

GROUND MOTION MAPS

How To Obtain the Basic Values



Seismic Ground Motions

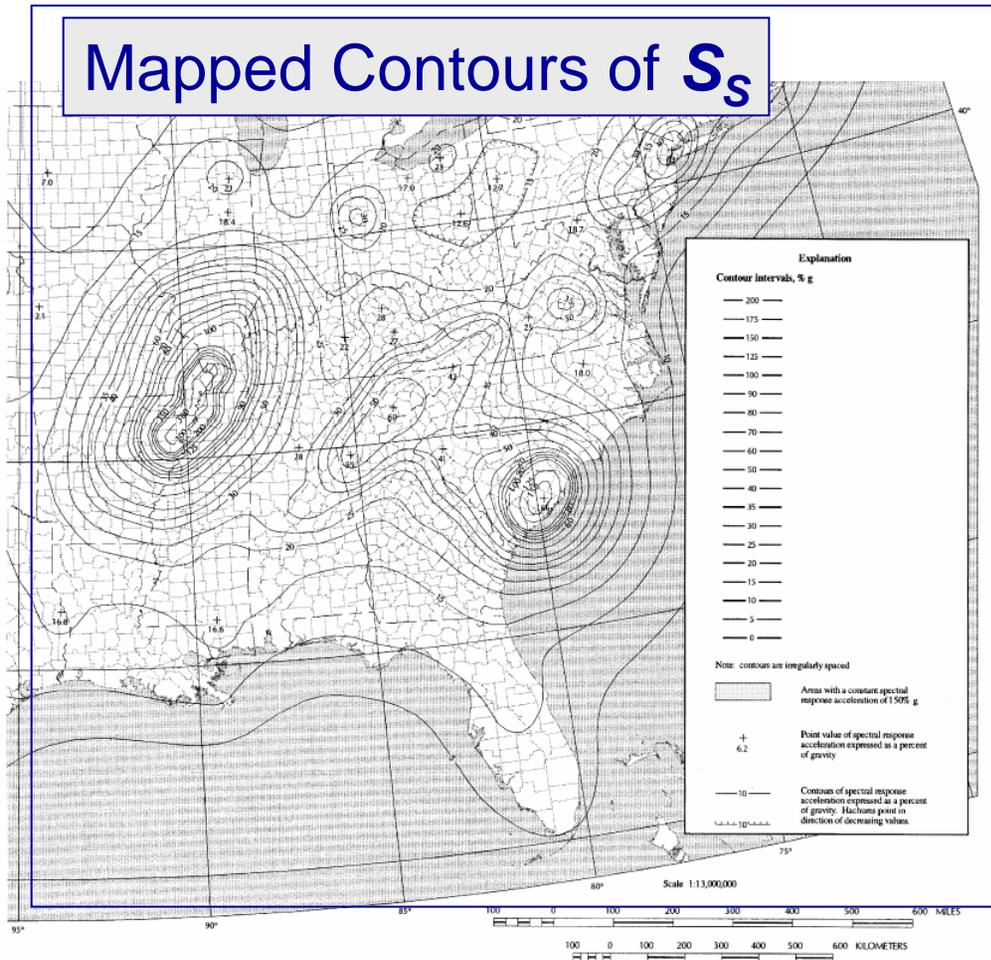
- 1 **Determine basic values from maps for bedrock conditions**
- 2, 3 Classify soil conditions at site and determine site coefficients
- 4 Determine site-adjusted values
- 4 Take two-thirds for use in design
- 5 Construct design response spectrum
- 7 Site-specific studies permitted/required

Mapped Acceleration Parameters

- Two sets of maps; acceleration parameter is in units of gravity
- S_S for spectral response acceleration at 0.2 sec
- S_1 for spectral response acceleration at 1.0 sec
- Shortcut to Seismic Design Category A:
 - $S_S < 0.15$ and $S_1 < 0.04$

Ground Motion Parameters & Seismic Hazard

Mapped Contours of S_S

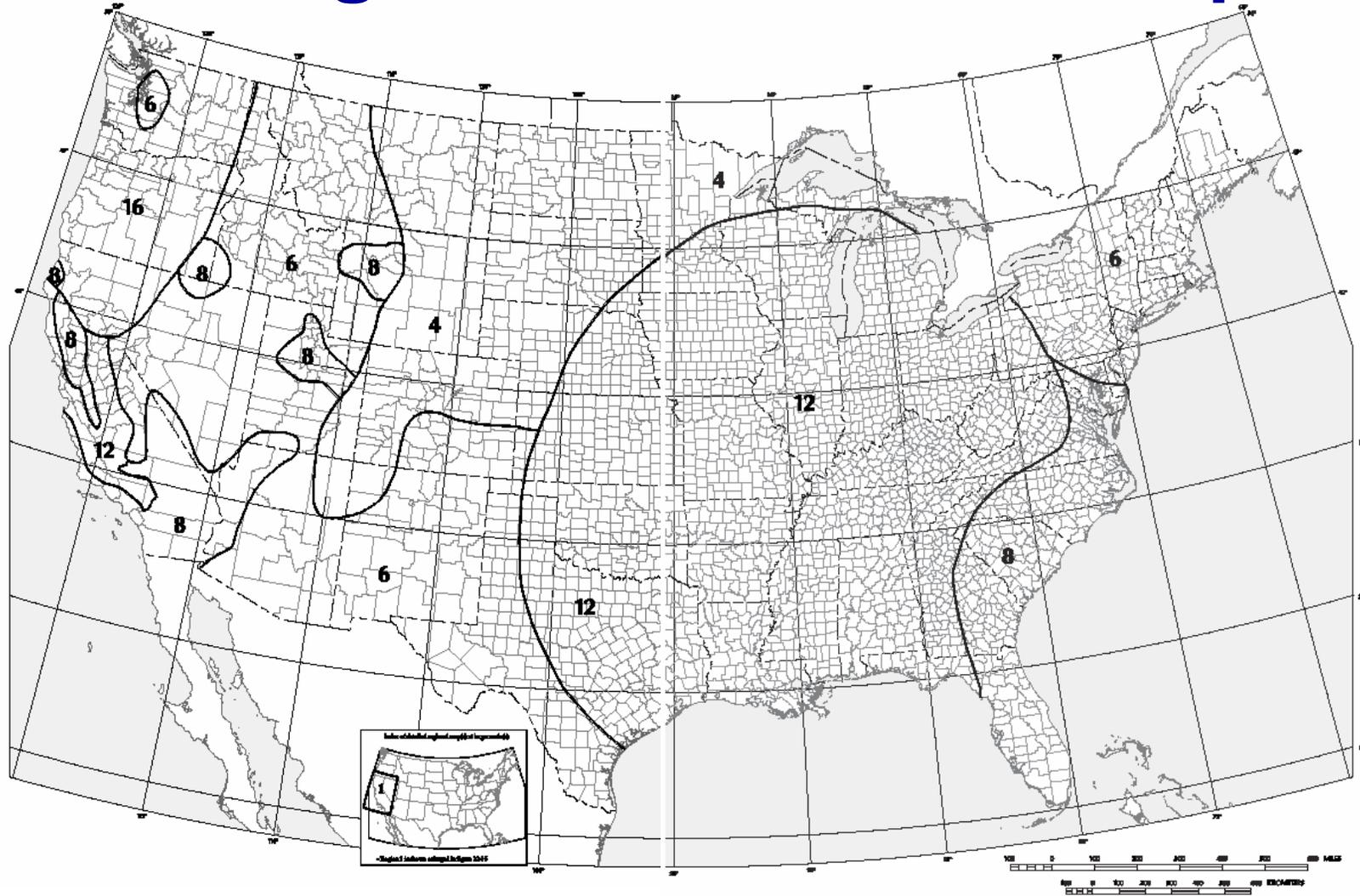


S_S and S_1 are the mapped 2% in 50 year spectral accelerations for firm rock

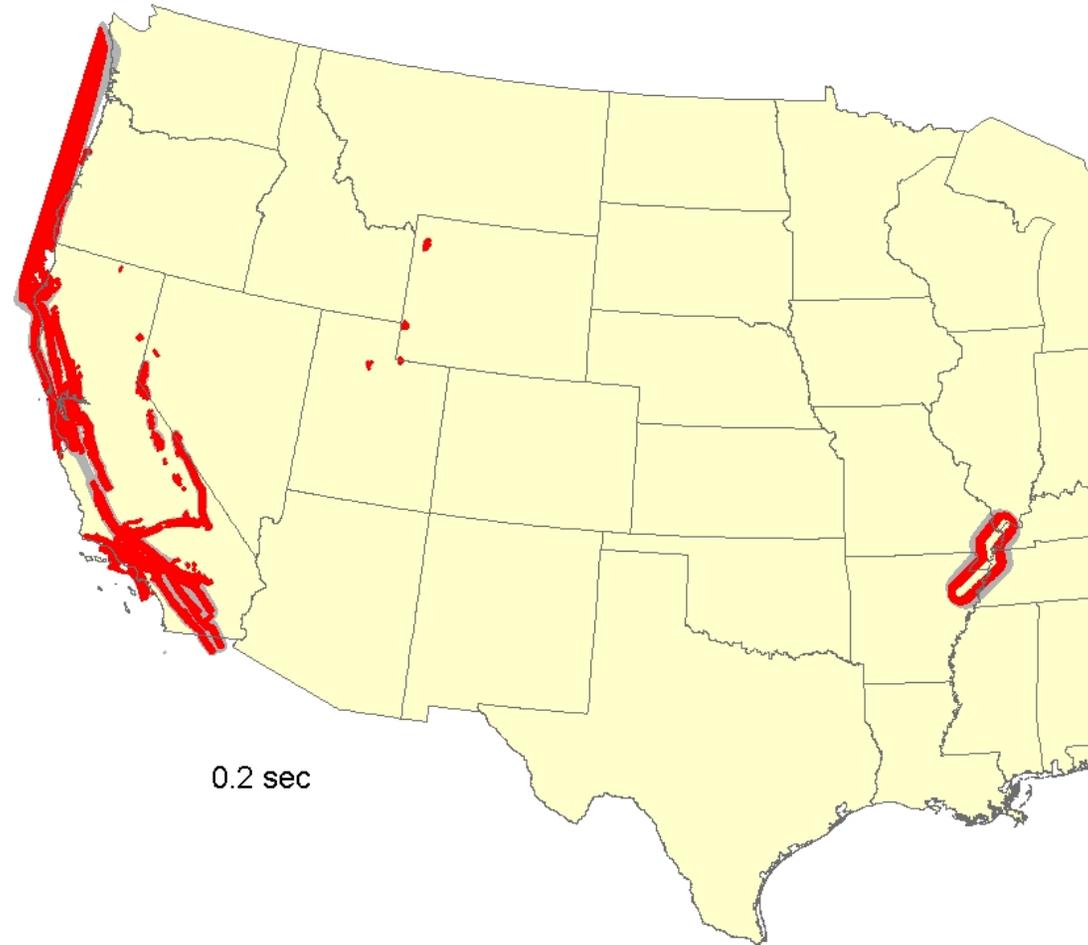
S_{DS} and S_{D1} are the design level spectral accelerations (modified for site and “expected good performance”)

FIGURE 9.4.1.1(a) – continued
MAXIMUM CONSIDERED EARTHQUAKE GROUND MOTION FOR
CONTINUOUS UNITED STATES, OF 0.2 s SPECTRAL RESPONSE
ACCELERATION (5% OF CRITICAL DAMPING), SITE CLASS B

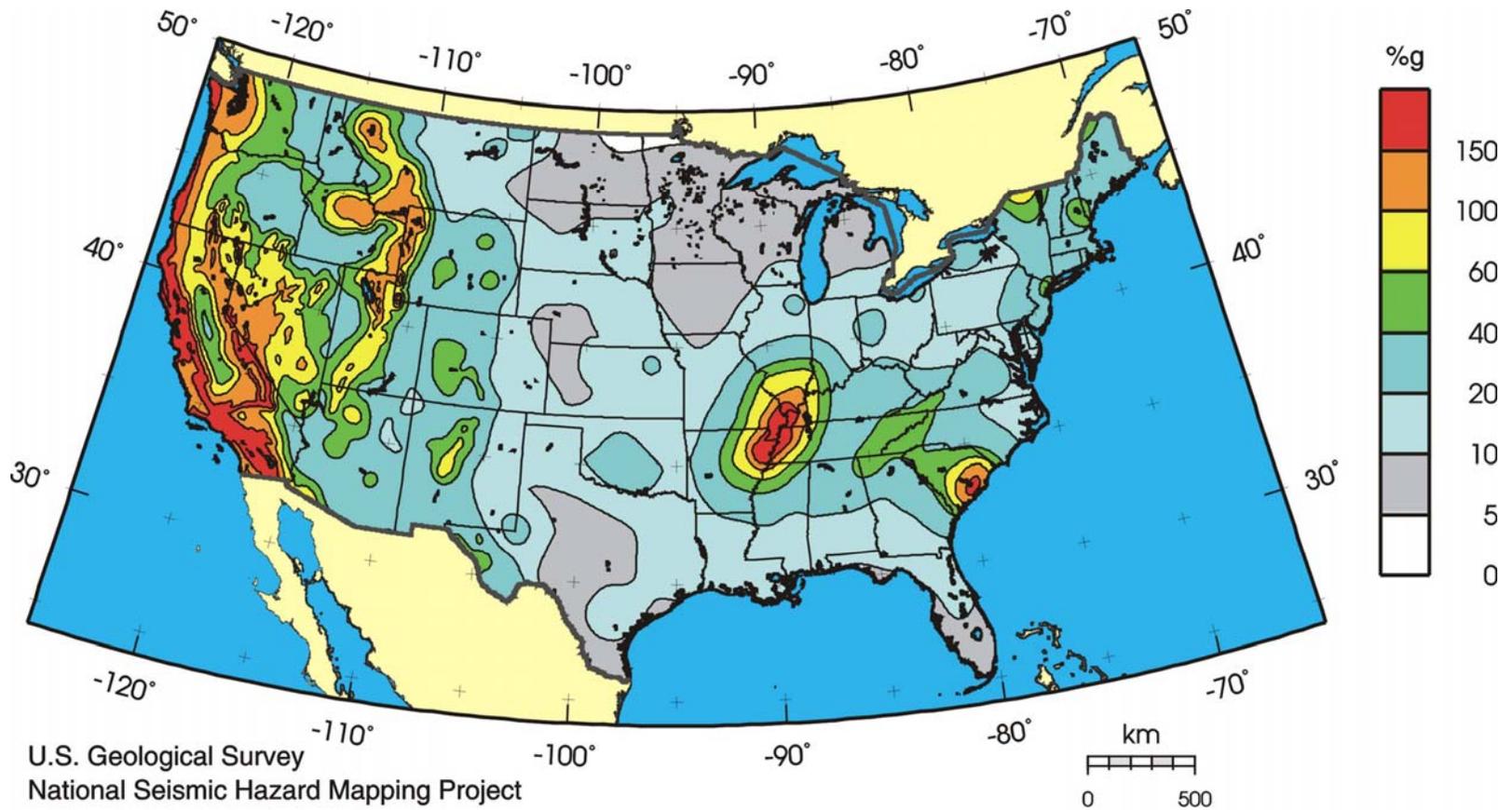
Long-Period Transition Maps



Location of Deterministic Areas



Typical Probabilistic Map



S_s - 0.2 Spectral Response Acceleration



FEMA

Instructional Materials Complementing *FEMA 451, Design Examples*

Ground Motion Maps 5b - 7

CD vs Internet

- Internet
- CD
- Both sources give the same answers
- Both sources have a similar user interface
- The graphics are somewhat different

Internet Ground Motion Tool

<http://earthquake.usgs.gov/research/hazmaps/>



SEISMIC DESIGN VALUES FOR BUILDINGS

S_s and S_1 , Hazard Curves, Uniform Hazard Spectra, and Residential Design Category

USGS Ground Motion Calculator

The screenshot shows a Microsoft Internet Explorer browser window displaying the USGS website. The address bar shows the URL: <http://earthquake.usgs.gov/research/hazmaps/design/index.php>. The page title is "Seismic Design Values for Buildings". The USGS logo is visible at the top left, and navigation links for "USGS Home", "Contact USGS", and "Search USGS" are at the top right. The main content area is titled "Seismic Design Values for Buildings" and features a section for a "New Earthquake Ground Motion Parameter Java Application". This section includes a description of the application, instructions on how to use it, and a list of ground motion parameters available in the new application. The list includes:

1. USGS Probabilistic Hazard Curves (1996 and 2002 for the 48 conterminous states, 1998 Alaska, 1998 Hawaii, 2003 for Puerto Rico and the Virgin Islands)
2. USGS Uniform Hazard response Spectra Curves (1996 and 2002 for the 48 conterminous states, 1998 Alaska, 1998 Hawaii, 2003 for Puerto Rico and the Virgin Islands)
3. NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures (1997, 2000, and 2003 editions)
4. ASCE 7 Standard, Minimum Design Loads for Buildings and Other Structures (1998, 2002, and 2005 editions)
5. International Building Code (2000, 2003, and 2006 editions)
6. International Residential Code (2000, 2003, 2004 supplement, and 2006 editions)
7. NFPA 5000 Building Construction and Safety Code (2003 and 2006 editions)

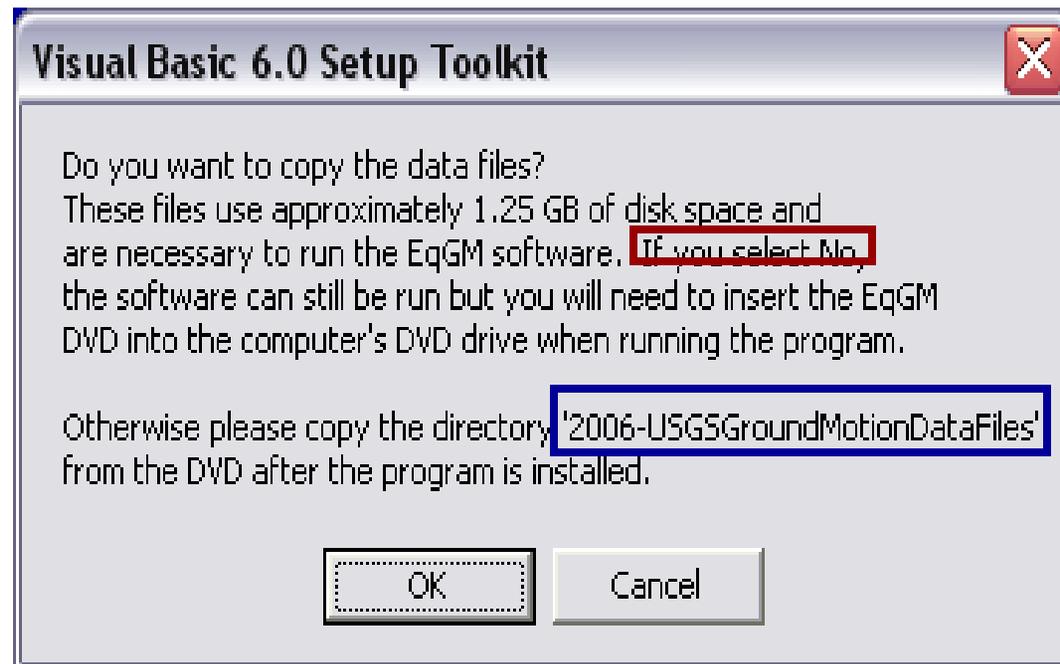
Additional links include "Ground motion maps are now available in PDF format" and "Ground Motion Data Files".



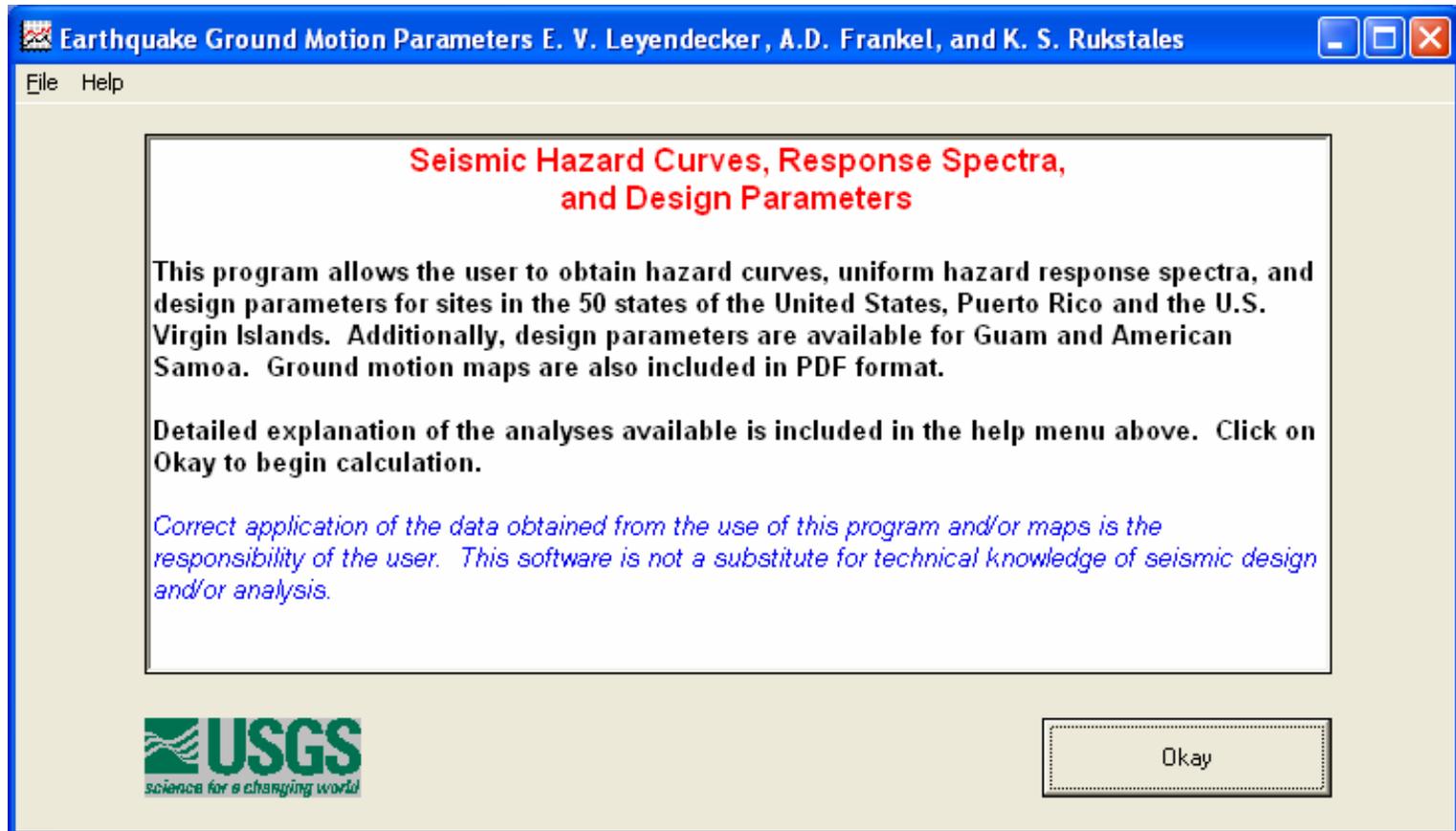
Installation



Installation Caution



Opening Screen



Analysis Options

Earthquake Ground Motion Parameters

File Project Name Help

Analysis Options ▾ International Building Code Description

- USGS Probabilistic Hazard Curves
- USGS Uniform Hazard Response Spectra
- NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures
- International Building Code
- International Residential Code
- ASCE 7 Standard, Minimum Design Loads for Buildings and Other Structures
- NFPA 5000 Building Construction and Safety Code

Select Site Location - See Site Location Notes

Latitude-Longitude : Recommended Zip Code

Latitude Longitude
(50.0 to 24.6) (-125.0 to -65.0)

Calculate Design Parameters

Ground Motion Parameters

Calculate S_s and S₁ Calculate S_M and S_D Values

Calculate Design Spectra

Map Spectrum Site-Modified Spectrum

Design Spectrum View Spectra

Clear Output View Maps

IBC Option

Earthquake Ground Motion Parameters

File Project Name Help

Analysis Options ▾ International Building Code Description

Select Geographic Region

Conterminous 48 States

Select Edition

2006 International Building Code

Select Site Location - See Site Location Notes

Latitude-Longitude : Recommended Zip Code

Latitude Longitude

(50.0 to 24.6) (-125.0 to -65.0)

Calculate Design Parameters

Ground Motion Parameters MCE Ground Motion

Calculate Ss and S1 Calculate SM and SD Values

Calculate Design Spectra

Map Spectrum Site-Modified Spectrum

Design Spectrum View Spectra

Clear Output View Maps

User Aids

The screenshot shows the 'Earthquake Ground Motion Parameters' software window. The title bar includes 'File', 'Project Name', and 'Help' menus. The main interface is divided into several sections:

- Analysis Options:** A dropdown menu set to 'International Building Code' with a 'Description' button to its right.
- Select Geographic Region:** A dropdown menu currently showing 'Conterminous 48 States'.
- Select Edition:** A dropdown menu showing '2006 International Building Code'.
- Select Site Location - See Site Location Notes:** Two radio buttons: 'Latitude-Longitude : Recommended' (selected) and 'Zip Code'.
- Latitude-Longitude Fields:** Two input boxes labeled 'Latitude' (range: 50.0 to 24.6) and 'Longitude' (range: -125.0 to -65.0).
- Calculate Design Parameters:** A dropdown menu set to 'MCE Ground Motion' and two buttons: 'Calculate Ss and S1' and 'Calculate SM and SD Values'.
- Calculate Design Spectra:** Four buttons: 'Map Spectrum', 'Site-Modified Spectrum', 'Design Spectrum', and 'View Spectra'.
- Output for Calculations:** A large empty rectangular area on the right side of the window.
- Bottom Buttons:** 'Clear Output' and 'View Maps' buttons.

Calculate S_s AND S_1

The screenshot shows the 'Earthquake Ground Motion Parameters' software interface. The window title is 'Earthquake Ground Motion Parameters'. The menu bar includes 'File', 'Project Name', and 'Help'. The 'Analysis Options' dropdown is set to 'International Building Code'. The 'Description' tab is active, showing the following information:

Output for Calculations

Conterminous 48 States
2006 International Building Code
Spectral Response Accelerations S_s and S_1
State - California
Zip Code - 94111
Zip Code Latitude = 37.798300
Zip Code Longitude = -122.400000
 S_s and S_1 = Mapped Spectral Acceleration Values
Site Class B - $F_a = 1.00$, $F_v = 1.00$
Data are based on a 0.01 deg grid spacing.

Period (sec)	Centroid S_a (g)	
0.2	1.500	S_s , Site Class B
1.0	0.602	S_1 , Site Class B

Period (sec)	Maximum S_a (g)	
0.2	1.500	S_s , Site Class B
1.0	0.614	S_1 , Site Class B

Period (sec)	Minimum S_a (g)	
0.2	1.500	S_s , Site Class B
1.0	0.600	S_1 , Site Class B

The interface also includes sections for 'Select Geographic Region' (Conterminous 48 States), 'Select Edition' (2006 International Building Code), and 'Select Site Location - See Site Location Notes' (Latitude-Longitude: Recommended, Zip Code). The 'Calculate Design Parameters' section has a dropdown for 'Ground Motion Parameters' set to 'MCE Ground Motion' and buttons for 'Calculate S_s and S_1 ' and 'Calculate S_M and S_D Values'. The 'Calculate Design Spectra' section has buttons for 'Map Spectrum', 'Site-Modified Spectrum', 'Design Spectrum', and 'View Spectra'. The 'Clear Output' and 'View Maps' buttons are at the bottom right.

Location By Zipcode

Earthquake Ground Motion Parameters

File Project Name Help

Analysis Options ▾ International Building Code Description

Select Geographic Region

Conterminous 48 States ▾

Select Edition

2006 International Building Code ▾

Select Site Location - See Site Location Notes

Latitude-Longitude : Recommended Zip Code

5-Digit Zip Code California ▾ 94111 ▾

Calculate Design Parameters

Ground Motion Parameters MCE Ground Motion ▾

Calculate Ss and S1 Calculate SM and SD Values

Calculate Design Spectra

Map Spectrum Site-Modified Spectrum

Design Spectrum View Spectra

Output for Calculations

Conterminous 48 States
2006 International Building Code
Spectral Response Accelerations Ss and S1
State - California
Zip Code - 94111
Zip Code Latitude = 37.798300
Zip Code Longitude = -122.400000
Ss and S1 = Mapped Spectral Acceleration Values
Site Class B - Fa = 1.00, Fv = 1.00
Data are based on a 0.01 deg grid spacing.

Period (sec)	Centroid Sa (g)	
0.2	1.500	Ss, Site Class B
1.0	0.602	S1, Site Class B

Period (sec)	Maximum Sa (g)	
0.2	1.500	Ss, Site Class B
1.0	0.614	S1, Site Class B

Period (sec)	Minimum Sa (g)	
0.2	1.500	Ss, Site Class B
1.0	0.600	S1, Site Class B

Clear Output View Maps

Calculate S_{MS} , S_{M1} , S_{DS} , S_{D1}

Earthquake Ground Motion Parameters

File Project Name Help

Analysis Options ▾ International Building Code Description

Select Geographic Region

Conterminous 48 States ▾

Select Edition

2006 International Building Code ▾

Select Site Location - See Site Location Notes

Latitude-Longitude : Recommended Zip Code

5-Digit Zip Code California ▾ 94111 ▾

Calculate Design Parameters

Ground Motion Parameters MCE Ground Motion ▾

Calculate Ss and S1 Calculate SM and SD Values

Calculate Design Spectra

Map Spectrum Site-Modified Spectrum

Design Spectrum View Spectra

Output for Calculations

Conterminous 48 States
 2006 International Building Code
 Spectral Response Accelerations Ss and S1
 State - California
 Zip Code - 94111
 Zip Code Latitude = 37.798300
 Zip Code Longitude = -122.400000
 Ss and S1 = Mapped Spectral Acceleration Values
 Site Class B - Fa = 1.00, Fv = 1.00
 Data are based on a 0.01 deg grid spacing.

Period (sec)	Centroid Sa (g)		
0.2	1.500	Ss	Site Class B
1.0	0.602	S1	Site Class B

Period (sec)	Maximum Sa (g)		
0.2	1.500	Ss	Site Class B
1.0	0.614	S1	Site Class B

Period (sec)	Minimum Sa (g)		
0.2	1.500	Ss	Site Class B
1.0	0.600	S1	Site Class B

Clear Output View Maps

Calculate Site Coefficients

Site Coefficients
✕

Soil Factors as a Function of Site Class and Spectral Accelerations

Values of Fa as a Function of Site Class and 0.2 sec MCE Spectral Acceleration

Site Class	Ss ≤ 0.25	Ss = 0.50	Ss = 0.75	Ss = 1.00	Ss ≥ 1.25
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	a	a	a	a	a

Values of Fv as a Function of Site Class and 1.0 sec MCE Spectral Acceleration

Site Class	S1 ≤ 0.10	S1 = 0.20	S1 = 0.30	S1 = 0.40	S1 ≥ 0.50
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	a	a	a	a	a

Notes:

Use straight-line interpolation for intermediate values of Sa and S1.

Note a: Site-specific geotechnical investigation and dynamic site response analyses shall be performed.

Calculate Site Coefficient

Spectral Accelerations

Ss, g S1, g

Site Class

- Site Class A
- Site Class B
- Site Class C
- Site Class D
- Site Class E
- Site Class F

Site Coefficients

Interpolated soil factors for the conditions shown. Values may also be entered manually.

Fa Fv

S_{MS} , S_{M1} , S_{DS} , S_{D1} Values

Earthquake Ground Motion Parameters

File Project Name Help

Analysis Options ▾ International Building Code Description

Select Geographic Region

Conterminous 48 States ▾

Select Edition

2006 International Building Code ▾

Select Site Location -See Site Location Notes

Latitude-Longitude : Recommended Zip Code

5-Digit Zip Code California ▾ 94111 ▾

Calculate Design Parameters

Ground Motion Parameters MCE Ground Motion ▾

Calculate S_s and S_1 Calculate S_M and S_D Values

Calculate Design Spectra

Map Spectrum Site-Modified Spectrum

Design Spectrum View Spectra

Output for Calculations

2006 International Building Code
Spectral Response Accelerations S_M s and S_{M1}
State - California
Zip Code - 94111
Zip Code Latitude = 37.798300
Zip Code Longitude = -122.400000
 S_M s = $F_a S_s$ and S_{M1} = $F_v S_1$
Site Class D - F_a = 1.00, F_v = 1.50
Data are based on a 0.01 deg grid spacing.

Period (sec)	S_a (g)	
0.2	1.500	S_M s, Site Class D
1.0	0.903	S_{M1} , Site Class D

Conterminous 48 States
2006 International Building Code
Spectral Response Accelerations S_D s and S_{D1}
State - California
Zip Code - 94111
Zip Code Latitude = 37.798300
Zip Code Longitude = -122.400000
 S_D s = $2/3 \times S_M$ s and S_{D1} = $2/3 \times S_{M1}$
Site Class D - F_a = 1.00, F_v = 1.50
Data are based on a 0.01 deg grid spacing.

Period (sec)	S_a (g)	
0.2	1.000	S_D s, Site Class D
1.0	0.602	S_{D1} , Site Class D

Clear Output View Maps

Calculate MCE Spectrum

Earthquake Ground Motion Parameters

File Project Name Help

Analysis Options ▾ International Building Code Description

Select Geographic Region

Conterminous 48 States ▾

Select Edition

2006 International Building Code ▾

Select Site Location -See Site Location Notes

Latitude-Longitude : Recommended Zip Code

5-Digit Zip Code California ▾ 94111 ▾

Calculate Design Parameters

Ground Motion Parameters MCE Ground Motion ▾

Calculate Ss and S1 Calculate SM and SD Values

Calculate Design Spectra

Map Spectrum Site-Modified Spectrum

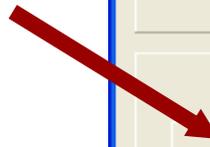
Design Spectrum View Spectra

Output for Calculations

Conterminous 48 States
 2006 International Building Code
 Map Response Spectra for Site Class B
 State - California
 Zip Code - 94111
 Zip Code Latitude = 37.798300
 Zip Code Longitude = -122.400000
 Ss and S1 = Mapped Spectral Acceleration Values
 Site Class B - Fa = 1.00, Fv = 1.00
 Data are based on a 0.01 deg grid spacing.

Period (sec)	Sa (g)	Sd in.
0.000	0.600	0.000
0.080	1.500	0.094
0.200	1.500	0.586
0.401	1.500	2.360
0.500	1.204	2.940
0.600	1.003	3.528
0.700	0.860	4.117
0.800	0.752	4.705
0.900	0.669	5.293
1.000	0.602	5.881
1.100	0.547	6.469
1.200	0.502	7.057
1.300	0.463	7.645
1.400	0.430	8.233
1.500	0.401	8.821
1.600	0.376	9.409
1.700	0.354	9.997

Clear Output View Maps



Calculate S_M Spectrum

Earthquake Ground Motion Parameters

File Project Name Help

Analysis Options ▾ International Building Code Description

Select Geographic Region

Conterminous 48 States ▾

Select Edition

2006 International Building Code ▾

Select Site Location -See Site Location Notes

Latitude-Longitude : Recommended Zip Code

5-Digit Zip Code California ▾ 94111 ▾

Calculate Design Parameters

Ground Motion Parameters MCE Ground Motion ▾

Calculate Ss and S1 Calculate SM and SD Values

Calculate Design Spectra

Map Spectrum Site-Modified Spectrum

Design Spectrum View Spectra

Output for Calculations

Conterminous 48 States
2006 International Building Code
Site Modified Response Spectra for Site Class D
State - California
Zip Code - 94111
Zip Code Latitude = 37.798300
Zip Code Longitude = -122.400000
SMs = FaSs and SM1 = FvS1
Site Class D - Fa = 1.00, Fv = 1.50
Data are based on a 0.01 deg grid spacing.

Period (sec)	Sa (g)	Sd in.
0.000	0.600	0.000
0.120	1.500	0.212
0.200	1.500	0.586
0.602	1.500	5.310
0.700	1.290	6.175
0.800	1.129	7.057
0.900	1.003	7.939
1.000	0.903	8.821
1.100	0.821	9.703
1.200	0.752	10.585
1.300	0.695	11.468
1.400	0.645	12.350
1.500	0.602	13.232
1.600	0.564	14.114
1.700	0.531	14.996
1.800	0.502	15.878
1.900	0.475	16.760
2.000	0.451	17.642

Clear Output View Maps

Calculate S_D Spectrum

Earthquake Ground Motion Parameters

File Project Name Help

Analysis Options ▾ International Building Code Description

Select Geographic Region

Conterminous 48 States ▾

Select Edition

2006 International Building Code ▾

Select Site Location -See Site Location Notes

Latitude-Longitude : Recommended Zip Code

5-Digit Zip Code California ▾ 94111 ▾

Calculate Design Parameters

Ground Motion Parameters MCE Ground Motion ▾

Calculate S_s and S_1 Calculate SM and SD Values

Calculate Design Spectra

Map Spectrum Site-Modified Spectrum

Design Spectrum View Spectra

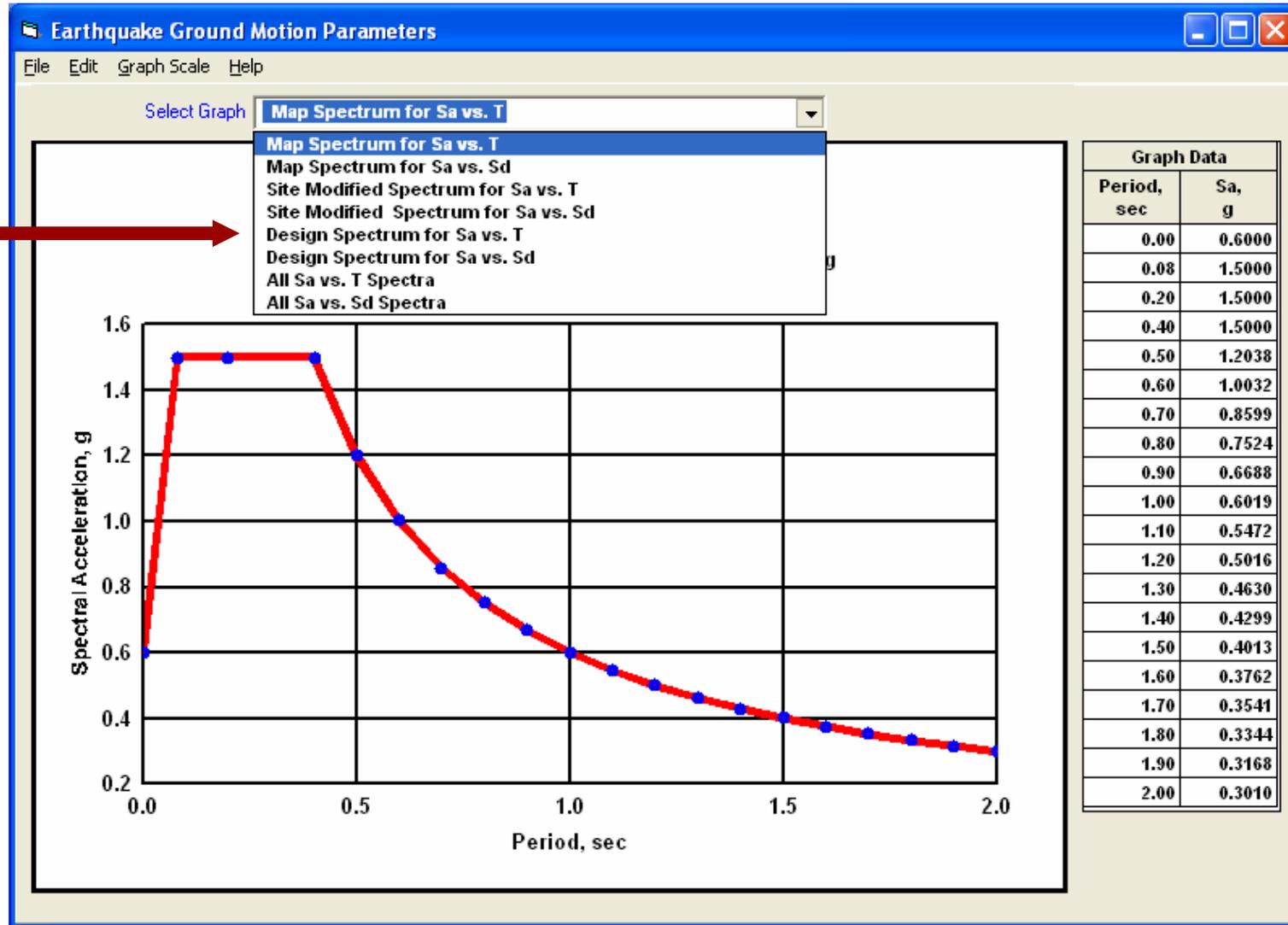
Output for Calculations

Conterminous 48 States
 2006 International Building Code
 Design Response Spectra for Site Class D
 State - California
 Zip Code - 94111
 Zip Code Latitude = 37.798300
 Zip Code Longitude = -122.400000
 SDs = 2/3 x SMs and SD1 = 2/3 x SM1
 Site Class D - Fa = 1.00, Fv = 1.50
 Data are based on a 0.01 deg grid spacing.

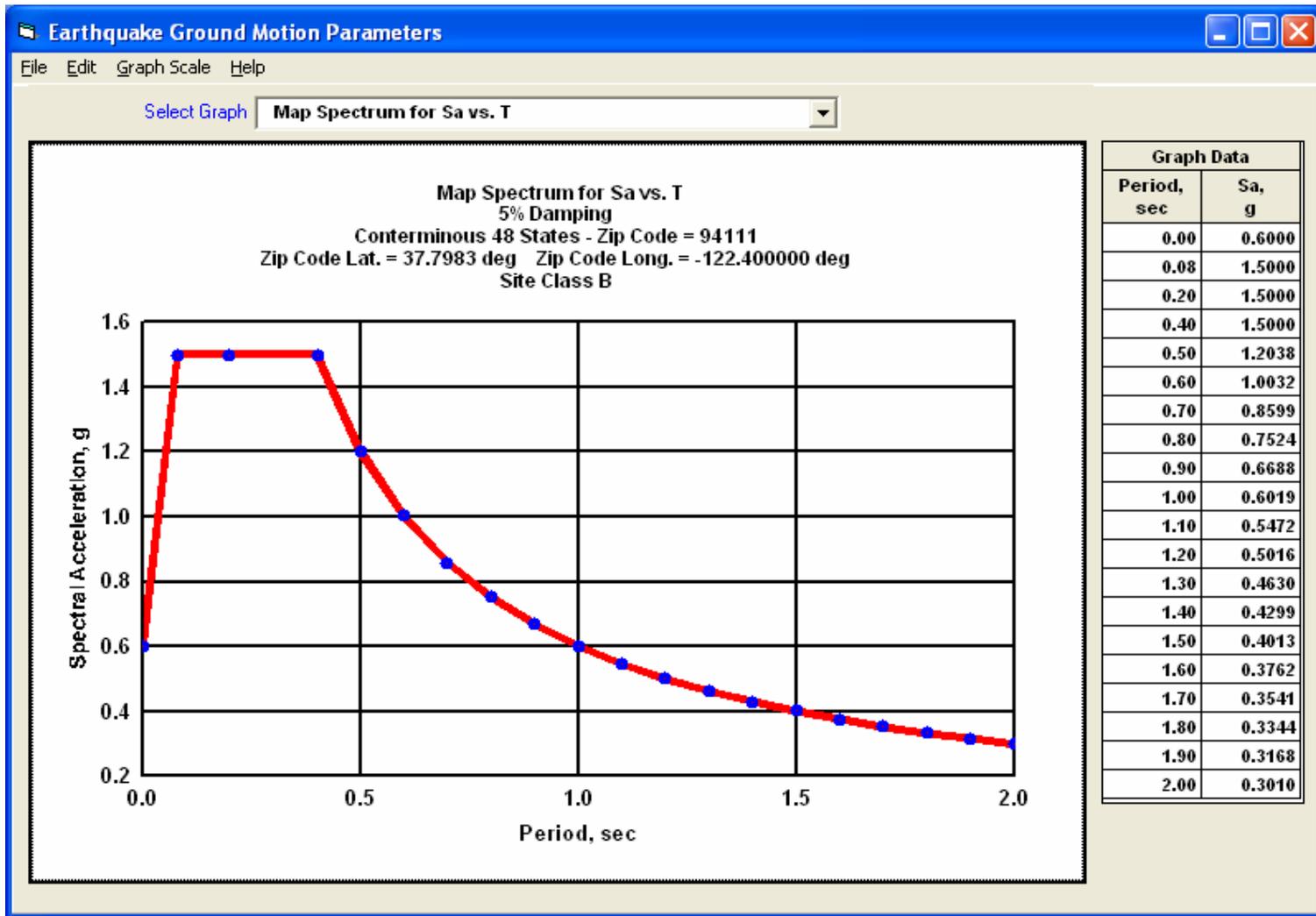
Period (sec)	Sa (g)	Sd in.
0.000	0.400	0.000
0.120	1.000	0.142
0.200	1.000	0.391
0.602	1.000	3.540
0.700	0.860	4.117
0.800	0.752	4.705
0.900	0.669	5.293
1.000	0.602	5.881
1.100	0.547	6.469
1.200	0.502	7.057
1.300	0.463	7.645
1.400	0.430	8.233
1.500	0.401	8.821
1.600	0.376	9.409
1.700	0.354	9.997
1.800	0.334	10.585
1.900	0.317	11.174
2.000	0.302	11.762

Clear Output View Maps

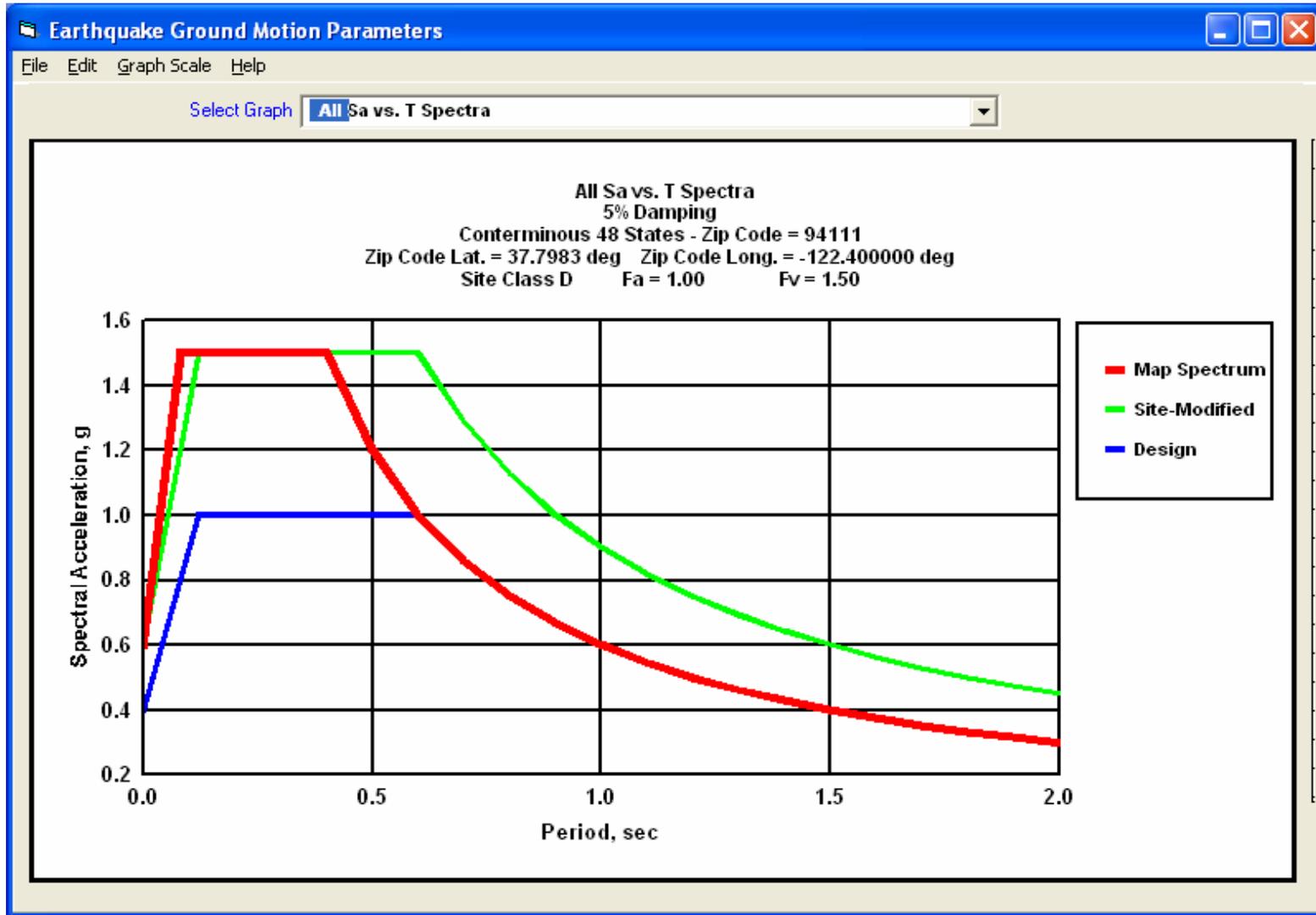
Graphic Options



Map Spectrum: $S_a - T$



All Spectra: $S_a - T$



Calculate Hazard Curves

Earthquake Ground Motion Parameters

File Project Name Help

Analysis Options ▾ USGS Probabilistic Hazard Curves Description

Select Geographic Region

Contiguous 48 States ▾

Select Edition

2002 Data ▾

Select Site Location - See Site Location Notes

Latitude-Longitude : Recommended Zip Code

5-Digit Zip Code California ▾ 94111 ▾

Hazard Curve

Ground Motion Parameters ▾ Peak Ground Acceleration

Calculate View

Single Hazard Values

PE and Exp. Time Return Period

Prob. of Exceedance (%) 2 ▾ Exp. Time (Years) 50 ▾

Calculate

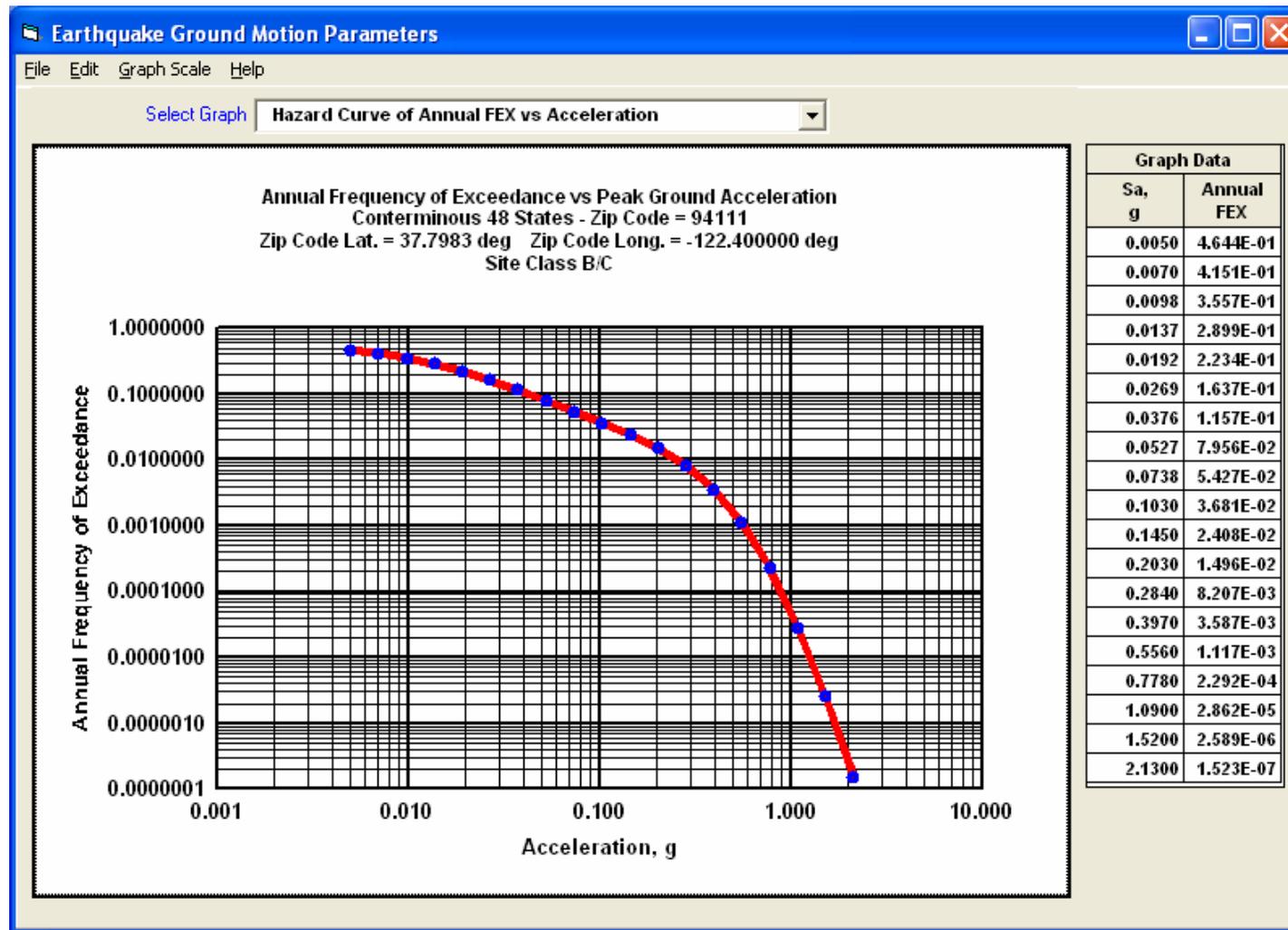
Output for Calculations

Peak Ground Acceleration
 State - California
 Zip Code - 94111
 Zip Code Latitude = 37.798300
 Zip Code Longitude = -122.400000
 B/C Boundary
 Data are based on a 0.05 deg grid spacing.
 Frequency of Exceedance values less than 10E-4 should be used with caution.

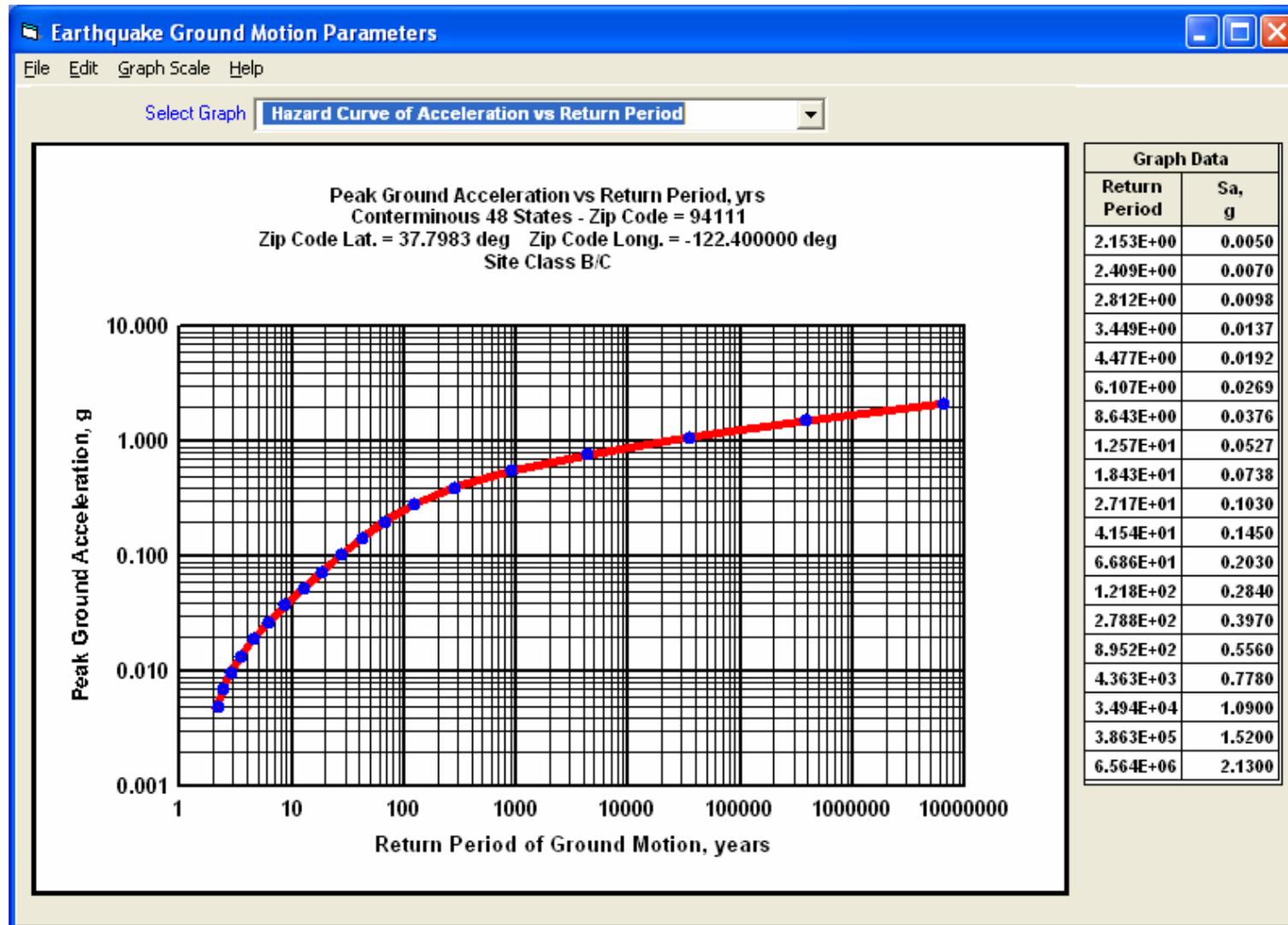
Ground Motion (g)	Frequency of Exceedance (per year)
0.0050	4.644E-01
0.0070	4.151E-01
0.0098	3.557E-01
0.0137	2.899E-01
0.0192	2.234E-01
0.0269	1.637E-01
0.0376	1.157E-01
0.0527	7.956E-02
0.0738	5.427E-02
0.1030	3.681E-02
0.1450	2.408E-02
0.2030	1.496E-02
0.2840	8.207E-03
0.3970	3.587E-03
0.5560	1.117E-03
0.7780	2.292E-04
1.0900	2.862E-05

Clear Output View Maps

Annual Frequency of Exceedance



Return Period



Single Values

Earthquake Ground Motion Parameters

File Project Name Help

Analysis Options ▾ USGS Probabilistic Hazard Curves Description

Select Geographic Region

Conterminous 48 States ▾

Select Edition

2002 Data ▾

Select Site Location -See Site Location Notes

Latitude-Longitude : Recommended Zip Code

5-Digit Zip Code California ▾ 94111 ▾

Hazard Curve

Ground Motion Parameters ▾ Peak Ground Acceleration ▾

Calculate View

Single Hazard Values

PE and Exp. Time Return Period

Prob. of Exceedance (%) 10 ▾ Exp. Time (Years) 50 ▾

Calculate

Output for Calculations

Ground Motion (g)	Frequency of Exceedance (per year)
0.0050	4.644E-01
0.0070	4.151E-01
0.0098	3.557E-01
0.0137	2.899E-01
0.0192	2.234E-01
0.0269	1.637E-01
0.0376	1.157E-01
0.0527	7.956E-02
0.0738	5.427E-02
0.1030	3.681E-02
0.1450	2.408E-02
0.2030	1.496E-02
0.2840	8.207E-03
0.3970	3.587E-03
0.5560	1.117E-03
0.7780	2.292E-04
1.0900	2.862E-05
1.5200	2.589E-06
2.1300	1.523E-07

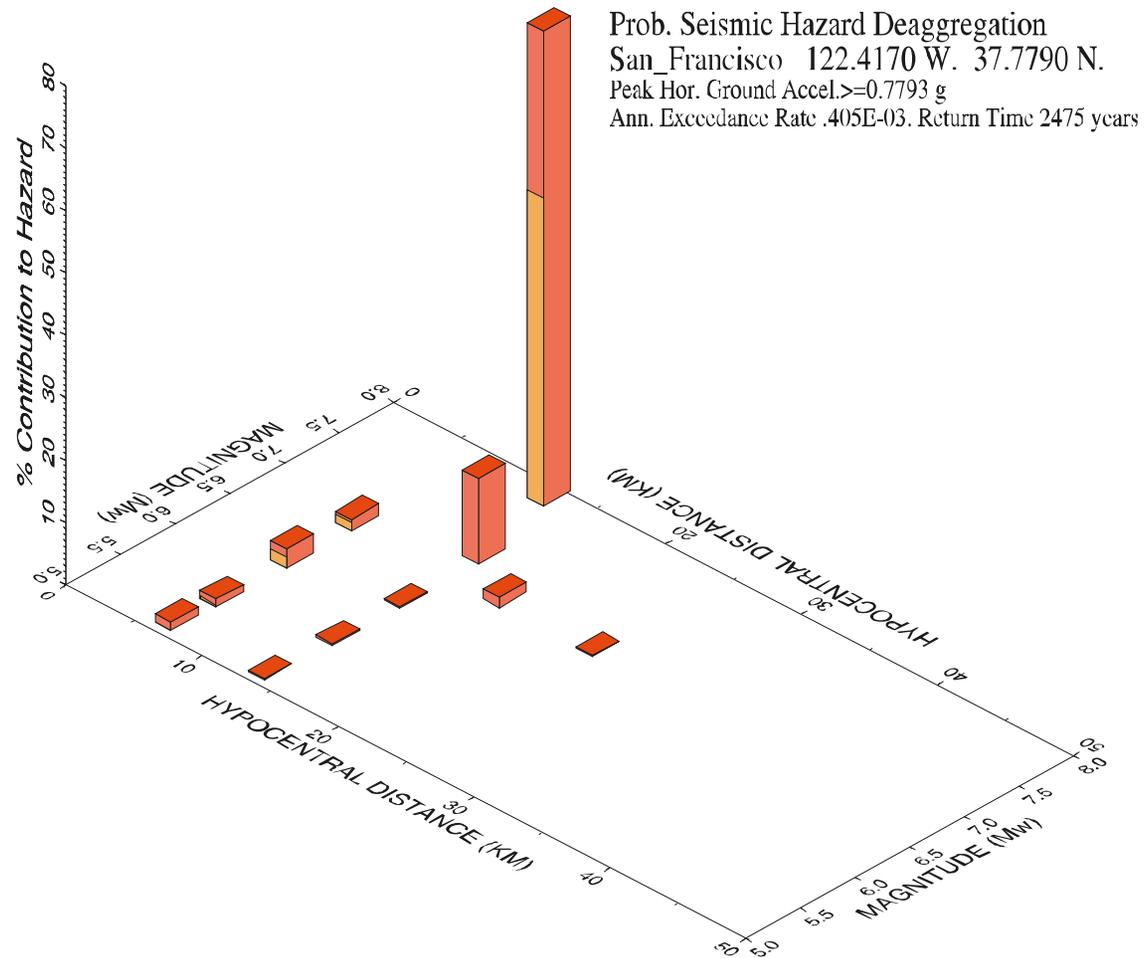
Ground Motion (g)	Frequency of Exceedance (per year)	Return Period (years)	Exp. P.E. (%)	Exp. Time (years)
0.4634	2.100E-03	0476	10.0	50

Clear Output View Maps

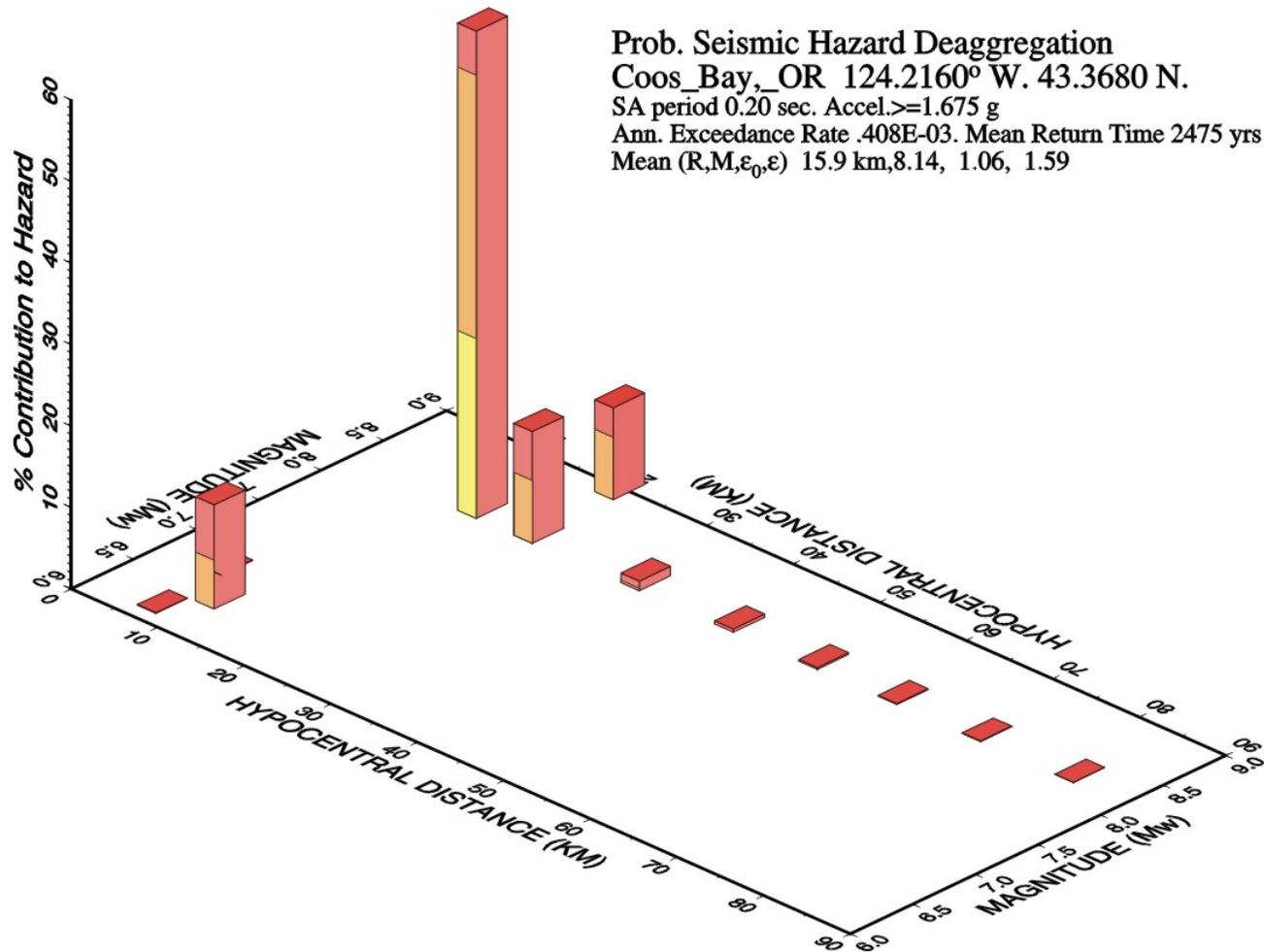
Deaggregation

- Breaking apart of the probabilistic hazard analysis
- Helps remove some of the “black box” effect
- Helps visualize the source of the hazard
- Many uses, e.g. liquefaction analysis, time history determination

Deaggregation – San Francisco

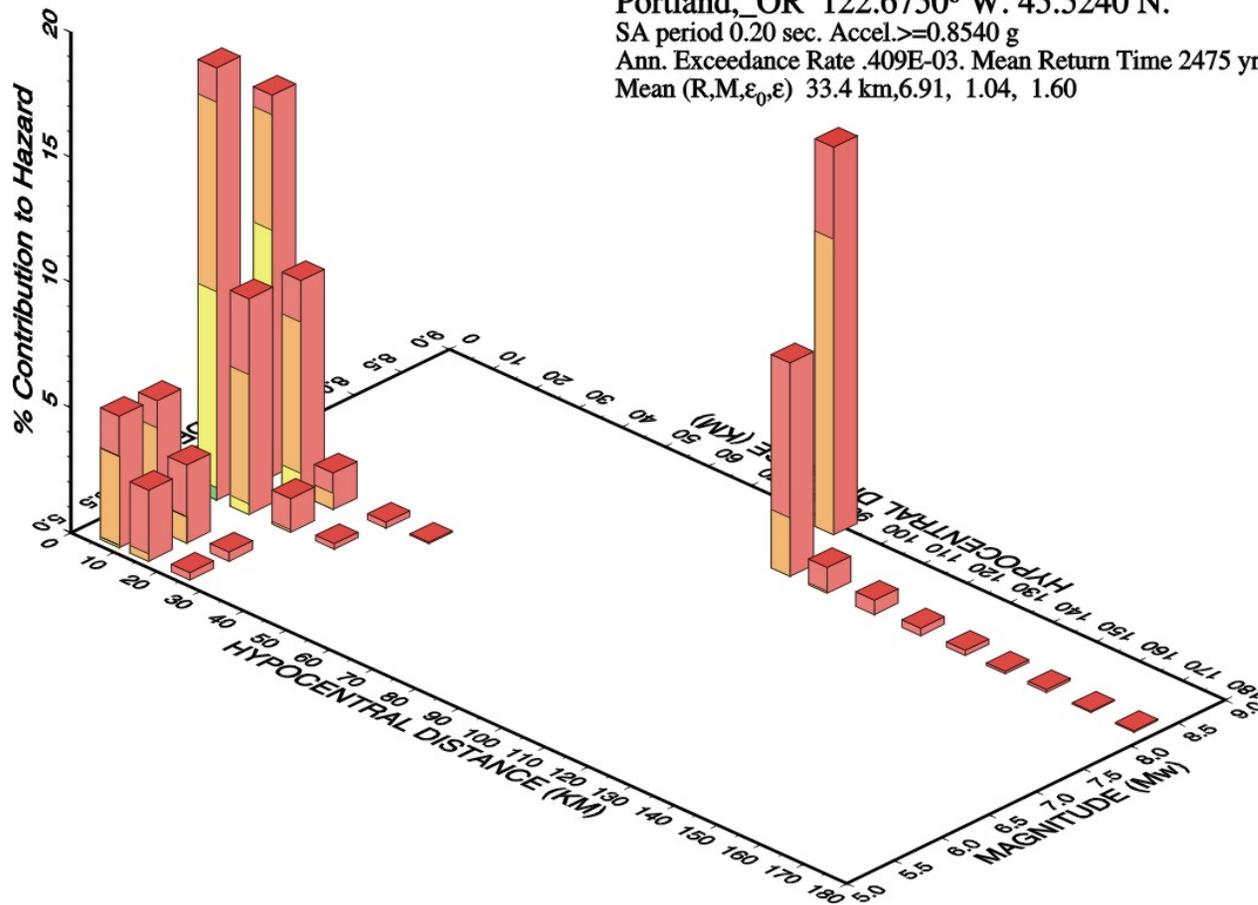


Deaggregation - Coos Bay, Oregon



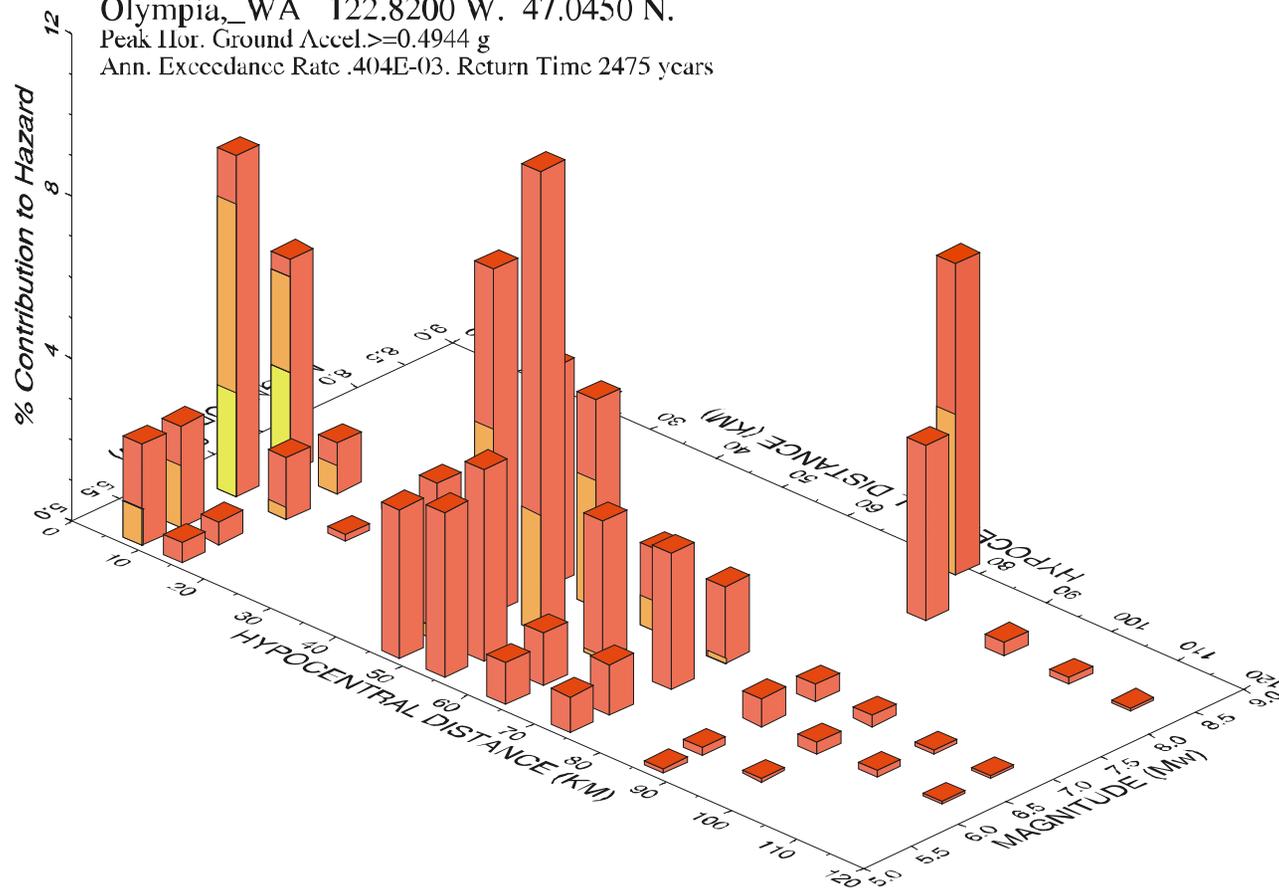
Deaggregation - Portland, Oregon

Prob. Seismic Hazard Deaggregation
 Portland, OR 122.6750° W. 45.5240 N.
 SA period 0.20 sec. Accel. ≥ 0.8540 g
 Ann. Exceedance Rate .409E-03. Mean Return Time 2475 yrs
 Mean (R,M, ϵ_0 , ϵ) 33.4 km, 6.91, 1.04, 1.60

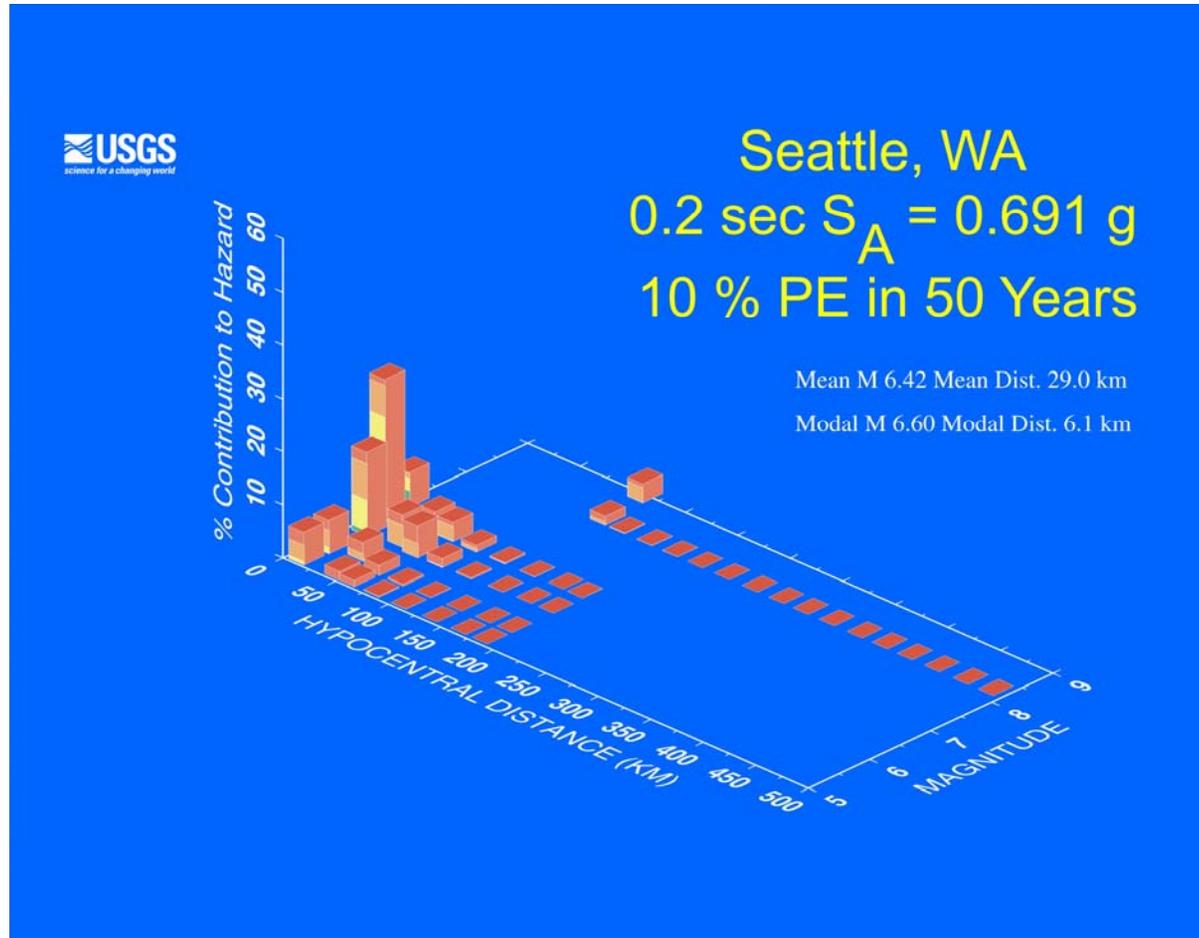


Deaggregation – Olympia, Washington

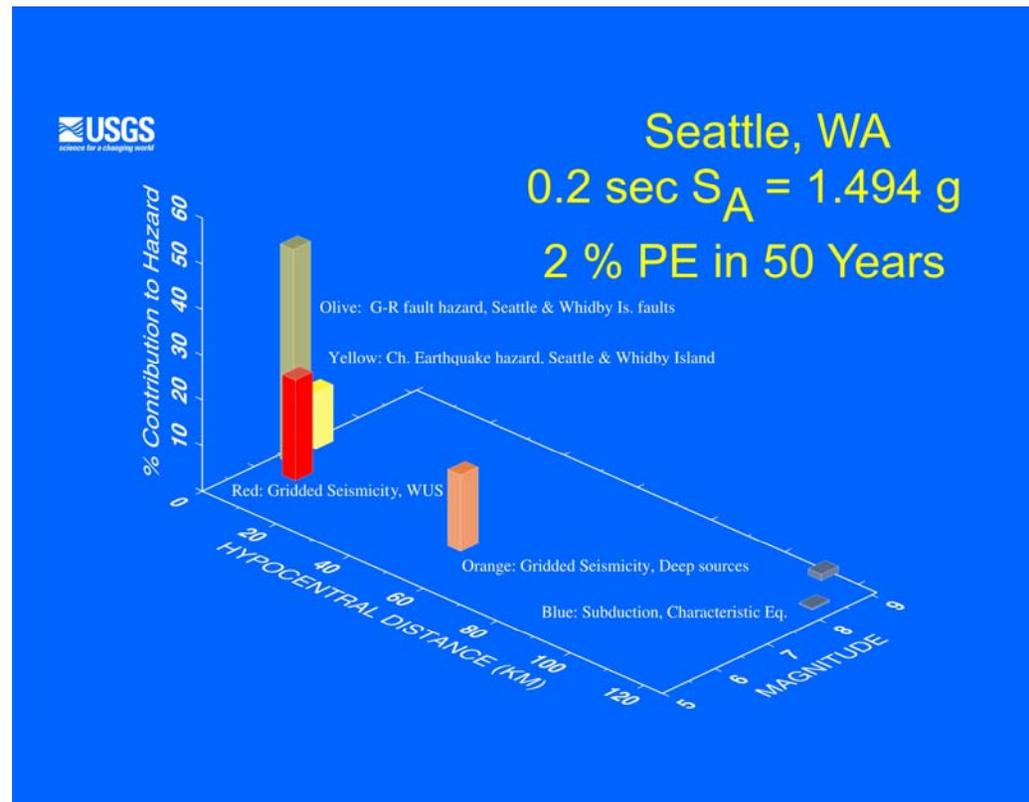
Prob. Seismic Hazard Deaggregation
 Olympia, WA 122.8200 W. 47.0450 N.
 Peak Hor. Ground Accel. ≥ 0.4944 g
 Ann. Exceedance Rate $.404E-03$. Return Time 2475 years



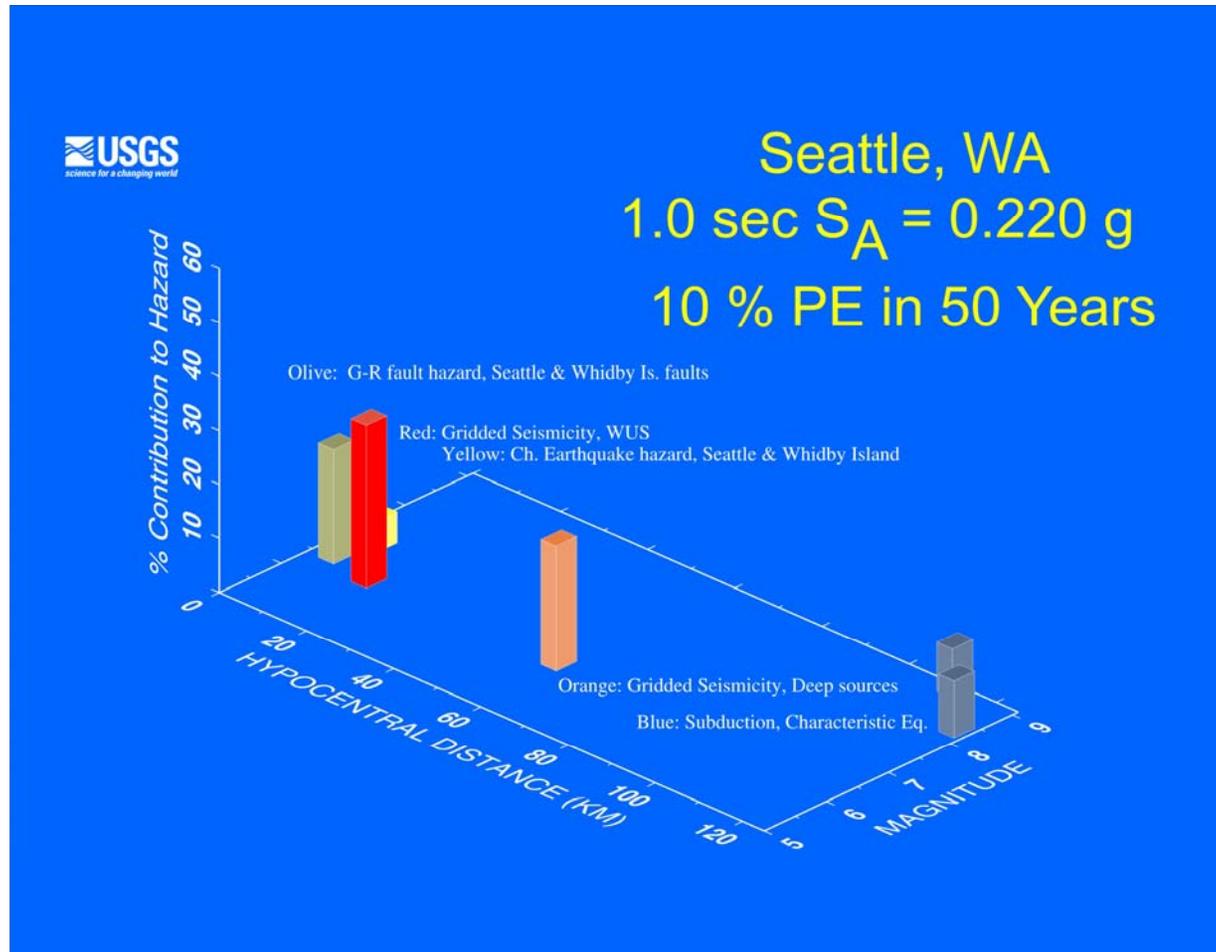
Seattle – 0.2 sec, Detailed



Seattle – 0.2 sec



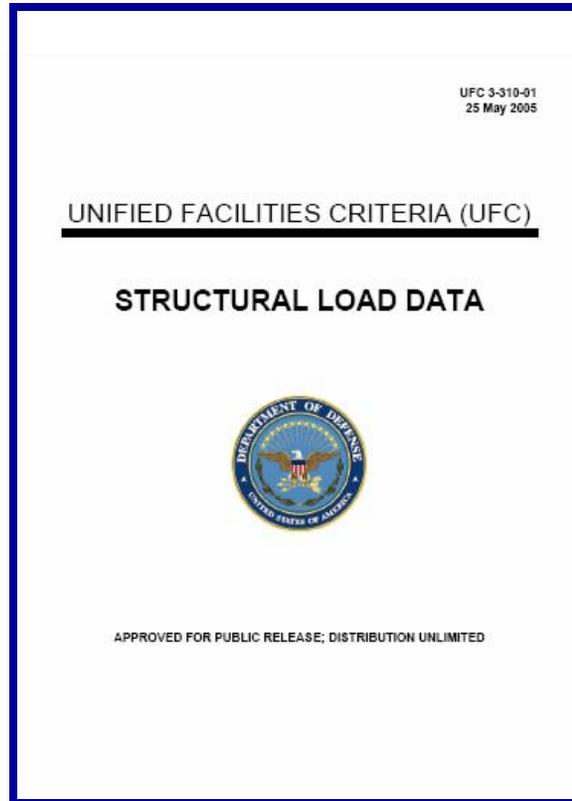
Seattle – 1.0 sec



Design Values Outside the United States

- Based on GASHAP Data
- 10% PE in 50 years
- PGA only
- Estimate 2% from 10% PE by multiplying by 2.0
- $S_s = 2.5 \times \text{PGA}$
- $S_1 = \text{PGA}$
- Use site-specific studies where available
- USGS studies where available

UFC 3-310-1



What is GSHAP?

