

*ISO-2 Project WIPP Independent Oversight – DE-AC30-06EW03005*

# **EFFICIENT AND EFFECTIVE DISPOSAL OF TRANSURANIC WASTE AT THE WASTE ISOLATION PILOT PLANT**

**February 2009**



**PECOS MANAGEMENT SERVICES, INC.**

**ISO-2 Project  
Carlsbad, NM**

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## ACRONYMS

<b>C&amp;C</b>	Consultation and Cooperation Agreement
<b>CH</b>	Contact handled
<b>DOE</b>	Department of Energy
<b>EPA</b>	Environmental Protection Agency
<b>FY</b>	Fiscal Year
<b>HERE</b>	Horizontal emplacement and retrieval equipment
<b>HWFP</b>	Hazardous Waste Facility Permit
<b>LWA</b>	Land Withdrawal Act
<b>mrem/hr</b>	Millirems per hour
<b>NMED</b>	New Mexico Environment Department
<b>NRC</b>	Nuclear Regulatory Commission
<b>PECOS</b>	PECOS Management Services, Inc.
<b>RH</b>	Remote handled
<b>TRU</b>	Transuranic
<b>WIPP</b>	Waste Isolation Pilot Plant
<b>WTS</b>	Washington TRU Solutions

# Efficient and Effective Disposal of Transuranic Waste at the Waste Isolation Pilot Plant

February 2009

## I. SCOPE AND PURPOSE

The scope of this report covers activities associated with operations at the Waste Isolation Pilot Plant (WIPP) related to staging contact handled (CH) and remote handled (RH) transuranic (TRU) waste containers for shipment to the WIPP and the subsequent disposal of those containers in the repository. The authors of this report recognize the fact that the requirement for regulatory change must be in place before any substantial change in current plans and procedures can be implemented; and this report does not address the specifics of those changes. The volumes of TRU wastes estimated to be emplaced in WIPP used in the analyses in this report are as of December 31, 2006 with no consideration to updates or additions.

The purpose of this report is to provide an analysis of current packaging, transportation, and disposal operations and to determine how effectively and efficiently these operations will emplace the projected TRU waste inventory. This report also addresses the impact of possible operational changes designed to make the best use of WIPP. It also examines potential health and safety issues associated with proposed or possible changes to current disposal operations.

## II. BACKGROUND

The National Academy of Sciences and others performed studies in the 1950s that determined the safest way to permanently store TRU waste was disposal in a deep, geologic repository. As a result of this conclusion, the Department of Energy (DOE) and its predecessor agencies conducted extensive technical and environmental studies, which identified ancient salt beds as appropriate geologic formations for TRU waste disposal. Eventually, the salt beds located near Carlsbad, New Mexico were selected as the most suitable location for a disposal site, and initial site design validation studies were initiated. Based on those studies, the Land Withdrawal Act (LWA),<sup>1</sup> which allowed DOE to operate WIPP, was passed in 1992. WIPP was opened in 1999.

There are four major components associated with TRU waste disposal at WIPP: packaging (including treatment and repackaging), characterization, transportation, and emplacement. Appropriate agencies have created regulations for each component, and in accordance with those regulations, plans and

procedures have been established by or under the direction of DOE in order to properly implement activities associated with each of the above four components. DOE's ultimate objective is to emplace in WIPP all legacy and existing defense-related TRU waste as well as an additional amount generated during the operational life of WIPP as allowed by LWA limits.

The LWA not only authorized DOE to open and operate WIPP for permanent TRU waste disposal; it also established a TRU waste design capacity of not more than 175,564 m<sup>3</sup>, of which, only 7,079 m<sup>3</sup> could be RH TRU waste per the 1988 Consultation and Cooperation (C&C) Agreement<sup>2</sup> between DOE and the state of New Mexico. Therefore, the difference between the total TRU waste design capacity of WIPP and the RH TRU waste limit establishes a CH TRU waste design objective of 168,485 m<sup>3</sup>.

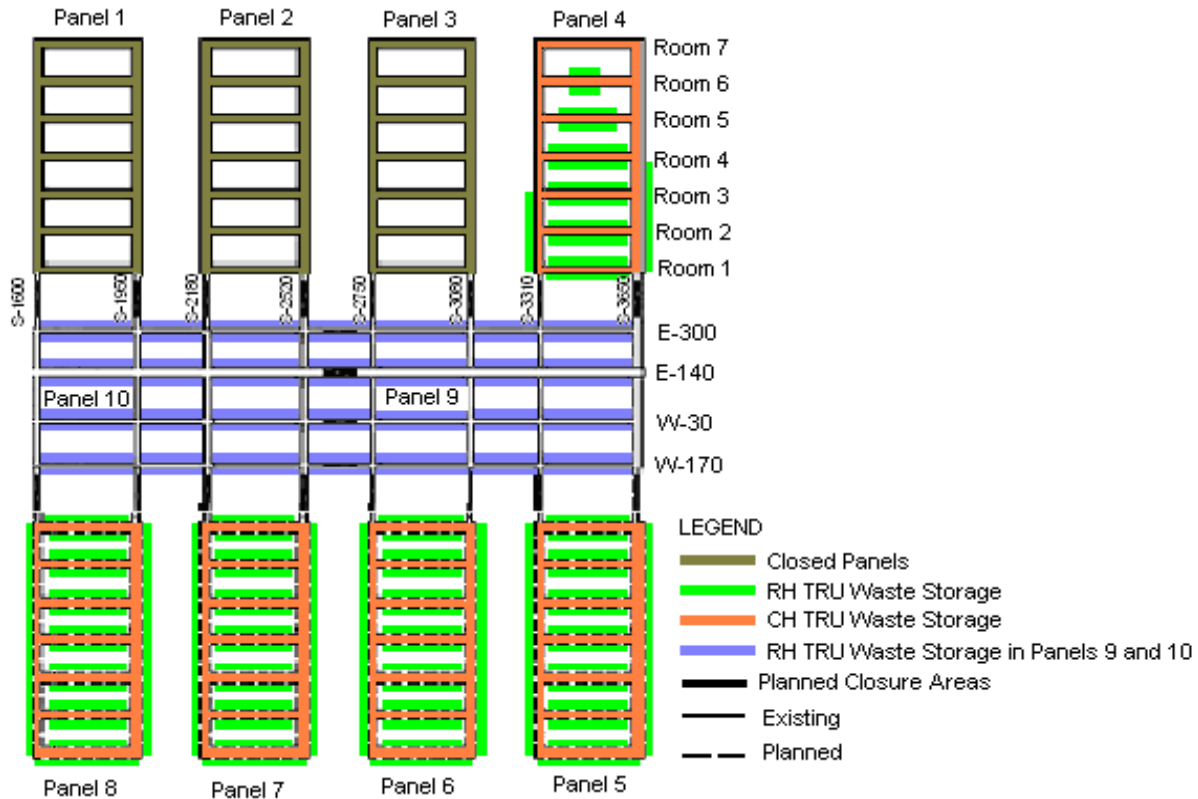
### **III. SUMMARY OF FINDINGS**

As shown in *Figure 1* on the following page, the disposal area at WIPP is laid out with eight panels branching off of the main waste handling access drifts. Panels 9 and 10 will be composed of the four main drifts (E-300, E-140, W-30 and W-170) and the crosscut drifts (S-1600 through S-3650) running through them. Waste is typically emplaced in a panel starting from the back (Room 7), with RH TRU waste entombed in boreholes before CH TRU waste is placed on the floor.

According to the Final Supplemental Environmental Impact Statement<sup>3</sup> (FSEIS), the original WIPP design assumed that Panels 1 through 8 would accommodate 133,600 m<sup>3</sup> of CH TRU waste (16,700 m<sup>3</sup> per panel) and 5,200 m<sup>3</sup> of RH TRU waste (650 m<sup>3</sup> per panel), relegating the remaining 34,885 m<sup>3</sup> of CH TRU waste and 1,879 m<sup>3</sup> of RH TRU waste to Panels 9 and 10. In contrast, the Hazardous Waste Facility Permit (HWFP)<sup>4</sup> shows the maximum allowed capacity of CH TRU waste as 18,000 m<sup>3</sup> in Panels 1 and 2 and 18,750 m<sup>3</sup> in Panels 3 through 7 (total of 129,750 m<sup>3</sup>). However, the amount of CH TRU waste actually emplaced in Panels 1 through 3 is 45,590 m<sup>3</sup>, which is 4,510 m<sup>3</sup> less than the FSEIS estimate and 9,160 m<sup>3</sup> less than the maximum permitted capacity.

Furthermore, the WIPP did not receive approval from the New Mexico Environment Department (NMED) for RH TRU waste disposal until November 2006, through a modification to the current HWFP. By that time, Panels 1 and 2 had already been closed,<sup>5</sup> and Panel 3 was almost full.<sup>6</sup> The 2006 HWFP modification limited the amount of RH TRU waste to be disposed to 356 m<sup>3</sup> in Panel 4; 445 m<sup>3</sup> in Panel 5; 534 m<sup>3</sup> in Panel 6; and 650 m<sup>3</sup> in Panel 7, for a total of 1,985 m<sup>3</sup> of RH TRU waste. The 2006 HWFP modification also authorized DOE to request that an increase in the permitted disposal capacity in Panels

5 and 6 to 650 m<sup>3</sup> of RH TRU waste each, which would increase the permitted RH TRU waste disposal capacity in Panels 4 through 7 to 2,306 m<sup>3</sup>.



**Figure 1: WIPP Underground Waste Disposal Area (PECOS Management Services)**

Currently, the only capacity-related modification DOE is including in the HWFP Renewal Application<sup>7</sup> to be submitted in May 2009 is to allow TRU waste disposal in Panel 8 of 18,750 m<sup>3</sup> of CH TRU waste and 650 m<sup>3</sup> of RH TRU waste. While the volume of CH TRU waste being disposed in Panel 4 appears to be equal to the permitted volume (18,750 m<sup>3</sup>), current operational reports indicate that less than the permitted quantity of RH TRU waste will be emplaced in Panel 4. Specifically, only 297 boreholes have been drilled in Panel 4 which is 47 percent of the permitted number. Moreover, the disposal sequence of RH and CH TRU waste has resulted in filling only 186 out of 272 boreholes to date. Assuming this rate will continue for the remaining 25 boreholes in Room 1, the estimated volume of RH TRU waste that will be disposed in Panel 4 is only about 175 m<sup>3</sup>, which is less than half of the permitted volume for that panel. In effect, this decreases the total amount of RH TRU waste that can possibly be disposed in Panels

4 through 8 from 2,635 m<sup>3</sup> to 2,454 m<sup>3</sup> or less under current and anticipated HWFP limits and increases the volume of RH TRU waste that will have to be disposed in Panels 9 and 10.

Adding the *actual* CH TRU waste disposal volume emplaced in Panels 1, 2, and 3, the RH TRU waste disposal volume estimated to be emplaced in Panel 4, and the volume that can be disposed in Panels 4 through 8 (Panels 5 through 8 for RH TRU waste) under the current and anticipated renewed HWFP, the total disposed volume of TRU waste would be only 141,800 m<sup>3</sup> (139,340 m<sup>3</sup> of CH TRU waste and 2,454 m<sup>3</sup> of RH TRU waste). Consequently, Panels 9 and 10 would have to accommodate at least 29,145 m<sup>3</sup> of CH TRU waste and 4,625 m<sup>3</sup> of RH TRU waste in order to attain the maximum capacity designated in the LWA and C&C Agreement. Alternately, DOE could request a modification to the HWFP that would allow a 25 percent increase in the capacity of CH TRU waste permitted to be disposed in Panels 6, 7, and 8. That would reduce the amount of CH TRU waste required to be disposed in Panels 9 and 10 to approximately 15,100 m<sup>3</sup>. Comparably, if DOE were to request and make full use of the allowed increase in RH TRU waste disposal capacity in Panels 5 and 6, thereby increasing the actually emplaced plus permitted capacity for RH TRU waste disposal to 2,775 m<sup>3</sup>, the amount of RH TRU waste to be emplaced in Panels 9 and 10 would be reduced to 4,304 m<sup>3</sup>.

While the LWA and the C&C Agreement establish the maximum allowable repository volume for total TRU waste and RH TRU waste disposal, the critical factor in evaluating the effectiveness and efficiency of emplacement is DOE's TRU waste disposal forecast. The 2007 Waste Inventory Report – 2007, Revision 1<sup>8</sup> (Waste Inventory) estimates there is 149,000 m<sup>3</sup> of CH TRU waste currently stored at generator sites, emplaced at WIPP, and projected for future creation. The 2007 Inventory also identifies an additional 25,900 m<sup>3</sup> of CH TRU waste in waste streams and sources potentially destined for disposal at WIPP that have yet to be approved for shipment to WIPP. If added to 149,000 m<sup>3</sup>, the resulting total CH TRU waste volume would be 174,900 m<sup>3</sup>. While this estimate is less than the WIPP limit of 175,564 m<sup>3</sup>, the amount of RH TRU waste also slated for emplacement prevents full disposal of this CH TRU waste volume.

For RH TRU waste, the 2007 Inventory shows an anticipated volume of 3,370 m<sup>3</sup> and a potential volume of 5,270 m<sup>3</sup>. These estimated RH TRU waste volumes are in 'final form' that is loaded in canisters for delivery to and disposal in WIPP. If all of this RH TRU waste were to be emplaced at WIPP, the total RH TRU waste volume of 8,640 m<sup>3</sup> would exceed the maximum permitted limit by 1,561 m<sup>3</sup>.

Since Panels 1 through 8 will accommodate no more than 139,340 m<sup>3</sup> of CH TRU waste under the current and anticipated renewed HWFP, and because the 2007 Inventory estimates there is 149,000 m<sup>3</sup> of CH

TRU waste to be disposed at WIPP, there must be additional disposal space for at least 9,660 m<sup>3</sup> of CH TRU waste in Panels 9 and 10 in order to accommodate the 2007 Inventory estimate; or, as previously stated, a permit modification be requested to increase the capacity of Panels 6, 7, or 8. Likewise, if 3,370 m<sup>3</sup> of RH TRU waste are to be emplaced at the WIPP, and Panels 4 through 8 can only accommodate 2,460 m<sup>3</sup> of RH TRU waste, the remaining 910 m<sup>3</sup> must be placed in Panels 9 and 10. If DOE requests and utilizes the additional 321 m<sup>3</sup> of RH TRU waste storage in Panels 5 and 6, only 589 m<sup>3</sup> would have to be emplaced in Panels 9 and 10.

Table 1 summarizes the disposition of the 2007 Inventory estimate of WIPP-bound TRU waste in Panels 1 through 8 and Panels 9 and 10 in WIPP under the current and anticipated HWFP. It also shows how much of the potential TRU waste volume presented in the 2007 Inventory would fit in Panels 9 and 10. According to the limits established by the LWA, there is ample space for both the CH and RH TRU waste already identified in the 2007 Inventory as acceptable for disposal at WIPP as long as the DOE disposes the full volume of RH TRU waste permitted for Panels 5 through 8 (no increase in permitted volume for Panels 5 and 6). In addition, about 70 percent of the potential RH TRU waste and nearly 75 percent of the potential CH TRU waste can also be accommodated. However, DOE will have to implement alternate or additional disposal approaches in order to dispose of the full volume of TRU waste authorized by the LWA.

Table 1. Comparison of TRU Waste Disposal in WIPP Panels (PECOS Management Services)

	Entire Repository	Panels 1 – 8	Panels 9 and 10			Waste That Will Not Fit in WIPP (m <sup>3</sup> )
			Maximum legally allowed (m <sup>3</sup> )	Confirmed WIPP-bound waste (m <sup>3</sup> )	Potential waste (m <sup>3</sup> )	
RH	7,079	2,454	4,625	916	5,270	1,561
CH*	168,485	139,340	29,145	9,660	25,900	6,415
<b>TOTAL</b>	<b>175,564</b>	<b>141,800</b>	<b>33,770</b>	<b>10,570</b>	<b>31,170</b>	<b>7,970</b>

\* Assuming RH TRU waste maximum is achieved.

The following sections of this report provide a review of current waste disposal operations at WIPP and present discussions regarding the use of Panels 9 and 10 under existing emplacement conditions. Various alternatives, including the use of shielded containers to manage RH TRU waste as CH TRU waste, are



examined not only as they relate to limits set by the LWA and C&C Agreement, but also from the perspective of their ability to handle the 2007 Inventory estimates of TRU waste volume. Finally, this report addresses restrictions arising from packaging, characterization, or transportation issues as they relate to the effective use of WIPP.

### **Current TRU Waste Disposal Operations at WIPP**

The packaging, characterization, and transportation components of TRU waste disposal operations control the “flow” of waste for disposition at WIPP. In particular, effective management of each component is essential for efficient coordination of CH and RH TRU waste emplacement. In order to understand the interplay among these components, it is essential to first comprehend the disposal capacity of WIPP and the emplacement capabilities inherent in the current operational structure.

The rooms in an underground waste disposal panel were designed to accommodate RH TRU waste in the walls and CH TRU waste on the floor. To accomplish this, boreholes are drilled horizontally into the walls of each room. RH TRU waste, sealed in a specially designed canister, is loaded into a borehole, which is capped in order to shield workers from exposure to radiation. Once boreholes are filled and capped, CH TRU waste is placed on the floor in front of them.

Regarding RH TRU waste disposal operations, the processes to drill and fill RH TRU waste boreholes are both labor-intensive and time-consuming. At a maximum rate of two holes per eight-hour shift, a single row of boreholes with a minimum spacing of eight feet (center-to-center) is drilled into the long sides of each room’s salt pillar and, for Panels 6 and 7, into the outside walls of the access drifts of those panels. Because current DOE operating procedures do not allow drilling and emplacement to occur simultaneously in a room, the current operating procedure is to drill all planned RH TRU waste boreholes in a room prior to disposing any RH TRU waste there. The borehole drilling equipment is then moved to the next room and the horizontal emplacement and retrieval equipment (HERE) is moved in to fill the boreholes. A single RH TRU waste canister is loaded into each borehole using the HERE through a process that requires another full, eight-hour shift. Since there is only one HERE available, disposal is limited to one RH TRU waste canister at a time. Therefore, operational constraints alone limit disposal of RH TRU waste at WIPP to a maximum of six canisters per week for a five-day workweek comprised of two eight-hour shifts per day.

By contrast, the CH TRU waste management process makes it possible to transport between four and five shipments per day to WIPP, consisting of as many as forty-two 55-gallon drums per shipment. Since waste can be stored temporarily above ground for only a short time, DOE has minimal flexibility in

delaying the disposal of CH TRU waste in order to facilitate that of RH TRU waste. Additionally, the WIPP operators have indicated that because it is too difficult and time-consuming to move the HERE back and forth between rooms and a concern about possible radiation exposure to WIPP workers if the HERE were to be used in a room where CH TRU waste had already been emplaced, RH TRU waste disposal ceases in a room once CH TRU waste starts being emplaced. As a result, the receipt and disposal of CH TRU waste has caused numerous RH TRU waste boreholes to be bypassed, as discussed with PECOS personnel in July 2008 and January 2009.

As stated in the Documented Safety Analysis,<sup>9</sup> the original design goal for WIPP was to achieve an annual disposal rate of 14,160 m<sup>3</sup> of CH TRU waste (about 50 shipping containers or 17 shipments per week) and 283 m<sup>3</sup> of RH TRU waste (equivalent to 318 canisters per year or about six shipments per week). That goal effectively balanced the delivery and disposal of CH and RH TRU waste such that no boreholes would be bypassed. However, DOE has only managed to emplace an average of approximately 6,000 m<sup>3</sup> of CH TRU waste per year and approximately 100 m<sup>3</sup> of RH TRU waste<sup>7</sup> per year (based on the number of canisters and the volume of each canister).

There is further evidence that DOE is experiencing difficulty effectively managing the concurrent disposal of CH and RH TRU waste. There has been a drop in the overall volume of TRU waste emplaced since RH TRU waste disposal operations started with initial receipt of RH TRU waste canisters on January 24, 2007.<sup>10</sup> In fiscal year (FY) 2006, about 10,556 m<sup>3</sup> of TRU waste was disposed in WIPP. Compare that to FY 2007, when the amount disposed was approximately 8,582 m<sup>3</sup>; and to FY 2008, when the amount of TRU waste disposed was about 5,600 m<sup>3</sup>, the smallest volume since FY 2001. Additionally, only 114 RH canisters were emplaced in FY 2008, the first full year of RH TRU waste disposal. This translates to an average of about 2.2 canisters per week, much less than the original design goal of six canisters per week.

The forecast<sup>11</sup> for RH TRU waste emplacement in Panel 4 presented by DOE during the January 2008 WIPP quarterly meeting, showed that 76 RH TRU waste canisters were scheduled for disposal in Room 3. On June 16, 2008, however, a review of information in the WIPP Waste Information System indicated that only 39 RH TRU waste canisters had been emplaced in Room 3, and that CH TRU waste disposal was underway in that room. The cessation of RH TRU waste emplacement in Room 3 was verified during a July 2008 site visit, when PECOS staff observed CH TRU waste being emplaced in Room 3. At that time, it was also noted that only 63 boreholes had been drilled in Room 2, indicating that DOE did not anticipate filling it to capacity. This information illustrates that CH TRU waste emplacement is

overtaking RH TRU waste disposal and will substantially reduce the amount of RH TRU waste Panels 4 through 8 can accommodate unless DOE improves production rates for shipping RH TRU waste to WIPP.

While several safety problems hampered disposal in FY 2008, the most prevalent operational issue appears to stem from difficulties DOE encountered as it attempted to integrate and coordinate CH and RH TRU waste emplacement activities. DOE's failure to achieve its RH TRU waste disposition goals appear to be caused by the failure of the generator sites to deliver the correct mix of CH and RH TRU waste coupled with the combination of equipment limitations and conservative work rules that limit the flexibility of WIPP operators to emplace RH TRU waste.

### **Capacity of Panels 9 and 10 for TRU Waste Disposal – Current Operating Plans**

According to the FSEIS, Panels 9 and 10 are composed of the four access drifts divided by 12 salt pillars, which are approximately 300 feet long by 123 feet wide, and nine salt pillars approximately 230 feet long by 123 feet wide. Two of the access drifts average 14 feet wide and two average 33 feet wide. In contrast, Draft 3 of the HWFP renewal application indicates that Panels 9 and 10 have not yet been designed. Therefore, the following discussion is based on the FSEIS description of Panels 9 and 10.

The total length of each of the four access drifts for both panels is approximately 2000 feet. The available floor area of the two panels (access drifts and cross drifts) is approximately 163,000 ft<sup>2</sup>. That floor area is approximately 1.5 times the floor area of one of Panels 1 through 8. Using the current dimensions of the access and cross drifts that would comprise Panels 9 and 10, those two panels can accommodate approximately 28,000 m<sup>3</sup> of CH TRU waste. That is insufficient capacity to accommodate the 29,145 m<sup>3</sup> of legally allowed CH TRU waste that will not fit into Panels 1 through 8.

The current operating plan for RH TRU waste disposal in Panels 9 and 10 involves drilling boreholes comparable to those in Panels 4 through 8. To accommodate the current drilling equipment, the main access drifts (E-300, E-140, W-30, W-170) must be widened by at least eight and as much as 19 feet, depending on the width of each drift. Widening the drifts can be accomplished by shaving the sides of the salt pillars between the drifts; however a pillar width of at least 100 feet would have to be maintained for stability during waste emplacement. Up to 32 boreholes, spaced eight feet on center, can be drilled into each long side of the 12 larger pillars, and up to 20 boreholes can be drilled into each long side of the nine smaller pillars. Drilling these boreholes would result in as much as 1,004 m<sup>3</sup> of RH TRU waste storage capacity. If boreholes are also drilled on the outer sides of drifts E-300 and W-170, an additional 335 m<sup>3</sup> of RH TRU waste could be disposed, resulting in a total maximum capacity of 1,339 m<sup>3</sup>. This volume is

less than the RH TRU waste design capacity for Panels 9 and 10 (1,879 m<sup>3</sup>) presented in the FSEIS and is consistent with previous DOE and Sandia National Laboratory reports including the Remote Handled Transuranic System Assessment, Remote Handled Transuranic Waste Study, and Recommended Strategy for the Disposal of Remote-Handled Transuranic Waste. Note that by widening the access drifts so the boreholes could be drilled, sufficient floor space will be added to Panels 9 and 10 to accommodate the balance of CH TRU waste legally allowed to be disposed in WIPP.

There are significant safety issues associated with modifying Panels 9 and 10 to allow borehole drilling. The main access and cross drifts that comprise Panels 9 and 10 range in age from approximately three to 15 years and have been continuously maintained with strategic roof bolting, wire mesh, and trimming to compensate for creep closure. However, drift closure averages about six inches per year<sup>12</sup> and requires trimming approximately every two years to maintain the required vertical clearance. Since the drifts are among the oldest mined sections, decreasing the size of the pillars could place additional stress on previously mined areas, thereby inducing rock falls, which could result in a significant health and safety concern. Drilling boreholes in Panels 9 and 10 would also cause additional stress to the salt pillars, though no information has been obtained as to whether this stress would create safety issues.

Clearly, using only horizontal boreholes in Panels 9 and 10 would not accommodate all of the legally allowed RH TRU waste. Moreover, safety issues associated with panel age indicate that alternative emplacement methods are required in order to achieve the maximum allowed disposal of RH TRU waste. Such options are discussed below.

### **Emplacement Options**

Alternative TRU waste emplacement approaches will help DOE accomplish disposal of the full volume of RH TRU waste allowed by the C&C Agreement in WIPP and at the same time minimize the use or modification of Panels 9 and 10. PECOS has evaluated the following alternative TRU waste emplacement approaches, which are discussed in detail in the following sections, include:

1. Use shielded containers to dispose RH TRU waste on the floor of the panels.
2. Mine and use additional rooms or panels.
3. Add additional boreholes to existing panels.
4. Emplace up to two RH TRU waste canisters in each borehole.
5. Use boreholes in panel floors to dispose of RH TRU waste.

Note that any of these alternatives would require approval by appropriate regulatory agencies. Depending upon the alternative proposed, it is expected the approval process would take from a minimum of six months to several years. As points of reference, the approval process for RH TRU waste disposal at the WIPP took over four years; and the proposal to use shielded containers has now been under review by the Environmental Protection Agency (EPA) and the Nuclear Regulatory Commission (NRC) for over one year. If approved by the EPA and NRC, the use of shielded containers in WIPP will still require NMED approval via a HWFP modification, which will take at least six more months. Therefore, the presumption that DOE will be able to implement any of the alternatives discussed below in conjunction with disposal of TRU waste in Panel 5 may be overly optimistic.

### ***1. Shielded Containers***

DOE is currently seeking approval from EPA, the U.S. Department of Transportation, and NRC to use shielded containers, which will enable RH TRU waste to be handled as CH TRU waste. The Planned Change Request submitted to EPA<sup>13</sup> states that shielded containers are constructed with one-inch-thick lead shielding sandwiched between a double-walled steel shell with a three-inch thick steel lid and base. These containers are designed to hold RH TRU waste in such a way that the resulting dose rate on the outer container surface is less than 200 millirems per hour (mrem/hr). In effect, this alternative allows RH TRU waste in shielded containers to be managed as CH TRU waste and stacked on the floor of the rooms, rather than placed in boreholes. As a part of the request to use shielded containers, DOE<sup>14</sup> estimated that approximately 27 percent of the RH TRU waste to be emplaced at the WIPP has sufficiently low radioactivity to qualify for disposal in shielded containers. If approved by EPA and NRC, DOE will then submit a Class 2 HWFP modification request to NMED, adding shielded containers to the list of approved storage containers for the WIPP.

The advantage of using shielded containers is twofold. First, DOE gains flexibility in planning and sequencing RH TRU waste shipments. This would result in optimal borehole use in Panels 5 through 8 because higher radioactivity RH TRU waste could be packaged and shipped for borehole emplacement thereby reserving the lower radioactivity RH TRU waste for disposal in shielded containers. Second, both the LWA and C&C Agreement simply define RH TRU waste as having a package surface dose rate greater than 200 mrem/hr; neither prohibits DOE from converting RH TRU waste to CH TRU waste through the use of shielded containers or other repackaging approaches. Therefore, because shielded containers legally meet the criteria for CH TRU waste, DOE should be able to dispose and account for the TRU waste in shielded containers as CH TRU waste. This approach would enable DOE to place shielded containers on the floor and fill all the permitted RH

TRU waste boreholes and negate the need to request a HWFP modification to increase the allowed RH TRU waste capacity in the panels.

However, at this time, DOE has indicated it intends to count TRU waste volume in shielded containers as RH TRU waste. The result of that decision is that the allowed RH TRU waste disposal volume for Panels 5 through 8, the RH TRU waste volume disposed in those panels will have to be split between shielded containers and boreholes unless DOE requests the HWFP modification to increase the permitted RH TRU waste disposal capacity for Panels 5 through 8. DOE's intent with respect to counting shielded containers as RH TRU waste also means that if DOE fully utilizes the number of boreholes permitted in Panels 5 through 8 under the current HWFP limits, they will only be able to use shielded containers in Panels 9 and 10.

DOE has proposed that shielded containers be transported in HalfPACTs, which would decrease the number of RH TRU waste shipments. Three shielded containers can be shipped in each HalfPACT, allowing a maximum of nine 30 gallon drums of RH TRU waste per truckload, as opposed to shipping the typical three 55 gallon drums (equivalent to 1 canister) in a single RH-72B shipping container. Thus, the use of shielded containers would diminish transportation-related risks, as well as decrease the number of boreholes required in Panels 9 and 10. However, DOE must update its operational plans with respect to TRU waste packaging, shipping, and disposal sequencing to ensure that generator sites treat, package, and ship higher activity RH TRU waste first. Additionally, operational plans should continue to focus on filling canisters with the maximum possible volume of RH TRU waste.

The use of shielded containers will also significantly reduce health and safety issues associated with RH TRU waste emplacement because they do not require specialized equipment and shielding for emplacement. While there is a possibility that workforce radiation exposure may be slightly higher (since surface dose rates for shielded containers are expected to be greater than those for CH TRU waste containers), current WIPP radiation protection programs will prevent negative health impacts on the workforce.

PECOS has reviewed the formal DOE proposal to use shielded containers for low activity RH TRU waste and has found that the containers' design appears adequate for the operational needs at WIPP. No information was presented, however, regarding the ability and capacity of generator site waste characterization programs to effectively prioritize and implement the identification, characterization, packaging and shipment of the RH TRU waste that is too radioactive to be disposed in shielded

containers so that it can be emplaced in the horizontal boreholes of the rooms in the panels first—before CH TRU waste and any shielded containers would be emplaced on the floor in those same rooms.

The DOE estimate is that 27 percent (910 m<sup>3</sup>) of WIPP-bound RH TRU waste in the 2007 Inventory can be accommodated in shielded containers. That leaves a remainder of 2,460 m<sup>3</sup> of RH TRU waste to be disposed in boreholes. Subtracting the estimate of 175 m<sup>3</sup> disposed in Panel 4, 2,285 m<sup>3</sup> of RH TRU waste would remain to be disposed in Panels 5 through 10. The anticipated HWFP disposal capacity for Panels 5 through 8 is 2,279 m<sup>3</sup> of RH TRU waste. Thus, if 100 per cent of the boreholes are filled in Panels 5 through 8, capacity for only 6 m<sup>3</sup> of RH TRU waste (7 boreholes) would be needed in Panels 9 and 10. However, if DOE is allowed to increase the allowed RH TRU waste disposal capacity in Panels 5 and 6 to the same as in Panel 7, that would provide total borehole disposal space for up to 2,775 m<sup>3</sup> of RH TRU waste. For that allowed capacity, even if only 88 percent of permitted RH TRU waste disposal boreholes in Panels 5 through 8 were used; there would not be a need for any boreholes in Panels 9 and 10.

From the perspective of maximum repository capacity, the use of shielded containers would accommodate 1911 m<sup>3</sup> of RH TRU waste assuming the 27 percent estimate applies. If the permit were modified to increase the allowable capacity for RH TRU waste disposal in Panels 5 and, all the boreholes in Panels 5 through 8 were filled, and the shielded containers were also disposed in Panels 5 through 8, that would still leave at least 2,393 m<sup>3</sup> of RH TRU waste to be disposed in Panels 9 and 10. That volume is more than can be accommodated with the current borehole plan for those panels.

## ***2. Additional Rooms or Panels***

There are no apparent physical or mechanical constraints to mining additional rooms or disposal panels. The extent of the salt beds coupled with existing mining equipment capabilities could easily accommodate 30 or more additional rooms in the existing panels. Also, more panels could be mined by extending the main access drifts. Further, the demonstrated WIPP safety record thus far, indicates that there would be no additional health and safety issues associated with this option.

Adding rooms to Panels 5 through 8 and securing approval for CH TRU waste and RH TRU waste storage capacity beyond 18,750 m<sup>3</sup> and 650 m<sup>3</sup> per panel respectively would require only a Class 2 HWFP modification. Assuming that Panels 9 and 10 were used to dispose CH TRU waste, only one additional room would be necessary in any of Panels 6, 7 or 8 to accommodate the currently

acceptable CH TRU waste. For RH TRU waste, each additional room could store 93 m<sup>3</sup> of RH TRU waste in boreholes, according to the existing waste-per-room ratio. Assuming the volume of RH TRU waste disposed in Panels 1 through 8 was limited to 2,454 m<sup>3</sup>, it would require at least 10 additional rooms in Panels 6, 7 and 8 or one additional side panel to dispose of the remaining 916 m<sup>3</sup> identified in the 2007 Inventory and eliminate the need to drill boreholes in Panels 9 and 10. Only seven additional rooms would be required to accommodate 589 m<sup>3</sup> of RH TRU waste if the HWFP is modified to increase the permitted disposal volume in Panels 5 and 6. If DOE obtains approval to use shielded containers, the addition of one more room in Panels 6, 7 or 8 would forestall the need for any RH TRU waste disposal in Panels 9 and 10. Adding extra rooms to panels 6, 7 or 8 would give DOE some flexibility if RH TRU waste shipping delays were to result in unfilled boreholes in other rooms in those same panels.

To accommodate the remaining RH TRU waste regulatory limit, an additional 47 rooms would be required even with increased capacity in Panels 5 and 6. This could be accomplished by expanding Panels 6, 7 and 8 to 23 rooms each. Shielded containers would reduce the number of extra rooms required to dispose of the regulatory limit of RH TRU waste to 26, which could be achieved by increasing Panels 6, 7, and 8 to 16 rooms.

As with additional rooms, there are no apparent physical or mechanical constraints to mining additional panels. However, it would require a Class 3 HWFP modification and EPA approval, since extensive mining could impact the performance assessment and change the human intrusion analyses.

DOE has expressed no formal plans for this option as of yet. However, if they continue to have difficulties with the flow of RH TRU waste such that boreholes are frequently bypassed or if the main access drifts deteriorate more than expected, mining extra panels and rooms could prove appealing and highly effective as the safer and more efficient approach for disposal of the full amount of RH TRU waste destined for WIPP.

### ***3. Additional Boreholes in Panels 5, 6, 7 and 8***

A review by PECOS<sup>15</sup> of available information addressing the distance between boreholes indicated that current spacing was determined through an analysis of criticality effects, heat generation, and salt deformation for various configurations. RH TRU waste regulatory limits and available wall space were also taken into account. The analysis suggested that potential geomechanical concerns regarding accelerated creep closure were minimized by using a spacing of eight feet center-to-center. PECOS



evaluated the feasibility of reducing this spacing to six feet and resolved that it would not result in criticality or heat generation issues. Further, RockSol Consulting Group, Inc. and Washington TRU Solutions (WTS) performed a geomechanical analysis<sup>16</sup> and concluded that such a reduced spacing would be workable with respect to salt deformation. The only unresolved question was how much time would elapse between drilling and emplacement before salt creep rendered the boreholes unusable.

If boreholes are installed with six-foot center-to-center spacing, PECOS has calculated the volume of RH TRU waste that could be disposed in each of Panels 5 through 8 would increase from 650 m<sup>3</sup> to 708 m<sup>3</sup>. Considering the volume of RH TRU waste estimated to be emplaced in Panel 4 (175 m<sup>3</sup>), 2,832 m<sup>3</sup> of RH TRU waste could be disposed in Panels 5 through 8 using six-foot center-to-center spacing for the boreholes. This would result in a total of 3,007 m<sup>3</sup> in Panels 4 through 8 and would leave 363 m<sup>3</sup> of the 2007 Inventory RH TRU waste estimate to be disposed in Panels 9 and 10. However, it would still be necessary to dispose 4,072 m<sup>3</sup> of RH TRU waste in Panels 9 and 10 in order to meet the repository's regulatory limit.

A change of spacing between boreholes would require a HWFP modification to increase the quantity of RH TRU waste allowed in Panels 5 through 8. This alternative likely would also require EPA approval due to changes in geomechanical performance, though it does not appear that significant changes to disposal procedures would be required. The success of this alternative plan would also rely heavily on increased productivity for characterizing, shipping, and disposing RH TRU waste in order to fill all possible boreholes prior to CH TRU waste placement.

If the six-foot spacing alternative is used in conjunction with the disposal of 27 per cent of RH TRU waste in shielded containers (1911 m<sup>3</sup>) in Panels 5 through 8, Panels 9 and 10 would have to be accommodate 2,161 m<sup>3</sup> in order to achieve maximum allowable RH TRU waste disposal capacity. If the six-foot spacing alternative was also applied to Panels 9 and 10, approximately 1,458 m<sup>3</sup> of the remaining RH TRU waste volume could be put in boreholes in Panels 9 & 10. Disposing of the remaining volume of RH TRU (703 m<sup>3</sup>) waste in boreholes would require eight more rooms be mined in any one or a combination of Panels 5 through 8.

#### ***4. Additional Canisters in Boreholes***

PECOS presents two alternatives for this disposal approach: 1) place two RH TRU waste canisters in each borehole, or 2) dispose of two RH TRU waste canisters in every other borehole. The

geomechanical analysis performed by RockSol Consulting Group, Inc. and WTS cited above considered the two-canister emplacement scheme and concluded that doubling the borehole depth was technically feasible. However, increased fracturing around borehole openings could shorten both the life of the room and the time available for canister emplacement. There would also be additional maintenance requirements and costs to consider.

As with decreasing the spacing between boreholes, emplacing additional canisters per borehole would require a HWFP modification to increase the quantity of RH TRU waste allowed in Panels 5 through 8. More than likely this alternative would also require EPA approval, due to changes in geomechanical performance, though it does not appear that significant changes to disposal procedures would be required. The success of this alternative plan relies heavily on increased productivity for characterizing, shipping, and disposing RH TRU waste since the workforce must emplace more RH TRU waste canisters prior to CH TRU waste placement.

If the HWFP were modified to allow emplacement of two canisters per borehole and to increase the allowed RH TRU waste disposal volume in each of Panels 5 through 8, each panel could each contain 1,300 m<sup>3</sup> of RH TRU waste for a total of 5,200 m<sup>3</sup>. When added to the estimated volume of RH TRU waste in Panel 4, this would provide a potential emplacement capacity for 5,375 m<sup>3</sup> of RH TRU waste. The use of additional canisters in boreholes would enable the emplacement of the 2007 Inventory estimate of RH TRU waste without using shielded containers or Panels 9 and 10.

With respect to the regulatory limit, emplacing two canisters per borehole would leave 1,704 m<sup>3</sup> of RH TRU waste to be emplaced. This volume could be accommodated through several alternatives. One would be the use of shielded containers placed in Panels 5 through 8 (as either CH TRU Waste or via a HWFP modification to increase the allowed RH TRU waste disposal capacity in those panels). Another would be to emplace that volume in shielded containers on the floors of Panels 9 and 10. A third alternative would be to mine 10 more rooms and load two RH TRU waste canisters into each borehole in those additional rooms. Any of these three options would negate the need to dispose any RH TRU waste in boreholes in Panels 9 and 10.

Emplacement of two canisters in every other borehole of Panels 5 through 8 would increase the volume of RH TRU waste that could be emplaced in those panels to 3,900 m<sup>3</sup> and the total RH TRU waste disposal volume in Panels 4 through 8 to 4,075 m<sup>3</sup>. This approach would also eliminate the need for RH TRU waste disposal in Panels 9 and 10 based on the 2007 Inventory. Of the 3,004 m<sup>3</sup> of RH TRU waste that still would be disposed in order to meet the regulatory limit, no more than

1,339 m<sup>3</sup> can be emplaced in 8 feet on center horizontal boreholes in Panels 9 and 10. Therefore, a combination of supplemental disposal methods, such as shielded containers and additional rooms in existing panels, would be necessary.

When double emplacement of RH TRU waste canisters in Panels 5 through 8 is combined with a decreased borehole spacing of six feet on center, as much as 5,664 m<sup>3</sup> of RH TRU waste could be placed in Panels 5 through 8 for a total of 5,839 m<sup>3</sup> in Panels 4 through 8. Shielded containers placed in any combination of Panels 5 through 10 could accommodate the balance of the 7,079 m<sup>3</sup> regulatory limit. Similarly, if an extra canister is placed in every other borehole and spacing is reduced between those boreholes, 5,550 m<sup>3</sup> of RH TRU waste could be disposed in Panels 4 through 8, leaving 1,604 m<sup>3</sup> for disposal in Panels 9 and 10—ideally, in shielded containers. Based on estimates in the 2007 Inventory, the combination of additional canisters in boreholes and the use of shielded containers would eliminate the need for RH TRU waste emplacement in boreholes in Panels 9 and 10.

Health and safety risks associated with drilling longer boreholes and adding a second canister to them are expected to be greater than those associated with current RH TRU waste disposal operations at WIPP. In particular, disposing two canisters in one borehole would entail increased drilling and emplacement time. Because workers can only place one canister in a borehole per eight-hour shift, an interim shielded plug would be required following emplacement of the first canister. This is not anticipated to be a major concern, but should be considered when determining the cost-effectiveness of this option.

### ***5. Disposing RH TRU Waste in the Repository Floor***

Instead of using horizontal boreholes, a final emplacement option involves storing drums of RH TRU waste in the disposal room floor. By drilling boreholes in the floor at six-foot centers, it would be possible to install 1,778 boreholes per panel. Due to ceiling height constraints, these boreholes could not be drilled as deeply as their wall counterparts. Therefore, facility canisters would have to be modified to hold one or two 55-gallon drum(s) of RH TRU waste rather than three. For the one-drum (0.21 m<sup>3</sup>) scenario, each panel could accommodate 373 m<sup>3</sup> of RH TRU waste. The per-panel capacity increases to 747 m<sup>3</sup> for the two-drum case. At most, this option provides 100 m<sup>3</sup> more storage than its wall-based counterpart and would definitely require both NMED and EPA approval.

Floor-based emplacement would require significant changes: vertical drilling equipment; smaller facility canisters; new shipping casks; modification of existing canisters to allow individual RH TRU

waste drum transfer; and steel floor plates to support CH TRU waste equipment. Further, implementing this option would mandate a rewrite of emplacement operation procedures and subsequent training for WIPP disposal operations staff. Consequently, this option is considered to be unfeasible as a result of relatively small gains in RH TRU waste capacity compared to the time and cost required to make the necessary operational changes.

## **6. Waste “Flow” Issues**

Balancing the disposal operations between emplacement of RH and CH TRU waste was based on the goal of receiving at least seventeen shipments per week of CH TRU waste and six shipments per week of RH TRU waste. The combined total of 99 TRUPACT II and HalfPACT shipping containers appears to be more than enough to support up to forty CH TRU waste shipments per week. Each RH TRU waste canister can only be shipped to WIPP in an RH-72B shipping cask, which holds one canister, or in a CNS10-106B, which holds three drums of RH TRU waste (the equivalent of one canister). DOE has 12 RH-72-B shipping containers and one CNS10-106B, an adequate quantity to support a goal of six to seven shipments per week. Therefore, transportation capability and capacity does not appear to be constraining the emplacement of TRU waste.

DOE estimated in 2002<sup>17</sup> that at least 2,000 RH TRU waste boreholes would be bypassed by FY 2008 as a result of delays in approving RH TRU waste disposal in WIPP and implementation problems identified with RH TRU waste treatment and packaging operations. Through FY 2008, the estimated number of waste boreholes bypassed had grown to approximately 3,100, translating to a loss of close to 2,700 m<sup>3</sup> of RH TRU waste disposal capacity. The 2,190 boreholes planned for Panels 1 through 3 were never drilled. At most, only 182 boreholes will be filled in Panel 4, a shortfall of 548 from the design number. Panels 5 and 6 will have a total of 360 fewer boreholes than the design capacity according to current limits in the HWFP. While regulations were the deciding factor in the past, the slowness and/or difficulty of implementation of the packaging and characterization operations, and availability of sufficient RH TRU waste shipping containers appear to be contributing factors to DOE’s current inability to efficiently disposition waste at WIPP.

Each active generator site in the DOE complex has a certified characterization program, ensuring a sufficient number of containers are prepared for treatment and repackaging or transport to WIPP. However, only Idaho National Laboratory, Argonne National Laboratory, Oak Ridge National Laboratory, Savannah River, and Los Alamos National Laboratory have been certified for RH TRU

waste characterization. Depending on RH TRU waste packaging efficiency, this situation could limit DOE's ability to meet its disposal goal of six canisters per week.

Approximately 80 percent of RH TRU waste identified in the 2007 Inventory is currently in storage at generator sites. Of that, it is estimated that over 90 percent will require packaging or repackaging. Further, substantially more time is required to prepare RH TRU waste for disposal in WIPP than CH TRU waste since all RH TRU waste preparation operations must be conducted in special glove boxes or hot cells. Moreover, ongoing mission-related activities are typically given higher priority than RH TRU waste disposal programs at generator sites, which impacts RH TRU waste disposal by hindering the steady flow of shipment-ready canisters.

#### **IV. CONCLUSIONS**

Based on current HWFP limitations, operating procedures, and the assumption that DOE is able to achieve the permitted disposal capacities for Panels 5 through 8, there is insufficient floor space in Panels 9 and 10 to store the estimated residual volume of currently acceptable CH TRU waste once Panels 1 through 8 are filled. Therefore, either the capacity of Panels 9 and 10 would have to be increased by widening the drifts or additional rooms would have to be mined in Panels 6 through 8.

If Panels 4 through 8 are filled to the permitted capacity with RH TRU waste (boreholes only), shielded containers could be used to accommodate most of the remaining volume of RH TRU waste (916 m<sup>3</sup>) identified in the 2007 Inventory in Panels 9 and 10. However, since existing operational progress indicates that it is unlikely DOE will be able to fill Panels 5 through 8 to the permitted RH TRU waste capacity, it is probable that a combination of the use of shielded containers, the drilling and filling some horizontal boreholes in Panels 9 and 10, or the mining one or two additional rooms in Panels 7 or 8 will be required to accommodate the 2007 Inventory volume of RH TRU waste.

In order to dispose the maximum allowed volume of RH TRU waste, DOE would have to implement alternatives beyond the use of shielded containers and the current emplacement methods.

Prior to implementation of alternative plans, concurrent shipment and disposal of RH and CH TRU waste must be coordinated to ensure that as many boreholes as possible are filled in Panels 5 through 8. Timely RH TRU waste shipments are integral to achieving this balance as well as an investment in an additional HERE and a review of the current work rules regarding RH TRU waste disposal. Given the time required to load, transport, and unload canisters; and the number of RH TRU waste shipping containers available,

WIPP is limited to receiving a maximum of seven RH TRU waste shipments per week. Under present operating conditions, WIPP must attain and maintain the receipt of at least six and ideally seven RH TRU waste shipments per week in order to fill the boreholes in Panels 5 through 8 and improve the RH TRU waste disposal efficiency in order to stay ahead of the CH TRU waste disposal operations. In fact, at least 88 percent of the remaining inventoried RH TRU waste bound for disposal at WIPP must be disposed in these panels if shielded containers are to be used to their fullest extent.

The overall environmental, health, and safety impacts on the entire TRU waste management program must be considered when determining which alternative best suits effective and efficient waste disposal at WIPP. Direct and indirect risks exist across the board, ranging from generator-site personnel engaged in characterization and packaging efforts, to transportation personnel expediting waste transfer, and disposal personnel who are responsible for final waste emplacement.

Shielded containers are the most preferred alternative for increasing the amount of RH TRU waste that can be emplaced at WIPP. They provide the greatest health and safety risk reduction and offer the greatest opportunity for improvement in disposal efficiency, with minimal investment in new equipment. Of the four main alternatives that could complement the use of shielded containers, mining additional rooms and panels has the least health and safety risk at the repository, and no significant negative impact on generator sites, because emplacement and mining operations can be conducted simultaneously. In essence, the necessary equipment and operational procedures to mine additional rooms or panels are already in place, and modifications to the HWFP and the EPA certification would be minimal. In addition, the issues with the age and associated stability of the main access drifts that are proposed to comprise Panels 9 and 10 and the fact that the earliest DOE could begin to work on Panel 9 is at least four years from now, supports the conclusion that it would be safer to develop and propose mining additional panels and rooms than to use those drifts for TRU waste disposal.

The option of either inserting two canisters per borehole or drilling boreholes closer together would not require equipment changes; though both options would require an analysis of mine stability health and safety implications, extensive revisions to procedures, and additional disposal crew training. The only discernable health and safety impact on generator sites would be an increased risk of leaks or spills arising from delays in disposal operations for new procedure implementation. The final option, RH TRU waste storage in the repository floor, would require extensive health and safety analyses, procedure revisions, and equipment modifications and therefore is not considered feasible.

Implementation of any of the four viable approaches would require approval by both EPA and NMED. However, DOE is not proposing to include the shielded containers or any other approach to improve the efficiency of disposal of RH TRU waste in either the recertification application to EPA to be submitted in March 2009 or the NWFP renewal application to be submitted to NMED in May 2009. While this approach may pave an easier path with respect to renewal and recertification, it will push DOE's ability to propose efficiency-boosting modifications to 2010 or later. This would mean longer delays in implementing very necessary operational changes at WIPP, and it would increase the challenges associated with accommodating the projected RH TRU waste volume.

## **V. RECOMMENDATIONS**

In order to improve the TRU waste disposal efficiency and effective of WIPP, DOE should implement the following recommendations, which are listed in order of importance to accomplishing the WIPP mission:

1. Prepare and issue a revision to the National TRU Waste Management Plan (last updated in 2002) in order to provide its staff, maintenance and operation contractors, congress, regulatory agencies, and the public with an up-to-date assessment of expected activities and costs required to efficiently dispose of at least the quantity of waste identified in the 2007 Inventory. This revised plan should indicate major regulatory actions necessary to achieve this result.
2. Include the request to use shielded containers in its application for renewal of the HWFP based on the premise that shielded containers are considered as CH TRU waste and are therefore integrated into the volumetric limits for each panel. In so doing, DOE may secure from NMED a more timely authorization to use shielded containers. This would ensure that the new HWFP would not require either a Class 2 or Class 3 modification in order to increase the RH TRU waste disposal capacity of the panels, which will be necessary if DOE intends to use both boreholes and shielded containers in the same panel.
3. Also include a request to increase the RH TRU waste disposal capacity in Panels 5 and 6 to be the same as for Panels 7 and 8 (650 m<sup>3</sup>) and to increase the permitted capacity for CH TRU waste disposal in Panels 6, 7, and 8 by 25 percent each in order to improve operational flexibility of WIPP.
4. Conduct a study of the issues associated with the current work limitations for RH TRU waste disposal and determine what additional equipment or operational changes could be made to improve the efficiency of using RH TRU waste boreholes in Panels 5 through 8.

5. Streamline the review and approval process for WIPP operational changes. Environmental, health, and safety risks associated with leaving TRU waste at generator sites is much greater than long- or short-term risks of waste emplacement at WIPP. At minimum, a board that includes members from EPA, NMED, and NRC should be formed and empowered to conduct joint reviews of proposed changes and to facilitate their approval.

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