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

April 22, 1998

MEMORANDUM TO: N. King Stablein, Acting Chief
ENGB/DWM/NMSS

THRU: Richard M. Weller, Section Leader
Engineering and Material Section
ENGB/DWM/NMSS

FROM: Mysore Nataraja, Sr. Geotechnical Engineer
Daniel Rom, Geotechnical Engineer
Engineering and Material Section
ENGB/DWM/NMSS

SUBJECT: TRIP REPORT - VISIT TO CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES, SAN ANTONIO, TEXAS, APRIL 7-8, 1998

On April 7 and 8, 1998, M. Nataraja and D. Rom met with members of the Center for Nuclear Waste Regulatory Analyses (CNWRA) in San Antonio, Texas, to discuss a number of topics related to Repository Design and Thermal-Mechanical Effects Key Technical Issue (KTI). M. Nataraja, who participated in the Probabilistic Seismic Hazard Analysis (PSHA) Final Results Meeting, which was held in Las Vegas, Nevada, earlier the same week, summarized the events of the PSHA Meeting.

Participating CNWRA staff included A. Chowdhury, S. Hsiung, A. Ghosh, G. Ofoegbu, and R. Chen. The topics discussed by the U.S. Nuclear Regulatory Commission and CNWRA staff included the following:

1. Briefing on the PSHA meeting of April 6 and its implications. (Nataraja)

2. Summary of references to Viability Assessment (VA) Design, obtained during our Appendix-7 Meeting. (CNWRA staff, Rom)

3. a) Summary of Reference Documents on DOE Thermal studies obtained during Appendix 7 Meeting. (Chen)

   b) Summary of CNWRA Reports on thermal studies to date. (Chen)

4. Current work in progress on thermo-mechanical (TM) subissue. (Hsiung, Ofoegbu, Chen, Ghosh)

CONTACT: M. Nataraja, ENGB (6695)
D. Rom, ENGB (6704)

5. Inputs to Issue Resolution Status Report (IRSR) Rev-1. (Nataraja, Chowdhury)

6. Plans for VA Review. (Nataraja, Chowdhury)

7. Plans for TR-3 Review. (Nataraja, Chowdhury)

8. Past, Present, and Future of Seismo Module. (Hsiung)

9. Identification of potential audits/surveillance and observation during FY1998.

10. Generic discussions on budget/schedule and interactions with other KTIs

M. Nataraja distributed copies of R.W. Barnard's (Sandia National Laboratory) presentation on "Seismic-Disturbance Calculations for TSPA-VA" of April 6, 1998, and discussed the findings with the group. The scenarios that were discussed included: a) rockfall; b) faulting; c) alterations of groundwater flow; and d) water-table rise. A copy of this handout is attached. The major disturbance expected to affect waste packages (WPs) was determined to be rockfall. Also, hydraulic conductivity of the mass, as affected by rockfall, was discussed. The Wernicke findings were also discussed at the meeting.

D. Rom discussed some of his initial responses to his review of the draft references to the VA Design. Individual CNWRA staff then discussed their reviews of individual volumes of the draft references to VA Design. It was the staff's impression that the documents are sufficiently general to cover the multitude of design options still under consideration. The design will require further refinements as the scope of work becomes better defined.

A great deal of discussion centered on the status of thermal studies and thermo-mechanical sub-issues. CNWRA staff summarized the modeling studies that are being conducted to analyze drift-scale and repository-scale TM problems.

It was decided to make every attempt to meet the current deadline of May, 1998, to develop the first draft of inputs to the IRSR, Rev-1. All the work done under the SEISMO module to date would be summarized under section 4.3 of the IRSR.

Nominal discussion was held regarding VA review and plans for TR-3 review. Additional information should be forthcoming later this year.

A substantial amount of time was spent discussing the SEISMO issue. The bases for the code were discussed, and it became apparent that additional modifications may be required to refine the model. Some possible modifications were proposed, including WP stiffness, a cylinder vs. sphere model, and variation of parameters due to heat. It was decided that CNWRA would provide a list of potential code modifications that could be incorporated. D. Rom would receive the necessary training to exercise the code and conduct seismic analyses.

Potential quality assurance audits, surveillances, and observations for FY1998 were discussed, and budgeting issues were examined.

In summary, all of the planned topics were reviewed in the course of the 2-day meeting. The relevance of the SEISMO code with respect to quantifying the rockfall hazard emerged as a focal point of the meeting. Further refinements to the code and additional modeling should be priority items.

Attachment: As stated

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(10)

Seismic-Disturbance Calculations for TSPA-VA

R. W. Barnard

Sandia National Laboratories

Albuquerque, NM 87185

rwbarna@sandia.gov

Introduction

- Philosophy of TSPA analyses
  - to present comprehensive picture of future behavior of repository system
  - guided by scenarios that distinguish between the nominal behavior and disturbances
    - scenario analyses allow us to assign probabilities to likelihood of occurrence of disturbances and to risks of those events
    - probability estimates for disturbed scenarios are developed from probabilities of input data and models
- Disturbed scenarios vs nominal conditions
  - initiator is an event (earthquake, volcano, etc.)
  - assumed to be of low probability (~10^{-7} — 10^{-8} per year)
    - disturbed scenarios do not include expected changes, such as climate

Overview of Disturbed Scenarios

- Rockfall
- Faulting
  - outside repository
  - in repository
- Alterations of groundwater flow near repository
- Water-table rise

Rockfall Analyses

- Initiating event or process
  - thermo-mechanical
  - seismic
- Consequences (effect of rockfall)
  - waste-package damage
    - susceptibility of waste package to damage
    - sizes of rocks that can fall
- Performance measures
  - increase in radionuclide source term
  - incorporation into base-case flow analyses

Analysis Approach for Thermo-Mechanical Rockfall

- Based on modeling by John Kemeny (U of AZ)
  - temperature changes cause stresses that can cause spalling and rockfall
  - principal stress rotates from vertical to horizontal at high temperatures
  - stress changes cause spalling and rockfall
  - degree of spalling depends on rock quality and temperature
    - rock quality is measure of number of fractures in samples
      - high rock quality -> few fractures, but bigger rocks
      - low rock quality -> many fractures, but small pieces
- Analyses for TSPA-VA will use current site data and PSHA results

Preliminary Analyses of Thermo-Mechanical Rockfall

- Thermal spalling is greatest at time of peak temperature (~100 years in this analysis)
  - high-quality rock has only minor spalling (<10% chance of rockfall)
  - low-quality rock fills drift with rubble (~80% chance of rockfall)
- Data used for Example analyses:

Material Type	RQD Range	Probability
Strong	85 – 100	0.10
Medium	25 – 85	0.70
Weak	14 – 25	0.16
Very Weak	0 – 14	0.04

Analysis Approach for Seismically Induced Rockfall

- Evaluate three factors (analysis is time dependent)
  - probability of rocks falling
  - condition of waste package
  - sizes of available rocks that can fall
- Probability analysis is based on empirical work by Kaiser et al. (1992)
  - inputs are Peak Ground Velocity and tunnel stability descriptors
    - (rock wall quality, failure potential, local mining stiffness, support effectiveness)
    - probability is incorporated from PGV curves for annual exceedence at various velocities
  - results presented as a damage function ranging from no damage to significant

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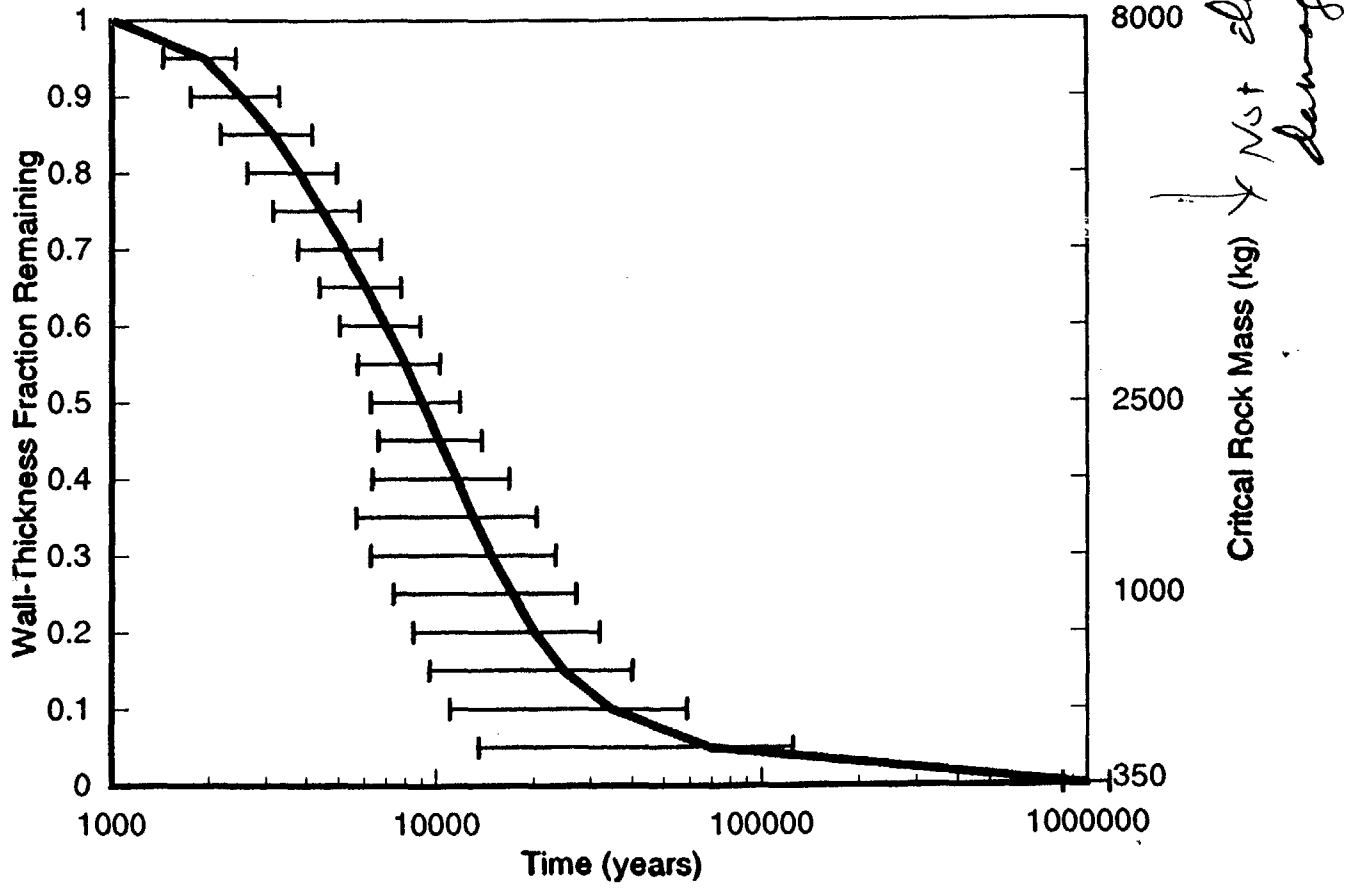
Analysis Approach for Seismically Induced Rockfall (Continued)

38,000 KG Rock required to split open

- Waste-package degradation determines the minimum size rock that can damage a waste package
  - expressed as a function of time



Not able damage

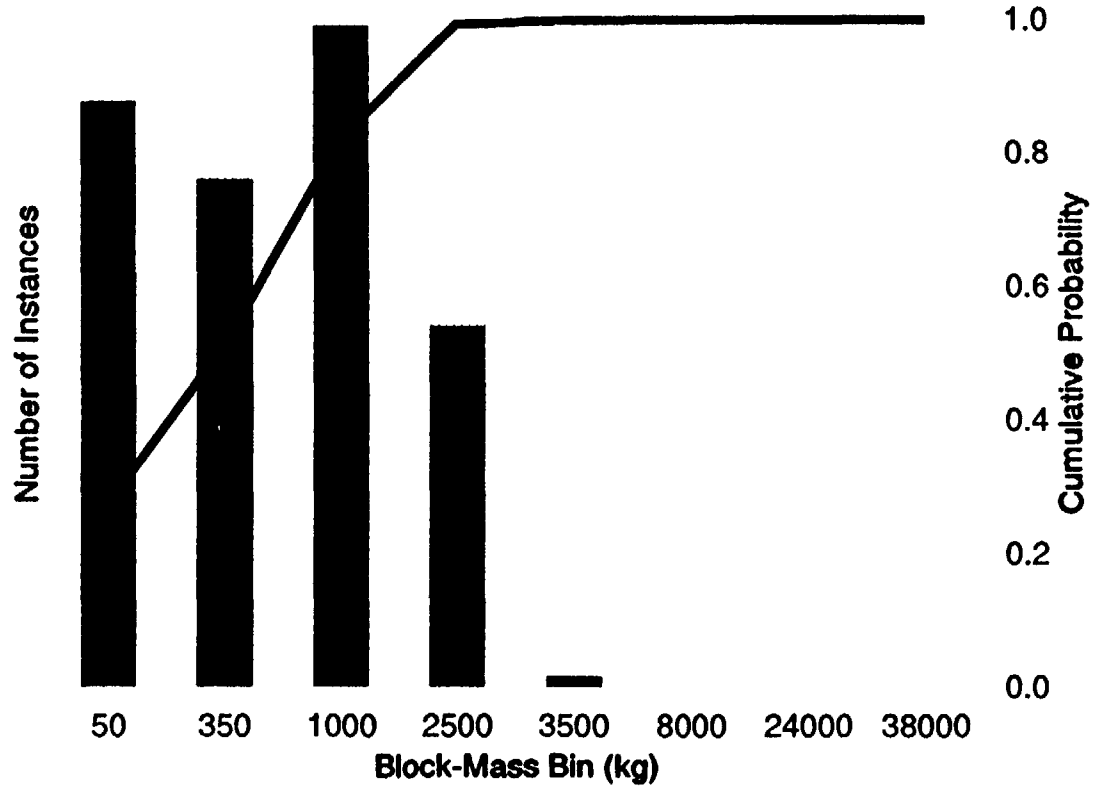
Preliminary Results of Seismic Rockfall Analyses

- (Example calculations for probability did not use ESF rock-size data)

Rock Quality	Maximum Rock Size	Probability of Falling	
		in first 1000 years	after 1000 years
Strong	.86 M 1200 Kg 0.5 m 300 Kg York	0.01	0.0
Medium	0.2 m	0.14	0.07
Weak	0.1 m	0.064	0.032
Very Weak	0.075 m	0.032	0.032
(no rockfall)	—	0.754	0.866

Analysis Approach for Seismically Induced Rockfall (Continued)

- Potential rock sizes derived from ESF data



Key Block Joint Survey

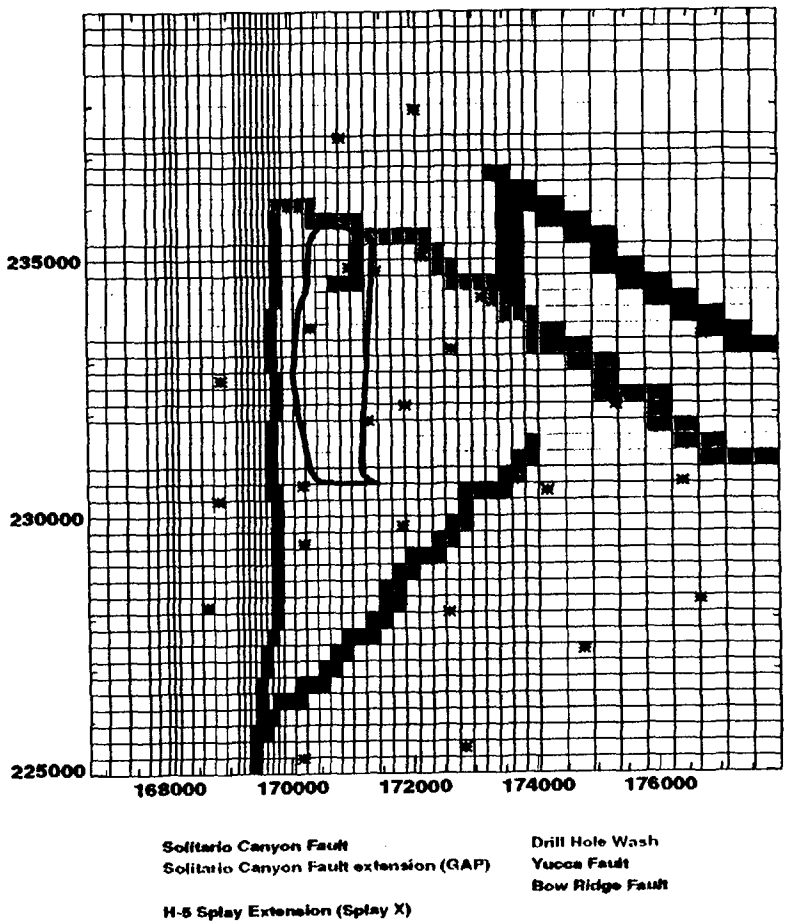
Incorporation of Rockfall Analyses into TSPA-VA

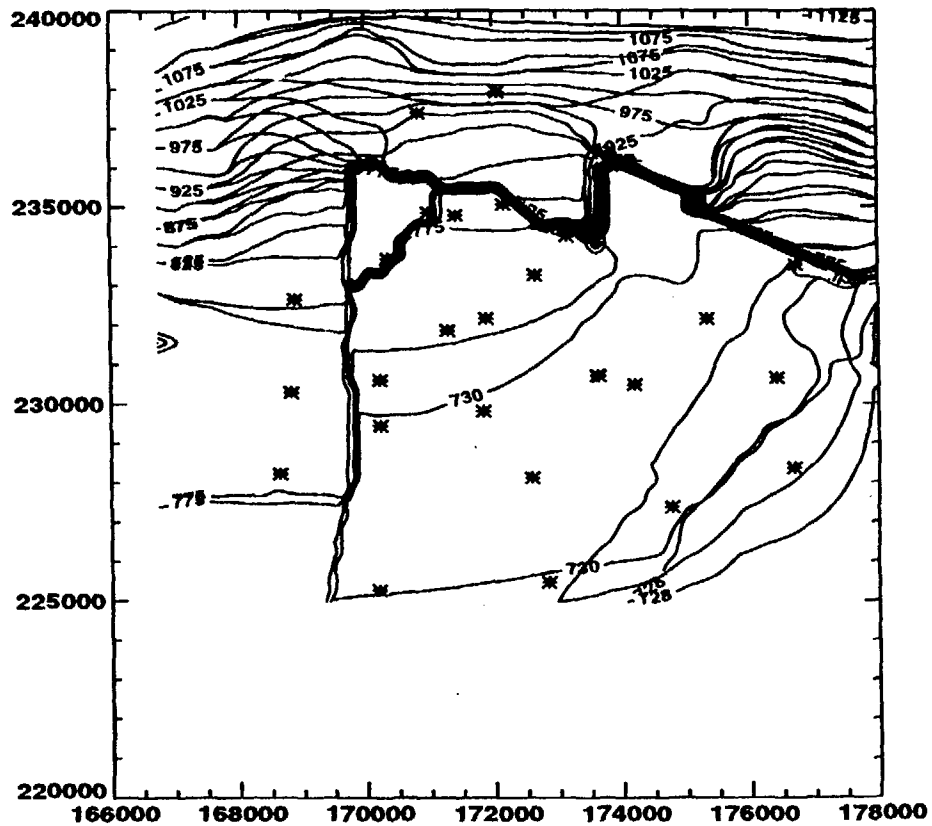
- Apply PGV data from PSHA to probability analysis
  - PSHA currently has PGV values only at 10^{-3} and 10^{-4} probabilities
  - 5 – 10 Hz spectrum is more applicable than 1 – 2 Hz
  - curves needed for Point B (repository); calculated from Point A data
- Use RQD data from ESF
- Use block-size distribution developed from ESF keyblock study

Faulting

- Fault displacement inside the repository is not expected to have any direct PA impact from waste-package disruption
  - clearance between 1.8-m waste package and 5-m tunnel diameter is much greater than maximum expected fault displacement (0.3 m). Only package reorientation would occur
- Faulting outside repository block can potentially alter flow paths in saturated zone for contaminated groundwater
  - PSHA suggests that most likely locations for faulting are re-activation of existing structures
  - these are represented in models by changed hydrologic properties
- Effects of hydrologic changes from faulting are to alter head structure in SZ
  - flow paths may change sufficiently to have impact on dose at receptor point (20 km)

SZ Flow Modeling Results





Base Case

Low-Permeability Fault Along Drill Hole Wash

Other Seismically Induced Disturbances

- Water-table rise and seismic pumping
  - analyzed previously and shown to be of limited PA impact
    - seismic pumping effects are short-time transients (hours, days)
  - water-table rise is only a few meters
    - could potentially flush radionuclides into SZ if they were in transit in UZ
- Alteration of UZ flow paths (focused flow)
  - can change the seepage model used in TSPA-VA
  - can't be phenomenologically modeled with the continuum hydrologic models

Summary

- TSPA-VA incorporates seismic disturbances for the first time
- Rockfall is the major disturbance expected to give a PA impact
- PSHA data will be used to provide probabilities of seismic disturbances