GROUND MOTION TIME HISTORIES FOR THE VAN NUYS BUILDING

Prepared for the PEER Methodology Testbeds Project
by Paul Somerville and Nancy Collins
URS Corporation, Pasadena, CA
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Site Conditions

The site condition is classified as NEHRP category S_D based on blow count data. This report describes ground motion time histories for S_D soil conditions.

Uniform Hazard Spectra

Uniform hazard spectra for the site were derived from the USGS probabilistic ground motion maps for rock site conditions (Frankel et al., 1996; 2001). Modification to account for near fault rupture directivity effects, and the use of separate response spectra for the fault normal and fault parallel components of ground motion, is not be required, for the reasons stated below.

Soil spectra were generated from the rock site spectra by multiplying the rock spectra by the ratio of soil to rock spectra for the Abrahamson and Silva (1997) ground motion model. These ratios are for the mode magnitude and distance combinations from the deaggregation of the hazard, listed in Table 2.

Table 1. Equal Hazard Response Spectra for the Van Nuys building

Van Nuys - 50% in 50 years		
Period	**Rock**	**Soil**
0.01	0.248	0.232
0.1	0.422	0.336
0.2	0.554	0.491
0.3	0.522	0.543
0.5	0.375	0.479
0.8	0.24	0.34
1.0	0.188	0.287
1.5	0.125	0.21
2.0	0.100	0.174

Van Nuys - 10% in 50 years		
Period	**Rock**	**Soil**
0.01	0.628	0.490
0.1	1.213	0.819
0.2	1.434	1.099
0.3	1.377	1.276
0.5	1.125	1.339
0.8	0.71	0.98
1.0	0.528	0.806
1.5	0.32	0.53
2.0	0.235	0.420

Van Nuys - 2% in 50 years		
Period	**Rock**	**Soil**
0.01	0.989	0.698
0.1	1.898	1.135
0.2	2.262	1.559
0.3	2.200	1.872
0.5	1.754	1.980
0.8	1.37	1.67
1.0	0.945	1.443
1.5	0.57	0.97
2.0	0.401	0.729

Deaggregation of the Hazard

The deaggregation of the hazard shows that the hazard at the site is dominated by nearby earthquakes. The higher ground motions for the 2% in 50 year probability level than for the 10% in 50 year level will reflect not larger magnitudes, but higher ground motion levels for the same magnitude (larger number of standard deviations above the median).

Table 2. Deaggregation of Uniform Hazard Spectra, 5% damping, soil, East (Transverse) Sa at 1 seconds, at the Van Nuys building

Hazard Level	Earthquake Source	M mean	R mean
50% in 50 years	Santa Susana, Northridge blind thrust	6.75	20 km
10% in 50 years	Northridge blind thrust, Santa Susana	6.75	10 km
2% in 50 years	Northridge blind thrust, Santa Susana	6.75	5 km

Representation of Near Fault Rupture Directivity Effects in the Ground Motion Recordings

Although the site is located near active faults in map view, none of the faults that dominate the seismic hazard at the site are oriented in such a way that the site will experience strong rupture directivity effects. For example, the fault that caused the 1994 Northridge earthquake is located about 10 km below the site, but it dips up to the north-northeast and focuses forward rupture directivity toward the northern part of the San Fernando Valley. Suitable recordings do not include the recordings of the Northridge earthquake from the northern San Fernando Valley and the Santa Clarita basin, because they all contain strong forward rupture directivity effects.

The longitudinal axis of the building is oriented east-west and the transverse axis is oriented north-south. We used the east-west and north-south components of the recordings to represent the longitudinal and transverse components of ground motion respectively.

Process of Selecting Ground Motion Recordings

The recordings satisfy the magnitude and distance criteria from the deaggregation, and the recording site criterion of S_D. Additional criteria are that the earthquake have a thrust mechanism, including blind thrust mechanisms (like the 1994 Northridge earthquake), and that the recording not contain strong forward rupture directivity effects. Suitable earthquakes include the 1971 San Fernando, 1986 North Palm Springs, 1997 Whittier Narrows, and 1994 Northridge earthquakes.

Site Effects in the Ground Motion Recordings

All of the selected recordings are from soil sites. Much better representations of appropriate site effects could be made in the selection of time histories, for example by using recordings from sites with comparable seismic velocity profiles, if there were seismic velocity data at the site (as exists for the ROSRINE sites).

Scaling of the Ground Motion Recordings

For each set of recordings, a scaling factor was found by matching the east component time history to the longitudinal uniform hazard spectrum at a period of 1.5 sec. This scaling factor was then applied to all three components of the recording. This scaling procedure preserves the relative scaling between the three components of the recording.

Process of Selecting Ground Motion Recordings

The recordings listed in Tables 3, 4 and 5 were selected to satisfy to the extent possible the magnitude and distance combinations from the deaggregation listed in Table 2. All of the recordings are from thrust earthquakes in the Los Angeles region. In most cases, the selected recordings are from earthquakes having appropriate magnitudes and distances.

Detailed information on the characteristics of the most of the recording sites is not known.

Time Histories for 50% in 50 years

The time histories used to represent the 50% in 50 year ground motions are listed in Table 3. These time histories are derived from the 1971 San Fernando, 1986 North Palm Springs, 1987 Whittier Narrows, and 1994 Northridge earthquakes.

Time Histories for 10% in 50 years

The time histories used to represent the 10% in 50 year ground motions are listed in Table 4. These time histories are derived from the 1971 San Fernando and 1994 Northridge earthquakes.

Time Histories for 2% in 50 years

The time histories used to represent the 2% in 50 year ground motions are listed in Table 5. With the exception of the Van Nuys recording of the 1971 San Fernando earthquake, all of these time histories are from the 1994 Northridge earthquake.

Variability in the Ground Motion Recordings

The variability in the ground motion recordings for each component for each ground motion level is shown in Figures 1 and 2 for the horizontal and vertical components respectively. These figures show the median and plus and minus one standard deviation level for each set of ten recordings. The scaling causes the variability to go to zero for the longitudinal component at 1.5 seconds.

Comparison of Scaled Recording Spectra with the Uniform Hazard Spectra

Figures 3 through 5 show the longitudinal and transverse response spectra averaged over the ten recordings for the three ground motion levels. For all three ground motion levels, the average response spectra of the longitudinal and transverse components of the recordings are similar to each other, and they are also similar to the uniform hazard response spectra at periods longer than 0.5 seconds. At periods shorter than 0.5 seconds, the average response spectra of the recordings are larger than the uniform hazard spectra.

Table 3. Time histories representing 50% in 50 years hazard level at the Van Nuys Building

Earthquake	Mw, Strike (^oE of N)	Station	Distance	Site	Scale	Reference
North Palm Springs 1986.7.8	6.0 287	plma	9.6	soil	2.392	Hartzell (1989)
Northridge 1994.1.17	6.7 122	env1	17.7	soil	0.433	Wald et al. (1996)
		env9	17.9	soil	0.519	
		nhl2	18.4	soil	0.691	
		vnsc	12.8	soil	1.173	
		whox	20.0	soil	0.761	
San Fernando 1971.2.9	6.6 290	253	16.3	soil	1.754	Heaton (1982)
		466	16.4	soil	1.620	
		vnuy	9.5	soil	0.736	
Whittier Narrows 1987.10.1	6.0 280	athl	16.6	soil	3.885	Hartzell and Iida (1990)

Table 4. Time histories representing 10% in 50 years hazard level at the Van Nuys Building

Earthquake	Mw, Strike (^oE of N)	Station	Distance	Site	Scale	Reference
Northridge 1994.1.17	6.7 122	cnpk	17.7	soil	2.081	Wald et al. (1996)
		spva	9.2	soil	1.227	
		vnsc	12.8	soil	2.961	
		vnuy	11.3	soil	1.043	
		whox	20.0	soil	1.922	
San Fernando 1971.2.9	6.6 290	253	16.3	soil	4.427	Heaton (1982)
		461	16.2	soil	4.370	
		466	16.4	soil	4.087	
		glen	18.8	soil	3.853	
		vnuy	9.5	soil	1.858	

Table 5. Time histories representing 2% in 50 years hazard level at the Van Nuys building

Earthquake	Mw, Strike (^oE of N)	Station	Distance	Site	Scale	Reference
Northridge 1994.1.17	6.7 122	env1	17.7	soil	2.001	Wald et al. (1996)
		env9	17.9	soil	2.396	
		nhl2	18.4	soil	3.193	
		nord	9.4	soil	3.601	
		nrr1	13.7	soil	3.298	
		rosc	10.8	soil	2.901	
		spva	9.2	soil	2.246	
		vns1	12.8	soil	3.246	
		vnuy	11.3	soil	1.909	
San Fernando 1971.2.9	6.6 290	vnuy	9.5	soil	3.401	Heaton (1982)

References

Abrahamson, N.A. and W.J. Silva (1997). Empirical response spectral attenuation relations for shallow crustal earthquakes. *Seismological Research Letters* 68, 94-127.

Frankel, A., et al., 1996. USGS National Seismic Maps: Documentation. USGS Open File Report 96-532.

Somerville, P.G. (2002). Characterizing near fault ground motion for the design and evaluation of bridges. Proceedings of the Third National Seismic Conference and Workshop on Bridges and Highways. *This paper is posted on the testbed website.*

Somerville, P.G. (2000). Magnitude scaling of near fault ground motions. *Earthquake Engineering and Engineering Seismology* 2, 15-24.

Somerville, P.G., H. Krawinkler and B. Alavi (2000). Development of improved ground motion representation and design procedures for near-fault ground motions. Final Report to CSMIP Data Utilization Program, Contract No. 1097-601.

Somerville, P.G., K. Irikura, R. Graves, S. Sawada, D. Wald, N. Abrahamson, Y. Iwasaki, T. Kagawa, N. Smith and A. Kowada (1999). Characterizing earthquake slip models for the prediction of strong ground motion. *Seismological Research Letters* 70, 59-80.

Somerville, P.G., N.F. Smith, R.W. Graves, and N.A. Abrahamson (1997). Modification of empirical strong ground motion attenuation relations to include the amplitude and duration effects of rupture directivity, *Seismological Research Letters* 68, 199-222.

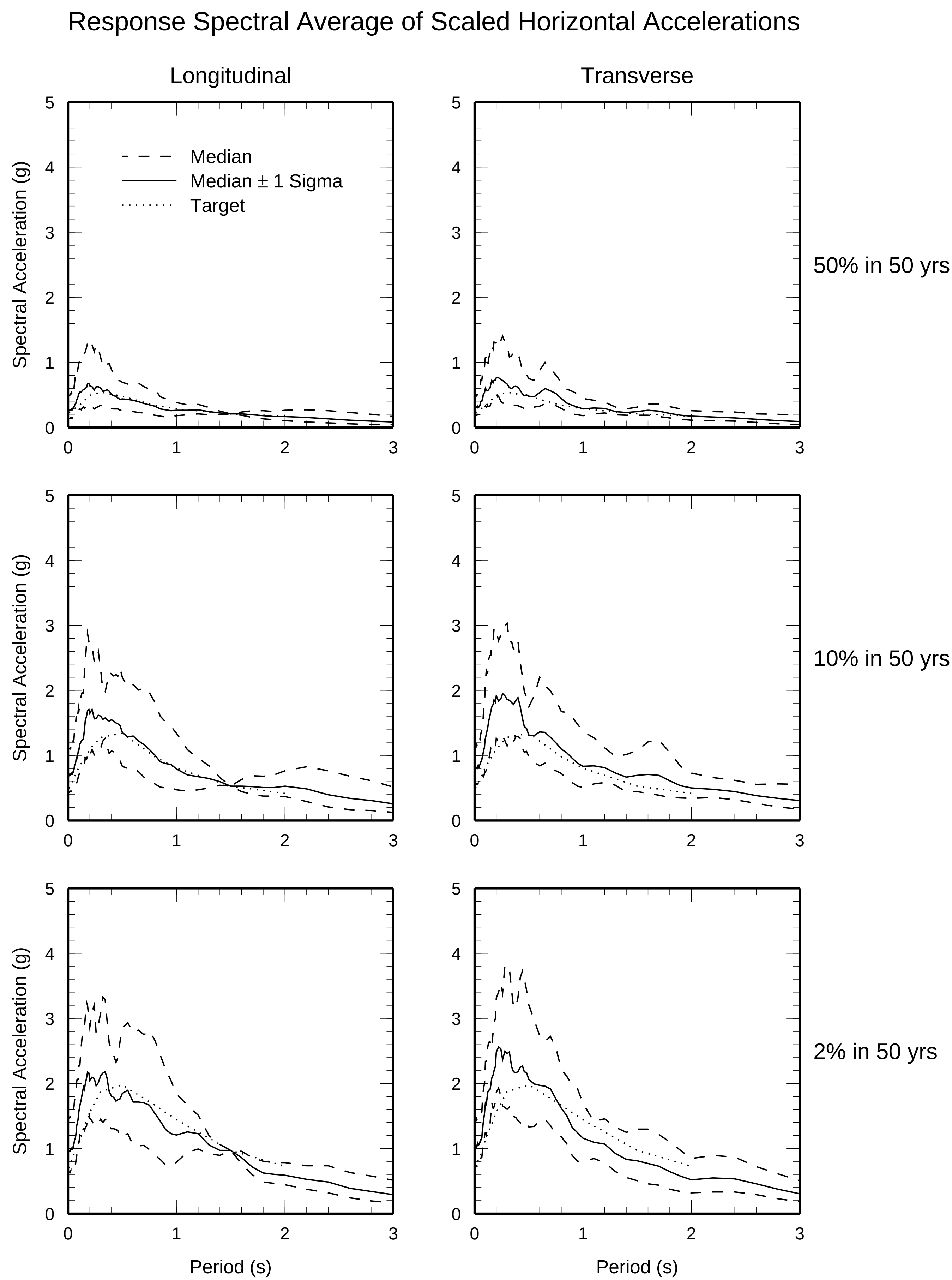

Figure 1. Variability in the ground motions of each set of ten scaled recordings for the longitudinal and transverse components for each of three ground motion levels.

Response Spectral Average of Scaled Vertical Accelerations

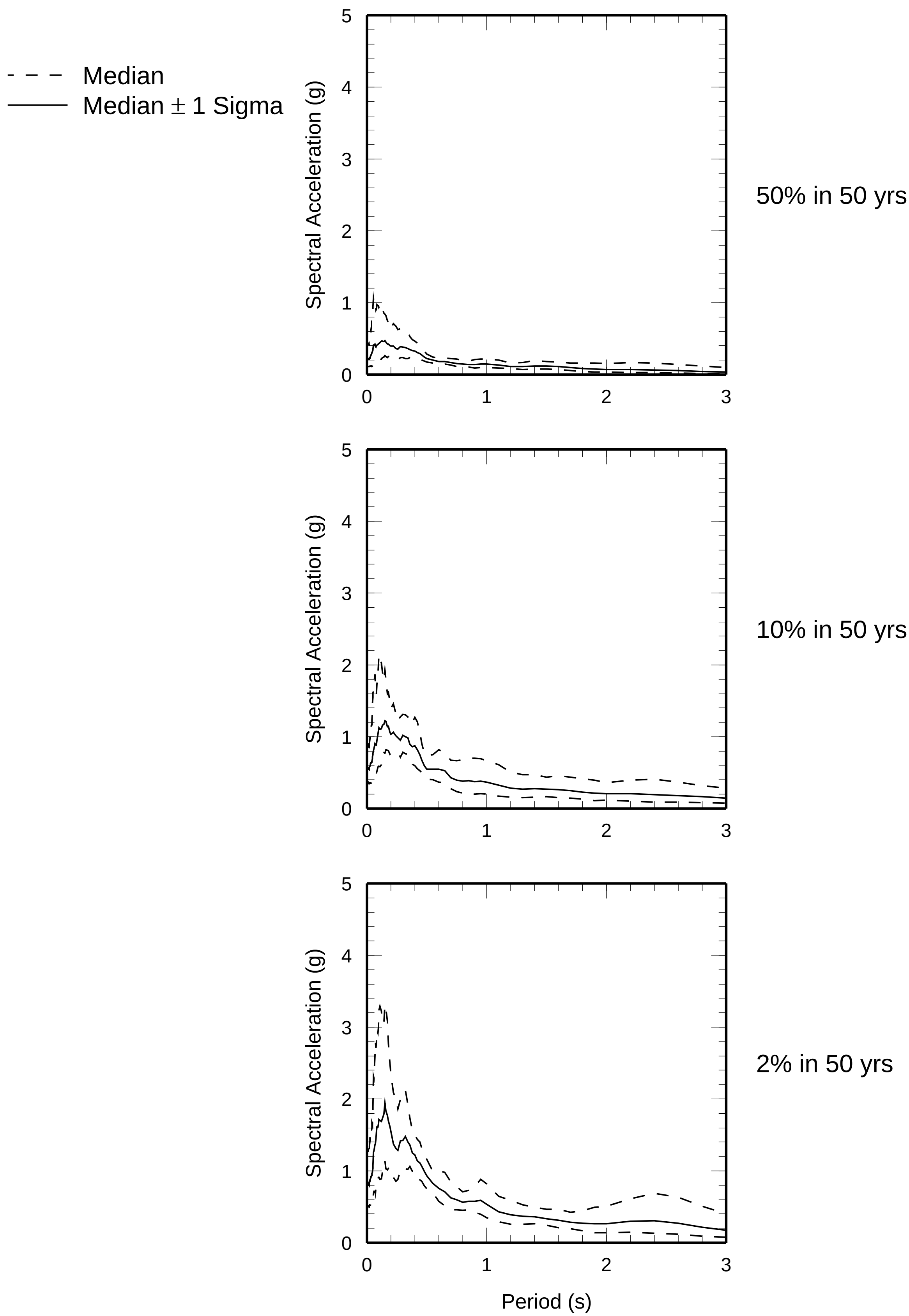

Figure 2. Variability in the ground motions of each set of ten scaled recordings for the vertical component for each of three ground motion levels.

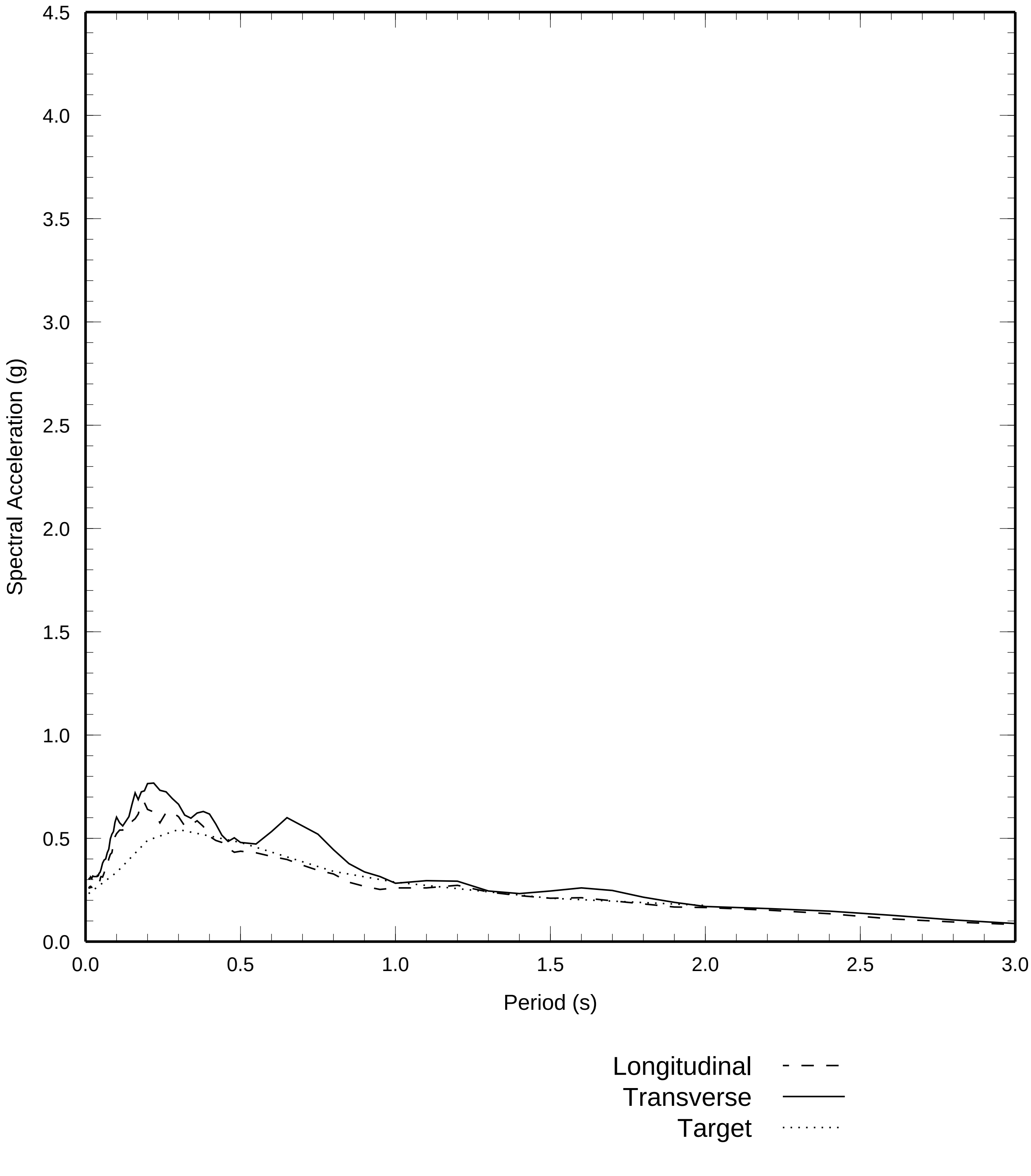

Figure 3. Comparison of the longitudinal and transverse response spectra averaged over the ten scaled recordings for the 50% in 50 year ground motion level.

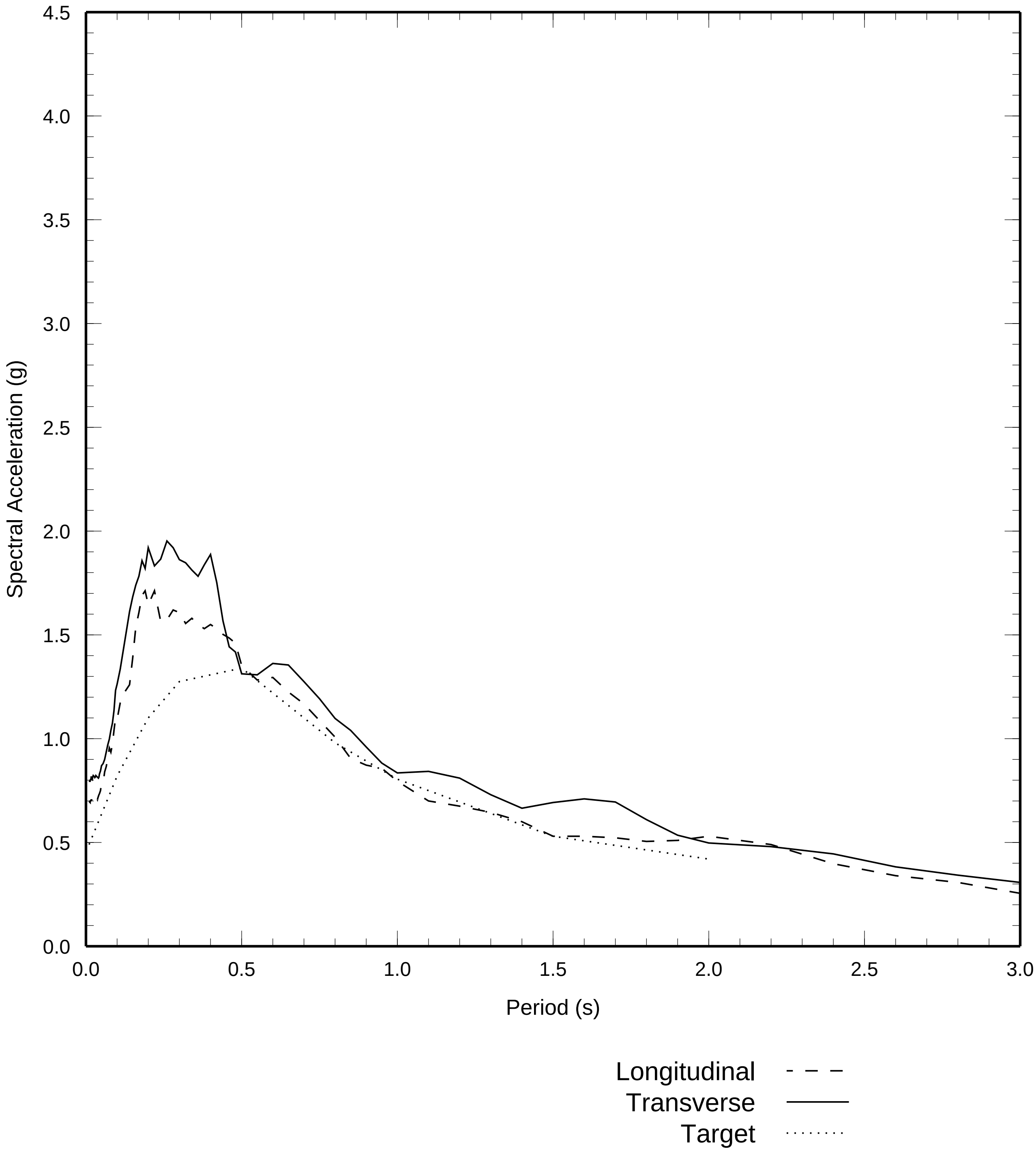

Figure 4. Comparison of the longitudinal and transverse response spectra averaged over the ten scaled recordings for the 10% in 50 year ground motion level.

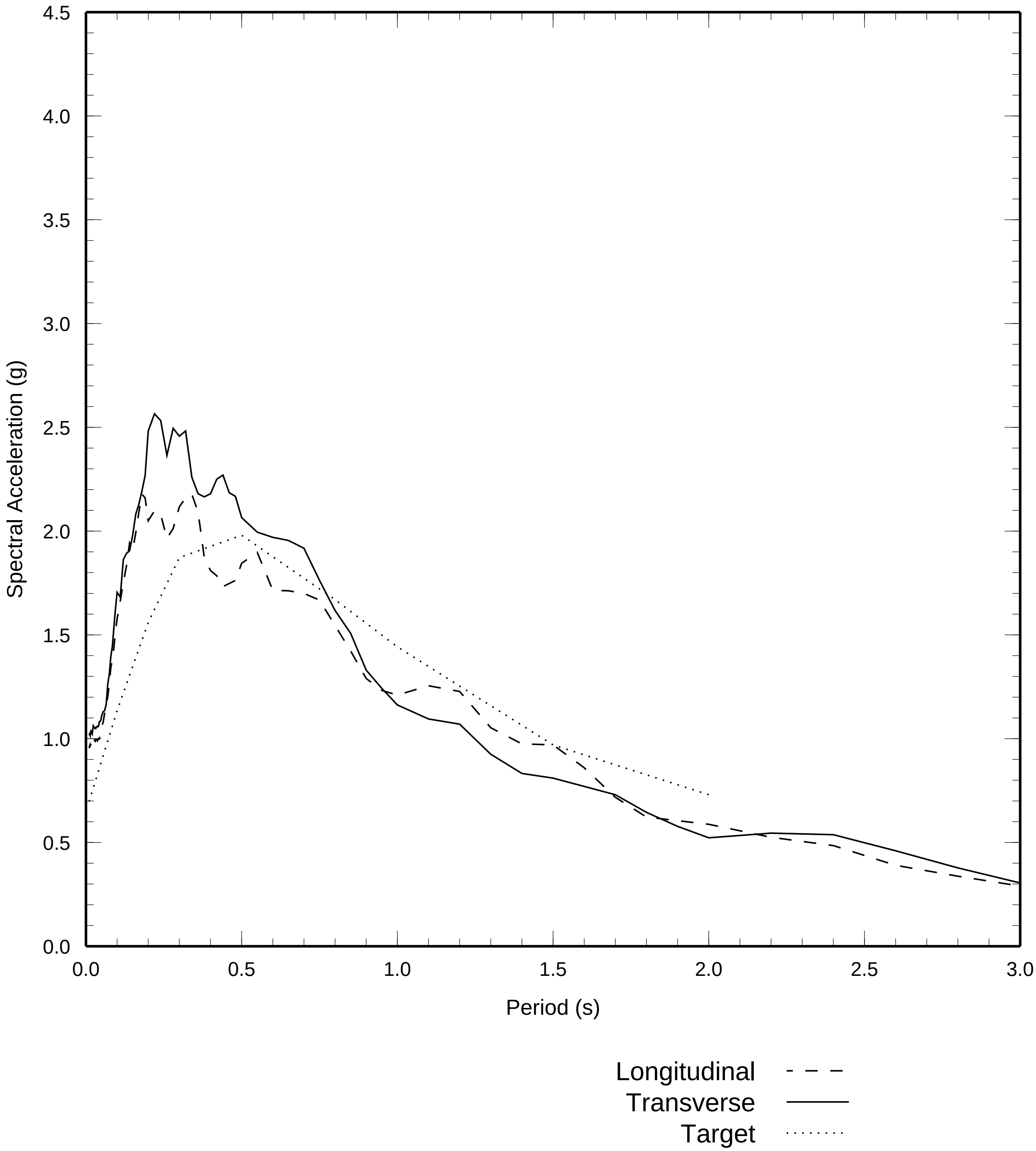

Figure 5. Comparison of the longitudinal and transverse response spectra averaged over the ten scaled recordings for the 2% in 50 year ground motion level.