LA-UR- 98-439

Title: MIXED WASTE FOCUS AREA - WASTE FORM INITIATIVE

CONF-980307--

Author(s): R. Nakaoka, LANL,
R. Waters and P. Pohl, SNL
J.Roach, INEEL

Submitted to: Waste Management '98
Tucson, AZ
March, 1998

Los Alamos
NATIONAL LABORATORY

Form No. 836 R5
ST 2629 10/91

DISCLAIMER

DISCLAIMER

Portions of this document may be illegible electronic image products. Images are produced from the best available original document.

LA-UR- 98-439
CONF-980307--

MIXED WASTE FOCUS AREA - WASTE FORM INITIATIVE

Ron Nakaoka, LANL, Robert Waters and Phil Polli, SNL, and Jay Roach, INEEL

ABSTRACT

The mission of the U.S. Department of Energy's (DOE) Mixed Waste Focus Area (MWFA) is to provide acceptable technologies that enable implementation of mixed waste treatment systems which are developed in partnership with end-users, stakeholders, tribal governments, and regulators. To accomplish this mission, a technical baseline was established in 1996 and revised in 1997. The technical baseline forms the basis for determining which technology development activities will be supported by the MWFA. The primary attribute of the technical baseline is a set of prioritized technical deficiencies or roadblocks related to implementation of mixed waste treatment systems.

The Waste Form Initiative (WFI) was established to address an identified technical deficiency related to waste form performance. The primary goal of the WFI was to ensure that the mixed low-level waste (MLLW) treatment technologies being developed, currently used, or planned for use by DOE would produce final waste forms that meet the waste acceptance criteria (WAC) of the existing and/or planned MLLW disposal facilities. The WFI was limited to an evaluation of the disposal requirements for the radioactive component of MLLW. Disposal requirements for the hazardous component are dictated by the Resource Conservation and Recovery Act (RCRA), and were not addressed. This paper summarizes the technical basis, strategy, and results of the activities performed as part of the WFI.

INTRODUCTION

The Assistant Secretary for the Office of Environmental Management (EM) at the DOE established focus areas as a new approach to environmental research and technology development. The MWFA was formed to develop and facilitate implementation of technologies required to meet the DOE's commitments for characterization, treatment, and disposal of mixed low-level and mixed transuranic wastes.

The mission of the MWFA is to provide acceptable processing systems that are capable of treating DOE's existing and projected mixed waste inventory, in accordance with the RCRA Land Disposal Restrictions, and applicable WACs. To accomplish this mission, the MWFA developed and maintains a technical baseline that identifies and prioritizes the technology deficiencies associated with management and disposition of the DOE mixed waste inventory. A deficiency represents some roadblock related to a technical aspect of characterization, treatment, handling, or disposal of mixed waste, as identified by EM customers throughout the DOE complex.

FY 1996 Technical Baseline

The MWFA established the first technical baseline in fiscal year 1996 (FY 1996). This baseline was accomplished by working with DOE site representatives and other technical experts to

evaluate the waste management strategies, capabilities of existing and planned facilities, and the existing and projected inventory characteristics. The deficiencies identified were prioritized based on such factors as affected waste volume, number of customers, number of affected waste streams, risk associated with the stored waste, and related compliance commitments. The FY 1996 MWFA technical baseline included 30 prioritized deficiencies. The fourteenth ranked deficiency was titled "Waste Form Performance." This deficiency was defined as follows:

> The performance criteria for regulated hazardous constituents are generally established in State and Environmental Protection Agency (EPA) regulations, such as Toxicity Characteristic Leaching Procedure (TCLP) requirements. No such requirements have been finalized for radionuclides, so the increased durability of vitrified, slagged, or encapsulated waste forms has not been incorporated into disposal facility permitting or performance assessments. An objective, technically defensible evaluation of the long-term performance of advanced waste forms must be conducted. The evaluation must satisfy regulator and stakeholder concerns to allow flexibility in siting and operating low-level waste disposal facilities to best exploit the more durable, higher waste-loading forms.

The WFI was established to address this deficiency. As noted above, the EPA regulations define the performance criteria for final waste forms relative to hazardous constituents. Specific performance criteria for final waste forms relative to the radioactive component of the waste have not been established. Disposal requirements for radioactive waste are determined by site-specific performance assessments (PAs) and associated WACs. In general, the PAs that have been developed for DOE LLW disposal sites give only short-term credit to waste form performance in the algorithms used to determine disposability of a specific waste form. DOE has been developing and testing certain advanced waste forms (e.g., glass, ceramics, polymers, etc.) that are expected to provide long-term stabilization of radionuclides. Accounting for long-term performance of advanced waste forms in site-specific PAs may increase the allowable radionuclide concentrations and total inventories for disposal. The original goal of the WFI was to develop the data and analytical tools needed to (1) help determine the most appropriate final waste form, and (2) provide technical justification for incorporating long-term waste form performance into performance assessments (PAs). If this goal could be accomplished to the satisfaction of regulators and stakeholders, the conservatism built into the existing methodologies used to determine disposability of a final waste form would be greatly reduced while the cost-effectiveness of the DOE mixed waste treatment systems would be increased.

FY 1997 Technical Baseline

The MWFA technical baseline development process was repeated in FY 1997 using similar techniques and criteria to identify and prioritize the deficiencies. The waste form performance deficiency ranking and definition were modified in the FY 1997 technical baseline. The primary reason for these changes was due to the preliminary results from the Residuals Analysis project being conducted by Sandia National Laboratories (SNL)[1]. Although the PAs do not consider waste form performance in determining disposability of a final waste form, the initial analysis conducted by SNL indicated that relatively few waste streams actually pose a disposability

problem in their planned final waste form. Consequently, the emphasis of the MWFA WFI was revised to provide an objective, technical justification for determining when the use of an advanced waste form is appropriate. For the FY 1997 MWFA technical baseline, the waste form performance deficiency was ranked fourth, primarily due to the near-term closure of what had originally been identified as a deficiency with potentially significant impact to the DOE mixed waste inventory. Based on the revised focus of the WFI, the deficiency definition provided in the FY 1997 MWFA technical baseline is as follows:

> The performance criteria for regulated hazardous constituents are generally established in State and EPA regulations, such as TCLP requirements. No such requirements have been finalized for radionuclides, so the increased durability of vitrified, slagged, or encapsulated waste forms has not been incorporated into disposal facility permitting or performance assessments. An objective, technically defensible evaluation of the value of advanced waste forms in disposal site performance assessments is being conducted. Data needs identified in the evaluation will be addressed as required.

This paper documents the methodologies, results, and limitations of the refined RA performed through the MWFA WFI effort. Potential areas for additional analyses are also provided as appropriate.

WFI STRATEGY

The strategy for WFI activities evolved over the course of the project. The initial strategy was based on the following assumptions:

- MLLW would be required to be treated to meet RCRA defined criteria prior to disposal.
- RCRA-required treatment of MLLW would result in a final waste form for disposal.
- PA methodologies were adequate for establishing permissible exposure based on release of radionuclides from the disposal site.
- Radionuclide limits established through PA modeling were conservative due to the fact that they did not take into account waste form performance.
- Radionuclide limits established through PA modeling would restrict a significant volume of MLLW from disposal due to conservative assumptions associated with waste form performance.
- Existing performance data specific to waste form and radionuclide species were not sufficient to effectively evaluate the disposal options available for a significant fraction of the DOE MLLW inventory.

These assumptions were based on conversations with staff at Hanford, Idaho National Engineering and Environmental Laboratory, Los Alamos National Laboratory, Savannah River

Site (SRS), and SNL who were knowledgeable of the issues associated with the PA and the disposal of MLLW. The basic premise of the WFI from the start of the project was that determining acceptable disposal pathways for MLLW depended on site- and waste-specific attributes. A generic or global evaluation of the disposal issues would not result in the identification of research and development activities at the level of detail necessary to affect site operations.

The initial strategy was designed to clearly establish the impact of including some measure of long-term waste form performance in the PA methodology for estimating radionuclide release and thus exposure. The activities identified in the strategy were intended to be direct comparisons of radionuclide releases assuming that 1) no credit was taken for waste form performance and 2) that waste form performance was included in the PA model. The strategy revolved around the evaluation of two specific sites: a humid site where the exposure pathway from groundwater is significant and an arid site where exposure from this pathway is minimal. The selection of sites was limited to those that had a well-developed PA for LLW. Initially, the disposal site at the Nevada Test Site (NTS) was selected for evaluation. This selection was later modified based on the recommendation of SNL and the recognition that NTS does not include a groundwater pathway in their exposure calculations due to the specific hydrological characteristics of the site (primarily low precipitation, high evapotranspiration, and great depth to groundwater in the region of the disposal site). Hanford was selected as a representative arid disposal site instead of NTS. SRS was selected as a representative humid site for evaluation.

The intent of the activities identified in the WFI strategy was to establish the extent to which accounting for waste form performance in estimating radionuclide release affected the disposal limits for a specific site. It was also intended to serve as an example of how waste form performance could be included in PA models. Incorporation of this methodology would then be based on site-specific considerations and could be applied at any number of disposal sites with the appropriate modifications.

The initial strategy outlined in this section was documented in an Integrated Project Plan and the FY 1997 Project Execution Guidance for the WFI. In August 1996, the strategy was presented at a meeting of EM-30 DOE-Headquarters/Field Office representatives in Las Vegas, Nevada, to get feedback on the direction of the WFI and concurrence that the activities proposed would address EM-30 needs. The general consensus of the group was that the disposal of MLLW was not an issue that required MWFA attention. The contention put forward by this group was that the limits established for both Hanford and NTS would allow disposal of a majority of MLLW without waste form performance modifications to the PA. Also, the group recommended that DOE limit the development of MLLW disposal units as a cost saving measure. They suggested that DOE use Hanford as the primary DOE facility, use NTS as a back-up option for the wastes that Hanford could not accept, and continue to maintain the commercial disposal option.

The WFI strategy was modified as a result of the feedback received at the Las Vegas meeting. The emphasis and activities shifted to determining and documenting the acceptability of the treated DOE MLLW inventory at Hanford and Envirocare of Utah under the existing WAC. This focus was adopted to directly establish whether the initial assumption (that radionuclide limits

established through PA modeling would restrict a significant volume of MLLW from disposal due to conservative assumptions associated with waste form performance) was, in fact, the case. Activities were initiated to refine the RA and to compare the estimated radionuclide concentrations in the final waste form against the WACs for Hanford and Envirocare. The MWFA position was that the path forward for the WFI was dependent on defining the problem: activities associated with waste form performance and modification of PA models would be pursued only if there was a significant volume of MLLW that exceeded established disposal limits, and all activities would be directed at specific problems (i.e., those waste streams/waste forms for which disposal was a problem).

SUMMARY OF THE WFI RESIDUALS ANALYSIS PROJECT

In August 1996, the MWFA requested that SNL conduct a refined RA project to evaluate the disposability of certain potentially problematic MLLW streams that had recently been identified through scoping analyses. This previous work on disposal issues was conducted by SNL for the FFCAct Disposal Workgroup[1,2]. The disposal capabilities of the fifteen sites selected through this process were quantified and qualified in the scoping-level performance evaluation (PE) project completed in early 1996[2]. An additional scoping-level RA project provided estimates of volumes and radionuclide concentrations for treated MLLW that were based on DOE's current and five-year projected inventory of approximately 130,000 m^3. The RA provided a means for identifying MLLW streams that may be potentially problematic in terms of disposal.

The 105 waste streams (approximately 6400 m^3 of treated MLLW) that were considered as potentially problematic in the refined RA conducted for the MWFA had total radionuclide concentrations, based on the scoping-level estimates used in the RA project, that were greater than 10 times the concentration limits derived from the PE project for the Hanford Reservation. In the refined analysis, the radionuclide concentrations of these waste streams were compared with the WAC for the LLW disposal facility at Hanford (the WAC for a MLLW facility at Hanford are not yet complete) and with the WAC for Envirocare's commercial disposal facility for MLLW in Utah. At Hanford, the WAC are based on the LLW PA recently completed for its currently operating shallow land burial site. The WAC provides limiting activity concentrations for Category 1 and Category 3 wastes, which correspond to the PA results of the homesteader and post-drilling scenarios, respectively. Envirocare of Utah is a commercial site, and details about the development of their WAC are not available.

The details of the methodology, results, and conclusions of the SNL study are contained in the report by Waters et al.[3] and summarized here.

The waste characterization data used in the analysis were obtained from the 1995 Mixed Waste Inventory Report (MWIR) database and augmented and modified during site reviews. While more detailed waste characterization data are expected to be available at the sites, the level of data contained in the MWIR database was expected to be sufficient for this scoping-level analysis.

The characterization data contained in the MWIR database are based on untreated waste. Prior to disposal, these waste streams must be treated to remove or stabilize the hazardous constituents

contained in the waste. This treatment and stabilization will change the concentrations of radionuclides remaining in the residual wastes. These after-treatment radionuclide concentrations are the ones that must be considered for waste disposal; therefore, estimates of the changes in concentrations due to treatment were made.

The comparisons of radionuclide concentrations in the potentially problematic waste streams to the WAC at Hanford and Envirocare were made using the sum-of-fractions (SOF) method described in 10 CFR Part 61.55.

A summary of the equations, assumptions used to estimate radionuclide concentration in the final waste form, and the available data used to calculate SOF is contained in the SNL report[3].

Results of these calculations are presented in Figure 1 for Hanford and Figure 2 for Envirocare. At Hanford, all but 97 m^3 of waste were acceptable for disposal, most using Category 3 disposal. Of the 97 m^3, 79 m^3 is associated with one waste stream with a SOF of 2. With more refined analysis, this waste stream may be shown to be acceptable for disposal at Hanford. The remaining 18 m^3 of waste that exceeded the Category 3 limits at Hanford represent a small inventory of radionuclides and may also be shown to be disposable at Hanford with more refined analysis.

In addition to the Category 1 and 3 limits for disposal at Hanford, a separate set of trigger limits is contained in the WAC for mobile radionuclides in waste. Wastes with radionuclide concentrations exceeding these trigger limits were reviewed by technical experts at Hanford to provide an indication of their disposability. Due to the limited data available, a firm declaration of disposability could not be made. However, based on the data available, there appear to be no radiological limitations to disposal of these wastes at Hanford.

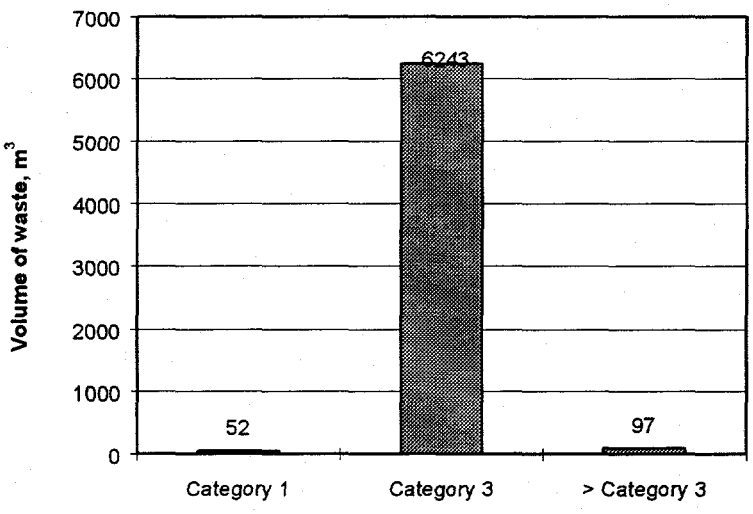

Figure 1. Classification of potentially problematic waste streams based on categories in the Hanford WAC.

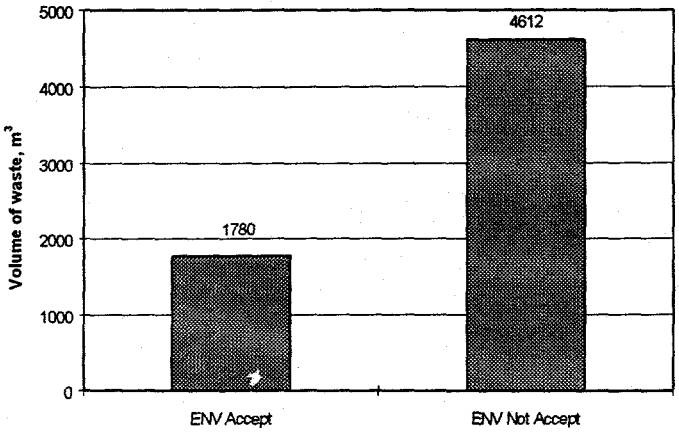

Figure 2. Classification of potentially problematic waste streams based on the Envirocare WAC.

Approximately 4600 m^3 of the 6400 m^3 of waste exceeded the WAC limits at Envirocare, illustrating that this site has relatively restrictive radionuclide limits. More refined analyses may indicate that some of these wastes streams would be acceptable for disposal at this site.

Conclusions of the RA Project

Based on the results of the analyses summarized here and discussed more fully in the SNL report, the following conclusions and recommendations can be made:

- Of the approximately 6400 m^3 of treated MLLW that was identified as potentially problematic for disposal at Hanford based on the PE-derived limits, all but 97 m^3 meets the WAC for either Category 1 or Category 3 wastes at Hanford. Additional documented justification for disposal of the 97 m^3 may allow its disposal at Hanford, with possible additional measures. Disposal of this waste in concrete boxes (as is the current practice for Category 3 waste) may be sufficient, thus removing the need for additional measures.
- The majority of the MLLW acceptable for disposal at Hanford is in Category 3, indicating that additional intruder barriers will be required to dispose of this waste compared to Category 1 disposal. However, potential changes in DOE Order 5820.2A that are currently being evaluated related to assessment of disposal facility performance may affect these results.
- Of the approximately 6400 m^3 of treated MLLW that was identified as potentially problematic for disposal, approximately 4600 m^3 exceeds the WAC for disposal at the Envirocare of Utah facility. This result illustrates that the WAC for the Envirocare

facility is relatively restrictive compared to the radionuclide concentrations in DOE MLLW.

- The evaluation analyzed only a portion of the MLLW for disposal. Approximately 8700 m^3 of MLLW was insufficiently characterized to allow the sites to determine a treatment process for these waste streams. Some of this volume is associated with MLLW streams that have not been generated. Other insufficiently characterized waste streams may require advanced treatment processes or special waste forms to be acceptable for disposal.

  In addition, approximately 27,000 m^3 of MLLW is currently not characterized with respect to radionuclides and their concentrations and was not analyzed with respect to its disposability. The MLLW in both of these categories must be analyzed before a complete evaluation of the disposability of MLLW can be made.

REVIEW, COMMENTS, AND CONCURRENCE

The RA described in the previous section showed that a majority of MLLW met the WACs for Hanford and/or Envirocare. This result was arrived at without the performance of the waste form being taken into account. One of the original assumptions for the WFI was that a significant volume of MLLW would not meet the disposal limits of existing or planned facilities. The RA was conducted to narrow the focus of the WFI to those waste streams that exceeded the disposal limits of these facilities. Subsequent activities outlined in the WFI strategy were to be directed at these specific waste streams. The realization arrived at by this exercise was that the conservative nature of the PA did not restrict a large volume of MLLW from disposal and that accounting for waste form performance was not necessary, based on the current and projected inventory.

The conclusion drawn by the MWFA was to discontinue the WFI based on the results of the RA. Prior to close-out, concurrence with this conclusion was solicited from the Site Technology Coordination Groups (STCGs). A letter was prepared and site-specific data packages were compiled for STCG review and comment. This review was conducted in July 1997. The STCGs were asked to review the RA and provide comments on the following issues:

- Based on your site knowledge and on the information contained in Attachments 1 and 2, indicate whether you concur with our conclusion that disposal of treated MLLW from your site is not a technical problem and the development of new waste forms is not required for your site. (Attachment 1 was a copy of the SNL RA report. Attachment 2 was a site-specific list of the waste streams evaluated, waste stream characteristics, and conclusions on disposability of waste at Hanford and Envirocare).
- Some waste streams have not been evaluated for disposability because necessary data were lacking for them at the time of our analysis. These waste streams are listed in Attachment 3. If your site is listed in Attachment 3, indicate if data for any of the waste streams are now available and if you would like us to evaluate the disposability of these waste streams. For the waste streams that you would like us to analyze, please provide with your response the necessary data as listed in the column headings in

Attachment 2. (Attachment 3 was a site-specific list of waste streams that were not evaluated due to lack of characterization data).

- Attachment 4 is a list of waste streams which appear to have characteristics that may cause them to be incompatible with the selected waste forms. This determination was made by comparing the waste stream data in the MWIR with the compatibility information contained in the literature[4]. Please review these waste streams and indicate if there are waste form compatibility issues that we can help you address.
- Based on the letter to the STCG requesting review, eleven sites responded with comments, questions, and new data. All relevant comments were addressed in the revision of the draft report prepared by SNL. While most comments indicated concurrence with the conclusions of the report, comments from two sites (SRS and DOE Chicago Operations Office) indicated partial disagreement with either the content of the report or the conclusions derived from it. The specific comments from these sites are presented and addressed in the final SNL RA report[3].

CONCLUSIONS

The MWFA WFI has completed an evaluation of the DOE mixed waste inventory for disposability issues related to the final waste form. Over 94,000 m^3 of a possible 130,000 m^3 of MLLW were considered in the evaluation. The results indicate that only approximately 97 m^3 of MLLW pose a potential problem for disposal. While some detailed questions and concerns were raised by certain sites during their review of the evaluation and results, the consensus was that waste form performance was generally not an issue. Likely, the most significant remaining issues with regard to waste forms are the potential problems of compatibility between the waste and waste forms and the economic tradeoffs between applicable waste types. In this instance, the DOE site reviewers generally agreed that these problems should be resolved at the site level on a waste stream specific basis and that a national program is not required. Based on the conclusions of the SNL report[3] and the DOE complex-wide agreement with the results and conclusions, the MWFA is eliminating "waste form performance" as a national technical deficiency and closing out the WFI. Waste form related issues that are identified will be addressed on a case-by-case basis by the affected site(s).

REFERENCES

1. Waters, Robert D., Marilyn M. Gruebel, Brenda S. Langkopf, and Paul B. Kuehne, 1997. *Analysis of the Technical Capabilities of DOE Sites for Disposal of Residuals from the Treatment of Mixed Low-Level Waste*, SAND97-1098. Sandia National Laboratories, Albuquerque, New Mexico.

2. Waters, Robert D., Marilyn M. Gruebel, Maryann B. Hospelhorn, Alva M. Parsons, Bruce M. Thomson, Margaret S.Y. Chu, Gregory P. Zimmerman, John D. Tauxe, Douglas A. Lombardi, Maria L. Socolof, James C. Wang, David Kocher, and Donald W. Lee, 1996. *Performance Evaluation of the Technical Capabilities of DOE Sites for Disposal of Mixed Low-Level Waste—Volume 2: Technical Basis and Discussion of Results,* DOE/ID-10521/2. U.S. Department of Energy, Office of Waste Management (EM-30), Idaho Falls, Idaho.

3. Waters, R., Phillip I. Pohl, Wu-Ching Cheng, Marilyn M. Gruebel, Timothy A. Wheeler, and Brenda S. Langkopf, 1997. *Evaluation of the Capabilities of the Hanford Reservation and Envirocare of Utah for Disposal of Potentially Problematic Mixed Low-Level Waste Streams*, Draft April 1997. Sandia National Laboratories, Albuquerque, New Mexico.

4. Mayberry, J.L. and L.M. DeWitt, eds., 1993. *Technical Area Status Report for Low-Level Mixed Waste Final Waste Forms*, Volume 1, DOE/MWIP-3. Science Applications International Corporation, Idaho Falls, Idaho.