Seismic Hazard for Commercial Nuclear Power Plants – Current Practice and Its Relationship to the NSHMP

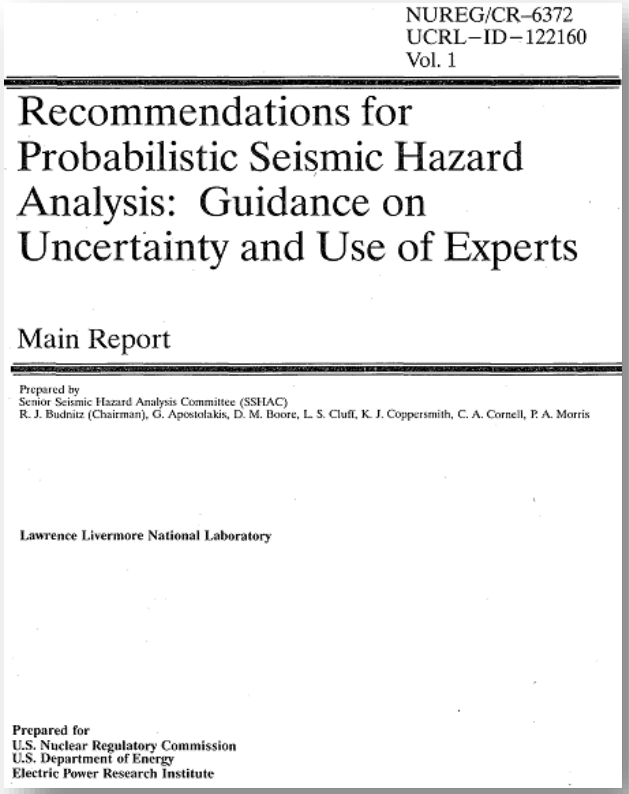
Robert Youngs
Amec Foster Wheeler

ATC/USGS Seismic Hazard User Needs Workshop
September 21/22, 2015
Menlo Park, California

Current US Nuclear Regulatory Commission Guidance

- Regulatory Guide 1.208 (NRC, 2007) – part of the definition of an "Accepted PSHA Model" is one that that has been developed following a SSHAC process
- NRC 50.54(f) Request to all operating nuclear power plant operators (NRC, 2012) – provide updated seismic hazard assessment based on seismic hazard models developed by a SSHAC Level 3 or 4 process

SSHAC Guidelines and Guidance


NUREG/CR–6372
UCRL–ID–122160
Vol. 1

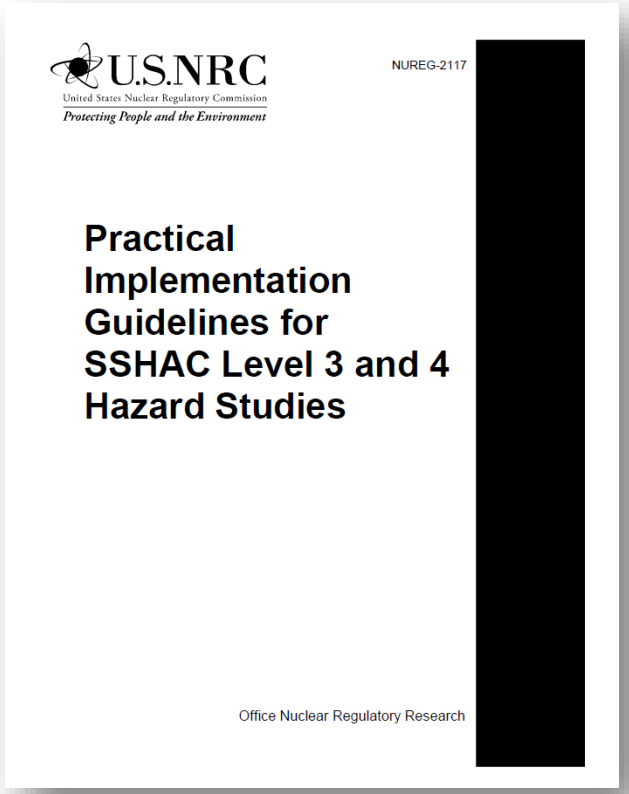
Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts

Main Report

Prepared by
Senior Seismic Hazard Analysis Committee (SSHAC)
R. J. Budnitz (Chairman), G. Apostolakis, D. M. Boore, L. S. Cluff, K. J. Coppersmith, C. A. Cornell, P. A. Morris

Lawrence Livermore National Laboratory

Prepared for
U.S. Nuclear Regulatory Commission
U.S. Department of Energy
Electric Power Research Institute



NUREG/CR-6372 (1997)
- **Defined basic concepts and objectives of a SSHAC process**
- **Defined Study Levels**

NUREG-2117 (2012)
- **Refined objectives of SSHAC study**
- **Provided implementation guidelines**
- **Refined roles of participants**

Goal of a SSHAC Process

"The fundamental goal of a SSHAC process is to properly carry out and completely document the activities of evaluation and integration, defined as:

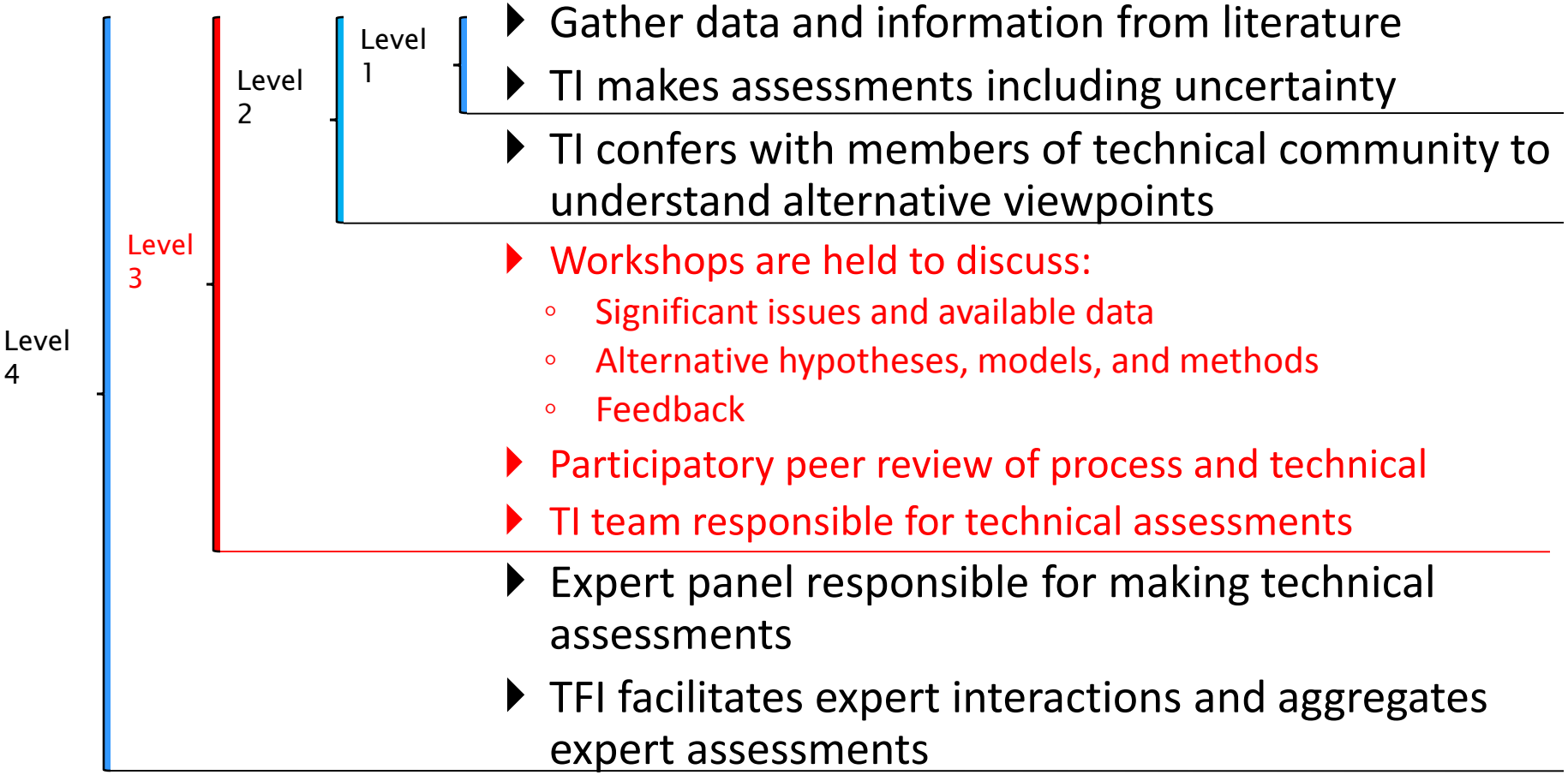
- Evaluation: The consideration of the complete set of data, models, and methods proposed by the larger technical community that are relevant to the hazard analysis.
- Integration: Representing the center, body, and range of technically defensible interpretations [CBR of the TDI] in light of the evaluation process (i.e., informed by the assessment of existing data, models, and methods)."

NUREG-2117

Fundamental Features of the SSHAC Process

- Comprehensive databases available to all participants
- Clearly defined roles and responsibilities
- Ownership of hazard model by evaluator/integrator
- Structured interactions among participants
- Clear sequence of tasks and events
- Peer review, participatory preferred
- Complete documentation, including responses to written review comments

Four Study Levels of SSHAC Processes



TI Technical Integrator

TFI Technical Facilitator/Integrator

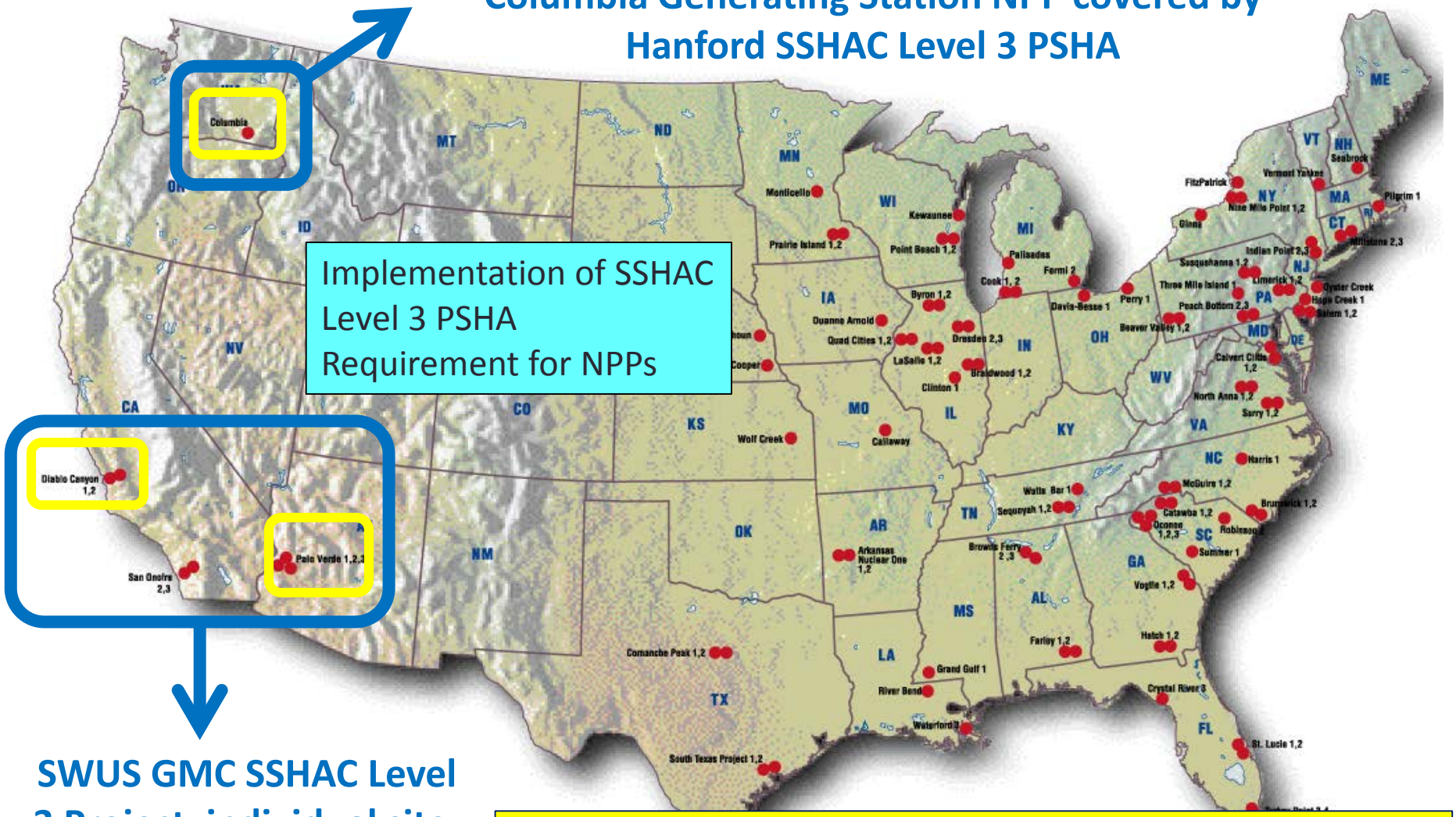
Participatory Peer Review Panel

- Operates throughout the duration of the project
- Made up of subject matter experts and individuals with SSHAC experience
- Reviews and provides written comments on project documentation
- Provides technical review
  - Full range data, models, and methods have been considered
  - All technical decisions have been adequately justified
- Provides process review
  - Process used conforms to SSHAC level selected
  - Provides closure letter that process was complete and all PPRP comments satisfactorily resolved

NSHMP and PSHA for Nuclear Power Plants

- NSHMP is not a SSHAC Process – NSHMP results not currently used to define seismic hazard at commercial NPPs
- NSHMP is an important resource for SSHAC Level 3 studies for NPPs
  - Provides data, models, and methods
  - Program and related USGS funded research provides technical experts to provide input into the evaluation process through workshop participation

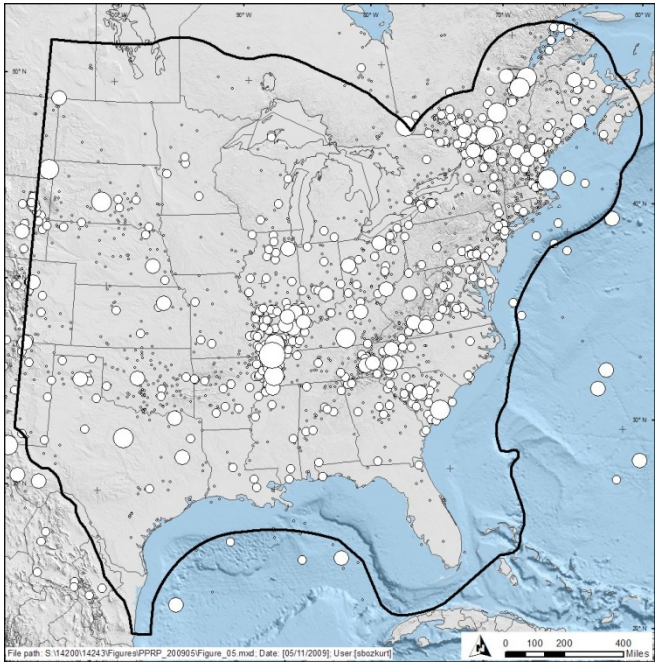
Columbia Generating Station NPP covered by Hanford SSHAC Level 3 PSHA



SWUS GMC SSHAC Level 3 Project, individual site-specific SSC projects

The CEUS SSC model and EPRI 2013, from regional SSHAC Level 3 studies, to be used for PSHA at plants east of the Rockies

The Central and Eastern United States Seismic Source Characterization for Nuclear Facilities Project, NUREG-2115 (2012)



U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

U.S. DEPARTMENT OF ENERGY

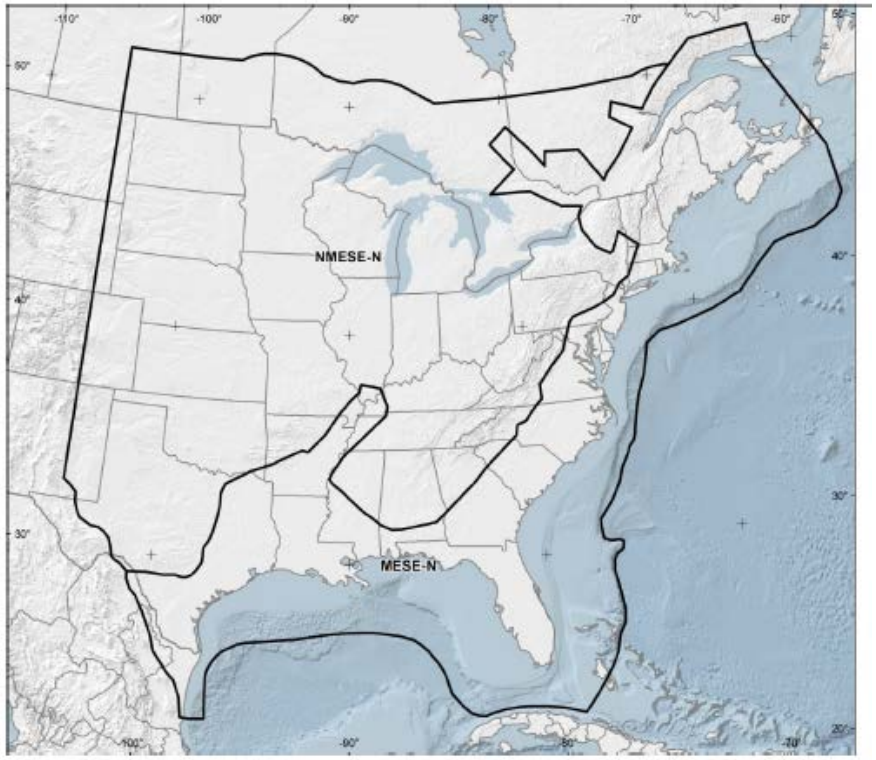
EPRI

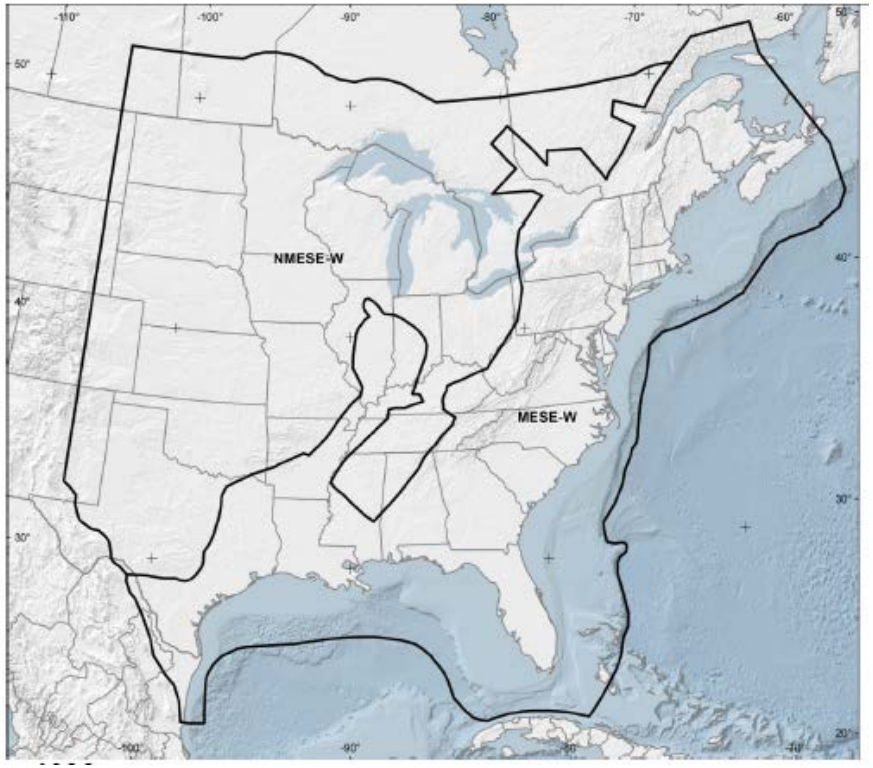
Conducted as a SSHAC Level 3 Study

Focus of Application

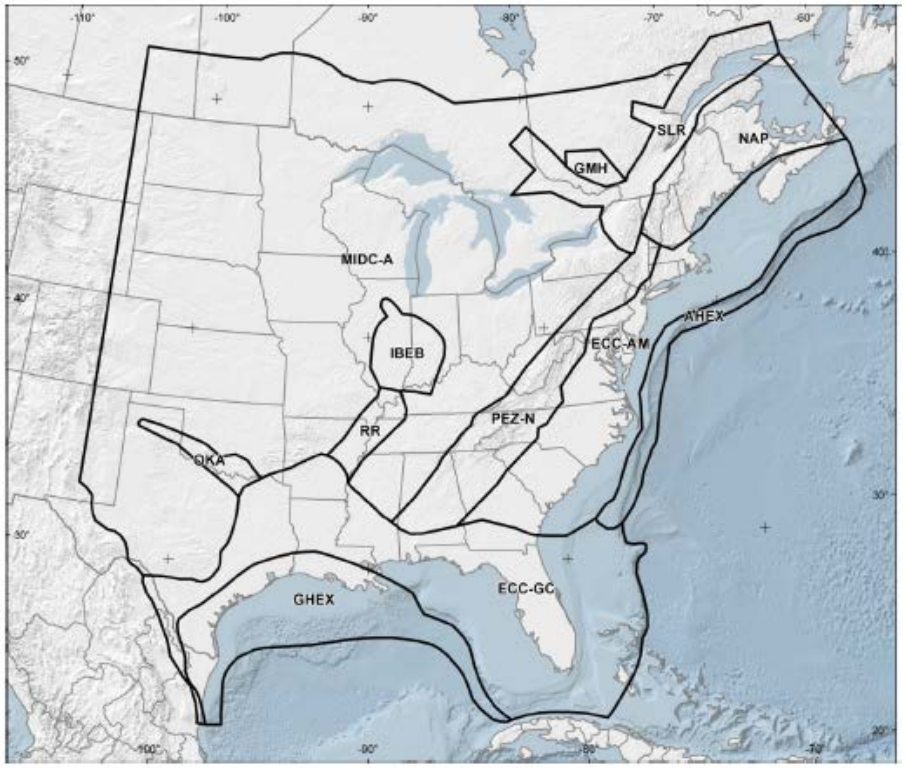
- The SSC and GMC models developed in SSHAC Level 3 studies for NPPs are intended ultimately for site-specific applications
- Mandate of capturing the CBR of the TDI leads to characterization of uncertainties that is generally more extensive than is practical for seismic hazard mapping

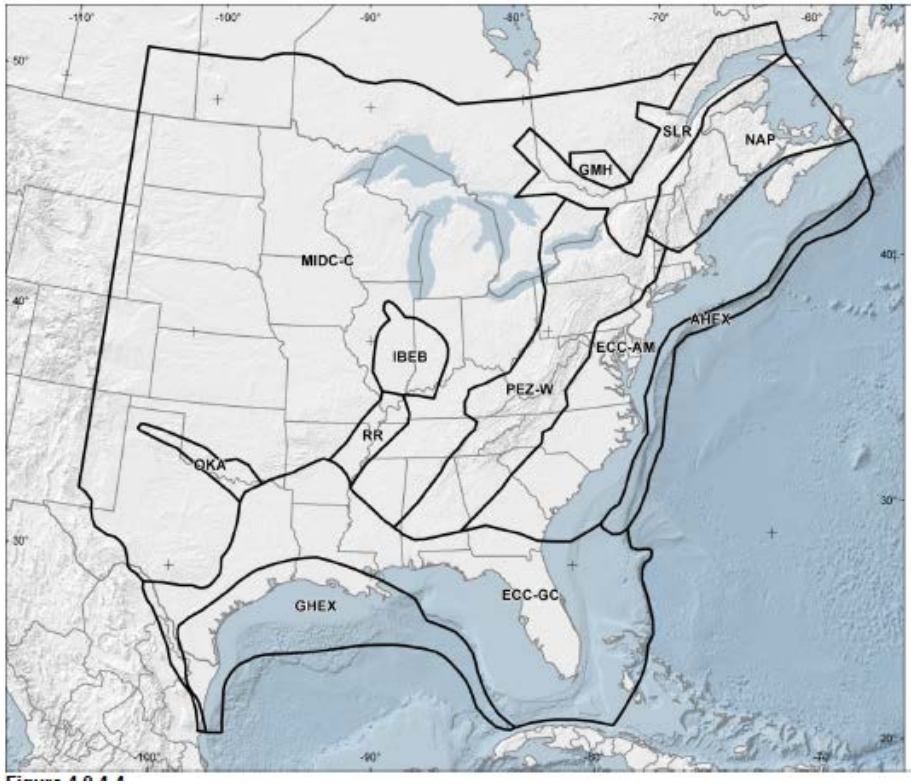
Alternative “Mmax” Source Zones





Alternative “Seismotectonic” Source Zones



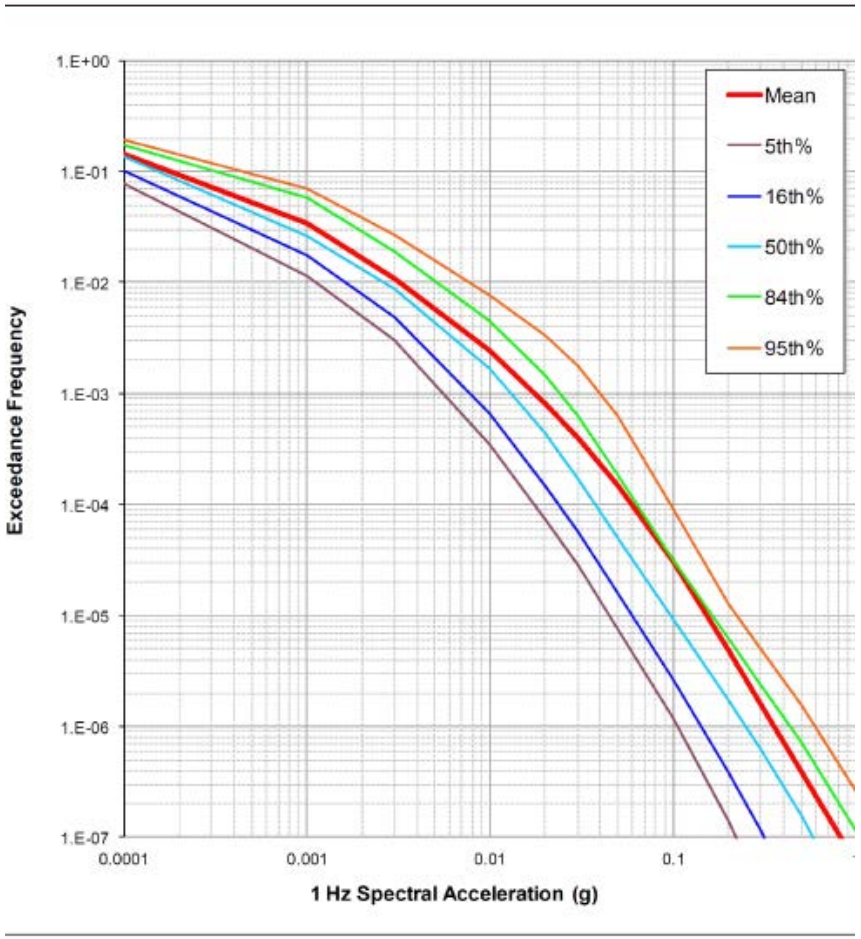


Uncertainty in Earthquake Recurrence Modeling

- Alternative assessments of magnitude ranges and weights for application of truncated exponential recurrence model
- Assessed catalog completeness for each alternative set of magnitude ranges
- For each magnitude range and each seismic source, develop 8 alternative models for the spatial distribution of seismicity rate and *b*-value
- Develop distribution of Mmax for each source based on global SCR data and observed seismicity

Use of Seismic Hazard Results

- Full distribution of seismic hazard results needed over broad range of AEFs
- Comparison with design needs mean hazard at AEF of 10^{-4} and 10^{-5}
- Use in seismic probabilistic risk assessments needs full distribution over AEF range of 10^{-2} to 10^{-8}



NSHMP Input to CEUS SSC Model

- NSHMP earthquake catalog was starting basis for CEUS SSC earthquake catalog
- NSHMP experts provided review of catalog
- Comparisons with NSHMP catalog declustering method used for evaluation of catalog processing
- Experts participated in workshops providing discussions of data, models, and methods for seismic source definition, seismic source zonation, earthquake recurrence, Mmax
- Results of NSHMP workshop on Mmax considered in evaluations

EPRI 2004/2006 Review Project (2013)

- EPRI (2004) SSHAC Level 3 study to develop ground motion characterization model for application to NPP in CEUS
- EPRI (2006) SSHAC Level 2 refinement to EPRI (2004) addressing aleatory variability
- EPRI (2013) SSHAC Level 2 refinement to EPRI (2004) and EPRI (2006) to address new data and models
  - Interim model to be replaced by SSHAC Level 3 NGA-East project results
- NSHMP provided models and subject matter experts at project workshops

SSHAC Level 3 Studies for Western US Commercial Nuclear Power Plants

- Hanford Sitewide PSHA addressing both SSC and GMC
- Southwestern US (SWUS) GMC for Diablo Canyon and Palo Verde
- Separate SSC SSHAC Level 3 SSC projects for Diablo Canyon and Palo Verde
- In all three studies NSHMP and USGS funded research provided data, models, and experts to present evaluations at workshops

Ongoing Monitoring of Seismic Hazard Issues for US NPPs

- The NSHMP provides periodic updates to the characterization of seismic hazards in the US
- As such, it provides both NPP operators and the NRC
  - An evaluation and implementation of new data, models, and methods
  - A quantitative assessment of the impact of new data, models, and methods on seismic hazard
- Evaluation of updates to the NSHMP assessments provides input into the assessment of the need for an update, revision, or refinement to the existing hazard models for specific NPPs or groups of NPPs