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# Evaluation of Feeds for Melt and Dilute Process Using an Analytical Hierarchy Process

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February 2000

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**Westinghouse Savannah River Company**
**Savannah River Site**
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# EVALUATION OF FEEDS FOR MELT AND DILUTE PROCESS USING AN ANALYTICAL HIERARCHY PROCESS (U)

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## CONCURRENT SIGNATURES OF TEAM MEMBERS

| | | | |
|---|---|---|---|
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| Joseph F. Krupa<br>Principal Technical Advisor,<br>Strategic Planning and Integration<br>Sitewide Integration & Program Development Division | Date | William F. Swift<br>Manager, Alternative Technologies<br>Spent Fuel Storage Division | Date |
| Wade E. Bickford<br>Senior Advisory Engineer<br>Strategic Planning and Integration<br>Sitewide Integration & Program Development Division | Date | Thad Adams, Ph.D.<br>Senior Engineer<br>Materials Application and Corrosion Technology<br>Savannah River Technology Center | Date |

## LIST OF ACRONYMS

| | |
|---|---|
| AHP | Analytic Hierarchy Process |
| DDIS | (Mined Geologic Disposal System) Draft Disposability Interface Specification |
| DOE | Department of Energy |
| DU | Depleted Uranium |
| DWPF | Defense Waste Processing Facility |
| EBR | Experimental Breeder Reactor |
| EIS | Environmental Impact Statement |
| ES&H | Environmental, Safety, & Health |
| FRR | Foreign Research Reactor |
| HFIR | High Flux Isotope Reactor |
| HLW | High Level Waste |
| LEU | Low Enriched Uranium |
| LLW | Low Level Waste |
| MGDS | Mined Geologic Disposal System |
| NRC | Nuclear Regulatory Commission |
| NWPA | Nuclear Waste Policy Act |
| O&M | Operations & Maintenance |
| PWF | Primary Waste Form |
| QA | Quality Assurance |
| ROD | Record of Decision |
| RRTT | Research Reactor (Spent Nuclear Fuel) Task Team |
| S&S | Safeguards & Security |
| SC | South Carolina |
| SNF | Spent Nuclear Fuel |
| SRS | Savannah River Site |
| TPC | Total Project Cost |
| TSF | Treatment and Storage Facility |
| WSMS | Westinghouse Safety Management Solutions |
| WSRC | Westinghouse Savannah River Company |

## EXECUTIVE SUMMARY

The Analytical Hierarchy Process using a ratings methodology was used to rank potential feed candidates for disposition through the Melt and Dilute facility proposed for disposition of Savannah River Site aluminum-clad spent nuclear fuel. Because of the scoping nature of this analysis, the expert team convened for this purpose concentrated on technical feasibility and potential cost impacts associated with using melt and dilute versus the current disposition option.

Some of the materials have currently defined disposition paths, however, significant costs are involved in their implementation. A number of plutonium scrap materials were determined to be attractive candidates, for which a significant and costly immobilization program has been developed. Melt and dilute may provide an alternative that meets some expressed concerns about the immobilization waste form, since the plutonium would be homogeneously dispersed throughout the melt and dilute product and thus significant processing and shielding capability would be required to recover plutonium. This alternative needs additional examination as a potential backup technology that could result in substantial cost avoidance.

Depleted, low enriched, and natural uranium are obvious feeds for the process for use in diluting high enriched to enrichments that are not weapons capable. Melt and dilute is also an obvious alternative for off-spec HEU should current negotiations with TVA reach an impasse.

Finally, the melt and dilute waste form is also a possibility for miscellaneous higher isotopes because of their small quantity.

Figure E-1 illustrates the ratings for the range of recommended candidates.

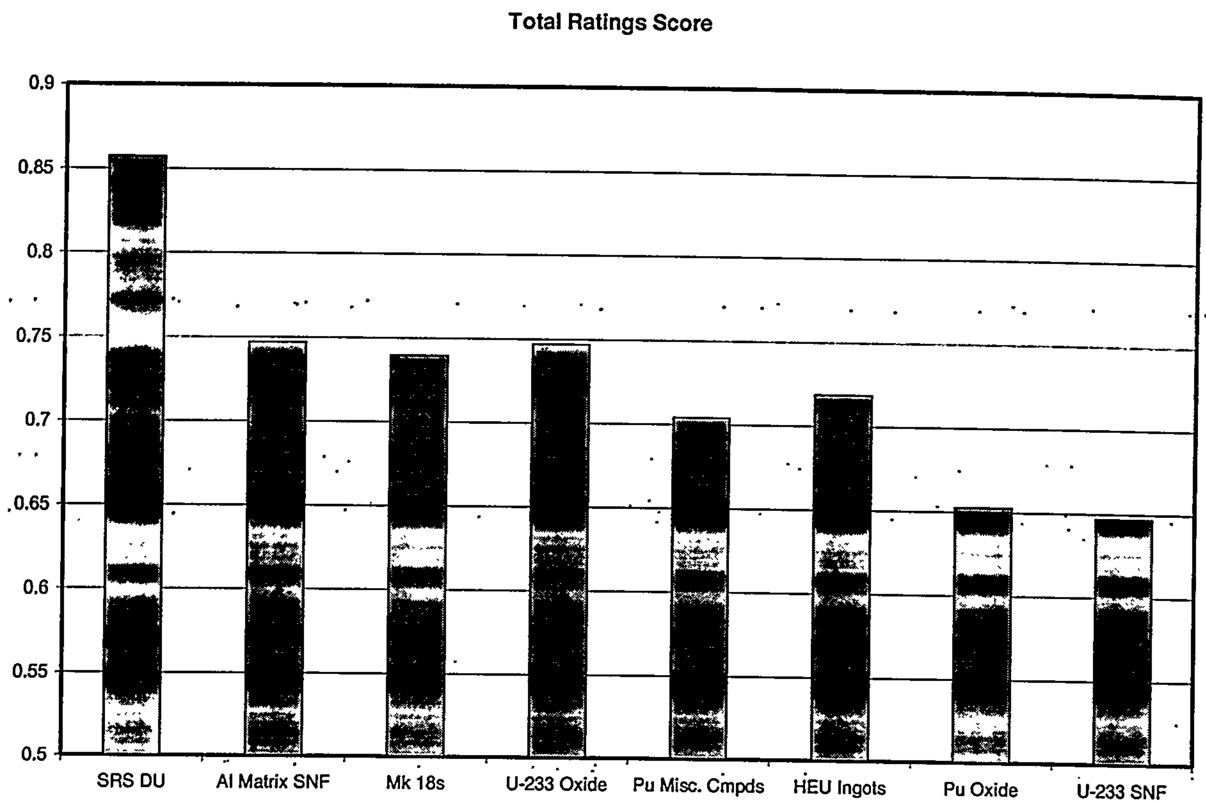



**Figure E-1. Ratings of Selected Recommended Candidates**

# INTRODUCTION

## Initiation of Task

WSRC was requested[1] to evaluate whether nuclear materials other than aluminum-clad spent nuclear fuel should be considered for treatment to prepare them for disposal in the melt and dilute facility as part of the Treatment and Storage Facility (TSF) currently projected for construction in the L-Reactor process area. Spent Fuel Storage Division convened a number of experts on the melt and dilute technology, the TSF project, and nuclear materials at Department of Energy sites to develop an evaluation approach and a path forward. A preliminary evaluation of illustrative candidate materials was determined to be an appropriate first step to respond to this request.

The decision analysis process used to develop this analysis considered many variables and uncertainties, including repository requirements that are not yet finalized. This report documents results of the decision analysis.

## Background

The Record of Decision for the Environmental Impact Statement on the Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor (FRR) Spent Nuclear Fuel (SNF) directed the DOE to implement alternative treatment and packaging technologies that could be utilized in place of conventional chemical processing to achieve safe and cost effective interim storage and ultimate disposal.

For the last three years, WSRC has been evaluating two candidate SNF disposal methodologies, melt and dilute, and direct disposal, both options being co-disposed with HLW glass canisters as alternatives to conventional processing. In the Spring of 1998, WSRC completed an analysis of the merits of the two technologies at the request of DOE-SR. Based on that analysis, which used an analytical hierarchy process, WSRC recommended that, between these two options, the melt and dilute process be used for aluminum-clad SNF disposition. The description below of the envisioned melt and dilute process is excerpted from that study[2].

### Melt & Dilute Technology Description

In the melt and dilute technology, the SNF will be melted in a furnace. Depleted uranium and aluminum (as needed to control the metallurgy and process temperature) will be added to the melt in order to reduce the $^{235}$U enrichment to below 20%, the level required to be treated as low enriched uranium (LEU). If required, neutron absorber materials will also be added to the melt to minimize the potential for long-term criticality in the repository. The melt will be solidified and placed in a steel canister. Several ingots may be stacked in each canister. The canister will then be back-filled with helium, sealed, and temporarily stored at SRS in concrete storage modules.

The canisters will ultimately be shipped to a federal geologic repository for final disposal with glass high level waste (HLW) canisters produced in the Defense Waste Processing Facility. The melting process will cause volatilization of some fission products. Those gases will be collected and processed onsite as either HLW or low level waste (LLW), with the exception of minimal quantities of noble gases such as krypton which will be released to the facility stack. A flow diagram of the process is shown in Figure 1.

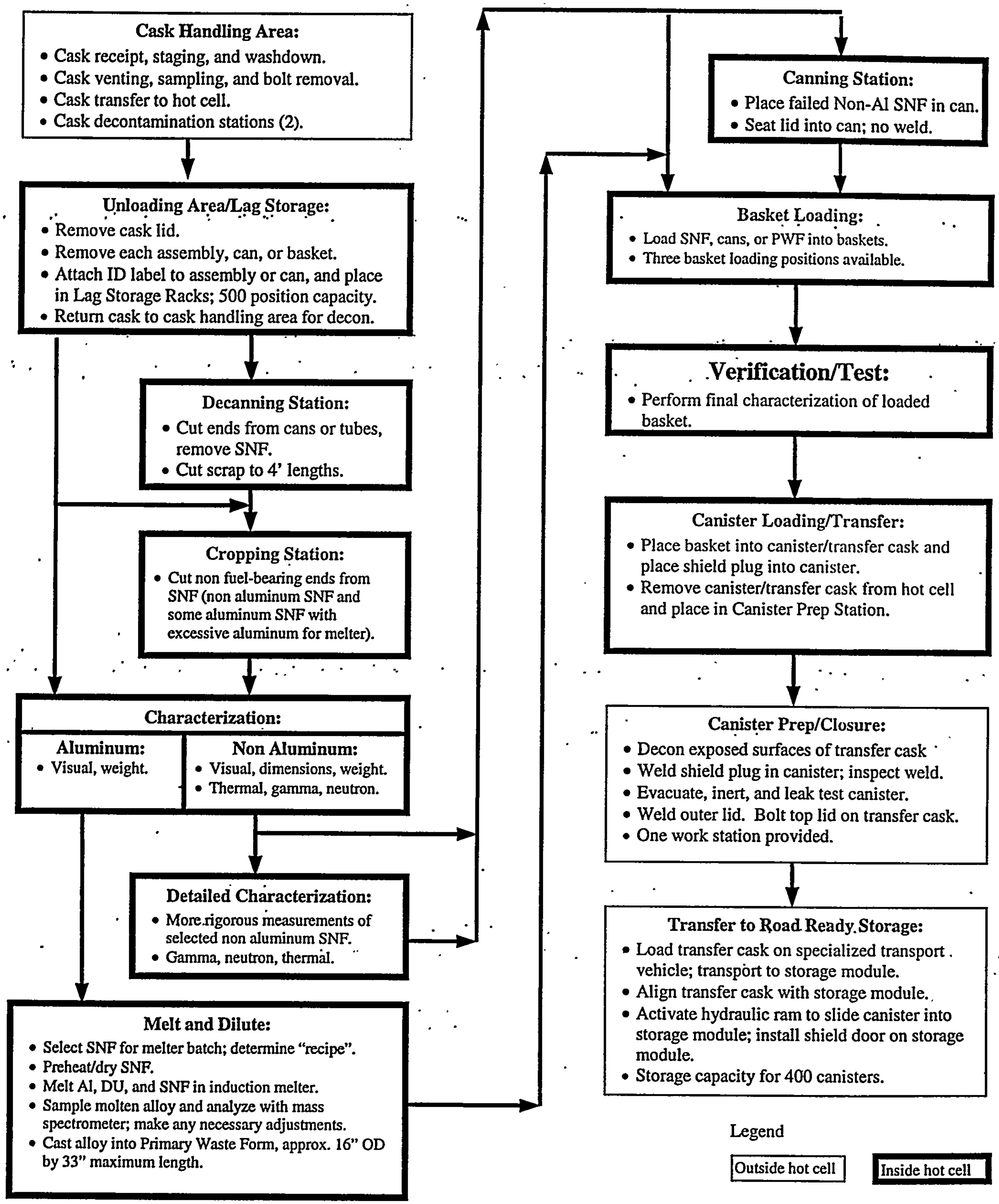



**Figure 1. Facility Process Flow Diagram, Melt & Dilute**

## DISCUSSION

### Analytic Hierarchy Process

The decision process for evaluating the suitability of melt and dilute process facilities for disposition of materials was structured using the Analytic Hierarchy Process (AHP). Expert Choice™ decision support software, which has as its basis the Analytical Hierarchy Process, was utilized to help record and document the expert rankings developed in this analysis of the application of melt and dilute technology to alternate feed streams. AHP enhances decision making by providing a logical framework in which all elements of a decision can be defined, organized, and carefully evaluated. AHP as a mathematical methodology for measurement and decision making was developed by Dr. Thomas L. Saaty more than 20 years ago to deal with problems that had both objective and subjective components.

As Dr. Saaty notes in his book *Decision Making for Leaders*[3] "In solving problems by explicit logical analysis, three principles can be distinguished: the principle of constructing hierarchies, the principle of establishing priorities, and the principle of logical consistency. These natural principles of analytic thought underlie the AHP." He goes on to say "In utilizing these three principles, the AHP incorporates both the qualitative and the quantitative aspects of human thought: the qualitative to define the problem and its hierarchy, and the quantitative to express judgments and preferences concisely. The process itself is designed to integrate these two properties."

The AHP depends on imagination, experience, and knowledge to structure the hierarchy of a problem and on logic, intuition, and experience to provide judgments. It provides a framework for connecting elements of one part of a problem with those of another to obtain the combined outcome. AHP provides a process for identifying, understanding, and assessing the interactions of a system as a whole.

Most people cannot deal with more than seven decision considerations at a time. AHP deals with this cognitive limitation by subdividing the decision into logical groupings of decision criteria in a hierarchy. Influence in this hierarchical structure is distributed downward. The top level, or goal, has the greatest importance (or priority) and thus has a value of one. This value is apportioned among the elements in the second level, and the values of each of these in turn is apportioned among those of the third level, and so-on to the lowest-level objectives/criteria. These objective/criterion priority values are derived by the ECPro™ program[4] based upon pair-wise comparisons of the objectives at each of the model nodes[a].

In a situation where there are multiple candidates to be evaluated, like the nuclear materials in this study, the lowest level of the hierarchy is used to develop a rating scale, using pair-comparisons. Candidates are then evaluated as to which description most accurately describes their relationship to the bottom-most criteria. From this, a total score is derived that allows ranking the candidate materials against the goal of using melt and dilute technology for their disposal.

An important aspect of using the AHP ratings methodology to evaluate materials, was the discussion of attributes and development of consensus among the participants.

[a] The elements of a decision are represented by nodes. A node may represent an objective, a criterion, a subcriterion, an uncertainty (scenario), an alternative, (etc.). ECPro™ for Windows, User Manual page 345.

## Creation Of Team

A team of materials experts from the Savannah River Technology Center, operations and project experts from Spent Fuel Storage Division, and nuclear materials disposition experts from Strategic Planning and Integration Department comprised the evaluation team. Appropriate management input was solicited during the evaluation as it progressed.

Biographical information for each of the team members is provided in Appendix A.

## Assumptions

The following assumptions were used during the evaluation.

- An illustrative group of materials would suffice for this evaluation to show proof of principle for the attractiveness of melt and dilute as a disposal path for materials.
- Although health, safety, and the environment are pre-eminent concerns, they were not included in this analysis because they did not have a differentiating impact on the SNF alternatives decision. Neither WSRC nor DOE intends to build or operate facilities that would have a negative impact on worker or public safety and health or the environment. Rather, these variables would be reflected in costs required to modify the baseline melt and dilute facility to handle new feed materials.
- The impact of Non-governmental Organizations (NGOs) in the Spent Fuel Alternatives study was found not to be decisional in the final analysis. They were not considered in this study.
- Since there is no melt and dilute facility, modifications which might suggest construction of a Greenfield facility rather than use of the L-Reactor Process Building were considered. The impact would be taken up in cost effected criteria.

## Decision Objectives

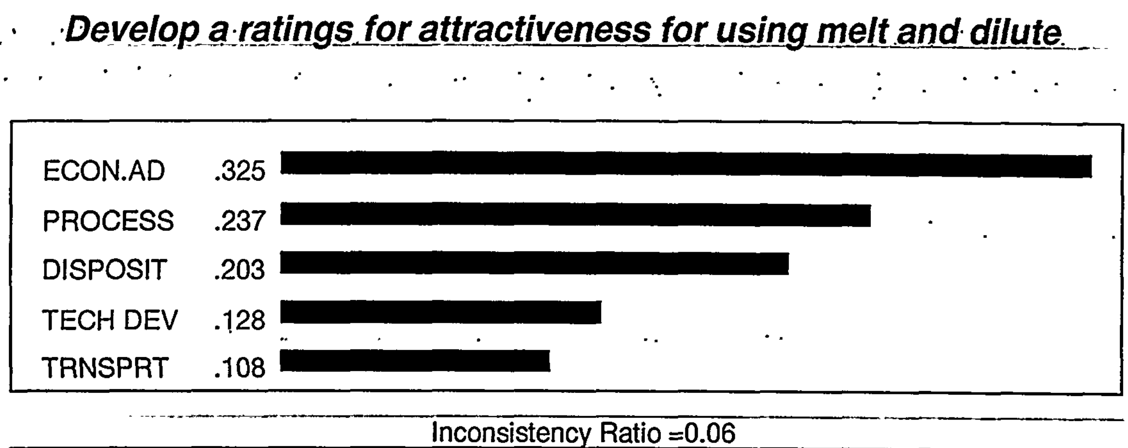
The overall goal of the study was to select potential candidates for disposal via melt and dilute technology. Using the first basic function of AHP, that of structuring complexity, the team identified a number of primary objectives that, if satisfied, would achieve this goal. To this end, the team agreed that the best candidate materials would meet the following objectives:

1. Be most compatible with the melt and dilute process as it is currently conceived;
2. Result in a waste form that was acceptable at its ultimate disposition point;
3. Had low implementation cost and high potential programmatic savings;
4. Was compatible with current transportation, packaging, and storage;
5. Required the least amount of technical development for the process and the final waste form.

With these primary objectives in mind, the team then identified 17 supporting decision criteria against which the candidate materials could be evaluated. These elements were then organized into a hierarchy structure that formed the basis for the team's decision analysis model.

### Criteria Descriptions

The 17 supporting criteria developed to meet the primary decision objectives are provided below. For each of the criteria considered and selected for inclusion in the decision analysis model, a 'Criterion Definition' is provided along with justification for its inclusion. 'Criterion Definitions' were also developed for each of the five primary decision objectives to facilitate the generation of supporting decision criteria. The overall assessment of the importance of the five primary objectives is shown below in Figure 2. Note that an inconsistency ratio below 0.1 indicates an adequately consistent set of pair-wise comparisons.




| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| ECON.AD | Potential for savings |
| PROCESS | Disposition process compatability with M&D |
| DISPOSIT | Compatability of waste form with Yucca, WIPP, LLW etc. |
| TECH DEV | Technology Development Required |
| TRNSPRT | Ability to ship and receive |

**Figure 2. Summary Importance of the Five Evaluation Criteria**

*Compatibility with Melt and Dilute*

Material attractiveness was considered to be affected by the degree which they could be accommodated in the proposed melt and dilute facility (either as envisaged in the L-Reactor process room or in a new Greenfield facility). Criteria that contributed to material attractiveness included the following:

1. Feed composition. Materials whose composition was well known was judged to be more attractive than materials with less well characterized or unknown provenance. Poorly characterized materials would require characterization before introduction into the process with concomitant increase in cost and/or dose to personnel.
2. Temperature. Materials that could be processed at or below the currently planned 850°C operating temperature were judged to be more attractive than materials which required higher temperatures to successfully prepare for disposition.
3. Off-gas Requirements. Materials which had the same or lower (because of low volatile fission product inventory, e.g., iodine-129 or cesium-137) were judged as more attractive than those which had higher volatile fission product content.
4. Material Compatibilities. Those materials that could be treated in a steel crucible were considered to be more attractive for melt and dilute processing than those that required more exotic types of crucibles.
5. Alloy Composition. Those materials whose disposition alloy was similar to the eutectic U/Al alloy proposed for melt and dilute were judged to be more attractive than more complex materials that required new or yet to be determined alloys for effective disposition.
6. Pretreatment Requirements. Some materials would require pretreatment before introduction into the melt and dilute system, either size reduction, as in the case of fuel rods or conversion to solids in the case of solution. Lower levels of pretreatment were seen as more attractive.

*Compatibility of the Waste Form Produced with Disposition in the Mined Geologic Disposal System (MGDS), WIPP or Burial at the NTSl.*

7. Path Availability. Materials with currently defined disposition paths, including an available operating facility and adequate funding, were seen as less attractive than those where a disposition path was yet to be determined.
8. Attractiveness of Melt and Dilute Wasteform. Material attractiveness for this criteria was determined by the judgement of how difficult it would be to qualify a melt and dilute type of waste form for the proposed disposition site.

*Economic Advantage of Disposition Through the Melt and Dilute Facility*

9. Implementation Cost. Those materials which required little in the way of implementation cost, e.g., only operating cost or minimal capital cost, were seen as more attractive than materials that required major capital investment or design alterations for the melt and dilute facility.

10. Cost Savings. If disposition through melt and dilute would result in a significant capital or operating savings, it was seen to be attractive.

11. Quantity. The quantity of material was a complex criteria. Very small quantities offered the potential of minimal impact on the facility, whereas significant quantities offered the potential of savings through long term continuous operation on a single feed.

*Transportation Impacts Including Consideration of the Ease of Shipping, Receiving, Packaging and Storage.*

12. Receiving. Availability of facilities for receiving materials made them more attractive for melt and dilute processing.

13. Shipping. Availability of shipping casks or packages and facilities for shipment made materials more attractive.

14. Packaging. If a material was already packaged or ready for shipment, it was seen as more attractive than materials that required packaging.

15. Storage. Material already possessing on-site storage or that required minimal changes to allow storage of the final waste form was seen as more attractive.

*Technology Development Required*

16. Processing Development. Material that fit within current processing development or existing processing experience was seen as more attractive than materials that would require additional process development.

17. Waste Form Development. If a materials waste form was bounded by current testing or required minimal modifications it was seen as more a more attractive candidate.

*Summary of Criteria Priorities*

After all objectives and associated criteria were evaluated for importance at each of the model nodes, the overall results were synthesized using the ECPro™ program. Table 1 below provides a prioritized summary of all objectives/criteria and their relative overall importance (global priority) in selecting the preferred alternative. Note that these data are arranged in the model hierarchy levels, and within those levels, are listed according to the priority of the individual criteria.

| OBJECTIVES | CRITERIA | | OBJECTIVES | CRITERIA |
|---|---|---|---|---|
| Econ. Ad. = .325 | Economic Advantage | | Disposition = .203 | |
| | Savings = 0.154 | | | Attractiveness = 0.138 |
| | Implementation Cost = 0.109 | | | Path Availability = 0.066 |
| | Quantity = 0.062 | | | |
| | | | Tech Dev = .128 | Technology Development required |
| | | | | Waste Form = 0.077 |
| Process = .237 | Compatibility with Melt and Dilute process | | | Processing = 0.051 |
| | Feed = 0.065 | | | |
| | Material Complement = 0.042 | | Transportation = .108 | Transportation Impacts |
| | Offgas = 0.039 | | | Receiving = 0.035 |
| | Temperature = .035 | | | Packaging = 0.03 |
| | Pretreatment = 0.030 | | | Storage = 0.023 |
| | Alloy = 0.025 | | | Shipping = 0.018 |

**Table 1. Summary of Objective/Criterion Priorities (Global)**

Figure 3 below provides a prioritized summary of the overall importance (or global priority) of all of the criteria. This list is significant in that suitability of candidate materials was judged directly against these criteria. Note that economic advantages accounts for about 1/3 of the importance in the decision, and that the first six criteria (potential for savings, attractiveness of the waste form, implementation cost) account for approximately 61% of the importance in the determination of the attractiveness of materials for melt and dilute treatment..

Team scores were developed for each of the criteria by taking the geometric mean of Team responses and calculated the distribution using EC Pro software. The geometric mean was used because it centers on one rather than zero, so that opposite but equal views would cancel out. The geometric mean was also conservative in that it can be shown that the geometric mean is less than or equal to the arithmetic mean, tending to damp out strong responses. Details of the criteria evaluations are given in Appendix B.

## Development Of The Ratings Scheme

In order to use the criteria above for a ratings scheme, a set of descriptors was developed for an ordinal scale for each of the criteria. These descriptors were then pair-wise compared using the Team geometric mean as above and EC Pro software. Details of the ratings evaluation are shown in Appendix C.

## Develop a ratings for attractiveness for using melt and dilute

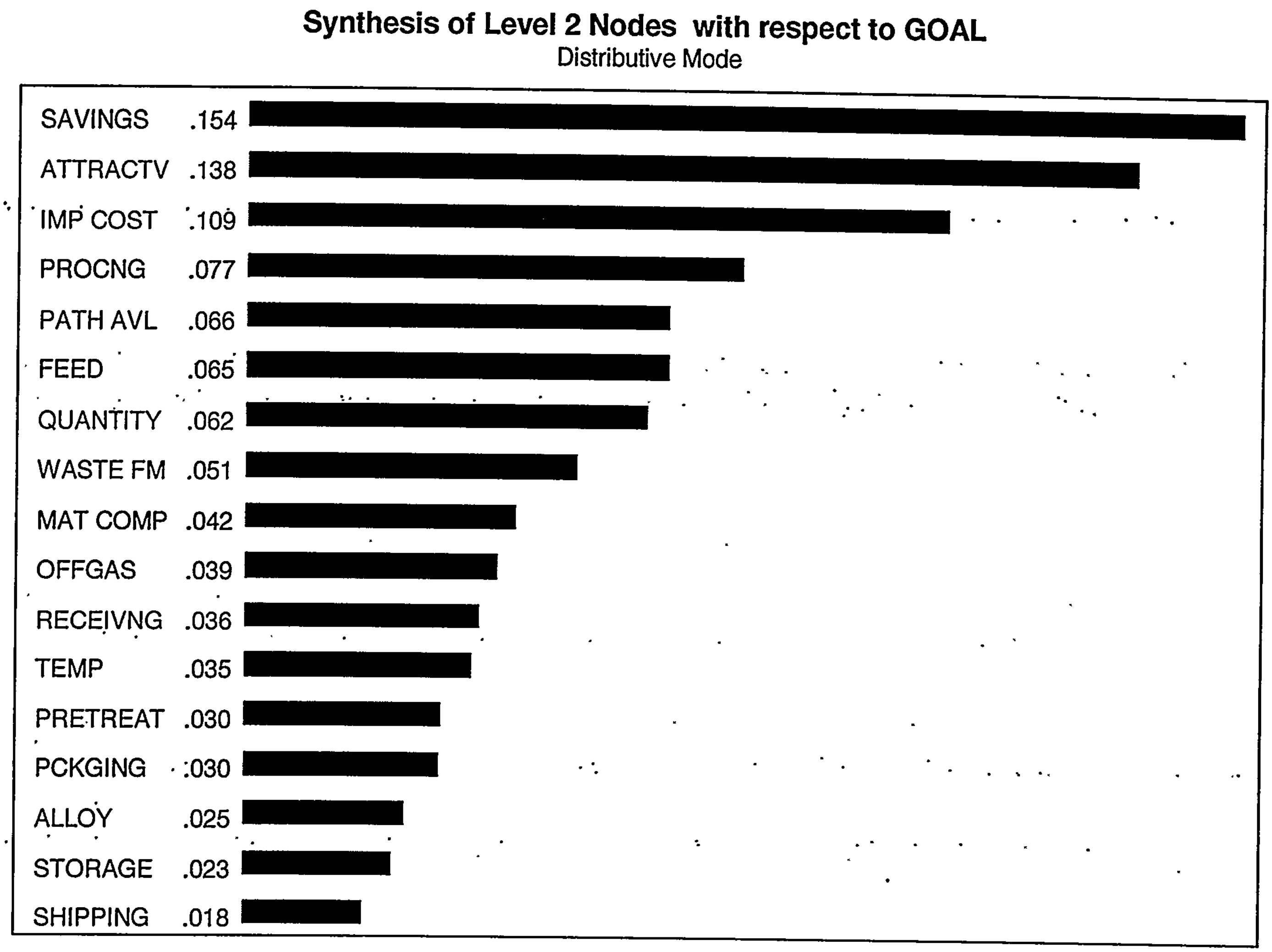



**Figure 3. Relative Weights of Criteria**

| Abbreviation | Definition |
|---|---|
| SAVINGS | Potential savings of using M&D |
| ATTRACTV | Attractiveness of waste form; ease of certification |
| IMP COST | Cost to implement |
| PROCNG | Additional process R&D required. |
| PATH AVL | Availability of current disposition path |
| FEED | Knowledge of feed composition |
| QUANTITY | Quantity of material to be processed (months) |
| WASTE FM | Additional waste form R&D required. |
| MAT COMP | Compatibilities of materials with equipment |
| OFFGAS | Offgas treatment required |
| RECEIVNG | Ability to receive material |
| TEMP | Process Temperature required |
| RECEIVNG | Ability to receive material |
| PATH AVL | Availability of current disposition path |
| PCKGING | Shipping prepations required. |
| ALLOY | Composition of final waste form (alloy?) |
| WASTE FM | Additional waste form R&D required. |
| STORAGE | Material storage availability |
| SHIPPING | Ability to ship out material |

**Table 2. Definitions for Criteria Abbreviations**

### Materials To Be Evaluated

This evaluation used primarily the three sources cited below to produce a list of potential candidate materials for screening, as summarized in Table 3. This materials list is not considered an exhaustive list, as DOE has an ongoing Stewardship program that continues to refine site material holdings and the status of their disposition paths.

- In 1998, DOE/EM sponsored the Nuclear Materials Stewardship Program. This program examined the inventory of surplus materials across the Complex, and evaluated current and proposed disposition paths with respect to technical maturity, cost, schedule, and ES&H variables. Nuclear material management plans were produced for plutonium and special transuranics (i.e., Np-237, Pu-238, Am-242, Pu-242), uranium (HEU, LEU, NU, DU, U-233), thorium, and sources, standards, and samples.

- In 1999, DOE also performed a canyon utilization study. This was in response to a concern expressed by the Defense Nuclear Facility Safety Board that the canyons not be shut down prematurely while materials needing their capabilities remained in DOE inventories. This study swept the Complex to identify materials that may need canyon processing for stabilization or recovery.

- Finally, the DOE National Spent Nuclear Fuel program maintains a list of irradiated fuel and targets remaining in inventory across the complex.

The broad categories of material examined thus include uranium (HEU, LEU, NU, DU, U-233), plutonium (Pu-238, Pu-239), higher transuranics (Am-241 samples and standards, Am/Cm solutions, Am/Cm targets), and spent nuclear fuel (11 types, including SS-clad oxides, Zr-clad, metal fuels, graphite, etc.).

| HEU | # | KgU | Descriptio |
|---|---|---|---|
| Off Spec HEU | 1851 | XXXX | Tubes and Assemblies (Mk-22s) |
| Off Spec HEU | 5851 | XXXX | Ingots and Billets |
| Misc Stds (K) | 320 | 30.8 | Standards, Mound plates, PNNL Plates, Slightly Irradiated fuel |
| Off Spec HEU | | 1700 | Idaho oxide |
| Off Spec HEU | | 10000 | ORNL off spec metal |
| Off Spec HEU | | 500 | Hanford |
| Off Spec HEU | | 9500 | SRS Solutions |
| Total | | XXXX | |
| | | | |
| **LEU** | **Items** | **MTU** | |
| **SRS** | | | |
| M Area U metal | | 0.1 | |
| Recovered oxides | | 95.6 | |
| Vitrified waste | | 3.4 | |
| Non-SRS irradiated Al based fuel | | 0.4 | |
| SS & Zr fuel/targets | | 8 | |
| **Fernald** | | | |
| Chips in concrete | 1 | 0.005 | |
| Rockwell spills | 7 | 0.527 | |
| Misc Metal(dissolution) | 149 | 32.047 | |
| Misc Metal(oxidation) | 1 | 0.014 | |
| Misc Metal Recovery? | 2 | 3 | |
| Historical metal | 5 | 0.146 | |
| | | | |
| **NU** | | **MTU** | |
| **SRS** | | | |
| Bare NU metal | | 35.4 | |
| Pu Scrap | | 0.2 | |
| Discardable material | | 0.007 | |
| Inactive samples | | 0.11 | |
| | | | |

**Table 3. Melt and Dilute Feed Candidates**

| DU | | MTU | |
|---|---|---|---|
| SRS | | | |
| DU/Al powder/castings | | 0.6 | |
| Bare DU metal | | 938.2 | |
| Canned DU metal | | 1652.5 | |
| DU Solutions | | 236.9 | |
| DU Oxides | | 19428.1 | |
| Sludge & filter cake | | 25.2 | |
| Samples/stds | | 1.5 | |
| EBR-II | | 16.7 | |
| SS/Zr Fuel/targets | | 0.1 | |
| Pu/DU oxide fuel rods | | 1.7 | |
| Pu scrap | | 0.205 | |
| Lab Solutions | | 0.005 | |
| Discardable Material | | 0.001 | |
| | | | |
| Fernald | Items | MTU | |
| Chips in concrete | 1 | 0.009 | |
| Lead contaminated | 29 | 4.175 | |
| Nonburnable metal | 1 | 0.042 | |
| Rockwell spills | 17 | 3.063 | |
| Misc Metal (dissolution) | 234 | 89.025 | |
| Misc. Metal oxidation | 18 | 3.183 | |
| Scrap UO2 pellets | 23 | 2.186 | |
| Historical Materials | 2 | 0.027 | |
| | | | |
| | | | |
| U-233 | Items | Kg U-233 | |
| U-233 | 1505 | 790.7 | Total U is 1801 kg |
| U-233/SNF | | 1106.1 | Miscellaneous forms including carbide and MSRE recovery material |
| | | | |
| Pu-238 scrap | | | Various purities, lower than "fuel grade" for RTGs |
| | | Kgs | |
| Np237 Scrap | | 100's | Currently as solution, planned to convert to oxide |
| | # | Kgs | |
| Pu-239 | Items | | |
| Pits | #### | | |
| Metal and Alloy | 4559 | | |
| U/Pu/Zr Casting Scrap | 485 | | |
| Mixed Oxide Slugs | 179 | | |
| Oxide Powder | 9707 | | |
| Pu/U oxide | 277 | | |
| Pu scrap misc | 3341 | | |
| ZPPR plates | 42412 | | Alloy |
| Samples/Stds | 5 | | |
| Combustibles | 2452 | | |
| Misc. Compounds | 8999 | | |
| Ash | 9171 | | |
| Chlorides, flourides etc | 7119 | | |
| Pu/EU metal | 191 | | |
| | | | |
| Am 241 samples/stds | | | |
| | | | |
| Am 243 oxide | | | Currently tank 17.1 solution |
| | | | |
| Cm 244 solution | | | Currently tank 17.1 solution |

**Table 3. Melt and Dilute Feed Candidates (Continued)**

| | | | |
|---|---|---|---|
| Mk 18s | | | Am/Cm/Pu-244 in aluminum |
| | | | |
| Spent Fuel | MTU | Total Mass | |
| Oxide-Commercial | | 165.5 | SST or Zr Clad LEU |
| Oxide-Research | | 191.2 | SST/Zr Clad HEU/MEU, MOX |
| Oxide, U/Th | | 124.6 | SST or Zr Clad HEU/MEU/LEU |
| Oxide Disrupted TMI | | 331 | U Oxide failed or declad,, (LEU), TMI-2 |
| Metal(U,U-Mo)/Na | | 120.4 | Na bonded SST clad , HEU/MEU/LEU/DU (fermi blankets) |
| Metal U-Zr | | 0.1 | Zr Clad HEU/MEU/LEU/DU |
| Al-clad U metal | | 3534 | LEU (SPR), EBRII |
| Al Matrix | | 512.2 | U metal, oxide, silicide (19-93%) |
| Graphite | | 371 | U/Th carbide (HEU) |
| Misc Other | | 33.9 | U-Zr-Hx, sST/IncoloyAl Clad HEU/MEU triga fuels |
| Misc Other (failed) | | 12 | U oxide failed HEU/MEU (SST/Zr), U carbide (non-graphite), misc unknown |
| | | | |
| Irradiated Reactor Parts | | | |

**Table 3. Melt and Dilute Feed Candidates (Continued)**

## Results Of Analysis

With all criteria priorities and the ratings scheme defined by the team, materials were rated using the ECPro™ program to derive an overall rating for each material. Summary results from this evaluation are summarized in Table 4. Details of the analysis are given in Appendix D for all the materials. It should be noted that some candidate materials were not evaluated as the team determined they were not suitable candidates (e.g., DU chips in concrete).

Materials in Table 4 seem to group into three natural groups. Those with the highest rating, highlighted in dark gray, have ratings between 0.65 and 0.86. Since the rating of Al-matrix fuel slated for disposition in the melt-dilute facility is 0.752, these materials appear to be good candidates for disposition through that facility.

The second group, highlighted in light gray, has ratings from 0.65 to 0.55. These materials are less attractive but possible candidates. It may be that in doing process R&D for some of these materials, that some questions may be resolved that make them more attractive.

The first two groups include most of the plutonium materials currently scheduled for preparation for disposition in the new immobilization facility. Since this new facility represents a capital expenditure in excess of half a billion dollars, the use of melt and dilute for disposition of plutonium materials in lieu of immobilization deserves serious consideration. This kind of process also would make a homogeneous material meeting the original "Spent Fuel Standard" envisaged for plutonium disposition in the MGDS.

The third group, with a rating below 0.55, is significantly less attractive than the two above. The three groups can be seen visually in Figure 4.

Note that a number of uranium items scored highly in this rating. The melt-and-dilute process is essentially designed to use such material as an isotopic diluent for the Al/HEU spent fuel, and as expected would receive a high rating against the criteria used. For example scrap aluminum, if scored, would likewise be expected to receive a 'high' total score.

The ranking of score must then be tempered with the consideration of cost and 'risk' associated with continued storage of the material in its current form. For LEU/NU/DU metal or oxides, the materials are stable and have low associated health and safety concerns and minimal annual storage costs. DU NU, and LEU are also often amenable to disposal as low level waste (e.g., at the Nevada Test Site). Processing such materials in a melt-and-dilute facility in amounts beyond those needed for isotopic dilution of HEU, although highly compatible, could actually increase the costs associated with disposition. A more detailed economic analysis of LEU/NU/DU items on a case-by-case basis would thus be required to determine costs of continued storage or processing for disposal as low level waste in its current form, versus processing in the melt-and-dilute facility, storage, and eventual permanent disposal.

| Material | Total | Material | Total |
|---|---|---|---|
| SRS DU discardable material | 0.8571 | Pu/U oxide | 0.6526 |
| SRS DU Samples & Standards | 0.8571 | U-233/SNF | 0.6469 |
| Pu/EU metal | 0.8207 | Cm 244 solution | 0.6457 |
| SRS M Area U metal LEU | 0.8196 | Am 243 oxide | 0.6457 |
| SRS Recovered oxides LEU | 0.7994 | Am 241 samples/stds | 0.6457 |
| FMPC Misc DU metal (oxidation) | 0.7994 | Pu Mixed Oxide Slugs | 0.6442 |
| Plates, HEU Slightly irradiated | 0.7980 | Pu scrap misc | 0.6441 |
| SRS DU lab solutions | 0.7967 | Pu Ash | 0.6424 |
| SRS DU Oxides | 0.7694 | ZPPR plates | 0.6288 |
| Pu-238 scrap | 0.7690 | U/Pu/Zr Casting Scrap | 0.6200 |
| FMPC DU historical materials | 0.7674 | FMPC Rockwell spills LEU | 0.5915 |
| SRS EBR-II (DU) | 0.7636 | FMPC Misc LEU Metal(dissolution) | 0.5915 |
| Al-clad U metal SNF | 0.7636 | HEU SRS Solutions | 0.5812 |
| SRS Bare DU metal | 0.7568 | SRS NU (Pu) Scrap | 0.5742 |
| SRS Canned DU metal | 0.7568 | Pu Chlorides, flourides etc | 0.5658 |
| HEU-Tubes and Assemblies (Mk-22s) | 0.7549 | SRS DU Sludge and Filter Cake | 0.5653 |
| Al Matrix SNF | 0.7472 | Pu Combustibles | 0.5517 |
| FMPC Misc Metal(oxidation) LEU | 0.7441 | SRS DU SS/Zr fuel/targets | 0.5394 |
| Mk 18s | 0.7398 | SRS Pu/DU Oxide fuel rods | 0.5394 |
| HEU ORNL off spec metal | 0.7337 | Np 237 scrap | 0.5167 |
| SRS BARE NU Metal | 0.7319 | SRS Pu/DU scrap | 0.4890 |
| SRS NU inactive samples | 0.7248 | FMPC DU Nonburnable metal | 0.4706 |
| U-233 (canned oxide) | 0.7242 | Pu-239 Pits | 0.4574 |
| Metal and Alloy | 0.7236 | FMPC DU lead contaminated | 0.4097 |
| HEU Ingots and Billets | 0.7187 | Metal U-Zr SNF | 0.3382 |
| FMPC Scrap DU oxide pellets | 0.7162 | Metal(U,U-Mo)/Na SNF | 0.3382 |
| SRS NU Discardable Material | 0.7134 | Oxide-Research SNF | 0.3103 |
| SRS DU/Al powder castings | 0.7089 | Oxide-Commercial SNF | 0.3050 |
| SRS DU Solutions | 0.7068 | Oxide Disrupted TMI SNF | 0.2705 |
| Pu Misc. Compounds | 0.7041 | Oxide, U/Th SNF | 0.0000 |
| HEU Idaho oxide | 0.6939 | FMPC Chips in concrete LEU | 0.0000 |
| FMPC Misc Metal Recovery? LEU | 0.6876 | SRS Vitrified waste LEU | 0.0000 |
| FMPC DU Rockwell spills | 0.6856 | FMPC DU chips in concrete | 0.0000 |
| FMPC Misc DU metal (dissolution) | 0.6752 | Graphite SNF | 0.0000 |
| Pu Oxide Powder | 0.6735 | Misc Other SNF | 0.0000 |
| Pu Samples/Stds | 0.6708 | Misc Other (failed) | 0.0000 |
| HEU Hanford | 0.6633 | Irradiated Reactor Parts | 0.0000 |

NOTE: NR indicates Not Rated.

**Table 4. Final Ratings Totals for Materials Evaluated**

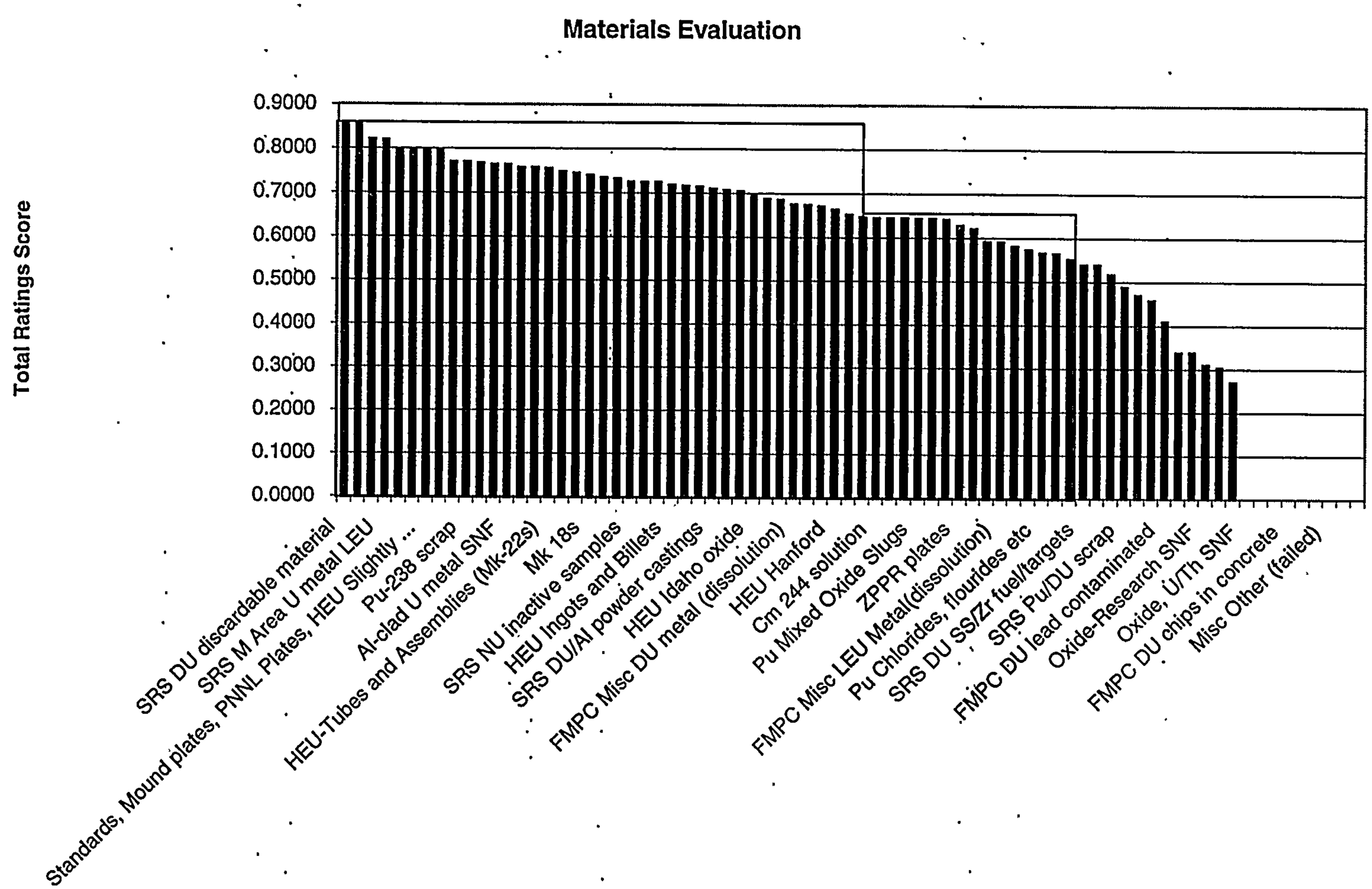



**Figure 4. Summary Ratings**

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## CONCLUSIONS

The melt and dilute facility represents an opportunity for disposition of a number of materials other than the Al matrix SNF for which it is intended. Although some materials on this list currently have planned dispositions, in a number of cases, melt and dilute represents a lower cost alternative.

This is especially true for miscellaneous plutonium materials currently slated for immobilization in a ceramic. Melt and dilute provides an alternative that, if combined with melt and dilute of Al-matrix fuel, could produce a waste form that would not require expensive new facilities (for immobilization and removal of cesium from SRS salt waste). This alternative would be at least as unattractive from a radiation and processing perspective as plutonium in commercial spent fuel.

Depleted uranium metal is the material of choice for operation of the melt and dilute facility, to be used for isotopic dilution of HEU in the U/Al spent fuel. As expected, DU metal and to a lessor degree oxides are highly compatible with the melt and dilute process and thus scored highly in this analysis due to high material compatibility. The same observation applies to NU and LEU.

However, the bulk of these materials as metal or oxides are stable and represent a very low risk and cost for continued storage. Also, DOE has not yet made a determination with regard to declaring inventories surplus to future use. If disposal becomes an option at some time in the future, packaging for disposal as low level waste (e.g., to the Nevada Test Site) has historically been a relatively low cost disposition path. As a results the economics of using a melt and dilute facility solely for processing LEU/NU/DU beyond that required for isotopic blend down of HEU in fuels could not likely be justified. The relatively high scores assigned to such materials relative to the criteria used in this analysis must be tempered by this economic reality.

Melt and dilute also provides a method for disposition of off-spec HEU materials should current negotiations with the Tennessee Valley Authority become unfruitful which would allow disposition of this material at 1% U-235 at moderate (operating only) cost.

It is also important to note that some materials appear to be very unattractive vis a vis the melt and dilute process. It is important that the Department of Energy follow through on development of disposition paths for these materials.

## PATH FORWARD

The following Phase II activities complete the requested assessment of the use of melt and dilute facility for the disposition of other materials:

1. Develop process flow sheets for each of the group one materials. Consider RCRA materials issues if applicable, waste streams and interim storage.

2. Identify disposition paths for waste forms following M-D treatment, i.e., LLW, WIPP or MGDS and feasibility of obtaining waste form qualification.

3. Develop preliminary cost estimates and schedules.

4. Develop Monte Carlo risk analysis for implementation for recommended candidates.

5. Develop a final recommendation and path forward for recommended candidates in the form of a final report.

A proposed schedule is shown below:

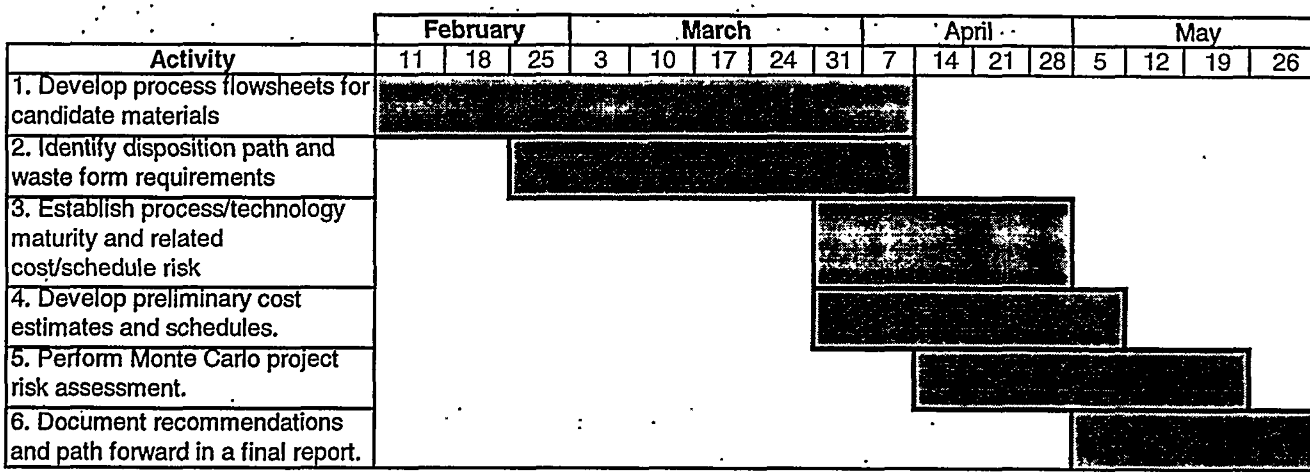


**Figure 5. Proposed Phase II Schedule**

## REFERENCES


1 G. Rudy to J. J. Buggy, letter, " Path Forward on Alternative Technology", dated September 7, 1999.

2 E. W. Zimmerman, Spent Nuclear Fuel Alternative Technology Decision Analysis, U-ESR-G-0004, Rev.0, June 28, 1998.

3 Dr. Thomas L. Saaty. *Decision Making for Leaders.* RWS Publications, Pittsburgh, PA 15213 (1995).

4 Faith Giglio. *ECpro for Windows, Decision Support Software User Manual.* Expert Choice, Inc., Pittsburgh, PA 15213 (1995).

## APPENDICES

# APPENDIX A

# CURRICULA VITAE

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### Harold B. Peacock, Jr., Ph.D.

Harold Peacock holds a B.S. degree in Mechanical Engineering and a M.S. degree in Metallurgy from the Georgia Institute of Technology. He received a Ph.D. degree in Metallurgical Engineering from the University of Tennessee. He has 30 years experience in R&D in the area of technology development.

Dr. Peacock is an Advisory Engineer at the Savannah River Technology Center and has published over 75 papers in journals and conference proceedings. He holds one U.S. patent in solid state welding. He developed a powder metallurgical process for blending and isostaticly compacting powders for extrusion billet cores as well as methods for extrusion of SRS reactor fuel tubes. He was principal investigator in the development of (1) long-term corrosion testing of aluminum alloys at high temperature and humidity conditions, (2) solid state welding of depleted uranium slugs for plutonium production, and (3) design and fabrication of targets for the accelerator production of tritium at Los Alamos. He is currently responsible for the development of the melt-dilute technology for treatment of aluminum-base research reactor spent nuclear fuel.

He is a member of the ASM International (ASM) and the Society of Engineering Mechanics (SEM), and has served as program Chairman for the ASM Society's Savannah River local chapter. He has taught mechanical and metallurgical engineering courses at Universities for the past 15 years.

### Thad Adams, Ph.D.

Dr. Thad Adams received his M.S. (1994) and Ph.D. (1997) from the University of Florida in Materials Science and Engineering. Prior to this, his B.S degree (1991) was earned from the University of Tennessee. His studies have concentrated on the liquid metal corrosion/embrittlement, advance nuclear fuel development, phase transformations and microstructural evolution in advanced materials. Additionally, Dr. Adams has worked in the areas of materials processing, metallic glasses, thin films, and temperature gradient zone melting. He has also performed fundamental thermodynamic modeling of advanced materials system with respect to phase formation and binary and ternary equilibrium and metastable phase diagrams. Dr. Adams has extensive knowledge of materials characterization techniques including SEM, EDAX/WDAX, TEM, XRD, Hi-Temp XRD, DSC, DTA, TGA. Dr. Adams has given numerous technical presentations and has published 10 technical papers in journals and conference proceedings. For the past two years, he has held the position of senior engineer at WSRC, where he leads the development effort for spent nuclear fuel alternative disposal technology (SNFADT).

### Helen Brooks

Ms. Brooks received a B.S. degree in Chemical Engineering from Tennessee Technological University and a Masters in Environmental Engineering from Auburn University. She has 11 years experience at Savannah River Site primarily associated with nuclear production reactor operations and spent nuclear fuel receipt engineering. Ms. Brooks has held positions in reactor operations supervision and management, heavy water operations, and fuel receipt engineering. In her current assignment, Ms. Brooks is responsible for the management of the Alternate Technology Program that includes validation of the melt-dilute technology and qualification of the waste form for the repository.

## Joseph F. Krupa

M.E. Ch. E. University of Idaho
M.Sc. in Chemistry, University of California Berkeley -- (AEC fellowship in Nuclear Science and Engineering
B.Sc. in Chemistry, U.S. Air Force Academy, CO

Mr. Krupa has over 26 years experience in the nuclear field. He started his career performing radiochemical analyses as a Nuclear Research Officer in the U.S. Air Force. He then spent 10 years at the Idaho Chemical Processing Plant performing studies of actinide removal from spent fuel waste using bidentate phosphorous ligands. He was the lead for a NRC funded experimental program to evaluate post-accident (nuclear) radio-iodine sampling and measurement equipment.

He developed Flourinel Dissolution Process reagent addition computer programs for which he was awarded George Westinghouse bronze award in 1985. He was a key player in the successful modification and implementation of the Fluorinel Process for Naval Fuel dissolution including developing analytical methods for process control, modeling of process dissolution criticality permitting deletion of a major system, operating the Fluorinel Dissolution Pilot Plant and acting as a startup engineer for the Fluorinel Dissolution hot startup.

From 1987-1992, he was a Nuclear Engineer for the Department of Energy's Savannah River Operations Office. During his tenure, he acted as DOE Nuclear Materials Manager; coordinated and reviewed technical planning studies on nuclear materials disposition, transportation and capital asset management, and participated in task forces on capital asset management, reconfiguration siting, and plutonium discard limits.

Mr. Krupa has, as a Principal Technical Advisor for Westinghouse Savannah River Company, published two studies of Al-clad spent fuel options to support Department of Energy Environmental Impact Statement Records of Decision. The latest study also provides cost and schedule information for a study of the non-proliferation impacts of spent fuel reprocessing. He has co-authored studies of life-cycle costs for spent fuel disposition with criticality prevention, SRS spent fuel storage, SRS plutonium discard limit implementation, SRS nuclear materials disposition and complex-wide nuclear material disposition issues.

He is active in the American Chemical Society (30 years) and American Nuclear Society, and has served as the Chairman of the American Chemical Society's Savannah River Local Section. He is also a member of the International Council of Systems Engineers (INCOSE) and the American Society for Engineering Management.

**William F. Swift**

Mr. Swift received his B.S. in Chemical Engineering from the University of Notre Dame. He has 18 years experience at Savannah River Site primarily associated with nuclear production reactor engineering. Mr. Swift has held engineering assignments in day-to-day operations, reactor components support, long-range planning and capital project development. He has also held engineering management assignments in systems engineering, as the engineering representative to the joint test group and for development of capital projects. Mr. Swift has also held positions as manager of solid waste engineering support and as manager of the site geotechnical groundwater modeling group. In his current assignment, Mr. Swift is responsible for supporting development of alternative technologies for disposition of spent nuclear fuel and development of a project to implement the chosen technology.

**Wade E. Bickford**

Wade Bickford is a Senior Consulting Engineer working for Westinghouse in the Strategic Planning and Integration Department at the Savannah River Site. He has over 25 years experience in nuclear design and safety in the DOE complex. At the Pacific Northwest National Laboratory at Hanford, Mr. Bickford rose to the position of Senior Scientist in fusion research, and later transitioned to nuclear reactor safety, and advanced nuclear concepts development. In 1988, Mr. Bickford accepted a position in the Reactor Physics group at the Savannah River Site for work on a new production reactor. During this period, he was the site representative to national technical working groups on facility design and thermal hydraulics, as well as task manager and technical contributor for reactor safety analysis and engineering studies to support environmental documentation. This diverse background led to a position in site planning in 1992, where he has supported site and national planning efforts for transition of DOE to post-Cold War missions. Wade Bickford received his undergraduate degree in Mathematics from Washington State University, and was elected to the Phi Beta Kappa honorary. He received his M.S. degree in Nuclear Engineering from the University of Washington. He is also a licensed Professional Engineer (Mechanical).

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# APPENDIX B

# CRITERIA EVALUATION

The table below indicates the raw scores and geometric means for the model criteria.

| | | Adams | Krupa | Bickford | Peacock | Swift | Brooks | G.M. | 1/G.M. |
|---|---|---|---|---|---|---|---|---|---|
| Disposition Compatibitility | Process | 5.000 | 0.333 | 0.167 | 7.000 | 6.000 | 4.000 | 1.897 | |
| Economic Advantage | Process | 0.500 | 0.250 | 0.143 | 1.000 | 0.500 | 0.333 | 0.379 | 2.637 |
| Transportation | Process | 4.000 | 3.000 | 5.000 | 5.000 | 3.000 | 1.000 | 3.107 | |
| Tech Development | Process | 1.000 | 4.000 | 1.000 | 5.000 | 1.000 | 0.250 | 1.308 | |
| Economic Advantage | Disposition Compatibitility | 3.000 | 0.333 | 4.000 | 2.000 | 0.200 | 0.200 | 0.827 | 1.209 |
| Transportation | Disposition Compatibitility | 5.000 | 3.000 | 6.000 | 5.000 | 1.000 | 0.500 | 2.466 | |
| Tech Development | Disposition Compatibitility | 2.000 | 3.000 | 5.000 | 1.000 | 0.500 | 1.000 | 1.570 | |
| Transportation | Economic Advantage | 5.000 | 5.000 | 3.000 | 0.250 | 3.000 | 3.000 | 2.351 | |
| Tech Development | Economic Advantage | 1.000 | 4.000 | 3.000 | 4.000 | 2.000 | 1.000 | 2.140 | |
| Tech Development | Transportation | 5.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.308 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Offgas | Temperature | 0.333 | 3.000 | 0.333 | 8.000 | 2.000 | 0.250 | 1.049 | |
| Alloy composition | Temperature | 1.000 | 3.000 | 0.333 | 9.000 | 2.000 | 1.000 | 1.619 | |
| Feed Knowledge | Temperature | 0.333 | 3.000 | 0.200 | 0.200 | 0.250 | 0.167 | 0.344 | 2.904 |
| Material Compatibility | Temperature | 1.000 | 1.000 | 0.200 | 6.000 | 0.500 | 0.333 | 0.765 | 1.308 |
| Pretreatment requirements | Temperature | 0.333 | 5.000 | 0.333 | 6.000 | 0.500 | 11.000 | 1.624 | |
| Alloy composition | Offgas | 5.000 | 3.000 | 2.000 | 0.167 | 2.000 | 6.000 | 1.979 | |
| Feed Knowledge | Offgas | 3.000 | 3.000 | 0.250 | 0.143 | 0.250 | 1.000 | 0.657 | 1.522 |
| Material Compatibility | Offgas | 3.000 | 1.000 | 0.250 | 0.200 | 1.000 | 0.500 | 0.649 | 1.540 |
| Pretreatment requirements | Offgas | 3.000 | 5.000 | 0.250 | 6.000 | 1.000 | 0.500 | 1.497 | |
| Feed Knowledge | Alloy Composition | 0.333 | 0.500 | 0.250 | 1.000 | 0.250 | 4.000 | 0.589 | 1.698 |
| Material Compatibility | Alloy Composition | 1.000 | 0.500 | 0.200 | 4.000 | 0.500 | 0.200 | 0.585 | 1.710 |
| Pretreatment requirements | Alloy Composition | 0.333 | 3.000 | 0.200 | 5.000 | 0.500 | 0.500 | 0.794 | 1.260 |
| Material Compatibility | Feed Knowledge | 3.000 | 1.000 | 0.200 | 6.000 | 3.000 | 1.000 | 1.487 | |
| Pretreatment requirements | Feed Knowledge | 4.000 | 3.000 | 2.000 | 1.000 | 3.000 | 3.000 | 2.449 | |
| Material Compatibility | Pretreatment requirements | 0.333 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.833 | 1.201 |

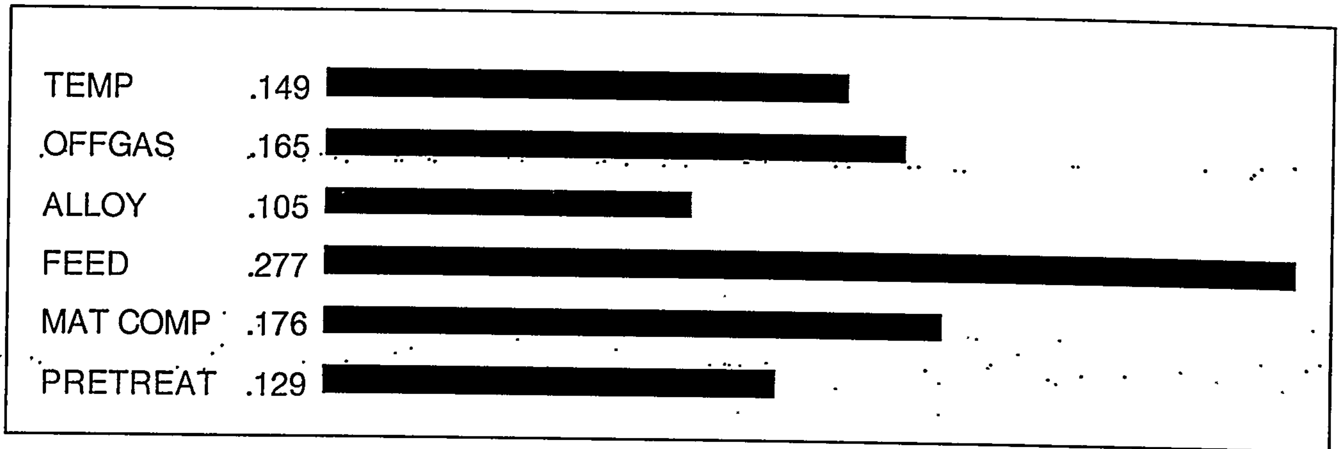
| | | Adams | Krupa | Bickford | Peacock | Swift | Brooks | G.M. | 1/G.M. |
|---|---|---|---|---|---|---|---|---|---|
| Attractiveness of Waste Fm | Availability of current path | 0.333 | 0.333 | 1.000 | 0.200 | 0.200 | 3.000 | 0.487 | 2.054 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Potential Cost Savings | Cost to Implement | 1.000 | 0.333 | 0.167 | 1.000 | 1.000 | 4.000 | 0.778 | 1.285 |
| Quantity of Material | Cost to Implement | 3.000 | 4.000 | 7.000 | 0.333 | 1.000 | 0.500 | 1.552 | |
| Quantity of Material | Potential Cost Savings | 3.000 | 5.000 | 7.000 | 7.000 | 1.000 | 0.500 | 2.676 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Shipping | Receiving | 4.000 | 1.000 | 4.000 | 5.000 | 1.000 | 4.000 | 2.615 | |
| Packaging | Receiving | 4.000 | 0.333 | 1.000 | 0.200 | 1.000 | 4.000 | 1.011 | 0.989 |
| Storage | Receiving | 4.000 | 2.000 | 0.333 | 1.000 | 1.000 | 3.000 | 1.414 | |
| Packaging | Shipping | 1.000 | 0.333 | 0.333 | 4.000 | 1.000 | 0.500 | 0.778 | 1.285 |
| Storage | Shipping | 0.333 | 1.000 | 0.333 | 5.000 | 1.000 | 0.500 | 0.808 | 1.238 |
| Storage | Packaging | 1.000 | 4.000 | 0.333 | 6.000 | 1.000 | 1.000 | 1.414 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Processing | Waste Form | 1.000 | 2.000 | 5.000 | 4.000 | 1.000 | 0.333 | 1.540 | |

## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.03

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| PROCESS | Disposition process compatability with M&D |
| TEMP | Process Temperature required |
| OFFGAS | Offgas treatment required |
| ALLOY | Composition of final waste form (alloy?) |
| FEED | Knowledge of feed composition |
| MAT COMP | Compatibilities of materials with equipment |
| PRETREAT | Levels of pretreatment required |

## *Develop a ratings for attractiveness for using melt and dilute*

| | |
|---|---|
| PATH AVL | .323 |
| ATTRACTV | .677 |

Inconsistency Ratio =0.0

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| DISPOSIT | Compatability of waste form with Yucca, WIPP, LLW etc. |
| PATH AVL | Availability of current disposition path |
| ATTRACTV | Attractiveness of waste form; ease of certification |

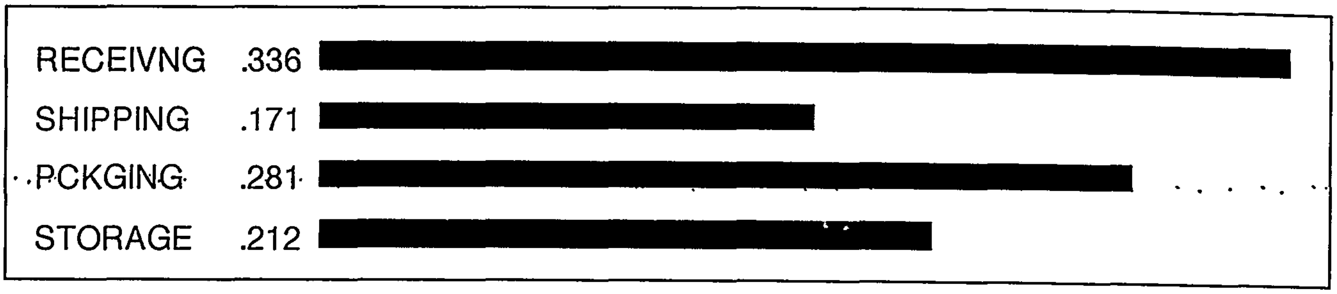
## *Develop a ratings for attractiveness for using melt and dilute*

| | |
|---|---|
| IMP COST | .334 |
| SAVINGS | .474 |
| QUANTITY | .192 |

Inconsistency Ratio =0.01

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| ECON.AD | Potential for savings |
| IMP COST | Cost to implement |
| SAVINGS | Potential savings of using M&D |
| QUANTITY | Quantity of material to be processed (months) |

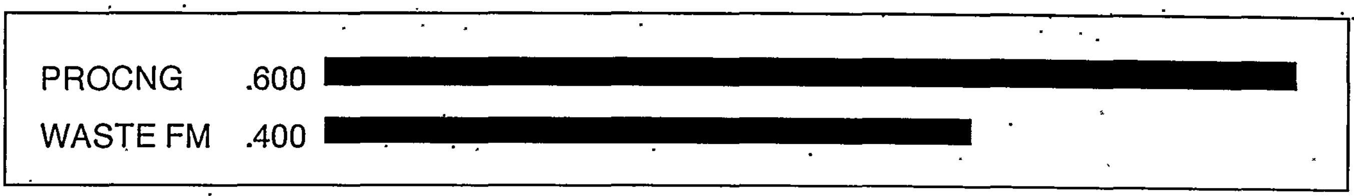
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.02

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| TRNSPRT | Ability to ship and receive |
| RECEIVNG | Ability to receive material |
| SHIPPING | Ability to ship out material |
| PCKGING | Shipping prepations required. |
| STORAGE | Material storage availability |

## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.0

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| TECH DEV | Technology Development Required |
| PROCNG | Additional process R&D required. |
| WASTE FM | Additional waste form R&D required. |

# APPENDIX C

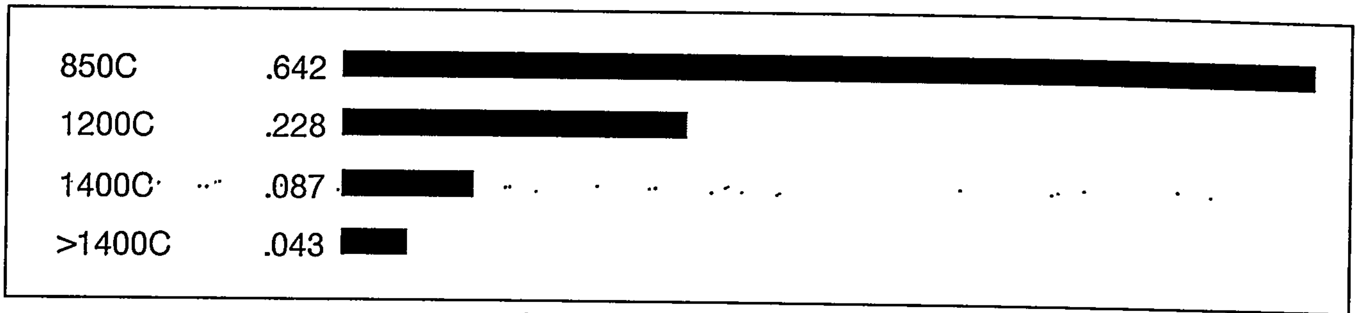
# RATINGS EVALUATIONS FOR MATERIALS

Scale pair-wise comparisons are given by evaluator in the table below.

| Evaluator | Adams | Peacock | Swift | Bickford | Brooks | Krupa | GM | 1/GM |
|---|---|---|---|---|---|---|---|---|
| **Temp** | | | | | | | | |
| 850 vs 1200 | 0.25 | 0.166667 | 0.2 | 0.166667 | 0.25 | 0.2 | 0.20274 | 4.932424 |
| 850 vs 1400 | 0.142857 | 0.142857 | 0.142857 | 0.142857 | 0.166667 | 0.142857 | 0.146575 | 6.822448 |
| 850 vs >1400 | 0.111111 | 0.111111 | 0.111111 | 0.125 | 0.125 | 0.111111 | 0.11556 | 8.653497 |
| 1200 vs 1400 | 0.333333 | 0.2 | 0.333333 | 0.166667 | 0.333333 | 0.2 | 0.250471 | 3.992478 |
| 1200 vs >1400 | 0.2 | 0.125 | 0.2 | 0.142857 | 0.2 | 0.142857 | 0.165311 | 6.04922 |
| 1400 vs > 1400 | 1 | 0.2 | 0.333333 | 0.166667 | 0.5 | 0.2 | 0.32183 | 3.107233 |
| **Offgas** | | | | | | | | |
| No-P vs ONEHEPA | 0.333333 | 0.25 | 0.5 | 0.25 | 0.25 | 0.2 | 0.28365 | 3.525469 |
| No-P vs M&DSYS | 0.25 | 0.2 | 0.5 | 0.2 | 0.2 | 0.142857 | 0.228639 | 4.373707 |
| No-P vs SAND | 0.142857 | 0.25 | 0.25 | 0.166667 | 0.125 | 0.111111 | 0.16566 | 6.036478 |
| ONEHEPA vs M&DSYS | 0.5 | 0.333333 | 0.5 | 0.25 | 0.5 | 0.333333 | 0.389136 | 2.569797 |
| ONEHEPA vs SAND | 0.142857 | 0.2 | 0.25 | 0.2 | 0.2 | 0.166667 | 0.190384 | 5.252546 |
| M&DSYS vs SAND | 0.333333 | 0.333333 | 0.2 | 0.25 | 0.333333 | 0.25 | 0.278136 | 3.595359 |
| **Alloy** | | | | | | | | |
| Compat vs Marg Dep | 1 | 0.5 | 0.25 | 0.25 | 0.5 | 0.333333 | 0.416342 | 2.401874 |
| Compat vs Sig Dep | 0.5 | 0.25 | 0.142857 | 0.2 | 0.2 | 0.2 | 0.228639 | 4.373707 |
| Compat vs New Mat | 0.2 | 0.166667 | 0.333333 | 0.166667 | 0.142857 | 0.142857 | 0.18319 | 5.458814 |
| Marg Dep vs Sig Dep | 0.5 | 0.5 | 0.166667 | 0.25 | 0.333333 | 0.333333 | 0.324027 | 3.086164 |
| Marg Dep vs New Mat | 0.2 | 0.333333 | 0.166667 | 0.2 | 0.142857 | 0.2 | 0.199735 | 5.006645 |
| Sig Dep vs New Mat | 0.2 | 1 | 0.5 | 0.25 | 0.25 | 0.333333 | 0.357377 | 2.798166 |
| **Feed** | | | | | | | | |
| WELLCHAR vs. Proc. Kno | 1 | 0.333333 | 0.333333 | 0.25 | 0.333333 | 0.333333 | 0.381571 | 2.620741 |
| WELLCHAR vs. Mat Des | 0.25 | 0.2 | 0.2 | 0.2 | 0.25 | 0.2 | 0.215443 | 4.641589 |
| WELLCHAR vs UK | 0.142857 | 0.166667 | 0.142857 | 0.166667 | 0.142857 | 0.125 | 0.14708 | 6.799043 |
| Proc Kno vs. Mat Des | 0.333333 | 0.25 | 0.333333 | 0.333333 | 0.5 | 0.25 | 0.324027 | 3.086164 |
| Proc Kno vs. UK | 0.142857 | 0.25 | 0.2 | 0.25 | 0.2 | 0.142857 | 0.192586 | 5.192494 |
| Mat Des vs. UK | 0.2 | 0.166667 | 0.333333 | 0.333333 | 0.25 | 0.333333 | 0.259962 | 3.846722 |
| **Mat Comp** | | | | | | | | |
| Current vs Graphite | 1 | 0.333333 | 0.5 | 0.142857 | 0.333333 | 0.333333 | 0.371893 | 2.688945 |
| Current vs. Nitride | 0.333333 | 0.25 | 0.25 | 0.125 | 0.166667 | 0.2 | 0.210422 | 4.752354 |
| Graphite vs. Nitride | 0.333333 | 0.2 | 0.333333 | 0.142857 | 0.25 | 0.333333 | 0.253368 | 3.946832 |
| **Pretreat** | | | | | | | | |
| No-P vs Min-P | 1 | 0.333333 | 0.333333 | 0.25 | 0.5 | 0.333333 | 0.408248 | 2.44949 |
| No-P vs Sig-P | 0.25 | 0.25 | 0.166667 | 0.2 | 0.25 | 0.166667 | 0.210422 | 4.752354 |
| Min-P vs Sig-P | 0.5 | 0.2 | 0.333333 | 0.25 | 0.333333 | 0.25 | 0.297582 | 3.360421 |

| Evaluator | Adams | Peacock | Swift | Bickford | Brooks | Krupa | GM | 1/GM |
|---|---|---|---|---|---|---|---|---|
| **Path Avl** | | | | | | | | |
| Defined vs. Available | 1 | 5 | 2 | 4 | 1 | 4 | 2.329986 | |
| Defined vs. Proposed | 3 | 6 | 3 | 5 | 2 | 6 | 3.846722 | |
| Defined vs Undef | 5 | 7 | 4 | 6 | 4 | 8 | 5.473161 | |
| Available vs Proposed | 4 | 3 | 2 | 5 | 2 | 4 | 3.140836 | |
| Available vs. Undef | 5 | 4 | 3 | 6 | 4 | 6 | 4.529869 | |
| Proposed vs. Undef | 5 | 4 | 2 | 5 | 3 | 4 | 3.659052 | |
| **Attractiv** | | | | | | | | |
| Similar vs. Sim-Mod | 1 | 0.25 | 0.5 | 0.25 | 1 | 0.333333 | 0.467328 | 2.139826 |
| Similar vs. Sig Eff | 0.2 | 0.2 | 0.2 | 0.333333 | 0.25 | 0.142857 | 0.213699 | 4.679487 |
| Sim-Mod vs Sig Eff | 0.2 | 0.2 | 0.25 | 0.25 | 0.2 | 0.2 | 0.215443 | 4.641589 |
| **Imp Cost** | | | | | | | | |
| Opsonly vs MinorCap | 0.5 | 0.5 | 0.5 | 0.166667 | 1 | 0.333333 | 0.43679 | 2.289428 |
| Opsonly vs SigCap | 0.25 | 0.333333 | 0.25 | 0.2 | 0.333333 | 0.2 | 0.255436 | 3.914868 |
| Opsonly vs MajCap | 0.142857 | 0.333333 | 0.166667 | 0.25 | 0.166667 | 0.111111 | 0.182332 | 5.484504 |
| MinorCap vs SigCap | 0.333333 | 0.5 | 0.333333 | 0.2 | 0.333333 | 0.25 | 0.312197 | 3.203101 |
| MinorCap vs MajCap | 0.2 | 0.25 | 0.2 | 0.25 | 0.2 | 0.166667 | 0.208995 | 4.784797 |
| SigCap vs MajCap | 0.333333 | 0.5 | 0.25 | 0.25 | 0.25 | 0.25 | 0.294398 | 3.396763 |
| **Savings** | | | | | | | | |
| MINRSAV vs MODSAV | 1 | 2 | 3 | 7 | 2 | 2 | 2.34901 | |
| MINRSAV vs SIGSAV | 4 | 3 | 4 | 8 | 4 | 4 | 4.279653 | |
| MINRSAV vs MAJSAV | 7 | 4 | 6 | 9 | 6 | 6 | 6.156148 | |
| MINRSAV vs MAXSAV | 9 | 4 | 8 | 9 | 8 | 9 | 7.559526 | |
| MODSAV vs SIGSAV | 3 | 2 | 3 | 7 | 3 | 2 | 3.018239 | |
| MODSAV vs MAJSAV | 5 | 3 | 5 | 8 | 5 | 5 | 4.966097 | |
| MODSAV vs MAXSAV | 9 | 4 | 7 | 9 | 7 | 8 | 7.089874 | |
| SIGSAV vs MAJSAV | 3 | 2 | 3 | 8 | 3 | 4 | 3.464102 | |
| SIGSAV vs MAXSAV | 5 | 3 | 5 | 9 | 6 | 6 | 5.381885 | |
| MAJSAV vs MAXSAV | 6 | 2 | 2 | 8 | 6 | 5 | 4.233866 | |
| **Quantity** | | | | | | | | |
| INSIG vs MINOR | 1 | 0.5 | 0.333333 | 0.2 | 1 | 0.333333 | 0.472382 | 2.116933 |
| INSIG vs MODERATE | 3 | 0.333333 | 0.2 | 0.166667 | 2 | 0.2 | 0.486956 | 2.053573 |
| INSIG vs SIGNIF | 3 | 0.25 | 0.142857 | 0.142857 | 3 | 0.166667 | 0.443921 | 2.252652 |
| MINOR vs MODERATE | 1 | 0.5 | 0.5 | 0.166667 | 1 | 0.5 | 0.524558 | 1.906369 |
| MINOR vs SIGNIF | 3 | 0.333333 | 0.25 | 0.142857 | 2 | 0.25 | 0.511252 | 1.955981 |
| MODERATE vs SIGNIF | 0.333333 | 0.5 | 0.5 | 0.166667 | 2 | 0.333333 | 0.458243 | 2.182247 |
| **RECEIVNG** | | | | | | | | |
| Cur. REC. vs REC MOD | 0.333333 | 0.333333 | 0.5 | 0.25 | 0.25 | 0.25 | 0.308857 | 3.237741 |
| CUR REC vs NOREC | 0.2 | 0.2 | 0.25 | 0.2 | 0.166667 | 0.142857 | 0.190384 | 5.252546 |
| RECMOD vs NOREC | 0.333333 | 0.25 | 0.333333 | 0.25 | 0.333333 | 0.2 | 0.278136 | 3.595359 |
| **SHIPPING** | | | | | | | | |
| SHIPCUR vs SHIP.INC | 0.333333 | 0.5 | 0.333333 | 0.25 | 0.333333 | 0.333333 | 0.339941 | 2.941683 |
| SHIPCUR vs SHIP.UN | 0.2 | 0.25 | 0.2 | 0.2 | 0.2 | 0.2 | 0.207578 | 4.817462 |
| SHIP.INC vs SHIP.UN | 0.333333 | 0.5 | 0.333333 | 0.25 | 1 | 0.333333 | 0.408248 | 2.44949 |
| **PCKGING** | | | | | | | | |
| PACKAGED vs PACK REQ | 0.333333 | 0.5 | 0.333333 | 0.333333 | 0.5 | 0.5 | 0.408248 | 2.44949 |
| PACKAGED vs FAC REQ | 0.2 | 0.333333 | 0.166667 | 0.25 | 0.25 | 0.2 | 0.227568 | 4.39429 |
| PACKAGED vs NOT DET | 0.142857 | 0.25 | 0.111111 | 0.2 | 1 | 0.142857 | 0.22 | 4.545463 |
| PACK REQ vs FAC REQ | 0.2 | 0.333333 | 0.25 | 0.25 | 2 | 0.25 | 0.357377 | 2.798166 |
| PACK REQ vs NOT DET | 0.2 | 0.333333 | 0.166667 | 0.2 | 2 | 0.166667 | 0.3008 | 3.324469 |
| FAC REQ vs NOT DET | 0.5 | 0.25 | 0.333333 | 0.25 | 3 | 0.2 | 0.429187 | 2.329986 |
| **STORAGE** | | | | | | | | |
| STG AV vs MIN MODS | 1 | 0.333333 | 0.5 | 0.25 | 1 | 0.333333 | 0.49028 | 2.039649 |
| STG AV vs MAJ MODS | 0.2 | 0.2 | 0.25 | 0.2 | 4 | 0.166667 | 0.331759 | 3.014233 |
| MIN MODS vs MAJ MODS | 0.2 | 0.333333 | 0.333333 | 0.25 | 2 | 0.25 | 0.374929 | 2.667168 |
| **PROCNG** | | | | | | | | |
| NOPRRR&D vs MOD R&D | 0.333333 | 0.5 | 0.333333 | 0.166667 | 0.333333 | 0.5 | 0.339941 | 2.941683 |
| NOPRRR&D vs MAJ R&D | 0.25 | 0.25 | 0.166667 | 0.142857 | 0.2 | 0.25 | 0.205085 | 4.876032 |
| MOD R&D vs MAJ R&D | 0.333333 | 0.5 | 0.333333 | 0.166667 | 0.333333 | 0.5 | 0.339941 | 2.941683 |
| **WASTE FM** | | | | | | | | |
| NOWR&D vs MODWR&D | 0.333333 | 0.333333 | 0.333333 | 0.166667 | 0.333333 | 0.5 | 0.317728 | 3.147345 |
| NOWR&D vs MAJWR&D | 0.2 | 0.5 | 0.166667 | 0.142857 | 0.2 | 0.25 | 0.221796 | 4.50865 |
| MODWR&D vs MAJWR&D | 0.2 | 0.333333 | 0.333333 | 0.166667 | 0.333333 | 0.5 | 0.291797 | 3.42704 |

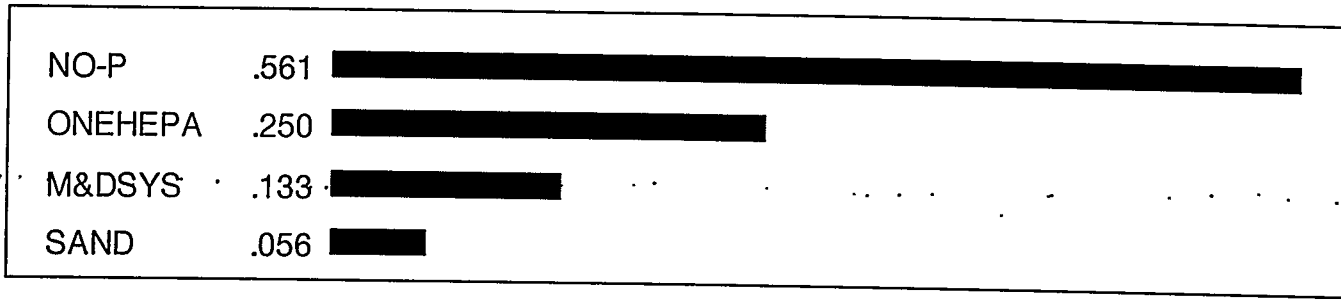
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.09

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| PROCESS | Disposition process compatability with M&D |
| TEMP | Process Temperature required |
| 850C | At or below 850C |
| 1200C | 850-1200C |
| 1400C | 1200-1400C |
| >1400C | Greater than 1400C |

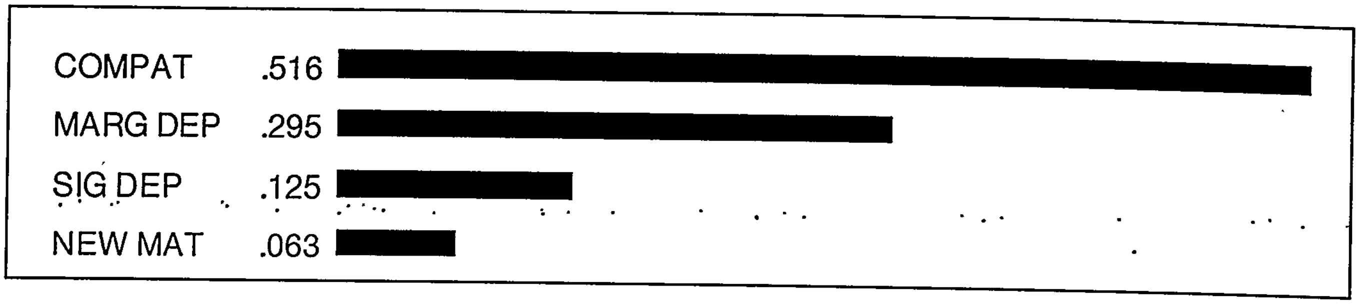
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.07

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| PROCESS | Disposition process compatability with M&D |
| OFFGAS | Offgas treatment required |
| NO-P | No Pretreatment required |
| ONEHEPA | Single HEPA system |
| M&DSYS | HEPA plus zeolite (M&D system) |
| SAND | Sand filter required |

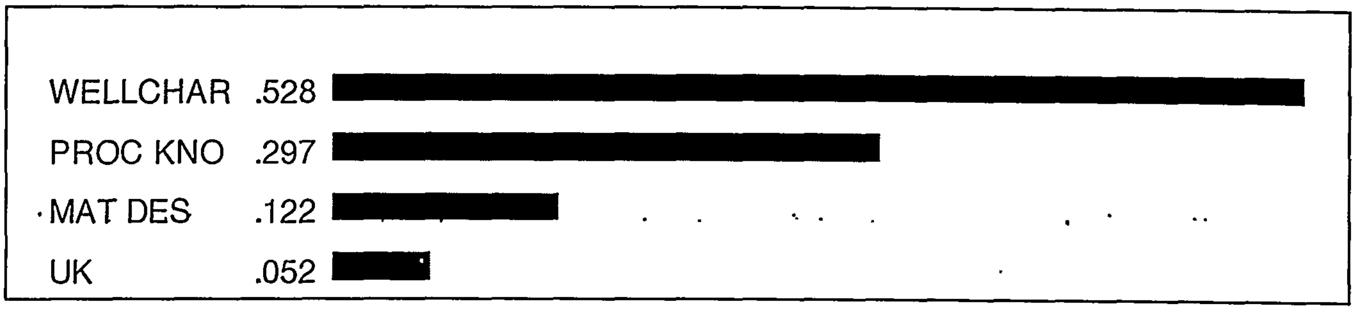
# *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.04

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| PROCESS | Disposition process compatability with M&D |
| ALLOY | Composition of final waste form (alloy?) |
| COMPAT | Essentially the same as current U/Al |
| MARG DEP | Marginal departure from current composition |
| SIG DEP | Significant departure from current composition |
| NEW MAT | Completely new material |

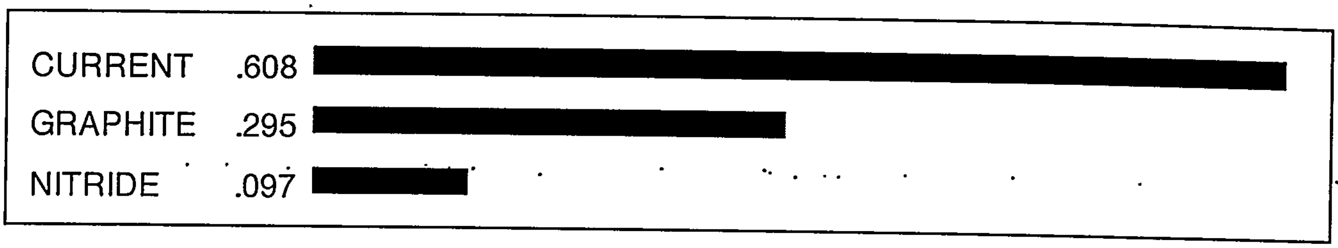
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.07

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| PROCESS | Disposition process compatability with M&D |
| FEED | Knowledge of feed composition |
| WELLCHAR | Feed well characterized |
| PROC KNO | Process knowledge of feed available |
| MAT DES | Material has a description, some uncertainty |
| UK | Material composition substantially unknown |

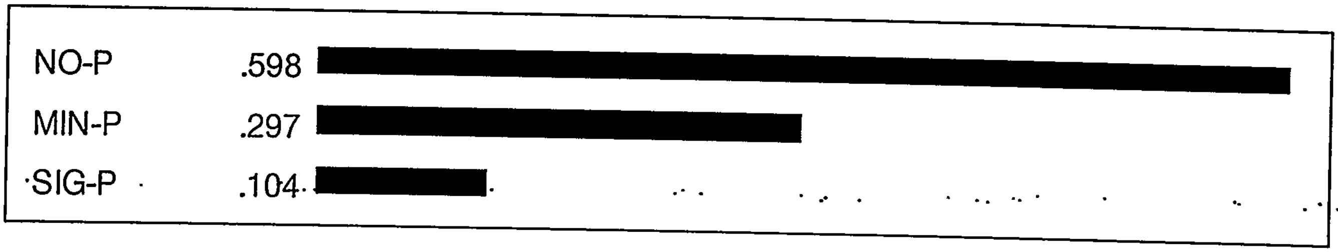
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.07

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| PROCESS | Disposition process compatability with M&D |
| MAT COMP | Compatibilities of materials with equipment |
| CURRENT | Steel crucible adequate |
| GRAPHITE | Requires graphite crucible |
| NITRIDE | Requires silicon nitride or more exotic crucible |

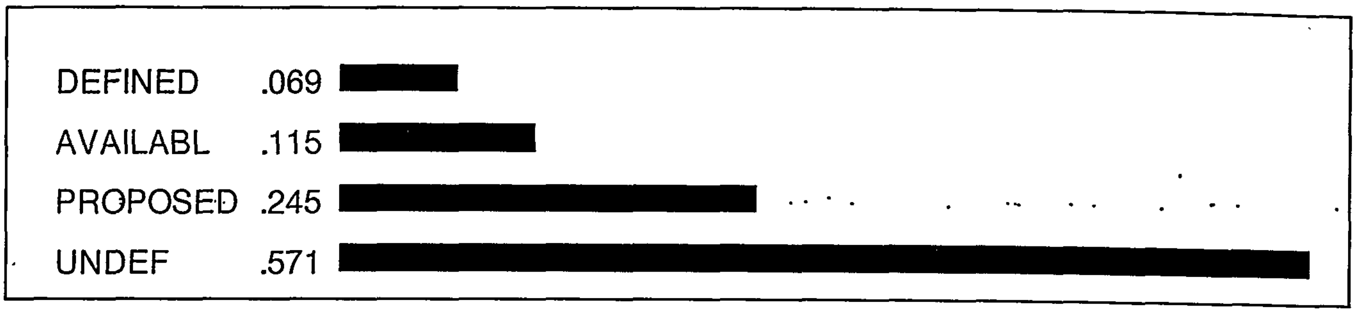
# *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.03

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| PROCESS | Disposition process compatability with M&D |
| PRETREAT | Levels of pretreatment required |
| NO-P | No Pretreatment required |
| MIN-P | Minimal pretreatment (some sorting, minor size reduction) |
| SIG-P | Significant pretreatment required.(compaction/cutting) |

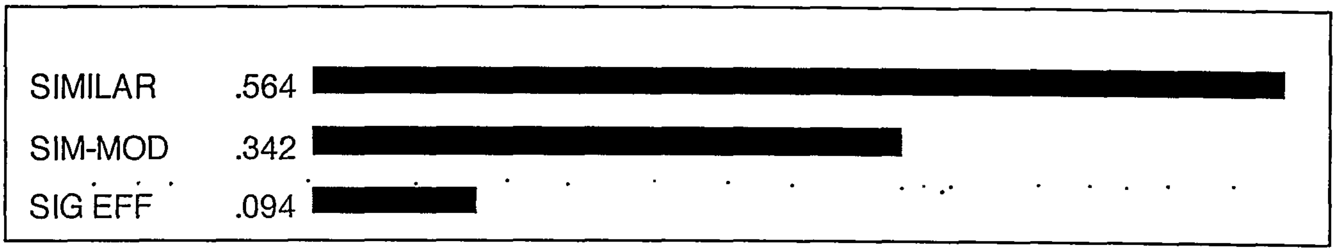
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.06

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| DISPOSIT | Compatability of waste form with Yucca, WIPP, LLW etc. |
| PATH AVL | Availability of current disposition path |
| DEFINED | Path currently defined, available and funded |
| AVAILABL | Path defined and available, not currently funded |
| PROPOSED | path developed, facilities and or funding not available |
| UNDEF | Path not currently defined (TBD) |

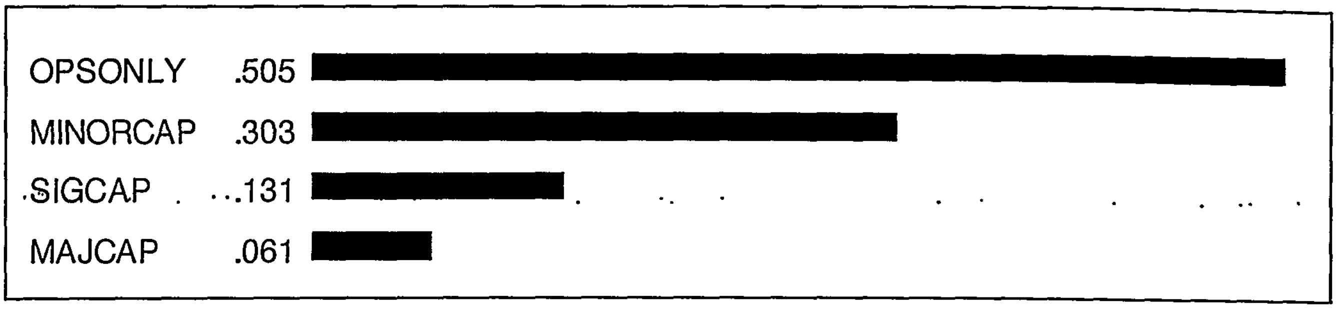
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.06

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| DISPOSIT | Compatability of waste form with Yucca, WIPP, LLW etc. |
| ATTRACTV | Attractiveness of waste form; ease of certification |
| SIMILAR | Very similar to M&D form or no issues |
| SIM-MOD | Similar with minor modifications to testing |
| SIG EFF | Requires significant waste form qualification effort |

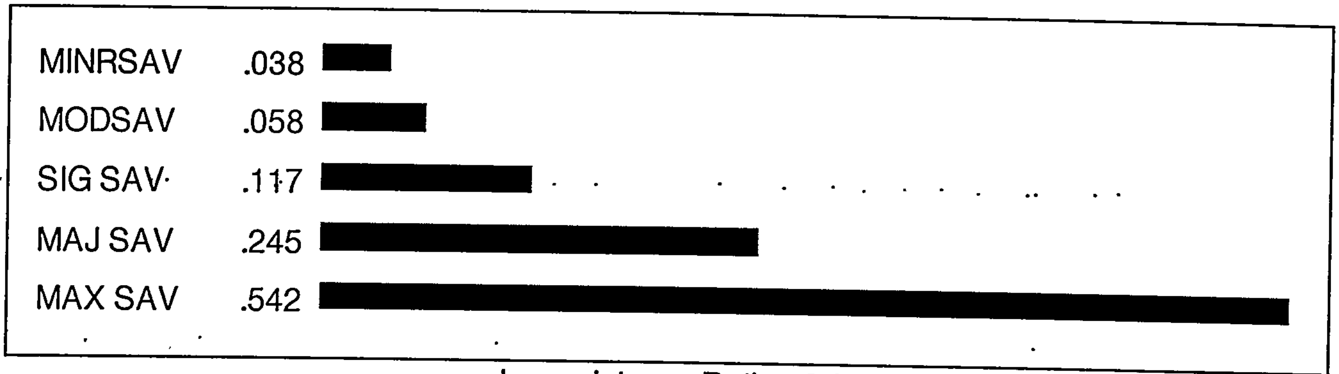
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.06

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| ECON.AD | Potential for savings |
| IMP COST | Cost to implement |
| OPSONLY | Operating costs Only |
| MINORCAP | Minor Capital (<$10M) required |
| SIGCAP | Capital cost ($10M<X<$100M) |
| MAJCAP | Greater than $100M Capital required |

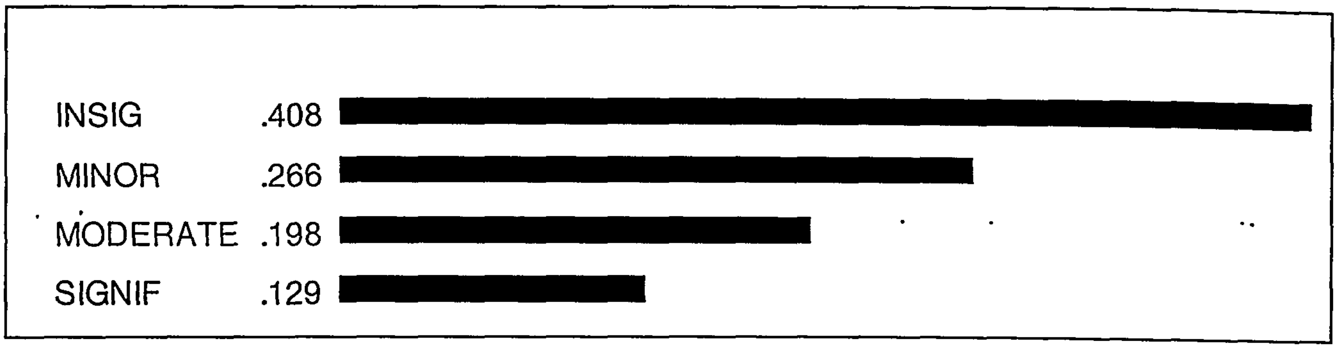
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.08

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| ECON.AD | Potential for savings |
| SAVINGS | Potential savings of using M&D |
| MINRSAV | <$10M savings |
| MODSAV | Savings $10M<X<$50M |
| SIG SAV | Savings $50M<X<$100M |
| MAJ SAV | Savings $100M<X<$500M |
| MAX SAV | >$500M savings |

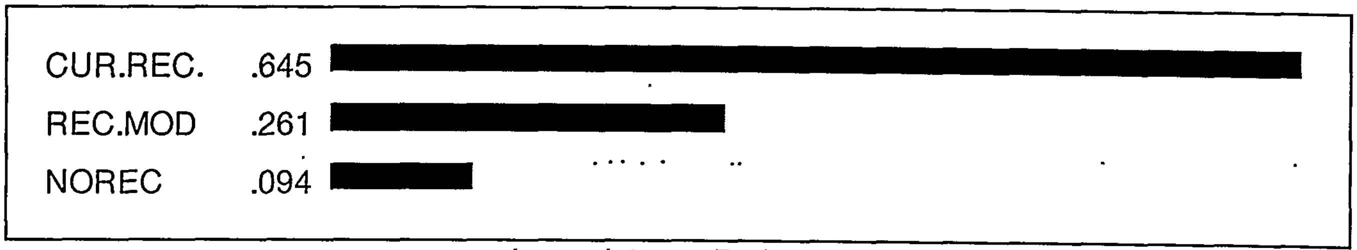
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.04

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| ECON.AD | Potential for savings |
| QUANTITY | Quantity of material to be processed (months) |
| INSIG | <1Month processing |
| MINOR | Process Time = 1Month <X< 6 Months |
| MODERATE | Processing Time 6 Months<X<12 Months |
| SIGNIF | Greater than 12 Months processing required |

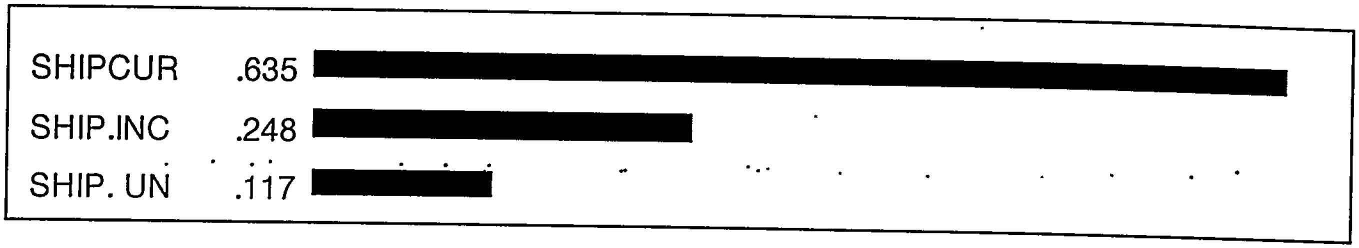
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.06

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| TRNSPRT | Ability to ship and receive |
| RECEIVNG | Ability to receive material |
| CUR.REC. | Receiving capability current |
| REC.MOD | Receiving requires mods |
| NOREC | No Receiving capability |

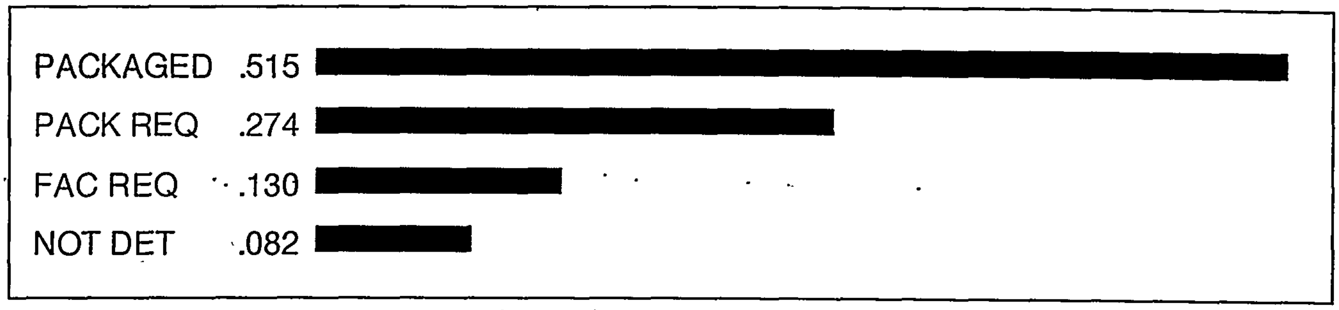
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.01

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| TRNSPRT | Ability to ship and receive |
| SHIPPING | Ability to ship out material |
| SHIPCUR | Shipping currently available (including cont.&certs) |
| SHIP.INC | Shipping incomplete--needs containers or certs |
| SHIP.. UN | Neither containers nor certificantions available |

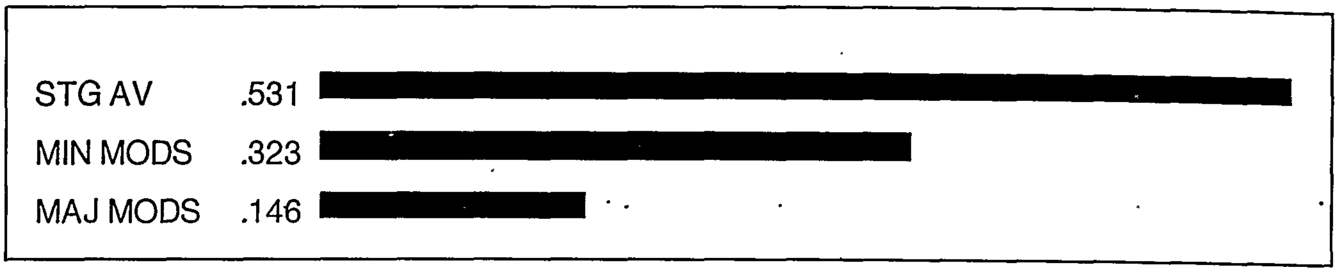
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.04

| Abbreviation | Definition |
| --- | --- |
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| TRNSPRT | Ability to ship and receive |
| PCKGING | Shipping prepations required. |
| PACKAGED | Material is packaged for shipping |
| PACK REQ | Packaging is required |
| FAC REQ | Packaging facilities required |
| NOT DET | Packaging requirements not determined |

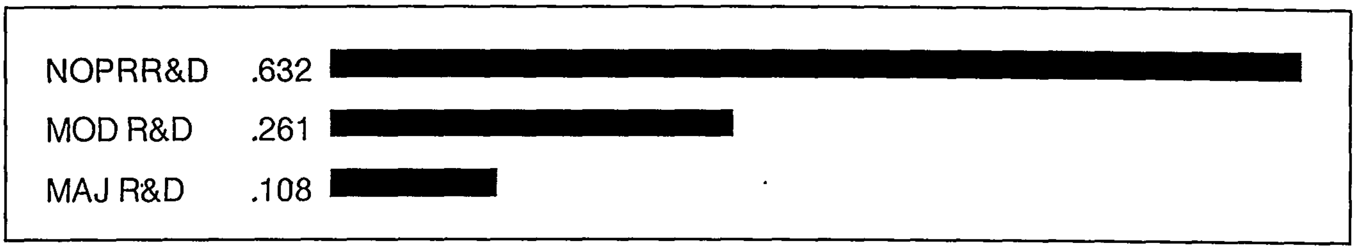
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.04

| Abbreviation | Definition |
| --- | --- |
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| TRNSPRT | Ability to ship and receive |
| STORAGE | Material storage availability |
| STG AV | Storage currently available with adequate capacity |
| MIN MODS | Minor new storage (minor mods or schedule mgmt) |
| MAJ MODS | Major new storage required |

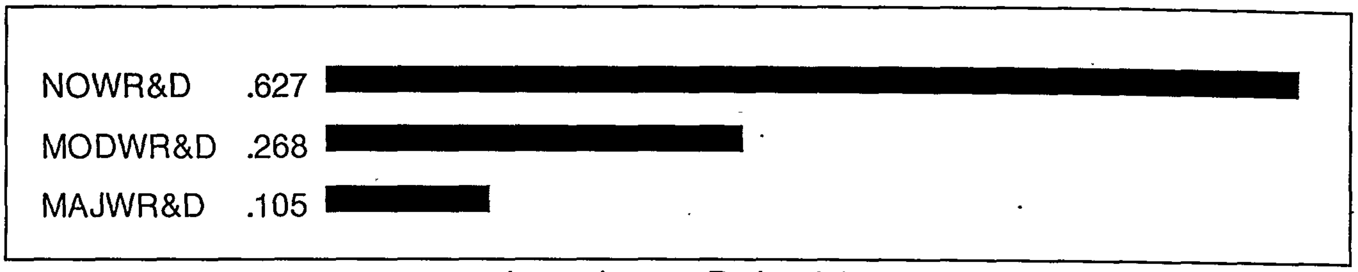
## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.03

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| TECH DEV | Technology Development Required |
| PROCNG | Additional process R&D required. |
| NOPRR&D | No Processing R&D required (in scope of current pgm) |
| MOD R&D | Moderate Process R&D required |
| MAJ R&D | Major process R&D required |

## *Develop a ratings for attractiveness for using melt and dilute*




Inconsistency Ratio =0.08

| Abbreviation | Definition |
|---|---|
| Goal | Develop a ratings for attractiveness for using melt and dilute |
| TECH DEV | Technology Development Required |
| WASTE FM | Additional waste form R&D required. |
| NOWR&D | No additional Waste Form R&D Required |
| MODWR&D | Moderate Waste form R&D required |
| MAJWR&D | Major Waste form R&D required, New |

# APPENDIX D

# MATERIALS RATINGS

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E:\MELT_D~1\ECPROS~1\M&DCAN1

| | Alternatives | TOTAL | PROCESS TEMP .0352 | OFFGAS .0391 | ALLOY .0248 | FEED .0655 | MAT COMP .0417 | PRETREAT .0305 |
|---|---|---|---|---|---|---|---|---|
| 1 | SRS DU discardable material | 0.857 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | NO-P |
| 2 | SRS DU Samples & Standards | 0.857 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | NO-P |
| 3 | Pu/EU metal | 0.821 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | NO-P |
| 4 | SRS M Area U metal LEU | 0.820 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | NO-P |
| 5 | SRS DU lab solutions | 0.797 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | MIN-P |
| 6 | SRS Recovered oxides LEU | 0.799 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | NO-P |
| 7 | FMPC Misc DU metal (oxidation) | 0.799 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | NO-P |
| 8 | Standards, Mound plates, PNNL Plates, HEU | 0.798 | 850C | ONEHEPA | COMPAT | WELLCHAR | CURRENT | NO-P |
| 9 | SRS DU Oxides | 0.769 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | NO-P |
| 10 | SRS EBR-II (DU) | 0.764 | 850C | M&DSYS | COMPAT | WELLCHAR | CURRENT | NO-P |
| 11 | Al-clad U metal SNF | 0.764 | 850C | M&DSYS | COMPAT | WELLCHAR | CURRENT | NO-P |
| 12 | Pu-238 scrap | 0.769 | 850C | ONEHEPA | MARG DEP | WELLCHAR | CURRENT | NO-P |
| 13 | FMPC DU historical materials | 0.767 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | MIN-P |
| 14 | SRS Bare DU metal | 0.757 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | NO-P |
| 15 | SRS Canned DU metal | 0.757 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | NO-P |
| 16 | Al Matrix SNF | 0.747 | 850C | M&DSYS | COMPAT | WELLCHAR | CURRENT | NO-P |
| 17 | FMPC Misc Metal(oxidation) | 0.744 | 850C | NO-P | COMPAT | PROC KNO | CURRENT | NO-P |
| 18 | SRS NU inactive samples | 0.725 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | MIN-P |
| 19 | Mk 18s | 0.740 | 850C | M&DSYS | COMPAT | WELLCHAR | CURRENT | NO-P |
| 20 | HEU-Tubes and Assemblies (Mk-22s) | 0.755 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | MIN-P |
| 21 | FMPC Scrap DU oxide pellets | 0.716 | 850C | NO-P | COMPAT | PROC KNO | CURRENT | MIN-P |
| 22 | HEU ORNL off spec metal | 0.734 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | NO-P |
| 23 | SRS BARE NU Metal | 0.732 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | NO-P |
| 24 | Metal and Alloy | 0.724 | 850C | ONEHEPA | COMPAT | WELLCHAR | GRAPHITE | NO-P |
| 25 | SRS DU/Al powder castings | 0.709 | 850C | NO-P | COMPAT | PROC KNO | CURRENT | MIN-P |
| 26 | U-233 (canned oxide) | 0.724 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | NO-P |
| 27 | SRS DU Solutions | 0.707 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | SIG-P |
| 28 | Pu Misc. Compounds | 0.704 | 850C | ONEHEPA | COMPAT | PROC KNO | CURRENT | MIN-P |
| 29 | SRS NU Discardable Material | 0.713 | 850C | NO-P | COMPAT | MAT DES | CURRENT | NO-P |
| 30 | HEU Ingots and Billets | 0.719 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | NO-P |
| 31 | Pu Oxide Powder | 0.673 | 850C | ONEHEPA | MARG DEP | WELLCHAR | GRAPHITE | MIN-P |
| 32 | FMPC Misc Metal Recovery? | 0.688 | 850C | NO-P | MARG DEP | PROC KNO | CURRENT | MIN-P |
| 33 | HEU Idaho oxide | 0.694 | 850C | ONEHEPA | MARG DEP | WELLCHAR | CURRENT | NO-P |
| 34 | FMPC DU Rockwell spills | 0.686 | 850C | NO-P | COMPAT | PROC KNO | CURRENT | NO-P |
| 35 | Pu Samples/Stds | 0.671 | 850C | ONEHEPA | MARG DEP | WELLCHAR | CURRENT | MIN-P |
| 36 | Pu/U oxide | 0.653 | 850C | ONEHEPA | MARG DEP | WELLCHAR | GRAPHITE | MIN-P |
| 37 | FMPC Misc DU metal (dissolution) | 0.675 | 850C | NO-P | COMPAT | PROC KNO | CURRENT | NO-P |

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| | Alternatives | TOTAL | PROCESS TEMP .0352 | OFFGAS .0391 | ALLOY .0248 | FEED .0655 | MAT COMP .0417 | PRETREAT .0305 |
|---|---|---|---|---|---|---|---|---|
| 38 | Pu scrap misc | 0.644 | 850C | ONEHEPA | MARG DEP | WELLCHAR | GRAPHITE | MIN-P |
| 39 | HEU Hanford | 0.663 | 850C | NO-P | COMPAT | WELLCHAR | CURRENT | NO-P |
| 40 | ZPPR plates | 0.629 | 850C | ONEHEPA | SIG DEP | WELLCHAR | CURRENT | MIN-P |
| 41 | Pu Mixed Oxide Slugs | 0.644 | 850C | ONEHEPA | MARG DEP | WELLCHAR | GRAPHITE | MIN-P |
| 42 | U-233/SNF | 0.647 | 850C | M&DSYS | COMPAT | WELLCHAR | CURRENT | NO-P |
| 43 | Pu Ash | 0.642 | 850C | ONEHEPA | MARG DEP | MAT DES | CURRENT | MIN-P |
| 44 | Cm 244 solution | 0.646 | 850C | ONEHEPA | MARG DEP | MAT DES | CURRENT | NO-P |
| 45 | Am 243 oxide | 0.646 | 850C | ONEHEPA | MARG DEP | MAT DES | CURRENT | NO-P |
| 46 | Am 241 samples/stds | 0.646 | 850C | ONEHEPA | MARG DEP | MAT DES | CURRENT | NO-P |
| 47 | U/Pu/Zr Casting Scrap | 0.620 | 1200C | ONEHEPA | MARG DEP | PROC KNO | GRAPHITE | MIN-P |
| 48 | FMPC Rockwell spills LEU | 0.592 | 850C | NO-P | MARG DEP | PROC KNO | CURRENT | MIN-P |
| 49 | FMPC Misc LEU Metal(dissolution) | 0.592 | 850C | NO-P | MARG DEP | PROC KNO | CURRENT | MIN-P |
| 50 | HEU SRS Solutions | 0.581 | 850C | ONEHEPA | COMPAT | WELLCHAR | CURRENT | SIG-P |
| 51 | SRS NU (Pu) Scrap | 0.574 | 850C | ONEHEPA | MARG DEP | PROC KNO | CURRENT | NO-P |
| 52 | Pu Chlorides, flourides etc | 0.566 | 850C | ONEHEPA | MARG DEP | MAT DES | GRAPHITE | SIG-P |
| 53 | Pu Combustibles | 0.552 | 850C | ONEHEPA | COMPAT | MAT DES | CURRENT | SIG-P |
| 54 | SRS DU Sludge and Filter Cake | 0.565 | 850C | ONEHEPA | MARG DEP | MAT DES | CURRENT | MIN-P |
| 55 | SRS DU SS/Zr fuel/targets | 0.539 | 1200C | M&DSYS | SIG DEP | WELLCHAR | GRAPHITE | MIN-P |
| 56 | SRS Pu/DU Oxide fuel rods | 0.539 | 1200C | M&DSYS | SIG DEP | WELLCHAR | GRAPHITE | MIN-P |
| 57 | Np 237 scrap | 0.517 | 850C | ONEHEPA | MARG DEP | WELLCHAR | CURRENT | SIG-P |
| 58 | SRS Pu/DU scrap | 0.489 | 1200C | M&DSYS | SIG DEP | MAT DES | GRAPHITE | MIN-P |
| 59 | FMPC DU Nonburnable metal | 0.471 | 1200C | M&DSYS | SIG DEP | MAT DES | GRAPHITE | MIN-P |
| 60 | Pu-239 Pits | 0.457 | 850C | ONEHEPA | COMPAT | WELLCHAR | GRAPHITE | SIG-P |
| 61 | FMPC DU lead contaminated | 0.410 | 850C | M&DSYS | SIG DEP | MAT DES | CURRENT | MIN-P |
| 62 | Metal U-Zr SNF | 0.338 | 1200C | SAND | SIG DEP | WELLCHAR | GRAPHITE | SIG-P |
| 63 | Metal(U,U-Mo)/Na SNF | 0.338 | 1200C | SAND | SIG DEP | WELLCHAR | GRAPHITE | SIG-P |
| 64 | Oxide-Research SNF | 0.310 | 1400C | SAND | MARG DEP | WELLCHAR | GRAPHITE | SIG-P |
| 65 | Oxide-Commercial SNF | 0.305 | 1400C | SAND | MARG DEP | WELLCHAR | GRAPHITE | SIG-P |
| 66 | Oxide Disrupted TMI SNF | 0.270 | 1200C | SAND | MARG DEP | MAT DES | GRAPHITE | SIG-P |
| 67 | Oxide, U/Th SNF | 0.000 | | | | | | |
| 68 | FMPC Chips in concrete LEU | 0.000 | | | | | | |
| 69 | SRS Vitrified waste LEU | 0.000 | | | | | | |
| 70 | FMPC DU chips in concrete | 0.000 | | | | | | |
| 71 | Graphite SNF | 0.000 | | | | | | |
| 72 | Misc Other SNF | 0.000 | | | | | | |
| 73 | Misc Other (failed) | 0.000 | | | | | | |
| 74 | Irradiated Reactor Parts | 0.000 | | | | | | |

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| | Alternatives | TOTAL | PROCESS - TEMP .0352 | OFFGAS .0391 | ALLOY .0248 | FEED .0655 | MAT COMP .0417 | PRETREAT .0305 |
|---|---|---|---|---|---|---|---|---|
| 75 | FMPC LEU Chips in concrete | 0.000 | | | | | | |
| 76 | | | | | | | | |

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| | Alternatives | TOTAL | DISPOSIT-PATH AVL .0656 | ATTRACTV 1378 | ECON.AD - IMP.COST 1085 | SAVINGS 1539 | QUANTITY .0622 | TRNSPRT RECEIVNG .0361 |
|---|---|---|---|---|---|---|---|---|
| 1 | SRS DU discardable material | 0.857 | UNDEF | SIMILAR | OPSONLY | MINRSAV | INSIG | CUR.REC. |
| 2 | SRS DU Samples & Standards | 0.857 | UNDEF | SIMILAR | OPSONLY | MINRSAV | INSIG | CUR.REC. |
| 3 | Pu/EU metal | 0.821 | PROPOSED | SIM-MOD | OPSONLY | MAX SAV | MODERATE | REC.MOD |
| 4 | SRS M Area U metal LEU | 0.820 | PROPOSED | SIMILAR | OPSONLY | MINRSAV | INSIG | CUR.REC. |
| 5 | SRS DU lab solutions | 0.797 | UNDEF | SIMILAR | OPSONLY | MINRSAV | INSIG | CUR.REC. |
| 6 | SRS Recovered oxides LEU | 0.799 | DEFINED | SIMILAR | OPSONLY | MINRSAV | INSIG | CUR.REC. |
| 7 | FMPC Misc DU metal (oxidation) | 0.799 | DEFINED | SIMILAR | OPSONLY | MINRSAV | INSIG | CUR.REC. |
| 8 | Standards, Mound plates, PNNL Plates, HEU | 0.798 | PROPOSED | SIMILAR | OPSONLY | MINRSAV | INSIG | CUR.REC. |
| 9 | SRS DU Oxides | 0.769 | UNDEF | SIMILAR | OPSONLY | MINRSAV | SIGNIF | CUR.REC. |
| 10 | SRS EBR-II (DU) | 0.764 | PROPOSED | SIMILAR | OPSONLY | MODSAV | MODERATE | CUR.REC. |
| 11 | Al-clad U metal SNF | 0.764 | PROPOSED | SIMILAR | OPSONLY | MODSAV | MODERATE | CUR.REC. |
| 12 | Pu-238 scrap | 0.769 | UNDEF | SIMILAR | OPSONLY | MINRSAV | INSIG | REC.MOD |
| 13 | FMPC DU historical materials | 0.767 | UNDEF | SIMILAR | OPSONLY | MINRSAV | INSIG | CUR.REC. |
| 14 | SRS Bare DU metal | 0.757 | DEFINED | SIMILAR | OPSONLY | MINRSAV | SIGNIF | CUR.REC. |
| 15 | SRS Canned DU metal | 0.757 | DEFINED | SIMILAR | OPSONLY | MINRSAV | SIGNIF | CUR.REC. |
| 16 | Al Matrix SNF | 0.747 | PROPOSED | SIMILAR | OPSONLY | MINRSAV | SIGNIF | CUR.REC. |
| 17 | FMPC Misc Metal(oxidation) | 0.744 | PROPOSED | SIMILAR | OPSONLY | MINRSAV | INSIG | REC.MOD |
| 18 | SRS NU inactive samples | 0.725 | DEFINED | SIMILAR | OPSONLY | MINRSAV | INSIG | CUR.REC. |
| 19 | Mk 18s | 0.740 | PROPOSED | SIMILAR | OPSONLY | MODSAV | INSIG | REC.MOD |
| 20 | HEU-Tubes and Assemblies (Mk-22s) | 0.755 | PROPOSED | SIMILAR | OPSONLY | SIG.SAV | SIGNIF | CUR.REC. |
| 21 | FMPC Scrap DU oxide pellets | 0.716 | DEFINED | SIMILAR | OPSONLY | MODSAV | INSIG | CUR.REC. |
| 22 | HEU ORNL off spec metal | 0.734 | DEFINED | SIMILAR | OPSONLY | MINRSAV | SIGNIF | CUR.REC. |
| 23 | SRS BARE NU Metal | 0.732 | PROPOSED | SIMILAR | OPSONLY | MINRSAV | MODERATE | REC.MOD |
| 24 | Metal and Alloy | 0.724 | PROPOSED | SIM-MOD | MINORCAP | MAX.SAV | SIGNIF | REC.MOD |
| 25 | SRS DU/Al powder castings | 0.709 | PROPOSED | SIMILAR | OPSONLY | MINRSAV | MINOR | CUR.REC. |
| 26 | U-233 (canned oxide) | 0.724 | PROPOSED | SIMILAR | OPSONLY | MINRSAV | MODERATE | REC.MOD |
| 27 | SRS DU Solutions | 0.707 | PROPOSED | SIMILAR | OPSONLY | MINRSAV | SIGNIF | CUR.REC. |
| 28 | Pu Misc. Compounds | 0.704 | UNDEF | SIM-MOD | MINORCAP | MAX SAV | MODERATE | REC.MOD |
| 29 | SRS NU Discardable Material | 0.713 | PROPOSED | SIMILAR | OPSONLY | MINRSAV | INSIG | REC.MOD |
| 30 | HEU Ingots and Billets | 0.719 | AVAILABL | SIMILAR | OPSONLY | MINRSAV | SIGNIF | CUR.REC. |
| 31 | Pu Oxide Powder | 0.673 | PROPOSED | SIM-MOD | MINORCAP | MAX SAV | MINOR | REC.MOD |
| 32 | FMPC Misc Metal Recovery? | 0.688 | PROPOSED | SIMILAR | OPSONLY | MINRSAV | MINOR | REC.MOD |
| 33 | HEU Idaho oxide | 0.694 | UNDEF | SIMILAR | OPSONLY | MODSAV | MODERATE | REC.MOD |
| 34 | FMPC DU Rockwell spills | 0.686 | UNDEF | SIMILAR | OPSONLY | MINRSAV | MINOR | REC.MOD |
| 35 | Pu Samples/Stds | 0.671 | PROPOSED | SIM-MOD | OPSONLY | MINRSAV | INSIG | REC.MOD |
| 36 | Pu/U oxide | 0.653 | PROPOSED | SIM-MOD | MINORCAP | MAX SAV | SIGNIF | REC.MOD |
| 37 | FMPC Misc DU metal (dissolution) | 0.675 | UNDEF | SIMILAR | OPSONLY | MINRSAV | MODERATE | REC.MOD |

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| | Alternatives | TOTAL | DISPOSIT-PATH AVL .0656 | ATTRACTV .1378 | ECON.AD - IMP.COST .1085 | SAVINGS .1539 | QUANTITY .0622 | TRNSPRT RECEIVNG .0361 |
|---|---|---|---|---|---|---|---|---|
| 38 | Pu scrap misc | 0.644 | PROPOSED | SIM-MOD | MINORCAP | MAX SAV | SIGNIF | REC.MOD |
| 39 | HEU Hanford | 0.663 | PROPOSED | SIMILAR | OPSONLY | MODSAV | MODERATE | REC.MOD |
| 40 | ZPPR plates | 0.629 | PROPOSED | SIM-MOD | SIGCAP | MAX SAV | SIGNIF | REC.MOD |
| 41 | Pu Mixed Oxide Slugs | 0.644 | PROPOSED | SIM-MOD | MINORCAP | MAX SAV | MINOR | REC.MOD |
| 42 | U-233/SNF | 0.647 | PROPOSED | SIMILAR | OPSONLY | MINRSAV | MINOR | REC.MOD |
| 43 | Pu Ash | 0.642 | UNDEF | SIM-MOD | MINORCAP | MAX SAV | INSIG | REC.MOD |
| 44 | Cm 244 solution | 0.646 | UNDEF | SIM-MOD | OPSONLY | MINRSAV | INSIG | CUR.REC. |
| 45 | Am 243 oxide | 0.646 | UNDEF | SIM-MOD | OPSONLY | MINRSAV | INSIG | CUR.REC. |
| 46 | Am 241 samples/stds | 0.646 | UNDEF | SIM-MOD | OPSONLY | MINRSAV | INSIG | CUR.REC. |
| 47 | U/Pu/Zr Casting Scrap | 0.620 | UNDEF | SIM-MOD | MINORCAP | MAX SAV | MODERATE | REC.MOD |
| 48 | FMPC Rockwell spills LEU | 0.592 | PROPOSED | SIMILAR | MINORCAP | MINRSAV | INSIG | REC.MOD |
| 49 | FMPC Misc LEU Metal(dissolution) | 0.592 | PROPOSED | SIMILAR | MINORCAP | MINRSAV | INSIG | REC.MOD |
| 50 | HEU SRS Solutions | 0.581 | PROPOSED | SIMILAR | SIGCAP | MODSAV | SIGNIF | CUR.REC. |
| 51 | SRS NU (Pu) Scrap | 0.574 | PROPOSED | SIM-MOD | OPSONLY | MINRSAV | INSIG | REC.MOD |
| 52 | Pu Chlorides, flourides etc | 0.566 | UNDEF | SIM-MOD | SIGCAP | MAX SAV | MINOR | REC.MOD |
| 53 | Pu Combustibles | 0.552 | UNDEF | SIM-MOD | MINORCAP | SIG SAV | MODERATE | REC.MOD |
| 54 | SRS DU Sludge and Filter Cake | 0.565 | UNDEF | SIM-MOD | MINORCAP | MINRSAV | MINOR | CUR.REC. |
| 55 | SRS DU SS/Zr fuel/targets | 0.539 | PROPOSED | SIM-MOD | MINORCAP | MINRSAV | INSIG | CUR.REC. |
| 56 | SRS Pu/DU Oxide fuel rods | 0.539 | PROPOSED | SIM-MOD | MINORCAP | MINRSAV | INSIG | CUR.REC. |
| 57 | Np 237 scrap | 0.517 | UNDEF | SIM-MOD | MINORCAP | MINRSAV | MODERATE | REC.MOD |
| 58 | SRS Pu/DU scrap | 0.489 | PROPOSED | SIM-MOD | MINORCAP | MINRSAV | INSIG | CUR.REC. |
| 59 | FMPC DU Nonburnable metal | 0.471 | UNDEF | SIM-MOD | MINORCAP | MINRSAV | INSIG | REC.MOD |
| 60 | Pu-239 Pits | 0.457 | PROPOSED | SIM-MOD | MINORCAP | MODSAV | SIGNIF | NOREC |
| 61 | FMPC DU lead contaminated | 0.410 | UNDEF | SIG EFF | MINORCAP | MINRSAV | MINOR | REC.MOD |
| 62 | Metal U-Zr SNF | 0.338 | PROPOSED | SIM-MOD | SIGCAP | MINRSAV | MODERATE | NOREC |
| 63 | Metal(U,U-Mo)/Na SNF | 0.338 | PROPOSED | SIM-MOD | SIGCAP | MINRSAV | MODERATE | NOREC |
| 64 | Oxide-Research SNF | 0.310 | PROPOSED | SIM-MOD | MAJCAP | MINRSAV | SIGNIF | NOREC |
| 65 | Oxide-Commercial SNF | 0.305 | DEFINED | SIM-MOD | SIGCAP | MINRSAV | SIGNIF | NOREC |
| 66 | Oxide Disrupted TMI SNF | 0.270 | PROPOSED | SIM-MOD | MAJCAP | MINRSAV | SIGNIF | NOREC |
| 67 | Oxide, U/Th SNF | 0.000 | | | | | | |
| 68 | FMPC Chips in concrete LEU | 0.000 | | | | | | |
| 69 | SRS Vitrified waste LEU | 0.000 | | | | | | |
| 70 | FMPC DU chips in concrete | 0.000 | | | | | | |
| 71 | Graphite SNF | 0.000 | | | | | | |
| 72 | Misc Other SNF | 0.000 | | | | | | |
| 73 | Misc Other (failed) | 0.000 | | | | | | |
| 74 | Irradiated Reactor Parts | 0.000 | | | | | | |

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| | Alternatives | TOTAL | DISPOSIT-PATH-AVL .0656 | ATTRACTV .1378 | ECON AD - IMP COST .1085 | SAVINGS .1539 | QUANTITY .0622 | TRNSPRT - RECEIVNG .0361 |
|---|---|---|---|---|---|---|---|---|
| 75 | FMPC LEU Chips in concrete | 0.000 | | | | | | |
| 76 | | | | | | | | |

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| | Alternatives | TOTAL | SHIPPING .0184 | PCKGING .0302 | STORAGE .0228 | TECH DEV PROCNG .0768 | WASTE FM .0512 |
|---|---|---|---|---|---|---|---|
| 1 | SRS DU discardable material | 0.857 | SHIPCUR | PACKAGED | STG AV | NOPRR&D | NOWR&D |
| 2 | SRS DU Samples & Standards | 0.857 | SHIPCUR | PACKAGED | STG AV | NOPRR&D | NOWR&D |
| 3 | Pu/EU metal | 0.821 | SHIP.INC | PACK REQ | MIN MODS | NOPRR&D | NOWR&D |
| 4 | SRS M Area U metal LEU | 0.820 | SHIPCUR | PACKAGED | STG AV | NOPRR&D | NOWR&D |
| 5 | SRS DU lab solutions | 0.797 | SHIPCUR | PACKAGED | STG AV | MOD R&D | NOWR&D |
| 6 | SRS Recovered oxides LEU | 0.799 | SHIPCUR | PACKAGED | STG AV | NOPRR&D | NOWR&D |
| 7 | FMPC Misc DU metal (oxidation) | 0.799 | SHIPCUR | PACKAGED | STG AV | NOPRR&D | NOWR&D |
| 8 | Standards, Mound plates, PNNL Plates, HEU | 0.798 | SHIPCUR | PACKAGED | STG AV | NOPRR&D | NOWR&D |
| 9 | SRS DU Oxides | 0.769 | SHIPCUR | PACKAGED | STG AV | MOD R&D | NOWR&D |
| 10 | SRS EBR-II (DU) | 0.764 | SHIPCUR | PACKAGED | STG AV | NOPRR&D | NOWR&D |
| 11 | Al-clad U metal SNF | 0.764 | SHIPCUR | PACKAGED | STG AV | NOPRR&D | NOWR&D |
| 12 | Pu-238 scrap | 0.769 | SHIP.INC | PACK REQ | MIN MODS | NOPRR&D | NOWR&D |
| 13 | FMPC DU historical materials | 0.767 | SHIPCUR | PACKAGED | STG AV | MOD R&D | MODWR&D |
| 14 | SRS Bare DU metal | 0.757 | SHIPCUR | PACKAGED | STG AV | NOPRR&D | NOWR&D |
| 15 | SRS Canned DU metal | 0.757 | SHIPCUR | PACKAGED | STG AV | NOPRR&D | NOWR&D |
| 16 | Al Matrix SNF | 0.747 | SHIPCUR | PACKAGED | STG AV | NOPRR&D | NOWR&D |
| 17 | FMPC Misc Metal(oxidation) | 0.744 | SHIP.INC | PACK REQ | STG AV | NOPRR&D | NOWR&D |
| 18 | SRS NU inactive samples | 0.725 | SHIPCUR | PACK REQ | STG AV | MOD R&D | NOWR&D |
| 19 | Mk 18s | 0.740 | SHIP.INC | PACK REQ | MIN MODS | NOPRR&D | NOWR&D |
| 20 | HEU-Tubes and Assemblies (Mk-22s) | 0.755 | SHIPCUR | PACKAGED | STG AV | NOPRR&D | MODWR&D |
| 21 | FMPC Scrap DU oxide pellets | 0.716 | SHIPCUR | PACKAGED | STG AV | MOD R&D | NOWR&D |
| 22 | HEU ORNL off spec metal | 0.734 | SHIPCUR | PACK REQ | MIN MODS | NOPRR&D | NOWR&D |
| 23 | SRS BARE NU Metal | 0.732 | SHIP.INC | PACK REQ | MIN MODS | NOPRR&D | NOWR&D |
| 24 | Metal and Alloy | 0.724 | SHIP.INC | PACK REQ | MIN MODS | NOPRR&D | NOWR&D |
| 25 | SRS DU/Al powder castings | 0.709 | SHIPCUR | PACKAGED | STG AV | MOD R&D | NOWR&D |
| 26 | U-233 (canned oxide) | 0.724 | SHIP.INC | PACK REQ | MAJ MODS | NOPRR&D | NOWR&D |
| 27 | SRS DU Solutions | 0.707 | SHIPCUR | PACKAGED | STG AV | MOD R&D | NOWR&D |
| 28 | Pu Misc. Compounds | 0.704 | SHIP.INC | PACK REQ | MIN MODS | MOD R&D | NOWR&D |
| 29 | SRS NU Discardable Material | 0.713 | SHIP.INC | PACK REQ | MIN MODS | NOPRR&D | NOWR&D |
| 30 | HEU Ingots and Billets | 0.719 | SHIPCUR | PACK REQ | STG AV | NOPRR&D | MODWR&D |
| 31 | Pu Oxide Powder | 0.673 | SHIP.INC | PACK REQ | MIN MODS | MOD R&D | NOWR&D |
| 32 | FMPC Misc Metal Recovery? | 0.688 | SHIP.INC | PACK REQ | MIN MODS | NOPRR&D | NOWR&D |
| 33 | HEU Idaho oxide | 0.694 | SHIPCUR | PACKAGED | MIN MODS | MOD R&D | MODWR&D |
| 34 | FMPC DU Rockwell spills | 0.686 | SHIP.INC | PACK REQ | STG AV | MOD R&D | MODWR&D |
| 35 | Pu Samples/Stds | 0.671 | SHIP.INC | PACK REQ | STG AV | NOPRR&D | NOWR&D |
| 36 | Pu/U oxide | 0.653 | SHIP.INC | PACK REQ | MIN MODS | MOD R&D | NOWR&D |
| 37 | FMPC Misc DU metal (dissolution) | 0.675 | SHIP.INC | PACK REQ | STG AV | MOD R&D | MODWR&D |

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| | Alternatives | TOTAL | SHIPPING .0184 | PCKGING .0302 | STORAGE .0228 | TECH DEV PROCNG .0768 | WASTE FM .0512 |
|---|---|---|---|---|---|---|---|
| 38 | Pu scrap misc | 0.644 | SHIP.INC | FAC REQ | MIN MODS | MOD R&D | NOWR&D |
| 39 | HEU Hanford | 0.663 | SHIP.INC | PACK REQ | MIN MODS | MOD R&D | MODWR&D |
| 40 | ZPPR plates | 0.629 | SHIP.INC | PACK REQ | MIN MODS | MOD R&D | NOWR&D |
| 41 | Pu Mixed Oxide Slugs | 0.644 | SHIP.INC | PACK REQ | MIN MODS | MOD R&D | MODWR&D |
| 42 | U-233/SNF | 0.647 | SHIP.INC | PACK REQ | STG AV | MOD R&D | MODWR&D |
| 43 | Pu Ash | 0.642 | SHIP.INC | PACK REQ | MIN MODS | MAJ R&D | MAJWR&D |
| 44 | Cm 244 solution | 0.646 | SHIPCUR | PACKAGED | STG AV | MOD R&D | MODWR&D |
| 45 | Am 243 oxide | 0.646 | SHIPCUR | PACKAGED | STG AV | MOD R&D | MODWR&D |
| 46 | Am 241 samples/stds | 0.646 | SHIPCUR | PACKAGED | STG AV | MOD R&D | MODWR&D |
| 47 | U/Pu/Zr Casting Scrap | 0.620 | SHIP.INC | PACK REQ | MIN MODS | MOD R&D | MODWR&D |
| 48 | FMPC Rockwell spills LEU | 0.592 | SHIP.INC | PACK REQ | MIN MODS | MOD R&D | MODWR&D |
| 49 | FMPC Misc LEU Metal(dissolution) | 0.592 | SHIP.INC | PACK REQ | MIN MODS | MOD R&D | MODWR&D |
| 50 | HEU SRS Solutions | 0.581 | SHIPCUR | PACKAGED | STG AV | MOD R&D | MODWR&D |
| 51 | SRS NU (Pu) Scrap | 0.574 | SHIP.INC | PACK REQ | MIN MODS | MOD R&D | MODWR&D |
| 52 | Pu Chlorides, flourides etc | 0.566 | SHIP.INC | PACK REQ | MIN MODS | MAJ R&D | MODWR&D |
| 53 | Pu Combustibles | 0.552 | SHIP.INC | PACK REQ | MIN MODS | MOD R&D | NOWR&D |
| 54 | SRS DU Sludge and Filter Cake | 0.565 | SHIPCUR | PACKAGED | STG AV | MOD R&D | MODWR&D |
| 55 | SRS DU SS/Zr fuel/targets | 0.539 | SHIPCUR | PACKAGED | STG AV | MOD R&D | MODWR&D |
| 56 | SRS Pu/DU Oxide fuel rods | 0.539 | SHIPCUR | PACKAGED | STG AV | MOD R&D | MODWR&D |
| 57 | Np 237 scrap | 0.517 | SHIP.INC | PACK REQ | STG AV | MAJ R&D | MAJWR&D |
| 58 | SRS Pu/DU scrap | 0.489 | SHIPCUR | PACKAGED | STG AV | MOD R&D | MODWR&D |
| 59 | FMPC DU Nonburnable metal | 0.471 | SHIP.INC | PACK REQ | MIN MODS | MOD R&D | MODWR&D |
| 60 | Pu-239 Pits | 0.457 | SHIP. UN | FAC REQ | MAJ MODS | MOD R&D | MODWR&D |
| 61 | FMPC DU lead contaminated | 0.410 | SHIP.INC | PACK REQ | STG AV | MAJ R&D | MAJWR&D |
| 62 | Metal U-Zr SNF | 0.338 | SHIP. UN | FAC REQ | MAJ MODS | MAJ R&D | MAJWR&D |
| 63 | Metal(U,U-Mo)/Na SNF | 0.338 | SHIP. UN | FAC REQ | MAJ MODS | MAJ R&D | MAJWR&D |
| 64 | Oxide-Research SNF | 0.310 | SHIP. UN | NOT DET | MAJ MODS | MAJ R&D | MAJWR&D |
| 65 | Oxide-Commercial SNF | 0.305 | SHIP. UN | NOT DET | MAJ MODS | MAJ R&D | MAJWR&D |
| 66 | Oxide Disrupted TMI SNF | 0.270 | SHIP. UN | FAC REQ | MAJ MODS | MAJ R&D | MAJWR&D |
| 67 | Oxide, U/Th SNF | 0.000 | | | | | |
| 68 | FMPC Chips in concrete LEU | 0.000 | | | | | |
| 69 | SRS Vitrified waste LEU | 0.000 | | | | | |
| 70 | FMPC DU chips in concrete | 0.000 | | | | | |
| 71 | Graphite SNF | 0.000 | | | | | |
| 72 | Misc Other SNF | 0.000 | | | | | |
| 73 | Misc Other (failed) | 0.000 | | | | | |
| 74 | Irradiated Reactor Parts | 0.000 | | | | | |

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| | Alternatives | TOTAL | SHIPPING .0184 | PCKGING .0302 | STORAGE .0228 | TECH DEV-PROCNG .0768 | WASTE FM .0512 |
|---|---|---|---|---|---|---|---|
| 75 | FMPC LEU Chips in concrete | 0.000 | | | | | |
| 76 | | | | | | | |

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