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AX Tank Farm Tank Removal Study

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Abstract: This report considers the feasibility of exposing, demolishing, and removing underground storage tanks from the 241-AX Tank Farm at the Hanford Site. For the study, it was assumed that the tanks would each contain 360 ft³ of residual waste (corresponding to the one percent residual inventory target cited in the Tri-Party Agreement) at the time of demolition. The 241-AX Tank Farm is being employed as a "strawman" in engineering studies evaluating clean and landfill closure options for Hanford single-shell tank farms. The report is one of several reports being prepared for use by the Hanford Tanks Initiative Project to explore potential closure options and to develop retrieval performance evaluation criteria for tank farms.

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AX TANK FARM TANK REMOVAL STUDY

W. A. Skelly

September 1998

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ACRONYMS

CERCLA	<i>Comprehensive Environmental Response, Compensation and Liability Act</i>
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
HEPA	high-efficiency particulate air
HTI	Hanford Tanks Initiative
LLW	low-level waste
MOU	Memorandum of Understanding
NHC	Numatec Hanford Corporation
RCRA	<i>Resource Conservation and Recovery Act</i>
RFP	request for proposal
RO/RO	roll-on/roll-off
SOW	statement of work
SST	single-shell tank
STRARCH	stressed arch
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>
TRU	transuranic
TWRS	Tank Waste Remediation System
WAC	Washington Administrative Code
WBS	work breakdown structure

AX TANK FARM TANK REMOVAL STUDY

1.0 INTRODUCTION

1.1 FOREWORD

In May of 1996, the U.S. Department of Energy (DOE) implemented a five-year demonstration project known as the Hanford Tanks Initiative (HTI). The scope of HTI is to (1) demonstrate alternate retrieval technologies for tank waste; (2) retrieve hard-heel waste from tank 241-C-106 and assess compliance with retrieval performance evaluation criteria for that activity; (3) characterize residual waste in Tank 241-AX-104 and assess compliance with retrieval performance criteria for that tank; and (4) develop retrieval performance evaluation criteria supporting readiness to close single-shell tanks (SSTs) in the future. The HTI mission is to minimize technical uncertainties and programmatic risks by conducting demonstrations to characterize and remove tank waste using technologies and methods that will be needed in the future to carry out tank waste remediation and tank farm closure. A detailed description of the entire HTI Project is provided in the Hanford Tanks Initiative Plan, WHC-SD-WM-PMP-022.

The HTI project team is comprised of representatives from the Project Hanford Management Contract (PHMC), Pacific Northwest National Laboratory (PNNL), and private consultants. The team is working closely with Washington State Department of Ecology (Ecology), various northwest stakeholders, and native American tribes to identify and develop waste retrieval performance criteria for subsequent formulation of acceptable closure criteria and standards for tank farms.

In August of 1996, the DOE and Ecology signed a memorandum of understanding (MOU) in which they agreed to collaborate in addressing the issues of "what degree of waste removal should be used as the basis for waste retrieval systems technology development, retrieval systems engineering, and definition of completion of retrieval operations." In preparing the agreement, the two agencies conceded that "it has not been established that 99 percent waste retrieval as defined in the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement [TPA]) Milestone M-45-00 will be sufficient to allow closure of tank farms; nor has it been determined that 99 percent retrieval is technically achievable, or represents a performance objective that considers cost, technical practicality, exposure to radiation, and/or Nuclear Regulatory Commission requirements." Conditions of TPA Milestone M-45-00 stipulate that "in evaluating closure options for SSTs, contaminated soil, and ancillary equipment, Ecology and the Environmental Protection Agency (EPA) will consider cost, technical practicality, and potential exposure to radiation" (JEG 1997)

One essential element of the HTI mission is to provide a basis for future National Environmental Policy Act of 1969 (NEPA) safety, and regulatory actions affecting waste retrieval and operable unit closure of the Hanford Site tank farms. This goal is being met by development of retrieval performance criteria, through assessment of risk to human health and environment. Hence, several engineering studies have been conducted to provide the necessary data for evaluation of

risk to human health and environment. This report, AX Tank Farm Tank Removal Study, describes a methodology for exposing, demolishing, and removal of debris from the four SSTs in the farm. Demonstrating that tank removal is feasible and practical is one of the essential considerations involved in the larger issue of clean closure of tank farms at Hanford. Concepts are developed for performing the work, including descriptions of the layouts, equipment, labor and materials required, and evaluated with respect to cost, technical practicality and worker radiological exposures. Other studies that interact with this study are the AX Tank Farm Ancillary Equipment Study and the Soil Remediation Study.

1.2 STUDY SCOPE AND OBJECTIVES

In January of 1997, Numatec Hanford Corporation (NHC) issued a request for proposals (RFP) with a statement of work (SOW) for engineering services to support HTI in evaluating closure alternatives for development of retrieval performance evaluation criteria. Several tasks identified and described in the RFP were assigned to COGEMA Engineering Corporation (COGEMA), the following month. This report documents the results of engineering studies carried out by COGEMA in response to RFP Task 2, "Tank Removal Study." Related work on RFP Task 3, "Soil Remediation Study," is summarized in a separate report.

The SOW for the AX Tank Farm Tank Removal Study directed COGEMA to evaluate alternative approaches and concepts for removing AX tanks from the ground. For those concepts that are considered to be feasible, COGEMA was to provide conceptual engineering to quantify the technical approach, labor, equipment, materials, cost, and schedule involved. An analysis of worker radiological hazards was requested as well. Finally, the SOW requested an assessment of the impacts on tank removal of either of two scenarios, an 8,000-gal leak or a 40,000-gal leak during waste retrieval.

A directed assumption for the study was that the tanks would contain a residual waste inventory of 360 ft³ (i.e., one percent residual inventory) after waste retrieval that would be sufficient to comply with the TPA retrieval objective. The SOW requested documentation for any/all enabling assumptions applied in concept development. Study criteria regarding the chemical and radiological composition of the one percent residual inventory in the tanks were developed by COGEMA under a separate task (Task 4, "Waste Inventory Study").

The 241-AX tank farm is located in the 200 East Area of the Hanford Site. The farm contains four 100-Series (1 million gal capacity) tanks, each with a 75-ft inside diameter, 45.75-ft height measured from the top of the footings to the top of the dome, and a minimum 6 ft of soil cover. The AX farm was the last of 12 SST farms to be built at Hanford. The farm was constructed in 1963 to 1964, and individual tanks went into service in early 1965. The AX tanks were constructed to what was termed the "fifth generation" design. They were designed to receive and store Plutonium Uranium Extraction (PUREX) Plant and B Plant aging wastes that exhibited self-boiling and self-concentrating properties for periods of five to 10 years. Unique features of the fifth generation design included a grid of drain slots (used for leak detection) cast into the base slab of each tank, a 3/8-in carbon steel liner (earlier tanks had 1/4-in liners), elimination of cascade (overflow) lines between tanks, and an integral system of airlift circulators.

The 241-AX tank farm was designated in the RFP/SOW as the "strawman" to be evaluated in Task 3 and related engineering studies. Identification of AX farm for these studies was based on the understanding that it is likely to be designated by the DOE as the first tank farm to undergo closure consistent with TPA milestones in 2004 ("Submit Closure Plan for Selected Tank Farm"), 2012 ("Initiate Closure of Selected Tank Farm"), and 2014 ("Complete Closure of Selected Tank Farm"). While the AX tank farm is the smallest of the 12 SST farms at the Hanford Site, the AX tanks pose some of the greatest challenges for waste characterization, retrieval, and closure due to their dimensions, the configuration of in-tank hardware, the residual waste compositions, and the concentration of associated external ancillary equipment. Additionally, the 241-AX tank farm contains one tank (AX-104) that was sluiced extensively in the past and is currently empty except for a minimal volume of hard-heel waste residue. The HTI team plans to utilize this tank for deployment and demonstration of in-tank characterization technologies and for evaluation of performance objectives for retrieval and closure.

2.0 INFERRED SPATIAL DISTRIBUTION OF VADOSE ZONE CONTAMINATION

2.1 SUMMARY OF VADOSE ZONE CONTAMINATION WITHIN 241-AX TANK FARM

The report entitled *Report of Best-Estimate Past Release Vadose Zone Contamination of the 241-AX Tank Farm* (CEES 1997) provides an evaluation of the nature and extent of vadose zone contamination that has occurred during operations of the 241-AX tank farm. This report constitutes a best estimate of vadose zone contamination from past releases of chemical and radiological waste contaminants. This estimate was developed from information on the source, timing, nature, extent, and composition of the contaminant streams identified from available transfer data and operations logs. The evaluation included reviews of historical and recent reports of gamma logs taken in the 32 dry wells that monitor potential leakage from the tanks. Sources of gross gamma log data included original well logs plus two recent summary reports (DOE 1992 and DOE/GJO 1997).

The isotope ^{137}Cs is the principal radionuclide that is detected in borehole logging in the 200 Areas and is, therefore, most useful for evaluating vadose zone contamination associated with past leaks and/or spills. Six primary release zones ("plumes") that have been identified and correlated with specific tanks and specific material compositions are represented in Figure 2.1 together with seven secondary ^{137}Cs releases. The available information does not indicate leakage from any of the four SSTs in the farm, but there is much evidence indicating that significant releases have occurred at and near the surface of the tank farm from spills, transfer lines, and tank ancillary equipment, particularly the tank vent headers. Since no characterization data are available concerning physical and hydraulic properties of the soils at the site, the radiochemistry and composition of the zones of contamination were used as indicators of migration to the depths indicated by gamma-emitters measured in each dry well.

The maximum estimated depth of migration for ^{137}Cs contamination in Figure 2.1 is approximately 25.9 m (85 ft). The maximum measured concentration of ^{137}Cs in AX Tank Farm soils is approximately 4 nCi/g.

**Figure 2.1. AX Tank Farm Site Plan
with Contoured Contamination Plumes**

Contour Interval = 5 ft.

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2.2 DESCRIPTIONS OF INDIVIDUAL PLUMES BASED ON ^{137}Cs CONTAMINATION

The extent of vadose zone contamination within the 241-AX Tank Farm consists of the 13 individual contaminated soil sites ("plumes") shown in Figure 2.1. Volume estimates of the contaminated soil in each plume are provided in Table 2.1. Each plume is briefly described below:

- **AX-1** (northwest of Tank AX-103):
 ^{137}Cs contamination is indicated to depths of approximately 6.1 m (20 ft). The maximum measured concentration of ^{137}Cs was approximately 40 pCi/g.
- **AX-2** (immediately north and northwest of Tank AX-104):
 ^{137}Cs contamination indicated to depths of approximately 12 m (40 ft). The maximum measured concentration of ^{137}Cs was 100 pCi/g.
- **AX-3** (adjacent to and southwest of Tank AX-104):
 ^{137}Cs contamination is indicated to depths of approximately 21 m (70 ft). The maximum measured concentration of ^{137}Cs is approximately 34 pCi/g.
- **AX-4** (northeast of Tank AX-104 and northwest of Tank AX-101):
 ^{137}Cs contamination is indicated to depths of approximately 25.6 m (84 ft). The maximum measured concentration of ^{137}Cs is approximately 4,000 pCi/g.
- **AX-5** (immediately north and northwest of Tank AX-102):
 ^{137}Cs contamination is identified to depths of approximately 12 m (40 ft). The maximum measured concentration of ^{137}Cs is approximately 417.8 pCi/g.
- **AX-6** (northeast and east of Tank AX-102):
 ^{137}Cs contamination is indicated to a depths of approximately 22.9 m (75 ft). The maximum measured concentration of ^{137}Cs is approximately 15.8 pCi/g.

The remaining zones of contamination, AX-7 through AX-13, are generally shallow, secondary features, many of which will be eliminated in the process of excavating soil for tank removal.

- **AX-7** (west-southwest of Tank AX-103):
The zone of contamination extends to an approximate depth of 3.7 m (12 ft). The maximum measured concentration of ^{137}Cs is 7.5 pCi/g.

- **AX-8** (west-northwest of Tank AX-104):

Contamination extends to an approximate depth of 12.2 m (40 ft). The maximum measured concentration of ^{137}Cs is 1,456 pCi/g.

- **AX-9** (adjacent to Tank AX-101 to the northeast):

The zone of contamination extends to an approximate depth of 6.1 m (20 ft). The maximum measured concentration of ^{137}Cs is 8 pCi/g.

- **AX-10** (east of Tank AX-101):

The zone of contamination extends to an approximate depth of 3 m (10 ft). The maximum measured concentration of ^{137}Cs is 6 pCi/g.

- **AX-11** (southeast of Tank AX-101 and northeast of Tank AX-102):

The zone of contamination extends to an approximate depth of 7.6 m (25 ft). The maximum measured concentration of ^{137}Cs is approximately 51.5 pCi/g.

- **AX-12** (south of Tank AX-102):

The zone of contamination extends to an approximate depth of 6.1 m (20 ft). The maximum measured concentration of ^{137}Cs is approximately 13 pCi/g.

- **AX-13** (southeast of Tank AX-104):

The zone of contamination extends to an approximate depth of 6.1 m (20 ft). The maximum measured concentration of ^{137}Cs is approximately 9.8 pCi/g.

Table 2.1. Estimated Volume of Contaminated Soil in AX Tank Farm

Contaminant Plume	Estimated Volume		Estimated Volume (X2)	
	(liter)	(yd ³)	(liter)	(yd ³)
AX-1	5.34E+05	6.99E+02	1.07E+06	1.40E+03
AX-2	1.22E+06	1.60E+03	2.44E+06	3.19E+03
AX-3	8.02E+05	1.05E+03	1.60E+06	2.10E+03
AX-4	3.46E+06	4.53E+03	6.92E+06	9.05E+03
AX-5	1.10E+06	1.44E+03	2.20E+06	2.88E+03
AX-6	3.36E+06	4.40E+03	6.73E+06	8.80E+03
AX-7	2.17E+05	2.84E+02	4.35E+05	5.68E+02
AX-8	6.79E+05	8.88E+02	1.36E+06	1.78E+03
AX-9	2.57E+05	3.36E+02	5.14E+05	6.72E+02
AX-10	1.22E+05	1.59E+02	2.43E+05	3.18E+02
AX-11	2.11E+05	2.75E+02	4.21E+05	5.51E+02
AX-12	2.20E+05	2.88E+02	4.40E+05	5.76E+02
AX-13	2.43E+05	3.18E+02	4.86E+05	6.36E+02
Estimated Total	1.24E+07	1.63E+04	2.49E+07	3.25E+04

2.3 INFERRED DISTRIBUTION OF TRANSURANIC CONTAMINANTS

An evaluation was performed of the radiological inventory of the tanks and the release inventory of the zones of contamination to determine which transuranic (TRU) contaminants were released and their total estimated concentrations. The TRU contaminants associated with these releases are ^{237}Pu , ^{237}Np , ^{240}Pu , ^{241}Am , ^{242}mAm , ^{243}Am , and ^{243}Cm . The associated inventories are listed in Table 2.2. Further analysis was performed to determine if these inventories could exceed the 100 nCi/g concentration threshold in soil. Three potential zones of TRU soil contamination were identified: AX-2, AX-4, and AX-6. The mobility of all TRU contaminants identified above is low with the exception of ^{237}Np . At all three sites, transuranics are expected to be concentrated in restricted central areas of the plumes within the upper three meters (10 ft) of fill (see Figure 2.2). These potential TRU zones would all be eliminated in the process of removing soil to expose the tanks.

**Table 2.2 AX Tank Farm Release Radiological Inventory
Contaminant Plumes**

Transuranics	AX-2 (Ci)	AX-4 (Ci)	AX-6 (Ci)
^{237}Np	9.66E-03	6.52E-06	6.11E-04
^{238}Pu	7.29E-03	4.92E-06	2.13E-06
^{240}Pu	3.60E-02	2.43E-05	5.18E-06
^{241}Am	6.49E-01	4.38E-04	5.19E-05
^{243}mAm	NR	NR	NR
^{243}Am	1.99E-05	1.34E-08	9.28E-05
^{243}Cm	2.22E-04	1.50E-07	5.80E-09
Estimated Total TRU (Ci)	7.02E-01	4.74E-04	7.63E-04

Figure 2.2. Potential TRU Contaminated Soil Sites

2.4 PRESUMPTIVE PHYSICAL AND HYDROLOGIC PROPERTIES OF VADOSE ZONE SOILS

The stratigraphy underlying the 241-AX tank farm has been described and reported by numerous investigators (Price and Fecht 1976, Caggiano and Goodwin 1991, Lindsey and Law 1993). The 241-AX tank farm is underlain by three major stratigraphic units:

- Unconsolidated sand, silt, and gravel of the Hanford formation,
- Semiconsolidated sediments of the Ringold Formation, and
- Basalt flows of the Columbia River Group that form the bedrock beneath the tank farm area. From the ground surface to the base of the tanks, a depth of approximately 16.8 m (55 ft) is compacted backfill material of excavated Hanford formation.

The Hanford formation is subdivided into two units identified as H1 and H2, which make up the vadose zone sediments underlying the AX tank farm. Unit H1 occurs from zero to 15 m (0 to 50 ft) below the base of the tanks and consists of a westward thinning sequence of slightly silty, pebbly, very coarse to coarse sand and sandy, fine to very fine pebble gravel to pebbly, very coarse sand (Price and Fecht 1976). There is no direct evidence of clay-rich or silt-rich horizons within this unit. The absence of horizons of fine-textured material suggests that there is a limited potential for contaminant plume spreading at the contact of a silt interface. The potential does exist for encountering zones of higher moisture content where hydrologic breaks occur in the stratigraphic section.

Unit H1 is underlain by approximately 35 to 46 m (114 to 151 ft) of slightly silty, very coarse to medium sand (Price and Fecht 1976) assigned to unit H2. Unit H2 is interpreted to be dominated by well stratified sand typical of the sand-dominated facies (Piepho et al. 1996).

In general, the site soils are expected to exhibit the following physical characteristics:

- **Porosity**

The porosity, or saturated moisture content, was assumed to range from 35 to 42 percent depending on which specific soil type was referenced. The values selected for this study for the Hanford formation sandy sequence, the Hanford formation gravel sequence, and the backfill soil are 42, 35, and 37 percent, respectively.

- **Soil Moisture Content**

The residual soil moisture content was assumed to range from two to 4.5 percent. Values for the Hanford formation sandy sequence, the Hanford formation gravel sequence, and backfill are two percent, two percent, and 4.5 percent, respectively.

- **Hydraulic Conductivity**

The hydraulic conductivity, K , was assumed to range from $2.73\text{E-}04$ to $3.00\text{E-}02$ cm/sec. The values selected for hydraulic conductivities of Hanford formation sandy sequence, Hanford formation gravel sequence, and backfill are $1.55\text{E-}03$, $2.73\text{E-}04$, and $3.00\text{E-}02$ cm/sec, respectively.

- **Friction Angle, Cohesion, Bulk Density**

The following presumptive physical properties values were used in sample calculations of ground support requirements for the excavation scenarios described in Section 3.0.

The angle of internal friction was assumed to equal 42 degrees, cohesion to equal zero, and in-place bulk density to equal 140 lbs/ft^3 .

3.0 TANK REMOVAL

3.1 FUNCTIONAL REQUIREMENTS

A practical concept is required that will enable individual tanks in the 241-AX tank farm to be physically accessed and removed. Gaining access to the tanks will require excavation of soil from above and around the tanks down to the level of the footings. Based on the information presented in Section 2.0, the soil column from the surface to the tank footing level (i.e., from depths of zero to approximately 52 ft) contains extensive radiological and chemical contamination, with localized ^{137}Cs concentrations of up to 4 nCi/g , and the potential for encountering isolated small pockets of soil with transuranic concentrations exceeding 100 nCi/g . The evidence summarized in Section 2.0 indicates that soil contamination in the 241-AX tank farm has originated from numerous separate surface spills and leaks from transfer piping and ancillary equipment originating at shallow depths in the soil, rather than from any of the tanks themselves. Based on this information, a workable concept for tank removal must include, as an element, a concept for removing soil from above and around the tanks that provides for adequate worker protection, dust control, and physical isolation of the site.

The tank removal concept must include, as a second element, a workable concept for tank demolition. The four SSTs in the 241-AX tank farm are one-million-gal tanks, with nominal 75-ft diameters. The outside height of the tanks measured at the sidewall (i.e., from the top of the footing to the corner of the haunch) is approximately 38 ft. The inside height at the centerline is 44.5 ft. The tank domes vary in thickness from a minimum thickness of 15 in. at the center to a maximum of about 4 ft at the haunch. In the center-span area of the dome, radial and circular bars are No. 6. Circular bars are on one-foot spacings. Spacing varies for the radial bars; the closest spacing is about six inches at the haunch corner. In the haunch area, circular bars are larger (No. 9 and No. 11) and they are on closer centers (9.0 and 7.5 in. respectively). The tank sidewalls are 15 in. thick at the top and two ft thick at the base. Sidewall reinforcement consists of No. 8 longitudinal bars with a five-inch vertical spacing and vertical bars on about six-inch centers that were variously specified as No. 7, 8, and 9, depending on the vertical position. The

footing ring is three ft thick, the interior area of the base slab is 18 in. thick. The reinforcement plan for the base slab is similar to the central area of the dome, with No. 6 radial and circular bars. Radial bars in the footing ring are No. 8, and No. 8 dowels were used at the joint between the footing ring and the base slab. (For additional details on concrete reinforcement, refer to drawings H-2-44562 and H-2-44565.) The tanks have 3/8-in. carbon steel liners.

From this description, it is understood that the AX tanks are heavily reinforced concrete structures. Therefore, in evaluating different candidate demolition techniques for potential applicability to demolition of SSTs, additional functional requirements are that (a) the method must be able to fracture concrete containing imbedded reinforcing bar, and (b) the method must provide the capability to sever metal (reinforcing bar and liner plate).

The presence of the one percent residual waste inventories in the tanks imposes severe constraints on concept development. Even after most of the tank waste has been removed, the residual inventory represents an extraordinarily hostile environment for any type of manned activity. Best-basis estimates of ^{137}Cs and ^{90}Sr in one percent residual inventories for the four AX tanks are listed in Table 3.1. Strategies must be incorporated into conceptualization that minimize or eliminate both external (direct exposure) and internal (ingestion/respiration) doses for demolition workers and support personnel. The functional requirement or "standard of practicality" in this instance is to demonstrate with worker dose estimates that tanks can be demolished and all debris can be loaded out and removed from the site (with appropriate time, distance, and shielding provisions) in a manner that will enable worker doses to be maintained within acceptable limits. From discussions with Hanford radiological engineering personnel and the administrative control levels listed in Table H2-1 of the Hanford Site Radiological Control Manual (HSRCM, 1994), a maximum whole body dose of 1,500 mrem/yr was adopted as the exposure limit criterion for this study. This limit has been imposed on remedial activities at 100 K-Basins, which is the closest actual analog to the work contemplated in this study. It is unlikely that tank removal would qualify for consideration under any of the exceptional situations identified in the manual (i.e., for emergency exposures or planned special exposures) for which DOE might authorize higher limits.

**Table 3.1. Best-Basis Inventories for ^{137}Cs and ^{90}Sr
in 1% Residual Waste in the four AX Tanks**

Tank	^{137}Cs (Ci)	^{90}Sr (Ci)
AX-101	5.16E3	1.15E5
AX-102	7.17E3	5.19E4
AX-103	1.09E4	5.25E5
AX-104	1.09E4	5.25E5

DOE Order 6430.1A, *General Design Criteria*, imposes functional requirements for containment of radiological releases and positive ventilation control of temporary facilities. The containment requirement in the Order is the basis for proposing to construct an enclosure structure over the

tank farm as an essential element of the tank removal concept. From a logistical standpoint, the practicality of tank removal (i.e., soil excavation and tank demolition activities) would be severely diminished if footings and structural supports for the enclosure structure were to be placed inside the footprint of the excavation. It is considered essential to overall concept practicality to be able to demonstrate that the enclosure can be designed as a free-span structure with all structural loads bearing at the perimeter of the site.

3.2 REMEDIAL PROCESS SELECTION

3.2.1 Selection/Evaluation Criteria

Candidate demolition methods were evaluated relative to a number of generalized criteria. The principal criteria applied in the evaluation are summarized below.

- Capability to rubblize thick, heavily reinforced concrete structures and to cut up any included metal
- Workability inside confinement structure
- Worker protection: may be accomplished either by isolating workers in a controllable environment or by providing some degree of remote operation
- Overall productivity and cost.

Based on the description of tank construction, it is apparent that the selected method must be capable of rubblizing concrete with heavy reinforcement (in terms both of the spacing and sizes of the rebar involved). Certain portions of the tanks, notably the haunch and the footing ring, may be particularly difficult to demolish because of the thicknesses of concrete involved. An essential consideration was whether a given method was capable of cutting apart a reinforcing bar. Cutting rebar will be essential in order for large fragments of rubble to be physically separated and size-reduced to facilitate loading out and removing of material from the site. It would also be highly advantageous if the selected method provided the capability to cut up the liner plate into small pieces so that material from the liner could be processed with other types of debris.

Evaluation of demolition methods and selection of the optimal method for tank removal were completed before the enclosure structure concept had been developed. Consequently, specific constraints traceable to the enclosure were not imposed on the selection process. However, in a general sense it was understood that any demolition method requiring large mobile equipment items (e.g., large boom cranes) would be difficult to accommodate. Attempting to work inside an enclosure structure with large mobile cranes would create logistical problems such as (1) moving these items in and out of the enclosure without temporary loss of containment and, (2) maintaining adequate clearances (i.e., head room and swing room) for the equipment to work inside the structure without adding significantly to the size of the structure. Another consideration was that an increasingly substantial enclosure structure would be necessary if the

selected demolition method required the building to be equipped with any large fixed crane (e.g., a bridge crane).

For unique reasons, some alternatives may not be practical to carry out inside an enclosure or in a radiological environment. For example, explosive demolition methods generate high-velocity fragments and large amounts of air-suspended particulates. Containment of dust is essential if the dust carries radiological contaminants. However, high-velocity fragments from blasting could damage the containment structure and/or elements of its ventilation system.

In consideration of the radiological environment, there is a preference for demolition methods offering high productivities (i.e., high mass reduction per unit time) because of the inherent benefit of minimizing worker exposures in terms of time. Depending on maturity and availability, technologies would be preferred that are readily adaptable to remote operation or robotics (removing workers from the high dose rate environment), or to supplemental shielding strategies (e.g., shielding mobile equipment cabs).

Lastly, there is the criterion of cost. Other considerations being equal, the preferred method is the one that would enable the work to be done at the lowest cost.

3.2.2 Alternatives Considered for Tank Demolition

A review of the literature was undertaken to identify potentially applicable demolition methods for the tank removal application. A second objective was to locate case studies of other demolition projects involving radiological issues to determine which demolition methods had been used and what degree of success had been achieved in each case. Two of the references reviewed specifically address decommissioning, decontamination, and demolition of concrete and metal structures in radiological environments (DOE 1980, IAEA 1988). Candidate methods identified in these references and other sources are listed below:

- Controlled blasting
- Wrecking ball
- Hydraulic pick breaker
- Flame cutting
- Circular saws
- Explosive cutting
- Water jet cutting
- Hydraulic concrete demolition tools

3.2.3 Evaluation of Individual Alternatives

3.2.3.1 Alternatives rejected in preliminary screening. The following techniques were rejected during the screening process, for the reasons noted below:

- **Controlled blasting:** The process consists of drilling holes in concrete, loading them with explosives, and detonating them in a controlled sequence (DOE 1980). This technique is most applicable to thick (> 2 ft), heavily reinforced concrete. Controlled blasting does not sever rebar. Vibrations, high-velocity particles and dust production associated with this method make it poorly suited to applications

inside an enclosure. This technique is relatively labor-intensive and materials-intensive, and equipment and materials costs are relatively high. The method is not amenable to remote operations or robotics adaptations.

- Explosive cutting: This method employs placement of shape charges onto the outside surface of a reinforced concrete structure. These charges send a directed shock wave into the material upon detonation. Unlike controlled blasting, this technique cuts rebar as well as concrete. Many of the same arguments against applications of controlled blasting in an enclosure structure would also apply to this method. This technique is relatively labor-intensive and materials-intensive, and equipment and materials costs are relatively high. Placement of explosives, initiators, and blasting lines is not adaptable to remote operations.
- Flame cutting (thermic lance): A thermite reaction process is employed. The equipment consists of a thermite lance (a long iron pipe packed with thermite reagent), which is connected to a continuous source of oxygen gas. Thermite is a mixture of ferric oxide and powdered aluminum. Upon ignition, this combination burns at a temperature of about 2,200° C. With supplied oxygen, combustion temperatures can reach 5,000° C. The lance usually is mounted on some type of frame support structure that maintains the orientation of the lance to the work surface. The thermic lance produces large quantities of thick smoke, which makes it difficult to maintain visual control of the operation. The lance is consumed at a rate of one to two ft/min, making frequent replacement necessary. The technique appears to be labor intensive, and bulk removal rates are low. The technique does not appear to be adaptable to remote operation.
- Wrecking ball: This technique has a long history of use in nonradiological applications. It is capable of rubbleizing lightly reinforced concrete structures, but a supplemental method must be provided for severing rebar. Although productivity is high and costs are relatively low, the method is not recommended for radiological situations (DOE 1980).
- Circular saws: On a prototype basis, large circular saws with diamond or tungsten carbide blades have been mounted on the end of a telescoping boom for concrete demolition work. These saws can cut through rebar, but rebar tends to dislodge the abrasive materials, accelerating blade wear. Water must be provided for lubrication. Experience with prototypes appears to be mixed. Relative productivity is low to moderate. Labor and materials costs are expected to be relatively high.

3.2.3.2 Potentially Feasible Alternative. The following demolition methods were all considered to be feasible in initial screening, although differences were apparent from the outset in terms of relative practicality:

- Water jet cutting: This technology has undergone extensive development within the past 20 years. Cutting is done by a jet of water expelled under very high pressure from a small-diameter nozzle. The technology has been adapted to a

wide variety of industrial applications, most of which are remote operations. Water jets can cut concrete to thicknesses of three ft or more and can cut rebar assisted by abrasive solids. Productivity and costs are moderate.

- Hydraulic concrete demolition implements: Hydraulic-operated cutting and crushing implements are available that can be mounted on the boom of a large backhoe or hydraulic excavator for concrete demolition work. One implement is a hydraulic pick breaker. The pick breaker is a hydraulic-operated impact ram with a moll or chisel point. The ram applies up to 600 high-impact blows per minute to a concrete surface. Pick breakers are available in a wide range of sizes and input energy ratings. A second implement is a concrete pulverizer jaw, which is capable of closing on reinforced concrete slabs up to two ft thick, crushing the concrete into small fragments that fall away from the reinforcing steel. A third implement is a shear jaw, which is designed to cut through reinforced concrete panels, reinforcing bar, and steel plate. These implements are designed to be fully interchangeable on a single carrier. They may be used in sequence or independently, depending on the application. Demolition with hydraulic tools is well suited for demolition of heavily reinforced concrete structures and it is well suited to working in interior areas. Productivity is relatively high and costs are expected to be low relative to other feasible methods.

3.2.3.3 Selected method - hydraulic concrete demolition implements. The selected method for tank demolition is to use hydraulic concrete demolition implements mounted on hydraulic excavator carriers. The 241-AX tank farm enclosure structure (described in Section 3.3.1) will provide adequate clearances for excavator operation and the implements themselves pose no specific limitations with respect to indoor operation. This equipment is specifically designed for high productivity and low-cost operation in demolishing heavily reinforced concrete structures. The technology is proven and commercially available.

Two hydraulic excavators will be required. It is envisioned that much of the tank demolition work will be done with the two units working together. Conceptualization was based on handbook data for a Caterpillar 375 excavator. A number of different boom configurations are available for this unit. However, most configurations provide a 35- to 40-ft reach capability, which is adequate for this project. The width dimension of this excavator is approximately 11.5 ft; operating weight is approximately 170,000 lb. An excavator in this size range is not so large that it would be unable to work in between the tanks.

Conceptualization of the demolition implements is based on vendor data for LaBounty Manufacturing Model UP-70 concrete pulverizer and shear jaw sets and Stanley Model MB-5950 hydraulic impact breaker. These implements mount in place of the bucket and are operated with the bucket controls and hydraulic systems. The mounting arrangement and the individual implements are shown in Figure 3.1.

Hydraulic demolition implements have not been used in a highly radiological setting before. Some amount of equipment development/modification work will be required to apply the technology to tank removal. Based on dose and shielding calculations presented in Appendix A, it is envisioned that the excavator cabs will have to be equipped with extensive shielding

(including leaded glass windshields and multiple layers of steel plate on the top, sides and bottom of the cab) and an air supply/air purification system. The study cost estimate includes provisions for optional elevated cabs, six inches of steel plate shielding on the roof, sides and floor of the cab, and specially fabricated six-inch thick leaded glass windshields.

Figure 3.1. Excavator with Attachments

A front-end loader comparable to a Caterpillar 988 wheel loader will also be required for tank sidewall and base slab demolition. The cab of this unit would be modified to incorporate the same level of shielding as the excavator cabs. Four container-handling trucks will be used to move containers in and out of the excavation. To haul the heavy shielded containers that will be used to transport rubble from base slab demolition, the trucks will need to have four inches of steel shielding on the back of the cabs, and lesser thicknesses on the top and sides. Finally, a dozer comparable to a Caterpillar D10 is included in the estimate to address contingency situations where a piece of equipment is unable to exit the pit under its own power and must be dragged out.

3.2.4 Related Decommissioning Experience

Although decommissioning and closure of waste storage tanks is under active study at a number of DOE sites, actual removal of a full-size tank has not been undertaken at any site to date. A number of small research reactors and a few commercial reactors have undergone decommissioning, and these projects were reviewed to determine what demolition methods had been applied and the reported experiences with each.

One of the earliest of these projects was the Elk River Reactor (ERR) dismantling program (1971-1974) at Elk River, Minnesota. Several demolition methods were used. The eight-ft thick biological shield portion of the containment structure was demolished by controlled blasting. Blasting mats and continuous fog sprays of water were used to limit dust production. A wrecking ball was also used extensively, but only after all radiologically contaminated materials had been removed from the structure. Hydraulic pick breakers were used on an experimental basis at ERR, but productivity on thick reinforced concrete was considered unsatisfactory.

More powerful hydraulic breakers were used to dismantle the biological shield and other concrete portions of the R-1 research reactor in Stockholm, Sweden. One of the breaker units was mounted on a remote-controlled carrier.

Another such project was the decommissioning of the Sodium Reactor Experiment (SRE) in Chatsworth, California. This was a sodium-cooled, graphite-moderated research reactor. Decommissioning work was begun in 1968, and continued into the early 1980s. Unlike the Elk River program, the outer reactor building was not demolished at SRE. A plasma arc torch with remote controls was developed specifically to do the reactor core cutting work at SRE. A pick breaker was used successfully at SRE for light concrete demolition work.

The Shippingport reactor in western Pennsylvania was decommissioned beginning in the late 1980s. In that case, the entire pressure vessel and associated neutron shielding were removed as a single assembly. In the decommissioning plan for the Fort St. Vrain Nuclear Generating Station in Colorado, a variety of demolition strategies were proposed, including initial water flooding of the reactor vessel for shielding purposes; core drilling, diamond wire sawing and thermic lance cutting to remove the pressure vessel's top head concrete and liner elements, and a number of supplemental methods: plasma arc torch, portable band saws, hydraulic shears, and oxy-acetylene cutting for removal of segments of contaminated piping.

Conclusions from the literature review were that:

- To date, no consistent methodology or strategy has evolved for demolition of heavily reinforced concrete structures where high radiation doses are involved.
- Potential technology transfer opportunities from the nuclear reactor decommissioning experience to tank removal appear to be limited.

Through separate sources, information was obtained regarding the recent demolition of a radiologically contaminated surplus building at the Mound Laboratory facility in Ohio. The task was accomplished by two hydraulic excavators with an assortment of specially designed hydraulic demolition implements mounted on the ends of the booms. These implements were easily able to pulverize concrete and shear through concrete reinforcement and structural steel supports. The implements include interchangeable pulverizers, shears, and hydraulic impact breakers. Based on this initial input, the technology was investigated in greater detail and ultimately was determined to be the most practical available approach for tank demolition.

3.3 DESCRIPTION OF PROPOSED TANK REMOVAL CONCEPT

The concepts and strategies that were developed in this engineering study for demolition of the four 241-AX tanks containing one percent residual waste inventories are discussed in this subsection. The discussion is organized and presented according to the major work elements involved and the sequence of activities.

3.3.1 Tank Farm Enclosure and Support Facility

3.3.1.1 Introduction. The site enclosure concept includes two connected structures. One will be a large enclosure structure that will span the entire length and width of the excavation. The other will house support facilities for the tank removal operation.

Confinement will be provided on a site-wide basis, by a single free-span structure. The enclosure will provide a large containment volume for controlling and filtering any particulate emissions generated by the tank removal operation so that contaminants are not dispersed into the outside environment. The support area includes a decontamination chamber for waste containers, which is similar to a car wash. The structure concept includes provisions for containing all contaminated water generated by the container decontamination process. The decontamination chamber will have provisions for remotely conveying containers through the decontamination process.

Site personnel and waste containers will enter and exit through air lock access points within the connected support facility structure. The support structure will also include a dressout area and separate radiation monitoring equipment for personnel and containers. The main structure includes a separate entry point for mobile equipment and an equipment decontamination area.

3.3.1.2 Enclosure Description. The enclosure structure concept is an application of the STRARCH (STressed ARCH) system, a technology developed several years ago in Australia. The STRARCH truss system combines three common design and construction principles: the arch, the truss, and pre-stressing cables. Application of this truss concept across the width dimension of the excavation will provide a single-span building with dimensions 500 ft wide by 550 ft long as depicted in Figures 3.2 and 3.3.

The STRARCH trusses will be supported on a concrete foundation consisting of individual spread footings connected by a continuous grade beam forming the perimeter of the building. This type of foundation provides solutions for two problems encountered with construction in tank farms facilities. The isolated spread footings will be large enough that pilings would not be required, thus avoiding potential intrusive interactions with adjacent tank farm facilities. The grade beam will also provide for attachment of an inner and outer building shell at grade to implement a double-confinement ventilation scheme within the enclosure.

Erection of the trusses on the foundation will be done as follows:

Each truss has a "fixed" end and a "sliding" end. Initially, the trussed frames are placed on temporary scaffolding in a horizontal plane near ground level. Next, the fixed end of each truss is pinned to the foundation. Purlins, interior and exterior siding, lighting, and fire protection components are installed with the trusses in this configuration. Pre-stressing cables are placed in the tubes forming the bottom chord of the trusses at this stage. After assembly, the pre-stressing cables are hydraulically tensioned to raise the structure to its final height, shape, and span. When the final configuration is achieved, the sliding end is secured to the foundation.

Figure 3.2. Plan View of Enclosure Structure over AX Tank Farm

AX TANK FARM
PLAN VIEW

**Figure 3.3 Section Views of
Tank Farm Enclosure Structure**

3.3.1.3 Support Facility. The support facility will be a prefabricated metal building 75 ft wide by 75 ft long with an eave height of approximately 20 ft. The foundation will be a six-inch slab on grade butted up to the perimeter foundation of the enclosure facility. Construction of the support facility will be by conventional methods.

3.3.1.4 Enclosure Ventilation. Two primary confinement zones will be provided. The open air volume inside the inner liner of the enclosure is designated as Zone 1 and will have the highest negative differential with respect to ambient pressure outside the enclosure. The annulus between the inner and outer liners of the enclosure is designated as Zone 2, which will be maintained at an intermediate negative pressure differential. Air will be supplied to Zone 1 along the east wall of the enclosure through stainless steel supply ducts provided with quick-closing isolation valves or shutters. No separate supply will be provided for Zone 2. Airflow into Zone 2 will be leakage through the inner shell of the building from Zone 1. Exhaust air will be removed from Zone 1 through four individual exhaust branches consisting of large stainless steel ducts suspended from the building trusses near the north west corner of each tank. The operator will be able to select individual exhaust branches depending on the progress of demolition work on individual tanks.

The exhaust from the two Zones will be treated by two separate groups of filtration units with two stages of HEPA filters equipped with individual isolation valves. The filter train for Zone 1 also will be provided with electrostatic precipitators to remove the majority of air-suspended dust. This feature will extend the service life of the HEPA filters. The support facility area will be maintained at a negative pressure between Zone 2 and the ambient and will be serviced by separate dedicated HVAC and exhaust filtration systems.

Principal features of the ventilation scheme are as follows:

- Zone 1 system: 112,500 SCFM supply and HEPA-filtered 122,500 SCFM exhaust.
- Zone 2 system: 7,000 SCFM HEPA filtered exhaust.
- Support facility HVAC system: supply unit capacity 4750 SCFM, 25 tons of refrigeration capacity, and 120 kW heating coil; exhaust unit capacity 5000 SCFM.

Although the enclosure structure will be a substantial structure in terms of its size, it is conceptualized as a temporary structure. The building ventilation concept conforms to the applicable requirements in DOE 6430.1A, with the following exceptions:

1. Section 1550-99.0.2 (Confinement Ventilation Systems):
 - a. The ventilation system is not designed to provide 100 percent standby capacity. The system is designed with approximately 30 percent spare capacity to facilitate filter changeouts.

- b. No diesel generators are provided for stand-by power.

2. Section 1550-1.5.3 (Personnel Ventilation Air Requirements):

Workers inside the enclosure will be required to use supplied personal breathing air except in designated support areas. The ventilation system would maintain CO₂ and CO levels inside the enclosure within limits set by ASHRAE. However, the ventilation system may not conform to all requirements in ASHRAE 62-1989 with regard to dilution of vehicle exhaust emissions.

3.3.1.5 Lighting. Fixed lighting for operations will consist of low perimeter illumination and higher intensity illumination directly over the tanks. This concept is not intended to provide primary lighting for the tank removal operations, but rather supplemental lighting for any essential ancillary activities. All overhead lighting will be suspended from the arched trusses. The source of primary lighting for all tank operations will be by onboard lighting on support vehicles and operating equipment. To the extent that it is necessary and practical to do so, additional lighting could be provided by portable light plants.

3.3.1.6 Fire Protection. Fire protection for the interior of the enclosure will be suspended from the arched trusses. Zone 1 will be protected by dry foam and water spray systems. Water and foam delivery systems including reservoir, pumps, and piping will be sized for a four-hour fire. The support facility will be equipped with a conventional wet pipe system.

3.3.2 Placement of Shielding Grout Inside Tanks

The radiological source term in the four AX tanks (i.e., the one percent residual inventory) is large enough to require active management of worker exposures from the outset of tank removal. Dose assessments performed for this study (summarized in Appendix A) indicate that, during removal of cover soil over the domes, localized dose rates directly over the central portions of the domes of tanks AX-102, 103 and 104 would be in the range of 60 to 100 mrem/hr without supplemental shielding. At 60 mrem/hr, a worker engaged in removing cover soil would accumulate his annual allowable dose (1,500 mrem) in only 25 hours. Based on this assessment, it was concluded that some type of temporary shielding should be placed inside the tanks prior to initiating any actual decommissioning work on the tanks.

A safe, practical, and economical method of providing temporary shielding will be to pump some thickness of a cementitious mixture into the tanks to cover the source term, which is expected to be concentrated on the floor. A range of thicknesses of a hypothetical grout mix was evaluated for shielding effectiveness. It was shown that a one-foot thickness of a mix with a bulk density of about 140 lb/ft³ (a typical value for cementitious mixtures) would reduce worker dose rates by about two orders of magnitude.

A one-foot thickness of a highly flowable, self-leveling, low-strength grout will be pumped into the tanks. The selected formulation is Class A Controlled Density Fill (CDF), conforming to the material specification issued by the Washington Aggregates and Concrete Association (WACA 1997). Ingredients and proportions of Class A CDF are listed below.

<u>Ingredient</u>	<u>Quantity/yd³</u>
Water	50 gal
Cement	30 lb
Fly Ash	200 lb
Dry Sand	3200 lb

This is a low-strength (<100 lb/in²) grout with a bulk density of approximately 140 lb/ft³. The low compressive strength is desirable for ease of rubblization in conjunction with demolishing and removing tank base slab material.

Approximately 655 yd³ of CDF will be dispatched from a local ready-mix company to cover the floor of the four tanks to a depth of one foot. Approximately 19 truck loads (at 9 yd³/truck) of grout will be pumped into each tank. Grout placement will take one eight-hour shift per tank. A local subcontractor would furnish a concrete pump truck with a 140-ft boom and an operator. The remainder of the crew would consist of two Plant Forces health physics technicians to monitor zone entry/exit and ambient conditions within the tank farm, two laborers, and a flagger from Construction Forces who would assist the grout delivery and placement contractors (e.g., spotting the discharge end of the boom).

3.3.3 Removal of Cover Soil

For the purposes of this study, it is assumed that all riser penetrations (except one penetration per tank required for placement of shielding grout) will have been removed and all riser penetrations will have been plugged at the surface of the tank domes during remediation of ancillary facilities. With this assumption, no localized worker dose anomalies will be encountered at riser penetrations during the cover soil removal operation.

A second enabling assumption for this study is that all soil that must be removed to expose the four tanks will be presumed to be contaminated and will be moved to the Environmental Restoration Disposal Facility (ERDF) for disposal. By its nature, the excavation process will commingle soils that are contaminated to greater and lesser degrees, which would tend to thwart efforts to segregate nominally clean soil from contaminated soil. Efforts to segregate clean and contaminated would require extensive soil sampling and provisions for a large temporary holding area inside the enclosure structure for soil between sampling and analysis.

After placement of shielding grout inside the four AX tanks, dose calculations indicate that cover soil can be removed with conventional excavation equipment (i.e., the excavation equipment used to remove cover soil would not require any supplemental shielding). A shallow pit excavation will be developed in the process of exposing the four tank domes. After cover soil has been removed, the floor of the excavation will be approximately 12.5 ft below grade, at the same level as the haunch of the tanks. A ramp (haul road) will be developed along the east side of the pit with entry from the north (see Figure 3.4). The ramp will be constructed with an eight-percent slope, which can be negotiated by all mobile equipment items involved in the operation.

Excavation and transportation concepts were developed for this study conforming to the current ERDF operation. Contaminated soil will be moved from points of origin to ERDF in roll-on, roll-off (RO/RO) containers, which have a 20-ton capacity. The trucks used to transport RO/ROs are specially configured for handling (loading and unloading) containers of this type. Four container trucks will shuttle RO/ROs into and out of the excavation. These trucks will work exclusively inside the enclosure structure. These trucks are shown as capital in the cost estimate for the operation. Within the pit, RO/ROs will be loaded by a hydraulic excavator with a 3-yd³ bucket. The total bank volume of soil to be removed is 20,500 yd³ (or 27,675 t), which equates to 1,384 container loads. Each container will undergo external decontamination and radiation survey as it is transferred from inside the enclosure structure to the outside. A separate fleet of container trucks will pick up RO/ROs outside the enclosure and haul them between AX Tank Farm and ERDF. These trucks and the containers are contractor furnished equipment. All contractor costs are included in the \$60/t ERDF disposal fee.

Cover soil removal will require a crew of eight (one excavator operator, one oiler, two health physics technicians, four teamsters) for six weeks.

Figure 3.4. Pit Excavation After Cover Soil Removal

3.3.4 Demolition/Removal of Tank Domes

Using the selected demolition method (described in Section 3.2.3.3), tanks will be reduced to rubble beginning with the domes. Two hydraulic excavators equipped with specialized demolition implements will be used for concrete demolition work. The two excavators will work in tandem. Initially, a large hydraulic impact breaker will be mounted on one excavator. The second excavator will be equipped with a hydraulic shear jaw set capable of cutting completely through reinforced concrete panels up to 36 in thick. The initial effort will be to fracture a localized area in the central part of the dome with the impact breaker, severing imbedded rebar with the shear jaws as it becomes exposed. When a starter hole has been established, the impact breaker attachment will be exchanged for a concrete pulverizer jaw set. The pulverizer jaw crushes concrete into fine fragments that fall away from the reinforcing bar. The two excavators will work around the perimeter of each tank, with the lead unit pulverizing concrete around the edge of the hole and the second unit clipping off exposed rebar. In this manner, the starter hole will be expanded toward the haunch.

In the haunch area, tank domes are three to five ft thick and are very heavily reinforced. As the hole is enlarged toward the haunch, the pulverizer jaw set will become ineffective because the dome thickness approaches and then exceeds the jaw opening dimension. At this point in the operation, the pulverizer jaw set will be exchanged for the impact breaker. The breaker unit is capable of rubblelizing as much as 45 to 65 yd³ of reinforced concrete per day. The impact breaker and shear jaw attachments will be used for the remainder of the dome removal task. The excavators will work around the perimeter of each tank in sequence to rubblelize the four domes.

As shown in Figures 3.4 and 3.6, the pit floor during dome removal is at the same elevation as the corner of the haunch (i.e., approximately 12.5 ft below grade). Working from the peripheral area around the outside of the tanks, the excavators will have sufficient reach to completely rubblelize the domes without having to move out onto the surface of the domes at any time.

Rubble from demolition of the dome and haunch will accumulate on the floor of each tank. Approximately 260 yd³ of rubble will be created per tank from the dome removal operation. The rubble will form a second layer of temporary shielding material over the top of the CDF grout. The additional shielding value contributed by the rubble layer will have a significant impact on limiting worker doses during all subsequent tank removal activities.

Dome removal will be accomplished in 12 working days. The crew will consist of two excavator operators, two oilers (for scheduled maintenance), two health physics technicians, two laborers (who will assist with equipment decontamination when demolition implements have to be changed or unscheduled maintenance is necessary), and one millwright (who will be responsible for replacing wear parts and changing implements on the excavators).

3.3.5 Lateral Soil Removal

The extent of the excavation required to expose the sidewalls of the four AX tanks from the corner of the haunch down to the footings is shown in Figure 3.5 and 3.6. The sideslopes of the pit will be laid back at 1:1.5, which is the OSHA mandated limit for unsupported excavations in cohesionless soil. The access ramp (haul road) entering the pit from the northeast corner will be extended as the pit is deepened. The ramp will slope down at eight percent, which can be

negotiated by all mobile equipment involved in the operation. At completion, the ramp will be approximately 650 ft long, and will extend along the east and south sides of the pit, terminating on the west side. The final pit floor elevation will be approximately 52 ft below grade.

As discussed in connection with removal of cover soil, the assumption has been made for this study that all soil that must be removed to expose the four tanks will be presumed to be contaminated and will be moved to ERDF for disposal in 20-ton capacity RO/RO containers. The total bank volume of lateral soil to be removed is 144,300 yd³ (or 194,800 tons). At 20 tons per container, this amount of material equates to approximately 9,740 container loads. Four trucks will shuttle containers in and out of the pit, inside the AX tank farm enclosure. Containers will be loaded by one hydraulic excavator with a three-yard³ bucket. Approximately 44 RO/RO containers would be loaded and transported to ERDF per day. Although the equipment spread for tank removal includes two hydraulic excavators, rate-limiting factors for soil excavation are container size and movement. Using two excavators to load containers would not improve productivity.

Figure 3.5. Pit Excavation After Lateral Soil Removal

Figure 3.6. Pit Excavation Section Views

A separate fleet of container trucks will haul RO/ROs between AX tank farm and ERDF. These trucks and the containers are contractor furnished equipment. The \$60/t ERDF disposal fee includes contractor equipment costs. Lateral soil removal will require a crew of eight (one excavator operator, one oiler, four teamsters, and two health physics technicians) for 44 weeks.

3.3.6 Demolition of Tank Sidewalls

After removal of soil to expose the sidewalls of the four tanks, demolition work will resume with the sidewalls. For this activity, the two hydraulic excavators will be equipped with the pulverizer jaw and shear jaw implements. The two excavators will work together; the lead unit will pulverize concrete and the second unit will follow along behind and clip off rebar as it is exposed.

The outer sidewall height is approximately 38 ft from the top of the footing ring to the corner of the haunch. The carbon steel liner covers the inside surface to a height of approximately 32.5 ft. Therefore, depending on the exact breakline left around the top of the sidewall when the tank domes are demolished, there will be approximately 5.5 ft of exposed sidewall above the liner at the beginning of this task.

Approximately 61 yd³ per tank of concrete rubble will be produced from demolition of the upper 5.5-ft sidewall interval. Portions of the rubble from this interval will fall to the inside and the outside of the tank. For estimating purposes, it is assumed that all 61 yd³ would collect inside the tank and would be dispositioned (loaded out and hauled away) as part of the base slab rubble quantity.

When the sidewall has been demolished down to the top of the liner, the division of work between the two excavators will change somewhat. The excavator with the shear jaw implement will continue to trim exposed rebar as before. However, it will also be tasked with (1) pushing against the liner plate, forcing it away from the sidewall, so that the concrete edge remains accessible for the lead excavator (with the pulverizer jaw) to operate on, and (2) shear exposed portions of liner plate into 3 to 5-ft² segment. Liner plate segments will fall inward and accumulate on the floor of the tank. The liner plate pieces will be dispositioned with other base slab rubble.

It is assumed that all rubble concrete and rebar originating below the top of the liner will accumulate to the outside of the tank. Between the top of the liner and the top of footing ring, approximately 531 yd³ of concrete rubble will be produced per tank. In the absence of any specific information regarding concrete contamination, it is assumed for purposes of this study that this rubble would not be heavily contaminated (i.e., would exhibit levels of contamination comparable to the surrounding soil) and could therefore be shipped to ERDF for disposal.

A front-end loader will work around the tanks behind the two excavators, loading concrete rubble into containers. The cab of the loader will be equipped with environmental isolation and shielding provisions comparable to the two excavators. It is estimated that demolition and removal of sidewall debris from the four AX tanks will require a crew of 15 for six weeks. The crew will consist of three operators, three oilers, two teamsters, four laborers, one millwright, and two health physics technicians.

3.3.7 Base Slab and Footing Ring Removal

The final stage of tank demolition will involve the most adverse working and material handling conditions to be encountered at any time during the operation. In all of the activities performed up to this point, the soils and demolition debris that will have been removed from the site are expected to contain a small fraction of the overall radiological source term in the tank farm. The majority of the residual waste inventory is expected to be adhered to the liner plate over the floor area of the tank. It will be necessary for equipment operators to work in close proximity to the residual tank waste. Moreover, the cumulative effect of preceding activities (i.e., removal of surrounding soil and demolition of tank domes and sidewalls) will be to eliminate the beneficial effects of these materials as shielding.

The bottom surface area of each of the four AX tanks is approximately 4,420 ft². The best-estimate ¹³⁷Cs compositions in one-percent residual inventories for the four tanks are listed below, with corresponding concentrations over the bottom surface (assuming uniform distribution).

Tank	¹³⁷ Cs Inventory (Ci)	¹³⁷ Cs Concentration (Ci/ft ²)
AX-101	5,160	1.17
AX-102	7,170	1.62
AX-103/104	10,900	2.47

These values were used to evaluate potential exposure consequences, shielding requirements for equipment operators, and packaging constraints for debris removal.

The initial aspect of base slab demolition will be to remove an eight-foot-wide strip of the liner around the perimeter of the tank that overlays the footing ring. The shear and pulverizer jaw implements will be used to accomplish this element of the work. To do so, the excavator with the pulverizer jaw will grab the exposed edge of the liner and lift it slightly, bending or curling it up so that pieces can be sheared off by the other unit. The front-end loader will work behind the two excavators loading rubble into shielded containers.

The next work element will be to rubblize the footing ring. The footing ring is 14 ft wide and three ft thick. Because of the thickness of concrete involved, most of the demolition work on the footing ring will be done with the hydraulic impact breaker, supported by the shear jaw unit. This portion of the work will be similar to demolition of concrete in the haunch.

Base slab demolition can proceed to completion when the footing ring has been eliminated. The base slab thickness is 1.5 ft, which will enable the pulverizer jaw to be used for the remainder of the operation. As the liner edge is exposed, it will be curled up and sheared into manageably small (e.g., one ft by three ft) pieces suitable to be loaded into shielded containers. Each time the liner edge is lifted and curled up, the temporary shielding materials (i.e., the CDF grout and concrete rubble from the dome and upper sidewall) will slough away, exposing a limited area of the liner surface with adhered tank waste. Because of the severe gamma radiation hazard posed by direct exposure of tank waste, continuous diligence will be required on the part of the excavator operators to do the work with the minimum essential amount of liner surface area

exposed at any given time. Calculations to estimate shielding requirements for the various mobile equipment items (refer to Appendix A) assume that no more than 4 m² of liner surface would be exposed at a time. Working behind the excavators, the front-end loader will transfer rubble into shielded containers. Significant improvements in worker exposure estimates can be achieved by loading out base slab debris quickly and efficiently.

Base slab rubble will consist of a mixture of liner scrap, shielding grout, concrete rubble, and some amount of soil from below the slab that will be picked up with the debris. For estimating purposes, the following itemization of debris was developed.

Concrete debris from dome and haunch (319 yd ³ ; 20% swell):	383 yd ³
Concrete debris from base slab and footing ring (458 yd ³ ; 20% swell):	550 yd ³
CDF grout rubble (164 yd ³ ; 20% swell):	197 yd ³
Tank Waste (360 ft ³):	13.33 yd ³
Liner plate scrap (assuming 500% swell):	69 yd ³
Soil (uniform 3-in. lift under slab; 20% swell):	63 yd ³
Total per tank:	1,275 yd ³

Based on these values, base slab rubble is expected to exhibit specific activity levels of ¹³⁷Cs in the range of 0.2 to 0.5 Ci/ft³. As solid waste, the rubble would be categorized as remote-handle TRU. No existing waste package design is suitable for transporting material with ¹³⁷Cs activity levels in this range (WHC 1995). A completely new container would have to be developed for on-site transportation of base slab debris.

For this study, it was assumed that the same fleet of container-handling trucks used to transport RO/RO containers would be used for hauling packaged base slab debris. These trucks have a 38,000-lb payload limit. Shielding calculations indicate that a package with a given aspect ratio of 1:1.2:4 would require four inches of steel on the top and sides to limit doses to 10 mrem/hr at 1 m. Such a container would have a payload volume of about 117 ft³. Assuming a unit weight of rubble of 102 lb/ft³ and complete filling, the package would weigh about 26,000 lb and could hold about 12,000 lb of base slab rubble. For estimating purposes, the assumption was made that only about 3.5 yd³ of debris (corresponding to a fill factor of 80 percent) would actually be loaded into any given container. This would likely be done in practice as a way to avoid overfilling a container (making it difficult to close and secure it for shipping) and/or inadvertently loading too much ¹³⁷Cs activity into any one package. Based on this information, approximately 365 packaged loads of base slab debris will be produced per tank.

The packaged debris would be hauled approximately one mile to a waste processing facility, which is assumed to be collocated with the TWRS waste vitrification facilities. Costs developed for loadout and removal of base slab debris include transportation costs but exclude any costs for design, safety analysis, fabrication, or procurement of the transport packages. It is assumed that the packages would be "owned" by the waste processing facility (i.e., package costs would be included with capital costs for the facility) and that they would be designed to be reusable.

Base slab demolition will be performed by a crew of 20, consisting of three equipment operators, three oilers, four teamsters, two health physics technicians, six laborers, and two millwrights.

The laborers would support equipment decontamination and movement of containers through the airlocks into and out of the enclosure. The millwrights would support maintenance and repair of demolition equipment. Base slab demolition will take approximately 32 days to complete.

3.3.8 Backfilling the Excavation After Tank Removal

Costs are included in the Tank Removal Estimate for backfilling the excavation after all tank removal and soil remediation activities have been completed. For estimating purposes, direction was provided to assume that Pit 30 would be the source for the fill. A total of 164,800 yd³ of soil will be excavated from the site during the tank removal operation. An additional volume of 27,700 yd³ will be required to replace the volumes of the four AX tanks. Another 19,900 yd³ of material will be required to replace soil excavated for deep soil remediation (COGEMA Engineering 1997^b). The combined (bank) volume is 212,400 yd³. This total was increased by 10 percent. Any excess material would be placed as a uniform surcharge over the site. The total volume of material to be hauled and placed is 234,000 yd³. No compaction effort will be applied to the fill other than the wheel loads of placement equipment. A unit weight of 120 lb/ft³ was assumed.

Four truck tractors with 20-yd³ dump trailers will be used to haul and place material. The four trailers will be loaded at Pit 30 by a front-end loader with a 5-yd³ bucket. The one-way haul is approximately five miles. Material will be spread and graded by a dozer working inside the tank farm excavation. The work will take approximately 49 weeks to complete. As directed, no other site restoration costs were developed.

3.4 IMPLEMENTABILITY ISSUES

3.4.1 Scaleup of Enclosure Structure Concept

The enclosure structure proposed in this study to provide containment for the tank removal operation is a free-span structure that will cover an area 500 ft wide by 550 ft long. The structure concept is based on the application of STRARCH trusses with a 500-ft span. Similar enclosure designs have been proposed in other TWRS engineering studies (e.g., McConville 1995). Based on the available information, the 500-ft STRARCH truss span would involve a modest scale-up from existing applications, and therefore appears to be a practical design solution for the enclosure over the 241-AX Tank Farm. Most other SST farms include three or four rows of tanks. The STRARCH concept may not be adaptable for constructing much larger free-span structures over other tank farms. To that extent, the concepts developed in this study for removing AX farm tanks may not be transferable directly to other farms.

3.4.2 Worker Dose and Shielding Estimates

Scoping estimates of worker dose and shielding requirements have been made as part of this study. Preliminary best-basis inventory estimates for the one percent residual inventories in tanks were used in the scoping calculations. The estimates indicate that tank removal would be feasible for the given inventory estimates, based on the proposed shielding strategies and the projected efficiencies for accomplishing the work with the equipment spread identified for the concept operation.

An essential element of the tank removal strategy is to provide heavy shielding for cabs of all mobile equipment pieces working in the pit excavation. The hydraulic excavators and the front-end loader would have six inches of steel plate on exterior surfaces of the cabs and six-inch windshields of high-density leaded glass. These modifications would increase the weights of these items by about 50,000 lb each. Modifications of equipment items to carry the extra weight are regarded to be feasible, although it is conceded that significant equipment redesign would likely be required.

A modest increase in the ^{137}Cs quantities in the best-basis inventories have the effect of increasing shielding requirements (and weight) for all mobile equipment items involved. There is some limit to the workability of this strategy, and the current concept may already be approaching that limit. There is some risk that the concept may cease to be practical if ^{137}Cs inventories exceed the current estimates or worker productivities are significantly below expectations.

3.4.3 Radionuclides in Air-Suspended Particulates

Estimates of air-suspended particulates are provided in the data tables in Section 3.5. The method that was used to estimate radionuclides in particulates is described in the notes that accompany the tables. No standard method or experienced-based precedent is known for preparing estimates of this kind. Based on the assumptions applied, these estimates are believed to be highly conservative. However, the estimates are speculative, and supporting evidence is unavailable to substantiate the computational method or the results.

The intentional conservatism in radionuclide emissions estimates could have unintended consequences. The estimates could become the basis for the erroneous argument that tank removal cannot be done because public health and safety risks would be unacceptable (e.g., because of actinides in emissions). The recommendation would be that this aspect of the tank removal study results should be examined in greater detail as a separate activity.

3.4.4 Worker Health and Safety Considerations

It is envisioned that personnel working inside the pit excavation would be limited to teamsters and equipment operators in shielded cabs with on-board supplied air (i.e., all in-pit work would be "mask work"). The building ventilation system is designed to sweep air towards the pit, be collected in overhead ducts, and be then filtered and exhausted. This arrangement implies that support work in other areas of the building may not need to be done "on mask." However, for estimating purposes it was assumed that all remediation work would be mask work.

Worker dose estimates for construction of the enclosure structure indicate that cumulative doses could be significant during that portion of the operation. However, the dose rate for that activity is the assumed local background, 50 microrem/hr, which is less than detectable with personal dosimeters. The cumulative doses are more reflective of the long duration of construction rather than the presence of a dangerous radiological source while construction is being done.

Due to the essential conceptual nature of this study, the opportunity to address contingencies relating to radiological safety and develop specific strategies for worker protection during off-normal events is limited. For these reasons, worker health and safety provisions may be over-estimated or underestimated.

3.4.5 Packaging and Disposition of Base Slab Rubble

Based on a limited evaluation of the issue made during the tank removal study, it is understood that average ^{137}Cs concentrations in base slab debris would be so high that a new, heavily shielded container would have to be designed to enable the debris to be loaded out and removed from the pit excavation. Base slab debris probably would be designated as remote-handled TRU. The weight of an adequately shielded container would severely limit cargo capacity. At the present time, there is no on-site facility that is equipped to receive, store, or handle remote-handled TRU waste in significant quantities. Nor is there a plan to make such a facility available in the foreseeable future.

Consequently, packaging and disposition of base slab rubble is an open interface issue. Costs were included in the estimate for this study for transportation of base slab debris in small-volume shielded containers to a nearby point. No costs are included for procurement of the specialized transport packages that would be required or for any form of waste treatment. These issues will be addressed in a future engineering study.

3.4.6 Environmental Restoration Disposal Facility Interface

It has been assumed for this study that all soil excavated to expose the four AX tanks down to the footing ring level would be assumed to be contaminated and would be transported to ERDF for disposal. At the present time, ERDF is chartered to accept only waste from CERCLA remedial action sites at Hanford. Additionally, ERDF will only take waste with acceptable constituents in concentrations that do not exceed facility-specific waste acceptance criteria. It is currently unclear how these constraints would be resolved. Tank farms are not classified as CERCLA remedial action sites. Contaminated soil from tank farms may contain constituents, including land-banned constituents, which ERDF would be unable, under State of Washington regulations, to accept. ERDF waste acceptance criteria may have to be broadened to accommodate material originating in tank farms or a separate-but-equivalent disposal facility for tank farms waste may have to be constructed.

3.5 ENGINEERING DATA TABLES

Data tables (3.2 through 3.5.2) have been assembled to summarize the labor, equipment, and resources that would be committed to expose and demolish the four tanks in the 241-AX tank farm as per the concepts proposed and described above in this section. The tables also provide summary estimates of waste types and forms, emissions, and worker exposures that would be produced as consequences of prosecuting the work. This section includes as well information on project cost and schedule as well (Table 3.6 and Figure 3.7). Additional detail on project costs is presented in Appendix B. The estimate methodology is explained in Tables B-3 through B-6.

These tables do not include any quantities pertaining to the two leakage cases (i.e., hypothetical 8,000-gal and 40,000-gal leakage events during tank waste retrieval). Impacts on tank removal in response to leakage during waste retrieval are addressed separately in Section 4.0 of this report.

Table 3.2. Waste Form and Volume Projections

Waste Form	Characteristic
Cover Soil	
Waste volume (in place)	20,500 yd ³
Number of containers	1,384 container loads
Container size	20'L x 7.5'W x 5.5'H
Radionuclide Inventory	(Note 1)
Disposal location	Environmental Restoration Disposal Facility
Lateral Soil	
Waste volume (in place)	144,300 yd ³
Number of containers	9,740 container loads
Container size	20'L x 7.5'W x 5.5'H
Radionuclide Inventory	(Note 1)
Disposal location	Environmental Restoration Disposal Facility
Concrete Rubble from Tank Sidewalls	
Waste volume (in place)	2,124 yd ³
Number of containers	213 container loads
Container size	20'L x 7.5'W x 5.5'H
Radionuclide Inventory	(Note 1)
Disposal location	Environmental Restoration Disposal Facility
Rubble from Domes and Base Slabs	
Waste volume (loose)	5,100 yd ³
Number of containers	1,460 container loads
Container size	12.1'L x 4.2'W x 3.3'H
Radionuclide Inventory	(Note 2)
Disposal location	TWRS Vittrification Facility

Note 1: For this study, soil excavated to expose tanks and concrete debris from demolition of the tank sidewalls were assumed to exhibit sufficiently low levels of radiological and nonradiological contamination to conform to ERDF waste acceptance criteria, (i.e., that these materials would be acceptable for disposal at ERDF). Concurrently, it was assumed that a negligible portion of the one percent residual waste inventory in the four AX tanks would be present in these materials.

Note 2: It was assumed for this study that virtually all of the one percent residual waste inventory in the four AX tanks would be adhering to the liner plate, principally on the floor of tanks. Consequently, the assumed radionuclide inventory in rubble from demolition of the tank domes, liner plate and base slabs is the estimated one percent residual inventory for the four tanks.

Table 3.3. Construction Resource Requirements

Construction Resource	Quantity
Land (Temporary Laydown Area for Building Construction Outside AX Tank Farm)	Approximately 3 Acres
Water	
Waste Container Decontamination	1,277,200 gal
Mobile Equipment Decon.	327,200 gal
Concrete in Building Constr.	41,300 gal
Shielding Grout	32,800 gal
	Total = 1,678,500 gal
Energy	
Electrical	14.55 GWhr
Propane	N/A
Diesel Fuel	3,803,800 lbs
Gasoline	N/A
Concrete for Building Construction	
Cement	623,200 lb
Sand	1,724,000 lb
Gravel	2,519,400 lb
Rebar	300,000 lb
CDF Grout for Shielding inside Tanks	
Cement	19,700 lb
Flyash	131,000 lb
Sand	2,096,000 lb
Steel	5,500,500 lb
Excavation for Building Foundations	
Excavated Volume	2,400 yd ³
Backfill	1,200 yd ³
Excavation to Expose Tanks	
Excavated Volume	164,800 yd ³

Notes regarding water consumption:

Waste container decontamination: 100 gal/container

Mobile equipment decontamination: 200 gal/day per item

Notes regarding electrical energy consumption: Refer to Figure 3.7 for construction schedule information.

Power use estimate:

Use rate during building construction:

All sources: (2 kw)(8 hrs/day)(350 days) = 5,600 kWhr

Power use estimate (continued):

Use Rate During Tank Removal:

Ventilation: = (1,400 HP)(0.746 kw/HP)(24 hrs/day)(7/5)(328 days)
= 11,510,123 kWhr

Lighting: = (275 kw)(24 hrs/day)(7/5)(328 days)
= 3,030,720 kWhr

All Other: = (1.5 kw)(8 hrs/day)(328 days)
= 3,936 kWhr

Total electrical consumption = 14,550,400 kWhr = 14.55 GWhrs

Notes regarding fuel consumption calculations: Fuel consumption was calculated based on engine specific fuel consumption data provided by Caterpillar Inc. and the equipment spread, duty cycle, and engine model data listed below. Rated fuel consumption for CAT 3406CATAAC engine is 149.24 lb/hr; for CAT 3408TA engine is 167.44 lb/hr.

Enclosure Construction:

	<u>Schedule</u>	<u>Util_Rate</u>	<u>Opr. Hours</u>	<u>Engine</u>
(2) 200-T Crane	42 Wks	70%	2,352	CAT 3406CATAAC
(2) 40-T Crane	70 Wks	70%	3,920	CAT 3408TA
(2) Svc. Trucks	70 Wks	20%	1,120	CAT 3408TA

Tank Demolition/Removal:

	<u>Schedule</u>	<u>Util_Rate</u>	<u>Opr. Hours</u>	<u>Engine</u>
(2) Excavators	(Varies)	70%	1,811	CAT 3406CATAAC
(1) Wheel Loader	(Varies)	70%	282	CAT 3408TA
(4) Haul Trucks	(Varies)	70%	5,405	CAT 3408TA

Container-Handling Trucks (Assuming 25 mph average speed; CAT 3408TA engines):

	<u>Trips</u>	<u>Mileage</u>	<u>Hours</u>
Hauling to ERDF (9 mi haul)	11,337	204,066	8,163
Hauling to Vit Plant (1 mi haul)	1,460	2,920	117

Operating Hours and Fuel Consumption:

$$\text{CAT 3406CATAAC: } 2,352 + 1,811 = 4,163 \text{ hrs}$$

$$\begin{aligned}\text{Fuel Consumption} &= (4,163 \text{ hrs})(149.24 \text{ lb/hr}) \\ &= 621,300 \text{ lbs}\end{aligned}$$

$$\text{CAT 3408TA: } 3,920 + 1,120 + 282 + 5,405 + 8,163 + 117 = 19,007 \text{ hrs}$$

$$\begin{aligned}\text{Fuel Consumption} &= (19,007 \text{ hrs})(167.44 \text{ lb/hr}) \\ &= 3,182,500 \text{ lbs}\end{aligned}$$

$$\begin{aligned}\text{Total Fuel Consumption} &= 621,300 \text{ lbs} + 3,182,500 \text{ lbs} \\ &= 3,803,800 \text{ lbs}\end{aligned}$$

**Table 3.3.1. Particulate Emissions Originating Outside of
AX Tank Farm from Activities Associated with Tank Removal**

Activity	Particulate Emissions (tonne)
Clearing and Grubbing of Laydown Area for Building Constr. Materials	0.18
Paved Road Transportation of Waste Containers	12.5

Notes regarding emissions calculations:

Dozer Grading - Laydown Area:

Area = 3 Acres

Duration = 21 Days

Particulate Emissions = 0.18 tonne

(Basis: Clearing and grubbing emissions estimates, Kline et al (1995) Table A-10, p. A-36). Silt content 6%; soil moisture content 3 percent.

Paved Road Transportation Particulate Emissions:

Emissions Factor: $EF = 220 \{(\text{silt load})/12\}^{0.3}$

silt load = % silt = 5%

$EF = 220 \{5/12\}^{0.3} = 169.2 \text{ g/km}$

	<u>Trips</u>	<u>Haul Dist.</u>	<u>Emissions</u>
Cover Soil:	1,384	6.4 km	1.5 tonne
Lateral Soil:	9,740	6.4 km	10.5
Sidewall Concrete:	213	6.4 km	0.2
Dome/Base Slab Rubble:	1,460	1.3 km	<u>0.3</u>
			12.5 tonne

The emission factor is the amount of PM 10 particles in grams/vehicle kilometer traveled.
(Basis: Estimation procedure provided in EPA 451/R-93-004, "Estimation of Air Impacts from Area Sources of Particulate Matter Emissions at Superfund Sites," Report ASF-32.)

Table 3.3.2. Construction Vehicle Emissions⁽¹⁾

Emissions Category	Building Constr. Quantity (lb)	Tank Removal Quantity (lb)	Waste Transport Quantity (lb)
Particulates	272	282	331
SO _x	4,779	4,889	5,544
CO	6,104	6,435	7,952
Hydrocarbons	258	246	219
NO _x	42,656	43,257	47,729
Aldehydes	N/A	N/A	N/A
Organic Acids	N/A	N/A	N/A
Thermal Releases Btu ⁽²⁾	2.197 E10	2.248 E10	2.550 E10
NH ₃	0	0	0

Note 1: Quantities were calculated based on engine exhaust chemistry data provided by Caterpillar Inc. and the equipment spread, duty cycle, and engine model data listed in notes following Table 3.2.

Note 2: Thermal Releases: Thermal releases were calculated assuming that diesel engines lose 75 percent of the energy content of fuel consumed (18,390 Btu/lb; 1055.1 J/Btu) as heat (source: Kline et al 1995, Table A-10, Note 5).

Fuel Quantities:

	Bldg. Constr.	Tank Removal	Haul to ERDF
CAT 3406CATAAC:	351,000	270,300	(none)
CAT 3408TA:	843,900	952,200	1,386,400

**Table 3.3.3. Estimates of Particulate Emissions from
Confinement Structure over AX Tank Farm During Tank Removal**

Source	Estimated Dust Production	Estimate of Emissions from Enclosure ⁽¹⁾
Dust production from loading of soil into containers	230 kg	11.5 g
Concrete dust from pulverizing tank domes, sidewalls, and base slabs	187 kg	9.4 g
Pulverized tank waste produced by cutting liner apart	197 kg	9.8 g ⁽²⁾

Note 1: The air filtration system will consist of electrostatic precipitators ahead of HEPA filters. The combined decontamination factor for the two filtration elements is estimated to be about 20,000. HEPA filter elements alone are about 99.97 percent efficient (corresponding to a DF of 3,333), so the combined DF is expected to be conservative. In general, all particles that pass through HEPA filters are in the minus 0.3 micron size fraction.

Note 2: An estimate of the radiological inventory contained in the 9.9 g of emissions originating from tank waste is tabulated separately (refer to Table 3.3.4).

Additional Notes re. Calculations of Fugitive Dust Generated During Demolition and Loadout of Soil and Debris:

A. Dust Generated During Loading of Soil into Containers:

$$\begin{aligned} \text{Mass(M)} &= (1,384 + 9,740 \text{ containers})(20 \text{ t/container})(2,000 \text{ lb/t})(\text{kg}/2.2 \text{ lb}) \\ &= 2.022 \times 10^9 \text{ kg} \end{aligned}$$

$$\text{Particle size multiplier (K)} = 0.35$$

$$\text{Mean air velocity (U)} = 1 \text{ m/sec (assumed)}$$

$$\text{Moisture content (xH}_2\text{O)} = 3 \text{ percent (assumed)}$$

$$\begin{aligned} E &= (K)(0.0016)(M)(U/2.2)^{1.3}/(xH_2O/2)^{1.4} \\ &= (0.35)(0.0016)(2.022 \times 10^9 \text{ kg})[(U/2.2)^{1.3}]/(3/2)^{1.4} \end{aligned}$$

= 230 kg

(Basis: Estimation procedure provided in EPA 451/R-93-004, "Estimation of Air Impacts from Area Sources of Particulate Matter Emissions at Superfund Sites," Report ASF-32.)

B. Concrete Dust Generated by Pulverizing Tank Domes, Sidewalls, and Base Slabs:

Pulverization of reinforced concrete produces a significant amount of air-suspended particulates. Case-history-based data on particulate emissions is unavailable from vendor sources. It is understood from discussions with equipment vendors that dust generation from such activities varies considerably with the age and composition of the concrete undergoing size reduction, increasing the difficulty in predicting emissions for any given situation. For the tank removal application, the following hypothetical estimate has been developed:

In-place volume of concrete to be pulverized:

319 yd³/tank in dome and haunch
458 yd³/tank in base slab and footing ring

Total Volume = 777 yd³/tank x 4 tanks = 3,108 yd³

Assume 50 percent of total volume is demolished with pulverizer jaw and 50 percent is demolished with impact breaker, and pulverizer jaw produces five times as much dust as impact breaker.

Effective Pulverized Volume = 0.5(3,108)+0.5(3,108/5) = 1,865 yd³

Based on visual assessments of dust production in vendor videos, it is estimated that perhaps as much as 100 grams of air-suspended dust would be produced per cubic yard of concrete pulverized.

Dust Production = (100 g/yd³)(1,865 yd³)
= 186,500 g = 186.5 kg

C. Radiological Emissions in Air-Suspended Solids:

As indicated in Section 3.3.7, liner plate will be sheared into manageably small (nominally one ft by three ft) pieces to be loaded into shielded transport packages. Insofar as the tank demolition method proposed in this study has never been attempted in a radiological environment, there is no experience basis for evaluating how much of the residual waste inventory adhering to the inside of the tank liner might be pulverized as the liner plate is sheared into pieces. Because dust-size particles of tank waste could conceivably become suspended in air during loadout of base slab debris, an estimate of the potential dust production

from this source is of considerable interest. A hypothetical estimate is provided below. However, it should be emphasized that this is a speculative exercise, lacking any basis in experience.

Assume all contamination is adhered to the floor of the tanks. The bottom surface area of the tanks is approximately 4,420 ft². Assume that the liner plate covering the floor is sheared into rectangular pieces, each measuring one ft by three ft. The total sheared length to produce such pieces is approximately:

$$4,420 \text{ ft}^2 / 3 \text{ ft}^2 \text{ per piece} = 1,473 \text{ pieces per tank} \\ \text{or } 5,892 \text{ pieces total}$$

$$\text{Sidelenhth/tank} = [(8 \text{ ft/piece})/(2 \text{ sides}))(1,473 \text{ pieces/tank}) \\ = 5,892 \text{ lineal ft per tank}$$

Each tank is assumed to contain 360 ft³ of residual waste, which corresponds to a thickness of one in of waste uniformly distributed over the floor of the tank. Assume that a 1/4-in-wide zone of this one-in waste layer is pulverized as the liner plate is sheared.

$$\text{Pulverized volume/tank} = [(0.25 \text{ in.})(1 \text{ in.})/144 \text{ in}^2/\text{ft}^2](5,892 \text{ ft}) \\ = 10.23 \text{ ft}^3 \text{ per tank}$$

Additionally, assume that 10 percent of the pulverized waste volume becomes suspended in air during loadout of debris.

$$\text{Air-suspended tank waste dust} = (0.10)(10.23 \text{ ft}^3) \\ = 1.02 \text{ ft}^3 \text{ per tank}$$

Corresponding masses of tank waste vary from tank to tank according to the waste specific gravity reported for each tank.

<u>Tank</u>	<u>Sp.Gr.</u>	<u>Volume to Mass</u>	<u>Mass/DF</u>
AX-101	1.573	1.02 ft ³ = 45.4 kg	2.27 g
AX-102	1.57	1.02 ft ³ = 45.4 kg	2.27 g
AX-103	1.80	1.02 ft ³ = 52.1 kg	2.61 g
AX-104	1.80	1.02 ft ³ = 52.1 kg	2.61 g

Table 3.3.4. Radiological Inventory in Particulate Emissions (Curies)¹

Radionuclide	AX-101	AX-102	AX-103	AX-104
¹⁴ C	1.8 E-8	1.4 E-8	0	3.5 E-8
⁶⁰ Co	2.9 E-7	3.5 E-8	8.6 E-6	9.4 E-6
⁹⁰ Sr	1.6 E-2	7.4 E-3	7.5 E-2	7.5 E-2
⁹⁹ Tc	4.6 E-7	5.4 E-7	0	2.5 E-7
¹²⁹ I	2.3 E-10	9.5 E-8	0	4.7 E-10
¹³⁷ Cs	7.3 E-4	1.0 E-3	1.5 E-3	1.5 E-3
^{239/240} Pu	7.9 E-5	3.0 E-5	1.9 E-5	1.9 E-5
²⁴¹ Am	2.5 E-5	2.3 E-4	0	5.6 E-6

Note 1: Radionuclide concentrations in emissions are assumed to be the same as the best-estimates of concentrations in residual tank waste reported by COGEMA Engineering (1997a).

Table 3.4. Personnel Requirements

Category	Construction (FTEs)	
	Rad Workers	Non-Rad Workers
Building Constr.		
Supervisory	0	15
Direct Labor	0	58
Tank Removal		
Supervisory	8	1
Direct	20	0

FTE: full-time equivalent

Table 3.5.1. Worker Exposure Estimates

Unit Process/Crew	Avg. Exposure Rate (mrem/hr)	Individual Dose(mrem/indiv.)
Construct Enclosure (350 Days)		
4 Carpenters	0.05	16
6 Laborers	0.05	78
4 Operators	0.05	84
2 Oilers	0.05	78
10 Ironworkers	0.05	26
10 Sheetmetal workers	0.05	130
12 Sprinkler fitters	0.05	54
10 Electricians	0.05	50
Place CDF Grout (4 Days)		
1 Pump Truck Operator	0.05	1.3
2 HPTs	5.0	130
2 Laborers	5.77	150
1 Flagger	0.05	1.3
Remove Cover Soil (30 Days)		
1 Excavator Operator	0.058	11.3
1 Oiler	0.05	9.8
2 HPTs	0.05	9.8
4 Teamsters	0.055	10.7
Remove Tank Domes (12 Days)		
2 Excavator Operators	0.06	4.7
2 Oilers	0.16	12.5
2 HPTs	0.16	12.5
2 Laborers	0.16	12.5
1 Millwright	0.16	12.5
Remove Lateral Soil (220 Days)		
1 Excavator Operator	0.07	100
1 Oiler	0.13	186
2 HPTs	0.13	186
4 Teamsters	0.17	243
Remove Tank Sidewalls (30 Days)		
2 Excavator Operators	0.35	69
1 Front-End Loader Opr.	0.35	69
3 Oilers	0.25	50
2 HPTs	0.25	50
2 Teamsters	0.41	79
4 Laborers	0.25	50
1 Millwright	0.25	50

Unit Process/Crew	Avg. Exposure Rate (mrem/hr)	Individual Dose(mrem/indiv.)
Remove Base Slabs (32 Days)		
2 Excavator Operators	1.80	375
1 Front-End Loader Opr.	1.80	375
3 Oilers	0.25	52
2 HPTs	0.25	52
4 Teamsters	1.58	329
6 Laborers	0.25	52
2 Millwrights	0.25	52

Table 3.5.2. Cumulative Exposure Estimates by Unit Process

Unit Process	Cumulative Doses (mrem)
Construct Enclosure	3,732
Place CDF Grout	563
Remove Cover Soil	84
Remove Tank Domes	97
Remove Lateral Soil	1,630
Remove Tank Sidewalls	865
Remove Base Slabs	3,117

Table 3.6. Cost Breakdown

Cost Component	Cost ⁽¹⁾
Post-Retrieval Monitoring and Maintenance	N/A
Capital	
Building Construction	21,150,000
Soil Removal and Tank Demolition	40,000,000
Disposal of Soil and Debris	18,370,000
Site Remediation - Backfilling	1,810,000
	Total = 81,330,000
Research and Development	N/A
Operating	N/A
Decontamination and Decommissioning	N/A (Note 1)

Note 1: Costs are rounded to the nearest \$10,000. Costs include contingencies averaging 22 percent (itemized in Appendix B). Costs do not include escalation (all costs are in \$1998).

Note 2: Scope of work for this study does not include disposition of enclosure structure. Regrading (backfilling) costs applicable to the earthwork in this study are identified above as capital costs.

AX-Tank Farm Tank Removal Schedule (in Months)

WAS\091698A

Figure 3.7 Schedule

4.0 LEAKAGE ASSESSMENTS

4.1 INTRODUCTION

The SOW for this study directs COGEMA Engineering to evaluate the impacts of two hypothetical leakage cases on tank removal. The two scenarios address the anticipated range of potential losses of sluicing liquids into the soil column during retrieval of tank waste. Sluicing is the current baseline technology for retrieval. The volume for the minimum leakage case is 8,000 gal. This value is traceable to the minimum detection level associated with the current leak detection method, which is mass balance (Hertzel 1997). The volume for the maximum leakage case, 40,000 gal, corresponds to the maximum plausible leak during retrieval from Tank C-106 as determined by Lowe (1993).

There are several important distinctions between the remediation "base case" summarized in Section 3.0 and the leakage scenarios that will be considered here. The extent of vadose zone contamination in the base case is modeled after the inferred actual condition. As summarized in Section 2.0, locations and ^{137}Cs concentrations of existing vadose zone plumes have been defined, and reasonable assessments have been made regarding their vertical and lateral extent and physical interactions. The highest measured ^{137}Cs concentration value in the vadose zone at AX tank farm is about 4 nCi/g. Existing plumes are artifacts of leaks and spills that occurred 20-30 years ago; it is unlikely that significant spreading (plume growth) is still taking place.

The leakage scenarios are hypothetical. Given information for the scenarios is limited to liquid volumes and chemical inventories. The leak location, the volume and geometry of contaminated soil, maximum contaminant concentrations, and the variation of contaminants (particularly ^{137}Cs) in the soil away from the entry point are undefined. For the purpose of exploring these scenarios, inference and assumptions must be applied to fill gaps in problem definition. Based on the large quantities of ^{137}Cs and ^{90}Sr in the best-basis leakage inventory data, it can be expected that peak concentrations in soil from a sluicing leak would be several orders of magnitude higher than the highest measured values from existing contamination. Consideration must also be given to the potential for an extended period of time to pass between the leakage event and remediation. Extensive spreading of the initial plume volume could be expected to occur as a consequence.

4.2 ESTIMATION OF CONTAMINATED SOIL VOLUMES

To develop an estimate of the volumes of soil that would be impacted by releases of 8,000 gal or 40,000 gal, assumptions must be made concerning moisture retention properties of the soil. Soils in the textural classes that include "cobbly sand," "sand," "fine sand," and "loamy sand" exhibit field capacity values ranging from 4.5 to 10.5 percent and wilting point values from about 2.0 to 4.5 percent. Residual (ambient) moisture content in the middle levels of the vadose zone is variable, but through most of the year, it is likely to be in the range of 3.5 percent to 4.5 percent (i.e., in the upper part of the wilting point range). Based on these presumptive material properties, it can be inferred that the excess moisture-holding capacity for the soils in question would be limited to about six volume percent. With these assumptions, the calculated extent of

an 8,000-gal leak would be 17,825 ft³ of soil and the extent of a 40,000-gal leak would be 89,127 ft³ of soil.

A number of hypothetical leakage scenarios for the 241-AX tank farm were investigated by numerical modeling methods by Piepho et al. (1996). Leakage volumes ranging from 4,000 gal to 160,000 gal were considered. The predicted plumes all tended to have geometries that could be idealized as half-ellipsoids with variable aspect ratios, depending on the size of the leak and the time elapsed between leakage and remediation. The model results also indicated that, over periods of tens of years, leakage plumes could undergo significant (i.e., 2X to 3X) vertical spreading as a consequence of deep infiltration of meteoric water (i.e., rainfall, snowmelt). In recognition of these results, supplemental guidance was issued to the study team as follows:

- Assume an aspect ratio of 1.5:1 (V:H) for the 8,000-gal plume.
- Assume an aspect ratio of 2:1 (V:H) for the 40,000-gal plume.
- Double the plume dimensions in X, Y, and Z to account for the effects of spreading and delayed response.

With the original volume estimates described above and the supplemental assumptions, the following descriptions were developed for the two leakage plumes:

- **The 8,000-gal leakage case:** Half ellipsoid with (equal) minor axes of 35.7 ft (in the horizontal plane) and major axis of 53.6 ft (vertical); plume volume is 5,300 yd³.
- **The 40,000-gal leakage case:** Half ellipsoid with (equal) minor axes of 55.4 ft (in the horizontal plane) and major axis of 110.8 ft (vertical); plume volume is 26,400 yd³.

4.3 CONTAMINANT INVENTORY AND ¹³⁷CESIUM AND ⁹⁰STRONTIUM DISTRIBUTIONS IN LEAKAGE PLUMES

Inventory projections for individual tank waste constituents in leakage volumes were developed by COGEMA (1997⁹). The leakage inventories for ⁹⁰Sr and ¹³⁷Cs are reproduced in Table 4.1.

Table 4.1. Total Activities from Various Leakage Volumes and Sources (in Curies)

A_{total}	8,000-Gallon Leak		40,000-Gallon Leak	
	Sr-90	Cs-137	Sr-90	Cs-137
AX-101	4,473	2,364	22,363	11,820
AX-102	11,133	4,731	55,667	23,654
AX-103	95,354	4,161	476,772	20,805
AX-104	130,938	2,716	654,692	13,581

Normally, in soil contaminated with mixed fission products, ^{137}Cs is the principal contributor to direct exposure dose. In this case, ^{90}Sr may also be a significant dose contributor considering the extremely large inventory values involved. Radiation from ^{90}Sr decay has a very short penetration range in soil. Decay of ^{137}Cs produces a strong gamma product that can penetrate two to three ft of soil, depending on the soil density.

Cesium and strontium concentrations in the leakage plumes will be nonuniform. Both constituents sorb onto the soil column. The highest concentrations of sorbed contaminants in soil should occur at the point of entry of liquid into the soil. Concentrations should decrease away from the entry point in all directions where transport (i.e., moisture movement) takes place. For the two leakage cases, it is assumed that the point of entry would occur at the footing level (i.e., at the floor elevation of the pit excavation) on the perimeter of one of the four tanks.

The SOW requests an assessment of worker radiological exposure consequences for the two leakage scenarios. Due to the self-shielding property of soil and the sorption and retention of disproportionate amounts of ^{137}Cs and ^{90}Sr at or near the pit floor level, a method is required for making a reliable estimate of the fraction of the inventories for these constituents that would be retained at depths less than the self-shielding limits. A reliable estimation method is not presently available.

Mathematical models of ^{137}Cs and ^{90}Sr distributions in soil were devised for the purpose of examining potential worker exposure consequences. The models are integral equations in which ^{137}Cs and ^{90}Sr concentrations vary vertically but are invariant in the horizontal plane. The gradient expression was based on the observed variation of ^{137}Cs with depth in Drywell 11-03-02 as reported in DOE/GJO (1997). In the interval zero to 60 ft within this one well, ^{137}Cs concentrations decrease by a factor of 10 per each 20 ft of depth. From the integral equation, an expression was developed describing concentration through a given plume volume as a function of the maximum concentration, C_0 , at the upper surface. Since the total inventories are given, values of C_0 can be calculated from this expression. Additional details of this procedure are provided in Appendix A. The results are reproduced in Table 4.2.

**Table 4.2. Surface Soil ^{137}Cs and ^{90}Sr Concentrations (C_0)
for Leakage Cases (in nCi/g)**

	8,000 Gallon Leak		40,000 Gallon Leak	
	Sr-90	Cs-137	Sr-90	Cs-137
AX-101	2,139	1,130	4,252	2,248
AX-102	5,323	2,262	10,585	4,498
AX-103	45,594	1,990	90,658	3,956
AX-104	62,608	1,299	124,489	2,582

4.4 SCOPING ESTIMATES OF DOSE RATES FROM LEAKAGE PLUMES

Based on the values in Table 4.2, scoping estimates of surface dose rates were developed for the various leakage cases. The results of these calculations are listed in Table 4.3.

**Table 4.3. Estimated Dose Rates 1 meter Above the Center of
Specified Leakage Volumes and Sources (in mrem/hr)**

	8,000 Gallon Leak			40,000 Gallon Leak		
	Sr-90	Cs-137	Total	Sr-90	Cs-137	Total
AX-101	18	656	674	37	1348	1385
AX-102	45	1312	1357	92	2698	2790
AX-103	382	1154	1536	785	2373	3158
AX-104	524	753	1277	1078	1549	2627

Based on the estimates in Table 4.3, the worst-case scenarios involve leakage from Tank AX-103, followed closely by Tank AX-102. The worst-case dose rate from an 8,000-gal leak is about 1.5 rem/hr ; the worst-case dose rate from a 40,000-gal leak is about 3 rem/hr .

4.5 WORKER DOSE CONSEQUENCES FROM LEAKAGE SCENARIOS

Because of limited time and resources, the spatial variation of worker exposures from 8,000-gal and 40,000-gal plume sources could not be evaluated by numerical modeling (MCNP program) as was done to support various aspects of conceptualization of tank removal (see Appendix A). However, because the source term for the 8,000-gal leak is nearly the same as the source term for the one percent residual inventory in Tank AX-101 when the dome is removed, the previous

modeling work can be used to make some inferences about worker dose consequences from leakage.

Figure 4.1 shows 8,000-gal and 40,000-gal plume sources drawn on the floor of the pit excavation at selected locations. At Location A, the plumes are centered on the northwest edge of tank AX-103. At Location B, the plumes are centered on the southeast edge of the same tank. For that particular tank, Location A defines a maximum exterior plume configuration, while Location B is most interior. There are opposite configurations for the other three tanks. From the standpoint of worker doses, Configuration A is least adverse and Configuration B is most adverse. As long as workers are not directly over the plume areas, the aggregate effect of the plume sources at A and B is to raise local background within the pit excavation. ROM estimates are listed in Table 4.4.

**Table 4.4. ROM Estimates of Increases in Local Background
in the Pit Excavation due to Leakage (mrem/hr)**

	Location A	Location B
8,000-gal leakage source from AX-103	10	20
40,000-gal leakage source from AX-103	20	40

The increases in local background do not translate into significant increases in doses to tank removal workers, because all workers inside the pit would be enclosed in heavily shielded cabs with dose reduction factors (DRF) of between 100 and 1,000.

If equipment operators would be required to work directly over a plume source to accomplish base slab removal (i.e., the final tank removal activity), then worker dose estimates would rise sharply. Based on the data listed for tank AX-101 in Table 8 of Appendix A, an excavator operator in a cab with a DRF of 1,000 would get an additional 10 or 20 mrem dose per day. This is about the same as the estimated incremental dose rate from the radiological source in base slab debris.

It should be reiterated that these are ROM estimates that have been produced with virtually no hard information. The dose calculations are sensitive to several different input parameters (e.g., inventories, concentration gradients, C_0 estimates, task durations). Credibility of these estimates is speculative.

**Figure 4.1. Pit Excavation with
Hypothetical Leak Plume Locations**

4.6 CONSTRUCTIBILITY IMPACTS FROM LEAKAGE SCENARIOS

Depending on the size and location of the leakage plume, the pit excavation may have to be enlarged. From the standpoint of constructibility, leakage Location B in Figure 4.1 would produce the least impact. Leakage locations toward the perimeter of the excavation would require some amount of additional excavation. Location A is the most adverse position because it would require the pit to be extended in two directions. Enlargement of the pit in the east-west direction would carry the additional liability of increasing the span of the trusses of the enclosure structure. Estimates of additional soil volumes to be excavated, modifications to the enclosure structure, resource utilization, emissions, manning, and schedule impacts (if any) cannot be made with the leakage location undefined.

The additional radiological source in the pit floor could increase shielding requirements for mobile equipment items working inside the pit. It is likely that additional shielding would have to be placed underneath the cabs of the two excavators and the wheel loader, because these units would have to work directly over the leak source term at certain times during the operation. For base slab removal without the leakage source term, the front and sides of the cabs require the heaviest protection.

If a leakage plume is uncovered during tank removal, additional shielding clearly would be required for the container trucks. The trucks in the equipment spread for the tank removal concept are based on 20-ton container trucks in current use at ERDF. When all shielding requirements are fully accounted for, the suspension ratings of the container trucks working inside the enclosure would have to increase. It is possible that they would have to be reconceptualized as adaptations of off-road haul trucks with suspensions rated for at least 50 tons, such as the Caterpillar 773B.

With increased shielding of mobile equipment items as necessary, and based on the ROM dose assessments discussed in the previous subsection, it appears that tank removal could be performed in the presence of a leakage plume without any other modification to the concept operation described in Section 3.0. However, a modest upward revision in the radiological source term estimates for the leakage scenarios could easily raise annual doses for maximally exposed workers (equipment operators and/or teamsters) beyond the 1,500 mrem/yr study criterion.

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APPENDIX A

DOSE RATE ESTIMATES FOR AX TANK FARM REMEDIATION

Provided by Paul D. Rittman Ph.D. CHP
Flour Daniel Northwest, Inc.
September 1998

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1.0 INTRODUCTION

During the remediation of the 241-AX Tank Farm various potentially high dose rate situations will be encountered. The purpose of this report is to estimate dose rates for those situations. The first concern is the dose rates near the 241-AX Tank Farm while uncovering the tank domes and removing them. The MCNP program (Carter 1996) was used for these calculations since it handles air-scattered radiation accurately. The second concern is operator dose during the tank demolition. The ISO-PC program (Rittmann 1996) was used for these calculations because of the simple arrangements of source and dose point.

The MCNP program requires input files with three main parts. The first is the geometry of the facility. This includes the sizes and shapes and locations and composition of the various objects in the 241-AX Tank Farm. The second part of the input is the location and strength of the radiation sources. The third part of the input is the location of the detector points. Each of these is described separately below.

The ISO-PC calculations are presented for debris removal and shipping container design. Note that the English system of units was used for simplicity and congruence with the engineered drawings for 241-AX Tank Farm.

2.0 MCNP -- GEOMETRY PREPARATION

The position, shape, size, and composition of the various objects in the 241-AX Tank Farm was determined from engineering drawings. It was assumed that all dome penetrations were capped, and concrete structures above the dome were removed. The assumed excavation removes just enough soil above the four tanks to the outer edge of the tanks. The rectangular excavation has sloping walls.

The tops of the domes are assumed to be 6 feet below the surrounding soil surface. The excavation depth which exposes the tank domes completely is assumed to be 13 ft 9 in. The excavation has sloping walls at 1.5 to 1. The base of the excavation is 15 ft from the nearest edge of the tanks on all four sides.

The tank farm dose rates were analyzed for 13 geometries: (1) all four tank domes uncovered, (2) all four tank domes uncovered and one dome is removed (4 cases -- one for each tank), (3) one tank uncovered with four thicknesses of grout over the waste (4 cases -- one for each thickness), and (4) one tank uncovered and its dome removed with four thicknesses of grout over the waste (4 cases -- one for each thickness).

The geometry models were developed in spreadsheets to facilitate unit conversions and other calculations. The spreadsheets took longer to set up initially, but changes to the input were readily accommodated.

The tanks have an inside diameter of 75 ft 1 in., an inside height of 44 ft 6 in., and a concrete dome thickness at the center of 15 in. The outside diameter is 77 ft 7 in. The increase to a

diameter of 79 ft 1 in. at 25 ft above the tank bottom was not modeled, since this location is well below the bottom of the excavation.

Tank domes were modeled as ellipsoids which approximate the dimensions given on drawing H-2-44562. The inner and outer ellipsoid dimensions are given in Table 1 below. The vertical position of the surfaces was arranged to match the drawing dimensions at the center of the tank. The drawing shape and the ellipsoid model are compared in Table 2. The largest difference (3 in.) occurs at 3 ft inside the inner tank wall, where the dome has a vertical thickness of about 39 in. while the ellipsoid model gives a thickness of 36 in.

Table 1. Ellipsoids Which Represent 241-AX Tank Domes

	Semi-Major Axis	Semi-Minor Axis
Upper Surface	56 ft 7 in.	28 ft 3 in.
Lower Surface	37 ft 7 in.	12 ft 7 in.

Table 2. Comparison of Dome Dimensions with MCNP Model

Surface Height Read from Drawing H-2-44562			
Radial Position	Lower Surface	Upper Surface	Thickness
0 ft 0.00 in.	12 ft 0.00 in.	13 ft 3.00 in.	15.000 in.
13 ft 0.00 in.	11 ft 3.38 in.	12 ft 6.50 in.	15.125 in.
26 ft 0.00 in.	8 ft 6.81 in.	10 ft 1.81 in.	19.000 in.
30 ft 6.50 in.	6 ft 7.88 in.	8 ft 8.63 in.	24.750 in.
32 ft 6.50 in.	5 ft 5.78 in.	8 ft 0.38 in.	30.600 in.
34 ft 6.50 in.	4 ft 0.38 in.	7 ft 3.38 in.	39.000 in.
36 ft 6.50 in.	2 ft 1.88 in.	6 ft 5.63 in.	51.750 in.
36 ft 6.75 in.	2 ft 3.75 in.	6 ft 5.63 in.	49.875 in.
37 ft 6.50 in.	0 ft 0.00 in.	6 ft 1.00 in.	73.000 in.
38 ft 9.50 in.	0 ft 0.00 in.	5 ft 6.38 in.	66.375 in.
Surface Height Computed Using Ellipsoid Model			
Radial Position	Lower Surface	Upper Surface	Thickness
0 ft 0.00 in.	12 ft 0.00 in.	13 ft 3.00 in.	15.000 in.
13 ft 0.00 in.	11 ft 2.68 in.	12 ft 5.93 in.	15.253 in.
26 ft 0.00 in.	8 ft 6.04 in.	10 ft 1.09 in.	19.056 in.
30 ft 6.50 in.	6 ft 9.00 in.	8 ft 9.38 in.	24.378 in.
32 ft 6.50 in.	5 ft 8.54 in.	8 ft 1.33 in.	28.783 in.
34 ft 6.50 in.	4 ft 4.51 in.	7 ft 4.50 in.	35.996 in.
36 ft 6.50 in.	2 ft 4.30 in.	6 ft 6.83 in.	50.524 in.
36 ft 6.75 in.	2 ft 3.95 in.	6 ft 6.72 in.	50.768 in.
37 ft 6.50 in.	0 ft 0.11 in.	6 ft 1.64 in.	73.531 in.
38 ft 9.50 in.	0 ft 0.00 in.	5 ft 6.80 in.	66.795 in.
Note: Surface Heights are measured from the Tangent Line at 690.92 ft elevation. Dome thicknesses are measured along a vertical line.			

Sketches of the geometry models are shown in Appendix A. Appendix B gives listings of selected input files. The coordinate system origin for the four tank cases is the center of the tank farm. The coordinate system origin for the single tank cases to evaluate grout shielding effectiveness is the center of the tank. In all cases the vertical position of the origin is an elevation of 680 ft 2 in. above sea level, which is the approximate level of the soil surrounding the 241-AX Tank Farm.

Composition of the air, soil, concrete and waste solids are shown in Table 3. The air composition comes from ANSI/ANS-6.4.3-1991. The soil composition was determined from an average of Hanford surface soils (Brown 1992). The concrete composition is typical of that used at Hanford (Carter 1983).

Table 3. Assumed Composition of Air, Soil, and Concrete

Element	Mass Fractions, percent		
	Air	Soil	Concrete
Hydrogen	0.048	0.62	0.31
Carbon	0.014		
Nitrogen	75.191		
Oxygen	23.464	47.33	44.07
Sodium		1.68	1.82
Magnesium		2.72	3.76
Aluminum		6.86	6.07
Silicon		22.89	21.57
Phosphorus		0.22	0.09
Sulfur			0.09
Argon	1.282		
Potassium		1.07	
Calcium		5.97	13.06
Titanium		1.43	0.49
Manganese		0.15	0.13
Iron		9.06	7.88
Krypton			0.66
Density:	0.0012 g/cc	1.80 g/cc 112 lb/ft ³	2.258 g/cc 141 lb/ft ³
Note: Air is at 80°F with a relative humidity of 80 percent. Soil is assumed to have a volumetric water content of 10 percent.			

Tank waste was modeled as a three inch thick layer on the bottom of the tank. Self-attenuation is minimal. However, tank compositions are needed to give a credible estimate for the amount of bremsstrahlung radiation emitted by the beta rays within the waste.

Composition of the tank waste is based on information given in the documents which summarize the estimated tank contents after retrieval operations are completed. The case where 99 percent

has been removed is used for both the waste composition and the total radionuclide content. Water is assumed to be present to complete the missing weight fractions. The assumed compositions are shown in Table 4.

Table 4. Residual Tank Waste Elemental Composition

Element	Tank AX-101	Tank AX-102	AX-103 & AX-104
Hydrogen	3.811	4.722	4.722
Carbon	3.390	1.731	0.0
Nitrogen	22.079	3.693	0.213
Oxygen	42.709	64.925	62.394
Sodium	15.815	7.560	4.262
Magnesium	0.0	0.0	0.229
Aluminum	2.778	3.093	3.706
Silicon	1.014	2.249	3.875
Phosphorus	1.038	0.147	0.583
Sulfur	0.468	0.209	0.719
Chlorine	0.828	0.075	0.0
Potassium	0.300	0.018	0.0
Calcium	0.162	0.506	1.455
Chromium	0.744	0.015	0.174
Manganese	0.282	0.762	0.256
Iron	1.704	9.060	16.404
Nickel	0.048	0.344	0.850
Krypton	0.102	0.0	0.0
Barium	0.094	0.0	0.158
Lead	0.234	0.0	0.0
Uranium	2.400	0.890	0.0
Note: Values shown are percent by weight for the 99 percent retrieval.			

The hole in the dome (representing dome removal) was modeled using a conical surface. The apex of the cone is 120 ft below the original ground surface. The cone angle is 19.606 degrees. This produces an opening which effectively eliminates the dome.

Concrete represents grout shielding in the tanks, since its composition is similar to that of grout. Since the grout density is not known precisely, the shielding thicknesses are given in terms of areal density (lb/ft²). Lower density grouts will require greater thicknesses to achieve the same attenuation factor.

Additional surfaces were placed inside the domes and the tank wall and base to improve the monte carlo calculation efficiency.

3.0 MCNP -- SOURCE DEFINITION

The actual radiation source was the three inch thick layer on the bottom of the tank, but the radius only extended to three feet from the inner tank wall.

The radionuclide composition of the tank waste is based on information given in the documents which summarize the estimated tank contents after retrieval operations are completed. The case where 99 percent has been removed is used for both the waste composition and the total radionuclide content. The assumed compositions are shown in Table 5. A complete listing of all source input for MCNP is found in Appendix B.

**Table 5. Residual Radionuclide Inventory
(Assumes 99 Percent Retrieved)**

Nuclide	AX-101	AX-102	AX-103	AX-104
Co-60	2.2		61.7	61.7
Sr-90	7238	82340	527850	527850
Y-90	7238	82340	527850	527850
Tc-99	1.7	3.8	2.02	1.83
Sb-125			25.7	25.7
Te-125m			6.30	6.30
Cs-137	1684	11195	10820	10820
Ba-137m	1593	10590	10236	10236
Sm-151	0.05	1480	2250	4000
Eu-154			449	449
Eu-155			351	351

The photon spectra were generated using the ISO-PC program (Rittmann 1996). The input file used to generate these spectra is included in Appendix B. The photon spectra are shown in Table 6. Since the spectra for AX-103 and AX-104 are identical, only one was used in the dose rate calculations.

Since nearly all of the photons which are significant in producing the final dose rate come from the 0.66 MeV group (Cs-137), the first two and the last energy groups were omitted from the calculation. The two low energy groups are quickly attenuated, for example, the 24.6 keV group has a relaxation length in air of about 50 ft. The highest energy group has comparatively few photons.

For the 99.9 percent retrieval case, it happens that the projected residual activities are one-tenth of the 99 percent retrieval case used in the dose rate calculations. Therefore, all of the 99.9 percent dose rates are one-tenth of the 99 percent dose rates.

Table 6. Total Photon Production Rates (99 Percent Retrieval)

Tank AX-101 MeV photon/s		Tank AX-102 MeV photon/s		AX-103/104 MeV photon/s	
0.0143	8.32E+12	0.0143	8.96E+13	0.0142	6.02E+14
0.0246	4.36E+12	0.0246	4.69E+13	0.0246	3.15E+14
0.0336	6.95E+12	0.0338	5.72E+13	0.0344	2.20E+14
0.0447	1.82E+12	0.0447	1.97E+13	0.0447	1.40E+14
0.0548	1.33E+12	0.0548	1.44E+13	0.0548	9.64E+13
0.0649	1.13E+12	0.0649	1.22E+13	0.0649	8.25E+13
0.0749	1.03E+12	0.0749	1.11E+13	0.0749	7.49E+13
0.0849	9.29E+11	0.0849	1.01E+13	0.0850	7.21E+13
0.0949	8.35E+11	0.0949	9.08E+12	0.0949	6.14E+13
0.1379	4.18E+12	0.1380	4.55E+13	0.1374	3.17E+14
0.2433	1.30E+12	0.2433	1.42E+13	0.2434	9.68E+13
0.3450	6.30E+11	0.3450	6.90E+12	0.3450	4.66E+13
0.4663	4.81E+11	0.4663	5.29E+12	0.4659	3.61E+13
0.6615	5.33E+13	0.6614	3.56E+14	0.6606	3.68E+14
0.8179	1.07E+11	0.8179	1.18E+12	0.8303	1.02E+13
0.9869	7.30E+10	0.9870	8.10E+11	0.9939	1.01E+13
1.2437	2.01E+11	1.2039	4.21E+11	1.2514	1.35E+13
1.4499	1.26E+10	1.4500	1.41E+11	1.4989	1.51E+12
1.7412	1.20E+10	1.7415	1.36E+11	1.7411	8.77E+11
1.8695	6.44E+08	1.8695	7.25E+09	1.8694	4.72E+10
2.1681	4.29E+08	2.1682	4.88E+09	2.1680	3.13E+10
2.2000	7.98E+05	2.2000	9.02E+06	2.2000	5.84E+07
Note: These were computed by ISO-PC Version 2.1					

4.0 MCNP -- DETECTOR LOCATIONS

Point detectors were used for the dose rate tallies. These tallies were converted to mrem/h using the flux to dose equivalent factors in ANSI/ANS-6.1.1-1991.

In the four tank cases, the detectors were located on the centers of the domes, midway to the edge, above the inner wall, at the upper edge of the excavation, and at distances of 50 ft and 100 ft from the edge of the excavation. In addition, detectors were placed on perpendicular lines between the tanks. Both north-south and east-west lines were used. In all cases, the detectors were located 3 ft above whatever surface was there, or in the case of missing domes, whatever surface used to be there.

In the single tank cases, dose rate tallies were obtained at the center, midway to the edge, at the inner edge, at the bottom of the excavation, at the top of the excavation, and at distances of 50 ft, 100 ft, 150 ft, 200 ft, 300 ft, and 400 feet from the upper edge of the excavation.

5.0 MCNP -- DOSE RATE RESULTS

At present, the ambient background radiation in the 241-AX Tank Farm is about 0.05 mrem/h. As the soil over the tank domes is removed, this will increase.

Dose rates from MCNP for the 99 percent retrieval case are shown in Tables 7 and 8. Table 7 contains the dose rates from individual tanks at each of the detector locations. The last column shows the total from all four tanks combined. The relative errors reported by MCNP were generally less than 20 percent. Appendix C gives summary tables showing the relative errors reported by MCNP as well as the dose rates shown in Tables 7 and 8.

In Table 7, the first column of numbers gives the dose rates at the various dose points from just the residual activity in Tank AX-101. The dose rate directly over the AX-101 dome is 8.45 mrem/h. The dose rate over the AX-102 dome from the AX-101 source is 0.03 mrem/h. Therefore, dose accumulates during excavation only while the individuals are on top of a dome. The last column of Table 7 gives the dose rates after all four tanks have been uncovered.

Table 8 contains the dose rates after the first dome has been removed. The first column of numbers shows dose rates if the AX-101 dome is removed first. The second column of numbers shows the dose rates if AX-102's dome is removed first. The domes on the other tanks are still in place. Note that the numbers in Table 8 include the dose rates from the residual activity in each tank.

Dose rates from MCNP for 99.9 percent retrieval case are shown in Tables 9 and 10. The values shown on these tables are one-tenth the values shown on Tables 7 and 8, since the source strength has been reduced by a factor of 10.

The effect of grout shielding can be seen in the dose rates shown on Tables 11 and 12. These dose rates use the single tank geometry with the 99 percent retrieval source strengths. Actual MCNP dose rates and relative errors are shown in Appendix C. The main conclusion is that the 70 lb/ft² shield reduces the dose rates by about a factor of 10 at all detector locations. In addition, the 140 lb/ft² reduces dose rates by a factor of 100, and the 210 lb/ft² reduces dose rates by a factor of 1000. Another way of stating this is that every 50 lb/ft² reduces the dose rates by a factor of 5, and every 70 lb/ft² reduces dose rates by a factor of 10. Thus, a factor of 500 can be achieved with 190 lb/ft² of grout spread over the residual waste.

Table 7. Dose Rates (mrem/h) After Excavation -- 99 Percent Retrieval

Detector Location	AX-101	AX-102	AX-103	AX-104	Total
Center of the Dome					
AX-101	8.45	0.19	0.34	0.16	9.13
AX-102	0.03	62.42	0.16	0.33	62.93
AX-103	0.04	0.11	95.83	0.25	96.23
AX-104	0.02	0.23	0.26	99.28	99.79
Midway to Inner Edge					
AX-101 north	6.72	0.14	0.31	0.13	7.29
AX-102 south	0.02	44.24	0.14	0.30	44.70
AX-103 north	0.03	0.09	61.30	0.18	61.60
AX-104 south	0.01	0.20	0.19	69.70	70.11
Inner Edge of the Dome					
AX-101 east	0.10	0.15	0.11	0.09	0.45
AX-102 east	0.02	0.72	0.09	0.11	0.94
AX-103 west	0.01	0.06	1.12	0.18	1.37
AX-104 west	0.01	0.09	0.19	1.54	1.82
North-South Between Tanks					
100 ft N of Excavation	0.01	0.03	0.09	0.04	0.16
50 ft N of Excavation	0.02	0.04	0.13	0.07	0.26
N Edge of Excavation	0.05	0.08	0.45	0.10	0.67
Between AX-101 & AX-103	0.07	0.14	0.65	0.19	1.04
Center Point	0.04	0.29	0.36	0.37	1.06
Between AX-102 & AX-104	0.02	0.46	0.18	0.64	1.30
S Edge of Excavation	0.01	0.33	0.12	0.49	0.95
50 ft S of Excavation	0.01	0.10	0.09	0.14	0.34
100 ft S of Excavation	0.00	0.06	0.04	0.09	0.19
East-West Between Tanks					
100 ft E of Excavation	0.01	0.06	0.04	0.04	0.15
50 ft E of Excavation	0.01	0.10	0.08	0.08	0.28
E Edge of Excavation	0.05	0.30	0.12	0.13	0.59
Between AX-101 & AX-102	0.05	0.39	0.20	0.19	0.84
Between AX-103 & AX-104	0.02	0.16	0.56	0.52	1.27
W Edge of Excavation	0.01	0.09	0.43	0.45	0.98
50 ft W of Excavation	0.01	0.05	0.13	0.13	0.32
100 ft W of Excavation	0.00	0.03	0.09	0.08	0.20
Points Near Excavation					
NE Corner	0.03	0.08	0.10	0.07	0.29
AX-101 east	0.07	0.16	0.12	0.09	0.44
AX-102 east	0.02	0.47	0.12	0.12	0.74
SE Corner	0.01	0.21	0.06	0.10	0.39
NW Corner	0.01	0.04	0.32	0.09	0.47
AX-103 west	0.02	0.07	0.73	0.20	1.02
AX-104 west	0.01	0.09	0.21	0.72	1.03
SW Corner	0.01	0.08	0.09	0.30	0.47

Table 8. Total Dose Rates (mrem/h) with a Tank Dome Removed (99 percent)

Detector Location	AX-101	AX-102	AX-103	AX-104
Center of the Dome				
AX-101	1,944	111	245	124
AX-102	77	13,751	174	295
AX-103	114	159	20,660	274
AX-104	108	248	282	20,661
Midway to Inner Edge				
AX-101 north	1,868	75	215	106
AX-102 south	54	13,300	136	264
AX-103 north	80	109	19,890	207
AX-104 south	77	193	195	19,610
Inner Edge of the Dome				
AX-101 east	1,543	74	93	61
AX-102 east	11	11,140	68	85
AX-103 west	8	36	15,950	131
AX-104 west	7	53	141	16,020
North-South Between Tanks				
100 ft N of Excavation	5	16	60	35
50 ft N of Excavation	8	26	93	45
N Edge of Excavation	25	41	293	70
Between AX-101 & AX-103	68	73	786	134
Center Point	23	165	311	264
Between AX-102 & AX-104	12	476	132	832
S Edge of Excavation	7	173	81	304
50 ft S of Excavation	5	60	54	102
100 ft S of Excavation	2	33	26	68
East-West Between Tanks				
100 ft E of Excavation	5	44	34	30
50 ft E of Excavation	8	64	48	43
E Edge of Excavation	24	182	80	83
Between AX-101 & AX-102	41	290	144	142
Between AX-103 & AX-104	12	86	520	508
W Edge of Excavation	8	46	276	275
50 ft W of Excavation	4	28	93	103
100 ft W of Excavation	3	19	59	57
Points Near Excavation				
NE Corner	17	38	69	44
AX-101 east	35	81	88	65
AX-102 east	12	249	69	93
SE Corner	5	119	39	67
NW Corner	7	28	214	63
AX-103 west	8	38	430	143
AX-104 west	6	48	134	441
SW Corner	4	40	63	193

Table 9. Dose Rates (mrem/h) After Excavation -- 99.9 Percent Retrieval

Detector Location	AX-101	AX-102	AX-103	AX-104	Total
Center of the Dome					
AX-101	0.85	0.02	0.03	0.02	0.91
AX-102	0.00	6.24	0.02	0.03	6.29
AX-103	0.00	0.01	9.58	0.03	9.62
AX-104	0.00	0.02	0.03	9.93	9.98
Midway to Inner Edge					
AX-101 north	0.67	0.01	0.03	0.01	0.73
AX-102 south	0.00	4.42	0.01	0.03	4.47
AX-103 north	0.00	0.01	6.13	0.02	6.16
AX-104 south	0.00	0.02	0.02	6.97	7.01
Inner Edge of the Dome					
AX-101 east	0.01	0.02	0.01	0.01	0.05
AX-102 east	0.00	0.07	0.01	0.01	0.09
AX-103 west	0.00	0.01	0.11	0.02	0.14
AX-104 west	0.00	0.01	0.02	0.15	0.18
North-South Between Tanks					
100 ft N of Excavation	0.00	0.00	0.01	0.00	0.02
50 ft N of Excavation	0.00	0.00	0.01	0.01	0.03
N Edge of Excavation	0.00	0.01	0.04	0.01	0.07
Between AX-101 & AX-103	0.01	0.01	0.07	0.02	0.10
Center Point	0.00	0.03	0.04	0.04	0.11
Between AX-102 & AX-104	0.00	0.05	0.02	0.06	0.13
S Edge of Excavation	0.00	0.03	0.01	0.05	0.09
50 ft S of Excavation	0.00	0.01	0.01	0.01	0.03
100 ft S of Excavation	0.00	0.01	0.00	0.01	0.02
East-West Between Tanks					
100 ft E of Excavation	0.00	0.01	0.00	0.00	0.02
50 ft E of Excavation	0.00	0.01	0.01	0.01	0.03
E Edge of Excavation	0.00	0.03	0.01	0.01	0.06
Between AX-101 & AX-102	0.01	0.04	0.02	0.02	0.08
Between AX-103 & AX-104	0.00	0.02	0.06	0.05	0.13
W Edge of Excavation	0.00	0.01	0.04	0.04	0.10
50 ft W of Excavation	0.00	0.01	0.01	0.01	0.03
100 ft W of Excavation	0.00	0.00	0.01	0.01	0.02
Points Near Excavation					
NE Corner	0.00	0.01	0.01	0.01	0.03
AX-101 east	0.01	0.02	0.01	0.01	0.04
AX-102 east	0.00	0.05	0.01	0.01	0.07
SE Corner	0.00	0.02	0.01	0.01	0.04
NW Corner	0.00	0.00	0.03	0.01	0.05
AX-103 west	0.00	0.01	0.07	0.02	0.10
AX-104 west	0.00	0.01	0.02	0.07	0.10
SW Corner	0.00	0.01	0.01	0.03	0.05

Table 10. Total Dose Rates (mrem/h) with a Tank Dome Removed (99.9 Percent)

Detector Location	AX-101	AX-102	AX-103	AX-104
Center of the Dome				
AX-101	194	11.1	24.5	12.4
AX-102	7.7	1375	17.4	29.5
AX-103	11.4	15.9	2066	27.4
AX-104	10.8	24.8	28.2	2066
Midway to Inner Edge				
AX-101 north	187	7.5	21.5	10.6
AX-102 south	5.4	1330	13.6	26.4
AX-103 north	8.0	10.9	1989	20.7
AX-104 south	7.7	19.3	19.5	1961
Inner Edge of the Dome				
AX-101 east	154	7.4	9.3	6.1
AX-102 east	1.1	1114	6.8	8.5
AX-103 west	0.8	3.6	1595	13.1
AX-104 west	0.7	5.3	14.1	1602
North-South Between Tanks				
100 ft N of Excavation	0.5	1.6	6.0	3.5
50 ft N of Excavation	0.8	2.6	9.3	4.5
N Edge of Excavation	2.5	4.1	29.3	7.0
Between AX-101 & AX-103	6.8	7.3	78.6	13.4
Center Point	2.3	16.5	31.1	26.4
Between AX-102 & AX-104	1.2	47.6	13.2	83.2
S Edge of Excavation	0.7	17.3	8.1	30.4
50 ft S of Excavation	0.5	6.0	5.4	10.2
100 ft S of Excavation	0.2	3.3	2.6	6.8
East-West Between Tanks				
100 ft E of Excavation	0.5	4.4	3.4	3.0
50 ft E of Excavation	0.8	6.4	4.8	4.3
E Edge of Excavation	2.4	18.2	8.0	8.3
Between AX-101 & AX-102	4.1	29.0	14.4	14.2
Between AX-103 & AX-104	1.2	8.6	52.0	50.8
W Edge of Excavation	0.8	4.6	27.6	27.5
50 ft W of Excavation	0.4	2.8	9.3	10.3
100 ft W of Excavation	0.3	1.9	5.9	5.7
Points Near Excavation				
NE Corner	1.7	3.8	6.9	4.4
AX-101 east	3.5	8.1	8.8	6.5
AX-102 east	1.2	24.9	6.9	9.3
SE Corner	0.5	11.9	3.9	6.7
NW Corner	0.7	2.8	21.4	6.3
AX-103 west	0.8	3.8	43.0	14.3
AX-104 west	0.6	4.8	13.4	44.1
SW Corner	0.4	4.0	6.3	19.3

Table 11. Single Tank Dose Rates (mrem/h) After Excavation

Detector Location	No Shield	70 lb/ft ²	141 lb/ft ²	211 lb/ft ²
AX-101 Source				
3 ft Below Dome	2.9E+03	3.7E+02	3.6E+01	3.2E+00
Center of Tank	8.7E+00	9.5E-01	1.1E-01	6.1E-03
Midway to Edge	6.8E+00	6.7E-01	6.0E-02	5.7E-03
Inner Edge of Tank	1.1E-01	1.1E-02	8.7E-04	9.7E-05
Bottom Edge of Excavation	5.8E-02	5.7E-03	5.7E-04	4.9E-05
Upper Edge of Excavation	7.2E-02	7.6E-03	6.4E-04	5.7E-05
50 ft from Excavation	1.7E-02	1.8E-03	1.6E-04	1.3E-05
100 ft from Excavation	1.0E-02	9.5E-04	1.2E-04	8.8E-06
150 ft from Excavation	6.4E-03	6.5E-04	6.1E-05	5.9E-06
200 ft from Excavation	4.7E-03	4.3E-04	4.2E-05	4.2E-06
300 ft from Excavation	2.5E-03	2.0E-04	2.2E-05	1.6E-06
400 ft from Excavation	1.5E-03	1.3E-04	2.6E-05	9.8E-07
AX-102 Source				
3 ft Below Dome	2.1E+04	2.6E+03	2.4E+02	2.2E+01
Center of Tank	5.8E+01	5.5E+00	6.8E-01	6.1E-02
Midway to Edge	4.3E+01	4.6E+00	5.0E-01	2.8E-02
Inner Edge of Tank	7.1E-01	6.7E-02	5.5E-03	4.9E-04
Bottom Edge of Excavation	3.9E-01	3.7E-02	3.4E-03	2.7E-04
Upper Edge of Excavation	4.9E-01	5.1E-02	4.1E-03	3.8E-04
50 ft from Excavation	1.2E-01	1.2E-02	1.0E-03	9.0E-05
100 ft from Excavation	7.6E-02	6.4E-03	5.5E-04	5.9E-05
150 ft from Excavation	4.4E-02	4.1E-03	4.9E-04	3.7E-05
200 ft from Excavation	3.1E-02	2.8E-03	2.3E-04	2.5E-05
300 ft from Excavation	1.6E-02	1.5E-03	1.7E-04	2.3E-05
400 ft from Excavation	9.2E-03	8.8E-04	7.3E-05	8.1E-06
AX-103/104 Source				
3 ft Below Dome	3.1E+04	3.3E+03	3.3E+02	3.4E+01
Center of Tank	8.3E+01	1.1E+01	1.7E+00	2.0E-01
Midway to Edge	6.3E+01	6.4E+00	9.9E-01	1.0E-01
Inner Edge of Tank	1.1E+00	9.2E-02	1.3E-02	1.5E-03
Bottom Edge of Excavation	5.2E-01	5.1E-02	6.8E-03	7.8E-04
Upper Edge of Excavation	7.3E-01	8.3E-02	9.8E-03	1.1E-03
50 ft from Excavation	1.5E-01	1.5E-02	2.1E-03	2.3E-04
100 ft from Excavation	9.6E-02	1.4E-02	1.3E-03	1.2E-04
150 ft from Excavation	6.8E-02	6.8E-03	7.4E-04	8.2E-05
200 ft from Excavation	4.2E-02	4.1E-03	4.5E-04	5.1E-05
300 ft from Excavation	2.3E-02	2.8E-03	2.2E-04	5.4E-05
400 ft from Excavation	1.2E-02	1.2E-03	1.3E-04	2.0E-05
Note: Source strength based on 99 percent retrieval. The 99.9 percent retrieval would reduce all dose rates by a factor of 10.				

Table 12. Single Tank Dose Rates (mrem/h) With Dome Removed

Detector Location	No Shield	70 lb/ft ²	141 lb/ft ²	211 lb/ft ²
AX-101 Source				
3 ft Below Dome	2.5E+03	3.1E+02	3.0E+01	2.8E+00
Center of Tank	1.9E+03	2.6E+02	2.5E+01	2.3E+00
Midway to Edge	1.9E+03	2.4E+02	2.3E+01	2.1E+00
Inner Edge of Tank	1.5E+03	1.6E+02	1.4E+01	1.2E+00
Bottom Edge of Excavation	3.6E+01	4.2E+00	4.6E-01	3.8E-02
Upper Edge of Excavation	3.6E+01	4.0E+00	3.9E-01	3.4E-02
50 ft from Excavation	8.7E+00	1.1E+00	1.3E-01	9.6E-03
100 ft from Excavation	5.1E+00	6.2E-01	7.5E-02	5.6E-03
150 ft from Excavation	3.2E+00	4.2E-01	4.4E-02	3.8E-03
200 ft from Excavation	2.5E+00	3.1E-01	2.7E-02	3.2E-03
300 ft from Excavation	1.3E+00	1.4E-01	1.4E-02	1.4E-03
400 ft from Excavation	8.0E-01	9.8E-02	8.4E-03	7.6E-04
AX-102 Source				
3 ft Below Dome	1.8E+04	2.2E+03	2.0E+02	1.8E+01
Center of Tank	1.4E+04	1.8E+03	1.7E+02	1.5E+01
Midway to Edge	1.3E+04	1.6E+03	1.5E+02	1.4E+01
Inner Edge of Tank	1.1E+04	1.1E+03	9.5E+01	8.2E+00
Bottom Edge of Excavation	2.8E+02	3.0E+01	2.9E+00	2.5E-01
Upper Edge of Excavation	2.7E+02	2.7E+01	2.5E+00	2.2E-01
50 ft from Excavation	6.8E+01	7.3E+00	6.9E-01	6.5E-02
100 ft from Excavation	4.2E+01	4.4E+00	4.6E-01	4.0E-02
150 ft from Excavation	2.4E+01	2.8E+00	2.8E-01	2.3E-02
200 ft from Excavation	1.7E+01	2.1E+00	1.8E-01	1.7E-02
300 ft from Excavation	1.0E+01	1.0E+00	9.9E-02	8.6E-03
400 ft from Excavation	5.0E+00	5.9E-01	5.6E-02	4.8E-03
AX-103/104 Source				
3 ft Below Dome	2.7E+04	2.8E+03	2.8E+02	2.9E+01
Center of Tank	2.1E+04	2.3E+03	2.4E+02	2.5E+01
Midway to Edge	2.0E+04	2.1E+03	2.1E+02	2.2E+01
Inner Edge of Tank	1.6E+04	1.4E+03	1.3E+02	1.3E+01
Bottom Edge of Excavation	4.6E+02	3.7E+01	3.5E+00	3.7E-01
Upper Edge of Excavation	4.5E+02	3.5E+01	3.2E+00	3.2E-01
50 ft from Excavation	1.2E+02	1.2E+01	9.2E-01	8.6E-02
100 ft from Excavation	6.9E+01	5.3E+00	6.0E-01	5.0E-02
150 ft from Excavation	3.9E+01	3.4E+00	3.4E-01	3.4E-02
200 ft from Excavation	2.6E+01	2.6E+00	2.5E-01	2.9E-02
300 ft from Excavation	1.4E+01	1.4E+00	1.3E-01	1.3E-02
400 ft from Excavation	7.3E+00	7.1E-01	6.3E-02	7.2E-03
Note: Source strength based on 99 percent retrieval. The 99.9 percent retrieval would reduce all dose rates by a factor of 10.				

6.0 ISO-PC -- DEBRIS EXCAVATION

It is assumed that the tank dome can be removed with the waste well shielded by a layer of grout. The debris from demolition of the tank dome and walls adds to this shielding. However, when the debris is lifted into waste containers for shipment to its final resting location, some of the activity is again uncovered. This is particularly true during sectioning of the sheet steel on the floor of the tank. Most of the activity is assumed to adhere to this steel.

The ISO-PC model assumes that 4 m² of tank floor are exposed at a time. This was represented as a circular area 7' 5" (225.68 cm) in diameter. The source strength was the full tank inventory multiplied by 0.00115, which is 4 m² divided by the total source area, 347 m².

The source thickness was assumed to be 3 in. (7.62 cm). Since the steel liner on the bottom of the tank is being lifted, it was assumed to be a shield between the residual activity and the operator. The thickness of this steel is 3/8 in. (0.953 cm).

The source composition in ISO-PC approximates that shown on Table 4. Some of the elements are not available in the ISO-PC shield material library. Since the source region is only 3 in. thick, and composed of moderate density, low atomic number material, the assumptions made about its composition have little effect on the final dose rates.

Input files for the ISO-PC software are listed in Appendix D.

Computed dose rates for the 4 m² source are shown in Table 13. These are based on the 99 percent retrieval assumption. The excavator operator will be positioned about 15 ft from the waste when handling the nearest sections. This distance will increase to at most 50 ft or 60 ft, based on the length of the shovel arm.

Since the dose rates are greater than 100 mrem/h, various thicknesses of iron were also applied to the source, representing shielding on the outside of the excavator. The shielded dose rates are also shown on Table 13. About 2 in. of iron will reduce the dose rates by a factor of 10. Thus, 4 in. of iron is needed to obtain moderate dose rates at distances of 15 ft to 20 ft, where the operator is located during some of the removal excavation.

For the 99.9 percent retrieval case, the source is 10 times smaller. Thus the dose rates are 10 times smaller, and the iron thickness can be reduced by 2 inches.

Table 13. Dose Rates (mrem/h) During Debris Removal

Distance	AX-101	AX-102	AX-103/104
No Shield			
10	6.1E+02	4.2E+03	6.1E+03
15	2.8E+02	2.0E+03	2.8E+03
20	1.6E+02	1.1E+03	1.6E+03
25	1.0E+02	7.2E+02	1.0E+03
30	7.2E+01	5.0E+02	7.2E+02
35	5.3E+01	3.7E+02	5.3E+02
40	4.0E+01	2.8E+02	4.0E+02
50	2.6E+01	1.8E+02	2.5E+02
70	1.3E+01	8.9E+01	1.3E+02
100	6.1E+00	4.2E+01	6.0E+01
1" Iron			
10	1.7E+02	1.2E+03	1.5E+03
15	8.1E+01	5.5E+02	7.0E+02
20	4.6E+01	3.1E+02	4.0E+02
25	3.0E+01	2.0E+02	2.6E+02
30	2.0E+01	1.4E+02	1.8E+02
35	1.5E+01	1.0E+02	1.3E+02
40	1.1E+01	7.7E+01	9.8E+01
50	7.2E+00	4.9E+01	6.2E+01
70	3.5E+00	2.4E+01	3.0E+01
100	1.6E+00	1.1E+01	1.4E+01
2" Iron			
10	5.8E+01	3.9E+02	5.0E+02
15	2.8E+01	1.9E+02	2.4E+02
20	1.6E+01	1.1E+02	1.4E+02
25	1.0E+01	6.9E+01	8.9E+01
30	7.1E+00	4.8E+01	6.2E+01
35	5.2E+00	3.5E+01	4.5E+01
40	3.9E+00	2.7E+01	3.4E+01
50	2.5E+00	1.7E+01	2.2E+01
70	1.2E+00	8.2E+00	1.1E+01
100	5.6E-01	3.8E+00	4.9E+00
4" Iron			
10	5.2E+00	3.5E+01	5.1E+01
15	2.6E+00	1.8E+01	2.5E+01
20	1.5E+00	1.0E+01	1.5E+01
25	9.9E-01	6.7E+00	9.6E+00
30	6.9E-01	4.6E+00	6.7E+00
35	5.0E-01	3.4E+00	4.9E+00
40	3.8E-01	2.6E+00	3.7E+00
50	2.4E-01	1.6E+00	2.3E+00
70	1.2E-01	7.9E-01	1.1E+00
100	5.4E-02	3.6E-01	5.3E-01
Note: All distances are in feet. 99 percent waste retrieval has been assumed.			

7.0 ISO-PC -- SHIPPING CONTAINER DESIGN

After demolition of the dome and walls of the tank, the rubble will have a density of about 102 lbs/ft³. The average Cs-137 activity concentration in this rubble for Tanks AX-103 and AX-104 is about 0.5 curies per cubic foot. These features of the rubble were used to determine the dose rates near various iron-walled boxes representing shipping containers. Additional constraints on the box was a gross weight of 38,000 lbs, and relative dimensions for the height, width, and length of 1 to 1.2 to 4.

Table 14. Comparison of Shipping Boxes

Wall	2 inch	3 inch	4 inch	Units
Dimensions				
Height	3.44	3.13	2.87	feet
Width	4.13	3.76	3.44	feet
Length	13.76	12.52	11.48	feet
Volume	195	147	113	cu.ft
Weights				
Rubble	19,930	15,010	11,570	lb
Iron	17,930	22,810	26,330	lb
Total	37,860	37,820	37,900	lb
Dose Rates				
at 2 inches	235	55	13	mR/h
at 1 meter	141	33	8.5	mR/h
1t 10 meters	5.5	1.4	0.37	mR/h
Note: Rubble density is 102 lb/ft ³ , iron is 490 lb/ft ³ . Cs-137 concentration is 0.5 Ci/ft ³ .				

Due to the size of the container, the 200 mR/h dose rate limit on the outside of the container is not limiting. Rather, the dose rate at 1 meter from the side of the container is. In order to lower dose rates below the limit of 10 mR/h, the box will need to have 4 in. thick walls.

Dose rates were computed using the ISO-PC software. The input file is listed in Appendix D for reference.

8.0 DOSE RATE ESTIMATES FOR THE POSTULATED 241-AX TANK LEAKS

After removal of the tank floor, any contaminated soil would also need to be excavated and disposed of. This section calculates estimates for worker dose rates during excavation. Two leakage assumptions were evaluated: 30,283 L (8,000 gal) and 151,413 L (40,000 gal).

The volume of soil contaminated is assumed to have a semi-ellipsoid shape, where the flat surface is at the soil-air interface. The major axis of the ellipsoid is assumed to be vertical, and roughly 1.5 times the minor axis for the 8,000 gal leak. For the 40,000 gal leak the major axis is assumed to be twice the minor axis. This reflects the greater vertical movement of the larger leak.

Actual soil volumes contaminated were estimated by assuming the soil moisture would have increased about 0.75 percent. This increase is assumed to be the case after a significant period of time from when the leak occurred. The dimensions of the contaminated soil are shown in the table below.

Dimensions of the Contaminated Soil		
	8,000 gallon leak	40,000 gallon leak
Leak Volume	30,283 L (1,069 ft ³)	151,416 L (5,347 ft ³)
Soil Volume	4,038 m ³ (142,593 ft ³)	20,189 m ³ (712,963 ft ³)
Semi-Minor Axis (surface radius)	10.87 m (35.7 ft)	16.89 m (55.4 ft)
Semi-Major Axis (soil depth)	16.31 m (53.5 ft)	33.78 m (110.8 ft)
<p>Note: The leaked solution is assumed to increase the soil moisture by 0.75 percent. The contaminated soil volume is computed as follows:</p> $V_{\text{soil}} = V_{\text{leak}} / 0.0075 = 2\pi/3 \text{ La}^2 \text{ Lb}$ <p>where, V_{soil} = Leak Volume V_{leak} = Soil Volume La = semi-minor axis (radius at the surface) Lb = semi-major axis (greatest depth of contamination)</p>		

The two main radionuclides in the soil, Cs-137 and Sr-90, are both adsorbed onto soil particles. Thus the radionuclide concentration will not be uniform throughout the contaminated soil volume. From well data presented in the "AX Tank Farm Preliminary Report" (GJO-97-7-TAR/GJO-HAN-10, April 1997), the Cs-137 concentration decreases a factor of 10 in about 20 ft. (See Appendix A, graph 11-03-02.) It was assumed for simplicity that the exponential decrease in soil concentration only applies to the vertical dimension. Horizontally the soil concentration does not change. The equation below shows the spatial dependence of the nuclide concentration inside the contaminated soil volume.

$$C = C_0 \text{Exp}(-a Z)$$

where,

C = soil concentration at some location inside the semi-ellipsoid,

C₀ = soil concentration at the center of the full ellipsoid, i.e., at the soil-air interface

a = exponential slope, assumed to be 0.3777 per m (0.1151 per ft).

Z = depth below the surface (increases downward)

The initial soil concentration can be found by requiring that the volume integral of the concentration in the semi-ellipsoid equal the total activity leaked. The formula for this integral is shown below.

$$A_{\text{total}} = \frac{2 \pi L_a^2 C_0 \rho}{a} \left[\frac{1}{2} - \frac{1}{(a L_b)^2} + \frac{\text{Exp}(-a L_b)}{a L_b} \left(1 + \frac{1}{a L_b} \right) \right]$$

The density term (ρ) is the soil density, which is assumed to be 2.24 g/cc (140 lb/ft³). This high value represents the compacted nature of the soil under the tanks. Notice that the only unknown variable in this equation is the surface soil concentration (C_0). The total activity postulated to leak has been estimated by others and sent to me via electronic mail. The totals assumed in these calculations are shown in the table below.

Total Activity (Curies) from Postulated Leaks (99% Retrieval)				
A_{total}	8,000 Gallon Leak		40,000 Gallon Leak	
	Sr-90	Cs-137	Sr-90	Cs-137
AX-101	4,473	2,364	22,363	11,820
AX-102	11,133	4,731	55,667	23,654
AX-103	95,354	4,161	476,772	20,805
AX-104	130,938	2,716	654,692	13,581
Note: All values have been aged to 12/31/99. Y-90 and Ba-137m are not shown on the table, but are present in equilibrium amounts. The dose calculations include these equilibrium amounts.				

The concentration to total conversion factor (what is multiplied by C_0 in the above equation) turns out to be 2.091 Ci per nCi/g for the 8,000 gal leak and 5.259 Ci per nCi/g for the 40,000 gal leak. Thus the surface soil concentrations can be calculated by dividing the total activity discharged by the conversion factor. These concentrations are listed in the table below.

Surface Soil Concentrations (nCi/g) from Postulated Leaks				
	8,000 Gallon Leak		40,000 Gallon Leak	
	Sr-90	Cs-137	Sr-90	Cs-137
AX-101	2,139	1,130	4,252	2,248
AX-102	5,323	2,262	10,585	4,498
AX-103	45,594	1,990	90,658	3,956
AX-104	62,608	1,299	124,489	2,582

To examine the variation of activity with depth, the integral can be solved in more detail. The activity in the layer between Z_a and Z_b is shown below.

$$A_{\text{layer}} = \frac{\pi L_a^2 C_0 \rho}{(a L_b)^2} \left[F(Z_a) - F(Z_b) \right]$$

$$F(Z) = \text{Exp}(-aZ) \left[a(L_b^2 - Z^2) - 2 \left(\frac{1}{a} + Z \right) \right]$$

The volume of soil in this same layer is shown below:

$$C_{\text{layer}}^{\text{ave}} = \frac{3 C_0 \left[F(Z_b) - F(Z_a) \right]}{a^2 (Z_b - Z_a) \left[3 L_b^2 - (Z_a^2 + Z_a Z_b + Z_b^2) \right]}$$

Thus the average concentration in a layer is given by:

$$V_{\text{layer}} = \pi L_a^2 (Z_b - Z_a) \left[1 - \left(\frac{Z_a^2 + Z_a Z_b}{3 L_b^2} \right) \right]$$

The table below shows the average relative concentrations for both leak volumes. The averaging takes place over a 3 in. layer just below the depth shown in the first column. It is assumed that the surface concentration is 1.0 for this table.

Relative Soil Concentrations in Various 3 inch Layers	
Top of Layer, ft	Relative Concentration
0.00	0.9857
0.25	0.9578
0.50	0.9306
0.75	0.9042
1.00	0.8785
1.25	0.8536
1.50	0.8294
1.75	0.8059
Note: Averages concentrations are shown. The relative concentrations are the same for both leak volumes due to the thin layers which are near the surface.	

The ISO-PC program (Rittman 1995) was used to calculate dose rates from the soil layers with a concentration at the surface of 1 nCi/g. The soil density is 2.24 g/cc. It was represented as Hanford soil in ISO-PC. The end-of-cylinder geometry was used. The cylinder radius is the semi-minor axis length. Dose rates were computed at a height of 1 m above the center of the cylinder. The input file for this case is shown in the first attachment. Dose results are shown in the table below. The fractional contribution to the dose rate from each layer is also shown. The high soil density means that contamination below a depth of 2 ft contributes negligibly to the total dose rate.

Comparison of Dose Rates from Various Depths				
Depth of Top of Layer (ft)	ISO-PC Results, mrem/h		Fraction from Each Layer	
	Sr-90	Cs-137	Sr-90	Cs-137
0.00	7.19E-03	4.52E-01	84.60	77.12
0.25	1.02E-03	9.81E-02	11.95	16.72
0.50	2.17E-04	2.61E-02	2.55	4.44
0.75	5.42E-05	7.22E-03	0.64	1.23
1.00	1.51E-05	2.04E-03	0.18	0.35
1.25	4.56E-06	5.81E-04	0.05	0.10
1.50	1.47E-06	1.67E-04	0.02	0.03
1.75	4.97E-07	4.81E-05	0.01	0.01
Note: ISO-PC results assume the anterior-posterior exposure, since the produces the largest dose rate. Fractional contributions are in percent. In all cases, the dose point is 1 m above the surface of the soil.				

The dose rate from Sr-90 comes from the bremsstrahlung X-rays which are produced as the high energy beta particles slow down in the soil.

To compare the dose rates from the four tanks in 241-AX, the contamination was assumed to be at the surface value (Co) down to a depth of 2 ft. Various leak radii were used. The soil concentration was assumed to be 1 nCi/g in all cases. The ISO-PC input file is shown in the second attachment.

ISO-PC Dose Rates (mrem/h) for Unit Soil Concentrations		
Source Radius, ft	Sr-90	Cs-137
2.56	1.81E-03	0.122
3.97	3.21E-03	0.219
6.16	4.81E-03	0.330
9.55	6.21E-03	0.428
14.8	7.23E-03	0.500
23.0	7.93E-03	0.549
35.7 (8,000 gal)	8.37E-03	0.580
55.4 (40,000 gal)	8.66E-03	0.600
86.0	8.84E-03	0.613
133	8.95E-03	0.620
207	9.01E-03	0.625
321	9.05E-03	0.628
499	9.07E-03	0.630
Note: In all cases the soil concentration was 1 nCi/g, and the dose point was 1 m above the center of the circular area.		

Using the surface soil concentrations shown on the third table, the dose rates can be computed. The total dose rate is the sum of the products of the soil concentrations and the unit dose rate factors for Sr-90 and Cs-137. Results are shown in the table below.

Dose Rates (mrem/h) from Postulated Leaks at 1 m Above the Center						
	8,000 Gallon Leak			40,000 Gallon Leak		
	Sr-90	Cs-137	Total	Sr-90	Cs-137	Total
AX-101	18	656	674	37	1348	1385
AX-102	45	1312	1357	92	2698	2790
AX-103	382	1154	1536	785	2373	3158
AX-104	524	753	1277	1078	1549	2627

The worst-case tank is AX-103, followed closely by AX-102.

One final question is the dose rate at the edge of the circle, rather than directly above the center. ISO-PC cannot compute dose rates at this location. However, since the contamination circles are rather large the effect of going to the edge can be approximated by using the rectangular box geometry, for which an edge calculation can be made. The box geometry always calculates dose rates at the center of the box. The edge dose rate can be computed by doubling the other edge dimension and halving the concentration. The dose rate at the center of the doubled box is the same as the dose rate at the edge of the original box. To represent the two leak cases, the square areas must be 19.27 m (63.2 ft) and 29.94 m (98.2 ft) across.

The dose rates for Sr-90 and Cs-137 for both leak sizes are shown in the table below. The ISO-PC input file is included as the third attachment. The ratio of edge dose rates to center dose rates is 0.51 in all cases. For the circular area the ratio should be slightly less due to the variable gap between adjacent circles with no activity.

Dose Rates (mrem/h) and Ratios for Square Area Sources at 1 m Above the Square			
Leak Size	Dose Point	Sr-90	Cs-137
8,000 gallon	Center	8.34E-03	0.578
	Edge	4.26E-03	0.295
	Ratio	0.51	0.51
40,000 gallon	Center	8.61E-03	0.598
	Edge	4.37E-03	0.303
	Ratio	0.51	0.51
<p>Note: The surface area of the squares matches the surface area of the circles used before.</p> <p>Note: Source concentrations for the "Center" cases is 1.0 nCi/g. Dose rates for the "Edge" cases were computed by doubling SLTH and halving the source concentration, since this is geometrically equivalent to a dose rate at the center of one edge.</p>			

Using the factor of 0.51 to estimate dose rates at the edge of the circular areas gives the table shown below.

Dose Rates (mrem/h) from Postulated Leaks at 1 m Above the Ground Surface				
	8,000 Gallon Leak		40,000 Gallon Leak	
	Edge	Center	Edge	Center
AX-101	344	674	706	1385
AX-102	692	1357	1423	2790
AX-103	783	1536	1611	3158
AX-104	651	1277	1340	2627
<p>Note: Dose rates at the edge of the circular area were computed as 0.51 times the dose rate at the center.</p>				

The dose rates near the postulated leaks are large enough that special methods will be needed to remove the contaminated soil.

9.0 REFERENCES

- American National Standard for Neutron and Gamma-Ray Fluence-to-Dose Factors, ANSI/ANS-6.1.1-1991, American Nuclear Society, 1991.
- American National Standard for Gamma-Ray Attenuation Coefficients and Buildup Factors for Engineering Materials, ANSI/ANS-6.4.3-1991, American Nuclear Society, August, 1991.
- Brown, R. C., *Soil Density and Mass Attenuation Coefficients for Use in Shielding Calculations at the Hanford Waste Vitrification Plant*, WHC-SD-HWV-TI-020, Rev 0, January 1992, Westinghouse Hanford Company, Richland, Washington.
- Carter, L. L., "Bulk Shield Design for Neutron Energies Below 50 MeV", *Nuclear Technology/Fusion*, Vol. 3, pp 165-180, March 1983.
- Carter, L. L., *Certification of MCNP Version 4A for WHC Computer Platforms*, WHC-SD-MP-SWD-30001, Rev. 8, May 1996, Westinghouse Hanford Company, Richland, Washington.
- Rittmann, P. D., *ISO-PC Version 1.98 - User's Guide*, WHC-SD-WM-UM-030, Rev 0, May 1995, and *Summary of Changes to ISO-PC Version 2.1*, February 1996, Westinghouse Hanford Company, Richland, Washington. (Available from the Radiation Safety Information Computer Center as CCC-636)
- Van Riper, K. A., *SABRINA User's Guide*, LA-UR-93-3696, October 1993, Los Alamos National Laboratory, Los Alamos, New Mexico.

ATTACHMENT 1

SKETCHES OF THE MCNP GEOMETRY MODEL

Figure 1. Four Tank Case -- Domes Intact, East-West Plane Through Tanks 103 and 101

Center at (0 cm, 1554 cm, 0 cm) Full Width = 4000 cm

Note: Layer above tanks is air. Soil surrounds tanks.

Figure 2. Four Tank Case -- Domes Intact, East-West Plane Through Tank 101

Center at (1372 cm, 1554 cm, -600 cm) Full Width = 2600 cm

Note: Extra surfaces in the tank dome and walls are needed to improve the monte carlo calculation efficiency.

Figure 3. Four Tank Case -- Domes Intact, East-West Plane Through Tanks 103 and 101

Center at (0 cm, 1554 cm, -512 cm) Full Width = 600 cm

Note: Extra surfaces in the tank dome and walls are needed to improve the monte carlo calculation efficiency. Numbers show the relative importance of the region. Tank walls and dome are made of concrete. Soil lies between the tanks. Air (importance 7338 and 19) lies above and inside the tanks.

Figure 4. Four Tank Case -- Tank Wall/Base Corner, East-West Plane Through Tank 101

Center at (215 cm, 1554 cm, -1575 cm) Full Width = 80 cm

Note: Extra surfaces in the tank dome and walls are needed to improve the monte carlo calculation efficiency. Numbers show the material ID: 1=air, 2=soil, 3=concrete, 4=iron, 5=waste in AX-101.

Figure 5. Four Tank Case -- Tank Wall/Base Corner, East-West Plane Through Tank 101

Center at (215 cm, 1554 cm, -1575 cm) Full Width = 80 cm

Note: Extra surfaces in the tank dome and walls are needed to improve the monte carlo calculation efficiency. Numbers show the relative importance of the regions.

**Figure 6. Four Tank Case -- Dome Removed from AX-101, Plane
Through Tanks 103 & 101**

Center at (0 cm, 1554 cm, -512 cm) Full Width = 600 cm

Note: Extra surfaces in the tank dome and walls are needed to improve the monte carlo calculation efficiency. Numbers show the relative importance of the regions.

Figure 7. SABRINA 3-D Sketch of the Four Tank Case with AX-101 Dome Removed

ATTACHMENT 2

LISTING OF SELECTED MCNP INPUT FILES

Table 15. Four Tank Case -- Dome Intact, AX-101 Source

241-AX Tank Farm with Domes										
1	0	(-10:1:23)							\$ Outside world	
2	2	-1.8000	10	-9	-23				\$ Soil Under Tanks	
3	2	-1.8000	9	-4	-23	13	16	19	22 \$ Soil Around Tanks	
4	2	-1.8000	4	-3	-23	13	16	19	22 \$ Bottom of Excavation	
5	2	-1.8000	3	-2	-23	(24:-25:-26:27)				\$ Soil Around Excavation
c	Tank AX-101									
6	3	-2.2580	9	-8	-13				\$ Concrete Base - Outer	
7	3	-2.2580	8	-4	12	-13			\$ Concrete Wall - Outer	
8	3	-2.2580	8	-7	-12				\$ Concrete Base - Inner	
9	3	-2.2580	7	-4	11	-12			\$ Concrete Wall - Inner	
10	4	-7.8600	7	-6	-11				\$ Bottom Iron Liner	
11	5	-1.6350	6	-5	-11				\$ Waste on Bottom	
12	1	-0.0012	(5 -4):(4 -28))				-11		\$ Tank Air	
13	3	-2.2580	4	-29	(28:11)				\$ Dome Inner Layer	
14	3	-2.2580	4	-30	29	-13			\$ Dome Layer 2	
15	3	-2.2580	4	-31	30	-13			\$ Dome Layer 3	
16	3	-2.2580	4	-32	31	-13			\$ Dome Layer 4	
17	3	-2.2580	4	-33	32	-13			\$ Dome Layer 5	
18	3	-2.2580	4	-34	33	-13			\$ Dome Outer Layer	
c	Tank AX-102									
19	3	-2.2580	9	-8	-16				\$ Concrete Base - Outer	
20	3	-2.2580	8	-4	15	-16			\$ Concrete Wall - Outer	
21	3	-2.2580	8	-7	-15				\$ Concrete Base - Inner	
22	3	-2.2580	7	-4	14	-15			\$ Concrete Wall - Inner	
23	4	-7.8600	7	-6	-14				\$ Bottom Iron Liner	
24	6	-1.5700	6	-5	-14				\$ Waste on Bottom	
25	1	-0.0012	(5 -4):(4 -35))				-14		\$ Tank Air	
26	3	-2.2580	4	-36	(35:14)				\$ Dome Inner Layer	
27	3	-2.2580	4	-37	36	-16			\$ Dome Layer 2	
28	3	-2.2580	4	-38	37	-16			\$ Dome Layer 3	
29	3	-2.2580	4	-39	38	-16			\$ Dome Layer 4	
30	3	-2.2580	4	-40	39	-16			\$ Dome Layer 5	
31	3	-2.2580	4	-41	40	-16			\$ Dome Outer Layer	
c	Tank AX-103									
32	3	-2.2580	9	-8	-19				\$ Concrete Base - Outer	
33	3	-2.2580	8	-4	18	-19			\$ Concrete Wall - Outer	
34	3	-2.2580	8	-7	-18				\$ Concrete Base - Inner	
35	3	-2.2580	7	-4	17	-18			\$ Concrete Wall - Inner	
36	4	-7.8600	7	-6	-17				\$ Bottom Iron Liner	
37	7	-1.8000	6	-5	-17				\$ Waste on Bottom	
38	1	-0.0012	(5 -4):(4 -42))				-17		\$ Tank Air	
39	3	-2.2580	4	-43	(42:17)				\$ Dome Inner Layer	
40	3	-2.2580	4	-44	43	-19			\$ Dome Layer 2	
41	3	-2.2580	4	-45	44	-19			\$ Dome Layer 3	
42	3	-2.2580	4	-46	45	-19			\$ Dome Layer 4	
43	3	-2.2580	4	-47	46	-19			\$ Dome Layer 5	
44	3	-2.2580	4	-48	47	-19			\$ Dome Outer Layer	
c	Tank AX-104									
45	3	-2.2580	9	-8	-22				\$ Concrete Base - Outer	
46	3	-2.2580	8	-4	21	-22			\$ Concrete Wall - Outer	
47	3	-2.2580	8	-7	-21				\$ Concrete Base - Inner	
48	3	-2.2580	7	-4	20	-21			\$ Concrete Wall - Inner	
49	4	-7.8600	7	-6	-20				\$ Bottom Iron Liner	
50	7	-1.8000	6	-5	-20				\$ Waste on Bottom	

51	1	-0.0012	((5 -4):(4 -49))	-20	\$	Tank Air
52	3	-2.2580	4 -50 (49:20)		\$	Dome Inner Layer
53	3	-2.2580	4 -51 50 -22		\$	Dome Layer 2
54	3	-2.2580	4 -52 51 -22		\$	Dome Layer 3
55	3	-2.2580	4 -53 52 -22		\$	Dome Layer 4
56	3	-2.2580	4 -54 53 -22		\$	Dome Layer 5
57	3	-2.2580	4 -55 54 -22		\$	Dome Outer Layer
c Open Sky						
58	1	-0.0012	3 -2 -23 -24 25 26 -27		\$	Air in Excavation (13:34) (16:41) (19:48) (22:55)
59	1	-0.0012	2 -1 -23		\$	Air Above Grade
c Horizontal Planes						
1	PZ	30480.0		\$		Upper Boundary
2	PZ	0.00		\$		Ground Surface
3	PZ	-418.15		\$		Excavation Depth
4	PZ	-604.52		\$		Center of Inner Ellipsoid
5	PZ	-1569.72		\$		Upper Waste Surface
6	PZ	-1577.34		\$		Lower Waste Surface
7	PZ	-1578.29		\$		Iron/Concrete Boundary
8	PZ	-1585.91		\$		Weighting Surface
9	PZ	-1623.06		\$		Bottom of Tank
10	PZ	-1805.94		\$		Lower Boundary
c Vertical Cylinders						
11	C/Z	1371.60	1554.48	1143.00	\$	AX-101 Inner Surface
12	C/Z	1371.60	1554.48	1150.62	\$	Weighting Surface
13	C/Z	1371.60	1554.48	1181.10	\$	Outer Surface
14	C/Z	1371.60	-1554.48	1143.00	\$	AX-102 Inner Surface
15	C/Z	1371.60	-1554.48	1150.62	\$	Weighting Surface
16	C/Z	1371.60	-1554.48	1181.10	\$	Outer Surface
17	C/Z	-1371.60	1554.48	1143.00	\$	AX-103 Inner Surface
18	C/Z	-1371.60	1554.48	1150.62	\$	Weighting Surface
19	C/Z	-1371.60	1554.48	1181.10	\$	Outer Surface
20	C/Z	-1371.60	-1554.48	1143.00	\$	AX-104 Inner Surface
21	C/Z	-1371.60	-1554.48	1150.62	\$	Weighting Surface
22	C/Z	-1371.60	-1554.48	1181.10	\$	Outer Surface
23	CZ	30480.00		\$		Outer Boundary
c Sloped Planes						
24	P	2.00	0.00	-3.00	7274.24	\$ East Side
25	P	0.00	2.00	3.00	-7640.00	\$ South Side
26	P	2.00	0.00	3.00	-7274.24	\$ West Side
27	P	0.00	2.00	-3.00	7640.00	\$ North Side
c Ellipsoids for Tank Domes						
28	SQ	147102.93	147102.93	1312261.9	0 0 0	-193037571281.32
		1371.60	1554.48	-604.52		\$ AX-101 Inner
29	SQ	154001.3	154001.3	1356269.9	0 0 0	-208867329483.95
		1371.60	1554.48	-607.06		\$ Layer 1
30	SQ	163102.9	163102.9	1413055.2	0 0 0	-230473406678.01
		1371.60	1554.48	-612.14		\$ Layer 2
31	SQ	176710.94	176710.94	1486448.6	0 0 0	-262671731828.13
		1371.60	1554.48	-622.30		\$ Layer 3
32	SQ	213702.8	213702.8	1638809.6	0 0 0	-350218203035.58
		1371.60	1554.48	-657.86		\$ Layer 4
33	SQ	310839.7	310839.7	1965828.3	0 0 0	-611057488998.92
		1371.60	1554.48	-746.76		\$ Layer 5
34	SQ	741424.32	741424.32	2974452.1	0 0 0	-2205331147889.3
		1371.60	1554.48	-1043.94		\$ Upper Surface
35	SQ	147102.93	147102.93	1312261.9	0 0 0	-193037571281.32

	1371.60	-1554.48	-604.52				\$ AX-102 Inner
36 SQ	154001.3	154001.3	1356269.9	0	0	0	-208867329483.95
	1371.60	-1554.48	-607.06				\$ Layer 1
37 SQ	163102.9	163102.9	1413055.2	0	0	0	-230473406678.01
	1371.60	-1554.48	-612.14				\$ Layer 2
38 SQ	176710.94	176710.94	1486448.6	0	0	0	-262671731828.13
	1371.60	-1554.48	-622.3				\$ Layer 3
39 SQ	213702.8	213702.8	1638809.6	0	0	0	-350218203035.58
	1371.60	-1554.48	-657.86				\$ Layer 4
40 SQ	310839.7	310839.7	1965828.3	0	0	0	-611057488998.92
	1371.60	-1554.48	-746.76				\$ Layer 5
41 SQ	741424.32	741424.32	2974452.1	0	0	0	-2205331147889.3
	1371.60	-1554.48	-1043.94				\$ Upper Surface
42 SQ	147102.93	147102.93	1312261.9	0	0	0	-193037571281.32
	-1371.60	1554.48	-604.52				\$ AX-103 Inner
43 SQ	154001.3	154001.3	1356269.9	0	0	0	-208867329483.95
	-1371.60	1554.48	-607.06				\$ Layer 1
44 SQ	163102.9	163102.9	1413055.2	0	0	0	-230473406678.01
	-1371.60	1554.48	-612.14				\$ Layer 2
45 SQ	176710.94	176710.94	1486448.6	0	0	0	-262671731828.13
	-1371.60	1554.48	-622.3				\$ Layer 3
46 SQ	213702.8	213702.8	1638809.6	0	0	0	-350218203035.58
	-1371.60	1554.48	-657.86				\$ Layer 4
47 SQ	310839.7	310839.7	1965828.3	0	0	0	-611057488998.92
	-1371.60	1554.48	-746.76				\$ Layer 5
48 SQ	741424.32	741424.32	2974452.1	0	0	0	-2205331147889.3
	-1371.60	1554.48	-1043.94				\$ Upper Surface
49 SQ	147102.93	147102.93	1312261.9	0	0	0	-193037571281.32
	-1371.60	-1554.48	-604.52				\$ AX-104 Inner
50 SQ	154001.3	154001.3	1356269.9	0	0	0	-208867329483.95
	-1371.60	-1554.48	-607.06				\$ Layer 1
51 SQ	163102.9	163102.9	1413055.2	0	0	0	-230473406678.01
	-1371.60	-1554.48	-612.14				\$ Layer 2
52 SQ	176710.94	176710.94	1486448.6	0	0	0	-262671731828.13
	-1371.60	-1554.48	-622.3				\$ Layer 3
53 SQ	213702.8	213702.8	1638809.6	0	0	0	-350218203035.58
	-1371.60	-1554.48	-657.86				\$ Layer 4
54 SQ	310839.7	310839.7	1965828.3	0	0	0	-611057488998.92
	-1371.60	-1554.48	-746.76				\$ Layer 5
55 SQ	741424.32	741424.32	2974452.1	0	0	0	-2205331147889.3
	-1371.60	-1554.48	-1043.94				\$ Upper Surface

m1 \$ Air at 80°F and 20.0% Relative Humidity

1001.01p	-0.00048	\$ Hydrogen
6012.01p	-0.00014	\$ Carbon
7014.01p	-0.75191	\$ Nitrogen
8016.01p	-0.23464	\$ Oxygen
18040.01p	-0.01282	\$ Argon

m2 \$ Hanford Soil with 0.10 ml/cc Water

1001.01p	-0.00617	\$ Hydrogen
8016.01p	-0.47331	\$ Oxygen
11023.01p	-0.01678	\$ Sodium
12000.01p	-0.02722	\$ Magnesium
13027.01p	-0.06864	\$ Aluminum
14000.01p	-0.22887	\$ Silicon
15031.01p	-0.00222	\$ Phosphorus
19000.01p	-0.01068	\$ Potassium
20000.01p	-0.05969	\$ Calcium

		22000.01p	-0.01425	\$	Titanium
		25055.01p	-0.00151	\$	Manganese
		26000.01p	-0.09064	\$	Iron
m3	\$	Hanford Concrete			
		1001.01p	-0.00310	\$	Hydrogen
		8016.01p	-0.44070	\$	Oxygen
		11023.01p	-0.01820	\$	Sodium
		12000.01p	-0.03760	\$	Magnesium
		13027.01p	-0.06070	\$	Aluminum
		14000.01p	-0.21570	\$	Silicon
		15031.01p	-0.00090	\$	Phosphorus
		16032.01p	-0.00090	\$	Sulfur
		20000.01p	-0.13060	\$	Calcium
		22000.01p	-0.00490	\$	Titanium
		25055.01p	-0.00130	\$	Manganese
		26000.01p	-0.07880	\$	Iron
		36000.01p	-0.00660	\$	Krypton
m4	\$	Plain Iron			
		26000.01p	-1.00		
m5	\$	Tank Residual Sludge: AX-101			
		1001.01p	-0.03811	\$	Hydrogen
		6012.01p	-0.03390	\$	Carbon
		7014.01p	-0.22079	\$	Nitrogen
		8016.01p	-0.42709	\$	Oxygen
		11023.01p	-0.15815	\$	Sodium
		13027.01p	-0.02778	\$	Aluminum
		14000.01p	-0.01014	\$	Silicon
		15031.01p	-0.01038	\$	Phosphorus
		16032.01p	-0.00468	\$	Sulfur
		17000.01p	-0.00828	\$	Chlorine
		19000.01p	-0.00300	\$	Potassium
		20000.01p	-0.00162	\$	Calcium
		24000.01p	-0.00744	\$	Chromium
		25055.01p	-0.00282	\$	Manganese
		26000.01p	-0.01704	\$	Iron
		28000.01p	-0.00048	\$	Nickel
		36000.01p	-0.00102	\$	Krypton
		56000.01p	-0.00094	\$	Barium
		82000.01p	-0.00234	\$	Lead
		92238.01p	-0.02400	\$	Uranium
m6	\$	Tank Residual Sludge: AX-102			
		1001.01p	-0.04722	\$	Hydrogen
		6012.01p	-0.01731	\$	Carbon
		7014.01p	-0.03693	\$	Nitrogen
		8016.01p	-0.64925	\$	Oxygen
		11023.01p	-0.07560	\$	Sodium
		13027.01p	-0.03093	\$	Aluminum
		14000.01p	-0.02249	\$	Silicon
		15031.01p	-0.00147	\$	Phosphorus
		16032.01p	-0.00209	\$	Sulfur
		17000.01p	-0.00075	\$	Chlorine
		19000.01p	-0.00018	\$	Potassium
		20000.01p	-0.00506	\$	Calcium
		24000.01p	-0.00015	\$	Chromium
		25055.01p	-0.00762	\$	Manganese
		26000.01p	-0.09060	\$	Iron
		28000.01p	-0.00344	\$	Nickel
		92238.01p	-0.00890	\$	Uranium

```

m7 $ Tank Residual Sludge: AX-103 & AX-104
    1001.01p -0.04722 $ Hydrogen
    7014.01p -0.00213 $ Nitrogen
    8016.01p -0.62394 $ Oxygen
    11023.01p -0.04262 $ Sodium
    12000.01p -0.00229 $ Magnesium
    13027.01p -0.03706 $ Aluminum
    14000.01p -0.03875 $ Silicon
    15031.01p -0.00583 $ Phosphorus
    16032.01p -0.00719 $ Sulfur
    20000.01p -0.01455 $ Calcium
    24000.01p -0.00174 $ Chromium
    25055.01p -0.00256 $ Manganese
    26000.01p -0.16404 $ Iron
    28000.01p -0.00850 $ Nickel
    56000.01p -0.00158 $ Barium

mode p
print 40 120
prtmp j j 1
phys:p j 1 1
imp:p 0 1 1 3669 3669 2 2 5 5 10 10 19 46 111 265 637 1529 3669
      2 2 5 5 10 10 19 46 111 265 637 1529 3669
      2 2 5 5 10 10 19 46 111 265 637 1529 3669
      2 2 5 5 10 10 19 46 111 265 637 1529 3669 7338 7338

nps 600000
sdef wgt=6.74E+13 cel=11 erg=d1 pos=d2 ext=d3 rad=d4 axs=d5
sc1 Source Energy Distribution for AX-101
# sil spl
  L D $ photon spectrum from ISO-PC
  0.0447 1.82E+12 $ energy (MeV) and photons/sec
  0.0548 1.33E+12 $ total: 6.740E+13
  0.0649 1.13E+12
  0.0749 1.03E+12
  0.0849 9.29E+11
  0.0949 8.35E+11
  0.1379 4.18E+12
  0.2433 1.30E+12
  0.3450 6.30E+11
  0.4663 4.81E+11
  0.6615 5.33E+13
  0.8179 1.07E+11
  0.9869 7.30E+10
  1.2437 2.01E+11
  1.4499 1.26E+10
  1.7412 1.20E+10
  1.8695 6.44E+08
  2.1681 4.29E+08

sc2 POS - source position (center of base)
si2 L 1371.60 1554.48 -1577.34
sp2 D 1
sc3 EXT - source axial distribution (uniform)
si3 L 0.0 7.62
sc4 RAD - source radial distribution (uniform)
si4 L 0.0 1051.56 $ 3 ft from inner tank wall
sp4 D -21 1
sc5 AXS - direction of cylinder axis (vertical)
si5 L 0.0 0.0 1.0
sp5 D 1

```

c	Detector Locations				3 feet above surface.			
fc05	Over the Center of the Tank Dome							
f05:p	1371.60	1554.48	-91.44	10.0	\$	AX-101		
	1371.60	-1554.48	-91.44	10.0	\$	AX-102		
	-1371.60	1554.48	-91.44	10.0	\$	AX-103		
	-1371.60	-1554.48	-91.44	10.0	\$	AX-104		
fc15	Halfway between Center & Tank Edge							
f15:p	1371.60	2125.98	-140.09	10.0	\$	AX-101 north		
	1371.60	-2125.98	-140.09	10.0	\$	AX-102 south		
	-1371.60	2125.98	-140.09	10.0	\$	AX-103 north		
	-1371.60	-2125.98	-140.09	10.0	\$	AX-104 south		
fc25	Over the Inner Edge of the Tank Dome							
f25:p	2514.60	1554.48	-307.70	10.0	\$	AX-101 east		
	2514.60	-1554.48	-307.70	10.0	\$	AX-102 east		
	-2514.60	1554.48	-307.70	10.0	\$	AX-103 west		
	-2514.60	-1554.48	-307.70	10.0	\$	AX-104 west		
fc35	N-S Line Between Tanks							
f35:p	0.00	6868.00	91.44	10.0	\$	100 ft N of Excavation		
	0.00	5344.00	91.44	10.0	\$	50 ft N of Excavation		
	0.00	3820.00	91.44	10.0	\$	N Edge of Excavation		
	0.00	1554.48	-326.71	10.0	\$	Between AX-101 & AX-103		
	0.00	0.00	-326.71	10.0	\$	Center Point		
	0.00	-1554.48	-326.71	10.0	\$	Between AX-102 & AX-104		
	0.00	-3820.00	91.44	10.0	\$	S Edge of Excavation		
	0.00	-5344.00	91.44	10.0	\$	50 ft S of Excavation		
	0.00	-6868.00	91.44	10.0	\$	100 ft S of Excavation		
fc45	E-W Line Between Tanks							
f45:p	6685.12	0.00	91.44	10.0	\$	100 ft E of Excavation		
	5161.12	0.00	91.44	10.0	\$	50 ft E of Excavation		
	3637.12	0.00	91.44	10.0	\$	E Edge of Excavation		
	1371.60	0.00	-326.71	10.0	\$	Between AX-101 & AX-102		
	-1371.60	0.00	-326.71	10.0	\$	Between AX-103 & AX-104		
	-3637.12	0.00	91.44	10.0	\$	W Edge of Excavation		
	-5161.12	0.00	91.44	10.0	\$	50 ft W of Excavation		
	-6685.12	0.00	91.44	10.0	\$	100 ft W of Excavation		
fc55	Other Points Near Edge of Excavation							
f55:p	3637.12	3820.00	91.44	10.0	\$	NE Corner		
	3637.12	1554.48	91.44	10.0	\$	AX-101 east		
	3637.12	-1554.48	91.44	10.0	\$	AX-102 east		
	3637.12	-3820.00	91.44	10.0	\$	SE Corner		
	-3637.12	3820.00	91.44	10.0	\$	NW Corner		
	-3637.12	1554.48	91.44	10.0	\$	AX-103 west		
	-3637.12	-1554.48	91.44	10.0	\$	AX-104 west		
	-3637.12	-3820.00	91.44	10.0	\$	SW Corner		
c	Bins for Photon Tallies							
e0	0.03	0.05	0.07	0.10	0.13	0.16	0.20	0.25
	0.50	0.70	1.00	1.50	2.00	2.50		
c	ANSI/ANS-6.1.1-1991 fluence-to-dose, photons(mrem/hr)/(p/cm**2/s)							
de0	log	0.01	0.015	0.02	0.03	0.04	0.05	
		0.06	0.08	0.10	0.15	0.20	0.30	
		0.40	0.50	0.60	0.80	1.0	1.5	
		2.0	3.0	4.0	5.0	6.0	8.0	
df0	log	2.232e-5	5.652e-5	8.568e-5	1.184e-4	1.314e-4	1.382e-4	
		1.440e-4	1.624e-4	1.919e-4	2.797e-4	3.708e-4	5.616e-4	
		7.416e-4	9.144e-4	1.076e-3	1.379e-3	1.656e-3	2.246e-3	
		2.758e-3	3.672e-3	4.500e-3	5.292e-3	6.012e-3	7.488e-3	

Table 16. Four Tank Case -- Dome Removed, AX-103 Source

241-AX Tank Farm - Dome Removed from AX-103												
1	0		(-10:1:23)							\$	Outside world	
2	2	-1.8000	10	-9	-23					\$	Soil Under Tanks	
3	2	-1.8000	9	-4	-23	13	16	19	22	\$	Soil Around Tanks	
4	2	-1.8000	4	-3	-23	13	16	19	22	\$	Bottom of Excavation	
5	2	-1.8000	3	-2	-23	(24:-25:-26:27)					\$	Soil Around Excavation
c Tank AX-101												
6	3	-2.2580	9	-7	-13					\$	Concrete Base	
7	3	-2.2580	7	-4	11	-13				\$	Concrete Wall	
8	3	-2.2580	4	-13	-34	(11:28)				\$	Concrete Dome	
9	4	-7.8600	7	-6	-11					\$	Bottom Iron Liner	
10	5	-1.6350	6	-5	-11					\$	Waste on Bottom	
11	1	-0.0012	((5 -4): (4 -28))					-11		\$	Tank Air	
c Tank AX-102												
12	3	-2.2580	9	-7	-16					\$	Concrete Base	
13	3	-2.2580	7	-4	14	-16				\$	Concrete Wall	
14	3	-2.2580	4	-16	-41	(14:35)				\$	Concrete Dome	
15	4	-7.8600	7	-6	-14					\$	Bottom Iron Liner	
16	6	-1.5700	6	-5	-14					\$	Waste on Bottom	
17	1	-0.0012	((5 -4): (4 -35))					-14		\$	Tank Air	
c Tank AX-103 With Hole												
18	3	-2.2580	9	-7	-19					\$	Concrete Base	
19	3	-2.2580	7	-4	17	-19				\$	Concrete Wall	
20	3	-2.2580	4	-19	-48	(17:42)				56	\$	Concrete Dome
21	4	-7.8600	7	-6	-17					\$	Bottom Iron Liner	
22	7	-1.8000	6	-5	-17					\$	Waste on Bottom	
23	1	-0.0012	((5 -4): (4 -42))					-17		\$	Tank Air	
c Tank AX-104												
24	3	-2.2580	9	-7	-22					\$	Concrete Base	
25	3	-2.2580	7	-4	20	-22				\$	Concrete Wall	
26	3	-2.2580	4	-22	-55	(20:49)					\$	Concrete Dome
27	4	-7.8600	7	-6	-20					\$	Bottom Iron Liner	
28	7	-1.8000	6	-5	-20					\$	Waste on Bottom	
29	1	-0.0012	((5 -4): (4 -49))					-20		\$	Tank Air	
c Open Sky												
30	1	-0.0012	3	-2	-23	-24	25	26	-27	\$	Air in Excavation	
			(13:34) (16:41) (19:48) (22:55)									
31	1	-0.0012	2	-1	-23					\$	Air Above Grade	
32	1	-0.0012	4	42	-48	-56				\$	Air in Hole AX-103	
c Horizontal Planes												
1 PZ		30480.0	\$	Upper Boundary								
2 PZ		0.00	\$	Ground Surface								
3 PZ		-418.15	\$	Excavation Depth								
4 PZ		-604.52	\$	Center of Inner Ellipsoid								
5 PZ		-1569.72	\$	Upper Waste Surface								
6 PZ		-1577.34	\$	Lower Waste Surface								
7 PZ		-1578.29	\$	Iron/Concrete Boundary								
9 PZ		-1623.06	\$	Bottom of Tank								
10 PZ		-1805.94	\$	Lower Boundary								
c Vertical Cylinders												
11 C/Z		1371.60	1554.48	1143.00	\$	AX-101 Inner Surface						
13 C/Z		1371.60	1554.48	1181.10	\$	Outer Surface						
14 C/Z		1371.60	-1554.48	1143.00	\$	AX-102 Inner Surface						
16 C/Z		1371.60	-1554.48	1181.10	\$	Outer Surface						
17 C/Z		-1371.60	1554.48	1143.00	\$	AX-103 Inner Surface						

19	C/Z	-1371.60	1554.48	1181.10	\$	Outer Surface
20	C/Z	-1371.60	-1554.48	1143.00	\$	AX-104 Inner Surface
22	C/Z	-1371.60	-1554.48	1181.10	\$	Outer Surface
23	CZ	30480.00			\$	Outer Boundary
c Sloped Planes						
24	P	2.00	0.00	-3.00	7274.24	\$ East Side
25	P	0.00	2.00	3.00	-7640.00	\$ South Side
26	P	2.00	0.00	3.00	-7274.24	\$ West Side
27	P	0.00	2.00	-3.00	7640.00	\$ North Side
c Ellipsoids for Tank Domes						
28	SQ	147102.93	147102.93	1312261.9	0 0 0	-193037571281.32
		1371.60	1554.48	-604.52		\$ AX-101 Inner
34	SQ	741424.32	741424.32	2974452.1	0 0 0	-2205331147889.3
		1371.60	1554.48	-1043.94		\$ Upper Surface
35	SQ	147102.93	147102.93	1312261.9	0 0 0	-193037571281.32
		1371.60	-1554.48	-604.52		\$ AX-102 Inner
41	SQ	741424.32	741424.32	2974452.1	0 0 0	-2205331147889.3
		1371.60	-1554.48	-1043.94		\$ Upper Surface
42	SQ	147102.93	147102.93	1312261.9	0 0 0	-193037571281.32
		-1371.60	1554.48	-604.52		\$ AX-103 Inner
48	SQ	741424.32	741424.32	2974452.1	0 0 0	-2205331147889.3
		-1371.60	1554.48	-1043.94		\$ Upper Surface
49	SQ	147102.93	147102.93	1312261.9	0 0 0	-193037571281.32
		-1371.60	-1554.48	-604.52		\$ AX-104 Inner
55	SQ	741424.32	741424.32	2974452.1	0 0 0	-2205331147889.3
		-1371.60	-1554.48	-1043.94		\$ Upper Surface
56	K/Z	-1371.60	1554.48	-3657.60	0.126879 1	\$ Hole in AX-103
m1 \$ Air at 80°F and 20.0% Relative Humidity						
		1001.01p	-0.00048			\$ Hydrogen
		6012.01p	-0.00014			\$ Carbon
		7014.01p	-0.75191			\$ Nitrogen
		8016.01p	-0.23464			\$ Oxygen
		18040.01p	-0.01282			\$ Argon
m2 \$ Hanford Soil with 0.10 ml/cc Water						
		1001.01p	-0.00617			\$ Hydrogen
		8016.01p	-0.47331			\$ Oxygen
		11023.01p	-0.01678			\$ Sodium
		12000.01p	-0.02722			\$ Magnesium
		13027.01p	-0.06864			\$ Aluminum
		14000.01p	-0.22887			\$ Silicon
		15031.01p	-0.00222			\$ Phosphorus
		19000.01p	-0.01068			\$ Potassium
		20000.01p	-0.05969			\$ Calcium
		22000.01p	-0.01425			\$ Titanium
		25055.01p	-0.00151			\$ Manganese
		26000.01p	-0.09064			\$ Iron
m3 \$ Hanford Concrete						
		1001.01p	-0.00310			\$ Hydrogen
		8016.01p	-0.44070			\$ Oxygen
		11023.01p	-0.01820			\$ Sodium
		12000.01p	-0.03760			\$ Magnesium
		13027.01p	-0.06070			\$ Aluminum
		14000.01p	-0.21570			\$ Silicon
		15031.01p	-0.00090			\$ Phosphorus
		16032.01p	-0.00090			\$ Sulfur
		20000.01p	-0.13060			\$ Calcium
		22000.01p	-0.00490			\$ Titanium

		25055.01p	-0.00130	\$	Manganese
		26000.01p	-0.07880	\$	Iron
		36000.01p	-0.00660	\$	Krypton
m4	\$	Plain Iron			
		26000.01p	-1.00		
m5	\$	Tank Residual Sludge: AX-101			
		1001.01p	-0.03811	\$	Hydrogen
		6012.01p	-0.03390	\$	Carbon
		7014.01p	-0.22079	\$	Nitrogen
		8016.01p	-0.42709	\$	Oxygen
		11023.01p	-0.15815	\$	Sodium
		13027.01p	-0.02778	\$	Aluminum
		14000.01p	-0.01014	\$	Silicon
		15031.01p	-0.01038	\$	Phosphorus
		16032.01p	-0.00468	\$	Sulfur
		17000.01p	-0.00828	\$	Chlorine
		19000.01p	-0.00300	\$	Potassium
		20000.01p	-0.00162	\$	Calcium
		24000.01p	-0.00744	\$	Chromium
		25055.01p	-0.00282	\$	Manganese
		26000.01p	-0.01704	\$	Iron
		28000.01p	-0.00048	\$	Nickel
		36000.01p	-0.00102	\$	Krypton
		56000.01p	-0.00094	\$	Barium
		82000.01p	-0.00234	\$	Lead
		92238.01p	-0.02400	\$	Uranium
m6	\$	Tank Residual Sludge: AX-102			
		1001.01p	-0.04722	\$	Hydrogen
		6012.01p	-0.01731	\$	Carbon
		7014.01p	-0.03693	\$	Nitrogen
		8016.01p	-0.64925	\$	Oxygen
		11023.01p	-0.07560	\$	Sodium
		13027.01p	-0.03093	\$	Aluminum
		14000.01p	-0.02249	\$	Silicon
		15031.01p	-0.00147	\$	Phosphorus
		16032.01p	-0.00209	\$	Sulfur
		17000.01p	-0.00075	\$	Chlorine
		19000.01p	-0.00018	\$	Potassium
		20000.01p	-0.00506	\$	Calcium
		24000.01p	-0.00015	\$	Chromium
		25055.01p	-0.00762	\$	Manganese
		26000.01p	-0.09060	\$	Iron
		28000.01p	-0.00344	\$	Nickel
		92238.01p	-0.00890	\$	Uranium
m7	\$	Tank Residual Sludge: AX-103 & AX-104			
		1001.01p	-0.04722	\$	Hydrogen
		7014.01p	-0.00213	\$	Nitrogen
		8016.01p	-0.62394	\$	Oxygen
		11023.01p	-0.04262	\$	Sodium
		12000.01p	-0.00229	\$	Magnesium
		13027.01p	-0.03706	\$	Aluminum
		14000.01p	-0.03875	\$	Silicon
		15031.01p	-0.00583	\$	Phosphorus
		16032.01p	-0.00719	\$	Sulfur
		20000.01p	-0.01455	\$	Calcium
		24000.01p	-0.00174	\$	Chromium
		25055.01p	-0.00256	\$	Manganese
		26000.01p	-0.16404	\$	Iron

```

28000.01p  -0.00850 $ Nickel
56000.01p  -0.00158 $ Barium

mode      p
print    40 120
prtmp    j  j  1
phys:p   j  1  1
imp:p    0 1 1 2 2 1 1 2 1 1 1 1 1 2 1 1 1
          2 2 2 2 4 4 1 1 2 1 1 1 4 4 4

nps      400000
sdef wgt=1.429E+15 cel=22 erg=d1 pos=d2 ext=d3 rad=d4 axs=d5
sc1 Source Energy Distribution for AX-103
#      sil      spl
      L      D
0.0447 1.40E+14 $ photon spectrum from ISO-PC
0.0548 9.64E+13 $ energy (MeV) and photons/sec
0.0649 8.25E+13 $ total: 1.429E+15
0.0749 7.49E+13
0.0849 7.21E+13
0.0949 6.14E+13
0.1379 3.17E+14
0.2433 9.68E+13
0.3450 4.66E+13
0.4663 3.61E+13
0.6615 3.68E+14
0.8179 1.02E+13
0.9869 1.01E+13
1.2437 1.35E+13
1.4499 1.51E+12
1.7412 8.77E+11
1.8695 4.72E+10
2.1681 3.13E+10

sc2 POS - source position (center of base)
si2 L -1371.60 1554.48 -1577.34
sp2 D 1
sc3 EXT - source axial distribution (uniform)
si3 L 0.0 7.62
sc4 RAD - source radial distribution (uniform)
si4 L 0.0 1051.56 $ 3 ft from inner tank wall
sp4 D -21 1
sc5 AXS - direction of cylinder axis (vertical)
si5 L 0.0 0.0 1.0
sp5 D 1
c
c Detector Locations 3 feet above surface
fc05 Over the Center of the Tank Dome
f05:p 1371.60 1554.48 -91.44 10.0 $ AX-101
      1371.60 -1554.48 -91.44 10.0 $ AX-102
      -1371.60 1554.48 -91.44 10.0 $ AX-103
      -1371.60 -1554.48 -91.44 10.0 $ AX-104
fc15 Halfway between Center & Tank Edge
f15:p 1371.60 2125.98 -140.09 10.0 $ AX-101 north
      1371.60 -2125.98 -140.09 10.0 $ AX-102 south
      -1371.60 2125.98 -140.09 10.0 $ AX-103 north
      -1371.60 -2125.98 -140.09 10.0 $ AX-104 south
fc25 Over the Inner Edge of the Tank Dome
f25:p 2514.60 1554.48 -307.70 10.0 $ AX-101 east
      2514.60 -1554.48 -307.70 10.0 $ AX-102 east
      -2514.60 1554.48 -307.70 10.0 $ AX-103 west

```

	-2514.60	-1554.48	-307.70	10.0	\$	AX-104 west
fc35	N-S Line Between Tanks					
f35:p	0.00	6868.00	91.44	10.0	\$	100 ft N of Excavation
	0.00	5344.00	91.44	10.0	\$	50 ft N of Excavation
	0.00	3820.00	91.44	10.0	\$	N Edge of Excavation
	0.00	1554.48	-326.71	10.0	\$	Between AX-101 & AX-103
	0.00	0.00	-326.71	10.0	\$	Center Point
	0.00	-1554.48	-326.71	10.0	\$	Between AX-102 & AX-104
	0.00	-3820.00	91.44	10.0	\$	S Edge of Excavation
	0.00	-5344.00	91.44	10.0	\$	50 ft S of Excavation
	0.00	-6868.00	91.44	10.0	\$	100 ft S of Excavation
fc45	E-W Line Between Tanks					
f45:p	6685.12	0.00	91.44	10.0	\$	100 ft E of Excavation
	5161.12	0.00	91.44	10.0	\$	50 ft E of Excavation
	3637.12	0.00	91.44	10.0	\$	E Edge of Excavation
	1371.60	0.00	-326.71	10.0	\$	Between AX-101 & AX-102
	-1371.60	0.00	-326.71	10.0	\$	Between AX-103 & AX-104
	-3637.12	0.00	91.44	10.0	\$	W Edge of Excavation
	-5161.12	0.00	91.44	10.0	\$	50 ft W of Excavation
	-6685.12	0.00	91.44	10.0	\$	100 ft W of Excavation
fc55	Other Points Near Edge of Excavation					
f55:p	3637.12	3820.00	91.44	10.0	\$	NE Corner
	3637.12	1554.48	91.44	10.0	\$	AX-101 east
	3637.12	-1554.48	91.44	10.0	\$	AX-102 east
	3637.12	-3820.00	91.44	10.0	\$	SE Corner
	-3637.12	3820.00	91.44	10.0	\$	NW Corner
	-3637.12	1554.48	91.44	10.0	\$	AX-103 west
	-3637.12	-1554.48	91.44	10.0	\$	AX-104 west
	-3637.12	-3820.00	91.44	10.0	\$	SW Corner
c	Bins for Photon Tallies					
e0	0.03	0.05	0.07	0.10	0.13	0.16 0.20 0.25 0.30 0.40
	0.50	0.70	1.00	1.50	2.00	2.50
c	ANSI/ANS-6.1.1-1991 fluence-to-dose.photons(mrem/hr)/(p/cm**2/s)					
de0	log	0.01	0.015	0.02	0.03	0.04 0.05
		0.06	0.08	0.10	0.15	0.20 0.30
		0.40	0.50	0.60	0.80	1.0 1.5
		2.0	3.0	4.0	5.0	6.0 8.0
df0	log	2.232e-5	5.652e-5	8.568e-5	1.184e-4	1.314e-4 1.382e-4
		1.440e-4	1.624e-4	1.919e-4	2.797e-4	3.708e-4 5.616e-4
		7.416e-4	9.144e-4	1.076e-3	1.379e-3	1.656e-3 2.246e-3
		2.758e-3	3.672e-3	4.500e-3	5.292e-3	6.012e-3 7.488e-3

Table 17. Single Tank Case -- Dome Intact, AX-101 Source, 70.5 lb/ft³ Grout

241-AX Tank with 6" Concrete - Dome in Place

1	0	(-12:1:16)					\$ Outside world	0	
2	2	-1.8000	12	-11	-16		\$ Soil Under Tank	1	
3	2	-1.8000	11	-4	-16	15	\$ Soil Around Tank	1	
4	2	-1.8000	4	-3	-16	15	\$ Bottom of Excavation	4096	
5	2	-1.8000	3	-2	-16	(17:18)	\$ Outside Surface Soil	4096	
6	3	-2.2580	11	-10	-15		\$ Conc Base - Bottom	2	
7	3	-2.2580	10	-4	14	-15	\$ Conc Wall - Outer	11	
8	3	-2.2580	10	-9	-14		\$ Conc Base - Top	4	
9	3	-2.2580	9	-4	13	-14	\$ Conc Wall - Inner	32	
10	4	-7.8600	9	-8	-13		\$ Bottom Iron Liner	8	
11	5	-1.6350	8	-7	-13		\$ Waste - AX-101	8	
12	3	-2.2580	7	-6	-13		\$ Grout Layer 1	16	
13	3	-2.2580	6	-5	-13		\$ Grout Layer 2	32	
14	1	-0.0012	((5	-4):	(4	-19))	-13	\$ Tank Air	64
15	3	-2.2580	4	-20	(19:13)		\$ Dome Inner Layer	128	
16	3	-2.2580	4	-21	20	-15	\$ Dome Layer 2	256	
17	3	-2.2580	4	-22	21	-15	\$ Dome Layer 3	512	
18	3	-2.2580	4	-23	22	-15	\$ Dome Layer 4	1024	
19	3	-2.2580	4	-24	23	-15	\$ Dome Layer 5	2048	
20	3	-2.2580	4	-25	24	-15	\$ Dome Outer Layer	4096	
21	1	-0.0012	3	-2	-16	-17	-18	(15:25) \$ Air in Excavation	8192
22	1	-0.0012	2	-1	-16			\$ Air Above Grade	8192

c Horizontal Planes

1	PZ	24384.0	\$	Upper Boundary
2	PZ	0.00	\$	Ground Surface
3	PZ	-418.15	\$	Excavation Depth
4	PZ	-604.52	\$	Center of Inner Ellipsoid
5	PZ	-1554.48	\$	Grout/Debris Thickness
6	PZ	-1562.10	\$	Weighting Surface
7	PZ	-1569.72	\$	Upper Waste Surface
8	PZ	-1577.34	\$	Lower Waste Surface
9	PZ	-1578.29	\$	Iron/Concrete Boundary
10	PZ	-1585.91	\$	Weighting Surface
11	PZ	-1623.06	\$	Bottom of Tank
12	PZ	-1805.94	\$	Lower Boundary

c Vertical Cylinders

13	CZ	1143.00	\$	Inner Wall Surface
14	CZ	1150.62	\$	Weighting Surface
15	CZ	1181.10	\$	Outer Wall Surface
16	C/Z	9144.00	0.00	18288.00 \$ Outer Boundary

c Sloped Planes

17	P	2.00	0.00	-3.00	4531.04	\$	East Side
18	P	0.00	2.00	-3.00	4531.04	\$	North Side

c Ellipsoids for Tank Domes

19	SQ	147102.93	147102.93	1312261.9	0	0	0	-193037571281.32
		0.00	0.00	-604.52				\$ Inner Dome Surface
20	SQ	154001.3	154001.3	1356269.9	0	0	0	-208867329483.95
		0.00	0.00	-607.06				\$ Layer 1
21	SQ	163102.9	163102.9	1413055.2	0	0	0	-230473406678.01
		0.00	0.00	-612.14				\$ Layer 2
22	SQ	176710.94	176710.94	1486448.6	0	0	0	-262671731828.13
		0.00	0.00	-622.30				\$ Layer 3
23	SQ	213702.8	213702.8	1638809.6	0	0	0	-350218203035.58

	0.00	0.00	-657.86				\$ Layer 4
24 SQ	310839.7	310839.7	1965828.3	0	0	0	-611057488998.92
	0.00	0.00	-746.76				\$ Layer 5
25 SQ	741424.32	741424.32	2974452.1	0	0	0	-2205331147889.3
	0.00	0.00	-1043.94				\$ Outer Dome Surface

m1 \$ Air at 80°F and 20.0% Relative Humidity

1001.01p	-0.00048	\$ Hydrogen
6012.01p	-0.00014	\$ Carbon
7014.01p	-0.75191	\$ Nitrogen
8016.01p	-0.23464	\$ Oxygen
18040.01p	-0.01282	\$ Argon

m2 \$ Hanford Soil with 0.10 ml/cc Water

1001.01p	-0.00617	\$ Hydrogen
8016.01p	-0.47331	\$ Oxygen
11023.01p	-0.01678	\$ Sodium
12000.01p	-0.02722	\$ Magnesium
13027.01p	-0.06864	\$ Aluminum
14000.01p	-0.22887	\$ Silicon
15031.01p	-0.00222	\$ Phosphorus
19000.01p	-0.01068	\$ Potassium
20000.01p	-0.05969	\$ Calcium
22000.01p	-0.01425	\$ Titanium
25055.01p	-0.00151	\$ Manganese
26000.01p	-0.09064	\$ Iron

m3 \$ Hanford Concrete

1001.01p	-0.00310	\$ Hydrogen
8016.01p	-0.44070	\$ Oxygen
11023.01p	-0.01820	\$ Sodium
12000.01p	-0.03760	\$ Magnesium
13027.01p	-0.06070	\$ Aluminum
14000.01p	-0.21570	\$ Silicon
15031.01p	-0.00090	\$ Phosphorus
16032.01p	-0.00090	\$ Sulfur
20000.01p	-0.13060	\$ Calcium
22000.01p	-0.00490	\$ Titanium
25055.01p	-0.00130	\$ Manganese
26000.01p	-0.07880	\$ Iron
36000.01p	-0.00660	\$ Krypton

m4 \$ Plain Iron

26000.01p	-1.00	
-----------	-------	--

m5 \$ Tank Residual Sludge: AX-101

1001.01p	-0.03811	\$ Hydrogen
6012.01p	-0.03390	\$ Carbon
7014.01p	-0.22079	\$ Nitrogen
8016.01p	-0.42709	\$ Oxygen
11023.01p	-0.15815	\$ Sodium
13027.01p	-0.02778	\$ Aluminum
14000.01p	-0.01014	\$ Silicon
15031.01p	-0.01038	\$ Phosphorus
16032.01p	-0.00468	\$ Sulfur
17000.01p	-0.00828	\$ Chlorine
19000.01p	-0.00300	\$ Potassium
20000.01p	-0.00162	\$ Calcium
24000.01p	-0.00744	\$ Chromium
25055.01p	-0.00282	\$ Manganese
26000.01p	-0.01704	\$ Iron
28000.01p	-0.00048	\$ Nickel

```

36000.01p -0.00102 $ Krypton
56000.01p -0.00094 $ Barium
82000.01p -0.00234 $ Lead
92238.01p -0.02400 $ Uranium

mode p
print 40 120
prtmp j j 1
phys:p j 1 1
imp:p 0 1 1 4096 4096 2 11 4 32 8 8 16 32
      64 128 256 512 1024 2048 4096 8192 8192

nps 2000000
sdef wgt=6.74E+13 cel=11 erg=d1 pos=d2 ext=d3 rad=d4 axs=d5
sc1 Source Energy Distribution for AX-101
#      s11      spl
      L      D      $ photon spectrum from ISO-PC
0.0447 1.82E+12      $ energy (MeV) and photons/sec
0.0548 1.33E+12      $      total: 6.740E+13
0.0649 1.13E+12
0.0749 1.03E+12
0.0849 9.29E+11
0.0949 8.35E+11
0.1379 4.18E+12
0.2433 1.30E+12
0.3450 6.30E+11
0.4663 4.81E+11
0.6615 5.33E+13
0.8179 1.07E+11
0.9869 7.30E+10
1.2437 2.01E+11
1.4499 1.26E+10
1.7412 1.20E+10
1.8695 6.44E+08
2.1681 4.29E+08

sc2 POS - source position (center of base)
si2 L 0.00 0.00 -1577.34
sp2 D 1
sc3 EXT - source axial distribution (uniform)
si3 L 0.0 7.62
sc4 RAD - source radial distribution (uniform)
si4 L 0.0 1051.56 $ 3 ft from inner tank wall
sp4 D -21 1
sc5 AXS - direction of cylinder axis (vertical)
si5 L 0.0 0.0 1.0
sp5 D 1
c Detector Locations 3 feet above surface
fc05 Over the Tank Dome
f05:p 0.00 0.00 -312.42 10.0 $ 3 ft Below Dome
      0.00 0.00 -91.44 10.0 $ Center
      0.00 571.50 -140.09 10.0 $ Midway
      1143.00 0.00 -307.70 10.0 $ Inner Edge of Tank
fc15 To the East
f15:p 1638.30 0.00 -326.71 10.0 $ Bottom Edge of Excavation
      2265.52 0.00 91.44 10.0 $ Upper Edge of Excavation
      3789.52 0.00 91.44 10.0 $ 50 ft from Excavation
      5313.52 0.00 91.44 10.0 $ 100 ft from Excavation
      6837.52 0.00 91.44 10.0 $ 150 ft from Excavation
      8361.52 0.00 91.44 10.0 $ 200 ft from Excavation
      11409.52 0.00 91.44 10.0 $ 300 ft from Excavation

```



```

14457.52      0.00      91.44  10.0  $  400 ft from Excavation
c  Bins for Photon Tallies
e0  0.03  0.05  0.07  0.10  0.13  0.16  0.20  0.25  0.30  0.40
    0.50  0.70  1.00  1.50  2.00  2.50
c  ANSI/ANS-6.1.1-1991 fluence-to-dose,photons(mrem/hr/(p/cm**2/s))
de0  log    0.01  0.015  0.02  0.03  0.04  0.05
          0.06  0.08  0.10  0.15  0.20  0.30
          0.40  0.50  0.60  0.80  1.0  1.5
          2.0  3.0  4.0  5.0  6.0  8.0
df0  log    2.232e-5 5.652e-5 8.568e-5 1.184e-4 1.314e-4 1.382e-4
          1.440e-4 1.624e-4 1.919e-4 2.797e-4 3.708e-4 5.616e-4
          7.416e-4 9.144e-4 1.076e-3 1.379e-3 1.656e-3 2.246e-3
          2.758e-3 3.672e-3 4.500e-3 5.292e-3 6.012e-3 7.488e-3

```

Table 18. Single Tank Case -- Dome Removed, AX-102 Source, 211.5 lb/ft³ Grout

241-AX Tank with 18" Concrete - Dome Removed

1	0	(-16:1:20)	\$ Outside world	0
2	2	-1.8000 16 -15 -20	\$ Soil Under Tank	1
3	2	-1.8000 15 -4 -20 19	\$ Soil Around Tank	1
4	2	-1.8000 4 -3 -20 19	\$ Bottom of Excavation	7290
5	2	-1.8000 3 -2 -20 (21:22)	\$ Outside Surface Soil	7290
6	3	-2.2580 15 -13 -19	\$ Concrete Base	3
7	3	-2.2580 13 -4 17 -19	\$ Concrete Wall	7290
8	3	-2.2580 4 -19 -29 (17:23) 30	\$ Concrete Dome	7290
9	4	-7.8600 13 -12 -17	\$ Bottom Iron Liner	8
11	5	-1.5700 12 -11 -17	\$ Waste - AX-102	10
12	3	-2.2580 11 -10 -17	\$ Lower Grout Layer	30
13	3	-2.2580 10 -9 -17	\$ Grout Layer 2	90
14	3	-2.2580 9 -8 -17	\$ Grout Layer 3	270
15	3	-2.2580 8 -7 -17	\$ Grout Layer 4	810
16	3	-2.2580 7 -6 -17	\$ Grout Layer 5	2430
17	3	-2.2580 6 -5 -17	\$ Upper Grout Layer	7290
18	1	-0.0012 ((5 -4): (4 -23)) -17	\$ Tank Air	14580
19	1	-0.0012 3 -2 -20 -21 -22 (19:29)	\$ Air in Excavation	14580
20	1	-0.0012 2 -1 -20	\$ Air Above Grade	14580
21	1	-0.0012 4 23 -29 -30	\$ Air in Dome Hole	14580

c Horizontal Planes

1	PZ	24384.0	\$ Upper Boundary
2	PZ	0.00	\$ Ground Surface
3	PZ	-418.15	\$ Excavation Depth
4	PZ	-604.52	\$ Center of Inner Ellipsoid
5	PZ	-1524.00	\$ Grout/Debris Thickness
6	PZ	-1531.62	\$ Upper Weighting Surface
7	PZ	-1539.24	\$ Middle Weighting Surface
8	PZ	-1546.86	\$ Middle Weighting Surface
9	PZ	-1554.48	\$ Middle Weighting Surface
10	PZ	-1562.10	\$ Lower Weighting Surface
11	PZ	-1569.72	\$ Upper Waste Surface
12	PZ	-1577.34	\$ Lower Waste Surface
13	PZ	-1578.29	\$ Iron/Concrete Boundary
15	PZ	-1623.06	\$ Bottom of Tank
16	PZ	-1805.94	\$ Lower Boundary

c Vertical Cylinders

17	CZ	1143.00	\$ Inner Wall Surface
19	CZ	1181.10	\$ Outer Wall Surface
20	C/Z	9144.00	0.00 18288.00 \$ Outer Boundary

c Sloped Planes

21	P	2.00	0.00	-3.00	4531.04	\$ East Side
22	P	0.00	2.00	-3.00	4531.04	\$ North Side

c Ellipsoids for Tank Domes

23	SQ	147102.93	147102.93	1312261.9	0	0	0	-193037571281.32
		0.00	0.00	-604.52				\$ Inner Dome Surface
29	SQ	741424.32	741424.32	2974452.1	0	0	0	-2205331147889.3
		0.00	0.00	-1043.94				\$ Outer Dome Surface
30	KZ	-3657.60	0.126879	1	\$ Hole in Dome			

ml \$ Air at 80°F and 20.0% Relative Humidity

1001.01p	-0.00048	\$ Hydrogen
6012.01p	-0.00014	\$ Carbon
7014.01p	-0.75191	\$ Nitrogen

```

      8016.01p -0.23464 $ Oxygen
      18040.01p -0.01282 $ Argon
m2 $ Hanford Soil with 0.10 ml/cc Water
      1001.01p -0.00617 $ Hydrogen
      8016.01p -0.47331 $ Oxygen
      11023.01p -0.01678 $ Sodium
      12000.01p -0.02722 $ Magnesium
      13027.01p -0.06864 $ Aluminum
      14000.01p -0.22887 $ Silicon
      15031.01p -0.00222 $ Phosphorus
      19000.01p -0.01068 $ Potassium
      20000.01p -0.05969 $ Calcium
      22000.01p -0.01425 $ Titanium
      25055.01p -0.00151 $ Manganese
      26000.01p -0.09064 $ Iron

```

```

m3 $ Hanford Concrete
      1001.01p -0.00310 $ Hydrogen
      8016.01p -0.44070 $ Oxygen
      11023.01p -0.01820 $ Sodium
      12000.01p -0.03760 $ Magnesium
      13027.01p -0.06070 $ Aluminum
      14000.01p -0.21570 $ Silicon
      15031.01p -0.00090 $ Phosphorus
      16032.01p -0.00090 $ Sulfur
      20000.01p -0.13060 $ Calcium
      22000.01p -0.00490 $ Titanium
      25055.01p -0.00130 $ Manganese
      26000.01p -0.07880 $ Iron
      36000.01p -0.00660 $ Krypton

```

```
m4 $ Plain Iron
```

```
      26000.01p -1.00
```

```
m5 $ Tank Residual Sludge: AX-102
```

```

      1001.01p -0.04722 $ Hydrogen
      6012.01p -0.01731 $ Carbon
      7014.01p -0.03693 $ Nitrogen
      8016.01p -0.64925 $ Oxygen
      11023.01p -0.07560 $ Sodium
      13027.01p -0.03093 $ Aluminum
      14000.01p -0.02249 $ Silicon
      15031.01p -0.00147 $ Phosphorus
      16032.01p -0.00209 $ Sulfur
      17000.01p -0.00075 $ Chlorine
      19000.01p -0.00018 $ Potassium
      20000.01p -0.00506 $ Calcium
      24000.01p -0.00015 $ Chromium
      25055.01p -0.00762 $ Manganese
      26000.01p -0.09060 $ Iron
      28000.01p -0.00344 $ Nickel
      92238.01p -0.00890 $ Uranium

```

```
mode p
```

```
print 40 120
```

```
prdm p j j 1
```

```
phys: p j 1 1
```

```
imp: p 0 1 1 7290 7290 3 7290 7290 8 10 30 90 270 810 2430 7290 14580 3r
```

```
nps 600000
```

```
sdef wgt=5.07E+14 cel=11 erg=d1 pos=d2 ext=d3 rad=d4 axs=d5
```

```
sc1 Source Energy Distribution for AX-102
```

```
# sil spl
```

```

      L      D      $ photon spectrum from ISO-PC
0.0447 1.97E+13 $ energy (MeV) and photons/sec
0.0548 1.44E+13 $
0.0649 1.22E+13 $ total: 5.070E+14
0.0749 1.11E+13
0.0849 1.01E+13
0.0949 9.08E+12
0.1379 4.55E+13
0.2433 1.42E+13
0.3450 6.90E+12
0.4663 5.29E+12
0.6615 3.56E+14
0.8179 1.18E+12
0.9869 8.10E+11
1.2437 4.21E+11
1.4499 1.41E+11
1.7412 1.36E+11
1.8695 7.25E+09
2.1681 4.88E+09

sc2 POS - source position (center of base)
si2 L 0.00 0.00 -1577.34
sp2 D 1
sc3 EXT - source axial distribution (uniform)
si3 L 0.0 7.62
sc4 RAD - source radial distribution (uniform)
si4 L 0.0 1051.56 $ 3 ft from inner tank wall
sp4 D -21 1
sc5 AXS - direction of cylinder axis (vertical)
si5 L 0.0 0.0 1.0
sp5 D 1
c Detector Locations 3 feet above surface
fc05 Over the Tank Dome
f05:p 0.00 0.00 -312.42 10.0 $ 3 ft Below Dome
      0.00 0.00 -91.44 10.0 $ Center
      0.00 571.50 -140.09 10.0 $ Midway
      1143.00 0.00 -307.70 10.0 $ Inner Edge of Tank
fc15 To the East
f15:p 1638.30 0.00 -326.71 10.0 $ Bottom Edge of Excavation
      2265.52 0.00 91.44 10.0 $ Upper Edge of Excavation
      3789.52 0.00 91.44 10.0 $ 50 ft from Excavation
      5313.52 0.00 91.44 10.0 $ 100 ft from Excavation
      6837.52 0.00 91.44 10.0 $ 150 ft from Excavation
      8361.52 0.00 91.44 10.0 $ 200 ft from Excavation
      11409.52 0.00 91.44 10.0 $ 300 ft from Excavation
      14457.52 0.00 91.44 10.0 $ 400 ft from Excavation
c Bins for Photon Tallies
e0 0.03 0.05 0.07 0.10 0.13 0.16 0.20 0.25 0.30 0.40
    0.50 0.70 1.00 1.50 2.00 2.50
c ANSI/ANS-6.1.1-1991 fluence-to-dose, photons/hr/(p/cm**2/s)
de0 log 0.01 0.015 0.02 0.03 0.04 0.05
      0.06 0.08 0.10 0.15 0.20 0.30
      0.40 0.50 0.60 0.80 1.0 1.5
      2.0 3.0 4.0 5.0 6.0 8.0
df0 log 2.232e-5 5.652e-5 8.568e-5 1.184e-4 1.314e-4 1.382e-4
      1.440e-4 1.624e-4 1.919e-4 2.797e-4 3.708e-4 5.616e-4
      7.416e-4 9.144e-4 1.076e-3 1.379e-3 1.656e-3 2.246e-3
      2.758e-3 3.672e-3 4.500e-3 5.292e-3 6.012e-3 7.488e-3

```

ATTACHMENT 3

MCNP RESULTS SHOWING RELATIVE ERRORS REPORTED

Table 19. MCNP Dose Rates 3 Feet Above Surfaces With Soil Removed from Tank Domes -- 99 Percent Retrieval

Detector Location	AX-101 mrem/h	Source % RE	AX-102 mrem/h	Source % RE	AX-103 mrem/h	Source % RE	AX-104 mrem/h	Source % RE	Total mrem/h	Check
Center of the Dome										
AX-101	8.45	5.6	0.19	2.6	0.34	3.5	0.16	6.5	9.13	2.2%
AX-102	0.03	3.8	62.42	5.7	0.16	4.3	0.33	4.2	62.93	0.6%
AX-103	0.04	2.7	0.11	4.3	95.83	9.2	0.25	2.7	96.23	-3.5%
AX-104	0.02	4.0	0.23	2.6	0.26	3.6	99.28	10.6	99.79	3.8%
Midway to Inner Edge of the Dome										
AX-101 north	6.72	5.8	0.14	6.0	0.31	6.9	0.13	4.3	7.29	5.8%
AX-102 south	0.02	3.3	44.24	7.1	0.14	11.6	0.30	3.7	44.70	12.0%
AX-103 north	0.03	4.4	0.09	4.6	61.30	8.0	0.18	6.1	61.60	-12.8%
AX-104 south	0.01	9.0	0.20	2.3	0.19	5.6	69.70	8.4	70.11	7.5%
Inner Edge of the Dome										
AX-101 east	0.10	5.5	0.15	6.8	0.11	3.5	0.09	7.3	0.45	-7.4%
AX-102 east	0.02	4.9	0.72	5.6	0.09	5.4	0.11	5.2	0.94	-4.9%
AX-103 west	0.01	10.5	0.06	4.3	1.12	6.9	0.18	3.1	1.37	-31.6%
AX-104 west	0.01	3.3	0.09	4.7	0.19	4.2	1.54	15.6	1.82	3.1%
North-South Line Between Tanks										
100 ft N of Excavation	0.01	34.5	0.03	4.3	0.09	4.5	0.04	4.9	0.16	-1.3%
50 ft N of Excavation	0.02	6.5	0.04	2.9	0.13	3.1	0.07	17.4	0.26	-1.7%
N Edge of Excavation	0.05	3.5	0.08	3.7	0.45	2.7	0.10	3.0	0.67	-8.2%
Between AX-101 & AX-103	0.07	3.3	0.14	5.0	0.65	4.2	0.19	6.2	1.04	1.6%
Center Point	0.04	3.1	0.29	3.4	0.36	3.2	0.37	4.5	1.06	-2.0%
Between AX-102 & AX-104	0.02	4.1	0.46	4.4	0.18	3.4	0.64	4.7	1.30	-3.3%
S Edge of Excavation	0.01	4.4	0.33	2.9	0.12	9.2	0.49	4.6	0.95	14.1%
50 ft S of Excavation	0.01	5.7	0.10	6.7	0.09	25.8	0.14	3.9	0.34	24.6%
100 ft S of Excavation	0.00	4.5	0.06	3.0	0.04	6.1	0.09	6.1	0.19	10.0%
East-West Line Between Tanks										
100 ft E of Excavation	0.01	9.5	0.06	5.4	0.04	6.0	0.04	4.4	0.15	6.1%
50 ft E of Excavation	0.01	5.2	0.10	3.7	0.08	12.3	0.08	16.5	0.28	0.9%
E Edge of Excavation	0.05	3.2	0.30	2.7	0.12	4.0	0.13	7.5	0.59	-9.6%
Between AX-101 & AX-102	0.05	2.7	0.39	3.0	0.20	3.6	0.19	3.2	0.84	4.7%
Between AX-103 & AX-104	0.02	4.7	0.16	5.5	0.56	4.9	0.52	3.6	1.27	6.3%
W Edge of Excavation	0.01	4.3	0.09	4.4	0.43	3.8	0.45	7.1	0.98	-4.3%
50 ft W of Excavation	0.01	15.9	0.05	7.3	0.13	3.4	0.13	4.3	0.32	-0.2%
100 ft W of Excavation	0.00	4.1	0.03	5.1	0.09	12.6	0.08	3.0	0.20	14.1%

Table 19. MCNP Dose Rates 3 Feet Above Surfaces With Soil Removed from Tank Domes -- 99 Percent Retrieval (cont'd)

Detector Location	AX-101 Source mrem/h	Source % RE	AX-102 Source mrem/h	Source % RE	AX-103 Source mrem/h	Source % RE	AX-104 Source mrem/h	Source % RE	Total mrem/h	Check
Other Points Near Excavation										
NE Corner	0.03	4.7	0.08	16.4	0.10	2.8	0.07	13.4	0.29	1.7%
AX-101 east	0.07	2.2	0.16	4.6	0.12	2.7	0.09	5.5	0.44	-1.4%
AX-102 east	0.02	3.1	0.47	2.5	0.12	17.7	0.12	3.2	0.74	28.5%
SE Corner	0.01	4.2	0.21	3.6	0.06	12.6	0.10	3.1	0.39	-13.6%
NW Corner	0.01	4.7	0.04	5.4	0.32	4.6	0.09	4.8	0.47	5.4%
AX-103 west	0.02	11.3	0.07	7.4	0.73	5.4	0.20	3.6	1.02	1.2%
AX-104 west	0.01	5.4	0.09	4.8	0.21	4.4	0.72	4.7	1.03	1.3%
SW Corner	0.01	8.1	0.08	3.4	0.09	3.8	0.30	3.4	0.47	-2.7%

The column labeled "Check" compares the AX-103 dose rate with the mirror image dose rate location for AX-104. Since the sources are the same, the dose rates at mirror image locations should be the same. The dose rates shown above were also listed in Table 7.

Table 20. MCNP Dose Rates 3 Feet Above Surfaces With a Tank Dome Removed -- 99 Percent Retrieval

Detector Location	AX-101 mrem/h	Source % RE	AX-102 mrem/h	Source % RE	AX-103 mrem/h	Source % RE	AX-104 mrem/h	Source % RE	Total mrem/h	Check
Center of the Dome										
AX-101	1,943	0.5	103	2.5	236	4.8	115	7.7	2,397	1.8%
AX-102	14	4.7	13,750	0.3	111	4.9	232	4.7	14,107	-3.2%
AX-103	18	3.6	63	4.4	20,660	0.7	178	4.6	20,919	0.0%
AX-104	8	3.0	148	14.0	183	5.4	20,660	0.5	20,999	2.6%
Midway to Inner Edge of the Dome										
AX-101 north	1,867	0.6	68	4.2	208	3.6	99	7.1	2,241	-5.8%
AX-102 south	9	3.2	13,300	0.4	91	6.6	220	5.1	13,620	-7.8%
AX-103 north	18	11.2	48	2.4	19,890	0.6	145	13.6	20,101	1.4%
AX-104 south	6	3.3	123	4.3	125	9.1	19,610	0.4	19,864	-14.6%
Inner Edge of the Dome										
AX-101 east	1,543	0.8	74	3.1	93	5.8	61	3.0	1,771	10.2%
AX-102 east	10	4.6	11,140	1.5	67	9.6	84	3.3	11,301	9.5%
AX-103 west	7	9.4	34	2.9	15,950	0.5	130	3.3	16,122	-0.4%
AX-104 west	5	4.8	51	7.8	140	5.6	16,020	0.6	16,215	7.0%
North-South Line Between Tanks										
100 ft N of Excavation	5	9.9	16	4.0	60	4.1	35	15.5	116	-12.1%
50 ft N of Excavation	8	4.9	25	5.2	93	2.3	45	7.3	171	-8.6%
N Edge of Excavation	24	3.9	40	2.7	293	3.7	70	5.0	427	-3.7%
Between AX-101 & AX-103	67	3.6	72	4.2	785	2.4	133	4.5	1,057	-5.7%
Center Point	22	3.6	164	4.4	310	9.5	263	2.1	759	16.4%
Between AX-102 & AX-104	11	12.7	475	2.6	131	4.6	832	3.7	1,449	-1.4%
S Edge of Excavation	6	9.3	172	2.3	80	12.9	304	3.1	563	14.1%
50 ft S of Excavation	4	18.8	60	4.4	54	15.3	101	4.3	219	17.4%
100 ft S of Excavation	2	4.9	33	2.2	26	3.5	68	7.6	128	-29.8%
East-West Line Between Tanks										
100 ft E of Excavation	5	6.2	44	27.3	34	12.8	30	7.9	113	13.7%
50 ft E of Excavation	8	5.9	63	6.8	48	6.5	42	3.1	161	11.3%
E Edge of Excavation	23	6.4	182	7.2	80	5.3	83	7.2	368	-3.9%
Between AX-101 & AX-102	40	4.0	289	3.0	144	3.3	142	4.0	615	1.4%
Between AX-103 & AX-104	11	3.4	85	4.0	519	3.0	507	2.9	1,121	2.3%
W Edge of Excavation	7	7.5	45	4.4	275	3.6	274	4.0	601	0.3%
50 ft W of Excavation	4	6.0	28	11.3	93	2.8	103	5.1	226	-10.0%
100 ft W of Excavation	3	7.0	19	9.2	59	4.6	57	2.9	137	2.1%

Table 20. MCNP Dose Rates 3 Feet Above Surfaces With a Tank Dome Removed -- 99 Percent Retrieval (cont'd)

Detector Location	AX-101 mrem/h	Source % RE	AX-102 mrem/h	Source % RE	AX-103 mrem/h	Source % RE	AX-104 mrem/h	Source % RE	Total mrem/h	Check
Other Points Near Excavation										
NE Corner	17	8.7	38	5.7	69	5.6	44	5.2	168	3.4%
AX-101 east	35	3.0	81	4.4	87	5.9	64	9.4	267	-5.9%
AX-102 east	11	4.5	249	1.7	69	11.8	92	9.9	422	6.6%
SE Corner	5	3.2	119	6.3	38	3.4	67	2.9	229	-13.4%
NW Corner	6	9.5	27	11.8	213	7.2	63	4.7	310	10.2%
AX-103 west	7	6.6	37	5.3	430	3.8	142	6.7	616	-2.5%
AX-104 west	5	2.6	47	3.5	133	2.5	440	3.6	625	-6.5%
SW Corner	3	10.6	40	2.6	63	5.0	193	4.9	299	-0.6%

The column labeled "Check" compares the AX-103 dose rate with the mirror image dose rate location for AX-104. Since the sources are the same, the dose rates at mirror image locations should be the same. The dose rates shown above are strictly for the source identified in the column heading. The dose rates from residual activity in the tanks is not included. The values shown on Table 8 are the sum of these numbers and the other three columns shown on the previous table (domes intact).

Table 21. Single Tank Dose Rates After Excavation (Dome Intact) -- 99 Percent Retrieval

Detector Location	No Shield		70.5 lb/ft ²		141 lb/ft ²		211.5 lb/ft ²	
	mrem/h	% RE	mrem/h	% RE	mrem/h	% RE	mrem/h	% RE
Tank AX-101 Source								
3 ft Below Dome	2.9E+03	0.2	3.7E+02	0.3	3.6E+01	0.5	3.2E+00	0.8
Center of Tank	8.7E+00	3.2	9.5E-01	5.1	1.1E-01	11.0	6.1E-03	11.4
Midway to Edge	6.8E+00	3.8	6.7E-01	6.2	6.0E-02	8.3	5.7E-03	22.3
Inner Edge of Tank	1.1E-01	7.9	1.1E-02	6.1	8.7E-04	7.7	9.7E-05	18.8
Bottom Edge of Excavation	5.8E-02	3.8	5.7E-03	3.8	5.7E-04	9.5	4.9E-05	9.9
Upper Edge of Excavation	7.2E-02	2.0	7.6E-03	4.0	6.4E-04	5.6	5.7E-05	8.0
50 ft from Excavation	1.7E-02	3.5	1.8E-03	7.0	1.6E-04	5.1	1.3E-05	7.3
100 ft from Excavation	1.0E-02	6.4	9.5E-04	3.5	1.2E-04	22.9	8.8E-06	13.9
150 ft from Excavation	6.4E-03	6.4	6.5E-04	6.3	6.1E-05	6.3	5.9E-06	17.8
200 ft from Excavation	4.7E-03	8.9	4.3E-04	5.7	4.2E-05	7.3	4.2E-06	22.4
300 ft from Excavation	2.5E-03	6.7	2.0E-04	4.1	2.2E-05	9.4	1.6E-06	8.0
400 ft from Excavation	1.5E-03	16.7	1.3E-04	11.3	2.6E-05	53.4	9.8E-07	9.5
Tank AX-102 Source								
3 ft Below Dome	2.1E+04	0.2	2.6E+03	0.3	2.4E+02	0.5	2.2E+01	1.0
Center of Tank	5.8E+01	3.1	5.5E+00	4.4	6.8E-01	13.2	6.1E-02	18.9
Midway to Edge	4.3E+01	4.0	4.6E+00	6.4	5.0E-01	14.4	2.8E-02	12.6
Inner Edge of Tank	7.1E-01	3.9	6.7E-02	5.8	5.5E-03	8.1	4.9E-04	11.3
Bottom Edge of Excavation	3.9E-01	4.7	3.7E-02	6.8	3.4E-03	10.6	2.7E-04	7.6
Upper Edge of Excavation	4.9E-01	2.0	5.1E-02	5.6	4.1E-03	4.0	3.8E-04	6.5
50 ft from Excavation	1.2E-01	4.4	1.2E-02	8.1	1.0E-03	6.5	9.0E-05	9.2
100 ft from Excavation	7.6E-02	10.5	6.4E-03	6.8	5.5E-04	4.7	5.9E-05	12.4
150 ft from Excavation	4.4E-02	5.0	4.1E-03	5.4	4.9E-04	18.8	3.7E-05	10.6
200 ft from Excavation	3.1E-02	6.8	2.8E-03	4.3	2.3E-04	4.7	2.5E-05	11.5
300 ft from Excavation	1.6E-02	5.0	1.5E-03	7.1	1.7E-04	31.3	2.3E-05	50.0
400 ft from Excavation	9.2E-03	7.5	8.8E-04	7.1	7.3E-05	9.2	8.1E-06	24.7

Table 21. Single Tank Dose Rates After Excavation (Dome Intact) -- 99 Percent Retrieval (cont'd)

Detector Location	No Shield		70.5 lb/ft ²		141 lb/ft ²		211.5 lb/ft ²	
	mrem/h	% RE	mrem/h	% RE	mrem/h	% RE	mrem/h	% RE
Tank AX-103/104 Source								
3 ft Below Dome	3.1E+04	0.2	3.3E+03	0.5	3.3E+02	0.8	3.4E+01	1.4
Center of Tank	8.3E+01	5.6	1.1E+01	8.4	1.7E+00	21.5	2.0E-01	23.0
Midway to Edge	6.3E+01	7.7	6.4E+00	8.8	9.9E-01	21.4	1.0E-01	22.9
Inner Edge of Tank	1.1E+00	9.3	9.2E-02	5.2	1.3E-02	11.3	1.5E-03	16.1
Bottom Edge of Excavation	5.2E-01	7.6	5.1E-02	4.7	6.8E-03	7.7	7.8E-04	10.7
Upper Edge of Excavation	7.3E-01	5.2	8.3E-02	11.0	9.8E-03	7.9	1.1E-03	8.9
50 ft from Excavation	1.5E-01	7.2	1.5E-02	3.9	2.1E-03	11.5	2.3E-04	9.8
100 ft from Excavation	9.6E-02	8.3	1.4E-02	21.2	1.3E-03	9.8	1.2E-04	7.4
150 ft from Excavation	6.8E-02	17.2	6.8E-03	10.3	7.4E-04	11.1	8.2E-05	9.4
200 ft from Excavation	4.2E-02	12.8	4.1E-03	5.2	4.5E-04	6.0	5.1E-05	7.4
300 ft from Excavation	2.3E-02	12.6	2.8E-03	24.1	2.2E-04	5.2	5.4E-05	52.7
400 ft from Excavation	1.2E-02	8.5	1.2E-03	6.1	1.3E-04	6.8	2.0E-05	17.0

Note: Dose rates are computed at a height of 3 feet above the surfaces.

Table 22. Single Tank Dose Rates With Dome Removed -- 99 Percent Retrieval

Detector Location	No Shield		70.5 lb/ft ²		141 lb/ft ²		211.5 lb/ft ²	
	mrem/h	% RE	mrem/h	% RE	mrem/h	% RE	mrem/h	% RE
Tank AX-101 Source								
3 ft Below Dome	2.5E+03	0.9	3.1E+02	0.4	3.0E+01	0.7	2.8E+00	2.2
Center of Tank	1.9E+03	0.5	2.6E+02	0.3	2.5E+01	0.5	2.3E+00	0.8
Midway to Edge	1.9E+03	0.3	2.4E+02	0.5	2.3E+01	0.5	2.1E+00	0.9
Inner Edge of Tank	1.5E+03	0.4	1.6E+02	0.5	1.4E+01	0.7	1.2E+00	1.1
Bottom Edge of Excavation	3.6E+01	3.2	4.2E+00	2.7	4.6E-01	3.8	3.8E-02	3.1
Upper Edge of Excavation	3.6E+01	2.0	4.0E+00	2.3	3.9E-01	2.4	3.4E-02	2.5
50 ft from Excavation	8.7E+00	3.6	1.1E+00	3.9	1.3E-01	9.0	9.6E-03	3.9
100 ft from Excavation	5.1E+00	4.3	6.2E-01	2.7	7.5E-02	11.7	5.6E-03	4.4
150 ft from Excavation	3.2E+00	2.9	4.2E-01	3.0	4.4E-02	7.2	3.8E-03	6.9
200 ft from Excavation	2.5E+00	6.5	3.1E-01	5.3	2.7E-02	3.3	3.2E-03	22.3
300 ft from Excavation	1.3E+00	7.9	1.4E-01	2.8	1.4E-02	2.6	1.4E-03	8.9
400 ft from Excavation	8.0E-01	8.3	9.8E-02	11.7	8.4E-03	7.0	7.6E-04	7.7
Tank AX-102 Source								
3 ft Below Dome	1.8E+04	0.9	2.2E+03	0.3	2.0E+02	0.6	1.8E+01	2.3
Center of Tank	1.4E+04	0.5	1.8E+03	0.3	1.7E+02	0.5	1.5E+01	0.9
Midway to Edge	1.3E+04	0.3	1.6E+03	0.7	1.5E+02	0.6	1.4E+01	0.9
Inner Edge of Tank	1.1E+04	0.4	1.1E+03	0.8	9.5E+01	0.8	8.2E+00	1.1
Bottom Edge of Excavation	2.8E+02	3.1	3.0E+01	2.8	2.9E+00	3.1	2.5E-01	4.4
Upper Edge of Excavation	2.7E+02	1.7	2.7E+01	1.7	2.5E+00	1.8	2.2E-01	2.2
50 ft from Excavation	6.8E+01	4.3	7.3E+00	2.6	6.9E-01	2.2	6.5E-02	3.4
100 ft from Excavation	4.2E+01	6.8	4.4E+00	4.0	4.6E-01	5.5	4.0E-02	5.6
150 ft from Excavation	2.4E+01	2.8	2.8E+00	3.2	2.8E-01	3.7	2.3E-02	3.6
200 ft from Excavation	1.7E+01	3.6	2.1E+00	5.8	1.8E-01	3.7	1.7E-02	4.0
300 ft from Excavation	1.0E+01	19.1	1.0E+00	3.4	9.9E-02	5.8	8.6E-03	6.1
400 ft from Excavation	5.0E+00	5.2	5.9E-01	7.5	5.6E-02	7.8	4.8E-03	7.9

Table 22. Single Tank Dose Rates With Dome Removed -- 99 Percent Retrieval

Detector Location	No Shield		70.5 lb/ft ²		141 lb/ft ²		211.5 lb/ft ²	
	mrem/h	% RE	mrem/h	% RE	mrem/h	% RE	mrem/h	% RE
Tank AX-103/104 Source								
3 ft Below Dome	2.7E+04	1.7	2.8E+03	1.2	2.8E+02	0.9	2.9E+01	1.7
Center of Tank	2.1E+04	0.3	2.3E+03	0.8	2.4E+02	0.9	2.5E+01	1.6
Midway to Edge	2.0E+04	0.3	2.1E+03	0.6	2.1E+02	1.0	2.2E+01	1.8
Inner Edge of Tank	1.6E+04	0.5	1.4E+03	0.7	1.3E+02	1.3	1.3E+01	2.0
Bottom Edge of Excavation	4.6E+02	2.6	3.7E+01	3.9	3.5E+00	4.0	3.7E-01	5.1
Upper Edge of Excavation	4.5E+02	2.5	3.5E+01	3.0	3.2E+00	3.0	3.2E-01	3.0
50 ft from Excavation	1.2E+02	5.9	1.2E+01	10.3	9.2E-01	4.0	8.6E-02	3.5
100 ft from Excavation	6.9E+01	6.7	5.3E+00	2.7	6.0E-01	10.1	5.0E-02	4.2
150 ft from Excavation	3.9E+01	2.4	3.4E+00	3.0	3.4E-01	3.3	3.4E-02	5.8
200 ft from Excavation	2.6E+01	2.7	2.6E+00	5.8	2.5E-01	8.0	2.9E-02	18.9
300 ft from Excavation	1.4E+01	5.2	1.4E+00	8.5	1.3E-01	8.1	1.3E-02	8.6
400 ft from Excavation	7.3E+00	4.0	7.1E-01	7.1	6.3E-02	4.7	7.2E-03	8.8

ATTACHMENT 4

ISO-PC INPUT FOR TANK DEBRIS REMOVAL

Table 23. 4 m² Source Representing Exposed Tank Bottom

```

0          2 Dose Rates Near 241-AX Exposed Waste -- 4 m²
101-AX at 10, 15, 20, 25, 30, 35, 40, 50, 70, 100 feet
&Input IGeom= 9, SLTH= 112.84, T= 7.62,0.953, NShld= 2, JBuf= 1,
X= 313.37,465.77,618.17,770.57,922.97,1075.37,1227.77,1532.57,
2142.17,3056.57, NTheta= 53, DUnit= 1, SFact= 0.01151, DosePrfx= -3,
Weight(472)= 2.2, Weight(82)= 7238.0, Weight(84)= 7238.0,
Weight(141)= 1.70, Weight(269)= 0.00, Weight(270)= 0.00,
Weight(335)= 1684, Weight(336)= 1593.1, Weight(403)= 0.05,
Weight(415)= 0.0, Weight(418)= 0.0 &
Ag 38 0.0005
Al 7 0.0454
Ba 39 0.0008
Bi 14 0.0017
Ca 33 0.0026
Cl 30 0.0135
CO3 23 0.0368
Cr 34 0.0122
Fe 9 0.0279 7.86
K 32 0.0049
La 39 0.0002
Mn 34 0.0046
Na 25 0.2586
Ni 10 0.0008
NOx 23 0.3610
O 23 0.1998
Pb 14 0.0022
PO4 28 0.0170
Si 27 0.0166
SO4 29 0.0077
Sr 18 0.0001
C 6 0.0186
U 15 0.0392
Zr 11 0.0016
1 H2O 1 0.5608
102-AX
&Input Weight(472)= 0.0, Weight(82)= 82340.0, Weight(84)= 82340.0,
Weight(141)= 3.80, Weight(269)= 0.00, Weight(270)= 0.00,
Weight(335)= 11195, Weight(336)= 10590.5, Weight(403)= 1480,
Weight(415)= 0.0, Weight(418)= 0.0 &
Al 7 0.0486
Ca 33 0.0079
Cl 30 0.0012
CO3 23 0.0272
Cr 34 0.0002
Fe 9 0.1422 7.86
K 32 0.0003
Mn 34 0.0120
Na 25 0.1187
Ni 10 0.0054
NOx 23 0.0580
O 23 0.4262
PO4 28 0.0023
Si 27 0.0353
SO4 29 0.0033
U 15 0.0140
1 H2O 1 0.6673

```

103-AX

&Input Weight(472)= 61.7, Weight(82)= 527850.0, Weight(84)= 527850.0,
 Weight(141)= 2.02, Weight(269)= 25.70, Weight(270)= 6.30,
 Weight(335)= 10820, Weight(336)= 10235.7, Weight(403)= 2250,
 Weight(415)= 449.0, Weight(418)= 351.0 &

Al	7	0.0667	
Ba	39	0.0028	
Ca	33	0.0262	
Cr	34	0.0031	
Fe	9	0.2953	7.86
Mg	26	0.0041	
Mn	34	0.0046	
Na	25	0.0767	
Ni	10	0.0153	
NOx	23	0.0038	
O	23	0.4431	
PO4	28	0.0105	
Si	27	0.0697	
S04	29	0.0129	
1 H2O	1	0.7650	

104-AX

&Input Weight(472)= 61.7, Weight(82)= 527850.0, Weight(84)= 527850.0,
 Weight(141)= 1.83, Weight(269)= 25.70, Weight(270)= 6.30,
 Weight(335)= 10820, Weight(336)= 10235.7, Weight(403)= 4000,
 Weight(415)= 449.0, Weight(418)= 351.0 &

Al	7	0.0667	
Ba	39	0.0028	
Ca	33	0.0262	
Cr	34	0.0031	
Fe	9	0.2953	7.86
Mg	26	0.0041	
Mn	34	0.0046	
Na	25	0.0767	
Ni	10	0.0153	
NOx	23	0.0038	
O	23	0.4431	
PO4	28	0.0105	
Si	27	0.0697	
S04	29	0.0129	
1 H2O	1	0.7650	

This is the End of the 241-AX Cases !!

&Input Next= 6 &

Table 24. 4 m² Source Representing Debris Removal -- 2 inches of Iron Shielding

```

0      2 Dose Rates Near 241-AX Exposed Waste -- 2 inch Fe Shield
101-AX at 10, 15, 20, 25, 30, 35, 40, 50, 70, 100 feet
&Input IGeom= 9, SLTH= 112.84, T= 7.62,6.033, NShld= 2, JBuf= 2,
X= 313.37,465.77,618.17,770.57,922.97,1075.37,1227.77,1532.57,
2142.17,3056.57, NTheta= 53, DUnit= 1, SFact= 0.01151, DosePrfx= -3,
Weight(472)= 2.2, Weight(82)= 7238.0, Weight(84)= 7238.0,
Weight(141)= 1.70, Weight(269)= 0.00, Weight(270)= 0.00,
Weight(335)= 1684, Weight(336)= 1593.1, Weight(403)= 0.05,
Weight(415)= 0.0, Weight(418)= 0.0 &
Ag 38 0.0005
Al 7 0.0454
Ba 39 0.0008
Bi 14 0.0017
Ca 33 0.0026
Cl 30 0.0135
CO3 23 0.0368
Cr 34 0.0122
Fe 9 0.0279 7.86
K 32 0.0049
La 39 0.0002
Mn 34 0.0046
Na 25 0.2586
Ni 10 0.0008
NOx 23 0.3610
O 23 0.1998
Pb 14 0.0022
PO4 28 0.0170
Si 27 0.0166
SO4 29 0.0077
Sr 18 0.0001
C 6 0.0186
U 15 0.0392
Zr 11 0.0016
1 H2O 1 0.5608
102-AX
&Input Weight(472)= 0.0, Weight(82)= 82340.0, Weight(84)= 82340.0,
Weight(141)= 3.80, Weight(269)= 0.00, Weight(270)= 0.00,
Weight(335)= 11195, Weight(336)= 10590.5, Weight(403)= 1480,
Weight(415)= 0.0, Weight(418)= 0.0 &
Al 7 0.0486
Ca 33 0.0079
Cl 30 0.0012
CO3 23 0.0272
Cr 34 0.0002
Fe 9 0.1422 7.86
K 32 0.0003
Mn 34 0.0120
Na 25 0.1187
Ni 10 0.0054
NOx 23 0.0580
O 23 0.4262
PO4 28 0.0023
Si 27 0.0353
SO4 29 0.0033
U 15 0.0140
1 H2O 1 0.6673

```

103-AX

```

&Input Weight(472)= 61.7, Weight(82)= 527850.0, Weight(84)= 527850.0,
Weight(141)= 2.02, Weight(269)= 25.70, Weight(270)= 6.30,
Weight(335)= 10820, Weight(336)= 10235.7, Weight(403)= 2250,
Weight(415)= 449.0, Weight(418)= 351.0 &
Al 7 0.0667
Ba 39 0.0028
Ca 33 0.0262
Cr 34 0.0031
Fe 9 0.2953 7.86
Mg 26 0.0041
Mn 34 0.0046
Na 25 0.0767
Ni 10 0.0153
NOx 23 0.0038
O 23 0.4431
P04 28 0.0105
Si 27 0.0697
S04 29 0.0129
1 H2O 1 0.7650

```

104-AX

```

&Input Weight(472)= 61.7, Weight(82)= 527850.0, Weight(84)= 527850.0,
Weight(141)= 1.83, Weight(269)= 25.70, Weight(270)= 6.30,
Weight(335)= 10820, Weight(336)= 10235.7, Weight(403)= 4000,
Weight(415)= 449.0, Weight(418)= 351.0 &
Al 7 0.0667
Ba 39 0.0028
Ca 33 0.0262
Cr 34 0.0031
Fe 9 0.2953 7.86
Mg 26 0.0041
Mn 34 0.0046
Na 25 0.0767
Ni 10 0.0153
NOx 23 0.0038
O 23 0.4431
P04 28 0.0105
Si 27 0.0697
S04 29 0.0129
1 H2O 1 0.7650

```

This is the End of the 241-AX Cases !!

&Input Next= 6 &

Table 25. ISO-PC Input File for Shipping Container Design

```

1      3 Shipping Box for Hot Rubble (1:1.2:4) -- 2in & 1m & 10m
4 inch Iron Walls -- 2.87'x3.44'x11.48'
&Input SLTH= 349.91, Y= 87.48, T= 104.97,10.16, X= 120.21,215.13,1115.13,
IGeom= 10, NShld= 2, JBuf= 2, NTheta= 35, NPsi= 25,
DosePrfx=-3, IConc= 2, SFact= 17.66, Source= 3.15E+10,0.662 &
Conc 16 1.630
1 Iron 9 0.005 7.86
3 inch Iron Walls -- 3.13'x3.76'x12.52'
&Input SLTH= 381.61, Y= 95.40, T= 114.48,7.62, X= 127.18,222.10,1122.10,
Next= 4 &
2 inch Iron Walls -- 3.44'x4.13'x13.76'
&Input SLTH= 419.40, Y= 104.85, T= 125.83,5.08, X= 135.98,230.90,1130.90 &
End of Rubble Box Cases
&Input Next= 6 &

```

Wall Thick	Rubble Vol.	Rubble Wt.	Iron Wt.
4 inch	113 cu.ft	11,570 lb	26,330 lb
3 inch	147 cu.ft	15,010 lb	22,810 lb
2 inch	195 cu.ft	19,930 lb	17,930 lb

Total weight of loaded box is about 38,000 pounds.

ATTACHMENT 5

ISO-PC INPUT FILE FOR 3 INCH LAYERS

```

1      2 Effect of Exponential Distribution
First 3 inches -- Sr-90
&Input SLTH= 1688.6, IGeom= 9, T= 7.62, NShld= 1, X= 107.62,
  NTheta= 93, DUnit= 1, DosePrfx= -3, SFact= 0.9857,
  IConc= 3, SrcPrfx= -9, Weight(82)= 1.0.1 &
1 Soil 21 2.24
Second 3 inches (0.25 to 0.50 feet)
&Input T= 7.62, 7.62, X= 115.24, SFact= 0.9578, NShld= 2 &
1 Soil 21 2.24 2.24
Third 3 inches (0.50 to 0.75 feet)
&Input T= 7.62,15.24, X= 122.86, SFact= 0.9306, Next= 4 &
Fourth 3 inches (0.75 to 1.00 feet)
&Input T= 7.62,22.86, X= 130.48, SFact= 0.9042 &
Fifth 3 inches (1.00 to 1.25 feet)
&Input T= 7.62,30.48, X= 138.10, SFact= 0.8785 &
Sixth 3 inches (1.25 to 1.50 feet)
&Input T= 7.62,38.10, X= 145.72, SFact= 0.8536 &
Seventh 3 inches (1.50 to 1.75 feet)
&Input T= 7.62,45.70, X= 153.34, SFact= 0.8294 &
Eighth 3 inches (1.75 to 2.00 feet)
&Input T= 7.62,53.34, X= 160.96, SFact= 0.8059 &
First 3 inches -- Cs-137
&Input T= 7.62, X= 107.62, SFact= 0.9857, NShld= 1,
  Next= 1, Weight(82)= 3*0, Weight(335)= 1.0.946 &
1 Soil 21 2.24
Second 3 inches (0.25 to 0.50 feet)
&Input T= 7.62, 7.62, X= 115.24, SFact= 0.9578, NShld= 2 &
1 Soil 21 2.24 2.24
Third 3 inches (0.50 to 0.75 feet)
&Input T= 7.62,15.24, X= 122.86, SFact= 0.9306, Next= 4 &
Fourth 3 inches (0.75 to 1.00 feet)
&Input T= 7.62,22.86, X= 130.48, SFact= 0.9042 &
Fifth 3 inches (1.00 to 1.25 feet)
&Input T= 7.62,30.48, X= 138.10, SFact= 0.8785 &
Sixth 3 inches (1.25 to 1.50 feet)
&Input T= 7.62,38.10, X= 145.72, SFact= 0.8536 &
Seventh 3 inches (1.50 to 1.75 feet)
&Input T= 7.62,45.70, X= 153.34, SFact= 0.8294 &
Eighth 3 inches (1.75 to 2.00 feet)
&Input T= 7.62,53.34, X= 160.96, SFact= 0.8059 &
This is the End of the 241-AX Layer Cases !!
&Input Next= 6 &

```

ATTACHMENT 6

ISO-PC INPUT FILE FOR 2 FOOT LAYERS

```

1      2 241-AX Hot Soil -- 2 ft Depth -- 1 nCi/g
2.56 ft radius -- Sr-90
&Input SLTH= 77.9, IGeom= 9, T= 60.96, NShld= 1, X= 160.96,
  NTheta= 73, DUnit= 1, DosePrfx= -3,
  IConc= 3, SrcPrfx= -9, Weight(82)= 1.0,1 &
1 Soil 21 2.24
3.97 ft radius -- Sr-90
&Input SLTH= 120.9, Next= 4 &
6.16 ft radius -- Sr-90
&Input SLTH= 187.6 &
9.55 ft radius -- Sr-90
&Input SLTH= 291.2 &
14.8 ft radius -- Sr-90
&Input SLTH= 451.9 &
23.0 ft radius -- Sr-90
&Input SLTH= 701.2 &
35.7 ft radius -- Sr-90
&Input SLTH= 1088.1 &
55.4 ft radius -- Sr-90
&Input SLTH= 1688.6 &
86.0 ft radius -- Sr-90
&Input SLTH= 2620.4 &
133 ft radius -- Sr-90
&Input SLTH= 4066.4 &
207 ft radius -- Sr-90
&Input SLTH= 6310.3 &
321 ft radius -- Sr-90
&Input SLTH= 9792.4 &
499 ft radius -- Sr-90
&Input SLTH= 15196 &
2.56 ft radius -- Cs-137
&Input SLTH= 77.9, Weight(82)= 0.0,0, Weight(335)= 1.0,946 &
3.97 ft radius -- Cs-137
&Input SLTH= 120.9, Next= 4 &
6.16 ft radius -- Cs-137
&Input SLTH= 187.6 &
9.55 ft radius -- Cs-137
&Input SLTH= 291.2 &
14.8 ft radius -- Cs-137
&Input SLTH= 451.9 &
23.0 ft radius -- Cs-137
&Input SLTH= 701.2 &
35.7 ft radius -- Cs-137
&Input SLTH= 1088.1 &
55.4 ft radius -- Cs-137
&Input SLTH= 1688.6 &

```

<<same SLTH values as Sr-90 case>>

This is the End of the 241-AX Cases !!
 &Input Next= 6 &

ATTACHMENT 7

ISO-PC INPUT FILE FOR SQUARE SOURCES


```

1      2 241-AX Hot Soil -- Square Model
8,000 gallon leak -- Center -- Sr-90
&Input IGeom= 10, SLTH= 1927.1, Y= 1927.1, T= 60.96, X= 160.96.
  NTheta= 33, NPsi= 33, DUnit= 1, DosePrfx= -3, NShld= 1,
  IConc= 3, SrcPrfx= -9, Weight(82)= 1.0.1 &
1 Soil 21 2.24
8,000 gallon leak --- Edge --- Sr-90
&Input SLTH= 3854.2, SFact= 0.5, Next= 4 &
40,000 gallon leak -- Center -- Sr-90
&Input SLTH= 2994, Y= 2994, SFact= 1 &
40,000 gallon leak --- Edge --- Sr-90
&Input SLTH= 5988, SFact= 0.5 &
8,000 gallon leak -- Center -- Cs-137
&Input SLTH= 1927.1, Y= 1927.1, SFact= 1,
  Weight(82)= 3*0, Weight(335)= 1.0, 0.946 &
8,000 gallon leak --- Edge --- Cs-137
&Input SLTH= 3854.2, SFact= 0.5 &
40,000 gallon leak -- Center -- Cs-137
&Input SLTH= 2994, Y= 2994, SFact= 1 &
40,000 gallon leak --- Edge --- Cs-137
&Input SLTH= 5988, SFact= 0.5 &
This is the End of the 241-AX Cases !!
&Input Next= 6 &

```

APPENDIX B

TANK REMOVAL COST ESTIMATE

FLUOR DANIEL NORTHWEST, INC.
COGEMA ENGINEERING CORP.
JOB NO. Z466AAA3
FILE NO. Z466AAA3

** IEST - INTERACTIVE ESTIMATING **
TANK REMOVAL
241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
PHMCR01 - PROJECT COST SUMMARY

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DATE 05/27/98 13:37:26
BY R.OHRT

SORT =====	DESCRIPTION =====	ESCALATED	CONTINGENCY		TOTAL
		TOTAL COST =====	% =====	TOTAL =====	DOLLARS =====
BHI	BECHTEL HANFORD INTERNATIONAL	13,600,000	35	4,760,000	18,360,000
FDNW	FLUOR DANIEL NORTHWEST	24,220,000	38	9,320,000	33,540,000
LMHC	LOCKHEED MARTIN HANFORD CORP.	10,530,000	76	8,000,000	18,530,000
=====					
	SUBTOTAL	48,350,000	46	22,080,000	70,430,000
=====					
SITE	SITE ALLOCATIONS	6,810,000	60	4,090,000	10,900,000
=====					
	TOTAL ESTIMATED CONSTRUCTION COST (TECC)	55,160,000	47	26,170,000	81,330,000

TYPE OF
ESTIMATE PLANNING ESTIMATE MAY 27, 1998

FDNW LEAD
ESTIMATOR *PO* ESTIMATING
MANAGER *[Signature]*

PROJECT
MANAGER

CLIENT

REMARKS:

(ROUNDED/ADJUSTED TO THE NEAREST " 10,000 / 100,000 " - PERCENTAGES NOT RECALCULATED TO REFLECT ROUNDING)

FLUOR DANIEL NORTHWEST, INC.
COGEHA ENGINEERING CORP.
JOB NO. Z466AAA3
FILE NO. Z466AAA3

** IEST - INTERACTIVE ESTIMATING **
TANK REMOVAL
241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
PHNCR02 - WORK BREAKDOWN STRUCTURE (WBS) SUMMARY

PAGE 2 OF 17
DATE 05/27/98 13:37:32
BY R.OHRT

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	SUB TOTAL	SITE ALLOCAT'N	TOTAL DOLLARS		
=====	=====	=====	=====	=====	=====	=====	=====	=====		
111000	DEFINITIVE DESIGN - TANK REMOVAL	1481470	0.00	0	1481470	95	1407397	2888867	758616	3647483
112000	DEFINITIVE DESIGN - BUILDING	1632098	0.00	0	1632098	35	571234	2203332	578595	2781927
113000	SAFETY ANALYSIS	4999996	0.00	0	4999996	100	4999496	9999492	2625867	12625359
119000	DEFINITIVE DESIGN - BACKFILL	125637	0.00	0	125637	15	18846	144483	37941	182424
SUBTOTAL 11	DEFINITIVE DESIGN	8239201	0.00	0	8239201	85	6996973	15236174	4001019	19237193
121000	ENGR'G INSP - TANK REMOVAL	2040481	0.00	0	2040481	40	816192	2856673	750162	3606835
SUBTOTAL 12	ENGINEERING/INSPECTION	2040481	0.00	0	2040481	40	816192	2856673	750162	3606835
131000	CONSTRUCTION MANAGEMENT FOR CPAF	328856	0.00	0	328856	80	263085	591941	156924	748865
132000	CONSTRUCTION MANAGEMENT FOR F/P	2358207	0.00	0	2358207	25	589552	2947759	781451	3729210
SUBTOTAL 13	CONSTRUCTION MANAGEMENT	2687063	0.00	0	2687063	32	852637	3539700	938375	4478075
SUBTOTAL 1	ENGINEERING	12966745	0.00	0	12966745	67	8665802	21632547	5689556	27322103
210000	FDNW PROCUREMENT	7813124	0.00	0	7813124	65	5078531	12891655	3385348	16277003
SUBTOTAL 21	PROCUREMENT	7813124	0.00	0	7813124	65	5078531	12891655	3385348	16277003
310100	CDF FILL TANK BOTTOMS	42303	0.00	0	42303	75	31728	74031	2202	76233
310200	REMOVE SOIL ABOVE TANKS	115384	0.00	0	115384	75	86539	201923	53198	255121
310300	PULVERIZE TANK DOMES	41583	0.00	0	41583	75	31188	72771	20403	93174
310400	REMOVE SOIL AT TANK SIDES	816965	0.00	0	816965	75	612724	1429689	374714	1804403
310500	REMOVE TANK WALLS	183502	0.00	0	183502	75	137627	321129	100468	421597
310600	REMOVE TANK BOTTOMS	194976	0.00	0	194976	75	146232	341208	107345	448553
SUBTOTAL 31	FA CONST-ONSITE E/C	1394713	0.00	0	1394713	75	1046038	2440751	658330	3099081
320700	MAIN BUILDING	11116023	0.00	0	11116023	20	2223204	13339227	1027119	14366346
320800	SUPPORT FACILITY	205110	0.00	0	205110	25	51278	256388	19741	276129
320900	BACKFILL	1256124	0.00	0	1256124	20	251225	1507349	116066	1623415
SUBTOTAL 32	CONSTRUCTION-FIXED PRICE	12577257	0.00	0	12577257	20	2525707	15102964	1162926	16265890

FLUOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
 JOB NO. Z466AAA3
 FILE NO. Z466AAA3

** IEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCRO2 - WORK BREAKDOWN STRUCTURE (WBS) SUMMARY

PAGE 3 OF 17
 DATE 05/27/98 13:37:32
 BY R.OHRT

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	SUB TOTAL	SITE ALLOCAT'N	TOTAL DOLLARS
=====	=====	=====	=====	=====	=====	=====	=====	=====
330200	SOIL DISPOSAL - TOP OF TANKS	1660500	0.00	0	1660500	35	581175	2241675
330400	SOIL DISPOSAL - SURROUNDING TANKS	11688000	0.00	0	11688000	35	4090800	15778800
330500	DISPOSAL - TANK WALL DEBRIS	254880	0.00	0	254880	35	89208	344088
SUBTOTAL 33	DISPOSAL / BURIAL	13603380	0.00	0	13603380	35	4761183	18364563
SUBTOTAL 3	CONSTRUCTION	27575350	0.00	0	27575350	30	8332928	35908278
PROJECT TOTAL		48,355,219	0.00	0	48,355,219	46	22,077,261	70,432,480
							10,896,160	81,328,640

1. ESTIMATE PURPOSE

THIS ESTIMATE WILL BE USED FOR A SCOPING STUDY.

2. ESTIMATE TECHNICAL BASIS

A. THIS ESTIMATE HAS BEEN PREPARED FOR TASK 2 OF THE "HANFORD TANKS INITIATIVE -- SST CLOSURE ASSESSMENT" WORK PACKAGE AWARDED TO SESC, NOW COGEMA ENGINEERING CORP. BY NHC.

B. A DESCRIPTION OF THE TECHNICAL SCOPE OF WORK MAY BE FOUND IN THE FOLLOWING REFERENCE DOCUMENTS:
ATTACHMENT - "SCOPE OF TECHNICAL SERVICES TO BE PROVIDED BY FLUOR DANIEL NORTHWEST" UNDATED.
REQUEST FOR ESTIMATING SERVICES, DATED MARCH 19, 1997.

C. THE FOLLOWING CONSTRAINTS AND/OR SPECIAL CONDITIONS EXIST:

* WORK DONE IN WBS 31XXXX IS DONE IN A CONTROLLED ENVIRONMENT, THE EQUIPMENT OPERATORS ALSO ARE OPERATING IN A SHIELDED, AIR CONDITIONED, BREATHING AIR SUPPLIED CAB. THERE HAS BEEN NO ALLOWANCE FOR BURN-OUT, HOWEVER SWP AND MASK WORK WAS FACTORED ONTO THE PRODUCTIVITY RATES.

* THE ESTIMATE ASSUMES THAT, PRIOR TO INITIATION OF WASTE RETRIEVAL OPERATIONS, CONTROL OF AX TANK FARM WOULD PASS FROM THE CURRENT OPERATIONS ACTIVITY TO A SEPARATE RETRIEVAL FUNCTION. AT COMPLETION OF RETRIEVAL, THE CONTROL WOULD BE GIVEN TO A THIRD ENTITY FOR CLOSURE. CURRENT TANK FARM PRACTICES WOULD CHANGE ALLOWING FOR A MORE PRODUCTIVE WORK SHIFT AND ALLOWING FOR MORE CONVENTIONAL CONSTRUCTION PRACTICES, SIMILAR TO DOE'S ENVIRONMENTAL RESTORATION CONTRACTORS. FOR FURTHER DESCRIPTIONS OF MAJOR ASSUMPTIONS AND CONCEPTS SEE THE COGEMA REPORT "COGEMA RPT25".

D. THIS ESTIMATE ORIGINALLY ISSUED 09/05/97 HAS BEEN UPDATED TO REFLECT LATEST LABOR RATES AND SITE ALLOCATIONS.

3. ESTIMATE METHODOLOGY

A. DIRECT COSTS:

HISTORICAL DATA HAS BEEN USED WHERE JUDGED TO BE PRUDENT, EXPERT OPINION WAS UTILIZED WHEN OTHER METHODS WERE NOT AVAILABLE AND A BOTTOMS-UP APPROACH WAS USED WHEREVER POSSIBLE.

(1) CONSTRUCTION LABOR, MATERIAL AND EQUIPMENT UNITS HAVE BEEN ESTIMATED BASED UPON ONE OR MORE OF THE FOLLOWING STANDARD COMMERCIAL ESTIMATING RESOURCES, PUBLISHED ESTIMATING MANUALS: R.S. MEANS AND RICHARDSON'S PROCESS PLANT CONSTRUCTION ESTIMATING STANDARDS.

THE UNITS MAY HAVE BEEN FACTORED/ADJUSTED BY THE ESTIMATOR AS APPROPRIATE TO REFLECT INFLUENCES BY CONTRACT, WORK SITE, OR OTHER IDENTIFIED PROJECT OR SPECIAL CONDITIONS.

(2) FLUOR DANIEL HANFORD & PROJECT HANFORD MANAGEMENT CONTRACT (PHMC) SUBCONTRACTOR DIRECT COSTS FOR LOCKHEED MARTIN HANFORD CORP., NUMATEC HANFORD CORP. HAVE BEEN PROVIDED BY FDNW PROJECT MANAGEMENT FOR INCLUSION INTO THIS ESTIMATE.

B. DIRECT COST FACTORS

(1) SALES TAX HAS BEEN APPLIED TO ALL MATERIALS AND EQUIPMENT PURCHASES AT 8%.

(2) A FACTOR OF 15% HAS BEEN APPLIED TO DIRECT CRAFT LABOR FOR GENERAL REQUIREMENTS; THIS INCLUDES HAULING MEN AND MATERIAL, CLEAN-UP AND LABOR SUPPORT AND QC INSPECTION.

FLUOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
 JOB NO. 2466AAA3
 FILE NO. 2466AAA3

** TEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCR03 - ESTIMATE BASIS SHEET

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B. DIRECT COST FACTORS (CONT'D)

- (3) A FACTOR OF 23.58% HAS BEEN ADDED TO DIRECT LABOR FOR TECHNICAL SERVICES - THIS INCLUDES CONSTRUCTION OVERHEAD OF; MANAGEMENT, SUPERINTENDENT, DOCUMENT CONTROL, TURNOVER, ENGINEERING, SURVEY AND CLERICAL; QUALITY ASSURANCE ENGINEERING, CONSTRUCTION SUPPORT AND PROJECT MANAGEMENT.
- (4) CONSUMABLES ARE ESTIMATED AT 3.2% OF DIRECT CRAFT LABOR COSTS.
- (5) SPECIAL WORK PROCEDURE (SWP) FACTORS ARE ALREADY INCLUDED IN THE MANHOURS, AS ALL WORK WAS MANLOADED HAVING ALREADY TAKEN INTO CONSIDERATION THE PRODUCTIVITY LOSSES DUE TO MASK WORK, SUIT UP, ZONE WORK, ETC.
- (6) OVERTIME REQUIREMENTS AND SHIFT DIFFERENTIAL PAY FOR CRAFT LABOR ARE UNION NEGOTIATED UNDER THE HANFORD SITE STABILIZATION AGREEMENT. NO PREMIUM PAY WAS JUDGED TO BE NECESSARY FOR THIS WORK.
- (7) GENERAL FOREMAN FACTOR OF 7% HAS BEEN APPLIED TO DIRECT CRAFT LABOR CREWS.
- (8) CONTRACT ADMINISTRATION FACTOR OF 18.75% HAS BEEN APPLIED TO THE DIRECT CONTRACT VALUE WHICH INCLUDES COSTS FOR BID PACKAGE PREPARATION, CONTRACT MANAGEMENT & ADMINISTRATION AND PROJECT MANAGEMENT & PLANNING SUPPORT
- (9) A FACTOR OF 10% HAS BEEN APPLIED TO DIRECT CRAFT LABOR TO ALLOW FOR USAGE OF GOVERNMENT OWNED EQUIPMENT CONTROLLED BY DYNCORP.

C. INDIRECT COSTS

FIXED PRICE CONTRACTOR OVERHEAD, PROFIT, BOND AND INSURANCE COSTS HAVE BEEN APPLIED ARE THE FOLLOWING PERCENTAGES: LABOR =25%, EQUIPMENT USE =25%, MATERIAL =25%, SUBCONTRACT =10%, AND EQUIPMENT =25%, AND ARE REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL REPORT.

D. RATES

- (1) FOR ESTIMATING PURPOSES, AVERAGE FDNW RATES BY OPERATIONS CODE HAVE BEEN DEVELOPED BASED UPON RECENT COST HISTORY AND ADJUSTED TO REFLECT INDUSTRY AVERAGE AE/CM RATES.
- (2) FLUOR DANIEL NORTHWEST SERVICES (CONSTRUCTION CRAFT LABOR) RATES ARE THOSE LISTED IN APPENDIX A OF THE HANFORD SITE STABILIZATION AGREEMENT (HSSA). THE HSSA RATES INCLUDE BASE WAGE, FRINGE BENEFITS AND OTHER COMPENSATION AS NEGOTIATED BETWEEN FLUOR DANIEL HANFORD, INC. AND THE NATIONAL BUILDING AND CONSTRUCTION TRADES DEPARTMENT AFL-CIO, FLUOR DANIEL FEDERAL EMPLOYMENT INSURANCE AND G&A/FEE TO DEVELOPE A FULLY BURDENED RATE BY CRAFT.
- (3) FDH & PHMC SUBCONTRACTOR STANDARD LABOR RATES ARE THOSE LISTED IN THE FINANCIAL DATA SYSTEM (FDS) FDST 321R REPORT ORGANIZATION RATES PLUS ADDERS.

E. SITE ALLOCATIONS FACTORS

- SITE ALLOCATION FACTORS ARE DEVELOPED AND PROVIDED BY FLUOR DANIEL HANFORD (FDH) FOR ESTIMATING USE.
- (1) DYNCORP EQUIPMENT USAGE: APPLIED TO HOME OFFICE ENGINEERING FOR GOVERNMENT OWNED EQUIPMENT CONTROLLED BY DYNCORP 0.25%
 - (2) GOVERNMENT FURNISHED SERVICES (GFS) APPLIED TO ALL COSTS TO LIQUIDATE GOVERNMENT FURNISHED SERVICES PROVIDED TO THE ENTERPRISE COMPANIES: 7% FOR FDNW.
 - (3) HANFORD SITE GENERAL AND ADMINISTRATIVE (G&A): APPLIED TO ALL COSTS TO LIQUIDATE THE HANFORD GENERAL AND ADMINISTRATIVE SERVICES, 18.0%

FDNW APPLIES THE ABOVE FACTORS TO ESTIMATED COSTS AS AS SHOWN IN THE PHMCR06 REPORT.

- (1) DYNCORP EQUIPMENT USAGE: 0.25% APPLIED TO HOME OFFICE ENGINEERING AND CONSTRUCTION MANAGEMENT LABOR; 10% APPLIED TO CONSTRUCTION LABOR.
- (2) FDH GFS/G&A CONST. MGMT: GFS (7%) AND G&A (18.0%) COMPOUNDED AND APPLIED TO FIXED PRICE CONSTRUCTION MANAGEMENT, 26.26%
- (3) FDH SUBCONTRACT: G&A FEE (7.7%) APPLIED TO FIXED PRICE CONTRACTS.
- (4) FDH GFS/G&A LABOR: GFS (7%) AND G&A (18%) COMPOUNDED AND APPLIED TO HOME OFFICE ENGINEERING, CONSTRUCTION MANAGEMENT LABOR AND TO FDNWS CONSTRUCTION LABOR AT 26.26%.

FLUOR DANIEL NORTHWEST, INC.
COGEMA ENGINEERING CORP.
JOB NO. Z466AAA3
FILE NO. Z466AAA3

** IEST - INTERACTIVE ESTIMATING **
TANK REMOVAL
241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
PHMCR03 - ESTIMATE BASIS SHEET

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4. ESCALATION

ESCALATION PERCENTAGES WERE NOT PROVIDED, ALL COSTS REFLECT CURRENT MAY 1998 PRICES.

5. CONTINGENCY

A. DEFINITION OF CONTINGENCY AS PROVIDED BY DOE

"CONTINGENCY COVERS COSTS THAT MAY RESULT FROM INCOMPLETE DESIGN, UNFORESEEN AND UNPREDICTABLE CONDITIONS, OR UNCERTAINTIES WITHIN THE DEFINED PROJECT SCOPE. THE AMOUNT OF CONTINGENCY WILL DEPEND ON THE STATUS OF DESIGN, PROCUREMENT, AND CONSTRUCTION; AND THE COMPLEXITY AND UNCERTAINTIES OF THE COMPONENT PARTS OF THE PROJECT. CONTINGENCY IS NOT TO BE USED TO AVOID MAKING AN ACCURATE ASSESSMENT OF EXPECTED COST" (OFFICE OF WASTE MANAGEMENT (EM-30) COST AND SCHEDULE GUIDE.

B. CONTINGENCY ALLOWANCE GUIDELINES

THE DOE GUIDELINE CONTINGENCY ALLOWANCE FOR AN ENVIRONMENTAL RESTORATION PLANNING ESTIMATE WITH EXPERIMENTAL/SPECIAL CONDITIONS = UP TO 100%

C. METHODOLOGY

CONTINGENCY IS EVALUATED AT THE LOWEST WORK BREAKDOWN STRUCTURE (WBS) LEVEL WITHIN THE COST ESTIMATE DETAILS. IT IS SUMMARIZED AT UPPER WBS LEVELS AND REPORTED ON THE SUMMARY REPORTS.

D. ANALYSIS

AN ASSESSMENT OF DESIGN MATURITY, WORK COMPLEXITY AND PROJECT UNCERTAINTIES HAS BEEN PERFORMED. AN EXPLANATION OF THIS ASSESSMENT AND CONTINGENCY RATES WHICH HAVE BEEN ADDED TO THE COST OF WORK ARE AS FOLLOWS:

WBS 111000 DEFINITIVE DESIGN TANK REMOVAL - A 35% CONTINGENCY WAS APPLIED TO THIS EXCAVATION/DEMOLITION DESIGN ACTIVITY DUE TO THE LACK OF HISTORICAL DATA AND THE EXTRA PRECAUTIONS THAT MAY NEED TO BE TAKEN FOR A PILOT PROJECT SUCH AS THIS THAT HAS NO PRECEDENCE. *TOTAL CONTINGENCY = 95%

WBS 112000 DEFINITIVE DESIGN OF BUILDING - A 25% CONTINGENCY WAS APPLIED HERE TO COVER POSSIBLE UNFORESEEN DESIGN PROBLEMS, SINCE THIS IS POSSIBLY THE LARGEST BUILDING OF THIS TYPE EVER TO BE CONSTRUCTED. *TOTAL CONTINGENCY = 35%

WBS 113000 SAFETY ANALYSIS OF TANK REMOVAL - A 35% CONTINGENCY WAS APPLIED TO THIS ACTIVITY SINCE THIS IS A PARTICULARLY DIFFICULT COST TO PREDICT ESPECIALLY HAVING SUCH EXPERIMENTAL CONDITIONS. *TOTAL CONTINGENCY = 100%

WBS 119000 DEFINITIVE DESIGN OF BACKFILLING - A 15% CONTINGENCY WAS FELT ADEQUATE FOR WHAT SHOULD BE COMPARATIVELY A SIMPLE DESIGN. *TOTAL CONTINGENCY = 15%

WBS 121000 ENGINEERING/INSPECTION - THIS ACTIVITY COVERING THE WASTE ACCEPTANCE PROFILE AND WASTE SAMPLING COSTS WAS BASED ON A PERCENTAGE OF BURIAL COSTS DUE TO THEIR DIRECT RELATIONSHIP. SAMPLING COSTS AND REQUIREMENTS ARE RELATIVELY UNSTABLE SO A 25% CONTINGENCY WAS DEEMED APPROPRIATE. * TOTAL CONTINGENCY = 40%

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D. ANALYSIS (CONT'D)

WBS 131000 AND 132000 CONSTRUCTION MANAGEMENT - THE DOLLAR AMOUNT USED FOR THIS ACTIVITY IS NORMALLY ADDED AUTOMATICALLY TO ALL FDNW WORK AS AN ALLOCATION, IT WAS ASSIGNED ITS OWN WBS HERE TO MAKE THE COST MORE VISIBLE TO THE CUSTOMER. THE CONTINGENCIES APPLIED HERE ARE THE SAME AS WOULD HAVE BEEN APPLIED HAD CONSTRUCTION MANAGEMENT BEEN LEFT AS AN ALLOCATION TO THE RESPECTIVE CONSTRUCTION ACTIVITY, 30% AND 20%. *TOTAL CONTINGENCY = 80% AND 25%

WBS 210000 PROCUREMENT - A CONTINGENCY OF 35% HAS BEEN APPLIED MOSTLY DUE TO THE UNKNOWN DESIGN/FABRICATION COSTS TO EQUIP THE MACHINERY WITH THE LEVEL OF SHIELDING AND THE CORRESPONDING CHASSIS MODIFICATIONS AND UPGRADES TO HANDLE THE EXTRA WEIGHT AND SPECIAL REQUIREMENTS FOR THIS ONE-OFF APPLICATION. *TOTAL CONTINGENCY = 65%

WBS 31XXXX TANK REMOVAL - A CONTINGENCY OF 30% HAS BEEN APPLIED BECAUSE A SMALL MISCALCULATION IN THE EXPECTED PRODUCTIVITY DUE TO UNFORESEEN DELAYS AT ANY POINT DURING THIS BROAD ACTIVITY WILL HAVE A LARGE COST IMPACT OVERALL, ALSO, HIGHER THAN ANTICIPATED CONTAMINATION LEVELS WILL HAVE A LARGE COST IMPACT. *TOTAL CONTINGENCY = 75%

WBS 320700 MAIN BUILDING - A CONTINGENCY OF 20% WAS APPLIED TO THE CONSTRUCTION OF THE MAIN BUILDING AS IT WAS FELT THAT SINCE THE CONDITIONS AT THIS TIME ARE ASSUMED TO BE FREE OF CONTAMINATION HAZZARDS SO THAT THE BUILDING CAN BE CONSTRUCTED WITHOUT MAJOR COST DIFFERENCES FROM THAT OF NORMAL COMMERCIALY CONSTRUCTED BUILDINGS OF THIS KIND.
 *TOTAL CONTINGENCY = 20%

WBS 320800 SUPPORT FACILITY - A 25% CONTINGENCY WAS APPLIED HERE FOR SIMILAR REASONS TO THE ABOVE MAIN STRUCTURE WITH THE ADDITIONAL CUSHION FOR THE SPECIALIZED EQUIPMENT THAT HAS NOT YET BEEN FULLY REALIZED. *TOTAL CONTINGENCY = 25%

WBS 320900 BACKFILL - A 20% CONTINGENCY HAS BEEN APPLIED TO THIS ACTIVITY TO ALLOW FOR SOME ADDITIONAL PRODUCTIVITY LOSSES THAT MAY NOT YET BE ENVISIONED SUCH AS NOT HAVING AN EASILY LOADED FILL MATERIAL AT PIT 30. *TOTAL CONTINGENCY = 20%

WBS 33XXXX DISPOSAL COSTS - A 20% CONTINGENCY HAS BEEN APPLIED TO DISPOSAL COSTS IN THE EVENT THAT THE SOIL AND DEBRIS DOES NOT MEET THE ACCEPTANCE CRITERIA REQUIRED BY ERDF AND OTHER MEANS OF DISPOSAL IS REQUIRED. *TOTAL CONTINGENCY = 35%

* E. PROGRAMATIC RISK (CONTINGENCY)

=====

*THE ABOVE LISTED CONTINGENCIES MAY INCLUDE AN ADDITIONAL 0% TO 60% CONTINGENCY. THIS IS TO PROVIDE ADDITIONAL CONTINGENCY AGAINST THE PROGRAMATIC RISK SOURCES CAUSED BY THE MINIMAL AMOUNT OF CHARACTERIZATION DATA. WORKER EXPOSURE CHARACTERIZATION ALSO, MAY BE INADEQUATE WHICH COULD IMPACT THE PROPOSED CONCEPTS. OTHER MAJOR SOURCES OF PROGRAMATIC UNCERTAINTY ARE:

- A) TANK WASTE RETRIEVAL MAY NOT HAVE ACHIEVED THE ASSUMED 1% RESIDUAL INVENTORY TARGET, THIS WILL HAVE A TREMENDOUS COST IMPACT (30% ALLOWANCE FOR WBS 111, 113, 131, 21 AND 31)
- B) LEAKAGE DURING RETRIEVAL COULD LEAD TO SIGNIFICANTLY HIGHER LEVELS OF CONTAMINATION IN THE SOIL (15% CONTINGENCY ALLOWANCE FOR WBS 111, 113, 121, 131, 31 AND 33)
- C) INDIRECT MANPOWER COSTS MAY BE UNDERESTIMATED (5% ALLOWANCE FOR CONSTRUCTION MANAGEMENT)
- D) SAR/USQ COSTS MAY BE INSUFFICIENT (35% ALLOWANCE FOR WBS 113 AND 10% ALLOWANCE FOR WBS 112).

OTHER CONSIDERATIONS ARE FOR POSSIBLE ADDITIONAL SAFETY PROVISIONS THAT MAY BE REQUIRED FOR MOBILE EQUIPMENT THAT WOULD AFFECT EQUIPMENT CAPITAL COST AND/OR PROCUREMENT MPR.

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6. ROUNDING

THE PROJECT COST SUMMARY REPORT IS SUMMARIZED AND ADJUSTED/ROUNDED AS FOLLOWS:
THE ESCALATED TOTAL COST COLUMN, CONTINGENCY TOTAL COLUMN AND TOTAL DOLLARS COLUMN SUB-TOTALS ARE SUMMARIZED BY CONTRACTOR.
THE COLUMN SUBTOTALS ARE ADJUSTED/ROUNDED TO THE NEAREST \$1,000/\$10,000. THE PROJECT TOTAL SUMMARY LINE TOTALS ARE
ADJUSTED/ROUNDED TO THE NEAREST \$10,000/\$100,000.

7. REMARKS

MAJOR ASSUMPTIONS WHICH HAVE BEEN MADE IN THE PREPARATION OF THIS ESTIMATE ARE AS FOLLOWS:

- A.) ALL ANCILLARY EQUIPMENT IS TO HAVE BEEN REMOVED PRIOR TO BEGINNING OF WORK.
- B.) ALL EXCAVATION AND BACKFILL OPERATIONS ARE TO BE DONE WITH MACHINES.
- C.) WASTE GENERATED AND HANDLED IN WBS 310600 HAS NO DISPOSAL COSTS APPLIED, THAT IS, THE BURIAL OR TREATMENT COSTS ARE TO BE INCLUDED IN A PROCESS IMPACT STUDY.
- D.) THE BUILDINGS ARE STILL EXISTING AT THE END OF THE JOB, COSTS HAVE NOT BEEN INCLUDED FOR DISMANTLING THE BUILDING.
- E.) THE WASH FACILITY HAS NO DESIGN, LAYOUT, SPECS, ETC, THE BASIS FOR THE COSTS WERE EXTRACTED FROM W-259 FINAL ESTIMATE THAT HAD A SIMILAR FACILITY.
- F.) ALL SWP AND MASK WORK HAS BEEN MANLOADED AND ALL INEFFICIENCIES HAVE BEEN TAKEN INTO ACCOUNT, THEREFORE, NO FURTHER FACTORING PERCENTAGES WERE ADDED.
- G.) BACKFILL MATERIALS ARE ASSUMED TO BE AVAILABLE AT PIT 30, OR A SIMILAR DISTANCE.
- H.) THE ESTIMATE ASSUMES THAT, PRIOR TO REMOVAL ACTIVITIES, CONTROL OF AX TANK FARM WOULD PASS FROM THE CURRENT OPERATIONS ACTIVITY TO A SEPARATE RETRIEVAL FUNCTION. AT COMPLETION OF RETRIEVAL, THE CONTROL WOULD BE GIVEN TO A THIRD ENTITY FOR CLOSURE. CURRENT TANK FARM PRACTICES WOULD CHANGE ALLOWING FOR A MORE PRODUCTIVE WORK SHIFT AND ALLOWING FOR MORE CONVENTIONAL CONSTRUCTION PRACTICES SIMILAR TO DOE'S ENVIRONMENTAL RESTORATION CONTRACTORS. FOR FURTHER DESCRIPTIONS OF MAJOR ASSUMPTIONS AND CONCEPTS SEE THE COGEMA REPORT "COGEMA RPT25".

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PHMCRO4 - COMPANY/WBS SUMMARY

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SORT CODE/WBS	DESCRIPTION	ESTIMATE	ESCALATION	SUB TOTAL	CONTINGENCY		SUB	SITE	TOTAL	
		SUBTOTAL	% TOTAL		%	TOTAL	TOTAL	ALLOCAT'N	DOLLARS	
=====		=====	=====	=====	=====	=====	=====	=====	=====	
BHI	BECHTEL HANFORD INTERNATIONAL									
330200	SOIL DISPOSAL - TOP OF TANKS	1660500	0.00	0	1660500	35	581175	2241675	0	2241675
330400	SOIL DISPOSAL - SURROUNDING TANK	11688000	0.00	0	11688000	35	4090800	15778800	0	15778800
330500	DISPOSAL - TANK WALL DEBRIS	254880	0.00	0	254880	35	89208	344088	0	344088
	SUBTOTAL 33 DISPOSAL / BURIAL	13603380	0.00	0	13603380	35	4761183	18364563	0	18364563
	SUBTOTAL 3 CONSTRUCTION	13603380	0.00	0	13603380	35	4761183	18364563	0	18364563
	TOTAL BHI BECHTEL HANFORD INTERNATIONAL	13603380	0.00	0	13603380	35	4761183	18364563	0	18364563
FDNW	FLUOR DANIEL NORTHWEST									
131000	CONSTRUCTION MANAGEMENT FOR CPAF	328856	0.00	0	328856	80	263085	591941	156924	748865
132000	CONSTRUCTION MANAGEMENT FOR F/P	2358207	0.00	0	2358207	25	589552	2947759	781451	3729210
	SUBTOTAL 13 CONSTRUCTION MANAGEMENT	2687063	0.00	0	2687063	32	852637	3539700	938375	4478075
	SUBTOTAL 1 ENGINEERING	2687063	0.00	0	2687063	32	852637	3539700	938375	4478075
210000	FDNW PROCUREMENT	7813124	0.00	0	7813124	65	5078531	12891655	3385348	16277003
	SUBTOTAL 21 PROCUREMENT	7813124	0.00	0	7813124	65	5078531	12891655	3385348	16277003
310100	CDF FILL TANK BOTTOMS	39245	0.00	0	39245	75	29434	68679	2202	70881
310200	REMOVE SOIL ABOVE TANKS	92450	0.00	0	92450	75	69338	161788	53198	214986
310300	PULVERIZE TANK DOMES	32409	0.00	0	32409	75	24307	56716	20403	77119
310400	REMOVE SOIL AT TANK SIDES	651312	0.00	0	651312	75	488484	1139796	374714	1514510
310500	REMOVE TANK WALLS	160568	0.00	0	160568	75	120426	280994	100468	381462
310600	REMOVE TANK BOTTOMS	170513	0.00	0	170513	75	127885	298398	107345	405743
	SUBTOTAL 31 FA CONST-ONSITE E/C	1146497	0.00	0	1146497	75	859874	2006371	658330	2664701
320700	MAIN BUILDING	11116023	0.00	0	11116023	20	2223204	13339227	1027119	14366346
320800	SUPPORT FACILITY	205110	0.00	0	205110	25	51278	256388	19741	276129

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 PHMCR04 - COMPANY/WBS SUMMARY

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SORT CODE/WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	SUB TOTAL	SITE ALLOCAT'N	TOTAL DOLLARS		
=====	=====	=====	=====	=====	=====	=====	=====	=====		
320900	BACKFILL	1256124	0.00	0	1256124	20	251225	1507349	116066	1623415
	SUBTOTAL 32 CONSTRUCTION-FIXED PRIC	12577257	0.00	0	12577257	20	2525707	15102964	1162926	16265890
	SUBTOTAL 3 CONSTRUCTION	13723754	0.00	0	13723754	25	3385581	17109335	1821256	18930591
	TOTAL FDNW FLUOR DANIEL NORTHWEST	24223941	0.00	0	24223941	38	9316749	33540690	6144979	39685669
LMHC	LOCKHEED MARTIN HANFORD CORP.									
111000	DEFINITIVE DESIGN - TANK REMOVAL	1481470	0.00	0	1481470	95	1407397	2888867	758616	3647483
112000	DEFINITIVE DESIGN - BUILDING	1632098	0.00	0	1632098	35	571234	2203332	578595	2781927
113000	SAFETY ANALYSIS	4999996	0.00	0	4999996	100	4999496	9999492	2625867	12625359
119000	DEFINITIVE DESIGN - BACKFILL	125637	0.00	0	125637	15	18846	144483	37941	182424
	SUBTOTAL 11 DEFINITIVE DESIGN	8239201	0.00	0	8239201	85	6996973	15236174	4001019	19237193
121000	ENGR'G INSP - TANK REMOVAL	2040481	0.00	0	2040481	40	816192	2856673	750162	3606835
	SUBTOTAL 12 ENGINEERING/INSPECTION	2040481	0.00	0	2040481	40	816192	2856673	750162	3606835
	SUBTOTAL 1 ENGINEERING	10279682	0.00	0	10279682	76	7813165	18092847	4751181	22844028
310100	CDF FILL TANK BOTTOMS	3058	0.00	0	3058	75	2294	5352	0	5352
310200	REMOVE SOIL ABOVE TANKS	22934	0.00	0	22934	75	17201	40135	0	40135
310300	PULVERIZE TANK DOMES	9174	0.00	0	9174	75	6881	16055	0	16055
310400	REMOVE SOIL AT TANK SIDES	165653	0.00	0	165653	75	124240	289893	0	289893
310500	REMOVE TANK WALLS	22934	0.00	0	22934	75	17201	40135	0	40135
310600	REMOVE TANK BOTTOMS	24463	0.00	0	24463	75	18347	42810	0	42810
	SUBTOTAL 31 FA CONST-ONSITE E/C	248216	0.00	0	248216	75	186164	434380	0	434380
	SUBTOTAL 3 CONSTRUCTION	248216	0.00	0	248216	75	186164	434380	0	434380
	TOTAL LMHC LOCKHEED MARTIN HANFORD COR	10527898	0.00	0	10527898	76	7999329	18527227	4751181	23278408

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SORT CODE/WBS =====	DESCRIPTION =====	ESTIMATE	ESCALATION		SUB	CONTINGENCY		SUB	SITE	TOTAL
		SUBTOTAL	%	TOTAL	TOTAL	%	TOTAL	TOTAL	ALLOCAT'N	DOLLARS
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
PROJECT TOTAL		48,355,219	0.00	0	48,355,219	46	22,077,261	70,432,480	10,896,160	81,328,640

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** TEST - INTERACTIVE ESTIMATING **
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PHMCRO5 - CONSTRUCTION MANAGEMENT/OTHER COST SUMMARY

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WBS	DESCRIPTION	ESTIMATE SUBTOTAL	CONSTRUCTION %	MANAGEMENT TOTAL	OTHER COSTS	SUB TOTAL	TOTAL
=====	=====	=====	=====	=====	=====	=====	=====
111000	DEFINITIVE DESIGN - TANK REMOVAL	1481470	0.00	0	0	0	1481470
112000	DEFINITIVE DESIGN - BUILDING	1632098	0.00	0	0	0	1632098
113000	SAFETY ANALYSIS	4999996	0.00	0	0	0	4999996
119000	DEFINITIVE DESIGN - BACKFILL	125637	0.00	0	0	0	125637
SUBTOTAL 11	DEFINITIVE DESIGN	8239201		0	0	0	8239201
121000	ENGR'G INSP - TANK REMOVAL	2040481	0.00	0	0	0	2040481
SUBTOTAL 12	ENGINEERING/INSPECTION	10279682		0	0	0	10279682
131000	CONSTRUCTION MANAGEMENT FOR CPAF	328856	0.00	0	0	0	328856
132000	CONSTRUCTION MANAGEMENT FOR F/P	2358207	0.00	0	0	0	2358207
SUBTOTAL 13	CONSTRUCTION MANAGEMENT	12966745		0	0	0	12966745
SUBTOTAL 1	ENGINEERING	12966745		0	0	0	12966745
210000	FDNW PROCUREMENT	7813124	0.00	0	0	0	7813124
SUBTOTAL 21	PROCUREMENT	7813124		0	0	0	7813124
310100	CDF FILL TANK BOTTOMS	42303	0.00	0	0	0	42303
310200	REMOVE SOIL ABOVE TANKS	115384	0.00	0	0	0	115384
310300	PULVERIZE TANK DOMES	41583	0.00	0	0	0	41583
310400	REMOVE SOIL AT TANK SIDES	816965	0.00	0	0	0	816965
310500	REMOVE TANK WALLS	183502	0.00	0	0	0	183502
310600	REMOVE TANK BOTTOMS	194976	0.00	0	0	0	194976
SUBTOTAL 31	FA CONST-ONSITE E/C	1394713		0	0	0	1394713
320700	MAIN BUILDING	11116023	0.00	0	0	0	11116023
320800	SUPPORT FACILITY	205110	0.00	0	0	0	205110
320900	BACKFILL	1256124	0.00	0	0	0	1256124
SUBTOTAL 32	CONSTRUCTION-FIXED PRICE	13971970		0	0	0	13971970

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 PHMCR05 - CONSTRUCTION MANAGEMENT/OTHER COST SUMMARY

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WBS	DESCRIPTION	ESTIMATE SUBTOTAL	CONSTRUCTION %	MANAGEMENT TOTAL	OTHER COSTS	SUB TOTAL	TOTAL
=====	=====	=====	=====	=====	=====	=====	=====
330200	SOIL DISPOSAL - TOP OF TANKS	1660500	0.00	0	0	0	1660500
330400	SOIL DISPOSAL - SURROUNDING TANKS	11688000	0.00	0	0	0	11688000
330500	DISPOSAL - TANK WALL DEBRIS	254880	0.00	0	0	0	254880
SUBTOTAL 33	DISPOSAL / BURIAL	27575350		0	0	0	27575350
SUBTOTAL 12	ENGINEERING/INSPECTION	10279682		0	0	0	10279682
131000	CONSTRUCTION MANAGEMENT FOR CPAF	328856	0.00	0	0	0	328856
132000	CONSTRUCTION MANAGEMENT FOR F/P	2358207	0.00	0	0	0	2358207
SUBTOTAL 13	CONSTRUCTION MANAGEMENT	12966745		0	0	0	12966745
SUBTOTAL 1	ENGINEERING	12966745		0	0	0	12966745
210000	FDNW PROCUREMENT	7813124	0.00	0	0	0	7813124
SUBTOTAL 21	PROCUREMENT	7813124		0	0	0	7813124
310100	CDF FILL TANK BOTTOMS	42303	0.00	0	0	0	42303
310200	REMOVE SOIL ABOVE TANKS	115384	0.00	0	0	0	115384
310300	PULVERIZE TANK DOMES	41583	0.00	0	0	0	41583
310400	REMOVE SOIL AT TANK SIDES	816965	0.00	0	0	0	816965
310500	REMOVE TANK WALLS	183502	0.00	0	0	0	183502
310600	REMOVE TANK BOTTOMS	194976	0.00	0	0	0	194976
SUBTOTAL 31	FA CONST-ONSITE E/C	1394713		0	0	0	1394713
320700	MAIN BUILDING	11116023	0.00	0	0	0	11116023
320800	SUPPORT FACILITY	205110	0.00	0	0	0	205110
320900	BACKFILL	1256124	0.00	0	0	0	1256124
SUBTOTAL 32	CONSTRUCTION-FIXED PRICE	13971970		0	0	0	13971970

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 PHMCRO6 - SITE ALLOCATIONS BY WBS

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WBS	DESCRIPTION	ESTIMATE SUBTOTAL	DYN EQ.USAGE	FDH GFS/G&A CONST.MGMT	FDH MPR F.P./S.C.	FDH GFS/G&A LABOR	FDH MPR/G&A MATERIAL	SITE ALLOC SUBTOTAL
=====	=====	=====	=====	=====	=====	=====	=====	=====
111000	DEFINITIVE DESIGN - TANK REMOVAL	1481470	0	0	0	389034	0	389034
112000	DEFINITIVE DESIGN - BUILDING	1632098	0	0	0	428589	0	428589
113000	SAFETY ANALYSIS	4999996	0	0	0	1312999	0	1312999
119000	DEFINITIVE DESIGN - BACKFILL	125637	0	0	0	32992	0	32992
SUBTOTAL 11	DEFINITIVE DESIGN	8239201	0	0	0	2163614	0	2163614
121000	ENGR'G INSP - TANK REMOVAL	2040481	0	0	0	535830	0	535830
SUBTOTAL 12	ENGINEERING/INSPECTION	2040481	0	0	0	535830	0	535830
131000	CONSTRUCTION MANAGEMENT FOR CPAF	328856	822	0	0	86358	0	87180
132000	CONSTRUCTION MANAGEMENT FOR F/P	2358207	5896	0	0	619265	0	625161
SUBTOTAL 13	CONSTRUCTION MANAGEMENT	2687063	6718	0	0	705623	0	712341
SUBTOTAL 1	ENGINEERING	12966745	6718	0	0	3405067	0	3411785
210000	FDNW PROCUREMENT	7813124	0	0	0	0	2051726	2051726
SUBTOTAL 21	PROCUREMENT	7813124	0	0	0	0	2051726	2051726
310100	CDF FILL TANK BOTTOMS	42303	340	0	0	892	26	1258
310200	REMOVE SOIL ABOVE TANKS	115384	6122	0	0	16077	8200	30399
310300	PULVERIZE TANK DOMES	41583	3148	0	0	8267	244	11659
310400	REMOVE SOIL AT TANK SIDES	816965	43088	0	0	113149	57885	214122
310500	REMOVE TANK WALLS	183502	15245	0	0	40033	2132	57410
310600	REMOVE TANK BOTTOMS	194976	16563	0	0	43494	1283	61340
SUBTOTAL 31	FA CONST-ONSITE E/C	1394713	84506	0	0	221912	69770	376188
320700	MAIN BUILDING	11116023	0	0	855933	0	0	855933
320800	SUPPORT FACILITY	205110	0	0	15793	0	0	15793
320900	BACKFILL	1256124	0	0	96722	0	0	96722
SUBTOTAL 32	CONSTRUCTION-FIXED PRICE	12577257	0	0	968448	0	0	968448

FLUOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
 JOB NO. Z466AAA3
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** IEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCR06 - SITE ALLOCATIONS BY WBS

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WBS	DESCRIPTION	ESTIMATE SUBTOTAL	DYN EQ.USAGE	FDH GFS/G&A CONST.MGMT	FDH MPR F.P./S.C.	FDH GFS/G&A LABOR	FDH MPR/G&A MATERIAL	SITE ALLOC SUBTOTAL
=====	=====	=====	=====	=====	=====	=====	=====	=====
330200	SOIL DISPOSAL - TOP OF TANKS	1660500	0	0	0	0	0	0
330400	SOIL DISPOSAL - SURROUNDING TANKS	11688000	0	0	0	0	0	0
330500	DISPOSAL - TANK WALL DEBRIS	254880	0	0	0	0	0	0
SUBTOTAL 33	DISPOSAL / BURIAL	13603380	0	0	0	0	0	0
SUBTOTAL 3	CONSTRUCTION	27575350	84506	0	968448	221912	69770	1344636
=====								
PROJECT TOTAL		48,355,219	91,224	0	968,448	3,626,979	2,121,496	6,808,147

FLUOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
 JOB NO. Z466AAA3
 FILE NO. Z466AAA3

** IEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCRO7 - SITE ALLOCATION ESCALATION/CONTINGENCY REPORT

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WBS	DESCRIPTION	SITE ALLOC SUBTOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
=====	=====	=====	=====	=====	=====	=====
111000	DEFINITIVE DESIGN - TANK REMOVAL	389034	0.00	0	389034	758616
112000	DEFINITIVE DESIGN - BUILDING	428589	0.00	0	428589	578595
113000	SAFETY ANALYSIS	1312999	0.00	0	1312868	2625867
119000	DEFINITIVE DESIGN - BACKFILL	32992	0.00	0	32992	37941
SUBTOTAL 11	DEFINITIVE DESIGN	2163614	0.00	0	2163614	4001019
121000	ENGR'G INSP - TANK REMOVAL	535830	0.00	0	535830	750162
SUBTOTAL 12	ENGINEERING/INSPECTION	535830	0.00	0	535830	750162
131000	CONSTRUCTION MANAGEMENT FOR CPAF	87180	0.00	0	87180	156924
132000	CONSTRUCTION MANAGEMENT FOR F/P	625161	0.00	0	625161	781451
SUBTOTAL 13	CONSTRUCTION MANAGEMENT	712341	0.00	0	712341	938375
SUBTOTAL 1	ENGINEERING	3411785	0.00	0	3411785	5689556
210000	FDNW PROCUREMENT	2051726	0.00	0	2051726	3385348
SUBTOTAL 21	PROCUREMENT	2051726	0.00	0	2051726	3385348
310100	CDF FILL TANK BOTTOMS	1258	0.00	0	1258	2202
310200	REMOVE SOIL ABOVE TANKS	30399	0.00	0	30399	53198
310300	PULVERIZE TANK DOMES	11659	0.00	0	11659	20403
310400	REMOVE SOIL AT TANK SIDES	214122	0.00	0	214122	374714
310500	REMOVE TANK WALLS	57410	0.00	0	57410	100468
310600	REMOVE TANK BOTTOMS	61340	0.00	0	61340	107345
SUBTOTAL 31	FA CONST-ONSITE E/C	376188	0.00	0	376188	658330
320700	MAIN BUILDING	855933	0.00	0	855933	1027119
320800	SUPPORT FACILITY	15793	0.00	0	15793	19741
320900	BACKFILL	96722	0.00	0	96722	116066
SUBTOTAL 32	CONSTRUCTION-FIXED PRICE	968448	0.00	0	968448	1162926

FLUOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
 JOB NO. Z466AAA3
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** IEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCR07 - SITE ALLOCATION ESCALATION/CONTINGENCY REPORT

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WBS	DESCRIPTION	SITE ALLOC SUBTOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
=====	=====	=====	=====	=====	=====	=====
330200	SOIL DISPOSAL - TOP OF TANKS	0	0.00	0	0	0
330400	SOIL DISPOSAL - SURROUNDING TANKS	0	0.00	0	0	0
330500	DISPOSAL - TANK WALL DEBRIS	0	0.00	0	0	0
SUBTOTAL 33	DISPOSAL / BURIAL	0	0.00	0	0	0
SUBTOTAL 3	CONSTRUCTION	1344636	0.00	1344636	35	476620
=====						
PROJECT TOTAL		6,808,147	0.00	6,808,147	60	10,896,160

FLUOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
 JOB NO. Z466AAA3
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** IEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCRO8 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
111000	DEFINITIVE DESIGN - TANK REMOVAL										
111000.00	TECHNICAL SERVICES										
111000.0001000	***** DEFINITIVE DESIGN - REMOVAL *****	000	1 L/S	0	0	0	0	0	0	0	0
111000.0001005	DEFINITIVE DESIGN, 1-1/2 MANYEAR	000	1 L/S	3120	194438	0	0	0	0	0	194438
111000.0001010	PROCEDURES, 4 MANYEARS	000	1 L/S	8320	518502	0	0	0	0	0	518502
111000.0001020	AIR PERMITTING (ALLOWANCE)	000	1 L/S	4012	250028	0	0	0	0	0	250028
111000.0001040	MOBILE EQUIPMENT SPECIFI- CATIONS AND DRAWINGS, 4 MANYEARS.	000	1 L/S	8320	518502	0	0	0	0	0	518502
SUBTOTAL	TECHNICAL SERVICES			23,772		0		0		0	
					1,481,470		0		0		1,481,470
TOTAL	COST CODE 00000			23,772		0		0		0	
	WBS 111000				1,481,470		0		0		1,481,470
	(ESCALATION 0.00% - CONTINGENCY 95.00 %)										
TOTAL WBS 111000	DEFINITIVE DESIGN - TANK REMOVAL			23,772		0		0		0	
					1,481,470		0		0		1,481,470

FLUOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
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** IEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCRO8 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
112000	DEFINITIVE DESIGN - BUILDING										
112000.00	TECHNICAL SERVICES										
112000.0002000	***** DEFINITIVE DESIGN - BUILDING *****	000	1 L/S	18166	1132105	0	0	0	0	0	1132105
	AT 10% OF WBS 3207 & 3208										
112000.0002010	SAFETY ANALYSIS OF HVAC	000	1 L/S	8023	499993	0	0	0	0	0	499993
SUBTOTAL	TECHNICAL SERVICES			26,189		0	0	0	0	0	
					1,632,098		0		0		1,632,098
TOTAL	COST CODE 00000			26,189		0	0	0	0	0	
	WBS 112000				1,632,098		0		0		1,632,098
	(ESCALATION 0.00% - CONTINGENCY 35.00 %)										
TOTAL WBS 112000	DEFINITIVE DESIGN - BUILDING			26,189		0	0	0	0	0	
					1,632,098		0		0		1,632,098

FLUOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
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** IEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCRO8 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
113000	SAFETY ANALYSIS										
113000.00	TECHNICAL SERVICES										
113000.0001030	SAFETY ANALYSIS/DOCUMENTATION (ALLOWANCE)	000	1 L/S	80231	4999996	0	0	0	0	0	4999996
SUBTOTAL	TECHNICAL SERVICES			80,231	4,999,996	0	0	0	0	0	4,999,996
TOTAL	COST CODE 00000			80,231	4,999,996	0	0	0	0	0	4,999,996
	WBS 113000										
	(ESCALATION 0.00% - CONTINGENCY 99.99 %)										
TOTAL WBS 113000 SAFETY ANALYSIS				80,231	4,999,996	0	0	0	0	0	4,999,996

FLUOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
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** IEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCR08 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
119000	DEFINITIVE DESIGN - BACKFILL										
119000.00	TECHNICAL SERVICES										
119000.0002000	***** DEFINITIVE DESIGN - BACKFILL ***** AT 10% OF WBS 320900	000	1 L/S	2016	125637	0	0	0	0	0	125637
SUBTOTAL	TECHNICAL SERVICES			2,016	125,637	0	0	0	0	0	125,637
TOTAL	COST CODE 00000 WBS 119000 (ESCALATION 0.00% - CONTINGENCY 15.00 %)			2,016	125,637	0	0	0	0	0	125,637
TOTAL WBS 119000	DEFINITIVE DESIGN - BACKFILL			2,016	125,637	0	0	0	0	0	125,637

FLUOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
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** IEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCR08 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
121000	ENGR'G INSP - TANK REMOVAL										
121000.00	TECHNICAL SERVICES										
121000.0002000	***** E & I DURING CONSTRUCTION *****	000	0	0	0	0	0	0	0	0	0
121000.0002010	WASTE ACCEPTANCE PROFILE, AT 5% OF WBS 33.	000	1 L/S	10914	680160	0	0	0	0	0	680160
121000.0002020	WASTE SAMPLING, AT 10% OF WBS 33.	000	1 L/S	21828	1360321	0	0	0	0	0	1360321
SUBTOTAL	TECHNICAL SERVICES			32,742		0	0	0	0	0	
					2,040,481		0		0		2,040,481
TOTAL	COST CODE 00000 WBS 121000			32,742		0	0	0	0	0	
	(ESCALATION 0.00% - CONTINGENCY 40.00 %)				2,040,481		0		0		2,040,481
TOTAL WBS 121000	ENGR'G INSP - TANK REMOVAL			32,742		0	0	0	0	0	
					2,040,481		0		0		2,040,481

FLUOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
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** IEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCR08 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
131000	CONSTRUCTION MANAGEMENT FOR CPAF										
131000.00	TECHNICAL SERVICES										
131000.0001000	***** CONSTRUCTION MANAGEMENT ***** AT 23.58% OF WBS 310	000	1 L/S	5470	328856	0	0	0	0	0	328856
131000.0001002	THIS PERCENTAGE IS CURRENTLY APPLIED TO ALL FDNWS CRAFT LABOR AS AN ALLOCATION.	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			5,470	328,856	0	0	0	0	0	328,856
TOTAL	COST CODE 00000 WBS 131000 (ESCALATION 0.00% - CONTINGENCY 80.00 %)			5,470	328,856	0	0	0	0	0	328,856
TOTAL WBS 131000	CONSTRUCTION MANAGEMENT FOR CPAF			5,470	328,856	0	0	0	0	0	328,856

FLUOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
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** IEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCR08 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
132000	CONSTRUCTION MANAGEMENT FOR F/P										
132000.00	TECHNICAL SERVICES										
132000.0001000	***** CONSTRUCTION MANAGEMENT ***** AT 18.75% OF WBS 320 THIS PERCENTAGE IS CURRENTLY APPLIED TO FIXED PRICE LABOR AS AN ALLOCATION TO ALL JOBS GREATER THAN \$5 MILLION.	000	1 L/S	39225	2358207	0	0	0	0	0	2358207
132000.0001002		000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			39,225	2,358,207	0	0	0	0	0	2,358,207
TOTAL	COST CODE 00000 WBS 132000 (ESCALATION 0.00% - CONTINGENCY 25.00 %)			39,225	2,358,207	0	0	0	0	0	2,358,207
TOTAL WBS 132000	CONSTRUCTION MANAGEMENT FOR F/P			39,225	2,358,207	0	0	0	0	0	2,358,207

FLUOR DANIEL NORTHWEST, INC.
COGEMA ENGINEERING CORP.
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** IEST - INTERACTIVE ESTIMATING **
TANK REMOVAL
241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
PHMCRO8 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
210000	FDNW PROCUREMENT										
210000.01	GENERAL REQUIRMENTS										
210000.0101000	***** EQUIPMENT PROCUREMENT *****	460	0	0	0	0	0	0	0	0	0
210000.0101002	CATERPILLAR 375	460	2 EA	0	0	0	1628000	0	0	81400	1709400
210000.0101004	HYDRAULIC CIRCUIT OPTION	460	2 EA	0	0	0	30680	0	0	1534	32214
210000.0101006	ELEVATED CAB (5'-11")	460	2 EA	0	0	0	46800	0	0	2340	49140
210000.0101014	SHIELDED CAB (ALLOWANCE)	460	0	0	0	0	0	0	0	0	0
210000.0101015	LEAD GLASS, 3' X 5' X 6" W/FRAME.	460	2 EA	0	0	0	400000	0	0	20000	420000
210000.0101016	STEEL PLATE, 6" THICK, 54,000 LB PER CAB, FABRICATED @ \$4/LB	460	2 EA	0	0	0	432000	0	0	21600	453600
210000.0101020	CATERPILLAR D10 BULLDOZER	460	1 EA	0	0	0	750000	0	0	37500	787500
210000.0101024	SHIELDED CAB (ALLOWANCE)	460	0	0	0	0	0	0	0	0	0
210000.0101025	LEAD GLASS, 3' X 5' X 6" W/FRAME.	460	1 EA	0	0	0	200000	0	0	10000	210000
210000.0101026	STEEL PLATE, 6" THICK, 54,000 LB PER CAB, FABRICATED @ \$4/LB	460	1 EA	0	0	0	216000	0	0	10800	226800
210000.0101050	UP-70 BASE UNIT	460	2 EA	0	0	0	154000	0	0	7700	161700
210000.0101052	SHEAR JAW	460	1 EA	0	0	0	45000	0	0	2250	47250
210000.0101054	PULVERIZER	460	1 EA	0	0	0	33000	0	0	1650	34650
210000.0101056	HYDRAULIC BREAKER, MB5950	460	1 EA	0	0	0	99000	0	0	4950	103950
210000.0101070	QUICK COUPLER	460	2 EA	0	0	0	11400	0	0	570	11970
210000.0101072	COUPLERS	460	5 EA	0	0	0	3000	0	0	150	3150
210000.0101110	CATERPILLAR 988 WHEEL LOADER	460	1 EA	0	0	0	565000	0	0	28250	593250
210000.0101114	SHIELDED CAB (ALLOWANCE)	460	0	0	0	0	0	0	0	0	0
210000.0101115	LEAD GLASS, 3' X 5' X 6" W/FRAME.	460	1 EA	0	0	0	200000	0	0	10000	210000
210000.0101116	STEEL PLATE, 6" THICK, 54,000 LB PER CAB, FABRICATED @ \$4/LB	460	1 EA	0	0	0	216000	0	0	10800	226800
210000.0101150	TRUCKS	460	5 EA	0	0	0	450000	0	0	22500	472500
210000.0101152	SHIELDED CABS, 3" THICK STEEL AT SIDES, 1" AT FRONT, FLOOR, ROOF AND FIREWALL, 4" AT BACK.	460	0	0	0	0	0	0	0	0	0
210000.0101154	STEEL, FABED @ 13,000 LB PER CAB.	460	65000 LB	0	0	0	260000	0	0	13000	273000

FLUOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
 JOB NO. Z466AAA3
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** IEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCR08 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
210000.0101156	LEADED GLASS (21 SF PER CAB)	460	5 L/S	0	0	0	700000	0	0	35000	735000
210000.0101158	UPGRADED SUSPENSION, (ALLOWANCE)	460	5 L/S	0	0	0	250000	0	0	12500	262500
210000.0101160	TRAILER, ROLL-ON ROLL-OFF	460	4 EA	0	0	0	200000	0	0	10000	210000
SUBTOTAL	GENERAL REQUIRMENTS			0	0	0		0		344,494	
	SALES TAX 8.00 %						6,889,880		0		7,234,374
	OH&P (ON MARKUPS ONLY)						551190		0		551190
										27559	27559
TOTAL	COST CODE 46001			0	0	0		0		372,053	
	WBS 210000				0		7,441,070		0		7,813,123
	(ESCALATION 0.00% - CONTINGENCY 65.00 %)										
TOTAL WBS 210000	FDNW PROCUREMENT			0	0	0		0		372,053	
							7,441,070		0		7,813,123

FLUOR DANIEL NORTHWEST, INC.
COGEMA ENGINEERING CORP.
JOB NO. 2466AAA3
FILE NO. 2466AAA3

** TEST - INTERACTIVE ESTIMATING **
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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
310100	CDF FILL TANK BOTTOMS										
310100.01	GENERAL REQUIRMENTS										
310100.0101000	***** HPT'S ***** 2 MEN FOR 4 DAYS	460 W	1 L/S	64	3058	0	0	0	0	0	3058
	SUBTOTAL GENERAL REQUIRMENTS	(SWP)		64	3,058	0	0	0	0	0	3,058
TOTAL	COST CODE 46001 WBS 310100 (ESCALATION 0.00% - CONTINGENCY 75.00 %)			64	3,058	0	0	0	0	0	3,058
310100.02	SITWORK										
310100.0201000	***** CDF FILL TANK BOTTOMS *****	460 W	0	0	0	0	0	0	0	0	0
310100.0201002	UTILIZING TREMMIES, FILL EACH TANK WITH 12" OF CONTROLLED DENSITY FILL.	460 W	0	0	0	0	0	0	0	0	0
310100.0201004	LABORERS, 2 MEN X 4 DAYS	460 W	1 L/S	64	1839	0	0	0	0	0	1839
310100.0201008	FLAGGER, 1 MAN X 4 DAYS	460 W	1 L/S	32	920	0	0	0	0	0	920
310100.0201020	42 METER BOOM PUMP W/OPER.	460 W	0	0	0	0	0	0	0	0	0
310100.0201021	MOB/DEMOS.	460 W	1 L/S	0	0	0	0	500	0	0	500
310100.0201022	OPERATOR & PUMP, 4 DAYS	460 W	4 DAY	0	0	0	0	5120	0	0	5120
310100.0201023	PLUS \$2.75/CY	460 W	655 CY	0	0	0	0	1801	0	0	1801
310100.0201026	CLASS A CDF (100 PSI)	460 W	655 CY	0	0	0	0	28329	0	0	28329
	SUBTOTAL SITWORK	(SWP)		96	2,759	0	0	35,750	0	0	38,509
	CONSUMABLES 3.20 %						88				88
	GENERAL FOREMAN 7.00 %			6	193						193
	GENERAL REQUIREMENTS 15.00 %			15	442						442
	SALES TAX 8.00 %						7		0		7
	OH&P (ON MARKUPS ONLY)									4	4
TOTAL	COST CODE 46002 WBS 310100 (ESCALATION 0.00% - CONTINGENCY 75.00 %)			118	3,394	0	95	35,750	0	4	39,245

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS	

TOTAL WBS 310100 CDF FILL TANK BOTTOMS				182		6,452	0	95	35,750	0	4	42,303

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
310200	REMOVE SOIL ABOVE TANKS										
310200.01	GENERAL REQUIRMENTS										
310200.0102000	***** HPT'S ***** 2 MEN FOR 6 WEEKS	460 M	1 L/S	480	22934	0	0	0	0	0	22934
SUBTOTAL	GENERAL REQUIRMENTS	(MASK)		480	22,934	0	0	0	0	0	22,934
TOTAL	COST CODE 46001 WBS 310200 (ESCALATION 0.00% - CONTINGENCY 75.00 %)			480	22,934	0	0	0	0	0	22,934
310200.02	SITWORK										
310200.0201000	***** EXCAVATE SOIL ABOVE TANKS *****	460 M	0	0	0	0	0	0	0	0	0
310200.0201002	REMOVE SOIL FROM AX TANK FARM TO EXPOSE TANK DOMES, APPROX 20,500 CY OR 27,675 TONS, ASSUME 3 CY BUCKET.	460 M	0	0	0	0	0	0	0	0	0
310200.0201003	TRUCKS WITH ROLL-OFF TRAIL- ERS CARRYING 20 TON DUMP CONTAINERS FOR PICK-UP AT SITE BY OTHERS.	460 M	0	0	0	0	0	0	0	0	0
310200.0201004	OPERATOR & OILER	460 M	27675 TON	493	16560	0	0	0	0	0	16560
310200.0201006	TEAMSTERS (4 EA) W/20 TON ROLL-OFF TRAILER.	460 M	27675 TON	985	33195	0	0	0	0	0	33195
310200.0201007	ALLOWANCE FOR LINERS, ONE FOR EACH 20 TON LOAD @ \$15 EACH.	460 M	1384 EA	0	0	0	20760	0	0	1038	21798
310200.0201008	EXCAVATOR FUEL @ 16 GAL/HR X \$1.35/GAL X 240 HRS.	460 M	1 L/S	0	0	0	5184	0	0	259	5443
SUBTOTAL	SITWORK	(MASK)		1,478	49,755	0	25,944	0	0	1,297	76,996
	CONSUMABLES 3.20 %						1592		0		1592
	GENERAL FOREMAN 7.00 %			103	3482						3482
	GENERAL REQUIREMENTS 15.00 %			237	7985						7985
	SALES TAX 8.00 %						2202		0		2202

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
=====											
	OH&P (ON MARKUPS ONLY)									189	189
TOTAL	COST CODE 46002			1,818		0		0		1,486	
	WBS 310200				61,223		29,739		0		92,449
	(ESCALATION 0.00% - CONTINGENCY 75.00 %)										

TOTAL WBS 310200 REMOVE SOIL ABOVE TANKS				2,298		0		0		1,486	115,383
					84,157		29,739		0		

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
310300	PULVERIZE TANK DOMES										
310300.01	GENERAL REQUIRMENTS										
310300.0103000	***** HPT'S ***** 2 MEN FOR 12 DAYS	460 M	1 L/S	192	9174	0	0	0	0	0	9174
SUBTOTAL	GENERAL REQUIRMENTS		(MASK)	192	9,174	0	0	0	0	0	9,174
TOTAL	COST CODE 46001 WBS 310300 (ESCALATION 0.00% - CONTINGENCY 75.00 %)			192	9,174	0	0	0	0	0	9,174
310300.02	SITework										
310300.0204000	***** CREATE STARTER HOLE IN TANK DOME *****	460 M	0	0	0	0	0	0	0	0	0
310300.0204002	***** UTILIZING CATERPILLAR 375 EXCAVATOR W/HYDRAULIC BREAK- ER ATTACHMENT, BREAK HOLE THRU TOP CENTER OF DOMES, *****	460 M	0	0	0	0	0	0	0	0	0
310300.0204003	***** AFTER HOLE IS LARGE ENOUGH TO PERMIT USAGE OF PULVERIZ- ER, DECON AND REPLACE BREAK ER. ALLOW ONE DAY. *****	460 M	0	0	0	0	0	0	0	0	0
310300.0204006	***** OPERATOR *****	460 M	1 TK	8	269	0	0	0	0	0	269
310300.0204008	***** OILER *****	460 M	1 TK	8	269	0	0	0	0	0	269
310300.0204010	***** LABORERS, 2 MEN - 1 DAY *****	460 M	1 TK	16	460	0	0	0	0	0	460
310300.0204011	***** MILLWRIGHT - 1 DAY *****	460 M	1 TK	8	270	0	0	0	0	0	270
310300.0204012	***** ALLOWANCE FOR REMAINING 3 TANKS. *****	460 M	0	0	0	0	0	0	0	0	0
310300.0204014	***** OPERATORS *****	460 M	3 TKS	24	806	0	0	0	0	0	806
310300.0204016	***** OILERS *****	460 M	3 TKS	24	806	0	0	0	0	0	806
310300.0204018	***** LABORERS *****	460 M	3 TKS	48	1612	0	0	0	0	0	1612
310300.0204019	***** MILLWRIGHT *****	460 M	3 TKS	24	811	0	0	0	0	0	811
310300.0204100	***** PULVERIZE REMAINDER OF TANK DOME *****	460 M	0	0	0	0	0	0	0	0	0

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
310300.0204120	UTILIZING (2) CATERPILLAR 375 EXCAVATORS W/PULVERIZER, SHEAR AND GRAPPLE, REMOVE DOME. ALLOW 2 DAYS PER TANK.	460 M	0	0	0	0	0	0	0	0	0
310300.0204122	OPERATORS (2)	460 M	1 TK	32	1075	0	0	0	0	0	1075
310300.0204124	OILERS (2)	460 M	1 TK	32	1075	0	0	0	0	0	1075
310300.0204126	LABORERS (4)	460 M	1 TK	64	1839	0	0	0	0	0	1839
310300.0204128	MILLWRIGHTS (2)	460 M	1 TK	32	1081	0	0	0	0	0	1081
310300.0204130	ALLOWANCE FOR REMAINING 3 TANKS AT 2 DAYS PER TANK.	460 M	0	0	0	0	0	0	0	0	0
310300.0204132	OPERATORS	460 M	3 TKS	96	3225	0	0	0	0	0	3225
310300.0204134	OILERS	460 M	3 TKS	96	3225	0	0	0	0	0	3225
310300.0204136	LABORERS	460 M	3 TKS	192	5518	0	0	0	0	0	5518
310300.0204138	MILLWRIGHTS	460 M	3 TKS	96	3243	0	0	0	0	0	3243
310300.0204200	LABORERS TO BE ON HAND FOR DECONTAMINATION OF ATTACH- MENTS BEFORE CHANGEOUTS, MILLWRIGHT IS FOR REPAIR AND MAINTENANCE OF ATTACHMENTS.	460 M	0	0	0	0	0	0	0	0	0
310300.0204201	ALLOW TWO LABORERS AND ONE MILLWRIGHT PER OPERATING EXCAVATOR FOR JOB DURATION.	460 M	0	0	0	0	0	0	0	0	0
SUBTOTAL	SITWORK	(MASK)		800	25,584	0	0	0	0	0	25,584
	CONSUMABLES 3.20 %						818		0		818
	GENERAL FOREMAN 7.00 %			56	1790						1790
	GENERAL REQUIREMENTS 15.00 %			128	4106						4106
	SALES TAX 8.00 %						65		0		65
	OH&P (ON MARKUPS ONLY)									44	44
TOTAL	COST CODE 46002			984	31,481	0	884	0	0	44	32,409
	WBS 310300										
	(ESCALATION 0.00% - CONTINGENCY 75.00 %)										
TOTAL WBS 310300 PULVERIZE TANK DOMES				1,176	40,655	0	884	0	0	44	41,583

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WBS ITEM	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
000	REMOVE SOIL AT TANK SIDES										
000.01	GENERAL REQUIRMENTS										
000.0104000	***** HPT'S ***** 2 MEN FOR 44 WEEKS	460 M	1 L/S	3467	165653	0	0	0	0	0	165653
SUBTOTAL	GENERAL REQUIRMENTS	(MASK)		3,467	165,653	0	0	0	0	0	165,653
TOTAL	COST CODE 46001 WBS 310400 (ESCALATION 0.00% - CONTINGENCY 75.00 %)			3,467	165,653	0	0	0	0	0	165,653
000.02	SITWORK										
000.0203000	***** EXCAVATE TO UNCOVER TANK SIDES *****	460 W	0	0	0	0	0	0	0	0	0
000.0203001	REMOVE SOIL DOWN TO BASE OF TANKS UTILIZING EXCAVATOR WITH 3 CY BUCKET, APPROX. 144,300 CY OR 194,800 TONS.	460 W	0	0	0	0	0	0	0	0	0
000.0203002	TRUCKS WITH ROLL-OFF TRAIL- ERS CARRYING 20 TON DUMP CONTAINERS FOR PICK UP AT SITE BY OTHERS.	460 W	0	0	0	0	0	0	0	0	0
000.0203004	OPERATOR & OILER	460 W 194800 TON		3467	116457	0	0	0	0	0	116457
000.0203006	TEAMSTERS (4 EA)	460 W 194800 TON		6935	233710	0	0	0	0	0	233710
000.0203007	ALLOWANCE FOR LINERS, ONE FOR EACH 20 TON LOAD @ \$15 EACH.	460 W 9715 EA		0	0	0	145725	0	0	7286	153011
000.0203010	EXCAVATOR FUEL @ 16 GAL/HR X \$1.35/GAL X 1734 HRS.	460 W	1 L/S	0	0	0	37454	0	0	1873	39327
SUBTOTAL	SITWORK	(SWP)		10,402	350,167	0	183,179	0	0	9,159	542,505
	CONSUMABLES 3.20 %						11205				11205
	GENERAL FOREMAN 7.00 %			728	24511						24511
	GENERAL REQUIREMENTS 15.00 %			1669	56201						56201
	SALES TAX 8.00 %						15550		0		15550

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
=====											
	OH&P (ON MARKUPS ONLY)									1337	1337

TOTAL	COST CODE 46002			12,799		0		0		10,496	
	WBS 310400				430,880		209,935		0		651,312
	(ESCALATION 0.00% - CONTINGENCY 75.00 %)										

TOTAL WBS 310400 REMOVE SOIL AT TANK SIDES				16,266		0		0		10,496	
					596,533		209,935		0		816,965

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
310500	REMOVE TANK WALLS										
310500.01	GENERAL REQUIRMENTS										
310500.0105000	***** HPT'S ***** 2 MEN FOR 6 WEEKS	460 M	1 L/S	480	22934	0	0	0	0	0	22934
SUBTOTAL	GENERAL REQUIRMENTS	(MASK)		480	22,934	0	0	0	0	0	22,934
TOTAL	COST CODE 46001 WBS 310500 (ESCALATION 0.00% - CONTINGENCY 75.00 %)			480	22,934	0	0	0	0	0	22,934
310500.02	SITWORK										
310500.0205000	***** REMOVAL OF TANK WALLS *****	460 M	0	0	0	0	0	0	0	0	0
310500.0205002	UTILIZING (2) CATERPILLAR 375 EXCAVATORS WITH PULVERI- ZER AND SHEAR, REMOVE WALLS AND LINER. RUBBLE TO BE	460 M	0	0	0	0	0	0	0	0	0
310500.0205003	LOADED INTO 20 TON ROLL-OFF CONTAINERS FOR ERDF WITH A CATERPILLAR 988 FRONT-END LOADER.	460 M	0	0	0	0	0	0	0	0	0
310500.0205006	ALLOWANCE FOR ONE TANK.	460 M	0	0	0	0	0	0	0	0	0
310500.0205008	OPERATOR (3) 1.5 WEEKS	460 M	1 TK	180	6046	0	0	0	0	0	6046
310500.0205010	OILERS (3) 1.5 WEEKS	460 M	1 TK	180	6046	0	0	0	0	0	6046
310500.0205012	TEAMSTERS (2) 1.5 WEEKS	460 M	1 TK	120	4044	0	0	0	0	0	4044
310500.0205016	LABORERS (6) 1.5 WEEKS	460 M	1 TK	360	12132	0	0	0	0	0	12132
310500.0205018	MILLWRIGHTS (2) 1.5 WEEKS	460 M	1 TK	120	4054	0	0	0	0	0	4054
310500.0205020	ALLOWANCE FOR 3 REMAINING TANKS.	460 M	0	0	0	0	0	0	0	0	0
310500.0205022	OPERATORS (3) 4.5 WEEKS	460 M	3 TKS	540	18139	0	0	0	0	0	18139
310500.0205024	OILERS (3) 4.5 WEEKS	460 M	3 TKS	540	18139	0	0	0	0	0	18139
310500.0205026	TEAMSTERS (2) 4.5 WEEKS	460 M	3 TKS	360	12092	0	0	0	0	0	12092
310500.0205030	LABORERS (6) 4.5 WEEKS	460 M	3 TKS	1080	31039	0	0	0	0	0	31039
310500.0205032	MILLWRIGHTS (2) 4.5 WEEKS	460 M	3 TKS	360	12161	0	0	0	0	0	12161
310500.0205040	LABORERS TO BE ON HAND FOR DECONTAMINATION OF ATTACH-	460 M	0	0	0	0	0	0	0	0	0

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
310500.0205041	MENTS BEFORE CHANGEOUTS AND COORDINATING CONTAINER MOVE- MENTS THRU AIRLOCKS. MILL- WRIGHTS WILL MAINTAIN AND REPAIR THE ATTACHMENTS.	460 M	0	0	0	0	0	0	0	0	0
310500.0205044	ALLOWANCE FOR LINERS, ONE FOR EACH 20 TON LOAD @ \$15 EACH.	460 M	213 EA	0	0	0	3195	0	0	160	3355
<hr/>											
SUBTOTAL	SITWORK	(MASK)		3,840		0		0		160	
	CONSUMABLES 3.20 %				123,892		3,195		0		127,247
	GENERAL FOREMAN 7.00 %			268	8672		3964				3964
	GENERAL REQUIREMENTS 15.00 %			616	19884						8672
	SALES TAX 8.00 %						572		0		19884
	OH&P (ON MARKUPS ONLY)									226	572
<hr/>											
TOTAL	COST CODE 46002			4,725		0		0		386	
	WBS 310500				152,449		7,732		0		160,568
	(ESCALATION 0.00% - CONTINGENCY 75.00 %)										
<hr/>											
TOTAL WBS 310500	REMOVE TANK WALLS			5,205		0		0		386	
					175,383		7,732		0		183,502

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
310600	REMOVE TANK BOTTOMS										
310600.01	GENERAL REQUIRMENTS										
310600.0106000	***** HPT'S ***** 2 MEN FOR 32 DAYS	460 M	1 L/S	512	24463	0	0	0	0	0	24463
	SUBTOTAL			512	24,463	0	0	0	0	0	24,463
	TOTAL			512	24,463	0	0	0	0	0	24,463
	COST CODE 46001 WBS 310600 (ESCALATION 0.00% - CONTINGENCY 75.00 %)										
310600.02	SITWORK										
310600.0206000	***** REMOVAL OF TANK BOTTOM *****	460 M	0	0	0	0	0	0	0	0	0
310600.0206002	UTILIZING CATERPILLAR 375 EXCAVATORS W/ PICK HAMMER, PULVERIZER & SHEAR AND CAT- ERPILLAR 988 LOADER, REMOVE	460 M	0	0	0	0	0	0	0	0	0
310600.0206003	BASE OF TANK, LINER, CDF FILL, 360 CF OF SOLIDIFIED SLUDGE, PLUS 3" OF UNDERLY- ING SOIL. DUE TO THE HIGH	460 M	0	0	0	0	0	0	0	0	0
310600.0206004	RADIATION, SPECIAL CONTAIN- ERS WILL BE REQUIRED, THESE WILL HOLD APPROX. 3.5 CY, 365 OF THESE CONTAINERS WILL	460 M	0	0	0	0	0	0	0	0	0
310600.0206005	BE REQUIRED FOR EACH TANK, 1460 TOTAL. ASSUME THAT 4 TRUCKS & TRAILERS CAN OPER- ATE WITHIN THE PIT AREA AND	460 M	0	0	0	0	0	0	0	0	0
310600.0206006	EACH TRUCK IS ABLE TO COMPL- ETE 2 LOADS PER HOUR. IT IS ESTIMATED THAT EACH TANK WILL TAKE 8 DAYS.	460 M	0	0	0	0	0	0	0	0	0
310600.0206036	ALLOWANCE FOR ONE TANK:	460 M	0	0	0	0	0	0	0	0	0
310600.0206038	OPERATORS (3) 8 DAYS	460 M	1 TK	192	6449	0	0	0	0	0	6449
310600.0206040	OILERS (3) 8 DAYS	460 M	1 TK	192	6449	0	0	0	0	0	6449

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310600.0206042	TEAMSTERS (4) 8 DAYS	460 M	1 TK	256	8627	0	0	0	0	0	8627
310600.0206048	LABORERS (6) 8 DAYS	460 M	1 TK	384	11036	0	0	0	0	0	11036
310600.0206050	MILLWRIGHTS (2) 8 DAYS	460 M	1 TK	128	4324	0	0	0	0	0	4324
310600.0206100	ALLOWANCE FOR THREE REMAIN- ING TANKS:	460 M	0	0	0	0	0	0	0	0	0
310600.0206102	OPERATORS (3) 24 DAYS	460 M	3 TKS	576	19348	0	0	0	0	0	19348
310600.0206104	OILERS (3) 24 DAYS	460 M	3 TKS	576	19348	0	0	0	0	0	19348
310600.0206106	TEAMSTERS (2) 24 DAYS	460 M	3 TKS	384	12941	0	0	0	0	0	12941
310600.0206110	LABORERS (6) 24 DAYS	460 M	3 TKS	1152	33108	0	0	0	0	0	33108
310600.0206112	MILLWRIGHTS (2) 24 DAYS	460 M	3 TKS	384	12972	0	0	0	0	0	12972
310600.0206120	LABORERS TO BE ON HAND FOR DECONTAMINATION OF ATTACH- MENTS BEFORE CHANGEOUTS AND COORDINATING CONTAINER MOVE-	460 M	0	0	0	0	0	0	0	0	0
310600.0206121	MENTS THRU AIRLOCKS. MILL- WRIGHTS MAINTAIN AND REPAIR THE ATTACHMENTS.	460 M	0	0	0	0	0	0	0	0	0
SUBTOTAL	SITework	(MASK)		4,224		0		0		0	
	CONSUMABLES 3.20 %				134,602		0		0		134,602
	GENERAL FOREMAN 7.00 %			295	9422		4307				4307
	GENERAL REQUIREMENTS 15.00 %			677	21603						9422
	SALES TAX 8.00 %						344		0		21603
	OH&P (ON MARKUPS ONLY)									232	344
											232
TOTAL	COST CODE 46002			5,197		0		0		232	
	WBS 310600				165,627		4,651		0		170,512
	(ESCALATION 0.00% - CONTINGENCY 75.00 %)										
TOTAL WBS 310600 REMOVE TANK BOTTOMS				5,709		0		0		232	
					190,090		4,651		0		194,975

FLOOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
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** TEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCR08 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
320700	MAIN BUILDING										
320700.13	SPECIAL CONSTRUCTION										
320700.1307000	***** MAIN BUILDING *****	501	0	0	0	0	0	0	0	0	0
320700.1307002	FOUNDATION	501	0	0	0	0	0	0	0	0	0
320700.1307004	SPREAD FOOTINGS, 10' X 10' X 2' THICK.	501	46 EA	290	8700	0	20700	8510	0	8201	46111
320700.1307006	END WALL FOOTINGS, 6' X 6' X 18" THICK.	501	38 EA	125	3750	0	4940	4750	0	2648	16088
320700.1307008	GRADE BEAM, 18"W X 4'H.	501	2100 LF	1401	48657	0	33747	0	0	20601	103005
320700.1307020	SUPERSTRUCTURE	501	275000 SF	10175	353378	0	1039500	0	0	348220	1741098
320700.1307030	EXTERIOR CLOSURE	501	440000 SF	10120	359665	0	792000	0	0	287916	1439581
320700.1307032	DOORS	501	1600 SF	0	0	0	0	43200	0	4320	47520
320700.1307040	INTERIOR CLOSURE	501	400000 SF	9200	326968	0	320000	0	0	161742	808710
320700.1307042	DOORS	501	1000 SF	0	0	0	0	27000	0	2700	29700
320700.1307050	MECHANICAL	501	0	0	0	0	0	0	0	0	0
320700.1307052	FIRE PROTECTION	501	275000 SF	11000	362450	0	338250	0	0	175175	875875
320700.1307060	ELECTRICAL	501	0	0	0	0	0	0	0	0	0
320700.1307062	SERVICE AND DISTRIBUTION	501	275000 SF	1925	59213	0	68200	0	0	31853	159266
320700.1307064	LIGHTING, AT ONE WATT PER SQUARE FOOT	501	275000 SF	6875	211475	0	220000	0	0	107869	539344

SUBTOTAL	SPECIAL CONSTRUCTION			51,111	1,734,256	0	2,837,337	83,460		1,151,245	5,806,298
	SALES TAX 8.00 %						226986			0	226986
	OH&P (ON MARKUPS ONLY)									56746	56746

TOTAL	COST CODE 50113 WBS 320700 (ESCALATION 0.00% - CONTINGENCY 20.00 %)			51,111	1,734,256	0	3,064,323	83,460		1,207,991	6,090,031

320700.15	MECHANICAL										
320700.1507000	***** WASH FACILITY *****	501	0	0	0	0	0	0	0	0	0
320700.1507002	ALLOWANCE BASED ON SIMILAR REQUIREMENT FOR W259. PRICE INCLUDES POWER, PIPING, TANKS, COMPRESSOR, BUILDING,	501	1 L/S	8827	335170	1744	846098	12650	0	297018	1492680
320700.1507004	FREEZE PROTECTION, HEPA FILTRATION, TRANSFER PUMPS,	501	0	0	0	0	0	0	0	0	0

FLUOR DANIEL NORTHWEST, INC.
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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
320700.1507100	AND INSTRUMENTATION. ***** VENTILATION SYSTEM *****	501	0	0	0	0	0	0	0	0	0
320700.1507102	*SUPPLY*	501	0	0	0	0	0	0	0	0	0
320700.1507103	FAN, 112,500 SCFM, 200 HP	501	1 EA	64	2275	0	24750	0	0	6756	33781
320700.1507105	EVAPORATIVE COOLER, 112,500 SCFM	501	1 EA	160	5686	0	43600	0	0	12322	61608
320700.1507107	PREFILTER	501	1 EA	0	0	0	16875	0	0	4219	21094
320700.1507109	VALVE/DAMPER, 72" DIA	501	1 EA	8	284	0	1000	0	0	321	1605
320700.1507110	DISCHARGE NOZZLES/GRILLS	501	2 EA	10	355	0	1000	0	0	339	1694
320700.1507120	DUCT, 16 GA SST, 84" DIA FABRICATE	501	150 LF	99	3518	0	3750	0	0	1817	9085
320700.1507122	INSTALL	501	150 LF	198	7037	0	0	0	0	1759	8796
320700.1507124	DUCT, 16 GA SST, 60" DIA FABRICATE	501	200 LF	94	3341	0	3560	0	0	1725	8626
320700.1507126	INSTALL	501	200 LF	188	6682	0	0	0	0	1671	8353
320700.1507128	HANGER ALLOWANCE	501	1 L/S	32	1137	0	200	0	0	334	1671
320700.1507200	*EXHAUST*	501	0	0	0	0	0	0	0	0	0
320700.1507202	FAN, 122,500 SCFM	501	1 EA	64	2275	0	27750	0	0	7506	37531
320700.1507204	VALVE/DAMPER, 80"	501	5 EA	25	889	0	2500	0	0	847	4236
320700.1507206	VALVE/DAMPER, 72"	501	1 EA	6	213	0	700	0	0	228	1141
320700.1507208	SUCTION NOZZLES/GRILLS	501	5 EA	25	889	0	2500	0	0	847	4236
320700.1507210	DUCT, 16 GA SST, 84" FABRICATE	501	300 LF	198	7037	0	7500	0	0	3634	18171
320700.1507212	INSTALL	501	300 LF	396	14074	0	0	0	0	3519	17593
320700.1507214	DUCT, 16 GA SST, 60" FABRICATE	501	650 LF	306	10875	0	11570	0	0	5611	28056
320700.1507216	INSTALL	501	650 LF	611	21715	0	0	0	0	5429	27144
320700.1507220	HANGER ALLOWANCE	501	1 L/S	88	3128	0	550	0	0	920	4598
320700.1507300	*STACK* 106" DIAMETER BY 200 FT HIGH EXCAVATION/BACKFILL FOR STACK PAD, FAN EQUIPMENT PAD AND DEAD MAN ANCHORS (ASSUME MACHINE DIG)	501	0	0	0	0	0	0	0	0	0
320700.1507302	STACK FOUNDATION, ALLOW FOR 8' X 20' X 20'	501	1 L/S	200	6292	0	0	0	0	1573	7865
320700.1507306	ISOKINETIC STACK SAMPLING SYSTEM	501	1 EA	240	7382	0	1000000	0	0	251846	1259228
320700.1507312	INSTALL AIR MONITOR IN STACK	501	1 EA	24	738	0	11000	0	0	2935	14673
320700.1507320	20 FT X 3/16" WALL	501	4270 LB	43	1726	0	12810	0	0	3634	18170

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320700.1507321	WELD STACK SECTIONS AT 10 FT	501	2 EA	7	281	0	62	0	0	86	429
320700.1507322	20 FT X 1/4" WALL	501	5690 LB	57	2289	0	17070	0	0	4840	24199
320700.1507323	WELD STACK SECTIONS AT 10 FT	501	2 EA	8	321	0	62	0	0	96	479
320700.1507324	20 FT X 5/16" WALL	501	7120 LB	71	2851	0	21360	0	0	6053	30264
320700.1507325	WELD STACK SECTIONS AT 10 FT	501	2 EA	42	1686	0	234	0	0	480	2400
320700.1507326	20 FT X 3/8" WALL	501	8540 LB	85	3413	0	25620	0	0	7258	36291
320700.1507327	WELD STACK SECTIONS AT 10 FT	501	2 EA	57	2289	0	290	0	0	645	3224
320700.1507328	40 FT X 1/2" WALL	501	22780 LB	228	9154	0	68340	0	0	19374	96868
320700.1507329	WELD STACK SECTIONS AT 10 FT	501	4 EA	132	5300	0	780	0	0	1520	7600
320700.1507330	40 FT X 5/8" WALL	501	28470 LB	285	11443	0	85410	0	0	24213	121066
320700.1507331	WELD STACK SECTIONS AT 10 FT	501	4 EA	180	7227	0	1940	0	0	2292	11459
320700.1507332	40 FT X 3/4" WALL	501	34160 LB	342	13731	0	102480	0	0	29053	145264
320700.1507333	WELD STACK SECTIONS AT 10 FT	501	4 EA	222	8913	0	2332	0	0	2811	14056
320700.1507340	BASE PLATE, 106" DIA X 24" WIDE X 1-3/4" THICK, RING	501	3985 LB	120	4818	0	9963	0	0	3695	18476
320700.1507342	UPPER PLATE, 106" DIA X 20" WIDE X 1-3/4" THICK, RING	501	3322 LB	100	4015	0	8305	0	0	3080	15400
320700.1507344	GUSSETS, 24" X 24" X 1" 48 EA	501	3950 LB	79	3172	0	9875	0	0	3262	16309
320700.1507346	BOLTS AND NUTS	501	48 EA	24	964	0	6480	0	0	1861	9305
320700.1507348	WELD STACK BASE AND GUSSETS	501	520 LF	442	17746	0	3640	0	0	5347	26733
320700.1507500	HEPA FILTER HOUSING 122,500 SCFM	501	1 L/S	0	0	0	595000	0	0	148750	743750
320700.1507502	EQUIPMENT SLAB ON GRADE, ALLOW FOR 12" X 40' X 60'	501	1 L/S	300	9000	0	8000	0	0	4250	21250
320700.1507504	ELECTROSTATIC PRECIPITATOR	501	1 L/S	164	5045	0	171500	0	0	44136	220681
320700.1507506	PREFILTER	501	1 L/S	0	0	0	18375	0	0	4594	22969
<hr/>											
SUBTOTAL	MECHANICAL			15,251		1,744		12,650		939,973	
	SALES TAX 8.00 %				567,576		3,185,498		0		4,707,441
	OH&P (ON MARKUPS ONLY)						254839		0		254839
										63709	63709
<hr/>											
TOTAL	COST CODE 50115 WBS 320700			15,251		1,744		12,650		1,003,682	
					567,576		3,440,337		0		5,025,990

FLUOR DANIEL NORTHWEST, INC.
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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
=====											
	(ESCALATION	0.00%	-	CONTINGENCY	20.00%						

TOTAL WBS 320700 MAIN BUILDING

 66,362 1,744 96,110 2,211,674
 2,301,832 6,504,661 0 11,116,022

FLUOR DANIEL NORTHWEST, INC.
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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
320800	SUPPORT FACILITY										
320800.15	MECHANICAL										
320800.1508000	***** SUPPORT FACILITY *****	501	0	0	0	0	0	0	0	0	0
	75' X 75' X 20' EAVE HT										
320800.1508002	FOUNDATION AND DRIVE WAY	501	0	0	0	0	0	0	0	0	0
320800.1508004	FORMS	501	475 LF	38	1169	29	352	0	0	388	1938
320800.1508006	REBAR	501	12750 LB	89	3091	0	3188	0	0	1570	7849
320800.1508008	SLAB ON GRADE, INCLUDING DRIVE WAY	501	9375 SF	188	5061	1594	12188	0	0	4711	23554
320800.1508020	BUILDING	501	0	0	0	0	0	0	0	0	0
320800.1508022	75' X 75' X 20' EAVE HT METAL BLDG, 26 GA, CLEAR SPAN.	501	5625 SF	338	11830	5625	28125	0	0	11395	56975
320800.1508024	ENTRANCE CANOPY, 4' X 8'	501	2 EA	8	284	106	450	0	0	210	1050
320800.1508026	DOORS, 3670	501	2 EA	8	246	106	570	0	0	231	1153
320800.1508028	WINDOWS, 4030	501	6 EA	12	369	36	1110	0	0	379	1894
320800.1508030	ROLL-UP DOORS, 20 X 24	501	2 EA	48	1476	400	26000	0	0	6969	34845
320800.1508040	GUTTER, VALLEY TYPE BETWEEN BUILDINGS	501	100 LF	14	498	0	320	0	0	205	1023
320800.1508042	INSULATION, R11	501	8750 SF	70	2476	0	3500	0	0	1494	7470
320800.1509000	***** MAINTENANCE FACILITY *****	501	0	0	0	0	0	0	0	0	0
	30' X 50' X 20' EAVE HT										
320800.1509002	FOUNDATION AND DRIVE WAY	501	0	0	0	0	0	0	0	0	0
320800.1509004	FORMS	501	340 LF	27	831	20	252	0	0	276	1379
320800.1509006	REBAR	501	4500 LB	32	1111	0	1125	0	0	559	2795
320800.1509008	SLAB ON GRADE, INCLUDING DRIVE WAYS	501	3300 SF	66	1777	561	4290	0	0	1657	8285
320800.1509020	BUILDING	501	0	0	0	0	0	0	0	0	0
320800.1509022	30' X 50' X 20' EAVE HT METAL BLDG, 26 GA, CLEAR SPAN.	501	1500 SF	0	0	1500	0	0	0	375	1875
320800.1509026	DOORS, 3670	501	2 EA	8	246	106	570	0	0	231	1153
320800.1509028	WINDOWS, 4030	501	6 EA	12	369	36	1110	0	0	379	1894
320800.1509030	ROLL-UP DOORS, 20 X 24	501	2 EA	48	1476	400	26000	0	0	6969	34845
320800.1509042	INSULATION, R11	501	4700 SF	38	1344	0	1880	0	0	806	4030

SUBTOTAL	MECHANICAL			1,044	33,654	10,519	111,030	0	0	38,804	194,007

FLUOR DANIEL NORTHWEST, INC.
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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
	SALES TAX 8.00 %						8882		0		8882
	OH&P (ON MARKUPS ONLY)									2220	2220
TOTAL	COST CODE 50115			1,044		10,519		0		41,024	
	WBS 320800				33,654		119,912		0		205,110
	(ESCALATION 0.00% - CONTINGENCY 25.00 %)										
TOTAL WBS 320800 SUPPORT FACILITY				1,044		10,519		0		41,024	
					33,654		119,912		0		205,110

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
320900	BACKFILL										
320900.02	SITWORK										
320900.0209000	***** BACKFILL *****	501	0	0	0	0	0	0	0	0	0
320900.0209002	BRING IN BACKFILL FROM PIT 30, APPROXIMATELY A 5 MI. ROUND TRIP. USE FOUR 40 TON TRUCK TRACTORS W/20 TON DUMP	501	0	0	0	0	0	0	0	0	0
320900.0209003	TRAILERS MAKING 1-1/2 LOADS PER HOUR EACH, LOADED BY TRUCK MOUNTED FRONT END	501	0	0	0	0	0	0	0	0	0
320900.0209004	DOZER WILL BE USED FOR BACK- FILLING. TOTAL PRODUCTION IS 120 CY/HR. JOB DURATION WILL BE 49 WEEKS.	501	0	0	0	0	0	0	0	0	0
320900.0209010	OPERATOR, DOZER	501	1 EA	1950	61347	0	0	0	0	15337	76684
320900.0209012	OPERATOR, LOADER	501	1 EA	1950	61347	0	0	0	0	15337	76684
320900.0209014	TEAMSTERS (4), TRK TRCTR	501	4 EA	7800	246168	0	0	0	0	61542	307710
320900.0209016	TEAMSTER, WATER TRUCK	501	1 EA	1950	61542	0	0	0	0	15386	76928
320900.0209018	LABORER, GRADE CHECKER	501	1 EA	1950	52494	0	0	0	0	13124	65618
320900.0209020	40 TON TRUCK TRACTOR (4)	501	48 MO	0	0	172800	0	0	0	43200	216000
320900.0209022	20 CY DUMP TRAILER (4)	501	48 MO	0	0	66000	0	0	0	16500	82500
320900.0209024	FRONT END LOADER	501	12 MO	0	0	136800	0	0	0	34200	171000
320900.0209026	DOZER, 200 HP	501	12 MO	0	0	111600	0	0	0	27900	139500
320900.0209028	WATER TRUCK	501	12 MO	0	0	34800	0	0	0	8700	43500

SUBTOTAL	SITWORK			15,600		522,000		0		251,226	

TOTAL	COST CODE 50102			15,600		522,000		0		251,226	
	WBS 320900				482,898			0			1,256,124
	(ESCALATION 0.00% - CONTINGENCY 20.00 %)										

TOTAL WBS 320900	BACKFILL			15,600		522,000		0		251,226	

					482,898			0			1,256,124

FLUOR DANIEL NORTHWEST, INC.
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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
330200	SOIL DISPOSAL - TOP OF TANKS										
330200.02	SITEWORK										
330200.0202000	***** DISPOSAL OF SOIL ABOVE TANKS *****	460	0	0	0	0	0	0	0	0	0
330200.0202002	SUBCONTRACTOR CHARGE TO PICK UP LOADED TRAILERS OUT- SIDE 241-AX TANK FARM AND DELIVER TO AND DUMP AT ERDF.	460	27675 TON	0	0	0	0	1660500	0	0	1660500
330200.0202003	COST IS \$60 PER TON.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	SITEWORK			0	0	0	0	1,660,500	0	0	1,660,500
TOTAL	COST CODE 46002 WBS 330200 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	1,660,500	0	0	1,660,500
TOTAL WBS 330200	SOIL DISPOSAL - TOP OF TANKS			0	0	0	0	1,660,500	0	0	1,660,500

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	SUB- MATERIAL CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
330400	SOIL DISPOSAL - SURROUNDING TANKS									
330400.02	SITework	460	0	0	0	0	0	0	0	0
330400.0204000	DISPOSAL OF SOIL SURROUNDING TANK SIDES	460	194800 TON	0	0	0	11688000	0	0	11688000
330400.0204002	SUBCONTRACTOR COSTS TO PICK UP LOADED TRAILERS OUT- SIDE 241-AX TANK FARM AND DELIVER TO AND DUMP AT ERDF.	460	0	0	0	0	0	0	0	0
330400.0204003	COST IS \$60 PER TON.	460	0	0	0	0	0	0	0	0
SUBTOTAL SITework										

TOTAL	COST CODE 46002 WBS 330400 (ESCALATION 0.00% - CONTINGENCY 35.00 %)				0	0	11,688,000	0	0	11,688,000

TOTAL WBS 330400 SOIL DISPOSAL - SURROUNDING TANKS			0	0	0	0	11,688,000	0	0	11,688,000

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
330500	DISPOSAL - TANK WALL DEBRIS										
330500.02	SITWORK										
330500.0205000	***** DISPOSAL OF TANK WALL DEBRIS *****	460	0	0	0	0	0	0	0	0	0
330500.0205002	SUBCONTRACTOR COSTS TO PICK UP LOADED TRAILERS OUT- SIDE 241-AX TANK FARM AND DELIVER TO AND DUMP AT ERDF.	460	4248 TON	0	0	0	0	254880	0	0	254880
330500.0205003	COST IS \$60 PER TON. 2124 CY OF REINFORCED CONCRETE AT APPROX. 4000 LB PER CY = 4248 TON.	460	0	0	0	0	0	0	0	0	0

SUBTOTAL	SITWORK			0		0		254,880		0	

TOTAL	COST CODE 46002 WBS 330500 (ESCALATION 0.00% - CONTINGENCY			0	0	0	0	254,880	0	0	254,880

TOTAL WBS 330500	DISPOSAL - TANK WALL DEBRIS			0		0		254,880		0	

					0		0		0		254,880

FLUOR DANIEL NORTHWEST, INC.
 COGEMA ENGINEERING CORP.
 JOB NO. Z466AAA3
 FILE NO. Z466AAA3

** IEST - INTERACTIVE ESTIMATING **
 TANK REMOVAL
 241-AX TANK FARM CLOSURE - PLANNING ESTIMATE
 PHMCR08 - ESTIMATE DETAIL BY WBS / COST CODE

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 BY R.OHRT

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB- CONTRACT	EQUIP- MENT	OH&P / B & I	TOTAL DOLLARS
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
REPORT TOTAL				323,489		534,263		13,735,240		2,888,630	
				16,878,401		14,318,682				0	48,355,218

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