NATIONAL
ENRICHMENT
FACILITY

10 CFR 30.6
10 CFR 40.5
10 CFR 70.5

November 22, 2004

NEF#04-051

ATTN: Document Control Desk
Director
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Louisiana Energy Services, L. P.
National Enrichment Facility
NRC Docket No. 70-3103

Subject: Clarifying Information Related to Probabilistic Seismic Hazard Analysis

References:

1. Letter NEF#03-003 dated December 12, 2003, from E. J. Ferland (Louisiana Energy Services, L. P.) to Directors, Office of Nuclear Material Safety and Safeguards and the Division of Facilities and Security (NRC) regarding "Applications for a Material License Under 10 CFR 70, Domestic licensing of special nuclear material, 10 CFR 40, Domestic licensing of source material, and 10 CFR 30, Rules of general applicability to domestic licensing of byproduct material, and for a Facility Clearance Under 10 CFR 95, Facility security clearance and safeguarding of national security information and restricted data"

2. Letter NEF#04-002 dated February 27, 2004, from R. M. Krich (Louisiana Energy Services, L. P.) to Director, Office of Nuclear Material Safety and Safeguards (NRC) regarding "Revision 1 to Applications for a Material License Under 10 CFR 70, "Domestic licensing of special nuclear material," 10 CFR 40, "Domestic licensing of source material," and 10 CFR 30, "Rules of general applicability to domestic licensing of byproduct material"

3. Letter NEF#04-029 dated July 30, 2004, from R. M. Krich (Louisiana Energy Services, L. P.) to Director, Office of Nuclear Material Safety and Safeguards (NRC) regarding "Revision to Applications for a Material License Under 10 CFR 70, "Domestic licensing of special nuclear material," 10 CFR 40, "Domestic licensing of source material," and 10 CFR 30, "Rules of general applicability to domestic licensing of byproduct material"

NMSS01

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4. Letter NEF#04-037 dated September 30, 2004, from R. M. Krich (Louisiana Energy Services, L. P.) to Director, Office of Nuclear Material Safety and Safeguards (NRC) regarding "Revision to Applications for a Material License Under 10 CFR 70, "Domestic licensing of special nuclear material," 10 CFR 40, "Domestic licensing of source material," and 10 CFR 30, "Rules of general applicability to domestic licensing of byproduct material"

By letter dated December 12, 2003 (Reference 1), E. J. Ferland of Louisiana Energy Services (LES), L. P., submitted to the NRC applications for the licenses necessary to authorize construction and operation of a gas centrifuge uranium enrichment facility. Revision 1 to these applications was submitted to the NRC by letter dated February 27, 2004 (Reference 2). Subsequent revisions (i.e., revision 2 and revision 3) to these applications were submitted to the NRC by letters dated July 30, 2004 (Reference 3) and September 30, 2004 (Reference 4), respectively.

In a November 12, 2004, conference call between LES and NRC representatives, the NRC requested that clarification be provided concerning the probabilistic seismic hazard analysis. This information is included in the Enclosure, "Clarifying Information Related to Probabilistic Seismic Hazard Analysis."

If you have any questions or need additional information, please contact me at 630-657-2813.

Respectfully,

Daniel G. Green for

R. M. Krich
Vice President – Licensing, Safety, and Nuclear Engineering

Enclosure:
Clarifying Information Related to Probabilistic Seismic Hazard Analysis

cc: T.C. Johnson, NRC Project Manager

ENCLOSURE

Clarifying Information Related to Probabilistic Seismic Hazard Analysis

Clarifying Information Related to Probabilistic Seismic Hazard Analysis

Evaluation of United States Geological Society Probabilistic Seismic Hazards Analyses and Methods

In response to an NRC request, Louisiana Energy Services (LES) has evaluated the United States Geological Society (USGS) probabilistic seismic hazards analyses and methods.

To perform this evaluation, reports that document the USGS National Seismic Hazard Maps were reviewed. The reports (Frankel et al., 1996; National Seismic-Hazard Maps: Documentation, USGS Open File Report 96-532, June 1996) (Frankel et al., 2002; Documentation for the 2002 Update of the National Seismic Hazard Maps, USGS Open File Report 02-420, 2002) describe documentation for the USGS national-scale seismic hazard maps. Also, USGS seismic hazard curves determined for the NEF site locale determined by the USGS were obtained. It is noted that the LES site-specific seismic hazard assessment conducted for the National Enrichment Facility (NEF) site incorporated seismicity models and procedures used for the Department of Energy (DOE) Waste Isolation Pilot Plant (WIPP) site located about 70 miles west of the NEF site. Therefore, seismic hazard curves determined by the USGS for the coordinates nearest to the WIPP site in southeast New Mexico were also obtained for preparation of this response. In addition, for comparative purposes, seismic hazard curves determined by the USGS for the nearest coordinate to the Clinton Nuclear Power Plant (NPP) in central Illinois were also obtained.

Earthquake catalogs for the Central and Eastern US (CEUS) and the Western US (WUS) upon which the USGS national seismic hazard study is based were also obtained from the USGS. Earthquake activity rates were determined for the USGS catalogs and compared to earthquake recurrence rates determined for the catalog assembled for the NEF site-specific seismic hazard study. Earthquakes recurrence models were compared for an area with a 200-mile radius from the NEF site. Additional seismic hazard sensitivity analyses were performed to assess whether seismic hazard differences can be attributed to earthquake activity rates derived from various earthquake catalogs.

USGS Seismic Hazard Methodology

The following discussion addresses the major characteristics of the USGS seismic hazard methodology. This discussion is focused on the geographic region surrounding the NEF site in southeast New Mexico.

The USGS method fuses a national hazard map from two separate probabilistic seismic hazard assessments. A CEUS hazard assessment using four attenuation models and a CEUS earthquake catalog is combined with a WUS hazard assessment determined using three attenuation models and WUS earthquake catalog. The USGS seismic hazard boundary between these distinct studies (i.e., CEUS and WUS) lies east of the Basin and Range Province in New Mexico and to the west of the NEF site (about 90 miles).

The USGS describes in their documentation that hazard calculations were done with sizeable overlap between runs, the CEUS extended west to –115° W and the WUS extended east to –100° W. The NEF site latitude is –103° W. As a result, the NEF site is located in the boundary zone within which USGS CEUS and WUS hazard calculations overlapped.

The USGS also describes in their documentation that the area of New Mexico and West Texas was assigned to the WUS attenuation zone. It is not clear from this comment whether all of New Mexico is in the WUS attenuation zone, or whether the attenuation boundary co-exists with the earthquake catalog boundary. In addition, the USGS documentation describes that b-values of –0.8 and –0.95 were used for the WUS and the CEUS, respectively.

The USGS documentation is not specific on the methods used to combine the WUS and CEUS seismic hazard results in the overlap region. The only related quote (Frankel et al., 1996; page 2) is "we added the rates of exceedance for the two sets of runs so that the hazard contribution for earthquakes on the other side of the attenuation boundary was included."

The USGS method used a maximum magnitude of 7 for the large background zone containing the NEF site in their seismic hazard calculations. Finally, the USGS method determines activity rates (a-values) using "smoothed historical seismicity." The USGS method also uses large background seismicity zones, which are added (with adaptive weights) to three additional seismicity models to calculate seismic hazard.

USGS Seismic Hazard Curves

An examination of the CEUS and WUS earthquake catalogs was performed as part of the evaluation. These catalogs were obtained and displayed for regions encompassing the NEF site and the Central US mid-continent including the Clinton NPP site. In Figure 1, earthquake epicenters for the USGS CEUS catalogs (shown in red) and WUS catalogs (shown in blue) are identified. The three sites for which USGS seismic hazard curves were obtained are also shown in Figure 1. These sites are the NEF site, the WIPP site, both in southeast New Mexico, and the Clinton NPP site in central Illinois.

USGS seismic hazard curves for peak horizontal ground acceleration (firm rock site condition) for the nearest latitude and longitude coordinates to the NEF, WIPP, and Clinton NPP sites are shown on Figure 2. Also shown is one of the individual peak ground acceleration (pga) hazard curves determined in the NEF site-specific hazard study. The NEF site-specific curve corresponds to the 200-mile radius zone with $M_x = 6.5$ and a locally determined b-value of –0.74 from the composite earthquake catalog compiled for the NEF site-specific hazard study. This scenario is viewed to be conservative for the NEF site on the basis that west Texas earthquakes associated with the Rio Grande rift are attributed to a geologically homogeneous 200-mile radius zone. Resulting earthquake statistics produce a conservative b-value of –0.74 determined for the 200-mile zone. Other examined seismic scenarios that differentiate the site region into Central Basin Platform and Rio Grande Rift/basin and Range seismic sources result in lower seismic hazard estimates for the NEF site.

The USGS seismic hazard estimates at 10^{-4}/yr probability of exceedance shown on Figure 2 were reviewed for each of the three sites (i.e., NEF, Clinton NPP, and WIPP). The distinguishing feature for the USGS seismic hazard assessments is the significant (i.e., 2.6 times) difference between the pga results at 10^{-4}/yr probability of exceedance for the NEF site and the Clinton NPP site. Examination of the regional seismicity (CEUS and WUS USGS catalog earthquake locations plotted on Figure 1) within 200 miles of these sites does not support this level of hazard difference between the two sites given that USGS hazard method involves definition of earthquakes activity rates based on "smoothed patterns of historical seismicity."

In addition to obtaining pga hazard curves, spectral acceleration hazard curves were obtained from the USGS in order to construct uniform hazard response spectra for the NEF site. The USGS uniform hazard response spectra for exceedance probabilities equal to 10^{-3}/yr and 10^{-4}/yr are compared to the NEF site-specific response spectrum on Figure 3. The NEF site-specific spectrum was developed using Newmark and Hall (Newmark and Hall, 1978; Development of Criteria for Seismic Review of Selected Nuclear Power Plants, NUREG/CR-0098, U.S. Nuclear Regulatory Commission) spectral amplification factors and an anchoring zero-period acceleration of 0.15g determined from weighted seismic hazard curves at an annual probability of exceedance of 10^{-4}. The NEF site-specific spectrum lies approximately midway between the USGS 10^{-3}/yr and 10^{-4}/yr uniform hazard response spectra.

Earthquake Recurrence Rates for USGS Earthquake Catalogs

During performance of the site-specific seismic hazard assessment for the NEF site, a composite earthquake catalog was prepared from publications for New Mexico earthquakes (Sanford et al, 2002; Earthquake Catalogs for New Mexico and bordering areas: 1869-1998, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Circular 210), as well as similar listings for west Texas, and the Advanced National Seismic System (ANSS) for more recent events through June of 2003. Earthquake epicenters located within 200 miles of the NEF site are shown on Figure 4.

Earthquakes in the USGS CEUS and WUS catalogs are also plotted on Figure 4. The USGS catalogs include events of M=3 and larger, whereas the composite catalog prepared for the NEF site-specific study includes all earthquake events compiled for the 200-mile region. Smaller events with magnitudes < 3 in the composite catalog are shown as x – symbols.

Earthquake recurrence rates among these catalogs are compared for the area defined by the 200-mile radius from the NEF site. Only three earthquakes in the USGS WUS catalog are located within 200 miles of the NEF site; these events were combined with the USGS CEUS catalog for recurrence model computations.

Recurrence models are compared on Figure 5. The model originally determined in the NEF site-specific seismic hazard assessment slightly exceeds models obtained from the USGS catalogs. The original model had a b-value of –0.74 and rate of M=5 and greater events of 0.0256/yr. Earthquake recurrence rates for b-values of -0.95 (implemented by USGS for the CEUS) and b-value of -0.80 (for WUS) would be lower than used in the NEF site-specific seismic hazard study.

Determination of earthquake recurrence models for the USGS catalogs for the 200-mile region of the NEF site supports a conclusion that seismic hazard differences do not result from differences between the catalog used for the NEF site-specific hazard study and the catalogs used by the USGS for their national hazard maps.

Seismic Hazard Sensitivity Analyses

The previous discussion confirmed that seismic hazard differences do not result from differences in activity rates determinable from the available earthquake catalogs for the 200-mile area. Hazard differences thus can result from programmatic or philosophical differences between the NEF site-specific and USGS national-scale seismic hazard studies. These programmatic differences include the USGS method of combining WUS and CEUS maps in the geographic area containing the NEF site, as well as adding hazard contributions from large background zones. The effect of combining the seismic hazard results in the overlap region could not be determined from the available USGS documentation (Frankel et al., 1996; Frankel et al., 2002). Furthermore, seismic hazard differences are not directly attributed to substantial differences in ground motion attenuation models. The NEF site-specific seismic hazard assessment used several eastern US models, but centered on versions of the Nuttli attenuation models (Nuttli, 1973; Design Earthquake for the Central United States, Miscellaneous Paper, S-73-1, U.S. Army Waterways Experiment Station) (Nuttli, 1988; Nuttli-Newmark attenuation model, Letter to Dr. Jean Savy dated September 19, 1986, Source: Jean Savy, Lawrence Livermore National Laboratory, April 1988) that are viewed to be conservative ground motion predictors. The conservatism of the Nuttli attenuation models was further demonstrated in the LES Response to NRC Clarification Request 2 concerning External Hazards Analyses (submitted to NRC in letter NEF#04-035 dated August 31, 2004) wherein peak ground motion for the 1992 earthquake in southeast New Mexico was estimated from the USGS isoseismal map. Observed seismic intensities of V MMI for the 1992 earthquake correlate empirically to pga < 0.05g, whereas the Nuttli attenuation models predict pga values of 0.1 – 0.13g for near epicentral distances to a magnitude 5 earthquake. Therefore, it is concluded that appropriate and conservative attenuation models were used in the NEF site-specific seismic hazard study.

Seismic hazard sensitivity studies were performed by LES as part of this evaluation. These sensitivity studies focused on the parameters of maximum magnitude (M_x) and activity rate for earthquakes larger than magnitude 5.0. Sensitivity to attenuation model, such as using a WUS model, was not examined on the basis that the Nuttli models for the US mid-continent conservatively model ground motions for a local magnitude 5 earthquake, as reflected in the LES Response to NRC Clarification Request 2 concerning External Hazards Analyses. The following input modifications were made and impacts at the 10^{-4}/yr seismic hazard level for the NEF site are noted. Resulting seismic hazard curves are plotted on Figure 6 in comparison to the individual hazard curve for the 200-mile zone with M_x=5 and a b-value of –74 from the NEF site-specific study (labeled NEF 200 mile catalog low b on Figure 6) and the USGS estimate for the nearest grid point to the NEF site.

<u>Sensitivity Case 1</u>

The maximum magnitude M_x is raised from 6.5 to 7 to correspond to maximum magnitudes used by the USGS for the large CEUS background zone that contains the NEF site (labeled M7 on Figure 6). An M_x = 6.5 was originally used in the NEF site-specific study for the 200-mile zone. The resulting pga is raised to 0.24g for the 10^{-4}/yr probability of exceedance.

<u>Sensitivity Case 2</u>

The activity rate for M=5 and larger earthquakes is increased by a factor of 2, while maintaining the M_x=7 (labeled M7 R2x on Figure 6). The resulting 10^{-4}/yr pga is about 0.33g. The rationale

for doubling of the activity rate was to account for the possibility that WUS and CEUS seismic hazard components were 'added' to form a national map.

Sensitivity Case 3

The activity rate for M=5 and larger earthquakes is increased by a factor of 3, so that the mean return period for M>5 is about 12 years (labeled M7 R3x on Figure 6). This is extremely conservative when coupled with the low b-value of –0.74. The resulting pga is near 0.4g.

These sensitivity studies increased the 10^{-4} pga hazard estimate, but also impacted the hazard curve at higher probabilities. The original NEF site-specific hazard curve for the 200-mile zone and USGS estimate for NEF are both near 0.07g at 10^{-3}/year. The changes made in the above three sensitivity cases did not change the overall slopes of the hazard curves. Therefore, while attaining a comparable 10^{-4}/yr pga, seismic hazard at higher probabilities substantially exceeds that determined by the USGS.

Conclusion

The USGS probabilistic seismic analyses and methods have been evaluated by LES. USGS data and results have been compared to the NEF site-specific data and results. The USGS analyses and methods contain some inconsistencies that may explain the differences between the results of the USGS national-scale seismic hazard studies and NEF site-specific seismic hazard analysis performed by LES. These inconsistencies include the incorporation of earthquakes with maximum magnitudes as large as magnitude 7 into the USGS background source zone, where LES has concluded that earthquakes up to a maximum of magnitude 6.5 could occur as background earthquakes. In addition, in order to generate peak ground acceleration values similar to those predicted by the USGS results, LES would have to triple the activity rates of the background earthquakes in the NEF site-specific analysis. Tripling the earthquake activity is not realistic because, at that activity rate, magnitude 5 earthquakes would reoccur about every 12 years in the vicinity around the NEF site. The historical earthquake record for southern New Mexico does not support this rate of earthquake activity.

A more likely explanation of the difference between the results of USGS national-scale seismic hazard studies and NEF site-specific analysis is the way in which the USGS overlapped their seismic hazard maps from the CEUS with those from the WUS. USGS documentation does not provide a complete description of how USGS overlapped the seismic hazard results from these two regions, but suggests that in the overlap regions, the seismic hazards were simply added together. This suggests that the USGS may "double counting" the seismic hazard in the overlap zone. The NEF site is located in this overlap zone.

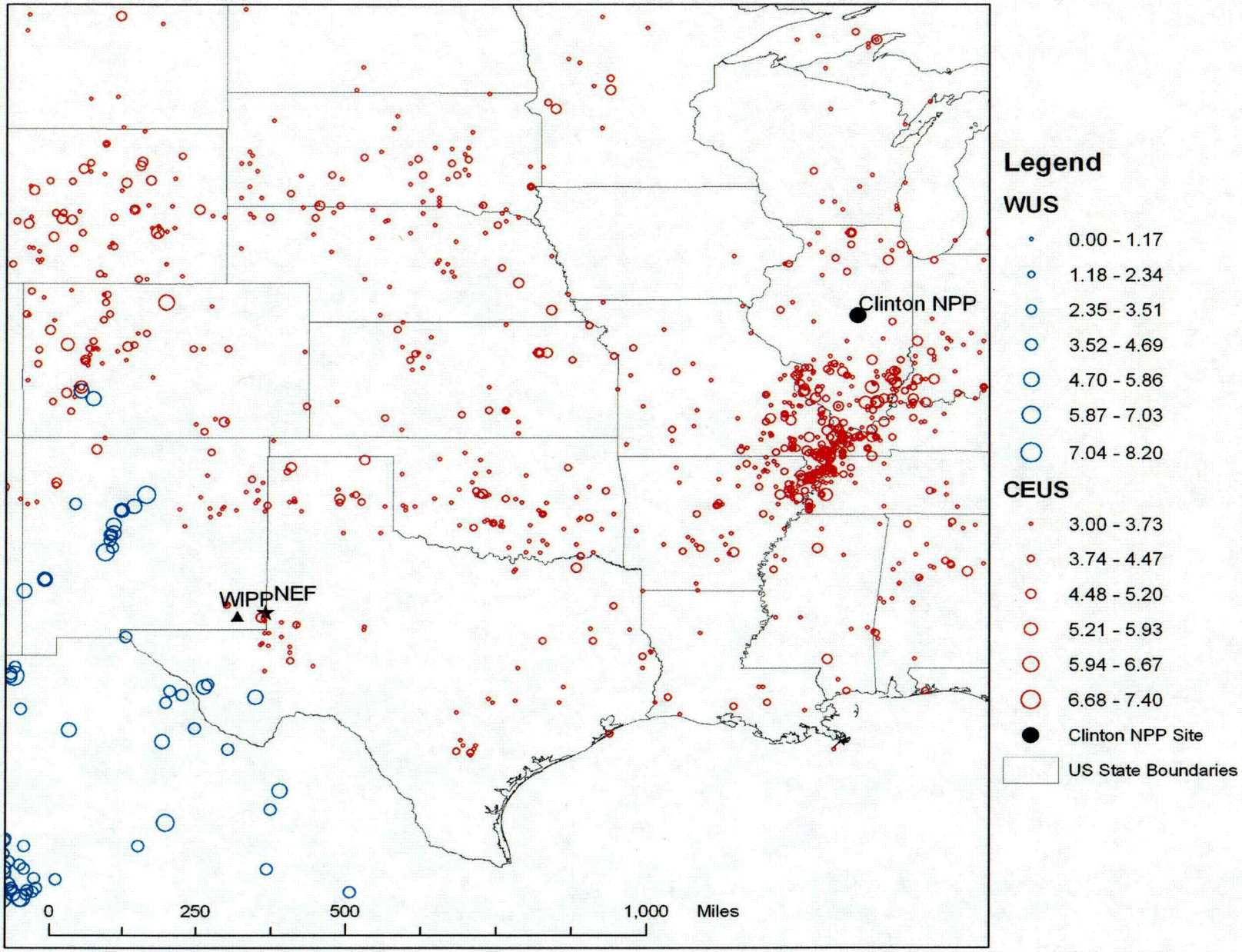
Clinton NPP
WIPP
NEF
0
250
500
1,000
Miles
Legend
WUS
0.00 - 1.17
1.18 - 2.34
2.35 - 3.51
3.52 - 4.69
4.70 - 5.86
5.87 - 7.03
7.04 - 8.20
CEUS
3.00 - 3.73
3.74 - 4.47
4.48 - 5.20
5.21 - 5.93
5.94 - 6.67
6.68 - 7.40
Clinton NPP Site
US State Boundaries

Figure 1

C-01

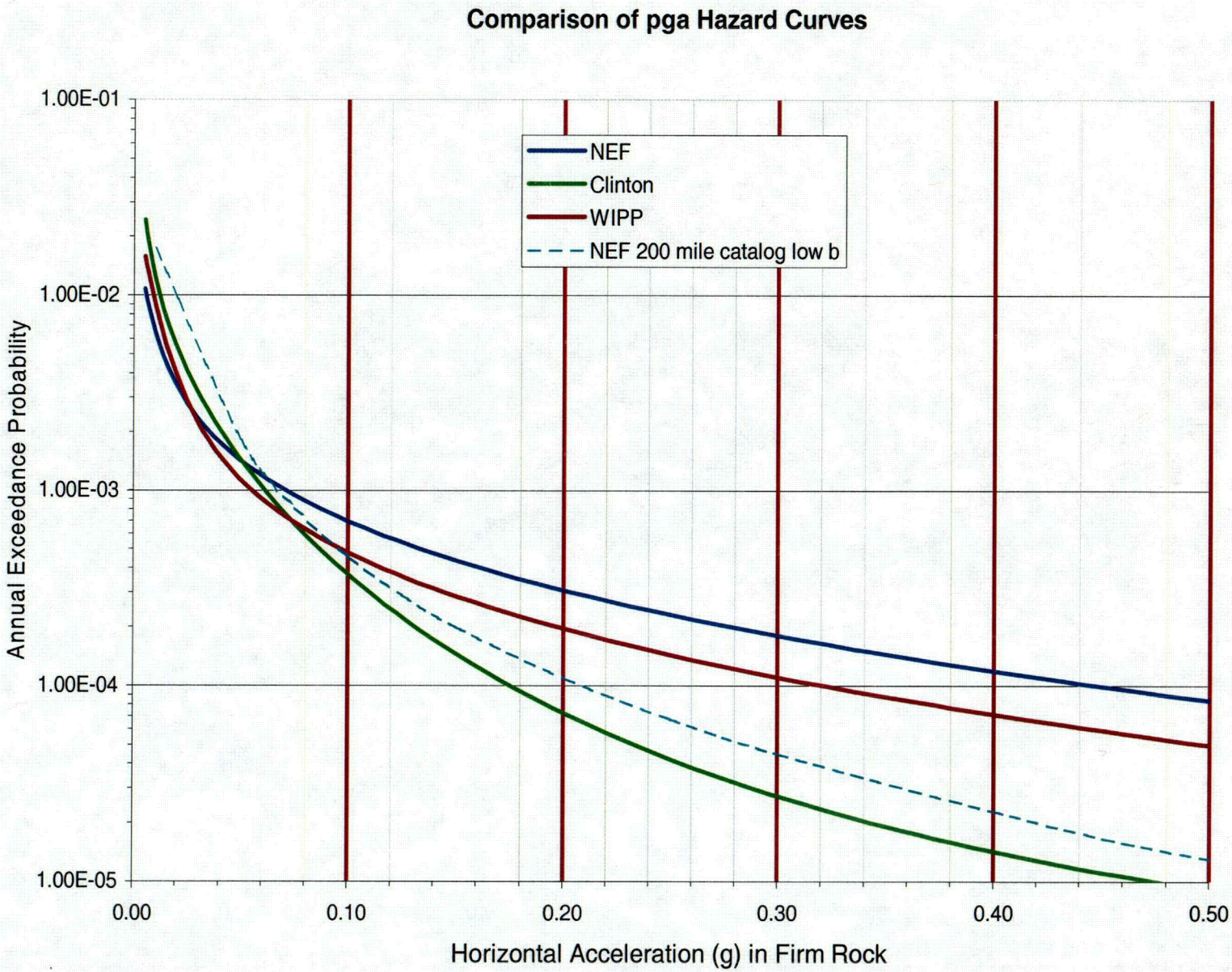
Comparison of pga Hazard Curves
NEF
Clinton
WIPP
NEF 200 mile catalog low b
Annual Exceedance Probability
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
0.00
0.10
0.20
0.30
0.40
0.50
Horizontal Acceleration (g) in Firm Rock

Figure 2

C-02

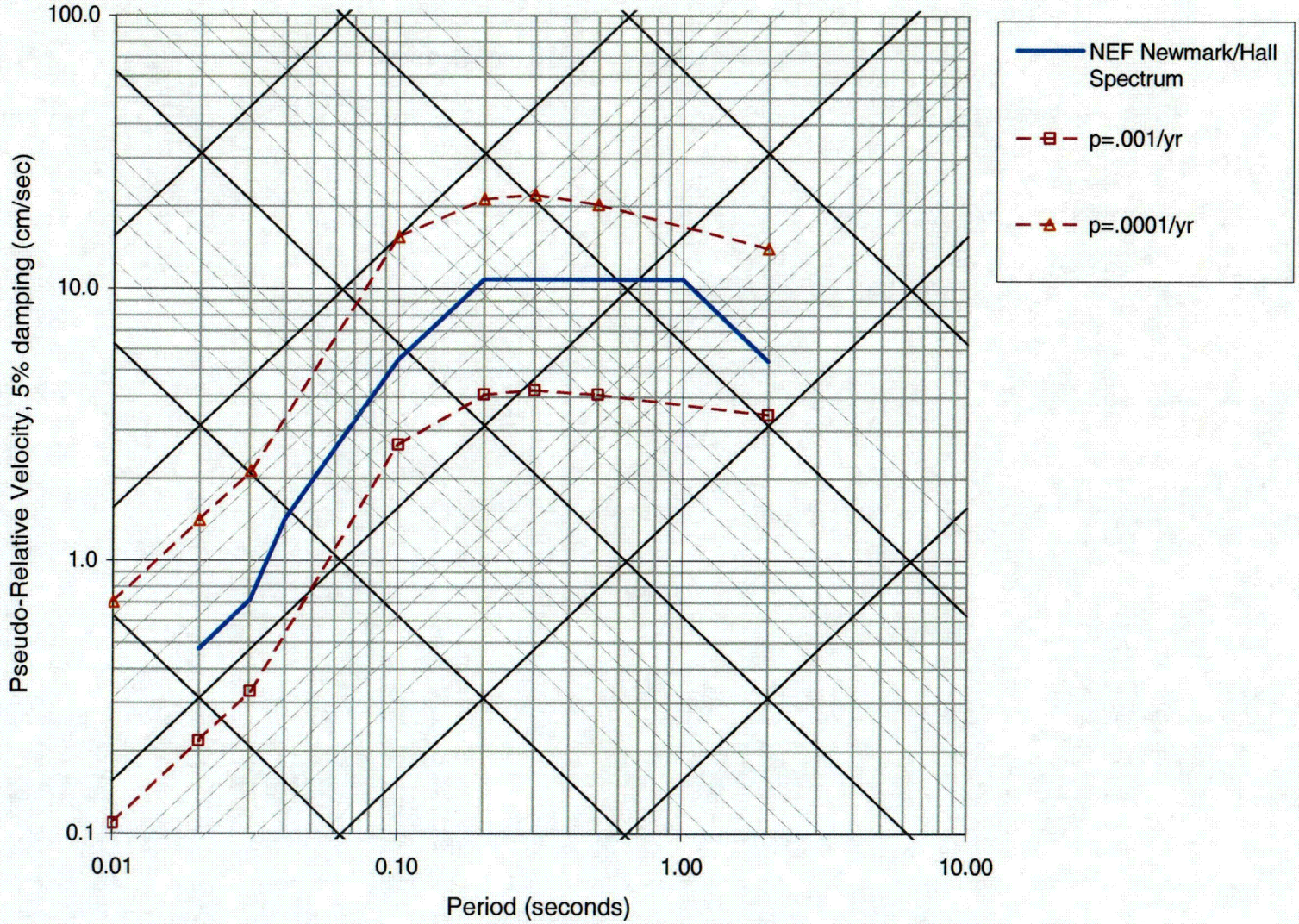
100.0
10.0
1.0
0.1
0.01
0.10
1.00
10.00
Pseudo-Relative Velocity, 5% damping (cm/sec)
Period (seconds)
NEF Newmark/Hall Spectrum
p=.001/yr
p=.0001/yr

Figure 3

C-02

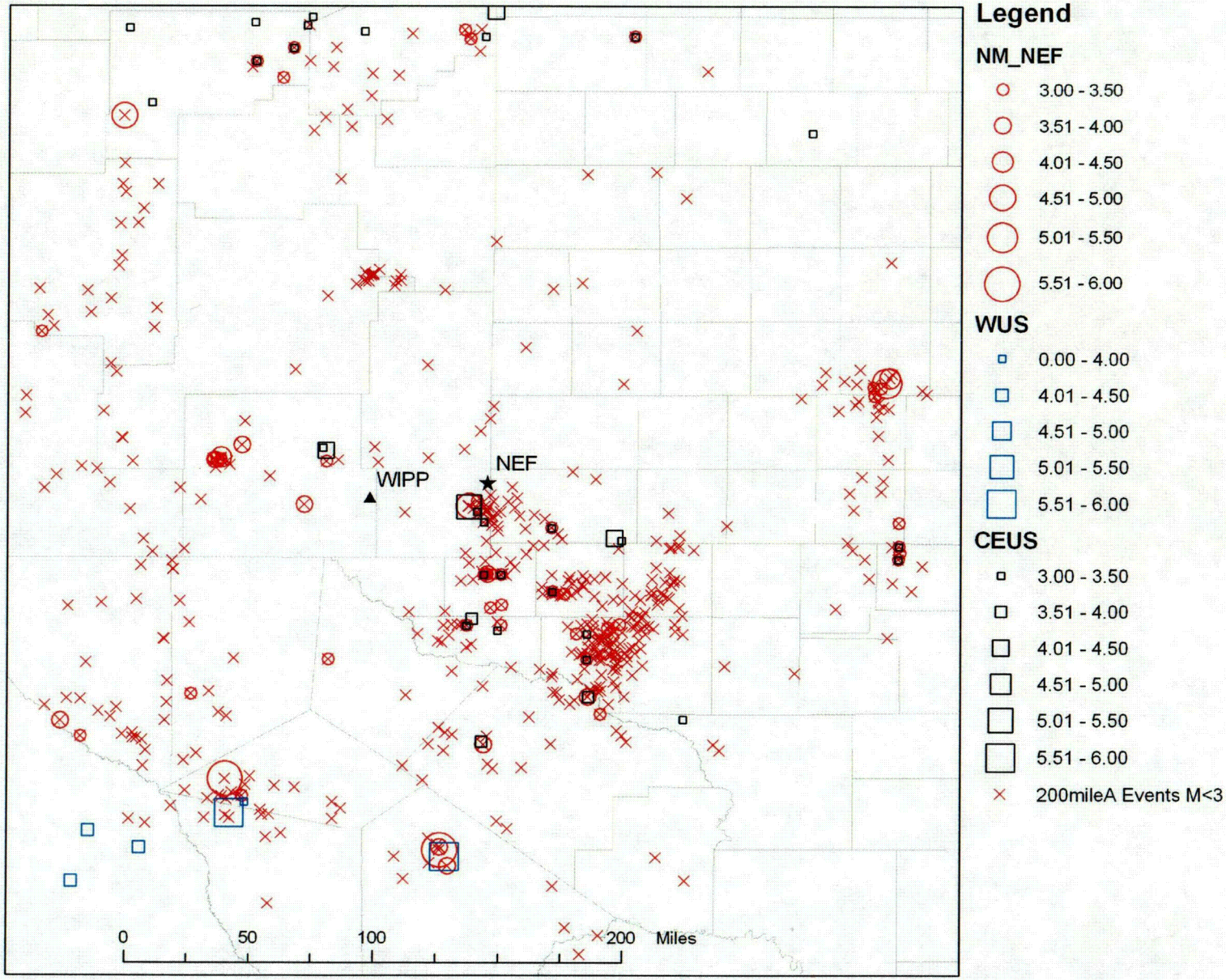
Legend
NM_NEF
3.00 - 3.50
3.51 - 4.00
4.01 - 4.50
4.51 - 5.00
5.01 - 5.50
5.51 - 6.00
WUS
0.00 - 4.00
4.01 - 4.50
4.51 - 5.00
5.01 - 5.50
5.51 - 6.00
CEUS
3.00 - 3.50
3.51 - 4.00
4.01 - 4.50
4.51 - 5.00
5.01 - 5.50
5.51 - 6.00
200mileA Events M<3
NEF
WIPP
0
50
100
200
Miles

Figure 4

C-04

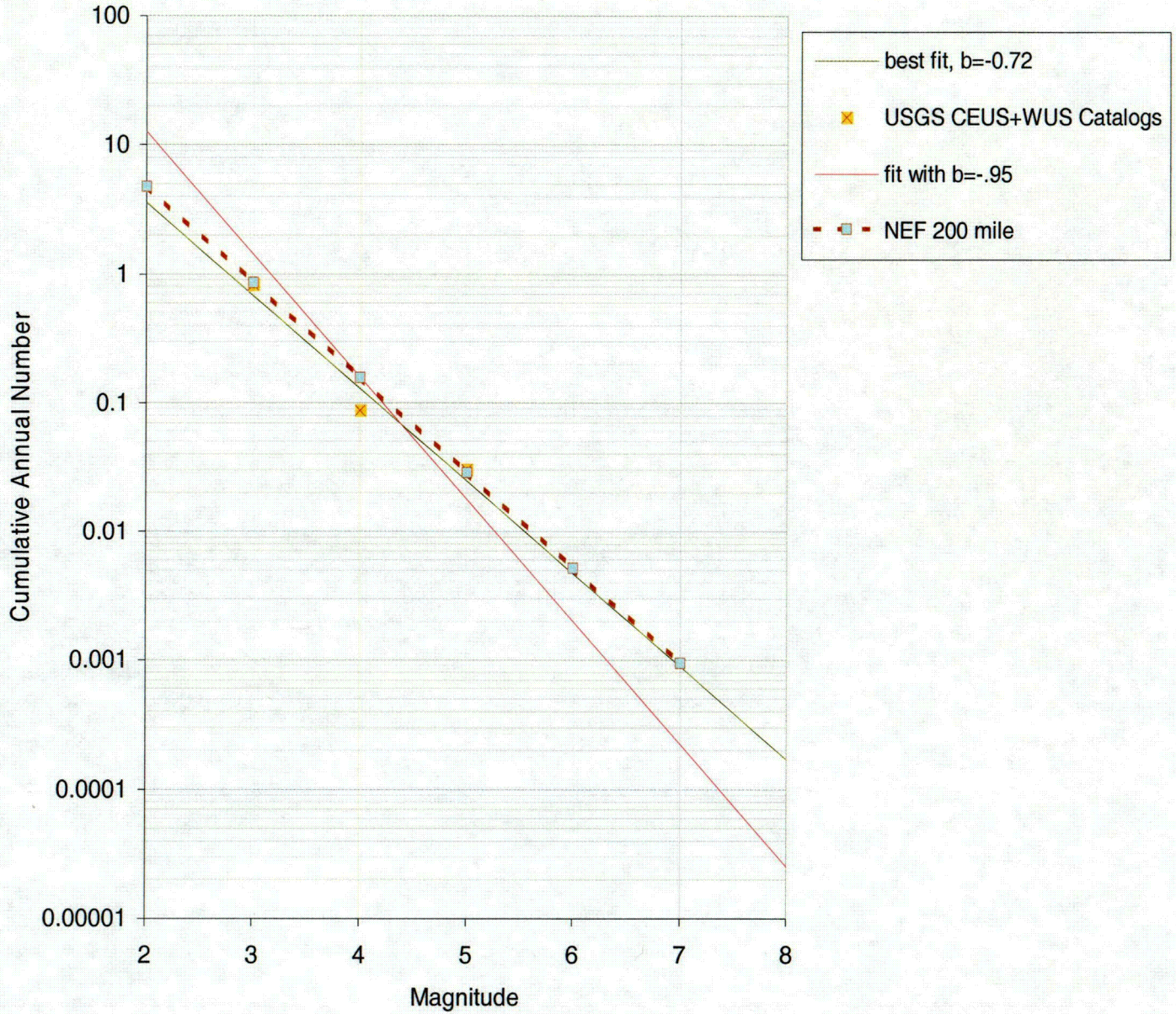
100
10
1
0.1
0.01
0.001
0.0001
0.00001
Cumulative Annual Number
2
3
4
5
6
7
8
Magnitude
best fit, b=-0.72
USGS CEUS+WUS Catalogs
fit with b=-.95
NEF 200 mile

Figure 5

C-05

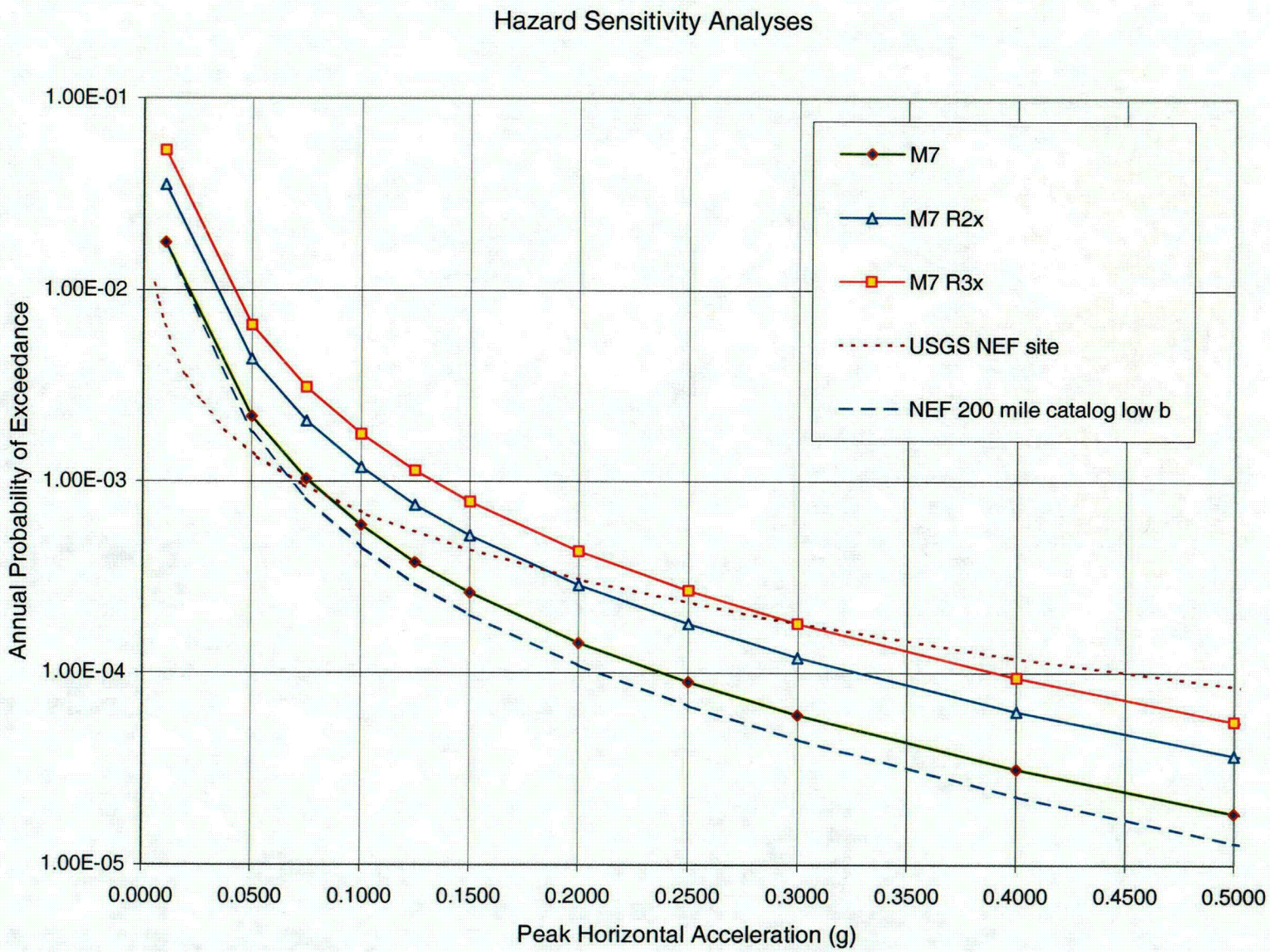
Hazard Sensitivity Analyses
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
Annual Probability of Exceedance
0.0000
0.0500
0.1000
0.1500
0.2000
0.2500
0.3000
0.3500
0.4000
0.4500
0.5000
Peak Horizontal Acceleration (g)
M7
M7 R2x
M7 R3x
USGS NEF site
NEF 200 mile catalog low b

Figure 6

C-06