ENVIRONMENTAL MEASUREMENTS LABORATORY

EML-609

West Valley Demonstration Project
Waste Management Area #3 -- Closure Alternative I

Prepared by: *Stephen F. Marschke*

Prepared for: *West Valley Nuclear Services Company, Inc.*
Daniel Westcott

June 2000

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DISCLAIMER

Abstract

The Draft Environmental Impact Statement for the completion of the West Valley Demonstration Project and closure and/or long-term management of facilities at the Western New York Nuclear Service Center divided the site into Waste Management Areas (WMAs), and for each WMA, presented the impacts associated with five potential closure alternatives. This report focuses on WMA 3 (the High-Level Waste (HLW) Storage Area (Tanks 8D-1 and 8D-2), the Vitrification Facility and other facilities) and closure Alternative I (the complete removal of all structures, systems and components and the release of the area for unrestricted use), and re-estimates the impacts associated with the complete removal of the HLW tanks, and surrounding facilities.

A 32-step approach was developed for the complete removal of Tanks 8D-1 and 8D-2, the Supernatant Treatment System Support Building, and the Transfer Trench. First, a shielded Confinement Structure would be constructed to reduce the shine dose rate and to control radioactivity releases. Similarly, the tank heels would be stabilized to reduce potential radiation exposures. Next, the tank removal methodology would include: 1) excavation of the vault cover soil, 2) removal of the vault roof, 3) cutting off the tank's top, 4) removal of the stabilized heel remaining inside the tank, 5) cutting up the tank's walls and floor, 6) removal of the vault's walls, the perlite blocks, and vault floor, and 7) radiation surveying and backfilling the resulting hole. After the tanks are removed, the Confinement Structure would be decontaminated and dismantled, and the site backfilled and landscaped.

The impacts (including waste disposal quantities, emissions, work-effort, radiation exposures, injuries and fatalities, consumable materials used, and costs) were estimated based on this 32 step removal methodology, and added to the previously estimated impacts for closure of the other facilities within WMA 3 to obtain the total impacts from implementing Alternative I at WMA 3.

Executive Summary

The Draft Environmental Impact Statement for completion of the West Valley Demonstration Project and closure and/or long-term management of facilities at the Western New York Nuclear Service Center divided the site into Waste Management Areas (WMAs), and for each WMA, presented the impacts (including resource requirements, occupational issues, waste disposal, and cost estimates) associated with five potential closure alternatives. This report focuses on WMA 3 (the High-Level Waste (HLW) Storage Area, (Tanks 8D-1 and 8D-2), the Vitrification Facility and other facilities) and closure Alternative I (the complete removal of all structures, systems and components and the release of the area for unrestricted use), and re-estimates the associated impacts.

The first step of this re-analysis was to develop a methodology for the implementation of the complete removal of the HLW storage tanks which is realistic, implementable, and as detailed as practicable (at this stage of the project). To this end, a significant effort has been extended to determine how other sites with underground HLW storage tanks are addressing the issue of complete removal. Also, various manufacturers of remotely controlled manipulator arms that might be utilized during tank closure were contacted and asked to provide information as to how their products would perform the complete removal of an underground HLW storage tank

To determine how other U. S. Department of Energy (DOE) sites are addressing the problem of removal of underground HLW storage tanks, information on studies performed at three DOE sites concerning HLW tank removal was obtained and evaluated: the Hanford Site, Idaho National Engineering and Environmental Laboratory (INEEL), and the Savannah River Site (SRS). Two greatly different tank removal methodologies were presented (the SRS did not develop a specific removal methodology). At Hanford, a non-shielding confinement would be constructed, the earth surrounding the tanks would be removed, and the tanks would be demolished using conventional heavy construction equipment. In this report this methodology will be referred to as "Outside-In." At INEEL, soil stabilization would be performed, a non-shielding double confinement would be constructed, and remotely controlled manipulators would be used to dig-out contaminated soil and to cut-up the tanks. The INEEL methodology is referred to as "Top-Down" in this report.

To determine whether existing design manipulators would be capable of performing the remote removal of Tanks 8D-1 and 8D-2, two manipulator manufacturers (*i.e.*, EagleTech and GreyPilgrim) were contacted and asked to provide information on their systems. The two manufacturers have designed vastly different products. EagleTech manufactures a heavy duty manipulator, made with commercial steel components, capable of lifting heavy objects, and which has been commercially available for some time. GreyPilgrim, on the other hand, manufactures a serpentine manipulator which can 'snake' its way around any internal tank obstructions, but to date only a few short range versions have been produced. There are other

advantages and disadvantages of each manipulator, but together they span the spectrum of manipulators currently available.

The results of this research indicate that: 1) the DOE sites that have investigated HLW storage tank removal have found it to be a difficult and costly process, 2) because of its difficulty, no DOE site has been identified that has selected complete tank removal as the preferred tank closure alternative, and 3) notwithstanding the first two results, both manipulator manufacturers believe that their manipulators can perform the job.

Based on this information, a 32 step approach was developed for the complete removal of Tanks 8D-1 and 8D-2, the STS Support Building, and the Transfer Trench. First a shielded Confinement Structure was constructed to reduce the shine dose rate and to control radioactivity releases. Similarly, the tank heels would be stabilized to reduce potential radiation exposures. The removal methodology would include: 1) excavation of the vault cover soil, 2) removal of the vault roof, 3) cutting off the tank's top, 4) removal of the stabilized heel remaining inside the tank, 5) cutting up the tank's walls and floor, 6) removal of the vault's walls, the perlite blocks, and vault floor, and 7) radiation surveying and backfilling the resulting hole. After the tanks are removed, the Confinement Structure would be decontaminated and dismantled. The primary advantage of this methodology is that the manipulator would have access to the entire tank throughout the dismantling process.

The impacts (including waste disposal quantities, emissions, work-effort, radiation exposures, injuries and fatalities, consumable materials used, and costs) were estimated based on this 32 step removal methodology, and added to the impacts previously estimated for closure of the other WMA 3 facilities to obtain the total impacts from implementing Alternative I at WMA 3. These estimated impacts include:

Resource Requirements – It was estimated that about 2,017 work-years would be required to implement Alternative I at WMA 3. Standard construction materials (*i.e.*, steel and concrete) would be required to construct confinement structures.

Operational Issues – A collective occupational radiation exposure of about 172 worker-rem was calculated. It was estimated that it would take about 11.3 years to remove the HLW storage tanks and vaults, with additional time required for preparation and planning, decontamination and construction. A 21½ year overall schedule was estimated for the closure of WMA 3, however, this schedule would need to be coordinated with the closure of the other WMAs.

Waste Disposal – A total of 1,460,000 ft^3 of low specific activity (LSA), 244,000 ft^3 of Class A, 6,850 ft^3 of Class C, and 10,100 ft^3 of greater than Class C (GTCC) waste were estimated to be generated. It was estimated that no Class B, hazardous or mixed waste would be generated.

Cost Estimate – A total cost of $541 million* was estimated for the implementation of Alternative I at WMA 3. The major components of this cost are: labor – $141 million (26.1%), waste disposal – $176 million (32.5%), contingency – $180 million (33.3%), and miscellaneous $44 million (8.1%).

* To be consistent with previously prepared DEIS cost estimates, all costs are presented in 1993 dollars.

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Acronyms and Abbreviations

ACECO	American Crane and Equipment Corporation
CDF	Controlled Density Fill
CERs	Closure Engineer Reports
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLSM	Controlled Low Strength Material
CMA	Container Management Area
CTRS	Cooperative Telerobotic Retrieval System
D&D	Decontamination and Decommissioning
DAWP	Dual Arm Work Platform
DEIS	Draft Environmental Impact Statement
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
ED&I	Engineering, Design and Inspection
EMMA™	Easily Manipulated Mechanical Armature
EPA	U.S. Environmental Protection Agency
GTCC	Greater Than Class C
HEPA	High Efficiency Particulate Air filter
HLW	High-Level Waste
HVAC	Heating, Ventilation and Air Conditioning
ICPP	Idaho Chemical Process Plant
INEEL	Idaho National Engineering and Environmental Laboratory
LLW	Low Level Radioactive Waste
LSA	Low Specific Activity
NRC	U.S. Nuclear Regulatory Commission
NYSERDA	New York State Energy Research and Development Authority
OSHA	Occupational Safety and Health Act
P&P	Preparation and Planning
PVS	Permanent Ventilation System

ACRONYMS AND ABBREVIATIONS (Cont'd)

RHWF	Remote Handled Waste Facility
SDSB	Shielded Debris Shuttle Box
SRS	Savannah River Site
SSTs	Single Shell Tanks
STRARCH	STRessed ARCH
STS	Supernatant Treatment System
TRCC	Total Removal Clean Closure
WCRs	Waste Characterization Report
WMAs	Waste Management Area
WNYNSC	Western New York Nuclear Service Center
WVDP	West Valley Demonstration Project
WVNS	West Valley Nuclear Services

Special Notice in Reporting of Measurement Units

It is the policy of the Environmental Measurements Laboratory to use SI units in its publications with an option of traditional units in parentheses. An exception to this rule is being made for this report because the data are to be used for environmental impact evaluation where the principal parties, including regulatory bodies, specify limits and report results and data in traditional units. To prevent crowding of the data and to maintain clarity, only the traditional units will be reported in this report. The exception to this rule is for radioactivity levels, where both traditional and SI units will be given.

1.0 Introduction

1.1 PURPOSE

The Draft Environmental Impact Statement (DEIS) for completion of the West Valley Demonstration Project (WVDP) and closure and/or long-term management of facilities at the Western New York Nuclear Service Center (WNYNSC) divided the site into Waste Management Areas (WMAs), and for each WMA, presented the impacts (including waste disposal quantities, emissions, work-effort, radiation exposures, injuries and fatalities, consumable materials used, and costs) associated with five potential closure alternatives. This report focuses on a single WMA (*i.e.,* WMA 3, the High-Level Waste (HLW) Storage Area and Vitrification Facility), and a single closure alternative (*i.e.,* Alternative I, the complete removal of all structures, systems and components and the release of the area for unrestricted use), and re-estimates the associated impacts.

The impacts presented in the DEIS were based on a series of waste characterization reports (WCRs) and closure engineering reports (CERs), including West Valley Nuclear Services (WVNS; 1995a,b) for the HLW Storage Area and Vitrification Facility. Since the issuance of these two reports, a number of events have occurred which necessitate their revision, including a better understanding of the expected condition of the facilities at the end of their useful life, and a better understanding of the various approaches to decontamination and dismantlement that could be utilized. With this in mind, the impacts associated with implementation of Alternative I at WMA 3 were updated in Dames and Moore (2000).

The purpose of this report in <u>not</u> to supercede Dames and Moore (2000), but to provide an alternative assessment of the impacts associated with the implementation of closure Alternative I for the HLW storage tanks of WMA 3. The focus of this study is to better understand the potential impacts associated with the complete removal of the HLW storage Tanks 8D-1 and 8D-2. This alternative assessment was deemed appropriate because of the uniqueness of the removal of the highly radioactively contaminated underground storage tanks – other sites have *studied* the removal of such tanks, but none have been identified that have actually removed such tanks.

1.2 SCOPE

As stated above, Dames and Moore (2000) updated the impacts associated with closure of <u>all</u> of the facilities within WMA 3 via complete removal (*i.e.*, Alternative I). This report focuses on the re-evaluation of the impacts associated with the implementation of Alternative I on the HLW storage Tanks 8D-1 and 8D-2, and certain facilities in their immediate vicinity (*i.e.*, the STS Support Building and the Transfer Trench). The impacts from WMA 3 facilities not considered in this report will be taken from Dames and Moore (2000), so that the total impact from closure of WMA 3 via Alternative I can be presented. Impacts to be estimated include waste disposal quantities, emissions, work-effort, radiation exposures, injuries and fatalities, consumable materials used, and costs. However, prior to calculating any impacts, the first step of this re-analysis was to develop a methodology for the implementation of the complete removal of the HLW storage tanks which is more detailed than those presented in either WVNS (1995b) or Dames and Moore (2000). To this end, a significant effort has been extended to determine how other sites with underground HLW storage tanks are addressing the issue of complete removal (see Section 2.1). Also, various manufacturers of remotely controlled manipulator arms that might be utilized during tank closure were contacted and asked to provide information as to how their products could be used to perform the complete removal of an underground HLW storage tank (see Section 2.3).

The last section of this Introduction presents a description of the facilities that are addressed in this report. This is followed by a Background Information section which presents information on similar projects at other DOE sites (Section 2.1), the selection of a methodology for Tanks 8D-1 and 8D-2 (Section 2.2), remote manipulators that could be used to disassemble the tanks/vaults (Section 2.3), other assumptions utilized (Section 2.4), and applicable regulations (Section 2.5). Section 3 ‘Methodology’ presents the 32 steps that have been developed to remove the tanks/vaults (Section 3.1), provides other major assumptions (and their basis) that were utilized, and presents a breakdown of the cost estimates for each major task: 1) preparation and planning, 2) Confinement Structure construction, 3) tank and vault removal, 4) Supernatant Treatment System (STS) Support Building and Transfer Trench removal, 5) Confinement Structure Decontamination and Decommission (D&D), and 6) D&D of other WMA 3 facilities (Sections 3.2 through 3.4). Section 4, the last section of this report, presents the estimated impacts (including resource requirements, occupational issues, waste disposal, and cost estimates) associated with the complete removal of all structures, systems and components from WMA 3.

1.3 FACILITY DESCRIPTION

As stated above, this report evaluates the impacts of implementing site closure Alternative I at WMA 3 of the WVDP. Figure 1.1 is a photograph of the general area of WMA 3. Tanks 8D-1 and 8D-2 are in the center of the photo, under the steel trusses, while the STS Support Building is in the foreground, to the right of the tanks. The Permanent Ventilation System Building is to the left of the tanks, while the Vitrification Facility and Process Building are behind them. While there are a number of other facilities in WMA 3, only those facilities that are directly affected by this re-assessment of tank removal methodologies are summarized below, Dames and Moore (2000) can be consulted to obtain information on other WMA 3 facilities.

HLW Storage Tank 8D-1 – Tank 8D-1 is 70 ft in diameter and 27 ft in height with a capacity of 750,000 gallons. The tank was constructed of nominally 0.5 in, reinforced carbon steel plate. The tank's roof is supported by 45 8-in diameter vertical schedule 80 pipe columns. These pipe columns rest on a horizontal gridwork of wide flange beams and cross members in the bottom 3 ft of the tank. This gridwork is shown in Figure 1.2, which was taken during tank construction, and in detailed schematics in Figures 1.3 and 1.4. The wide flange beams are supported by 1 in thick steel plates, which are in turn supported by 1½ in diameter stay bolts, that are welded to doubler plates on the tank floor.

Tank 8D-1 was not used during reprocessing operations, but major modifications were made during the WVDP to house inside Tank 8D-1 STS equipment, consisting of ion exchangers, filters, tank, pumps and associated piping for supernatant treatment. Table 1.1 (from WVNS 1995a) gives a list of the STS equipment within Tank 8D-1. During initial supernatant processing, approximately 132,000 lbs of spent zeolite resin from the STS was discharged directly into Tank 8D-1. The primary source of residual radioactive contamination within Tank 8D-1 would be contained in these spent resins, with some residual contamination due to corrosion/adsorption of the tank walls (WVNS 1995a). During vitrification, a pump is used to transfer the spent zeolite to Tank 8D-2 and from there to the Vitrification Facility for processing into glass. The WVDP installed several mobilization pumps, as well as a decant and a transfer pump, into Tank 8D-1 in order to support this transfer.

HLW Storage Tank 8D-2 – Tank 8D-2 is located in an underground concrete vault adjacent to Tank 8D-1, it is identical in size and construction to Tank 8D-1. It was used to store high- level radioactive waste from the PUREX fuel reprocessing operation. A decant pump, a transfer pump and several mobilization pumps (and associated piping) were installed in Tank 8D-2 during the WVDP to facilitate transfer of supernatant to the STS in Tank 8D-1 and to transfer the remaining waste to the Vitrification Facility for processing into glass.

At the end of vitrification, there will be some level of material remaining in the tanks – if simply the amount below the suction level of the transfer pump. This material would consist of a mixture of spent zeolite, PUREX sludge and wash liquid, and neutralized THOREX waste. Currently, it is estimated that less than 20,000 Ci (6.94×10^{14} Bq) of ^{137}Cs and ^{90}Sr and less than 100 Ci (3.47×10^{12} Bq) of transuranic radionuclides would remain in Tank 8D-2 after the completion of vitrification. For Tank 8D-1 it is estimated that less than 100,000 Ci (3.47×10^{15} Bq) of ^{137}Cs and ^{90}Sr and less than 100 Ci (3.47×10^{12} Bq) of transuranic radionuclides would remain.

Underground Vaults – Tanks 8D-1 and 8D-2 are each located in separate underground concrete vaults. The dimensions of these vaults are 78 ft-7 in outside diameter by 36 ft-9 in high and have a 2 ft thick concrete roof, with 18 in side walls. Six 30-in diameter concrete vertical columns pass through each tank to provide support to the vault's roof. These columns are encased in

48 in diameter steel pipes that are welded to the top and bottom of the tanks. The columns are located approximately 16 ft from the center of each tank. Within the vaults, the tanks rest on a 12 in layer of perlite blocks supported by a layer of pea gravel in a carbon steel pan. The floor of each vault is 27 in thick except under the six roof support columns, where thicker rings support the vault roof. Beneath the concrete vaults is a 4 in thick gravel bed. The vaults are covered with 8 to 9 ft of earth. The WVDP modified the 8D-1 vault during the installation of STS equipment inside Tank 8D-1.

As shown in Figure 1.1, the WVDP added two steel truss structures over the 8D-1 vault and three trusses over the 8D-2 vault to support waste mobilization, transfer and decant pumps which were lowered into the tanks. Each truss structure is approximately 11 ft 8 in square, and ranges in length from about 90 to 160 ft to span the vaults. The trusses are supported on individual concrete footings on either side of the vaults. A schematic of a typical truss structure spanning a HLW tank is shown in Figure 1.4.

WVNS (1995a) reports that groundwater has leaked into the vaults and is removed as needed. Water levels in the vaults are kept under 10 in. Radioactivity has been measured in the water in both vaults, indicating that they are likely to be contaminated, and will require treatment as radioactive waste.

STS Support Building – During the WVDP the STS Support Building was constructed adjacent to Tank 8D-1 to prepare and add fresh zeolite to the ion exchange columns. The STS Support Building was built on fifty-five 55-ft long cast-in-place piles. It is a two story structure, the upper level is constructed of a steel framework covered with steel siding and the lower level is constructed of reinforced concrete. Estimates of the construction material used in the STS Support Building are given in Table 1.2. A shielded Valve Aisle is located on the first floor of the Building, which contains remotely operated valves and instrumentation used to control the operation of the STS. As shown in Figure 1.5, the STS Support Building also houses a Control Room, a refrigeration system used to cool the supernatant, as well as storage tanks for fresh water and fresh zeolite. Table 1.3 lists equipment contained within the STS Support Building. Except for the Valve Aisle (which was contaminated from valve and piping leaks), the Building is maintained as a radiologically clean area. Because of its close proximity to Tank 8D-1, closure of the STS Support Building has been assumed to be linked to closure of the tanks and as such has been included in this report.

HLW Piping Trench – The HLW transfer lines from the waste tanks to the Vitrification Facility are inside a pipe trench, shown in Figure 1.6. The trench is approximately 450 ft long, 3 ft deep, and 2½ to 6 ft wide. The concrete wall thickness of the trench ranges from 18 to 24 in and the removable covers are 24 in thick. The two primary pipes are 3 in stainless steel, and are enveloped by 6 in stainless steel pipes. The trench contains two spare pipes. The portion of the transfer trench that connects Tanks 8D-3 and 8D-4 to Tank 8D-1 and the portion which connects

Tank 8D-2 to the Vitrification Facility would be removed prior to the construction of the Confinement Structure, and is not part of this report. While the portion of the pipe transfer trench located near Tanks 8D-1 and 8D-2 would be left in place until after the Confinement Structure had been constructed and as such has been included in this report.

TABLE 1.1

STS EQUIPMENT CONTAINED IN TANK 8D-1 (WVNS 1995a)

Equipment	Dimensions	Material	Weight (lb)
IX Column C-001	3'ID × 13'L	304L SS	9,200
IX Column C-002	3'ID × 13'L	304L SS	9,200
IX Column C-003	3'ID × 13'L	304L SS	9,200
IX Column C-004	3'ID × 13'L	304L SS	9,200
Feed Tank D-001	4'6"OD × 23'5"L	304L SS	N/A
Sluice Water Tank D-004	N/A	N/A	N/A
Pre-Filter F-001	3'2"OD × 16'	304L SS	1,000
Supernatant Cooler E-001	10 3/4" × 10'	304L SS	6,700
Sand Filter F-002	N/A	N/A	N/A

TABLE 1.2

STS SUPPORT BUILDING CONSTRUCTION MATERIALS
(WVNS 1995b)

Material	**Quantity**
1. Reinforced concrete	900 yd^3
2. Metal siding wall with steel framing @ 8 lbs/ft^2	3335 ft^2
3. Steel roof panels supported by steel framing @ 8 lbs/ft^2	2050 ft^2
4. Miscellaneous steel	10 tons

TABLE 1.3

EQUIPMENT CONTAINED IN THE STS SUPPORT BUILDING
(WVNS 1995a)

Equipment	Dimensions	Material	Weight (lb)
Zeolite Batch Tank D-002	3' OD × 17' L	304L SS	2,200
Air Break Tank D-006	14" OD × 6' L	304L SS	300
Zeolite Fines Tank D-005	5' OD × 13'	304L SS	2,180
Fresh Water Tank D-003	108" OD × 202" L	304L SS	8,700
Water Break Tank	26" OD × 5'9" L	304L SS	625
Brine Cooler V-0018	10 3/4" OD × 12' L	304L SS	7,400

Figure 1.1. HLW Tank Farm Area at West Valley.

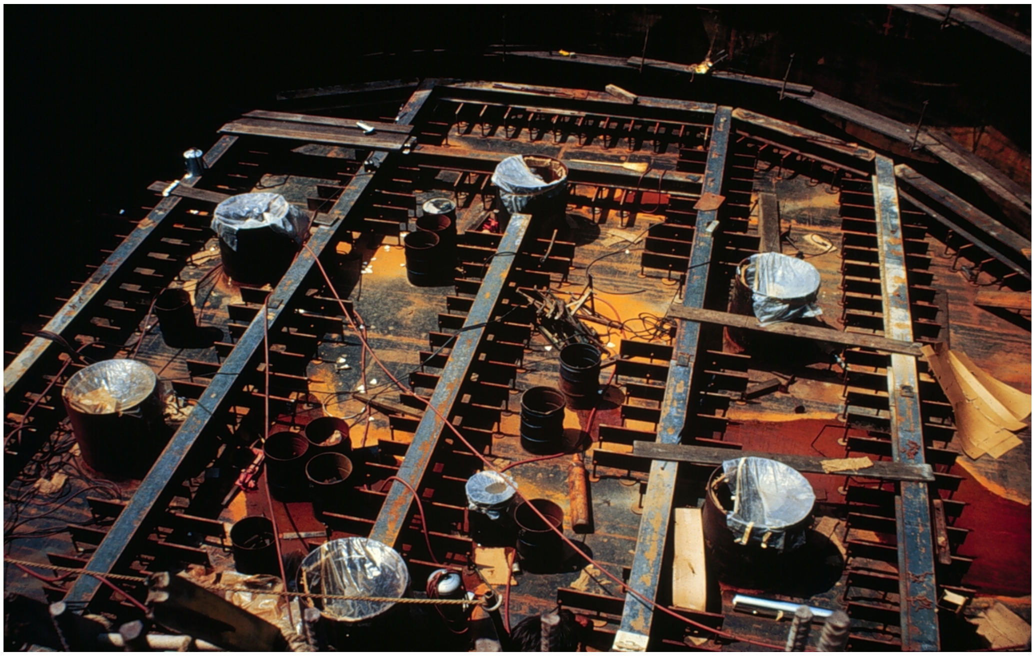

Figure 1.2. Construction photograph of HLW storage tank.

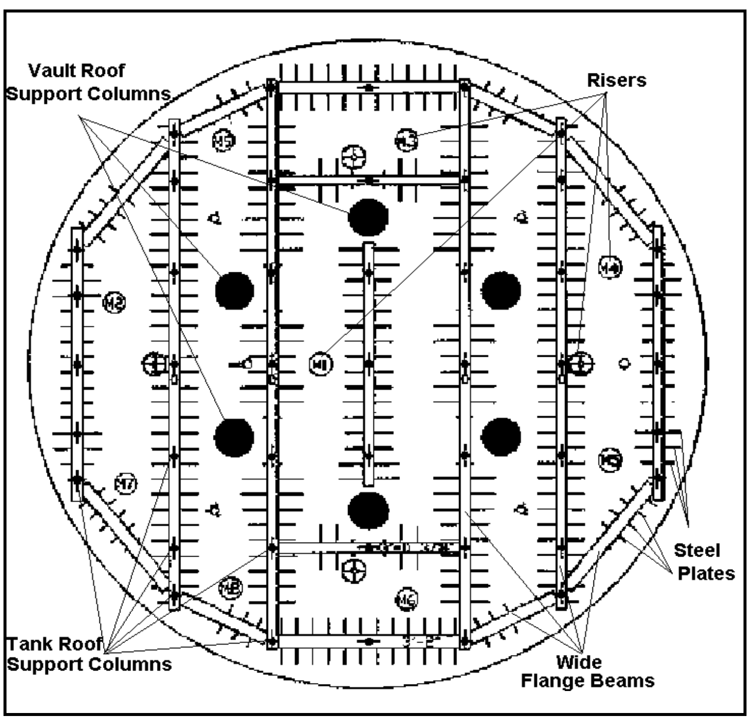

Figure 1.3. Interior structure of an HLW storage tank.

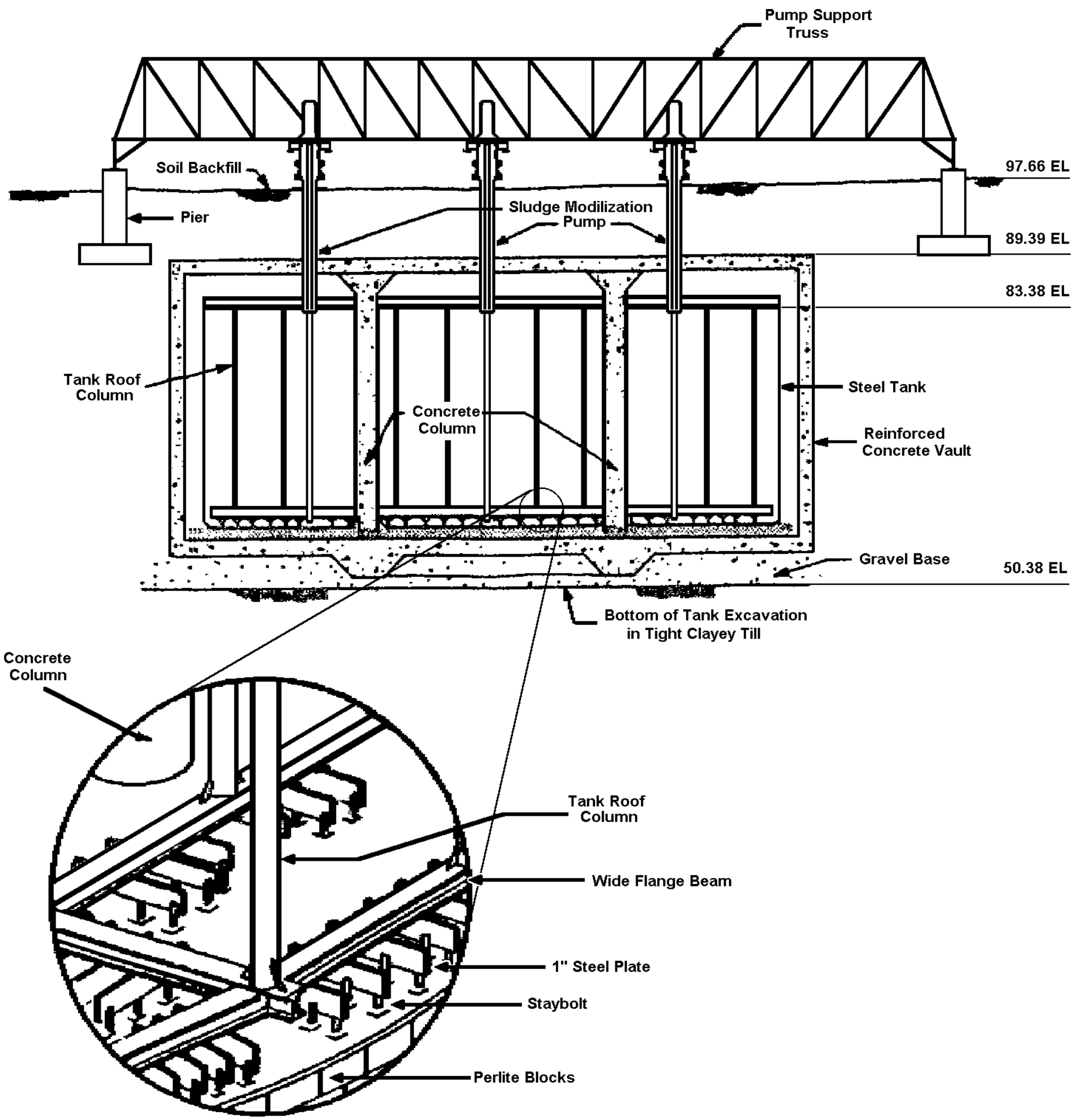

Figure 1.4. Cross-section of an HLW Tank with details of bottom gridwork.

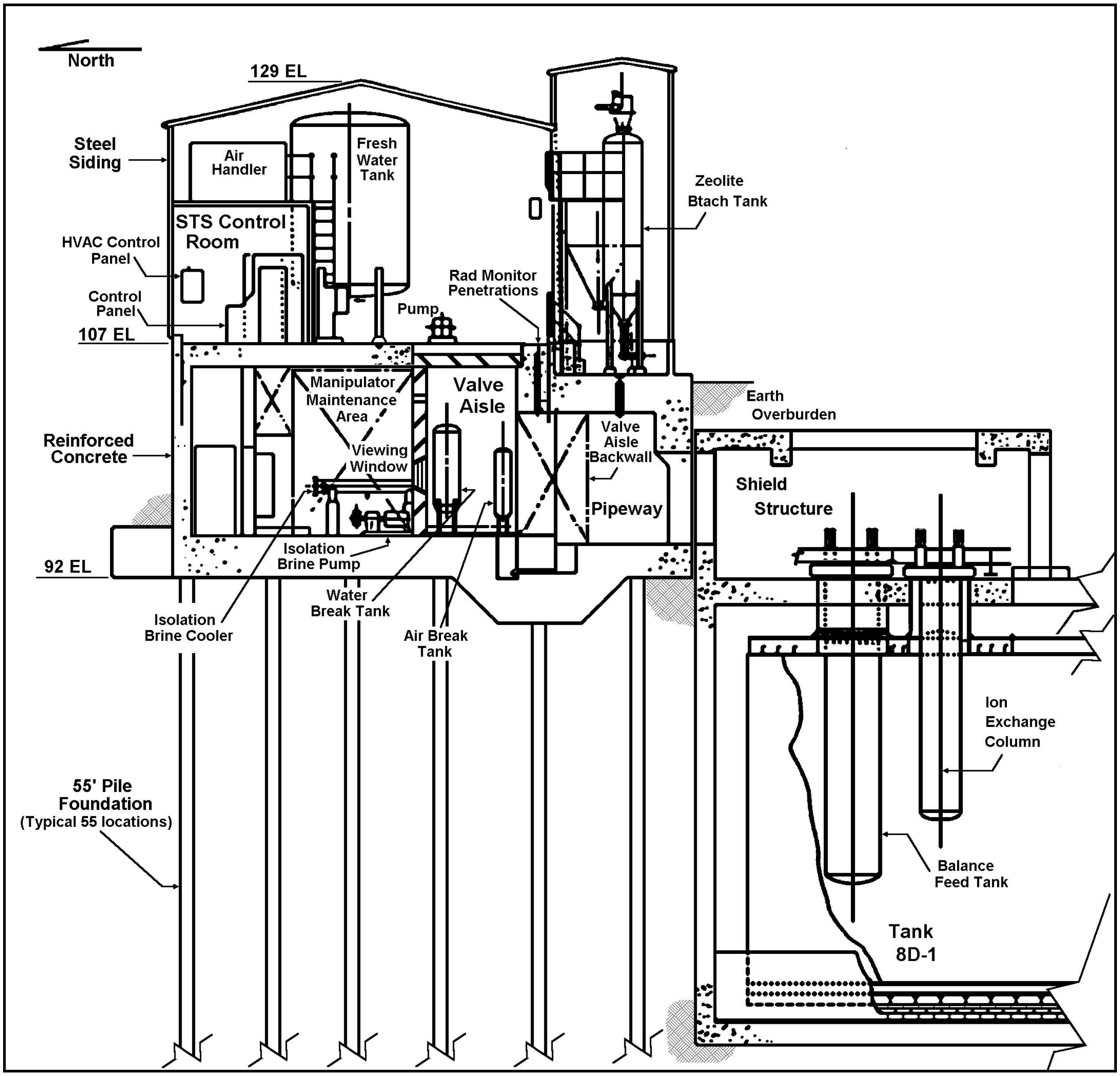

Figure 1.5. STS support building.

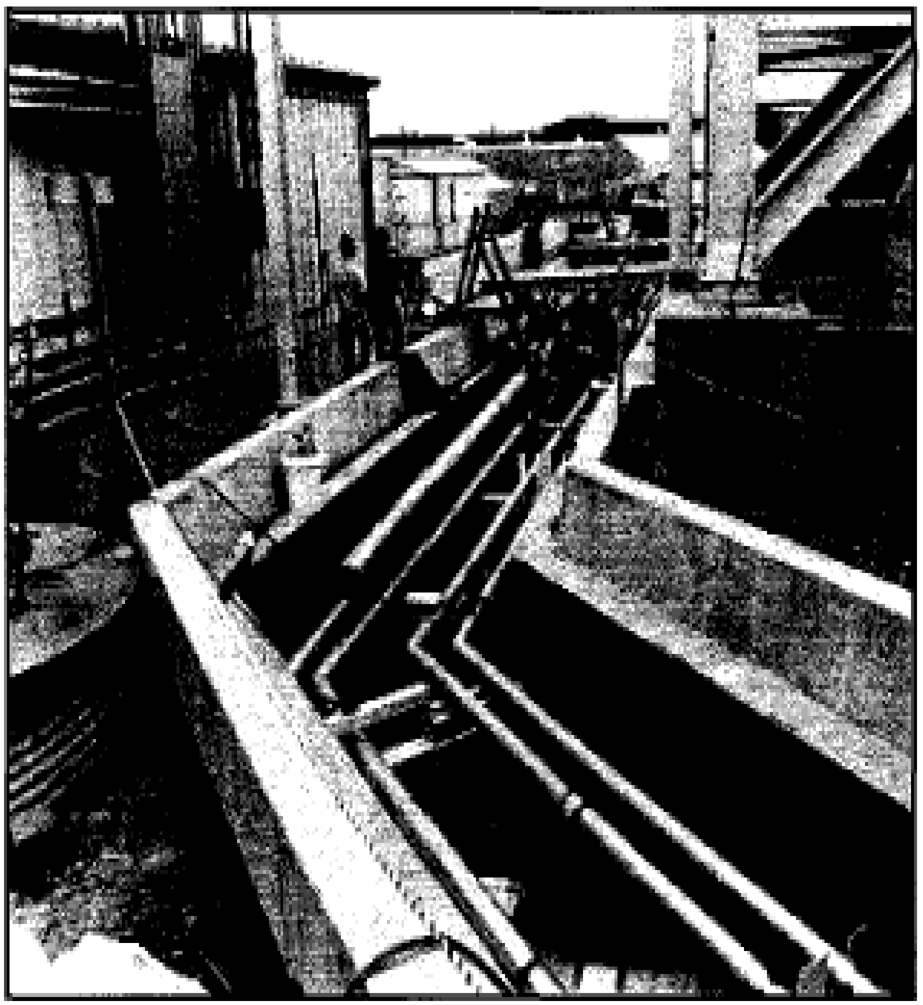

Figure 1.6. HLW Transfer Trench.

2.0 Background Information

2.1 UNDERGROUND RADIOACTIVE WASTE STORAGE TANK REMOVAL AT OTHER SITES

In order to determine how other DOE sites are addressing the problem of removal of underground HLW storage tanks, an Internet search was conducted. As a result of that search, information on studies performed at three (3) DOE sites concerning HLW tank removal was obtained and evaluated: the Hanford Site, INEEL, and the SRS. A summary of DOE site tank closure information is provided in Table 2.1, while a more detailed discussion for each site is provided below.

2,1,1 Hanford AX Tank Farm Removal

"AX Tank Farm Tank Removal Study" (Skelly 1997) and "Retrieval Performance Evaluation Methodology for the AX Tank Farm" (Jacobs 1999) present a closure study that was performed for the 241-AX tank farm located on the Hanford Site in southeastern Washington State. The 241-AX tank farm is located in the 200 East Area and contains four (4) one million gallon capacity single-shell tanks, each with a 75 ft inside diameter, 45¾ ft height, and a minimum of 6 ft of soil cover.

Tank Removal Methodology — Removal of the tanks would consist of the following activities:

- Placing 1 ft of highly flowable, low strength grout into each tank to reduce worker exposures.
- Constructing a confinement enclosure.
- Removing the soil cover from the tank domes, and placing the excavated soil into containers for transport and disposal.
- Demolishing the tank domes and allowing the concrete rubble to fall into the tanks.
- Excavating lateral soil surrounding the tanks, and placing it in containers for transport and disposal.
- Demolishing the tank sidewalls, and placing the rubble in containers for transport and disposal.
- Demolishing the tank slab and footing, and placing the debris in containers for transport to a reprocessing facility.

The first step is needed because the dose rate above the tanks during removal of cover soil was calculated to be in the range of 60 to 100 mrem/h. Based on this, it was deemed necessary for some type of temporary shielding to be placed inside the tanks prior to initiating decommissioning work. A 1 ft thick layer of a highly flowable, self-leveling, low-strength grout would be pumped into the tanks to provide the shielding. The selected grout formulation is Class A Controlled

Density Fill (CDF), as specified by the Washington Aggregates and Concrete Association (WACA 1997). This is a low-strength grout with a bulk density of approximately 140 lb/ft^3. The low-strength is desirable for ease of rubblization in conjunction with demolishing and removing tank base slab material. With this shielding grout, the following dose rates were calculated:

Operation	Dose Rate (mrem/h)
Construct Enclosure	.05
Place CDF Grout	.05 to 5.77
Remove Cover Soil	.05 to .058
Remove Tank Domes	.06 to .16
Remove Lateral Soil	.07 to .17
Remove Tank Sidewalls	.25 to .41
Remove Base Slabs	.34 to 2.5

Even with the placement of the CDF grout, the cumulative exposure for removal of the Hanford tanks was estimated to be 75.8 person-rem. Inhalation worker doses due to transuranic radionuclides were found to be negligible, compared to the shine dose from ^{137}Cs. (Parsons 1999; Tables 6.1-4 and 6.1-8).

The confinement enclosure would be an application of the commercially available STRARCH (STRessed ARCH) system, which was developed in Australia. The STRARCH truss system combines three common design and construction principles: the arch, the truss, and pre-stressing cables. Application of the STRARCH concept would provide a single-span building, with dimensions of 500 ft by 550 ft, that would cover the entire excavation area, as shown in Figures 3.1 and 3.2. This is larger than any existing application of the STRARCH structure and would require some scale-up.

Demolition of the tank's domes and walls would be performed utilizing conventional heavy construction equipment. However, to protect the operators from the residual tank radioactivity, the cabs of this equipment would be provided with heavy shielding. Six inch steel plates would be attached to all exterior surfaces of the cabs, and 6 in of high-density leaded glass would be placed in the windshields. These modifications would increase the weight of each vehicle by about 50,000 lbs. Additional significant modifications to the vehicles would be necessary for them to carry the extra weight. Because increases in the residual radioactivity level would require increases in the shielding (and weight), there is some risk that this methodology would cease to be practical if radioactivity levels exceed the current estimate.

Space is also a concern with this methodology, because the slope of the excavation must be such that cave-ins do not occur, and gradual enough to allow equipment to travel into and out of the excavation. This results in a 413½ ft by 400½ ft hole, even through the tanks only occupy an area of about 175 ft square. In addition to the size of the excavation, additional space would be required to store the spoils removed from the hole. Because they would be located in a congested area on the WVDP site, the space requirements of this removal method is not considered to be viable for Tanks 8D-1 and 8D-2.

Preparation and Planning — Hanford includes a significant amount of funds for design support activities, including design, permitting, procedures, safety analysis, and specifications. A total of about 20% was allocated for these activities.

Cost — The total cost for removal of the four (4) tanks of the AX tank farm is given as \$183,102,403, including \$18,317,204 (10%) for STRARCH construction, \$135,457,468 (74%) for soil removal and tank demolition, and \$29,327,731 (16%) for waste disposal (Parsons 1999, Table 6.1-9).

2.1.2 Idaho Chemical Process Plant Tank Farm Closure

INEEL/EXT-97-01204 (INEEL 1998) presents a closure study performed for the Idaho Chemical Process Plant (ICPP) located at the INEEL. The ICPP tank farm consists of eleven 300,000 gallon underground radioactive waste storage tanks. The tanks are 50 ft in diameter, with an overall height of approximately 30 ft, and are contained within concrete vaults. Several approaches to closure were analyzed, including Total Removal Clean Closure (TRCC) in which all 11 tanks (and associated vaults, piping, and auxiliary equipment) and 133,800 m^3 of contaminated soil identified as Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) waste were removed from the site. As a rough order of magnitude estimate of personnel exposures to complete both the tank removal and soil removal tasks, 9,433 person-rem is reported

Tank Removal Methodology — The TRCC approach investigated for the ICPP includes the following steps:

1) Remove tank heels,* as much as practical,
2) Remove (D&D) all tanks, vaults, piping, CERCLA soil, and auxiliary equipment associated with the tank farm,
3) Package all waste and ship it to the appropriate disposal site, and
4) Fill the excavation pit to grade level.

Because of the presence of alpha contamination, the tanks would be remotely excavated within a double containment structure. A negative pressure would be maintained between the primary and secondary containment. Additionally, the Confinement Structure would be within a weather enclosure to allow for year-round operations. These structures, as well as the gantry crane suspended retrieval manipulators, are shown in Figure 2.3. The main portion of the weather enclosure would be approximately 260 ft by 360 ft, with an extension on the east side of approximately 180 ft by 200 ft.

The poor soil conditions in the tank farm area results in highly restrictive load limitations, and requires that subsurface concrete walls be constructed to serve as structural support for the gantry crane. These walls (approximately 6 ft wide and 50 ft high) would be constructed by jet-grouting cement into the ground. The walls thus created would be 67% soil and 33% cement. Additionally, a paraffin-based grout would be jet-grouted into the soil surrounding the tanks in order to control the generation of fugitive dust during excavation. Dust control is a concern due to the expected alpha contamination of the soil surrounding the tanks. Field tests have indicated that the paraffin-based grout is 99% effective in dust control, and due to its low melting point, the paraffin could be easily removed from the soil before treatment and/or disposal.

Manipulator — Dismantling of the tanks and vaults would be accomplished remotely using a teleoperated gantry crane, similar to the INEEL developed Cooperative Telerobotic Retrieval System (CTRS; Hyde 1995). The CTRS consists of an 80 ft wide gantry crane; two trolley assemblies with vertically telescoping masts each having 22 ft of vertical travel; six degree-of-freedom manipulators mounted to the base of each mast; and a trolley and 5-ton hoist assembly mounted on a separate track. The manipulators can be used in cooperation with each other or can be operated separately, and are mounted so that they can also be used in cooperation with the hoist hook for attaching or removing a load. The CTRS would have two closed circuit television cameras mounted to the legs of the crane for visualization of the workplace during operation. To the extent feasible, the CTRS project utilized existing, commercial technology. The gantry crane was manufactured by the American Crane and Equipment Corporation (ACECO) to INEEL specifications. The manipulators were two Titan II devices from Schilling Development, and an

* At the start of closure, the ICPP tanks are each anticipated to contain a 12" heel. The removal process for this heel would consist of heel flushing, agitation, and removal. The heel remaining in the tanks after washing and completion of the heel removal process could be stabilized to meet incidental waste criteria. For Tanks 8D-1 and 8D-2, a process similar to ICPP's heel removal process will reduce the heel to as small as feasible prior to the start of closure. Therefore, where the ICPP heel removal process ends, the WVDP heel removal process begins.

off-the-shelf controller was purchased from Cimetrix.

Cost — The cost estimate for TRCC is $3.139 billion for tank removal, $1.836 billion for CERCLA soil removal, and $357 million in shared costs. These cost have been escalated to the year in which they are spent. In unescalated 1998 dollars, the tank removal cost is $1.044 billion, while the CERCLA soil removal unescalated costs were not provided in INEEL/EXT-97-01204.

- The above tank removal cost estimate includes several activities that are not being considered as part of the WVDP tank closure estimate. These activities include heel removal ($517 million, escalated), debris cleaning facility (*i.e.,* CMA; $224.5 million, escalated), LLW disposal site development ($51 million, escalated), soil stabilization (necessary for foundations and dust control; $412 million, escalated), and remote removal of soil stabilization ($183 million, unescalated).

- Also included are Project and Construction Management fees (5% of construction, each), as well as General and Administrative, Performance Incentive Factors, and Procurement Fees (23%, 5.5% and 3%, respectively).

- A remote operations inefficiency factor of 3.5 has been added to the tank removal labor estimate ($293 million, unescalated). (It appears odd to impose such a heavy penalty for remote operations, since the entire facility has been designed for remote operations.)

- $6.6 million (unescalated) was allocated for a "Teleoperated Gantry Crane with End Effectors."

- The project was assumed to begin in 2004 with process development, and be completed in 2037 with post-excavation activities, for a total project duration of approximately 34 years. Tank and soil removal activities were assumed to take approximately 8 years, from 2027 to 2034.

2.1.3 Savannah River Closure Plan for F- and H-Area Tanks

At the SRS, the F- and H-Area HLW Tank Farms are located in the central portion of the SRS, a minimum distance of approximately 5.5 miles from the SRS boundary. The F-Area HLW Tank Farm is located on a 22-acre site and consists of 22 waste tanks, while the H-Area HLW Tank Farm is located on a 45-acre site and consists of 29 waste tanks. All of the tanks were built of carbon steel inside reinforced concrete containment vaults, but were built with four different designs: Type I – 12 tanks, 750,000 gallons; Type II – 4 tanks, 1,030,000 gallons; Type III – 27 tanks, 1,300,000 gallons; and Type IV – 8 tanks, 1,300,000 gallons.

Appendix A of the SRS report "Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems" (DOE 1996) provides an "Analysis of High-Level Waste Tank System Closure Alternatives," including "Clean Tanks to the Extent Allowing Removal of Tanks," Option E. Advantages and disadvantages of Option E are provided, but the specific removal methodology is yet to be defined. Advantages of tank removal are given as:

- There is a potential to dispose of the contaminated components of the tank in a waste disposal facility that has better barriers to the migration of contamination than the current location of the waste tanks.

- This option exposes the surrounding soils such that they could be exhumed. This is the only option that has the potential to leave the waste tank area as an unrestricted area for future uses.

Disadvantages of this option that were identified in Appendix A are:

- High radiation exposure to workers during the removal process.

- Extremely high cost to remove the tank.

- Considerable impact on other SRS operations.

- Extremely high cost to dispose of the tank components elsewhere. Also, disposal of the tank could create another zone of restricted use (*i.e.*, the restricted use zone is merely shifted rather than being eliminated).

The cost to implement Option E is given in DOE (1996) Table A-2 as "Unknown but believed to be greater than $50 million per tank."

DOE (1996), Appendix A, further states that Option E has "not been demonstrated in actual HLW tanks. A number of techniques have been studied involving such techniques as robotic arms, wet-dry vacuum cleaners, and remote cutters. However, none of these techniques can be considered viable at this time. For example, no robotic arms have been demonstrated that could navigate through the forest of cooling coils that are found in most SRS waste tanks. ... Alternatively, the tank could be cut into steel plates and disposed of elsewhere. Each of these techniques requires either: (1) developing robotic techniques that can navigate through the forest of cooling coils found in most SRS high-level waste tanks, or (2) cutting the cooling coils. Such cleaning techniques would require large costs to develop using today's techniques and would require a long time to carry out because they focus on small areas of the tank at a time."

2.2 TANK REMOVAL METHODOLOGY SELECTION

Based on the discussion presented in the previous sections, three (3) potential tank removal methodologies could be implemented for Tanks 8D-1 and 8D-2. These potential methodologies are:

1) **Outside-In** – This methodology is basically the one analyzed for the Hanford AX tank farm (Skelly 1997 and Jacobs 1999). With this methodology the soil surrounding the vaults is excavated, and the vaults and tanks are demolished using conventional techniques. A non-shielding Confinement Structure would be provided to control radioactivity releases. Because of the amount of ^{137}Cs expected to be present in the tanks at the initiation of closure, the shine dose rate is anticipated to be too high to allow workers to implement this methodology for Tanks 8D-1 and 8D-2, even if grout is injected to provide shielding. Similarly, the presence of transuranic radionuclides may pose an airborne inhalation concern for workers during the dismantlement process. Additionally, the walls of the excavation pit would need to be sloped in order to prevent cave-ins. This would result in a large excavation area that would not fit into the congested Tanks 8D-1 and 8D-2 site. For these reasons, the 'Outside-In' methodology has not been analyzed.

2) **Top-Down** – This methodology is similar to the INEEL approach (INEEL 1998) discussed above. A shielded Confinement Structure would be required to reduce the shine dose rate and to control radioactivity releases. A manipulator arm would be attached to an overhead bridge to perform cutting, crushing, and scooping operations, while an ordinary crane would be attached to a second bridge to perform heavy lifting. Then the cover soil and vault roof are completely removed, giving the manipulator access to the entire tank. The primary advantage of this methodology is that the manipulator and lifting crane would have access to the entire tank, and that they would also have access to each other should one or the other breakdown. Also, the size of the equipment used would not be limited to the size of the risers. The primary disadvantage of this methodology is that shielding would be provided by the Confinement Structure, requiring that it be a very robust, heavy and expensive structure.

3. **Inside-Out** – This is the methodology that was analyzed in the original and revised closure engineering reports (WVNS 1995b and Dames and Moore 2000, respectively). Essentially, with this methodology an in-tank robotic system is lowered into the tanks, and waste is removed from the tank through a shielded structure (*i.e.*, a 'gamma-gate') located over the center of the tank. In addition to the shielded structure to reduce gamma-shine exposures, a non-shielding Confinement Structure would be provided to control radioactivity releases. The primary advantage of this methodology is that the cover soil and vault roof remain essentially in place and provide shielding until the tank, and its associated contamination, has been removed. The primary disadvantage of this methodology is that all work would be performed through small openings, such that if 'something' goes wrong access to the work-

site would be difficult. Also, this approach requires a very sophisticated robotic device, capable of freely moving (*i.e.*, 'snaking') around the tank and performing a variety of functions. Such a device would require development, and could be difficult to service and maintain.

Since the 'Inside-Out' methodology has already been analyzed for Tanks 8D-1 and 8D-2, and since the 'Outside-In' methodology is unlikely to be implementable for Tanks 8D-1 and 8D-2, the 'Top-Down' methodology has been selected for detailed analysis, supplemented by injection of low strength grout to stabilize the heel and provide shielding as discussed in the Hanford study. The details of the 'Top-Down' approach as applied to Tanks 8D-1 and 8D-2 are provided in the 32 steps presented in Section 3.1.

2.3 MANIPULATOR VENDOR INFORMATION

Argonne National Laboratory performed a survey of over 70 manufacturers of commercially available manipulators and cranes/gantries (Henley 1996). Manufacturers of remotely controlled manipulator arms include: EagleTech, General Atomics Advanced Technologies, GreyPilgrim, PaR Systems, Schilling Robotics, and Spar Advanced Technology Systems. However, as documented in Henley (1996), most of these manufacturers make manipulator arms of limited reach (*i.e.*, 36 in to <200 in), and they would not be capable of reaching all areas within Tanks 8D-1 and 8D-2 from a platform outside of the tanks. Therefore, they will be of limited use for remote removal of Tanks 8D-1 and 8D-2. EagleTech and GreyPilgrim make long-reach manipulator arms, which could be used for the remote removal of Tanks 8D-1 and 8D-2 under the 'Top-Down' approach. Therefore, these two manufacturers were contacted and asked to provide information on their systems that would be useful to develop a disassembly methodology for an underground HLW storage tank. The information received from these two manufacturers, along with other sources on information on their manipulators, is summarized below.

2.3.1 <u>EagleTech</u>

EagleTech, Inc. of Solon, Ohio manufactures a heavy-duty hydraulic manipulator for use in harsh environments. Figures 2.4 and 2.5 are photographs of the EagleTech manipulator – notice that this manipulator is constructed of heavy weight steel components. Information regarding the EagleTech manipulator was obtained from the manufacturer (Trost 1999), waste removal test performed for Hanford (Evans 1996 and Berglin 1997), and the Fernald Large-Scale Demonstration and Deployment Project Internet site.

The EagleTech system is comprised of: 1) a manipulator, with dual arm gripper, 2) various end effectors, including a rotary cutter, a water-jet cutter, and an extractor, 3) a mobile bridge from which to attach the manipulator, 4) a cryogenic (CO_2) decontamination system, and 5) a tele-remote control/command center. A cost of approximately $6 million was estimated by EagleTech to manufacture, deliver and set-up this manipulator system, with an estimated 14 months from the time of the order placement to completion of on-site set-up.

The manipulator itself, consists of four (4) modular segments: 1) a vertical boom assembly, 2) the knuckle assembly, 3) the jib boom assembly, and 4) a dual-arm gripper. The vertical boom is affixed to the mobile bridge by a mobile undercarriage and has an overall extended length of 44½ ft, consisting of the fixed main boom and three telescoping stages which allow for opening/folding of the manipulator. The knuckle assembly has an overall length of 6 ft, while the jib boom has an extended length of 30½ ft, and consists of four (4) segments similar to the vertical boom. The dual-arm gripper has an overall length of 11 ft, and is designed to have a 360E continuous rotation and can articulate in a vertical 180E up/down motion.

The manipulator has an overall vertical reach of 51.5 ft from the bottom of the bridge, and a horizontal reach of 39 ft-11 in. The EagleTech manipulator as tested for sludge retrieval from the Hanford single shell tanks (SSTs) (Berglin et al. 1997) had a reach of over 45 ft vertically and 45 ft horizontally. These overall reach capabilities, the kinematic arrangement of the manipulator, and the fact that the manipulator and its mobile undercarriage can traverse the full deck length of the movable bridge, make the EagleTech manipulator capable of reaching all locations within Tanks 8D-1 and 8D-2.

The EagleTech manipulator is not capable of "snaking" around the in-tank support columns and other vertical interference. In congested tanks, it would be necessary to cut away vertical interference in order to access all of the tank. The dual-arm gripper facilitates such cutting, as one arm could hold and support the object to be cut while the other uses a rotary saw, or other type of cutter, to cut.

Because of its robustness, this manipulator has a very high load capacity (3,200 lbs), which may allow for the tanks and vaults to be cut into larger segments, thereby reducing the disassembly time.

The design of the EagleTech manipulator is based on the principles that promote continuous operation for up to 6 months in a radioactive and chemically harsh environment with only a minimum amount of maintenance. For example, the design of the EagleTech manipulator allows for the vertical and jib boom segments including the manipulator arm to be withdrawn from the tank, decontaminated and extended onto the deck of the mobile bridge in order to perform any interim "hands on" maintenance or schedule periodic inspection in accordance with established programs. The high degree of maintainability is also due to the fact that the EagleTech manipulator employs commercially available components. In this regard, spare boom sections, end effectors, pumps, diesel generators and other critical components can be stocked.

2.3.2 GreyPilgrim

GreyPilgrim, LLC, of Rockville, Maryland, has developed a unique manipulator concept that may be applicable to tank remediation if scaled-up from the current prototype. The manipulator is referred to as the Easily Manipulated Mechanical Armature (EMMA™) serpentine manipulator and consists of rigid sections connected by flexible joints. Each joint is comprised of a flexible tube made of a urethane type material which is displaced by applying forces to a metal collar using six steel cables. The EMMA™ manipulator system is described by GreyPilgrim as follows:

> “EMMA™ consists of several stages that are composed of alternating cylindrical rigid segments (which provide structural strength) and flexible couplings (which provide rotational stiffness and damping). Each stage can form a curve independent in degree and orientation from those formed by other stages. Each stage is controlled by cables spaced equally about the manipulator’s circumference, kept in constant tension and terminated at the stage’s final segment, such that changes in cable length result in coupling bending and the curvature of the stage. Cables attached to outer stages are routed through conduit in inner stages, thus, permitting decoupled stage motion.
>
> “The manipulator’s workplace is a function of the number of its stages and the amount of rotation allowed in each stage. When mounted to a vertically-movable mast or deployment device, EMMA™ has a completely convex workplace.

Figures 2.6 is a photograph of the EMMA™ manipulator, while Figure 2.7 is a closeup view which shows the manner in which the cables are attached to the various stages of the EMMA™. Information regarding the EMMA™ manipulator was obtained from Evans (1996, 1997) and Wentz (1999).

The EMMA™ manipulator is attractive for several reasons including:

1) The manipulator is cable-driven, making it possible to remotely locate actuators. This may allow an EMMA™ manipulator to be deployed in a tank with the actuators located outside of the tank. This would be advantageous from a maintenance and decontamination view point.

2) The manipulator can be designed with a minimum of electronic components located in the tank. All electronics required for control of the manipulator are mounted at the base of the manipulator, and can be kept safely outside of the radioactive environment.

3) For ease of decontamination, the arm can easily be encased in a double flexible sleeve or jacket, which would prevent accumulation of radioactive contamination on the equipment surfaces. All surfaces exposed to tank waste, such as end-effectors, can be designed to

prevent the waste from adhering and to minimize crevices.

4) The center of the manipulator is an open channel that could be used to route either end-effector utility services, or waste conveyance lines.

To date the longest EMMA™ constructed is 33 ft long, but preliminary designs for a 50 ft version have been developed. This 50 ft arm is deployed vertically and is capable of deploying a 200 lb end effector at a horizontal extension of 40 ft. The scalability of the EMMA™ system is shown in Table 2.2.

Each joint of the EMMA™ manipulator is capable of bending in any plane (being able to essentially sweep-out a cone in space). This makes each joint of the EMMA™ manipulator very dexterous, with the overall dexterity of the manipulator limited by the number of joints. The dexterity of the EMMA™ manipulator may be sufficient for working around in-tank obstructions.

Maintenance alternatives for unexpected component failures on the EMMA™ arm include removing the arm from the tank to a radiation protection area maintenance shop, or replacing the entire arm with a new one. Contact maintenance would require significant decontamination and reduction in dose rate.

EMMA™ systems, regardless of load and dexterity capability, feature an open volume (and often a hollow core) that permits easy routing of cables, wires and hoses within the arm's structure and along its length. This characteristic makes it simple to provide power or material feeds to end-of-arm tooling and eliminates the problems associated with managing umbilical bundles experienced by traditional manipulators.

The primary disadvantage of the EMMA™ manipulators is in the area of control. The accuracy of positioning the manipulator is limited by two main factors: the varying strain in a given cable and the varying moment experienced by a given joint. Though the EMMA™ manipulator may not be as precise as is possible for more traditional manipulators, this level of accuracy is not required for most tank removal operations.

The EMMA™ manipulator is likely to cost less then other manipulators in terms of hardware, but significant development costs remain in order for EMMA™ to reach the level of technical maturity of the other concepts (Evans 1996).

2.4 MAJOR ASSUMPTIONS UTILIZED

Most assumptions used to estimate the quantities of resource commitments, waste generation, environmental releases, etc. are the same assumptions as were used in Dames and Moore (2000), and which were in turn (mostly) taken from WVNS (1995b). The discussion below presents only those assumptions that were not included in or which differ from the assumptions presented in Dames and Moore (2000).

Water – Water used for decommissioning consists of the following categories:

- Domestic use – Based on data from the U.S. Army Corp of Engineers (1998), 50 gallons of water per person per work-day were utilized to estimate water requirements.

- Facility cleaning – See Dames and Moore (2000).

- Personnel and equipment cleaning – Water for personnel and equipment cleaning has been estimated based on the following assumptions:

  - For personnel: 20 gallons per wash per person
  - For equipment: 50 gallons per wash

- Concrete preparation – The U.S. Army Corp of Engineers (1992) provided data that shows that the water content of concrete ranges from 143 to 275 lb/yd^3. Water requirements were estimated based on the midpoint of this range.

- Dust suppression – The U.S. Environmental Protection Agency (EPA 1982, p. 5-16) states that "Wetting of access roads twice a day with 2.3 liters of water per square meter will suppress dust from normal construction practices an estimated 30 to 50 percent."

- Miscellaneous consumption such as spillage cleaning, etc. – Water for miscellaneous use is estimated to be about 25% of that for personnel and equipment decontamination.

2.5 APPLICABLE REGULATIONS

To ensure the protection of the health and safety of the public and workers, and to protect the environment, the closure of WMA 3 would be performed in accordance with all applicable regulations of the U.S. Nuclear Regulatory Commission (NRC), the EPA, the DOE, the U.S. Department of Transportation (DOT), the Occupational Safety and Health Administration (OSHA), and New York State. Dames and Moore (2000), Section 4.2 should be consulted for a listing of regulations that are applicable to implementation of closure Alternative I at WMA 3.

TABLE 2.1

TANK REMOVAL STATISTICS AT OTHER DOE SITES

	Hanford	Idaho	Savannah River
Number of Tanks	4	11 + 133,800 m^3 contaminated soil	51
Cost (millions)	$183.1	$5,331.5 ($3,139.1 tanks, $1,835.8 soil, and $356.6 shared)	>$2,550 (>$50 per tank)
Duration	65½ months	34 years	—

TABLE 2.2

SCALABILITY OF THE EMMA™ MANIPULATOR

Length (ft/m)	Largest Diameter (in/m)	No. of Stages	Payload Capacity (lbs/kg)
50/15.2	18/0.457	5	200/91
33/10	24/0.609	4	200/91
25/7.6	18/0.457	4	200/91
15/4.6	16/0.406	3	75/34
12.5/3.8	3/0.076	5	1/0.45
8/2.4	14/0.356	2	100/45

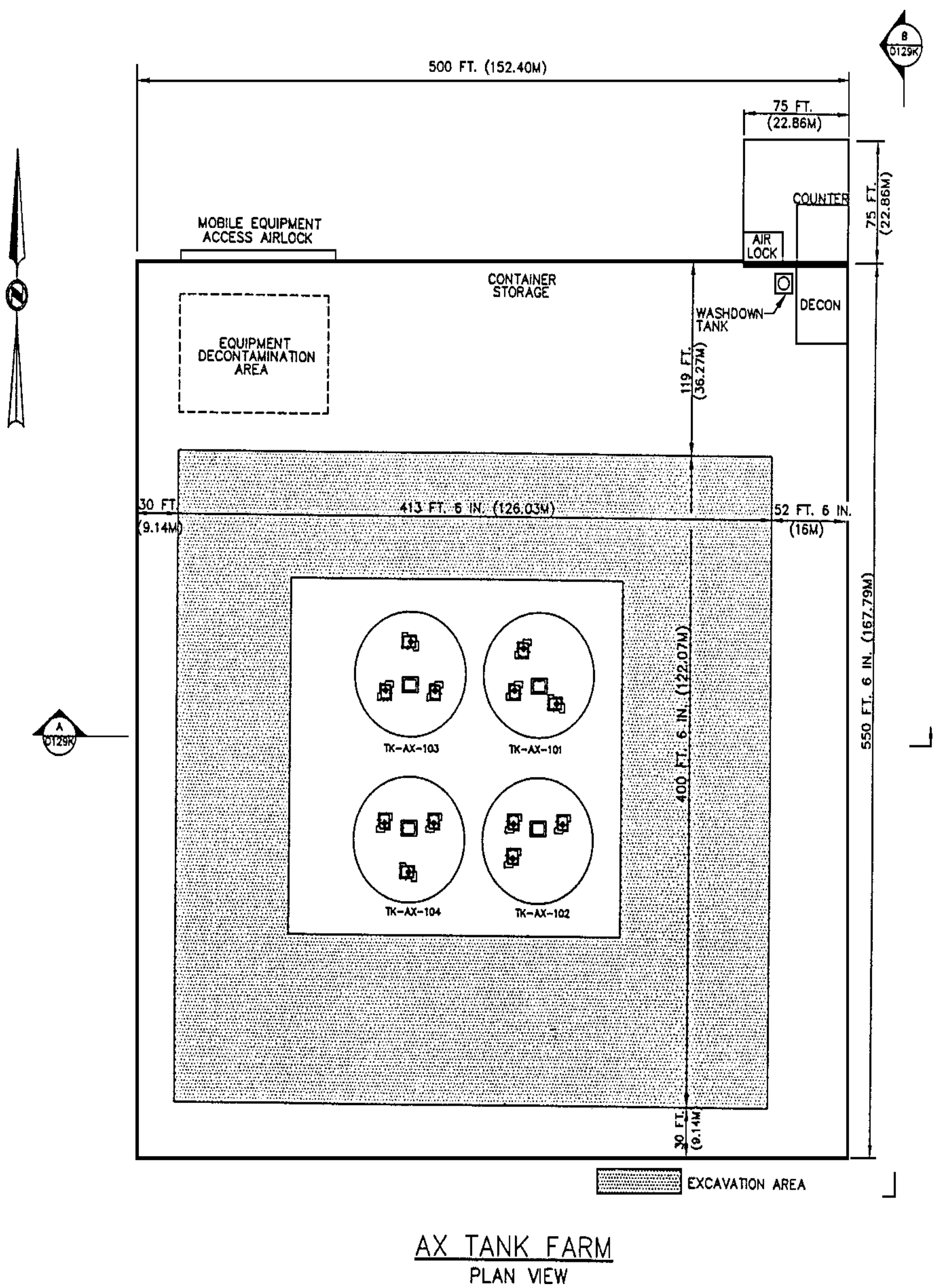

Figure 2.1. Hanford Tank Closure Methodology - plan view (Skelly 1997).

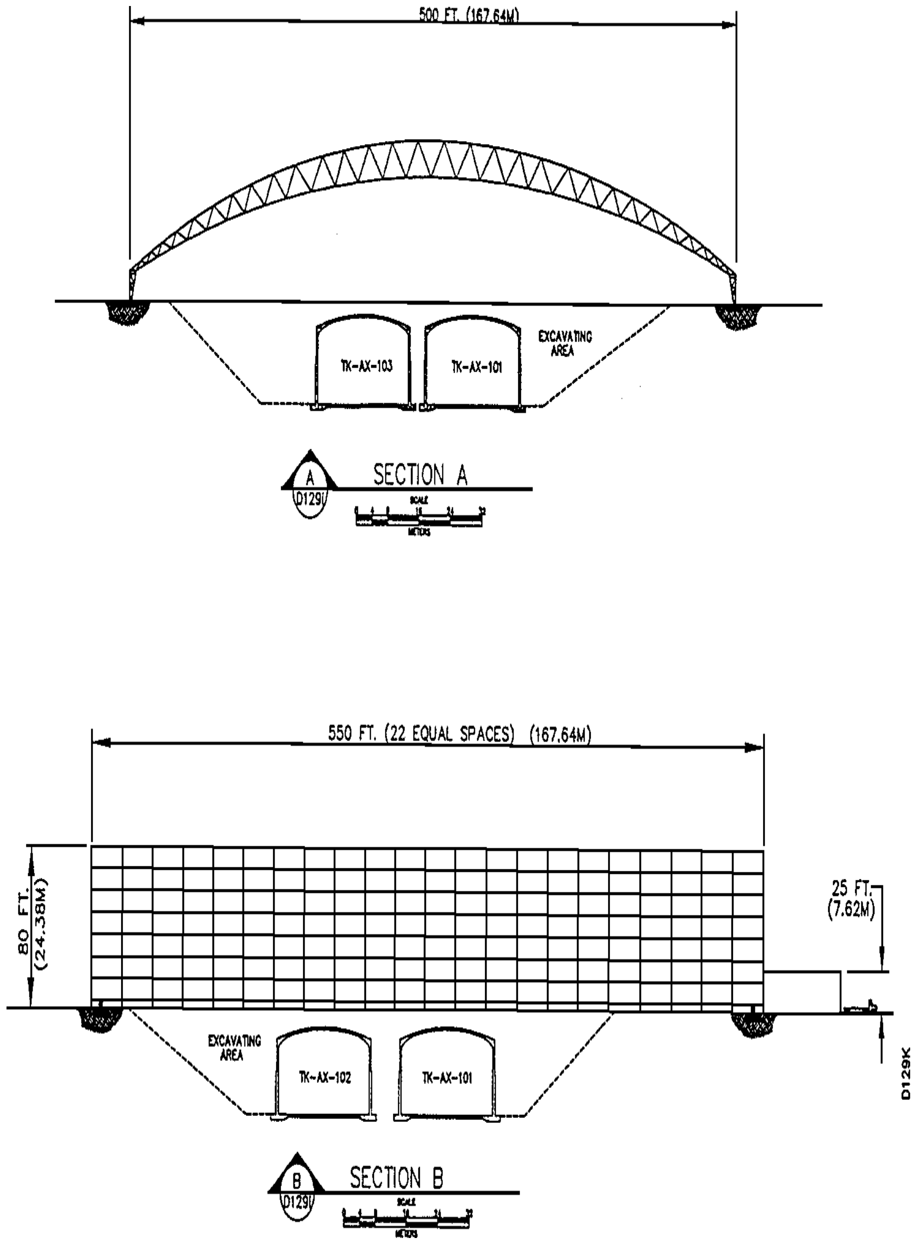

Figure 2.2. Hanford Tank Closure Methodology - cross sectional views (Skelly 1997).

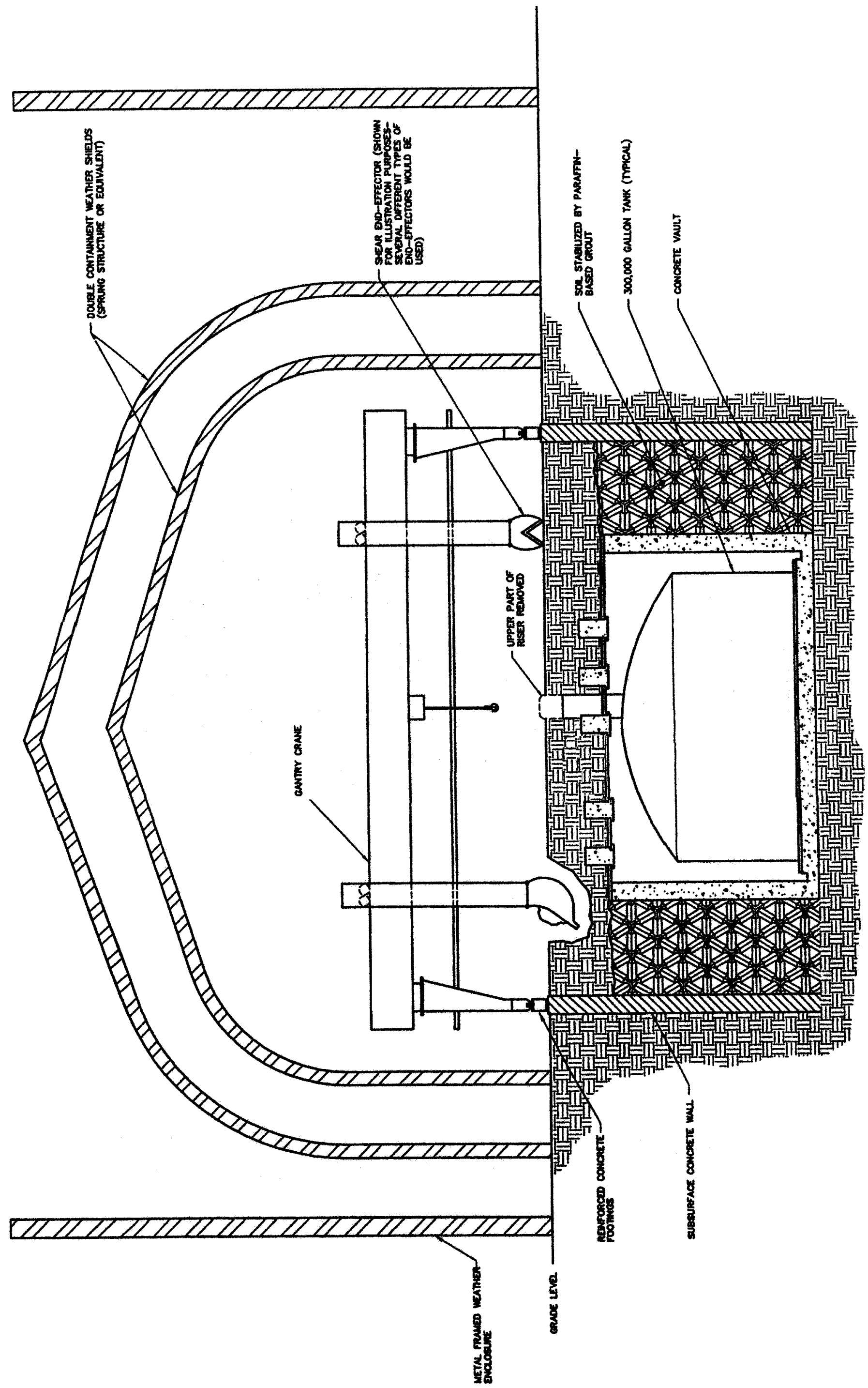

Figure 2.3. ICPP Tank Closure Methodology (INEEL 1998).

Figure 2.4. EagleTech Dual Arm Manipulator
(Photo 1 of 2)

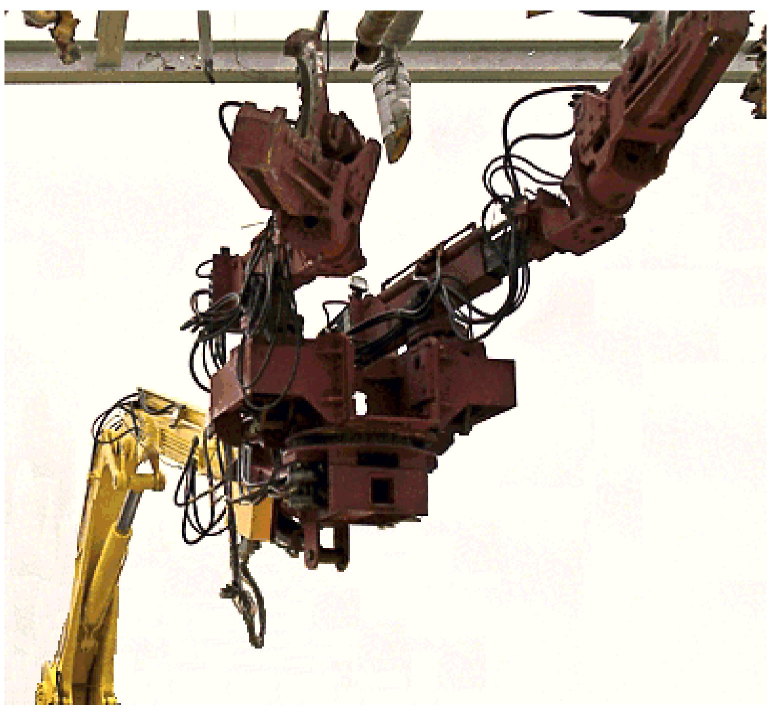

Figure 2.5. EagleTech Dual Arm Manipulator
(Photo 2 of 2).

Figure 2.6. GreyPilgram's EMMA™ Manipulator.

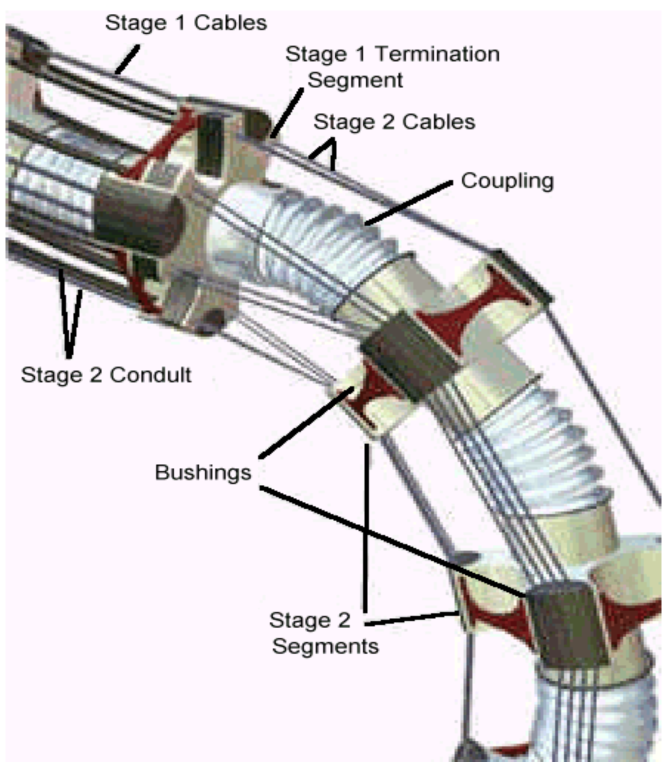

Figure 2.7. Closeup of EMMA™ Manipulator.

3.0 Methodology

3.1 Tank Removal Methodology Details

The details of the 'Top-Down' approach as applied to Tanks 8D-1 and 8D-2 are given in the following 32 steps:

1) Remove structures, buildings, roadways, Tanks 8D-3 and 8D-4, etc. in the area of the STS Support Building and Tanks 8D-1 and 8D-2 (see Dames and Moore 2000).

2) Remove upper (metal sided) portion of the STS Support Building.

3) Pull mobilization, decant and transfer pumps from both tanks.

4) Insert injection tubes in each riser vacated by the pumps to pump a removal grout of controlled low strength material (CLSM) to stabilize any residual heel within both tanks.

5) Inject grout simultaneously through all risers to maximize mixing and encapsulation of the remaining heel. (Note: If detailed studies determine it prudent, reversible grout could also be injected in the annulus between the tank and vault wells using existing access risers.)

6) Remove STS equipment from Tank 8D-1.

7) Remove Tanks 8D-1 and 8D-2 trusses and external equipment.

8) Construct a new Confinement Structure around STS Support Building and Tanks 8D-1 and 8D-2. Characteristics of the Confinement Structure include:

    1. Shielded walls and roof
    2. HVAC system with HEPA filters
    3. Multiple bridge canes w/ lifting cane and manipulator arm w/ multiple end effectors
    4. Remote visual system
    5. Control room
    6. Shielded debris shuttle box (SDSB) load in/load out area
    7. Decontamination area, including airlock into enclosure area

9) Remove cover layer of soil from the area above Tank 8D-2. At least initially, it is likely that this step could be performed non-remotely utilizing a 'Bobcat' or similar vehicle. The final layers would likely needs to be removed remotely utilizing the manipulator

arm with a scoop end effector.

10) Using the lifting crane and manipulator arm with a diamond saw end effector, cut-off the top of the Tank 8D-2 concrete vault:

    1. Insert "eye-bolt" into section of vault roof to be cut out
    2. Insert lifting crane hook into eye-bolt
    3. Use a diamond saw cut out section of vault roof
    4. Transfer roof section to the debris shuttle box (DSB), place cap onto box
    5. Transfer DSB to the Decontamination Area, and remove to the CMA

11) Using the lifting crane and manipulator arm, cut-off the carbon steel sheeting from the Tank 8D-2 roof supports:

    1. Hold on to a section of the tank's roof with the lifting crane (*e.g.*, with a magnetic grapple)
    2. Use a plasma arc torch to cut the roof into 3.5' × 7.5' sections
    3. Transfer section to SDSB, place cap onto SDSB
    4. Transfer SDSB to the Decontamination Area, and remove to the CMA
    5. Risers will be segmented, as necessary, to fit into the SDSB

12) Using the manipulator arm to first breakup and then either scoop or vacuum the stabilized heel from the tank

13) Similarly, cut up the carbon steel walls of Tank 8D-2 (see Step 11 for details)

14) Remove the stabilized heel from Tank 8D-2

15) Finally, cut up the floor structure of Tank 8D-2 (see Step 11 for details)

16) Provide temporary cover over Tank 8D-2 vault

17) Repeat Steps 9 through 16 for Tank 8D-1

18) STS Support Building removal

    1. Using the manipulator with a diamond saw end effector, cut-off the top of the valve aisle
    2. Remove equipment for valve aisle
    3. Vacuum valve aisle

19) Remove piping from the Transfer Trench

20) Using the manipulator with the diamond saw end effector, cut up and remove the Transfer Trench

21) Scabble Tank 8D-2 vault walls to remove outer surface of higher contamination material

    1. Assume waste would be classified as Class A

22) Excavate soil from around Tank 8D-2 vault, use sheet pilings to stabilize surrounding earth

23) Use the diamond saw end effector, cut up Tank 8D-2 vault walls (see Step 10 for details)

    1. Assume wall sections would be classified as LSA waste

24) Remove Tank 8D-2 vault floor

    1. Use manipulator arm with the scoop to pick-up perlite blocks
    2. Use the diamond saw to cut up the vault concrete bottom

25) Repeat Steps 21 through 24 for Tank 8D-1 vault

26) Excavate soil from around the STS Support Building foundation, use sheet pilings to stabilize surrounding earth

27) Use diamond saw to cut up STS Support Building walls and floor

28) Decontaminate the interior of the Confinement Structure to remove loose contamination

29) Remove concrete roof from Confinement Structure

    1. Assume that concrete and other construction materials are LSA waste

30) Use diamond saw to cut up Confinement Structure walls

    1. Assume that concrete from the enclosure and decontamination areas are LSA waste

31) Radiation survey area – survey–remove soil–re-survey, repeat as needed to meet unrestricted release criteria

    1. The actual depth of soil removal would depend on the results of the survey, for this analysis it was assumed that the top 6" of soil would be removed and disposed of as LSA waste

32) Backfill excavated areas.

3.2 PREPARATION AND PLANNING

Activities performed during the Preparation and Planning (P&P) phase of a project include developing the design, preparation of necessary regulatory documents, procurement of materials and equipment, and the training of personnel. Several sources were consulted to aid in the estimation of the P&P work effort:

1) DOE G 430.1-1 (DOE 1997, p. 25-3) recommends a total Engineering, Design, and Inspection (ED&I) cost of from 15 to 25% of construction costs.

2) As stated above, P&P costs for the removal of the Hanford tanks was estimated to be about 20% of the total cost (Skelly 1997).

3) For the Remote Handled Waste Facility (RHWF) construction (BTG 1999), ED&I costs were estimated at 11.4% of construction costs. As a cost savings measure, this facility will be constructed outside the WVDP controlled area, in a non-radiological area with the associated less preparation, training, etc. requirements.

4) For research facilities, laboratories, etc. with an overall construction cost of -$5 million, R.S. Means Co. (Means 1999, p. 490) recommends that architectural fees (including structural, mechanical and electrical engineering fees) should be estimated at 9.5% of total construction cost. Because the Means estimates are intended for commercial, rather than DOE facilities, this allowance for P&P costs is likely to be low.

Based on this information, the P&P costs were estimated at 20% of construction and/or operation costs – the midpoint of the DOE G 430.1 recommendation and consistent with what was used at Hanford. The P&P labor effort was back-calculated from the P&P cost using the Engineering hourly rate.

3.3 Removal of Tanks 8D-1 and 8D-2

Section 3.1, above, gives a 32 step approach that would be utilized for the removal of Tanks 8D-1 and 8D-2, the STS Support Building, and the Transfer trench. In this section, those 32 steps have been combined into four (4) functional areas:

1) Confinement Structure construction,
2) Tank and vault removal,
3) STS support building and Transfer Trench removal, and
4) Confinement Structure D&D.

The discussions below describe how the committed resources, personnel requirements, environmental releases, waste generated, closure costs, and other impacts were estimated for each of these four functional areas.

3.3.1 Confinement Structure Construction

All work associated with the removal of Tanks 8D-1 and 8D-2 would need to be performed within a shielded Confinement Structure to reduce exposures to surrounding personnel and to control radioactivity releases. A plan view of the proposed Confinement Structure is shown in Figure 3.1. The Confinement Structure would have the same dimensions as the structure presented in Dames and Moore (2000), except that it would be extended 40 ft in one direction to enclose the entire STS Support Building and 20 ft in the other direction to allow for a crane maintenance area. Figures 3.2 through 3.4 show additional views of the proposed Confinement Structure, including Figure 3.3 which shows the proposed crane maintenance area. The walls of the Confinement Structure were estimated to be 3 ft thick to provide shielding for when the covering soil and vault roof have been removed. A structural steel frame would be required to provide support for the shielding roof (the specific design criteria for this frame have not been established at this time). As was done for the STS Support Building, the Confinement Structure would be supported by cast-in-place piles that would extend into the undisturbed clay (-55 ft). A long-reach manipulator arm that could reach the bottom of the vaults would be attached to an overhead bridge, and would perform cutting, crushing, digging, and scooping operations. Heavy duty lifting of concrete and steel debris would be performed by a standard crane with a magnetic grapple and/or bucket. This crane would be attached to a second overhead bridge, as shown in Figure 3.2.

To estimate the cost associated with the construction of the shielded Confinement Structure two (2) primary references were used: 1) Means (1999) was used to estimate the cost and labor associated with wall, roof and floor construction, and 2) a recent WVNS facility cost calculation (BTG 1999) was used for site-work, internal finishing, monitor and control, shield doors, etc. The estimated cost for construction of the Confinement structure is about $41 million, as shown in Table 3.1. The cost of the long-reach manipulator arm is the largest single cost item shown in Table 3.1. This cost is based on data provided in INEEL (1998), Evans (1996) and Trost (1999). Four million dollars have been allocated for the construction of the steel frame of the Confinement Structure, although this value could readily increase once design criteria have been established, its impact on the total construction cost would be small.

3.3.2 Tank and Vault Removal

Removal of the tanks and vaults would essentially be the 'Top-Down' methodology discussed in Section 3.1. After stabilization of any residual heel and the removal of surface structures, the first step would be the removal of the cover soil, followed by cutting-up the vault roof, and continuing to move down through the tank/vault.

In general the durations necessary to perform each function associated with tank removal were estimated. These durations were then converted to work effort by multiplying by the size of the removal system operating crew. An operating crew of eight (8) was assumed: Supervisor, Crane Operator, 2 Manipulator Operators, Decontamination Operator, 2 Maintenance Technicians, and Utility Person. This assumption is based on EagleTech's (Trost 1999) recommendation of a crew of five for operation of the manipulator, plus three additional personal to perform auxiliary functions (e.g., decontamination, crane operation, etc.).

The total calculated work effort was increased by 25% to account for 'lost time,' *i.e.*, time spent performing non-productive tasks, such as breaks, training, briefings/debriefing, paperwork, regulatory compliance, suit-up/out, etc. Although NUREG/CR-6174 (Smith et al. 1996, p. C.53) utilizes a lost time adjustment factor of 57.4%, a smaller factor was assumed for this analysis since most work would be performed remotely and not require workers to suit-up on a regular basis.

Table 3.2 shows the durations, labor requirements and costs estimated for the various tasks associated with tank removal. Major parameters and/or assumptions used to calculate the durations required for heel, tank and vault removal, and maintenance are discussed in some detail below.

Stabilized Heel Removal – Regardless of how efficient the vitrification process is at removing HLW from the tanks, there will be some amount of HLW remaining in the tanks at the end of vitrification – if simply the amount that is below the suction level of the removal pumps. This remaining HLW is referred to as the tank's heel. It was assumed that a sufficient amount of solidifying agent (such as CLSM) would be added to the heel so that it's final classification would be as Class C waste (for this analysis 40 in of CLSM was assumed to be required).

To prevent this heel radioactivity from spreading and contaminating other areas within the Confinement Structure, it must be removed prior to cutting the tanks' walls and floors. It was assumed that the manipulator would have an end-effector (such as a vacuum or a scoop) which could be used to remove the stabilized heel. The Table 3.2 work effort necessary to remove the heel was based on a clean-up rate of 25 ft^3/h (Berglin et al. 1997).

Tank Removal – The steel shell of the tanks was assumed to be cut into 3.5 ft by 7.5 ft segments, as per NUREG/CR-6174 (Smith et al. 1996, p.C.57). It was assumed that it would take a half hour for the crane to move each segment to the SDSB Loadin/Loadout Area (see Figures 3.4 and 3.5), return the crane to the cutting location, and attach it to the next segment to be cut. Fuel (gasoline and oxygen) requirements were estimated based on experience gained with an oxy-gasoline torch (DOE 1998a). Consumable costs were estimated at 3% of labor costs, plus $70 per hour spent cutting (Scientech 2000).

The removal rate of the steel gridwork on the bottom of the tanks (hours per pound), was assumed to take the same time as the removal of the tank's shell. For example, if it were to take 65 work-hours to remove one ton of the tank's steel shell, then it was assumed that it would take 65 work-hours to remove 1 ton of the tank's steel gridwork.

Vault Removal – The top of the vault would be removed first to allow access to the tank. After the tank has been removed, the vault walls and floor would be removed. It was assumed that the vault would be cut into 2,000 pound segments with a diamond saw or a similar cutting device. The cost of diamond saw blades was assumed to be $0.44 per in-ft (Smith 1996, p C.64). As with the steel shell of the tank, a half hour was assumed to be required to transport the cut segment to the Confinement Structure Loadin/Loadout Area, return it to the active cutting location, and attach it to the next segment to be cut.

Maintenance – Maintenance of the manipulator during tank/vault removal operations could be a significant effort. To this end, a Crane Maintenance Area has been included in the Confinement Structure design where the manipulator could be decontaminated and personnel could repair the crane/manipulator and be shielded from the residual tank radioactivity, see Figure 3.3. Maintenance labor was estimated at 20% of operation labor hours based on experience with the dual arm work platform (DAWP, DOE 1998b). DOE (1998b) states that "The maintenance and repair of the DAWP was observed to be approximately 20% of the working time ...". Tools and consumables were estimated at 3% of maintenance labor. Additionally, 50% of the cost of a manipulator was included in the Table 3.2, Tools and Consumables Category, for replacement parts and vendor assistance.

Lessons learned from the DAWP (DOE 1998b, p. 21) also include that "Some maintenance activities required that the manipulator arm be sent back to Schilling [the manufacturer] for repairs, and a *considerable source of down time* [emphasis added] was attributed to shipping out one or both arms for maintenance. Commercial user(s) of the DAWP are highly encouraged to purchase a third spare arm, and if possible, train a nuclear technician in the maintenance of the DAWP."

3.3.3 STS Support Building and Transfer Trench Removal

As indicated in Section 3.1, this work would be accomplished in two phases. During the first phase (shown as Steps 2, 3, 6 and 7 in Section 3.1), the STS equipment and mobilization pumps in Tanks 8D-1 and 8D-2 would be removed, along with their support trusses, and the upper (metal sided) level of the STS Support Building. This work would be performed prior to the construction of the Confinement Structure. It is assumed that the STS equipment and the mobilization pumps within the tanks would be highly contaminated, and would be pulled and placed inside shielded casks. However, all other structures removed during this first phase (including the pump support trusses, and the sheet metal siding and structural steel of the upper STS Support Building) are assumed to be radiologically clean, and would be removed manually and disposed of as construction waste.

The second phase would consist of the removal of the Transfer Trench (Steps 19 and 20) and the lower (reinforced concrete) level of the STS Support Building (Steps 26 and 27). Because of the high levels of radiation expected in these areas, this second phase of the removal would be performed remotely within the Confinement Structure. All material removed during this phase was assumed to be disposed of as radioactive waste.

The duration, work effort and cost estimated for each activity associated with the D&D of the transfer trench are shown in Table 3.3. The work effort and cost estimated for each activity associated with the D&D of the STS Support Building are shown in Tables 3.4 for the upper portion, and Table 3.5 for the lower portion.

3.3.4 Confinement Structure D&D

Once Tanks 8D-1 and 8D-2 (and their vaults), the STS Support Building, and the Transfer Trench have been disassembled and removed, the Confinement Structure would be decontaminated and disassembled. During the cutting of the tanks it is anticipated that radioactivity would become airborne and redeposit on the interior surfaces of the Confinement structure, thus, necessitating the decontamination of these surfaces prior to their removal. In anticipation of this, all interior surfaces of the Confinement Structure would be provided with a layer of strippable covering to facilitate decontamination. Furthermore, for this evaluation it was assumed that the resulting radiation levels would be such that 'hands on' decontamination could be performed. In addition to the waste generated from the decontamination of the walls and ceiling, it was assumed that the top 6 in of soil within the Confinement Structure would likewise become contaminated and would need to be disposed of as radioactive waste. All waste generated during this decontamination effort was assumed to be Class A. Following the decontamination of the Confinement Structure, it would be disassembled using conventional building demolition techniques. During this demolition, precautions (*e.g.*, water sprays) would be taken to reduce the generation of re-suspended material, thereby minimizing the potential for the release of any residual radioactivity that may remain in the decontaminated Confinement Structure.

The work effort and cost estimated for each activity associated with the D&D of the Confinement Structure are shown in Table 3.6. Unitized work rates associated with decontamination, backfill and radiation surveys were taken from Dames and Moore (1999), while the other unitized work rates (*i.e.*, conventional demolition) were taken from Means (1999).

3.4 DECONTAMINATION AND REMOVAL OF OTHER WMA 3 FACILITIES

The committed resources, personnel requirements, environmental releases, waste generated, closure costs, and other impacts for implementation of Alternative I for the other facilities of WMA 3 (*e.g.*, the Vitrification Facility, the Con-Ed Building, the Cold Chemical Facility, etc.) were based on the values presented in Dames and Moore (2000). However, Dames and Moore (1999) was used to modify the Dames and Moore (2000) values to remove the impacts associated with closure of Tanks 8D-1 and 8D-2, the STS Support Building and those sections of the Transfer Trench that would be under the Confinement Structure. The resultant impact estimates are shown in the Chapter 4 impact tables, in the "Other WMA 3 Facilities" column.

TABLE 3.1
CONFINEMENT STRUCTURE CONSTRUCTION COSTS

Confinement Construction			Labor (wk-h)	Costs ($)			
				Labor	Materials	Equipment	Total
Site-work			4820	$170,000	$129,000	$106,000	$405,000
Enclosure Construction							
	Foundation	Excavate	271	$9,540	$0	$6,550	$16,100
		Piles	2610	$92,200	$394,000	$53,200	$539,000
	Concrete	Walls	24400	$862,000	$1,000,000	$19,200	$1,880,000
		Roof	6610	$233,000	$483,000	$8,480	$725,000
	Structural Steel		23300	$822,000	$3,040,000	$185,000	$4,040,000
	Roofing		926	$32,700	$13,900	$5,910	$52,500
	Cranes		4840	$171,000	$1,480,000	$2,080	$1,650,000
	Robotic Arm		0	$0	$0	$6,000,000	$6,000,000
	End Effectors		0	$0	$500,000	$0	$500,000
	Shield Doors		2000	$70,600	$264,000	$15,300	$349,000
	HVAC		20700	$732,000	$1,760,000	$99,200	$2,590,000
	Lighting & Wiring		10200	$359,000	$325,000	$2,090	$686,000
	Misc. Electrical		13200	$466,000	$1,120,000	$63,200	$1,650,000
	Initial Spare Parts		0	$0	$408,000	$600,000	$1,010,000
Auxiliary Buildings							
	Foundation	Excavate	170	$6,010	$0	$4,130	$10,100
		Piles	1170	$41,200	$176,000	$23,800	$241,000
	Concrete	Walls	5130	$181,000	$210,000	$4,030	$395,000
		Roof	1480	$52,200	$108,000	$1,900	$162,000
		Slab	47	$1,670	$10,100	$461	$12,200
	Roofing		207	$7,310	$3,110	$0	$10,400
	Finish Interior		3260	$115,000	$98,900	$1,670	$216,000
	Equipment		1400	$49,200	$73,900	$4,380	$127,000
	HVAC		4840	$171,000	$256,000	$15,200	$442,000
	Monitor/Control		3570	$126,000	$342,000	$1,060	$469,000
	Misc. Electrical		3080	$109,000	$163,000	$9,670	$281,000
	Plumping		2100	$74,000	$111,000	$6,590	$192,000
	Initial Spare Parts		0	$0	$70,900	$0	$70,900
Total Construction			140000	$4,950,000	$12,500,000	$7,240,000	$24,700,000
Support Staff			311000	$11,200,000	$0	$0	$11,200,000
Preparation & Planning			106000	$4,950,000	$0	$0	$4,950,000

TABLE 3.2
TANK AND VAULT REMOVAL COST

Tank/Vault Removal	Duration (h)	Labor (wk-h)	Cost ($)		
			Labor	Tools and Consumables	Total
Stabilize Heels	760	6080	$215,000	$164,000	$379,000
Startup	2820	23100	$814,000	$340,000	$1,150,000
Remove Vault Cover Soil	617	9880	$348,000	$10,500	$359,000
Cut-up Vault Tops	4590	36700	$1,300,000	$117,000	$1,410,000
Remove Stabilized Heels	3090	24700	$873,000	$26,200	$899,000
Cut up Tank Shell	1120	8930	$315,000	$87,600	$403,000
Cut up Steel Framework	1060	8470	$299,000	$83,000	$382,000
Remove Vault Bottoms	7650	61200	$2,160,000	$143,000	$2,300,000
Cut up Vault Walls	5010	40100	$1,410,000	$123,000	$1,540,000
Sheet Piling	282	2170	$76,500	$2,290	$78,800
Maintenance	4810	38400	$1,360,000	$3,040,000	$4,400,000
Total	31800	260000	$9,170,000	$4,160,000	$13,300,000
Support Staff		576000	$20,800,000	$0	$20,800,000
Preparation and Planning		53500	$1,930,000	$0	$1,930,000

TABLE 3.3
TRANSFER TRENCH REMOVAL COST

Transfer Trench Removal	Duration (h)	Labor (wk-h)	Cost ($)		
			Labor	Tools and Consumables	Total
Remove pipe	945	7560	$267,000	$8,000	$275,000
Remove concrete	5120	41000	$1,450,000	$131,000	$1,580,000
Remove liner	1510	12100	$427,000	$12,800	$440,000
Maintenance	1520	12100	$428,000	$12,800	$441,000
Total	9100	72800	$2,570,000	$164,000	$2,730,000
Support Staff	—	161000	$5,830,000	$0	$5,830,000
Preparation and Planning	—	15100	$546,000	$0	$546,000

TABLE 3.4

UPPER STS SUPPORT BUILDING REMOVAL COST

Upper STS Support Bldg Removal Tasks	Labor (wk-h)	Cost ($)		
		Labor	Tools and Consumables	Total
Rad survey	504	$17,800	$533	$18,300
Remove STS equip. from Tank 8D-1	14200	$499,000	$337,000	$837,000
Remove tank trusses	1280	$45,300	$30,600	$75,900
Remove metal siding	1480	$52,400	$1,570	$53,900
Total	17400	$615,000	$370,000	$985,000
Support Staff	38600	$1,400,000	$0	$1,400,000
Preparation and Planning	5450	$197,000	$0	$197,000

TABLE 3.5

LOWER STS SUPPORT BUILDING REMOVAL COST

Lower STS Support Bldg Removal Tasks	Duration (h)	Labor (wk-h)	Cost ($)		
			Labor	Tools and Consumables	Total
Remove tanks	36	288	$10,100	$304	$10,500
Remove piping & valves	1460	11700	$413,000	$12,400	$426,000
Remove concrete	3040	24300	$857,000	$123,000	$980,000
Maintenance	908	7260	$256,000	$7,690	$264,000
Total	5450	43600	$1,540,000	$143,000	$1,680,000
Support Staff	—	96500	$3,490,000	$0	$3,490,000
Preparation & Planning	—	9300	$336,000	$0	$336,000

TABLE 3.6

CONFINEMENT STRUCTURE D&D COST

Confinement Demolition	Labor (wk-h)	Costs ($)		
		Labor	Equipment and Consumables	Total
Enclosure Decontamination	16400	$580,000	$115,000	$695,000
Walls Removal	10200	$361,000	$219,000	$580,000
Roof Removal	5000	$176,000	$87,500	$264,000
Slab Removal	307	$10,800	$4,480	$15,300
Structural Steel Removal	2160	$76,000	$18,300	$94,400
Misc. Equipment Removal	1160	$41,100	$3,660	$44,700
Cranes & Rails Removal	1730	$61,000	$808	$61,800
Electrical Removal	10000	$353,000	$25,300	$379,000
HVAC Removal	8520	$301,000	$38,100	$339,000
Rad Surveys	2190	$77,200	$2,320	$79,500
Backfill	2220	$78,300	$126,000	$204,000
Total	60000	$2,120,000	$640,000	$2,760,000
Support Staff	133000	$4,800,000	$0	$4,800,000
Preparation & Planning	11800	$551,000	$0	$551,000

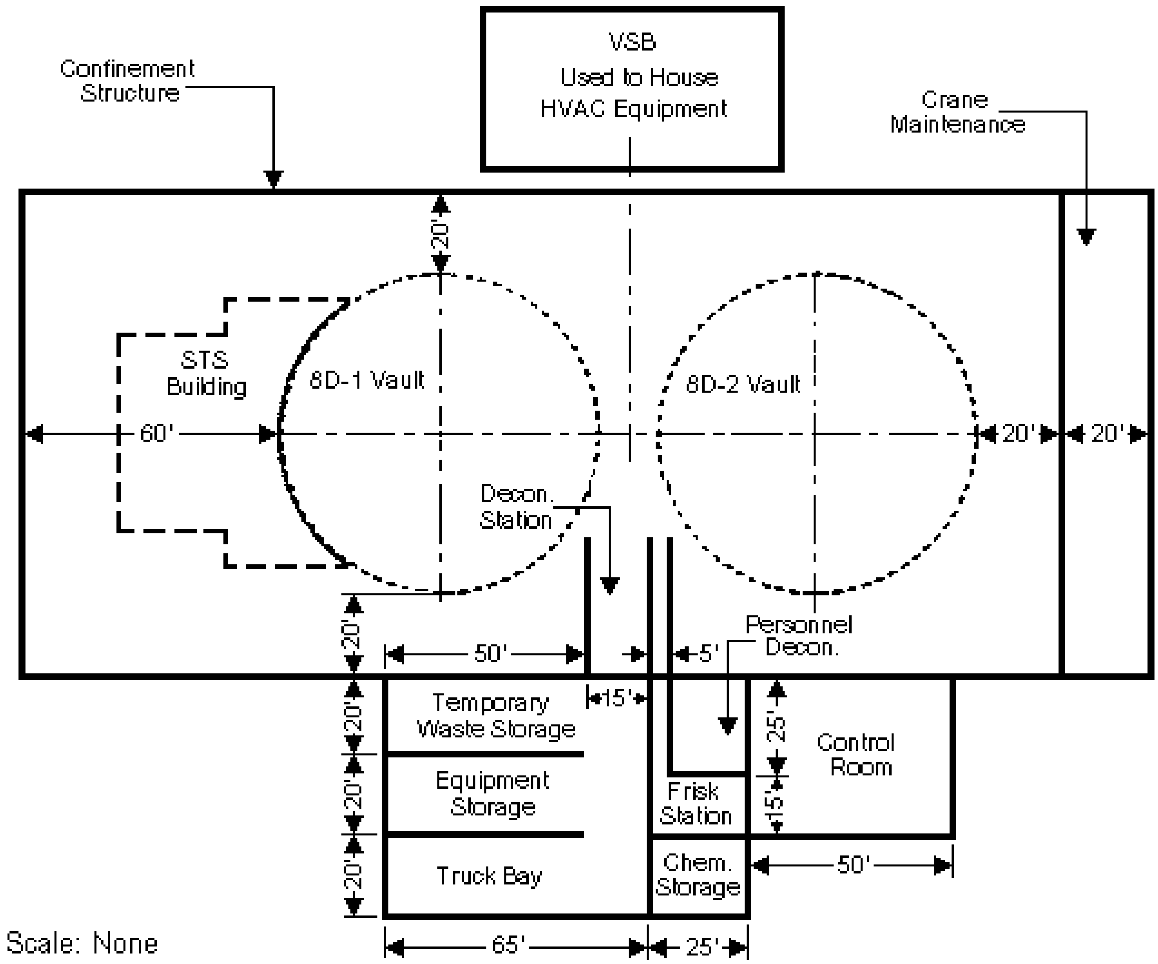

Figure 3.1. Plan view of the Confinement Structure.

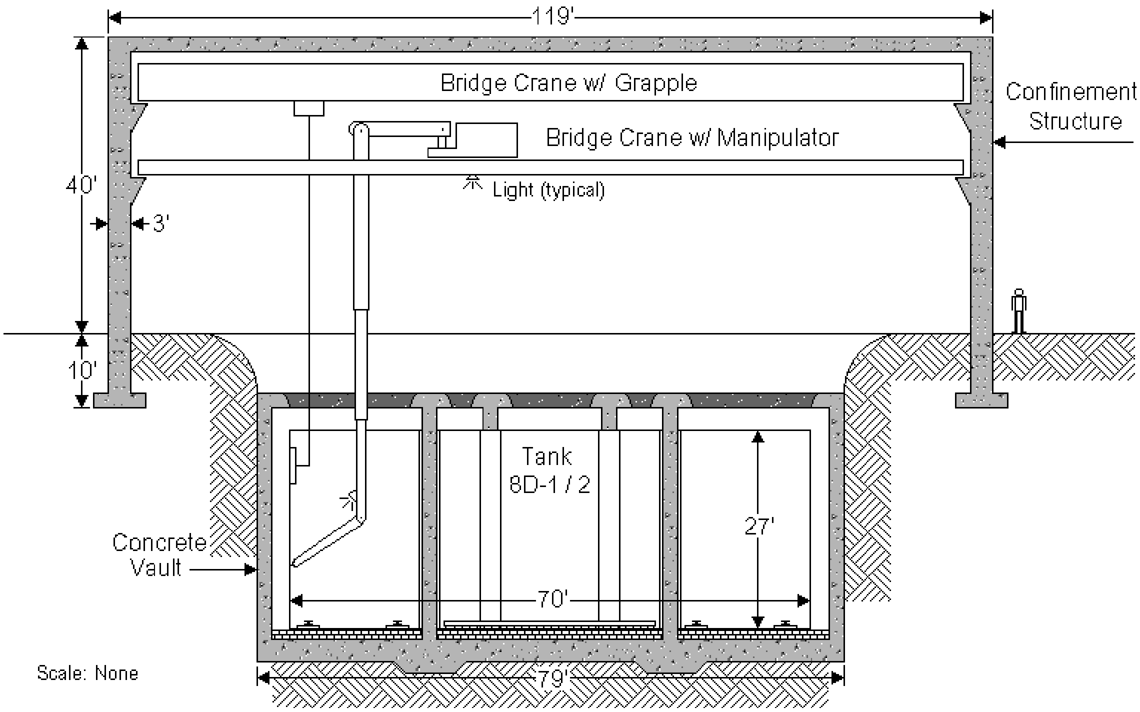

Figure 3.2. Cross section view of the Confinement Structure.

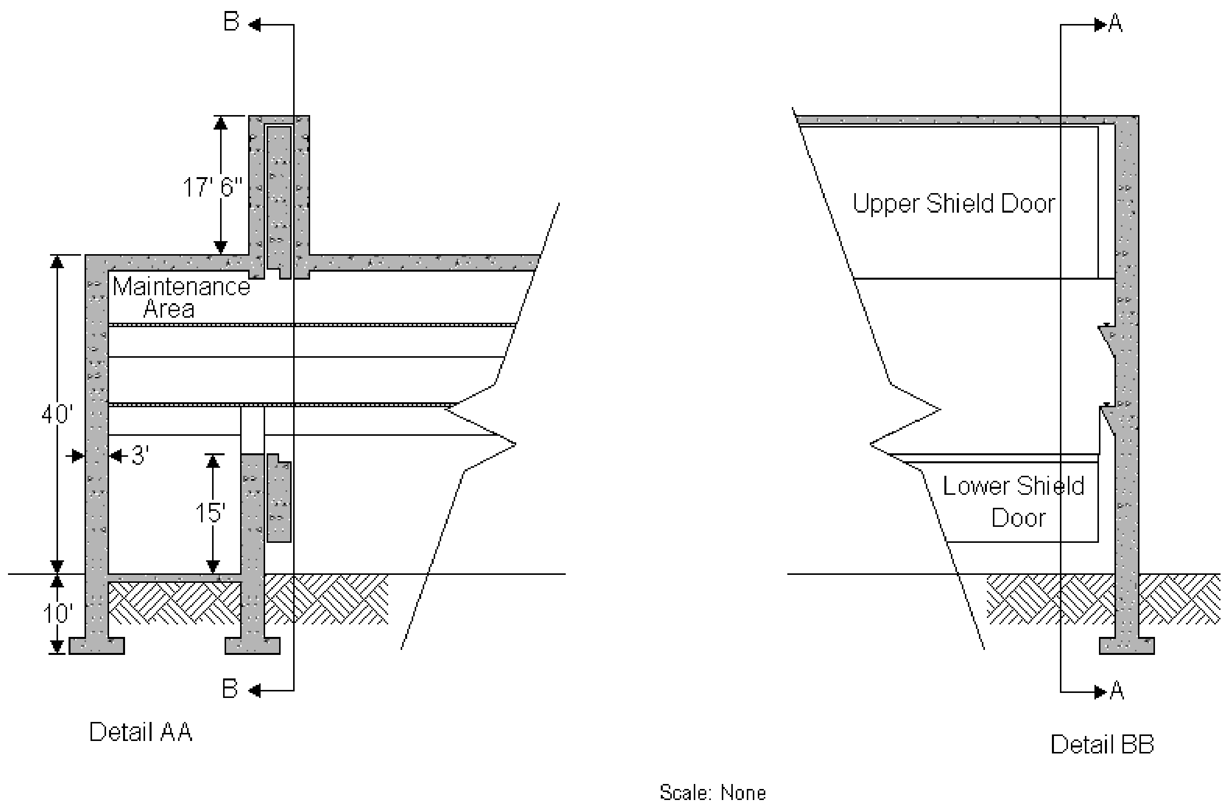

Figure 3.3. Confinement Structure crane maintenance area.

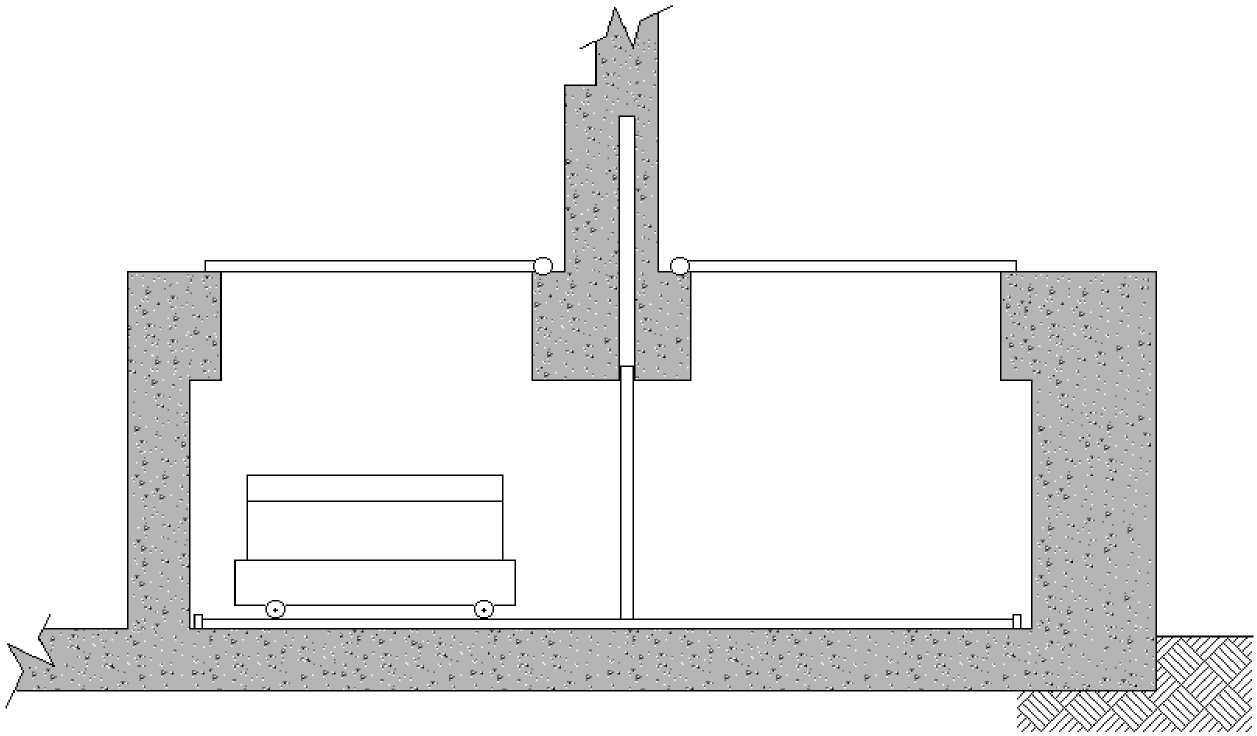

Figure 3.4. Confinement Structure loadin/loadout area.

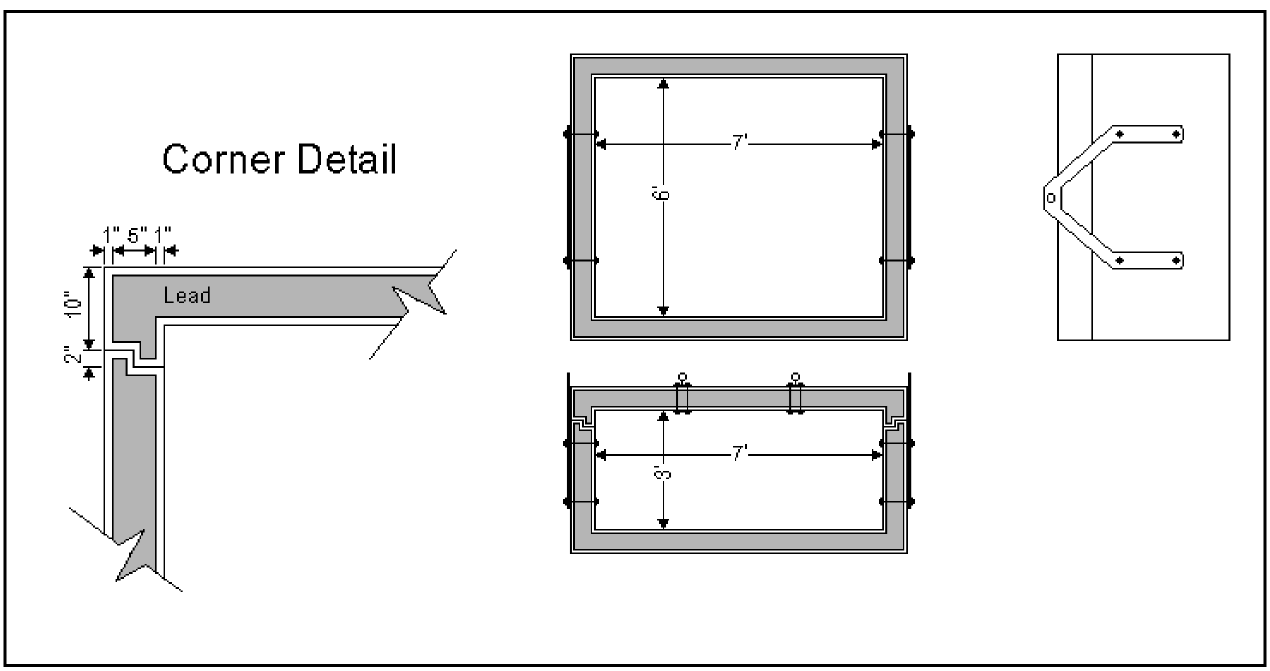

Figure 3.5. Shielded debris shuttle box.

4.0 Results and Conclusions

This section presents the summary tables for the implementation of closure Alternative I at WMA 3. Four categories of closure engineering data are presented:

1) **Resource Requirements** – includes estimated quantities of construction material, equipment usage, consumable materials and supplies, fuel consumption, water use, and number of personnel.

2) **Operational Issues** – includes estimates of environmental radiological and non-radiological emissions, noise levels, project schedule, and personnel radiation exposure/

3) **Waste Generated** – includes estimated volumes of radioactive, hazardous, mixed and clean waste to be shipped off-site for disposal.

4) **Cost Estimate** – includes cost estimates for new construction, consumable materials, energy and fuel, labor, and waste disposal/storage.

In the "Other WMA 3 Facilities' column on the following tables, the impact estimates associated with closure of WMA 3 facilities other than the Tanks 8D-1 and 8D-2, the STS Support Building and the Transfer Trench (*e.g.*, the Vitrification Facility, the Con-Ed Building, the Cold Chemical Facility, etc.) are presented. These committed resources, personnel requirements, environmental releases, waste generated, closure costs, and other impacts are based on the values presented in Dames and Moore (2000), modified via the Dames and Moore (1999) methodology to remove the impacts associated with closure of the facilities specifically addressed in this report (*i.e.*, Tanks 8D-1 and 8D-2, the STS Support Building and the Transfer Trench).

4.1 Resource Requirements

Personnel Required – The total personnel requirement to implement Alternative I at WMA 3 is about 2,017 work-years. The estimated number of personnel by job category (*e.g.*, laborer, engineer, administrator) is shown in Table 4.1, while the estimated number of personnel by activity (*e.g.*, preparation and planning, decontamination, new construction) is shown in Table 4.2.

Construction Materials – Steel and concrete are the two most used construction materials. Table 4.3 gives the estimated quantities of the construction materials used. In addition, aluminum would be used for HVAC ducting and copper would be used for electrical wiring, but the design has not progressed to the point where detailed estimates of the quantities of these materials can be made. Finally, as shown in Table 4.3, approximately 32,000 yd^3 of clean fill would be needed to backfill and landscape the excavations resulting from the removal of the WMA 3 facilities.

Specialized Equipment – Specialized equipment would include a remote controlled manipulator to be used to disassemble Tanks 8D-1 and 8D-2. Existing manipulator arms have been discussed in Section 2.2, and may fulfill the needs for tank disassembly, alternatively, a manipulator may need to be specifically designed to meet the specific requirements of Tanks 8D-1 and 2, in which case the costs presented below would need to be adjusted upward.

Consumable Materials – The estimated quantities of materials used during the implementation of Alternative I at WMA 3 are given in Table 4.4. Consistent with Dames and Moore (2000), the 20 yd^3 Rolloffs used to transport LSA and clean waste off-site for disposal were assumed to be recycled, therefore, only 30 Rolloffs would be required, regardless of the volume of these wastes.

Water, Energy and Fuel – Table 4.5 presents the estimated quantities of water, electricity and fuel used during implementation of Alternative I at WMA 3. The water requirements for "Other WMA 3 Facilities" were calculated as part of this study, since they were not provided in Dames and Moore (2000). The manipulator electricity requirement is based on a 150 H.P. specification provided by the vendor (Trost 1999).

4.2 Operational Issues

Duration of Activities – Table 4.6 gives the estimated duration of activities required to close WMA 3. Note that none of the durations are summed. This is because each activity stands on its own, and can be on-going concurrently with other activities – so simply adding the individual durations would **not** give the total project duration. A potential schedule for implementing Alternative I is shown in Figure 4.1. However, because the closure of WMA 3 would be integrated with the closure of the other WMA's, Figure 4.1 should only be thought of as representative.

Occupational Radiation Exposure – Occupational radiation exposures calculated to occur are given in Table 4.7. In Table 4.7 the 'Material Removal' row refers to tank/vault removal, as well as Vitrification Facility demolition. For Tanks 8D-1 and 2 and STS Support Building operations, the following dose rates were assumed: decontamination – 0.5 mrem/h, material removal (control room crew) – 0.05 mrem/h, and maintenance – 1.5 mrem/h.

Injuries and Fatalities – The numbers of injuries and fatalities estimated to result during the implementation of Alternative I at WMA 3 are given in Table 4.8. Since there cannot be a fractional fatality, the estimated number of fatalities of 0.16 can be interpreted to mean that there is a 16% chance of a single fatality occurring during WMA 3 closure activities.

Environmental Releases – Radiological and non-radiological environmental release estimates are presented in Table 4.9. Non-radiological release estimates were made for flue gas emissions due to heating requirement, construction equipment exhaust, and emissions during waste shipping. Particulate emissions that would be generated by use of the on-site roadways is assumed to be negligible.

Control methods could be used to reduce the amount of fugitive dust generated below that shown in Table 4.9. Watering is the method most often used at construction sites because water and the necessary equipment are usually available. The effectiveness of watering depends greatly on the frequency of application, a twice daily application with complete coverage is estimated to reduce fugitive dust emissions by up to 50%.

Noise – During WMA 3 closure activities, increased sound levels would be produced in the vicinity of the site. These increased sound levels would primarily result from the use of construction equipment. Given in Table 4.10 is a list of equipment that could be used during closure operations, and the attendant sound-pressure levels measured at 50 ft from each unit. To place these noise levels in perspective, 90 dbA is approximately the noise level of a food blender at three (3) ft, while riding in an automobile at 40 mph produces approximately 75 dbA., and normal speech is 60dbA.

4.3 WASTE GENERATED

The volumes of waste estimated to result from implementation of Alternative I at WMA 3 are given in Table 4.11. These waste volumes were taken mostly from Dames and Moore (2000), with additional LSA waste added due to the contamination of the interior concrete walls and ceiling, and soil floor of the Confinement Structure, and Class C waste added due to heel removal. As with Dames and Moore (2000), no hazardous or mixed waste was estimated to be generated.

4.4 COST ESTIMATE

As shown in Table 4.12, a total cost of $541 million* was estimated for the implementation of Alternative I at WMA 3. This cost was divided $303 million (56%) from closure of Tanks 8D-1 and 8D-2 and the STS Support Building, and $239 million (44%) from closure of the other facilities within WMA 3. The major components of this cost are: labor – $141 million (26.1%), waste disposal – $176 million (32.5%), contingency – $180 million (33.3%), and miscellaneous $44 million (8.1%).

The costs presented in Table 4.12 represent the **minimum** estimate for implementing Alternative I at WMA 3, and are intended to be used for making cost comparisons between this

* To be consistent with previously prepared DEIS cost estimates, all costs are presented in 1993 dollars.

and other closure alternatives – the Table 4.12 cost estimates should **not** be considered as absolute or bid-document costs. There are a number of factors that would contribute to the overall cost of implementing Alternative I at WMA 3 which have not been included in the Table 4.12 estimates, including DOE and NYSERDA oversight, insurance, licensing and permitting fees, taxes, contractor profit, shift differential, and mobilization and demobilization.

Accuracy – The accuracy of a cost estimate, or how close the cost estimate is to actual costs, is primarily dependent on how well the project scope is defined. As a project moves through its life cycle, cost estimates are commonly made at key decision points (*e.g.*, screening of alternatives, final design). Typically, the further into its life cycle, the more defined a project scope becomes, and therefore, the accuracy of the cost estimate is improved. This process is depicted by the EPA in Figure 4.2 (EPA 1998). The cost estimates presented in this report should be considered as screening-level cost estimates. The screening-level accuracy range of -50 to +100 percent means that for an estimate of $541 million the actual cost is expected to be between $270.5 million and $1.082 billion.

The accuracy of a cost estimate should not be confused with contingency. The accuracy of an estimate can only be established once the project has been completed and the estimated cost can be compared to the actual cost. Whereas, contingency is defined as an amount added to a cost estimate to cover costs associated with unknowns, unforeseen circumstances, or unanticipated conditions that are not possible to evaluate from the data on hand at the time the estimate is prepared. The accuracies depicted in Figure 4.2 include the appropriate amount contingency in the base cost estimate.

TABLE 4.1

RESOURCE REQUIREMENTS: PERSONNEL REQUIRED BY JOB CATEGORY
(work-years)

Job Category	Tanks 8D-1/2 and STS Bldg	Other WMA 3 Facilities	Total
D&D Operations Laborers	205	184	389
Construction Laborers	104	98	202
Maintenance Personnel	54	43	96
Engineers	240	192	432
Radiation and Safety	58	53	111
Security	43	34	77
Environmental Assessment	114	91	205
Analytical Laboratory	71	57	128
Project Administration	35	28	63
Quality Assurance	50	40	89
Human Resources	50	40	89
Financial and Purchasing	74	59	133
TOTAL	1099	918	2017

TABLE 4.2

RESOURCE REQUIREMENTS: PERSONNEL REQUIRED BY ACTIVITY
(work-years)

Activity	Tanks 8D-1/2 and STS Bldg	Other WMA 3 Facilities	Total
Preparation and Planning	104	26	130
Decontamination	0	585	585
New Construction	336	20	356
Final Closure	659	287	946
TOTAL	1099	918	2017

TABLE 4.3

RESOURCE REQUIREMENTS: CONSTRUCTION MATERIAL

Activity	Tanks 8D-1/2 and STS Bldg	Other WMA 3 Facilities	Total
Concrete (yd^3)	8860	—	8860
Steel – Structural (tons)	2980	—	2980
Rebar (tons)	2520	—	2520
Backfill (yd^3)	18,800	13,200	32,000
Roofing Material (ft^2)	40,500	—	40,500

TABLE 4.4
RESOURCE REQUIREMENTS: CONSUMABLE MATERIALS

Item	Tanks 8D-1/2 and STS Bldg	Other WMA 3 Facilities	Total
Protective Clothing:			
Coveralls	55400	267000	322000
Booties	55400	267000	322000
Lab. Gloves	55400	267000	322000
Heavy Rubber Gloves	83000	400000	483000
Cotton Gloves	83000	400000	483000
Plastic Sheeting (rolls)	286	1890	2180
Sample Bags	24700	164000	188000
Respirator Cartridges	5940	20100	26100
HEPA Filter Cartridges	5	24	29
Bioassay Containers	3010	9870	12900
Tape (rolls)	3280	21800	25000
Filter Papers for Sampling	3280	21800	25000
Smears for Sampling	14300	94600	109000
Herculite Sheeting (rolls)	286	1890	2180
Tygon Tubing for Sampling (ft)	1780	11800	13600
TLDs	21	97	118
Small Tools	450	2290	2740
Waste Containers:			
Boxes (B-12)	735	2274	3009
High Integrity Containers	36	24	60
NUHOMS Canisters	49	27	76
Rolloffs (20 yd^3)	30		30

TABLE 4.5
RESOURCE REQUIREMENTS: WATER, ENERGY AND FUELS

Item Description	Tanks 8D-1/2 and STS Bldg	Other WMA 3 Facilities	Total
Water (gallons):			
Domestic - Operations	3,710,000	3,390,000	7,100,000
Support Staff	9,480,000	7,630,000	17,100,000
Facility Decon	see 'Liquid Waste' on Table 4.9		
Personnel Decon	289,000	1,770,000	2,060,000
Equipment Decon	723,000	2,210,000	2,940,000
Concrete Mix	374,000	—	374,000
Miscellaneous	253,000	996,000	1,250,000
Total Water	14,800,000	16,000,000	30,800,000
Electricity (kw-h):			
Equipment and Tools	249,000	300,000	549,000
Ventilation System	19,000,000	26,600,000	45,600,000
Air Conditioning	—	2,850,000	2,850,000
Lighting	748,000	580,000	1,330,000
Manipulator	5,170,000	—	5,170,000
Total Electricity	25,200,000	30,300,000	55,500,000
Natural Gas (ft^3)	116,000,000	77,300,000	193,000,000
Diesel Fuel (gallons)	250,000	108,000	358,000
Gasoline (gallons)	334	3,870	4,200
Oxygen (for cutting, ft^3)	40,100	—	40,100

TABLE 4.6

OPERATIONAL ISSUES: DURATION OF ACTIVITIES (y)

Activity Description	Tanks 8D-1/2 and STS Bldg	Other WMA 3 Facilities
Preparation and Planning	8	2.1
Decontamination	—	6.6
New Construction	4.3	0.3
Final Closure	11.3	4.4

TABLE 4.7

OPERATIONAL ISSUES: ESTIMATED PERSONNEL RADIATION EXPOSURE (worker-rem)

Operation	Tanks 8D-1/2 and STS Bldg	Other WMA 3 Facilities	Total
Decontamination	8.2	55.8	64.0
Material Removal	19.0	2.7	21.7
Maintenance	86.7	—	86.7
TOTAL	113.9	58.5	172.4

TABLE 4.8

OPERATIONAL ISSUES: INJURIES AND FATALITIES

Injury or Fatality	Tanks 8D-1/2 and STS Bldg	Other WMA 3 Facilities	Total
Non-Lost Workday Injuries	44.9	38.6	83.5
Lost Workday Injuries	40.3	34.5	74.8
Fatalities	0.085	0.074	0.16

TABLE 4.9
OPERATIONAL ISSUES: ENVIRONMENTAL RELEASES

Environmental Releases	Tanks 8D-1/2 and STS Bldg	Other WMA 3 Facilities	Total
Radioactive Airborne Releases From Building Ventilation (Ci/TBq)			
^{137}Cs	9.0/0.31	0.23/8.0e-3	9.2/0.32
^{90}Sr	4.8/0.17	0.18/6.2e-3	5/0.17
^{60}Co	4.0e-6/1.4e-7	1.5e-5/5.2e-7	1.9e-5/6.6e-7
TRU	0.021/7.2e-4	2.6e-5/9.0e-7	0.021/7.3e-4
TOTAL	13.8/0.48	0.41/0.014	14.2 / 0.49
Liquid Waste (ft^3)	4000	80000	84000
Flue Gas Emissions (tons)			
Nitrogen Oxides	0.22	0.15	0.37
Carbon Monoxide	0.21	0.14	0.35
Non-radioactive Releases From Construction Equipment: (tons)			
Particulates	3.6	1.5	5.0
Carbon Monoxide	10.9	16.0	26.9
Hydrocarbons	4.0	2.5	6.5
Nitrogen Oxides	50.3	37.0	87.3
Aldehydes	0.8	0.5	1.3
Sulfur Oxides	3.3	2.3	5.6
Fugitive Dust (tons)	170.0	170.0	340.0
Shipping Emissions (tons):			
Hydrocarbons	13.0	32.0	45.0
Carbon Monoxide	42.0	110.0	150.0
Nitrogen Oxides	58.0	150.0	210.0

TABLE 4.10

OPERATIONAL ISSUES: NOISE* (dBA at 50 ft)**

Equipment	Idle	Maximum
Front-End Loader	75	90
Bulldozer with ripper	75	90
Bulldozer	70	88
Scraper	70	86
Grader	74	89
Compactor	75	90
Flatbed truck	70	86
Cherry picker	65	81

*Source: EPA (1985)

*dbA is decibels on the A scale, which adjusts noise levels to account for human hearing capabilities.

TABLE 4.11

WASTE GENERATED: DISPOSAL VOLUME

Waste Type	Tanks 8D-1/2 and STS Bldg	Other WMA 3 Facilities	Total
Radioactive Waste (ft^3)			
LSA	396000	1060000	1460000
Class A	59500	184000	244000
Class B	0	0	0
Class C	4130	2720	6850
Greater Than Class C	6510	3610	10100
TOTAL Radioactive Waste (ft^3)	466000	1250000	1720000
Hazardous Waste (ft^3)	0	0	0
Mixed Waste (ft^3)	0	0	0
Industrial (Clean) Waste (yds^3)	1030	2500	3530

TABLE 4.12
COST ESTIMATE: COST FOR CLOSURE

Cost Component	Tanks 8D-1/2 and STS Bldg	Other WMA 3 Facilities	Total
Construction Materials	$13,200,000	$340,000	$13,500,000
Equipment	$7,880,000	$2,380,000	$10,300,000
Consumable Materials	$6,330,000	$7,690,000	$14,000,000
Energy and Fuel	$3,230,000	$3,030,000	$6,250,000
Labor: By Category			
Operations	$21,000,000	$18,000,000	$39,000,000
Support Staff	$56,000,000	$45,800,000	$102,000,000
Total Labor: By Category	$77,000,000	$63,900,000	$141,000,000
Labor: By Activity			
Preparation and Planning	$8,470,000	$2,340,000	$10,800,000
Decontamination	$0	$41,000,000	$41,000,000
New Construction	$16,200,000	$0	$16,200,000
Final Closure	$52,300,000	$20,500,000	$72,800,000
Total Labor: By Activity	$77,000,000	$63,900,000	$141,000,000
Waste Disposal			
Low Specific Activity	$10,800,000	$28,900,000	$39,700,000
Class A Waste	$2,410,000	$7,460,000	$9,880,000
Class B Waste	$0	$0	$0
Class C Waste	$1,700,000	$1,120,000	$2,820,000
Greater Than Class C	$79,200,000	$43,900,000	$123,000,000
Hazardous Waste	$0	$0	$0
Mixed Waste	$0	$0	$0
Industrial (Clean) Waste	$134,000	$325,000	$458,000
Total Waste Disposal	$94,200,000	$81,700,000	$176,000,000
Contingency (50%)	$101,000,000	$79,500,000	$180,000,000
TOTAL (1993)	$303,000,000	$239,000,000	$541,000,000

ACTIVITY DESCRIPTION	Project Year																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Other Facility P&P	, ,	, ,																							
Other Facility Decontamination			, ,	, ,	, ,	, ,	, ,	, ,	,																
Other Facility New Construction							,																		
Other Facility Final Closure								, ,	, ,	, ,	, ,	,													
Tanks P&P			, ,	, ,	, ,	, ,		,	, ,	,									,	, ,	,				
Tanks New Construction						,	, ,	, ,	, ,	, ,															
Tanks Final Closure										, ,	, ,	, ,	, ,	, ,	, ,	, ,	, ,	, ,	, ,	, ,	, ,	,			

Figure 4.1. Potential WMA 3, Alternative I Schedule (activity durations taken from Table 4.6).

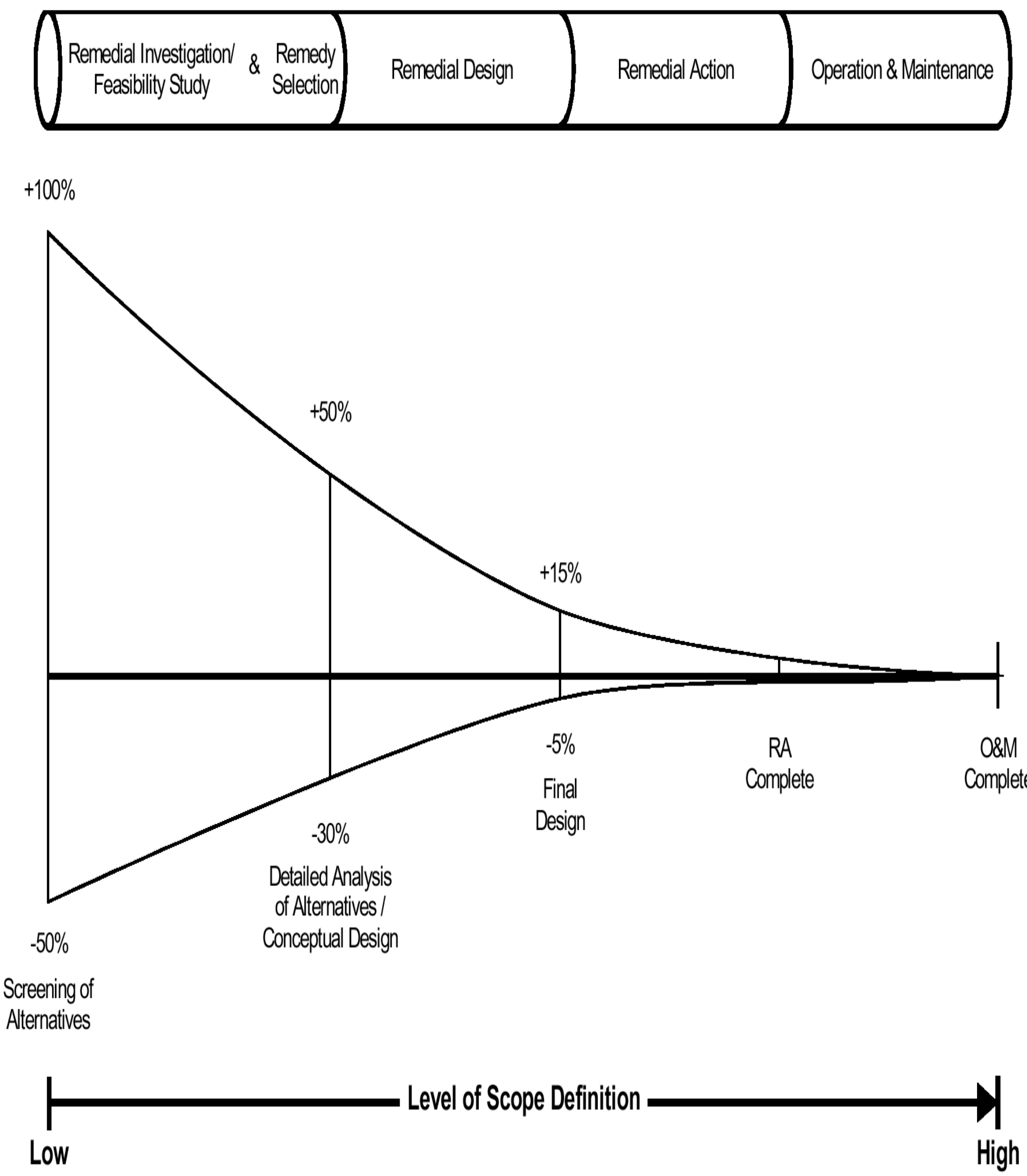

Figure 4.2. Expected cost estimate accuracy (EPA 540-R-98-045, EPA 1998).

References

Berglin, E. J., B. K. Hatchell, and J. A. Yount
Hanford Tank Initiative, Fiscal Year 1997, Retrieval Technology Demonstrations
HNF-SD-HTI-RPT-001, Revision 0,October 7 (1997) [available from Document Control Services, P. O. Box 950, Mailstop H6-08, Richland, WA 99352]

BTG Inc., Delta Research Division
Remote Handled Waste Facility (RHWF), Cost Estimate, Niceville, FL, September 1 (1999)

Dames and Moore
Resource Estimate for WMA 3 – Closure Alternative I," Calculation BUF-98-062
Revision 1.00, Orchard Park, NY, November 12 (1999)

Dames and Moore
Revised Conceptual Approach for Closure Alternative I for Waste Management Area #3
Revision 1, Job No: 30822-244/4062, Orchard Park, NY, February 23 (2000)

Evans, M. S., Brigham Young University
Issues Associated with Manipulator-Based Waste Retrieval from Hanford Underground Storage Tanks with a Preliminary Review of Commercial Concepts
WHC-SD-WM-TA-181, Westinghouse Hanford Co., Richland, WA, Rev. 0A, July (1996)

Evans, M. S.
A Review of the EMMA Manipulator System with Regard to Waste Retrieval from Hanford Underground Storage Tanks, An Independent Report
An Independent Report, February 7 (1997)

Henley, D. R. and T. J. Litka
A Survey of Commercially Available Manipulators, End-Effectors, and Delivery Systems for Reactor Decommissioning Activities
ANL/D&D/TM-95/1, Argonne National Laboratory, Argonne, IL, May (1996)

Hyde, R. A. and K .M. Croft
Cooperative Telerobotic Retrieval System Phase 1 Technology Evaluation Report
Lockheed Idaho Technologies Company, INEL-94/0231, Idaho Falls, ID, March (1995)

Jacobs Engineering Group, Inc.
Retrieval Performance Evaluation Methodology for the AX Tank Farm
DOE/RL-98-72, , Richland, WA, April (1999)

Lockheed Martin
ICPP Tank Farm Closure Study
INEEL/EXT-97-01204 , Idaho Falls, ID, February (1998)

Parsons Infrastructure and Technology Group, Inc.
Hanford Tanks Initiative, Engineering Study Refinements Report
HNF-4195, Rev. 0 (1999)

RS Means, Co.
Building Construction Cost Data 2000
58th Annual Edition, Kingston, MA (1999)

Scientech
Preliminary Closure Report on the Deactivation and Decommissioning of the Remote Handled Waste Facility
Idaho Falls, ID, February 14 (2000)

Skelly, W. A.
AX Tank Farm Tank Removal Study
SGN Eurisys Services Corporation, SESC-EN-RPT-003, Rev. 0, Richland, WA, September (1997)

Smith, R. I. et al.
Revised Analyses of Decommissioning for the Reference Boiling Water Reactor Power Station
Pacific Northwest National Laboratory, NUREG/CR-6174, PNL-9975, Richland, WA, July (1996)

Trost, V.,
In-Tank Manipulator for D&D Services
EagleTech, Solon, OH
Personal Correspondence, December 7 (1999)

U.S. Army Corp of Engineers
Engineering Manual, Engineering and Design, Roller-Compacted Concrete
Manual No. EM 1110-2-2006, Washington, D.C., February 1 (1992)

U.S. Army Corp of Engineers
Technical Instruction, Water Supply
TI 814-01, Washington, D.C., August 3 (1998)

U.S. Department of Energy
Industrial Wastewater Closure Plan for F- and H-Area High-Level Waste Tank Systems
Revision 1, Akin, SC, July 10 (1996)

U.S. Department of Energy
Cost Estimating Guide
DOE G 430.1-1, Associate Deputy Secretary for Field Management, March 28 (1997)

U.S. Department of Energy
Innovative Technology Summary Report, Oxy-Gasoline Torch
OST Reference #1847, DOE/EM-0401, Office of Environmental Management, Washington, D.C., December (1998a)

U.S. Department of Energy
Innovative Technology Summary Report, Dual Arm Work Platform Teleoperated Robotics System
OST Reference #1787, DOE/EM-0389, Office of Environmental Management, Washington, D.C., December (1998b)

U.S. Department of Energy
Decommissioning Handbook
DOE/EM-0383, Washington, D.C., January (2000)

U.S. Environmental Protection Agency
Control Techniques for Particulate Emissions from Stationary Sources – Volume 1
EPA-450/3-81-005a, Research Triangle Park, NC, September (1982)

U.S. Environmental Protection Agency
Compilation of Air Pollutant Emission Factors
AP-42, Fourth Edition, Research Triangle Park, NC, September (1985)

U.S. Environmental Protection Agency
Remedy Cost Estimating Procedures Manual: A Guide to Developing and Documenting Remedial Alternative Cost Estimates During the Feasibility Study
EPA 540-R-98-045, Final Review Draft, Washington, DC, December 4 (1998)

Washington Aggregates and Concrete Association
Suggested Specification for Controlled Density Fill
Bellevue, WA (1997)

Wentz, J. D. and G. S. Weldon
Applicability of a Cable Driven Manipulator System for Hazardous Environments
Nuclear Energy 039: 117-119 (1999)

West Valley Nuclear Services
West Valley Demonstration Project, High Level Waste Storage Area and Vitrification Facility Waste Characterization Report
WVNS-EIS-017, Revision 1, West Valley, NY, September (1995a)

West Valley Nuclear Services
West Valley Demonstration Project, High Level Waste Storage Area and Vitrification Facility Closure Engineering Evaluation
WVDP-EIS-033, Revision 0, West Valley, NY, September (1995b)

West Valley Nuclear Services
West Valley Demonstration Project, Container Management and Retrievable Storage Areas Engineering Report
WVDP-EIS-039, Revision 0, West Valley, NY, September (1995c)