sampled	Grids Above Limits	Percent of Grids Above Limit
Interiors			
White House (7)	80	0	0.00%
Thermite Building (9)	72	0	0.00%
Sodium Reduction Building (11)	91	0	0.00%
Little Bertha Building (12)	22	6	27.27%
Chemcial C Building (13)	189	47	24.87%
R&D Building (15)	519	1	0.19%
Chemical A Building (16)	2208	104	4.71%
Exteriors			
Chemical C Building (13)	27	3	11.11%
Chemical A Building (16)	59	2	3.39%

4.2 Ponds

Over the course of Fansteel's operations from 1956 to 1989 (and between 2000 and 2001), ten holding ponds have been used at the site. During site operations, the ponds held acid slurries, process water, and wastewater treatment slurries. The holding ponds now contain sludges or residues contaminated with organic, inorganic, and radioactive waste. The presence of hazardous and radioactive contaminants increases the probability that some of the material in the ponds will have to be disposed as mixed waste.

There are two types of ponds at the Fansteel site. The first type includes those that were used to store process residues. The second type are those that were and are currently used for wastewater treatment. Ponds 1N and 1S, 2, 3, 4, and 5 were principally used to hold processing residues (Ponds 2 and 5 also received wastewater at some point). All of these ponds, with the exception of Pond 3, have been filled in.

Ponds 5, 6, 7, 8, and 9 are wastewater treatment settling ponds and contain principally calcium carbonate and calcium fluoride. Ponds 6 through 9 are connected in series and water and calcium fluoride sludge and water can pass between them. Before Ponds 8 and 9 were built in 1984, Ponds 2, 5, 6, and 7 were connected in series. Water from the wastewater treatment plant is still pumped into Ponds 8 and 9. As the calcium fluoride settles out, the water is pumped to Ponds 6 and 7 for further clarification where it is eventually released to the Arkansas River through permitted outfall 001.

The most recent characterization of the holding ponds performed by Earth Sciences Consultants, Inc. indicates that Ponds 2, 3, and 5 through 9 were sampled explicitly to characterize the material in the ponds. Ponds 1S and 1N were partially characterized through soil borings. Pond 4 has been filled in for approximately 23 years and the area has not been characterized. No soil testing has been done within the pond berms or between or under the ponds. The Pond residues all have concentrations in excess of the soil limits established in Fansteels license, and the residues from Ponds 2 and 3 appear to contain mixed waste because the residue has chromium present above the RCRA TCLP limit of 5 mg/l.

4.3 Surface and Subsurface Soils

Surface and subsurface soils at the Fansteel site have been contaminated with a number of different isotopes over the years, as well as chemicals. The primary radioactive isotopes of concern are U-238, U-235, U234, Th-232, Th-230, and Th-228. The presence of chemical and radiological contaminants in the surface soil at the site raises the possibility that the soil might be considered mixed waste and would require disposal currently available at a single facility (Envirocare in Clive, Utah).

For cost estimating purposes, ICF divided the site into seven areas of concern.

- Area 1 encompasses surface and subsurface soils bounded by the Chemical A building in the northwest corner, Pond 5 to the south, and the property boundary on the east. Widespread contamination was found in this area. The average depth of contamination was 13 feet. One sample contained barium above the RCRA TCLP level of 100 mg/l, indicating that some of this soil may be mixed waste.

- Area 2 encompasses the area north of the ore storage pad and Area 1, south of the "non-impacted area, west of the property boundary and East of an imaginary line running from north to south through the mid point of Pond 3, but excluding all soils within the Pond 3 french drain. Fewer samples were taken in this area (compared to Area 1), but based on the range of depths of contamination above the limits and the presence of former Pond 2 and part of former Pond 4 which were not sampled at all, an average depth of contamination of 15 feet was assigned.

- Area 3 includes the soils and subsurface soils within the Pond 3 french drain, excluding Pond 3. This area includes part of former Pond 4 and was not sampled at all. The liner of Pond 3 was known to have breached in a release incident in 1989. Based on engineering judgement, soils in this area are assumed to be contaminated to a depth of 10 feet.

- Area 4 encompasses surface soils between the Sodium Reduction Building, the Thermite Building, the Ore Storage Pad, and Pond 6. Surface soils in this area were found to be contaminated.

- Area 5 includes the soil stored between the Ore Storage Pad and the R&D building as well as the surface soil in this area. This stored soil was excavated when the perimeter french drain was installed and is known to be contaminated. Surface soils in this area are likely to be contaminated.

- Area 6 includes ten percent of the surface soils in the "non-impacted area." A small area of contamination was found through surface scans and sampling.

- Area 7 includes the soils extending 10 feet beyond the perimeter of ponds 5, 6, 7, 8 and 9 as well as the soil between these ponds. This area was not sampled in order to not breach the liners of these ponds. Because soil between the ponds and below the ponds is likely an average depth of contamination of 7 feet was assigned.

4.4 Groundwater

Due to contamination of surface and subsurface soils at the Fansteel site, Earth Science's investigated the existence and extent of groundwater contamination and presented the results in their *Remediation Assessment* report dated December 1993. The results of this assessment indicate that the shallow aquifer is contaminated with a number of different isotopes as well as metals and an organic compound. The primary radioactive isotopes of concern are U-233, U-234, U-235, U-238, Th-228, Th-230, and Th-232. Based on Earth Science's investigation the deeper bedrock aquifer does not appear to have been affected by Fansteel's operations. Additional sampling has been conducted since the 1993 assessment.

Radiological contamination was found above the levels listed in Fansteel's NRC license in 23 of the 25 shallow wells and one of the four deep wells. However, only five of the shallow wells and none of the deep wells appear to have significant contamination detected on an ongoing basis. The wells where significant, lasting contamination was found are located in the borrow pit area (MW-56S) and along the eastern property line (MW-66S, MW-67S, MW-73S, and MW-74S). Fansteel has already installed a groundwater collection and treatment system that covers the area downgradient of the processing area.

5.0 Key Assumptions for Unrestricted Release Scenarios

The assumptions used in the unrestricted release scenario are presented below. In preparing these assumptions, this analysis sought to utilize assumed values that are reasonable, but conservative - and not worst-case.

5.1 Buildings

Our overall approach to the decontamination and decommissioning (D&D) of the buildings is based upon the consideration of whether the structure is known to be contaminated and the building construction materials. In addition, the D&D process should be conducted in such a manner as to minimize the generation of additional radioactive and/or hazardous waste; while taking cost into consideration. Our assumptions are as follows:

- All of the buildings are structurally sound.

- Fixed contamination (>5,000 dpm/100 cm^2) must be removed by scabbling concrete or wood walls and ceilings to 1/8 inch.

- Loose contamination (>1,000 dpm/100 cm^2) must be removed by chemical cleaning (for metal and other impervious surfaces) and/or scabbling wood or concrete walls and ceilings to 1/8 inch.

- Areas of contamination identified during the survey are assumed to have fixed contamination.

- Contaminated floors will be chemically cleaned or scabbled to 1/4 inch. Ten percent of the floors are assumed to be badly worn or cracked and will require repeat cleaning or scabbling.

- Scabbling or chemical cleaning will be applied to the percentage of grids on a surface found to be contaminated. (Hence if half the grids on the floor of a building are contaminated, half the floor will be scabbled or cleaned.)

- Materials such as ceiling tiles, plywood, duct work, piping, floor tiles, and insulation will be removed and surveyed when placed into B-25 boxes for disposal.

- Buildings will undergo D&D unless it is more cost effective to take down and dispose of them as radioactive waste. (The D&D wastes will be considered radioactive and the remaining structure will be considered to be radioactive.) Decontaminated buildings will be left standing.

- When estimates of equipment in the buildings were not provided, this analysis assigned each building to be empty or full, based on observations made during the site visit. Empty rooms were considered to contain an amount of equipment equivalent to 5 percent of the room's volume, and full rooms were considered to contain an amount of equipment equivalent to 30 percent of the room's volume. One third of equipment in buildings was assumed to be clean, one third assumed to require disposal as LLW, and one third was assumed to require cleaning in order to be disposed as LLW.

5.2 Ponds

Various sources list the quantities and/or volumes of pond residues. However, discrepancies exist between these sources, and no density data are provided to compare mass and volume estimates. Further, as the pond material is dried, the density of the residue will change. Exhibit 5 presents two estimates of pond volume and one estimate of pond residue mass before dewatering, and one estimate of pond residue mass after dewatering.

Exhibit 5. Estimates of Pond Residues from Various Sources

A	B	C	D	E	F	G	H
Pond Number	**Length (ft)**	**Width (ft)**	**Residue Depth (ft)**	**Calculated Volume of WIP (ft3)**	**WIP estimate (1994) (ft3)**	**Tons WIP**	**Dewatered Tons WIP**
2	351	151	10	530,010	275,000	16,298	13,038
3	400	250	10	1,000,000	200,000		
5	200	100	3	60,000	90,000	67,703	54,163
6	200	100	3	60,000	10,000		
7	250	150	3	112,500	160,000		
8	350	350	13	1,592,500	2,150,000		
9	600	250	13	1,950,000	2,000,000		
Total				5,305,010	4,885,000	84,001	67,201

Sources:

Columns B and C: 1997 EA, P-3-27
Columns D: Site Visit Report
Column E: Product of Columns B, C, and D
Column F: Table 2-2 of Fansteel's June 20, 1994 License Application
Columns G and H: Fansteel 2002 Cost Estimate

Of the three available estimates of pond residue volume, we choose to use the 1994 estimate (column F) because it was a volume estimate (needed for estimating excavation costs) and because it was a single source from Fansteel. Because Fansteel is located in an area of net positive rainfall, the pond residues will require dewatering prior to shipment to a LLW disposal facility. We estimated dewatering costs based on this excavation volume. Dewatering will produce a smaller amount of residue to be disposed off-site. We used the Column H estimate as the amount of residue requiring disposal. Because our shipping costs were on a mass basis but the disposal costs were on a volume basis, we assume a density of 2,500 kg/m3 for the dried pond residue. This estimate was taken from p. 7-37 of NUREG CR/1754 for a tailings pond residue from rare earth processing.

In addition to the ponds, we assumed that the pond liners and some amount of soil below each pond might be contaminated. Based on the typical permeability of clay, we assumed contamination of one foot of the clay liner over the operating lifetime of the facility. Therefore, we multiplied the footprint of the pond by one foot to calculate the amount of liner that needed to be removed and disposed. Because of the liner breach incident in Pond 3, we assumed that 10 feet of soil needed to be excavated and disposed of under 10 percent of the footprint of Pond 3.

5.3 Surface and Subsurface Soils

As shown in Exhibit 6, we calculated the physical area of each of the seven site areas (as described in Section 4.3) and subtracted the pond areas (to avoaid double counting). For each area, we assigned a percentage of the area contaminated and a depth of contamination. As described in Section 4.3, when possible, these depths and areas were based on sampling results.

Exhibit 6. Soil Contamination

Soil Area	Length (ft)	Width (ft)	Area with Ponds (ft^2)	Area without Ponds (ft^2)	Percent of Area Affected	Contam. depth (ft)
1	640	330	211,200	211,200	70%	13
2	460	460	211,600	158,599	50%	15
3	550	410	225,500	125,500	50%	10
4	450	160	72,000	72,000	30%	0.5
5	525	150	78,750	78,750	70%	0.5
6	650	650	422,500	422,500	10%	0.5
7	660	650	429,000	79,000	100%	7

These amounts of soil that we estimate need to be removed are significantly higher than those estimated by Fansteel. In part, this difference results from our treatment of unsampled or undersampled areas. In the absense of data showing an area was clean, we assumed it was likely to be contaminated if it was located near areas of known contamination. Further, we believe that Ponds 2 and 4, which held ore processing residues are likely to have contaminated nearby soil, based on groundwater monitoring results.

To facilitate estimating shipping costs, we assumed a density of 1.86 g/cm^3 for clay and 1.76 g/cm^3 for clayey-soil, based on typical values presented on the Internet.[3]

5.4 Vegetation

We assumed an acre of heavy brush and one acre of light brush would need to be removed in non-impacted areas to get at surface contamination (based on the surface scans and samples taken in that area). This vegetation will be removed, surveyed and disposed of as either radioactive or non-radioactive (a 10:90 split for radioactive/non-radioactive vegetation is assumed). Non-radioactive vegetation will be left on site.

5.5 Groundwater

Assuming that the soil removal described above removes all of the potential source materials, this analysis assumes long-term groundwater remediation will not be necessary. However, short-term groundwater remediation will be necessary during the period when the site is being remediated and for a period afterward to allow the site to flush. Thus, we assume Fansteel will continue to operate their groundwater treatment system for 10 years, which includes 2 to 3 years to remediate the site and 7 to 8 years to allow the site's groundwater to flush.

[3] http://www.falcon-drilling.com/core.htm

5.6 Off-Site Releases

This analysis assumes that there have been no off-site releases as determined by soil sampling conducted to verify no off-site migration of releases.

5.7 General Decommissioning Estimate Process

Based on guidance provided by the NRC in NUREG/CR-1754, NUREG/CR-1754 Addendum 1, and NUREG/CR-6477, this cost estimate considered the six major cost categories required by NRC in decommissioning funding plans:

- Planning and preparation;
- Decontamination and/or dismantlement of radioactive facility components;
- Packaging, shipping, and disposal of radioactive wastes;
- Restoration of contaminated areas on facility grounds;
- Final radiation survey; and
- Site stabilization and long-term surveillance.

This cost estimate also makes the following assumptions:

- Within each room/area cost estimate this analysis includes the labor, materials and equipment, and waste handling and management necessary to meet decontamination objectives. The individual room/areas are then added to provide a total cost estimate.

- An independent third party contractor will perform all work.

- The cost estimate adds a contingency factor of 25 percent to the sum of all estimated costs.

- The cost estimate does not take credit for (1) any salvage value that might be realized from the sale of potential assets during or after decommissioning, or (2) reduced taxes that might result from payment of decommissioning costs or site control and maintenance costs.

- A single decontamination step such as HEPA vacuuming and chemical cleaning is assumed to reduce the level of surface contamination on a component by one or two orders of magnitude.[4]

- Planning, preparation, and final radiation survey costs are based upon estimates provided in NUREG/CR-1754, Addendum 1.

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[4] E S. Murphy, 1981. *Technology, Safety and Costs of Decommissioning Reference Non-Fuel-Cycle Nuclear Facilities.* NUREG/CR-1754. U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, Washington.

- Planning and preparation activities include the preparation of a detailed decommissioning plan, preparing other state and/or local documentation, developing work plans, performing staff training, and procuring special equipment. Planning and preparation costs will be assumed to account for approximately 15 percent of the total decommissioning costs. Based upon the potential for high radiation exposures possible during removal of materials and wastes, this planning estimate is reasonable.

- The final radiation survey will be performed to ensure that the materials license can be terminated and the premises released. Final radiation survey costs will include the cost of performing measurements to verify compliance with NRC guidelines on acceptable surface contamination levels, and the cost for preparing the survey report. The cost for the final radiation survey will be assumed to be 7 percent of the total decommissioning costs based upon previous NRC experience.

6.0 Derivation of Unit Costs

6.1 Building Decontamination

The unit costs for scabbling 1/8 inch from floors ($14.68/ft^2), walls ($17.12/ft^2), and ceilings ($20.53/ft^2) are found on page B-5 of the *Cost Estimate for Decommissioning the Advanced Medical Systems Facility in Cleveland, Ohio,* prepared for U.S. NRC, Office of Nuclear Materials Safety and Safeguards, by ICF Incorporated, April 1998. Because it is common to scabble 1/4 inch from floors, the cost to scabble floors was doubled ($29.36/ft^2).

6.2 Equipment Decontamination

The following unit cost estimates for the chemical cleaning of floors, walls and ceilings, in buildings with a mixture of significant contaminants, presented in Exhibit 7, were gathered from the *Revised Analyses of Decommissioning Reference Non-Fuel-Cycle Facilities* (NUREG/CR-6477), completed in July 1998. Each unit cost estimate includes the full cost of handling waste generated by its chemical cleaning process (packaging, supercompaction, transportation, and disposal) in addition to manpower and equipment.

Exhibit 7. Costs Associated with Chemically Cleaning Equipment Contaminated with Mixed Isotopes

	Cost ($ thousands/ 60 m^2)						
	Manpower	Equipment	Packaging	Supercompaction	Transportation	Disposal	Total
Floors	5.87	1.86	0.10	0.23	0.03	1.14	9.23
Walls	6.54	2.07	0.23	0.44	0.07	3.12	12.47
Ceilings	4.68	1.48	0.55	1.18	0.17	5.98	14.04

To estimate the cost of chemically cleaning a volume of miscellaneous equipment, this analysis generated a new unit cost per piece of equipment based on a weighted average of the total unit costs for cleaning individual pieces of equipment listed in NUREG/CR-6477 and a weighted average of these items' respective volumes, as shown in Exhibits 8-9. Volumes were calculated from component dimensions found in NUREG/CR-6477 Appendix D. The list of items used to calculate average volume and cost for tritium and mixed contamination vary slightly as NUREG/CR-6477 did not contain the unit cost of chemically cleaning each item for each contamination scenario. For example, the cost of chemically cleaning cabinets was available for tritium but not mixed contamination, whereas the cost of cleaning sinks and drains was available for mixed but not tritium contamination. The weights of each item in the calculation were chosen to reflect that item's expected prevalence in chemically cleaned buildings.

Exhibit 8. Weighted average to calculate cost of Chemical Cleaning for Miscellaneous Equipment with Mixed Decontamination

	Cost ($ thousands/component)							
	Manpower	Equip.	Packaging	Supercomp.	Transport.	Disposal	Weight	Total
Fumehood	3.17	1.00	0.13	0.29	0.04	1.44	1.0	6.07
Workbench	3.57	1.13	0.19	0.42	0.06	2.10	2.0	14.94
Refrigerator	1.25	0.39	0.21	0.46	0.07	2.31	1.0	4.69
Sink and Drain	0.57	0.18	0.07	0.15	0.02	0.77	4.0	7.04
Ventilation	7.90	2.49	0.07	0.15	0.02	0.75	0.5	5.69
Glove Box	1.10	0.35	0.10	0.21	0.03	1.04	1.0	2.83
Total							9.5	41.26

Exhibit 9. Weighted Average to Calculate Average Component Size

	Weight	Component Dimensions (m3)	Weighted Component Dimensions (m3)	Included in H-3 Contamination	Included in Mixed Contamination
Fumehood	1.0	2.84	2.84	1	1
Workbench	2.0	0.37	0.74	1	1
Refrigerator	1.0	0.56	0.56	1	1
Cabinets	4.0	0.52	2.08	1	
Sink and Drain	1.0	0.47	0.47		1
Ventilation	0.5	3.09	1.55	1	1
Glove Box	1.0	0.32	0.32	1	1
Total	10.5	8.17	8.55	6	6

6.3 Vegetation

This analysis referenced RS Means *Environmental Remediation Cost Data-Unit Price* for 2000 to estimate the costs involved in clearing vegetation and disposing of the portion that is not radioactive. The unit costs presented in Exhibit 10 are found in RS Means section 17 01 0108, page 4-1.

Exhibit 10. Costs to Clear Vegetation

	Unit	Labor	Equipment	Materials	Total
Clear and Grub, Heavy Trees to 16" Diameter, Cut and Chip	ACRE	$2,211.00	$2,303.00	$0.00	$4,514.00
Clearing - Light Brush without Grub	ACRE	$35.88	$24.75	$0.00	$60.63
Nonradioactive–Machine Load Spoils, 2 Mile Haul, Haul to Dump	Cubic Yards	$18.16	$13.15		$31.31

6.4 Excavation

Fansteel estimated that the unit cost to excavate and load soil is $12/yd^3 in their August 1999 cost estimate.

6.5 Dewatering

ICF assumed that a 5 ft^3 filter press would be used to dewater the pond residues. Based on typical operating parameters listed in RS Means *Environmental Remediation Estimating Methods*, pp. 141-146, we estimated that a typical flow rate for a 5 ft^3 filter press is 600 gallons per minute. Using this flow rate, we estimated the number of hours the filter press would need to run. We then estimated the capital and operating costs using RS Means *Environmental Remediation Assemblies* for 2001, p. 3-94, which lists the operating cost of $214.47/hr and the capital cost of $46,732.

6.6 Backfill

Fansteel estimated that the unit cost to excavate and load soil is $0.09/ft^3 in their August 1999 cost estimate.

6.7 Packaging Debris

This analysis used NUREG CR/6477's unit cost of $645 to obtain each B-25 box, found on page A.5. This analysis then assumed a unit cost of $1.25/ft^3 for containerizing debris. Only mixed waste and equipment will be packaged in B-25 boxes. Bulk soil and pond residues will be sent by rail gondola. The cost to load gondola's is assumed to be $1.98/yd^3, based on the cost to load bulk waste into a truck as presented in RS Means *Environmental Remediation Cost Data-Unit Price* for 2001, page 9-173.

6.8 Shipping and Disposal

This analysis used internet mapping software to estimate the distance between Fansteel and the Envirocare facility located in Clive, Utah as 1,350 miles, and the distance between Fansteel and the WCS facility in Andrews County, Texas as 670 miles. This analysis used the cost to ship radioactive waste by truck for distances over 500 miles of $3.49/mile, from RS Means *Environmental Remediation Cost Data-Unit Price* for 2001, page 9-181. The cost of shipping by rail gondola was $0.05/m^3-km from "FUSRAP Experience Transporting LLW and 11e(2) Waste Materials by Rail, Intermodal Container, and Truck (Packaging)."[5]

This cost estimate used three disposal rates to bound the cost ($5/ft^3, $11/ft^3, and $17/ft^3), assuming the waste will be disposed as LLW. Mixed waste is considered to be approximately three times the cost of disposal of LLW. The range for LLW and the increase for mixed waste corresponds to data provided by a DOE web site that describes the range of disposal costs for DOE and commercial sites (http://emi-web.inel.gov/contracts/range.html). Additionally, this range of costs corresponds directly with input from NRC staff. As part of this project NRC staff researched disposal costs by contacting the U.S. Corps of Engineers (USACE) and reviewing rates in their current Envirocare contract, and reviewing licensee decommissioning funding plan proposals and other available documents. NRC confirmed that approximately $11/ft^3 is an "average" LLW disposal rate at Envirocare and that $5/ft^3 and $17/ft^3 adequately describe the range of anticipated LLW disposal costs. Furthermore, NRC confirmed with USACE that mixed waste disposal at Envirocare should be assumed to be three times the cost of LLW disposal. The cost for disposal at WCS appears to be similar. In Fansteel's 2002 cost estimate, they present an assumed cost for WCS on a per ton basis. Using the densities described in section 5, their cost is approximately$6/ft^3 for disposal at WCS, which is the lower bound disposal cost used in this analysis.

6.9 Analytical Sampling

This analysis referenced RS Means *Environmental Remediation Cost Data-Assemblies* for 2001, page 3-270 to obtain the unit cost estimate of $128.77 per sample for isotopic alpha spectroscopy of vegetation, soil, or sediment.

6.10 Ground Water Treatment

Fansteel describe their groundwater treatment system in their 2002 cost estimate as a boiler, which is not the type of groundwater treatment system ICF observed during our site visit. Because we are unsure of the cost to run Fansteel's current system, we assumed that the cost to run the boiler was approximately equal to the cost to run Fansteel's current system. Because

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[5] www.hq.usace.mil/cecw/fusrap/techpap/pkgin.htm.

Fansteel estimated the cost to run groundwater treatment system to be $14 million for 20 years, we used the annual operating cost of $700,000/yr. We assumed the system would be run for 10 years.

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