The End of the Line, Preparing the Main Plant Process Building for Demolition at the West Valley Demonstration Project - 9256

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ABSTRACT
The West Valley Demonstration Project (WVDP) Act of 1980 authorized the Department of Energy to conduct a high-level radioactive waste management demonstration project at the site of the former Spent Fuel Reprocessing Plant in West Valley, New York to demonstrate solidification techniques to prepare high-level liquid waste for disposal. The reprocessing facility at this site was the only commercial NRC-licensed spent fuel reprocessing plant to have operated in the United States. The spent fuel reprocessing operations ended in 1972 and DOE's cleanup operations have been underway since 1982. High-level waste solidification was safely concluded in 2002 and follow-on activities at the site have been concentrated on facility decontamination and waste management and off-site disposal.

Among the features that remain at the WVDP site is the highly-contaminated Main Plant Process Building (MPPB). The five-story reinforced concrete structure, which was formerly used to reprocess irradiated nuclear fuel, contains residual levels of contamination in some areas that prohibit safe human entry. DOE's long-range plans for the site include demolition of the MPPB. Current site contractor, West Valley Environmental Services LLC (WVES), while actively working to dismantle equipment and decontaminate areas inside the MPPB, has developed a conceptual two-phase plan for demolishing the structure that provides a cost-effective, lower-dose alternative to conventional demolition techniques.

This paper discusses the current condition of the MPPB and the demolition-ready preparations conducted in the facility thus far. This paper also introduces the concept of a two-part surgical demolition plan that has been proposed and is being evaluated as a safe method of demolishing the structure. The practical applications that support feasibility for the demolition approach are being demonstrated through current work applications in the MPPB.

INTRODUCTION
The demolition of the Main Plant Process Building (MPPB) at the West Valley Demonstration Project (WVDP) presents a first-of-a-kind challenge. With a total inventory of about 6.66E+14 Bq (18,000 curies), the MPPB contains 2.22E+14 Bq (6,000 curies) of Cesium-137, a gamma radiation emitter, distributed throughout the plant. As the only commercial spent fuel reprocessing facility to have operated in the U.S., the MPPB demolition is without precedence for demolition of a gamma-contaminated non-reactor facility. Traditionally, DOE sites have used a three-step demolition approach, as further described below, where contact-handled decontamination operations could be performed effectively at a reasonable cost prior to facility demolition.

The MPPB at West Valley is a uniquely complex structure in terms of configuration and extent of contamination. The characteristics of the MPPB make the success of using a traditional approach to demolition at West Valley unlikely. The 1960-vintage facility is comprised of a labyrinth of interconnected steel reinforced concrete walls, ceilings and foundations ranging from .9 meters (36 inches) to 1.8 meters (69 inches) thick that was largely designed for "hands-on" maintenance. It lacks access to many enclosed cells, and lacks material handling and infrastructure capabilities for cost-effective remote operations in many areas. Extensive Cs-137 contamination from spent nuclear fuel reprocessing provides substantial gamma radiation in a number of closed-cell areas, requiring semi-remote and remote management. Substantive inventories of alpha-producing long-lived transuranic elements provide additional operational and waste management complications.

In addition to the employee safety concerns posed by demolition of the MPPB structure, maintaining public safety and minimizing release of radioactive contamination is a paramount concern during demolition planning. With the nearest off-site resident located just 1.3 kilometers (0.8 miles) from the MPPB, the WVDP does not have the benefit of a large controlled area to serve as a radiological buffer. Demolition of the MPPB will clearly be a first-of-a-kind effort.

Existing Condition of MPPB

While extensive equipment removal and decontamination has been conducted in select areas of the MPPB, a number of areas still contain original process equipment and high levels of contamination from irradiated fuel reprocessing. Historical equipment removal activities and decontamination has been directed by the need to reuse some areas of the MPPB and by dose reduction priorities. As such, the work has been tedious and has necessitated worker exposure to conduct hands-on activities where remote capabilities are not present.

Thus far, the decontamination techniques employed at the WVDP have been limited to a traditional approach: gutting vessels and piping followed by surface decontamination. With a few minor exceptions necessary to gain access into specific areas, the inner walls and the outer shell of the structure remain in tact.

The MPPB's original ventilation system, which consists of a single main stack High-Efficiency Particulate Air (HEPA) filtration system and a double HEPA filter system servicing the "Head End" cells area of the plant, is permitted and remains in operation. Current site activities include preparing the MPPB for eventual demolition and preparing a demolition plan for its removal. To that end, vessel and equipment removal and dose reduction activities are ongoing in multiple areas of the structure and a draft demolition plan has been developed.

Considerations and Challenges Associated with MPPB Demolition

Overall, there are approximately 6,000 curies of Cs-137 inside the MPPB that have the potential of contributing to public dose during the structure's decontamination and demolition. Two cells, the Process Mechanical Cell and the General Purpose Cell, contribute nearly 50% of the potential airborne radiological dose from the MPPB. One process vessel in Extraction Cell -1 contains approximately one-half of the total dose resulting from vessels inside the MPPB. Due to high dose levels and the inaccessibility of those areas, equipment removal and dose reduction using a traditional approach to decontamination and demolition would be costly, time consuming, and expend considerable worker dose. Several additional areas are similar in configuration.

Embedded process piping, the large number of limited-access cells, and high contamination levels make equipment removal prior to interior wall removal extremely challenging. The WVDP's experience with equipment dismantlement and decontamination activities has thus far proven to be tedious and have limited success in achieving overall dose reduction. In terms of site-wide dose contributors, MPPB activities are the most significant contributors to the workforce's overall cumulative dose.

Estimated airborne contamination releases during demolition of the MPPB were calculated using site-specific computer-based modeling (CAP88-PC) assessments. Using this technique to estimate the potential dose to the Maximally Exposed Off-Site Individual (MEOSI) during structure demolition, it was concluded that substantial preventative measures would be required to minimize public dose using the traditional three-part demolition process that mobilizes contamination at the ground level. Conversely, using demolition techniques that minimize airborne contaminant mobilization and utilize the existing HEPA filter vetilation system would result in a MEOSI dose that is less than the maximally allowed

Environmental Protection Agency (EPA) National Emission Standards for Hazardous Air Pollutants (NESHAP) maximum of 100 µSv (10 mrem) per year.

In considering alternatives for preparing for and actual demolition of the West Valley MPPB, the WVDP looked to past DOE experiences with contaminated structure demolition, including the Hanford site's Building 233-S. This project provides some insight into the decontamination and demolition of a contaminated reinforced concrete structure, including the efficacy of performing surface decontamination using conventional techniques. Despite multiple attempts to decontaminate the facility prior to demolition, surgical demolition techniques were partially employed by default. While this experience is useful for comparison, it should be noted that the West Valley MPPB differs from past DOE experiences in two fundamental ways: The high levels of gamma-emitting radiation present in the MPPB will require a significant portion of the demolition and decontamination be conducted by remote means, and the close proximity of the plant to areas inhabited by the public require substantial planning and engineering efforts be employed to protect the safety of off-site residents. Based on the levels of contamination that exist in the MPPB, conventional decontamination techniques are expected to be more difficult to employ and less effective than past DOE experiences.

The Need for Optimizing a Demolition Approach

The desire to achieve MPPB demolition remains, therefore, a plan was sought that would be technically feasible, cost-effective, and result in achieving safe demolition while incurring the lowest possible dose to the public and workers.

Public dose is determined by the type and extent of air emissions during the demolition activity. Worker safety is measured by dose exposures received when preparing the structure for demolition and during the actual demolition itself, as well as, industrial hazards associated with either phase of the work. Finally, overall cost effectiveness is determined by evaluating the life cycle costs associated with building preparations, building dismantlement and waste management, including packaging, transportation and disposal. Using these considerations, various demolition approaches were evaluated with the best possible option being identified for the MPPB. These considerations — public and worker safety, cost-effectiveness, technical feasibility — are further discussed below, as well as some site-specific activities that support the feasibility of a unique demolition method at West Valley.

Conventional (Three-Step) Demolition Approach

One way of measuring worker safety is through the life-cycle dose estimated for the job. The traditional 3-step demolition approach consists of the following steps:

Step 1: Removal of equipment, vessels and piping
Step 2: Surface decontamination of walls, floors and ceilings
Step 3: Open air demolition of the building

Each of these steps represents worker dose and can be quantified through dose estimation. For purposes of this evaluation, however, a more intuitive analysis was conducted to establish a preferable demolition approach. Although the traditional three-step approach has been successfully used for removal of contaminated facilities at several DOE sites, the radiological conditions of the MPPB make it highly unlikely that Steps 1 and 2 can achieve an end state suitable for a "clean" open air demolition at a reasonable cost.

A contributor to the total anticipated worker dose is the number of decontamination passes required: the longer the decontamination takes the more dose the workers will receive. Even after considerable effort is placed on decontaminating the building, the demolition will still require controllable "surgical" (i.e., such as diamond saw or diamond wire saw cutting) demolition, therefore, much of the costs and worker dose incurred in Steps 1 and 2 are unnecessary and avoidable.

It is noted that the traditional three-step approach to demolition requires that the three steps be completed in sequence to accomplish the overall demolition objective for the use of unconfined, macro, aggressive demolition techniques. It should also be noted that in many areas the MPPB was designed as a hands-on facility and therefore it does not have remote or semi-remote tooling installation or removal, remote material handling infrastructure, access and material flow paths that would simplify equipment removal. This then would require additional effort to implement such capabilities.

Additionally, there are two theoretical options for implementing the traditional three-step demolition approach for the MPPB:

- Extensive source term removal in Steps 1 and 2 so that the Step 3 demolition is not constrained by the 100 μSv (10 mrem) per year MEOSI dose limit. This would constitute a long and costly decontamination phase followed by a short and less costly demolition phase. This option would result in higher worker exposure rates.
- Execute Steps 1 and 2 on a reasonable cost, short schedule, best-effort basis followed by a traditional demolition approach with the schedule driven by the 100 μSv (10 mrem) per year MEOSI dose limitation. Thus, if the calculated MEOSI dose during demolition is 0.20 kSv (200 mrem), (determined as a function of the results of the best-effort decontamination), a 20-year demolition schedule would be planned.

Two-Stage Inside-Out Demolition Approach

An Inside-Out Demolition option uses a two-phase approach that does not require surface decontamination (i.e., eliminates Step 2 of the traditional three-step demolition approach) and combines Steps 1 and 3. A critical consequence of eliminating Step 2 (surface decontamination) is that it allows flexibility in the timing of Step 1 (equipment, vessels and piping removal) since it is no longer required to occur first. Unlike the traditional three-step approach to demolition, this approach can take full advantage of combining Steps 1 and 3 since activities can be completed in parallel rather than in sequence. This has the added benefit of eliminating repetitive set up and demobilization activities in work areas.

Major preparatory activities necessary to prepare the MPPB for an Inside-Out Demolition approach would include the following:

- Drain liquids from vessels and piping and/or grout vessel bottoms
- Vacuum floors and walls using single or double HEPA filter Portable Ventilation Units (PVUs) which exhaust inside the MPPB through the MPPB HEPA ventilation stack release
- Spray fixatives on all contaminated walls and ceilings
- Spray fixatives on or grout all contaminated floors
- Spray fixative on all external surfaces of equipment, vessels, piping, etc. located inside contaminated cells
- Fix MPPB ventilation-related leaks
- Address MPPB ventilation systems filter change outs, repairs and/or upgrades

Public Safety

The allowable Airborne Contamination Release (ACR) during demolition depends on radionuclide constituent inventory, distance of the MEOSI from the point of release, and the height of the release. At West Valley, the MEOSI dose is dominated by a small percentage of long-lived radionuclides that comprise only 6% of the inventory but account for 86% of the MEOSI dose. In determining methods of minimizing public dose during structure demolition, a combination of maximizing the defense-in-depth of multiple engineering controls, maintaining the ventilation boundary containment while using the HEPA filter ventilation capture integrity to the fullest extent and utilizing the stack release point while maximizing the practical removal of the radiological inventory from within that boundary containment offer the best off-site contamination control options.

Preliminary modeling for the demolition project using the existing MPPB radionuclide inventory indicated that in order to stay below the 100 μSv/year (10 mrem/year) regulatory threshold without limiting the schedule for the demolition, air emission controls for the demolition of the MPPB had to include HEPA filtration and fixed surface contamination at a minimum. Of most significance, this MEOSI analysis demonstrated that with the application of existing controls none of the radionuclide inventory had to be removed before demolition could begin. See Table I.

Table I. Preliminary CAP88 Modeling of the Demolition of the MPPB

CASE DESCRIPTION	TOTAL MEOSI DOSE (SIEVERT)
Inside Demolition: Stack Release	1.0 (.4 mrem)
Outside Demolition: Ground Release	$7.8000{*}10^{-05}$ (7.8 mrem)
Total Dose from Demolition	$8.2000{*}10^{-05}$ (8.2 mrem)

Worker Safety

Based on existing conditions in the MPPB and the existing infrastructure inside the facility, worker safety can be enhanced by employing an Inside-Out Demolition plan for the MPPB. Worker safety is enhanced by using this method instead of conventional demolition by the reduction or elimination of the extensive hands-on radiological work that would be required by utilizing conventional demolition techniques. In addition to reduced radiological exposure rates, exposure to industrial hazards are expected to be fewer due to the reduced amount of time required to complete demolition using this method of demolition.

Cost Effectiveness

The third factor considered in the selection of a demolition approach is cost effectiveness. Cost effectiveness is defined in terms of life cycle costs associated with the decontamination and demolition phase of the project.

Removal Cost = Cost of removal of equipment, vessels and piping (Step 1)
+ Cost of surface decontamination (Step 2)
+ Cost of demolition (Step 3)

In both cases (three-step versus two step demolition), from a total Project life cycle cost point-of-view, the “hotel” load or annual site operating costs would have to be added to the direct demolition scope execution costs for establishing Project budget needs. Both these options are technically feasible, but both are not cost effective. In both options, surgical removal of the structure would still be required.

Selection of an Optimal Demolition Approach

Considering each of the three criteria, it was determined that an optimal option for the MPPB is an inside-out demolition approach based on improved worker safety and overall cost effectiveness. It appears that public safety could be achieved using any approach, however, ensuring public safety while using conventional demolition techniques would result in significant additional life-cycle costs. The Inside-Out option combines innovation and feasibility in an approach for this first-of-a-kind challenge, incorporating MEOSI dose minimization principles.

“Inside–Out” Demolition

Considering all factors for conventional versus two-part Inside-Out demolition, pursuing the surgical demolition method parallel with equipment removal and contamination demobilization offers the best alternative for demolishing the West Valley MPPB.

Inside Phase of Demolition

The MPPB has operational HEPA filter systems tied to a ventilation stack under a NESHAP permit. The “inside-out” demolition strategy takes advantage of this existing capability by carrying out the MPPB demolition in two distinct Phases.

During the Inside Phase of the Inside-Out Demolition, the MPPB containment and ventilation systems are maintained intact and operational. Release of airborne contamination generated during the Inside Phase demolition activities must pass through the MPPB’s HEPA filters (two major HEPA filter ventilation systems exist with capture efficiencies greater than 100:1 and 10,000:1 respectively). During the Inside Phase, extensive contaminated internal wall sections are removed concurrent with residual equipment removal. Removal is accomplished through controllable “surgical” slab cutting operations on the internal walls, such as pictured in Figure 1. Cutting techniques such as diamond wire saw, diamond saw and equivalent are used (without permanently breaching the outer ventilation containment shell) to minimize cut airborne contamination generation; local containment and HEPA filtration are used to capture a large portion of the airborne contamination.

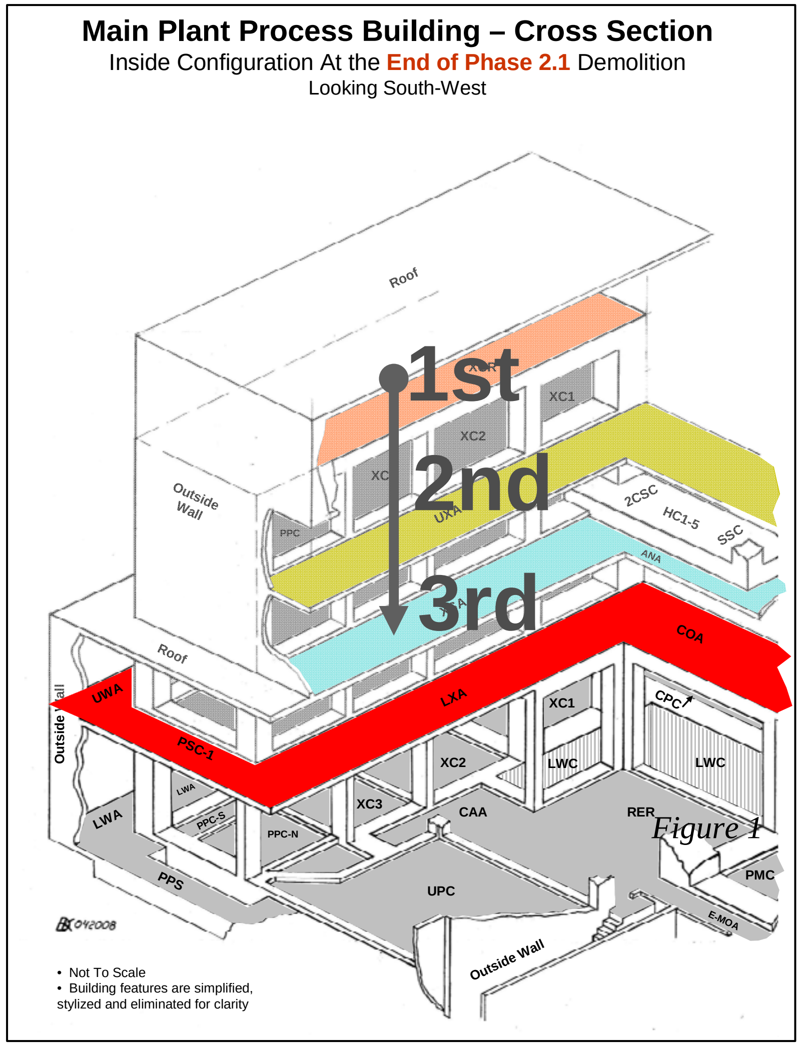


Figure 1

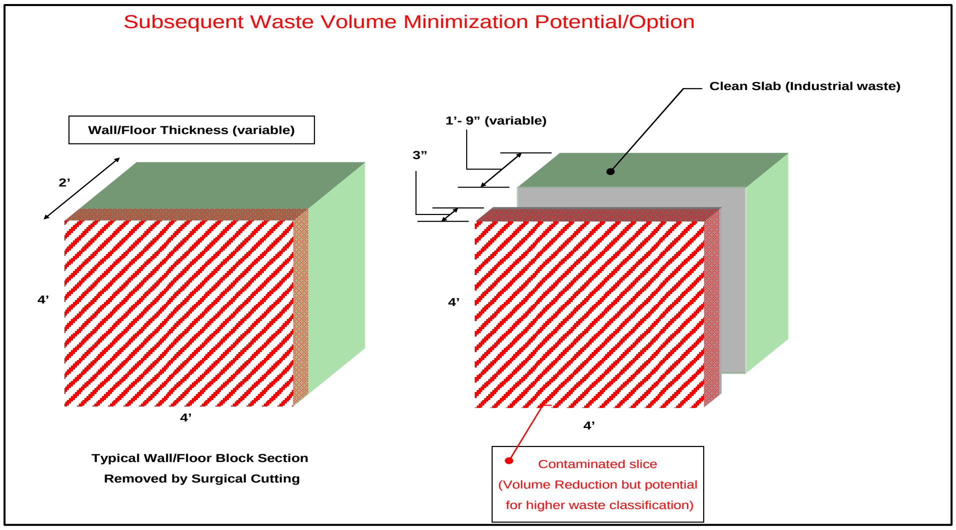
Removal of Equipment, Vessels and Piping

In parallel with the wall section removal, residual contaminated equipment, vessels and piping are also removed during the Inside Phase of the Inside-Out Demolition. This parallel removal of walls and equipment, vessels and piping is enabled because the Inside-Out Demolition Plan does not require any prior surface decontamination (e.g., scabbling, scarifying, pressure spray) of walls, floors, and ceilings. In fact the MEOSI dose is minimized in the Inside-Out Demolition by avoiding surface decontamination. The contamination is left in place and fixed to the surface, thus minimizing the generation of airborne contamination during demolition.

Floor slab cutting and removals are generally deferred to the Outside Phase of the Inside-Out Demolition. However, depending on the logistics for equipment and material handling considerations along with worker safety considerations, there is the option of addressing selected floor sections during the Inside Demolition.

Outside Phase of Demolition

The Outside Phase of the Inside-Out Demolition is carried out under a new or modified EPA permit and is considered a ground level diffuse source release. The allowable MEOSI Dose of 100 µSv (10 mrem) per year may be applicable cumulatively to the Inside Phase and the Outside Phase (e.g., if each took a year to accomplish, each would be limited to 100 µSv (10 mrem) MEOSI dose).



Demolition of the MPPB shell (and remaining internal structures) requiring and resulting in breach of containment will be carried out after the existing MPPB ventilation systems have been shut off. Extensive use of local containment tents and single or double HEPA filtered portable ventilation units (PVUs) is anticipated during the majority of activities for the Outside Phase of the Inside-Out Demolition. Similar to a traditional 3-step demolition approach, the overwhelming majority of residual equipment is not present at this time, having been removed during the Inside Phase of the Inside-Out Demolition or before. Unlike a traditional 3-step approach, substantive portions of the contaminated internal building structure have already been removed during the Inside Phase of the Inside-Out Demolition reducing the overall scope of the shell demolition.

Public Safety Assurance and CAP88-PC Modeling Results

CAP-88-PC modeling of the Inside-Out Demolition combines inventory, demolition technique and control factors for estimating the MEOSI dose. The CAP88-PC analysis conservatively assumed a .6 meter by 1.2 meter (2 foot by 4 foot) block to ensure that the calculation included a conservative contamination release contribution from cutting, i.e., larger blocks would have smaller contributions. The model for the Outside Phase of the Inside-Out Demolition used 166 wall and floor “elements” depending on location within the MPPB and physical characteristics (e.g. wall or floor thickness) with a Becquerel (curie) inventory assigned to each element for a more detailed and accurate representation of the contamination in the MPPB.

- The results demonstrate that the NESHAP limit of 100 µSv (10 mrem) per year maximum MEOSI dose can be met with this option with the inside phase being less than 1.0 Sv (1 mrem) and the Outside Phase MEOSI dose estimated at 80 µSv (8 mrem). These results demonstrate the public safety is assured.
- Public safety can be assured using either the three-step traditional approach or the Inside-Out Demolition approach, the differentiator being schedule and cost. The three-step approach is expected to take significantly longer and cost significantly more.

It was also determined that the schedule for the Inside-Out Demolition would not be driven by the 100 µSv (10 mrem) per year MEOSI dose constraint and the rate at which the work is physically accomplished.

Waste Management Options

The controllable "surgical" slab cutting approach for the walls, floors and ceilings such as diamond wire saw cutting or equivalent provides significant flexibility in options for managing subsequent waste disposal, taking into account receiver site availabilities and waste classifications and minimizing the volumes of orphan wastes. This is expected to be a critical cost component since transportation and disposal costs are expected to be a dominant fraction of the total project cost making waste minimization (i.e., both volume and weight) important.

Based on data obtained during decontamination of the MPPB's Chemical Process Cell, it is expected that the maximum contamination penetration for painted walls will generally be less than 3 inches. It is anticipated that for some of the unlined floors, the contamination penetration may be higher based on chemical facilitators. Alternately, metal-lined surfaces are generally expected to have minimal penetration of contamination past the metal liner. Depending on overall wall thickness, slab sections would be cut from walls using controllable demolition techniques (such as diamond wire saw) leaving behind residual structural support pillars (during the inside demolition phase) to maintain building integrity. It is assumed that if the contaminated face is sliced off such a removed slab, the remaining concrete will be uncontaminated and could be classified as industrial waste or very low level waste, offering an opportunity for reducing radiological waste volume and disposal cost. See Figure 2.

Figure 2

The implementation of such waste volume reduction is expected to consider the waste disposal and shipping options available at the time of generation. For example, if an as-removed slab were TRU waste, slicing off 8 cm (3 inches) from the contaminated face would maintain the TRU classification but greatly reduce the volume, thereby minimizing the residual quantity of TRU waste to be managed. If an as-removed slab were Class A low level waste, similar slicing could yield a Class C waste form, maintaining a low level waste designation but greatly reducing the volume. If a Class C designation were not advantageous, the slab could be left alone and the disadvantageous situation avoided. In this way, flexibility in future waste management decision-making is maximized.

Cost Effectiveness

The cost effectiveness of the Inside-Out Demolition is highlighted through the following elements:

- Elimination of extensive surface decontamination operations represents significant potential cost savings in comparison to the traditional three-step demolition approach, in addition to reduced worker and MEOSI (public) dose. A best effort life cycle cost comparison shows the Inside-Out Demolition approach is more cost effective than the traditional three-step demolition approach.
- Removal of equipment, vessels and piping in parallel with the Inside Phase of the Inside-Out Demolition is reasonably expected to be more cost effective (with higher worker productivity) due to better access and the potential for removing vessels as a whole or with minimum size reduction using demolition tooling instead of hands-on people.
- The waste management flexibility (for both waste volume and classification) inherent in the slab cutting and removal approach for walls and floors allows for disposal cost optimization decision-making at the time that the waste is generated taking into account receiver site options available to DOE at the time.

Recent Applications at the WVDP

West Valley continues to remove equipment, vessels and other material from the MPPB as part of the current contract. This equipment removal has required that large scale access be made in some areas of the plant. Figures 3 and 4 show a recent wall removal from the Product Purification

Figure 3

Cell (PPC) wall using a large 1.8 meter (72 inch) diameter wall saw. The large diameter saw was effective at cutting the .6 meter (25 inch) by 1 meter (42 inch) blocks weighing 1 metric ton (2300 lbs), from the wall. This cutting was limited to the non-contaminated portion of the wall. Once the clean blocks were removed, a containment tent was constructed to allow the breakthrough to the contaminated side of the cell. This block cutting technique is expected to directly apply to the inside phase of the Inside-Out Demolition approach.

SUMMARY AND CONCLUSIONS

The Inside-Out Demolition proposal for the MPPB is a safe, economical and cost-effective approach that embodies key physical principles that minimize MEOSI dose and therefore maximize public safety. The option also has residual contamination fixed in place, reduced dose through the use of selected floor and vessel grouting, and equipment and wall slab concurrent removals including the use of machines instead of people to maximize worker safety. A separate life-cycle cost comparison demonstrates that the Inside-Out Demolition is less costly than a traditional 3-step demolition approach establishing it as cost effective and economic. Equipment and wall slab concurrent removals and the ability to reduce waste volumes are expected to further enhance the cost effective and economic nature of this option. The Inside-Out Demolition is demonstrably (through modeling) feasible and practical using standard industry techniques and technology.

Figure 4

The Inside-Out Demolition allows DOE considerable waste management flexibility (waste volume and classification) inherent in the slab cutting and removal approach for walls, floors and ceilings for waste disposal cost optimization decision-making when the waste is generated taking into account receiver site options available to DOE at the time.

There is no supporting documentation to indicate that cost-effective decontamination of gamma radiation contaminated surfaces such as those in the MPPB can be achieved. It is concluded that the traditional approaches that have relied on contact-handled decontamination operations (as precedents) for reducing the residual contamination inventory prior to demolition will not be practical or cost effective for demolition of the MPPB. As such, it is further concluded that the Inside-Out Demolition approach will be not only cost effective but also the only feasible practical approach for MPPB Demolition.

The Inside-Out Demolition approach overcomes the high technical, cost and schedule risks associated with achieving high cleanliness objectives for the traditional 3-step demolition approach. It does this with an innovative and feasible approach having a high technical confidence of achievement while accommodating the unique conditions of West Valley's MPPB (e.g., Cs-137 inventory, high dose factor radionuclides, penetrated contamination, hands-on limited access design, nearby residents, tower cells with thick reinforced concrete walls, floors and ceilings, existing permitted stack and HEPA filtered release) by controlling sequence and using available engineering controls to achieve "defense-in-depth" for the demolition activity.

While still in its conceptual phase, the WVDP is actively considering this approach as the most viable option available for MPPB demolition. Planning for additional studies to verify structural integrity using this demolition method and studies to determine demolition-ready radiological conditions inside the facility are underway.