variance (square root of the sum of the squares) for those models giving values for the geometric mean horizontal motion rather than the random horizontal component of motion. Use the BJF factors for the component-to-component variance for the random horizontal.

F2-3.2 Sigma_Sigma

Sigma-sigma has not been well studied. Use 0.1 natural log units based on my judgment.

F2-3.3 Sigma_Mu

Use the standard deviation of the median value of the weighted ground motion based on the weights given in section F2-2 combined with the weighted average proponent model epistemic uncertainty (square root of the sum of the squares), with a lower limit of 0.2 natural log units.

F2-4 REGRESSION MODELS

The facilitation team developed regression models to parameterize my point estimates in terms of the dependence on magnitude, distance, and style-of-faulting. The regression models given in Volume 11B of the data package adequately model my point estimates of mu, sigma, sigma-mu, and sigma-sigma.

F2-5 SPECIAL CASES

F2-5.1 Multiple Fault Scenarios

Compute the motions as the square root of the sum of the squares of the motions from the individual faults. This assumes that the motions from each fault overlap in time at the site, and that the motions from each fault are uncorrelated.

F2-5.2 Low Angle Fault Scenarios

The empirical models account for this case. Do not make a change for this model.

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APPENDIX F2-A: Deriving the Sa(T=0.05s)/Sa(T=0.10s) Factor

I used the stochastic model point source model (using the computer program SMSIM, Boore, 1996) for a coastal California, rock site ground motion model (Appendix G in Boore, 1996). I computed the motions for T = 0.10 and 0.05 sec oscillators for M = 5, 6.5, 7.5 and R = 5, 15, and 50. I formed the ratios of the response spectra at the two periods and plotted the ratios vs magnitude (Fig. D1). I then fit curves to these ratios, with the result:

$$Sa(T=0.05s)/Sa(T=0.10s) = 0.9327 - 0.05047*M + 0.00245*M**2 - 0.00263*Rps + 0.0003303*M*Rps$$

where Rps = point source distance. As can be seen in Fig. D1, the range of factors in my simulations over a set spanning M = 5 to 7.5 and Rps = 5 to 50 km is only 0.68 to 0.74. For this reason and to simplify the procedure I recommend that

$$Sa(T=0.05)/Sa(T=0.1) = 0.7$$

TABLE F2-1
D. M. BOORE: HORIZONTAL POINT ESTIMATES
PEAK GROUND ACCELERATION

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.14919	0.63260	0.31234	0.10000
2	5.00	1	0.14319	0.63260	0.32244	0.10000
3	5.00	5	0.05679	0.63260	0.24565	0.10000
4	5.00	5	0.06240	0.63260	0.33435	0.10000
5	5.80	10	0.08957	0.58371	0.20000	0.10000
6	5.80	20	0.07154	0.58371	0.22390	0.10000
7	6.50	1	0.38525	0.54186	0.39468	0.10000
8	6.50	1	0.41908	0.54186	0.49926	0.10000
9	6.50	1	0.39064	0.54186	0.44869	0.10000
10	6.50	5	0.36702	0.54186	0.42916	0.10000
11	6.50	5	0.25808	0.54186	0.35909	0.10000
12	6.50	50	0.02821	0.54186	0.23269	0.10000
13	6.50	50	0.02942	0.54186	0.20118	0.10000
14	7.00	10	0.23292	0.51275	0.32608	0.10000
15	7.50	50	0.05789	0.50601	0.22828	0.10000
16	7.50	50	0.06540	0.50601	0.24984	0.10000
17	5.00	1	0.06659	0.63260	0.29977	0.10000
18	5.80	5	0.14647	0.58371	0.25451	0.10000
19	5.80	5	0.08812	0.58371	0.24928	0.10000
20	5.00	10	0.05755	0.63260	0.20000	0.10000
21	5.00	10	0.07746	0.63260	0.24277	0.10000
22	5.00	50	0.00704	0.63260	0.33711	0.10000
23	5.00	50	0.00758	0.63260	0.34169	0.10000
24	5.00	160	0.00114	0.63260	0.62439	0.10000
25	5.80	1	0.25631	0.58371	0.38706	0.10000
26	5.80	5	0.23127	0.58371	0.37947	0.10000
27	5.80	5	0.14330	0.58371	0.29328	0.10000
28	5.80	10	0.11035	0.58371	0.24831	0.10000
29	5.80	10	0.15939	0.58371	0.32389	0.10000
30	5.80	10	0.08385	0.58371	0.27738	0.10000
31	5.80	50	0.01303	0.58371	0.41328	0.10000
32	5.80	50	0.01379	0.58371	0.43780	0.10000
33	6.50	5	0.28566	0.54186	0.35783	0.10000
34	6.50	10	0.18238	0.54186	0.31601	0.10000
35	6.50	10	0.28517	0.54186	0.40414	0.10000
36	6.50	10	0.16104	0.54186	0.29979	0.10000
37	6.50	20	0.09142	0.54186	0.25699	0.10000
38	6.50	20	0.12788	0.54186	0.32974	0.10000
39	6.50	20	0.07954	0.54186	0.22867	0.10000
40	6.50	100	0.01231	0.54186	0.31929	0.10000
41	6.50	160	0.00560	0.54186	0.41771	0.10000
42	7.00	1	0.43824	0.51275	0.34602	0.10000
43	7.00	10	0.35682	0.51275	0.35833	0.10000
44	7.00	10	0.20232	0.51275	0.29417	0.10000
45	7.00	50	0.04249	0.51275	0.23329	0.10000
46	7.00	50	0.04774	0.51275	0.23704	0.10000
47	7.50	1	0.52288	0.50601	0.37962	0.10000
48	5.00	10	0.28542	0.50601	0.33668	0.10000
49	5.00	10	0.42367	0.50601	0.43496	0.10000
50	8.00	50	0.07589	0.50601	0.24963	0.10000
51	8.00	160	0.02045	0.50601	0.27435	0.10000

TABLE F2-2
D. M. BOORE: HORIZONTAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.05 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.27749	0.65243	0.47990	0.10000
2	5.00	1	0.26627	0.65243	0.46670	0.10000
3	5.00	5	0.09988	0.65243	0.20539	0.10000
4	5.00	5	0.10966	0.65243	0.20095	0.10000
5	5.80	10	0.15678	0.60300	0.22342	0.10000
6	5.80	20	0.12083	0.60300	0.23553	0.10000
7	6.50	1	0.69824	0.56066	0.36691	0.10000
8	6.50	1	0.75877	0.56066	0.44831	0.10000
9	6.50	1	0.70642	0.56066	0.42981	0.10000
10	6.50	5	0.67739	0.56066	0.44334	0.10000
11	6.50	5	0.47179	0.56066	0.39667	0.10000
12	6.50	50	0.04023	0.56066	0.28649	0.10000
13	6.50	50	0.04228	0.56066	0.28720	0.10000
14	7.00	10	0.39682	0.53118	0.31447	0.10000
15	7.50	50	0.07644	0.52488	0.34229	0.10000
16	7.50	50	0.08728	0.52488	0.35951	0.10000
17	5.00	1	0.11740	0.65243	0.20626	0.10000
18	5.80	5	0.25572	0.60300	0.25114	0.10000
19	5.80	5	0.15205	0.60300	0.27090	0.10000
20	5.00	10	0.10241	0.65243	0.31947	0.10000
21	5.00	10	0.14022	0.65243	0.35767	0.10000
22	5.00	50	0.00989	0.65243	0.27148	0.10000
23	5.00	50	0.01075	0.65243	0.25534	0.10000
24	5.00	160	0.00124	0.65243	0.49432	0.10000
25	5.80	1	0.47286	0.60300	0.41930	0.10000
26	5.80	5	0.42889	0.60300	0.41648	0.10000
27	5.80	5	0.25852	0.60300	0.37976	0.10000
28	5.80	10	0.19544	0.60300	0.28478	0.10000
29	5.80	10	0.28447	0.60300	0.34648	0.10000
30	5.80	10	0.14844	0.60300	0.37851	0.10000
31	5.80	50	0.01869	0.60300	0.47960	0.10000
32	5.80	50	0.01974	0.60300	0.51750	0.10000
33	6.50	5	0.51807	0.56066	0.33519	0.10000
34	6.50	10	0.32746	0.56066	0.29644	0.10000
35	6.50	10	0.52056	0.56066	0.41803	0.10000
36	6.50	10	0.28588	0.56066	0.33884	0.10000
37	6.50	20	0.15273	0.56066	0.26047	0.10000
38	6.50	20	0.21861	0.56066	0.33041	0.10000
39	6.50	20	0.13236	0.56066	0.29967	0.10000
40	6.50	100	0.01488	0.56066	0.36799	0.10000
41	6.50	160	0.00652	0.56066	0.43117	0.10000
42	7.00	1	0.78691	0.53118	0.35714	0.10000
43	7.00	10	0.63346	0.53118	0.40336	0.10000
44	7.00	10	0.34912	0.53118	0.34442	0.10000
45	7.00	50	0.05913	0.53118	0.28924	0.10000
46	7.00	50	0.06771	0.53118	0.29887	0.10000
47	7.50	1	0.89134	0.52488	0.44879	0.10000
48	5.00	10	0.46672	0.52488	0.39777	0.10000
49	5.00	10	0.70051	0.52488	0.51238	0.10000
50	8.00	50	0.09159	0.52488	0.45833	0.10000
51	8.00	160	0.02018	0.52488	0.41281	0.10000

TABLE F2-3
D. M. BOORE: HORIZONTAL POINT ESTIMATES: SPECTRAL ACCELERATION AT 0.10 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.27334	0.66967	0.51247	0.10000
2	5.00	1	0.26227	0.66967	0.50386	0.10000
3	5.00	5	0.10524	0.66967	0.20000	0.10000
4	5.00	5	0.11524	0.66967	0.20000	0.10000
5	5.80	10	0.17942	0.61967	0.22441	0.10000
6	5.80	20	0.14208	0.61967	0.28452	0.10000
7	6.50	1	0.79034	0.57665	0.41582	0.10000
8	6.50	1	0.87456	0.57665	0.55378	0.10000
9	6.50	1	0.81287	0.57665	0.49375	0.10000
10	6.50	5	0.75019	0.57665	0.47093	0.10000
11	6.50	5	0.53348	0.57665	0.38946	0.10000
12	6.50	50	0.05189	0.57665	0.30028	0.10000
13	6.50	50	0.05419	0.57665	0.26218	0.10000
14	7.00	10	0.46251	0.54654	0.37293	0.10000
15	7.50	50	0.09772	0.54009	0.38246	0.10000
16	7.50	50	0.11191	0.54009	0.39768	0.10000
17	5.00	1	0.12290	0.66967	0.20000	0.10000
18	5.80	5	0.29680	0.61967	0.28173	0.10000
19	5.80	5	0.17682	0.61967	0.30078	0.10000
20	5.00	10	0.10616	0.66967	0.34157	0.10000
21	5.00	10	0.14322	0.66967	0.40097	0.10000
22	5.00	50	0.01209	0.66967	0.24420	0.10000
23	5.00	50	0.01310	0.66967	0.24568	0.10000
24	5.00	160	0.00143	0.66967	0.48470	0.10000
25	5.80	1	0.51495	0.61967	0.44929	0.10000
26	5.80	5	0.47605	0.61967	0.43665	0.10000
27	5.80	5	0.28721	0.61967	0.36107	0.10000
28	5.80	10	0.21673	0.61967	0.30052	0.10000
29	5.80	10	0.31551	0.61967	0.39188	0.10000
30	5.80	10	0.16647	0.61967	0.32546	0.10000
31	5.80	50	0.02405	0.61967	0.40117	0.10000
32	5.80	50	0.02509	0.61967	0.45991	0.10000
33	6.50	5	0.59017	0.57665	0.38351	0.10000
34	6.50	10	0.37351	0.57665	0.34577	0.10000
35	6.50	10	0.59127	0.57665	0.46083	0.10000
36	6.50	10	0.32752	0.57665	0.32565	0.10000
37	6.50	20	0.18310	0.57665	0.30784	0.10000
38	6.50	20	0.25242	0.57665	0.35936	0.10000
39	6.50	20	0.15634	0.57665	0.27577	0.10000
40	6.50	100	0.01908	0.57665	0.41850	0.10000
41	6.50	160	0.00775	0.57665	0.46690	0.10000
42	7.00	1	0.89674	0.54654	0.40089	0.10000
43	7.00	10	0.71549	0.54654	0.43065	0.10000
44	7.00	10	0.40556	0.54654	0.34398	0.10000
45	7.00	50	0.07534	0.54654	0.33072	0.10000
46	7.00	50	0.08630	0.54654	0.33524	0.10000
47	7.50	1	1.00818	0.54009	0.47314	0.10000
48	5.00	10	0.54374	0.54009	0.44256	0.10000
49	5.00	10	0.81113	0.54009	0.52174	0.10000
50	8.00	50	0.11757	0.54009	0.48252	0.10000
51	8.00	160	0.02191	0.54009	0.50496	0.10000

TABLE F2-4
D. M. BOORE: HORIZONTAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.20 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.21108	0.71148	0.47764	0.10000
2	5.00	1	0.20419	0.71148	0.47402	0.10000
3	5.00	5	0.08710	0.71148	0.20000	0.10000
4	5.00	5	0.09458	0.71148	0.20000	0.10000
5	5.80	10	0.16670	0.66268	0.21601	0.10000
6	5.80	20	0.13622	0.66268	0.28724	0.10000
7	6.50	1	0.70273	0.62098	0.44388	0.10000
8	6.50	1	0.77052	0.62098	0.55652	0.10000
9	6.50	1	0.72490	0.62098	0.51070	0.10000
10	6.50	5	0.67225	0.62098	0.47485	0.10000
11	6.50	5	0.49154	0.62098	0.38296	0.10000
12	6.50	50	0.05644	0.62098	0.31300	0.10000
13	6.50	50	0.05941	0.62098	0.23931	0.10000
14	7.00	10	0.44347	0.59199	0.38485	0.10000
15	7.50	50	0.11227	0.58586	0.40840	0.10000
16	7.50	50	0.12879	0.58586	0.40367	0.10000
17	5.00	1	0.09971	0.71148	0.20000	0.10000
18	5.80	5	0.25726	0.66268	0.29793	0.10000
19	5.80	5	0.16651	0.66268	0.26740	0.10000
20	5.00	10	0.08817	0.71148	0.26949	0.10000
21	5.00	10	0.11673	0.71148	0.35655	0.10000
22	5.00	50	0.01211	0.71148	0.22459	0.10000
23	5.00	50	0.01315	0.71148	0.24498	0.10000
24	5.00	160	0.00187	0.71148	0.49051	0.10000
25	5.80	1	0.43814	0.66268	0.43825	0.10000
26	5.80	5	0.40232	0.66268	0.42095	0.10000
27	5.80	5	0.25602	0.66268	0.31384	0.10000
28	5.80	10	0.19673	0.66268	0.29418	0.10000
29	5.80	10	0.28038	0.66268	0.37636	0.10000
30	5.80	10	0.15672	0.66268	0.26049	0.10000
31	5.80	50	0.02516	0.66268	0.42483	0.10000
32	5.80	50	0.02794	0.66268	0.36462	0.10000
33	6.50	5	0.53378	0.62098	0.39471	0.10000
34	6.50	10	0.34289	0.62098	0.33411	0.10000
35	6.50	10	0.52469	0.62098	0.43798	0.10000
36	6.50	10	0.31252	0.62098	0.32013	0.10000
37	6.50	20	0.17702	0.62098	0.29717	0.10000
38	6.50	20	0.25202	0.62098	0.37550	0.10000
39	6.50	20	0.15930	0.62098	0.25913	0.10000
40	6.50	100	0.02329	0.62098	0.41560	0.10000
41	6.50	160	0.01041	0.62098	0.47419	0.10000
42	7.00	1	0.80724	0.59199	0.42424	0.10000
43	7.00	10	0.66441	0.59199	0.42823	0.10000
44	7.00	10	0.39809	0.59199	0.34559	0.10000
45	7.00	50	0.08503	0.59199	0.35492	0.10000
46	7.00	50	0.09664	0.59199	0.33360	0.10000
47	7.50	1	0.95971	0.58586	0.51975	0.10000
48	5.00	10	0.54633	0.58586	0.47689	0.10000
49	5.00	10	0.77038	0.58586	0.51445	0.10000
50	8.00	50	0.13491	0.58586	0.48046	0.10000
51	8.00	160	0.02927	0.58586	0.55333	0.10000

TABLE F2-5
D. M. BOORE: HORIZONTAL POINT ESTIMATES SPECTRAL ACCELERATION AT 0.50 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.11369	0.77480	0.29740	0.10000
2	5.00	1	0.11098	0.77480	0.30212	0.10000
3	5.00	5	0.04705	0.77480	0.20000	0.10000
4	5.00	5	0.05393	0.77480	0.31695	0.10000
5	5.80	10	0.10305	0.72795	0.20315	0.10000
6	5.80	20	0.08760	0.72795	0.24544	0.10000
7	6.50	1	0.51137	0.68803	0.27261	0.10000
8	6.50	1	0.55262	0.68803	0.36393	0.10000
9	6.50	1	0.51806	0.68803	0.32801	0.10000
10	6.50	5	0.48170	0.68803	0.30903	0.10000
11	6.50	5	0.33849	0.68803	0.29283	0.10000
12	6.50	50	0.04628	0.68803	0.25221	0.10000
13	6.50	50	0.04998	0.68803	0.24380	0.10000
14	7.00	10	0.34437	0.66034	0.32042	0.10000
15	7.50	50	0.10937	0.65440	0.27702	0.10000
16	7.50	50	0.12483	0.65440	0.28724	0.10000
17	5.00	1	0.05624	0.77480	0.28491	0.10000
18	5.80	5	0.17256	0.72795	0.20068	0.10000
19	5.80	5	0.09944	0.72795	0.25597	0.10000
20	5.00	10	0.04571	0.77480	0.20272	0.10000
21	5.00	10	0.06124	0.77480	0.27953	0.10000
22	5.00	50	0.00769	0.77480	0.22496	0.10000
23	5.00	50	0.00832	0.77480	0.23430	0.10000
24	5.00	160	0.00176	0.77480	0.45601	0.10000
25	5.80	1	0.28031	0.72795	0.29396	0.10000
26	5.80	5	0.26005	0.72795	0.31403	0.10000
27	5.80	5	0.15636	0.72795	0.26923	0.10000
28	5.80	10	0.12523	0.72795	0.26526	0.10000
29	5.80	10	0.18230	0.72795	0.32405	0.10000
30	5.80	10	0.09464	0.72795	0.28288	0.10000
31	5.80	50	0.01843	0.72795	0.42581	0.10000
32	5.80	50	0.01921	0.72795	0.51552	0.10000
33	6.50	5	0.37870	0.68803	0.31405	0.10000
34	6.50	10	0.24897	0.68803	0.32784	0.10000
35	6.50	10	0.38882	0.68803	0.35972	0.10000
36	6.50	10	0.21620	0.68803	0.28905	0.10000
37	6.50	20	0.12901	0.68803	0.25969	0.10000
38	6.50	20	0.18231	0.68803	0.33941	0.10000
39	6.50	20	0.11735	0.68803	0.22388	0.10000
40	6.50	100	0.02328	0.68803	0.34779	0.10000
41	6.50	160	0.01215	0.68803	0.41708	0.10000
42	7.00	1	0.65061	0.66034	0.25222	0.10000
43	7.00	10	0.55030	0.66034	0.30902	0.10000
44	7.00	10	0.29977	0.66034	0.25931	0.10000
45	7.00	50	0.07516	0.66034	0.26618	0.10000
46	7.00	50	0.08635	0.66034	0.30425	0.10000
47	7.50	1	0.80395	0.65440	0.27804	0.10000
48	5.00	10	0.44274	0.65440	0.30808	0.10000
49	5.00	10	0.67156	0.65440	0.37559	0.10000
50	8.00	50	0.14398	0.65440	0.27050	0.10000
51	8.00	160	0.04367	0.65440	0.41657	0.10000

TABLE F2-6
D. M. BOORE: HORIZONTAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 1.00 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.05077	0.82272	0.20777	0.10000
2	5.00	1	0.04829	0.82272	0.25406	0.10000
3	5.00	5	0.02078	0.82272	0.25317	0.10000
4	5.00	5	0.02418	0.82272	0.49105	0.10000
5	5.80	10	0.05295	0.77866	0.20000	0.10000
6	5.80	20	0.04446	0.77866	0.23070	0.10000
7	6.50	1	0.30479	0.74108	0.20000	0.10000
8	6.50	1	0.31933	0.74108	0.30317	0.10000
9	6.50	1	0.29622	0.74108	0.29291	0.10000
10	6.50	5	0.28605	0.74108	0.27666	0.10000
11	6.50	5	0.18743	0.74108	0.33632	0.10000
12	6.50	50	0.03051	0.74108	0.27067	0.10000
13	6.50	50	0.03068	0.74108	0.30220	0.10000
14	7.00	10	0.21027	0.71497	0.26106	0.10000
15	7.50	50	0.07767	0.70910	0.23239	0.10000
16	7.50	50	0.08638	0.70910	0.26409	0.10000
17	5.00	1	0.02589	0.82272	0.44020	0.10000
18	5.80	5	0.08945	0.77866	0.36661	0.10000
19	5.80	5	0.04973	0.77866	0.34652	0.10000
20	5.00	10	0.01977	0.82272	0.20000	0.10000
21	5.00	10	0.02570	0.82272	0.23830	0.10000
22	5.00	50	0.00375	0.82272	0.21840	0.10000
23	5.00	50	0.00393	0.82272	0.24368	0.10000
24	5.00	160	0.00105	0.82272	0.42656	0.10000
25	5.80	1	0.14475	0.77866	0.28871	0.10000
26	5.80	5	0.13368	0.77866	0.31701	0.10000
27	5.80	5	0.07648	0.77866	0.34486	0.10000
28	5.80	10	0.06291	0.77866	0.24631	0.10000
29	5.80	10	0.09209	0.77866	0.31278	0.10000
30	5.80	10	0.04838	0.77866	0.30594	0.10000
31	5.80	50	0.01060	0.77866	0.43187	0.10000
32	5.80	50	0.01119	0.77866	0.48362	0.10000
33	6.50	5	0.21308	0.74108	0.26923	0.10000
34	6.50	10	0.14595	0.74108	0.30634	0.10000
35	6.50	10	0.22857	0.74108	0.33093	0.10000
36	6.50	10	0.12285	0.74108	0.31132	0.10000
37	6.50	20	0.07628	0.74108	0.25422	0.10000
38	6.50	20	0.10393	0.74108	0.34845	0.10000
39	6.50	20	0.06771	0.74108	0.26978	0.10000
40	6.50	100	0.01644	0.74108	0.29750	0.10000
41	6.50	160	0.00922	0.74108	0.40024	0.10000
42	7.00	1	0.39166	0.71497	0.25673	0.10000
43	7.00	10	0.34312	0.71497	0.30801	0.10000
44	7.00	10	0.18397	0.71497	0.29585	0.10000
45	7.00	50	0.05090	0.71497	0.29206	0.10000
46	7.00	50	0.05535	0.71497	0.34534	0.10000
47	7.50	1	0.52693	0.70910	0.34228	0.10000
48	5.00	10	0.29289	0.70910	0.27779	0.10000
49	5.00	10	0.45647	0.70910	0.44204	0.10000
50	8.00	50	0.11008	0.70910	0.20583	0.10000
51	8.00	160	0.04045	0.70910	0.34348	0.10000

TABLE F2-7
D. M. BOORE: HORIZONTAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 2.00 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.01800	0.88358	0.31131	0.10000
2	5.00	1	0.01578	0.88358	0.43214	0.10000
3	5.00	5	0.00922	0.88358	0.44283	0.10000
4	5.00	5	0.00937	0.88358	0.65892	0.10000
5	5.80	10	0.02169	0.84293	0.34180	0.10000
6	5.80	20	0.01653	0.84293	0.36987	0.10000
7	6.50	1	0.12981	0.80831	0.23913	0.10000
8	6.50	1	0.12452	0.80831	0.24498	0.10000
9	6.50	1	0.11316	0.80831	0.20000	0.10000
10	6.50	5	0.10301	0.80831	0.22319	0.10000
11	6.50	5	0.07882	0.80831	0.21401	0.10000
12	6.50	50	0.01476	0.80831	0.42250	0.10000
13	6.50	50	0.01379	0.80831	0.46915	0.10000
14	7.00	10	0.09729	0.78426	0.23511	0.10000
15	7.50	50	0.04089	0.77857	0.50374	0.10000
16	7.50	50	0.04152	0.77857	0.55522	0.10000
17	5.00	1	0.01080	0.88358	0.50814	0.10000
18	5.80	5	0.03732	0.84293	0.39597	0.10000
19	5.80	5	0.02174	0.84293	0.41406	0.10000
20	5.00	10	0.00821	0.88358	0.25718	0.10000
21	5.00	10	0.00917	0.88358	0.45640	0.10000
22	5.00	50	0.00176	0.88358	0.42797	0.10000
23	5.00	50	0.00170	0.88358	0.50730	0.10000
24	5.00	160	0.00055	0.88358	0.60523	0.10000
25	5.80	1	0.05417	0.84293	0.24750	0.10000
26	5.80	5	0.04635	0.84293	0.32645	0.10000
27	5.80	5	0.03136	0.84293	0.31191	0.10000
28	5.80	10	0.02443	0.84293	0.28419	0.10000
29	5.80	10	0.03097	0.84293	0.32879	0.10000
30	5.80	10	0.01929	0.84293	0.37921	0.10000
31	5.80	50	0.00462	0.84293	0.70473	0.10000
32	5.80	50	0.00447	0.84293	0.72100	0.10000
33	6.50	5	0.09550	0.80831	0.21019	0.10000
34	6.50	10	0.06416	0.80831	0.21903	0.10000
35	6.50	10	0.08304	0.80831	0.21251	0.10000
36	6.50	10	0.05115	0.80831	0.26189	0.10000
37	6.50	20	0.03709	0.80831	0.24300	0.10000
38	6.50	20	0.04433	0.80831	0.27320	0.10000
39	6.50	20	0.02917	0.80831	0.32362	0.10000
40	6.50	100	0.00889	0.80831	0.36221	0.10000
41	6.50	160	0.00507	0.80831	0.60176	0.10000
42	7.00	1	0.18094	0.78426	0.20000	0.10000
43	7.00	10	0.12949	0.78426	0.25827	0.10000
44	7.00	10	0.08046	0.78426	0.27746	0.10000
45	7.00	50	0.02712	0.78426	0.38658	0.10000
46	7.00	50	0.02702	0.78426	0.43312	0.10000
47	7.50	1	0.22024	0.77857	0.21250	0.10000
48	5.00	10	0.13195	0.77857	0.36065	0.10000
49	5.00	10	0.16590	0.77857	0.44999	0.10000
50	8.00	50	0.06575	0.77857	0.28822	0.10000
51	8.00	160	0.02875	0.77857	0.49552	0.10000

TABLE F2-8
D. M. BOORE: HORIZONTAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 3.33 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.00811	0.86063	0.53592	0.10000
2	5.00	1	0.00644	0.86063	0.67803	0.10000
3	5.00	5	0.00301	0.86063	0.31872	0.10000
4	5.00	5	0.00261	0.86063	0.49998	0.10000
5	5.80	10	0.01085	0.79229	0.46462	0.10000
6	5.80	20	0.00670	0.79229	0.47766	0.10000
7	6.50	1	0.08046	0.73402	0.31913	0.10000
8	6.50	1	0.07180	0.73402	0.31592	0.10000
9	6.50	1	0.06592	0.73402	0.32658	0.10000
10	6.50	5	0.05763	0.73402	0.35986	0.10000
11	6.50	5	0.04756	0.73402	0.39059	0.10000
12	6.50	50	0.00876	0.73402	0.61106	0.10000
13	6.50	50	0.00724	0.73402	0.66328	0.10000
14	7.00	10	0.06135	0.69350	0.40387	0.10000
15	7.50	50	0.03049	0.68354	0.49215	0.10000
16	7.50	50	0.02611	0.68354	0.61248	0.10000
17	5.00	1	0.00334	0.86063	0.33745	0.10000
18	5.80	5	0.01541	0.79229	0.46358	0.10000
19	5.80	5	0.00921	0.79229	0.51723	0.10000
20	5.00	10	0.00325	0.86063	0.33105	0.10000
21	5.00	10	0.00318	0.86063	0.53491	0.10000
22	5.00	50	0.00060	0.86063	0.20000	0.10000
23	5.00	50	0.00054	0.86063	0.27373	0.10000
24	5.00	160	0.00018	0.86063	0.33072	0.10000
25	5.80	1	0.02971	0.79229	0.44377	0.10000
26	5.80	5	0.02229	0.79229	0.50500	0.10000
27	5.80	5	0.01605	0.79229	0.47797	0.10000
28	5.80	10	0.01311	0.79229	0.46031	0.10000
29	5.80	10	0.01284	0.79229	0.51970	0.10000
30	5.80	10	0.00873	0.79229	0.63843	0.10000
31	5.80	50	0.00222	0.79229	0.73800	0.10000
32	5.80	50	0.00188	0.79229	0.79835	0.10000
33	6.50	5	0.06118	0.73402	0.32251	0.10000
34	6.50	10	0.03893	0.73402	0.38926	0.10000
35	6.50	10	0.03958	0.73402	0.35858	0.10000
36	6.50	10	0.02773	0.73402	0.52384	0.10000
37	6.50	20	0.02117	0.73402	0.43779	0.10000
38	6.50	20	0.02083	0.73402	0.46556	0.10000
39	6.50	20	0.01567	0.73402	0.56064	0.10000
40	6.50	100	0.00454	0.73402	0.57117	0.10000
41	6.50	160	0.00313	0.73402	0.64451	0.10000
42	7.00	1	0.12015	0.69350	0.30377	0.10000
43	7.00	10	0.06358	0.69350	0.33234	0.10000
44	7.00	10	0.04587	0.69350	0.49980	0.10000
45	7.00	50	0.01789	0.69350	0.50976	0.10000
46	7.00	50	0.01568	0.69350	0.56556	0.10000
47	7.50	1	0.15112	0.68354	0.30267	0.10000
48	5.00	10	0.08531	0.68354	0.49638	0.10000
49	5.00	10	0.08400	0.68354	0.45359	0.10000
50	8.00	50	0.05201	0.68354	0.28424	0.10000
51	8.00	160	0.02336	0.68354	0.36676	0.10000

TABLE F2-9
D. M. BOORE: HORIZONTAL POINT ESTIMATES
PEAK GROUND VELOCITY

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	5.63744	0.63355	0.30714	0.10000
2	5.00	1	5.34570	0.63355	0.32694	0.10000
3	5.00	5	2.53868	0.63355	0.30562	0.10000
4	5.00	5	3.16611	0.63355	0.51962	0.10000
5	5.80	10	5.54542	0.58682	0.23247	0.10000
6	5.80	20	4.49709	0.58682	0.26603	0.10000
7	6.50	1	32.52051	0.54723	0.22786	0.10000
8	6.50	1	33.15668	0.54723	0.31239	0.10000
9	6.50	1	30.08151	0.54723	0.26110	0.10000
10	6.50	5	28.69017	0.54723	0.20000	0.10000
11	6.50	5	18.69324	0.54723	0.20000	0.10000
12	6.50	50	2.62938	0.54723	0.34200	0.10000
13	6.50	50	2.60177	0.54723	0.29430	0.10000
14	7.00	10	22.77278	0.51988	0.22215	0.10000
15	7.50	50	8.36202	0.50040	0.37089	0.10000
16	7.50	50	8.93632	0.50040	0.37049	0.10000
17	5.00	1	3.33298	0.63355	0.44472	0.10000
18	5.80	5	10.54929	0.58682	0.36606	0.10000
19	5.80	5	5.37063	0.58682	0.34252	0.10000
20	5.00	10	2.01408	0.63355	0.20000	0.10000
21	5.00	10	2.68060	0.63355	0.22924	0.10000
22	5.00	50	0.29354	0.63355	0.21760	0.10000
23	5.00	50	0.30720	0.63355	0.26757	0.10000
24	5.00	160	0.06052	0.63355	0.46622	0.10000
25	5.80	1	15.07693	0.58682	0.28742	0.10000
26	5.80	5	13.71370	0.58682	0.25911	0.10000
27	5.80	5	7.81970	0.58682	0.20000	0.10000
28	5.80	10	6.27613	0.58682	0.25295	0.10000
29	5.80	10	9.12798	0.58682	0.25511	0.10000
30	5.80	10	4.56310	0.58682	0.20977	0.10000
31	5.80	50	0.82666	0.58682	0.46172	0.10000
32	5.80	50	0.85114	0.58682	0.45643	0.10000
33	6.50	5	22.01258	0.54723	0.20000	0.10000
34	6.50	10	14.51244	0.54723	0.24682	0.10000
35	6.50	10	21.57574	0.54723	0.20000	0.10000
36	6.50	10	11.62623	0.54723	0.20000	0.10000
37	6.50	20	7.52492	0.54723	0.26537	0.10000
38	6.50	20	10.09189	0.54723	0.26984	0.10000
39	6.50	20	6.24234	0.54723	0.22083	0.10000
40	6.50	100	1.38147	0.54723	0.40595	0.10000
41	6.50	160	0.66802	0.54723	0.65143	0.10000
42	7.00	1	46.70370	0.51988	0.23657	0.10000
43	7.00	10	36.13906	0.51988	0.28411	0.10000
44	7.00	10	18.52680	0.51988	0.24293	0.10000
45	7.00	50	4.98080	0.51988	0.32964	0.10000
46	7.00	50	5.24308	0.51988	0.31889	0.10000
47	7.50	1	65.92093	0.50040	0.40169	0.10000
48	5.00	10	33.51372	0.50040	0.34425	0.10000
49	5.00	10	49.55303	0.50040	0.54845	0.10000
50	8.00	50	14.51932	0.50040	0.37427	0.10000
51	8.00	160	5.60324	0.50040	0.64135	0.10000

TABLE F2-10
D. M. BOORE: VERTICAL POINT ESTIMATES
PEAK GROUND ACCELERATION

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.11402	0.71508	0.37006	0.10000
2	5.00	1	0.09926	0.71508	0.47342	0.10000
3	5.00	5	0.03255	0.71508	0.20000	0.10000
4	5.00	5	0.03130	0.71508	0.22040	0.10000
5	5.80	10	0.05920	0.66220	0.21872	0.10000
6	5.80	20	0.04497	0.66220	0.34656	0.10000
7	6.50	1	0.34390	0.59419	0.21624	0.10000
8	6.50	1	0.34347	0.59419	0.20000	0.10000
9	6.50	1	0.33136	0.59419	0.20865	0.10000
10	6.50	5	0.28975	0.59419	0.25501	0.10000
11	6.50	5	0.21902	0.59419	0.20000	0.10000
12	6.50	50	0.01667	0.59419	0.33062	0.10000
13	6.50	50	0.01840	0.59419	0.26415	0.10000
14	7.00	10	0.18832	0.56181	0.20000	0.10000
15	7.50	50	0.03541	0.55559	0.21494	0.10000
16	7.50	50	0.03952	0.55559	0.28440	0.10000
17	5.00	1	0.03698	0.71508	0.20000	0.10000
18	5.80	5	0.09011	0.66220	0.29901	0.10000
19	5.80	5	0.05658	0.66220	0.28630	0.10000
20	5.00	10	0.03731	0.71508	0.20000	0.10000
21	5.00	10	0.04424	0.71508	0.33679	0.10000
22	5.00	50	0.00353	0.71508	0.21817	0.10000
23	5.00	50	0.00353	0.71508	0.20000	0.10000
24	5.00	160	0.00050	0.71508	0.39837	0.10000
25	5.80	1	0.20276	0.66220	0.34989	0.10000
26	5.80	5	0.16856	0.66220	0.35557	0.10000
27	5.80	5	0.10892	0.66220	0.24307	0.10000
28	5.80	10	0.07677	0.66220	0.21655	0.10000
29	5.80	10	0.10838	0.66220	0.31092	0.10000
30	5.80	10	0.06192	0.66220	0.22077	0.10000
31	5.80	50	0.00729	0.66220	0.51975	0.10000
32	5.80	50	0.00780	0.66220	0.42894	0.10000
33	6.50	5	0.24964	0.59419	0.20000	0.10000
34	6.50	10	0.14700	0.59419	0.20000	0.10000
35	6.50	10	0.23939	0.59419	0.32624	0.10000
36	6.50	10	0.12830	0.59419	0.20000	0.10000
37	6.50	20	0.06659	0.59419	0.20883	0.10000
38	6.50	20	0.10498	0.59419	0.36544	0.10000
39	6.50	20	0.05674	0.59419	0.20000	0.10000
40	6.50	100	0.00616	0.59419	0.37455	0.10000
41	6.50	160	0.00252	0.59419	0.52136	0.10000
42	7.00	1	0.40253	0.56181	0.20000	0.10000
43	7.00	10	0.29257	0.56181	0.29839	0.10000
44	7.00	10	0.16286	0.56181	0.20000	0.10000
45	7.00	50	0.02458	0.56181	0.22789	0.10000
46	7.00	50	0.02797	0.56181	0.30719	0.10000
47	7.50	1	0.52422	0.55559	0.26848	0.10000
48	5.00	10	0.23518	0.55559	0.20000	0.10000
49	5.00	10	0.35553	0.55559	0.32731	0.10000
50	8.00	50	0.05090	0.55559	0.21890	0.10000
51	8.00	160	0.01006	0.55559	0.30579	0.10000

TABLE F2-11
D. M. BOORE: VERTICAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.05 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.29134	0.74602	0.28753	0.10000
2	5.00	1	0.25322	0.74602	0.37902	0.10000
3	5.00	5	0.07582	0.74602	0.21405	0.10000
4	5.00	5	0.07321	0.74602	0.20469	0.10000
5	5.80	10	0.12726	0.69468	0.37495	0.10000
6	5.80	20	0.09167	0.69468	0.30962	0.10000
7	6.50	1	0.81804	0.63035	0.39655	0.10000
8	6.50	1	0.81003	0.63035	0.27898	0.10000
9	6.50	1	0.78597	0.63035	0.27443	0.10000
10	6.50	5	0.68034	0.63035	0.29323	0.10000
11	6.50	5	0.49885	0.63035	0.33317	0.10000
12	6.50	50	0.02805	0.63035	0.41588	0.10000
13	6.50	50	0.03150	0.63035	0.31111	0.10000
14	7.00	10	0.41089	0.59908	0.32795	0.10000
15	7.50	50	0.05987	0.59370	0.26752	0.10000
16	7.50	50	0.06764	0.59370	0.26199	0.10000
17	5.00	1	0.08702	0.74602	0.20739	0.10000
18	5.80	5	0.19958	0.69468	0.44204	0.10000
19	5.80	5	0.12293	0.69468	0.34736	0.10000
20	5.00	10	0.08845	0.74602	0.20458	0.10000
21	5.00	10	0.10650	0.74602	0.30122	0.10000
22	5.00	50	0.00642	0.74602	0.29402	0.10000
23	5.00	50	0.00647	0.74602	0.23436	0.10000
24	5.00	160	0.00062	0.74602	0.46907	0.10000
25	5.80	1	0.48148	0.69468	0.49721	0.10000
26	5.80	5	0.38546	0.69468	0.39322	0.10000
27	5.80	5	0.24896	0.69468	0.34065	0.10000
28	5.80	10	0.16954	0.69468	0.38298	0.10000
29	5.80	10	0.23616	0.69468	0.36419	0.10000
30	5.80	10	0.13347	0.69468	0.35498	0.10000
31	5.80	50	0.01265	0.69468	0.58858	0.10000
32	5.80	50	0.01350	0.69468	0.53831	0.10000
33	6.50	5	0.57668	0.63035	0.33993	0.10000
34	6.50	10	0.32305	0.63035	0.33202	0.10000
35	6.50	10	0.53096	0.63035	0.42008	0.10000
36	6.50	10	0.28207	0.63035	0.29023	0.10000
37	6.50	20	0.13578	0.63035	0.31149	0.10000
38	6.50	20	0.21717	0.63035	0.41757	0.10000
39	6.50	20	0.11525	0.63035	0.28768	0.10000
40	6.50	100	0.00851	0.63035	0.43063	0.10000
41	6.50	160	0.00326	0.63035	0.53770	0.10000
42	7.00	1	0.95736	0.59908	0.35616	0.10000
43	7.00	10	0.64958	0.59908	0.39906	0.10000
44	7.00	10	0.35648	0.59908	0.26961	0.10000
45	7.00	50	0.04229	0.59908	0.30033	0.10000
46	7.00	50	0.04836	0.59908	0.30195	0.10000
47	7.50	1	1.24159	0.59370	0.32250	0.10000
48	5.00	10	0.51714	0.59370	0.32562	0.10000
49	5.00	10	0.79402	0.59370	0.42984	0.10000
50	8.00	50	0.08536	0.59370	0.24836	0.10000
51	8.00	160	0.01223	0.59370	0.35465	0.10000

TABLE F2-12
D. M. BOORE: VERTICAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.10 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.24204	0.74602	0.39650	0.10000
2	5.00	1	0.22229	0.74602	0.44014	0.10000
3	5.00	5	0.06757	0.74602	0.20000	0.10000
4	5.00	5	0.06878	0.74602	0.20000	0.10000
5	5.80	10	0.12732	0.69468	0.20000	0.10000
6	5.80	20	0.09787	0.69468	0.36150	0.10000
7	6.50	1	0.78319	0.63035	0.21590	0.10000
8	6.50	1	0.81799	0.63035	0.20000	0.10000
9	6.50	1	0.79310	0.63035	0.20000	0.10000
10	6.50	5	0.66349	0.63035	0.23795	0.10000
11	6.50	5	0.50915	0.63035	0.20000	0.10000
12	6.50	50	0.03142	0.63035	0.30398	0.10000
13	6.50	50	0.03644	0.63035	0.27455	0.10000
14	7.00	10	0.40565	0.59908	0.20000	0.10000
15	7.50	50	0.06708	0.59370	0.22253	0.10000
16	7.50	50	0.07794	0.59370	0.27280	0.10000
17	5.00	1	0.07703	0.74602	0.20000	0.10000
18	5.80	5	0.20709	0.69468	0.27043	0.10000
19	5.80	5	0.12848	0.69468	0.25003	0.10000
20	5.00	10	0.07747	0.74602	0.20000	0.10000
21	5.00	10	0.09727	0.74602	0.31486	0.10000
22	5.00	50	0.00664	0.74602	0.20000	0.10000
23	5.00	50	0.00706	0.74602	0.20000	0.10000
24	5.00	160	0.00065	0.74602	0.43114	0.10000
25	5.80	1	0.45669	0.69468	0.30699	0.10000
26	5.80	5	0.38285	0.69468	0.32634	0.10000
27	5.80	5	0.24534	0.69468	0.23793	0.10000
28	5.80	10	0.16270	0.69468	0.22685	0.10000
29	5.80	10	0.24229	0.69468	0.32879	0.10000
30	5.80	10	0.13671	0.69468	0.22620	0.10000
31	5.80	50	0.01415	0.69468	0.42456	0.10000
32	5.80	50	0.01522	0.69468	0.47612	0.10000
33	6.50	5	0.55235	0.63035	0.20000	0.10000
34	6.50	10	0.32074	0.63035	0.20000	0.10000
35	6.50	10	0.53809	0.63035	0.34712	0.10000
36	6.50	10	0.29370	0.63035	0.20000	0.10000
37	6.50	20	0.13739	0.63035	0.20000	0.10000
38	6.50	20	0.22830	0.63035	0.38694	0.10000
39	6.50	20	0.12456	0.63035	0.20000	0.10000
40	6.50	100	0.00975	0.63035	0.39293	0.10000
41	6.50	160	0.00355	0.63035	0.42947	0.10000
42	7.00	1	0.92313	0.59908	0.20000	0.10000
43	7.00	10	0.66256	0.59908	0.31526	0.10000
44	7.00	10	0.37061	0.59908	0.20000	0.10000
45	7.00	50	0.04658	0.59908	0.21996	0.10000
46	7.00	50	0.05555	0.59908	0.29108	0.10000
47	7.50	1	1.20178	0.59370	0.24330	0.10000
48	5.00	10	0.51393	0.59370	0.20000	0.10000
49	5.00	10	0.82072	0.59370	0.33449	0.10000
50	8.00	50	0.09485	0.59370	0.25124	0.10000
51	8.00	160	0.01235	0.59370	0.35178	0.10000

TABLE F2-13
D. M. BOORE: VERTICAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.20 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.12462	0.70713	0.50178	0.10000
2	5.00	1	0.12102	0.70713	0.49133	0.10000
3	5.00	5	0.03834	0.70713	0.20000	0.10000
4	5.00	5	0.04098	0.70713	0.20546	0.10000
5	5.80	10	0.08163	0.67134	0.20000	0.10000
6	5.80	20	0.06872	0.67134	0.46928	0.10000
7	6.50	1	0.47259	0.62063	0.20000	0.10000
8	6.50	1	0.49409	0.62063	0.20000	0.10000
9	6.50	1	0.48039	0.62063	0.21650	0.10000
10	6.50	5	0.42890	0.62063	0.30308	0.10000
11	6.50	5	0.32279	0.62063	0.23173	0.10000
12	6.50	50	0.02641	0.62063	0.36626	0.10000
13	6.50	50	0.03160	0.62063	0.39398	0.10000
14	7.00	10	0.27126	0.59908	0.22352	0.10000
15	7.50	50	0.05854	0.59370	0.29923	0.10000
16	7.50	50	0.06991	0.59370	0.33439	0.10000
17	5.00	1	0.04315	0.70713	0.20297	0.10000
18	5.80	5	0.13045	0.67134	0.24661	0.10000
19	5.80	5	0.08441	0.67134	0.30033	0.10000
20	5.00	10	0.04321	0.70713	0.23352	0.10000
21	5.00	10	0.05605	0.70713	0.34299	0.10000
22	5.00	50	0.00511	0.70713	0.20000	0.10000
23	5.00	50	0.00567	0.70713	0.20000	0.10000
24	5.00	160	0.00076	0.70713	0.44620	0.10000
25	5.80	1	0.26304	0.67134	0.30578	0.10000
26	5.80	5	0.23705	0.67134	0.38285	0.10000
27	5.80	5	0.15504	0.67134	0.23895	0.10000
28	5.80	10	0.10375	0.67134	0.20000	0.10000
29	5.80	10	0.15573	0.67134	0.42351	0.10000
30	5.80	10	0.09021	0.67134	0.22914	0.10000
31	5.80	50	0.01168	0.67134	0.42079	0.10000
32	5.80	50	0.01377	0.67134	0.42668	0.10000
33	6.50	5	0.33898	0.62063	0.20000	0.10000
34	6.50	10	0.20336	0.62063	0.20000	0.10000
35	6.50	10	0.34629	0.62063	0.38900	0.10000
36	6.50	10	0.19758	0.62063	0.23290	0.10000
37	6.50	20	0.09810	0.62063	0.27505	0.10000
38	6.50	20	0.16282	0.62063	0.48862	0.10000
39	6.50	20	0.09337	0.62063	0.28711	0.10000
40	6.50	100	0.01010	0.62063	0.51508	0.10000
41	6.50	160	0.00419	0.62063	0.54226	0.10000
42	7.00	1	0.56285	0.59908	0.20000	0.10000
43	7.00	10	0.44472	0.59908	0.37081	0.10000
44	7.00	10	0.25778	0.59908	0.23960	0.10000
45	7.00	50	0.04041	0.59908	0.29684	0.10000
46	7.00	50	0.04986	0.59908	0.39269	0.10000
47	7.50	1	0.73116	0.59370	0.33005	0.10000
48	5.00	10	0.35034	0.59370	0.24886	0.10000
49	5.00	10	0.55055	0.59370	0.36432	0.10000
50	8.00	50	0.08269	0.59370	0.29710	0.10000
51	8.00	160	0.01418	0.59370	0.47609	0.10000

TABLE F2-14
D. M. BOORE: VERTICAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.50 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.05258	0.70713	0.45198	0.10000
2	5.00	1	0.05257	0.70713	0.42459	0.10000
3	5.00	5	0.01683	0.70713	0.20000	0.10000
4	5.00	5	0.01847	0.70713	0.20248	0.10000
5	5.80	10	0.04351	0.67134	0.20000	0.10000
6	5.80	20	0.03908	0.67134	0.53219	0.10000
7	6.50	1	0.25719	0.62063	0.20000	0.10000
8	6.50	1	0.28930	0.62063	0.21224	0.10000
9	6.50	1	0.27751	0.62063	0.24661	0.10000
10	6.50	5	0.23437	0.62063	0.32056	0.10000
11	6.50	5	0.18402	0.62063	0.28224	0.10000
12	6.50	50	0.02004	0.62063	0.40333	0.10000
13	6.50	50	0.02483	0.62063	0.44688	0.10000
14	7.00	10	0.16293	0.59908	0.34780	0.10000
15	7.50	50	0.04651	0.59370	0.40640	0.10000
16	7.50	50	0.05403	0.59370	0.36499	0.10000
17	5.00	1	0.01873	0.70713	0.20491	0.10000
18	5.80	5	0.06631	0.67134	0.21042	0.10000
19	5.80	5	0.04328	0.67134	0.21776	0.10000
20	5.00	10	0.01870	0.70713	0.23803	0.10000
21	5.00	10	0.02459	0.70713	0.32468	0.10000
22	5.00	50	0.00308	0.70713	0.30020	0.10000
23	5.00	50	0.00347	0.70713	0.31842	0.10000
24	5.00	160	0.00078	0.70713	0.49342	0.10000
25	5.80	1	0.12531	0.67134	0.36386	0.10000
26	5.80	5	0.11917	0.67134	0.36776	0.10000
27	5.80	5	0.08097	0.67134	0.24144	0.10000
28	5.80	10	0.05497	0.67134	0.23886	0.10000
29	5.80	10	0.08079	0.67134	0.45535	0.10000
30	5.80	10	0.04850	0.67134	0.23208	0.10000
31	5.80	50	0.00774	0.67134	0.55652	0.10000
32	5.80	50	0.00950	0.67134	0.51599	0.10000
33	6.50	5	0.18643	0.62063	0.25299	0.10000
34	6.50	10	0.11931	0.62063	0.34209	0.10000
35	6.50	10	0.19303	0.62063	0.49235	0.10000
36	6.50	10	0.11698	0.62063	0.33947	0.10000
37	6.50	20	0.06155	0.62063	0.37379	0.10000
38	6.50	20	0.09769	0.62063	0.56470	0.10000
39	6.50	20	0.05800	0.62063	0.31207	0.10000
40	6.50	100	0.00946	0.62063	0.53408	0.10000
41	6.50	160	0.00480	0.62063	0.56717	0.10000
42	7.00	1	0.33288	0.59908	0.20005	0.10000
43	7.00	10	0.25185	0.59908	0.46804	0.10000
44	7.00	10	0.15671	0.59908	0.31199	0.10000
45	7.00	50	0.03044	0.59908	0.34233	0.10000
46	7.00	50	0.03852	0.59908	0.45522	0.10000
47	7.50	1	0.41526	0.59370	0.28631	0.10000
48	5.00	10	0.20845	0.59370	0.32852	0.10000
49	5.00	10	0.30834	0.59370	0.40348	0.10000
50	8.00	50	0.06768	0.59370	0.45030	0.10000
51	8.00	160	0.01710	0.59370	0.55724	0.10000

TABLE F2-15
D. M. BOORE: VERTICAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 1.00 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.02516	0.70713	0.49096	0.10000
2	5.00	1	0.02343	0.70713	0.49316	0.10000
3	5.00	5	0.00835	0.70713	0.23322	0.10000
4	5.00	5	0.00852	0.70713	0.23263	0.10000
5	5.80	10	0.02427	0.67134	0.20212	0.10000
6	5.80	20	0.02047	0.67134	0.29882	0.10000
7	6.50	1	0.15930	0.62063	0.28130	0.10000
8	6.50	1	0.17138	0.62063	0.20822	0.10000
9	6.50	1	0.15922	0.62063	0.24129	0.10000
10	6.50	5	0.13787	0.62063	0.33158	0.10000
11	6.50	5	0.10798	0.62063	0.20000	0.10000
12	6.50	50	0.01368	0.62063	0.45100	0.10000
13	6.50	50	0.01679	0.62063	0.39269	0.10000
14	7.00	10	0.10262	0.59908	0.20000	0.10000
15	7.50	50	0.03443	0.59370	0.26211	0.10000
16	7.50	50	0.03950	0.59370	0.37091	0.10000
17	5.00	1	0.00923	0.70713	0.24410	0.10000
18	5.80	5	0.03545	0.67134	0.30427	0.10000
19	5.80	5	0.02473	0.67134	0.26398	0.10000
20	5.00	10	0.00921	0.70713	0.24837	0.10000
21	5.00	10	0.01115	0.70713	0.32028	0.10000
22	5.00	50	0.00177	0.70713	0.37368	0.10000
23	5.00	50	0.00184	0.70713	0.31732	0.10000
24	5.00	160	0.00057	0.70713	0.50534	0.10000
25	5.80	1	0.07237	0.67134	0.45050	0.10000
26	5.80	5	0.06332	0.67134	0.42667	0.10000
27	5.80	5	0.04379	0.67134	0.23828	0.10000
28	5.80	10	0.03069	0.67134	0.20000	0.10000
29	5.80	10	0.04235	0.67134	0.35891	0.10000
30	5.80	10	0.02883	0.67134	0.23053	0.10000
31	5.80	50	0.00503	0.67134	0.67154	0.10000
32	5.80	50	0.00614	0.67134	0.46051	0.10000
33	6.50	5	0.11193	0.62063	0.20000	0.10000
34	6.50	10	0.07446	0.62063	0.20000	0.10000
35	6.50	10	0.10136	0.62063	0.30170	0.10000
36	6.50	10	0.07223	0.62063	0.23415	0.10000
37	6.50	20	0.03788	0.62063	0.21824	0.10000
38	6.50	20	0.05507	0.62063	0.31668	0.10000
39	6.50	20	0.03846	0.62063	0.23846	0.10000
40	6.50	100	0.00729	0.62063	0.45411	0.10000
41	6.50	160	0.00405	0.62063	0.63472	0.10000
42	7.00	1	0.20427	0.59908	0.27724	0.10000
43	7.00	10	0.14722	0.59908	0.36222	0.10000
44	7.00	10	0.10070	0.59908	0.23794	0.10000
45	7.00	50	0.02245	0.59908	0.32572	0.10000
46	7.00	50	0.02681	0.59908	0.39173	0.10000
47	7.50	1	0.27132	0.59370	0.25287	0.10000
48	5.00	10	0.13720	0.59370	0.22190	0.10000
49	5.00	10	0.18748	0.59370	0.37945	0.10000
50	8.00	50	0.04960	0.59370	0.23337	0.10000
51	8.00	160	0.01630	0.59370	0.42446	0.10000

TABLE F2-16
D. M. BOORE: VERTICAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 2.00 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.00992	0.70713	0.55535	0.10000
2	5.00	1	0.00806	0.70713	0.62071	0.10000
3	5.00	5	0.00339	0.70713	0.21353	0.10000
4	5.00	5	0.00302	0.70713	0.27253	0.10000
5	5.80	10	0.01136	0.67134	0.35190	0.10000
6	5.80	20	0.00829	0.67134	0.27266	0.10000
7	6.50	1	0.09186	0.62063	0.26468	0.10000
8	6.50	1	0.09017	0.62063	0.24863	0.10000
9	6.50	1	0.08036	0.62063	0.20000	0.10000
10	6.50	5	0.06859	0.62063	0.38835	0.10000
11	6.50	5	0.05303	0.62063	0.20410	0.10000
12	6.50	50	0.00819	0.62063	0.47627	0.10000
13	6.50	50	0.00967	0.62063	0.65250	0.10000
14	7.00	10	0.05373	0.59908	0.28290	0.10000
15	7.50	50	0.02066	0.59370	0.55448	0.10000
16	7.50	50	0.02364	0.59370	0.78504	0.10000
17	5.00	1	0.00374	0.70713	0.23472	0.10000
18	5.80	5	0.01690	0.67134	0.34340	0.10000
19	5.80	5	0.01013	0.67134	0.40337	0.10000
20	5.00	10	0.00364	0.70713	0.22809	0.10000
21	5.00	10	0.00368	0.70713	0.33459	0.10000
22	5.00	50	0.00082	0.70713	0.29778	0.10000
23	5.00	50	0.00074	0.70713	0.20000	0.10000
24	5.00	160	0.00031	0.70713	0.40567	0.10000
25	5.80	1	0.03653	0.67134	0.40660	0.10000
26	5.80	5	0.02829	0.67134	0.50031	0.10000
27	5.80	5	0.01967	0.67134	0.34329	0.10000
28	5.80	10	0.01342	0.67134	0.34559	0.10000
29	5.80	10	0.01613	0.67134	0.42922	0.10000
30	5.80	10	0.01244	0.67134	0.41090	0.10000
31	5.80	50	0.00243	0.67134	0.80875	0.10000
32	5.80	50	0.00309	0.67134	0.67644	0.10000
33	6.50	5	0.05934	0.62063	0.21993	0.10000
34	6.50	10	0.03957	0.62063	0.20000	0.10000
35	6.50	10	0.04729	0.62063	0.35419	0.10000
36	6.50	10	0.03576	0.62063	0.33171	0.10000
37	6.50	20	0.02101	0.62063	0.22873	0.10000
38	6.50	20	0.02718	0.62063	0.46050	0.10000
39	6.50	20	0.01919	0.62063	0.42248	0.10000
40	6.50	100	0.00413	0.62063	0.63825	0.10000
41	6.50	160	0.00270	0.62063	0.73801	0.10000
42	7.00	1	0.11642	0.59908	0.35782	0.10000
43	7.00	10	0.07009	0.59908	0.37122	0.10000
44	7.00	10	0.04925	0.59908	0.35177	0.10000
45	7.00	50	0.01338	0.59908	0.50949	0.10000
46	7.00	50	0.01627	0.59908	0.67299	0.10000
47	7.50	1	0.13835	0.59370	0.35172	0.10000
48	5.00	10	0.07162	0.59370	0.36706	0.10000
49	5.00	10	0.09263	0.59370	0.46475	0.10000
50	8.00	50	0.03606	0.59370	0.28919	0.10000
51	8.00	160	0.01426	0.59370	0.48117	0.10000

TABLE F2-17
D. M. BOORE: VERTICAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 3.33 SEC PERIOD

CASE No.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.00477	0.72379	0.92441	0.10000
2	5.00	1	0.00388	0.72379	1.02715	0.10000
3	5.00	5	0.00163	0.72379	0.55050	0.10000
4	5.00	5	0.00146	0.72379	0.69499	0.10000
5	5.80	10	0.00675	0.68801	0.42730	0.10000
6	5.80	20	0.00494	0.68801	0.40473	0.10000
7	6.50	1	0.05809	0.63730	0.35744	0.10000
8	6.50	1	0.06017	0.63730	0.27889	0.10000
9	6.50	1	0.05477	0.63730	0.20618	0.10000
10	6.50	5	0.04798	0.63730	0.46134	0.10000
11	6.50	5	0.03376	0.63730	0.21316	0.10000
12	6.50	50	0.00525	0.63730	0.55556	0.10000
13	6.50	50	0.00607	0.63730	0.61207	0.10000
14	7.00	10	0.03777	0.61575	0.29256	0.10000
15	7.50	50	0.01504	0.61037	0.54513	0.10000
16	7.50	50	0.01629	0.61037	0.68859	0.10000
17	5.00	1	0.00180	0.72379	0.58149	0.10000
18	5.80	5	0.01075	0.68801	0.48666	0.10000
19	5.80	5	0.00637	0.68801	0.45583	0.10000
20	5.00	10	0.00175	0.72379	0.57265	0.10000
21	5.00	10	0.00178	0.72379	0.75353	0.10000
22	5.00	50	0.00040	0.72379	0.27701	0.10000
23	5.00	50	0.00036	0.72379	0.39423	0.10000
24	5.00	160	0.00016	0.72379	0.45134	0.10000
25	5.80	1	0.02057	0.68801	0.57496	0.10000
26	5.80	5	0.01758	0.68801	0.63970	0.10000
27	5.80	5	0.01097	0.68801	0.48094	0.10000
28	5.80	10	0.00767	0.68801	0.49367	0.10000
29	5.80	10	0.00914	0.68801	0.59601	0.10000
30	5.80	10	0.00708	0.68801	0.50772	0.10000
31	5.80	50	0.00142	0.68801	0.85446	0.10000
32	5.80	50	0.00182	0.68801	0.69425	0.10000
33	6.50	5	0.04150	0.63730	0.20000	0.10000
34	6.50	10	0.02456	0.63730	0.24642	0.10000
35	6.50	10	0.02925	0.63730	0.35687	0.10000
36	6.50	10	0.02167	0.63730	0.32481	0.10000
37	6.50	20	0.01344	0.63730	0.28852	0.10000
38	6.50	20	0.01606	0.63730	0.38322	0.10000
39	6.50	20	0.01280	0.63730	0.51911	0.10000
40	6.50	100	0.00253	0.63730	0.82091	0.10000
41	6.50	160	0.00180	0.63730	0.80928	0.10000
42	7.00	1	0.08010	0.61575	0.45456	0.10000
43	7.00	10	0.04594	0.61575	0.36458	0.10000
44	7.00	10	0.03301	0.61575	0.46265	0.10000
45	7.00	50	0.00946	0.61575	0.58622	0.10000
46	7.00	50	0.01083	0.61575	0.66578	0.10000
47	7.50	1	0.10514	0.61037	0.28790	0.10000
48	5.00	10	0.04847	0.61037	0.51393	0.10000
49	5.00	10	0.06191	0.61037	0.49521	0.10000
50	8.00	50	0.02837	0.61037	0.32298	0.10000
51	8.00	160	0.01088	0.61037	0.35571	0.10000

TABLE F2-18
D. M. BOORE: VERTICAL POINT ESTIMATES
PEAK GROUND VELOCITY

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	3.88858	0.62369	0.20000	0.10000
2	5.00	1	3.66232	0.62369	0.20000	0.10000
3	5.00	5	0.83821	0.62369	0.20000	0.10000
4	5.00	5	0.89974	0.62369	0.20000	0.10000
5	5.80	10	2.42393	0.57616	0.20000	0.10000
6	5.80	20	1.86606	0.57616	0.44090	0.10000
7	6.50	1	12.98893	0.53579	0.20000	0.10000
8	6.50	1	14.79397	0.53579	0.34837	0.10000
9	6.50	1	12.98248	0.53579	0.29288	0.10000
10	6.50	5	13.15960	0.53579	0.37869	0.10000
11	6.50	5	9.31642	0.53579	0.24233	0.10000
12	6.50	50	1.04531	0.53579	0.28273	0.10000
13	6.50	50	1.39697	0.53579	0.44049	0.10000
14	7.00	10	9.95682	0.50781	0.20000	0.10000
15	7.50	50	3.65805	0.48785	0.29944	0.10000
16	7.50	50	4.57237	0.48785	0.51247	0.10000
17	5.00	1	0.95957	0.62369	0.20000	0.10000
18	5.80	5	4.02337	0.57616	0.22159	0.10000
19	5.80	5	2.49333	0.57616	0.33395	0.10000
20	5.00	10	0.92797	0.62369	0.20000	0.10000
21	5.00	10	1.18479	0.62369	0.20000	0.10000
22	5.00	50	0.12743	0.62369	0.20000	0.10000
23	5.00	50	0.13861	0.62369	0.20000	0.10000
24	5.00	160	0.02803	0.62369	0.20000	0.10000
25	5.80	1	7.63536	0.57616	0.20000	0.10000
26	5.80	5	7.17495	0.57616	0.28243	0.10000
27	5.80	5	4.42173	0.57616	0.20000	0.10000
28	5.80	10	2.99451	0.57616	0.20000	0.10000
29	5.80	10	4.14464	0.57616	0.37371	0.10000
30	5.80	10	2.63851	0.57616	0.26694	0.10000
31	5.80	50	0.35141	0.57616	0.52035	0.10000
32	5.80	50	0.46347	0.57616	0.47054	0.10000
33	6.50	5	10.42233	0.53579	0.20000	0.10000
34	6.50	10	6.94081	0.53579	0.20000	0.10000
35	6.50	10	8.68423	0.53579	0.35642	0.10000
36	6.50	10	6.34164	0.53579	0.27235	0.10000
37	6.50	20	3.44859	0.53579	0.20000	0.10000
38	6.50	20	4.66256	0.53579	0.41189	0.10000
39	6.50	20	3.33761	0.53579	0.34932	0.10000
40	6.50	100	0.44755	0.53579	0.20000	0.10000
41	6.50	160	0.19570	0.53579	0.35343	0.10000
42	7.00	1	15.62568	0.50781	0.20000	0.10000
43	7.00	10	12.44673	0.50781	0.39138	0.10000
44	7.00	10	9.46423	0.50781	0.26956	0.10000
45	7.00	50	2.05968	0.50781	0.25237	0.10000
46	7.00	50	2.71398	0.50781	0.50666	0.10000
47	7.50	1	19.01198	0.48785	0.33017	0.10000
48	5.00	10	12.83757	0.48785	0.20000	0.10000
49	5.00	10	15.26005	0.48785	0.42082	0.10000
50	8.00	50	6.69893	0.48785	0.20000	0.10000
51	8.00	160	1.64870	0.48785	0.27705	0.10000

APPENDIX F3

EXPERT EVALUATION OF GROUND-MOTION ATTENUATION RELATIONSHIPS FOR THE PROBABILISTIC SEISMIC HAZARD ASSESSMENT OF THE YUCCA MOUNTAIN NUCLEAR WASTE REPOSITORY

Kenneth W. Campbell

APPENDIX F3
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APPENDIX F3

EXPERT EVALUATION OF GROUND-MOTION ATTENUATION RELATIONSHIPS FOR THE PROBABILISTIC SEISMIC HAZARD ASSESSMENT OF THE YUCCA MOUNTAIN NUCLEAR WASTE REPOSITORY

Kenneth W. Campbell
EQE International, Inc.
2942 Evergreen Parkway, Suite 302
Evergreen, Colorado 80439

F3-1 INTRODUCTION

This report documents the basis for my expert evaluation of ground-motion attenuation relationships for the Yucca Mountain Nuclear Waste Repository. This evaluation is based on my synthesis and analysis of data, discussions, and information obtained during a series of ground-motion characterization workshops and from a vast amount of information provided by the facilitation team in an eleven-volume Yucca Mountain Ground Motion Data Package. The methodology that I used to develop the ground-motion estimates is based on weighting several credible models for estimating ground motions in regions where empirical attenuation relationships are not available.

I was asked to provide ground-motion estimates for 51 individual combinations of earthquake magnitude, horizontal distance, faulting mechanism, location with respect to the fault trace, and rupture depth. These 51 cases are presented in Table F3-1. Earthquake magnitude was defined as moment magnitude (M_w). Horizontal distance (R_{hor}) was defined as the distance from a hypothetical site to the surface trace of the fault. Faulting mechanism was defined as strike slip on a vertical fault plane or normal on a 60° dipping fault plane. The location with respect to the fault trace was defined as a site that either lies on the hanging wall (HW) or the footwall (FW) side of the fault plane. Shallow rupture was defined as a rupture plane whose initial centroid was located at a depth of 5 km, but whose rupture plane was confined between depths of 0 and 14 km. Deep rupture was defined as a rupture plane whose down-dip edge was constrained to occur at a depth of 14 km.

I was also asked to provide a method for estimating ground motions for a parallel fault rupture scenario and for a low angle (30° dipping) fault rupture. No actual ground-motion estimates were required for these scenarios, only a procedure for making those estimates.

The ground-motion parameters for which I was asked to provide estimates were peak ground acceleration (PGA), peak ground velocity (PGV), and 5%-damped response spectral acceleration (SA) at frequencies of 0.33, 0.5, 1, 2, 5, 10, and 20 Hz. Both the horizontal and the vertical components were required. The horizontal component was defined as the random horizontal component. For each of the 51 cases in Table F3-1, I was asked to provide four quantities for each ground-motion parameter: the median value (μ), the aleatory variability (σ), the epistemic uncertainty in the median value (σ_μ), and the epistemic uncertainty in the aleatory variability (σ_σ). The hypothetical site on which these ground-motion estimates were provided was located on an outcrop of the materials found at a depth of 300 m below the top of Yucca Mountain, and is referred to as YM300 in this report.

F3-2 GROUND-MOTION MODELS

There were a number of proponent ground-motion models that were solicited by the facilitation team specifically for this study and that were subsequently documented in the Yucca Mountain Ground Motion Data Package that was provided to all experts. In addition, each expert was asked to provide additional models to the facilitation team for consideration by all experts. I did not provide the team with any additional models. The ground-motion models that I used in my expert evaluations and those that I did not are described below.

The ground-motion models that I used to develop my expert evaluations were the hybrid empirical model proposed by myself (Campbell Hybrid model), the stochastic point source simulation model proposed by Silva (Silva PS model), the stochastic finite fault simulation model proposed by Silva (Silva FF model), the semi-empirical Green's function finite fault simulation model proposed by Somerville (Somerville FF model), and the compound fractile finite fault model proposed by Zeng and Anderson (Anderson FF). These models are described in detail in the Yucca Mountain Ground Motion Data Package. All of the models were developed for the YM300 crustal profile.

The ground-motion models that I considered but did not use in my evaluation were the strong-motion empirical models developed by Sabetta and Pugliese (1996) and McGarr (1984), the blast models developed by R. J. Bennett *et al.* (S-Cubed, written communication, 1997), and the theoretical models, other than those mentioned above, that were used in the Yucca Mountain scenario ground-motion study. The empirical models were rejected as being too restricted in their geographical extent or parametric range of applicability. I did not have any confidence that the source and crustal properties associated with the Italian recordings used by Sabetta and Pugliese were appropriate to the Yucca Mountain region. McGarr's model was too restricted to be easily integrated with the other empirical models that were used in the Campbell Hybrid model. The blast models are based on seismic sources with much different source mechanisms than earthquakes and their shallow source depth and travel paths are not consistent with those expected from earthquakes. The theoretical models used for the scenario earthquake study were applied only to a very restricted subset of possible earthquake scenarios and were not generally applicable to the more generalized ground-motion estimates requested in this study.

F3-2.1 Campbell Hybrid Model

The Campbell Hybrid model uses empirical attenuation relationships developed from strong-motion recordings primarily from California to estimate the ground-motion parameters, then it adjusts these estimates using theoretical source and crustal adjustment factors to represent the region of interest. The theoretical adjustment factors are developed from a point source stochastic simulation model by taking the ratio of the theoretical estimates of the ground-motion parameters between California (CA) and YM300. The model was applied exactly as described in the Yucca Mountain Strong Motion Data Package, so a complete description will not be provided here. The more important elements of the model are described below.

The specific empirical attenuation relationships that were used with the Campbell Hybrid model are described in Table F3-2. The weights assigned to each of the empirical model classes are given in Table F3-3. Also given in this table are the values of parameters that were required to evaluate the models. The theoretical YM300/CA adjustment factors were weighted to give a median stress drop of 60 bars and an epistemic uncertainty in the natural log of this stress drop of 0.2, consistent with the value of these parameters determined for an average source mechanism in California as derived from stochastic simulations of California strong-motion recordings (W. Silva, oral comm., 1997). These weights are given in Table

F3-4. The adjustment factors were applied to the empirical ground-motion estimates for a strike-slip source mechanism, which have an average stress drop of about 45 bars (W. Silva, oral comm., 1997). The use of the strike-slip mechanism was intended to approximate the lower median stress drop expected for normal earthquakes in an extensional stress regime as estimated by Becker and Abrahamson (1997).

I have included the empirical attenuation relationship developed by Spudich *et al.* (1997) for an extensional stress environment as one member of the set of attenuation relationships included in the Campbell Hybrid model rather than as a separate model. This was done for the following reasons:

- The functional form of the Spudich relationship is identical to that proposed by Boore *et al.* (1997) and, in my judgment, is less physically based than other functional forms that are available for the western U.S.

- The magnitude scaling term in the Spudich relationship was adopted directly from Boore *et al.* (1997) and was not evaluated independently from the regression analysis of the extensional strong-motion recordings.

- The Spudich relationship includes earthquakes such as those from the Imperial Valley of California that are included in other attenuation relationships that are used in the Campbell Hybrid model.

- The aleatory variability of the Spudich relationship is much higher than that of Boore *et al.* (1997) based on western U.S. recordings, possibly indicating a statistically inferior regression model and/or a less reliable set of strong-motion parameters and supporting data than is available for the western U.S.

- The predictions of PGA from the Spudich relationship for the set of strong-motion parameters, magnitudes, and distances of interest in this study are very similar (i.e., well within one standard deviation) of those estimated for strike-slip faults in the western U.S. from the relationship of Boore *et al.* (1997), which has an identical functional form and magnitude scaling term, indicating that there is not a significant difference between these two relationships.

As part of this project, the facilitation team compared the predictions of ground motion for the strong-motion recordings compiled by Spudich *et al.* (1997) with those given by the attenuation relationship of Abrahamson and Silva (1997) for western U.S. strike-slip earthquakes. They found that the extensional recordings had amplitudes generally lower than those predicted from the Abrahamson and Silva relationship. However, I have tentatively considered these differences as insignificant because of their relatively small differences and because of the use of data from crustal environments and site conditions potentially very different from the Great Basin in general and the Yucca Mountain region in particular.

I have used the comparison of the predictions of Spudich *et al.* (1997) with those of Boore *et al.* (1997), the comparison of the extensional stress regime recordings with predictions from the Abrahamson and Silva (1997) attenuation relationship, and the independent evaluations of high-frequency stress drop from normal-faulting earthquakes in the U.S. provided by the facilitation team to tentatively conclude that the empirical attenuation relationships in the western U.S. should be evaluated for strike-slip faulting to approximate the extensional stress environment in the Yucca Mountain region. Based on this conclusion, I adjusted the predictions from the Spudich relationship with the regional adjustment factors and I combined these predictions with those from the western U.S. attenuation relationships evaluated for strike-slip faulting.

Because of its empirical nature and its reliance on multiple attenuation relationships, the Campbell Hybrid model can be used to directly estimate all of the variabilities and uncertainties required for this study (i.e., σ, σ_μ, and σ_σ). The procedure used to estimate these parameters is described in the Yucca Mountain Strong Motion Data Package.

F3-2.2 Anderson, Silva, and Somerville Finite Fault Models

These finite fault models use theoretical and in some cases empirical source and propagation models to estimate ground motions. They use a three-dimensional description of the fault to account for the kinematic effects of propagation of the rupture front along the fault plane. This allows these faults to directly incorporate important finite source characteristics such as source directivity in their theoretical estimates. All three of these finite fault models have been validated and/or calibrated to strong-motion recordings, but the Anderson FF model, because it is newer, has undergone less validation than the others. A more thorough description of these models is given in the Yucca Mountain Strong Motion Data Package.

Because of their theoretical nature, these models are best used for estimating median ground motions (i.e., μ). Some validation studies have been performed to estimate σ, but because the specific earthquake data required for these studies is fairly comprehensive, these estimates are not as reliable as those determined from empirical attenuation relationships. Estimates of σ_μ and σ_σ, although provided by some investigators, are largely based on the opinions of the proponents of these models.

F3-2.3 Silva Point Source Model

The Silva PS model uses simple stochastic simulation theory and theoretical seismological models to estimate ground motions at a given location. The source model used in these estimates is based on the ω^2 source scaling relation. The ground motions are simulated using random process theory based on the concept of band-limited white noise. The model has been calibrated with strong-motion data and with the attenuation relationship of Abrahamson and Silva (1997). Like empirical attenuation relationships, it produces estimates of the ground-motion parameters without having to generate time series. This model is described in the Yucca Mountain Strong Motion Data Package.

The facilitation team provided an attenuation relationship based on the simulations from this model that could be used to provide median ground-motion estimates at all of the magnitudes and distances of interest in this study. This relationship included stress drop as a parameter for flexibility in application to the Yucca Mountain region. The Silva PS model, being point source, is calibrated to a larger number of strong motion recordings than the finite fault versions. However, the same limitations apply with respect to the estimation σ.

F3-3 POINT ESTIMATES

Point estimates of μ, σ, σ_μ, and σ_σ were provided for all 51 cases using the selected models discussed above. These evaluations were made for both the random horizontal and the vertical components of all nine ground-motion parameters of interest by applying weights to the estimates provided by the selected models. The weighting scheme was designed to be case-specific to more heavily weight those models that in my opinion were the best for making predictions for that particular case. The weights were the same for both the random horizontal and the vertical components. The weights were adjusted through an iteration process until the desired weighted estimates were obtained. Any irregularities in the point estimates were smoothed out in the regression models developed from these point estimates. These regression models are presented in a later section.

F3-3.1 Weighting Scheme

F3-3.1.1 Median Estimates (μ). The weighting scheme used in developing the point estimates of the median ground motions (μ) is presented in Table F3-5. These weights were determined by applying a set of loosely defined rules that depended on the particular case being evaluated. In general, the greatest weight was given to the Campbell Hybrid model because of its robust empirical basis. However, this model was given relatively less weight for those cases that are not well-represented in the empirical database. These weights depended on the frequency of the ground-motion parameter and the magnitude and distance of the hypothetical site from the earthquake source in an interrelated but systematic manner.

In general, the Campbell Hybrid model was given less weight than the theoretical models at low frequencies, small magnitudes, and large distances. Of the finite source models, the Anderson FF model was given less weight than the Silva FF and Somerville FF models because of its more limited validation and its undesirable, overly strong dependence on radiation pattern and directivity. The Silva PS model was given relatively high weight at small magnitudes where there were no estimates from the Silva FF and Somerville FF models. The weight given to the Silva PS model was gradually decreased to zero at magnitude 6.5 where estimates were available from all three finite fault models.

F3-3.1.2 Variabilities (σ, σ_μ, and σ_σ). I have very little confidence in the variabilities provided with the theoretical proponent models. Therefore, I used only the Campbell Hybrid model for estimating these parameters. Any undesirable fluctuations in these parameters that resulted from using only a single model were smoothed out in the regression models used to provide continuous estimates of these parameters. Of course, the term "single model" is a misnomer here, since the Campbell Hybrid model uses up to six attenuation relationships as the basis for its estimates. The epistemic uncertainty in the median estimate of ground motion was increased to reflect the added uncertainty in the various ground motion estimates that were used to develop it.

F3-3.2 Random Horizontal Component

The point estimates of the random horizontal components of the median ground-motion parameters were derived directly from the weighted horizontal estimates of these parameters obtained from the selected ground-motion models. Consistent with the weighting scheme, the estimates of the variabilities were taken directly from the Campbell Hybrid model. A summary of the horizontal point estimates for all 51 cases is provided in Tables F3-6 through F3-14.

F3-3.3 Vertical Component

The point estimates of the vertical components was done a little differently than the horizontal components because of the lack of vertical components for the Silva FF model. The Silva PS model had both vertical and horizontal estimates of median ground motions and was based on the same source and crustal models as the Silva FF model. Because of this similarity, the vertical-to-horizontal ratio from the Silva PS model was used to estimate vertical ground motions from the horizontal component of the Silva FF model. Weighted estimates of the vertical components of the median ground motions were then derived in the same manner as the horizontal components. Consistent with the weighting scheme, the estimates of the variabilities were taken directly from the Campbell Hybrid model. A summary of the vertical point estimates for all 51 cases are given in Tables F3-15 through F3-23.

F3-4 REGRESSION MODELS

The facilitation team took my point estimates for μ, σ, σ_μ, and σ_σ and performed a regression analyses to develop a set of attenuation relationships for the ground-motion parameters of interest. These regression models were adjusted through several iterations until they provided continuous estimates for these parameters that I believed were realistic and systematic.

F3-4.1 Median Estimates (μ)

For the median ground motions, the facilitation team used the functional form and statistical procedure recommended by Abrahamson and Silva (1997). For the variabilities they used simpler models that captured the important behavior of these parameters. I recommended that the distance parameter R_{SEIS}, the closest distance to the seismogenic rupture zone, be used for these analyses. The number of parameters and functional form of these regression models were adjusted through an iterative process until they provided an acceptable predictive model for each parameter.

I first recommended that the functional form for the median estimates be adjusted to reflect the combined magnitude-distance term recommended by Campbell (1997). However, this model did not appear to model the point estimates better than the original model. Furthermore, it appeared to provide unrealistic estimates at very short distances. This behavior might have been corrected by further iteration in which the functional form of other parts of the model were changed. This, however, did not seem necessary since the original functional form appeared to fit the point estimates and provide realistic magnitude and distance scaling at near-source distances.

I first asked that the regression model for the median estimates of ground motion from dipping normal faults explicitly include a parameter that distinguished between the hanging wall and the footwall. However, including this parameter did not seem to improve the model, and in fact provided unrealistic behavior at some frequencies, so I recommended that this parameter be removed and the added randomness absorbed in the standard error of the estimate of the regression model.

F3-4.2 Variability Estimates (σ, σ_μ, and σ_σ)

The regression model for the aleatory variability (σ) was found to be a very strong and well-behaved function of magnitude and frequency. No additional adjustments were required. The regression model for the epistemic uncertainty (σ_μ) was found to be a strong function of both frequency and distance; however, the distance dependence was erratic due to the strong and erratic influence of the median estimates of the Anderson FF model. Because of this erratic behavior, I asked the facilitation team to remove the distance parameter and leave only the frequency parameter. The final model predicts higher values of σ_μ at both high and low frequencies which are consistent with my understanding of the expected behavior of this uncertainty.

The regression model for the epistemic uncertainty in the aleatory variability (σ_σ) was very nearly constant. There was a slight dependence on distance for some frequencies, but this dependence resulted in values that I considered to be too small (i.e., less than 0.08). Therefore, I recommended that a constant value of 0.1 be used for this parameter for both the random horizontal and the vertical components.

F3-5 SPECIAL CASES

I was asked to provide a recommendation on how to estimate ground motions for two special rupture scenarios that are being considered by the source characterization panel. These rupture scenarios refer to multiple parallel faults and low angle (i.e., about a 30° dipping) faults.

F3-5.1 Multiple Parallel Faults

Multiple parallel faults represent an earthquake in which multiple ruptures are triggered on closely spaced parallel faults. My recommendation for modeling this special case is based on an assumption that rupture begins on one of the faults, then triggers rupture on the other faults in what can be referred to as a cascaded rupture scenario. In my opinion, this scenario can be compared to a single earthquake in which one sub-event triggers a second sub-event which triggers and third sub-event, etc. Consistent with this analogy, I recommend that the multiple parallel fault scenario be assigned the moment magnitude that corresponds to the total seismic moment released on all of the faults that make up the rupture, and that the distance associated with this scenario be taken as the distance to the closest rupture.

I believe that the median estimates of ground motion provided by the recommended procedure will be generally conservative. Therefore, I do not recommend that the epistemic uncertainty in these estimates be increased from that estimated for a standard rupture scenario. I do, however, expect that the multiple parallel fault scenario will cause more randomness in the recorded ground motions, so I recommend that the value of σ be increased by a factor of 1.2 over that estimated from the standard rupture scenario.

F3-5.2 Low Angle Faults

I do not know of any recordings from a low angle normal fault. There are, however, recordings either directly over or very near to low-angle thrust faults, such as a subduction zone megathrust interface or a continental thrust fault. Low angle thrust faults and megathrust interfaces appear to produce near-source ground motions that are similar in amplitude to continental reverse faults unless they are unusually deep (e.g., the 1987 Whittier Narrows and 1994 Northridge earthquakes). Based on this observation, I recommend that low angle normal faults be treated as standard high angle normal faults for purposes of estimating median ground motions unless they are unusually deep. The estimates should be modified as follows depending on the depth of the bottom of the fault: (1) for depths less than 8 km, no change; (2) for depths greater than 15 km, multiply the estimates by 1.2; (3) for depths between 8 and 15 km, multiple the estimates by a factor that linearly increases from 1.0 to 1.2.

I would also expect that the values of σ and σ_μ would be greater for this scenario. The larger value for the aleatory variability is expected because of the assumption of a larger variation in stress drop and radiation pattern, although this opinion has not been confirmed with observations. The larger value for epistemic uncertainty is used to compensate for the lack of any validation. The recommended values for σ and σ_μ for this scenario should be taken to be 1.2 times higher than those estimated for a high angle normal fault.

F3-6 REFERENCES

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TABLE F3-1
IDENTIFICATION OF CASES

CASE	DEPTH	M_w	R_{HOR} (KM)	FAULT TYPE
1	Shallow	5.0	1	SS
2	Shallow	5.0	1	HW
3	Shallow	5.0	10	SS
4	Shallow	5.0	10	HW
5	Shallow	5.0	50	SS
6	Shallow	5.0	50	HW
7	Shallow	5.0	160	SS
8	Deep	5.0	1	SS
9	Deep	5.0	5	SS
10	Deep	5.0	5	HW
11	Shallow	5.8	1	SS
12	Shallow	5.8	5	HW
13	Shallow	5.8	5	FW
14	Shallow	5.8	10	SS
15	Shallow	5.8	10	HW
16	Shallow	5.8	10	FW
17	Shallow	5.8	50	SS
18	Shallow	5.8	50	HW
19	Deep	5.8	5	HW
20	Deep	5.8	5	FW
21	Deep	5.8	10	SS
22	Deep	5.8	20	HW
23	Shallow	6.5	1	SS
24	Shallow	6.5	1	HW
25	Shallow	6.5	1	FW
26	Shallow	6.5	5	SS
27	Shallow	6.5	5	HW
28	Shallow	6.5	5	FW
29	Shallow	6.5	10	SS
30	Shallow	6.5	10	HW
31	Shallow	6.5	10	FW
32	Shallow	6.5	20	SS
33	Shallow	6.5	20	HW
34	Shallow	6.5	20	FW
35	Shallow	6.5	50	SS

TABLE F3-1
IDENTIFICATION OF CASES

CASE	DEPTH	M_W	R_{HOR} (KM)	FAULT TYPE
36	Shallow	6.5	50	HW
37	Shallow	6.5	100	SS
38	Shallow	6.5	160	SS
39	Shallow	7.0	1	SS
40	Shallow	7.0	10	SS
41	Shallow	7.0	10	HW
42	Shallow	7.0	10	FW
43	Shallow	7.0	50	SS
44	Shallow	7.0	50	HW
45	Shallow	7.5	1	SS
46	Shallow	7.5	10	SS
47	Shallow	7.5	10	HW
48	Shallow	7.5	50	SS
49	Shallow	7.5	50	HW
50	Shallow	8.0	50	SS
51	Shallow	8.0	160	SS

TABLE F3-2
SELECTED ATTENUATION RELATIONSHIPS FOR THE HYBRID EMPIRICAL MODEL

CLASS	REFERENCE	FAULT TYPE	SITE CONDITION	σ
1	Abrahamson & Silva (1997)	Strike slip	Rock	N.A.
1	Campbell (1997)	Strike slip	Soft Rock, D=2 km	$\sigma = f(\mu)$
1	Idriss (University of California, Davis, written communications, 1991, 1997)	Strike slip	Rock	N.A.
1	Sadigh et al. (1997)	Strike slip	Rock	N.A.
2	Boore et al. (1997)	Strike slip	$V_{S,30}$ = 620 m/sec	N.A.
2	Spudich et al. (1996)	N.A.	Rock	N.A.
3	Joyner & Boore (1988)	N.A.	Rock	N.A.

TABLE F3-3
WEIGHTS USED FOR THE CAMPBELL HYBRID EMPIRICAL MODEL

MODEL CLASS	RANDOM HORIZONTAL		VERTICAL
	PGV	ALL OTHERS	
1	0.75	0.75	1.0
2	0	0.25	0
3	0.25	0	0

TABLE F3-4
WEIGHTS FOR THE THEORETICAL ESTIMATES OF THE REGIONAL CAMPBELL YM300/CA ADJUSTMENT FACTORS

STRESS DROP, $\Delta\sigma$ (BARS)	RANDOM HORIZONTAL COMPONENT
30	0.02
45	0.10
60	0.76
85	0.10
120	0.02
Weighted Median $\Delta\sigma$ = 60.4 Weighted $\sigma_{\ln(\Delta\sigma)}$ = 0.199	

TABLE F3-5
WEIGHTS FOR EVALUATING HORIZONTAL AND VERTICAL POINT ESTIMATES OF SA, PGA, AND PGV

CASE	FREQUENCY (HZ)	MODEL				
		CAMPBELL	SOMER-VILLE	SILVA PS	SILVA FF	ANDERSON
1–4	0.33	0.25	—	0.50	—	0.25
	0.50	0.33	—	0.45	—	0.22
	All others	0.50	—	0.34	—	0.16
5–6	0.33	0.17	—	0.56	—	0.27
	0.50	0.25	—	0.50	—	0.25
	All others	0.33	—	0.45	—	0.22
7	All	0	—	0.70	—	0.30
8–10	0.33	0.25	—	0.50	—	0.25
	0.50	0.33	—	0.45	—	0.22
	All others	0.50	—	0.34	—	0.16
11–16	0.33	0.33	0.22	0.11	0.12	0.22
	All others	0.50	0.17	0.08	0.09	0.16
17–18	0.33	0.25	0.25	0.12	0.13	0.25
	All others	0.33	0.22	0.11	0.12	0.22
19–22	0.33	0.33	0.22	0.11	0.12	0.22
	All others	0.50	0.17	0.08	0.09	0.16
23–36	All	0.67	0.11	0	0.11	0.11
37	All	0.50	0.17	0	0.17	0.16
38	All	0.25	0.25	0	0.25	0.25
39–49	All	0.67	0.11	0	0.11	0.11
50	All	0.50	0.17	0	0.17	0.16
51	All	0.25	0.25	0	0.25	0.25

TABLE F3-6
K. W. CAMPBELL: HORIZONTAL POINT ESTIMATES
PEAK GROUND ACCELERATION

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.15683	0.63400	0.45104	0.11400
2	5.00	1	0.18764	0.63400	0.44792	0.11400
3	5.00	5	0.05466	0.65000	0.35772	0.09000
4	5.00	5	0.07114	0.64900	0.40247	0.09200
5	5.80	10	0.09729	0.58200	0.26161	0.06100
6	5.80	20	0.07793	0.59300	0.25931	0.04400
7	6.50	1	0.41902	0.53000	0.38678	0.04000
8	6.50	1	0.44992	0.53000	0.47983	0.04000
9	6.50	1	0.41243	0.53000	0.41965	0.04000
10	6.50	5	0.35617	0.53000	0.33721	0.04000
11	6.50	5	0.26314	0.53000	0.33466	0.04000
12	6.50	50	0.02985	0.55700	0.29984	0.02100
13	6.50	50	0.03135	0.55700	0.29833	0.02100
14	7.00	10	0.24540	0.49700	0.31905	0.03900
15	7.50	50	0.06139	0.50300	0.26687	0.04300
16	7.50	50	0.06838	0.49900	0.26025	0.04100
17	5.00	1	0.05620	0.64700	0.54042	0.09400
18	5.80	5	0.16290	0.57800	0.34360	0.06900
19	5.80	5	0.09740	0.58300	0.36051	0.06000
20	5.00	10	0.06533	0.64800	0.27155	0.09300
21	5.00	10	0.09075	0.64200	0.26852	0.10100
22	5.00	50	0.00635	0.66100	0.41708	0.07900
23	5.00	50	0.00683	0.66100	0.43385	0.07900
24	5.00	160	0.00078	0.66100	0.74144	0.07900
25	5.80	1	0.27385	0.57800	0.41931	0.06900
26	5.80	5	0.23766	0.57800	0.35031	0.06900
27	5.80	5	0.14912	0.57800	0.36283	0.06900
28	5.80	10	0.12083	0.57800	0.29383	0.06900
29	5.80	10	0.17246	0.57800	0.30078	0.06900
30	5.80	10	0.08461	0.58200	0.39688	0.06100
31	5.80	50	0.01084	0.60500	0.59133	0.03200
32	5.80	50	0.01131	0.60500	0.61026	0.03200
33	6.50	5	0.30413	0.53000	0.34623	0.04000
34	6.50	10	0.19854	0.53000	0.32376	0.04000
35	6.50	10	0.26996	0.53000	0.34376	0.04000
36	6.50	10	0.16982	0.53000	0.32504	0.04000
37	6.50	20	0.10078	0.53700	0.28475	0.02600
38	6.50	20	0.13497	0.53300	0.34932	0.03500
39	6.50	20	0.08533	0.53900	0.30135	0.02200
40	6.50	100	0.01341	0.55700	0.43997	0.02100
41	6.50	160	0.00498	0.55700	0.63341	0.02100
42	7.00	1	0.45944	0.49700	0.33008	0.03900
43	7.00	10	0.32809	0.49700	0.31129	0.03900
44	7.00	10	0.20863	0.49700	0.29214	0.03900
45	7.00	50	0.04567	0.52300	0.27876	0.04500
46	7.00	50	0.05049	0.51900	0.27304	0.03900
47	7.50	1	0.50690	0.48700	0.33727	0.04300
48	5.00	10	0.28319	0.48700	0.29876	0.04300
49	5.00	10	0.36567	0.48700	0.36296	0.04300
50	8.00	50	0.07877	0.49400	0.30402	0.04000
51	8.00	160	0.02277	0.51400	0.42621	0.05500

TABLE F3-7
K. W. CAMPBELL: HORIZONTAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.05 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.29995	0.64900	0.57346	0.09300
2	5.00	1	0.35387	0.64800	0.45607	0.09300
3	5.00	5	0.10104	0.66300	0.39369	0.07600
4	5.00	5	0.12677	0.66100	0.32477	0.07800
5	5.80	10	0.16352	0.59300	0.32897	0.03800
6	5.80	20	0.12542	0.60200	0.30661	0.02900
7	6.50	1	0.70488	0.53800	0.39909	0.02100
8	6.50	1	0.75240	0.53800	0.44534	0.02100
9	6.50	1	0.68863	0.53800	0.42224	0.02100
10	6.50	5	0.60759	0.53800	0.35217	0.02100
11	6.50	5	0.44634	0.53800	0.39280	0.02100
12	6.50	50	0.04107	0.56200	0.37716	0.04500
13	6.50	50	0.04319	0.56200	0.39244	0.04500
14	7.00	10	0.39506	0.50300	0.31677	0.04200
15	7.50	50	0.08132	0.50700	0.34371	0.06700
16	7.50	50	0.09054	0.50400	0.33007	0.06200
17	5.00	1	0.10433	0.66000	0.57747	0.07900
18	5.80	5	0.26683	0.58900	0.37690	0.04400
19	5.80	5	0.15869	0.59300	0.42227	0.03800
20	5.00	10	0.12180	0.66100	0.35550	0.07800
21	5.00	10	0.17284	0.65500	0.34457	0.08400
22	5.00	50	0.00992	0.67200	0.45528	0.07100
23	5.00	50	0.01061	0.67200	0.49847	0.07100
24	5.00	160	0.00105	0.67200	0.70417	0.07100
25	5.80	1	0.47645	0.58900	0.48049	0.04400
26	5.80	5	0.41923	0.58900	0.39844	0.04400
27	5.80	5	0.25297	0.58900	0.48167	0.04400
28	5.80	10	0.20304	0.58900	0.36904	0.04400
29	5.80	10	0.28661	0.58900	0.34486	0.04400
30	5.80	10	0.14227	0.59200	0.51980	0.03900
31	5.80	50	0.01533	0.61300	0.69773	0.03300
32	5.80	50	0.01569	0.61300	0.73060	0.03300
33	6.50	5	0.51185	0.53800	0.35587	0.02100
34	6.50	10	0.33468	0.53800	0.33789	0.02100
35	6.50	10	0.45448	0.53800	0.36573	0.02100
36	6.50	10	0.28242	0.53800	0.38217	0.02100
37	6.50	20	0.15973	0.54400	0.31655	0.01900
38	6.50	20	0.21588	0.54000	0.37955	0.02000
39	6.50	20	0.13424	0.54600	0.38097	0.02000
40	6.50	100	0.01552	0.56200	0.53933	0.04500
41	6.50	160	0.00647	0.56200	0.70266	0.04500
42	7.00	1	0.78445	0.50300	0.36471	0.04200
43	7.00	10	0.54715	0.50300	0.35145	0.04200
44	7.00	10	0.34037	0.50300	0.35208	0.04200
45	7.00	50	0.06198	0.52600	0.34852	0.07000
46	7.00	50	0.06921	0.52200	0.33573	0.06400
47	7.50	1	0.84839	0.49300	0.38741	0.05300
48	5.00	10	0.45321	0.49300	0.33056	0.05300
49	5.00	10	0.58293	0.49300	0.39263	0.05300
50	8.00	50	0.09828	0.49900	0.39596	0.05700
51	8.00	160	0.02392	0.51700	0.55379	0.08100

TABLE F3-8
K. W. CAMPBELL: HORIZONTAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.10 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.31946	0.66700	0.54046	0.10500
2	5.00	1	0.38194	0.66700	0.58883	0.10500
3	5.00	5	0.11152	0.68100	0.26800	0.08700
4	5.00	5	0.14676	0.68000	0.35697	0.08900
5	5.80	10	0.19289	0.61100	0.26170	0.05500
6	5.80	20	0.15239	0.62000	0.30092	0.04500
7	6.50	1	0.81655	0.55600	0.38087	0.04100
8	6.50	1	0.89724	0.55600	0.51664	0.04100
9	6.50	1	0.81904	0.55600	0.43548	0.04100
10	6.50	5	0.68940	0.55600	0.33578	0.04100
11	6.50	5	0.51563	0.55600	0.30063	0.04100
12	6.50	50	0.05248	0.58100	0.35756	0.04800
13	6.50	50	0.05495	0.58100	0.31781	0.04800
14	7.00	10	0.46234	0.52100	0.32388	0.05200
15	7.50	50	0.10095	0.52500	0.37623	0.06900
16	7.50	50	0.11337	0.52100	0.34333	0.06600
17	5.00	1	0.11685	0.67800	0.38603	0.09000
18	5.80	5	0.32919	0.60700	0.37242	0.06000
19	5.80	5	0.19381	0.61200	0.40046	0.05400
20	5.00	10	0.13338	0.67900	0.38588	0.08900
21	5.00	10	0.18613	0.67400	0.39672	0.09500
22	5.00	50	0.01280	0.69100	0.33995	0.07900
23	5.00	50	0.01369	0.69100	0.38095	0.07900
24	5.00	160	0.00138	0.69100	0.63067	0.07900
25	5.80	1	0.54393	0.60700	0.44841	0.06000
26	5.80	5	0.49569	0.60700	0.34511	0.06000
27	5.80	5	0.29445	0.60700	0.39032	0.06000
28	5.80	10	0.23162	0.60700	0.30997	0.06000
29	5.80	10	0.33316	0.60700	0.34058	0.06000
30	5.80	10	0.16579	0.61100	0.39297	0.05500
31	5.80	50	0.02077	0.63200	0.57492	0.04300
32	5.80	50	0.02054	0.63200	0.64057	0.04300
33	6.50	5	0.59559	0.55600	0.34261	0.04100
34	6.50	10	0.38507	0.55600	0.32038	0.04100
35	6.50	10	0.53056	0.55600	0.38330	0.04100
36	6.50	10	0.32627	0.55600	0.27578	0.04100
37	6.50	20	0.19194	0.56200	0.30485	0.03700
38	6.50	20	0.25021	0.55800	0.34777	0.03900
39	6.50	20	0.15849	0.56400	0.27522	0.03600
40	6.50	100	0.02062	0.58100	0.57368	0.04800
41	6.50	160	0.00819	0.58100	0.70662	0.04800
42	7.00	1	0.90085	0.52100	0.35714	0.05200
43	7.00	10	0.62375	0.52100	0.34521	0.05200
44	7.00	10	0.39794	0.52100	0.25599	0.05200
45	7.00	50	0.07772	0.54400	0.36197	0.07000
46	7.00	50	0.08737	0.54000	0.32754	0.06500
47	7.50	1	0.94122	0.51100	0.37112	0.06000
48	5.00	10	0.51831	0.51100	0.33726	0.06000
49	5.00	10	0.67010	0.51100	0.35946	0.06000
50	8.00	50	0.12622	0.51700	0.45113	0.06300
51	8.00	160	0.02720	0.53500	0.63680	0.08100

TABLE F3-9
K. W. CAMPBELL: HORIZONTAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.20 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.24514	0.69800	0.51382	0.10600
2	5.00	1	0.29141	0.69800	0.56237	0.10600
3	5.00	5	0.09037	0.71200	0.26798	0.08700
4	5.00	5	0.11726	0.71000	0.31413	0.08800
5	5.80	10	0.18239	0.64300	0.24869	0.06000
6	5.80	20	0.14853	0.65200	0.30883	0.04800
7	6.50	1	0.75359	0.58900	0.41983	0.05000
8	6.50	1	0.81648	0.58900	0.53010	0.05000
9	6.50	1	0.75665	0.58900	0.47442	0.05000
10	6.50	5	0.64478	0.58900	0.37454	0.05000
11	6.50	5	0.49146	0.58900	0.31927	0.05000
12	6.50	50	0.05814	0.61300	0.37635	0.05000
13	6.50	50	0.06129	0.61300	0.30588	0.05000
14	7.00	10	0.45918	0.55500	0.34805	0.06000
15	7.50	50	0.12173	0.55900	0.43356	0.07200
16	7.50	50	0.13682	0.55500	0.39847	0.07000
17	5.00	1	0.09159	0.70900	0.45519	0.09000
18	5.80	5	0.28404	0.63900	0.40519	0.06500
19	5.80	5	0.18766	0.64300	0.33587	0.05900
20	5.00	10	0.10850	0.71000	0.31132	0.08900
21	5.00	10	0.14702	0.70500	0.34044	0.09600
22	5.00	50	0.01329	0.72100	0.28452	0.07800
23	5.00	50	0.01319	0.72100	0.37125	0.07800
24	5.00	160	0.00201	0.72100	0.58304	0.07800
25	5.80	1	0.47856	0.63900	0.44745	0.06500
26	5.80	5	0.42347	0.63900	0.35604	0.06500
27	5.80	5	0.26605	0.63900	0.33556	0.06500
28	5.80	10	0.21177	0.63900	0.31216	0.06500
29	5.80	10	0.29919	0.63900	0.33753	0.06500
30	5.80	10	0.15993	0.64300	0.31039	0.06000
31	5.80	50	0.02107	0.66300	0.61995	0.04300
32	5.80	50	0.02433	0.66300	0.50886	0.04300
33	6.50	5	0.55663	0.58900	0.36255	0.05000
34	6.50	10	0.36053	0.58900	0.31343	0.05000
35	6.50	10	0.48504	0.58900	0.36053	0.05000
36	6.50	10	0.31944	0.58900	0.29063	0.05000
37	6.50	20	0.18803	0.59500	0.30149	0.04500
38	6.50	20	0.25742	0.59100	0.37609	0.04800
39	6.50	20	0.16526	0.59700	0.26956	0.04400
40	6.50	100	0.02553	0.61300	0.56153	0.05000
41	6.50	160	0.01169	0.61300	0.69349	0.05000
42	7.00	1	0.84222	0.55500	0.39185	0.06000
43	7.00	10	0.60683	0.55500	0.35290	0.06000
44	7.00	10	0.40463	0.55500	0.29277	0.06000
45	7.00	50	0.09109	0.57700	0.39949	0.07100
46	7.00	50	0.10123	0.57400	0.35501	0.06700
47	7.50	1	0.94693	0.54500	0.45621	0.06800
48	5.00	10	0.54808	0.54500	0.40912	0.06800
49	5.00	10	0.67101	0.54500	0.37280	0.06800
50	8.00	50	0.15397	0.55100	0.49137	0.06800
51	8.00	160	0.03877	0.56800	0.71848	0.08100

TABLE F3-10
K. W. CAMPBELL: HORIZONTAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.50 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.11568	0.75700	0.42849	0.11700
2	5.00	1	0.14184	0.75700	0.45804	0.11700
3	5.00	5	0.04467	0.77100	0.33880	0.09500
4	5.00	5	0.05942	0.77000	0.40063	0.09700
5	5.80	10	0.11056	0.70400	0.26663	0.07600
6	5.80	20	0.09438	0.71300	0.26309	0.06200
7	6.50	1	0.55089	0.65200	0.27903	0.06800
8	6.50	1	0.58164	0.65200	0.36035	0.06800
9	6.50	1	0.53766	0.65200	0.31778	0.06800
10	6.50	5	0.46034	0.65200	0.24920	0.06800
11	6.50	5	0.34131	0.65200	0.26816	0.06800
12	6.50	50	0.04893	0.67500	0.30693	0.05200
13	6.50	50	0.05328	0.67500	0.31414	0.05200
14	7.00	10	0.37140	0.61800	0.32561	0.07400
15	7.50	50	0.12381	0.62200	0.34020	0.07600
16	7.50	50	0.13854	0.61900	0.34512	0.07600
17	5.00	1	0.04695	0.76800	0.54042	0.09900
18	5.80	5	0.18171	0.70100	0.27618	0.08100
19	5.80	5	0.10411	0.70400	0.35615	0.07500
20	5.00	10	0.05090	0.76900	0.24751	0.09800
21	5.00	10	0.06981	0.76400	0.28540	0.10600
22	5.00	50	0.00756	0.78000	0.30281	0.08300
23	5.00	50	0.00872	0.78000	0.27334	0.08300
24	5.00	160	0.00175	0.78000	0.57902	0.08300
25	5.80	1	0.29175	0.70100	0.33228	0.08100
26	5.80	5	0.26091	0.70100	0.32768	0.08100
27	5.80	5	0.15771	0.70100	0.32862	0.08100
28	5.80	10	0.13888	0.70100	0.28409	0.08100
29	5.80	10	0.19833	0.70100	0.31923	0.08100
30	5.80	10	0.09264	0.70400	0.37384	0.07600
31	5.80	50	0.01541	0.72300	0.62511	0.05000
32	5.80	50	0.01530	0.72300	0.74242	0.05000
33	6.50	5	0.40434	0.65200	0.31340	0.06800
34	6.50	10	0.27262	0.65200	0.33338	0.06800
35	6.50	10	0.37015	0.65200	0.33804	0.06800
36	6.50	10	0.22516	0.65200	0.30349	0.06800
37	6.50	20	0.14123	0.65800	0.28028	0.06100
38	6.50	20	0.19190	0.65400	0.34682	0.06600
39	6.50	20	0.12504	0.65900	0.26480	0.05900
40	6.50	100	0.02596	0.67500	0.45449	0.05200
41	6.50	160	0.01320	0.67500	0.63553	0.05200
42	7.00	1	0.68767	0.61800	0.27434	0.07400
43	7.00	10	0.51458	0.61800	0.31744	0.07400
44	7.00	10	0.31198	0.61800	0.27130	0.07400
45	7.00	50	0.08329	0.64000	0.31709	0.07100
46	7.00	50	0.09415	0.63700	0.35810	0.06900
47	7.50	1	0.79216	0.60900	0.28452	0.07900
48	5.00	10	0.45704	0.60900	0.29608	0.07900
49	5.00	10	0.59211	0.60900	0.34164	0.07900
50	8.00	50	0.16426	0.61500	0.38295	0.07600
51	8.00	160	0.05602	0.63100	0.60572	0.07900

TABLE F3-11
K. W. CAMPBELL: HORIZONTAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 1.00 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.04731	0.79800	0.37638	0.12400
2	5.00	1	0.05820	0.79800	0.43594	0.12400
3	5.00	5	0.01850	0.81100	0.35780	0.10100
4	5.00	5	0.02500	0.81000	0.50206	0.10300
5	5.80	10	0.05395	0.74600	0.27684	0.09100
6	5.80	20	0.04636	0.75500	0.25786	0.07700
7	6.50	1	0.30772	0.69600	0.21691	0.09000
8	6.50	1	0.31859	0.69600	0.32054	0.09000
9	6.50	1	0.29143	0.69600	0.29693	0.09000
10	6.50	5	0.26238	0.69600	0.24222	0.09000
11	6.50	5	0.18199	0.69600	0.32160	0.09000
12	6.50	50	0.03129	0.71900	0.30774	0.06900
13	6.50	50	0.03182	0.71900	0.38146	0.06900
14	7.00	10	0.21434	0.66400	0.25635	0.09500
15	7.50	50	0.08372	0.66800	0.28904	0.09400
16	7.50	50	0.09308	0.66400	0.32776	0.09500
17	5.00	1	0.01924	0.80900	0.66543	0.10500
18	5.80	5	0.08693	0.74300	0.48805	0.09700
19	5.80	5	0.04984	0.74700	0.48477	0.09000
20	5.00	10	0.02033	0.80900	0.18365	0.10400
21	5.00	10	0.02758	0.80500	0.22099	0.11200
22	5.00	50	0.00313	0.82000	0.40294	0.08700
23	5.00	50	0.00352	0.82000	0.36505	0.08700
24	5.00	160	0.00095	0.82000	0.57773	0.08700
25	5.80	1	0.13803	0.74300	0.38888	0.09700
26	5.80	5	0.12638	0.74300	0.39040	0.09700
27	5.80	5	0.07274	0.74300	0.44504	0.09700
28	5.80	10	0.06566	0.74300	0.28541	0.09700
29	5.80	10	0.09740	0.74300	0.32030	0.09700
30	5.80	10	0.04700	0.74600	0.39645	0.09100
31	5.80	50	0.00820	0.76500	0.60472	0.06400
32	5.80	50	0.00877	0.76500	0.70971	0.06400
33	6.50	5	0.21495	0.69600	0.28064	0.09000
34	6.50	10	0.15359	0.69600	0.31885	0.09000
35	6.50	10	0.21413	0.69600	0.31854	0.09000
36	6.50	10	0.12467	0.69600	0.32233	0.09000
37	6.50	20	0.07990	0.70200	0.27435	0.08300
38	6.50	20	0.10688	0.69800	0.37329	0.08700
39	6.50	20	0.07013	0.70400	0.31209	0.08100
40	6.50	100	0.01715	0.71900	0.38208	0.06900
41	6.50	160	0.00859	0.71900	0.61184	0.06900
42	7.00	1	0.37706	0.66400	0.28714	0.09500
43	7.00	10	0.30690	0.66400	0.31404	0.09500
44	7.00	10	0.18551	0.66400	0.29378	0.09500
45	7.00	50	0.05381	0.68500	0.33302	0.08500
46	7.00	50	0.05819	0.68200	0.40688	0.08600
47	7.50	1	0.47539	0.65400	0.34507	0.10100
48	5.00	10	0.28707	0.65400	0.25438	0.10100
49	5.00	10	0.38674	0.65400	0.42445	0.10100
50	8.00	50	0.11479	0.66000	0.32491	0.09700
51	8.00	160	0.04590	0.67700	0.47887	0.09400

TABLE F3-12
K. W. CAMPBELL: HORIZONTAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 2.00 SEC PERIOD

CASE No.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.01180	0.84400	0.52384	0.13400
2	5.00	1	0.01594	0.84400	0.48973	0.13400
3	5.00	5	0.00503	0.85700	0.56941	0.11100
4	5.00	5	0.00690	0.85600	0.59896	0.11300
5	5.80	10	0.01992	0.79500	0.43127	0.11100
6	5.80	20	0.01611	0.80300	0.42186	0.09800
7	6.50	1	0.13960	0.74700	0.28682	0.11500
8	6.50	1	0.14308	0.74700	0.29839	0.11500
9	6.50	1	0.12991	0.74700	0.28765	0.11500
10	6.50	5	0.11313	0.74700	0.31483	0.11500
11	6.50	5	0.08903	0.74700	0.32982	0.11500
12	6.50	50	0.01493	0.76900	0.45494	0.09400
13	6.50	50	0.01511	0.76900	0.56184	0.09400
14	7.00	10	0.10504	0.71600	0.32105	0.12200
15	7.50	50	0.04502	0.72000	0.53620	0.11900
16	7.50	50	0.04869	0.71700	0.62436	0.12000
17	5.00	1	0.00456	0.85400	0.85279	0.11500
18	5.80	5	0.03617	0.79200	0.45125	0.11600
19	5.80	5	0.02138	0.79500	0.48735	0.11000
20	5.00	10	0.00618	0.85500	0.33902	0.11400
21	5.00	10	0.00816	0.85000	0.35573	0.12200
22	5.00	50	0.00105	0.86600	0.51825	0.09600
23	5.00	50	0.00106	0.86600	0.58131	0.09600
24	5.00	160	0.00042	0.86600	0.76188	0.09600
25	5.80	1	0.05545	0.79200	0.35937	0.11600
26	5.80	5	0.05028	0.79200	0.41450	0.11600
27	5.80	5	0.03324	0.79200	0.40843	0.11600
28	5.80	10	0.02379	0.79200	0.39066	0.11600
29	5.80	10	0.03230	0.79200	0.40620	0.11600
30	5.80	10	0.01960	0.79500	0.47817	0.11100
31	5.80	50	0.00312	0.81300	0.82942	0.08400
32	5.80	50	0.00319	0.81300	0.88153	0.08400
33	6.50	5	0.10114	0.74700	0.30082	0.11500
34	6.50	10	0.06829	0.74700	0.31275	0.11500
35	6.50	10	0.08870	0.74700	0.30715	0.11500
36	6.50	10	0.05808	0.74700	0.38263	0.11500
37	6.50	20	0.03926	0.75200	0.31400	0.10900
38	6.50	20	0.04870	0.74900	0.36120	0.11300
39	6.50	20	0.03298	0.75400	0.43697	0.10600
40	6.50	100	0.00847	0.76900	0.43990	0.09400
41	6.50	160	0.00401	0.76900	0.79330	0.09400
42	7.00	1	0.19350	0.71600	0.25225	0.12200
43	7.00	10	0.13692	0.71600	0.30921	0.12200
44	7.00	10	0.09273	0.71600	0.38105	0.12200
45	7.00	50	0.02879	0.73700	0.41198	0.10800
46	7.00	50	0.03064	0.73400	0.50676	0.11000
47	7.50	1	0.23284	0.70700	0.28003	0.12700
48	5.00	10	0.14295	0.70700	0.42464	0.12700
49	5.00	10	0.17572	0.70700	0.47320	0.12700
50	8.00	50	0.07185	0.71300	0.36780	0.12300
51	8.00	160	0.03450	0.72900	0.56066	0.11600

TABLE F3-13
K. W. CAMPBELL: HORIZONTAL POINT ESTIMATES SPECTRAL ACCELERATION AT 3.33 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.00340	0.84700	0.71550	0.13900
2	5.00	1	0.00459	0.84700	0.74832	0.13900
3	5.00	5	0.00147	0.86000	0.69703	0.11100
4	5.00	5	0.00208	0.85900	0.80285	0.11300
5	5.80	10	0.00841	0.80000	0.53073	0.11100
6	5.80	20	0.00609	0.80800	0.55284	0.09800
7	6.50	1	0.07209	0.75300	0.35350	0.11500
8	6.50	1	0.07362	0.75300	0.32531	0.11500
9	6.50	1	0.06791	0.75300	0.34277	0.11500
10	6.50	5	0.06125	0.75300	0.36731	0.11500
11	6.50	5	0.05000	0.75300	0.40127	0.11500
12	6.50	50	0.00797	0.77500	0.60584	0.09400
13	6.50	50	0.00756	0.77500	0.72195	0.09400
14	7.00	10	0.05823	0.72300	0.42429	0.12200
15	7.50	50	0.02830	0.72600	0.51711	0.11900
16	7.50	50	0.02808	0.72300	0.65830	0.12000
17	5.00	1	0.00131	0.85800	0.89531	0.11500
18	5.80	5	0.01525	0.79600	0.49342	0.11600
19	5.80	5	0.00806	0.80000	0.56937	0.11000
20	5.00	10	0.00189	0.85800	0.57155	0.11400
21	5.00	10	0.00241	0.85400	0.53519	0.12400
22	5.00	50	0.00037	0.86900	0.60821	0.09600
23	5.00	50	0.00038	0.86900	0.58191	0.09600
24	5.00	160	0.00012	0.86900	0.76686	0.09600
25	5.80	1	0.02275	0.79600	0.48024	0.11600
26	5.80	5	0.02255	0.79600	0.50198	0.11600
27	5.80	5	0.01578	0.79600	0.45116	0.11600
28	5.80	10	0.01102	0.79600	0.51758	0.11600
29	5.80	10	0.01231	0.79600	0.55565	0.11600
30	5.80	10	0.00752	0.79900	0.69946	0.11100
31	5.80	50	0.00141	0.81800	0.85972	0.08400
32	5.80	50	0.00119	0.81800	0.96615	0.08400
33	6.50	5	0.05567	0.75300	0.38091	0.11500
34	6.50	10	0.03588	0.75300	0.41885	0.11500
35	6.50	10	0.04295	0.75300	0.38912	0.11500
36	6.50	10	0.02954	0.75300	0.54536	0.11500
37	6.50	20	0.01958	0.75800	0.44232	0.10900
38	6.50	20	0.02211	0.75500	0.50389	0.11300
39	6.50	20	0.01670	0.76000	0.59572	0.10600
40	6.50	100	0.00354	0.77500	0.60831	0.09400
41	6.50	160	0.00212	0.77500	0.78530	0.09400
42	7.00	1	0.11288	0.72300	0.33501	0.12200
43	7.00	10	0.07286	0.72300	0.34848	0.12200
44	7.00	10	0.05019	0.72300	0.51401	0.12200
45	7.00	50	0.01640	0.74400	0.52213	0.10800
46	7.00	50	0.01664	0.74000	0.61464	0.11000
47	7.50	1	0.14997	0.71300	0.33329	0.12700
48	5.00	10	0.08412	0.71300	0.51248	0.12700
49	5.00	10	0.10035	0.71300	0.50394	0.12700
50	8.00	50	0.04851	0.71900	0.41432	0.12300
51	8.00	160	0.02198	0.73500	0.49377	0.11600

TABLE F3-14
K. W. CAMPBELL: HORIZONTAL POINT ESTIMATES
PEAK GROUND VELOCITY

CASE No.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	6.63860	0.73100	0.57332	0.19600
2	5.00	1	8.18581	0.73100	0.58301	0.19600
3	5.00	5	2.26876	0.73100	0.29743	0.13100
4	5.00	5	3.09310	0.73100	0.45337	0.13800
5	5.80	10	5.96975	0.66600	0.25136	0.14200
6	5.80	20	4.80004	0.66800	0.21667	0.10900
7	6.50	1	37.28022	0.61100	0.32930	0.13800
8	6.50	1	38.74037	0.61100	0.38815	0.13800
9	6.50	1	35.36159	0.61100	0.36600	0.13800
10	6.50	5	30.79080	0.61100	0.23019	0.13800
11	6.50	5	22.13452	0.61100	0.31591	0.13800
12	6.50	50	2.88233	0.61900	0.32730	0.10500
13	6.50	50	2.98282	0.61900	0.36086	0.10500
14	7.00	10	23.47610	0.57300	0.24734	0.13800
15	7.50	50	8.32337	0.56600	0.34307	0.13200
16	7.50	50	9.10473	0.56400	0.38677	0.13100
17	5.00	1	2.34005	0.73000	0.59039	0.14400
18	5.80	5	10.65910	0.66600	0.41477	0.15600
19	5.80	5	5.87083	0.66600	0.39903	0.14000
20	5.00	10	2.56407	0.73100	0.25909	0.14000
21	5.00	10	3.58413	0.73000	0.25154	0.16300
22	5.00	50	0.31756	0.73500	0.37796	0.09300
23	5.00	50	0.35317	0.73500	0.36130	0.09300
24	5.00	160	0.06570	0.73500	0.69923	0.09300
25	5.80	1	17.65386	0.66600	0.42437	0.15600
26	5.80	5	15.57512	0.66600	0.35315	0.15600
27	5.80	5	9.48561	0.66600	0.32309	0.15600
28	5.80	10	7.32386	0.66600	0.29310	0.15600
29	5.80	10	10.76958	0.66600	0.26768	0.15600
30	5.80	10	5.28294	0.66600	0.36777	0.14200
31	5.80	50	0.75865	0.67300	0.65835	0.08100
32	5.80	50	0.79487	0.67300	0.66997	0.08100
33	6.50	5	25.12508	0.61100	0.28158	0.13800
34	6.50	10	16.30602	0.61100	0.26409	0.13800
35	6.50	10	22.90958	0.61100	0.25665	0.13800
36	6.50	10	13.66907	0.61100	0.30957	0.13800
37	6.50	20	8.19863	0.61200	0.23433	0.12300
38	6.50	20	11.05582	0.61100	0.29057	0.13200
39	6.50	20	7.12903	0.61200	0.30575	0.11800
40	6.50	100	1.45679	0.61900	0.38915	0.10500
41	6.50	160	0.55795	0.61900	0.73544	0.10500
42	7.00	1	47.49108	0.57300	0.32957	0.13800
43	7.00	10	33.87643	0.57300	0.41390	0.13800
44	7.00	10	20.06264	0.57300	0.32681	0.13800
45	7.00	50	5.24521	0.58200	0.29611	0.13100
46	7.00	50	5.66115	0.58000	0.34570	0.12700
47	7.50	1	58.27975	0.56200	0.55636	0.13900
48	5.00	10	30.98703	0.56200	0.34253	0.13900
49	5.00	10	41.76862	0.56200	0.65424	0.13900
50	8.00	50	12.66615	0.56300	0.36846	0.13300
51	8.00	160	4.76428	0.57200	0.49541	0.14100

TABLE F3-15
K. W. CAMPBELL: VERTICAL POINT ESTIMATES
PEAK GROUND ACCELERATION

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.10617	0.68700	0.64998	0.13000
2	5.00	1	0.12027	0.68700	0.48743	0.13000
3	5.00	5	0.03371	0.68800	0.45765	0.09000
4	5.00	5	0.04019	0.68700	0.38728	0.09200
5	5.80	10	0.05913	0.66800	0.34449	0.07500
6	5.80	20	0.05682	0.67100	0.42437	0.04400
7	6.50	1	0.31800	0.59100	0.39266	0.10900
8	6.50	1	0.34623	0.59100	0.35709	0.10900
9	6.50	1	0.32903	0.59100	0.37305	0.10900
10	6.50	5	0.28446	0.59100	0.28168	0.10900
11	6.50	5	0.20884	0.59100	0.35886	0.10900
12	6.50	50	0.01797	0.60000	0.34213	0.15600
13	6.50	50	0.02050	0.60000	0.38721	0.15600
14	7.00	10	0.17951	0.58300	0.28892	0.08500
15	7.50	50	0.03787	0.58800	0.29717	0.12000
16	7.50	50	0.04513	0.58600	0.36054	0.11000
17	5.00	1	0.03797	0.68700	0.51445	0.09400
18	5.80	5	0.09408	0.66800	0.47608	0.09000
19	5.80	5	0.06481	0.66900	0.42824	0.07300
20	5.00	10	0.03969	0.68700	0.33012	0.09300
21	5.00	10	0.06640	0.68600	0.35909	0.10500
22	5.00	50	0.00368	0.69100	0.47066	0.07900
23	5.00	50	0.00391	0.69100	0.45205	0.07900
24	5.00	160	0.00035	0.69100	0.71627	0.07900
25	5.80	1	0.18222	0.66800	0.53577	0.09000
26	5.80	5	0.18198	0.66800	0.39652	0.09000
27	5.80	5	0.10949	0.66800	0.38363	0.09000
28	5.80	10	0.07359	0.66800	0.35795	0.09000
29	5.80	10	0.12285	0.66800	0.36717	0.09000
30	5.80	10	0.06359	0.66800	0.37421	0.07600
31	5.80	50	0.00559	0.67700	0.77894	0.03200
32	5.80	50	0.00682	0.67700	0.75640	0.03200
33	6.50	5	0.22965	0.59100	0.32717	0.10900
34	6.50	10	0.13989	0.59100	0.30890	0.10900
35	6.50	10	0.21909	0.59100	0.41332	0.10900
36	6.50	10	0.12736	0.59100	0.34857	0.10900
37	6.50	20	0.06718	0.59200	0.28678	0.11500
38	6.50	20	0.10211	0.59100	0.48324	0.11100
39	6.50	20	0.05939	0.59200	0.35464	0.11800
40	6.50	100	0.00714	0.60000	0.45674	0.15600
41	6.50	160	0.00213	0.60000	0.77441	0.15600
42	7.00	1	0.37762	0.58300	0.33209	0.08500
43	7.00	10	0.27600	0.58300	0.38638	0.08500
44	7.00	10	0.16227	0.58300	0.34348	0.08500
45	7.00	50	0.02686	0.59500	0.26030	0.14900
46	7.00	50	0.03247	0.59200	0.37990	0.13600
47	7.50	1	0.48778	0.58100	0.41359	0.08500
48	5.00	10	0.21561	0.58100	0.29680	0.08500
49	5.00	10	0.31344	0.58100	0.46850	0.08500
50	8.00	50	0.04782	0.58400	0.44735	0.09800
51	8.00	160	0.01053	0.59400	0.50852	0.15200

TABLE F3-16
K. W. CAMPBELL: VERTICAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.05 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.23760	0.71600	0.71755	0.09300
2	5.00	1	0.26754	0.71600	0.51334	0.09300
3	5.00	5	0.06958	0.71900	0.54870	0.07600
4	5.00	5	0.08429	0.71900	0.42287	0.07800
5	5.80	10	0.11491	0.69800	0.48708	0.06100
6	5.80	20	0.10453	0.70200	0.41241	0.04300
7	6.50	1	0.69233	0.62500	0.51922	0.05900
8	6.50	1	0.74236	0.62500	0.45460	0.05900
9	6.50	1	0.71168	0.62500	0.46441	0.05900
10	6.50	5	0.61465	0.62500	0.34515	0.05900
11	6.50	5	0.43725	0.62500	0.47850	0.05900
12	6.50	50	0.02888	0.63800	0.46754	0.13400
13	6.50	50	0.03344	0.63800	0.48807	0.13400
14	7.00	10	0.36565	0.61900	0.39134	0.05800
15	7.50	50	0.06053	0.62800	0.38360	0.10900
16	7.50	50	0.07270	0.62500	0.40772	0.09600
17	5.00	1	0.07961	0.71800	0.58943	0.07900
18	5.80	5	0.18554	0.69700	0.63269	0.07200
19	5.80	5	0.12725	0.69800	0.53209	0.06000
20	5.00	10	0.08320	0.71900	0.46077	0.07800
21	5.00	10	0.14144	0.71700	0.35155	0.08400
22	5.00	50	0.00638	0.72400	0.47071	0.07100
23	5.00	50	0.00725	0.72400	0.45425	0.07100
24	5.00	160	0.00045	0.72400	0.76637	0.07100
25	5.80	1	0.37779	0.69700	0.69485	0.07200
26	5.80	5	0.35869	0.69700	0.51274	0.07200
27	5.80	5	0.22185	0.69700	0.53661	0.07200
28	5.80	10	0.14582	0.69700	0.50848	0.07200
29	5.80	10	0.23265	0.69700	0.47761	0.07200
30	5.80	10	0.12109	0.69800	0.55926	0.06200
31	5.80	50	0.00907	0.70900	0.84953	0.05000
32	5.80	50	0.01073	0.70900	0.90667	0.05000
33	6.50	5	0.49007	0.62500	0.41182	0.05900
34	6.50	10	0.28680	0.62500	0.38995	0.05900
35	6.50	10	0.44913	0.62500	0.51482	0.05900
36	6.50	10	0.26088	0.62500	0.45661	0.05900
37	6.50	20	0.12930	0.62800	0.36029	0.07400
38	6.50	20	0.19884	0.62600	0.55359	0.06400
39	6.50	20	0.11330	0.62800	0.46291	0.08100
40	6.50	100	0.00938	0.63800	0.56693	0.13400
41	6.50	160	0.00294	0.63800	0.79473	0.13400
42	7.00	1	0.82482	0.61900	0.45149	0.05800
43	7.00	10	0.56933	0.61900	0.51632	0.05800
44	7.00	10	0.33153	0.61900	0.45218	0.05800
45	7.00	50	0.04445	0.63300	0.35876	0.14200
46	7.00	50	0.05378	0.63100	0.42050	0.12700
47	7.50	1	1.04288	0.61900	0.49211	0.05800
48	5.00	10	0.43691	0.61900	0.43615	0.05800
49	5.00	10	0.64200	0.61900	0.61318	0.05800
50	8.00	50	0.07128	0.62300	0.53204	0.08000
51	8.00	160	0.01164	0.63500	0.60982	0.14400

TABLE F3-17
K. W. CAMPBELL: VERTICAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.10 SEC PERIOD

CASE No.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.21064	0.72400	0.67833	0.10500
2	5.00	1	0.24045	0.72400	0.55691	0.10500
3	5.00	5	0.06968	0.72700	0.34004	0.08700
4	5.00	5	0.08364	0.72600	0.27315	0.08900
5	5.80	10	0.12890	0.70500	0.30013	0.06200
6	5.80	20	0.11903	0.70900	0.44955	0.04500
7	6.50	1	0.72475	0.63100	0.38074	0.05900
8	6.50	1	0.79023	0.63100	0.33160	0.05900
9	6.50	1	0.75754	0.63100	0.36328	0.05900
10	6.50	5	0.62377	0.63100	0.27546	0.05900
11	6.50	5	0.46851	0.63100	0.33452	0.05900
12	6.50	50	0.03436	0.64200	0.38397	0.13300
13	6.50	50	0.03934	0.64200	0.39589	0.13300
14	7.00	10	0.39108	0.62400	0.26982	0.05700
15	7.50	50	0.07118	0.63200	0.34919	0.10800
16	7.50	50	0.08384	0.63000	0.35735	0.09500
17	5.00	1	0.07804	0.72600	0.39342	0.09000
18	5.80	5	0.20901	0.70400	0.41368	0.07200
19	5.80	5	0.14432	0.70500	0.36497	0.06100
20	5.00	10	0.08141	0.72600	0.37815	0.08900
21	5.00	10	0.13404	0.72500	0.46066	0.09500
22	5.00	50	0.00760	0.73100	0.33794	0.07900
23	5.00	50	0.00826	0.73100	0.33066	0.07900
24	5.00	160	0.00067	0.73100	0.69204	0.07900
25	5.80	1	0.41203	0.70400	0.47059	0.07200
26	5.80	5	0.38911	0.70400	0.41031	0.07200
27	5.80	5	0.23262	0.70400	0.38951	0.07200
28	5.80	10	0.15386	0.70400	0.36628	0.07200
29	5.80	10	0.26079	0.70400	0.40986	0.07200
30	5.80	10	0.13284	0.70500	0.39231	0.06200
31	5.80	50	0.01195	0.71500	0.68224	0.05000
32	5.80	50	0.01288	0.71500	0.79681	0.05000
33	6.50	5	0.50962	0.63100	0.28926	0.05900
34	6.50	10	0.30867	0.63100	0.27422	0.05900
35	6.50	10	0.47532	0.63100	0.41244	0.05900
36	6.50	10	0.28248	0.63100	0.31842	0.05900
37	6.50	20	0.14008	0.63300	0.27161	0.07400
38	6.50	20	0.21477	0.63200	0.47371	0.06400
39	6.50	20	0.12621	0.63400	0.31463	0.08000
40	6.50	100	0.01222	0.64200	0.52353	0.13300
41	6.50	160	0.00415	0.64200	0.67642	0.13300
42	7.00	1	0.86904	0.62400	0.31192	0.05700
43	7.00	10	0.60504	0.62400	0.38639	0.05700
44	7.00	10	0.35774	0.62400	0.30515	0.05700
45	7.00	50	0.05183	0.63700	0.31506	0.14100
46	7.00	50	0.06269	0.63500	0.35867	0.12700
47	7.50	1	1.08842	0.62400	0.40714	0.06000
48	5.00	10	0.46505	0.62400	0.31279	0.06000
49	5.00	10	0.68518	0.62400	0.45843	0.06000
50	8.00	50	0.08713	0.62700	0.50123	0.08000
51	8.00	160	0.01378	0.63900	0.63848	0.14400

TABLE F3-18
K. W. CAMPBELL: VERTICAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.20 SEC PERIOD

CASE No.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.11928	0.71300	0.69994	0.10600
2	5.00	·1	0.12934	0.71300	0.65252	0.10600
3	5.00	5	0.04483	0.71500	0.26598	0.08700
4	5.00	5	0.04964	0.71500	0.27857	0.08800
5	5.80	10	0.08995	0.70100	0.24905	0.07300
6	5.80	20	0.08656	0.70400	0.57827	0.07200
7	6.50	1	0.45518	0.63300	0.36983	0.06600
8	6.50	1	0.46998	0.63300	0.37398	0.06600
9	6.50	1	0.45167	0.63300	0.40249	0.06600
10	6.50	5	0.40641	0.63300	0.36599	0.06600
11	6.50	5	0.29733	0.63300	0.35891	0.06600
12	6.50	50	0.02952	0.64300	0.40872	0.14700
13	6.50	50	0.03323	0.64300	0.45699	0.14700
14	7.00	10	0.27965	0.62900	0.32990	0.07000
15	7.50	50	0.06577	0.63600	0.43973	0.11900
16	7.50	50	0.07616	0.63400	0.45761	0.10700
17	5.00	1	0.04847	0.71400	0.30686	0.09000
18	5.80	5	0.13445	0.70000	0.39023	0.07700
19	5.80	5	0.09665	0.70100	0.41715	0.07200
20	5.00	10	0.04786	0.71500	0.33256	0.08900
21	5.00	10	0.08233	0.71300	0.61085	0.09600
22	5.00	50	0.00667	0.71800	0.39161	0.07800
23	5.00	50	0.00673	0.71800	0.28190	0.07800
24	5.00	160	0.00081	0.71800	0.69006	0.07800
25	5.80	1	0.25542	0.70000	0.46322	0.07700
26	5.80	5	0.25377	0.70000	0.50751	0.07700
27	5.80	5	0.15656	0.70000	0.35465	0.07700
28	5.80	10	0.11098	0.70000	0.28802	0.07700
29	5.80	10	0.17952	0.70000	0.52898	0.07700
30	5.80	10	0.09258	0.70100	0.34330	0.07300
31	5.80	50	0.01067	0.70900	0.64581	0.09000
32	5.80	50	0.01346	0.70900	0.67833	0.09000
33	6.50	5	0.32873	0.63300	0.33642	0.06600
34	6.50	10	0.20397	0.63300	0.30833	0.06600
35	6.50	10	0.30921	0.63300	0.43675	0.06600
36	6.50	10	0.19094	0.63300	0.34353	0.06600
37	6.50	20	0.10513	0.63400	0.34800	0.08500
38	6.50	20	0.15489	0.63300	0.55000	0.07300
39	6.50	20	0.09544	0.63500	0.36308	0.09100
40	6.50	100	0.01331	0.64300	0.60613	0.14700
41	6.50	160	0.00545	0.64300	0.70300	0.14700
42	7.00	1	0.55351	0.62900	0.35046	0.07000
43	7.00	10	0.41380	0.62900	0.40295	0.07000
44	7.00	10	0.25411	0.62900	0.35382	0.07000
45	7.00	50	0.04676	0.64100	0.37306	0.15200
46	7.00	50	0.05622	0.63900	0.45840	0.13800
47	7.50	1	0.70222	0.62900	0.49575	0.07000
48	5.00	10	0.34508	0.62900	0.36290	0.07000
49	5.00	10	0.47169	0.62900	0.40407	0.07000
50	8.00	50	0.08523	0.63200	0.56350	0.09100
51	8.00	160	0.01902	0.64200	0.73033	0.15500

TABLE F3-19
K. W. CAMPBELL: VERTICAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.50 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.04732	0.73400	0.70969	0.11700
2	5.00	1	0.05404	0.73400	0.62177	0.11700
3	5.00	5	0.01724	0.73500	0.41310	0.09500
4	5.00	5	0.02123	0.73500	0.36666	0.09700
5	5.80	10	0.04848	0.71900	0.28977	0.07600
6	5.80	20	0.04940	0.72200	0.65510	0.07700
7	6.50	1	0.24900	0.65000	0.25799	0.08000
8	6.50	1	0.27118	0.65000	0.30046	0.08000
9	6.50	1	0.25620	0.65000	0.32164	0.08000
10	6.50	5	0.22341	0.65000	0.33943	0.08000
11	6.50	5	0.16858	0.65000	0.35760	0.08000
12	6.50	50	0.02198	0.65800	0.39878	0.16100
13	6.50	50	0.02522	0.65800	0.46612	0.16100
14	7.00	10	0.17494	0.64400	0.41002	0.08500
15	7.50	50	0.05626	0.64800	0.43707	0.13400
16	7.50	50	0.06100	0.64700	0.41928	0.12200
17	5.00	1	0.02015	0.73500	0.43567	0.09900
18	5.80	5	0.07022	0.71900	0.35942	0.08100
19	5.80	5	0.04632	0.71900	0.34492	0.07500
20	5.00	10	0.02051	0.73500	0.31973	0.09800
21	5.00	10	0.03300	0.73400	0.54440	0.10600
22	5.00	50	0.00331	0.73800	0.36267	0.08300
23	5.00	50	0.00369	0.73800	0.34572	0.08300
24	5.00	160	0.00056	0.73800	0.73250	0.08300
25	5.80	1	0.11469	0.71900	0.53924	0.08100
26	5.80	5	0.12724	0.71900	0.50978	0.08100
27	5.80	5	0.08200	0.71900	0.35320	0.08100
28	5.80	10	0.06083	0.71900	0.35922	0.08100
29	5.80	10	0.09540	0.71900	0.56601	0.08100
30	5.80	10	0.04919	0.71900	0.33574	0.07600
31	5.80	50	0.00615	0.72600	0.79146	0.09900
32	5.80	50	0.00821	0.72600	0.75952	0.09900
33	6.50	5	0.18541	0.65000	0.36194	0.08000
34	6.50	10	0.12301	0.65000	0.44966	0.08000
35	6.50	10	0.18019	0.65000	0.54422	0.08000
36	6.50	10	0.11128	0.65000	0.43287	0.08000
37	6.50	20	0.06536	0.65200	0.44016	0.09900
38	6.50	20	0.09342	0.65100	0.64233	0.08700
39	6.50	20	0.05667	0.65200	0.35495	0.10600
40	6.50	100	0.01169	0.65800	0.54696	0.16100
41	6.50	160	0.00556	0.65800	0.64101	0.16100
42	7.00	1	0.34520	0.64400	0.27669	0.08500
43	7.00	10	0.25651	0.64400	0.47782	0.08500
44	7.00	10	0.15656	0.64400	0.39264	0.08500
45	7.00	50	0.03541	0.65300	0.35238	0.16600
46	7.00	50	0.04264	0.65100	0.48103	0.15200
47	7.50	1	0.43841	0.64300	0.35390	0.08500
48	5.00	10	0.22442	0.64300	0.36561	0.08500
49	5.00	10	0.30249	0.64300	0.41320	0.08500
50	8.00	50	0.07893	0.64500	0.57582	0.10700
51	8.00	160	0.02349	0.65300	0.63697	0.16800

TABLE F3-20
K. W. CAMPBELL: VERTICAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 1.00 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.02026	0.75200	0.80925	0.12400
2	5.00	1	0.02277	0.75200	0.73986	0.12400
3	5.00	5	0.00739	0.75400	0.52158	0.10100
4	5.00	5	0.00928	0.75400	0.47024	0.10300
5	5.80	10	0.02231	0.73700	0.32804	0.09100
6	5.80	20	0.02249	0.73900	0.41974	0.08100
7	6.50	1	0.13963	0.66600	0.36196	0.09000
8	6.50	1	0.15511	0.66600	0.30695	0.09000
9	6.50	1	0.14029	0.66600	0.29806	0.09000
10	6.50	5	0.13124	0.66600	0.36976	0.09000
11	6.50	5	0.09490	0.66600	0.27199	0.09000
12	6.50	50	0.01322	0.67300	0.47775	0.16900
13	6.50	50	0.01636	0.67300	0.48396	0.16900
14	7.00	10	0.09994	0.65900	0.28218	0.09500
15	7.50	50	0.03887	0.66200	0.40408	0.14300
16	7.50	50	0.04535	0.66100	0.50769	0.13100
17	5.00	1	0.00817	0.75300	0.65841	0.10500
18	5.80	5	0.03616	0.73600	0.49773	0.09700
19	5.80	5	0.02516	0.73700	0.41709	0.09000
20	5.00	10	0.00774	0.75300	0.51534	0.10400
21	5.00	10	0.01229	0.75300	0.48843	0.11200
22	5.00	50	0.00130	0.75600	0.54345	0.08700
23	5.00	50	0.00171	0.75600	0.40211	0.08700
24	5.00	160	0.00027	0.75600	0.79605	0.08700
25	5.80	1	0.05834	0.73600	0.64874	0.09700
26	5.80	5	0.06360	0.73600	0.61412	0.09700
27	5.80	5	0.04166	0.73600	0.38959	0.09700
28	5.80	10	0.02840	0.73600	0.32868	0.09700
29	5.80	10	0.04645	0.73600	0.50058	0.09700
30	5.80	10	0.02896	0.73700	0.37489	0.09100
31	5.80	50	0.00325	0.74300	0.88702	0.10500
32	5.80	50	0.00517	0.74300	0.69312	0.10500
33	6.50	5	0.09974	0.66600	0.32774	0.09000
34	6.50	10	0.06945	0.66600	0.34923	0.09000
35	6.50	10	0.09262	0.66600	0.31824	0.09000
36	6.50	10	0.06611	0.66600	0.37543	0.09000
37	6.50	20	0.03497	0.66700	0.33287	0.10800
38	6.50	20	0.05072	0.66700	0.44118	0.09600
39	6.50	20	0.03620	0.66800	0.36894	0.11500
40	6.50	100	0.00711	0.67300	0.44963	0.16900
41	6.50	160	0.00298	0.67300	0.74142	0.16900
42	7.00	1	0.19275	0.65900	0.35073	0.09500
43	7.00	10	0.15377	0.65900	0.36723	0.09500
44	7.00	10	0.09917	0.65900	0.32051	0.09500
45	7.00	50	0.02388	0.66700	0.40054	0.17400
46	7.00	50	0.02872	0.66500	0.49191	0.16000
47	7.50	1	0.27419	0.65800	0.38784	0.10100
48	5.00	10	0.13951	0.65800	0.32018	0.10100
49	5.00	10	0.19678	0.65800	0.43525	0.10100
50	8.00	50	0.05113	0.65900	0.54972	0.11600
51	8.00	160	0.01782	0.66600	0.55129	0.17700

TABLE F3-21
K. W. CAMPBELL: VERTICAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 2.00 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.01180	0.84400	0.52384	0.13400
2	5.00	1	0.01594	0.84400	0.48973	0.13400
3	5.00	5	0.00503	0.85700	0.56941	0.11100
4	5.00	5	0.00690	0.85600	0.59896	0.11300
5	5.80	10	0.01992	0.79500	0.43127	0.11100
6	5.80	20	0.01611	0.80300	0.42186	0.09800
7	6.50	1	0.13960	0.74700	0.28682	0.11500
8	6.50	1	0.14308	0.74700	0.29839	0.11500
9	6.50	1	0.12991	0.74700	0.28765	0.11500
10	6.50	5	0.11313	0.74700	0.31483	0.11500
11	6.50	5	0.08903	0.74700	0.32982	0.11500
12	6.50	50	0.01493	0.76900	0.45494	0.09400
13	6.50	50	0.01511	0.76900	0.56184	0.09400
14	7.00	10	0.10504	0.71600	0.32105	0.12200
15	7.50	50	0.04502	0.72000	0.53620	0.11900
16	7.50	50	0.04869	0.71700	0.62436	0.12000
17	5.00	1	0.00456	0.85400	0.85279	0.11500
18	5.80	5	0.03617	0.79200	0.45125	0.11600
19	5.80	5	0.02138	0.79500	0.48735	0.11000
20	5.00	10	0.00618	0.85500	0.33902	0.11400
21	5.00	10	0.00816	0.85000	0.35573	0.12200
22	5.00	50	0.00105	0.86600	0.51825	0.09600
23	5.00	50	0.00106	0.86600	0.58131	0.09600
24	5.00	160	0.00042	0.86600	0.76188	0.09600
25	5.80	1	0.05545	0.79200	0.35937	0.11600
26	5.80	5	0.05028	0.79200	0.41450	0.11600
27	5.80	5	0.03324	0.79200	0.40843	0.11600
28	5.80	10	0.02379	0.79200	0.39066	0.11600
29	5.80	10	0.03230	0.79200	0.40620	0.11600
30	5.80	10	0.01960	0.79500	0.47817	0.11100
31	5.80	50	0.00312	0.81300	0.82942	0.08400
32	5.80	50	0.00319	0.81300	0.88153	0.08400
33	6.50	5	0.10114	0.74700	0.30082	0.11500
34	6.50	10	0.06829	0.74700	0.31275	0.11500
35	6.50	10	0.08870	0.74700	0.30715	0.11500
36	6.50	10	0.05808	0.74700	0.38263	0.11500
37	6.50	20	0.03926	0.75200	0.31400	0.10900
38	6.50	20	0.04870	0.74900	0.36120	0.11300
39	6.50	20	0.03298	0.75400	0.43697	0.10600
40	6.50	100	0.00847	0.76900	0.43990	0.09400
41	6.50	160	0.00401	0.76900	0.79330	0.09400
42	7.00	1	0.19350	0.71600	0.25225	0.12200
43	7.00	10	0.13692	0.71600	0.30921	0.12200
44	7.00	10	0.09273	0.71600	0.38105	0.12200
45	7.00	50	0.02879	0.73700	0.41198	0.10800
46	7.00	50	0.03064	0.73400	0.50676	0.11000
47	7.50	1	0.23284	0.70700	0.28003	0.12700
48	5.00	10	0.14295	0.70700	0.42464	0.12700
49	5.00	10	0.17572	0.70700	0.47320	0.12700
50	8.00	50	0.07185	0.71300	0.36780	0.12300
51	8.00	160	0.03450	0.72900	0.56066	0.11600

TABLE F3-22
K. W. CAMPBELL: VERTICAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 3.33 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.00169	0.78800	1.09920	0.13900
2	5.00	1	0.00226	0.78800	1.10327	0.13900
3	5.00	5	0.00059	0.79000	0.90037	0.11100
4	5.00	5	0.00091	0.78900	0.91120	0.11300
5	5.80	10	0.00439	0.77300	0.50030	0.11100
6	5.80	20	0.00413	0.77500	0.64680	0.09800
7	6.50	1	0.04151	0.70000	0.50066	0.11500
8	6.50	1	0.05066	0.70000	0.49276	0.11500
9	6.50	1	0.04543	0.70000	0.47348	0.11500
10	6.50	5	0.04417	0.70000	0.56552	0.11500
11	6.50	5	0.02893	0.70000	0.46797	0.11500
12	6.50	50	0.00382	0.70600	0.64162	0.17500
13	6.50	50	0.00483	0.70600	0.91242	0.17500
14	7.00	10	0.03213	0.69200	0.40550	0.12200
15	7.50	50	0.01325	0.69500	0.64421	0.14800
16	7.50	50	0.01634	0.69400	0.81930	0.13600
17	5.00	1	0.00054	0.78900	1.08609	0.11500
18	5.80	5	0.01001	0.77300	0.62674	0.11600
19	5.80	5	0.00531	0.77300	0.58721	0.11000
20	5.00	10	0.00060	0.78900	0.90635	0.11400
21	5.00	10	0.00144	0.78900	0.89639	0.12400
22	5.00	50	0.00009	0.79200	0.90668	0.09600
23	5.00	50	0.00023	0.79200	1.19029	0.09600
24	5.00	160	0.00002	0.79200	0.87387	0.09600
25	5.80	1	0.01268	0.77300	0.66035	0.11600
26	5.80	5	0.01862	0.77300	0.76270	0.11600
27	5.80	5	0.00910	0.77300	0.61134	0.11600
28	5.80	10	0.00463	0.77300	0.55539	0.11600
29	5.80	10	0.00778	0.77300	0.78351	0.11600
30	5.80	10	0.00577	0.77300	0.80086	0.11100
31	5.80	50	0.00049	0.77900	0.91297	0.09300
32	5.80	50	0.00115	0.77900	1.25032	0.09300
33	6.50	5	0.03172	0.70000	0.43275	0.11500
34	6.50	10	0.01918	0.70000	0.41740	0.11500
35	6.50	10	0.02647	0.70000	0.51492	0.11500
36	6.50	10	0.01871	0.70000	0.57109	0.11500
37	6.50	20	0.01011	0.70100	0.50449	0.11800
38	6.50	20	0.01364	0.70000	0.59397	0.11300
39	6.50	20	0.01085	0.70100	0.77483	0.12400
40	6.50	100	0.00143	0.70600	0.85496	0.17500
41	6.50	160	0.00078	0.70600	0.84026	0.17500
42	7.00	1	0.06232	0.69200	0.54459	0.12200
43	7.00	10	0.04550	0.69200	0.51633	0.12200
44	7.00	10	0.03064	0.69200	0.62588	0.12200
45	7.00	50	0.00777	0.69900	0.65102	0.17800
46	7.00	50	0.01012	0.69800	0.81504	0.16500
47	7.50	1	0.08756	0.69100	0.48247	0.12700
48	5.00	10	0.04340	0.69100	0.59736	0.12700
49	5.00	10	0.06419	0.69100	0.67377	0.12700
50	8.00	50	0.02288	0.69300	0.72047	0.12300
51	8.00	160	0.00943	0.69900	0.68016	0.18000

TABLE F3-23
K. W. CAMPBELL: VERTICAL POINT ESTIMATES
PEAK GROUND VELOCITY

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	2.75875	0.70500	0.66526	0.19600
2	5.00	1	3.12226	0.70500	0.61871	0.19600
3	5.00	5	0.93296	0.70300	0.36223	0.13100
4	5.00	5	1.15376	0.70300	0.33082	0.13800
5	5.80	10	2.68354	0.68600	0.24056	0.14200
6	5.80	20	2.62518	0.68600	0.46480	0.10900
7	6.50	1	13.62704	0.60700	0.33457	0.13800
8	6.50	1	15.77485	0.60700	0.45385	0.13800
9	6.50	1	14.60730	0.60700	0.39073	0.13800
10	6.50	5	13.71329	0.60700	0.45010	0.13800
11	6.50	5	10.35880	0.60700	0.33822	0.13800
12	6.50	50	1.23053	0.61200	0.39295	0.15600
13	6.50	50	1.60122	0.61200	0.52679	0.15600
14	7.00	10	10.05228	0.59900	0.24932	0.13800
15	7.50	50	3.60724	0.60100	0.40119	0.13200
16	7.50	50	4.44701	0.59900	0.61452	0.13100
17	5.00	1	1.04033	0.70300	0.44087	0.14400
18	5.80	5	4.45109	0.68600	0.36802	0.15600
19	5.80	5	2.86244	0.68600	0.45573	0.14000
20	5.00	10	1.06252	0.70300	0.30357	0.14000
21	5.00	10	1.80913	0.70300	0.46217	0.16300
22	5.00	50	0.13784	0.70500	0.37517	0.09300
23	5.00	50	0.16999	0.70500	0.37906	0.09300
24	5.00	160	0.02015	0.70500	0.81692	0.09300
25	5.80	1	6.99665	0.68600	0.46941	0.15600
26	5.80	5	7.52566	0.68600	0.55111	0.15600
27	5.80	5	4.73640	0.68600	0.31977	0.15600
28	5.80	10	3.28442	0.68600	0.29801	0.15600
29	5.80	10	5.25751	0.68600	0.46819	0.15600
30	5.80	10	3.00636	0.68600	0.37030	0.14200
31	5.80	50	0.30379	0.69000	0.79816	0.08100
32	5.80	50	0.48754	0.69000	0.76283	0.08100
33	6.50	5	10.76594	0.60700	0.32741	0.13800
34	6.50	10	7.32413	0.60700	0.29354	0.13800
35	6.50	10	10.77394	0.60700	0.44162	0.13800
36	6.50	10	7.03702	0.60700	0.35924	0.13800
37	6.50	20	3.79664	0.60700	0.25600	0.12300
38	6.50	20	5.85031	0.60700	0.49843	0.13200
39	6.50	20	3.79388	0.60700	0.42516	0.11800
40	6.50	100	0.54107	0.61200	0.42789	0.15600
41	6.50	160	0.18701	0.61200	0.84403	0.15600
42	7.00	1	16.87021	0.59900	0.32449	0.13800
43	7.00	10	15.29462	0.59900	0.50730	0.13800
44	7.00	10	9.86153	0.59900	0.37831	0.13800
45	7.00	50	2.26745	0.60600	0.33159	0.14900
46	7.00	50	2.91340	0.60400	0.57051	0.13600
47	7.50	1	21.30142	0.59700	0.57685	0.13900
48	5.00	10	12.61132	0.59700	0.29534	0.13900
49	5.00	10	18.10722	0.59700	0.70412	0.13900
50	8.00	50	5.20460	0.59800	0.59487	0.13300
51	8.00	160	1.69181	0.60600	0.60372	0.15200

APPENDIX F4

EXPERT REPORT ON YUCCA MOUNTAIN GROUND MOTION ATTENUATION

A. McGarr
U.S. Geological Survey
345 Middlefield Road
Menlo Park, CA 94025

APPENDIX F4
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APPENDIX F4

EXPERT REPORT ON YUCCA MOUNTAIN GROUND MOTION ATTENUATION

A. McGarr
U.S. Geological Survey
345 Middlefield Road
Menlo Park, CA 94025

F4-1 INTRODUCTION

The ideal data set for evaluating the design ground motion at Yucca Mountain would have been a set of strong motion records from the scenario earthquakes proposed by the seismic source characterization teams. In the absence of such records, the next best data would be from earthquakes of magnitude greater than 5 within the Basin and Range Province which includes Yucca Mountain; unfortunately, such data are currently limited to records from the 1992 Little Skull Mountain earthquake of M5.7 (e.g. Spudich *et al.*, 1996). Accordingly, it was necessary to evaluate the ground motion for the 51 cases (combinations of magnitude, distance, and style of faulting) using less direct information.

The less specific data, as used here, are of four types: first, empirical ground motion relations for western North America, mostly California; second, empirical ground motion relations for earthquakes in extensional tectonic regimes worldwide; third, the point source model of Silva; fourth, finite faulting models. These four independent categories of ground motion data can all be adapted to the repository circumstances at Yucca Mountain, where we attempt to evaluate the ground motion assuming that the top 300 m of ground have been removed.

As Yucca Mountain is situated within an extensional tectonic regime, one of the background issues is whether earthquakes in extensional regimes produce less ground motion, all other factors being equal, than do earthquakes in more compressive regimes. Empirical studies (e.g., McGarr, 1984; N. A. Abrahamson, consultant, written communication, 1993; Boore *et al.*, 1994; Campbell and Bozorgnia, 1994; and most recently, Spudich *et al.*, 1996) indicate that this is the case and so the point of view taken here is that ground motion from earthquakes in extensional regimes is, indeed, less than elsewhere (e.g., much of California). Moreover, I assume that this is primarily a source effect, which applies to both normal and strike-slip faulting earthquakes within extensional tectonic provinces. This viewpoint, then, is the basis for dividing the empirical relationships into the two categories as just described and also the source corrections discussed later.

Definitions:

μ_{med} is the geometric mean of the ground motion estimates (μ's).

σ_{al} is the geometric mean of the individual σ's for each model.

σ_{μ} is the standard deviation of the μ's.

σ_{σ} is the standard deviation of the σ's.

F4-2 WEIGHTING SCHEME FOR PROPONENT GROUND MOTION MODELS

Among the agreed-upon suite of proponent models, each expert was required to assess each model for its applicability to the various scenario earthquake, frequency, distance, component combination. To calculate weighted medians of the ground motion parameters, as well as the various measures of uncertainty, the proponent models were divided into different classes, each of which was assigned a weight. then within each class, individual models were assigned weights. A summary of the actual nonzero weights for classes and models is given in the "Summary Table of Weights" (F4-2.4).

F4-2.1 Classes Of Proponent Models

I defined four classes of proponent models: (1) Empirical (California), (2), Empirical (Extensional), (3) Point source numerical simulations, and (4) Finite fault numerical simulations. the empirical (CA) models are attenuation relations based on data primarily from California (Abrahamson and Silva, 1997; Boore *et al.*, 1997; Campbell, 1997; Idriss, University of California, Davis, written communication, 1991; and Sadigh *et al.*, 1997. The empirical (ext.) models are attenuation relations developed from ground motion recordings of earthquakes in extensional tectonic regimes (Spudich *et al.*, 1996; Abrahamson and Silva, 1997; McGarr, 1984). The Sabetta and Pugliese (1996) model, an empirical relation based on Italian earthquakes, falls into neither of the two empirical classes, but, for reasons to be given, was considered and not used here. Models developed from nuclear explosion data at the Nevada Test Site (R. J. Bennett *et al.,* S-Cubed, written communication, 1997)) are also in the empirical category but, as will be explained, played no role in the point estimates of ground motion. For the point source simulation class the only available model was that developed by W. Silva. The finite fault simulation class includes three quite different models developed by Y. Zeng and J. Anderson, P. Somerville, and W. Silva (N. A. Abrahamson and A. M. Becker, Consultants, written communication, 1997b).

The four classes of models are weighted equally, primarily because each is unique and independent in its set of approaches to point ground motion estimates. Similar remarks apply to the corresponding weights for uncertainties. In the absence of information suggesting superiority of a particular class or classes, it seems advisable to adhere to equal class weights.

F4-2.2 Model Weights: Horizontal Component

Within each class, for a particular model, the medians and various uncertainties receive the same weights. This is because there was no reason to suppose that the strengths or weaknesses of any model of ground motion median estimates would not apply also to the associated uncertainties.

In the following sections, the discussion of models is organized according to the four classes, described before; models assigned a weight of zero are discussed afterward. Adjustments for each model are discussed at the same time.

F4-2.2.1 Empirical Models.

F4-2.2.1.1 Empirical (CA) Models

Adjustments: Campbell Table 8.3.2 (Data Package Vol. 1) for CA to YM_{300}; Silva Table 7.3 (ibid.) for stress drop, where YM/CA=42.5/57 (Becker and Abrahamson, 1997).

Models used:

Abrahamson and Silva (1997, strike-slip only). This model was assigned a weight of 1 because it is based on an up-to-date, appropriate data set. The strike-slip predictions are used for both strike-slip and normal events. The normal faulting factors presented in the Data Package Vol. 1 are not used. Rather, the source scaling from the point source model is used instead. This model was used for all SA's and PGA's and is applicable to all magnitudes and distances under consideration.

Boore, Joyner, Fumal (1997, Vs-620m/s). Again, this model was assigned weight 1 because it is based on a very modern, appropriate data set. The velocity of 620 m/s is used to be consistent with the average rock site for California which is used as the basis for the crust/site adjustment factor. It was used for all SA's and PGA's. For f=20 Hz, I arithmetically averaged the b coefficients for PGA and f=10 Hz values to interpolate. Of the various Boore, Joyner, Fumal relations under consideration, this is the one recommended by the authors.

Campbell (1997, soft rock). This is based on an appropriate data set and is the most modern of all the Campbell models. I used it for all SA's, PGA's, and PGV's. In contrast to Campbell (1997, hard rock), the soft rock sites are deemed to be more typical of California sites. Additionally, this model is recommended by the author from amongst his various regression models and so is was assigned a weight of 1.

Idriss (University of California, Davis, written communications, 1991, 1997). Idriss used an independent method of fitting a regression curve to ground motion data recorded at rock sites. I used this model for all SA's. Idriss 97 was used for PGA's. Thus the Idriss models were assigned a weight of 1.

Sadigh et al. (1993). Sadigh used another independent method of fitting a curve to ground motion data recorded at typical California rock sites. This model, with a weight of 1, was used for all SA's and PGA's.

Joyner-Boore (1988). I used this venerable model with a weight of 1 for PGV's only because of the scarcity of trustworthy models that yield PGV. For the SA's and PGA's BJF '97 is far more up-to-date.

F4-2.2.1.2 Empirical (Extensional) Models

Adjustments: CA to YM_{300} as for F4-2.2.1.1, no stress drop correction.

Models used:

Spudich et al. (1996). This model, assigned a weight of 1, is exceptionally appropriate as it is based on ground motion data exclusively from earthquakes in extensional regimes. I used this model for all SA's and PGA's. For f=20 Hz I arithmetically averaged the b coefficients for PGA and f=10 Hz to calculate 20 Hz SA for purposes of interpolation.

Abrahamson and Silva (1997, normal faulting events). This model, also assigned weight 1, is appropriate here in that it is based on a subset of normal-faulting earthquakes from A&S '97. This was used for all SA's and PGA's.

McGarr (1984, extensional). I used this model for PGV for those cases for which epicentral distance is less than or comparable to hypocentral depth, which is taken to be at the bottom of the rupture zone. These values are tabulated on p. 4.1.4-1 of Data Package Vol. I and were calculated from equation (16a) of McGarr (1984). No adjustments are applied because the data used to develop this model are mostly from rock sites having Vs at least as high as 1900 m/s. The aleatory uncertainty is assumed to be 0.5. This relation was used partly because it is one of the few that yield PGV and is based on a very independent data set.

F4-2.2.1.3 Empirical Models Assigned Weight Zero

All Campbell models except Campbell '97 (soft rock), because these are either redundant or inappropriate. Moreover, the author recommended Campbell (1997, soft rock).

All Boore-Joyner-Fumal except BJF Vs because of redundancy, based on recommendations of the authors.

Sabetta and Pugliese because this is quite an old data set (no post-1985 data), many S wave triggers (see Spudich *et al.*, 1996) and the site characteristics are exceptionally uncertain.

F4-2.2.2 Numerical Simulations. There are two distinct types of numerical simulations, point sources and finite fault. Both are appropriate for YM300 conditions.

F4-2.2.2.1 Point Source Simulation (Silva)

This model was assigned a weight of 1 for all ground motion estimates with YM_{300} site conditions and the YM stress drop of 42.5 bars. The empirical PGV/PGA (8.6.1-1 of Data Package Vol. 1) was used to calculate PGV. Aleatory uncertainty for stress drop is taken as 0.5. For the SS and HW cases, the point source distance is the vector sum of the JB distance and the depth to the center of the rupture plane. For the FW cases, this distance is the slant distance to the center of the rupture plane.

F4-2.2.2.2 Finite Fault Simulations

The following three models were weighted equally in this class because they are all quite independent, with unique strengths and weaknesses.

Somerville Finite (Somerville *et al.*, 1997). This model was used for all ground motion estimates for M(5.8. Its main advantage is that it take rupture directivity into account. There may be some problems at low frequency, however, resulting in unrealistically low ground motion estimates. I finally elected to use these results in spite of the apparent problems that surfaced at the May 7, 1997, meeting at Woodward-Clyde.

Silva Finite. This model, an extension of his point source model, was used for all ground motion point estimates of M≥5.8.

Anderson composite finite fault (Zeng and Anderson, 1996). This model was used for all point estimates. The advertised aleatory uncertainty is unrealistically low and should be increased, perhaps by taking stress drop uncertainty into account. Some of the resulting point estimates are remarkably high suggesting possibly some instability.

Note: For all finite fault models, a YM/CA stress drop correction was applied.

F4-2.2.3 Blast Models. These models, even though they are the only models local to Yucca Mountain, were assigned zero weight because they yield results that are unrealistically large at small epicentral distances. Moreover, the Rg phase dominates the blast data in a way that would not be expected for earthquakes, unless exceptionally shallow.

F4-2.2.4 Horizontal Component Variability. For all models that yield the average horizontal component, the aleatory uncertainty is increased by vector addition of the average of the two factors given in Table 4.1.2 of Data Package Vol. 1.

F4-2.3 Model Weights - Vertical Component

The class weighting scheme is the same as for the horizontal components. Within each of the classes, as before, models are weighted equally. Fewer models are available, however.

F4-2.3.1 Empirical (CA) Models.

Models used:

Abrahamson and Silva (1997, strike-slip).

Campbell (1997, soft rock).

Sadigh.

F4-2.3.2 Empirical (Extensional) Models.

Models used:

Abrahamson and Silva (1997, normal).

F4-2.3.3 Point Source Model.

Silva. To calculate the vertical component, I used the Silva point source ratio Z/H.

F4-2.3.4 Finite Fault Models.

Models used:

Somerville for M(5.8.

Anderson.

F4-2.3.5 Adjustments. The source adjustment is the same as for the horizontal component. For the site/path adjustment, I used Walck's formula:

$$\mu_{YMZ} = \mu_{CAZ} \times (YM_H/CA_H) \times (YM_Z/YM_H) \times (CA_H/CA_Z)$$

where the first factor is the Campbell adjustment, the second is the Silva point source ratio, and the third is the empirical model H/Z. Admittedly, this may amount to over analysis inasmuch as, from a few trials, I find the product of the last two factors is close to 1.

F4-2.4 Summary Table of Weights

HORIZONTAL

Class, Model	Class Wt.	Wt.	CA to YM300	Stress Drop
Empirical (CA)	1			
A&S '97 (SS)		1	Y	Y
BJF 97 Vs=620 m/s		1	Y	Y
Campbell 97 (soft rock)		1	Y	Y
Idriss 97		1	Y	Y
JB 88 (PGV only)		1	Y	Y
Sadigh		1	Y	Y
Empirical (ext.)	1			
Spudich		1	Y	N
A&S 97 (N)		1	Y	N
McGarr 84 (PGV only)		1	N	N
Pt. Source	1			
Silva (Use V/A for PGV)		1	N	N
Finite Source	1			
Anderson		1	N	Y
Silva		1	N	Y
Somerville		1	N	Y

Adjustments: Use Campbell Table 8.3.2 (Data Package Vol. 1) for CA to YM300.
Use Silva Table 7.3 (ibid.) for stress drop, where YM/CA is 42.5 bars/57 bars.

VERTICAL

Class, Model	Class Wt.	Wt.	CA to YM300	Stress Drop	Z/H
Empirical (CA)	1				
A&S '97 (SS)		1	Y	Y	N
Campbell '97 (soft rock)		1	Y	Y	N

Class, Model	Class Wt.	Wt.	CA to YM300	Stress Drop	Z/H
Sadigh		1	Y	Y	N
Empirical (ext.)	1				
A&S 97 (N)		1	Y	N	N
Pt. source	1				
Silva		1	N	N	Y

Class, Model	Class Wt.	Wt.	CA to YM300	Stress Drop	Z/H
Finite source	1				
Somerville (M>5.79)		1	N	Y	N
Anderson		1	N	Y	N

Adjustments: For CA to YM300, use Walck's formula.
For Stress drop, same as for H.
For Silva pt. source, use Silva pt. source ratio Z/H
For Silva pt. source PGV(Z), use Silva empirical. V/A.

F4-3 ADJUSTMENTS TO WEIGHTED POINT ESTIMATES

There were none. Previously, I considered using the precarious boulder results to limit PGA but finally decided that, at this time, such an adjustment is not warranted.

F4-4 EPISTEMIC UNCERTAINTY

Based on my weighting scheme, the epistemic uncertainties (σ_μ and σ_σ) were computed by the facilitation team. These statistical estimates were not altered.

F4-5 FINAL POINT ESTIMATES

After making the adjustments to the weighted estimates as described above, my final point estimates of m, s, s_m, and s_s for the horizontal component for the 51 cases are given in Tables F4-1 to F4-9 for the nine ground motion parameters. The corresponding point estimates for the vertical component are given in Tables F4-10 to F4-18.

F4-6 EVALUATION OF REGRESSION MODELS

The facilitation team developed regression models to parameterize my point estimates in terms of the dependence on magnitude, distance, and style-of-faulting. I reviewed the final regression models given in Volume 11D of the data package.

F4-6.1 Mu

Regression fits look fine; in the case of PGA the regressions allow for magnitude saturation at small distances. No distinction was made between HW and FW for normal faults.

F4-6.2 Sigma

Regression fits look fine.

F4-6.3 Sigma mu

These regressions include distance dependence only. The point estimates did not argue persuasively for magnitude dependence. For the distance dependence the quadratic fit seems fine.

F4-6.4 Sigma sigma

The regression fits look good.

F4-7 SPECIAL CASES

The ground motion models developed in this study are for "typical" events that cover the majority of the source models developed by the source experts. There are two source models that have geometries significantly different from those considered in developing the base models. These are simultaneous rupture of multiple parallel faults (local events) and a low angle fault. These two cases are discussed below.

F4-7.1 Multiple Parallel Faults

Parallel simultaneous ruptures:

(1) For given M, calculate M_o from $\log M_o = 16.05 + 1.5M$.

(2) Distribute M_o evenly among multiple faults, $M_o = nM_{of}$.

(3) Calculate $M_f = (\log M_{of} - 16.05)/1.5$, which is the magnitude of each individual event on a single fault.

(4) Calculate ground motion using previous rules assuming that only nearest fault contributes significantly to mu.

(5) Enlarge aleatory sigma by 20% to account for possibility of constructive or destructive interference from other ruptures.

F4-7.2 Low Angle Fault

Deep detachment surface:

(1) Treat exactly as for normal fault dip-slip cases using same rules. Assume hypocenter is at deepest part of fault plane.

(2) Enlarge epistemic sigma by 30% to account for stress drop uncertainty.

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TABLE F4-1
A. McGARR: HORIZONTAL POINT ESTIMATES
PEAK GROUND ACCELERATION

Case No.	Magnitude	Distance (km)	Mu	Sigma	Sigma Mu	Sigma Sigma
1	5.00	1	0.12521	0.65221	0.36507	0.08907
2	5.00	1	0.16195	0.65688	0.35962	0.08844
3	5.00	5	0.04721	0.65455	0.34109	0.08867
4	5.00	5	0.06612	0.65688	0.33346	0.08844
5	5.80	10	0.08551	0.61124	0.17324	0.08753
6	5.80	20	0.06749	0.61054	0.18911	0.08769
7	6.50	1	0.38603	0.58723	0.31804	0.09205
8	6.50	1	0.41976	0.58821	0.41766	0.09326
9	6.50	1	0.32315	0.58899	0.31122	0.09278
10	6.50	5	0.35842	0.58517	0.38397	0.09139
11	6.50	5	0.20904	0.58886	0.24898	0.09277
12	6.50	50	0.02673	0.58466	0.22833	0.09132
13	6.50	50	0.02805	0.58440	0.24146	0.09129
14	7.00	10	0.22608	0.56513	0.26768	0.10192
15	7.50	50	0.05498	0.56414	0.20112	0.10674
16	7.50	50	0.06200	0.56229	0.24435	0.10568
17	5.00	1	0.04642	0.65221	0.61058	0.08907
18	5.80	5	0.13838	0.61182	0.23658	0.08744
19	5.80	5	0.07490	0.61144	0.28809	0.08750
20	5.00	10	0.05700	0.65455	0.14223	0.08867
21	5.00	10	0.07695	0.65221	0.22216	0.08907
22	5.00	50	0.00598	0.65221	0.35455	0.08907
23	5.00	50	0.00622	0.64989	0.40264	0.08966
24	5.00	160	0.00085	0.64757	0.62439	0.09042
25	5.80	1	0.25314	0.61200	0.34501	0.08777
26	5.80	5	0.22326	0.61085	0.35782	0.08761
27	5.80	5	0.12140	0.61105	0.23108	0.08757
28	5.80	10	0.10672	0.61402	0.21330	0.08838
29	5.80	10	0.15274	0.61105	0.28354	0.08757
30	5.80	10	0.07145	0.61168	0.27983	0.08784
31	5.80	50	0.01202	0.60888	0.46203	0.08747
32	5.80	50	0.01276	0.61138	0.49412	0.08751
33	6.50	5	0.28242	0.58588	0.29242	0.09153
34	6.50	10	0.17872	0.58700	0.25296	0.09198
35	6.50	10	0.27834	0.58663	0.36760	0.09189
36	6.50	10	0.13346	0.58535	0.23886	0.09142
37	6.50	20	0.08861	0.58472	0.20556	0.09132
38	6.50	20	0.12521	0.58738	0.28025	0.09210
39	6.50	20	0.06728	0.58365	0.21823	0.09100
40	6.50	100	0.01139	0.58477	0.27506	0.09165
41	6.50	160	0.00509	0.58978	0.42529	0.09537
42	7.00	1	0.43269	0.56843	0.28894	0.10330
43	7.00	10	0.34164	0.56933	0.34762	0.10381
44	7.00	10	0.16714	0.56467	0.19750	0.10182
45	7.00	50	0.04034	0.56398	0.18777	0.10157
46	7.00	50	0.04529	0.56506	0.22353	0.10189
47	7.50	1	0.50870	0.57305	0.35356	0.11543
48	5.00	10	0.27447	0.56890	0.31262	0.11172
49	5.00	10	0.40176	0.56454	0.45398	0.10676
50	8.00	50	0.07201	0.57128	0.25320	0.10191
51	8.00	160	0.01924	0.56732	0.25924	0.09901

TABLE F4-2
A. MCGARR: HORIZONTAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.05 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.23293	0.66080	0.53004	0.08395
2	5.00	1	0.29505	0.66316	0.32601	0.08334
3	5.00	5	0.08674	0.66316	0.38582	0.08334
4	5.00	5	0.11470	0.66552	0.20912	0.08293
5	5.80	10	0.15173	0.61921	0.24388	0.08527
6	5.80	20	0.11579	0.61648	0.23319	0.08521
7	6.50	1	0.69176	0.59350	0.35426	0.09081
8	6.50	1	0.75147	0.59408	0.41858	0.09196
9	6.50	1	0.53598	0.59335	0.31652	0.09071
10	6.50	5	0.65316	0.59064	0.44026	0.09047
11	6.50	5	0.34934	0.59205	0.33485	0.09031
12	6.50	50	0.03900	0.59007	0.29150	0.09011
13	6.50	50	0.04112	0.58974	0.32908	0.09012
14	7.00	10	0.38444	0.56893	0.29561	0.10206
15	7.50	50	0.07665	0.56861	0.27704	0.10699
16	7.50	50	0.08700	0.56660	0.32435	0.10597
17	5.00	1	0.08549	0.66080	0.66347	0.08395
18	5.80	5	0.24437	0.61704	0.28170	0.08459
19	5.80	5	0.12224	0.61707	0.38088	0.08497
20	5.00	10	0.10528	0.67265	0.23115	0.08291
21	5.00	10	0.14528	0.66316	0.26277	0.08334
22	5.00	50	0.00928	0.65844	0.36660	0.08475
23	5.00	50	0.00956	0.65844	0.43628	0.08475
24	5.00	160	0.00109	0.65140	0.50966	0.08823
25	5.80	1	0.47237	0.61749	0.41806	0.08482
26	5.80	5	0.41845	0.61941	0.42099	0.08585
27	5.80	5	0.20604	0.61882	0.35046	0.08541
28	5.80	10	0.19151	0.62056	0.29376	0.08616
29	5.80	10	0.27510	0.61709	0.34532	0.08496
30	5.80	10	0.11927	0.61628	0.40227	0.08483
31	5.80	50	0.01813	0.61663	0.54892	0.08514
32	5.80	50	0.01913	0.61787	0.59579	0.08517
33	6.50	5	0.50520	0.58919	0.32942	0.08966
34	6.50	10	0.31751	0.59391	0.27829	0.09146
35	6.50	10	0.50069	0.59127	0.42177	0.09018
36	6.50	10	0.21820	0.59235	0.33193	0.09089
37	6.50	20	0.14804	0.59224	0.24508	0.09140
38	6.50	20	0.21267	0.59329	0.31691	0.09099
39	6.50	20	0.10410	0.58962	0.33092	0.09013
40	6.50	100	0.01417	0.58916	0.34145	0.09018
41	6.50	160	0.00617	0.58953	0.45208	0.09014
42	7.00	1	0.77515	0.57360	0.33274	0.10364
43	7.00	10	0.60359	0.57481	0.41314	0.10425
44	7.00	10	0.26677	0.56963	0.28680	0.10234
45	7.00	50	0.05781	0.56766	0.24226	0.10184
46	7.00	50	0.06584	0.56905	0.28245	0.10209
47	7.50	1	0.88934	0.57933	0.41930	0.11669
48	5.00	10	0.46035	0.57421	0.36960	0.11271
49	5.00	10	0.67955	0.56907	0.53377	0.10698
50	8.00	50	0.09587	0.57771	0.36158	0.10204
51	8.00	160	0.02048	0.57158	0.35635	0.09867

TABLE F4-3
A. McGARR: HORIZONTAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.10 SEC PERIOD

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.25255	0.69718	0.44454	0.09060
2	5.00	1	0.32633	0.69235	0.52935	0.08843
3	5.00	5	0.09517	0.69718	0.23287	0.09060
4	5.00	5	0.13543	0.69476	0.31223	0.08942
5	5.80	10	0.17258	0.63608	0.20009	0.09041
6	5.80	20	0.13523	0.63645	0.24725	0.09045
7	6.50	1	0.78402	0.61132	0.34662	0.09768
8	6.50	1	0.86727	0.61082	0.47691	0.09780
9	6.50	1	0.64324	0.61224	0.32901	0.09816
10	6.50	5	0.72461	0.60718	0.43661	0.09500
11	6.50	5	0.41271	0.61035	0.22043	0.09668
12	6.50	50	0.04951	0.60797	0.27267	0.09531
13	6.50	50	0.05196	0.60752	0.27543	0.09485
14	7.00	10	0.44550	0.58653	0.32080	0.10659
15	7.50	50	0.09464	0.58748	0.33134	0.11387
16	7.50	50	0.10794	0.58367	0.36506	0.11095
17	5.00	1	0.09623	0.68753	0.44076	0.08701
18	5.80	5	0.28199	0.63704	0.25552	0.09056
19	5.80	5	0.14624	0.63629	0.30596	0.08999
20	5.00	10	0.11520	0.69718	0.29476	0.09060
21	5.00	10	0.15661	0.68753	0.35325	0.08701
22	5.00	50	0.01123	0.69235	0.24848	0.08843
23	5.00	50	0.01160	0.68753	0.31549	0.08701
24	5.00	160	0.00126	0.68032	0.42887	0.08637
25	5.80	1	0.51208	0.63819	0.40882	0.09128
26	5.80	5	0.46240	0.63666	0.40126	0.09048
27	5.80	5	0.23657	0.63776	0.24428	0.09180
28	5.80	10	0.21123	0.63729	0.27558	0.09178
29	5.80	10	0.30405	0.63639	0.35997	0.09044
30	5.80	10	0.13817	0.63388	0.26457	0.08927
31	5.80	50	0.02273	0.63601	0.45063	0.09040
32	5.80	50	0.02374	0.63664	0.52169	0.09105
33	6.50	5	0.57705	0.60969	0.32333	0.09624
34	6.50	10	0.36264	0.60921	0.28539	0.09621
35	6.50	10	0.57040	0.60836	0.42752	0.09584
36	6.50	10	0.25955	0.60869	0.19739	0.09597
37	6.50	20	0.17680	0.60642	0.24853	0.09437
38	6.50	20	0.24544	0.60855	0.31811	0.09542
39	6.50	20	0.12707	0.60752	0.19069	0.09512
40	6.50	100	0.01796	0.60586	0.36022	0.09419
41	6.50	160	0.00723	0.60612	0.43847	0.09427
42	7.00	1	0.87781	0.58919	0.33754	0.10839
43	7.00	10	0.67820	0.59070	0.41991	0.10963
44	7.00	10	0.32068	0.58695	0.15892	0.10695
45	7.00	50	0.07216	0.58496	0.27582	0.10566
46	7.00	50	0.08242	0.58705	0.30345	0.10690
47	7.50	1	0.98266	0.59546	0.43184	0.12326
48	5.00	10	0.52439	0.59037	0.40456	0.11804
49	5.00	10	0.76957	0.58686	0.52580	0.11330
50	8.00	50	0.11603	0.60112	0.43406	0.11027
51	8.00	160	0.02186	0.59392	0.45212	0.10429

TABLE F4-4
A. McGARR: HORIZONTAL POINT ESTIMATES
SPECTRAL ACCELERATION AT 0.20 SEC PERIOD

Case No.	Magnitude	Distance (km)	Mu	Sigma	Sigma Mu	Sigma Sigma
1	5.00	1	0.19209	0.72598	0.41417	0.08696
2	5.00	1	0.24739	0.73070	0.50903	0.08878
3	5.00	5	0.07508	0.72127	0.26024	0.08588
4	5.00	5	0.10545	0.71892	0.27923	0.08563
5	5.80	10	0.15816	0.67162	0.18066	0.09110
6	5.80	20	0.12788	0.66737	0.24396	0.08916
7	6.50	1	0.70120	0.64193	0.37011	0.09346
8	6.50	1	0.76870	0.64650	0.47601	0.09669
9	6.50	1	0.61049	0.65056	0.36481	0.09957
10	6.50	5	0.65317	0.64284	0.42569	0.09448
11	6.50	5	0.40377	0.64394	0.22869	0.09441
12	6.50	50	0.05392	0.64204	0.28184	0.09350
13	6.50	50	0.05702	0.63967	0.24439	0.09231
14	7.00	10	0.43035	0.62164	0.32298	0.10382
15	7.50	50	0.11023	0.62069	0.33856	0.10927
16	7.50	50	0.12589	0.61824	0.34846	0.10761
17	5.00	1	0.07250	0.71657	0.52574	0.08558
18	5.80	5	0.24240	0.66910	0.27668	0.08997
19	5.80	5	0.14288	0.66855	0.23413	0.08953
20	5.00	10	0.09217	0.72127	0.24548	0.08588
21	5.00	10	0.12207	0.71892	0.32175	0.08563
22	5.00	50	0.01152	0.72598	0.20731	0.08696
23	5.00	50	0.01103	0.71423	0.35588	0.08571
24	5.00	160	0.00174	0.71892	0.40683	0.08563
25	5.80	1	0.43222	0.66884	0.39554	0.08998
26	5.80	5	0.38759	0.66833	0.38931	0.09002
27	5.80	5	0.21960	0.66925	0.20678	0.08997
28	5.80	10	0.18907	0.67081	0.26835	0.09052
29	5.80	10	0.26709	0.66775	0.34321	0.08916
30	5.80	10	0.13500	0.67086	0.19482	0.09108
31	5.80	50	0.02347	0.66950	0.46958	0.08997
32	5.80	50	0.02609	0.66923	0.41429	0.08997
33	6.50	5	0.52340	0.64079	0.32970	0.09270
34	6.50	10	0.33299	0.64382	0.27829	0.09447
35	6.50	10	0.50803	0.64253	0.40365	0.09357
36	6.50	10	0.26164	0.64028	0.19585	0.09247
37	6.50	20	0.17085	0.64243	0.24444	0.09394
38	6.50	20	0.24507	0.64119	0.31662	0.09324
39	6.50	20	0.13636	0.64179	0.16381	0.09321
40	6.50	100	0.02201	0.64092	0.34995	0.09317
41	6.50	160	0.00975	0.64254	0.42500	0.09441
42	7.00	1	0.80047	0.62368	0.35782	0.10505
43	7.00	10	0.63776	0.62357	0.39741	0.10504
44	7.00	10	0.33463	0.62047	0.18668	0.10327
45	7.00	50	0.08216	0.62060	0.28265	0.10333
46	7.00	50	0.09307	0.62093	0.28406	0.10347
47	7.50	1	0.95190	0.62808	0.45612	0.11687
48	5.00	10	0.53334	0.62652	0.41618	0.11545
49	5.00	10	0.74366	0.61879	0.49779	0.10793
50	8.00	50	0.13531	0.63335	0.42231	0.10312
51	8.00	160	0.02984	0.62857	0.48561	0.09967