USER NEED LETTER/

FEB 13 1989

MEMORANDUM FOR: Eric S. Beckjord, Director
Office of Nuclear Regulatory Research

FROM: Robert M. Bernero, Director
Office of Nuclear Material Safety and Safeguards

SUBJECT: HLWM STATEMENT OF RESEARCH NEEDS

Enclosed for appropriate action is a statement from the Division of High-Level Waste Management (HLWM) of research needed to support the role of the Nuclear Regulatory Commission (NRC) in the national High-Level Waste (HLW) repository program. The enclosed statement is an update of the 1984 statement of research needs and reflects the focus of the program of the Department of Energy (DOE) on one potential site in Nevada.

The HLW research work currently underway (which has evolved through ongoing interactions between RES and HLWM staff), is consistent with the enclosed statement of needed research. For both research currently under contract and new work, priority should be given to research which supports NRC activities identified in SECY-88-285, as follows (in descending order of priority): (1) Activities that reduce regulatory uncertainty (e.g., development of rules and regulatory guides) and (2) activities which develop independent capability of NRC staff to perform repository system performance assessments. Highest schedular attention within each area of priority should be placed on those activities which could significantly impact DOE's site characterization program.

As in the past, HLWM staff will work closely with RES to ensure that existing and future research projects are timely, consistent with identified needs, and integrated with the HLW licensing program in a manner consistent with HLWM programmatic priorities. To assist in this effort, it is requested that all proposed new RES work be accompanied by supporting documentation that addresses:

(1) The relationship of the scope of the proposed new work to the needs addressed in SECY-88-285,

(2) The relationship of the schedule of the proposed new work to the schedular needs addressed in SECY-88-285,

(3) The relationship of the proposed new work to the enclosed user need statement (i.e., specific topics, questions/concerns being addressed), and

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Add: LSDR Bcyl.

(4) The relationship of the proposed new work to technical work being done by DOE.

I appreciate the close and effective working relationship that has been evidenced to date between HLWM and RES staff. Please contact Ronald L. Ballard (X23455/5-H-1) if you have any questions or comments about the enclosed NMSS Statement of HLWM Research Needs.

(Signed) Robert M. Bernero

Robert M. Bernero, Director
Office of Nuclear Material Safety
and Safeguards

Enclosure:
As stated

DISTRIBUTION:

Central Files	REBrowning, DHLWM	BJYoungblood, DHLWM	RLBallard, HLGP
JOBunting, HLEN	JLinehan, RLPD	HLGP r/f	NMSS r/f
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*SEE PREVIOUS CONCURRENCE

OFC	HLGP*	HLGP*	HLGP*	HLGP*	HLGP*	RLPD*	HLEN*
NAME	DBrooks/cj	DChery	PJustus	SCoplan	RLBallard	JLinehan	JBunting
DATE	2/3/89	1/18/89	1/18/89	2/3/89	2/2/89	2/3/89	2/3/89

OFC	HLWM*	HLWM*	NMSS	NMSS			
NAME	BJYoungblood	RBrowning	MRKnapp	RMBernero			
DATE	2/3/89	2/3/89	2/ /89	2/13/89			

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(4) The relationship of the proposed new work to technical work being done by DOE.

I appreciate the close and effective working relationship that has been evidenced to date between HLWM and RES staff. Please contact Ronald L. Ballard (X23455/5-H-1) if you have any questions or comments about the enclosed NMSS Statement of HLWM Research Needs.

Robert M. Bernero, Acting Director
Office of Nuclear Material Safety
and Safeguards

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OFC	HLGP *	HLGP *	HLGP*	HLGP *	HLGP	RLPD	HLEN
NAME	DBrooks:cj	DChery	PJustus	SCoplan	RLBallard	JLinehan	JBunting
DATE	2/3/89	2/ /89	2/ /89	2/3/89	2/2/89	2/3/89	2/3/89

OFC	HLWM	HLWM	NMSS	NMSS			
NAME	BJYoungblood	RBrowning	MRKnapp	RMBernero			
DATE	2/3/89	2/3/89	2/ /89	2/ /89			

needs. HLWM staff will also continue to assess research needs and update the NMSS Statement of HLWM Research Needs accordingly. In addition, we encourage RES staff to continue to discuss with us specific ideas about research projects to support the NRC HLWM program.

Please contact Ronald L. Ballard (X23455/5-H-1) if you have any questions or comments about the enclosed NMSS Statement of HLWM Research Needs.

Robert E. Browning, Director
Division of High-Level Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosures:
As stated

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PAltomare, HLEN			

SEE PREVIOUS CONCURRENCE

OFC	HLGP	HLGP	HLGP	HLGP	RLPD	HLEN	RLPD
NAME	DBrooks/RB	DChery	PJustus	SCoplan	JLinehan	RWeller	JHolonich
DATE	1/18/89	1/18/89	1/18/89	1/18/89	1/19/89	1/18/89	1/18/89

OFC	HLEN	HLGP	HLWM	HLWM			
NAME	JBunting	RBallard	BJYoungblood	REBrowning			
DATE	1/19/89	1/18/89	1/19/89	1/19/89			

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Enclosure

HLWM STATEMENT OF RESEARCH NEEDS

The following research is needed to support independent reviews and evaluations by NMSS/HLWM of DOE site characterization activities and performance calculations for a deep geologic repository for high-level radioactive waste. The areas of technical work in HLW have been identified by the licensing staff based on its consideration of the findings required by 10CFR60. The specific areas for HLWM research support were selected based primarily on the following criteria:

- The research supports development of specific NRC regulations, regulatory guides, technical positions, or performance assessment methodologies,
- The research supports staff analysis of highly uncertain or poorly understood phenomena or processes important to evaluating the safety of a repository that are anticipated to require an independent assessment of their significance, or
- The research supports staff analysis of unconventional approaches being used by DOE to collect data or develop models.

A comprehensive set of general technical areas and specific technical problems must be addressed by DOE in its programs to support its license application. NRC research should provide an independent capability for assessment of DOE activities rather than a remedy of deficiencies in the work being conducted by the DOE. The focus of the technical work is to assess the capabilities, limitations, assumptions and uncertainties associated with:

- Identification of failure modes and for quantifying or assessing risks associated with components of the high-level radioactive waste disposal system;
- Extrapolation of short-term laboratory and field observations to long-term predictions for making the HLW regulatory performance assessments.

While the needs identified focus primarily on the information or capability that is required to independently assess DOE's license application, HLWM research support programs need to be structured to provide interim results as they become available to provide staff guidance, and positions that can be used by the staff in their consultation with DOE.

A. WASTE FORM AND PACKAGING

1. Identification and Assessment of Potential Failure Modes for Waste Packages

Research is needed to critically evaluate waste package failure modes. These modes should include general corrosion, stress corrosion cracking,

pitting corrosion, crevice corrosion, and hydrogen embrittlement. The work must permit application of the results to the container materials most likely to be considered by the DOE (currently stainless steel, a nickel alloy, copper, and copper-based alloys), and to the most likely weak points in the packages (currently considered to be the container weldments). Specific reporting requirements include an evaluation of factors in waste package fabrications processes that may adversely affect waste package performance. Studies should document the sensitivity of corrosion rates and mechanical properties to these processes. The results should be presented in a format that will permit the staff to efficiently review DOE fabrication design specifications as they may affect estimates of waste package reliability.

2. Evaluation of Interactions Between Waste Packages and the Repository Environment

Research is needed to identify and critically evaluate the properties of container materials and of environmental parameters that may have a significant influence on the chemical, physical, and radiolytic interactions between waste packages and the repository environment. The work must address how container materials and their alteration products interact with the waste form and how these interactions could affect the release of radionuclides (including synergistic effects). Specific reporting requirements include the identification and the relative importance of properties and parameters in these interactions.

3. Assessment of Corrosion Rates

Research is needed to critically assess methods for extrapolating the results of short-term test data to long-term containment times. As a particular example, pitting corrosion is regarded as a likely failure mode for waste package containers. Work is needed to independently assess the rate of pit growth as a function of heat flux, temperature level, and pit age. Of special importance is the need for identifying mechanisms of pit growth. Specific reporting requirements include criteria for making reliable extrapolations that the staff can use to (1) formulate guidance to the DOE on acceptable prediction techniques and (2) review DOE data on pitting corrosion of HLW package containers. To the extent that pitting data are derived from isothermal tests, reporting should assess the validity of such extrapolations when applied to repository conditions. Reporting should also describe the assumptions and limitations, as well as the laboratory protocols, for all predictive techniques evaluated.

4. Analogs of Leaching and Migration

Research is needed to evaluate the validity of conclusions based on analogs. The work must assess the assumptions that must be made and the limitations of using analogs. The staff anticipates that the DOE may use information derived from analogs to validate models of leaching of the

spent fuel and high-level waste form after failure of the containment. Analogs may be found in nature or may be simulated in the laboratory. In the case of natural analogs, it will be necessary to identify those factors which permit identifying particular specimens as valid analogs for the waste package/repository situation. This will involve consideration of (1) the effects of oxidation states and redox kinetics, (2) retardation processes, (3) colloid formation, and (4) organic complexation on the mobility of redox sensitive radionuclides. Specific reporting requirements include the identification of criteria that the staff could use in (1) formulating guidance to the DOE on appropriate analog studies and (2) reviewing DOE data on spent fuel and HLW leaching and migration effects.

B. REPOSITORY DESIGN AND ROCK MECHANICS

1. Rock-Mass Sealing (Sealing of Shafts and Boreholes in the Unsaturated Zone)

Research is needed to evaluate the technical capability to seal shafts, drifts and boreholes as necessary to achieve acceptable repository performance. The work should include a scoping study to estimate the seal performance needed for a repository located in unsaturated tuff, and an assessment of material properties and constriction techniques potentially suitable for achieving the level of seal performance identified. Specific reporting requirements include information suitable for use in a review of DOE's proposed repository design.

C. EARTH SCIENCES

1. Analog Studies of Conditions/Processes/Environments

Research is needed to evaluate data/information from natural settings and archeologic studies that are related to processes that are being studied in the laboratory. As part of its independent performance assessment capability, NRC must have a basis for comparing laboratory study results with estimates of repository performance over long time periods. There is considerable uncertainty in extropolating such information from laboratory or in-situ field tests to the time scales required for repository performance evaluations. In particular, geochemical studies need to be focused on natural settings where appropriate water/rock/physical-chemical conditions that are relevant to geologic repositories prevail, and, for radionuclide-migration analog studies, where an appropriate source term is available. Specific reporting requirements include an evaluation of the similarities between the natural analog or setting and expected near-and far-field repository environments, and processes being observed under site conditions in the field or laboratory.

2. Groundwater Chemistry

Research is needed to independently assess information on the evolution of groundwater chemistry resulting from of waste emplacement and the interactions between rock/backfill/water. This information will provide data concerning changes expected in the environment of waste packages for comparison to DOE project-produced data. The technical work should include assessments of rock-surface processes that are involved in the control of the redox state of groundwater and radionuclides. Information is also needed on the kinetics of redox processes, which is important to the understanding of redox conditions of both pre-closure and post-closure groundwater and its effect on waste package stability and radionuclide migration. Specific reporting requirements include the basic data of the experimental work, documentation of the experimental procedures used, including all assumptions and limitations, and a set of criteria that can be used by the licensing staff to help evaluate DOE data, analyses and conclusions concerning the chemical evolution of groundwater over time in both the near-field and the far-field.

3. Radionuclide Transport

Research is needed to evaluate radionuclide source term, and valence effects on radionuclide sorption and solubility. The technical work should include an assessment of the basic behavior of redox-active elements (in both dry and wet environments), radionuclide/rock/water interactions, vapor phase transport, transport pathway identification, and "scaling" problems. Specific reporting requirements include the basic data of the experimental work, documentation of the experimental procedures used, including all assumptions and limitations, and a set of criteria that can be used by the licensing staff to help evaluate DOE data, analyses and conclusions concerning radionuclide transport, isolation of waste, or repository performance.

4. Mineralogy

Research is needed to evaluate rock/backfill/EBS mineralogy (rock/backfill/water interaction in order to independently review DOE's assessment of releases from the engineered system. The technical work should include an assessment of the physical changes in the backfill that may be expected as a result of changes in backfill mineralogy over time and an assessment of the changes in water chemistry that may result, as well as changes in sorptive capability of the backfill/EBS materials. Specific reporting requirements include the basic data of the experimental work, documentation of the experimental procedures used, including all assumptions and limitations, and a set of criteria that can be used by the licensing staff to help evaluate DOE data, analyses and conclusions concerning backfill/EBS performance.

5. Response of Groundwater Levels and Underground Openings to Strong Ground Motion

Research is needed to independently assess compliance with the safety aspects of the design criteria for the geologic repository operations area with respect to the effects of strong ground motion from near-field seismic events. Although the geologic repository operations area includes both the surface facilities and the underground openings, this work should be focused on the effects of depth on the nature of the vibratory spectra with depth in a generalized rock media, the effect of the insertion of a network of both vertical and horizontal tubular voids in this media, and boundary conditions between the voids and the media. Specific reporting requirements include (1) a world-wide database of groundwater flow modifications and adjustments in response to fault movement and/or seismic events; (2) recommendations for the instrumentation of sites in tuff or similar rock where documented alterations of the groundwater regime have occurred; (3) predictive models for groundwater response to seismic events; (4) a database documenting the effects of both natural earthquakes and artificially-generated seismic events on underground openings; (5) recommendations for the installation of seismic instrumentation in deep mines, which are similar to the proposed repository by tuff (where earthquakes have been observed); and (6) suitable analytical methods for modelling the static and dynamic response of an underground opening in rock.

6. Groundwater Flow and Radionuclide Transport

Research is needed to independently assess the effects of the spatial variability on simulations and predictions of three-dimensional groundwater flow and radionuclide transport. In addition, NRC needs the capability to independently simulate those processes, incorporating important stochastic effects. Specific reporting requirements include (1) an evaluation of the importance of performing stochastic analyses of three-dimensional groundwater flow and radionuclide transport during site characterization and performance assessment; (2) techniques for predicting behavior of large scale heterogeneous groundwater systems using measured field data and spatial variability; (3) techniques for estimating error and uncertainty for models; and (4) a comparison of different techniques for incorporating three-dimensional spatial variability into flow and transport models.

7. Uncertainty in Probabilistic Seismic Hazard Assessment

Research is needed to (1) assess uncertainty associated with probabilistic seismic hazard analysis when the data set is not complete; (2) assess the different types of distribution functions which can be issued to fit this data set and to evaluate the advantages and disadvantages of each distribution; and (3) use data from other regions, due to the deficiency of observations at the Yucca Mountain site, for the assessment of

variation in acceleration expected from regions of compressional tectonics as compared to extensional regions, and for the assessment of applicability of strong ground motion data from strike-slip and thrust earthquakes in California to normal and extensional stress regimes in Nevada. Specific reporting requirements include documenting the data and all of the assumptions and limitations used to arrive at the conclusions in each of the three areas of proposed research.

8. Climate Changes and Effects on Unsaturated Flow Conditions

Research is needed to critically evaluate available methods for projecting future climate changes and likely effects on infiltration at Nevada. The evaluation should, to the extent practical, establish bounds on the range of infiltration rates to be expected during the next 100,000 years and, where bounds cannot be determined, the evaluation should assess the potential for additional DOE research to produce this information in time to support a license application. Specific reporting requirements include the identification of criteria that the staff could use in (1) formulating guidance to DOE, and (2) in reviewing DOE Data. The reporting must identify the assumptions and limitations of the technical approaches used and should provide recommendations on how climate changes and effects can be adequately modeled or their effects estimated.

9. Coupled Interactions of Thermal-Mechanical-Hydrologic Systems

Research is needed to evaluate coupled thermal-mechanical-hydrologic effects over time, particularly in the near-field, and their effects with respect to the performance objectives for containment, radionuclide releases from the engineered system, and radionuclide releases to the accessible environment over 10,000 years. Specific reporting requirements include the identification and evaluation of coupled processes that may be important to meeting the above-cited repository performance objectives. The reporting must identify the assumptions and limitations of the technical approaches used in the studies and should provide recommendations on how coupled processes may be adequately modelled (or their effects estimated/bounded), and analytical approaches that could be used, along with substantive criteria that the licensing staff could apply in implementing the recommended approaches.

D. SYSTEMS PERFORMANCE

1. Independent Systems Assessment Methodology for Evaluation of Total System Performance

Research is needed to critically evaluate analytical models and computer models that combine and predict geologic stability, groundwater flow, radionuclide transport, groundwater concentrations of radionuclides and potential radiation exposures (radiation doses) to individual members of the public. It is essential that the models and codes have a sound

basis and are accepted by the technical community and have the capability to convolute the predicted responses of all subsystems to the total system performance response. Specific reporting requirements include the development or recommendation of a set of models and computer codes that can be used to independently assess saturated/unsaturated system performance in tuff.

2. HLW Preclosure Safety Systems Analysis

Research is needed to develop a systematic methodology that will identify and qualitatively prioritize the structures, systems, components and operations that are important to safety. NRC regulations specify general design criteria for the structures, systems and components important to safety (both surface and subsurface) during the preclosure phase of repository development (10CFR60.131(b)). The licensing staff must be in a position to independently assess the preclosure safety analysis and requires technical support in developing a methodology for analyzing preclosure safety. Specific reporting requirements include the full documentation of the methodology, and should also include a provision for technology transfer that will permit licensing staff to become familiar with the application of the methodology.