UNALLOCATED OFF-SPECIFICATION HIGHLY ENRICHED URANIUM: RECOMMENDATIONS FOR DISPOSITION

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ABSTRACT

The U.S. Department of Energy (DOE) has made significant progress with regard to disposition planning for 174 metric tons (MTU) of surplus Highly Enriched Uranium (HEU). Approximately 55 MTU of this 174 MTU are "off-spec" HEU. ("Off-spec" signifies that the isotopic or chemical content of the material does not meet the American Society for Testing and Materials standards for commercial nuclear reactor fuel.) Approximately 33 of the 55 MTU have been allocated to off-spec commercial reactor fuel per an Interagency Agreement between DOE and the Tennessee Valley Authority (1). To determine disposition plans for the remaining ~22 MTU, the DOE National Nuclear Security Administration (NNSA) Office of Fissile Materials Disposition (OFMD) and the DOE Office of Environmental Management (EM) co-sponsored this technical study. This paper represents a synopsis of the formal technical report (NNSA/NN-0014).

The ~ 22 MTU of off-spec HEU inventory in this study were divided into two main groupings: one grouping with plutonium (Pu) contamination and one grouping without plutonium. This study identified and evaluated 26 potential paths for the disposition of this HEU using proven decision analysis tools. This selection process resulted in recommended and alternative disposition paths for each group of HEU. The evaluation and selection of these paths considered criteria such as technical maturity, programmatic issues, cost, schedule, and environment, safety and health compliance. The primary recommendations from the analysis are comprised of 7 different disposition paths. The study recommendations will serve as a technical basis for subsequent programmatic decisions as disposition of this HEU moves into the implementation phase.

INTRODUCTION

The objectives of this study are as follows:

1. Establish a baseline inventory of DOE surplus and soon-to-be surplus HEU containing Pu or other contaminants.
2. Define alternatives/paths for interim storage, processing, and disposition of this material. Consider both near-term and long-term paths with regard to technical maturity and availability.
3. Provide disposition strategies that are consistent with the current policies promoted by the recent HEU, Pu, and Spent Nuclear Fuel Environmental Impact Statement (EIS) Records Of Decision (2,3,4).
4. Conduct analyses of options using decision-based evaluations that consider risk, schedule, and cost information
5. Recommend to OFMD and EM Office of Integration and Disposition (EM-20) management, in association with other responsible DOE program offices, an optimum disposition pathway for every item in the scope.
6. Provide input for the development of site and program baselines.

ASSUMPTIONS

The following major assumptions served as bases for the analyses:

1. The conversion of surplus HEU to commercial nuclear fuel should be maximized. The use of commercial facilities for HEU processing and downblending should be maximized to the extent practical.
2. Defense Nuclear Facilities Safety Board (DNFSB) recommendations 94-1 and 2000-1 will be implemented as scheduled.(5)
3. The Plutonium Immobilization Plant (PIP), or equivalent capabilities, will be ultimately constructed and/or made available for dispositioning impure plutonium which is not suitable for MOX Fuel.(6)
4. DOE/OFMD will construct a Pit Disassembly and Conversion Facility (PDCF), which will clean and oxidize the HEU for return to Y-12 for eventual commercial use. In accordance with OFMD guidance, the current scope of the PDCF will not be modified to include the off-spec HEU represented by this study until the material covered by the Bilateral Plutonium Disposition Agreement with the Russian Federation has been processed through the facility. The scope of the PDCF shall be restricted until after the completion of this mission.
5. The SRS conventional processing facilities, including H-Canyon, will be available for processing until the FY08/09 time frame when DOE has demonstrated implementation of the Melt and Dilute technology for disposal of aluminum-based spent nuclear fuel.(7)
6. Bonded and contaminated HEU/Pu parts at the Rocky Flats Environmental Technology Site will be shipped to SRS for storage pending disposition.

MATERIAL SCOPE

The unallocated, off-spec HEU materials in the study were divided into two groups, with and without plutonium. These groups were then further divided into 15 subgroups based on material characteristics as presented in Figure 1.

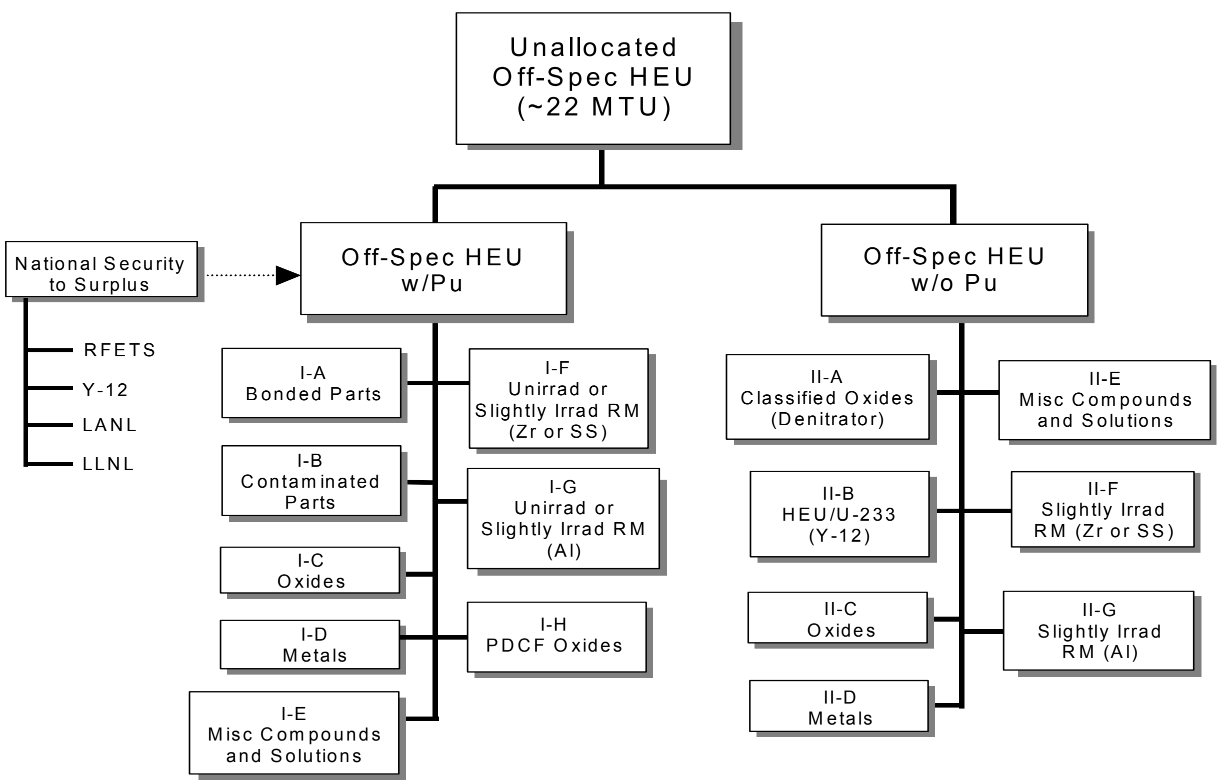

Fig. 1. Material Groups Included in this Study.

The actual quantities of the off-spec HEU by site are classified, however Figure 2 graphically summarizes the locations and amounts of the unallocated off-spec HEU distributed across DOE sites.

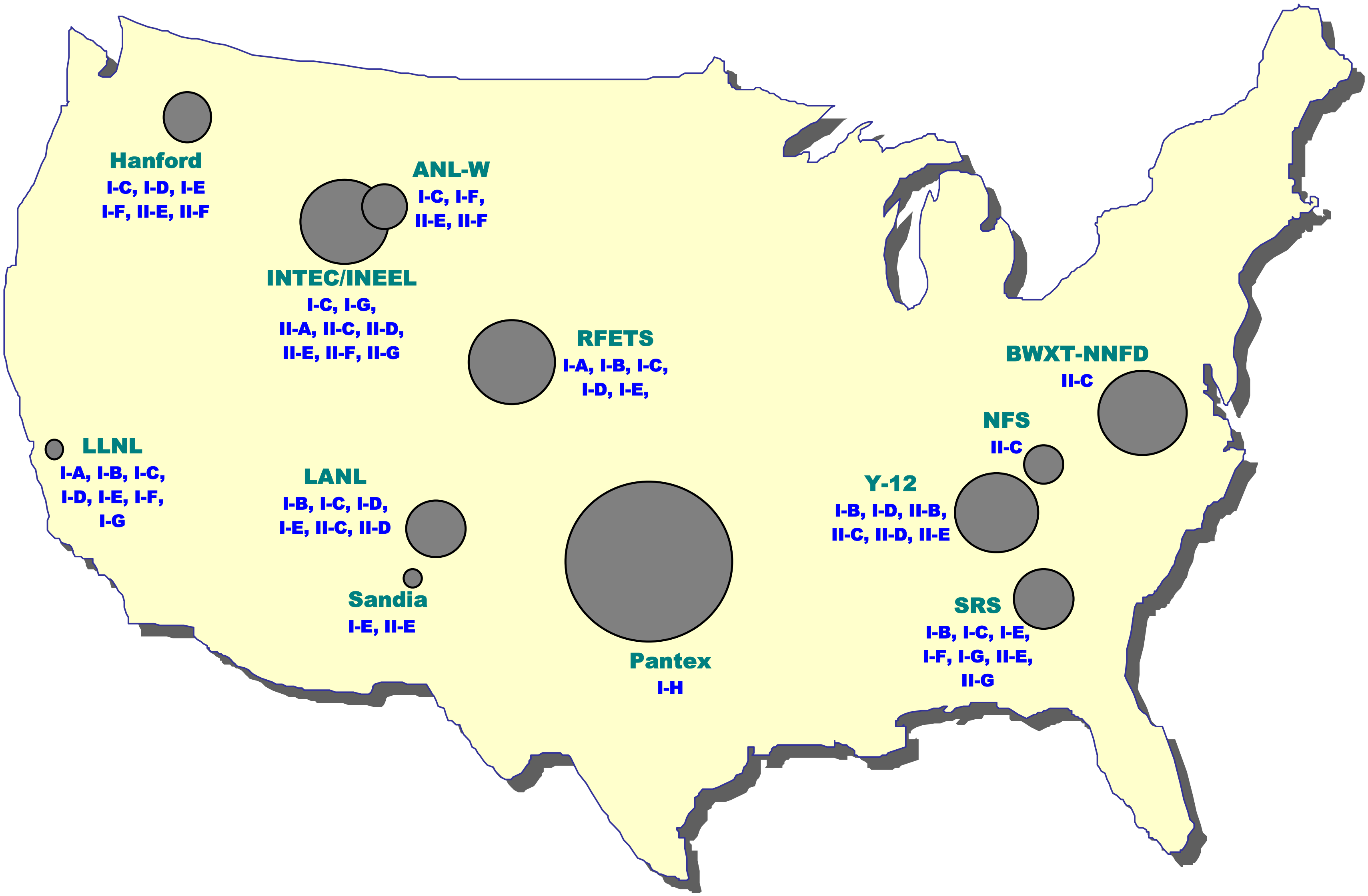

Fig. 2. Locations and Relative Quantities of Unallocated Off-Spec HEU.

METHODOLOGY

The complexity of the disposition issues surrounding off-spec HEU led the study's Technical Evaluation Team (TET) to implement an analytical approach that used principles of systems engineering in concert with proven decision-analysis tools. Twenty-six different disposition paths were identified and examined. The evaluation of these paths considered criteria such as technical maturity, programmatic issues, cost, schedule, and environmental, safety, and health compliance. Preliminary screening of the disposition paths was based on the Kepner-Tregoe decision methodology. The Analytical Hierarchy Process was used to rank the detailed disposition path/material group scenarios against the decision criteria. In some cases, specific material/path combinations were studied in more detail in "custom analyses" that supplemented the decision process.

The study was structured into phases in order to break down the complex problem into a series of more easily managed decisions and analyses. Five discrete phases are described below:

Phase I – Study Scope and Inventory

The initial phase included defining the problem, establishing the study objectives, and identifying the material inventory to be addressed by the study. The TET accomplished this phase with input from SMEs.

Phase II – Disposition Paths and Screening Criteria

Phase II of the process began the detailed options analysis portion of the study. The first part of Phase II involved developing a comprehensive set of generic disposition paths that applied to all in-scope materials. During this process, the TET also considered disposition paths defined in a predecessor study that addressed the RFETS HEU parts only (8). In addition, the TET examined process data from a parallel study by the EM Nuclear Material Stewardship Program that documented resources available for use in nuclear materials disposition across the complex (9). Disposition paths examined in this study are presented in Table I below.

Table I. Disposition Paths Analyzed

#	Disposition Path	#	Disposition Path
1	Disposal via Melt and Dilute	14	SRS Oxidation in Existing Furnaces, then Immobilization
2	Direct Disposal to LLW	15	SRS Oxidation in Existing Furnaces, then H-Canyon
3	Direct Disposal to WIPP	16	SRS Oxidation in Existing Furnaces, then Melt and Dilute
4	Direct to Immobilization (or its equivalent)	17	SRS New Oxidation Capability, then to Y-12 / Commercial
5	Direct to Y-12 or Commercial Processing	18	SRS New Oxidation Capability, then Immobilization
6	Deferred PDCF, then to Y-12 or Commercial Processing	19	SRS New Oxidation Capability, then Melt and Dilute
7	Deferred PDCF, then Immobilization	20	SRS F-Canyon Processing to ~1 wt. % Fissile for LLW
8	Deferred PDCF, then Melt and Dilute	21	SRS F-Canyon Processing to HLW
9	LANL ARIES/Oxidation, then to Y-12/Commercial	22	SRS H-Canyon Processing to Fuel
10	LANL ARIES/Oxidation, then Immobilization	23	SRS H-Canyon Processing to HLW
11	LANL ARIES/Oxidation, then H-Canyon Processing	24	Dry Blend to LLW
12	LANL ARIES/Oxidation, then Melt and Dilute	25	Advanced Surface Decontamination
13	SRS Oxidation in Exist. Furnaces, then Y-12/ Comm.	26	ANL-W Processing

The second part of Phase II initiated the process of screening the path options for each material group. For this effort, the TET used the Kepner-Tregoe (K-T) problem solving and decision methodology (10). The basic premise of the K-T technique revolves around stating the objectives of the analysis and then organizing them into "musts" and "wants." The "musts" are described as measurable requirements that are required to be met in order to achieve a successful solution. The "wants" are not mandatory to achieve a solution, but represent preferences. Both the "must" (path screening) criteria and the "want" (path prioritization) criteria were defined in this phase. The following "musts" were formulated:

- The option must be technically compatible (including transportation) with the HEU form being dispositioned.
- The option must be capable of meeting the nonproliferation objectives of OFMD, which are to render surplus HEU non-weapons usable and, where practical, recover the commercial value of the material (11,12).
- The characteristics of the proposed physical end state form must be compatible with the acceptance criteria of the proposed end-state location and all packaging/transportation systems.
- The material being dispositioned must be compatible with the acceptance criteria of the facility performing the disposition.
- The material must be compatible with the classification restrictions of the facility performing the disposition.

If the "must" criteria failed to clearly eliminate a path alternative during the preliminary screening, the path was then evaluated against the "want" criteria. From these criteria, the most viable alternatives would be those that best satisfy more "wants" or more of the higher ranked wants. Path alternatives that rated highest against the "want" criteria are carried through to the more rigorous decision analysis. The following "wants" were formulated:

- Technical Maturity – The path maximizes use of technology, processes, and equipment that exist and are ready for use.
- Programmatic Issues – The path is the simplest, with the fewest and least complicated process steps. The path is most compatible with planned missions and has the highest degree of acceptance from stakeholders.
- Cost – The path has the lowest capital, near term, and life-cycle costs.
- Schedule – The path is most compatible with planned closure schedules and achieves disposition in a timely manner.
- Environmental, Safety and Health (ES&H) Compliance – The path minimizes transport steps and handling by personnel. The material is in its lowest risk form and is adequately packaged. The generation of waste products is minimized.

Phase III – Preliminary Screening of Paths

Decision analysis methods used in this study increased in complexity as the study progressed. Early decisions were less complex and therefore required less complicated decision processes; others were more rigorous and involved numerical evaluation. The earlier decisions were binary pass/fail analyses using K-T "must" criteria, followed by numerical scoring using K-T "want" criteria as defined above. Finally, the Analytical Hierarchy Process (AHP) was applied for the most complex analyses.

Preliminary screening was used in this study to reduce the number of disposition path alternatives to a manageable number prior to the more complex and rigorous decision analysis that followed. In Phase III, disposition paths were evaluated against the pass/fail screening criteria (musts). This process was conducted for each of the 15 material groups individually. If a disposition path option met all the must criteria for a particular material group, it became a feasible path for that material group. However, if it failed to satisfy any one of the 5 musts, it was rejected from further consideration as a viable path for that material group. For each material group, the feasible paths were evaluated against the wants (all weighted equally) and given a score (1-10), according to how well each path satisfied the wants. The score was based on the judgment of the TET.

Phase IV – Scenario Development and AHP Decision Analysis Method

The decision process typically stops at this point where a high scoring disposition path has been identified for each material group. The high score for each material group, as determined by the K-T analysis, represents the TET's judgment. However, the TET was concerned that, by applying only the highest scoring paths, the result would be a disposition solution that may overlook integration opportunities and could result in over- or under-utilization of DOE or commercial resources. Therefore, the study group structured material/path combinations, or integrated scenarios, that not only took into account the highest K-T scores, but also explicitly emphasized specific variables of interest to DOE so as to present additional attractive options to be evaluated with the high-score results.

The first part of Phase IV of the study was the development of integrated scenarios. The goal was a total disposition solution that considered the complex interactions between transportation systems, storage options, and processing of similar material streams at facilities throughout the complex in an effort to achieve maximum efficiency and meet DOE policy objectives. Each scenario represents a unique set of disposition paths with one specific path for each of the 15 material groups.

Disposition scenarios generally utilized the top 3 highest scoring paths for each material group. Development of these scenarios centered around representation of different themes. In this context, a "theme" refers to a current DOE objective (e.g., "minimizing transportation," "earliest completion," "deferred processing," or "maximize use of commercial facilities"). The TET members utilized representative themes for scenario development that represented current trends in the HEU Disposition Program. Scenario development also took into account schedules for DOE program missions, such as the TVA Off-Spec Fuel Project, the SRS canyon capacity and closure, construction and operation of the OFMD planned disposition facilities, and storage facility capacity. The TET then reached a group consensus on which disposition paths would best apply to each scenario. Paths with scores lower than the top 3 were occasionally used in scenarios if the TET judged it necessary. The TET recognized the large number of scenarios which could be created from the top 3 paths for each of the 15 material groups; however, the following seven scenarios were considered representative of many different approaches to disposition of this material:

1. <u>High Score Path.</u> This scenario captures the material/path combination that received the highest score when a K-T decision process was applied to the materials on an individual basis; it does not consider integration opportunities. This scenario would typically be the end-point for a typical decision process and would serve as the basis for the final recommendations. As a result, this scenario is not considered integrated.

2. <u>Maximize Use of Available Canyon Capacity.</u> The goal for formulating this theme was to utilize the SRS H-Canyon capacity to the maximum extent possible without significantly extending its use beyond FY08/09. (EM has agreed to keep a canyon (presumably H-Canyon) available until the demonstration of Melt and Dilute, which is scheduled for operational startup in FY08/FY09 (13).) This scenario was constructed to bound the analysis by maximizing the use of an operational, government-owned facility for recovery of the HEU. The TET considered it important to evaluate scenarios that represented examples of using primarily government-owned facilities versus using primarily commercial facilities. Scenario 4, Maximum Use of Commercial Processing, serves as the counterpoint to this scenario.

3. <u>Earliest Schedule Completion</u>**.** Programmatic drivers for the disposition of the surplus HEU include site and facility closure schedules and timely disposition of the material. Intuitively, the sooner a job is completed, the higher the potential for cost savings. As a result, the TET decided that a scenario structured around minimizing time-to-completion was justified. Each material/path combination was evaluated; materials were assigned to that path which, in the judgment of the TET, would result in the earliest completion of stabilization/processing leading to the final disposition end state.

4. Maximize Use of Commercial Processing. This scenario was crafted around the theme to align materials to commercial processing to the maximum extent possible as an alternative to SRS canyon processing. Experience to date has shown that commercial processing is typically less expensive than canyon processing (with a few exceptions).

5. Balanced Facility Utilization. This scenario was developed to provide a balance between DOE and commercial processing options while emphasizing HEU recovery.

6. Deferred Case (Minimal Action). This theme involved selecting for every material group a path that would defer action in order to delay near-term costs and near-term impacts to workers and the environment until operation of a next generation of facilities. It should be noted, however, that deferring near-term cost typically increases life-cycle costs.

7. Maximize On-Site Processing (Minimum HEU Transportation). Processing of materials onsite typically minimizes worker exposure associated with packaging and potential risks associated with transporting HEU. Transportation risks are often cited as the major factor for public and stakeholder concern. Therefore, a scenario built around the theme of minimizing transportation should increase public acceptance and reduce programmatic risk.

The next part of Phase IV involved the numerical scoring of the scenarios. The first step in this decision process was to determine scoring criteria. The TET started with the 5 K-T "wants" previously utilized in the preliminary screening. These were expanded to one more level of detail, for a total of 15 criteria. Once the criteria were established, they were assigned a weight according to relative importance. To accomplish the weighting, a decision method was selected that could synthesize the combination of data, experience, insight, and expert opinion of the TET in a credible and proven manner. For this, the TET chose the Analytical Hierarchy Process (AHP), an analytical tool developed at the Wharton School of Business by Thomas Saaty (14). The assumption forming the basis of this technique is that humans are more capable of making relative judgments than absolute judgments. In practice, the AHP implements this assumption by employing a pair-wise comparison process to derive relative importance (weights). Although AHP appears simplistic, the technique has been validated by complex mathematical calculations and is used extensively by government and private industry for a multitude of decision-analysis applications. The bases for all decisions using this system are a combination of facts and expert opinion.

Weighting of the decision criteria and then the final scoring of the scenarios were performed in much the same manner. The ExpertChoice™ (15) software package was used to compile the data and calculate the weights utilizing the AHP technique. The criteria and subcriteria with their resulting weights are presented in Table II.

Table II. Detailed Decision Criteria

ID	Criteria
A	**Technical Maturity (16.9%)**
1	Maximize technical process maturity (27.8%)
2	Maximize facility/equipment availability (20.7%)
3	Maximize acceptance of product and waste forms (51.5%)
B	**Programmatic Issues ((9.8%)**
4	Minimize mission and policy inconsistencies (55.1%)
5	Minimize scenario complexity (19.4%)
6	Maximize stakeholder acceptance (25.5%)
C	**Cost (15.6%)**
7	Minimize near-term cost (to FY05) (41.0%)
8	Minimize capital cost (26.3%)
9	Minimize life-cycle cost (32.7%)
D	**Schedule (15.8%)**
10	Maximize integration with site closure schedules (52.5%)
11	Maximize efficiencies realized by integration of materials into other material processing streams (17.7%)
12	Maximize integration with disposition facility schedules (29.8%)
E	**Environmental, Safety, and Health Compliance (41.9%)**
13	Maximize National Environmental Policy Act (NEPA) compatibility (11.9%)
14	Maximize worker/public health and safety (56.1%)
15	Minimize environmental risk (32.0%)

After all the possible pairs of scenarios were scored by each of the TET members, the individual scores were mathematically compiled using the ExpertChoice™ software to derive the final scores as shown in Figure 3.

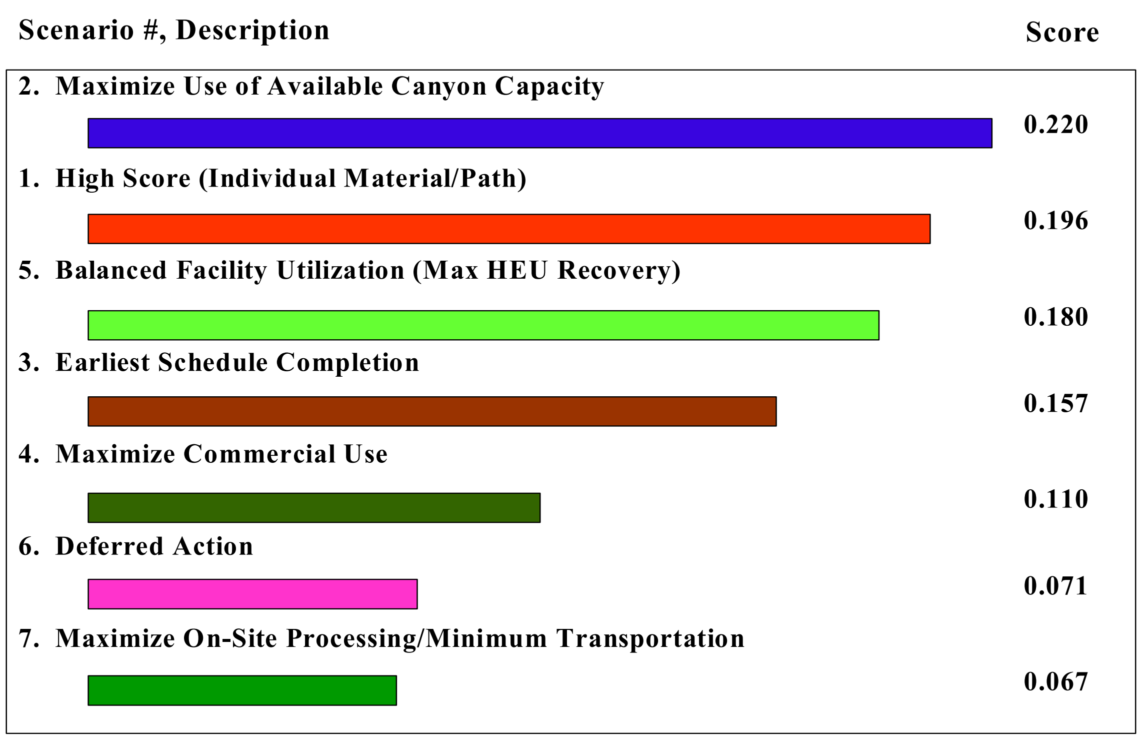

Fig. 3. Scoring Results for the Integrated Material Disposition Scenarios.
(Note: scenarios are arranged by score, not by numerical order.)

Phase V – Custom Analysis and Recommendation Procedure

The application of AHP resulted in relative scores for all seven scenarios. The TET judged that, due to the close scoring, the three highest scoring scenarios should be further analyzed by "custom analyses" to derive the final recommended disposition paths for the materials groups. This recommendation activity constituted Phase V of the study. In the custom analysis, the team performed selective analyses on several of the scenarios, focusing on the uncertainties associated with the material groups and the paths to which they were assigned in the scenario scoring. The objectives of the custom analyses were to:

- Fine tune AHP results with respect to facility limitations on schedule and capacity,
- Factor in final available information on material characteristics,
- Consider site input relative to existing baselines for disposition,
- Consider additional/proposed site processing capabilities and insights.
- Consider expanded commercial processing capabilities, and
- Consider feedback on the recommendations by site SMEs (during the draft review process).

The results of the AHP decision analysis were coupled with the results of these custom analyses to yield the final recommendation of the disposition path for each material group. The recommended primary disposition path was the path that was part of the top scored scenario from the AHP decision analysis unless a custom analysis determined that a different primary path should be followed. The recommended alternative disposition path was determined by selecting the highest ranked path from the preliminary screening unless a custom analysis determined that a different alternative path should be followed. If the highest ranked path was the primary recommendation, then the next highest ranked path became the recommended alternative path.

RECOMMENDATIONS

This report recommends seven different paths as primary disposition paths for the 15 material subgroups. An alternative (or backup) disposition path is also recommended for each material subgroup (by site). The mass of material recommended to each primary path is not included in this report because quantities at each site are classified and can be found in the classified report, *Unallocated Off-Specification HEU Material Inventories (U),* BWXT Y-12 L.L.C. document number HDPO/01-01. However, Figure 4 is included to illustrate the distribution of the recommended disposition paths by HEU mass quantities. The recommended primary disposition paths are:

- Commercial processing to off-spec fuel,
- Processing in the SRS H-Canyon to off-spec fuel,
- Processing to immobilization,
- Processing in SRS H-Canyon to high level waste (HLW),
- ANL-W processing using electrometallurgical treatment to waste,
- Direct disposal to WIPP, and
- LANL decontamination and oxidation, followed by shipment to Y-12 for off-spec fuel.

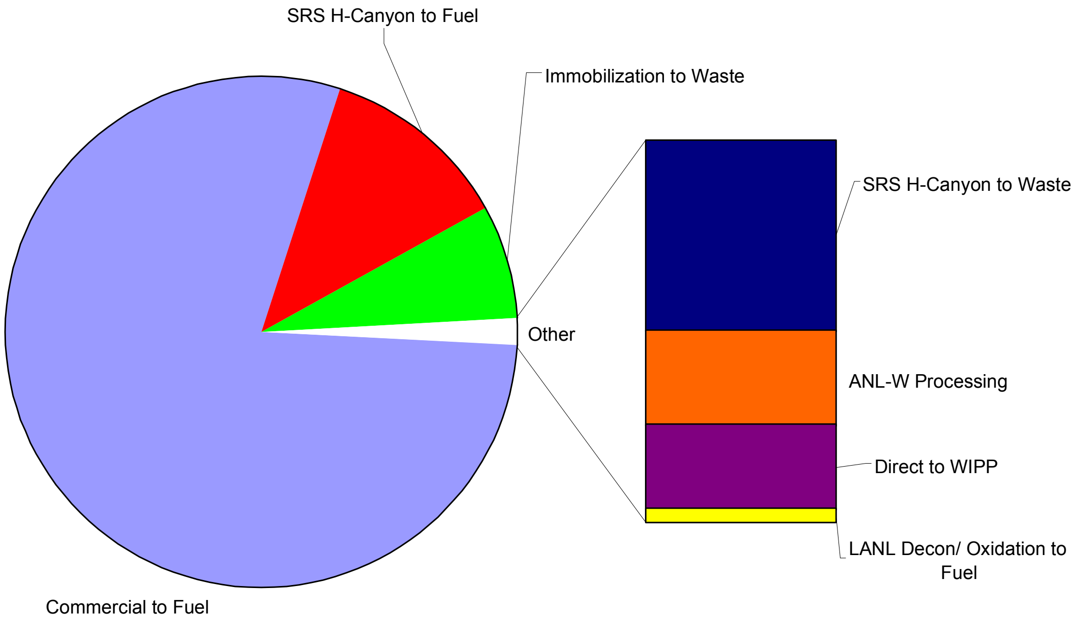

Fig. 4. Distribution of Recommended Disposition Paths on a Mass Basis.

The bulk of the HEU material in this study is recommended for commercial processing. Materials that are recommended for shielded facilities such as SRS H-Canyon typically do not meet the Pu acceptance criteria for Y-12 (16) or commercial processing facilities. Recommendations for all the material groups are summarized below.

Group I Materials – HEU with Plutonium

Many of the Group I materials are currently designated by OMFD for immobilization (primarily Groups I-C, I-D, I-E, I-F, and I-G). Some residues in Group I-E have been identified by DOE for direct disposal to the Waste Isolation Pilot Plant (WIPP).[a] In general, this study deferred to DOE baseline plans for immobilization or for direct disposal to WIPP. Recovery of HEU is also a potential disposition path for Group I materials. The focus of HEU recovery was primarily on Groups I-A and I-B classified parts. In some instances, Group I-C oxides and Group I-D metals were considered for HEU recovery (based on specific material and site considerations). The ability to handle and separate HEU from Pu in the SRS H-Canyon, as well as H-Canyon's availability, influenced the recommendation to use this path for recovery of HEU from Pu-contaminated items. Preliminary assessments indicate that processing these materials in H-Canyon can be accommodated in the available H-Canyon "window" ending in the FY08/09 time frame. Group I-H is the largest group of materials in Group I. Commercial processing is recommended for the majority of the Group I-H material because the bulk Pu-contamination is expected to be below the Y-12 or commercial acceptance criteria.

<u>Group I-A – HEU/Pu Bonded Parts.</u> The final study recommendation is to process the RFETS bonded parts in H-Canyon, add the separated uranium to the existing HEU solutions, and store them for eventual blend-down and use in the Off-Spec Fuel Program[b]. The Pu from the bonded parts will be recovered and converted to oxide in HB-line and packaged according to the 3013 standard[c] (17) for storage pending final disposition.

Lawrence Livermore National Laboratory (LLNL) has several bonded parts, for which the baseline plan is to remove the bulk Pu at LLNL and reduce it to an oxide for 3013 packaging, leaving contaminated HEU shells. The recommendation for the HEU shells is to ship them to SRS for H-Canyon processing to fuel. Other bonded parts at LLNL are mostly Pu with little HEU. The recommendation for these parts is to burn them to oxide at LLNL and place the oxide in 3013 packages for immobilization.

Group I-B – HEU/Pu Contaminated Parts. The contaminated HEU parts from RFETS will be shipped to SRS for storage, along with the bonded parts in Group I-A. The recommendation for these contaminated HEU/Pu parts is to process them in H-Canyon to recover the HEU. This study also recommends that the parts at Y-12 and Los Alamos National Laboratory (LANL) be shipped to SRS "just-in-time" for processing in H-Canyon to recover the HEU for fuel. The need for "just-in-time" shipments is based on storage limitations at SRS (while RFETS parts are being stored). The alternative path for parts at Y-12 and LANL is decontamination/oxidation at LANL. This alternative is attractive because the LANL parts are already there and the parts at Y-12 are only slightly Pu-contaminated.

The recommendation for the parts at LLNL is to ship the parts that are amenable to LANL electrolytic decontamination to LANL for cleaning and oxidation with the oxide then being shipped to Y-12 or a commercial processor for HEU recovery for fuel. The recommendation for parts at LLNL not amenable to electrolytic decontamination is processing in H-Canyon to recover the HEU for fuel. The recommended path for SRS parts in this material group is H-Canyon processing to fuel.

Group I-C – HEU/Pu Oxides. For the Pu-contaminated oxides at Hanford, RFETS, LLNL, and Argonne National Laboratory – West (ANL-W), the study team concurs with the site baseline plans to repackage the oxides to the 3013 standard and ship to SRS for immobilization. Note that with the recent delay in funding for facilities related to plutonium disposition (e.g., immobilization), OFMD is currently evaluating other options for these oxides which include additional canyon processing options at SRS. It should be noted that certain of these HEU/Pu oxides, particularly some at RFETS, could be processed in H-Canyon to recover the HEU. If OFMD pursues canyon processing instead of immobilization, this study would recommend the use of H-Canyon for processing the oxides in this group high in HEU content on a mass basis (e.g. RFETS oxides). However, this study will defer to the final outcome of the OFMD Pu disposition studies with respect to the disposition of the HEU associated with Pu disposition.

The recommended disposition path for the slightly Pu-contaminated oxides from the Idaho Nuclear Technology and Engineering Center (INTEC), SRS, and LANL is to process them in H-Canyon for recovery of the HEU. These materials would add only marginally to the time allotted in H-Canyon for HEU recovery.

Group I-D – HEU/Pu Metals. The study concurs with the site baseline plan of immobilization for the HEU/Pu metal at Hanford. Small quantities of HEU metals contaminated with Pu located at LANL, LLNL, and RFETS are recommended for shipment to SRS for processing in H-Canyon to recover the HEU for fuel. The metals at LLNL will be oxidized and consolidated as oxides at LLNL before being shipped to H-Canyon for processing to fuel.

Group I-E – HEU/Pu Miscellaneous Compounds and Solutions. The recommendation for most of the materials in this group at Sandia, LLNL, Hanford, and RFETS is to follow the site baselines for direct disposal to WIPP. A small amount of material at LANL and RFETS is judged to be suitable for HEU recovery and is recommended for processing in H-Canyon for fuel. The materials at RFETS under International Atomic Energy Agency (IAEA) inspection are recommended for disposition by immobilization (or its equivalent), as is an extremely small quantity of HEU solution at Hanford.

At SRS, this study concurs with the current site plans for disposition of HEU/Pu residues, which includes processing in H-Canyon to recover the HEU for fuel, processing in H-Canyon to waste, and immobilization. SRS is evaluating these plans with the objective of minimizing canyon processing. This study will defer to the final decisions at SRS concerning disposition of this material.

Group I-F – HEU/Pu Unirradiated or Slightly Irradiated Reactor Material (Zr, SS, or Misc.)[d]. The materials at ANL-W, SRS, and LLNL are recommended for ANL-W processing, subject to additional development and National Environmental Policy Act (NEPA) analysis. The material at Hanford consists of excess sodium-bonded fuel pins, which would be declad and the pellets shipped to SRS for immobilization.

Group I-G – HEU/Pu Unirradiated or Slightly Irradiated Reactor Material (Al) . Spent fuel is not within the scope of this study, however the disposition of any HEU recovered from scheduled canyon dissolution of these materials is included. Several items at SRS in Group I-G are categorized as spent nuclear fuel and have been irradiated to the point of containing reportable quantities of Pu. DOE has determined that these items are unstable for continued storage and are, therefore, included on the H-Canyon schedule for processing. The SRS baseline is to recover the HEU in all cases except for the Sodium Reactor Experiment (SRE) fuel. The recommendation of this study is to allocate the recovered HEU (except from SRE fuel) to the TVA as part of the Off-Spec Fuel Project. In the case of the SRE fuel, due to the presence of thorium and in-growth of ^{232}U and ^{233}U, the SRS site baseline is to process it in H-Canyon for uranium isotopic dilution and then flush to the SRS HLW tanks. This study concurs with the SRS baseline for the SRE fuel. In addition, a very small amount of material in this group at INTEC and LLNL is recommended for processing in H-Canyon to fuel.

Group I-H – HEU/Pu PDCF Oxides. This is the largest group of material in Group I. This study assumed that the HEU recovered from surplus pit processing in PDCF would be in an oxide form. Preliminary assessments indicate that most of this HEU (>90%) will meet the acceptance criteria for bulk Pu contamination for receipt at Y-12 or for processing in commercial facilities to downblend for use in off-spec commercial fuel. Therefore, this study recommends commercial or Y-12 processing leading to use as off-spec commercial fuel for the bulk of the PDCF oxides. The recommendation for the remaining ~10% of the material not expected to meet the Y-12 bulk Pu acceptance criteria is to send it directly to immobilization.

Group II Materials – HEU without Plutonium

The primary recommendation for most Group II materials is to use commercial facilities for processing and downblending whenever possible. However, there are a number of exceptions based on material characteristics. The small quantity of Group II materials that are recommended for processing in H-Canyon can be accommodated in the available H-Canyon "window" ending in the FY08/09 time frame. The study recommendations are presented below.

Group II-A – HEU Classified Oxides (INTEC DNP). This group consists of ~1.7 MTU of oxides at INTEC (known as denitrator product, or DNP). The uranium isotopics are classified and the material is too high in ^{232}U concentration to meet the TVA off-spec fuel specifications[e]. Blending with additional HEU is required to mask the classified isotopics of the oxide and to reduce the ^{232}U content to within TVA off-spec fuel specifications. During the course of the study, the material characteristics were presented to a commercial vendor, who responded that 86% of the material (Subgroups A and B of the ~1.7 MTU) could be accepted for commercial processing to fuel. The remaining ~14% of the material (Subgroup C) was rejected by a commercial vendor because of radiation dose and waste permit issues.

The study recommendation is to process 86% of this material at a commercial vendor and to process the remaining 14% at H-Canyon to produce fuel. The alternative option for Subgroup C is processing in the Remote Analytical Laboratory (RAL) at INTEC using existing equipment. This facility is expected to remain in operation during the time frame projected for the processing of this material.

Group II-B – HEU/^{233}U (Y-12). This group consists of classified pieces at Y-12 with a ^{233}U content. The recommendation for this small amount of material in Group II-B is shipment to SRS for H-Canyon dissolution, isotopic dilution, and discharge to the SRS HLW tanks, as in the case of the SRE fuel at SRS (Group I-G).

Group II-C – HEU Oxides. The bulk of this material is at BWX Technologies – Naval Nuclear Fuel Division (in Lynchburg, VA), Nuclear Fuel Services (NFS) and Y-12, with small amounts at INTEC and LANL. The recommendation for this group is commercial processing to fuel for inclusion in the Off-Spec Fuel Program.

Group II-D – HEU Metals. A small amount of material resides at INTEC, with smaller amounts at Y-12 and LANL. The recommendation for this group is commercial processing to fuel for inclusion in the Off-Spec Fuel Program.

Group II-E – HEU Miscellaneous Compounds and Solutions. The majority of the material in this group is recommended for commercial processing. One exception is a small amount of HEU alloyed with neptunium (Np) at Y-12 that can not be processed commercially. The recommendation for this HEU/Np material is H-Canyon processing with separation of the HEU for use in fuel. The DOE Offices of Nuclear Energy, Science and Technology and EM are expected to develop a disposition plan for the separated Np.

Group II-F – HEU Slightly Irradiated Reactor Material (Zr, SS, or misc.). The bulk of the material in this group at INTEC is amenable to commercial processing to fuel along with a small amount of material at Hanford that would need to be declad first. For the small amount of ANL-W material in Group II-F, discussions have been initiated with ANL-W to evaluate their small holding of SS and Zr items for decladding and subsequent processing at ANL-W using the electrometallurgical treatment (EMT) process or other suitable process.

Group II-G – HEU Slightly Irradiated Reactor Material (Al). The recommendation for the small amount of material at INTEC and INEEL is to process commercially. The primary recommendation for the slightly irradiated reactor materials in this group at SRS is processing and recovery of the HEU in H-Canyon for use as fuel. This option presents little or no impact on the current canyon processing schedule. The process to consolidate such items at SRS pending disposition has been under way for the last several years, with items from Pacific Northwest National Laboratory (PNNL) and the DOE Mound Plant already stored in K-Area at SRS.

PATH FORWARD

The TET strongly recommends that DOE begin detailed implementation planning as soon as possible. Should assumptions change, particularly regarding Pu disposition facilities, the TET concludes that similar levels of integration efficiencies would be realized by simply substituting a replacement Pu disposition capability within the recommendations. Such changes may, however, require re-optimization of material scheduling in affected facilities. The implementation phase for each group (or subgroup) of unallocated off-spec material should begin with the recommendations in this study and include the following steps:

- Review the recommended disposition path to determine if it is still applicable and viable.
- Investigate other technologies that have become available since the initial study and recommendation.
- Compile project quality estimates for the recommended primary and alternate disposition paths.
- Review material transportation requirements.
- Review NEPA requirements and develop documentation as necessary.
- Proceed with the recommended path or new path, pending concurrence and approval from headquarters and affected programs.
- Develop detailed project plans.
- Proceed with disposition of the material.

FOOTNOTES

[a] The WIPP is a DOE facility in southeastern New Mexico for the deep geologic disposal of DOE defense transuranic waste.

[b] The Off-Spec Fuel Program will convert surplus off-spec HEU to commercial reactor fuel. Current plans are to process approximately 33 MTU of off-specification HEU for use by the Tennessee Valley Authority (TVA) in its nuclear plants. Planning for the inclusion of additional quantities of off-spec surplus HEU continues.

[c] The 3013 standard refers to a DOE stabilization and storage standard for Pu to allow storage pending disposition. The standard is met by first high-temperature firing the material in a furnace, then packaging in a 3013 canister configuration.

[d] Structural materials in reactor fuels include stainless steel (SS), zirconium (Zr), and aluminum (Al).

[e] The TVA off-spec fuel specifications are located in the Interagency Agreement DE-SA09-01SR18976/TVA No. P-01N8A-249655-001 between DOE and TVA for the Off-Spec Fuel Project.

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