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APPROACH TO SEISMIC DESIGN

[Redacted Version of Slides]

17 May 2011

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Agenda

- **Introduction to the Generation mPower Project**
  - Plot Plan and General Arrangements of Primary Structures
- **Use of USGS 2008 Seismic Hazard Data**
  - Contour Map Development
  - WUS vs. CEUS Data
  - USGS Combined Contours
  - Comparison of USGS to Recent ESP/COL Applications
- **Seismic Spectra Selection Process**
  - Soil Profile Selection
  - CSDRS Selection and Evaluation
  - Comparison of Eastern Tennessee to Selected CSDRS
  - Compatibility of CSDRS to USGS
- **Other Seismic Considerations**
  - Recommended V/H Ratio
  - Other Ongoing Studies

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Introduction to the Generation mPower Project

Martin Reifschneider

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Two Module Site Arrangement

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Site Arrangement / Plan View

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Site Arrangement / Cross Section

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Reactor Service Building / 3D Model

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RSB Plan El. [ ]

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RSB Cross Section

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RCB Plan EL. [ ]

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RCB Cross Section

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Use of USGS 2008 Seismic Hazard Data

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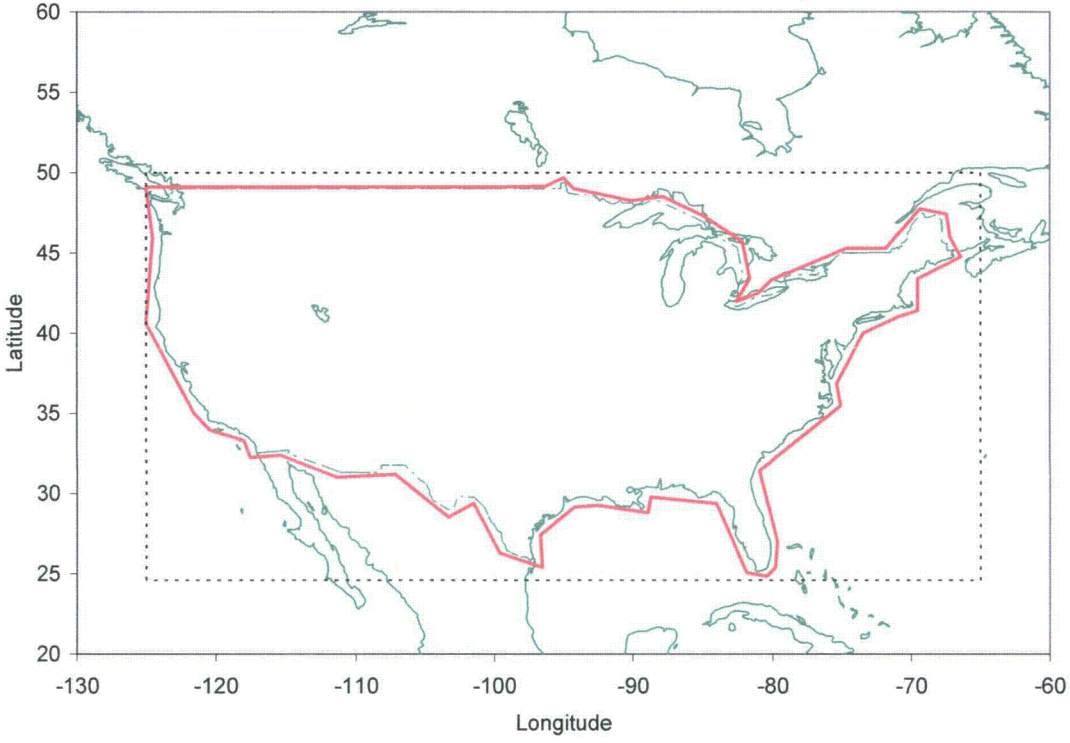
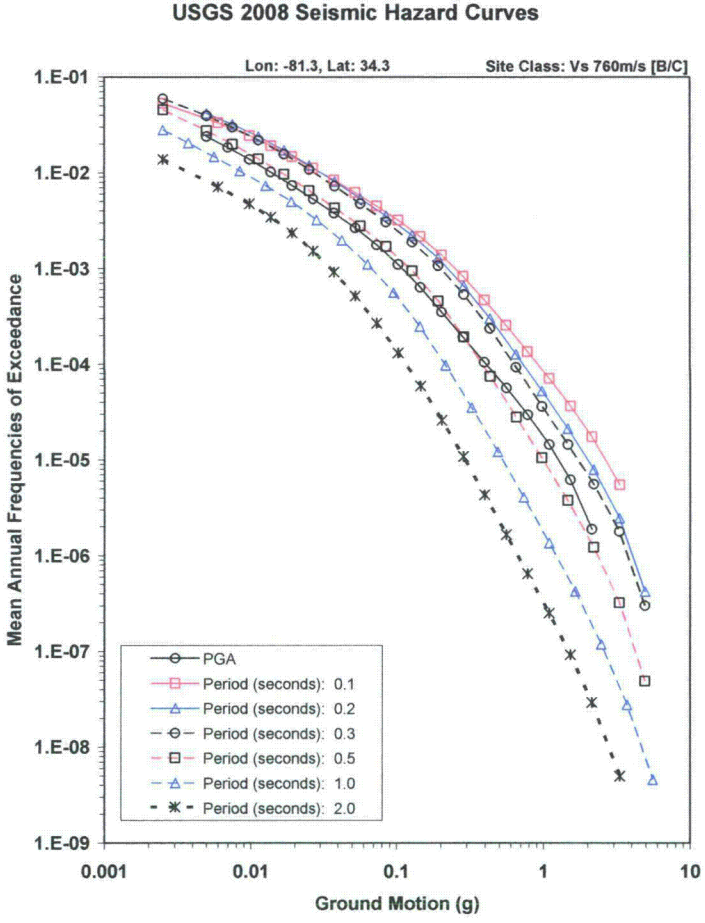
USGS 2008 Seismic Hazard Data

http://earthquake.usgs.gov/hazards/products/conterminous/2008/data/





- Originally, **611,309** grid locations spaced at 0.05°, filtered to **362,509** land-only values
- Originally, NEHRP Site Class B/C seismic hazard curves
- Use amplification factors from Petersen et al. (2008) to convert to hard rock ["Site Class A"] hazard curves
- PGA and 6 response spectral periods: 0.1, 0.2, 0.3, 0.5, 1.0, and 2.0 seconds

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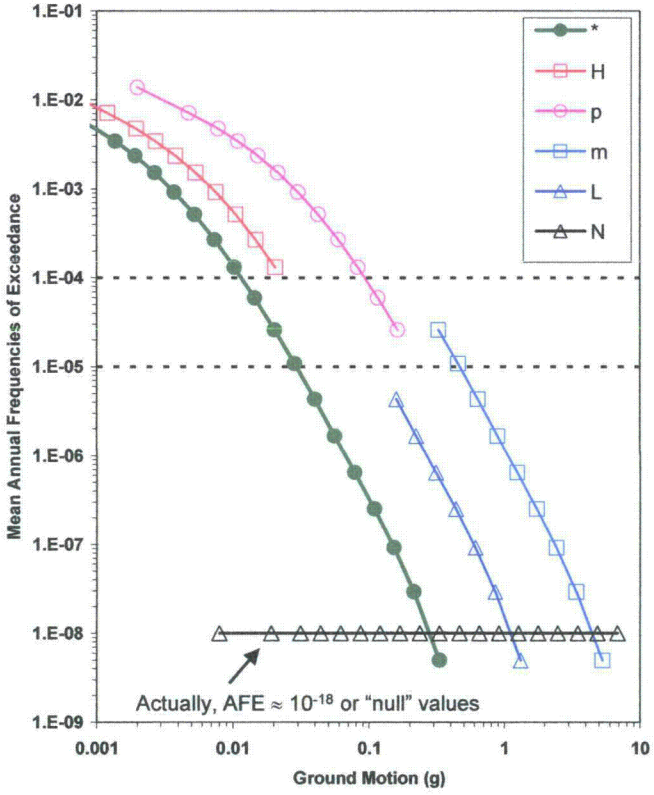
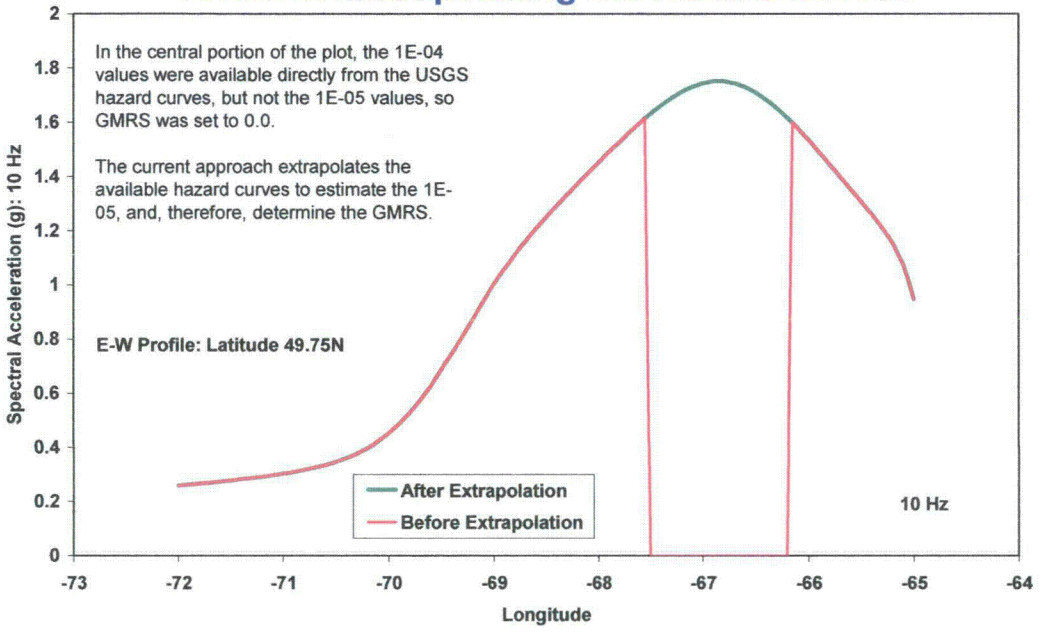
USGS 2008 Seismic Hazard Data

Schematic Hazard Curves



Intensity range of USGS hazard curves		Min	Max
	PGA	0.005	2.13
	10 Hz	0.0025	3.3
	5 Hz	0.005	7.38
	3.333 Hz	0.0025	7.38
	2 Hz	0.0025	7.38
	1 Hz	0.0025	5.54
	0.5 Hz	0.0025	3.3

Effect of Extrapolating the Hazard Curves



- Several hazard curves, particularly in high-hazard areas, did not encompass both 10^{-4} and 10^{-5} hazard levels needed for Ground Motion Response Spectra (GMRS) estimate
  >>> *range needed extending lower or higher*
- Extrapolation of the curves appears reasonable and precluded setting to *NULL* or "0" values

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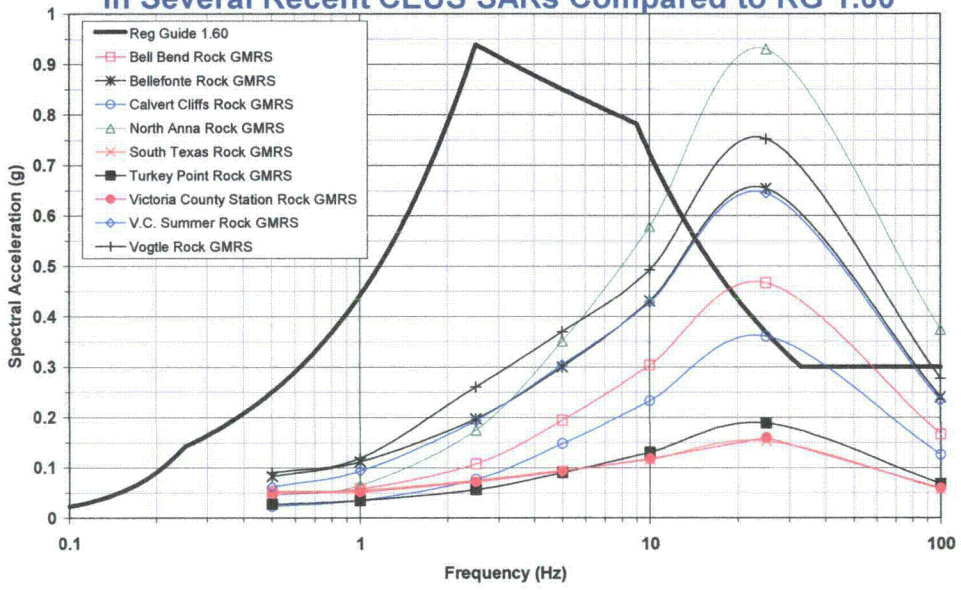
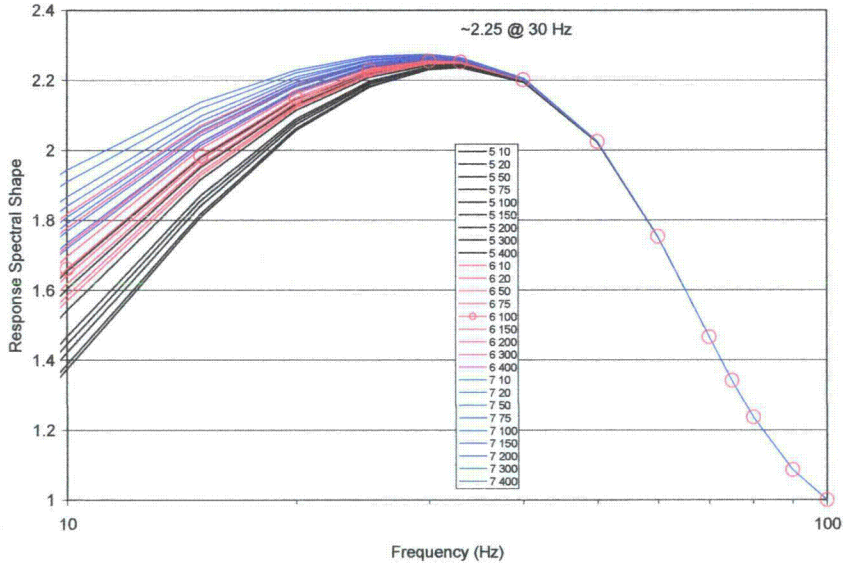
USGS 2008 Seismic Hazard Data

GMRS Calculated from Hard Rock PSHA as Reported in Several Recent CEUS SARs Compared to RG 1.60



CEUS Response Spectral Shapes: NUREG/CR-6728



Several studies indicate that CEUS response spectra peak between 10 Hz and PGA: e.g., hard rock GMRS as can be calculated from FSAR PSHA results [available on NRC web site]

Use NUREG/CR-6728 spectral shapes to estimate CEUS spectral peak missed in 2008 USGS hazard results:

Sa(g) @ 30 Hz ≈ 2.25 x PGA

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USGS 2008 Seismic Hazard Data

Regulatory Guide 1.208: Definition of the GMRS/FIRS

The site-specific PSHA seismic hazard curve slope factor $A_R(f)$ is determined from:

$$A_R(f) = Sa(f \mid 10^{-5}) / Sa(f \mid 10^{-4}) \quad \text{Eq. 1}$$

where *f* is frequency and $Sa(f \mid 10^{-4})$ and $Sa(f \mid 10^{-5})$ are response spectral acceleration values for the hazard levels of 10^{-4} and 10^{-5}, respectively.

The "Design Factor" DF(f), based on A_R, is given by:

$$DF(f) = \textit{maximum}\ \{\ 1.0,\ 0.6 \times A_R(f)^{0.80}\ \} \quad \text{Eq. 2}$$

Finally, design response spectrum DRS(f) is given by:

$$DRS(f) = Sa(f \mid 10^{-4}) \times DF(f) \quad \text{for } A_R(f) \leq 4.2 \quad \text{Eq. 3}$$
$$= 0.45 \times Sa(f \mid 10^{-5}) \quad \text{for } A_R(f) > 4.2$$

where the design response spectrum [DRS(f)] is, depending on subsurface horizon and design intent, the GMRS or Foundation Input Response Spectra (FIRS).

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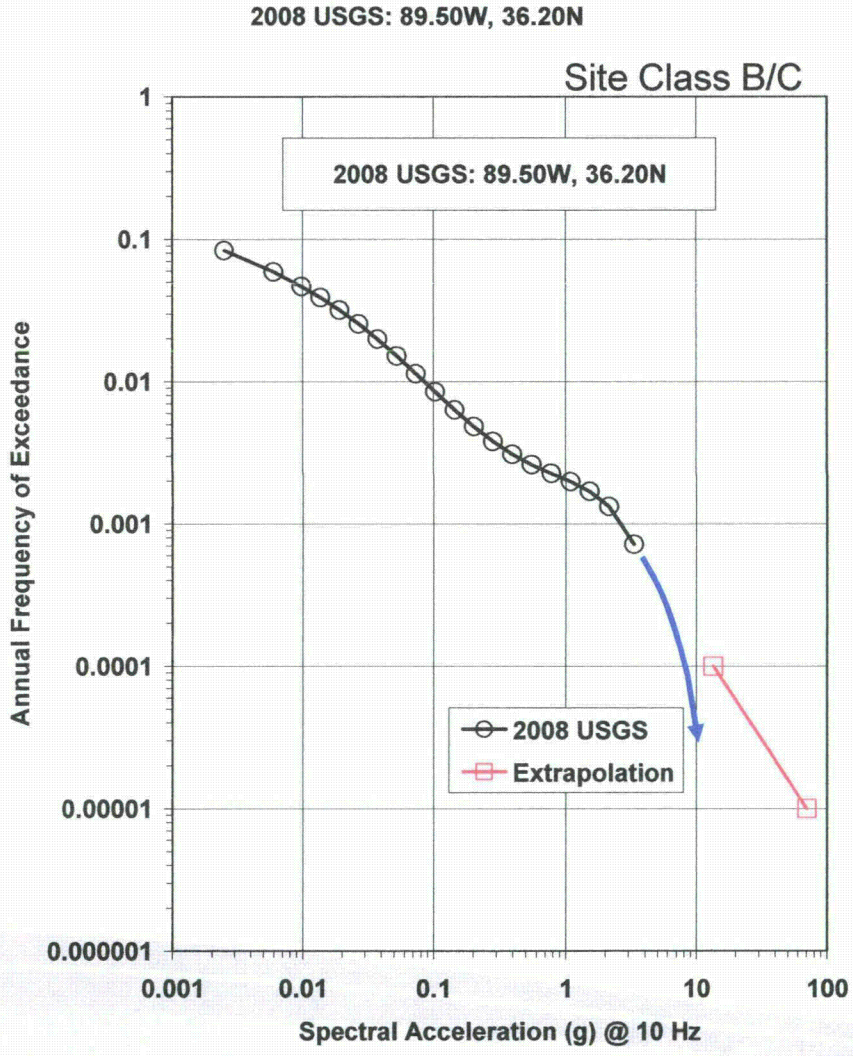

Maximum GMRS for CEUS:
New Madrid area

Log-log extrapolation to 10^{-4} and 10^{-5}:

- Site Class B/C GMRS: 31.7g
- Hard Rock GMRS at 10 Hz: 18.2g

If PSHA curve were explicitly calculated to 10^{-4} and 10^{-5}, likely would give smaller ground motions.

Extrapolations do no appear to affect high fractile curves or even the mean.

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USGS 2008 Seismic Hazard Data
(Reflects Bechtel Calculations)

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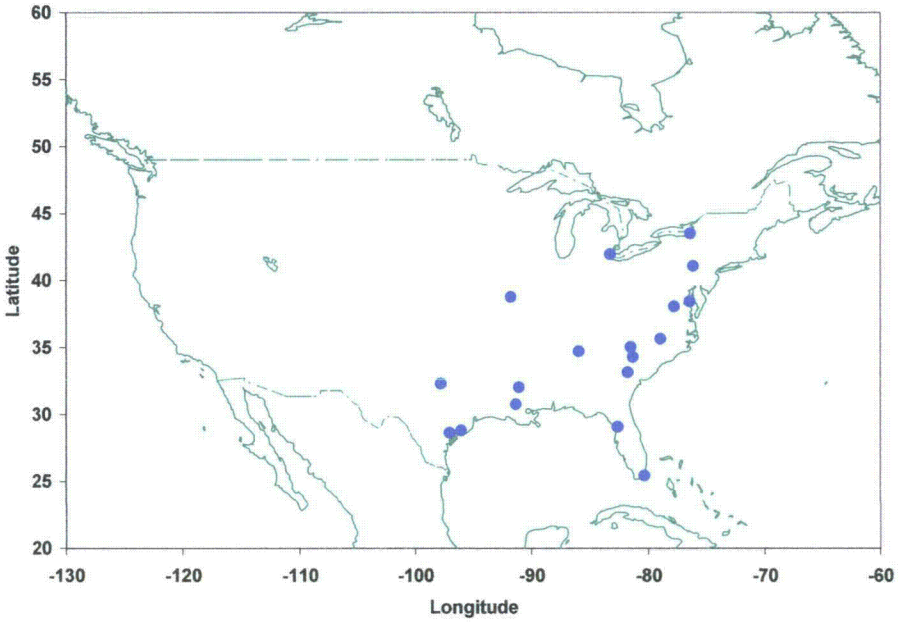

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Comparison between Hard Rock GMRS Calculated from the 2008 USGS National Hazard Map Hazard Curves and Hard Rock GMRS Calculated from PSHA Results Reported in 18 SARs for Recent ESP/COLA Applications

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Seismic Spectra Selection Process

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Seismic Spectra Selection Process

- Review of Soil Profiles (COLAs, DCDs, other)
- Selection of Design Soil/Rock Profiles for mPower
- Review of Response Spectra (CSDRS, FIRS, GMRS, Reg. Guide 1.60, Newmark & Hall, USGS Data)
- CSDRS for mPower
- Site Response Analysis with mPower CSDRS as input
- Comparison to COLA FIRS

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Seismic Spectra Selection Process

- **Design Control Documents:**
  - ABWR
  - AP1000
  - ESBWR
  - US APWR
  - US EPR
- **COLAs:**
  - Bell Bend Nuclear Power Plant
  - Bellefonte Nuclear Plant, Units 3 and 4
  - Callaway Plant, Unit 2
  - Calvert Cliffs Nuclear Power Plant, Unit 3
  - Comanche Peak Nuclear Power Plant, Units 3 and 4
  - Fermi, Unit 3
  - Grand Gulf Nuclear Station, Unit 3
  - Levy Nuclear Plant, Units 1 and 2
  - Nine Mile Point 3 Nuclear Power Plant
  - North Anna 3
  - River Bend Station, Unit 3
  - Shearon Harris Nuclear Power Plant, Units 2 and 3
  - South Texas Project, Units 3 and 4
  - Turkey Point, Units 6 and 7
  - Victoria County Station, Units 1 and 2
  - V. C. Summer Nuclear Station, Units 2 and 3
  - Vogtle Electric Generating Plant, Units 3 and 4
  - William States Lee III Nuclear Station, Units 1 and 2

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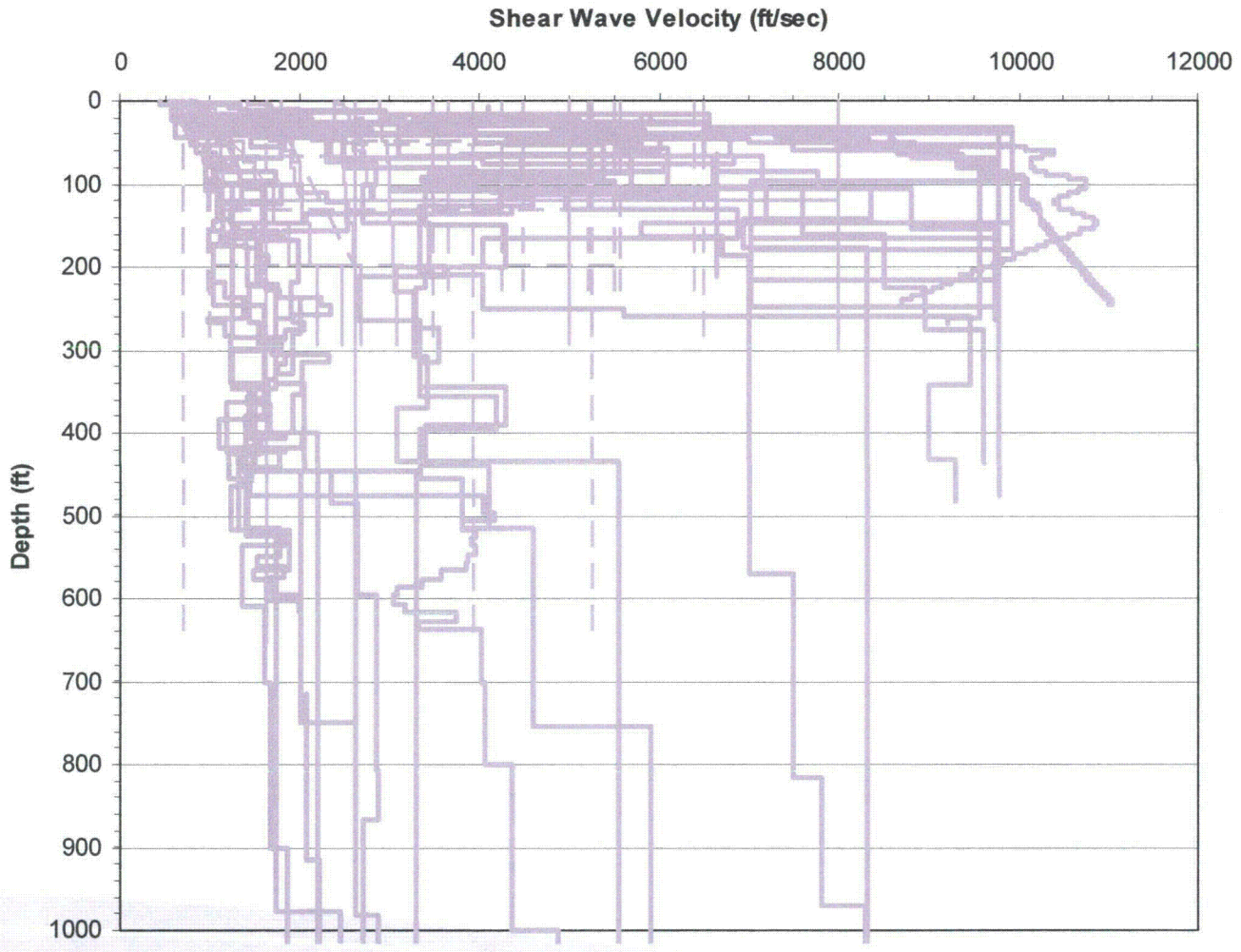
Soil Profile Selection



Range of Shear Wave Velocities from DCDs and COLAs

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Soil Profile Selection Strategy

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Design Soil Profile Selection

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CSDRS Selection

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Horizontal CSDRS

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CSDRS Evaluation

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WUS CSDRS Input

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CEUS CSDRS Input

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CSDRS vs Eastern Tennessee

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Design Soil Profiles

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Other Seismic Considerations

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Recommended V/H Ratio

Methodology

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Recommended V/H

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Recommended V/H

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Recommended V/H

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Recommended V/H for CEUS

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Recommended V/H for WUS

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Other Ongoing Studies

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Other Ongoing Studies (cont.)

CEUS-SSC (SSHAC Level 3)

- SSHAC* Level 3 (NUREG/CR-6372 (1997))
- New source model
  - (Where, how often, maximum magnitude, uncertainties.)
- EPRI (2004, 2006) ground motion prediction equations (GMPE)
  - (SA (Mag, Dist), aleatory uncertainty.)
  - (To be replaced with updated NGA-East GMPE ~2013)
- Model assessments at seven test sites
- Two study-specific amplification factors
  - (shallow and deep soil sites)
- Schedule – Dec 2011

**Senior Seismic Hazard Analysis Committee [SSHAC]*

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