MEETING OF THE U.S. NUCLEAR WASTE TECHNICAL REVIEW BOARD'S PANEL ON STRUCTURAL GEOLOGY AND GEOENGINEERING

TOPICAL REPORT: METHODOLOGY TO ASSESS SEISMIC HAZARDS AT YUCCA MOUNTAIN

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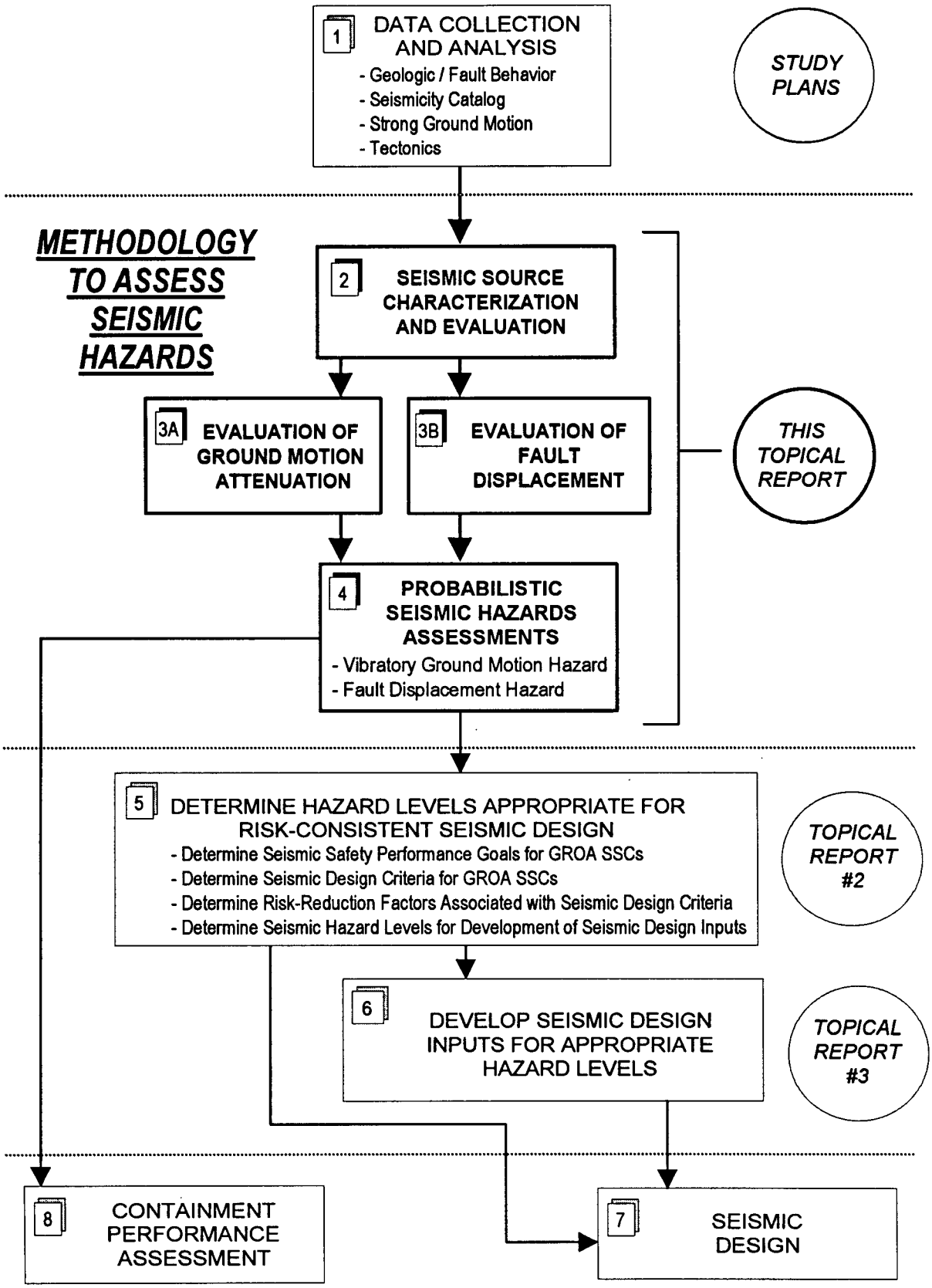
SEISMIC HAZARDS PROGRAM



ASSESSMENT METHODOLOGY OBJECTIVES

- **Meet regulatory requirements**
  - Describe and assess features that might affect GROA design and performance
  - Design structures, systems and components important to safety so that natural phenomena anticipated at the GROA will not interfere with necessary safety functions
  - Design GROA facilities to provide protection against radiation exposures and releases of radioactive material
  - Design GROA facilities to provide retrievability of waste during preclosure period
  - Adequately investigate and evaluate potentially adverse conditions

ASSESSMENT METHODOLOGY OBJECTIVES

- To meet these objectives the methodology should:
  - Meet the needs of seismic safety design and waste containment performance assessment
    - » Assess vibratory ground motion and fault displacement hazards
    - » Determine hazards at the surface and in the subsurface
    - » Be applicable for both the pre-closure and post-closure time frames
  - Facilitate regulatory review and decision-making

DESIGN CONTEXT

- The goal of seismic design is to ensure that society is not exposed to unacceptable risks related to the occurrence of earthquakes.
- Risk is a function of an event's frequency of occurrence and its consequences.
- Performance goal-based design process links consequences, frequency of occurrence, seismic design criteria, and the hazard level appropriate for design.

DESIGN CONTEXT

- **Performance goal-based design process**
  - Establish performance categories for structures, systems and components based on the adverse consequences of their failure
  - Establish performance goals (annual probabilities of failure that design should ensure are not exceeded) such that risk is constant across the performance categories
  - Establish design and acceptance evaluation criteria for each performance category.
    - » Criteria may result in risk reduction
    - » More conservative criteria result in greater risk reduction
  - For each performance category, hazard level (annual probability of exceedance) appropriate for design equals the performance goal times the risk reduction factor

METHODOLOGY

- A probabilistic methodology is adopted to:
  - Explicitly incorporate the frequency of earthquake occurrence
  - Explicitly incorporate variability of inputs to the hazard assessment
  - Provide the integrated hazard from all significant sources
  - Support design for waste isolation
- A probabilistic assessment is required to:
  - Support the assessment of the long-term performance of a repository with respect to waste containment
  - Support the performance goal-based seismic design process

METHODOLOGY

- Relies on established, generally accepted data collection and analyses
- Components
  - Seismic source identification and characterization
  - Assessment of frequency of occurrence and maximum magnitude
  - Evaluation of
    - » ground motion attenuation, or
    - » fault displacement
  - Integrate over input data and evaluations
  - Propagate uncertainties
  - Sensitivity analyses
- Based on experience

SEISMIC SOURCE EVALUATION

- **Seismic source characterization**
  - Spatial description of faults and volumetric source zones
  - Potential for activity
  - Dependencies
- **Recurrence**
  - For fault sources: based on geologic and paleoseismic data related to recurrence intervals and slip rates
  - For volumetric sources: based on geologic and seismic data
  - Poissonian and characteristic descriptions will be tested with the available data and incorporated as appropriate
  - Temporal clustering can be treated using the probabilistic approach

SEISMIC SOURCE EVALUATION

- **Maximum magnitude**
  - For fault sources: determined from empirical relations between magnitude and rupture length, rupture area, and displacement, using the available data
  - Will incorporate evaluations of fault segmentation if appropriate
  - For volumetric sources: determined from tectonic analysis; the magnitudes of earthquakes with observed surface rupture provide an upper bound

GROUND MOTION ATTENUATION EVALUATION

- Empirical and numerical methods will be used
- Near-field effects will be evaluated for near-field sources
- Site response evaluation
  - Local Geology
  - Topography
  - Depth of burial

FAULT DISPLACEMENT EVALUATION

- Methodology employs empirical relationships between displacement and magnitude
- Secondary faulting is incorporated
  - Amount and distribution
  - Empirical relationships based on available data from similar tectonic regimes
- New faulting can be incorporated into the probabilistic assessment

HAZARD ASSESSMENT

- Integrates over all inputs
- Results in curve showing annual probability that various levels of hazard (ground motion or fault displacement) will be exceeded
- Propagate uncertainty
  - Logic tree method
  - Monte Carlo method
- Carry out sensitivity analyses
  - Sensitivity to input variability
  - Disaggregation to identify strong contributors to hazard at various probability exceedance levels
  - Comparison of calculated and observed seismicity

SUMMARY

- **A probabilistic methodology:**
  - Provides the results needed for performance goal-based design and for assessment of the long-term performance of a repository with respect to waste containment
  - Incorporates explicitly:
    - » Frequency of earthquake occurrence
    - » Variability in hazard assessment inputs
    - » Hazard contribution from all significant sources
  - Provides a basis for design and licensing decisions based on:
    - » established safety performance goals
    - » demonstrated compliance with waste containment performance goals
    - » extensive documentation of data and interpretations