LNP Seismic Evaluation Update

04-27-12

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NRC RAI Letter 108 – Fukushima Recommendations Seismic Evaluation Update

- Evaluate the seismic hazards at your site against current NRC requirements and guidance,
- and, if necessary, update the design basis and structures systems and components important to safety to protect against the updated hazards
- (seismic portion only - of detailed Recommendation 2.1 - Enclosure 7 of SECY-12-0025).

Agenda

- Intro & Agenda Overview – **B Kitchen**
- Review of Preliminary Evaluation – **B Youngs**
- Phase 2 – CEUS update method – **B Youngs**
- Actions based on results – **AK Singh**
- Schedule and follow-up – **Vann Stephenson**

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Preliminary Assessment of Impact of New CEUS SSC Model on Seismic Hazard Assessment for LNP

Robert Youngs
AMEC E&I
April 27, 2012

Purpose of Preliminary Evaluation

- To provide Progress Energy with an early indication of the impact of the new Central and Eastern United States Seismic Source Characterization (CEUS SSC) model for use in planning

- Preliminary evaluation will be followed by full implementation of the CEUS SSC model to compute GMRS and FIRS for comparison with values in LNP FSAR

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Seismic Hazard Model for LNP Presented in FSAR

- Distributed seismicity modeled using EPRI-SOG (1988) seismic source characterization
  - Six expert teams developed sets of seismic sources covering the central and eastern United States (CEUS)
  - Utilized those sources for each team that account for 99% of the hazard

- Repeated large magnitude earthquakes near Charleston, SC modeled using the Updated Charleston Seismic Source (UCSS) developed for the Vogtle COLA

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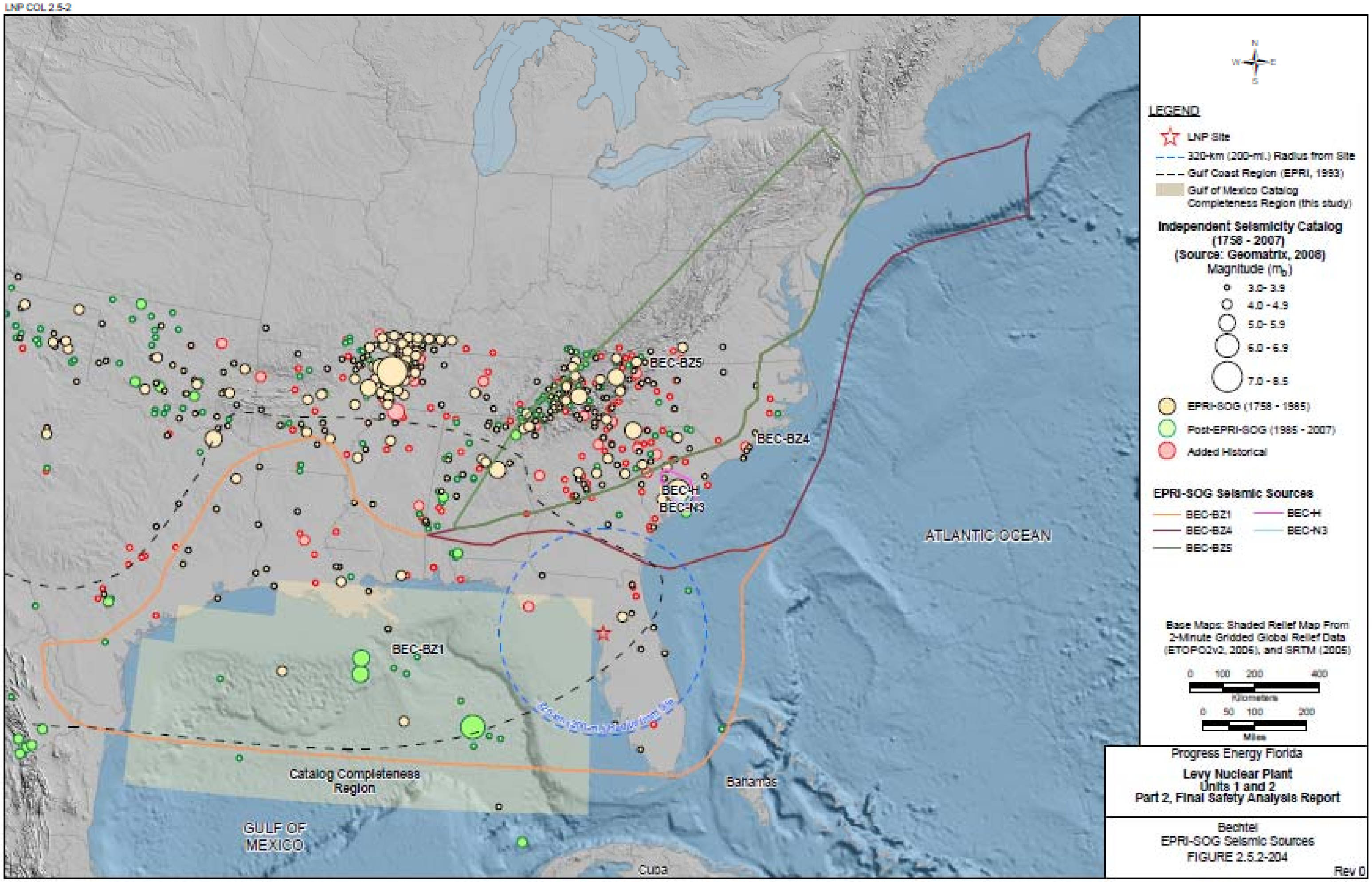
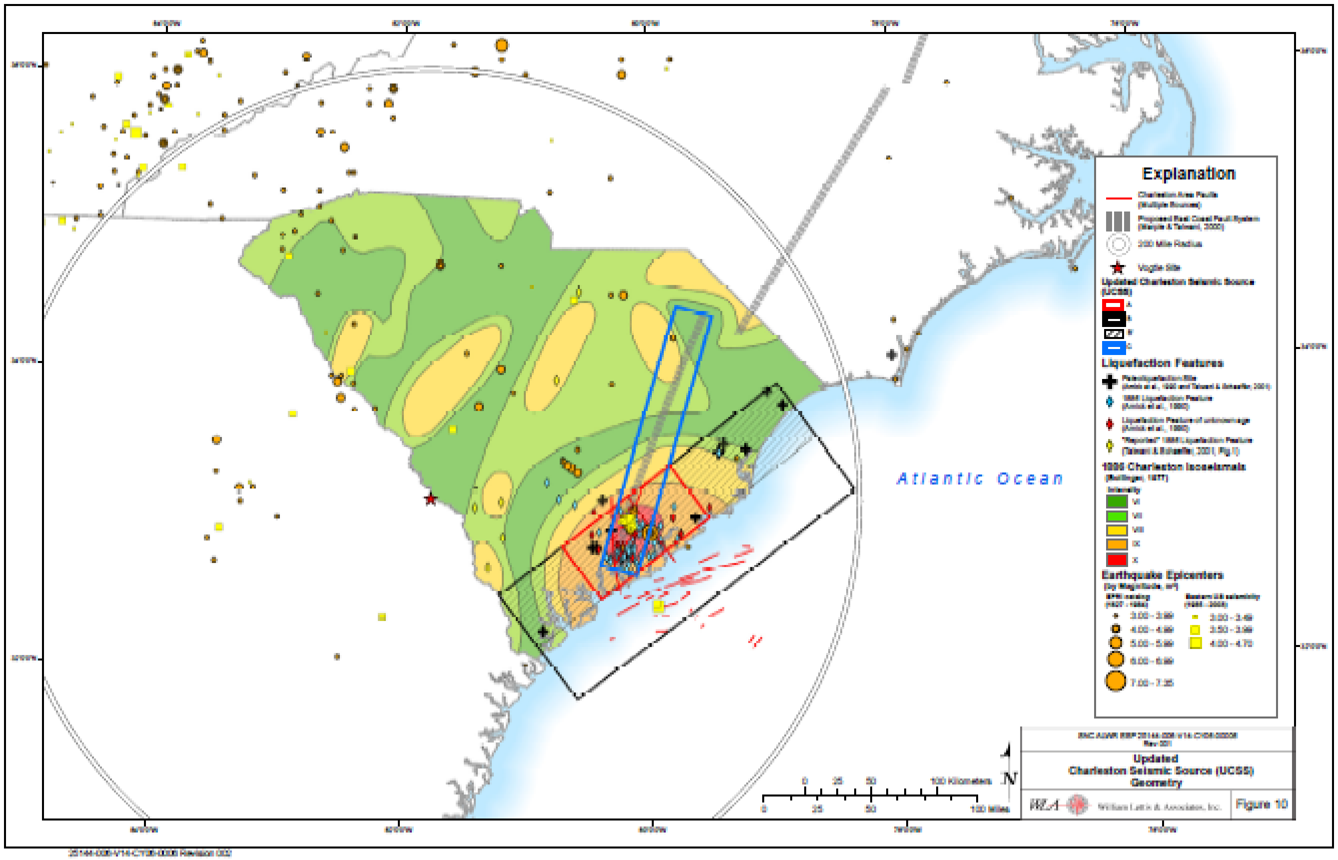
Example of EPRI-SOG Seismic Source Zones Bechtel Team

LNP COL 2.5-2

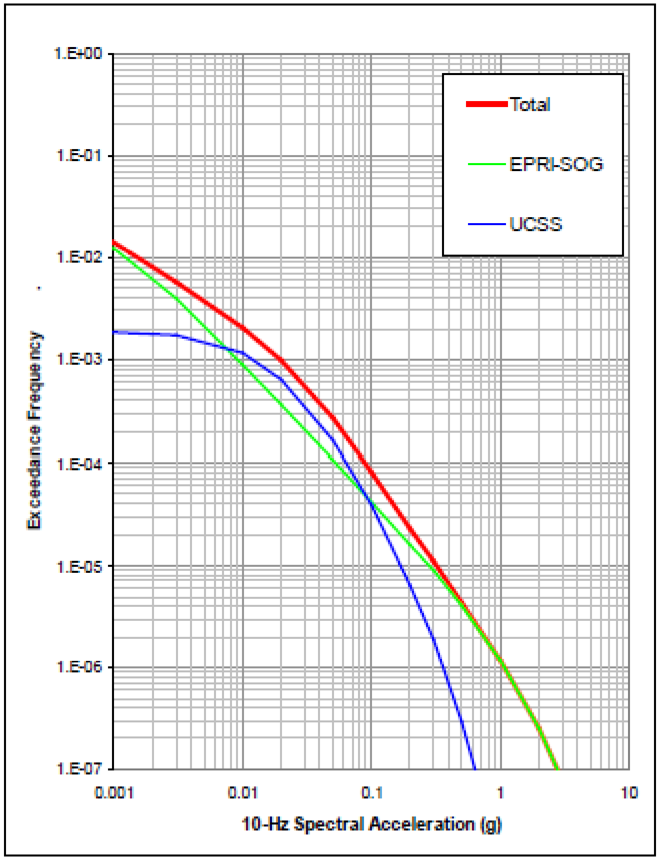


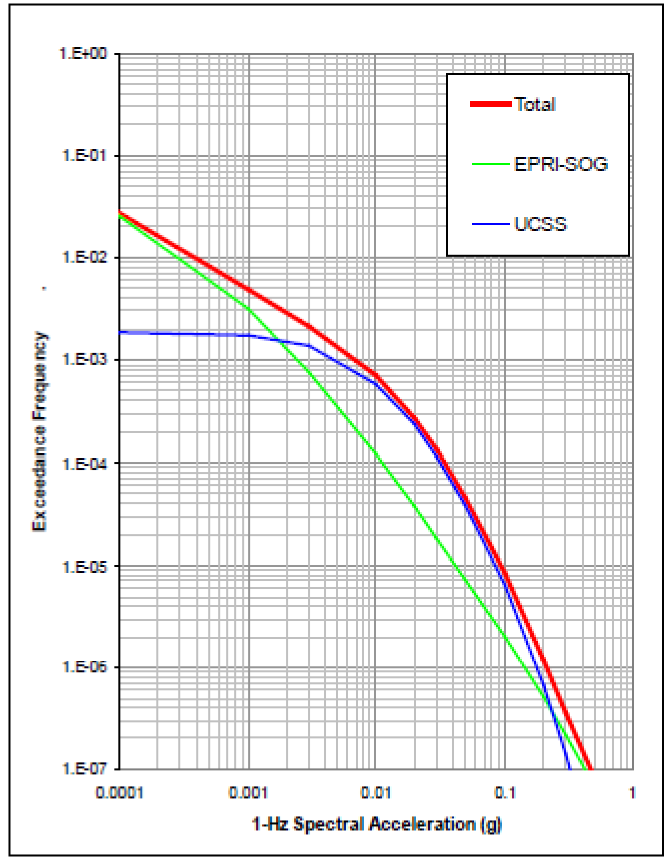
Updated Charleston Seismic Source (UCSS)



FSAR Figure 2.5.2-213

Hard Rock Hazard Curves for LNP Presented in FSAR





FSAR Figure 2.5.2-233

Summary of CEUS SSC Model

- Distributed seismicity modeled by two alternative sets of large regional seismic source zones
  - Mmax Zones (and a single zone for the entire region)
  - Seismotectonic Zones

- Individual sources of repeated large magnitude earthquakes (RLME)

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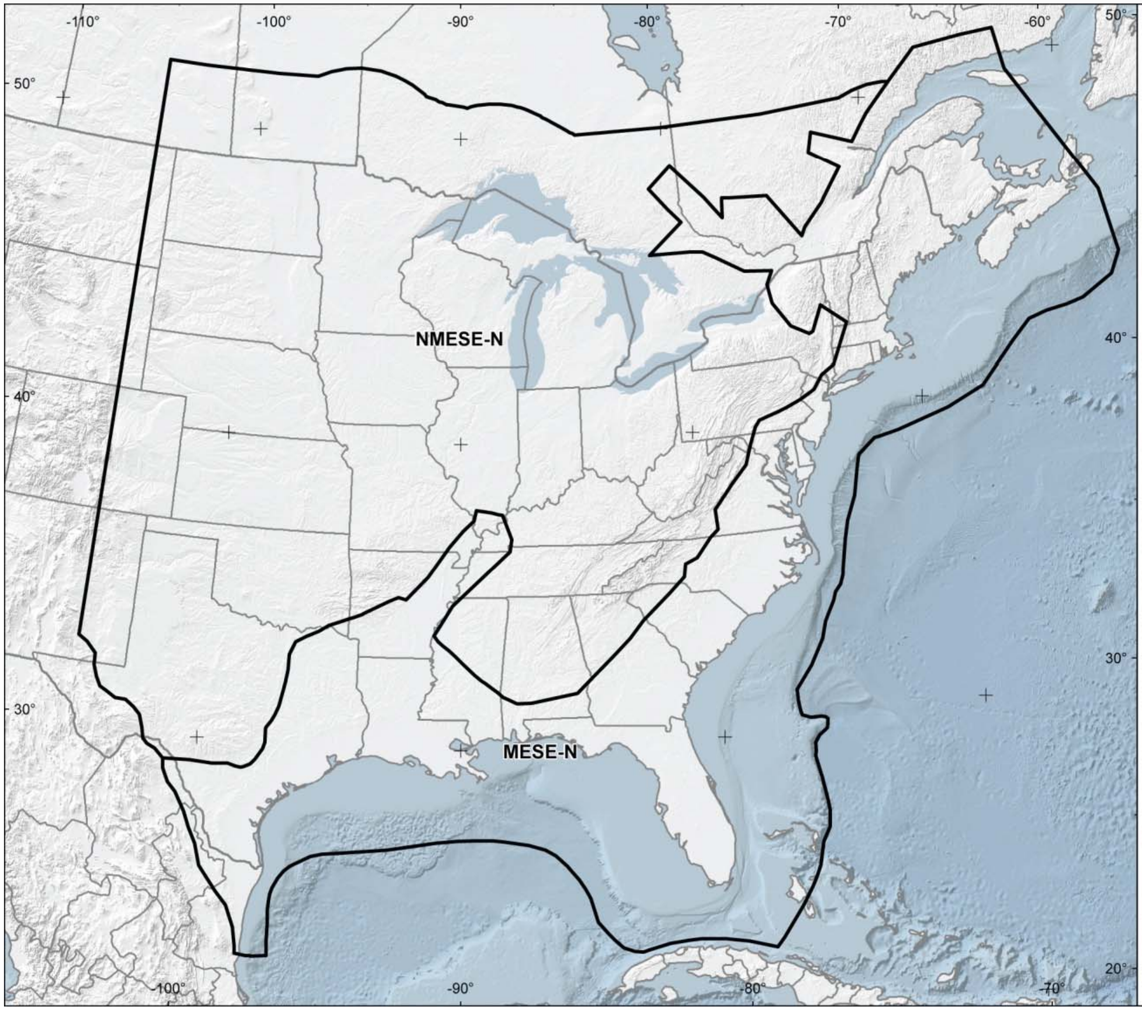
CEUS SSC Mmax Zones (also entire Study Region)



Explanation

Mesozoic and Non-Mesozoic–narrow (1)

Abbreviations:

MESE-N = Mesozoic and younger extended prior–narrow

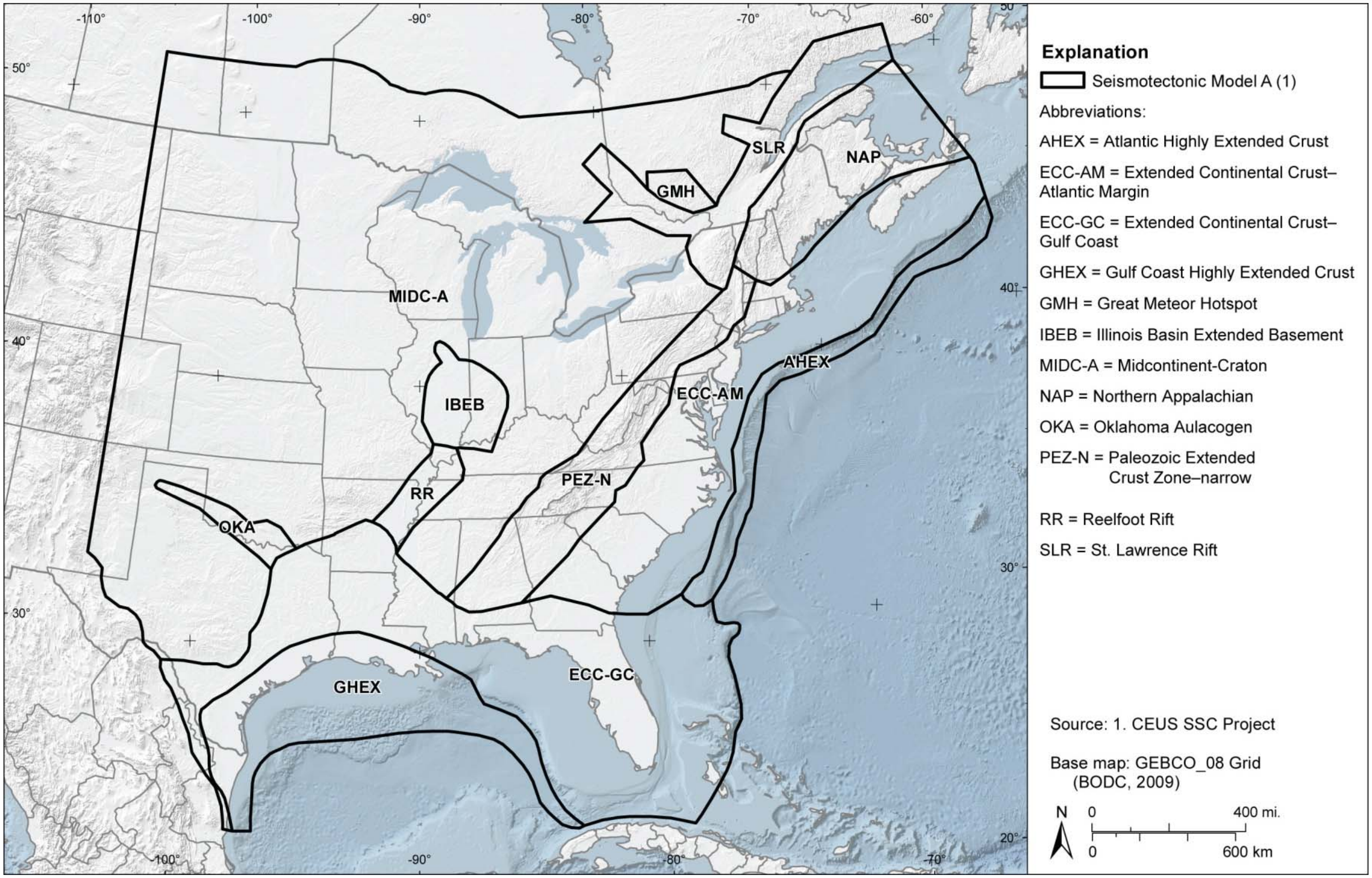
NMESE-N = Non-Mesozoic and younger extended prior–narrow

Source: 1. CEUS SSC Project

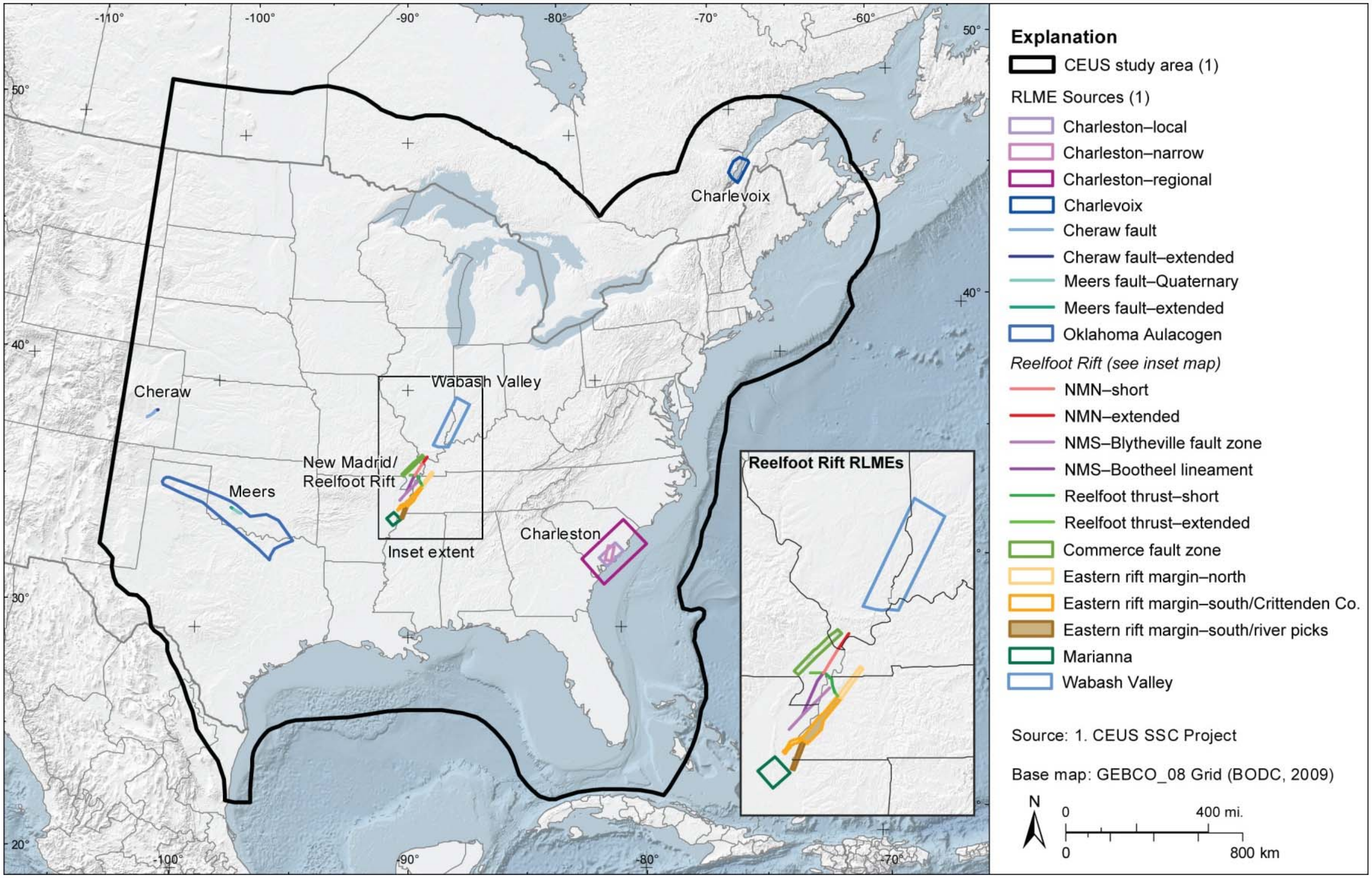
Base map: GEBCO_08 Grid (BODC, 2009)

N 0 400 mi. 0 600 km

CEUS SSC Seismotectonic Source Zones



CEUS SSC RLME Sources



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Summary of Changes from LNP COLA Model to CEUS SSC Model – Distributed Seismicity Sources

- Sources
  - EPRI-SOG – 6 sets of alternative source zones
  - CEUS SSC – one set of alternative zones, generally larger, but covering similar regions
- Seismicity rates
  - EPRI-SOG – spatially varying, 1°x1° cells, based on body wave magnitude scale m_b
  - CEUS SSC – spatially varying, ¼°x¼° or ½°x½° cells, based on moment magnitude scale **M**
- Maximum magnitude distributions
  - EPRI-SOG – various somewhat ad hoc methods
  - CEUS SSC –Bayesian approach using updated Stable Continental Region (SCR) prior distributions leading to generally broader distributions with somewhat higher mean values

Testing Effect of Updated Characterization of Distributed Seismicity Sources

1. Test effect of new maximum magnitude distributions
   - Replace EPRI-SOG Mmax with average CEUS SSC Mmax for region occupied by EPRI-SOG source
   - Recalculate hard rock hazard from EPRI-SOG sources with modified Mmax

2. Test effect of updated seismicity rates
   - Calculate predicted rate of earthquakes within 100, 200, and 300 km of LNP using EPRI-SOG sources with modified Mmax
   - Compare with predicted rate of earthquakes using the CEUS SSC seismic source model
   - Scale rock hazard from Step 1 using ratio of predicted seismicity rates

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1. Testing Effect of Change in Mmax

- Identify correspondence between EPRI-SOG and CEUS SSC sources
- Develop composite Mmax distribution for CEUS SSC sources of interest
- Replace Mmax distribution for EPRI-SOG sources with composite distribution for the CEUS SSC source that encompasses the same region

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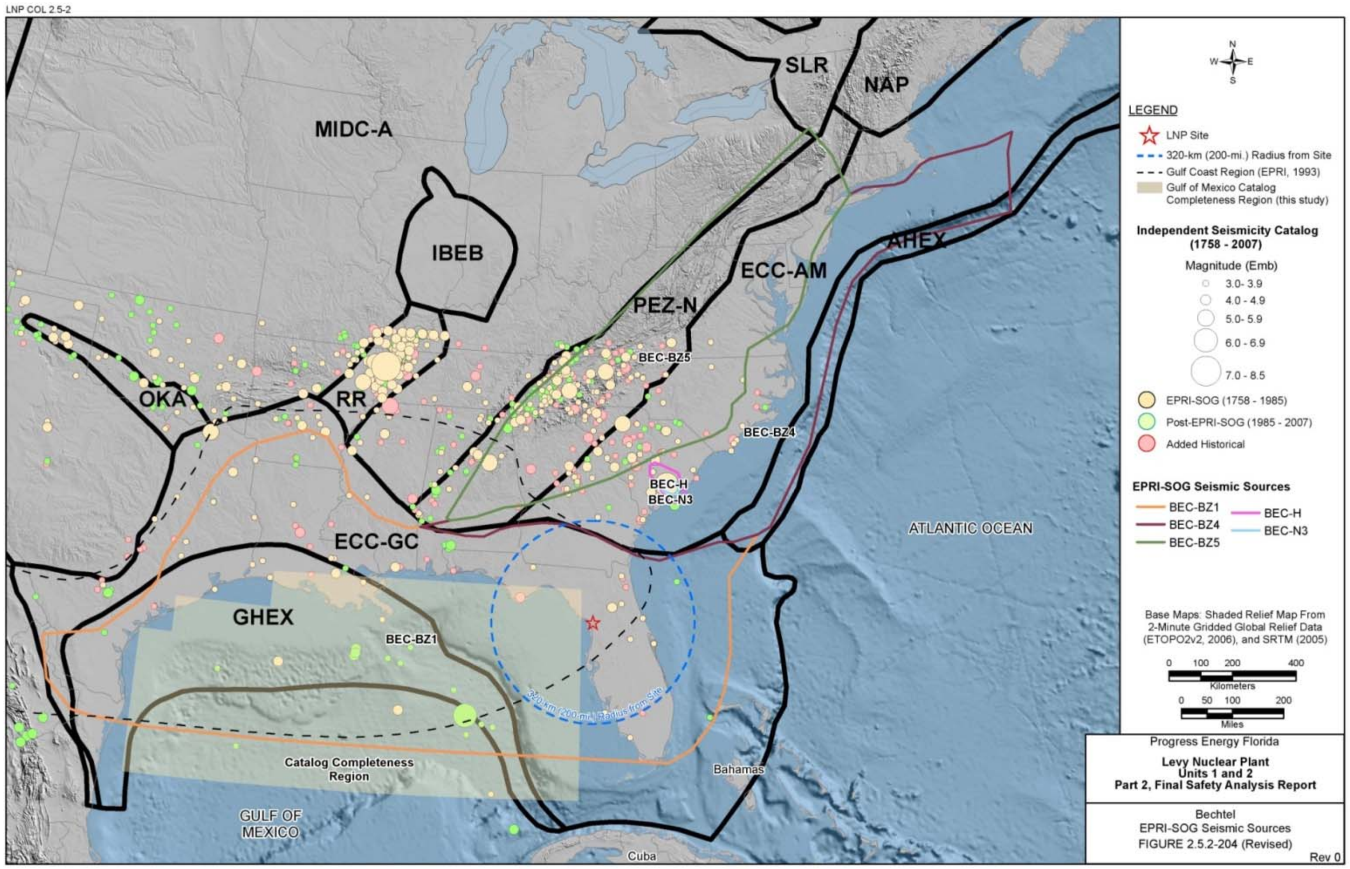
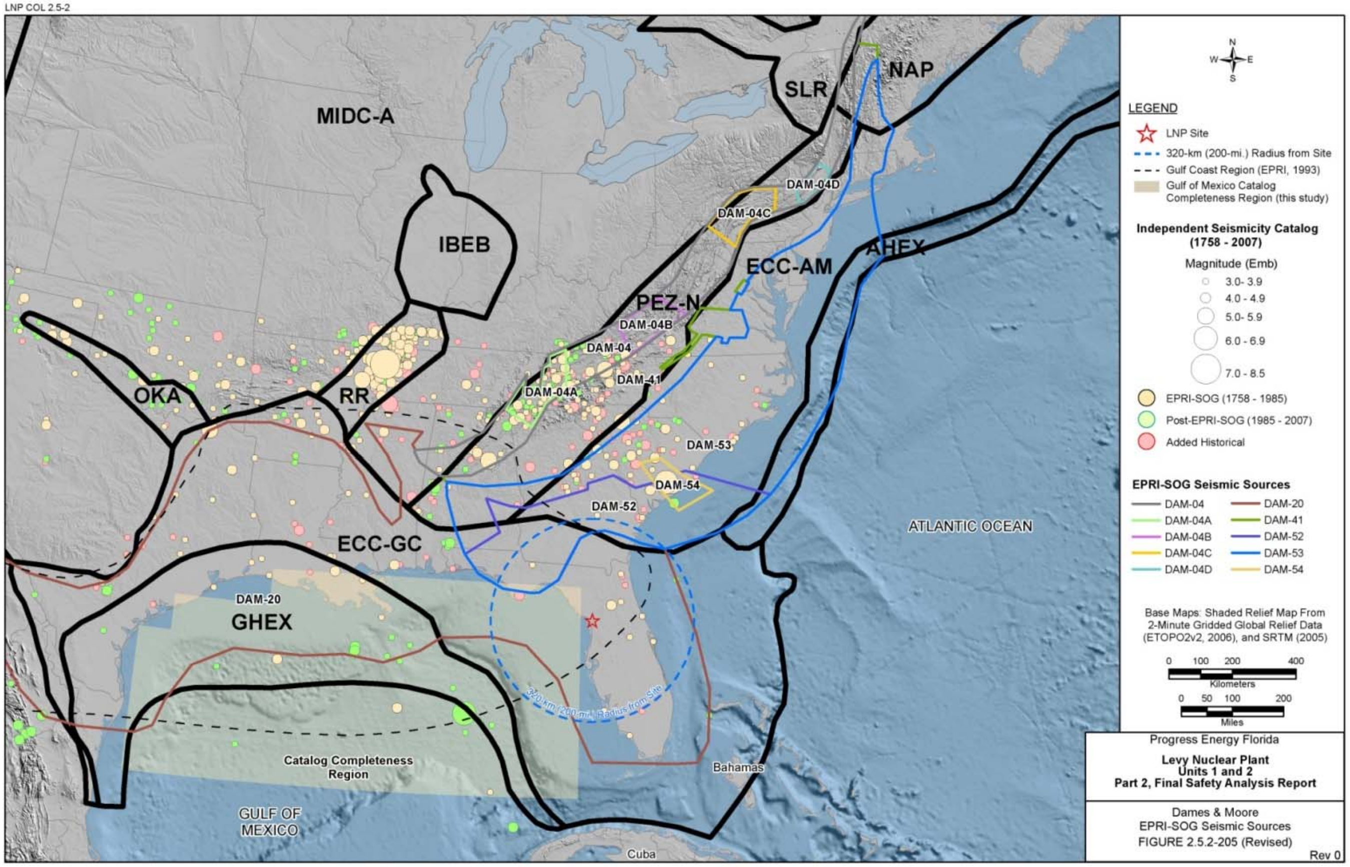
Bechtel Team Sources

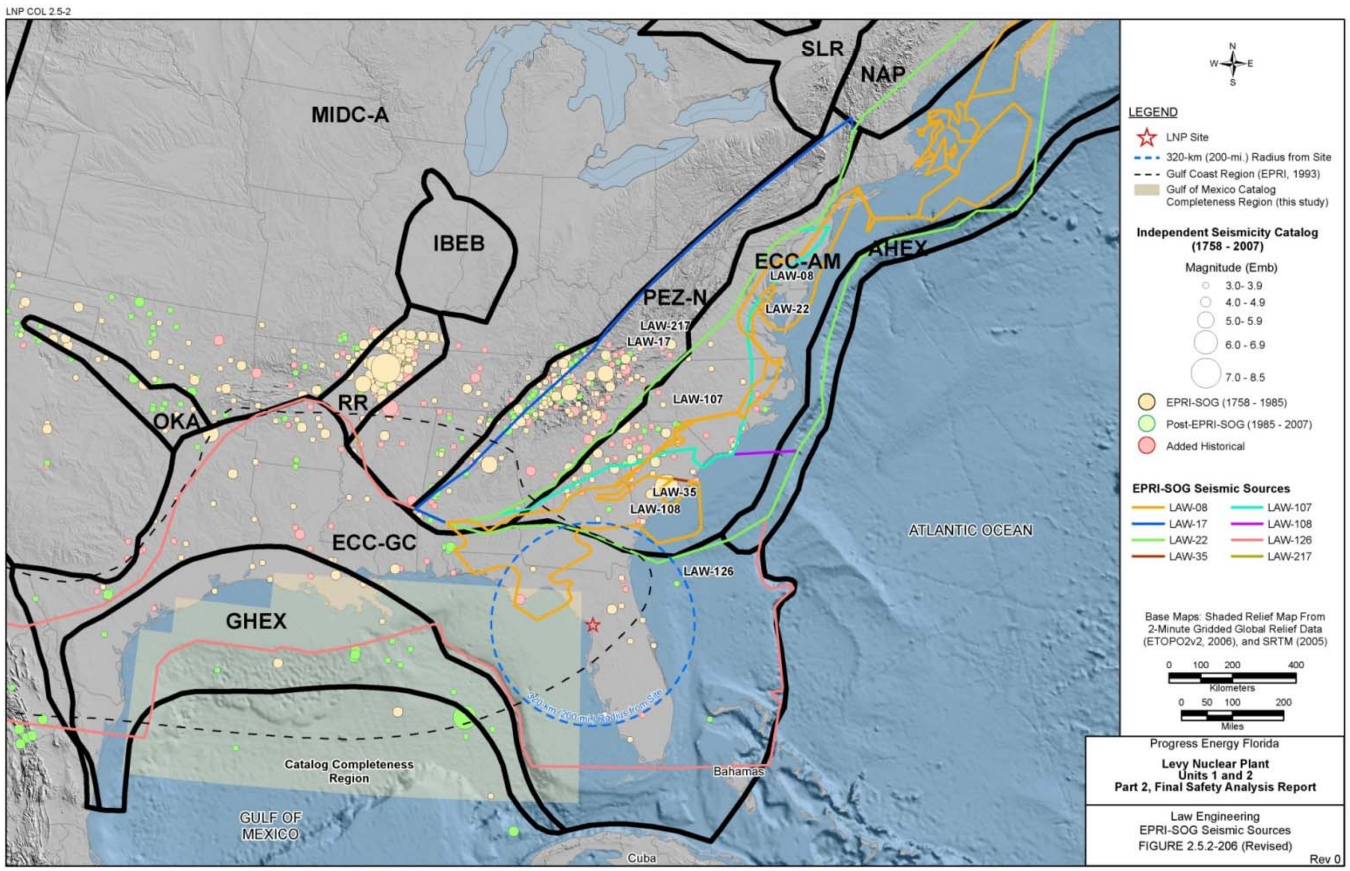


Dames & Moore Team Sources

LNP COL 2.5-2



Law Engineering Sources



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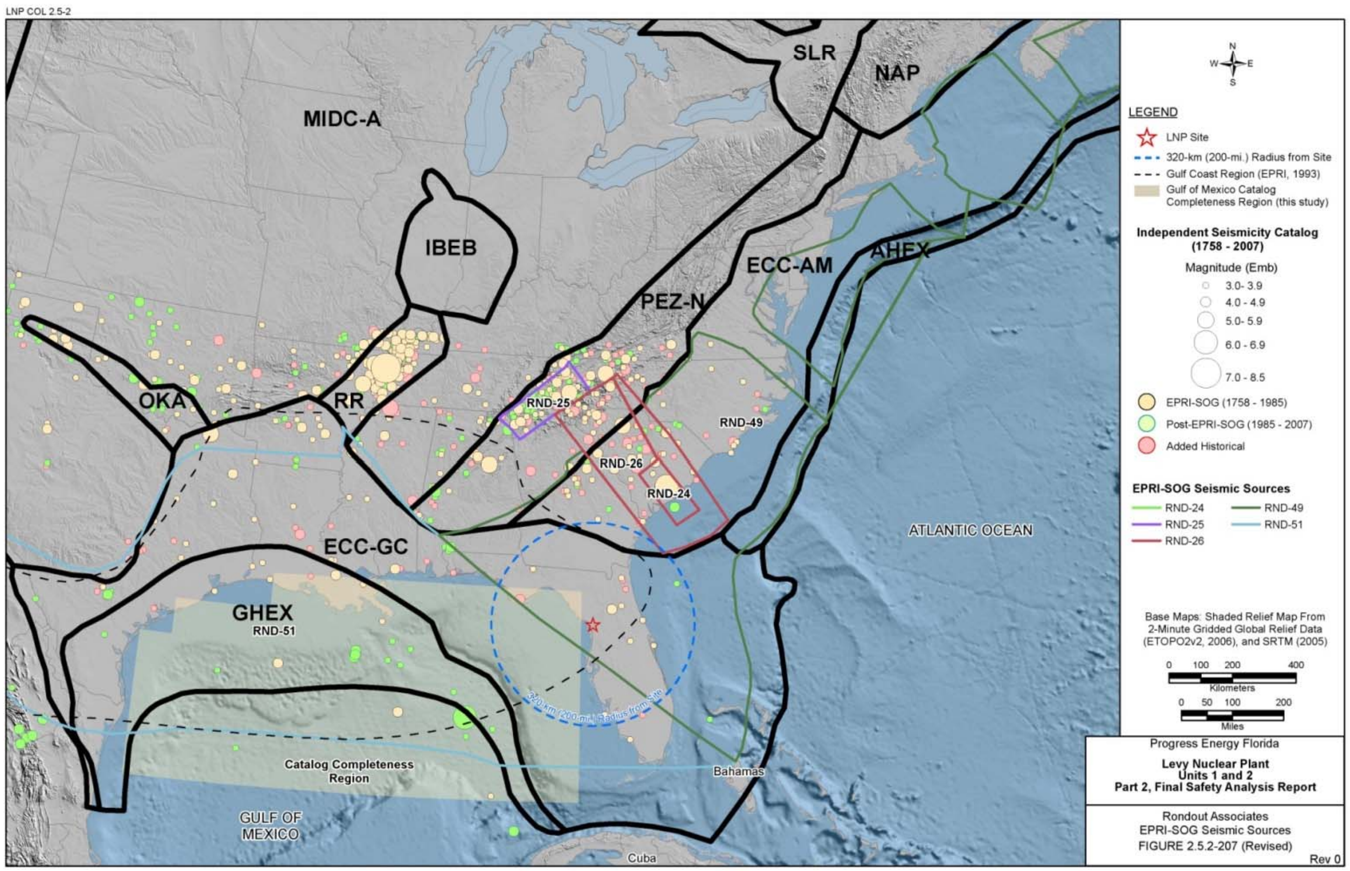
Rondout Associates Team Sources



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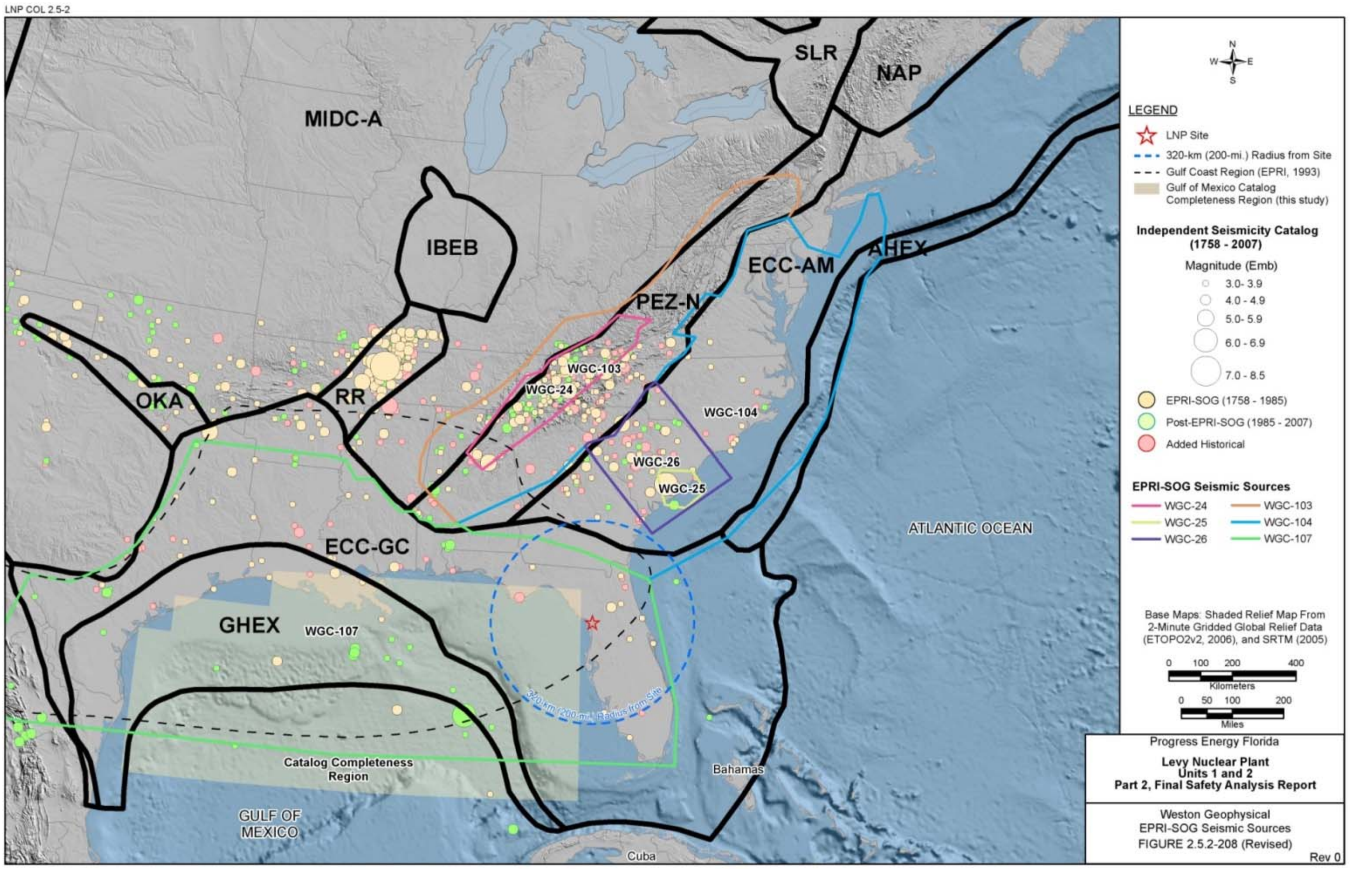
Weston Geophysical Team Sources



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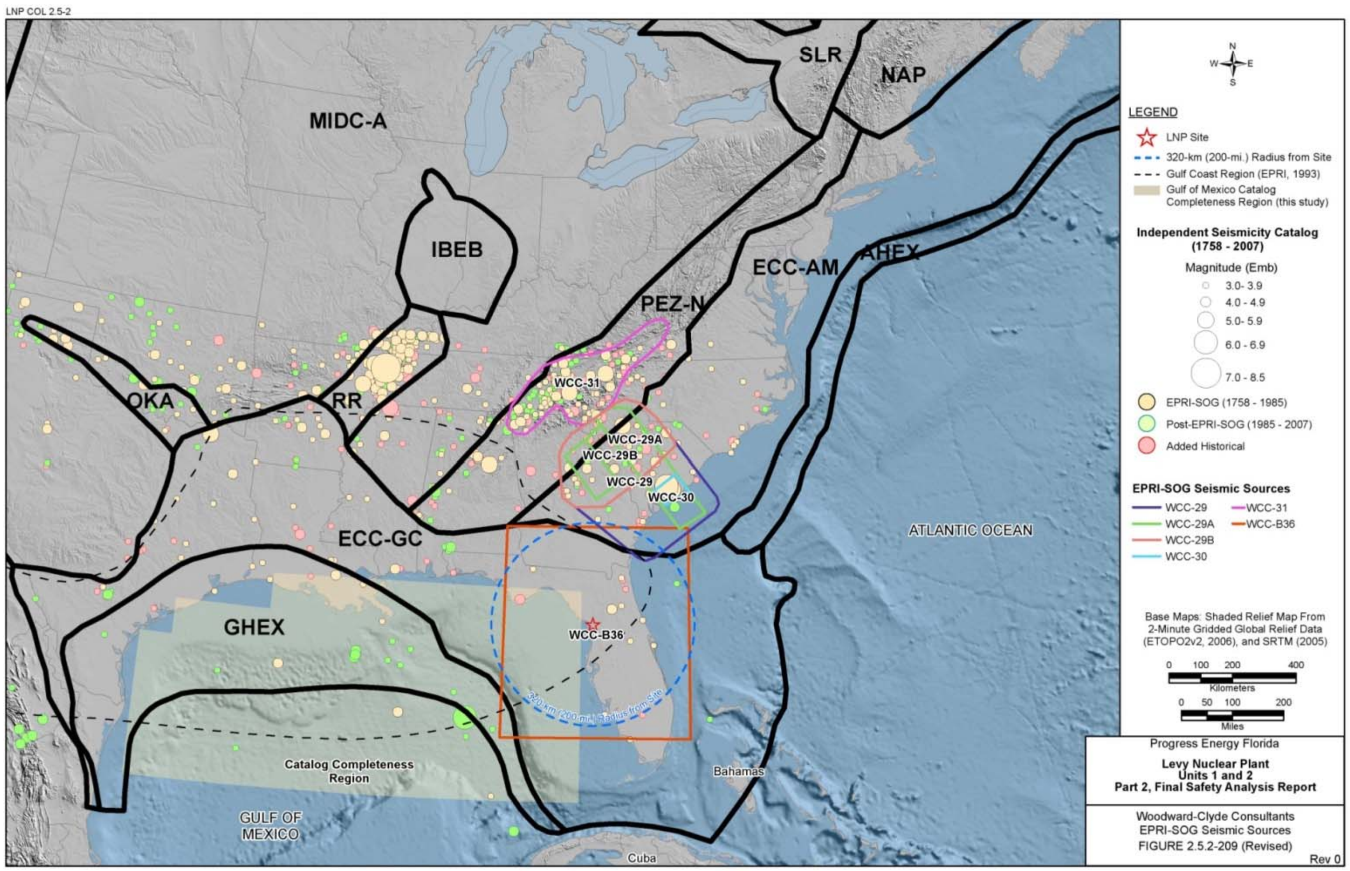
Woodward-Clyde Consultants Team Sources



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Source Correspondence

- EPRI-SOG sources of primary importance to LNP hazard occupy the region covered by the CEUS SSC seismotectonic sources ECC-AM, ECC-GC, and PEZ-N
  - Used only the Narrow versions as they have the highest weight
- These regions are also covered by the MESE-N and Study Region Mmax zones
- Developed composite Mmax distributions for the three CEUS SSC seismotectonic sources as a weighted average of distributions for the seismotectonic and Mmax zones

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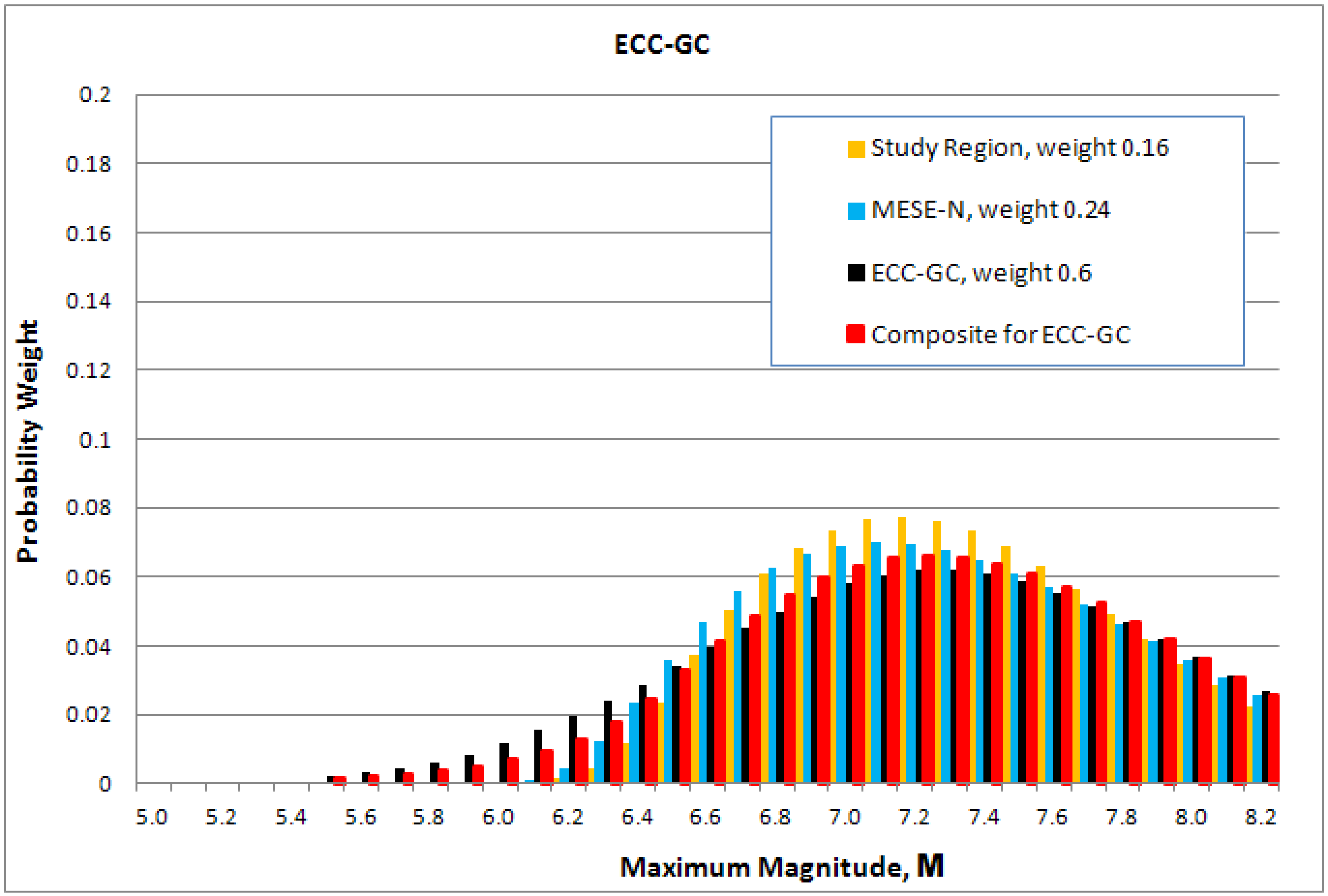
Example Composite Mmax Distribution for ECC-GC



Composite Mmax Distributions Used to Replace EPRI-SOG Source Maximum Magnitude Distributions

Continuous maximum magnitude distributions represented by 5 discrete weighted alternatives in CEUS SSC model

Weight	Composite for ECC-AM	Composite for ECC-GC	Composite for PEZ-N
0.101	6.2	6.2	6.0
0.244	6.8	6.8	6.5
0.31	7.2	7.2	7.0
0.244	7.7	7.7	7.4
0.101	8.1	8.1	8.0

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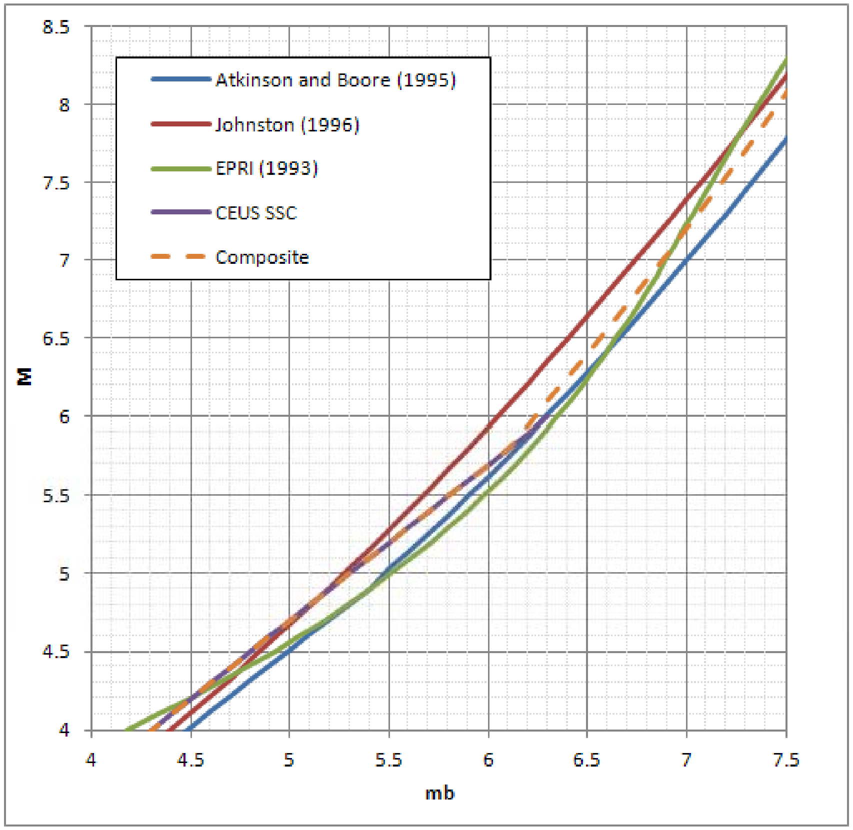
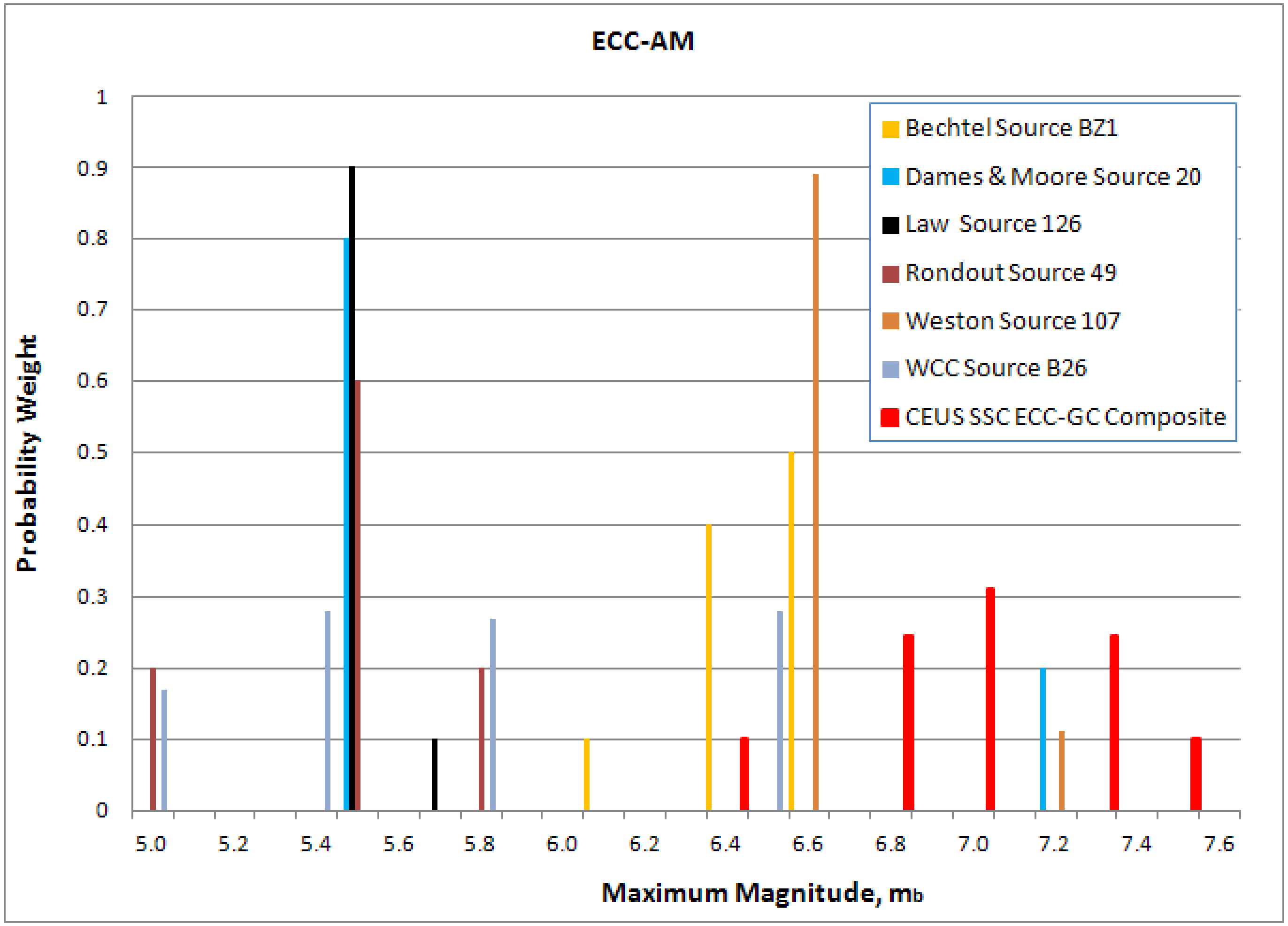
Implementation for EPRI-SOG Sources

- EPRI-SOG sources define seismicity rates in terms of m_b scale, requiring conversion of Mmax values from **M** to m_b
- Developed a composite m_b to **M** conversion from the three used in the LNP FSAR
- Utilized CEUS SSC m_b to **M** conversion for $m_b \leq 6.1$
- Converted composite Mmax distributions in terms of **M** into m_b for use with EPRI-SOG seismicity parameters



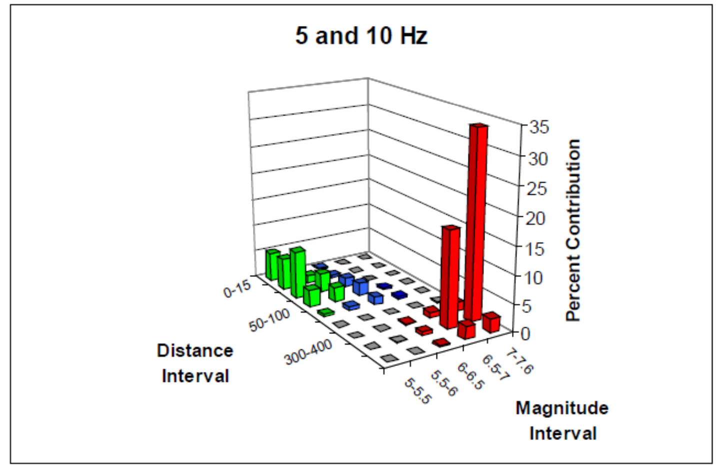
Comparison of EPRI-SOG and CEUS SSC Composite Mmax Distributions for LNP Site Host Zone

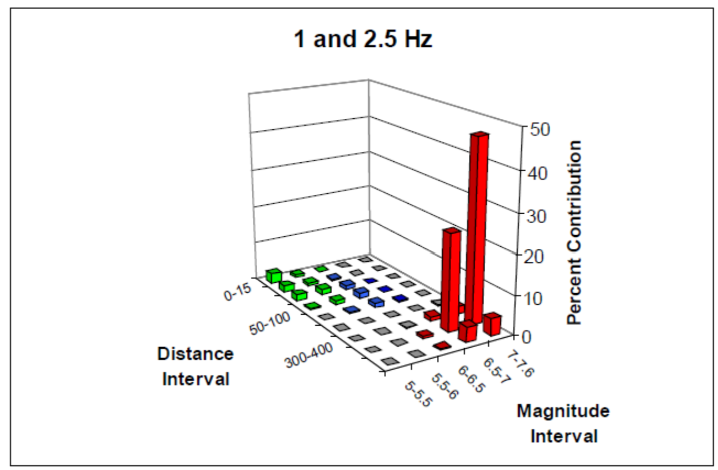


2. Evaluation of Differences in Seismicity Rates

- Seismic hazard scales directly with seismicity rate
- With the exception of contribution from Charleston, most of the site hazard is from earthquakes within 200 km of the site
- Compare seismicity rates predicted from the EPRI-SOG sources (with modified Mmax) with those predicted from the CEUS SSC model

10^{-4} Hazard Deaggregation





FSAR Figure 2.5.2-240

Magnitudes Used for Seismicity Rate Comparisons

- EPRI-SOG predicts seismicity rates are in terms of m_b
- CEUS SSC predicts seismicity rates are in terms of **M**
- From the CEUS SSC study **M** ~ m_b – 0.3 for region around LNP site
- Defined comparable m_b magnitudes

CEUS SSC Magnitudes	EPRI-SOG Magnitudes
M 5.0	m_b 5.3
M 5.45	m_b 5.75
M 5.95	m_b 6.25

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Result of Comparison of Seismicity Rates

Modified EPRI-SOG Sources		CEUS SSC Model		Ratio
Magnitude	Mean Cumulative Annual Frequency	Magnitude	Mean Cumulative Annual Frequency	CEUS SSC / Modified EPRI-SOG
100 km Radius Around Site				
≥ m_b 5.3	1.88E-04	≥ **M** 5.0	1.00E-04	0.53
≥ m_b 5.75	6.49E-05	≥ **M** 5.45	3.47E-05	0.53
≥ m_b 6.25	1.75E-05	≥ **M** 5.95	1.04E-05	0.59
200 km Radius Around Site				
≥ m_b 5.3	7.83E-04	≥ **M** 5.0	4.45E-04	0.57
≥ m_b 5.75	2.72E-04	≥ **M** 5.45	1.54E-04	0.57
≥ m_b 6.25	7.35E-05	≥ **M** 5.95	4.63E-05	0.63
300 km Radius Around Site				
≥ m_b 5.3	1.66E-03	≥ **M** 5.0	1.05E-03	0.63
≥ m_b 5.75	5.74E-04	≥ **M** 5.45	3.62E-04	0.63
≥ m_b 6.25	1.54E-04	≥ **M** 5.95	1.08E-04	0.70

Hazard Sensitivity Calculations for Hard Rock

- Estimated effect of new Mmax distributions by recomputing hazard using CEUS SSC Mmax distributions for EPRI-SOG sources
  - For consistency with new CEUS model performed these calculations using a minimum magnitude of **M** 5.0 → m_b 5.3
  - Used EPRI (2004, 2006) ground motion prediction equations (GMPEs)

- Estimated effect of new seismicity parameters by scaling hazard results by average ratio of 0.6 for predicted seismicity rates for comparable magnitudes (CEUS SSC rate/EPRI-SOG rate)

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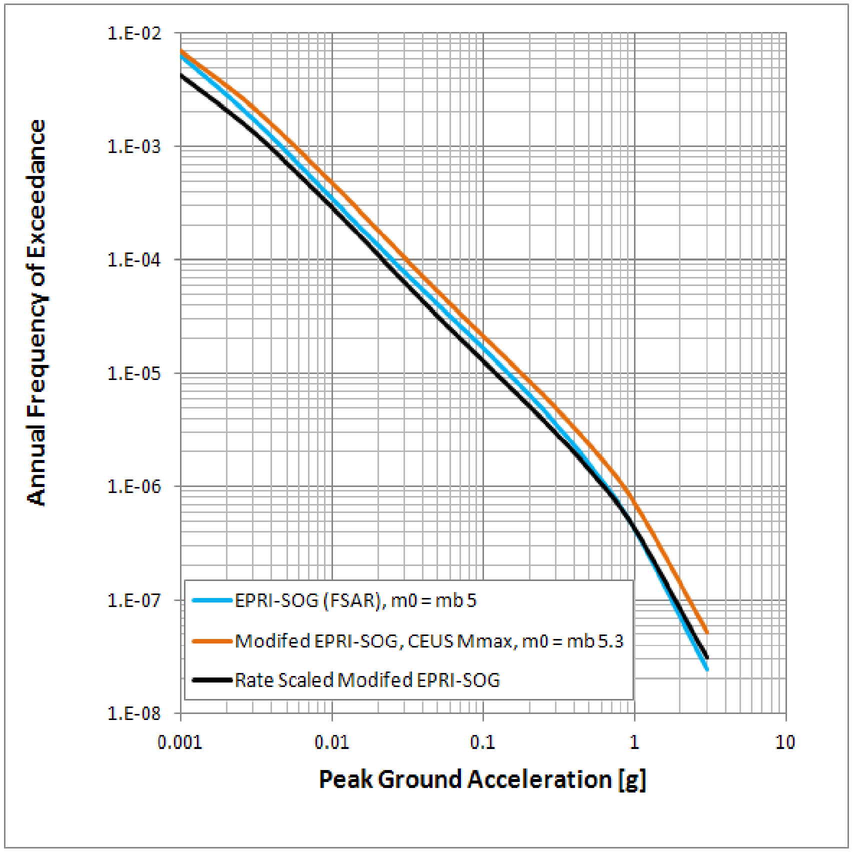
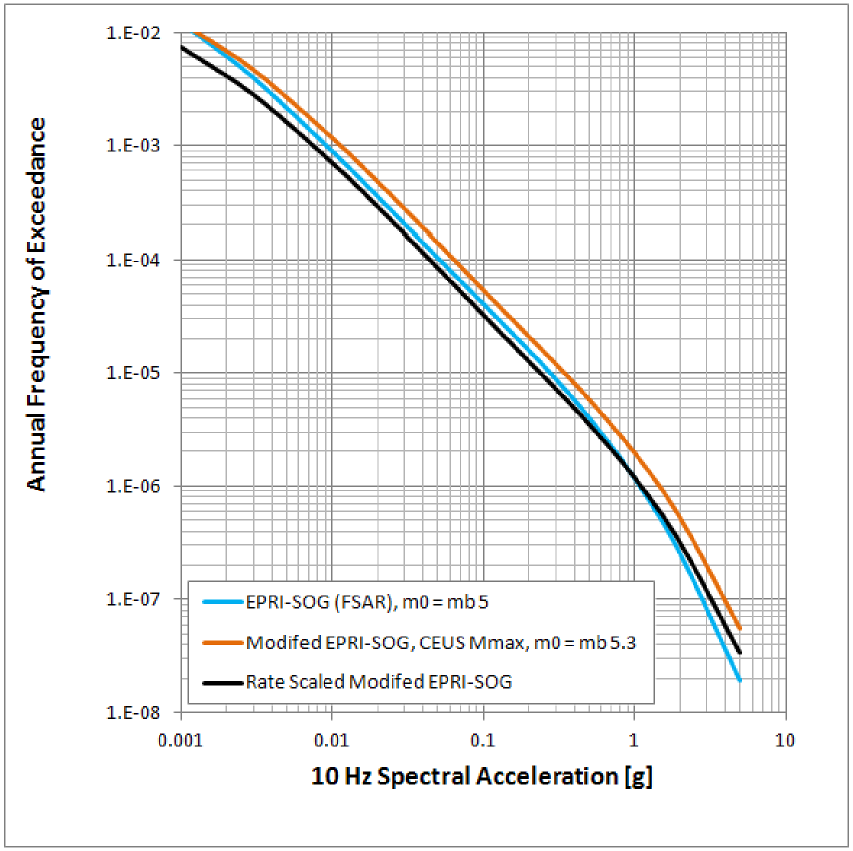
Sensitivity Calculation Results for Distributed Seismicity Sources





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Conclusion for Distributed Seismicity Sources

- Effect of new CEUS SSC maximum magnitude distributions is to increase hazard
- Effect of new CEUS SSC seismicity parameters is to decrease hazard
- Net effect is comparable or slightly lower hard rock hazard for the LNP site at 10 Hz and PGA

Summary of Changes from LNP COLA Model to CEUS SSC Model – Charleston Seismic Source

- Location
  - UCSS – 4 alternative geometries
  - CEUS SSC Charleston RLME – 3 alternative geometries covering same region, average distance to LNP site is ~ 5km greater (420 km vs. 425 km)

- Seismicity rate
  - UCSS – 1.8×10^{-3} per year
  - CEUS SSC Charleston RLME – 1.8×10^{-3} per year

- Maximum magnitude
  - UCSS – **M** 6.7 (0.1), **M** 6.9 (0.25), **M** 7.1 (0.3), **M** 7.3 (0.25), **M** 7.5 (0.1), implemented as m_b, with variability ±½ m_b units
  - CEUS SSC – **M** 6.7 (0.1), **M** 6.9 (0.25), **M** 7.1 (0.3), **M** 7.3 (0.25), **M** 7.5 (0.1), with variability ±½ **M** units

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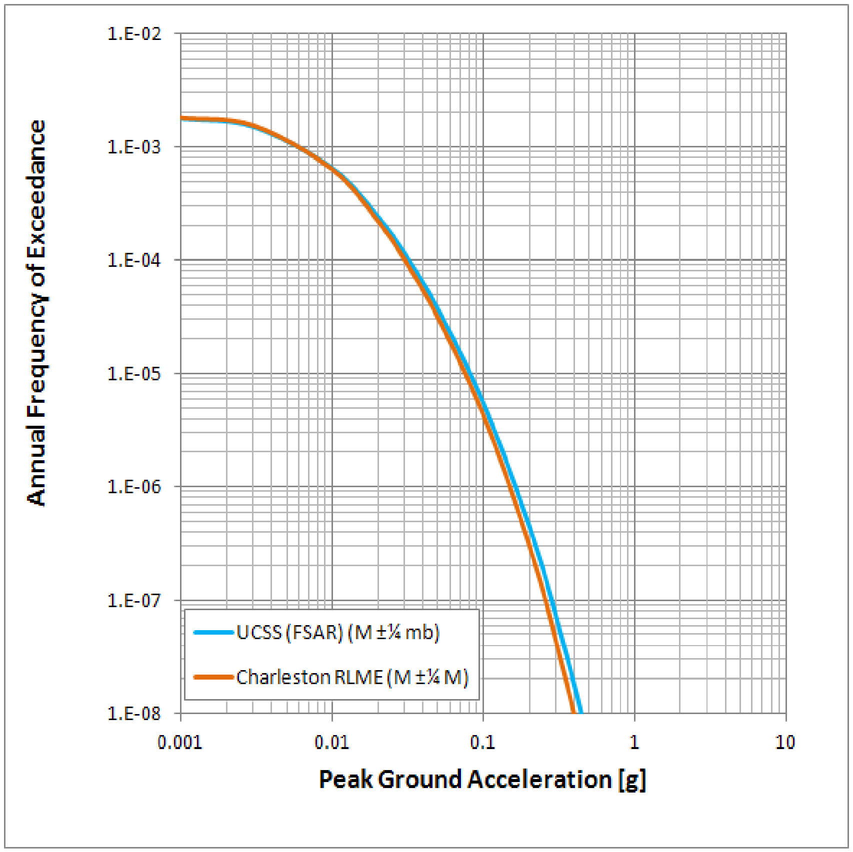
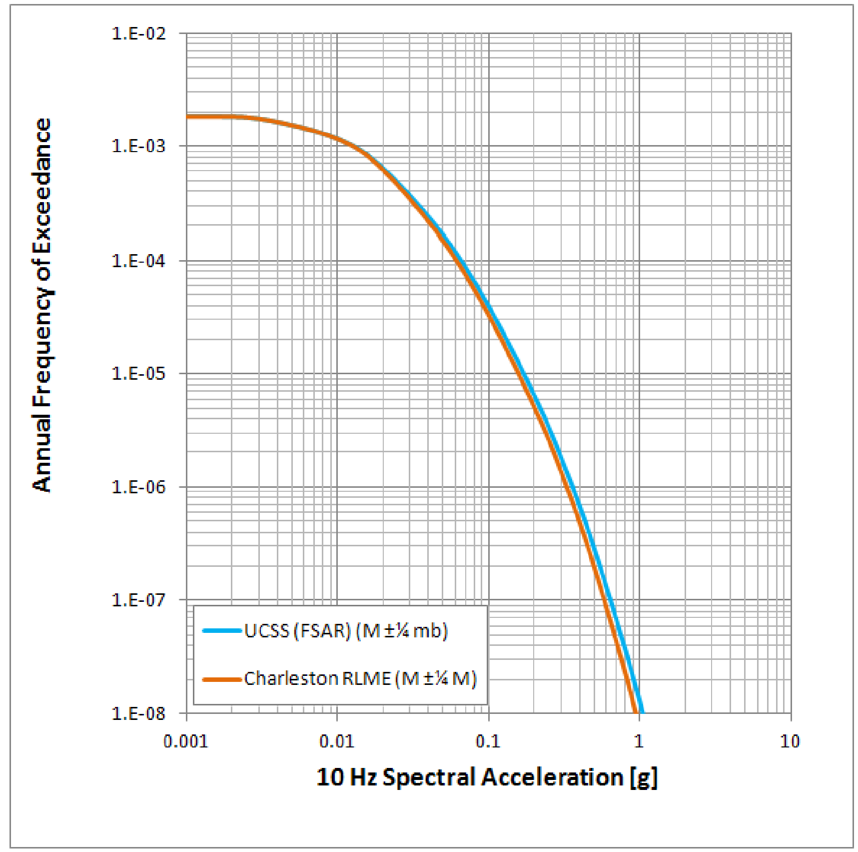
Comparison of FSAR and CEUS SSC Hard Rock Hazard for Charleston Source





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Results for Charleston Source

- Slightly lower hazard from CEUS SSC Charleston RLME than from UCSS used in FSAR

- Difference is due to implementation of the characteristic magnitude distribution in the two analyses
  - In FSAR, UCSS Charleston magnitudes were converted from **M** to m_b and implemented using ±¼ m_b magnitude variability→ ±~0.4 **M**
  - For CEUS SSC Charleston RLME, magnitudes remain in **M** and are implemented using ±¼ **M** magnitude variability
  - Thus for FSAR calculations, larger **M** magnitudes were included than are in the CEUS SSC characterization

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Conclusion

- The anticipated impact of using the new CEUS SSC source model is to produce hard rock hazard at the LNP site that is slightly lower that the hard rock hazard presented in the FSAR

- The preliminary evaluation will be followed by full implementation of the CEUS SSC model

Completion of Response to NRC RAI Letter 108

1. Compute rock hazard at LNP site using the CEUS SSC model and the EPRI (2004, 2006) GMPEs

2. Use new hard rock hazard to compute new GMRS at elevation +36 feet implementing change to CAV model. Compare to GMRS in FSAR

3. Use new hard rock hazard to compute new SCOR FIRS at elevation +11 feet implementing change to CAV model. Compare to scaled SCOR FIRS in FSAR

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Assessment of Impact of New CEUS SSC Model on Seismic Hazard & Response for LNP

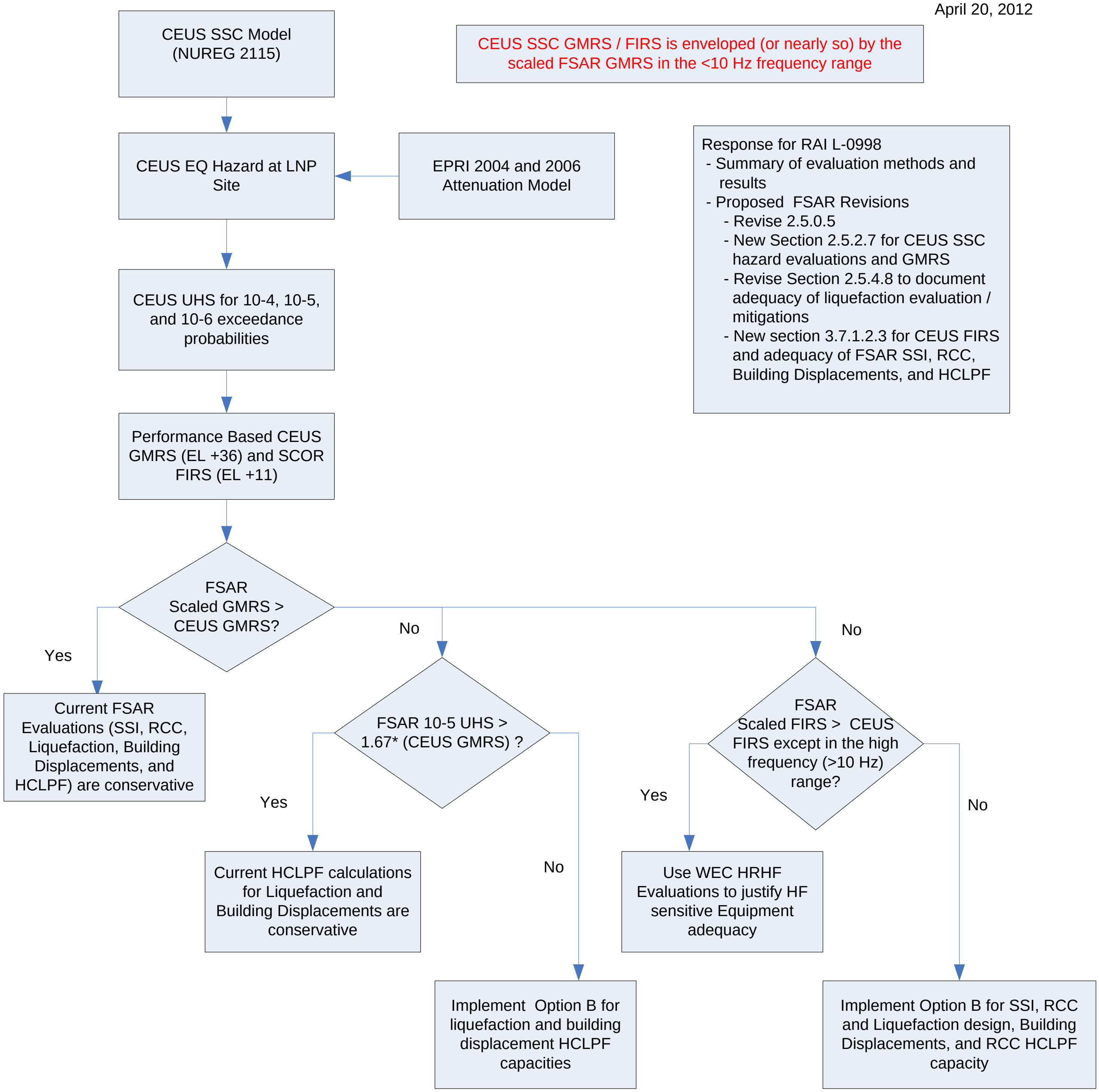
A. K. Singh

Sargent & Lundy

April 27, 2012

OPTION A: EVALUATION OF CEUS SSC SEISMIC HAZARDS AT LNP SITE

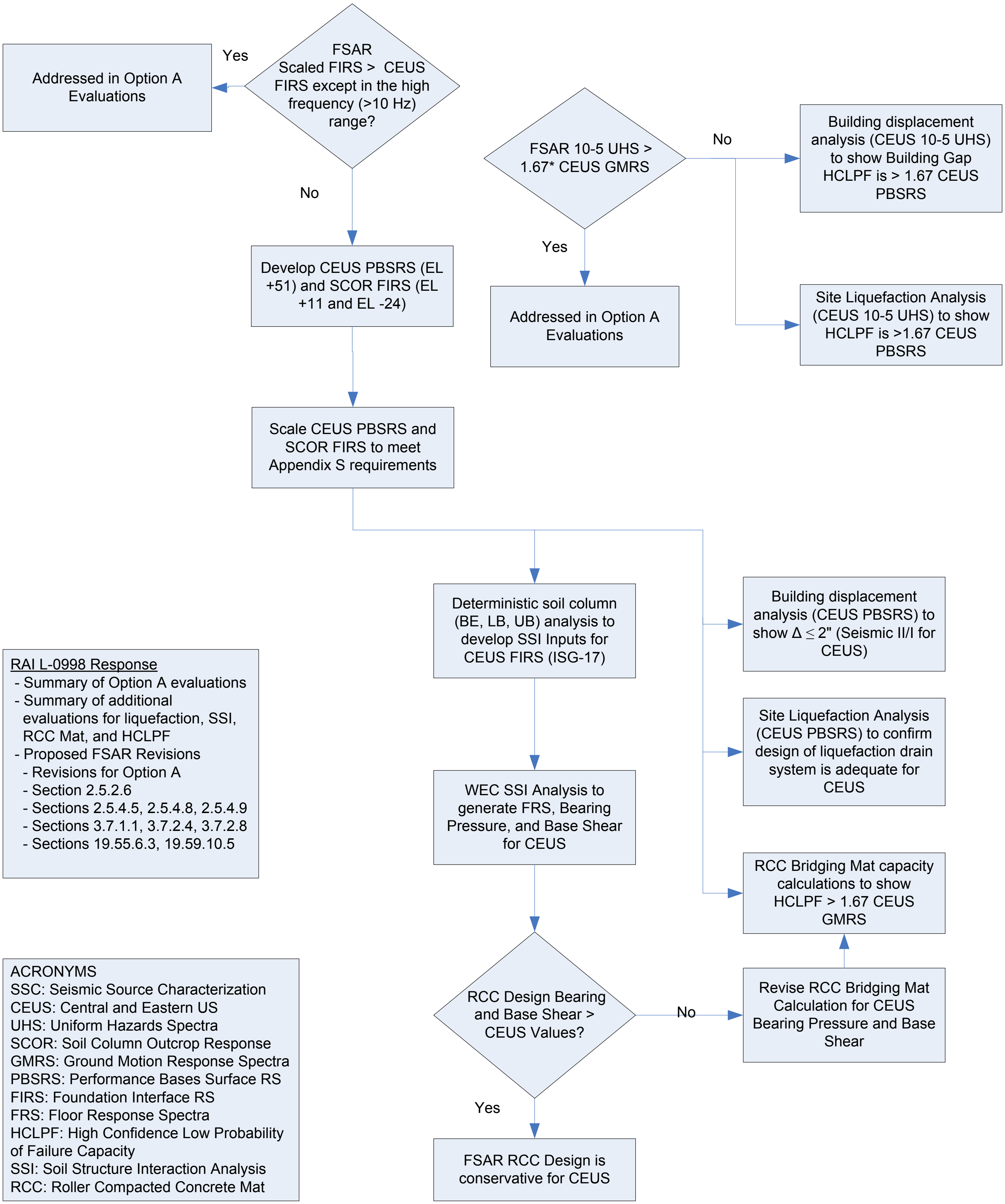
April 20, 2012



ACRONYMS
SSC: Seismic Source Characterization
CEUS: Central and Eastern US
UHS: Uniform Hazards Spectra
HCLPF: High Confidence Low Probability of Failure Capacity
SCOR: Soil Column Outcrop Response
GMRS: Ground Motion Response Spectra
FIRS: Foundation Interface RS
SSI: Soil Structure Interaction Analysis
RCC: Roller Compacted Concrete Mat

OPTION B: EVALUATION OF SITE SPECIFIC DESIGNS AND HCLPF CAPACITIES FOR CEUS SSC

04 20 2012



<u>RAI L-0998 Response</u>
- Summary of Option A evaluations
- Summary of additional evaluations for liquefaction, SSI, RCC Mat, and HCLPF
- Proposed FSAR Revisions
  - Revisions for Option A
  - Section 2.5.2.6
  - Sections 2.5.4.5, 2.5.4.8, 2.5.4.9
  - Sections 3.7.1.1, 3.7.2.4, 3.7.2.8
  - Sections 19.55.6.3, 19.59.10.5

ACRONYMS
SSC: Seismic Source Characterization
CEUS: Central and Eastern US
UHS: Uniform Hazards Spectra
SCOR: Soil Column Outcrop Response
GMRS: Ground Motion Response Spectra
PBSRS: Performance Bases Surface RS
FIRS: Foundation Interface RS
FRS: Floor Response Spectra
HCLPF: High Confidence Low Probability of Failure Capacity
SSI: Soil Structure Interaction Analysis
RCC: Roller Compacted Concrete Mat

SCHEDULE AND FOLLOW-UP FOR CEUS SSC EVALUATIONS RAI

Vann Stephenson

Progress Energy

April 27, 2012

Schedule for Option A Evaluations

- June 2012 - CEUS SSC Seismic Hazards, GMRS, and FIRS
- July 2012 - NRC Follow-up Meeting
- July 2012 - CEUS SSC Evaluation RAI Response
- August 2012 - COLA R5

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Schedule for Option B Evaluations

- June 2012 - CEUS SSC Seismic Hazards, GMRS, and FIRS
- July 2012 - CEUS SSC PBSRS and SSI Inputs
- Establish Schedule for SSI Analysis, Design Calculation Revisions, RAI Response, and COLA R5
- August 2012 - NRC Meeting on Option B Plans
- November 2012 (Tentative) - CEUS SSC Evaluation RAI Response
- November 2012 (Tentative) - COLA R5

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