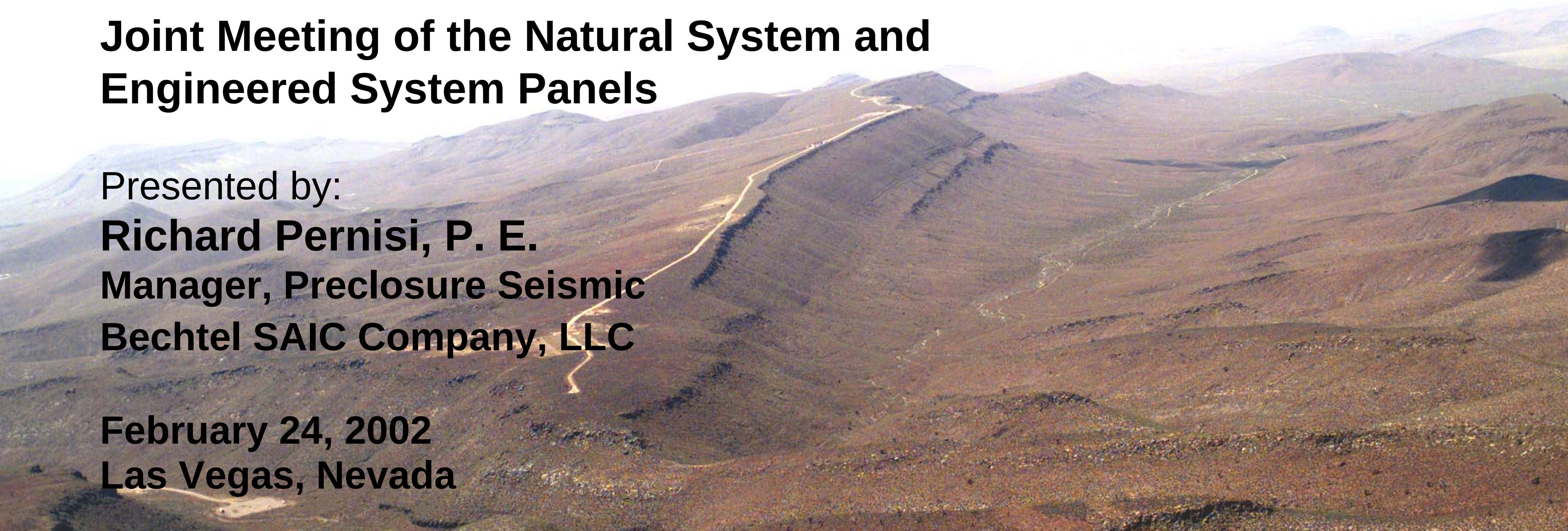
U.S. Department of Energy
Office of Civilian Radioactive Waste Management

YUCCA MOUNTAIN PROJECT

Preclosure Seismic Strategy for Classification and Design of Structures Systems, and Components Important to Safety

Presented to:
Nuclear Waste Technical Review Board
Joint Meeting of the Natural System and Engineered System Panels



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Introduction

- Background
- Strategy Team
- Purpose of Strategy
- Approach
- Strategy Concepts
- Summary of Preclosure Seismic Design Strategy
- Key Elements of Strategy
- Comparison of Inputs and Probabilities

Background

- Seismic Topical Report (STR) #1 Methodology to Assess Fault Displacement and Ground Motion Hazards - 1994; revision 1 - 1997
- STR #2 Preclosure Seismic Design Methodology - 1995; revision 2 - 1997
- Probabilistic Seismic Hazard Analysis - 1998
- Geotechnical Investigations 2000 - 2001; final report - 2002
- Ground Motion Input report - 2003
- STR #3 Preclosure Seismic Design Inputs - 2003

Strategy Team

- **Strategy was developed by an experienced team:**
  - **Kevin Coppersmith**
  - **C. Allin Cornell**
  - **Robert Kennedy**
  - **Jeff Kimball**
  - **Doug Orvis**
  - **Richard Pernisi**
  - **J. Carl Stepp**

Purpose of Strategy

- **To identify the risk-informed methodology that will be used to:**
  - **Establish seismic design basis ground motions (DBGM)**
  - **Prepare analyses**
  - **Design the preclosure surface and subsurface systems, structures, and components (SSCs) identified as important to safety**
- **To outline the methods used to define appropriate DBGMs based on risk significance of SSCs Important to Safety**
- **To affirm the plan given in STR #2 to apply conservative design methodologies, codes and standards to the seismic design solutions**
- **To assure that the license application will document that preclosure surface and subsurface SSCs Important to Safety have been designed adequately to meet preclosure performance objectives per 10 CFR 63.111**

Approach

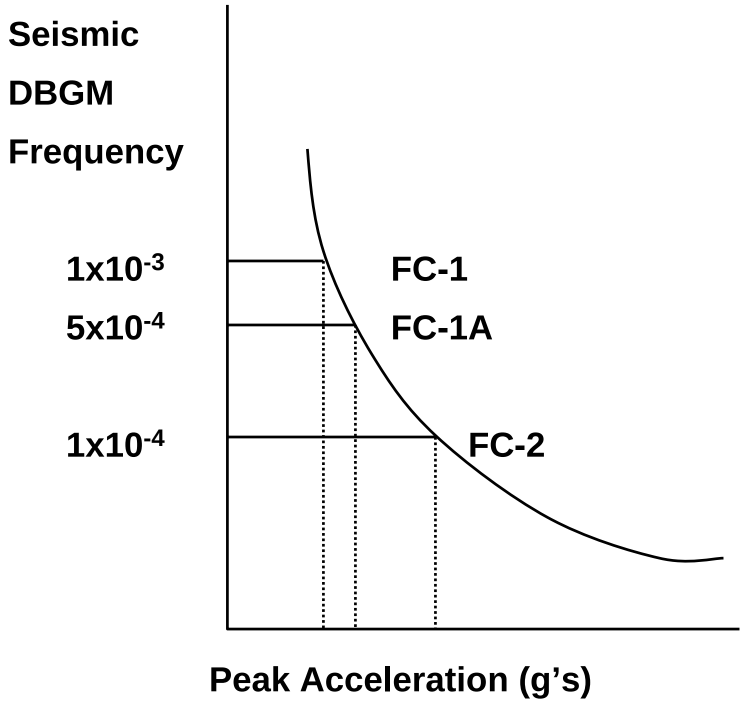
- **STR #2 provides a risk-informed basis for establishing seismic design bases**
  - **Meeting seismic safety performance objectives is a function of the combination of:**
    - **Level of DBGMs**
    - **Design procedures/acceptance criteria**
  - **STR #2 defined DBGM frequency categories as FC1, and FC2 at annual exceedance frequencies of 10^{-3} and 10^{-4} respectively**
  - **FC-1 and FC-2 DBGM are to be used for design of SSCs important to safety**

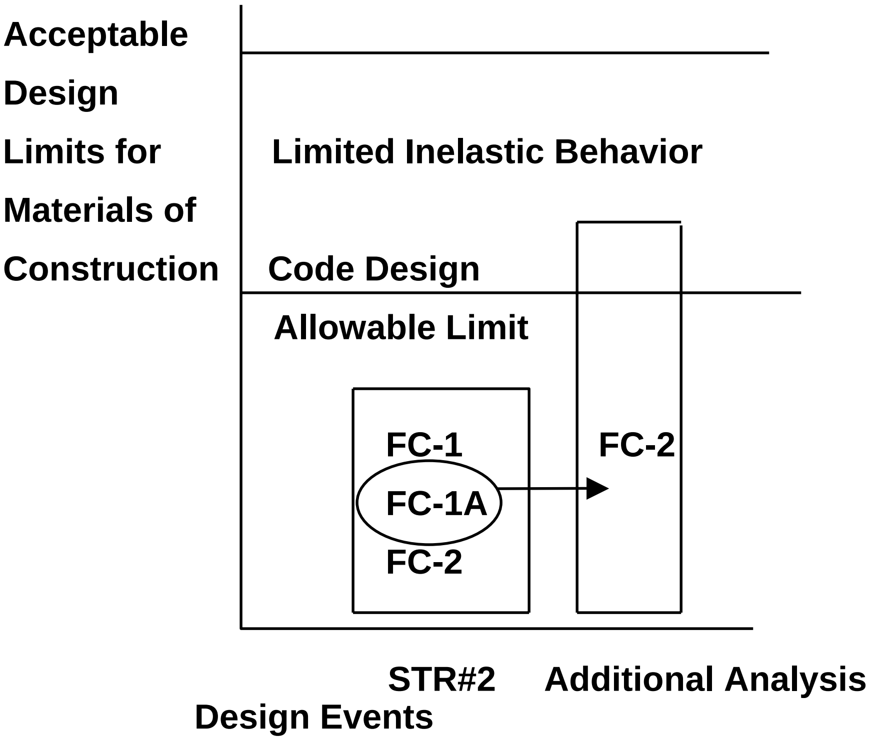
***Topical Report YMP/TR-003-NP, *Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain,* Rev. 2, August, 1997**

Approach
(Continued)

- **The preclosure strategy to be used by Yucca Mountain Project is consistent with STR #2 and provides a more detailed implementation relative to the NRC risk-informed regulatory policy by:**
  - **Including an additional reference probability level for DBGM designated as FC-1A (annual exceedance probability of $5x10^{-4}$) to allow for additional grading of design solutions according to risk significance**
  - **Including confirmatory analyses and limited risk analyses to be conducted, when appropriate, to ensure performance objectives are met**
  - **Including design acceptance criteria associated with applicable parts of the NRC Standard Review Plans for nuclear power plants to ensure adequate margins in the design solutions**
- **Risk-informed approach to establishing seismic design levels has been endorsed by the NRC in recent licensing actions and rulemaking plans**

Strategy Concepts





Summary of Preclosure Seismic Design Strategy

- Seismic safety of the preclosure facilities will be assured using this strategy
- Strategy is consistent with the risk-informed regulatory policy outlined in 10 CFR Part 63 and the Yucca Mountain Review Plan
- Strategy is consistent with STR #2 and represents a more detailed implementation of the approach to establishing DBGMs based on risk significance
- Seismic design strategy is based on the identification of SSCs important to safety using the Preclosure Safety Analysis
- Confirmatory analyses and limited risk analyses will be conducted To provide assurance that preclosure performance objectives of 63.111 are met
- This strategy will be included in STR #3

Key Elements of Strategy

- **Preclosure Design Basis Ground Motion Levels:**
  - **The DBGMs for SSCs important to safety will be those associated with mean annual probabilities of exceedance of:**
    - **10^{-3} (FC-1),**
    - **5×10^{-4} (FC-1A), or**
    - **10^{-4} (FC-2)**
  - **and be dependent on the functions and risk significance specific to the SSCs**
- **Use of Appropriate standards**
  - **The codes, standards, and acceptance criteria for design solutions will be those referenced in NUREG 0800 an NRC Standard for nuclear power plant design, determined to be applicable, in whole or part, to Yucca Mountain Project SSCs**
  - **Therefore, the design solutions for SSCs important to safety will have seismic margins (risk reduction factors) commensurate with those of nuclear power plants**

Key Elements of Strategy

(Continued)

- **Initial Analysis and Design**
  - Prepare detail engineering calculations for SSCs (i.e., Soil Structure Interaction Analysis for Surface Buildings) for a specific DBGM such as FC-1A
  - Coordinate the design with the Preclosure Safety Analysis group to determine those SSCs that are important to safety
  - Iterate the design to ensure that the functions and performance requirements are ensured during all conditions under which the SSCs are credited with mitigating or precluding dose consequences
- **Confirmatory Analyses**
  - Conduct for SSCs Important to Safety designed to a DBGM and then evaluate to an event sequence at a higher level of DBGM with a postulated failure which could lead to offsite doses exceeding those given in 63.111

Key Elements of Strategy

(Continued)

- Conducted at beyond the initial DBGM levels and is intended to demonstrate that SSCs Important to Safety designed for a particular level of DBGMs will respond to higher ground motions within the elastic or limited inelastic range of the construction materials, thus precluding loss of intended safety function
- Beyond DBGM levels will be those associated with 5×10^{-4}/yr for SSCs designed at FC-1; and will be 1×10^{-4}/yr for SSCs designed at FC-1A

- **Limited risk analysis:**
  - In cases where confirmatory analyses indicate that the code allowable stress limits are exceeded, limited risk analyses will be conducted:
    - To further understand the significant event sequences contributing to seismic risk and to ensure adequate seismic design solutions are implemented
    - Risk analyses will provide assurance that preclosure performance objectives of 10 CFR 63.111 are met, redesign to higher levels of ground motions (such as from FC-1A to FC-2) will be performed to ensure objectives are met

Comparison of Inputs and Probabilities

Comparison of Seismic Design Bases, R_R, and Failure Probabilities

Yucca Mt. Design Frequency Categories vs. Other Facility Design Frequency Categories	Design Basis Ground Motion mean annual exceedance probability (return period)	R_R, Risk Reduction Ratio[1]	Mean annual probability of failure[2] (chance/yr)[3]
YMP Frequency Category 2	1×10^{-4} (10,000 yr)	10 (5 to >20)	1×10^{-5} (1:100,000)
NRC Requirements for New nuclear power plants	$\sim 10^{-4}$ (10,000 yr)[4]	~10 (5 to >20	$\sim 10^{-5}$ (1:100,000)
DOE Standard 1020: Performance Category PC4 (operating reactors)	1×10^{-4} (10,000 yr)	10	10^{-5} (1:100,000)
YMP Frequency Category 1A	5×10^{-4} (2000 yr)	~10 (5 to >20)	$\sim 5 \times 10^{-5}$ (1:20,000)
NRC Requirements for Private Fuel Storage ISFSI	5×10^{-4} (2000 yr)	≥5	$\leq 10^{-4}$ (≥1:10,000)
DOE Standard 1020-94: PC3 (non-reactor nuclear facilities)	5×10^{-4} (2000 yr)	5	1×10^{-4} (1:10,000)
YMP Frequency Category 1	1×10^{-3} (1000 yr)	~10 (5 to >20)	1×10^{-4} (1:10,000)
DOE Standard 1020-94: PC2 (essential buildings)	1×10^{-3} (1000 yr)	2	5×10^{-4} (1:2,000)
International Building Code 2000	2/3 of 4×10^{-4} (2500 yr)	~0.4	1×10^{-3} (1:1,000)
UBC-97 and DOE-STD-1020-94 PC1	2×10^{-3} (500 yr)	~2	1×10^{-3} (1:1,000)

[1] Ratio of design basis ground motion exceedance probability to failure probability is termed "risk reduction ratio", R_R. R_R is function of design margin due to design procedures, acceptance criteria, codes, and standards.
[2] "Failure" defined as loss of intended function. Dose due to failure must be assessed separately and is less than or equal to the probability of failure.
[3] In some cases, such as DOE Standard 1020, these probabilities represent performance goals. In other cases, they are implicit goals and are calculated based on estimates of R_R and the DBGM exceedance probability. They provide a generalized basis for comparison.
[4] Reg. Guide 1.165 specifies that a *median* hazard level of 10^{-5} be used for design; this corresponds approximately with a *mean* hazard level of 10^{-4}