Mr. Ronald A. Milner, Director
for Program Management and Integration
Office of Civilian Radioactive Waste Management
U.S. Department of Energy, RW 30
1000 Independence Avenue, S.W.
Washington, D.C. 20585

June 10, 1996

SUBJECT: MINUTES OF THE NOVEMBER 17, 1995, TECHNICAL EXCHANGE ON KEY ISSUES FOR A GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN

Dear Mr. Milner:

Enclosed are the minutes of the U.S. Nuclear Regulatory Commission - U.S. Department of Energy (DOE) key issues technical exchange that was held on November 17, 1995, by videoconfeence between DOE contractor facilities in Las Vegas, Nevada, and Washington, D.C., as part of a continuing series of interactions between NRC and DOE.

Other organizations represented at the technical exchange were the State of Nevada; Nye County, Nevada; the Nuclear Waste Technical Review Board; the U.S. Geological Survey; Nuclear Energy Institute; DOE's Management and Operating Contractor; and NRC's Center for Nuclear Waste Regulatory Analyses.

If you have any questions regarding these minutes, please contact Robert Johnson of my staff. He can be reached at 301-415-7282.

Sincerely,

[Original signed by John Thoma for]

John H. Austin, Chief
Performance Assessment and High Level
Waste Integration Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As Stated

cc: See attached list

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NMSS r/f, PAHL r/f, MJBell, CJHaughney, KTI Team Leads
NRC Attendees, On-site Reps
w/o Enclosure: MFWeber, RLJohnson

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NAME	RJohnson/kv		JThoma JOT		JAustin JOT for JA					
DATE	6/10/96		6/10/96		6/10/96		/ /96		/ /96	

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CC List for letter to R. Milner dated: June 10, 1996

cc: C. Johnson, State of Nevada
J. Meder, Nevada Legislative Counsel Bureau
M. Murphy, Nye County, NV
M. Baughman, Lincoln County, NV
D. Bechtel, Clark County, NV
P. Niedzielski-Eichner, Nye County, NV
B. Mettam, Inyo County, CA
V. Poe, Mineral County, NV
W. Cameron, White Pine County, NV
R. Williams, Lander County, NV
L. Fiorenzi, Eureka County, NV
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C. Schank, Churchill County, NV
L. Bradshaw, Nye County, NV
W. Barnard, NWTRB
R. Holden, NCAI
A. Melendez, NIEC
S. Brocoum, YMPO
R. Arnold, Pahrump, NV
N. Stellavato, Nye County, NV
W. Barnes, YMPO
D. Horton, YMPO
F. Rodgers, DOE/Wash, DC

MINUTES OF THE NOVEMBER 17, 1995
U.S. NUCLEAR REGULATORY COMMISSION/U.S. DEPARTMENT OF ENERGY
TECHNICAL EXCHANGE ON KEY ISSUES FOR A GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN

On November 17, 1995, staff from the U.S. Nuclear Regulatory Commission met with representatives of the U.S. Department of Energy (DOE) to discuss items of mutual interest regarding key technical issues for a geologic repository at Yucca Mountain. The technical exchange was held by videoconference between DOE facilities in Washington, D.C. and Las Vegas, Nevada. Attachment 1 is the agenda for the technical exchange.

Other organizations represented were the State of Nevada Nuclear Waste Project Office (NV NWPO); Nye County, Nevada; the Nuclear Waste Technical Review Board (NWTRB); the United States Geological Survey (USGS); DOE's Management and Operating Contractor (M&O); Nuclear Energy Institute (NEI); and NRC's Center for Nuclear Waste Regulatory Analyses (CNWRA). Attachment 2 is the attendance list for the technical exchange.

The purpose of this technical exchange was for all parties to exchange perceptions of the key technical issues most important to repository performance and begin to discuss approaches to their resolution.

NRC began with its perceptions of the key technical issues (Attachment 3). The NRC staff explained that the focus of its reduced program is on 10 key technical issues that the staff judges to be most significant to repository performance and eventual licensing. NRC also described its process for identifying its 10 key technical issues. This process included consideration of the staff's comments on DOE's Site Characterization Plan; the key technical uncertainties documented in NRC's License Application Review Plan (NUREG-1323); results of staff performance assessments; and DOE's Waste Isolation Strategy. The 10 issues represent the collective views of multidisciplinary teams of NRC and CNWRA technical staff and approval by NRC management. Each of the 10 issues were summarized giving the scope, significance, and path to resolution.

Next, DOE summarized its perceptions of the key issues (Attachment 4). A program overview was given where DOE stressed the limitations of its reduced budget. DOE expressed its desire for issue resolution progress for issues where NRC and DOE agree, but within the constraints of its budget. DOE also explained that prelicensing interactions with NRC were no longer "business as usual." DOE's Viability Assessment in 1998 is considered to be DOE's report to Congress and not a licensing document for NRC. NRC staff stressed the intent to continue operating in a prelicensing mode and expected to be asked

to comment on DOE's Viability Assessment from a licensing perspective. DOE stated that comments on sufficiency of information for licensing would be expected from NRC on DOE's Viability Assessment products so as to define the differences between the two agencies.

Following this overview, DOE discussed the key technical issues derived from the Waste Containment and Isolation Strategy. This draft strategy, under review by DOE, is considered to be a postclosure safety case. Five hypotheses making up this strategy were described along with the work needed to test each hypothesis under DOE's reduced program. Another presentation identified significant site and design issues identified in DOE's Total System Performance Assessments (TSPAs) of Yucca Mountain. Conclusions were given about the significance to performance of the following disruptive events: direct and indirect effects of volcanism, limited seismic effects, human intrusion, climate change, and erosion. Furthermore, important information needed for DOE's TSPAs were discussed. Finally, a TSPA perspective on the significance of NRC's key technical issues was given.

The representative from NV-NWPO gave some views on the NRC and DOE presentations since views on the key issues have previously been described. A concern was expressed with the impression given by DOE that the current reduced program is no longer in a prelicensing mode because of its revised mission of preparing a Viability Assessment in 1998. Furthermore, a question was raised about NRC's role given the revised program. NV-NWPO also noted that the Waste Containment and Isolation Strategy represents a significant change to DOE's program with greater reliance on the engineered barrier system. Such a shift in emphasis was claimed to be inconsistent with NRC's multiple barrier/defense in depth policy.

The representative from Nye Co. thought the exchange was effective and suggested that all parties consider the information presented and respond at the next NRC-DOE Management meeting.

A general discussion followed on whether or not there was agreement between NRC and DOE on NRC's 10 key technical issues. The results of these discussion are noted on Attachment 5. In summary, there was general agreement between NRC and DOE on the importance of 8 of the 10 issues. In general, DOE's assessment of important performance-based technical issues differed from NRC's key technical issues in that disruptive scenarios, such as igneous activity and structural deformation/seismicity did not have as central a role as assigned by NRC. NRC included them in priority 1 and 2, respectively, in their grouping of key technical issues. For igneous activity and structural deformation/seismicity, DOE did not agree that there was a technical basis for the significance to repository performance of these disruptive event issues. NRC explained that its views on key issues reflected its role as a regulator

to focus on potential vulnerabilities for eventual licensing.

NRC and DOE agreed that it will be important for the future of the National program to demonstrate significant progress toward issue resolution in FY96. NRC explained that it was important to make progress not only on issues where there is agreement but also to achieve a better understanding and focus on those issues where there is disagreement. NRC plans on presenting a draft procedure for issue resolution to DOE at the January NRC-DOE Management meeting.

Robert L. Johnson
Division of Waste Management
Office of Nuclear Material
Safety and Safeguards
U.S. Nuclear Regulatory Commission

Christian E. Einberg
Regulatory Integration Division
Office of Civilian Radioactive
Waste Management
U.S. Department of Energy

DOE-NRC Technical Exchange on Key Issues
for a Geologic Repository at Yucca Mountain
Videoconference: DC & Las Vegas, NV

November 17, 1995

Time (EST)	Item	Discussion Lead
10:00 - 10:10 am	Opening Remarks	DOE, NRC, State of Nevada, Affected Local Governments
10:10 am - 11:30 am	NRC Perception of Key Issues - Process of Identification - Summary of Issues - Plans for Resolution	NRC
11:30 - 11:50 am	Break	
11:50 am - 1:10 pm	DOE Perception of Key Issues - Waste Isolation Strategy - Treatment of Issues in TSPA	Dr. S. Brocoum Dr. J. Younker Dr. A. Van Luik
1:10 - 1:20 pm	Break	
1:20 - 2:00 pm	Perception of Key Issues	State of Nevada, Affected Local Governments
2:00 - 2:45 pm	Discussion	DOE, NRC, State of Nevada, Affected Local Governments
2:45 - 3:00 pm	Closing Remarks	DOE, NRC, State of Nevada, Affected Local Governments

DOE/NRC Technical Exchange on Key Issues
for a Geologic Repository
Vidoeconference: DOE/HQ & YMSCO

Name:	Organization:	Phone:
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MARGARET FEDELLINE	USNRC	301/417-6708.
Keith I. McConnell	USNRC	301 415-7289
Robert L. Johnson	USNRC	301-415-7282
David Brooks	USNRC	301 415 7284

DOE/NRC Technical Exchange on Key Issues
for a Geologic Repository
Vidoeconference: DOE/HQ & YMSCO

Name:	Organization:	Phone:
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JIM YORK	WESTON	202-646-6650
Ray Wallace	USGS	
Gene Roseboom	USGS retired	
Alan Brownstein	DOE	202 586-4973

DOE - NRC TECHNICAL EXCHANGE ON KEY ISSUES FOR A GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN

VIDEO CONFERENCE • NOVEMBER 17, 1995

ATTENDANCE LIST

Name	Organization	Telephone
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Thomas Brockett	DOE/YMSCO	702-794-7590
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DOE - NRC TECHNICAL EXCHANGE ON KEY ISSUES FOR A GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN

VIDEO CONFERENCE - NOVEMBER 17, 1995

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N J. Chappell	TRW	794-1928

DOE/NRC Technical Exchange on Key Issues
for a Geologic Repository
Vidoeconference: DOE/HQ & YMSCO

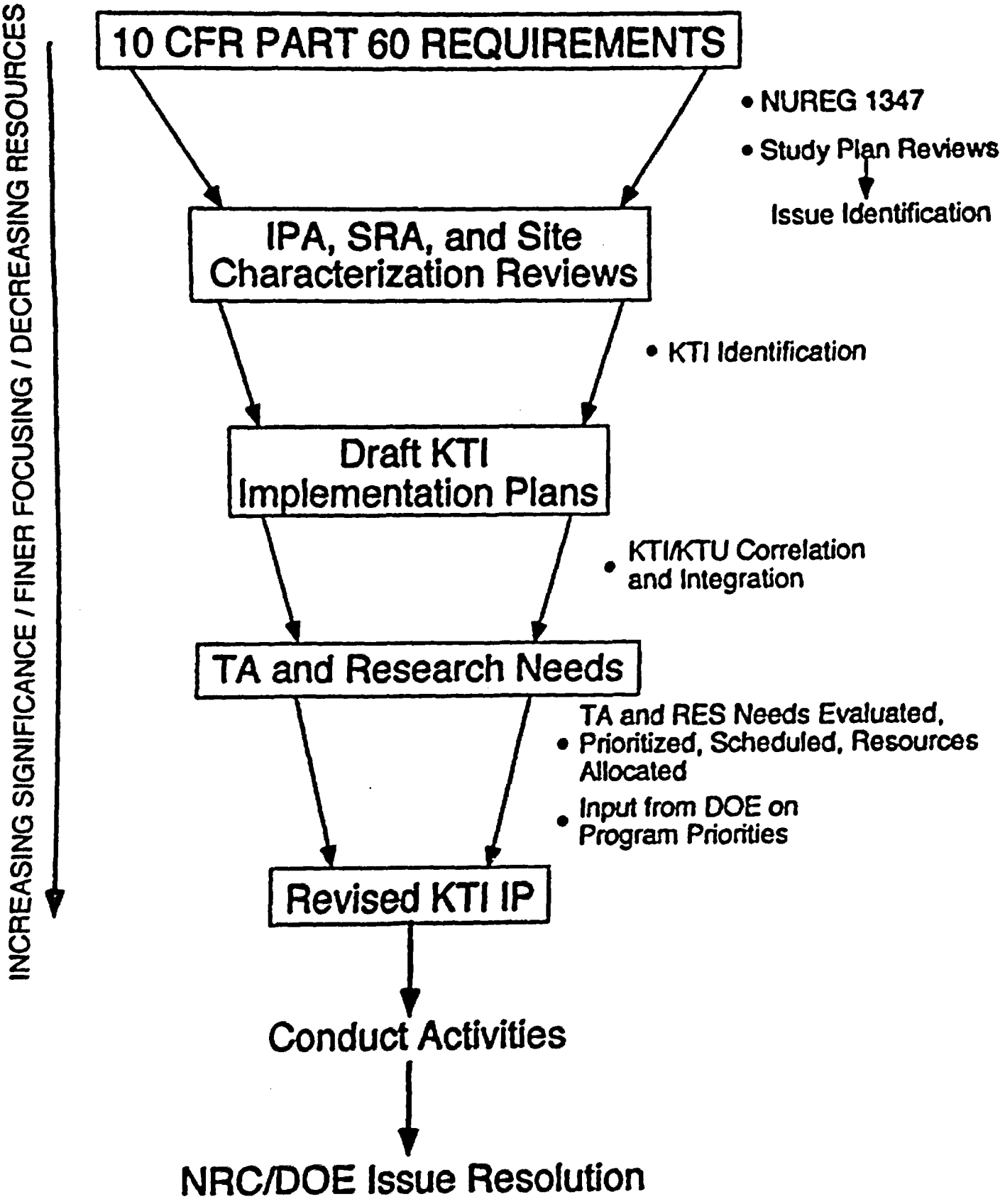
Name:	Organization:	Phone:
Andy Campbell	US NRC/ACNW	(301) 415-6897
John Dossett	National Congress of American Indians	(202) 466-7767

NRC/DOE TECHNICAL EXCHANGE ON KEY TECHNICAL ISSUES

KEY TECHNICAL ISSUES - IDENTIFICATION AND IMPLEMENTATION

SPEAKERS

- Perspective - Margaret Federline, Deputy Director DWM (415-6708)
- Introduction to Key Technical Issue (KTI) Process - Keith McConnell, Section Leader ENGB (415-7289)
- Description of Engineering and Geosciences KTIs - Michael Bell, Branch Chief ENGB (415-7286)
- Description of Performance Assessment and Hydrologic Transport KTIs -
  David Brooks, Section Leader PAHB (415-7284)
  Rex Wescott, Senior Hydrologist, PAHB (415-6727)


INCREASING SIGNIFICANCE / FINER FOCUSING / DECREASING RESOURCES
10 CFR PART 60 REQUIREMENTS
• NUREG 1347
• Study Plan Reviews
Issue Identification
IPA, SRA, and Site Characterization Reviews
• KTI Identification
Draft KTI Implementation Plans
• KTI/KTU Correlation and Integration
TA and Research Needs
• TA and RES Needs Evaluated, Prioritized, Scheduled, Resources Allocated
• Input from DOE on Program Priorities
Revised KTI IP
Conduct Activities
NRC/DOE Issue Resolution

DISCUSSION OF NRC KEY TECHNICAL ISSUES

Igneous Activity	Mike Bell
Structural Deformation and Seismicity	Mike Bell
Container Life and Source Term	Mike Bell
Repository Design and Thermal-Mechanical Effects	Mike Bell
Unsaturated and Saturated Flow Under Isothermal Conditions	Dave Brooks
Thermal Effects on Flow	Dave Brooks
Evolution of the Near-Field Environment	Dave Brooks
Radionuclide Transport	Dave Brooks
Total System Performance Assessment and Technical Integration	Rex Wescott
Support Revision of the EPA Standard and NRC HLW Rule	Rex Wescott

IGNEOUS ACTIVITY

SCOPE AND TECHNICAL SIGNIFICANCE

- **Includes concerns related to uncertainties in the age of volcanic events, energetics and volume of magma, physical and chemical character of the magma, the geometry of subsurface magma conduit systems and the resulting prediction of the probability and consequences of future volcanic events.**

IGNEOUS ACTIVITY

SIGNIFICANCE TO PERFORMANCE

- **Reasonable ranges of probability and consequence of future igneous activity have not been bounded by DOE's characterization or performance assessment efforts. Direct or indirect disruption of the site by future igneous activity could have a significant impact on repository performance.**

IGNEOUS ACTIVITY

PATH TO RESOLUTION - HIGH PRIORITY TASKS

- Perform consequence analysis and sensitivity study to determine the significance of issue on performance.
- Evaluate DOE's recent work on Igneous Activity including the results of TSPA.
- Focus Research and Technical Needs on bounding range of probabilities and assessing consequences.
- Develop acceptance criteria and review procedures.

STRUCTURAL DEFORMATION AND SEISMICITY

SCOPE AND TECHNICAL SIGNIFICANCE

- **Potentially disruptive hazards of faulting, earthquakes and differential translations and rotations capable of affecting groundwater flow and pre- and post-closure design considerations.**

STRUCTURAL DEFORMATION AND SEISMICITY

SIGNIFICANCE TO DESIGN AND PERFORMANCE

- Uncertainties in:

  - contemporary stress and strain distribution,

  - ages and magnitudes of movement on existing and blind faults,

  - recurrence rates of seismogenic structures, and

  - predictive tectonic models

  have made it difficult to establish tectonic loads necessary for assessment of repository design and performance.

- Faulting, seismicity, and other tectonic strains can affect groundwater flow, canister performance, and rock stability. Their potential cumulative effects on repository design and performance will necessarily have to be evaluated.

STRUCTURAL DEFORMATION AND SEISMICITY

PATH TO RESOLUTION - HIGH PRIORITY TASKS

- Develop input to consequence analyses on repository groundwater flow considering faulting, contemporary stress and strain, and seismicity.
- Continue with fault slip and seismic probability modules for the PA computer code to evaluate compliance with performance objective and design requirements.
- Evaluate DOE's:
  - repository fault geometries, fault slip histories, stratigraphy and seismicity
  - 2-D and 3-D tectonic models
  - interpretations of faulting and magmatism interactions
- Evaluate the cause and significance of the steep groundwater gradient.

PATH TO RESOLUTION - HIGH PRIORITY TASKS (continued)

- Review Seismic Hazards Topical Report.
- Develop acceptance criteria and review procedures.

CONTAINER LIFE AND SOURCE TERM

SCOPE AND TECHNICAL SIGNIFICANCE

- **Evaluating waste package degradation and release rate of radionuclides over long periods of time in deep geologic repository environment including degradation due to waste package corrosion, radiolysis, microbiological effects, and reactions with man-made materials.**

CONTAINER LIFE AND SOURCE TERM

SIGNIFICANCE TO PERFORMANCE

- **The waste package is the primary engineered barrier for the repository and is the source of radionuclide release from the repository.**

- **A major factor in the evaluation of release rates from the repository is the prediction of waste package degradation under repository relevant conditions.**

CONTAINER LIFE AND SOURCE TERM

PATH TO RESOLUTION - HIGH PRIORITY TASKS

- Evaluate significance of waste package lifetime and engineered barrier system release rate to repository performance.
- Evaluate DOE's studies, methodologies, acceptance criteria and supporting standards and related data on EBS/waste package.
- Near-Field Environment
  - Evaluate DOE's near-field environment model coupling heat and mass transport and chemical processes with aqueous complexing reactions and kinetic reactions of minerals.

PATH TO RESOLUTION - HIGH PRIORITY TASKS (continued)

- Examine the methodologies for using short-term laboratory data to predict long-term performance.

- Evaluate adequacy and conservatism of repassivation potential in predicting the long-term localized corrosion and stress corrosion cracking of container materials.

- Develop review procedures and acceptance criteria.

REPOSITORY DESIGN AND THERMAL-MECHANICAL EFFECTS

SCOPE AND TECHNICAL SIGNIFICANCE

- Evaluation of time-dependent response of jointed rock under thermal load for assessing design of the repository as it relates to the performance of the repository. Includes consideration of thermal-mechanical response of rock and its impact on retrievability and waste package degradation.

REPOSITORY DESIGN AND THERMAL-MECHANICAL EFFECTS

SIGNIFICANCE TO PERFORMANCE

- **The long-term mechanical response and thermal-mechanical interactions of jointed rock in a repository will be significant complicating factors in the prediction of the stability of repository openings and determining the possible effects on waste package and repository performance.**

REPOSITORY DESIGN AND THERMAL-MECHANICAL EFFECTS

PATH TO RESOLUTION - HIGH PRIORITY TASKS

- Interact with DOE on:
  - Acquisition and analyses of field and laboratory data
  - Thermal load considerations and scope of in-situ heater test
  - ESF/GROA Integration
  - Design Control Process
- Develop our analytical capabilities and evaluate significance of the stability of repository openings.
  - Modify rock joint constitutive model
  - Modify thermal-mechanical compliance determination codes

PATH TO RESOLUTION - HIGH PRIORITY TASKS (continued)

- Review Seismic Design Topical Report.
- Develop review procedures and acceptance criteria.

UNSATURATED AND SATURATED FLOW UNDER ISOTHERMAL CONDITIONS

SCOPE AND TECHNICAL SIGNIFICANCE

- **Evaluation of water and/or vapor movement through the unsaturated and saturated zone under isothermal conditions including the influence of structural features on hydrologic flow and the variability in hydrologic parameters within stratigraphic units so as to determine significant flow pathways to and from the respository.**

UNSATURATED AND SATURATED FLOW UNDER ISOTHERMAL CONDITIONS

SIGNIFICANCE TO PERFORMANCE

- Sufficient characterization of water and/or vapor movement through the unsaturated and saturated zones is key to determine whether:
  - there will be low seepage of groundwater onto the waste package, and
  - long transport times and large dilution in the natural barrier will limit the effects of release of radionuclides
- DOE Waste Isolation Strategy partitions the basis for waste containment and isolation and intends to address these two hypotheses.

UNSATURATED AND SATURATED FLOW UNDER ISOTHERMAL CONDITIONS

PATH TO RESOLUTION - HIGH PRIORITY TASKS

- Review TSPA.
- Evaluate conditions necessary to initiate episodic fracture flow through the unsaturated zone.
- Evaluate mechanisms controlling flux through the repository (infiltration, focused recharge, and fracture dominated flow); bound parameters for PA.
- Evaluate dilution due to groundwater mixing in the saturated zone.
- Develop review procedures and acceptance criteria.

THERMAL EFFECTS ON FLOW

SCOPE AND TECHNICAL SIGNIFICANCE

- **Prediction of the thermally driven redistribution of moisture through partially-saturated, fractured porous media caused by the emplacement of heat-generating high-level radioactive waste. Redistribution may result in extended periods of dryness in the repository or significant reflux to the repository.**

THERMAL EFFECTS ON FLOW

SIGNIFICANCE TO PERFORMANCE

- The near-field distribution of temperature, liquid saturation and humidity will influence corrosion of metals and near-field geochemistry. These are key factors in predicting containment within the waste package.

- DOE Waste Isolation Strategy in part relies on long containment times of radionuclides as a basis for waste containment and isolation.

THERMAL EFFECTS ON FLOW

PATH TO RESOLUTION - HIGH PRIORITY TASKS

- Review TSPA.
- Review Peer Review Report on DOE Thermohydrology Modeling and Testing Program (including independent evaluation of data and modeling).
- Evaluate the effect of heating on the perching of water and moisture movement through the repository (i.e., moisture reflux).
- Evaluate the evolution of temperature field for high thermal loadings.
- Evaluate the sufficiency of DOE's in-situ heater test to evaluate hydrologic response to repository thermal conditions.
- Develop review procedures and acceptance criteria.

EVOLUTION OF THE NEAR-FIELD ENVIRONMENT

SCOPE AND TECHNICAL SIGNIFICANCE

- **Evaluation of the evolution of near-field environment including addressing the possible effects resulting from difficulties in sampling and analyzing water in unsaturated media, the transient thermal regime of the near field, uncertainty in fluid fluxes, uncertain thermodynamic and kinetic properties of geologic and engineered materials, and interactions among natural and engineered system components.**

EVOLUTION OF THE NEAR-FIELD ENVIRONMENT

SIGNIFICANCE TO PERFORMANCE

- Groundwater chemistry in the near field exerts a primary control on waste package and waste form alteration, radioelement speciation and solubility, distribution of radioelements among solid (including colloids), liquid, and gas phases, and dissolution and precipitation reactions. Thus, near-field groundwater chemistry controls containment, release, and transport of radionuclides.

EVOLUTION OF THE NEAR-FIELD ENVIRONMENT

PATH TO RESOLUTION - HIGH PRIORITY TASKS

- Evaluate DOE's characterization of saturated and unsaturated zone geochemistries of Yucca Mountain.
  - Compile Yucca Mountain data and analyze for quality and significance.
- Evaluate effects of repository operations, EBS components, man-made materials, rock materials, their alteration products and interactions among these materials.
  - Apply coupled modeling capabilities to develop understanding of water chemistry variations

PATH TO RESOLUTION - HIGH PRIORITY TASKS (continued)

- Evaluate the evolution of the near-field groundwater chemistry due to thermal effects.
  - Apply modeling capabilities to understand mineral alteration and consequent effects on hydraulic properties
- Develop a strategy for validation of near-field geochemistry models to support site-scale and long-term predictions of performance.
  - Analyze the capability of modeling methodologies to represent present and paleothermal conditions of Yucca Mountain.

PATH TO RESOLUTION - HIGH PRIORITY TASKS (continued)

- Support the NRC IPA Phase 3 activities.
  - Develop parameter ranges for evaluations of overall system sensitivity to near-field geochemistry.
- Review DOE TSPA.
- Develop review procedures and acceptance criteria.

RADIONUCLIDE TRANSPORT

SCOPE AND TECHNICAL SIGNIFICANCE

- **Evaluation of processes and conditions affecting transport of radionuclides in a heterogeneous fractured geologic system of variable saturation including the effects of preferential pathways on dilution, sorption, solubility, and speciation.**

RADIONUCLIDE TRANSPORT

SIGNIFICANCE TO PERFORMANCE

- **Heterogeneities in the natural system make it difficult to predict the extent to which geochemical processes and conditions may affect radionuclide transport. Radionuclides must be transported from the repository to the accessible environment for there to be risk to public health and safety.**

RADIONUCLIDE TRANSPORT

PATH TO RESOLUTION - HIGH PRIORITY TASKS

- Review available data from DOE and others on methods and models to describe the site with regard to conditions and processes capable of affecting radionuclide transport in a fractured, variably saturated geologic medium.
- Conduct sensitivity studies to determine how the different parameters in the models affect the results and determine the likely ranges of these parameters which may be encountered at Yucca Mountain.
- Evaluate radionuclide concentrations in the saturated and unsaturated zone.
- Compare results with DOE models and report differences.
- Review DOE TSPA.
- Develop review procedures and acceptance criteria.

TOTAL SYSTEM PERFORMANCE ASSESSMENT AND TECHNICAL INTEGRATION

SCOPE AND TECHNICAL SIGNIFICANCE

- Total system performance assessment (TSPA) incorporates the relevant features, processes, events, uncertainties in parameters, selection of conceptual models, and prediction of future events into an analysis capable of estimating risk to an individual.

- Integration ensures that the key technical issues develop technical support for their resolution and that the transfer of information among program areas will result in demonstrations of compliance that are transparent, adequately supported, and complete.

TOTAL SYSTEM PERFORMANCE ASSESSMENT AND TECHNICAL INTEGRATION

REGULATORY SIGNIFICANCE OF ISSUE

- TSPA is required to demonstrate that the repository complies with a designated standard.
- The proposed performance assessment period (up to one million years) will require that the performance assessment consider combinations of extreme events, coupling of processes, and possible changes to the flow and transport system.
- Such complexities can not be considered only within the subsystem process models; they must be reflected in the modeling from a total system perspective.

TOTAL SYSTEM PERFORMANCE ASSESSMENT AND TECHNICAL INTEGRATION

PATH TO RESOLUTION - HIGH PRIORITY TASKS

- Document prelicensing reviews of DOE TSPA.
- Abstract/integrate process models for undisturbed system into total system model.
- Develop/identify an overall scenario analysis methodology.
- Incorporate revised models for external events into TPA code (Igneous Activity, Faulting/Seismicity, Climate).
- Perform importance analysis (relative importance of parameters, processes, KTUs and KTIs).

SUPPORT REVISION OF THE EPA STANDARD AND NRC HLW RULE

SCOPE

- Assist EPA in developing standard
- Development of NRC regulatory position
- Implementation may impose significant changes to the PA calculation, such as:
  - Calculation of dose (risk) versus cumulative release
  - Calculation of concentration (plume geometry versus time)
  - Determination of exposure scenario (identification of water withdrawal location and amount)
  - Determination of reference biosphere
  - Up to 10^6 years instead of 10^4 years

SUPPORT REVISION OF THE EPA STANDARD AND NRC HLW RULE

RESOLUTION OF KEY TECHNICAL ISSUE

- Interaction with EPA
- Interaction with NRC staff and Commission to develop regulatory positions
- Technical analyses for the following factors:
  - Dilution: What are the processes within the saturated zone that most influence dilution of releases?
  - Exposure Scenario: What are the key assumptions with respect to exposure scenarios that should be included in an implementable definition of a reference biosphere?
  - Peak Dose: What are the important characteristics (variation of dose over long times, important radionuclides, sensitive parameters) of the estimate of peak dose?

RESOLUTION OF KEY TECHNICAL ISSUE (continued)

- **Disruptive Events: How do disruptive events alter the timing and character of peak dose estimates relative to the undisturbed case?**

- **Human Intrusion: How should the stylized calculation for human intrusion be constrained?**

CORRELATION OF NRC KEY TECHNICAL ISSUES

AND

KEY TECHNICAL UNCERTAINTIES

November 15, 1995

PRIORITY OF NRC KEY TECHNICAL ISSUES

Priority 1	Priority 2	Priority 3
Support Revision of EPA Stand./NRC Rule	Container Life and Source Term	Radionuclide Transport
TSPA and Technical Integration	Structural Deformation and Seismicity	Repository Design and Thermal-Mechanical Effects
Igneous Activity	Evolution of Near-Field Environment	
Unsaturated and Saturated Flow Under Isothermal Cond.		
Thermal Effects on Flow		

Key Technical Issue - Support Revision of the EPA Standard and NRC Rule
Key Technical Uncertainties: None

Key Technical Issue - Total System Performance Assessment and Technical Integration

Key Technical Uncertainties:

- Conceptual model representations of the natural and engineered system (Type 4)
- Variability in Model parametric values (Type 4)
- Appropriateness of assumptions and simplifications in mathematical models (Type 4)
- Validation of mathematical models (Type 5)
- Prediction of Future System States (Type 5)

Key Technical Issue — Igneous Activity

Key Technical Uncertainties:

- Low resolution of exploration techniques to detect and evaluate igneous features (Type 4)
- Inability to sample igneous features (Type 5)
- Development and use of conceptual tectonic models as related to igneous activity (Type 5)
- New: Probability of igneous activity and resulting disruption of the candidate repository (Type 5)
- New: Consequences of igneous activity for repository performance (Type 5)
- Conceptual model representations of the natural and engineered systems (Type 4)
- Variability in model parametric values (Type 4)
- Appropriateness of assumptions and simplification in mathematical models (Type 4)
- Prediction of future system states (Type 5)

Key Technical Issue – Unsaturated and Saturated Flow Under Isothermal Conditions

Key Technical Uncertainties:

- Modeling groundwater flow through unsaturated fractured rock caused by the lack of codes tested against field and laboratory data (Type 4)
- Identifying which conceptual models adequately represent isothermal and nonisothermal liquid and vapor phase movement of water through unsaturated fractured rock at YM (Type 4)
- Uncertainties associated with determining characterization parameters (Type 4)
- Developing a conceptual groundwater flow model that is representative of the YM site groundwater flow system (Type 4)
- Experimental confirmation of the basic physical concepts of groundwater flow through unsaturated fractured rock is needed (Type 5)
- Development of new data collection and interpretation techniques are required for codes which model groundwater flow through unsaturated fractured rock (Type 5)
- Conceptual model representations of the natural and engineered systems (Type 4)
- Variability in model parametric values (Type 4)
- Appropriateness of assumptions and simplification in mathematical models (Type 4)
- Prediction of future system states (Type 5)
- Adverse effects of future groundwater withdrawals on the groundwater flow system (Type 4)
- Understanding the cause of the large hydraulic gradient located north of Yucca Mountain and potential for tectonic disruption of fault-related barriers (Type 4)
- Developing a mathematical groundwater flow model that is representative of the Yucca Mountain site groundwater flow system (Type 5)

Key Technical Issue — Thermal Effects on Flow

Key Technical Uncertainties:

- Identifying which conceptual models adequately represent isothermal and nonisothermal liquid and vapor phase movement of water through unsaturated fractured rock at YM (Type 4)
- Prediction of the TMHC responses of the host rock, surrounding strata, and groundwater system to thermal loads (Type 4)
- Prediction of the thermal, mechanical, and hydrological impact on the host rock surrounding the waste package (Type 4)
- Modeling the formation of perched zones by thermally driven flow (Type 5)
- Prediction of future changes to the hydrologic system resulting from a combination of climatic and tectonic changes and human activities (including heat effects from waste emplacement) (Type 5)

Key Technical Issue — Container Life and Source Term

Key Technical Uncertainties:

- Prediction of thermomechanical effects on the waste package and the EBS (Type 4)
- Prediction of environmental effects on the waste package and the EBS (Type 4)
- Prediction of criticality events in waste packages (Type 4)
- Prediction of release path parameters (such as the size, shape, and distribution of penetrations of waste packages) due to thermomechanical, environmental, or criticality effects (Type 4)
- Prediction of the releases of gaseous radionuclides from waste packages during the containment period and from the EBS during the post-containment period (Type 4)
- Prediction of the releases of non-gaseous radionuclides from waste packages during the containment period and from the EBS during the post-containment period (Type 4)
- Extrapolation of short-term laboratory and prototype test results to predict long-term performance of waste packages and EBS (Type 5)
- Understanding/predicting the effect of groundwater conditions on dissolution of waste form (Type 4)
- Identifying geochemical processes that adversely affect the EBS (Type 4)
- Determining the magnitude of the effect of the geochemical processes that adversely affect the EBS (Type 5)
- Understanding the effects of groundwater conditions on mode and rate of waste package corrosion (Type 4)

Key Technical Issue — Structural Deformation and Seismicity

Key Technical Uncertainties:

- Development and use of conceptual tectonic models as related to structural deformation (Type 5)
- Poor resolution of exploration techniques to detect and evaluate structural features (Type 4)
- Evaluation of faulting mechanisms in alluvium (Type 5)
- Inability to predict the likelihood of earthquake occurrence during the next 10,000 years (Type 4)
- Correlation of earthquakes with tectonic features (Type 5)
- Migrating seismicity between fault systems in the Basin and Range Tectonic Province (Type 5)
- Uncertainty in fault plane solutions (Type 5)
- Understanding the cause of the large hydraulic gradient located north of Yucca Mountain and potential for tectonic disruption of fault-related barriers (Type 4)

Key Technical Issue — Evolution of the Near-Field Environment

Key Technical Uncertainties:

- Prediction of the evolution of groundwater conditions near and within the EBS (Type 5)
- Prediction of the TMHC responses of the host rock, surrounding strata, and groundwater system to thermal loads (Type 4)
- Prediction of the thermal, mechanical, and hydrological impact on the host rock surrounding the waste package (Type 4)
- Determining the alteration of mineral assemblages due to thermal loading (Type 4)
- Identifying geochemical processes that adversely affect the EBS (Type 4)
- Determining the magnitude of the effect of the geochemical processes that adversely affect the EBS (Type 5)
- Characterizing the chemistry in the partially-saturated hydrologic zone of Yucca Mountain, Nevada (Type 4)
- Conceptual model representations of the natural and engineered systems (Type 4)
- Variability in model parametric values (Type 4)
- Appropriateness of assumptions and simplification in mathematical models (Type 4)
- Validation of mathematical models (Type 5)

Key Technical Issue — Radionuclide Transport

Key Technical Uncertainties:

- Equal or increased capacity of alteration mineral assemblages to inhibit radionuclide migration (Type 4)
- Characterizing the chemistry of the groundwater in the partially-saturated hydrologic zone of Yucca Mountain, Nevada (Type 4)
- Understanding the effects of degree of saturation on geochemical processes such as radionuclide sorption and precipitation and formation of particulates and colloids, and on the transport of radionuclides by particulates, colloids and complexes (Type 4)
- Parametric representation of retardation processes involving radionuclide-bearing particulates, colloids, and complexes (Type 4)
- Determining the alteration of mineral assemblages due to thermal loading (Type 4)
- Identifying geochemical processes that reduce radionuclide "retardation" (Type 4)
- Determining the magnitude of the effect of the geochemical processes that reduce radionuclide "retardation" (Type 5)
- Identifying geochemical conditions that would inhibit particulate and colloid formation (Type 4)
- Prediction of the evolution of groundwater conditions near and within the EBS (Type 5)
- Volatility and stability of chemical species of radionuclides (Type 4)
- Gas flow and gaseous radionuclide transport (Type 4)
- Conceptual model representations of the natural and engineered systems (Type 4)
- Variability in model parametric values (Type 4)
- Identifying geochemical processes that adversely affect the EBS (Type 4)
- Determining the magnitude of the effect of the geochemical processes that adversely affect the EBS (Type 5)
- Appropriateness of assumptions and simplification in mathematical models (Type 4)
- Validation of mathematical models (Type 5)
- Prediction of future system states (i.e., disruptive scenarios) (Type 5)

Key Technical Issue — Repository Design and Thermal-Mechanical Effects

Key Technical Uncertainties:

- Prediction of the TMHC responses of the host rock, surrounding strata, and groundwater system to thermal loads (Type 4)
- Prediction of the thermal, mechanical, and hydrological impact on the host rock surrounding the waste package (Type 4)
- Prediction of thermomechanical effects on the performance of waste packages and the EBS (Type 4)
- Predicting the long term performance of seals for shafts, ramps, and boreholes (Type 4)
- Predicting the long term performance of seals for the underground test boreholes (Type 4)
- Demonstration of compliance with the requirement to maintain the ability to safely retrieve HLW (Type 4)

YUCCA
MOUNTAIN
PROJECT

Studies

DOE/NRC Technical Exchange on Key Issues for a Geologic Repository at Yucca Mountain

November 17, 1995

U.S. Department of Energy
Office of Civilian Radioactive
Waste Management

Overview of DOE Presentations

- Perception of Key Technical Issues, S. J. Brocoum, Assistant Manager for Suitability and Licensing
- Waste Containment and Isolation Strategy for the Yucca mountain Site, J. L. Younker, M&O
- Significant Site and Design Issues Identified in TSPA of Yucca Mountain, A. Van Luik, DOE Team Leader for Technical Synthesis Team

YUCCA
MOUNTAIN
PROJECT

Studies

DOE Perception of Key Technical Issues

Presented to:
DOE/NRC Technical Exchange

Presented by:
Dr. Stephan J. Brocoum
Assistant Manager, Suitability and Licensing
Yucca Mountain Site Characterization Office

November 17, 1995

U.S. Department of Energy
Office of Civilian Radioactive
Waste Management

Outline

- Background
- Future Licensing Approach
- Interactions with NRC - General
- Interactions with NRC - Specific
- Summary

Background

- Message from Congress
  - The OCRWM Program will not be funded at the level assumed in the Program Plan
  - For FY 1996: 630M vs 315 M (Program)
    474M vs 250M (YMP)
- Funding targets for Yucca Mountain will not support concurrent development of suitability, NEPA, and licensing products
- Yucca Mountain Project has been refocused to support an Investment Analysis by 1999

Background
(Continued)

- Investment Analysis mission:
  - Complete a repository disposal system design sufficient for evaluation of performance and cost of development
- Key elements of Investment Analysis:
  - Repository and waste package design (including concept of operations)
  - Total system performance assessment
  - Plan for License Application/EIS development
  - MGDS Total System Life Cycle Cost
- Investment Analysis program relies on TSPA to identify key technical uncertainties/issues in order to focus site characterization

Future Licensing Approach

- DOE will develop a license application that satisfies the intent of the Nuclear Waste Policy Act, as amended, and complies with 10 CFR 60
  - The technical components of the licensing approach are contained in the evolving Waste Isolation Strategy
  - TSPA is an important element in the implementation of this strategy
- In the license application, DOE will demonstrate, consistent with the reasonable assurance standard, that the repository design and its geologic setting will protect public health and safety, and the environment
- EPA/NRC rulemakings in response to Energy Policy Act may change regulatory framework

Interactions with NRC - General

- DOE will continue to inform the NRC of our plans, as they are further developed
- Because of limited resources, we need to ensure that:
  - Future interactions are focused on resolving issues
  - We concentrate on those that are most important
  - We can demonstrate that progress is being made

Interactions with NRC - Specific

- In FY 1996, DOE will:
  - Produce Semi-annual Site Characterization Progress Reports
  - Submit Chapter 10 of the LA AO for NRC review
  - Submit a supplemental response for the Erosion Topical Report regarding BE-10 sample dating
  - Submit a response to NRC staff questions regarding Seismic Topical Report I
  - Submitted to NRC Seismic Topical Report II
  - Conduct quarterly DOE-NRC Technical Meetings on ESF, Management Meetings, and a limited amount of focused Technical Exchanges
  - Conduct bi-weekly Project Manager meetings with the NRC On-site Representatives

Interactions with NRC - Specific

(Continued)

- Under the current Program direction and funding, DOE will not be able to support:
  - Additional revisions to the LA AO beyond Revision 0
  - Additional topical report submittals
  - Submittals to obtain SCA open item closure
  - High level of support to NRC for Vertical Slice activities for those items we believe are important
- DOE will not develop:
  - Technical Basis Reports
  - Guideline Compliance Assessments/Higher-Level Findings
  - Technical Site Suitability Evaluation

Summary

- The Yucca Mountain Project is now focused on supporting an Investment Analysis
- Activities supporting LA and EIS are deferred
- Because interactions with NRC will be minimal, interactions need to be focused on resolving key issues
- Therefore, we have to make sure we focus our collective resources on a consistent set of key technical uncertainties/issues
- DOE is using the Waste Isolation Strategy and TSPA for identification of key technical uncertainties/issues

YUCCA
MOUNTAIN
PROJECT

Studies

Key Technical Issues Derived From Waste Containment and Isolation Strategy

Presented to:
DOE-NRC Technical Exchange

Presented by:
Dr. Jean L. Younker
Operations Manager, Suitability and Licensing
Management and Operating Contractor

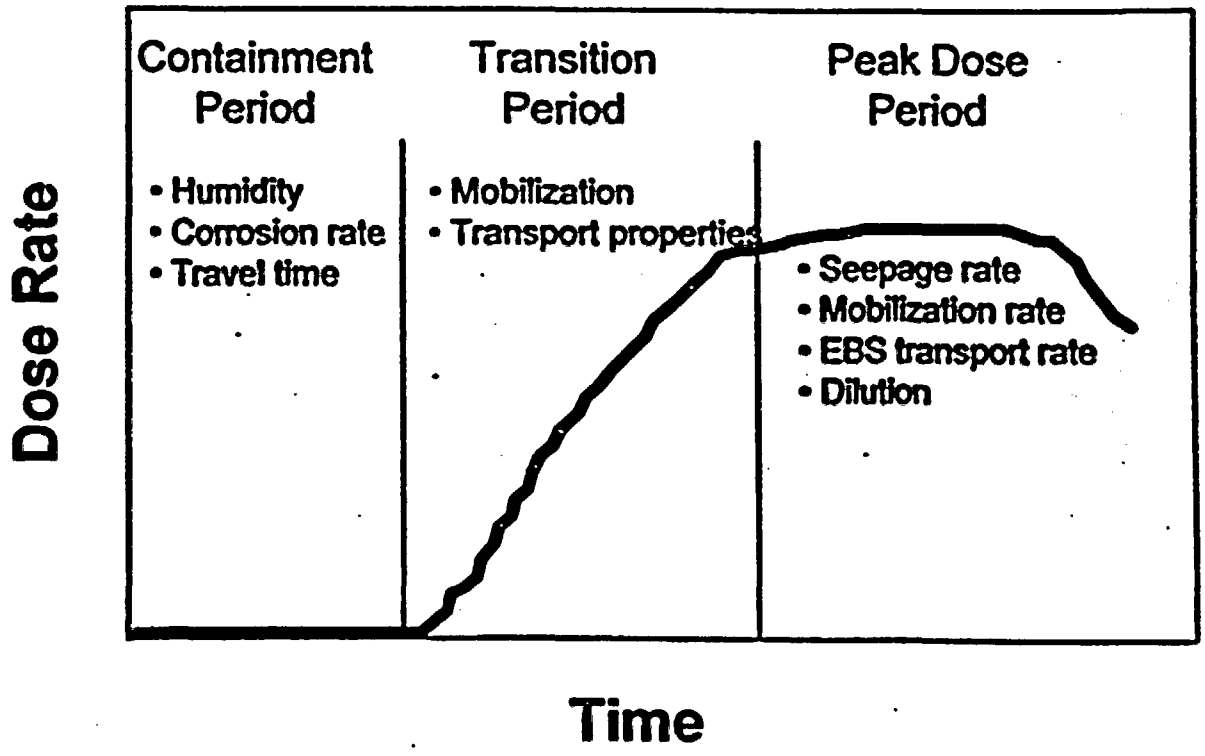
November 17, 1995

U.S. Department of Energy
Office of Civilian Radioactive
Waste Management

Strategy Focuses on Two Objectives

- Limit annual dose to member of the general public
  - Strategy describes how seepage in emplacement drifts, containment time, waste mobilization rates, effectiveness of engineered barriers, and dilution will be tested
- Containment of waste for thousands of years during high-inventory/high-temperature period
  - Strategy describes how dry conditions in the repository and low container corrosion rates will be tested

Key Attributes Affecting Performance



Hypotheses For This Strategy

1. Seepage contacting waste will be low
2. Dry conditions will lead to containment for thousands of years
3. Waste mobilization rates will be low
4. Engineered barriers will limit rate of release to a low value
5. Concentrations will be strongly diluted during transport in natural barriers

Cross-Cutting Issues

- Impacts of climate change on hydrology are covered in hypotheses and associated testing and modeling
- Effects of heat are addressed by thermal testing and modeling
- Potential effects of disruptive processes and events are also addressed
  - Tectonics and seismicity
  - Volcanism
  - Human interference

Hypothesis 1--Seepage Into Drifts
Work Needed To Test Hypothesis

- Synthesis of existing borehole data
- Observations in ESF
  - Inflow rates
  - Moisture content of near-field rock
  - Humidity in drift and host rock
- Large-scale and small-scale flow modeling (e.g., effects of heterogeneity, climate, thermal effects)
- Modeling to determine conditions under which seepage would be too high

Hypothesis 2--Containment
Work Needed To Test Hypothesis

- Represent environments
  - Observe amount and chemistry of water in ESF
  - Measure possible effect of backfills on humidity
  - Thermohydrologic testing and modeling
- Determine corrosion mechanisms/rates at low humidity
- Establish role of cathodic protection

Hypothesis 3--Waste Mobilization

Work Needed To Test Hypothesis

- Refine Neptunium solubility data
- Determine effect of radiation and chemistry on waste form dissolution
- Assess effect of containment on waste form alteration (e.g., oxidation of UO_2)
- Determine stability of colloids

Hypothesis 4--EBS Transport
Work Needed To Test Hypothesis

- Assess transport characteristics of the waste package
- Determine flow and evaporation characteristics of backfill
- Evaluate transport properties of backfill

Hypothesis 5--Dilution During Transport in Natural Barriers

Work Needed To Test Hypothesis

- Determine dispersiveness of local flow system
- Model saturated zone flow system
- Estimate range of scaling effects by analyses using different transport models

Summary

- Strategy is based on the work conducted to date
- We have identified the critical issues and defined how to resolve them
- Strategy calls for significant change in emphasis and provides a basis for estimating the needed work
- Focused efforts could resolve the key issues at a reasonable cost to support near-term milestones

YUCCA
MOUNTAIN
PROJECT

Studies

Significant Site and Design Issues Identified in Total System Performance Assessments of Yucca Mountain

Presented to:
DOE/NRC Technical Exchange

Presented by:
Dr. Abraham Van Luik
Team Leader
Yucca Mountain Site Characterization Office

November 17, 1995

U.S. Department of Energy
Office of Civilian Radioactive
Waste Management

Outline of Presentation

- Philosophy/general objectives of TSPA
- Disruptive events and their consequences
- Importance of components as a function of time
- Key technical uncertainties for TSPA
- PA view of NRC Key Technical Uncertainties

TSPA Philosophy/General Objectives

- Focus on system components significant to performance, as shown in previous analyses
- Incorporate processes which may potentially affect performance
- Be "representative" as information allows or "bounding/conservative" where less is known
- Incorporate uncertainty and variability explicitly
- Evaluate current understanding & uncertainty on different performance measures
- Provide input to assist in prioritizing site characterization and design efforts

Disruptive Events Evaluated

- Direct & indirect effects of volcanism
- Limited seismic effects
- Human intrusion
- Climate change*
- Erosion**

* Considered likely and included in nominal case
** Not considered a significant disruptive event

PA Conclusions Regarding Volcanic Disruptive Events

- Volcanic effects had no significant performance consequences (in terms of EPA's 40 CFR 191)
- Direct effects (waste entrainment in magma) and indirect effects (heat and corrosive fluids) have been considered
- For longer timeframes, significance increased because of the higher likelihood of a simulation including a volcanic event

PA Conclusions Regarding Seismic Disruptive Events

- Seismically induced water table height changes had no significant performance consequences (in terms of EPA's 40 CFR 191)

- Enhancements of the source-term through selective damaging of waste containers had little impact on performance

PA Conclusions Regarding Human Intrusion Disruptive Events

- Multiple-event human intrusion enhancements of aqueous releases had no significant performance consequences (in terms of EPA's 40 CFR 191)
- Relatively high localized doses are possible for the driller (waste on ground surface) and for a hypothetical person subsequently living on the drilling site (this result is relatively independent of site properties)
- Calculations beyond 10,000 years suggested that there continued to be a gradual enhancement of aqueous releases as intrusion-events multiplied

PA Conclusions Regarding Climate Changes

- Climate changes are assumed to occur as part of the nominal TSPA case
- Climate changes directly affect unsaturated zone infiltration rates in TSPAs
- The linkage between surficial infiltration rates and deep percolation has not yet been satisfactorily established
- Unsaturated zone flux has repeatedly been shown to be a dominant determinant of cumulative release and dose
- Increases in saturated zone flux decrease the calculated dose

PA Conclusions Regarding Erosion Disruptive Events

- Erosion has not been addressed in a DOE TSPA because it has not been deemed a credible disruptive scenario

- Removal of meters of the mountain surface would not affect the nature of the Paintbrush/Topopah Spring units interface, which controls the movement of water into the potential repository horizon

Previous Disruptive Event Analyses and Current PA Work

- Previous disruptive event analyses have suggested their performance consequences are not likely to be significant
- Minor efforts may continue to address additional aspects of selected disruptive event scenarios
- The main focus of current PA/TSPA work is evaluating the undisrupted performance of the engineered system within the site

Components Evaluated in TSPA-1995

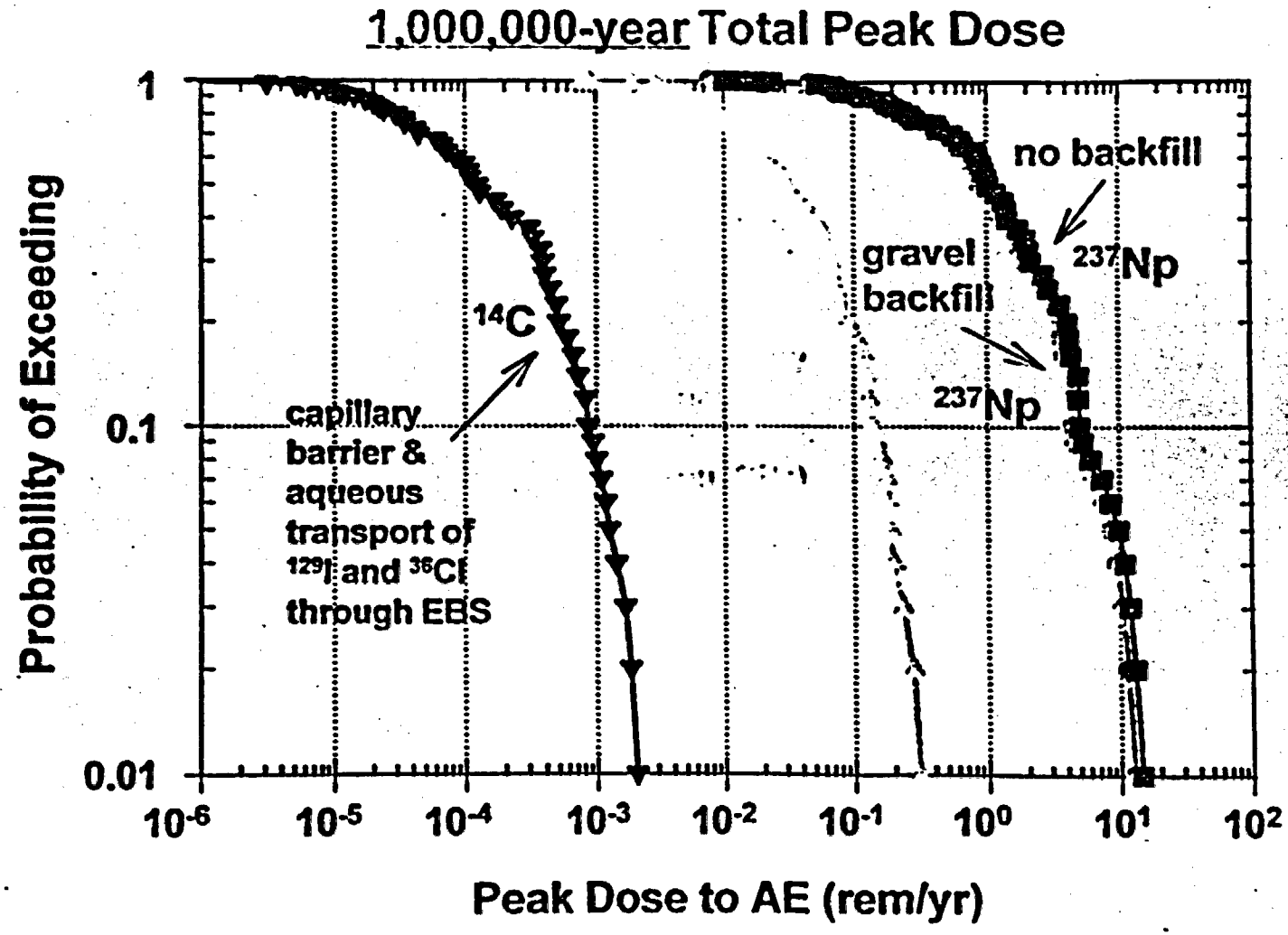
- Alternative drift-scale thermo-hydrologic environments
- Alternative waste package degradation models in humid air and aqueous environments (includes degradation vs time)
- Alternative percolation flux distributions intercepting repository drifts
- Alternative drift-scale aqueous transport models
- Alternative unsaturated zone percolation flux distribution (and transport) between fractures and matrix

Important TSPA Components vs Time

- 10,000 years
  - near field environment (esp. thermo-hydrology)
  - waste package degradation model
  - percolation flux distribution
  - dispersive effects in the unsaturated zone
- 1,000,000 years
  - near field environment (esp. hydrology)
  - Neptunium solubility
  - percolation flux distribution
  - dispersive/mixing effects in the saturated zone

Alternate Backfill/Barriers in Near Field

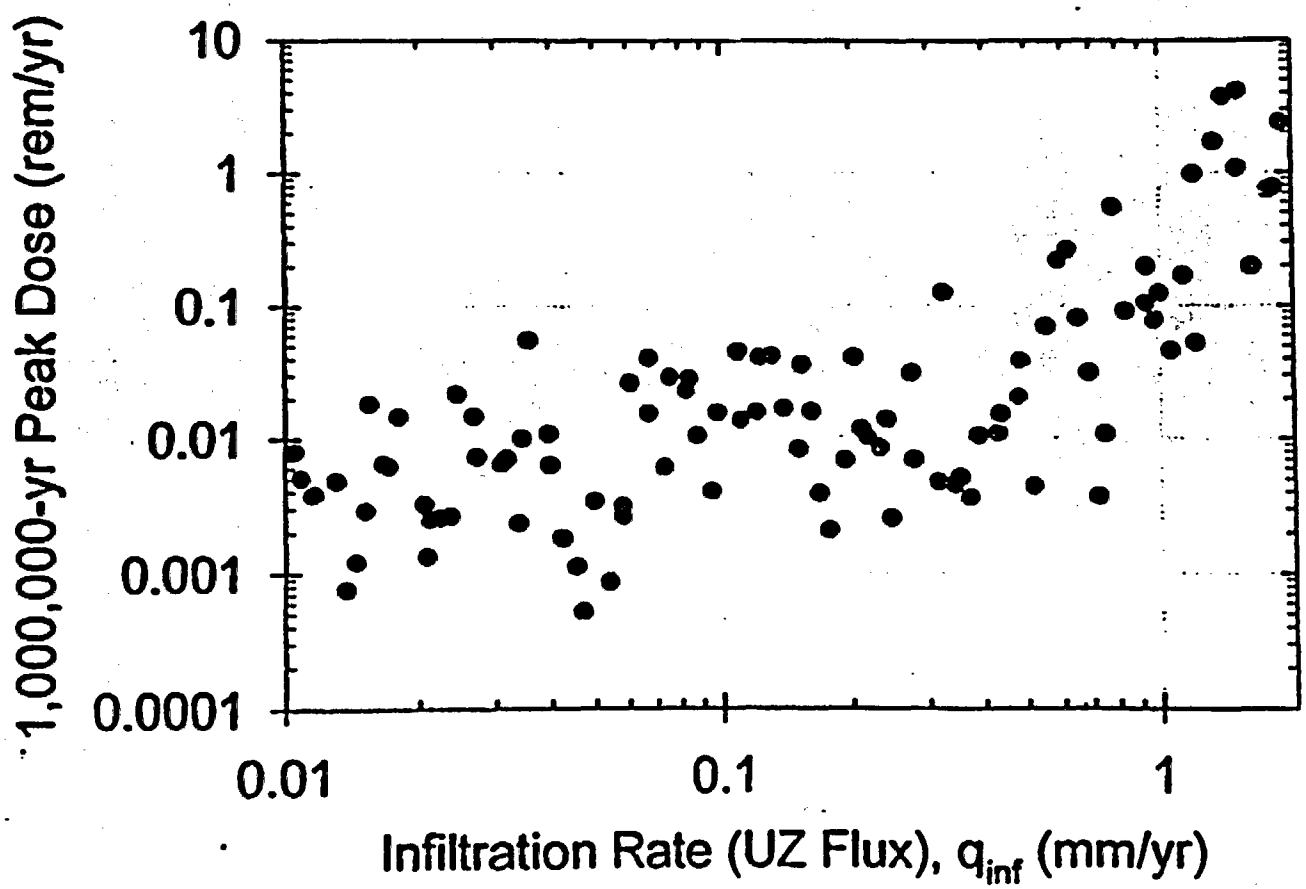
(83 MTU/acre, high q_{inf}=0.5-2.0 mm/yr, climatic variation of q_{inf})



Sensitivity of 1,000,000-year Total Peak Dose to Infiltration-rate distribution, q_{inf}

(83 MTU/acre, gravel backfill, climatic variation of q_{inf})

Entire q_{inf} range (0.01 - 2.0 mm/yr)



Information Needed to Enhance Representativeness
(TSPA Key Uncertainties)

	10,000 Years	1,000,000 Years
• Unsaturated zone percolation flux at repository horizon (as function of time)	++	++
• Backfill thermo-hydrologic characteristics	++	+
• Humidity in near field environment	++	
• Cathodic protection of corrosion resistant material	++	+
• Stability & mobility of colloids	+	++
• Neptunium solubility		++
• Mixing/dispersive effects in saturated zone	++	++
• Representative biosphere(s)	+	++

+ Potentially Significant + + Potentially Very Significant

PA Perspective on NRC Key Technical Issues

	Addressed in TSPA	Significant to TSPA
• Igneous activity	✓	-
• Structural deformation and seismicity	✓	-
• Hydrologic characterization of structural features which significantly affect water and vapor movement	✓	+
• Thermal effects and redistribution of moisture	✓	+
• Thermal-mechanical-hydrological-chemical coupled processes	0	

✓ Addressed 0 Not Addressed

+ Significant - Not Significant

PA Perspective on NRC Key Technical Issues

(Continued)

	Addressed in TSPA	Significant to TSPA
• Evolution of groundwater in the near-field environment	0	
• Waste package degradation	✓	+
• Geochemical effects on radionuclide transport within and beyond the thermally affected zone	✓	+/-
• Methods of assigning probability to and estimating the consequences of disruptive scenarios	✓	-
• Exploratory Studies Facility	0	
• Performance Assessment	✓	+

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 10, 1996

Mr. Ronald A. Milner, Director
for Program Management and Integration
Office of Civilian Radioactive Waste Management
U.S. Department of Energy, RW 30
1000 Independence Avenue, S.W.
Washington, D.C. 20585

SUBJECT: MINUTES OF THE NOVEMBER 17, 1995, TECHNICAL EXCHANGE ON KEY ISSUES FOR A GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN

Dear Mr. Milner:

Enclosed are the minutes of the U.S. Nuclear Regulatory Commission - U.S. Department of Energy (DOE) key issues technical exchange that was held on November 17, 1995, by videoconfeence between DOE contractor facilities in Las Vegas, Nevada, and Washington, D.C., as part of a continuing series of interactions between NRC and DOE.

Other organizations represented at the technical exchange were the State of Nevada; Nye County, Nevada; the Nuclear Waste Technical Review Board; the U.S. Geological Survey; Nuclear Energy Institute; DOE's Management and Operating Contractor; and NRC's Center for Nuclear Waste Regulatory Analyses.

If you have any questions regarding these minutes, please contact Robert Johnson of my staff. He can be reached at 301-415-7282.

Sincerely,

John O. Thoma for

John H. Austin, Chief
Performance Assessment and High Level
Waste Integration Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As Stated

cc: See attached list

CC List for letter to R. Milner dated: June 10, 1996

cc: C. Johnson, State of Nevada
J. Meder, Nevada Legislative Counsel Bureau
M. Murphy, Nye County, NV
M. Baughman, Lincoln County, NV
D. Bechtel, Clark County, NV
P. Niedzielski-Eichner, Nye County, NV
B. Mettam, Inyo County, CA
V. Poe, Mineral County, NV
W. Cameron, White Pine County, NV
R. Williams, Lander County, NV
L. Fiorenzi, Eureka County, NV
J. Hoffman, Esmeralda County, NV
C. Schank, Churchill County, NV
L. Bradshaw, Nye County, NV
W. Barnard, NWTRB
R. Holden, NCAI
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S. Brocoum, YMPO
R. Arnold, Pahrump, NV
N. Stellavato, Nye County, NV
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D. Horton, YMPO
F. Rodgers, DOE/Wash, DC