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Disposition of PUREX Facility Tanks D5 and E6 Uranium and Plutonium Solutions

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EXECUTIVE SUMMARY

Approximately 9 kilograms of plutonium and 5 metric tons of uranium in a 1 molar nitric acid solution are being stored in two PUREX facility vessels, tanks D5 and E6. The plutonium was accumulated during cleanup activities of the plutonium product area of the PUREX facility. Personnel at PUREX recently completed a formal presentation to the Surplus Materials Peer Panel (SMPP) regarding disposition of the material currently in these tanks. The peer panel is a group of complex-wide experts who have been chartered by EM-64 (Office of Site and Facility Transfer) to provide a third party independent review of disposition decisions. The information presented to the peer panel is provided in the first section of this report. The panel was generally receptive to the information provided at that time and the recommendations which were identified are briefly summarized as follows:

- 1) Provide a qualitative evaluation of the disposition options; performance of a detailed engineering study is unnecessary. This information is provided in section 2 of the attached engineering evaluation, and is based on the evaluation factors provided by the SMPP.
- 2) Continue to develop detailed information on the primary option of transferring the material to tank farms. This information is provided in section 3 of the attached engineering evaluation. The SMPP agreed with the WHC recommendation of dispositioning the PUREX D5/E6 material via this option as documented in their letter dated 11/5/93 (reference 2).
- 3) Continue to develop detailed information on the backup option of co-precipitation with transfer to transuranic drums until this backup option is no longer required. This information is provided in section 4 of the attached engineering evaluation.

It is recommended that the disposition of the PUREX D5/E6 material should be completed via transfer of neutralized solution to tank farms. Completion of the PUREX facility transition to an unoccupied facility will be enhanced with potential for an associated cost reduction by early completion of PUREX Deactivation. This task can be accomplished by transferring 50 batches of this material to the tank farms totaling approximately 200,000 gallons of solution. The material is diluted by other solution generated during PUREX deactivation activities. These other deactivation activities will generate 1.3 million gallons of solution which can be reduced to approximately 300,000 gallons with volume reduction activities. The total tank farm waste volume for PUREX deactivation is thus not impacted by completion of this disposition option. The number of batches can be reduced to approximately 20 batches totaling 80,000 gallons if the fissile quantity per batch can be increased to 500 grams per batch. This fissile limit is the topic of an ongoing Criticality Safety Evaluation Report.

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If the backup option of co-precipitation and storage in transuranic drums were implemented, the resultant number of drums would be approximately 400 if all WIPP criteria were met. If the wattage limit were met for interim storage at Hanford approximately 100 drums would be required. Additional concerns that are raised with this option include containment requirements to protect the worker, a personnel dose assessment and compliance with waste storage criteria. This option poses significant risk to the PUREX deactivation schedule because of the reviews and organizations that are involved in the implementation process. New equipment must also be designed, procured, built, installed, and tested.

The impact on the ultimate disposal cost is comparable for either option. Vitrification cost for this material transferred to tank farms is estimated to cost an additional \$4M based on an additional glass production of 14-25 metric tons. WIPP disposal cost for coprecipitation is estimated to cost an additional \$3M based on 400 drums at \$7000 per drum.

The appendix of this evaluation provides documentation of material data, calculations and historical information.

DISPOSITION OF PUREX TANKS D5 AND E6

URANIUM AND PLUTONIUM SOLUTIONS

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SECTION 1

DISCUSSION AND SUMMARY OF DISPOSITION ALTERNATIVES

1.1 Background

Approximately 9 kilograms of plutonium and 5 metric tons of uranium in a nitric acid solution are being stored in two PUREX facility vessels, tanks D5 and E6. The plutonium was accumulated during cleanup activities of the plutonium product area of the PUREX facility. The PUREX facility was in "Standby" status pending processing of residual N-reactor fuel during the cleanup activity. The Pu bearing solution is thus normally transferred to tank E6 as a preliminary activity to full solvent extraction operation. The PUREX plant is now in "Shutdown" status and is pursuing a deactivation phase to prepare the facility for future decontamination and decommissioning. In order to complete this deactivation phase the nuclear material in these tanks must be placed in proper interim storage pending final disposal of the material. Several options are possible and are briefly discussed in this paper. The long-term impacts of the disposition decision must be considered, as well as the cost and time to complete.

1.2 Material Information

Transfers of the plutonium cleanup solutions into tank E6 are performed in accordance with existing criticality precautions and procedures. Uranyl nitrate solution and nitric acid are added prior to the transfers. This is necessary in order to simulate normal feed for the solvent extraction process and also serve to ensure criticality safety and prevent precipitation or plutonium polymer formation. Cadmium nitrate solution (a soluble neutron poison) is used to ensure criticality safety during the transfer. As a result, two actinide streams which had previously been separated and purified are recombined as a result of rework (cleanup) activity along with nitric acid and cadmium nitrate solutions. Approximately 5300 gallons (20,000 liters) of this mixed actinide solution is split between tanks E6 and D5. Tank D5 was utilized due to the volume and quantity of plutonium cleanup solution. Only residual fission product activity leftover from previous operating periods is associated with this material along with americium activity from plutonium decay. As a result, 5 ounce samples of this material have a relatively low dose of 10 to 30 mrem/hr. A summary of the significant constituents in this material is provided in Table 1-1. Additional details and calculations are provided in the appendix.

1.3 Options Considered

Options considered for disposition of this material are:

- (1.) Plutonium separation by either
 - (1a) Continuous solvent extraction,
 - (1b) Batch solvent extraction,
 - (1c) Ion exchange,
- (2.) Co-precipitation with either
 - (2a) In-tank storage,
 - (2b) Removal and storage in transuranic drums,
 - (2c) Transfer neutralized solution to Tank Farm waste storage.

A brief discussion of each one of these options is provided in the following paragraphs.

1.3.1 Option 1a & 1b Solvent Extraction - (continuous or batch)

Plutonium separation by continuous or batch solvent extraction consists of the PUREX facility process of utilizing an organic extraction stream and plutonium valence adjustment to separate and purify the plutonium. The basic steps include (1) separating the uranium and plutonium, (2) purification of the plutonium solution, (3) concentration and loadout of the plutonium nitrate solution, (4) disposal to tank farms of the uranium solution as well as other process and flush solution. (See Fig. 1-1)

There are several positive aspects of the solvent extraction option. The separation can be done with a simplified or modified PUREX flowsheet. It is known that plutonium nitrate product specifications can be met. The volume of plutonium nitrate produced (approximately 30 liters) is much easier to handle than the 5300 gallons of solution currently in tanks D5 and E6. This plutonium nitrate solution can be converted into 4 small containers of plutonium oxide and stored in a stable form.

On the other hand, there are several aspects associated with this option which will make the task difficult to accomplish. Foremost is the perception of processing to obtain plutonium product material. An Environmental Impact Statement has previously been committed (per former Secretary of Energy, Admiral Watkins) prior to any processing activity. Engineering and safety evaluations will be required. Hazards will be reintroduced into the facility that have been eliminated such as handling organic solvent, steam controls and effluent controls. Operational safety requirements will also have to be reinstated that have been deactivated. Processing equipment and material requirements have not been maintained and personnel training will be required. For the recent uranium oxide stabilization operation, approximately 3 years worth of time was required to document, evaluate and prepare for all

aspects of the operation that took 4 weeks of operating time. As a result this option will be expensive and time consuming compared to other options. In addition, the plutonium separation is of dubious benefit since the plutonium is currently considered low value material. Another consideration is that the uranium and other wastes are transferred to the tank farms as in the other options and that this volume of material is comparable to or more than the other non-separations options.

1.3.2 Option 1c Ion Exchange

Plutonium separation by ion exchange consists of procurement and installation of an ion exchange column with the specific resin required in order to selectively separate plutonium from the other components. The basic steps consist of (1) selectively loading the resin with plutonium, (2) elution of the plutonium from the resin, (3) concentration and loadout of the plutonium nitrate solution, and (4) disposal to tank farms of the uranium solution, resin rinse, and used resin. (See Fig. 1-2)

The positive and negative aspects of ion exchange are similar to that of the solvent extraction option. Several notable differences are identified as follows. Ion exchange equipment would have to be designed and installed. The potential for making product-quality plutonium nitrate solution would require further evaluation. Plutonium separations by ion exchange have not been used at PUREX for over 20 years and introduces new hazards. A more detailed evaluation of this method would be required for using ion exchange resin in a strong nitric acid environment. Less tank farm volume is required for wastes but the additional disposal of the used resin must be addressed.

1.3.3 Option 2a Co-precipitation - In-tank Storage

This option consists of using sodium hydroxide to precipitate the uranium, plutonium and impurities. The remaining liquid would be removed and a wet cake of solids would remain in the tank. This option leaves the material in a solid, safe and sub-critical form suitable for minimal surveillance. The uranium and plutonium, however, would remain in the PUREX plant for storage. This would require revision of the project technical basis currently in the PUREX Deactivation Project Management Plan as the current intent is to remove this nuclear material from the facility. Future handling by other methods would still be required to remove the material during decommissioning. Further in-tank stabilization is possible by using concrete or polyethylene, however this may complicate future handling. It is preferred to remove this nuclear material from the PUREX facility, however, this option can be done if no other options are available. This option could be considered a default option.

1.3.4 Option 2b Co-precipitation - Transuranic Drum Storage

This option consists of collection of solid material with storage in transuranic drums. The basic steps include coprecipitation of the material, separation of the liquid and solid streams, collection of the solids, and packaging in a drum as transuranic waste. (See Fig. 1-3) The number of drums produced depends on the separation method and packaging requirements with a total range of 80-400 drums. The number of drums will vary depending on the total fissile quantity per drum or the allowable wattage per drum. Other important criteria considerations are the dose rate of the drum, the volume of solids produced, and the volume of absorbent required to eliminate any potential formation of free liquids. Details of the processing and packaging of this material is provided in Section 4 of this report. The liquid stream (without the uranium and plutonium) will be treated and transferred to tank farms (approximately 7000 gallons). Some of the concerns that must be addressed are the gas-generation rate, a personnel dose assessment, additional transuranic waste packaging requirements, WIPP acceptance criteria, RCRA permitting approval of the process, and modification of the drum transport requirements. New equipment must be designed, built and installed for removal of the bulk liquid.

Health and safety criteria must also be evaluated in order to provide containment barriers to protect the facility worker. Direct exposure of the material to the operators is possible because solids handling equipment may become plugged or require maintenance, the total quantity of precipitated solids in the inner container must be verified, proper closure verified, and packaging and venting verified. A glovebox arrangement which could house the required equipment is not readily available for this activity. Alternate handling methods may impact the ability to meet waste storage criteria. An ALARA evaluation is already factored into the implementation schedule for this option. To reduce the risk to workers the costs and implementation time will increase.

1.3.5 Option 2c Co-precipitation - Transfer Solution To Tank Farms

This option consists of neutralization and transfer of the existing solution to the tank farms in batches. The number of batches ranges between 20 and 50 and depends upon an allowable plutonium quantity per batch. The amount of plutonium per batch must also address an Unreviewed Safety Question (USQ) at the tank farm which currently limits the quantity of plutonium to 15 grams per batch. Transfers containing greater than 15 grams of fissile material will require documented justification and approval from the Criticality Safety Representative with Waste Tank Safety Assurance concurrence as required by the current Justification for Continued Operation (JCO). This approval can be obtained for up to 0.05 gram/gallon (200 grams per batch / ~50 batches total) based on existing specifications and potentially could be

increased to 0.125 gram/gallon (500 grams per batch / ~20 batches total). Because of the presence of uranium and cadmium, which both enhance criticality safety, it is expected that the 0.125 gram/gallon batch limit technically can be approved. If tank 105AW is used for receipt of this material, the USQ limit of 25 kilograms per waste tank would be approached and must also be addressed. A criticality safety evaluation report (CSER) is currently being prepared to address these issues and an initial draft of this CSER is included in Appendix G. Additional details pertaining to this disposition option are included in section 3 of this report.

Existing waste solution at PUREX also requires disposal and can be used to prepare the proper batch size. A total waste volume of 1.5 million gallons was projected and allotted for PUREX deactivation activities. Activities are ongoing to reduce the amount of waste volume required, however significantly more than the maximum volume required for D5/E6 dilution (~200,000 gallons) will be generated. The net volume of D5/E6 material transferred to tank farms is thus the nominal 7000 gallons of treated solution since the dilution material has already been allotted for transfer to tank farms (See Fig. 1-4).

It is important to compare the material quantities in tanks D5 and E6 to that already present in the tank farm. The uranium and plutonium is approximately comparable to one year's waste losses for the PUREX process. The amount of uranium is insignificant to the amount already present in the tank farm and the amount of plutonium is less than 2% of the amount already present in the tank farm. Table 1-2 provides a summary of this tank farm inventory information.

Several of the positive considerations associated with this option are identified as follows. There is no perception a plutonium product could be obtained from this activity. This task can be accomplished within the current safety, regulatory, and environmental authorizations of the PUREX "Shutdown" mode. Existing equipment is utilized with the exception of a few piping changes. Hazards, piping, and operational safety requirements already eliminated from the plant are not reactivated. This option can be completed using existing safety documentation, procedures and training. It also represents the option that is the most cost effective and requires the least amount of time to complete.

A summary comparison of the alternatives showing waste quantities, alternate waste forms, ROM costs and time is provided in Table 1-3. A significant annual cost reduction of \$36M is associated with completion of the PUREX deactivation project. Other options represent a higher project schedule uncertainty due to the many issues that must be addressed. Transfer of the neutralized material to tank farms represents minimal schedule risk pending resolution of the tank farm USQ.

1.4 Final Disposal Options Available

The final disposal endpoints of WIPP or High Level Vitrified Waste repositories must also be considered when evaluating the options. Table 1-4 provides a comparison of the final endpoint availability. Coprecipitation with storage in transuranic drums provides availability of either endpoint with minimal impact. Transfer of neutralized waste to tank farms provides direct access to vitrified waste. Transfer of the plutonium material in the tank farms to WIPP is not considered a current option for long-term disposition of the tank farm inventory.

1.5 Recommendation

It is recommended to pursue transfer of neutralized solution to tank farms as the primary option. As a backup option, co-precipitation with storage in transuranic waste drums will continue to be evaluated until a backup option is no longer required. The primary focus of the PUREX personnel will be on implementation needs. Completion of the PUREX facility transition to an unoccupied facility will be enhanced with associated cost reduction.

CONTENTS OF TANKS D5 AND E6

	TANK D5	TANK E6	TOTALS
VOLUME	10,900 liters	8900 liters	~ 20,000 liters
URANIUM	2900 kilograms	2400 kilograms	~ 5300 kilograms
PLUTONIUM	4000 grams	5000 grams	~ 9000 grams
NITRIC ACID	~ 0.9 molar	~ 1.5 molar	~ 1 molar
CADMIUM (soluble neutron poison)	~ 1.8 gram/liter	~ 8.8 gram/liter	~ 100 kilograms
U-235 CONTENT	< 0.95 wt%	< 0.95 wt%	~ 50 kilograms
DOSERATE (5 oz. sample)	30 mrem/hr	10 mrem/hr	

COLLECTION OF MATERIAL IS DIRECTLY RELATED TO PLUTONIUM CLEANUP ACTIVITIES ONLY

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TABLE 1-1

TANK FARM U/PU WASTE INVENTORY COMPARISON

	CURRENT WASTE INVENTORY SUMMARY		1983-1990 PUREX OPERATIONS	CURRENT D5 & E6
	SST	DST		
U	1,400,000 kg	36,000 kg	35,000 kg	5300 kg
Pu	380 kg	160 kg	35 kg	9 kg

D5/E6 URANIUM -

CORRESPONDS TO 14% OF 1983-1990 OPERATING PERIOD WASTE LOSS

LESS THAN 1 YEARS WORTH OF NORMAL PUREX OPERATING LOSS

INSIGNIFICANT TO THE AMOUNT OF URANIUM INVENTORY ALREADY EXISTING IN TANK FARMS

D5/E6 PLUTONIUM -

CORRESPONDS TO 25% OF 1983-1990 OPERATING PERIOD WASTE LOSS

APPROXIMATELY 1 YEARS WORTH OF NORMAL PUREX OPERATING LOSS

LESS THAN 2% OF EXISTING TANK FARM TOTAL PLUTONIUM INVENTORY

COMPARISON OF OPTIONS

METHOD	U TO TF kg	PU TO TF kg	VOL TO TF gallons	OTHER WASTE	ROM EQ. COST	ROM OP. COST	TIME months
TRANSFER TO TANK FARMS							
50 batches	5300	9	7000 (net)	none	\$50-100K	nominal	14
20 batches	5300	9	7000 (net)	none	\$50-100K	nominal	6
8 batches	5300	9	7000 (net)	none	\$50-100K	nominal	3
COPRECIPITATION	low	low	7000	80-400 TRU drums	\$.5-1M	\$1-2M	36
IN-TANK STABILIZATION	deferred	deferred	7000 (net) + deferred	deferred	\$50-100K	nominal	3
SOLVENT EXTRACTION	5300	low	50,000	30 liters of Pu nitrate sol'n	\$.5-1.0M	\$4-8M	36
BATCH EXTRACTION	5300	low	50,000	30 liters of Pu nitrate sol'n	\$.5-1.0M	\$4-8M	36
ION EXCHANGE	5300	low	45,000	30 liters of Pu nitrate sol'n ion exchange resin	\$.5-1.0M	\$4-8M	36

REMOVAL OF TANKS D5 AND E6 MATERIAL IS A CRITICAL PATH ACTIVITY FOR OTHER ACTIVITIES
 REPRESENTS HIGH PROJECT UNCERTAINTY DUE TO TOO MANY ISSUES
 SIGNIFICANT ANNUAL COST SAVINGS OF \$36M CAN BE ACCRUED BY EARLY COMPLETION OF TRANSITION PLAN

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 TABLE 1-3

FINAL DISPOSAL

WIPP	STORED IN TRANSURANIC DRUMS	\$3 M total cost / \$7000 PER DRUM
HIGH LEVEL WASTE REPOSITORY	VITRIFIED WASTE	\$4 M total cost (14-25 metric tons of glass produced) (approx. increase of ~0.06% in TWRS high-level waste glass, appendix E)

FINAL DISPOSAL OPTIONS AVAILABLE DEPENDING ON DISPOSITION OPTION

	WIPP	VITRIFICATION
TRANSFER TO TANK FARMS	sending tank farm waste to WIPP is not a current option	ok, mixes with existing tank farm waste already designated for vitrification
12 COPRECIPITATION	ok with WRAP interface	ok, via addition of drum waste to tank farm waste in vit. feed tanks, requires new equipment and cost
IN-TANK PRECIPITATION	requires future retrieval & treatment with WRAP interface	requires future retrieval & treatment
SEPARATIONS	conversion of Pu nitrate req'd at PRF with WRAP interface	U ok Pu ok via addition of nitrate or oxide material to tank farm waste in vit. feed tanks, requires new equipment and cost

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TABLE 1-4

Separate Plutonium Continuous Solvent Extraction

FIGURE 1-1

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Separate Plutonium Ion Exchange

FIGURE 1-2

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Co-Precipitation Remove and Store in Transuranic Drums Schematic

FIGURE 1-3

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Co-Precipitation Transfer Neutralized Solution to Tank Farms Schematic

* Existing waste water and acid is used as dilution material thus net volume transfer is 7000 gallons due to D5/E6.

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FIGURE 1-4

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SECTION 2

QUALITATIVE EVALUATION OF OPTIONS

Based on information provided from the Surplus Materials Peer Panel (reference 1, dated June 16, 1993) a comparison of the disposition options for this material was completed. The evaluation factors and their description are taken directly from the reference letter. Based on the initial presentation to the SMPP in October '93 it was agreed that a detailed, quantitative study was not required for this disposition decision. It was requested that a qualitative evaluation be performed of the factors identified so that a disposition decision would be completed and documented.

The qualitative evaluation is provided below and shows that transfer of this material to tank farms represents the least risk and most cost effective solution for disposition of this material. This conclusion is supported by recommendation A-1 of the Surplus Materials Peer Panel in the reference 2 report dated November 5, 1993. This recommendation states, "The solutions now stored in the Purex facility in tanks D5 and E6, should be neutralized and disposed to the Tank Farm as recommended by WHC. ... This recommendation is contingent upon acceptance by the Hanford Waste Management organization and successful resolution of the Tank Farm Unreviewed Safety Question (USQ)."

2.1 EVALUATION FACTORS FOR ENGINEERING STUDY

The evaluation factors and their description are taken directly from the reference 1 letter followed by the qualitative assessment or impact for each option. The qualitative terms used to compare the evaluation factors are LOW, MEDIUM, and HIGH. These terms are applied only to the disposition options being considered in this report of:

- A) Transfer Solution to Tank Farms, option 2c
- B) Coprecipitation - Transuranic Drum Storage, option 2b
- C) Separation of Plutonium, options 1a, 1b, and 1c

As a result of using the methodology of comparison within these options, there will generally always be a HIGH and LOW rated option. This will always be the case unless an alternate basis of comparison is provided in the discussion. The disposition options were developed in sufficient detail to prepare a subjective comparison of the options for each of the criteria that was applied. This ranking does not determine the relative ease or difficulty in completing a task since it only compares between the options. Generally a judgement of the ease or difficulty can be construed from the evaluation discussion. It is also important to note that the relative ranking is based on assessment of the capabilities and limitations that exist within the context of the current situation. Since many of the criteria items are currently being evaluated or negotiated, the dynamics of the situation could

change the ranking at a later date. Many organizations are involved with setting criteria and requirements that could modify the current assessment. It is unlikely, however, that the significant issues that currently exist will be altered within the time frame defined for PUREX deactivation.

2.1.1 Health and Safety Risk

Health and safety of the worker and protection of the environment are of paramount importance in the disposition process and should be weighted accordingly.

Transfer to Tank Farms -

LOW

The health and safety risk is primarily due to the worker exposure risk. This option is rated low because no contact with the material is required to complete this activity except for routine batch samples of low-level dilute material. Environmental risk is minimal for this option when compared to previous processing operations and is further discussed in section 2.1.4 pertaining to regulatory concerns.

Coprecipitation With Drum Storage -

MEDIUM

The health and safety risk is primarily due to the worker exposure risk. Coprecipitation with drum storage is rated medium because operators must handle the drums at the PUREX facility several times and at the interim storage facility (TRUSAF) for initial handling and additional handling when repackaged or transferred to WIPP. In addition, the total quantity of precipitated solids in the inner container must be verified, proper closure verified, and packaging and venting verified. This provides the possibility of direct exposure of the material to the operators. Containment provisions could extensively reduce the potential for worker exposure to contamination but must be balanced against the increased cost and time to implement this strategy. An ALARA evaluation is already factored into the implementation schedule for this option. To reduce the risk to workers the costs and implementation time will increase. To reduce worker exposure the centrifuge process can easily employ a wash cycle to reduce the dose rate. The dose rate from this material is already expected to be fairly low based on ISOSHIELD calculations of the unwashed sludge (Appendix F). Environmental risk is minimal for this option when compared to previous processing operations and is further discussed in section 2.1.4 pertaining to regulatory concerns.

Separation and Product Handling -

HIGH

The health and safety risk is primarily due to the worker exposure risk. Separation is rated high because of the anticipation of extensive repair work which would expose maintenance and operating personnel to additional radiation and skin contamination potential. Additional

sampling would also be required for the processing activity. The risk is much lower for the other two options because either minimal route changes are used and/or new equipment will be installed. Significantly more operating and maintenance personnel must be involved with this option which results in a higher rating compared to coprecipitation. Equipment requiring repair for this option may include several jumpers, pumps, agitators and pulsars. In addition, an environmental risk assessment would be required for the separation option, and it is highly likely that a full environmental impact statement (EIS) would be required. The environmental assessment would require extensive time and work to complete with low probability for approval resulting in a further high risk for this option.

2.1.2 Worker Exposure Risk

Disposition decisions will be made giving full consideration to radiological and chemical hazards and their impact on the worker who must either repackage, treat, stabilize, ship or store surplus nuclear materials. The annual dose rate for workers must be calculated as well as a total exposure expected throughout the life of the program up until placed into a disposal facility. Where possible, the impacts should be quantified or costed.

Transfer to Tank Farms -	LOW
Coprecipitation With Drum Storage -	MEDIUM
Separation and Product Handling -	HIGH

Refer to discussion in section 2.1.1. Worker exposure risk is similar to the discussion on health and safety of the worker.

2.1.3 Risk Assessment

The risk of an accident and the potential exposure to the workers and public caused by an accident must be quantified. The risk assessment must be conducted for both radiological and chemical aspects through the life of the program.

Preliminary Discussion - Options are being considered for documentation of the safety basis for PUREX deactivation as discussed in reference 15. The current approved PUREX FSAR may be used. This approach would effectively bound the deactivation activities based on the operating risk authorized with the approval of the current FSAR. Preparation of a task evaluation would ensure that the risk associated with this activity is not only bounded by the operating safety envelope but is clearly defined as well. Alternative safety documentation approaches such as revision and resubmittal of the current PUREX FSAR chapters or development of a formal interim safety basis would require extensive preparation and approval time.

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Transfer to Tank Farms -

LOW

No risk assessment issues were identified for the transfer to tank farms option since this activity is already a normal procedure and is clearly bounded within the existing operating envelope. Transfers could immediately commence with full compliance with risk assessment requirements.

Coprecipitation With Drum Storage -

MEDIUM

No risk assessment issues were identified for this option, however additional documentation would be required. Packaging of transuranic drums is a normal activity within the PUREX facility and will be required for other deactivation activities. Process activities involving centrifuging and handling of process solids and solutions have been previously performed as well as loadout of plutonium nitrate solutions. These activities are considered to be representative of the risks associated with coprecipitation and drums storage. As a result, it is expected that the activities would fall within the existing operating envelope and could be addressed by a task evaluation. A USQ evaluation is already factored into the implementation schedule for this option.

Separation and Product Handling -

HIGH

Separation represents a high risk for risk assessment because of the reintroduction of hazards into the PUREX facility that have already been eliminated. A readiness review would be required and among the many issues that must be addressed would be solvent temperature controls and the potential for red-oil formation. Reactivation of many operational safety requirement (OSR) instruments would be required along with calibration and maintenance of the equipment and instruments.

2.1.4 Regulatory Concerns Risk

Each disposition option must take into account the applicable federal and state regulations and any associated compliance agreements. An evaluation must be made to determine whether each option will meet all regulatory commitments, and highlight the non-compliance risks and the impacts of missing commitments.

Preliminary Discussion - Specific waste treatment vessels are permitted under interim status at PUREX. Other vessels were not required to be permitted for processing activities or solution handling since they are not considered as treatment or storage vessels for storage of waste solutions. Coprecipitation with drum storage or other disposal options requiring waste treatment will be addressed through negotiated Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) Milestones. The milestone negotiation would thus provide a mechanism

for addressing the RCRA regulatory aspects for the necessary activities to occur. In addition, a draft evaluation was performed of the potential gaseous effluent based on historic air emissions from a normally operating plant. It was concluded that waste treatment of this material would not result in an increase in air emissions because of the low material content in the facility compared to previous operations (reference 14; Oestreich, 1993).

Transfer to Tank Farms - LOW

Low regulatory risk was identified for the transfer to tank farms option because the treatment activity is already included in the Part A permit and the treatment vessel (tank F18) is defined as a TSD vessel. Transfers could commence with existing procedures which are in full compliance with the existing regulatory requirements.

Coprecipitation With Drum Storage - MEDIUM

Medium risk was identified for the coprecipitation option because final approval must still be negotiated and approved with regulatory agencies in the Tri-Party Agreement. The regulatory process is addressing this option and includes the full scope of this new activity and the associated equipment to be installed.

Separation and Product Handling - HIGH

The regulatory issues for the processing option have not been defined but it is anticipated that a significant number of problems would result since the regulatory agencies have not been amenable to processing in the past. High risk is identified for the separation option because of the many issues and the low probability of success that would be associated with processing the material. As a result this option has not been pursued with regulatory agencies.

2.1.5 Waste Minimization Impact

The ratio between the volume of material currently in the inventory and the volume of waste which is expected to be generated is required for each option. The volume must take into consideration transportation and disposal criteria as applicable to individual waste packages.

Preliminary Discussion - Information is provided in order to provide a comparison of the waste generated from the disposition decision. Within the context of this evaluation the ultimate disposal waste volume is not considered in the rating for this category. A rough estimate of the ultimate disposal waste volume is provided for information.

Transfer to Tank Farms - LOW

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Minimal additional waste is produced with the transfer to tank farms option. The volume of the material currently in the two tanks compared to the net volume transferred to the tank farm is approximately equal. Other deactivation solutions will be used to dilute this material as necessary and waste volume reduction activities for the PUREX deactivation project are being implemented. Ultimate disposal would be completed by vitrification of the material as part of Hanford tank waste remediation and is estimated to add less than 0.1% to vitrification waste volume already required.

Coprecipitation With Drum Storage - MEDIUM

Coprecipitation represents a medium impact because a similar net volume of solution is transferred to tank farms and an additional quantity of drums (100-400) are generated which must be interimly stored at the TRUSAF facility at Hanford. Future repackaging activities would generate additional waste. New equipment (such as the centrifuge, screw conveyor and piping) will also be installed in the PUREX facility. This equipment will become contaminated and must be disposed of as solid waste. Ultimate disposal of the drummed material would be accomplished at the WIPP facility and would require approximately 400 drums to meet the criteria.

Separation and Product Handling - HIGH

Separation represents a high impact because of the extensive equipment repairs anticipated to startup the process and the additional sampling requirements. Additional waste would be generated to convert the plutonium nitrate solution. Ultimate storage of plutonium oxide material would result in approximately 4 small cans of waste oxide.

2.1.6 Stakeholder Interest Risk

The impacts on the stakeholders must be evaluated for each option. Stakeholders include: workers, unions, local communities (and Indian tribes), state and federal regulatory authorities. Stakeholders at disposal facilities, alternate sites for processing and along the transportation routes must be considered. The amount of stakeholder opposition should be estimated for each option.

Preliminary Discussion - Strong concern has been shown by public organizations and regulators for any options associated with activities which could be perceived as separations production at PUREX or other facilities at Hanford (or nation-wide). Activist groups want to prioritize cleanup to minimize potential impacts on the Columbia river and the area's water table.

Transfer to Tank Farms - LOW

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This option has no perception of plutonium separation, the plutonium is very difficult and costly to retrieve and complies with existing regulatory requirements.

Coprecipitation With Drum Storage - LOW

This option does not result in plutonium separation, the plutonium is difficult to retrieve and the activities can comply with regulatory requirements.

Separation and Product Handling - HIGH

Plutonium separation is poorly regarded because it is perceived as plutonium recovery for defense purposes.

2.1.7 Life-Cycle Cost

The cost for each option should be estimated. The cost should be life cycle cost and include the items as listed in section 2.2 of this report. (Refer to section 2.2)

Transfer to Tank Farms - LOW

Transfer to tank farms is rated low because existing procedures and specifications can be utilized and only minor piping changes within the PUREX facility are required. Existing operating costs can be used to implement this option.

Coprecipitation With Drum Storage - MEDIUM

Coprecipitation represents a medium cost because new equipment must be designed, procured, built, installed and tested. These costs are roughly estimated to be \$0.5-1 million to complete. In addition, there is an incremental operating cost of \$1-2 million for additional operators and time associated with this activity over the transfer to tank farm option.

Separation and Product Handling - HIGH

Separation represents a high cost because of the significant operating cost associated with training, testing, maintaining and operating the facility. This operating cost is roughly estimated at \$4-8 million. There is also an additional equipment cost for separations associated with repair of existing equipment (jumpers, pumps, agitators, pulsars) that is estimated at \$0.5-1 million. Startup costs would also be very high for processing operations due to anticipated readiness reviews and system complexity.

2.1.8 Disposal Criteria Risk

The waste acceptance criteria for individual waste packages must be met as well as taking into consideration overall disposal facility constraints such as volume and curie limits.

Preliminary Discussion - Information is provided in order to provide a comparison of the interim storage criteria required for the disposition decision. Within the context of this evaluation the ultimate disposal waste criteria (WIPP or vitrification) is not considered in the rating for this category.

Transfer to Tank Farms -

LOW

No disposal criteria risk was identified for interim storage of this material at tank farms because of the much greater quantities of this same material already stored in the tank farms and because existing procedures and specifications can be used to implement this option. The plutonium quantity represents less than 2% of the existing tank farm material and the uranium quantity represents less than 1% of the existing tank farm material. No waste compatibility issues were identified since the existing material is similar to the material to be transferred. Tank farm personnel are currently working on restart of the 242A evaporator to make additional space available. A transfer of 400,000 gallons from tank 105AW is being scheduled for April which would make room for disposal of PUREX deactivation wastes. Thus, PUREX deactivation activities are contingent upon evaporator operation and the 105AW transfer. Activities are ongoing to reduce the amount of waste volume required, however significantly more than the maximum volume required for dilution of D5/E6 material (~200,000 gallons) will be generated. The net volume of D5/E6 material transferred to tank farms is thus the nominal 7000 gallons of treated solution since the dilution material has already been allotted for transfer to tank farms. (Longterm waste disposal criteria by vitrification has been studied for many years and has been implemented in France and is in the process of implementation at Savannah River.)

Coprecipitation With Drum Storage -

MEDIUM

Meeting interim storage requirements at Hanford would require approximately 100 drums and would minimize the impact of available storage space at the TRUSAF facility. The controlling factor for this material would be the wattage content per drum based on WIPP requirements for gas generation. Repackaging of the material would probably be required at a future date to meet the fissile content per package but may be required anyway to meet the future waste form requirements. Coprecipitation represents medium risk because WIPP criteria may modify the waste form requirements, compliance with wattage limits must be verified, and modifications to the drum transport requirements must be addressed. (A specific WIPP-certifiable package

was established during the review process which could be approved and was constrained by the fissile quantity per drum. Approximately 400 drums would be required in order to meet the current WIPP requirements.)

Separation and Product Handling - HIGH

Separation represents high risk since the separated plutonium nitrate must be handled and converted to oxide. Operation of the Plutonium Finishing Plant at Hanford is highly questioned at this time and is likely to require an Environmental Impact Statement in order to assure full public dialogue on the issue.

2.1.9 Technical Risks

Any technology utilized in each of the options must be evaluated to determine the confidence level of success. Obviously, a decision maker will have more confidence in proven technology than a technology in basic research and development. The risk of using non-proven technologies must be evaluated.

Preliminary Discussion - Only proven technologies and unit operations are utilized for these options. Technical engineering support is a separate topic and affects the implementation time, risk assessment and worker exposure risk for the option considered. Ultimate disposal technology issues associated with waste forms for WIPP or vitrification are not discussed in this section. Since no basic research is required to implement these options, they are all rated low.

Transfer to Tank Farms -	LOW
Coprecipitation With Drum Storage -	LOW
Separation and Product Handling -	LOW

2.1.10 Implementation Time and Schedule Impact

The use of well established, simple technologies that could be readily implemented is to be encouraged.

Transfer to Tank Farms -	LOW
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Transfer to tank farms is rated low because existing procedures and specifications can be utilized and only minor piping changes within the PUREX facility are required. Completion of this activity within the current deactivation schedule is very likely and the potential exists for significant cost savings if the schedule can be reduced as a result of this activity and other critical path deactivation activities.

Coprecipitation With Drum Storage -	HIGH
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Coprecipitation represents a high risk for completion within the current deactivation schedule even though it was modeled in the deactivation plan. This activity will require significant time and engineering logistics to complete. New equipment must be designed, procured, built, installed and tested which requires interaction with outside organizations. Additional reviews or interactions with outside agencies is also identified in the following sections:

- 2.1.2 Worker Exposure Risk, additional evaluation of the risks identified could impact the schedule or the cost.
- 2.1.3 Risk Assessment, ongoing actions and DOE reviews could require additional documentation resulting in schedule impact.
- 2.1.4 Regulatory Concerns Risk, multiple regulatory agencies are involved with current negotiations.
- 2.1.8 Disposal Criteria Risk, interim waste storage criteria reviews (Transuranic Waste Certification Review Committee), longterm waste storage criteria requirements (WIPP), transport criteria modifications (SARP).

Separation and Product Handling - HIGH

Separation represents a high impact because of the extensive time to obtain approval and the associated high operating costs compared to the other options. Furthermore, equipment requirements and system modifications which are currently undefined must be identified, designed and implemented.

SUMMARY OF EVALUATION FACTORS FOR D5/E6 DISPOSITION			
EVALUATION FACTOR	TRANSFER TO TANK FARMS	COPRECIPITATION & DRUM STORAGE	SEPARATE PU
1. Health and Safety Risk	LOW	MEDIUM	HIGH
2. Worker Exposure Risk	LOW	MEDIUM	HIGH
3. Risk Assessment	LOW	MEDIUM	HIGH
4. Regulatory Concerns Risk	LOW	MEDIUM	HIGH
5. Waste Minimization Impact	LOW	MEDIUM	HIGH
6. Stakeholder Interest Risk	LOW	LOW	HIGH
7. Life-Cycle Cost	LOW	MEDIUM	HIGH
8. Disposal Criteria Risk	LOW	MEDIUM	HIGH
9. Technical Risks	LOW	LOW	LOW
10. Implementation Time and Schedule Impact	LOW	HIGH	HIGH
OVERALL RATING	LOW	MEDIUM	HIGH

2.2 COST EVALUATION FACTORS TO INCLUDE IN ENGINEERING STUDY

The evaluation factors and their description are taken directly from the reference 1 letter. Based on the initial presentation to the SMPP it was agreed that a detailed, quantitative study was not required for this disposition decision. The qualitative terms used to compare the evaluation factors are LOW, MEDIUM, and HIGH. These terms are applied only to the disposition options being considered in this report. As a result of using the methodology of comparison within these options, there will generally always be a HIGH and LOW rated option. This will always be the case unless an alternate basis of comparison is provided in the discussion.

It was construed from the reference 1 letter from the SMPP that "waste (1)" is considered to be waste generated during any processing activity resulting from the disposition decision of this material. An alternate definition of "waste (2)" can be construed from subsequent guidance provided by DOE-RL to WHC in a letter dated 11/10/93 (reference 3). This letter discusses treatment of plutonium material as waste on a case-by-case basis. Information is provided in this evaluation in order to provide a comparison of the "waste (1)" generated from the disposition decision. Ultimate longterm disposal cost of the material once transferred to interim storage (tank farms, TRUSAF, PRF) is considered in section 2.2.12. Once at interim storage this material is likely to be considered "waste (2)" and is addressed as such in that section.

2.2.1 Storage cost of material prior to processing.

Transfer to Tank Farms -	LOW
Existing tanks.	
Coprecipitation With Drum Storage -	LOW
Existing tanks.	
Separation and Product Handling -	HIGH
Additional time required resulting in additional operating cost.	

2.2.2 Storage cost of waste generated from processing activities while awaiting transportation to disposal facility.

Transfer to Tank Farms -	LOW
Existing storage space is available at PUREX.	
Coprecipitation With Drum Storage -	LOW
Existing storage space is available at PUREX.	
Separation and Product Handling -	HIGH
Additional waste from repair activities will be generated which must be removed from the facility prior to operating to assure crane accessibility.	

2.2.3 Storage cost of product awaiting transportation.

Transfer to Tank Farms -	NONE
Coprecipitation With Drum Storage -	LOW
Existing storage space is available at PUREX.	
Separation and Product Handling -	LOW
Existing storage space is available at PUREX.	

2.2.4 Cost for transportation of materials to alternate sites for processing.
(These items are all marked not applicable (n/a) because transportation of the existing material to another site for processing is not considered a viable option).

Transfer to Tank Farms -	n/a
Coprecipitation With Drum Storage -	n/a
Separation and Product Handling -	n/a

2.2.5 Cost for transportation of waste to disposal facility.

Transfer to Tank Farms -	NONE
Coprecipitation With Drum Storage -	LOW
Costs to transport waste to be disposed at Hanford low level waste burial grounds is low because existing systems are used.	
Separation and Product Handling -	LOW
Costs to transport waste to be disposed at Hanford low level waste burial grounds is low because existing systems are used.	

2.2.6 Cost for transportation of waste to interim storage facility.
(Costs to transport waste to Hanford interim storage facilities are low because existing systems are used).

Transfer to Tank Farms -	LOW
Coprecipitation With Drum Storage -	LOW
Separation and Product Handling -	LOW

2.2.7 Cost for transportation of waste to longterm storage facility.

Transfer to Tank Farms -	LOW
Minimal additional waste is produced with this option.	
Coprecipitation With Drum Storage -	MEDIUM
New equipment (such as the centrifuge, screw conveyor and piping) will be installed in the PUREX facility. This equipment will become contaminated and must be disposed of as solid waste.	
Separation and Product Handling -	HIGH
Extensive equipment repairs are anticipated to startup the process and must be disposed as solid waste.	

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2.2.8 Total projected costs for the construction of any new facilities or modifications to existing facilities for processing.

- Transfer to Tank Farms - LOW
Minor piping modifications within the PUREX facility are required.
- Coprecipitation With Drum Storage - HIGH
New equipment must be designed, procured, built, installed and tested. These costs are roughly estimated to be \$0.5-1 million to complete.
- Separation and Product Handling - HIGH
There is an equipment cost for separations associated with repair of existing equipment (jumpers, pumps, agitators, pulsers) that is estimated at \$.5-1.0M.

2.2.9 Operating cost of the processing facility.

- Transfer to Tank Farms - LOW
- Coprecipitation With Drum Storage - MEDIUM
There is an incremental operating cost of \$1-2 million for additional operators and time associated with this activity over the transfer to tank farm option.
- Separation and Product Handling - HIGH
Separation represents a high cost because of the significant operating cost associated with training, testing, maintaining and operating the facility. This operating cost is estimated at \$4-8 million.

2.2.10 Disposal cost at disposal facility; \$7000 per drum for TRU waste at WIPP, \$33 per cubic foot for low level waste at NTS.

- Transfer to Tank Farms - LOW
Minimal additional waste is produced with this option.
- Coprecipitation With Drum Storage - MEDIUM
New equipment (such as centrifuge, screw conveyor, piping) will be installed in the PUREX facility, will become contaminated and must be disposed as solid waste.
- Separation and Product Handling - HIGH
Extensive equipment repairs are anticipated to startup the process and must be disposed as solid waste.

2.2.11 Cost for processing which may include repackaging, actinide separation, or treatment of the hazardous waste constituent.

- Transfer to Tank Farms - NONE
Separation of the fissile material from the tank farm waste would be very costly but is not considered an option at this time.
- Coprecipitation With Drum Storage - HIGH
Repackaging of the drums to meet WIPP requirements would be costly and would be completed at the WRAP facility. Repackaging of the drums produced is likely to be necessary either to meet modified WIPP requirements or to repackage to existing requirements as a result of minimizing the storage drums at the interim storage facility (TRUSAF).
- Separation and Product Handling - HIGH
Significant operating cost is accrued to separate this material as identified in section 2.2.9.

2.2.12 Ultimate Longterm Disposal Cost.

- Transfer to Tank Farms - HIGH
Vitrification cost for this material transferred to tank farms is estimated to cost an additional \$4M based on an additional glass production of 14-25 metric tons as identified in Appendix E. It is assumed that the cost of a vitrification plant is provided by another project (tank waste remediation).
- Coprecipitation With Drum Storage - HIGH
WIPP disposal cost for coprecipitation is estimated to cost an additional \$3M based on 400 drums at \$7000 per drum as identified by the SMPP. It is assumed that the cost of the WIPP facility is provided by another project (WIPP).
- Separation and Product Handling - HIGHER
Separation costs is higher because either vitrification and/or WIPP costs will still be accrued along with the additional cost of processing the product nitrate.

SUMMARY OF COST EVALUATION FACTORS FOR D5/E6 DISPOSITION			
COST EVALUATION FACTORS	TRANSFER TO TANK FARMS	COPRECIPITATION & DRUM STORAGE	SEPARATE PU
1. Storage Cost of Material Prior to Processing	LOW	LOW	HIGH
2. Storage Cost of Waste Generated	LOW	LOW	HIGH
3. Storage Cost of Product Awaiting Transportation	NONE	LOW	LOW
4. Cost for Transport of Materials to Alternate Site	n/a	n/a	n/a
5. Cost for Transport of Waste to Disposal Facility	NONE	LOW	LOW
6. Cost for Transport of Waste to Interim Storage Facility	LOW	LOW	LOW
7. Cost for Transport of Waste to Longterm Storage Facility	LOW	MEDIUM	HIGH
8. Costs for Construction of New Facilities or Modifications	LOW	HIGH	HIGH
9. Operating Cost for Processing	LOW	MEDIUM	HIGH
10. Disposal Cost at Disposal Facility	LOW	MEDIUM	HIGH
11. Cost for Repackaging, Separations or Treatment of Hazardous Waste Constituent	NONE	HIGH	HIGH
12. Ultimate Longterm Disposal Cost	HIGH	HIGH	HIGHER
OVERALL COST RATING	LOW	MEDIUM	HIGH

SECTION 3

TECHNICAL DISCUSSION OF TRANSFER TO TANK FARMS OPTION

An evaluation was completed to determine the best method for transfer of the PUREX D5/E6 material to tank farms to meet requirements pertaining to criticality safety, batch and transfer concentrations, total waste volume projections and waste compatibility.

3.1 Receiving Tanks

Tanks 105AW and 102AZ were identified as the best candidates for receipt of the D5/E6 material. Issues pertaining to each tank are discussed below.

3.2 Criticality Safety Evaluation Discussion

This solution with either the U or Cd present represents a subcritical Pu matrix for any foreseeable concentration or coprecipitation mechanism. With the gross amount of cadmium present, the material would be infinitely subcritical even in the absence of the uranium. Without any cadmium present the Pu:U ratio is greater than that needed to be infinitely subcritical. Computer calculations for material reactivity have shown, however, that it would take 3 to 10 times the mass of plutonium present to reach the minimum critical mass at the existing Pu/U ratio without any cadmium. This also requires no other constituents and idealized waste form and configuration. Iron also acts as a neutron absorber and is present in large quantities in the solids of tank 102AZ (~65 metric tons). The airlift circulators, however, do not suspend the solids, thus the D5/E6 material would not be intimately mixed with the existing 102AZ solids. The presence of iron is in no way required to have a safe mixture for D5/E6 solids in any tank within the tank farm.

Resolution of the tank farm USQ pertaining to criticality safety is still being pursued. Resolution of this issue may be necessary as the 25 kg limit is approached for tank 105AW. Tank 105AW currently contains 15.8 kg of Pu. Addition of 9 kg Pu from the D5/E6 material would result in a total Pu content of 24.8 kg. Since tank 105AW must remain available for PUREX deactivation activities, this limit must either be addressed or an alternate waste tank identified for receipt of D5/E6 material. This issue would be addressed through the ongoing USQ process since an arbitrary reduction of the waste tank total plutonium content down to 25 kg was implemented from the previous limit of 50 kg. There has been no driving issue for changing this limit, however, until disposition of the PUREX D5/E6 material was discussed. Alternatively, tank 102AZ contains approximately 8.8 kg which would result in a total

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Pu content of 17.8 kg after receipt of the D5/E6 material. Preparation of a criticality safety evaluation report specifically addressing disposal methods for D5/E6 material is currently being pursued and an initial draft is included in the appendix. Completion of this activity is necessary in order to increase the plutonium batch size from <0.05 grams per gallon to <0.125 grams per gallon.

3.3 D5/E6 Batch Size

The D5/E6 material transfer batch size is currently limited to <0.05 gram per gallon per standard F18 waste batch (4000 gallons nominal / ~200 grams per batch). This would result in approximately 50 waste transfers and a total volume of 200,000 gallons. Once the CSER is approved the D5/E6 material batch size would be limited to <0.125 gram per gallon per standard F18 waste batch (~500 grams per batch). This would result in approximately 20 waste transfers and a total volume of 80,000 gallons. Uranium concentration was also discussed. Previous documentation was discussed which recommends that uranium waste solutions be diluted to 35 grams U per liter or less prior to neutralization and subsequent transfer to 105-AW (see reference 6). This would result in approximately 10 transfers and a total volume of 40,000 gallons but would require a plutonium concentration of 1000 grams per batch. This amount is not being requested in the CSER, thus the <500 grams Pu per batch is the optimum batch size for D5/E6 material.

3.4 Waste Volume Discussion

Tank farm personnel are currently working on restart of the 242A evaporator to make additional space available. A transfer of 400,000 gallons from tank 105AW is being scheduled for April which would make room for disposal of PUREX wastes. Thus, PUREX deactivation activities are contingent upon evaporator operation and the 105AW transfer. In addition, space availability in 102AZ, if used, will be contingent upon the 242A evaporator restart so that condensate can be routed to an alternate tank. The Operational Waste Volume Projection document identifies 3 evaporator campaigns with a corresponding waste volume reduction of 8 million gallons. Three transfers from tank 105AW are also identified totaling approximately 800,000 gallons. The first two transfers totaling ~500,000 gallons are shown during third quarter of FY '94 with the third transfer of ~300,000 gallons shown during the first quarter of FY '95. Completion of these transfers will support the ongoing PUREX deactivation activities. See attachments 3-1 and 3-2 for supporting information on the waste volume projections.

Activities are ongoing to reduce the amount of waste volume required, however significantly more than the maximum volume required for D5/E6 dilution (~200,000 gallons) will be generated. The net volume of D5/E6 material transferred to tank farms is thus the nominal 7000 gallons of

treated solution since the dilution material has already been allotted for transfer to tank farms. The total tank farm waste volume for PUREX deactivation is thus not impacted by the disposition decision to transfer the material directly to tank farms or coprecipitation and storage into transuranic drums. The dilution material used will depend upon several independent factors such as a) handling of recovered acid at PUREX, b) operation of F11 concentrator at PUREX for volume reduction of dilute material, c) availability of routes at PUREX, d) acid concentration of flush solutions at PUREX. Deactivation activities will generate 1.3 million gallons of solution which can be reduced to approximately 350,000 gallons with volume reduction activities (see attachment 3-3 for supporting information). The waste solutions generated at PUREX must be properly managed to provide dilution capability for the D5/E6 activity.

3.5 Waste Compatibility Discussion

Waste compatibility must be evaluated by tank farm personnel. A memorandum from DOE-HQ, EM-64 identifies the need for further review of the Waste Compatibility Program. The memo identifies that mixing of the actual waste would seem prudent as a final step after characterization information has determined that the wastes appear to be compatible. Actual mixing and testing of samples would present a significant hazard if samples of 102AZ were required. It was pointed out that this material is no different than what has already been shipped to tank farms in the past and is similar to the material already stored in the anticipated receiving tanks. Previous waste compatibility assessments of similar material have been completed and identified no waste compatibility issues (Reference 18). Further discussion of this topic is included in Reference 19 and recommends "taking a graded approach to conducting actual mixing studies out of consideration for ALARA principles and the goal to conduct business in a cost effective manner".

3.6 Tank 105AW Issues

- A. Slurry Distributor - The slurry distributor would have to be moved after each transfer. This does not present a problem.
- B. 25 kg Pu limit - If the entire D5/E6 material were transferred into 105AW, then the current limit of 25 kg per tank would be approached and must be addressed.
- C. Waste Volume - Additional space will be available after the transfer of 400,000 gallons currently scheduled for April of '94.
- D. Routing - Does not present a problem since this is the standard PUREX waste routing.

3.7 Tank 102AZ Issues

- A. The 102AZ transfer route presents a problem. It has not been used since neptunium material was transferred from F18 to 102AZ. Since then the AR vault HVAC system has failed and has not been repaired. Since any leak that could potentially occur would drain into an AR vault tank it would be necessary to repair and restart the AR vault HVAC system. Repair of these fans would need to be identified as a high-priority activity.
- B. A waiver would be required for the 90-day rule for transfers to address tank bump concerns. This rule was defined when Hanford was generating high heat waste and is defined as an operating specification in OSD-T-151-00017, limit 17.3.3. The rule was defined to insure that solution transfers would not insulate existing solids and result in high sludge temperatures. This rule does not present a problem now and a waiver has been granted by tank farm operating personnel in the past.
- C. The air lift circulator could be turned up to increase evaporation. This would increase the available space if the condensate were routed to another tank in AP farm for use as evaporator feed. Space is not available in the AP farm to receive any condensate until after the evaporator is restarted.

Note: Increasing the air-lift circulator rate provides minimal suspension, if any, of solids in the tank. Minimal mixing of the transfer material with the existing solids will occur as a result of the air-lift circulator action.
- D. Space availability in 102AZ will be contingent upon the 242A evaporator restart so that condensate can be routed to an alternate tank.
- E. Solids level evaluation will be necessary to show that no problem will result.

3.8 Sampling Requirements

Protocol sampling may be required and can be accomplished if necessary. This material is no different than what has already been shipped to tank farms in the past and for which protocol sampling has already been completed. Previous production activities were also the basis for addressing any regulatory and safety analysis issues pertaining to PUREX deactivation activities. At the most, the D5/E6 material will represent only 7% of a neutralized batch since dilution is required with existing column flush solution. The column flush solution and recovered acid waste are included in the current waste volume projection of 1.5 million

gallons of tank farm waste projected and allotted for PUREX deactivation activities.

3.9 Transfers Within PUREX: Using Tank F8 For Dilution

To make transfers of D5/E6 material to tank farms considerable dilution of the material will be required to reduce the plutonium content per standard batch and to reduce the uranium content below 35 g/l. If limited to < 200 grams Pu per F18 batch, approximately 110 gallons of D5/E6 material would be required which equates to approximately 1 corrected weight factor. Even a 500 gram per batch limit would only allow D5/E6 transfers of 2 1/2 corrected weight factor. In lieu of installing and calibrating a batch flowmeter, F8 could be used to dilute the material to a larger batch size. This would allow larger transfers of D5/E6 material to F8 as well as allow a reasonable batch size for F8 to F18 transfers. Since further dilution to 4000 gallons will occur in F18, the dilution amount is not important other than to define a desired batch size for D5/E6 or subsequently for F8. For example, if an F8 to F18 batch size of 500 gallons is selected (approximately 5 corrected weight factor from F8) then 8 batches of material could be prepared in F8 to obtain 4000 gallons. This would allow transfers of approximately 8 corrected weight factor from D5/E6 (at 200 grams per batch). This results in a much more manageable batch size for D5/E6 and subsequently F8. Dilution material (column flush solution or denitrated recovered acid) will be collected in F10 where it can be used to dilute material in F8 and F18. Other tanks were considered for possible use as a dilution tank, such as F13 or F16, but F8 was selected based on available routes.

To briefly summarize, tank F8 will be used as an intermediate dilution tank. For batches of < 200 grams, it is necessary to dilute D5/E6 material by a factor of ~36. For batches of < 500 grams, it is necessary to dilute D5/E6 material by a factor of ~15. We are not pursuing a lesser dilution factor because of the uranium concentration and also to lessen the probability of a localized accumulation in the tank farm tank (though this is not an issue). Rather than perform the dilution in one tank, F18, the dilution will be performed in two tanks, F8 and F18. This allows control of the transfer volumes using the existing weight factor instrumentation and negates the need for a batch flowmeter.

The routes required to execute this activity are identified below. The necessary flexes of required length and nozzle size must be identified and their availability determined. If unavailable, flexes or other equipment should be immediately ordered.

The following routes are required:

- ex. - indicates an existing jumper
- hpt - indicates hot pipe trench piping

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- I. E6 to F8 modify F8 to E6 route and use E6 to H1 JGV and a portable jet to ET21A. (existing E6 to H1 jet removed)
E6 --> ET21A-ET21---FT111 --> F8
ex. hpt
- II. D5 to E6 existing pump route.
D5 --> DT3---ET29 --> ET39---ET4 --> E6
ex. hpt ex. hpt ex.
or
D5 to F8 install portable jet and use existing route in place.
D5 --> DT11---AT10 --> AT5---FT119 --> F8
hpt ex. hpt ex.
- III. F10 to F8 use F10 pump and connect flex from discharge over F9 condenser position to F8, a portable jet would also work but an available JGV is questionable. F10 --> F8
- IV. F10 to F18 existing jet in place. F10 --> FT101---FT6 --> F18
ex. hpt ex.
- V. F8 to F18 use F8 to E6 jet and move existing flex discharge from FT111 to FT128A (a longer flex may be required). The F18 to F13 route must be removed in order to install this route.
F8 --> FT128A---FT70 --> FT68---FT7 --> F18
ex.? hpt hpt
or
F8 to F18 use F8 to E6 jet and move existing flex discharge from FT111 to FT118. This route is not preferable compared to the alternate above because the F18 to 102AZ route will use the same nozzles as this route.
F8 --> FT118---FT27 --> FT37---FT13 --> F18
ex. hpt hpt
- VI. F18 to UGS existing route goes to 105AW. It is proposed to route this material via the NCAW route to 102AZ. This option would utilize a portable jet installed in F18 with the steam supply installed to the F16 jet controller nozzle at FG31 and the jet discharge to FT13 and a hairpin connection at F16. This route was installed for the J2 neptunium solution per CCO 92-007. F18 --> FT13---FT37 --> FT39A --> 102AZ
hpt

The following equipment for new canyon routes will be required:

Portable Jets (3) - E6 to F8, F18 to 102AZ,
+ spare (D5 to F8, F10 to F8 or other)
Flexes or jumpers (6) - minimum, each of various length and nozzle size

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The following existing equipment and ancillaries will be used:

Pumps	D5 and F10
Agitators	D5, E6, F8, F18
Jets	F10 to F18, F8 to F18, F18 to UGS, D5 to F8 (alt.)
JGV	JC-F10-1 , JC-F8-1 , JC-F16-2 , JC-D4-2 to DG14 (alt.), JC-E6-1 (or -2) for E6 to F8

ATTACHMENT 3-1 Dilute Receiver Tanks and Evaporator Operations
WHC-SD-WM-ER-029 Rev. 18

ATTACHMENT 3-2 PUREX Facility Waste Generation and Tank Levels

WHC-SD-WM-ER-029 Rev. 18

**FORECASTED POTENTIAL PUREX LIQUID
VOLUMES FOR DEACTIVATION**

LOCATION	VOLUME TO TANK FARMS DIRECT NEUTRALIZATION (GAL)	VOLUME TO TANK FARMS AFTER PROPOSED TREATMENTS (GAL) (INCLUDES CO-PRECIPITATION)	VOLUME TO TANK FARMS AFTER PROPOSED TREATMENTS (GAL) (D5/E6 NEUTRALIZATION)	VOLUME TO TANK FARMS AFTER PROPOSED TREATMENTS (GAL) (WITH OFFSITE HNO ₃ SHIPMENT)
Tanks D5 and E6	253,000 ⁽¹⁾	7,000	253,000 ⁽¹⁾	253,000 ⁽¹⁾
Tanks P2, P3, P4 and P14	288,000	190,000	Included in D5-E6	None ⁽²⁾
Tanks U1 and U2	45,000	30,000	Included in D5/E6	None ⁽²⁾
Flush solution (canyon vessels)	550,000	25,000	Included in D5-E6	Included in D5-E6
Canyon vessels (various)	55,000	13,000	Included in D5/E6	Included in D5/E6
Tank P1	96,000	25,000	Included in D5-E6	Included in D5-E6
Tank P4	32,000	32,000	32,000	32,000
Slug storage basin	53,000	10,000	Included in D5/E6	Included in D5/E6
TOTALS (gross)	1,372,000 ⁽³⁾	332,000	285,000	285,000
TOTALS (5M Na Basis)	470,000	53,000	56,000	7,200

- (1) 200 grams plutonium per batch basis.
- (2) Water substituted for D5/E6 dilution.
- (3) Waste volume projection 1,500,000 gallons.

SECTION 4

TECHNICAL DISCUSSION OF COPRECIPITATION AND STORAGE IN DRUMS OPTION

An evaluation was completed to determine a suitable waste package for the PUREX facility D5/E6 material to meet requirements for packaging, shipping, storage and regulatory issues.

4.1 WIPP Shipping Category and Wattage Limit

It was determined that the appropriate wattage limit could be applied based on TRUCON shipping category I.2 which has a bounding G-value of 1.3. With zero layers of sealed plastic the allowable wattage limit is 0.2536 watts per drum.

4.2 Fissile Content Per Package

Significant discussion pertained to how much plutonium or fissile material is allowable per drum. Cadmium is present as a neutron absorber in the waste matrix at a Cd:Pu ratio greater than 3:1. Uranium at ~0.95% enrichment is present at a U:Pu ratio of greater than 300:1. These components make this waste matrix infinitely subcritical based on the fissile content. In the packaging, transport and storage documents, however, the fissile content is used to evaluate other parameters other than criticality prevention, such as gas generation or health risk. Thus, the allowable fissile content may be much lower for this package than 200 grams based on these other considerations. As a result, an exemption will not be granted for the allowable fissile content based on criticality considerations alone. The criticality considerations must be documented but the other aspects must be looked at.

Discussions concluded that WIPP criteria is unlikely to be relaxed from the 200 grams fissile material per drum including the U-235 content. Other sites have tried to get an exemption for uranium content with borated or cadmium-laden material and have been unsuccessful. The fissile content of this package will thus be the limiting criteria to meet the WIPP requirements. The number of drums would thus be significantly increased (~3x) to meet this requirement.

The drum interrogation method may also reduce the allowable fissile content since a positive 2-sigma error factor must be applied to the value assigned to the drum. With the high density solids present and the uranium self shielding the error value for the Pu gram quantity could be high. It would thus be prudent to target a fissile quantity of 150 grams per drum to meet the WIPP requirements. An assigned fissile quantity based on analytical results of the material prior to

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precipitation would allow a better characterization of the material. In addition, the normal drum interrogation method (SGSAS) is setup to measure plutonium-239 content and not uranium content.

In addition, WHC packaging requirements limit the amount of fissile material per drum to <100 grams for those packages where the fissile material is contained within less than 20% of the drum volume. This requirement would now be applicable since the precipitated solids would occupy less than 10 gallons of the 55 gallon drum space. This would result in a further increase in the quantity of drums required (~2x).

4.3 Batch Size Per Drum

It was suggested by the WHC transuranic waste representative that 3 cases should be defined for the PUREX D5/E6 material as identified below:

A. WIPP Certifiable - (Fissile Quantity Controlled) - 394 Drums

This case would produce a WIPP certifiable package based on existing criteria. The batch size would be limited by the total fissile quantity with a target value of 150 grams +/- 2-sigma including U-235. This package would minimize the possibility of having to repackage the drum at a future date at the WRAP facility. Some risk still exists because the waste form required for WIPP may change. For example, polymer encapsulation or grout stabilization may be required for process solids or particulate. This processing activity would be performed at future WRAP facilities. (Refer to the tables 4-1 through 4-6 for calculation of the number of drums.)

B. Baseline Case - (Wattage Controlled) - 86 Drums

This case would produce a package that would meet most of the WIPP criteria except for the fissile quantity per drum. As stated previously the uranium and plutonium in this matrix (<0.95 wt% U-235) is subcritical for any precipitation mechanism since the total fissile material is well below the minimum critical mass for this material. The addition of cadmium provides additional criticality safety and results in an infinitely subcritical matrix. The basis for transport of this material at Hanford would be provided by an ongoing criticality safety evaluation. Approval by DOE-RL would be required for transport and storage of this material based on the CSER. The controlling factor for this material would be the wattage content per drum based on WIPP requirements for gas generation (this would thus also meet Hanford requirement for gas generation). It was determined that the appropriate wattage limit could be applied based on TRUCON shipping category I.2 which has a bounding G-value of 1.3. With

zero layers of sealed plastic the allowable wattage limit is 0.2536 watts per drum (refer to the tables 4-1 through 4-6 for calculation of the number of drums). Repackaging of the material would be required at a future date to meet the fissile content per package but may be required anyway to meet the future waste form requirements. This case appears to be a very reasonable course to pursue based on (1) meeting gas generation criteria, (2) the ongoing criticality safety evaluation to address the fissile content, (3) future WIPP waste form requirements and (4) minimizing interim waste storage space requirements.

C. Maximize Solids Per Drum - (Minimum Storage Volume) - 44 Drums

This case would produce a package which minimized the number of drums. The controlling factor would be the amount of solids that could be packaged within a 55 gallon drum with a 90 mil liner. The amount of absorbent would be optimized based on the calculated liquid retention (which would be determined by solid-liquid separation efficiency, assuming centrifugation). This package would exceed WIPP and WHC criteria for (1) fissile quantity (1340 grams versus 200 grams), and (2) the wattage limit for gas generation (0.495 watts per drum versus 0.2536 watts per drum). Excluding the amount of U-235 the fissile gram equivalence per drum would be 194 grams. This case is not considered feasible because of the substantial criteria waivers required but determines a minimum bounding case for the number of drums required for comparison purposes. (The number of drums was calculated by using 40 gallons of solids per drum and an estimated 4 gallons of absorbent per drum. An estimated solid-to-liquid conversion ratio of 1:3 was used which results in a bulk solids density of approximately 2.2 g/cc. The amount of absorbent required and the bulk solids density after centrifugation must be confirmed by laboratory work.)

4.4 Americium Buildup

Americium buildup should be included in the curie and watt content based on 2 half-lives of decay of plutonium-241 (28.8 years). Thus, 20 years into the future if repackaging is accomplished the wattage requirement to meet gas generation criteria will still be met. This would increase the number of drums from the baseline case from 86 drums to 103 drums (refer to tables 4-1 through 4-6 for calculation of the number of drums).

4.5 Gas Generation

Gas generation calculations could limit the amount of fissile material per drum to 6-7 Pu-239 fissile gram equivalents (FGE) depending on the

packaging method. Hanford has recognized that larger quantities of fissile material per package is currently necessary in order to reduce the number of drums stored at Hanford facilities.

The gas generation rate for this material is not known but is expected to be relatively low. The container will be vented by a vent clip or Nucfil[®] filter to release any gases/pressure that may be generated in the waste package. Estimations can be made based on a gas generation rate of 0.06 ft³/kw-hr of beta-gamma radiation energy (ref. 4) or 0.56 molecules per 100 eV for alpha radiolysis (ref. 5). The second value is well below the bounding G-value of 1.3 molecules per 100 eV for the TRUCON shipping category I.2. If actual data is required then testing of the material would have to be identified and completed.

Uranium must also be considered since U-235 has a Pu-239 FGE correction factor of 1. There is 50 kg of U-235 in this waste material compared to 9 kg of Pu. The amount of uranium would thus significantly impact the number of drums if a 1:1 gram equivalence is used. Subsequently it was determined that if the plutonium equivalence of uranium is based on the curie content rather than the gram content then the impact would be negligible since the half-life of U-235 is 7×10^8 years versus 24,000 years for Pu-239. This would provide a more realistic equivalence of the alpha particle production which relates to the gas generation.

4.6 Moisture Content

No free liquids are allowed. The solids need to be as dry as possible. Solid-liquid separation must be performed to minimize the amount of liquid present. Centrifuging appears to be the best option. Absorbent must also be used to ensure that any liquid that will separate from the solids over time will be absorbed and thus not remain as a free liquid. The absorbent is not required to be intimately mixed with the solid material, but can be placed in the bottom of the container in an amount equal to twice the volume of liquid that could be present. The solid waste material is then placed on top of the absorbent. Further discussion pertained to the potential for separation and pocket formation of liquid within the solid waste, such as interstitial liquid within the tank farm waste. It was stated that any free liquid that separates out must be readily absorbed. The waste drum must be able to pass a radiographic test (RTR) that shows no free liquid is present nor pockets of liquid in order to be certified as waste. This implies that in order to be readily absorbed the absorbent must be mixed with the waste or the waste must allow the liquid to drain to the bottom of the package where the absorbent is present. Since the waste matrix will be a solid cake that could form pockets that do not drain, it is suggested to mix absorbent with the solid. Intimate mixing, such as mixing or container rotation is not required. A layered approach or a screw conveyor would serve the required purpose. Alternatively, it can be

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shown through laboratory testing of the waste form or engineering evaluation of the waste form that the requirement will be met.

4.7 WIPP Requirements

It is the intent of WHC and the Transuranic Waste Certification Review Committee to meet the packaging requirements for WIPP. The waste form matrix for WIPP packages has not been defined as yet. Any repackaging would be performed at the WRAP facility. Packaging requirements are primarily identified in the TRUPACK II confinement code document (TRUCON, DOE/WIPP 89-004, Rev. 3). Minor adjustments to these requirements have been made at Hanford because it is recognized that larger quantities of fissile material per package is currently needed in order to reduce the number of drums stored at Hanford facilities.

4.8 TRU Drum SARP Applicability

The TRU Drum SARP, SD-RE-SAP-033, is suitable for use for packaging and transport of this material. It was specifically identified that this SARP has a high priority for review in CY 1994. The dose consequences and health risk assessment of the hypothetical accident conditions for this SARP will significantly impact the allowable quantity limits currently in the SARP. For example, the allowable fissile quantity per drum (currently 400 grams fissile per drum) is likely to significantly drop as a result of this evaluation. Basically, if the packaging requirements for interim storage can be met, then the packaging requirements for transport can be met.

4.9 Containment & Packaging

The outer containment shall be provided by DOT 7A Type A Specification 17C/UN1A2 galvanized 55 gallon drums. The secondary containment shall be a 90 mil high density polyethylene (HDPE) rigid liner. These provide two confinement barriers and meet the requirements for packaging and shipping (see figure 4-1). These two barriers are also vented, thus they are not sealed barriers. An inner container was identified by operating personnel as necessary for contamination control and handling activities by personnel. This can also be properly vented. A horse-tailed plastic bag is considered a sealed barrier and thus would serve to reduce the allowable quantity of gas generating material. If the plastic bag is not horse-tailed or a positive vent provided then it would not be considered a sealed barrier. It is currently envisioned that an inner container will be used similar in design to a 90-mil liner with a snap on lid. This container will be properly vented. Plastic draping will be used in a manner to prevent contamination of the external surface of the inner container. If the plastic is placed in the inner container prior to closure, the plastic will not be sealed.

4.10 Dose Rate

The dose rate requirement is 100 mrem/hr at contact. Packaging up to 200 mrem/hr at contact is not accepted. It is recommended that the solids should be washed to help remove soluble cesium and reduce the dose rate of the material. This will reduce operator exposure during packaging and future handling and addresses ALARA requirements. A wash cycle will be incorporated into the solids separation process (centrifugation). Initial ISOSHIELD calculations were performed to verify that this dose rate limit could be met. The results indicated a maximum dose rate of 110 mrem at contact (70 mrem at 1 meter) based on 30 gallons of unwashed sodium diuranate solids with twice the maximum measured cesium content (Appendix F).

4.11 Cadmium

The presence of cadmium does not present additional packaging or transport problems. Basically the required packaging and shipping for transuranic material will be required with additional labeling requirements. The TRU drum SARP is acceptable for use with radioactive mixed waste.

The cadmium content requires the waste to be designated as extremely hazardous per WAC-173-303. The total amount of 100 kilograms is estimated based on laboratory results and a knowledge of the amount of cadmium nitrate solution used for the plutonium cleanup activity. The cadmium is used as a neutron absorber and was added as part of normal criticality specification requirements and normal operating procedures for collection of material in the tanks identified. Removal of the cadmium from the waste matrix is not practical.

4.12 Immobilization

The immobilization requirement does not require additional processing for this material. As long as the material is in a solid form and essentially dry then the material matrix will be acceptable. When WIPP criteria is defined in future years, the waste matrix will have to be evaluated at that time. Any processing activity would be performed by the WRAP facility.

4.13 Destination

This material will be stored in the TRUSAF facility as opposed to the Central Waste Complex. There are too many curies per package to store in the CWC. Space is currently being made in the TRUSAF facility by moving low curie content packages to the CWC.

4.14 Absorbent

The proper absorbent material will be specified according to solid waste acceptance requirements. A suitable absorbent was not defined at this time.

4.15 pH

To avoid issues pertaining to hazardous waste regulations and longterm package corrosion, keep the pH of precipitated solution below 12.5 pH. Solids should have a basic pH, 7.0-12.5. The solids wash will also reduce the pH of the separated solids.

4.16 Regulatory Issues

Specific waste treatment vessels are permitted under interim status at PUREX. Other vessels were not required to be permitted for processing activities or solution handling since they are not considered as treatment or storage vessels for storage of waste solutions. Coprecipitation with drum storage or other disposal options requiring waste treatment will be addressed through negotiated Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) Milestones. The milestone negotiation would thus provide a mechanism for addressing the RCRA regulatory aspects for the necessary activities to occur. In addition, a draft evaluation was performed of the potential gaseous effluent based on historic air emissions from a normally operating plant. It was concluded that waste treatment of this material would not result in an increase in air emissions because of the low material content in the facility compared to previous operations (reference 14; Oestreich, 1993).

4.17 Weight

Initial calculations indicate that the SARP limit of a maximum gross weight of 700 pounds per drum can be met. It is estimated that 20 gallons of solids would weigh approx. 250-350 pounds depending on the average bulk density.

4.18 Miscellaneous Requirements

- A. Additional packing can be provided to reduce movement of the inner container within the drum.
- B. Surface Contamination - Can meet non-smearable requirements
- C. No pyrophoric material nor compressed gases
- D. Labeling and Marking per section 3.7 and 5.7 of reference 8 can be met
- E. Documentation per section 3.8 and 5.8 of reference 8 can be met

4.19 Processing and Packaging Summation

- A. Define batch quantity based on plutonium content and solids quantity of inner container
- B. Place layer of absorbent in bottom of inner container (manual)
- C. Install inner container in discharge position for collecting material (manual)
- D. Batch caustic addition to precipitate waste (remotely operated vessel)
 - i. Control of caustic flow and batch size required (batch flowmeter, piping and jumper)
 - ii. Keep pH below 12.5 or wash solids in centrifuge
 - iii. Agitation and sample capability required
- E. Solid-liquids separation, (centrifuge)
 - i. feed pump and piping tie-in required from precipitation vessel to centrifuge
- F. Wash solids for dose rate reduction (centrifuge)
 - i. Centrate collected and returned to precipitation vessel
- G. Continuous discharge capability of solids (centrifuge) with controlled addition of absorbent (hopper with manual addition)
- H. Mix and transport solids and absorbent mixture to inner container,
 - i. A screw conveyor could be used to meet both requirements.
 - ii. Minimize contamination of inner container
 - iii. Use plastic for contamination control but don't seal plastic
 - iv. Temporary stop and holdup capability required for solids
- I. Close inner container,
 - i. Properly vent
 - ii. Keep outside of inner container essentially free of external contamination
- J. Place absorbent in bottom of 55 gallon drum, if necessary (manual)
- K. Place 90 mil liner in 55 gallon drum (manual)
- L. Place layer of absorbent in bottom of 90 mil liner (manual)
- M. Move inner container from discharge position to 90-mil liner,
 - i. Handling mechanism (hoist) and fixtures on inner container required, (design)
 - ii. Install new inner container in discharge position (manual)
- N. Install packing to reduce inner container movement (manual)
- O. Close 90 mil liner, properly vent (manual)
- P. Close 55 gallon drum, properly vent (manual)
- Q. Label drum properly for TRU/RMW (manual)
- R. Complete documentation
- S. Within 90 days of filling, transfer drums to TRUSAF for storage

4.20 Centrifuge Requirements

The following features are necessary or desirable for the proposed centrifuge and availability was verified through vendor information:

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- A. Continuous operation, solids discharging centrifuge
- B. Configuration for ease of absorbent addition and mixing
- C. Automatic wash cycle,
- D. Portable size, mounted on skids for ease of location into M-cell
- E. Similar to 5 hp motor maximum with near micron separation capability
- F. Feed rate up to approximately 5 gpm
- G. Centrate collection and return to precipitation vessel

4.21 Containment Requirements

Health and safety criteria requires that containment barriers must be present to protect the worker. Direct exposure of the material to the operators is necessary because solids handling equipment may become plugged or require maintenance, the total quantity of precipitated solids in the inner container must be verified, proper closure verified, and packaging and venting verified. Containment provisions could extensively reduce the potential for worker exposure to contamination but must be balanced against the increased cost and time to implement this strategy. A glovebox arrangement is not readily available for this activity which could house the required equipment. Alternate handling methods may impact the ability to meet waste storage criteria. An ALARA evaluation is already factored into the implementation schedule for this option. To reduce the risk to workers the costs and implementation time will increase. To reduce worker exposure the centrifuge process can easily employ a wash cycle to reduce the dose rate. The dose rate from this material is already expected to be fairly low based on ISOSHIELD calculations of the unwashed sludge (Appendix F).

4.22 Possible Locations

A. TK-M1

Perform precipitation in TK-M1 and install solids handling equipment near TK-M1. Complete packaging in the Hot Shop. A route from the canyon to TK-M1 does not exist but one can be designed and installed (an example is provided below). Minimizes crane involvement in solids handling. An agitator must be installed in TK-M1 and the pump operation verified. Centrifuge equipment will be contact handled and maintained with a remote start feature. This alternative is preferred because the solids handling equipment does not have to be designed for remotability. The activity is also performed in M-cell where containment barriers can be designed and erected and the impact of any contamination incident is minimized and readily corrected. The risk to facility workers must be evaluated for this option because of the contamination potential within the M-cell area.

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TK-E6 to TK-M1 route:

TK-E6 to nozzle E-T2, via new jumper, use E6 jet
nozzle E-T2 to nozzle K-T6, via hot pipe trench, line #K129
nozzle K-T6 to nozzle K-T2, via new hairpin jumper
nozzle K-T2 to nozzle L-T6, via hot pipe trench, line #L216
nozzle L-T6 to nozzle L-P29, via new jumper
nozzle L-P29 to nozzle L-P82 via L-cell Package
nozzle L-P82 to nozzle L-G4, via new jumper
nozzle L-G4 (P & O) to nozzle M-G4 (P & O), new piping in P & O
nozzle M-G4 to TK-M1, via new jumper
An intermediate batch tank or batch flowmeter may be required

B. TK-K6

Perform precipitation in TK-K6 and install centrifugation equipment near TK-K6. Complete solids handling and packaging in the Hot Shop. The route from E6 to K6 exists with minor jumper changes. The remote crane is required for moving solids to the Hot Shop. Crane maintenance and operations will have a significant impact and conflict with deactivation activities could result. Design of the centrifuge equipment must incorporate features of remote operation.

C. TK-E6

Perform precipitation in TK-E6 and install centrifugation equipment near TK-E6. Complete solids handling and packaging in the Hot Shop. The route from E6 to K6 exists with minor jumper changes. The remote crane is required for moving solids to the Hot Shop. Crane maintenance and operations will have a significant impact and conflict of deactivation activities could result. Design of the centrifuge equipment must incorporate features of remote operation.

D. Sample Gallery

Use the E6 load-in station in the sample gallery and use existing piping penetrations to this location. Piping and remote jumpers must be designed and installed to connect to tank E6 and a pump installed. Precipitation would be performed in TK-E6 and the slurry would be pumped to the solids handling equipment located in the sample gallery. Packaging of the solids would be completed in the sample gallery. This location minimizes crane involvement with solids handling. Pump and agitator operation in Tk-E6 must be verified. Centrifuge equipment will be contact handled and maintained with a remote start feature. Containment barriers and ventilation must be designed and installed in the sample gallery.

D5/E6 MATERIAL EQUIVALENCE PER LITER OF SOLUTION					
ISOTOPE	Pu-239 FISSILE GRAM EQUIVALENT (1) x (2)	PLUTONIUM EQUIVALENT CURIE CONTENT (1) x (3) x (4)	ALPHA CURIE CONTENT (1) x (5)	WATTAGE CONTENT (1) x (3) x (6)	PLUTONIUM CONTENT (grams)
Pu (6%-240)	.43	.0392	.0342	.00109	.45
Pu (12%-240)	.41	.0658	.0468	.00151	.45
Am-241	negl.	negl.	negl.	negl.	
Pu (6% @ 29 yr)	.42	.0418	.0408	.00129	.45
Pu (12% @ 29yr)	.39	.0765	.0725	.00234	.45
U-238	n/a	n/a	n/a	negl.	
U-235	2.52	negl.	negl.	negl.	
Cs-137	n/a	n/a	n/a	negl.	
TOTALS / LITER (6%-240)	2.95	.0392	.0342	.00109	.45
TOTALS/ 232 L. (6%-240)	685	9.1	8.0	.2529	105

TRUCON WATTAGE LIMIT PER DRUM:
SHIPPING CATEGORY BOUNDING G-VALUE LAYERS OF PLASTIC

		0	1	2	3	4
I.2	1.3	0.2536	0.2212	0.1962	0.0573	0.0418
I.3	0.4	0.8241	0.7189	0.6375	0.1863	0.1359

1.

Using 0.2536 watts allowable per drum, TRUCON will allow 232 liters (.2536/.00109) of solution.
This is equivalent to 86 drums at 105 grams Pu per drum.
(~20 gallons of solids per drum at 3:1 liquid to solid volume reduction)

2.

Using the same wattage limit with plutonium-241 decayed by two half-lives (28.8 yrs), TRUCON will allow 196 liters (.2536/.00129) of solution. This is equivalent to 103 drums at 88 grams per drum.

3.

Total FGE equals 59,000 grams (2.95 x 20,000). This results in 394 drums at 150 FGE per drum.

D5/E6 MATERIAL EQUIVALENCE CONVERSION FACTORS							
ISOTOPE	(1) * AVE. CONC. g/l	(2) FGE CORR. FAC.	(3) CURIE SP. ACT. Ci/g	(4) PE-Ci CORR. FAC. (PE-Ci/g)	(5) ALPHA SP. ACT. alpha Ci/g	(6) WATTAGE CONVERSION w/ci (w/g)	(7) HALF-LIFE years
Pu (6%-240)	0.45	0.947	0.637	1/7.31 (0.0871)	0.076	0.00379 (0.00242)	-
Pu(12%-240)	0.45 theoretical	0.906	2.400	1/16.4 (0.146)	0.104	0.00140 (0.00336)	-
Am-241	1600 uCi/l ~ .0005 g/l	9/480	3.42	1	3.42	0.0334	433.6
U-238	262.5	-	3.4 E-7	-	-	0.0249	4.468 E+9
U-235	2.52	1	2.2 E-6	1	2.2 E-6	0.0271	7.038 E+8
Cs-137	500 uCi/l ~ .000006g/l	-	86.6	-	-	0.001	30.17
Pu-238		9/80	17.12	1/1.1	17.12	0.0332	87.74
Pu-239		1	0.062	1	0.062	0.0311	24,131
Pu-240		9/400	0.227	1	0.227	0.0312	6,569
Pu-241		9/4	103	1/52	0.0025	0.000033	14.4
Pu-242		9/1200	0.0039	1/1.1	0.0039	0.0295	3.763 E+5
Pu (6%-240) 29 yr decay	0.45	0.938	0.231	1/2.49 (0.0929)	0.0907	0.0124 (0.00287)	-
Pu(12%-240) 29 yr decay	0.45 theoretical	0.869	0.734	1/4.32 (0.170)	0.161	0.00708 (0.00520)	-

* - average concentration per 20,000 liters of solution,
yields 9 kg plutonium total and 5300 kg of uranium total

TABLE 4-2

WMC-SP-1072

WHC-SP-1072

Table 4-3

6% Pu-240
Pu-241 decay minimal

WIPPCALC (PUREX) Ver. 8-22-90

ITEM: dave
DATE MEASURED: 11/8/93
MEASUREMENT SYSTEM: Segmented Gamma Scan Assay System/PUREX
GRAMS PU: 100

The following values are based on Pu/AM-241 relative abundances
provided by PUREX Process Engineering

ISOTOPE	WT%	GMS	CI	FGE	PECI	ALCI	WATTS
PU-238	0.0300	0.0300	0.5135	0.0034	0.4668	0.5135	0.0170
PU-239	93.3700	93.3700	5.7898	93.3700	5.7898	5.7898	0.1801
PU-240	6.0240	6.0240	1.3668	0.1355	1.3668	1.3668	0.0427
PU-241	0.5423	0.5423	56.0577	1.2202	1.0780	0.0014	0.0019
PU-242	0.0351	0.0351	0.0001	0.0003	0.0001	0.0001	0.0000
AU-241	0.0018	0.0018	0.0062	0.0000	0.0062	0.0062	0.0002
TOTALS			63.7341	94.7294	8.7078	7.6778	0.2418
PER GRAM			.6373	.947	.0871	.0768	.00242

THERMAL POWER DENSITY = 0.0329 WATTS/CU FT

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Table 4-4

12% Pu-240
Pu-241 decay minimal

WIPPCALC (PUREX) Ver. 8-22-90

ITEM: dave
DATE MEASURED: 11/8/93
MEASUREMENT SYSTEM: Segmented Gamma Scan Assay System/PUREX
GRAMS PU: 100

The following values are based on Pu/AM-241 relative abundances
provided by PUREX Process Engineering

ISOTOPE	WT%	GMS	CI	FGE	PECI	ALCI	WATTS
PU-238	0.1090	0.1090	1.8658	0.0123	1.6962	1.8658	0.0619
PU-239	85.3100	85.3100	5.2900	85.3100	5.2900	5.2900	0.1645
PU-240	12.1000	12.1000	2.7455	0.2723	2.7455	2.7455	0.0857
PU-241	2.2200	2.2200	229.4819	4.9950	4.4131	0.0056	0.0076
PU-242	0.3035	0.3035	0.0012	0.0023	0.0011	0.0012	0.0000
AU-241	0.1407	0.1407	0.4813	0.0026	0.4813	0.4813	0.0161
TOTALS			239.8656	90.5944	14.6271	10.3893	0.3358
PER GRAM			2.40	.906	.146	.104	.00336

THERMAL POWER DENSITY = 0.0457 WATTS/CU FT

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Table 4-5

6% Pu-240
Pu-241 decayed 2 half-lives (28.8 years)

WIPPCALC (PUREX) Ver. 8-22-90

ITEM: dave
DATE MEASURED: 11/23/93
MEASUREMENT SYSTEM: Segmented Gamma Scan Assay System/PUREX
GRAMS PU: 100

The following values are based on Pu/AM-241 relative abundances
provided by PUREX Process Engineering

ISOTOPE	WT%	GMS	CI	FGE	PECI	ALCI	WATTS
PU-238	0.0300	0.0300	0.5135	0.0034	0.4668	0.5135	0.0170
PU-239	93.3700	93.3700	5.7898	93.3700	5.7898	5.7898	0.1801
PU-240	6.0240	6.0240	1.3668	0.1355	1.3668	1.3668	0.0427
PU-241	0.1356	0.1356	14.0170	0.3051	0.2696	0.0003	0.0005
PU-242	0.3510	0.3510	0.0014	0.0026	0.0013	0.0014	0.0000
AU-241	0.4085	0.4085	1.3973	0.0077	1.3973	1.3973	0.0467
TOTALS			23.0858	93.8243	9.2916	9.0691	0.2869

THERMAL POWER DENSITY = 0.0390 WATTS/CU FT

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Table 4-6

12% Pu-240
Pu-241 decayed 2 half-lives (28.8 years)

WIPPCALC (PUREX) Ver. 8-22-90

ITEM: dave
DATE MEASURED: 11/23/93
MEASUREMENT SYSTEM: Segmented Gamma Scan Assay System/PUREX
GRAMS PU: 100

The following values are based on Pu/AM-241 relative abundances
provided by PUREX Process Engineering

ISOTOPE	WT%	GMS	CI	FGE	PECI	ALCI	WATTS
PU-238	0.1090	0.1090	1.8658	0.0123	1.6962	1.8658	0.0619
PU-239	85.3100	85.3100	5.2900	85.3100	5.2900	5.2900	0.1645
PU-240	12.0650	12.0650	2.7375	0.2715	2.7375	2.7375	0.0854
PU-241	0.5550	0.5550	57.3705	1.2487	1.1033	0.0014	0.0019
PU-242	0.3035	0.3035	0.0012	0.0023	0.0011	0.0012	0.0000
AU-241	1.8057	1.8057	6.1765	0.0339	6.1765	6.1765	0.2062
TOTALS			73.4415	86.8786	17.0046	16.0724	0.5200

THERMAL POWER DENSITY = 0.0707 WATTS/CU FT

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FIGURE 4-1

DOT 7A Type A
49CFR 178.350
Steel Drum - 17C/90-mil HDPE Liner

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APPENDICES

MISCELLANEOUS DATA,
CALCULATIONS AND HISTORICAL INFORMATION

WHC-SP-1072

APPENDIX A:

D5 SAMPLE RESULTS

D5 SAMPLE RESULTS

SAMPLE #		P415	P669	P670	P825	P1837	P1838
DATE		4/3/92	8/3/92	8/3/92	10/14/92	9/17/93	9/17/93
Density	g/cc	1.353	1.444	1.443	1.39	1.396	1.397
Volume	liters		9760	9760	10,640	10,880	10,880
PuAT/AEA	g/liter	0.293	0.457	0.384	0.326	.379/.402	.399/.428
Total Pu	grams		4460	3750	3470	4120/4370	4340/4660
U	g/liter	237	299	298	263	266	267
Total U	kilograms		2920	2910	2800	2890	2900
H+	molarity	0.868			0.914	0.937	
GEA Am-241	uCi/liter	1240			1130	943	
GEA Cs-137		382			365	471	
GEA CePr-144		150			89.1	34.7	
GEA RuRh-106		137			73.4	41.8	
GEA Sb-125		122			142	129	
GEA Cs-134		7.5			6.2		
GEA U-235		5.2			4.2	4.2	
GEA others are < values							
TB	uCi/liter	3150				5410	
doserate 5 oz	mrem/hr					30	
U-235 isotopic	(<0.96 wt%)						
Pu-240 isotopic	(mostly 6%)						
ICP Cd	mg/liter					1832	
ICP Mn						456	
ICP Fe						1298	
ICP Cr						32	
ICP Ni						25	
ICP P						627	
ICP Pb						251	
ICP K						360	
ICP Al						106	

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APPENDIX A

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APPENDIX B:

E6 SAMPLE RESULTS

E6 SAMPLE RESULTS

SAMPLE #		P417	P418	P671	P672	P1839	P1840
DATE		4/3/92	4/3/92	8/3/92	8/3/92	9/17/93	9/17/93
Density	g/cc	1.395	1.398	1.432	1.432	1.418	1.421
Volume	liters			8860	8860	8940	8940
PuAT/AEA	g/liter	0.318	0.323	0.615	0.673	.545/.417	.526/.526
Total Pu	grams			5450	5960	4870	4700
U	g/liter	267	265	275	276	265	265
Total U	kilograms			2437	2445	2370	2370
H+	molarity	1.1				1.55	
GEA Am-241	uCi/liter	1290		1230		1600	
GEA Cs-137		21.6		23.		27.3	
GEA CePr-144		< 11.0		3.0		< 2.9	
GEA RuRh-106		< 18.7		4.5		< 3.5	
GEA Sb-125		< 11.5		9.2		8.7	
GEA Cs-134		< 1.1		.3		.2	
GEA U-235		5.4		4.1		4.2	
GEA others are < values							
TB	uCi/liter	1660					
doserate 5 oz	mrem/hr					10	
U-235 isotopic (<0.96 wt%)							
Pu-240 isotopic (mostly 6%)							
ICP Cd	mg/liter					8753	
ICP Mn						483	
ICP Fe						2190	
ICP Cr						102	
ICP Ni						67	
ICP P						649	
ICP Pb						345	
ICP K						358	
ICP Al						138	

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APPENDIX B

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APPENDIX C:

L11 TO E6 REWORK TRANSFERS TO TANKS D5 AND E6

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APPENDIX C:

L11 TO E6 REWORK TRANSFERS TO TANKS D5 AND E6

#	Date	Grams Pu	Cumulative Grams Pu	Comments
	6/23/90	-	0	2140 gallons of UNH added
1.	7/5/90	474	474	
2.	7/5/90	471	945	
3.	7/16/90	314	1259	
4.	8/29/90	97	1356	
5.	8/31/90	50	1406	
6.	8/31/90	39	1445	
7.	10/10/90	1880	3325	
8.	12/10/90	269	3594	
9.	1/3/91	97	3691	
10.	6/25/91	82	3773	
11.	6/27/91	94	3867	
12.	6/28/91	94	3961	
13.	6/28/91	94	4055	
14.	6/28/91	81	4136	
15.	8/13/91	701	4837	
16.	8/22/91	1472	6309	
17.	8/22/91	691	7000	
				Tank E6 was treated with potassium permanganate to destroy any oxalate that potentially could be present.
	3/31/92			approximately 2200 gallons of solution was transferred from tank E6 to tank D5 to make additional room in E6 for transfers. (approx. 3760 grams of Pu to D5)
			3240	
18.	4/14/91	243	3483	
19.	4/28/92	356	3839	
20.	4/28/92	412	4251	
21.	5/14/92	104	4355	
22.	5/26/92	207	4562	
23.	6/1/92	156	4718	
24.	11/12/92	22	4740	
25.	11/24/92	1	4741	
26.	1/15/93	301	5042	

* transfer dates do not include miscellaneous water additions to keep the specific gravity from rising as a result of evaporation due to agitation.

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APPENDIX D:

CADMIUM CONTENT OF TANKS D5 AND E6

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APPENDIX D:

CADMIUM CONTENT OF TANKS D5 AND E6

The initial cadmium results reported by the laboratory are:

D5	1830 ppm	0.0163M
E6	8750 ppm	0.0778M

This results in 20 kg of Cd in D5 at 1.83 g/liter and 78 kg in E6 at 8.75 g/liter. The units for the ppm values are in milligrams per liter or micrograms per cc so the concentration values are correct. Current inventory volumes were used of 10,880 liters in D5 and 8940 liters in E6 to obtain the total amount.

Prior to the lab result, the total amount of cadmium was estimated based on 20 of the 26 L11-E6 transfers using cadmium nitrate solution and an average of 3 divisions of TK-151 per transfer. This would give a maximum value for the amount of cadmium present with the exception of flushing the vessel. The total amount of cadmium is then:

20 transfers x 3" per transfer x 110 pounds solution per inch of
solution average per the calibration manual / 2.2 pounds per kg x
.07 wt % cadmium nitrate x 112.4 MW cadmium / 236.4 MW cadmium
nitrate =

$$20 \times 3 \times 110 / 2.2 \times .07 \times 112.4 / 236.4 = 100 \text{ kg Cd}$$

Since the lab total = 98 kg Cd, an independent match on the total is verified.

However, There was only 15 divisions (inches) on the TK-151 chart after the E6 to D5 transfer, thus 3/4 of the cadmium nitrate transfers were completed prior to the D5 to E6 transfer (45 of 60 divisions in TK-151). Since half of E6 was transferred to D5, I would expect D5 to contain 3/8 (3/4 x 1/2) of the cadmium and E6 to contain 5/8 of the cadmium (3/4 x 1/2 + 1/4). Thus I would expect 37 kg Cd in D5 and 62 kg Cd in E6 for a total of 99 kg.

Bottom line: The total amount agrees with the maximum possible but the ratio between the two tanks appears to be incorrect. It appears that the E6 value is somewhat high since we could have used 3AS solution (no cadmium) for several of these transfers (i.e., 20 of 26 transfers using cadmium nitrate is conservative). However, we could have picked up alot of cadmium when the final flush of TK-151 was completed at the end of the transfers. Based on this information, a cadmium to plutonium mass ratio of 3:1 can be used in the criticality safety evaluation report.

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APPENDIX E:

ESTIMATION OF VITRIFICATION COST PER CANISTER

APPENDIX E:

ESTIMATION OF VITRIFICATION COST PER CANISTER
(information provided courtesy of A. L. Pajunen)

Overall Results:

High Level Waste Glass	
Total Glass Produced:	14 to 25 metric tons
# of 10 cubic meter casks:	0.5 to 1
Increase to TWRS high level waste glass	~0.06 %
Estimated Cost:	
Production	~\$2.7 M
Disposal	~\$1.6 M
Total	~\$4.3 M
Low Level Waste Glass	
Total LLW Glass Produced (glass in sulfur):	~20 metric tons
LLW Glass Volume Produced:	~8 cubic meters
Increase to TWRS low level waste glass	~0.004 %
Estimated Cost:	
Production	~\$59 K
Disposal	~\$ 7 K
Total	~\$66 K

Basic Assumptions:

1. Tanks D5 and E6 neutralized and transferred to tank farms.
2. Waste is processed along with other tank waste (e.g., blended into overall tank waste and not maintained separate).
3. Processing consists of partitioning into high and low level waste fractions using the enhanced sludge wash process currently being developed in support of the DOE Tri-Party Agreement baseline, with the fractions converted to glass for disposal. HLW glass is disposed offsite in a repository. LLW glass is disposed onsite in vaults as glass cullet/sulfur cement matrix.
4. Partitioning distribution is based on performance modeling an average of the DST and SST waste composition derived from work in progress to support TPA baseline definition.
5. Low level waste loading assumed to be limited to 25 wt% waste oxide loading which is dominated by Na in the LLW vitrification feed.
6. Low level waste cost factors are derived from WHC-EP-0616 and descriptions of the DOE TPA planning basis which assumes a \$500 M capital cost facility operating for 14 years. These result in:
LLW Glass Production Cost: \$2.86 K per metric ton of LLW (glass and sulfur)
LLW Glass Disposal Cost: \$0.33 K per metric ton of LLW (glass and sulfur)

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7. Partition facility costs and condensate disposal costs were neglected.
8. High Level waste loading is assumed to be limited to a range of 25 to 45 wt% waste oxide loading. While uranium dominates the high level waste composition, it is assumed that intermingling with other waste results in total waste oxides determining the glass quantities.
9. High level waste cost factors are derived from DOE TPA planning basis assumptions which assumes a \$1,500 M capital cost facility operating for 20 years. Casks of 10 cubic meter are produced from the vitrification process (instead of 0.62 cubic meter canisters in the HWVP design) with a total disposal cost of \$2,700 M independent of total quantity disposed. These result in:
HLW Glass Production Cost: \$106 K to \$190 K per metric ton of glass
HLW Glass Disposal Cost: \$64 K to \$114 K per metric ton of glass

On a unit cask basis (10 cubic meters containing 26 metric ton of glass) these become:
HLW Glass Production Cost: \$2.76 M to 4.94 M per cask
HLW Glass Disposal Cost: \$1.66 M to 2.96 M per cask
10. A conservative estimate of 1500 gallons of 19 molar caustic was used to neutralize the D5/E6 material.
11. Total partitioning chemical additions are estimated at 1.08 kg chemical add per kg of total feed, including 0.18 kg Na per kg Na in the feed.
12. Low Level Waste Glass Data:
 - a. LLW waste glass loading limited to 25 wt% sodium dioxide (equivalent to 18.6 wt% Na. 2870 kg of Na from D5/E6 results in 15,460 kg of glass.
 - b. Assume 0.33 kg sulfur cement per kg of glass added for final disposal form. Results in 20,560 kg of LLW at a density of 2.6 kg/liter.
 - c. Current tank farm waste is estimated to produce 560,000 metric ton of LLW.
13. High Level Waste Glass Data:
 - a. Total waste metals from D5/E6 = 6290 kg (not as oxides)
 - b. Based on 25 to 45 wt% loading in the glass a range of 14,000 to 25,000 kg of waste glass will be produced at a density of 2.6 kg/liter. (If glass production is limited by 8 wt% U3O8 in glass, then 72,000 kg of glass would be produced. This is the maximum U reported which is made into glass but is not necessarily a limit and assumes no blending with other waste.)
 - c. All tank waste is estimated to produce from 23,600 to 42,400 metric ton of glass depending on the waste loading.

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APPENDIX F:

ISOSHIELD CALCULATIONS

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Microshield 3.12

(WESTINGHOUSE HANFORD CO. - #090)

Page : 1
File :
Run date: October 26, 1993
Run time: 4:24 p.m.

File Ref: _____
Date: ____/____/____
By: _____
Checked: _____

CASE: test 1

GEOMETRY 7: Cylindrical source from side - cylindrical shields

Distance to detector.....	X	28.5	cm.
Source length.....	L	71.	"
Dose point height from base.....	Y	35.5	"
Source cylinder radius.....	T1	22.180	"
Thickness of second shield.....	T2	0.160	"
Thickness of third shield.....	T3	6.	"
Thickness of fourth shield.....	T4	0.160	"

Source Volume: 109731. cubic centimeters

MATERIAL DENSITIES (g/cc):

Material	Source	Shield 2	Shield 3	Shield 4
-----	-----	-----	-----	-----
Air			.001220	
Aluminum				
Carbon				
Concrete				
Hydrogen				
Iron		7.860		7.860
Lead				
Lithium				
Nickel				
Tin				
Titanium				
Tungsten				
Urania				
Uranium				
Water				
Zirconium				
Na2U207+OH	1.70			

CASE: test 1

BUILDUP FACTOR: based on TAYLOR method.
Using the characteristics of the materials in shield 1.

INTEGRATION PARAMETERS:

Number of lateral angle segments (Ntheta).....	11
Number of azimuthal angle segments (Npsi).....	11
Number of radial segments (Nradius).....	11

SOURCE NUCLIDES:

Cs-137- Ba-137m: 1.0796e-01 curies

RESULTS:

Group #	Energy (MeV)	Activity (photons/sec)	Dose point flux MeV/(sq cm)/sec	Dose rate (mr/hr)
1	.6641	3.594e+09	5.291e+04	1.097e+02
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
TOTALS:		3.594e+09	5.291e+04	1.097e+02 - surface dose rate outer drum

Can ignore photon contribution from AM-241 due to low energy (60 KeV), they contribute less than 1% to gamma field.

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Microshield 3.12

(WESTINGHOUSE HANFORD CO. - #090)

age : 1

file :

Run date: October 26, 1993

Run time: 4:22 p.m.

File Ref: _____

Date: _____

By: _____

Checked: _____

CASE: test 1

GEOMETRY 7: Cylindrical source from side - cylindrical shields

Distance to detector.....	X	128.5	cm.
Source length.....	L	71.	"
Dose point height from base.....	Y	35.5	"
Source cylinder radius.....	T1	22.180	"
Thickness of second shield.....	T2	0.160	"
Thickness of third shield.....	T3	6.	"
Thickness of fourth shield.....	T4	0.160	"
Microshield inserted air gap.....	air	100.	"

Source Volume: 109731. cubic centimeters

MATERIAL DENSITIES (g/cc):

Material	Source	Shield 2	Shield 3	Shield 4	Air gap
-----	-----	-----	-----	-----	-----
Air			.001220		.001220
Aluminum					
Carbon					
Concrete					
Hydrogen					
Iron		7.860		7.860	
Lead					
Lithium					
Nickel					
Tin					
Titanium					
Tungsten					
Urania					
Uranium					
Water					
Zirconium					
Na2U207+OH	1.70				

CASE: test 1

BUILDUP FACTOR: based on TAYLOR method.
Using the characteristics of the materials in shield 1.

INTEGRATION PARAMETERS:

Number of lateral angle segments (Ntheta).....	11
Number of azimuthal angle segments (Npsi).....	11
Number of radial segments (Nradius).....	11

SOURCE NUCLIDES:

Ba-137m: 1.0796e-01 curies

RESULTS:

Group #	Energy (MeV)	Activity (photons/sec)	Dose point flux MeV/(sq cm)/sec	Dose rate (mr/hr)
-----	-----	-----	-----	-----
1	.6641	3.594e+09	3.264e+03	6.768e+00
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
TOTALS:		3.594e+09	3.264e+03	6.768e+00 - dose rate @ 1m from outer drum

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APPENDIX G:

DRAFT REPORT ON CRITICALITY SAFETY EVALUATION REPORT

WHC-SP-1072

Date of this Draft: December 6, 1993
CSER-WM3.393

Title: DISPOSITION OF PLUTONIUM AND URANIUM NITRATE SOLUTIONS FROM THE
PUREX HEADEND VESSELS, TK-D5 AND TK-E6

Prepared by: _____ Date: _____
W. E. Matheison
PUREX Criticality Safety Representative

Prepared by: _____ Date: _____
C. A. Rogers
Engineer, Criticality Engineering Analysis

Reviewed by: _____ Date: _____
T. S. Vail
TWRS Criticality Safety Representative

Reviewed by: _____ Date: _____
S. J. Altschuler
Engineer, Criticality Engineering Analysis

Approved by: _____ Date: _____
D. E. Friar
Acting Manager, Criticality Engineering Analysis

Approved by: _____ Date: _____
R. V. Skinner
Manager, North Facilities Safety Assurance

Approved by: _____ Date: _____
M. N. Islam
Manager, Waste Tank Farm Safety Assurance

1.0 INTRODUCTION

The PUREX Plant is currently in a Transition to Shutdown Status in which all components are being readied for eventual Decontamination and Decommissioning (D & D). During this transition period, all fissionable material must be either removed from the facility or stabilized. Fissionable material is considered stabilized when it is securely fixed in place, such as surface contamination within ducts, and does not present any criticality safety hazard.

A primary objective to insure that criticality safety will be maintained at all times before and during D & D activities and throughout the process of placing the facility in final lay-a-way status.

Since the beginning of the Stabilization Campaign in early 1990, plutonium has been flushed from:

- * the final plutonium solvent extraction vessels, including a flushing of the associated PUREX Canyon Cell floor;
- * the plutonium nitrate loadout vessels/gloveboxes in the Product Recovery (PR) Room; and,
- * the plutonium oxide (PuO_2) conversion facility equipment/gloveboxes in N Cell.

Flush solution was routed back to the large PUREX Headend vessels where it was mixed with uranyl nitrate (UNH) in accordance with the criticality safety requirements for feed for solvent extraction. At this time it was expected that PUREX would restart. However, after this took place, the US Government determined that PUREX would not restart. Consequently, solutions containing plutonium and uranium nitrate hexahydrate (UNH) stored in the Solvent Extraction Accountability Tank, Tk-D5, and the Solvent Extraction Feed Adjustment Tank, Tk-E6, must be disposed of as waste. Both of these tanks are large enough to hold 5000 gal of solution.

These solutions contain 5,300 kg, or 5.3 MT (metric tons), of uranium and about 9 kg plutonium. In addition, these solutions contain one molar nitric acid (1 M HNO_3) and about 100 kg of the soluble poison, cadmium [as cadmium nitrate, $\text{Cd}(\text{NO}_3)_2$]. The total volume is between 5000 and 6000 gal ($\approx 20,000 \text{ L}$).

The basis for safety used for this evaluation are the subcritical limits for the U/Pu mass ratio and the Cd/Pu atom ratio. Subcritical limits to be used in assessing the criticality safety of waste are provided in "CSER 92-009: An Analytical Model for Evaluating Subcritical Limits for Waste in Hanford Site Storage Tanks," WHC-SD-SQA-CSA-20356. A criticality safety evaluation of adding cadmium to waste containing plutonium bearing solids was written by R. D. Carter (1984). This evaluation, "CSAR 79-007, Addendum 2A: Waste Storage Tanks and Associated Equipment is provided in Appendix A.

Although the proportion of uranium to plutonium (i.e., the U/Pu mass ratio) is not sufficient to guarantee subcriticality under all conditions, it is large enough to ensure that the quantity of plutonium required for criticality is significantly larger than present in Tk-D5 and Tk-E6. Calculations made using the EGGNIT code show that the quantity of plutonium which would be required for criticality at the U/Pu mass ratio present is 3 to 10 times as great as the estimated plutonium actually present. That is to say, for the quantity of plutonium available criticality is not possible when it is mixed homogeneously with the uranium present.

The cadmium to plutonium (Cd/Pu) atom ratio in the solution is about 11. This quantity of cadmium ensures subcriticality under all conditions, regardless of what other components are present in the solution.

Criticality is therefore ensured for these solutions for the quantity of plutonium present by both the content of uranium and the content of cadmium. The content of cadmium is several times greater than the minimum required to assure criticality.

This CSER describes composition of the Pu/U solution within the Tk-D5 and Tk-E6 vessels and the various options available for disposal of this material. A discussion is provided of the criticality safety of these solutions.

The quantity of uranium shown by chemical analyses to be in this waste is sufficient to ensure subcriticality. In addition, only 6% of the cadmium shown to be present is required to ensure subcriticality during transfer or storage. The continued presence of both uranium and cadmium in the precipitate is ensured by the alkaline nature of the solution. Their combined presence reinforces safety for the proposed option of disposal to Tank Farms as a diluted, neutralized mixture or the alternate of disposal as solid waste.

The restriction of 0.125 g/L placed on the plutonium in solutions routed to Tank 102-SY (and by inference, for this material), provides further safety during transfer, in the event of misrouting, since only 500 g of plutonium will be involved. If the alternate disposal is chosen, criticality safety will continue to be ensured as long as coprecipitation of uranium and/or cadmium are ensured.

It is shown that the Double Contingency Policy is satisfied as a result of the presence of uranium and cadmium in the solution in sufficient concentrations to ensure an adequate margin of subcriticality under all foreseeable conditions, both normal and abnormal.

2.0 DESCRIPTION

Based upon laboratory analyses, about 9.0 kg of plutonium and 5,300 kg of uranium are stored with about 100 kg cadmium in the PUREX Headend tanks, Tk-D5 and Tk-E6. This material is contained in a uranyl nitrate/nitric acid (UNH/HNO₃) solution having a Pu/U mass ratio of between 0.0014 and 0.0021.

PUREX Tanks Tk-D5 AND Tk-E6 are standard PUREX flat bottom tanks with a nominal 10-ft diameter and 9-ft height. They are equipped with heat transfer coils, agitator, transfer pump or jet, and miscellaneous routing connections.

This plutonium was accumulated during flushes of the plutonium solvent extraction cycles and from the PuO₂ Facility (N Cell) gloveboxes after the "Stabilization Run" at PUREX in March, 1990. At this time the PUREX Plant was to be placed on Standby status, pending "Restart" to process the last of the N-Reactor fuel stored in the reactor basins. The plutonium-bearing solution was transferred back to Tk-E6. Product UNH solution was brought into the plant from UNH storage (in the 203-A area tanks adjacent to PUREX, 202-A) to provide an acceptable feed for solvent extraction as required by mandatory criticality prevention specifications (CPS). Transfers of plutonium were made from the geometrically favorable plutonium process vessel back into the large tank, Tk-E6, using cadmium nitrate solution as the motive fluid for the plutonium transfer jet. The use of cadmium nitrate was required by the CPS.

Thus two separate actinide streams (i.e., one for uranium and one for plutonium) were reintroduced to the PUREX canyon vessel(s) and these streams form the current mixture which also include residual fission products which were already present in the receiving tanks. This routing of the plutonium bearing material was made because routing to either Tank Farms or the Plutonium Finishing Plant (PFP) was not considered acceptable at that time.

A decision was subsequently made that PUREX was not to be included in any future "Processing Activity" relative to either the N Reactor fuel or Site Remediation. This meant that normal processing within the PUREX Plant would no longer be permitted. Furthermore the solvent extraction vessels were flushed of residual actinides and the canyon process systems were isolated from input and output streams. The aqueous makeup tanks and headers were flushed, drained, and blanked to provide additional isolation from the environment. Many of the instruments and procedures associated with the canyon processes were deactivated.

A tentative decision was made to route the Tk-D5/Tk-E6 solutions to Tank Farms thus providing additional feedstock to the Grout Facility, which was active at that time, and/or to the High Level Waste Vitrification Project (HWVP). This approach was temporarily deferred pending resolution of an Unreviewed Safety Question (USQ) related to criticality safety of Tank Farms.

2.1 DISPOSAL OPTIONS BEING CONSIDERED

The plutonium and associated uranium within the PUREX Headend tanks, Tk-D5 and Tk-E6, must either remain in its present status within the facility, be changed to an alternate form, or be removed from PUREX. Recovery of this material is no longer considered a viable option.

Historically, the separation and loadout of plutonium and uranium at PUREX has been conducted using the normal solvent extraction process equipment located in H, J, K, and L Cells. These cells have been recently flushed and drained.

They have also been isolated from the actinide bearing tanks, from the aqueous makeup tanks and headers, from steam and cooling water sources, and from the effluent streams.

Several options for disposal of waste are being considered. The most straight forward disposal method is to send the waste to Tank Farms as a dilute neutralized slurry containing uranium and cadmium intimately mixed with the plutonium.

The second best option appears to be precipitation and loadout into 55 gal drums as solid waste using absorbant material such as vermiculite or grout to stabilize the interstitial liquid. About 10 to 100 g of plutonium would be placed in each drum. Existing TRU waste restraints appear to be met by this option, but process flowsheet and disposal requirements remain uncertain. Precipitation followed by drum disposal has been selected for further review as an alternate to Tank Farm disposal.

Leaving the material as a precipitate in PUREX tanks, as mentioned in the following section, is no longer considered an viable option, but it is discussed to show that there would still be adequate criticality safety should the need arise. Batchwise solvent extraction followed by the uranium loaded out as solid waste may have benefits, but there is no insurance that the residual U-bearing material would be non-TRU. The same can be said of using ion exchange with the uranium loaded out as solid waste.

2.2 COPRECIPITATION-COMMON STATUS OF ALL OPTIONS

For all options under consideration waste solids are to be removed from solution through precipitation, a process in which sodium hydroxide (NaOH) is added causing solids to settle out. For the waste under consideration the plutonium, uranium, and cadmium all settle out together in a process usually known as co-precipitation, but is sometimes called co-solids formation. It is expected that the ratio of these elements to each other in the solids will be very nearly the same as it had been in the solution.

Assume the material is left in one tank. If this tank were Tk-D5, for example, the solution in Tk-E6 would be transferred into Tk-D5. This transfer would be followed by addition of sodium hydroxide (NaOH) in stoichiometric excess to ensure total co-precipitation of the uranium, plutonium, and cadmium within the tank. Due to the large volumes involved, the agitator would be operated during the period of NaOH addition and digestion to ensure uniformity. The material would next be permitted to settle and the supernate would be decanted off, leaving a moist cake. With time this cake would lose some of its moisture, but the uranium, plutonium, and cadmium would remain uniformly mixed in the solids.

Co-precipitated of the uranium, plutonium, and cadmium might also be accomplished in small batches and the product loaded out into drums. The batch size would be governed by weight and radiation limits placed upon TRU drums. The solids, which would be dewatered (if necessary) by centrifuge or

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other mechanism, would be mixed with absorbent and placed in a drum. During this entire process the uranium, plutonium, and cadmium would remain in a uniform mixture.

If sent to Tank Farms, the material would be transferred in small batches, after neutralization and dilution with water to ensure low uranium concentration. The neutralization process causes uranium, plutonium, and cadmium to either co-precipitate or at least to form solids in which they are all present in about the same proportions as before. The primary reason for dilution with water is to ensure fluidity during the transfer to minimize solids settling/plugging in the pipeline. Laboratory data and prior Tank Farm experience [Reberger (1993)] show that waste with up to 35 g/L of uranium as sodium diuranate remains stable long enough to permit transfer.

2.3 ROUTING WASTE TO TANK FARMS

The batch size for PUREX neutralization and transfer to Tank Farms would be governed by the Tank Farm CPS limit for Pu of 0.125 g/gallon. For example, a transfer of 250 kg of uranium into dilute nitric acid in Tk-F18, neutralization with NaOH, and dilution would result in about 15 g/L of uranium (acceptable for transfer without solids settling). The plutonium content of this waste would be about 410 g at a concentration of 0.09 g/gal (0.025 g/L) thus meeting the Tank Farm transfer CPS limit. Excess sodium hydroxide would be added to ensure solids formation of the uranium and cadmium concurrent with the plutonium.

Criticality prevention specification CPS-T-12-00010 governs these neutralization and transfer operations. Limits which apply to these operations are as follows:

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C. Maximum plutonium concentration in mixtures routed to:

Waste Storage Tanks:	0.05 g/gal
244-AR and CR Vault Tanks:	0.05 g/gal
102-SY:	0.125 g/gal

E. Actions required, upon determining the plutonium concentration in the solids results from sampling waste tank contents, are:

Conc. $\leq$ 1 g/l	No further analysis required
1 g/l $\leq$ Conc. $\leq$ 2 g/l	Notify Manager, CEA, new criticality analysis may be required.
2 g/l $\leq$ Conc.	Notify Manager, CEA, new criticality analysis shall be required (Exception: For Tank 102-SY, see paragraph F.)

F. For Waste Tank 102-SY, cadmium shall be added to the waste and transfer continued under the following conditions:

<u>Plutonium Concentration in Solids, g/L</u>	<u>Minimum Required Cadmium (as precipitated solids) Cd/Pu (mass ratio)</u>
0 < Conc. $\leq$ 2	0
2 < Conc. $\leq$ 30	0.33

Although this plutonium content is approximately twice the concentration of 0.05 g/gal permitted by Limit C in this CPS, it is permitted by Limit F which has previously applied only to Tank 102-SY.

The proposed modification to the CPS follows:

C. Maximum plutonium concentration in mixtures routed to:

Waste Storage Tanks:	0.05 g/gal
244-AR and CR Vault Tanks:	0.05 g/gal
102-SY and 105-AW:	0.125 g/gal

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E. Actions required, upon determining the plutonium concentration in the solids results from sampling waste tank contents, are:

Conc. $\leq$ 1 g/l	No further analysis required
1 g/l $\leq$ Conc. $\leq$ 2 g/l	Notify Manager, CEA, new criticality analysis may be required.
2 g/l $\leq$ Conc.	Notify Manager, CEA, new criticality analysis shall be required (Exception: For Tanks 102-SY and 105-AW, see paragraph F.)

F. For Waste Tanks 102-SY and 105-AW, cadmium shall be added to the waste and transfer continued under the following conditions:

<u>Plutonium Concentration in Solids, g/L</u>	<u>Minimum Required Cadmium (as precipitated solids) Cd/Pu (mass ratio)</u>
0 < Conc. $\leq$ 2	0
2 < Conc. $\leq$ 30	0.33

Transfer of solution into dilute nitric acid in Tk-F18 would permit pre-neutralization sampling for accountability and criticality safety purposes. If too much waste were found to be present, part of the waste would be rerouted to another tank. Water or dilute nitric acid is available within other PUREX tanks where it is scheduled for disposal, even if it is not used for this purpose.

This neutralization process co-precipitates the cadmium and uranium along with the plutonium. In this way the neutron absorbers will remain with the plutonium as it is transferred to Tank Farms.

When the slurry is received at the Tank Farm, it will be dispersed over a large area. Tanks anticipated to receive the material have one of several mechanisms for dispersion of the incoming waste. These methods include air lift circulators, movable distributors, and multiple entry nozzles. The reason for dispersing the incoming waste is to minimize localized accumulations of sequential transfer batches.

The presence of absorbers intimately mixed with the plutonium must be assured. Both the pH of the waste to be transferred and the pH of the alkaline matrix in waste storage tanks will ensure that the uranium, plutonium, and cadmium will remain insoluble. This insolubility provides high assurance that the uranium and cadmium will not be separated from the plutonium. However, when changes are made in the future, those changes should be evaluated for their impact upon criticality safety.

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The composition of the waste in tanks Tk-D5 and Tk-E6 was determined in 1993 [Harty (1993)]. The cadmium is known to be approximately as stated based upon records of its usage as a soluble poison in the plutonium transfer media as well as sample assays in the Tk-D5/Tk-E6 solutions. (The high actinide assay complicates good cadmium analyses of the Tk-D5/Tk-E6 solutions.)

Table 1. Composition of Tank Contents

Parameter	Tank Tk-D5	Tank Tk-E6	Combined Tanks
Volume	10900 L	8900 L	≈20000 L
HNO ₃	≈0.9 M	≈1.5 M	≈1 M
Cd	≈1.8 g/L	≈8.8 g/L	≈100 Kg
²³⁵ U Enrichment	< 0.95 wt%	< 0.95 wt%	≈50 Kg
U in UNH	≈270 g/L	≈270 g/L	≈270 g/L
U Total	≈2900 kg	≈2400 kg	5300 kg
Pu in Pu(NO ₃) ₄	≈0.3 g/L	≈0.6 g/L	≈0.45 g/L
Pu Total	≈4 kg	≈5 kg	≈9 kg
Pu/U Mass Ratio (U/Pu)	≈0.0014 ≈700	≈0.0021 ≈500	≈0.0017 ≈600
Cd/Pu Mass Ratio	6	15	11

The current inventory for the Tank Farm tank proposed to receive this Tk-D5/Tk-E6 material(105-AW) is 15.8 kg Pu. Addition of the 9 kg Pu from Tk-D5/Tk-E6 would increase the inventory to about 25 kg Pu. Although the CPS limit for this tank is 50 kg Pu, an administrative limit of 25 kg Pu, has been superimposed on all tanks, except 102-SY, pending resolution of the Tank Farm USQ. A discussion is provided in section 3.6 below, relative to the 25 kg Pu value and the appropriate transfers into 105-AW of this Tk-D5/Tk-E6 material, and other residual PUREX Pu-bearing waste solution.

3.0 CRITICALITY SAFETY DISCUSSION

There are three possible processes which might be used during the process of transferring this waste to the Tank Farms:

- 1) co-precipitation of plutonium, uranium, and cadmium in place;
- 2) precipitation in batches for removal as solid waste; or
- 3) neutralization in batches with excess caustic.

Each of these processes have a potential to change the concentrations of waste components. However, this evaluation looks at an infinite quantity of this waste under optimal conditions. Therefore, the following safety evaluation applies to all three of these processes.

3.1 PLUTONIUM CRITICAL PARAMETERS

The process through which the waste in PUREX Tanks Tk-D5 and Tk-E6 has been generated provided considerable mixing of the waste. It is very likely that the waste is homogeneous. However, there nevertheless remains a possibility that the waste components may not be distributed uniformly. Conservative assumptions are made to compensate for the lack of knowledge about the actual distribution of waste components.

^{240}Pu is fissionable, but not fissile. The presence of even a small quantity of moderating material increases the critical mass of this isotope very rapidly until criticality is not possible with it alone. In the environment of tank waste ^{240}Pu acts as a mild poison and its presence increases the quantity of ^{239}Pu required to achieve criticality. Therefore, it is conservative to ignore the presence of ^{240}Pu . In this evaluation it is conservatively assumed that all plutonium is ^{239}Pu (i.e., the ^{240}Pu is replaced with ^{239}Pu).

A model of waste, known as the Conservative Waste Model, is described in "CSER 92-009: An Analytical Model For Evaluating Subcritical Limits For Waste in Hanford Site Storage Tanks (Rogers 1993)". Subcritical limits provided in that report are the basis for this evaluation. An earlier report by Carter (1984) provided in Appendix A is also used.

The Conservative Waste Model composition was determined by tabulating 28 available waste analyses from 16 different single-shell tanks and selecting the maximum concentration of components which are good neutron scatterers and poor neutron absorbers and selecting minimum concentrations of components which are good neutron absorbers. The primary goal in formulating this waste model was to provide a waste composition known to have a larger macroscopic absorption cross section than that of any real waste. Critical parameters were calculated using the assumption of optimal water moderation. In this way, subcritical limits calculated using the Conservative Waste Model are conservative relative to the actual critical values for real waste.

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Criticality is not possible for plutonium in a pure plutonium-water mix unless the plutonium concentration exceeds 7.2 g/L. When plutonium is mixed with certain materials other than water, criticality becomes possible at lower concentrations. A lower critical concentration occurs when the total macroscopic absorption cross section is less than for a water-only mix. For criticality to be possible in tank waste it is necessary for the plutonium concentration to be at least 2.6 g/L over a large volume. Alternately, criticality is possible with a higher plutonium concentration over a smaller volume.

To achieve criticality with waste having a plutonium concentration of 4.0 g/L requires a 15.4-ft diameter, 53,750 L sphere containing 215 kg of plutonium. For a slab of this waste to go critical it would have to be almost 7-ft. thick.

At 10 g Pu/L the critical mass in tank waste is approximately 3.0 kg of plutonium in a volume of 300 liters.

The minimum critical areal density of plutonium in water is conservative when applied to waste. This provides a value of 240 g Pu/ft² as the lowest areal density which can be made critical. The areal density includes all plutonium above a unit area of floor, including plutonium located all the way to the top surface.

Subcriticality can be assured by the ratio of absorbers to plutonium present in the waste. When any one of the following ratios is met or exceeded, subcriticality is assured for all concentrations of plutonium.

1. When the ²³⁵U enrichment is less than that of natural uranium (0.72 wt%), the "always safe" limit value on the Pu/U mass ratio is 0.0013.
2. Cadmium and boron are strong absorbers of moderated neutrons. If the ratio of hydrogen to fissile atoms exceeds 250, subcriticality is assured when either the cadmium/fissile atom ratio exceeds 0.5 or the boron/fissile atom ratio exceeds 2.0. Fissile refers to ²³⁵U, ²³³U, and ²³⁹Pu.
5. Criticality is not possible when the hydrogen to plutonium atom ratio exceeds 3600.

3.2 URANIUM

In a homogenized mixture containing uranium criticality is not possible until the enrichment of the ^{235}U exceeds 1.03 wt%. Although criticality is possible in precisely defined heterogeneous arrays at enrichments as low as 0.72 wt%, the homogeneous configuration is the most reactive which would be possible to achieve in tank waste. Uranium in the two tanks under evaluation is reported to have an enrichment of 0.95 wt%. There is no chemical or physical means by which the ^{235}U can be separated from the ^{238}U . Because of the low enrichment criticality is not possible as a result of a chain reaction in the uranium.

It is conservative to treat ^{235}U as ^{239}Pu . Therefore, whenever the ^{235}U enrichment exceeds 0.72 wt%, the excess ^{235}U may be added to the plutonium and the limits for plutonium may be applied to the combination of plutonium and ^{235}U .

3.3 RATIO OF PLUTONIUM TO URANIUM

An important parameter to be used to justify a conclusion of subcriticality is the ratio of plutonium-to-uranium. "Nuclear Safety Guide, TID-7016 Revision 2" (Thomas 1978) states that criticality is not possible for plutonium combined with natural or depleted uranium provided the ratio of $\text{Pu}/(\text{Pu}+\text{U})$ does not exceed 0.0013. Natural uranium contains 0.72 wt% ^{235}U .

The reported enrichment of the uranium is 0.95 wt%. Since the uranium is enriched to more than 0.72 wt% in ^{235}U , the subcritical limit of 0.0013 on the Pu/U mass ratio can not be used to show subcriticality. In addition, the Pu/U mass ratio in Tank Tk-E6 is reported to be 0.0021, a value already above the subcritical limit.

Calculations by Geiger (see Appendix B) show that the quantity of this waste required before criticality is possible is somewhere between 15 and 55 metric tons of heavy metal. These calculations use the following assumption: (1) the Pu/U ratio is as shown in Table 1 for the combined solutions of Tanks Tk-D5 and Tk-E6; (2) no cadmium is present; (3) the waste is arranged in a sphere with full reflection; and, (4) optimal moderation is provided by the available water. Optimal moderation is found to occur when water fills about half of the interstitial volume in the sodium diuranate precipitate.

The quantity of waste required for criticality is more than 3 times that actually available, and may be more than 10 times as great. This is true without taking into account the cadmium. The available waste contains approximately 5 metric tons of uranium.

The presence of a small amount of cadmium would cause even these slightly reactive materials to be infinitely subcritical.

Colvin (1967) discusses a mechanism for separating the plutonium from the uranium in "Properties of Potential Uranium Precipitates as Related to Chemical Processing". The process described by Colvin raises the possibility

that at least part of the plutonium might separate from the uranium under certain conditions. For the separation process to work the plutonium and uranium must first be dissolved. If the rate of precipitation is different for the ^{239}Pu than for the ^{238}U , the ratio of these two isotopes in the precipitate can be different than the original ratio.

In practice it is expected that the plutonium will remain uniformly mixed with the uranium. Conditions under which the proportion of plutonium might be increased over a sizeable volume of waste are very unlikely to be achieved.

If chemical processes did somehow cause the Pu/U ratio to increase over a region within the waste, this would by itself not make criticality possible. Before criticality becomes possible several other independent conditions would also have to be fulfilled.

The concentrations of absorbers would have to be considerably less than their expected concentrations.

The plutonium would have to be concentrated by a factor of about 10, or more.

The quantity of plutonium concentrated into a small volume would have to be large enough to go critical.

The simultaneous occurrence of all three of these conditions is very unlikely. However, the presence of neutron poisons must be taken into account to justify an assertion of subcriticality under all circumstances.

3.4 MECHANISMS OF CONCENTRATION

Precipitation is a mechanism which is capable of concentrating the plutonium. To do so, the plutonium must first be dissolved. For a large fraction of the available plutonium to be dissolved it would be necessary for the chemicals causing the dissolution to cover the entire cross section of the tank. When all of the plutonium is dissolved, it would be spread across the entire tank. When the plutonium is precipitated, the layer containing the plutonium should cover the entire surface of the waste. The plutonium bearing region after precipitation would be expected to be of relatively uniform thickness over the entire cross section of the tank.

Both Tank D5 and Tank E6 have the same diameter of 119.3 in. When their plutonium contents are spread uniformly over their cross sectional areas, the areal density of plutonium for these tanks is 44 g/ft² and 67 g/ft², respectively. If this material is combined into a single tank, the areal density then would increase to 111 g/ft². These values are well below the minimum critical areal density of 240 g/ft² for plutonium in pure water.

Even a small concentration of cadmium in this waste would greatly increase both the critical areal density and the minimum critical concentration for plutonium.

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In order for criticality to occur it is necessary for the plutonium to be concentrated into a relatively small region, while at the same time for the concentration of cadmium in that region to be much less than the average for the tank.

When the plutonium concentration is 10 g/L and there is no cadmium or ^{238}U available, the critical mass is 3.0 kg for waste at optimal water content. This quantity of plutonium is about one-third of the total available. There is no postulated mechanism capable of increasing the concentration of the plutonium from 0.6 g/L as reported for tank Tk-E6 to 10 g/L. In addition, it would be necessary to concentrate 3.0 kg of the plutonium in a volume of 300 L. At the same time the uranium and cadmium would have to be removed from that same volume. This scenario requires several independent actions to occur, each of which is extremely improbable.

3.5 CADMIUM POISONING

Carter (see Appendix A) used the EGGNIT-II computer code to determine how much cadmium is required to prevent criticality in a solutions and mixtures containing plutonium. Although the anticipated plutonium concentration was only 2.6 g/L, Carter looked at the relationship between cadmium and the critical concentration of plutonium for plutonium concentrations of 17 to 30 g/L. Table 3 shows the relationship between cadmium and plutonium critical mass when the plutonium concentration is maintained constant at 17 g/L.

Table 3. Relationship Between Plutonium Critical Mass
and Cadmium Content
(Plutonium concentration held constant at 17 g/L.)

Plutonium Critical Mass kg	Cd/Pu Mass Ratio
150	0.11
300	0.12
infinite	0.13

The quantity of cadmium required by the CSER/CPS to be added to this waste was greater than the requirement of the CSER calculated data. For conservatism, the Cd/Pu mass ratio for a plutonium concentration of 17 g/L Pu was increased to 0.25 (vs 0.13 calculated for an infinite mass of Pu) for these waste handling operations. Similarly, the Cd/Pu mass ratio for a plutonium concentration of 30 g/L was increased to 0.33. These operating limits are about twice the values required by the CSER calculated data.

Whereas it was determined that no cadmium was needed to ensure safety for plutonium concentrations below 4 g/L in the solids, the decision was made to require addition of cadmium only when the plutonium concentration exceeded

50 % of that threshold, 2 g/L.

In 1984 a revision was proposed to the CPS to cover cadmium poisoned waste to be sent to Tank 102-SY. Carter (1984) wrote a criticality safety analysis report (CSAR) to form the basis for the revision. This CSAR is contained in Appendix B. The 105-AW tank is the tentative receiving tank for the Tk-D5/Tk-E6 material, rather than 102-SY described in the 1984 analysis, but the waste itself will meet the description of cadmium bearing waste covered by the proposed 1984 CPS. The limits proposed by Carter are as follows:

1. All wastes shall be maintained in the tank such that the precipitated solids shall remain with the plutonium material.
2. If dissolution were to occur, the plutonium concentration must be recalculated. If the plutonium concentration is predicted to be within the following ranges, appropriate cadmium additions shall be made:

Plutonium Concentration in Solids g/L	Minimum Cadmium Required (as precipitated solids) Cd/Pu Mass Ratio
$0 < \text{conc.} \leq 2$	0
$2 < \text{conc.} \leq 17$	0.25
$17 < \text{conc.} \leq 30$	0.33

3. Conditions shall be maintained to ensure that the required cadmium remains associated with the Pu solids.
4. Tank limits under these conditions may be increased to 125 kg of plutonium.

Because the concentration level in the 102-SY tank is based on, among other things, the total mass limit and since the mass limit is raised to 125 kg of plutonium, the concentration of plutonium in solutions routed to the tank shall be not more than 0.125 g/gal.

The receiving tank for Tk-D5/Tk-E6 solution (tentatively 105-AW) would also utilize the 0.125 g/l Pu limit for transfers but would not have the Pu mass limit increased above the current 50 kg value. Based upon limits within CPS-T-149-00010, Rev C-1, the 9 kg of plutonium estimated to be contained in both Tank Tk-D5 and Tk-E6, would remain subcritical for a concentration of up to 30 g Pu/L provided that 3 kg of cadmium were present. This would be true for an infinitely large system with no uranium present. In fact, there is about 100 kg of cadmium in the waste, a quantity more than 30 times as great as required.

Rogers (1993) shows that for a Cd/Pu atom ratio of 2 or more the system remains subcritical to a plutonium concentration of at least 400 g/L. Since the laboratory analyses for the material in Tanks Tk-D5 and Tk-E6 correspond to a Cd/Pu ratio of at least 6, sufficient cadmium is present to preclude criticality. This would be true even if there were no uranium present and for any foreseeable precipitation mode.

3.6 RECEIVER TANK

Waste from PUREX Tanks Tk-D5 and Tk-E6 tentatively will be pumped to waste storage Tank 105-AW. The current status of 105-AW, based on Tank Farm Inventory records [Reference(1993)] show 15.8 kg Pu in xxx,xxx gallons of waste which includes at least xxx,xxx gallons of solids .

Transfer of the 9 kg Pu from Tk-D5/Tk-E6 into this material would raise the inventory to approximately 25 kg Pu. This is below the current CPS limit of 50 Kg Pu, but at the administrative limit currently imposed upon most Tank Farm tanks, pending resolution of the Tank Farm criticality safety USQ. The introduction of the Tk-D5/Tk-E6, material with the excess amount of neutron absorbing uranium and cadmium, will actually somewhat reduce the nuclear reactivity of the current 105-AW material.

The administrative restraint placed upon Tank Farms "No further transfers shall occur if a tank, such as 105-AW reaches 25.0 kg Pu inventory," shall not stop the completion of transfers from Tk-D5/Tk-E6.

Similarly, since there will remain minimal transferrable Pu (<10 kg) in the flush solutions of PUREX vessels, the administrative restraint shall not prevent additional transfers to 105-AW following the Tk-D5/Tk-E6 transfers. [Conversely, relative to the administrative 25 kg limit, the inventory can be maintained as total Pu into 105-AW, excluding the Tk-D5/Tk-E6 Pu mass, due to its "effective negative Pu mass content," considering the amount of neutron osison present.]

The cadmium contained within the PUREX waste is considerably more than required to ensure subcriticality for the incoming waste. The excess cadmium will be effective in poisoning the waste already in Tank 105-AW. Therefore, therefore no increase in the reactivity of the tank waste is possible.

4.0 CONCLUSIONS

The largest measured plutonium concentration in this waste solution is 0.6 g/L, a quantity only 24% as large as the minimum critical plutonium concentration in tank waste of 2.6 g/L in solids. No concentrating mechanisms have been identified which would be capable of raising the plutonium even over a small volume to the level required for criticality. For criticality to occur with less than 10 kg of plutonium present, as is the case for this waste, the plutonium concentration would have to approach a value of 10 g/L. It is clear that criticality is extremely unlikely, even without considering the effect of good neutron absorbers present in the waste.

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The Pu/U mass ratio for the waste is given from sample analysis as being approximately 0.0021, a value large than the subcritical limit of 0.0013. Nevertheless, this ratio is sufficiently small to insure that the mass of plutonium required for criticality is relatively large, provided the ratio remains unchanged. The quantity of plutonium required certainly would exceed the estimate 9 kg which is present in this waste.

The primary control ensuring subcriticality is the presence of cadmium. The concentration of cadmium in this waste is approximately 30 times as great as would be required to assure subcriticality when the plutonium concentration is 30 g/L. Therefore, if the plutonium concentration were to be increased by a factor of 50, subcriticality would still be assured by the cadmium. Even then, there would still be a large margin of safety.

The presence of both the uranium and cadmium in the plutonium precipitate, ensured by the alkaline nature of the solution, reinforces the safety. The restriction that the plutonium concentration not exceed 0.125 g/L in solution routed to tank storage provides further safety during transfer.

If an alternate disposal method is chosen, criticality safety will continue to be assured as long as coprecipitation of the plutonium, uranium, and cadmium is assured.

5.0 REFERENCES

- Colvin, C. A., 1967, "Properties of Potential Uranium Precipitates as Related to Chemical Processing," ARH-147, October 30, 1967.
- Reberger, D. W., 1993, "Dilution of Uranium Waste Solutions In PUREX Tank F18," Letter 7C245-93-012, September 30, 1993.
- Rogers, C. A., 1993, "CSER 92-009: An Analytical Model For Evaluating Subcritical Limits For Waste in Hanford Site Storage Tanks," WHC-SD-SQA-CSA-20356, Rev. 0, November 1993.
- Carter, R. D., 1984, "CSAR 79-007, Addendum 2A, Waste Storage Tanks and Associated Equipment," April 1984.
- Thomas, J. T., 1978, Nuclear Safety Guide, IID-7016, Revision 2, NUREG/CR-0095, ORNL/NUREG/CSD-6, Oak Ridge National Laboratory, p. 54.
- Harty, D. P., 1993, "Disposition of PUREX Facility Tanks D5 and E6 Uranium and Plutonium Solutions," WHC-SP-1072

APPENDICES

- A CSAR 79-007, Addendum 2A, Waste Storage Tanks and Associated Equipment
- B EGGNIT-II Calculations of Minimum Critical Mass by J. L. Geiger

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APPENDIX H:

LETTER: "SURPLUS MATERIALS PEER PANEL MEETING"
Dated November 5, 1993

WHC-SP-1072

TO: JEFF KERRIDGE DOE/EM-64

FROM: AL WILLIAMS *A.K. Williams*

DATE: NOVEMBER 5, 1993

SUBJECT: SURPLUS MATERIALS PEER PANEL MEETING, HANFORD SITE,
OCTOBER 6-8, 1993. Report No. 3.

The Surplus Materials Peer Panel (SMPP) met at the Hanford Site on October 6-8, 1993. The agenda for the meeting is found in Attachment I. Members of the SMPP present and absent are as follows:

Members Present

A.K. Williams, Chairman
M.M. Beary
D.C. Moody
M. Dinehart
L.B. Gannon
R.E. Hanvey
A. Schneider
E. Moore
G. Offutt
J. Kerridge
M. Haas

Members Absent

M.J. Steindler
T.B. Cochran
N. Jessen

Activities of the Panel consisted of review of planned operations in the Plutonium Finishing Plant (PFP) for disposition of unstable residues and solutions, and plans for disposition of plutonium solutions contaminated with fission products in the Purex facility. Presentations were made by Westinghouse Hanford Co. (WHC) describing planned activities for disposition.

The principal recommendations of the SMPP are as follows:

- A-1. The solutions now stored in the Purex facility in tanks D5 and E6, should be neutralized and disposed to the Tank Farm as recommended by WHC. The quantities of material consist of 20,000 liters (approximately 5300 gallons) containing 5100 kg of uranium and 8.7 kg of plutonium. The net neutralized waste volume transferred to the Tank Farm would be approximately 7000 gallons. This recommendation is contingent upon acceptance by the Hanford Waste Management organization and successful resolution of the Tank Farm Unreviewed Safety Question (USQ).
- B-1. An overall strategy for disposition of surplus materials and use of the PFP needs to be developed. The existing assumptions, such as the need to purify plutonium to a pedigree purity should be re-examined in

terms of stabilization and potential operating personnel exposure and costs.

- B-2. The DOE guidance on product specification, which is a number of years old, needs to be reviewed since the plutonium is considered surplus.
- B-3. The NEPA approach of pursuing an Environmental Assessment (EA) needs to be reviewed. The Panel believes that an Environmental Impact Statement will likely be required. The approach of justifying use of carbon tetrachloride (CCl₄) beyond the Montreal Protocol deadline of January 1, 1996 may be flawed. Although the Panel agrees that CCl₄ must be used if the solvent extraction system is operated, the need for solvent extraction in order to stabilize residues has not been adequately justified and may not be necessary.
- B-4. Studies need to be conducted which provide more definitive analysis of alternatives beyond that from the June, 1992 workshop. Alternatives which need to be included in these studies include an option with no solvent extraction such as direct precipitation of solutions, and an option which allows neutralization of solutions and disposal to the Tank Farm.
- B-5. The technical basis for the Tank Farm fissile material limit of 0.05 grams per gallon needs to be re-examined. It is believed that a higher limit could be justified which would make a Tank Farm disposal option more attractive.
- B-6. Due to the limited amount of time for the review, the Panel did not have time to adequately address the urgency and safety implications of a delayed restart. Additional RL documentation is required to support any further assessment of startup urgency by the Panel.

More detailed discussions on these issues are provided in Attachment II.

The Panel discussed briefly disposition of unstable plutonium solutions at the Rocky Flats Plant. The revised Actinide Solution Disposition Study (ASDS) has not yet been released for Panel review. Panel members knowledgeable of Rocky Flats operations indicate that there may be safety concerns regarding continued storage of plutonium solutions requiring near-term action. The Panel would like to pursue this issue to determine if these safety concerns are legitimate and assist in preparing a recommended action.

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The responses to Panel questions on WIPP (see Report dated May 24, 1993) were distributed to Panel members.

Dr. Alfred Schneider and Dr. Thomas Cochran are new members of the Panel. A revised list of Panel members and their addresses is found in Attachment III.

Enclosures:

- Attachment I: Agenda
- Attachment II: Report
- Attachment III: Revised List of Panel Members and Addresses

Distribution:

M.M. Beary	SAIC	N. Jessen	MMEC
T.B. Cochran	NRDC	D. Moody	LATO/RF
M. Dinehart	LANL	E. Moore	WSRC
L.B. Gannon	SAIC	G. Offutt	WINCO
M. Haas	WHC/EM-64	A. Schneider	Consultant
R.E. Harvey	Sonalysts	M.J. Steindler	ANL

ATTACHMENT II

REPORT OF THE SURPLUS MATERIALS PEER PANEL MEETING AT HANFORD
OCTOBER 6-8, 1993

The Surplus Materials Peer Panel (SMPP) met at the Hanford site on October 6-8, 1993 to review Westinghouse Hanford Co. (WHC) plans for stabilization of plutonium solutions and selected reactive residues in the Purex facility and in the Plutonium Finishing Plant (PFP). A tour was also made of the PFP by selected members of the Panel. Besides WHC attendees, representatives from DOE-RL and DOE-HQ also attended the meeting.

M.J. Steindler, T.B. Cochran, and N. Jessen were absent from this meeting. Alfred Schneider and Thomas B Cochran are new members of the Panel and have been added to the distribution list.

This report contains seven recommendations. All recommendations with the exception of Recommendation B-6 were discussed with DOE-RL and WHC management at a closeout meeting held on October 8, 1993. This report provides additional comment and discussion of the Panel recommendations.

A. Disposition of plutonium nitrate solution from tanks D5 and E6 in the Purex facility

The contents of tank D5 consists of 10,600 liters of solution containing 2900 kg uranium ($<0.96\% \text{ U}^{235}$), 3.5 kg plutonium, 1-5 g/l cadmium, and 1M nitric acid. The contents of tank E6 consists of 9200 liters of solution containing 2300 kg uranium ($<0.96 \text{ wt}\% \text{ U}^{235}$), 5.2 kg plutonium, 2-5 g/l cadmium and 1M nitric acid. The solutions in each tank are also contaminated with fission products from cleanout operations.

Options under consideration for stabilization are solvent extraction (both continuous and batch), ion exchange, in-tank co-precipitation of the U/Pu mixture and storage, co-precipitation with removal and storage of the U-Pu mixture in drums, and co-precipitation of the U/Pu mixture and transfer of the neutralized solution to the Tank Farm.

The solvent extraction options would provide a purified product which could be transferred to the PFP for storage. Existing equipment in the Purex facility would be used for either the continuous or batch processes. The estimated waste volume to the Tank Farm is 50,000 gallons. Although transfers have been made previously to PFP, this option may no longer be available.

The ion exchange process option would also provide a purified product, however,

new equipment would need to be installed to perform the ion exchange separation. The estimated waste volume to the Tank Farm is 45,000 gallons.

In-tank co-precipitation and storage with no further processing can be accomplished, however, the solids would require further disposition in order to remove them prior to completing deactivation of the facility. This option may also result in waste which will require significant treatment to prepare it for disposal in a repository.

In-tank co-precipitation and storage of the U-Pu mixture in drums can be accomplished, however, filtration or other solid liquid separation and solids loadout equipment would be needed. The discharge to the Tank Farm would be approximately 7000 gallons. From 80 to 300 drums of U-Pu solids Transuranic (TRU) waste would be generated for storage. The large differential in drums is caused by criticality concerns. If the total fissile limit per drum is 200g, 300 drums are needed. The uranium in the tanks contain <0.96 wt. % U^{235} , thus a significant portion of the total fissile content is from uranium. If the Pu content is limited to 200g, then the total solids become limiting (est. 1600 gallons of solids and 20 gallons solids per drum).

In-tank co-precipitation and neutralization, followed by disposal of the slurry to the tank farm can be performed in existing equipment. This is the preferred option, assuming satisfactory resolution of the Unreviewed Safety Question (USQ) on criticality for the Tank Farm, and allowing transfers of 200 grams or more plutonium per batch. The volume of solution to the Tank Farm may be as low as 32,000 gallons (1100g Pu per batch, $U=40$ g/l), or as high as 200,000 gallons (200g Pu per batch, $U=6$ g/l). The diluent for transfer would be existing waste water and recovered acid, thus the net increase to the Tank Farm would be approximately 7000 gallons. The Pu addition to the Tank Farm would be less than 2% of the existing Pu inventory in the tanks. Tanks are limited to a maximum 25 kg Pu per tank. Pending resolution of the Tank Farm USQ, the current plutonium limit is 15 grams per batch. This limit would require 2.7 million gallons of diluent, which is considered unacceptable. A 500 gram per batch limit appears reasonable (Tank Farm volume would be 80,000 gallons). To achieve this limit, additional criticality evaluations would be necessary. Satisfactory resolution of the current USQ would raise the limit to 200 grams plutonium per batch.

Once Purex Deactivation is complete, overall surveillance and maintenance costs are expected to decrease from the current \$48 million to \$3 million. The Panel believes that this cost reduction is achieved with complete cleanout, and not just solution stabilization. Removal of the solution is but the first step, and will result in only a partial reduction in surveillance and maintenance activities.

Further study by Waste Management is required to resolve the Tank Farm USQ and

to further confirm that this waste can be handled with no adverse impact to waste Tank Farm operations or to waste process treatment operations.

The Panel Recommendation is as follows:

A-1. The solutions now stored in the Purex facility in tanks D5 and E6, should be neutralized and disposed to the Tank Farm. The quantities of material consist of 20,000 liters (approximately 5300 gallons) containing 5100 kg of uranium and 8.7 kg of plutonium. The net neutralized waste volume transferred to the Tank Farm would be approximately 7000 gallons. This recommendation is contingent upon acceptance by the Hanford Waste Management organization and successful resolution of the Tank Farm Unreviewed Safety Question (USQ).

B. Disposition of plutonium solutions and reactive residues from the Plutonium Finishing Plant (PFP).

The Plutonium Finishing Plant (PFP) contains plutonium solutions and reactive residues which require stabilization. Startup of the plant is awaiting completion of an Environmental Assessment (EA), which is now being expanded. The PFP consists of two major operations: The Plutonium Reclamation Facility (PRF) and the Remote Mechanical C (RMC) Line. The PRF is a solvent extraction system used for purifying plutonium materials, and the RMC line is used for conversion of purified plutonium solutions to a solid plutonium oxide. Startup of the PRF is scheduled for late summer of 1994. The RMC line would operate after the PRF operation was complete.

WHC has identified 5 categories of plutonium materials in the PFP inventory (excludes irradiated fuel). The total plutonium inventory consists of 7919 items with a net weight of 25,609 Kg. Details of this inventory are provided in Table 4-1 of WHC-SD-CP-VES-001, Rev. 0, "Summary Report on Hanford Plutonium Disposition Workshop", held in June 1992. A copy of this Table is attached to this report. The 5 categories identified in this report are as follows:

1. Material Which is Shippable and Long Term Storable
2. Material Which is Reactive and is Feed For Planned Stabilization Run
3. Material Which is Reactive But is Not Feed For Planned Stabilization Run
4. Material Which Requires Characterization and Probably Needs Stabilization or Processing.
5. Material Which Requires Process Development Before Processing

Materials in Category 2 would be processed during the planned Stabilization Run. A number of items in Category 3 (primarily the solutions) could also be processed

during this run. The total bulk material processed would be 55-60% of the total bulk.

Processing of aqueous solution from cleanup of gloveboxes and canyon sumps is also planned.

Alternatives presented to the public and the Panel are as follows:

- Use current PFP processes to stabilize reactive plutonium-bearing materials. This alternative would use available, proven processes, with a trained staff, and allows for start of facility retirement. It requires hands-on operations, requires the use of carbon tetrachloride for the solvent extraction system, and generates a liquid waste stream to the Tank Farms.
- No action. This alternative can be implemented immediately, however, surveillance must be continued indefinitely, reactive materials are not stabilized and it does not permit facility retirement.
- Transfer the chemically reactive materials to the tank farms. This alternative does not require operation of the stabilization processes and enables initiation of PFP retirement, however, it requires a large volume of diluent (6,000,000 gallons) to allow transfer to the Tank Farms. This volume is based on a limit of 0.05 grams plutonium per gallon (0.0132 g/l) established for the Tank Farms.
- Vitrification. This alternative places the material in a long-term storage form, which would be suitable for storage and/or shipment, however a processing facility would not be available for at least ten years. Plutonium processing has not been planned or engineered for the current vitrification facility (HWVP) design.
- Direct denitration with thermal stabilization. This alternative does not require the use of carbon tetrachloride, minimizes liquid effluent, and stabilizes the reactive materials. The technology has not been demonstrated beyond the laboratory, requires major facility modifications, and releases oxides of nitrogen to the environment.
- Precipitation with thermal stabilization. This alternative does not require the use of carbon tetrachloride, minimizes liquid effluent and stabilizes the reactive material. The technology is used at other DOE sites, but has not been demonstrated at PFP. Major facility modifications are required, the operational and safety problems are not completely known, and implementation requires 3-5 years.

- Transfer to another facility for stabilization. This alternative requires a stabilization and packaging facility. It eliminates the need for the PRF and RMC line, minimizes effluent discharges, and enables initiation of PFP retirement once the materials are removed. The materials do not meet current DOT shipping requirements, no other DOE sites are able to receive the materials, and interstate transportation approval is difficult.

Criteria used by WHC in comparing these alternatives include risk, regulatory compliance, relative technical feasibility, waste volume generation, schedule comparability, costs and public acceptance. The conclusion was that use of the current PFP processes to stabilize reactive plutonium bearing materials is the preferred alternative.

The above conclusion is based on the Alternatives Study Workshop held in June, 1992, and on DOE guidance which is approximately 3 years old. The approach by WHC for operation of the PFP is to provide an expanded EA, one FSAR, and two ORRs, one for PRF operation and one for RMC line operation. The PRF operation is scheduled to take approximately 44 weeks. Material to be processed are those solutions now being stored in PR cans and L-10 containers and reactive solids now stored in glovebox lines throughout the facility. The purified solution from PRF would then be processed through the RMC line. RMC line startup would be scheduled after completion of PRF operations. Although the PRF is normally used to support the RMC line operation by processing the recycle streams, WHC plans to disposition the recycle streams without use of the PRF. In response to questions from the Panel, WHC indicated that the treatment of these recycle streams from the RMC line is only conceptual. Current guidance from DOE to WHC is that the processed material should meet a purity specification similar to that for weapons grade material. All planning to date has been with the assumption that the stabilization run would be started in the immediate future (within 3 months). It now appears that startup would occur no sooner than late summer, 1994.

The PRF contains up to tens of kilograms of plutonium on the floor of the process cell and sumps in support gloveboxes. This material is the result of accumulations from leaks of process equipment from recycle operations during runs of the RMC line a number of years ago. Although this material is well within the criticality limits of the cell, it needs to be cleaned off the floor and processed for stabilization. Cleanup of the PRF would be necessary before there would be any significant cost savings from placing the facility in standby or shut-down condition.

Annual operating costs for surveillance of materials in the PFP are approximately \$100 million per year. These costs can be reduced to \$60 million per year by

stabilizing reactive materials, removing them from the glovebox lines, processing solutions for stabilization and storing the stabilized materials in the vault. To achieve this cost reduction, plutonium would also need to be removed from the ventilation ductwork.

Personnel radiation exposures from processing the material were also discussed. Americium in-growth continues to increase the radiation levels of the material. WHC expressed concern over these radiation levels if the material is processed directly through RMC line with no americium removal.

Currently, approximately 68 Rem of the total 137 Rem of Hanford site exposure is attributed to the PFP. This exposure in PFP is attributed to surveillance of this material in the process lines and the solution storage area, training and startup activities on PRF equipment, and to plutonium in ductwork. The removal of plutonium from ductwork was not considered within the scope of thermal stabilization. The ducts containing plutonium are not connected to process lines scheduled for use in the stabilization runs.

Materials which are already stored in vaults would not be processed. This material is considered stable, and there are no plans for dispositioning for at least the next decade.

The Panel Recommendations are as follows:

- B-1. An overall strategy for disposition of surplus materials and overall use of the PFP needs to be developed. The existing assumptions, such as the need to purify plutonium should be re-examined in terms of stabilization and potential operating personnel exposure and costs.

The short-term approach, which may have been valid when processing reactive materials was thought to be about ready to start, needs to be re-examined. In particular, removal of plutonium from the ducts could be included in planning, since resumption is now scheduled no sooner than late summer 1994. The Panel believes that the overall cost reductions of \$60 million projected by WHC will be difficult to meet until all material is dispositioned within the facility.

The EM-64 Disposition Guidance and Criteria for Surplus Materials Disposition Studies may be of value to WHC in preparing an overall strategy for surplus materials disposition.

- B-2. The DOE guidance on product specification, which is a number of years old, needs to be reviewed since the plutonium associated with this stabilization run is considered surplus.

Stabilization of materials may not include purification if the materials can be processed directly to a stable and storable form. Purification could be justified for removal of americium, if such a step results in significant reduction to the overall dose, or if the materials are in a form which cannot be stabilized directly by other means.

- B-3. The NEPA approach of pursuing an Environmental Assessment (EA) needs to be reviewed. The Panel believes that an Environmental Impact Statement will likely be required. The approach of justifying use of carbon tetrachloride (CCl₄) beyond the Montreal Protocol deadline of January 1, 1996 may be flawed. Although the Panel agrees that CCl₄ must be used if the solvent extraction system is operated, the need for solvent extraction in order to stabilize residues has not been satisfactorily justified and may not be necessary.

Information available to the Panel indicates that litigation is expected if an EA is published. The Dept. of Justice has indicated that the litigation will not be contested, and that the DOE will be forced to publish an EIS. An EIS may take up to two years to complete. Startup of the PFP in 1996 would not allow use of carbon tetrachloride in the PRF unless an exemption is given. The Panel believes that an exemption request may be denied, unless solvent extraction operations could be proven to be a processing step necessary to stabilize these materials. By removing the product purity specification (see item B-2 above), solvent extraction may become unnecessary.

- B-4. Studies need to be conducted which provide more definitive analysis of alternatives beyond that from the June, 1992 workshop. Alternatives which need to be included in these studies include an option with no solvent extraction such as direct precipitation of solutions, and an option which allows neutralization and disposal to the Tank Farm.

The Panel believes that additional work needs to be performed in reviewing options for stabilization of plutonium residues at the PFP. It is possible that some plutonium can be discarded to the Tank Farms, using an approach similar to that developed by Purex. The feasibility of such an approach merits further consideration. The Panel recognizes that Tank Farm considerations, particularly with respect to plutonium criticality, need to be carefully reviewed before implementing such an alternative. Coordination with the Purex

technical staff and Waste Management organizations on this matter is essential. As a minimum, this approach should be considered for RMC recycle streams to eliminate the need for PRF.

As discussed in item B-3 above, the Panel questions the need for operating the solvent extraction system if purification is not required for the product. Additional factors, including DOE Order Compliance, Non-Proliferation, Schedule, and Pedigree purity need to be factored into any additional evaluations.

Documentation to support the projected cost savings was not provided. The approach taken by WHC provides only a partial cleanup of the PFP, and there are too many follow-on activities to allow significant reduction in overall costs.

- B-5. The technical basis for the Tank Farm fissile material limit of 0.05 grams per gallon needs to be re-examined. It is believed that a higher limit could be justified which would make Tank Farm disposal more attractive. The Panel could not find documentation which provides a basis for this limit.
- B-6. Due to the limited amount of time for the review, the Panel did not have time to adequately address the urgency and safety implications of a delayed restart. Additional RL documentation is required to support any further assessment of startup urgency by the Panel.

Further study is required to define the urgency of processing.

C) Disposition of Plutonium Solutions at Rocky Flats

The Panel discussed briefly disposition of unstable plutonium solutions at the Rocky Flats Plant. The revised Actinide Solution Disposition Study (ASDS) has not yet been released for Panel review. Panel members knowledgeable in Rocky Flats operations indicate there may be safety concerns regarding continued storage of plutonium solutions, particularly those solutions located in B-771, which may require near term action. The general deterioration of the building and equipment is of concern. The Panel would like to pursue this issue to determine if these safety concerns are legitimate and assist in preparing a recommended action.

D) WIPP Questions

The response to Panel questions on WIPP were transmitted to EM-64 on September 14, 1993. The questions and the responses have been distributed to Panel members.

WHC-SP-1072

APPENDIX I:

MEMORANDUM: "SURPLUS NUCLEAR MATERIAL DISPOSITION PLANS"
Dated June 16, 1993

memorandum

WHC-OP-1072

DATE: JUN 16 1993

REPLY TO
ATTN OF: EM-64 (J. Kerridge 202-586-2054)

SUBJECT: Surplus Nuclear Material Disposition Plans

TO: Manager, Richland Operations Office
Acting Manager, Rocky Flats Office

The Office of Facility Transition and Management (EM-60) has assumed the responsibility for surplus nuclear material at the Rocky Flats Plant (RFP) and Hanford Purex Plant from the Office of Defense Programs (DP). We have been provided draft plans for solution stabilization at RFP and expect additional plans from the other sites as materials are surplused and turned over to EM. Dispositioning these materials is a new challenge for EM-60, and to facilitate development of complete and consistent disposition plans, the attached general guidance is provided.

I have attached evaluation factors that will be used to evaluate each option within your disposition plans. These factors were developed by EM-64, and validated by the EM-64 Surplus Materials Peer Panel, a group of complex-wide experts who have been chartered to provide a third party independent review of disposition decisions. It is recognized that information will not necessarily be available for all evaluation factors upon initial submission of the plans and reports. To the extent possible, however, documented estimates should be used where specific data are not readily available.

Due to the actinide concentration levels of some of these materials, conventional waste treatment facilities may not be acceptable. If actinide separation becomes the recommended option for any of your material, as a pretreatment to facilitate waste treatment and disposal, it will be selected without regard for the value of the recovered material. In other words, once the material is transferred to EM, the material will be managed for the purpose of meeting waste disposal criteria.

If you have questions during the development of disposition plans, please contact me or Jeff Kerridge, 202-586-2054.

Leanne Smith

Office of Site and Facility Transfer, EM-64
Office of Environmental Restoration and
Waste Management

Attachments

cc:
L. Harmon, EM-32
W. Kelly, EM-64
X. Ascanio, DP-6.1
L. Willett, DP-27

Evaluation Factors

Health and Safety. Health and safety of the worker and protection of the environment are of paramount importance in the disposition process and should be weighted accordingly.

Worker Exposure. Disposition decisions will be made giving full consideration to radiological and chemical hazards and their impact on the worker who must either repackage, treat, stabilize, ship, or store surplus nuclear materials. The annual dose rate for workers must be calculated as well as a total exposure expected throughout the life of the program up until placed into a disposal facility. Where possible, the impacts should be quantified or costed.

Risk Assessment. The risk of an accident and the potential exposure to the workers and public ~~cause~~ caused by an accident must be quantified. The risk must be conducted for both radiological and chemical aspects through the life of the program.

Regulatory Concerns. Each disposition option must take into account the applicable Federal and State regulations and any associated compliance agreements. An evaluation must be made to determine whether each option will meet all regulatory commitments, and highlight the non-compliance risks and the impacts of missing commitments.

Waste Minimization. The ratio between the volume of material currently in the inventory and the volume of waste which is expected to be generated is required for each option. The volume must take into consideration transportation and disposal criteria as applicable to individual waste packages.

Stakeholder Interest. The impacts on the stakeholders must be evaluated for each option. Stakeholders include: workers, unions, local communities, state and federal regulatory authorities. Stakeholders at disposal facilities, alternate sites for processing and along the transportation routes must be considered. The amount of stakeholder opposition should be estimated for each option.

Cost. The cost for each option should be estimated. The cost should be life cycle cost and include items such as:

- storage of material prior to processing;
- storage of waste generated from processing awaiting transportation to disposal facility;
- storage of product awaiting transportation;
- transportation of materials to alternate sites for processing;
- transportation of waste to disposal facility;
- transportation of waste to interim storage facility;

- transportation of product to long term storage facility;
- total projected costs for the construction of any new facilities or modifications to existing facilities for processing;
- operating cost of the processing facility;
- disposal cost at disposal facility use; \$700 \$7000/drum for TRU waste at WIPP and \$33/cubic ft at the Nevada Test Site (NTS) for Low Level Waste;
- processing may include repackaging, actinide separation, or treatment of the hazardous constituent

Disposal Criteria. The waste acceptance criteria for individual waste packages must be met as well as taking into consideration overall disposal facility constraints such as volume and curie limits.

Technical Risks. Any technology utilized in each of the options must be evaluated to determine the confidence level of success. Obviously, a decision maker will have more confidence in a proven technology than a technology in basic research and development. The risk of using non-proven technologies must be evaluated.

Implementation Time and Schedule. The use of well established, simple technologies that could be readily implemented is to be encouraged.

General Guidance

Value Engineering. It is imperative that the selection of options and their prioritization be documented and should be conducted in an easily defensible manner. This documentation can be the result of a value engineering study or alternative process of comparable rigor.

Urgency/Expediency. Surplus materials whose continued storage in their current configuration represents a risk to worker safety or the environment should be described in detail as to the basis for such a categorization and should include the extent of the risk and interim measures planned or underway, as well as ultimate disposition plans.

Material Volumes/Storage. Tables containing storage locations and volumes of surplus material should be provided. Specific information concerning permits for RCRA materials storage and storage restrictions should also be included. One of the options for disposition of surplus materials that should be evaluated is continued interim storage. While it is not the intent of EM-60 to store these materials indefinitely, availability of treatment capacity or disposal sites and DOE complex-wide prioritization schedules for materials disposition may require that this option of continued storage be exercised for an interim period.

Material Descriptions. Descriptions of the surplus materials should be as complete as possible. To promote public involvement, these plans should not contain classified material. Hazardous constituents and RCRA waste designations should also be described.

Ranking. Documented ranking criteria are essential. The criteria provided herein should be used as a starting set and may be augmented as appropriate. Numerical rankings of options for surplus material disposition and not essential but are encouraged. Commercial software should be used whenever possible. Most important is the communication of the decision process and the prioritization results in a clear concise format.

Site/Facility Issues. Disposition plans should include any site or facility specific information necessary to the decision process.

Compliance. A current compliance status (permitted storage, site FFCA, compliance order,...) should be communicated along with a brief history of compliance activities directly pertinent to the surplus materials.

Options. Three general options, at a minimum, should be considered: treating and disposing as a waste; shipping to another DOE location for dispositioning; or processing to concentrate the actinides and dispositioning the waste. Within each option, there are sub-options which should consider all possible technologies and facilities.

Documentation. Internal DOE review of disposition plans as well as communication of the plans to the public necessitates complete written documentation of decisions and processes leading to recommendations. The use of appendices is encouraged so the documentation can be complete while the plan is clear, concise, and easily communicated. Provide complete document references for cited supporting information.

Public Involvement. Plans should include approaches for public involvement in the disposition of surplus materials and are encouraged to go beyond the specific requirements ~~for~~ for obtaining permits for RCRA regulated materials.

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APPENDIX J:

REFERENCES

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REFERENCES

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