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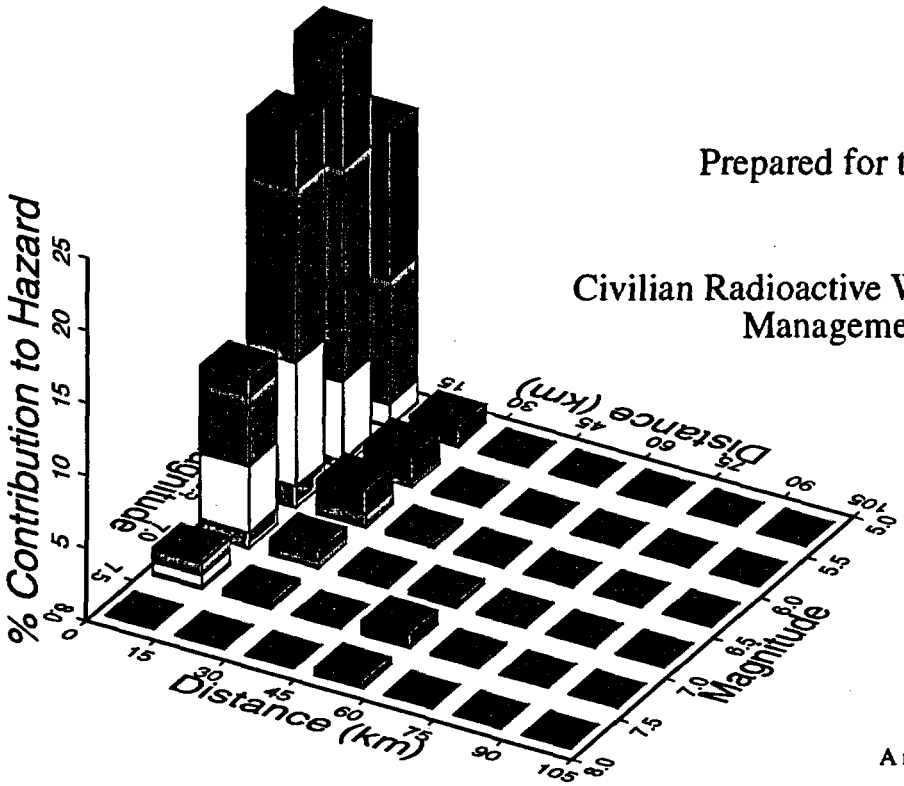
PROBABILISTIC SEISMIC HAZARD ANALYSES FOR FAULT DISPLACEMENT AND VIBRATORY GROUND MOTION AT YUCCA MOUNTAIN, NEVADA

FINAL REPORT
VOLUME 3
APPENDICES



Prepared for the U.S. Geological Survey

by the

Civilian Radioactive Waste Management System
Management & Operating Contractor

Ivan G. Wong and J. Carl Stepp
Report Coordinators

A report to the U.S. Department of Energy
that fulfills Level 3 Milestone SP32IM3
WBS Number 1.2.3.2.8.3.6

Prepared in cooperation with the U.S. Department of Energy
under Interagency Agreement DE-AI08-92NV 10874
Contract DE-AC04-94AL85000

Oakland, California
23 February 1998

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APPENDIX F

GROUND MOTION
EXPERT ELICITATION SUMMARIES

The following ground motion expert interpretations have received review by PSHA Review Panel members in accordance with quality assurance approved PSHA Project Plan requirements, but have not been reviewed for conformity with Department of the Interior, U.S. Geological Survey standards.

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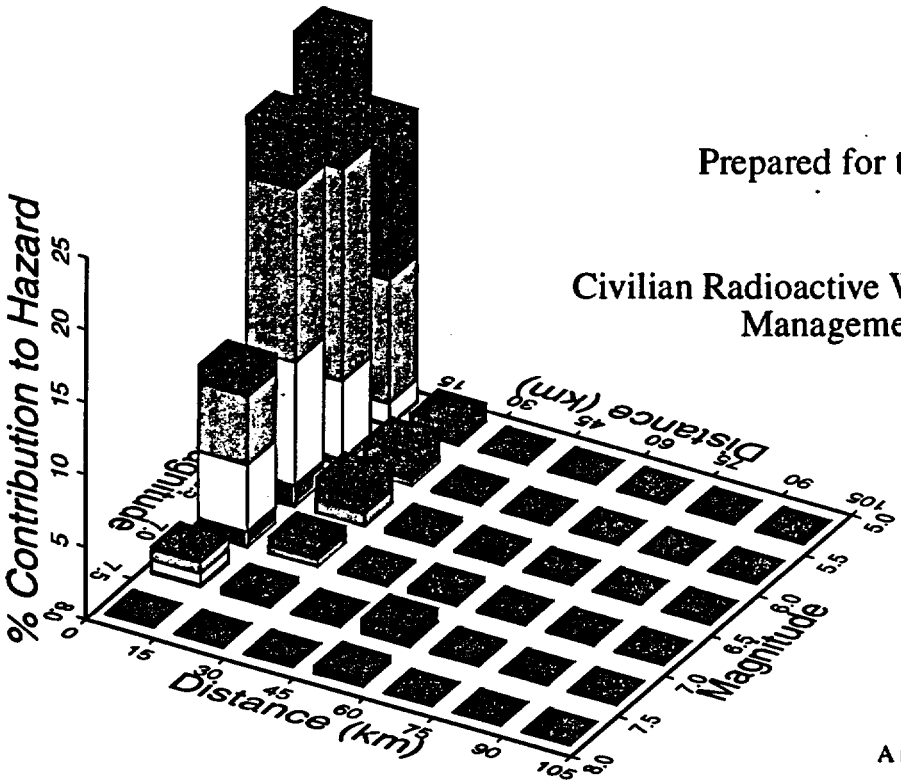

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APPENDIX F1

GROUND MOTIONS FOR THE YUCCA MOUNTAIN VICINITY, SOUTHERN NEVADA

John G. Anderson

APPENDIX F1
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APPENDIX F1

GROUND MOTIONS FOR THE YUCCA MOUNTAIN VICINITY, SOUTHERN NEVADA

John G. Anderson

F1-1 INTRODUCTION

In Fall, 1994, I was selected to be on a panel of "ground motion experts" with the responsibility to develop estimates of ground motions needed to prepare a licensing application for the proposed nuclear waste repository at Yucca Mountain, in southern Nevada. The panel met once in the spring of 1995, then due to funding and political considerations took a year off during FY 1996. The panel became active again early in 1997. Altogether, we met three times in Salt Lake City and twice in Oakland to compare approaches and share information. My stack of paper associated with this panel, if organized onto a single bookshelf, would take at least 1.3 meters of space, and the page count would be on the order of 6000 pages.

Ultimately, the panel was asked to prepare estimates of ground motions for 51 specified combinations of earthquake source and station location. The earthquake source was specified by moment magnitude, using Hanks and Kanamori (1979) as a definition to relate moment magnitude to seismic moment. The fault orientation and mechanism were given. The station location was also given. For each of these 51 combinations, each member of our panel was asked to provide his best estimate of nine ground motion parameters. These parameters were to be specified for both a random horizontal component and a vertical component. The ground motion parameters for each of these components were to be given together with three uncertainty values. To be specific, the mean estimate will be called 'mu', μ, the standard deviation of the data relative to this mean is 'sigma', σ, the uncertainty on the mean value is 'sigma-mu', σ_μ, and the uncertainty on the standard deviation is 'sigma-sigma', σ_σ. Thus the number of numbers to be specified by each expert is:

51 cases x 2 components/case x 9 parameters / component x 4 numbers / parameter
= 3672 numbers.

Information supplied to each expert included several "proponent models", in which people who have studied ground motions at Yucca Mountain provided the predictions of their model. Some of these models are empirical regressions, and some are physical models. To make the problem more tractable, I began by developing my estimates from weighted averages of some of these "proponent models". After the implications of these weighted averages were studied, I modified the input to some of the weighted averages, and then the point values themselves.

This report contains my personal evaluation of various proponent models, followed by my weighting scheme. I discuss reasons for modifying my weighting scheme and then my point estimates in some cases to produce my final point estimates.

F1-2 WEIGHTING SCHEME

The weighting scheme used to develop the preliminary point estimates is given in this section. I used the approach of first dividing the proponent models into model classes and then assigning weights to each class and to each model within a class consistent with the methodology described in Section 3.3.

F1-2.1 Model Classes

I divided the proponent models into two classes. My weighting scheme by class is as follows:

Synthetic models: 0.65
Empirical regressions: 0.35

My reasoning for this weighting is as follows:
First, I consider that the synthetic models are successful in fitting observations of ground motions where there are adequate data. Thus for these situations, it should make little difference whether one uses regressions or synthetic models. However, for some

combinations of magnitudes and distances, we are using a regression or synthetic seismogram model to extrapolate beyond the reaches of abundant data. In these situations, I trust the synthetics more for extrapolation than I trust regressions. While I recognize that the physical models for the synthetics are incomplete, there is no physical model at all behind the empirical regressions. Thus I have no reason at all to trust them for extrapolation.

Second, there is another type of extrapolation in our problem, and that is the extrapolation to a very specific site condition. For the regressions, it is necessary to make a very complicated set of adjustments to obtain those conditions. The regressions are dominantly developed for strike-slip and thrust earthquakes in a compressional environment, while the Yucca Mountain region has strike-slip and normal earthquakes in an extensional environment. The difference between a horizontal and vertical orientation for the maximum compressive stress is not explicitly taken into account in any of the models. However, our panel was presented with one study (Becker and Abrahamson 1997) indicating that on average the stress drop (defined in a special way) is smaller in extensional environments. Thus the panel was given the option to adjust regressions for this difference in average stress drops. There is a second adjustment to the regressions for the difference between the specific site condition in our project and the "average site condition" for the stations used to develop the regressions. This adjustment includes Q. Yet another adjustment for the regressions comes from the shortage of regressions for peak velocity or vertical components. One "fix" is to use ratios of these parameters to horizontal components, combined with a "trustworthy" horizontal regression. I am not aware of any documented studies which demonstrate that these adjustments are successful, although I do not see any major flaws in the physical reasoning behind them. Still, every time another adjustment is applied, more uncertainties are introduced. In contrast, the physical models do not require adjustments to calculate ground motions because the source and site condition can be input directly. Thus, the physical models are two or more steps more direct, a feature that I appreciate.

F1-2.2 Model Weights - Horizontal Component

I specified a weighting approach designed to include the full range of all of the models, and also put more emphasis on one or more preferred models. This approach is used for both the empirical regressions and the numerical simulation models.

To include the full range of the models, the probability distribution is considered to be a uniform distribution between the smallest (Ymin) and largest (Ymax) proponent model that I considered to be "qualified" as discussed below. (The uniform distribution is on the natural logarithm of the ground motion.) The median for this approach is given by the geometric mean of the largest and smallest proponent models. The epistemic uncertainty is computed from the standard deviation of the "boxcar" shaped probability distribution which is given by 0.29 ln(Ymax/Ymin). The second approach is based on my preferred model or models and is intended to give additional weight to the models that I believe to be most applicable.

The same weights are used for both the median (μ) and the aleatory uncertainty (σ).

F1-2.2.1 Empirical Models. In evaluating the empirical regressions, I look for models that are as consistent as possible with the physics of earthquakes as I understand it. My own studies indicate that the shape of regression curves ought to change with magnitude: large events ought to have a less rapid decay with distance than small events. The interaction of fault size and duration, and complexity in the Green's function, can cause varying rates of decay with distance that defy any simplistic $R^{-\gamma}$ model. Saturation is expected at short distances as magnitude increases, but it is not expected at large distances. I also expect regressions to show some nonlinear behavior in their relationship between soil and rock ground motions, although I consider this to be a weaker constraint. We are predicting motions on rock. The way soil/rock behavior is built in, however, is of the highest consequence because the majority of the available data constraining these regressions is recorded on soft sites. Thus the regressions will tend to follow the available soil data more closely, and misfit on the few rock sites can be difficult to distinguish from natural variability.

<u>Abrahamson and Silva (1997) regression</u>. This regression model is generally consistent with my expectations, both for magnitude-distance behavior, and in its ratio of soil/rock motions. In our tests on southern California data, it performs very well at all periods, although at 1 sec and 3 sec, its fit to the data is not as impressive as for PGA and SA at 0.3 Hz. I consider this model to be qualified. It is also my preferred model for the second approach.

Boore, et al. (1997); Spudich et al. (1997) regressions. These "USGS class" regressions do a very good job of fitting the data also. However, they do not allow for a variable ratio between soil and rock, or for a magnitude-dependent shape. The unusual definition of distance may in part compensate for the lack of magnitude-dependent shape, but I do not see a physical justification for using it. Thus, although I consider that it is crucial to take their predictions into account within my range of uncertainties, I feel less confident in using any of these to extrapolate to situations where there are little data. I consider these models to be qualified but not as preferred models.

Campbell regressions (1990, 1993/1994, 1997). These use a lot of data for short distances. Using the distance to "seismogenic rupture" instead of the fault is conceptually good, although I consider it a little ambiguous in its implementation. They are not constrained at larger distances which, although arguably less important, are distances for which we need to make estimates of motions. Thus, I feel I cannot assign the method as much weight as the other methods above. I consider these models to be qualified but not as preferred models.

Idriss (1997, written communication), Sadigh et al. (1997), Sabetta and Pugliese (1996). I have a high respect for each of these regressions, and consider that they all have some merit. I consider these models to be qualified but not as preferred models.

McGarr (1984) regression: Only the peak velocity model is recommended by McGarr as a proponent model applicable to Yucca Mountain. I consider that the physical assumptions behind this model are a little overly simplified. Therefore, I do not consider this model to be "qualified" and it is not included in defining the range of model estimates.

Weights:

I specified a relative weight of 0.1 for the boxcar model and a relative weight of 0.25 for the preferred model. (This sums to the total weight of 0.35 for the empirical models)

I considered the following empirical models to be qualified: Abrahamson and Silva (1997) with the normal faulting factor included; Boore et al. (1997); Campbell (1997) for soft rock;

Idriss (1997, written communication) with Idriss (1993) spectral shape; Sadigh et al. (1997); Sabetta and Pugliese (1996); and Spudich et al. (1996). The preferred empirical model is Abrahamson and Silva (1997).

F1-2.2.2 Numerical Simulations.

Zeng and Anderson synthetics. This model has the least amount of empiricism of any of the synthetic approaches. The source is described in a way that has been shown to include a plausible amount of complexity. Wave propagation from source to station is computed for a layered medium, so it includes body and surface waves, and scattering is incorporated. The disadvantage of this approach would be related to sensitivity of the results to Q and velocity models, which are uncertain. Still, having an approach that is predominantly a model of the physical phenomena that are involved gives me confidence in its ability to extrapolate to situations where there are little or no data. In spite of the model's successes, I recognize that there is still some physics that is not modeled properly, so I cannot give it a full weight.

Silva synthetics. This approach has the greatest amount of empiricism and the least amount of physics of any of the synthetic approaches. The spectrum of a M=5 subevent is specified, the attenuation with distance is greatly simplified, and wave propagation is not thoroughly incorporated. The advantage of this approach is that vagaries of wave propagation are "averaged out", i.e. it is less sensitive to uncertainties in regional velocity models for instance because this information is not used.

Somerville synthetics. This model is between the Zeng and Anderson approach and the Silva approach. The source is described with an empirical time function. However, wave propagation is modeled for a layered medium.

Point source model:

The point source proponent model was provided with the median and uncertainties in the point source stress drop to be specified by each expert. The following values are used:

median stress drop = 40 bars
standard deviation of stress drop = 0.5 (natural log units)
standard error of the median stress drop = 0.2 (natural log units)
standard error of the standard deviation of stress drop = 0.05

These values of the standard deviation and epistemic uncertainties are based on Ann Becker's evaluations of the normal faulting data.

Weights:

I consider all four of the numerical simulation models to be qualified. The three finite-fault synthetics are all preferred models, but the point source model is not preferred. I assigned a relative weight of 0.15 to the boxcar model and a relative weight of 0.50 to the preferred models. (This sums to the total weight of 0.65 for the numerical simulations).

Due to the differences in the finite fault simulations discussed above, I have given the following relative weights to the preferred models:

Silva finite fault	0.10
Somerville	0.15
Zeng and Anderson	0.25

More weight is given to the models with less empiricism. In some of the cases, I elected to deviate from the above approach to weighing the various models. These special cases are described below with the explanations.

F1-2.2.3 Weighting Scheme for Uncertainties. There are three types of uncertainties that need to be estimated: sigma, sigma-mu, and sigma-sigma, as defined above.

To estimate sigma, I recommend a weighted average of the values of sigma from each of the proponent models as the starting point. The weighting scheme was to be exactly the same as the scheme used to estimate the median value.

To estimate sigma-mu, I specified values of sigma-mu that I believe are reasonable to apply to each of the regressions and the synthetics as given below: These values replace the proponent model estimates of sigma mu. The total sigma-mu is computed by combining this proponent model sigma-mu with the variability of the weighted median ground motions computed using the weights described earlier.

To estimate sigma-sigma, the statistical estimates from the weighted averages are used. The magnitude 5 cases produced lower estimates of sigma-sigma than for the other magnitudes. I do not think that there should be a lower value of sigma-sigma for the lower magnitudes, so I used a constant value for all magnitudes computed from the average for magnitudes greater or equal to 5.8.

F1-2.2.4 Blast Models. The source for a blast is so different from the source of an earthquake that, in spite of all adjustments, I did not have much confidence in these models. Therefore, I gave zero weight to this class of models.

F1-2.2.5 Horizontal Component Variability. he proponent models for the horizontal component all predict the average of the two horizontal components. This project is using the random horizontal component, so the component-to-component variability needs to be added to the aleatory uncertainty. The average component-to-component variability is well determined from empirical models. The two proponent models are Boore et al. (1997) and Spudich et al. (1997). These two models are very similar. I selected the horizontal component to component variability from the Boore et al. (1997) model.

F1-2.3 Model Weights - Vertical Component

The weighting scheme described for the horizontal component is also used for the vertical component. For models without a vertical component, a zero weight is used. No scaling based on vertical/horizontal ratios is used.

F1-3 ADJUSTMENTS TO WEIGHTED POINT ESTIMATES

The weighting scheme described in Section F1-2 is used to develop preliminary point estimates for each of the 918 required estimates of the median and aleatory uncertainty. I reviewed these point estimates and made some adjustments for particular cases for which the weighted estimates were not consistent with my judgments.

The changes to the point estimates are listed below: for cases 22, 23, and 24, Spudich et al. (1997), Boore et al. (1997), and Sabetta and Pugliese (1996) were excluded. I consider that

the inflexible distance dependence and magnitude form used in these models will tend to cause these models to overestimate the ground motions for M=5 at 50 and 160 km distances.

F1-4 EPISTEMIC UNCERTAINTY

Based on my weighting scheme and proponent model sigma-mu (Table F1-1), the epistemic uncertainties (σ_μ and σ_σ) were computed by the facilitation team. I made the following modifications to these statistical estimates of the epistemic uncertainty:

I set a minimum value of 0.2 natural log units for the epistemic uncertainty to cover the cases in which the statistical estimate was low due to chance agreement of the various proponent models or few proponent models being available for some particular cases.

Table F1-1. Values of Sigma-Mu to be used for the Proponent Models

	X Distance			
M Range	**1,5 km**	**10 km**	**50 km**	**100,160 km**
5, 5.8	0.6	0.4	0.4	0.5
6.5	0.65	0.3	0.3	0.60
70, 7.5, 8.0	0.70	0.4	0.4	0.60

F1-5 FINAL POINT ESTIMATES

After making the adjustments to the weighted estimates as described above, my final point estimates of μ, σ, σ_μ, and σ_σ for the horizontal component for the 51 cases are given in Tables F1-2 to F1-10 for the nine ground motion parameters. The corresponding point estimates for the vertical component are given in Tables F1-11 to F1-19.

F1-6 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 11A of the data package. These regression models adequately model my point estimates of the median, aleatory uncertainty, epistemic uncertainty in the median, and epistemic uncertainty in the aleatory uncertainty.

F1-7 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.

F1-7.1 Multiple Parallel Faults

Some of the experts on describing sources have hypothesized that it is possible for more than one fault to rupture in a single earthquake. The question then is what the ground motion would be. What is needed is some approach that is simple to implement for a probabilistic seismic hazard assessment.

In order to discuss options, some terminology is needed. Suppose that there are J faults that are involved in a single earthquake. I characterize the moment, moment magnitude, and rupture distance to the jth fault as M_o^j, M_w^j, and R^j. The total moment and moment magnitude for the event are $M_o = \sum_{j=1}^{J} M_o^j$, and $M_w = \frac{2}{3}(\log(M_o - 16)$. Finally, let the ground motion parameter that we are seeking to predict be $Y = GM(M,R)$, and designate the ground motion from each of the subevents as Y_1, Y_2, ...

While any number of possibilities exist, I considered the following alternatives:

A1. Choose Y = max(Y_1, Y_2,...). This treats each subfault as an independent event, and acts as if the ruptures are sufficiently separated in time that the peak is controlled by the one causing the largest motions. However, having multiple ruptures on either side of the station

could lead to multiple sources of energy that are all contributing at the same time. Thus, intuitively we might expect something larger than the prediction in this approach.

A2. Define $R^m = \min\{R^1,...,R^J\}$. Use $Y = GM(M_w, R^m)$. If we had any strong motion data, this is the way that it would be entered into the regression. It does not model the physics correctly, but the ground motion it predicts will be greater than the approach A1. Some preliminary calculations by Paul Somerville, supplied to our panel, suggested that the predictions using this approach are smaller than his model. However, it should be clear that we do not know what input to a physical rupture model is appropriate for this situation.

A3. Let R^e be an "effective distance" defined as $\frac{1}{R^e} = \sum_{j=1}^{J} \frac{1}{R^j}$. Use $Y = GM(M_w, R^e)$.

This is strictly an "engineering fix" which adjusts to a closer distance, and thus predicts a larger ground motion than approach A1 or A2.

A4. Choose $Y = \{\sum_{j=1}^{J} Y_j^2\}^{1/2}$. This approach would rest on the physical assumption that the peak values of Y from all of the subfaults arrive at the same time, but interfere randomly.

A5. Choose $Y = \sum_{j=1}^{J} Y_j$. This approach would rest on the physical assumption that the peak values of Y from all of the subfaults arrive at the same time, and that they add constructively.

A6. Considering that subevent 1 causes the largest motions of any of the subevents, choose $Y = \{Y_1^2 + \sum_{j=2}^{J} (kY_j)^2\}^{1/2}$. This approach would rest on the physical assumption that the peak values of Y from all of the subfaults interfere randomly. It is modified from A4 with a judgmental assumption that ground motions from other subevents will be below their peak values at the time that the peak from the largest subevent arrives. The factor k is obviously arbitrary within the range $0 \le k \le 1$. Case A1 is the special case of this one in which $k=0$. Case 4 is a special case of this one where $k=1$. A value of $k=2/3$ seems plausible to me.

Considering these six alternatives, I think A1, A3, and A5 are least likely since they do not match the physics of the situation. A2 may match the practice of regression analysis, but actual recordings for this situation may tend to have positive residuals because of the special geometry. I prefer approach A6 with $k=2/3$; however, if this gives values of ground motions that are smaller than A2, then replace those values with the estimate using method A2.

F1-7.2 Low Angle Fault

The second difficult case is one of a detachment fault beneath the site. The hypothesis is that there could be some "normal" faulting detachment, potentially large, on a very shallow dipping fault. There are no data available to predict how such a fault could behave. One physical hypothesis is that an event of this type would be much like any other event. A second hypothesis is that such an event could have a longer rise time, looking more like a creep event. Defense of this hypothesis would rest on the lack of observations of any well documented events of this type. The reasoning would be that the lack of observations is caused by these events mostly occurring by creep, but once in a while they accelerate more to be an actual earthquake. To my mind, the most reasonable approach for this case is to assume that if there should be such an event, the ground motions that it causes will be similar to the ground motions caused by other earthquakes in the region. It is plausible that there have been some detachment events, but they have not been recognized as such; failure to recognize them would be more likely if they are otherwise typical. Lacking any other better information, for this type of event, my recommendation is to use the regressions we have without modification.

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TABLE F1-2
J. G. ANDERSON: HORIZONTAL POINT ESTIMATES
PEAK GROUND ACCELERATION

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.12411	0.65861	0.60000	0.09940
2	5.00	1	0.21635	0.66848	0.60000	0.09751
3	5.00	5	0.04459	0.66354	0.60000	0.09838
4	5.00	5	0.07861	0.66848	0.60000	0.09751
5	5.80	10	0.09918	0.60246	0.40000	0.11865
6	5.80	20	0.07996	0.60163	0.40000	0.11873
7	6.50	1	0.49138	0.57948	0.65000	0.11251
8	6.50	1	0.58235	0.58496	0.65000	0.11615
9	6.50	1	0.49031	0.58159	0.65000	0.11337
10	6.50	5	0.40357	0.57561	0.65000	0.11103
11	6.50	5	0.27324	0.58284	0.65000	0.11404
12	6.50	50	0.03178	0.57500	0.30000	0.11091
13	6.50	50	0.03063	0.57469	0.30000	0.11086
14	7.00	10	0.28433	0.54940	0.40000	0.12564
15	7.50	50	0.06512	0.55389	0.40000	0.13012
16	7.50	50	0.06628	0.55029	0.40000	0.12811
17	5.00	1	0.05417	0.67286	0.60000	0.05269
18	5.80	5	0.16911	0.60316	0.60000	0.11862
19	5.80	5	0.09635	0.60271	0.60000	0.11863
20	5.00	10	0.06634	0.66354	0.40000	0.09838
21	5.00	10	0.08545	0.65861	0.40000	0.09940
22	5.00	50	0.00580	0.65861	0.40000	0.09940
23	5.00	50	0.00555	0.65369	0.40000	0.10058
24	5.00	160	0.00076	0.64878	0.50000	0.10190
25	5.80	1	0.27500	0.60477	0.60000	0.11932
26	5.80	5	0.23217	0.60200	0.60000	0.11868
27	5.80	5	0.13897	0.60223	0.60000	0.11866
28	5.80	10	0.12399	0.61010	0.40000	0.12100
29	5.80	10	0.17957	0.60223	0.40000	0.11866
30	5.80	10	0.07494	0.60440	0.60000	0.11936
31	5.80	50	0.01290	0.60631	0.40000	0.06216
32	5.80	50	0.01273	0.61383	0.40000	0.06304
33	6.50	5	0.35218	0.57646	0.65000	0.11124
34	6.50	10	0.22425	0.57921	0.30000	0.11243
35	6.50	10	0.33871	0.57876	0.30000	0.11230
36	6.50	10	0.16640	0.57583	0.65000	0.11108
37	6.50	20	0.11192	0.57507	0.30000	0.11092
38	6.50	20	0.16599	0.57966	0.30000	0.11257
39	6.50	20	0.08065	0.57239	0.65000	0.10990
40	6.50	100	0.01559	0.57652	0.60000	0.11190
41	6.50	160	0.00544	0.59316	0.60000	0.12156
42	7.00	1	0.50377	0.55133	0.60000	0.12653
43	7.00	10	0.38880	0.55458	0.40000	0.12835
44	7.00	10	0.20551	0.54700	0.60000	0.12475
45	7.00	50	0.04945	0.54715	0.40000	0.12480
46	7.00	50	0.04857	0.54926	0.40000	0.12559
47	7.50	1	0.54649	0.57853	0.60000	0.14692
48	5.00	10	0.29788	0.56966	0.40000	0.14041
49	5.00	10	0.39649	0.55316	0.40000	0.12968
50	8.00	50	0.07505	0.58503	0.40000	0.07992
51	8.00	160	0.02345	0.57622	0.60000	0.07396

TABLE F1-3
J. G. ANDERSON: 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	0.21962	0.66700	0.60000	0.07622
2	5.00	1	0.36309	0.67199	0.60000	0.07449
3	5.00	5	0.08181	0.67199	0.60000	0.07449
4	5.00	5	0.12701	0.67699	0.60000	0.07296
5	5.80	10	0.16346	0.61190	0.40000	0.11023
6	5.80	20	0.12482	0.60578	0.40000	0.10898
7	6.50	1	0.78883	0.58479	0.65000	0.10645
8	6.50	1	0.89820	0.58975	0.65000	0.11012
9	6.50	1	0.76665	0.58320	0.65000	0.10570
10	6.50	5	0.67474	0.58136	0.65000	0.10581
11	6.50	5	0.45286	0.58163	0.65000	0.10514
12	6.50	50	0.04361	0.57927	0.30000	0.10469
13	6.50	50	0.04262	0.57887	0.30000	0.10466
14	7.00	10	0.44758	0.54791	0.40000	0.12662
15	7.50	50	0.09058	0.55293	0.40000	0.13241
16	7.50	50	0.09298	0.54901	0.40000	0.13032
17	5.00	1	0.10922	0.67982	0.60000	0.04674
18	5.80	5	0.26202	0.60503	0.60000	0.10813
19	5.80	5	0.15036	0.60649	0.60000	0.10881
20	5.00	10	0.12213	0.69203	0.40000	0.06961
21	5.00	10	0.16206	0.67199	0.40000	0.07449
22	5.00	50	0.00921	0.66711	0.40000	0.05695
23	5.00	50	0.00869	0.66711	0.40000	0.05695
24	5.00	160	0.00109	0.65221	0.50000	0.06686
25	5.80	1	0.47736	0.60699	0.60000	0.10872
26	5.80	5	0.40567	0.61356	0.60000	0.11139
27	5.80	5	0.23371	0.61142	0.60000	0.11033
28	5.80	10	0.20626	0.61684	0.40000	0.11236
29	5.80	10	0.29213	0.60651	0.40000	0.10881
30	5.80	10	0.12417	0.60413	0.60000	0.10826
31	5.80	50	0.01881	0.61804	0.40000	0.03868
32	5.80	50	0.01822	0.62182	0.40000	0.03960
33	6.50	5	0.57701	0.57538	0.65000	0.10302
34	6.50	10	0.37664	0.58812	0.30000	0.10868
35	6.50	10	0.56006	0.58070	0.30000	0.10490
36	6.50	10	0.27161	0.58483	0.65000	0.10717
37	6.50	20	0.17553	0.58611	0.30000	0.10852
38	6.50	20	0.25800	0.58596	0.30000	0.10735
39	6.50	20	0.12533	0.57872	0.65000	0.10465
40	6.50	100	0.01850	0.57817	0.60000	0.10465
41	6.50	160	0.00726	0.57862	0.60000	0.10465
42	7.00	1	0.85798	0.55091	0.60000	0.12790
43	7.00	10	0.65565	0.55480	0.40000	0.13006
44	7.00	10	0.33873	0.54622	0.60000	0.12607
45	7.00	50	0.07000	0.54543	0.40000	0.12584
46	7.00	50	0.06948	0.54814	0.40000	0.12671
47	7.50	1	0.89060	0.57994	0.60000	0.15113
48	5.00	10	0.48541	0.57051	0.40000	0.14410
49	5.00	10	0.63775	0.55230	0.40000	0.13204
50	8.00	50	0.10072	0.58885	0.40000	0.08569
51	8.00	160	0.02545	0.57608	0.60000	0.07834

TABLE F1-4
J. G. ANDERSON: 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	0.27826	0.72629	0.60000	0.09707
2	5.00	1	0.48422	0.71610	0.60000	0.09652
3	5.00	5	0.10119	0.72629	0.60000	0.09707
4	5.00	5	0.18575	0.72119	0.60000	0.09671
5	5.80	10	0.20065	0.63353	0.40000	0.12796
6	5.80	20	0.16039	0.63396	0.40000	0.12801
7	6.50	1	1.01411	0.61305	0.65000	0.12920
8	6.50	1	1.25153	0.61461	0.65000	0.13042
9	6.50	1	1.03999	0.61199	0.65000	0.12864
10	6.50	5	0.81889	0.60378	0.65000	0.12470
11	6.50	5	0.57148	0.60757	0.65000	0.12634
12	6.50	50	0.05993	0.60472	0.30000	0.12501
13	6.50	50	0.05698	0.60203	0.30000	0.12366
14	7.00	10	0.56552	0.56009	0.40000	0.13217
15	7.50	50	0.11973	0.57033	0.40000	0.14153
16	7.50	50	0.12691	0.56279	0.40000	0.13713
17	5.00	1	0.12606	0.68511	0.60000	0.05783
18	5.80	5	0.35628	0.63468	0.60000	0.12811
19	5.80	5	0.19970	0.63161	0.60000	0.12695
20	5.00	10	0.14936	0.72629	0.40000	0.09707
21	5.00	10	0.19680	0.70592	0.40000	0.09670
22	5.00	50	0.01241	0.71610	0.40000	0.09652
23	5.00	50	0.01174	0.70592	0.40000	0.09670
24	5.00	160	0.00140	0.69069	0.50000	0.09831
25	5.80	1	0.55892	0.63821	0.60000	0.12947
26	5.80	5	0.50366	0.63422	0.60000	0.12804
27	5.80	5	0.28199	0.63986	0.60000	0.13073
28	5.80	10	0.23985	0.63929	0.40000	0.13071
29	5.80	10	0.35203	0.63389	0.40000	0.12800
30	5.80	10	0.15166	0.62657	0.60000	0.12560
31	5.80	50	0.02490	0.65456	0.40000	0.07141
32	5.80	50	0.02364	0.65835	0.40000	0.07331
33	6.50	5	0.72848	0.60678	0.65000	0.12591
34	6.50	10	0.46044	0.60837	0.30000	0.12684
35	6.50	10	0.70615	0.60734	0.30000	0.12650
36	6.50	10	0.34014	0.60774	0.65000	0.12662
37	6.50	20	0.22633	0.60070	0.30000	0.12316
38	6.50	20	0.31735	0.60326	0.30000	0.12424
39	6.50	20	0.15737	0.60418	0.65000	0.12483
40	6.50	100	0.02506	0.60004	0.60000	0.12296
41	6.50	160	0.00918	0.60035	0.60000	0.12305
42	7.00	1	1.05676	0.56497	0.60000	0.13511
43	7.00	10	0.79509	0.57010	0.40000	0.13808
44	7.00	10	0.41749	0.56023	0.60000	0.13192
45	7.00	50	0.09343	0.55857	0.40000	0.13120
46	7.00	50	0.09229	0.56109	0.40000	0.13286
47	7.50	1	1.07643	0.59466	0.60000	0.15928
48	5.00	10	0.59081	0.58555	0.40000	0.15206
49	5.00	10	0.77500	0.56822	0.40000	0.14024
50	8.00	50	0.13350	0.63443	0.40000	0.10837
51	8.00	160	0.02994	0.61071	0.60000	0.09424

TABLE F1-5
J. G. ANDERSON: 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	0.21253	0.75048	0.60000	0.08726
2	5.00	1	0.36713	0.76045	0.60000	0.08706
3	5.00	5	0.07666	0.74055	0.60000	0.08821
4	5.00	5	0.13967	0.73559	0.60000	0.08897
5	5.80	10	0.19290	0.67167	0.40000	0.12614
6	5.80	20	0.16291	0.65818	0.40000	0.12219
7	6.50	1	0.97252	0.63718	0.65000	0.12026
8	6.50	1	1.17980	0.65105	0.65000	0.12674
9	6.50	1	1.02196	0.65803	0.65000	0.13015
10	6.50	5	0.80188	0.64246	0.65000	0.12287
11	6.50	5	0.56675	0.63835	0.65000	0.12050
12	6.50	50	0.06656	0.63731	0.30000	0.12030
13	6.50	50	0.06494	0.63044	0.30000	0.11766
14	7.00	10	0.56999	0.59392	0.40000	0.13309
15	7.50	50	0.15030	0.59980	0.40000	0.13938
16	7.50	50	0.15874	0.59278	0.40000	0.13557
17	5.00	1	0.09982	0.71644	0.60000	0.05958
18	5.80	5	0.31328	0.66445	0.60000	0.12392
19	5.80	5	0.20028	0.66170	0.60000	0.12302
20	5.00	10	0.11445	0.74055	0.40000	0.08821
21	5.00	10	0.14818	0.73559	0.40000	0.08897
22	5.00	50	0.01303	0.75048	0.40000	0.08726
23	5.00	50	0.01051	0.72570	0.40000	0.09100
24	5.00	160	0.00201	0.73559	0.50000	0.08897
25	5.80	1	0.50600	0.66414	0.60000	0.12391
26	5.80	5	0.43848	0.66353	0.60000	0.12392
27	5.80	5	0.25975	0.66463	0.60000	0.12392
28	5.80	10	0.22186	0.66860	0.40000	0.12500
29	5.80	10	0.32185	0.65864	0.40000	0.12223
30	5.80	10	0.15099	0.67076	0.60000	0.12612
31	5.80	50	0.02556	0.68556	0.40000	0.06030
32	5.80	50	0.02720	0.68514	0.40000	0.06040
33	6.50	5	0.70065	0.63179	0.65000	0.11813
34	6.50	10	0.42825	0.64154	0.30000	0.12203
35	6.50	10	0.65041	0.63582	0.30000	0.11971
36	6.50	10	0.34349	0.62979	0.65000	0.11725
37	6.50	20	0.22125	0.63987	0.30000	0.12151
38	6.50	20	0.33881	0.63629	0.30000	0.12002
39	6.50	20	0.17088	0.63492	0.65000	0.11933
40	6.50	100	0.03070	0.63597	0.60000	0.11994
41	6.50	160	0.01278	0.64211	0.60000	0.12281
42	7.00	1	1.02238	0.59574	0.60000	0.13386
43	7.00	10	0.80487	0.59900	0.40000	0.13591
44	7.00	10	0.44746	0.59163	0.60000	0.13176
45	7.00	50	0.11076	0.59190	0.40000	0.13190
46	7.00	50	0.11222	0.59254	0.40000	0.13227
47	7.50	1	1.17143	0.62217	0.60000	0.15375
48	5.00	10	0.65887	0.61950	0.40000	0.15180
49	5.00	10	0.83377	0.59386	0.40000	0.13627
50	8.00	50	0.16681	0.65700	0.40000	0.09999
51	8.00	160	0.04360	0.64045	0.60000	0.09158

TABLE F1-6
J. G. ANDERSON: 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	0.09182	0.81772	0.60000	0.07969
2	5.00	1	0.17663	0.79323	0.60000	0.08046
3	5.00	5	0.03461	0.81281	0.60000	0.07943
4	5.00	5	0.06542	0.79811	0.60000	0.07990
5	5.80	10	0.10844	0.72136	0.40000	0.13195
6	5.80	20	0.10151	0.72685	0.40000	0.13418
7	6.50	1	0.62512	0.69297	0.65000	0.13291
8	6.50	1	0.72492	0.69748	0.65000	0.13511
9	6.50	1	0.62977	0.70147	0.65000	0.13678
10	6.50	5	0.50364	0.69308	0.65000	0.13277
11	6.50	5	0.34712	0.69310	0.65000	0.13297
12	6.50	50	0.05285	0.69814	0.30000	0.13484
13	6.50	50	0.05828	0.69137	0.30000	0.13230
14	7.00	10	0.42692	0.64534	0.40000	0.14039
15	7.50	50	0.13294	0.65082	0.40000	0.14673
16	7.50	50	0.13968	0.64518	0.40000	0.14279
17	5.00	1	0.04782	0.76695	0.60000	0.06060
18	5.80	5	0.18569	0.72762	0.60000	0.13448
19	5.80	5	0.10197	0.72540	0.60000	0.13321
20	5.00	10	0.04771	0.79323	0.40000	0.08046
21	5.00	10	0.06542	0.78350	0.40000	0.08216
22	5.00	50	0.00671	0.79064	0.40000	0.06722
23	5.00	50	0.00796	0.79552	0.40000	0.06614
24	5.00	160	0.00163	0.78092	0.50000	0.07001
25	5.80	1	0.29543	0.71784	0.60000	0.13144
26	5.80	5	0.26108	0.72073	0.60000	0.13230
27	5.80	5	0.14513	0.71364	0.60000	0.13035
28	5.80	10	0.14499	0.72699	0.40000	0.13423
29	5.80	10	0.21267	0.72216	0.40000	0.13265
30	5.80	10	0.08279	0.72160	0.60000	0.13250
31	5.80	50	0.01904	0.74592	0.40000	0.06706
32	5.80	50	0.01898	0.75642	0.40000	0.06982
33	6.50	5	0.46682	0.69192	0.65000	0.13249
34	6.50	10	0.31615	0.69644	0.30000	0.13441
35	6.50	10	0.46655	0.69592	0.30000	0.13419
36	6.50	10	0.21889	0.69184	0.65000	0.13246
37	6.50	20	0.15813	0.69313	0.30000	0.13298
38	6.50	20	0.24457	0.70130	0.30000	0.13668
39	6.50	20	0.12575	0.69227	0.65000	0.13262
40	6.50	100	0.03114	0.69300	0.60000	0.13292
41	6.50	160	0.01463	0.70174	0.60000	0.13703
42	7.00	1	0.73935	0.64696	0.60000	0.14155
43	7.00	10	0.62325	0.64772	0.40000	0.14220
44	7.00	10	0.30515	0.64527	0.60000	0.14035
45	7.00	50	0.09002	0.64567	0.40000	0.14069
46	7.00	50	0.09322	0.64853	0.40000	0.14275
47	7.50	1	0.83194	0.67418	0.60000	0.16209
48	5.00	10	0.47527	0.66602	0.40000	0.15619
49	5.00	10	0.60988	0.64994	0.40000	0.14625
50	8.00	50	0.15882	0.71713	0.40000	0.10679
51	8.00	160	0.05723	0.70921	0.60000	0.10354

TABLE F1-7
J. G. ANDERSON: 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	0.03848	0.83470	0.60000	0.07295
2	5.00	1	0.07157	0.82983	0.60000	0.07357
3	5.00	5	0.01459	0.82497	0.60000	0.07440
4	5.00	5	0.02649	0.82497	0.60000	0.07440
5	5.80	10	0.05332	0.78390	0.40000	0.12761
6	5.80	20	0.04668	0.77780	0.40000	0.13073
7	6.50	1	0.32531	0.75929	0.65000	0.13322
8	6.50	1	0.33897	0.75905	0.65000	0.13728
9	6.50	1	0.29366	0.75099	0.65000	0.13450
10	6.50	5	0.26459	0.75485	0.65000	0.13543
11	6.50	5	0.16689	0.74962	0.65000	0.13387
12	6.50	50	0.03369	0.75189	0.30000	0.13086
13	6.50	50	0.03060	0.74996	0.30000	0.13399
14	7.00	10	0.22092	0.72545	0.40000	0.14131
15	7.50	50	0.08143	0.73839	0.40000	0.13724
16	7.50	50	0.08248	0.73188	0.40000	0.13754
17	5.00	1	0.01923	0.80619	0.60000	0.04866
18	5.80	5	0.08099	0.79699	0.60000	0.13633
19	5.80	5	0.04612	0.79288	0.60000	0.13484
20	5.00	10	0.01851	0.82013	0.40000	0.07543
21	5.00	10	0.02390	0.82013	0.40000	0.07543
22	5.00	50	0.00251	0.81501	0.40000	0.07523
23	5.00	50	0.00272	0.82955	0.40000	0.07216
24	5.00	160	0.00087	0.82469	0.50000	0.07298
25	5.80	1	0.13518	0.79064	0.60000	0.12931
26	5.80	5	0.11623	0.77322	0.60000	0.12975
27	5.80	5	0.06390	0.78821	0.60000	0.13368
28	5.80	10	0.06662	0.78645	0.40000	0.12831
29	5.80	10	0.10017	0.77485	0.40000	0.12996
30	5.80	10	0.04015	0.78745	0.60000	0.13335
31	5.80	50	0.01000	0.78801	0.40000	0.08169
32	5.80	50	0.01057	0.79829	0.40000	0.08448
33	6.50	5	0.22618	0.76405	0.65000	0.13487
34	6.50	10	0.16864	0.75653	0.30000	0.13220
35	6.50	10	0.25515	0.75155	0.30000	0.13453
36	6.50	10	0.11253	0.74926	0.65000	0.13376
37	6.50	20	0.08329	0.75034	0.30000	0.13031
38	6.50	20	0.12713	0.75584	0.30000	0.13575
39	6.50	20	0.06423	0.75055	0.65000	0.13420
40	6.50	100	0.02102	0.75253	0.60000	0.13101
41	6.50	160	0.01007	0.75449	0.60000	0.13177
42	7.00	1	0.34756	0.72444	0.60000	0.14096
43	7.00	10	0.30195	0.72178	0.40000	0.14501
44	7.00	10	0.17011	0.71521	0.60000	0.14153
45	7.00	50	0.04970	0.72526	0.40000	0.14124
46	7.00	50	0.04579	0.71639	0.40000	0.14205
47	7.50	1	0.43714	0.74001	0.60000	0.15057
48	5.00	10	0.27341	0.73851	0.40000	0.14979
49	5.00	10	0.33899	0.72074	0.40000	0.14591
50	8.00	50	0.10819	0.75977	0.40000	0.12039
51	8.00	160	0.04934	0.76032	0.60000	0.12097

TABLE F1-8
J. G. ANDERSON: 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	0.00967	0.91473	0.60000	0.09834
2	5.00	1	0.01766	0.90503	0.60000	0.09833
3	5.00	5	0.00429	0.89054	0.60000	0.09949
4	5.00	5	0.00722	0.89054	0.60000	0.09949
5	5.80	10	0.01764	0.86291	0.40000	0.14263
6	5.80	20	0.01324	0.85159	0.40000	0.15310
7	6.50	1	0.14955	0.84202	0.65000	0.15042
8	6.50	1	0.14694	0.83226	0.65000	0.15898
9	6.50	1	0.12619	0.83308	0.65000	0.15927
10	6.50	5	0.10994	0.83285	0.65000	0.15946
11	6.50	5	0.08031	0.83409	0.65000	0.15992
12	6.50	50	0.01482	0.84269	0.30000	0.15107
13	6.50	50	0.01245	0.82926	0.30000	0.15709
14	7.00	10	0.09530	0.81592	0.40000	0.15893
15	7.50	50	0.04246	0.84784	0.40000	0.15496
16	7.50	50	0.03945	0.82720	0.40000	0.14887
17	5.00	1	0.00529	0.93024	0.60000	0.03541
18	5.80	5	0.03223	0.84236	0.60000	0.14847
19	5.80	5	0.01781	0.84938	0.60000	0.15168
20	5.00	10	0.00620	0.89054	0.40000	0.09949
21	5.00	10	0.00689	0.89536	0.40000	0.09894
22	5.00	50	0.00097	0.88665	0.40000	0.07855
23	5.00	50	0.00079	0.88665	0.40000	0.07855
24	5.00	160	0.00051	0.88665	0.50000	0.07855
25	5.80	1	0.05348	0.87420	0.60000	0.14729
26	5.80	5	0.04402	0.84245	0.60000	0.14833
27	5.80	5	0.02789	0.84705	0.60000	0.15045
28	5.80	10	0.02181	0.86939	0.40000	0.14679
29	5.80	10	0.02737	0.85828	0.40000	0.15678
30	5.80	10	0.01554	0.84433	0.60000	0.14919
31	5.80	50	0.00377	0.87408	0.40000	0.11319
32	5.80	50	0.00355	0.87403	0.40000	0.11837
33	6.50	5	0.10674	0.84274	0.65000	0.15044
34	6.50	10	0.06854	0.84455	0.30000	0.15122
35	6.50	10	0.08816	0.83175	0.30000	0.15931
36	6.50	10	0.04899	0.82984	0.65000	0.15742
37	6.50	20	0.03960	0.84732	0.30000	0.15266
38	6.50	20	0.04725	0.82660	0.30000	0.15579
39	6.50	20	0.02678	0.82769	0.65000	0.15634
40	6.50	100	0.01006	0.84426	0.60000	0.15142
41	6.50	160	0.00501	0.85388	0.60000	0.15625
42	7.00	1	0.21678	0.81592	0.60000	0.15893
43	7.00	10	0.12529	0.79484	0.40000	0.16543
44	7.00	10	0.07081	0.79876	0.60000	0.16891
45	7.00	50	0.02427	0.81633	0.40000	0.15916
46	7.00	50	0.02062	0.79152	0.40000	0.16282
47	7.50	1	0.24029	0.82688	0.60000	0.16830
48	5.00	10	0.11234	0.81701	0.40000	0.16160
49	5.00	10	0.13137	0.78776	0.40000	0.16196
50	8.00	50	0.06787	0.86100	0.40000	0.16242
51	8.00	160	0.03689	0.86532	0.60000	0.16370

TABLE F1-9
J. G. ANDERSON: 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	0.00348	0.98219	0.60000	0.10129
2	5.00	1	0.00584	0.96740	0.60000	0.09676
3	5.00	5	0.00152	0.96740	0.60000	0.09676
4	5.00	5	0.00264	0.96740	0.60000	0.09676
5	5.80	10	0.00826	0.89185	0.40000	0.14181
6	5.80	20	0.00526	0.87786	0.40000	0.15200
7	6.50	1	0.07200	0.88468	0.65000	0.16220
8	6.50	1	0.06817	0.85442	0.65000	0.15369
9	6.50	1	0.05983	0.86099	0.65000	0.15885
10	6.50	5	0.05654	0.86581	0.65000	0.16260
11	6.50	5	0.04285	0.86895	0.65000	0.16557
12	6.50	50	0.00737	0.88514	0.30000	0.15858
13	6.50	50	0.00550	0.86360	0.30000	0.16081
14	7.00	10	0.04539	0.84914	0.40000	0.17006
15	7.50	50	0.02694	0.88919	0.40000	0.12968
16	7.50	50	0.02115	0.87418	0.40000	0.12221
17	5.00	1	0.00155	0.97729	0.60000	0.06387
18	5.80	5	0.01386	0.88358	0.60000	0.15653
19	5.80	5	0.00702	0.88264	0.60000	0.15561
20	5.00	10	0.00233	0.95757	0.40000	0.09449
21	5.00	10	0.00238	0.96248	0.40000	0.09555
22	5.00	50	0.00050	0.95267	0.40000	0.09359
23	5.00	50	0.00041	0.95267	0.40000	0.09359
24	5.00	160	0.00015	0.95267	0.50000	0.09359
25	5.80	1	0.02297	0.89964	0.60000	0.14690
26	5.80	5	0.02023	0.88146	0.60000	0.15537
27	5.80	5	0.01397	0.87741	0.60000	0.15163
28	5.80	10	0.01126	0.89500	0.40000	0.14368
29	5.80	10	0.01062	0.87660	0.40000	0.15088
30	5.80	10	0.00667	0.88068	0.60000	0.15386
31	5.80	50	0.00189	0.92592	0.40000	0.09874
32	5.80	50	0.00145	0.91665	0.40000	0.09830
33	6.50	5	0.05655	0.88682	0.65000	0.16167
34	6.50	10	0.03491	0.88393	0.30000	0.15842
35	6.50	10	0.03733	0.86239	0.30000	0.16017
36	6.50	10	0.02277	0.86639	0.65000	0.16356
37	6.50	20	0.01790	0.87865	0.30000	0.15357
38	6.50	20	0.01737	0.86969	0.30000	0.16634
39	6.50	20	0.01238	0.85816	0.65000	0.15649
40	6.50	100	0.00363	0.87205	0.60000	0.14893
41	6.50	160	0.00257	0.88894	0.60000	0.16201
42	7.00	1	0.12545	0.84476	0.60000	0.16560
43	7.00	10	0.06112	0.82039	0.40000	0.17091
44	7.00	10	0.03272	0.81881	0.60000	0.16914
45	7.00	50	0.01213	0.84134	0.40000	0.16246
46	7.00	50	0.00978	0.82097	0.40000	0.17157
47	7.50	1	0.15876	0.85261	0.60000	0.17609
48	5.00	10	0.05928	0.84187	0.40000	0.16559
49	5.00	10	0.07190	0.81800	0.40000	0.17039
50	8.00	50	0.04513	0.92864	0.40000	0.15902
51	8.00	160	0.02424	0.93020	0.60000	0.15859

TABLE F1-10
J. G. ANDERSON: HORIZONTAL POINT ESTIMATES
PEAK GROUND VELOCITY

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	5.95368	0.77651	0.60000	0.09377
2	5.00	1	11.94466	0.77651	0.60000	0.09377
3	5.00	5	2.33973	0.77651	0.60000	0.09377
4	5.00	5	4.82999	0.76681	0.60000	0.08963
5	5.80	10	6.58281	0.73789	0.40000	0.10574
6	5.80	20	5.77092	0.73518	0.40000	0.10859
7	6.50	1	37.87487	0.73826	0.65000	0.12078
8	6.50	1	42.64674	0.73784	0.65000	0.12504
9	6.50	1	36.03432	0.73784	0.65000	0.12504
10	6.50	5	33.90291	0.73015	0.65000	0.12098
11	6.50	5	21.35413	0.72875	0.65000	0.12033
12	6.50	50	2.66481	0.72948	0.30000	0.11687
13	6.50	50	2.62790	0.72653	0.30000	0.11911
14	7.00	10	25.61209	0.71950	0.40000	0.13054
15	7.50	50	6.65118	0.71862	0.40000	0.13758
16	7.50	50	7.08289	0.70574	0.40000	0.13552
17	5.00	1	2.88039	0.75041	0.60000	0.04856
18	5.80	5	12.21397	0.73389	0.60000	0.10805
19	5.80	5	6.47582	0.73304	0.60000	0.10765
20	5.00	10	2.98180	0.76197	0.40000	0.08776
21	5.00	10	4.17823	0.76681	0.40000	0.08963
22	5.00	50	0.32234	0.75714	0.40000	0.08604
23	5.00	50	0.35921	0.76197	0.40000	0.08776
24	5.00	160	0.06889	0.74751	0.50000	0.08307
25	5.80	1	17.18409	0.74141	0.60000	0.10711
26	5.80	5	16.05410	0.72978	0.60000	0.10614
27	5.80	5	9.52540	0.73245	0.60000	0.10741
28	5.80	10	7.80374	0.74290	0.40000	0.10765
29	5.80	10	12.21401	0.73521	0.40000	0.10860
30	5.80	10	5.11692	0.73209	0.60000	0.10727
31	5.80	50	0.92102	0.74839	0.40000	0.08574
32	5.80	50	0.95812	0.75016	0.40000	0.08729
33	6.50	5	26.39163	0.73692	0.65000	0.12027
34	6.50	10	17.90324	0.73584	0.30000	0.11974
35	6.50	10	26.67163	0.73044	0.30000	0.12114
36	6.50	10	12.92577	0.72822	0.65000	0.12012
37	6.50	20	8.97351	0.73337	0.30000	0.11854
38	6.50	20	12.96219	0.73093	0.30000	0.12141
39	6.50	20	6.85566	0.72373	0.65000	0.11777
40	6.50	100	1.47121	0.73356	0.60000	0.11890
41	6.50	160	0.53372	0.74577	0.60000	0.12519
42	7.00	1	50.85425	0.71709	0.60000	0.12918
43	7.00	10	36.90607	0.71115	0.40000	0.13164
44	7.00	10	18.94126	0.70719	0.60000	0.12915
45	7.00	50	4.43288	0.71535	0.40000	0.12848
46	7.00	50	4.50998	0.70723	0.40000	0.12917
47	7.50	1	61.70474	0.73257	0.60000	0.14612
48	5.00	10	32.23119	0.72249	0.40000	0.14002
49	5.00	10	39.51812	0.70725	0.40000	0.13646
50	8.00	50	11.39069	0.74528	0.40000	0.12715
51	8.00	160	4.17337	0.75030	0.60000	0.12935

TABLE F1-11
J. G. ANDERSON: VERTICAL POINT ESTIMATES
PEAK GROUND ACCELERATION

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.06378	0.65949	0.60000	0.12094
2	5.00	1	0.09231	0.66794	0.60000	0.12009
3	5.00	5	0.02423	0.65949	0.60000	0.12094
4	5.00	5	0.03063	0.66530	0.60000	0.12031
5	5.80	10	0.05316	0.65523	0.40000	0.14238
6	5.80	20	0.06651	0.63641	0.40000	0.13725
7	6.50	1	0.29684	0.62878	0.65000	0.12843
8	6.50	1	0.34868	0.63915	0.65000	0.13192
9	6.50	1	0.35225	0.62724	0.65000	0.12800
10	6.50	5	0.30597	0.62302	0.65000	0.12693
11	6.50	5	0.22112	0.62724	0.65000	0.12800
12	6.50	50	0.01982	0.62417	0.30000	0.12720
13	6.50	50	0.02435	0.62148	0.30000	0.12658
14	7.00	10	0.18926	0.62894	0.40000	0.13031
15	7.50	50	0.04332	0.63855	0.40000	0.13414
16	7.50	50	0.05311	0.63778	0.40000	0.13381
17	5.00	1	0.02533	0.64999	0.60000	0.12236
18	5.80	5	0.07798	0.63372	0.60000	0.13678
19	5.80	5	0.06272	0.64448	0.60000	0.13907
20	5.00	10	0.03258	0.67375	0.40000	0.11974
21	5.00	10	0.06918	0.64312	0.40000	0.12368
22	5.00	50	0.00410	0.65474	0.40000	0.12159
23	5.00	50	0.00365	0.64101	0.40000	0.12413
24	5.00	160	0.00045	0.65738	0.50000	0.12121
25	5.80	1	0.14869	0.63948	0.60000	0.13787
26	5.80	5	0.16475	0.63372	0.60000	0.13678
27	5.80	5	0.09909	0.63948	0.60000	0.13787
28	5.80	10	0.06674	0.64601	0.40000	0.13948
29	5.80	10	0.12768	0.63795	0.40000	0.13755
30	5.80	10	0.05887	0.64102	0.60000	0.13822
31	5.80	50	0.00621	0.63641	0.40000	0.13725
32	5.80	50	0.00755	0.64255	0.40000	0.13858
33	6.50	5	0.24213	0.62148	0.65000	0.12658
34	6.50	10	0.14657	0.63031	0.30000	0.12888
35	6.50	10	0.28602	0.63531	0.30000	0.13051
36	6.50	10	0.13342	0.62417	0.65000	0.12720
37	6.50	20	0.07673	0.62724	0.30000	0.12800
38	6.50	20	0.14856	0.63723	0.30000	0.13120
39	6.50	20	0.06182	0.62148	0.65000	0.12658
40	6.50	100	0.00823	0.63185	0.60000	0.12936
41	6.50	160	0.00205	0.62417	0.60000	0.12720
42	7.00	1	0.37990	0.63663	0.60000	0.13331
43	7.00	10	0.34283	0.63778	0.40000	0.13381
44	7.00	10	0.16806	0.63317	0.60000	0.13190
45	7.00	50	0.02878	0.63240	0.40000	0.13160
46	7.00	50	0.03869	0.63240	0.40000	0.13160
47	7.50	1	0.69730	0.65737	0.60000	0.14381
48	5.00	10	0.23206	0.63855	0.40000	0.13414
49	5.00	10	0.39478	0.64738	0.40000	0.13835
50	8.00	50	0.06157	0.63912	0.40000	0.09000
51	8.00	160	0.01270	0.64124	0.60000	0.09134

TABLE F1-12
J. G. ANDERSON: 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	0.13347	0.67393	0.60000	0.06680
2	5.00	1	0.18731	0.67393	0.60000	0.06680
3	5.00	5	0.04507	0.67129	0.60000	0.06812
4	5.00	5	0.05963	0.68343	0.60000	0.06245
5	5.80	10	0.09997	0.67209	0.40000	0.12087
6	5.80	20	0.11158	0.65903	0.40000	0.11773
7	6.50	1	0.60196	0.64703	0.65000	0.11350
8	6.50	1	0.69029	0.65202	0.65000	0.11562
9	6.50	1	0.71534	0.64396	0.65000	0.11232
10	6.50	5	0.61004	0.64396	0.65000	0.11232
11	6.50	5	0.42481	0.64089	0.65000	0.11124
12	6.50	50	0.02887	0.64549	0.30000	0.11290
13	6.50	50	0.03687	0.64703	0.30000	0.11350
14	7.00	10	0.33989	0.64818	0.40000	0.11581
15	7.50	50	0.06402	0.65467	0.40000	0.11847
16	7.50	50	0.07822	0.65543	0.40000	0.11889
17	5.00	1	0.04883	0.67604	0.60000	0.06578
18	5.80	5	0.14738	0.66709	0.60000	0.11946
19	5.80	5	0.11678	0.67593	0.60000	0.12212
20	5.00	10	0.06320	0.70297	0.40000	0.05591
21	5.00	10	0.13313	0.67393	0.40000	0.06680
22	5.00	50	0.00682	0.67129	0.40000	0.06812
23	5.00	50	0.00696	0.68343	0.40000	0.06245
24	5.00	160	0.00058	0.67604	0.50000	0.06578
25	5.80	1	0.30288	0.67593	0.60000	0.12212
26	5.80	5	0.30355	0.66517	0.60000	0.11898
27	5.80	5	0.19563	0.66517	0.60000	0.11898
28	5.80	10	0.12937	0.67785	0.40000	0.12280
29	5.80	10	0.22267	0.66364	0.40000	0.11863
30	5.80	10	0.10612	0.66210	0.60000	0.11831
31	5.80	50	0.00987	0.66210	0.40000	0.11831
32	5.80	50	0.01181	0.67401	0.40000	0.12147
33	6.50	5	0.48935	0.64549	0.65000	0.11290
34	6.50	10	0.27891	0.65740	0.30000	0.11817
35	6.50	10	0.52724	0.65049	0.30000	0.11495
36	6.50	10	0.25454	0.64857	0.65000	0.11413
37	6.50	20	0.13869	0.64857	0.30000	0.11413
38	6.50	20	0.26216	0.65740	0.30000	0.11817
39	6.50	20	0.10770	0.64242	0.65000	0.11177
40	6.50	100	0.01080	0.64857	0.60000	0.11413
41	6.50	160	0.00316	0.63973	0.60000	0.11086
42	7.00	1	0.79242	0.65855	0.60000	0.12113
43	7.00	10	0.63653	0.66239	0.40000	0.12333
44	7.00	10	0.31664	0.65356	0.60000	0.11845
45	7.00	50	0.04579	0.65125	0.40000	0.11729
46	7.00	50	0.05981	0.65010	0.40000	0.11672
47	7.50	1	1.35242	0.67925	0.60000	0.13410
48	5.00	10	0.42535	0.65390	0.40000	0.11806
49	5.00	10	0.74040	0.66465	0.40000	0.12430
50	8.00	50	0.09158	0.66378	0.40000	0.07215
51	8.00	160	0.01473	0.65955	0.60000	0.06882

TABLE F1-13
J. G. ANDERSON: 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	0.14358	0.72387	0.60000	0.08768
2	5.00	1	0.21911	0.73443	0.60000	0.08924
3	5.00	5	0.05581	0.73443	0.60000	0.08924
4	5.00	5	0.07690	0.74605	0.60000	0.09187
5	5.80	10	0.12015	0.68991	0.40000	0.15612
6	5.80	20	0.14451	0.67802	0.40000	0.14957
7	6.50	1	0.69039	0.66357	0.65000	0.13438
8	6.50	1	0.84340	0.66972	0.65000	0.13824
9	6.50	1	0.87979	0.66972	0.65000	0.13824
10	6.50	5	0.69046	0.66357	0.65000	0.13438
11	6.50	5	0.52342	0.66664	0.65000	0.13628
12	6.50	50	0.03783	0.66357	0.30000	0.13438
13	6.50	50	0.04730	0.66511	0.30000	0.13532
14	7.00	10	0.39644	0.67336	0.40000	0.14211
15	7.50	50	0.08229	0.68253	0.40000	0.14900
16	7.50	50	0.09791	0.67793	0.40000	0.14547
17	5.00	1	0.05885	0.72387	0.60000	0.08768
18	5.80	5	0.18801	0.67954	0.60000	0.15036
19	5.80	5	0.15102	0.67954	0.60000	0.15036
20	5.00	10	0.07559	0.74288	0.40000	0.09106
21	5.00	10	0.16114	0.71648	0.40000	0.08709
22	5.00	50	0.00825	0.74024	0.40000	0.09044
23	5.00	50	0.00797	0.72123	0.40000	0.08742
24	5.00	160	0.00081	0.72915	0.50000	0.08836
25	5.80	1	0.35533	0.67493	0.60000	0.14804
26	5.80	5	0.37619	0.67954	0.60000	0.15036
27	5.80	5	0.22244	0.67340	0.60000	0.14730
28	5.80	10	0.14317	0.68607	0.40000	0.15391
29	5.80	10	0.29315	0.68607	0.40000	0.15391
30	5.80	10	0.12861	0.67493	0.60000	0.14804
31	5.80	50	0.01286	0.68801	0.40000	0.15500
32	5.80	50	0.01375	0.68607	0.40000	0.15391
33	6.50	5	0.54287	0.66664	0.65000	0.13628
34	6.50	10	0.33094	0.66818	0.30000	0.13725
35	6.50	10	0.63894	0.66818	0.30000	0.13725
36	6.50	10	0.31466	0.66511	0.65000	0.13532
37	6.50	20	0.15833	0.66511	0.30000	0.13532
38	6.50	20	0.31703	0.67471	0.30000	0.14156
39	6.50	20	0.13572	0.66088	0.65000	0.13277
40	6.50	100	0.01408	0.65743	0.60000	0.13078
41	6.50	160	0.00427	0.66242	0.60000	0.13368
42	7.00	1	0.90562	0.67950	0.60000	0.14663
43	7.00	10	0.74908	0.68911	0.40000	0.15405
44	7.00	10	0.37997	0.67336	0.60000	0.14211
45	7.00	50	0.05691	0.67067	0.40000	0.14020
46	7.00	50	0.07430	0.67413	0.40000	0.14267
47	7.50	1	1.54266	0.69406	0.60000	0.15826
48	5.00	10	0.49762	0.67985	0.40000	0.14693
49	5.00	10	0.89378	0.68791	0.40000	0.15325
50	8.00	50	0.11464	0.70386	0.40000	0.10366
51	8.00	160	0.01686	0.70492	0.60000	0.10448

TABLE F1-14
J. G. ANDERSON: 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	0.09530	0.68923	0.60000	0.06986
2	5.00	1	0.12766	0.71035	0.60000	0.07419
3	5.00	5	0.04435	0.70718	0.60000	0.07330
4	5.00	5	0.05031	0.70190	0.60000	0.07199
5	5.80	10	0.09233	0.65049	0.40000	0.15539
6	5.80	20	0.12191	0.64396	0.40000	0.15180
7	6.50	1	0.53242	0.65116	0.65000	0.14171
8	6.50	1	0.55432	0.64770	0.65000	0.13937
9	6.50	1	0.58307	0.64616	0.65000	0.13835
10	6.50	5	0.55121	0.64271	0.65000	0.13613
11	6.50	5	0.38906	0.63964	0.65000	0.13421
12	6.50	50	0.03658	0.63272	0.30000	0.13015
13	6.50	50	0.04760	0.64271	0.30000	0.13613
14	7.00	10	0.34350	0.65794	0.40000	0.13770
15	7.50	50	0.08702	0.65982	0.40000	0.13890
16	7.50	50	0.10808	0.66328	0.40000	0.14150
17	5.00	1	0.04324	0.70718	0.60000	0.07330
18	5.80	5	0.13677	0.63897	0.60000	0.14924
19	5.80	5	0.11382	0.64550	0.60000	0.15262
20	5.00	10	0.04595	0.71299	0.40000	0.07500
21	5.00	10	0.12379	0.70190	0.40000	0.07199
22	5.00	50	0.00883	0.70892	0.40000	0.06851
23	5.00	50	0.00750	0.67723	0.40000	0.06238
24	5.00	160	0.00100	0.69783	0.50000	0.06526
25	5.80	1	0.24693	0.64051	0.60000	0.15001
26	5.80	5	0.28649	0.65241	0.60000	0.15650
27	5.80	5	0.17210	0.64550	0.60000	0.15262
28	5.80	10	0.11572	0.66009	0.40000	0.16115
29	5.80	10	0.23704	0.65625	0.40000	0.15878
30	5.80	10	0.10260	0.64051	0.60000	0.15001
31	5.80	50	0.01217	0.65049	0.40000	0.15539
32	5.80	50	0.01658	0.65049	0.40000	0.15539
33	6.50	5	0.41027	0.63964	0.65000	0.13421
34	6.50	10	0.25199	0.63272	0.30000	0.13015
35	6.50	10	0.49643	0.64616	0.30000	0.13835
36	6.50	10	0.25521	0.63964	0.65000	0.13421
37	6.50	20	0.13948	0.64271	0.30000	0.13613
38	6.50	20	0.28301	0.65846	0.30000	0.14687
39	6.50	20	0.13011	0.64117	0.65000	0.13516
40	6.50	100	0.01762	0.64924	0.60000	0.14040
41	6.50	160	0.00601	0.64424	0.60000	0.13711
42	7.00	1	0.65462	0.65794	0.60000	0.13770
43	7.00	10	0.64684	0.67100	0.40000	0.14753
44	7.00	10	0.33569	0.66024	0.60000	0.13937
45	7.00	50	0.05831	0.65371	0.40000	0.13472
46	7.00	50	0.08283	0.65487	0.40000	0.13552
47	7.50	1	1.10802	0.67518	0.60000	0.15089
48	5.00	10	0.45521	0.66750	0.40000	0.14476
49	5.00	10	0.73504	0.67134	0.40000	0.14779
50	8.00	50	0.11738	0.70993	0.40000	0.09915
51	8.00	160	0.02268	0.69937	0.60000	0.09117

TABLE F1-15
J. G. ANDERSON: 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	0.03461	0.70674	0.60000	0.05557
2	5.00	1	0.05549	0.70938	0.60000	0.05658
3	5.00	5	0.01312	0.72258	0.60000	0.06250
4	5.00	5	0.02005	0.70674	0.60000	0.05557
5	5.80	10	0.05091	0.64925	0.40000	0.15674
6	5.80	20	0.07600	0.65269	0.40000	0.15880
7	6.50	1	0.28059	0.65246	0.65000	0.14631
8	6.50	1	0.35104	0.64900	0.65000	0.14379
9	6.50	1	0.34972	0.65054	0.65000	0.14490
10	6.50	5	0.30222	0.64132	0.65000	0.13846
11	6.50	5	0.24210	0.64593	0.65000	0.14162
12	6.50	50	0.02860	0.63863	0.30000	0.13667
13	6.50	50	0.03920	0.63748	0.30000	0.13592
14	7.00	10	0.23688	0.65572	0.40000	0.14267
15	7.50	50	0.07639	0.66105	0.40000	0.14682
16	7.50	50	0.08323	0.65644	0.40000	0.14308
17	5.00	1	0.01561	0.74899	0.60000	0.07761
18	5.80	5	0.07051	0.65768	0.60000	0.16189
19	5.80	5	0.05091	0.64348	0.60000	0.15347
20	5.00	10	0.02033	0.70198	0.40000	0.05393
21	5.00	10	0.04626	0.69776	0.40000	0.05268
22	5.00	50	0.00385	0.72115	0.40000	0.05793
23	5.00	50	0.00435	0.70055	0.40000	0.04796
24	5.00	160	0.00063	0.71059	0.50000	0.05237
25	5.80	1	0.10383	0.65076	0.60000	0.15764
26	5.80	5	0.14270	0.67268	0.60000	0.17197
27	5.80	5	0.09774	0.64769	0.60000	0.15585
28	5.80	10	0.06844	0.66115	0.40000	0.16411
29	5.80	10	0.13211	0.66459	0.40000	0.16640
30	5.80	10	0.05844	0.66651	0.60000	0.16770
31	5.80	50	0.00723	0.64769	0.40000	0.15585
32	5.80	50	0.01101	0.65576	0.40000	0.16068
33	6.50	5	0.24617	0.65745	0.65000	0.15004
34	6.50	10	0.17192	0.65400	0.30000	0.14744
35	6.50	10	0.32681	0.65246	0.30000	0.14631
36	6.50	10	0.17436	0.64593	0.65000	0.14162
37	6.50	20	0.09853	0.65246	0.30000	0.14631
38	6.50	20	0.19322	0.65937	0.30000	0.15151
39	6.50	20	0.08057	0.64593	0.65000	0.14162
40	6.50	100	0.01513	0.64747	0.60000	0.14270
41	6.50	160	0.00603	0.64593	0.60000	0.14162
42	7.00	1	0.41676	0.67339	0.60000	0.15720
43	7.00	10	0.43246	0.66726	0.40000	0.15200
44	7.00	10	0.22559	0.65917	0.60000	0.14541
45	7.00	50	0.04310	0.65572	0.40000	0.14267
46	7.00	50	0.06536	0.65687	0.40000	0.14358
47	7.50	1	0.57789	0.67488	0.60000	0.15856
48	5.00	10	0.28605	0.65915	0.40000	0.14525
49	5.00	10	0.45321	0.66414	0.40000	0.14936
50	8.00	50	0.11083	0.70875	0.40000	0.09052
51	8.00	160	0.02744	0.71245	0.60000	0.09346

TABLE F1-16
J. G. ANDERSON: 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	0.01569	0.71898	0.60000	0.02452
2	5.00	1	0.02295	0.74274	0.60000	0.03950
3	5.00	5	0.00552	0.72795	0.60000	0.02956
4	5.00	5	0.00828	0.71528	0.60000	0.02282
5	5.80	10	0.02151	0.68143	0.40000	0.13285
6	5.80	20	0.02740	0.67595	0.40000	0.13874
7	6.50	1	0.13121	0.68518	0.65000	0.13981
8	6.50	1	0.16387	0.67576	0.65000	0.14189
9	6.50	1	0.14674	0.67230	0.65000	0.13950
10	6.50	5	0.15014	0.67422	0.65000	0.14082
11	6.50	5	0.11533	0.66347	0.65000	0.13372
12	6.50	50	0.01272	0.67980	0.30000	0.13613
13	6.50	50	0.02246	0.66078	0.30000	0.13206
14	7.00	10	0.10488	0.69653	0.40000	0.14760
15	7.50	50	0.04057	0.68614	0.40000	0.14004
16	7.50	50	0.05275	0.68017	0.40000	0.14371
17	5.00	1	0.00531	0.71686	0.60000	0.02351
18	5.80	5	0.03241	0.67902	0.60000	0.14061
19	5.80	5	0.02735	0.68401	0.60000	0.14378
20	5.00	10	0.00597	0.70789	0.40000	0.02036
21	5.00	10	0.01285	0.71528	0.40000	0.02282
22	5.00	50	0.00121	0.71543	0.40000	0.01850
23	5.00	50	0.00195	0.71755	0.40000	0.01992
24	5.00	160	0.00029	0.72230	0.50000	0.02326
25	5.80	1	0.05133	0.70985	0.60000	0.15191
26	5.80	5	0.06535	0.68747	0.60000	0.14606
27	5.80	5	0.04567	0.67441	0.60000	0.13783
28	5.80	10	0.02959	0.68758	0.40000	0.13654
29	5.80	10	0.05575	0.67172	0.40000	0.13628
30	5.80	10	0.03640	0.68555	0.60000	0.14478
31	5.80	50	0.00359	0.69795	0.40000	0.14334
32	5.80	50	0.00655	0.67441	0.40000	0.13783
33	6.50	5	0.10873	0.68326	0.65000	0.13847
34	6.50	10	0.08182	0.68172	0.30000	0.13742
35	6.50	10	0.11766	0.65809	0.30000	0.13046
36	6.50	10	0.09168	0.66462	0.65000	0.13444
37	6.50	20	0.03949	0.68326	0.30000	0.13847
38	6.50	20	0.07980	0.66078	0.30000	0.13206
39	6.50	20	0.04988	0.65809	0.65000	0.13046
40	6.50	100	0.00766	0.67097	0.60000	0.13048
41	6.50	160	0.00315	0.68172	0.60000	0.13742
42	7.00	1	0.17045	0.70613	0.60000	0.15506
43	7.00	10	0.19912	0.68401	0.40000	0.14655
44	7.00	10	0.12073	0.68401	0.60000	0.14655
45	7.00	50	0.02385	0.68424	0.40000	0.13871
46	7.00	50	0.03566	0.67518	0.40000	0.14014
47	7.50	1	0.26612	0.73763	0.60000	0.18206
48	5.00	10	0.13927	0.68808	0.40000	0.14140
49	5.00	10	0.22823	0.68209	0.40000	0.14512
50	8.00	50	0.05822	0.73901	0.40000	0.10757
51	8.00	160	0.02017	0.72950	0.60000	0.10109

TABLE F1-17
J. G. ANDERSON: 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	0.00535	0.74083	0.60000	0.05673
2	5.00	1	0.00814	0.73027	0.60000	0.05138
3	5.00	5	0.00162	0.73766	0.60000	0.05504
4	5.00	5	0.00244	0.73133	0.60000	0.05188
5	5.80	10	0.00814	0.72890	0.40000	0.15389
6	5.80	20	0.00863	0.72174	0.40000	0.17478
7	6.50	1	0.07747	0.73163	0.65000	0.17064
8	6.50	1	0.10304	0.69927	0.65000	0.16982
9	6.50	1	0.08477	0.69503	0.65000	0.16666
10	6.50	5	0.09284	0.70386	0.65000	0.17335
11	6.50	5	0.06191	0.69503	0.65000	0.16666
12	6.50	50	0.00630	0.71818	0.30000	0.16036
13	6.50	50	0.01372	0.69773	0.30000	0.16866
14	7.00	10	0.04800	0.72129	0.40000	0.16589
15	7.50	50	0.01992	0.73051	0.40000	0.17307
16	7.50	50	0.03657	0.70863	0.40000	0.17920
17	5.00	1	0.00130	0.73502	0.60000	0.05368
18	5.80	5	0.01722	0.70023	0.60000	0.15884
19	5.80	5	0.00893	0.70638	0.60000	0.16317
20	5.00	10	0.00160	0.73027	0.40000	0.05138
21	5.00	10	0.00484	0.72710	0.40000	0.04996
22	5.00	50	0.00029	0.73238	0.40000	0.05238
23	5.00	50	0.00102	0.72710	0.40000	0.04996
24	5.00	160	0.00004	0.75351	0.50000	0.06411
25	5.80	1	0.02833	0.75847	0.60000	0.17745
26	5.80	5	0.03583	0.71521	0.60000	0.16972
27	5.80	5	0.02316	0.72174	0.60000	0.17478
28	5.80	10	0.00982	0.72736	0.40000	0.15277
29	5.80	10	0.01829	0.72673	0.40000	0.17875
30	5.80	10	0.01544	0.71675	0.60000	0.17089
31	5.80	50	0.00126	0.71622	0.40000	0.14503
32	5.80	50	0.00350	0.71982	0.40000	0.17327
33	6.50	5	0.05427	0.72471	0.65000	0.16525
34	6.50	10	0.03856	0.72779	0.30000	0.16762
35	6.50	10	0.06147	0.71617	0.30000	0.18318
36	6.50	10	0.04818	0.71425	0.65000	0.18161
37	6.50	20	0.01914	0.72471	0.30000	0.16525
38	6.50	20	0.03821	0.70580	0.30000	0.17485
39	6.50	20	0.02393	0.69773	0.65000	0.16866
40	6.50	100	0.00282	0.72279	0.60000	0.16379
41	6.50	160	0.00163	0.72779	0.60000	0.16762
42	7.00	1	0.08861	0.72705	0.60000	0.17033
43	7.00	10	0.09911	0.71439	0.40000	0.18395
44	7.00	10	0.05745	0.71286	0.60000	0.18267
45	7.00	50	0.01144	0.72052	0.40000	0.16530
46	7.00	50	0.02570	0.70172	0.40000	0.17365
47	7.50	1	0.11571	0.75240	0.60000	0.19136
48	5.00	10	0.06462	0.74741	0.40000	0.18705
49	5.00	10	0.13770	0.74128	0.40000	0.20746
50	8.00	50	0.04427	0.78063	0.40000	0.14388
51	8.00	160	0.01940	0.78538	0.60000	0.14718

TABLE F1-18
J. G. ANDERSON: 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	0.00172	0.79952	0.60000	0.07516
2	5.00	1	0.00294	0.78790	0.60000	0.06615
3	5.00	5	0.00057	0.79212	0.60000	0.06941
4	5.00	5	0.00117	0.78473	0.60000	0.06372
5	5.80	10	0.00441	0.76674	0.40000	0.16974
6	5.80	20	0.00479	0.74345	0.40000	0.17920
7	6.50	1	0.04079	0.77565	0.65000	0.19693
8	6.50	1	0.06270	0.74021	0.65000	0.19293
9	6.50	1	0.05420	0.73521	0.65000	0.18854
10	6.50	5	0.06335	0.74136	0.65000	0.19395
11	6.50	5	0.03295	0.73293	0.65000	0.18654
12	6.50	50	0.00330	0.77222	0.30000	0.19376
13	6.50	50	0.00665	0.75672	0.30000	0.20789
14	7.00	10	0.03026	0.79220	0.40000	0.21535
15	7.50	50	0.01281	0.78183	0.40000	0.20546
16	7.50	50	0.01975	0.75343	0.40000	0.20678
17	5.00	1	0.00043	0.79793	0.60000	0.07392
18	5.80	5	0.01097	0.74461	0.60000	0.18017
19	5.80	5	0.00580	0.74038	0.60000	0.17662
20	5.00	10	0.00053	0.79582	0.40000	0.07228
21	5.00	10	0.00197	0.78473	0.40000	0.06372
22	5.00	50	0.00011	0.79793	0.40000	0.07392
23	5.00	50	0.00050	0.78526	0.40000	0.06412
24	5.00	160	0.00003	0.81959	0.50000	0.09098
25	5.80	1	0.01266	0.77135	0.60000	0.17377
26	5.80	5	0.02133	0.74729	0.60000	0.18247
27	5.80	5	0.01036	0.74115	0.60000	0.17726
28	5.80	10	0.00466	0.76290	0.40000	0.16642
29	5.80	10	0.00880	0.74845	0.40000	0.18345
30	5.80	10	0.00739	0.75459	0.60000	0.18880
31	5.80	50	0.00061	0.76175	0.40000	0.16544
32	5.80	50	0.00177	0.75690	0.40000	0.19083
33	6.50	5	0.03717	0.76453	0.65000	0.18681
34	6.50	10	0.01879	0.75071	0.30000	0.17472
35	6.50	10	0.03036	0.75175	0.30000	0.20330
36	6.50	10	0.02208	0.74291	0.65000	0.19532
37	6.50	20	0.01017	0.77913	0.30000	0.20013
38	6.50	20	0.01555	0.74405	0.30000	0.19635
39	6.50	20	0.01502	0.75019	0.65000	0.20189
40	6.50	100	0.00121	0.76453	0.60000	0.18681
41	6.50	160	0.00086	0.76453	0.60000	0.18681
42	7.00	1	0.05217	0.77645	0.60000	0.20042
43	7.00	10	0.05235	0.76649	0.40000	0.21916
44	7.00	10	0.03337	0.75573	0.60000	0.20894
45	7.00	50	0.00745	0.78452	0.40000	0.20801
46	7.00	50	0.01359	0.76649	0.40000	0.21916
47	7.50	1	0.08370	0.80411	0.60000	0.22692
48	5.00	10	0.03555	0.77837	0.40000	0.20222
49	5.00	10	0.07235	0.77378	0.40000	0.22620
50	8.00	50	0.03412	0.84048	0.40000	0.16943
51	8.00	160	0.01277	0.84418	0.60000	0.17227

TABLE F1-19
J. G. ANDERSON: VERTICAL POINT ESTIMATES
PEAK GROUND VELOCITY

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	2.80810	0.65924	0.60000	0.08546
2	5.00	1	4.29556	0.66083	0.60000	0.08648
3	5.00	5	0.90284	0.66083	0.60000	0.08648
4	5.00	5	1.48331	0.65924	0.60000	0.08546
5	5.80	10	2.94654	0.63290	0.40000	0.12525
6	5.80	20	3.73412	0.61474	0.40000	0.11732
7	6.50	1	17.20402	0.63012	0.65000	0.11997
8	6.50	1	25.50247	0.62147	0.65000	0.11992
9	6.50	1	21.73553	0.62415	0.65000	0.12255
10	6.50	5	24.66848	0.61595	0.65000	0.11400
11	6.50	5	14.60814	0.61993	0.65000	0.11843
12	6.50	50	1.22950	0.61990	0.30000	0.10950
13	6.50	50	2.44010	0.61772	0.30000	0.11600
14	7.00	10	13.23987	0.64282	0.40000	0.13144
15	7.50	50	4.39409	0.63815	0.40000	0.13276
16	7.50	50	7.06752	0.63410	0.40000	0.13639
17	5.00	1	0.99430	0.65924	0.60000	0.08546
18	5.80	5	5.57618	0.61282	0.60000	0.11554
19	5.80	5	3.61064	0.61743	0.60000	0.11985
20	5.00	10	1.07860	0.66716	0.40000	0.09061
21	5.00	10	2.89521	0.65343	0.40000	0.08181
22	5.00	50	0.17204	0.66294	0.40000	0.08784
23	5.00	50	0.23777	0.63548	0.40000	0.07137
24	5.00	160	0.02367	0.67667	0.50000	0.09700
25	5.80	1	7.57530	0.62714	0.60000	0.11978
26	5.80	5	10.35665	0.61474	0.60000	0.11732
27	5.80	5	5.78659	0.61013	0.60000	0.11279
28	5.80	10	3.55716	0.62982	0.40000	0.12232
29	5.80	10	7.32232	0.61627	0.40000	0.11876
30	5.80	10	3.82405	0.61743	0.60000	0.11985
31	5.80	50	0.34628	0.62829	0.40000	0.12086
32	5.80	50	0.68701	0.61743	0.40000	0.11985
33	6.50	5	14.87275	0.63165	0.65000	0.12144
34	6.50	10	9.29801	0.62345	0.30000	0.11320
35	6.50	10	16.00772	0.62569	0.30000	0.12406
36	6.50	10	10.05691	0.61329	0.65000	0.11105
37	6.50	20	4.60363	0.61931	0.30000	0.10890
38	6.50	20	8.79620	0.61772	0.30000	0.11600
39	6.50	20	5.39304	0.61595	0.65000	0.11400
40	6.50	100	0.59426	0.62743	0.60000	0.11743
41	6.50	160	0.18813	0.62167	0.60000	0.11133
42	7.00	1	22.74919	0.64512	0.60000	0.13366
43	7.00	10	25.58826	0.63837	0.40000	0.13490
44	7.00	10	14.56536	0.63299	0.60000	0.12954
45	7.00	50	2.53180	0.63706	0.40000	0.12596
46	7.00	50	4.69880	0.63299	0.40000	0.12954
47	7.50	1	38.22290	0.66313	0.60000	0.15761
48	5.00	10	17.87472	0.64124	0.40000	0.13575
49	5.00	10	32.33877	0.64370	0.40000	0.14617
50	8.00	50	9.00461	0.68372	0.40000	0.14362
51	8.00	160	2.67731	0.70749	0.60000	0.16129

APPENDIX F2

MY RULES (FOR COMPUTING GROUND MOTIONS FOR PSHA OF YUCCA MOUNTAIN WASTE REPOSITORY)

David M. Boore

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APPENDIX F2

MY RULES (FOR COMPUTING GROUND MOTIONS FOR PSHA OF YUCCA MOUNTAIN WASTE REPOSITORY)

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F2-1 INTRODUCTION

Because of the huge number of ground motion values that I am to provide (Tables F2-1 to F2-18), I have decided that the only practical way to provide the numbers is to first specify weights used in combining the proponent estimates and then review the resulting weighted ground motions. These weights are specified in this documentation. Included are very brief discussions of the reasons for the various weights. It should be understood that the actual weights are based on my judgment; my comments regarding the weights will not attempt to justify the precise numerical values, but rather will dwell more on the relative weights of the various proponent models.

F2-2 WEIGHTING SCHEME

F2-2.1 Distances

The distances are computed assuming Wells & Coppersmith (1994) width as a function of M, centered at the depth (shallow) or with bottom edge at greatest depth (deep). The point source calculations should use a distance as per Walt Silva's suggestion (rps = sqrt(rjb**2 + h**2), where rps = equivalent point source distance, rjb = "Joyner-Boore" distance, and h = depth to midpoint of rupture surface on fault).

F2-2.2 Classes Of Proponent Models

I divide the proponent models into three classes: 1) empirical, 2) point source simulations, and 3) finite fault simulations.

F2-2.3 Between-Class Weights

When combining the various proponent models, the weights should be normalized so that various classes have the following relative weights:

Type of Motion	Class	Weight
Horizontal	Empirical	2
Horizontal	Pt. Source	1
Horizontal	Finite Fault	1
Vertical	Empirical	4
Vertical	Pt. Source	1
Vertical	Finite Fault	1

For the horizontal component motions I decided that the empirical and the simulated motions should be given equal weight. I further decided that the point source and finite simulations should be given equal weight. The point source is a well-established model that has been well tested; in particular, it has been shown to provide good predictions of ground motions close to large earthquakes, where it would seem that the point source approximation is not valid. The use of some variant of closest distance to the fault in applying the point source model may overcome the apparent deficiency of the point source model at close distance to faults. The finite fault models are not as well validated and require the estimation of a number of parameters. The motions can be sensitive to such things as radiation pattern if adequate randomization is not included. The computation of motions at high frequencies using the finite source models must be done with care if a propagating rupture is to be properly modeled. On the other hand, what is needed may not be the proper mathematical modeling of the idealized rupture; randomness probably should be included to account for the complexities of the real world. In this sense the finite-fault models take on the flavor of the point source stochastic model.

For vertical motions it is my opinion that the numerical simulations have not been adequately validated, and for this reason I have downweighted them relative to the empirical models (giving them 1/2 the weight of the empirical models).

F2-2.4 Within-Class Weights

F2-2.4.1 Empirical Model Weights. Fourteen empirical models were considered. Six models were given zero weight (see below). The remaining eight models were separated into two categories based on the distance measure used, those using the Joyner-Boore" distance and those using any other distance measure.

For spectral acceleration, the weights were evenly balanced between these two distance groups. For the relations using a distance measure different from Joyner-Boore, I gave most weight to AS97 as I feel that it is the most current and complete study. With respect to peak velocity, few proponent models are available; I gave equal weight to all models providing peak velocity, with the exception of those proponent models receiving no weight for any ground motion estimates. The weights applied to the empirical models are summarized below.

<u>Models used in analysis:</u>

- BJF 97: weight = 1 except weight = 0.5 for M = 5 and weight = 0 for pga
- SEA97: weight = 1
- AS97: weight = 1
- Campbell 97 (soft rock): weight = 0.6
- Idriss 97 (written communication): weight = 0.2
- JB88: weight = 0 except for pgv, for which weight = 1
- Sadigh 97: weight = 0.2
- McGarr: weight = 1 (this is for pgv only)

<u>Models given zero weight:</u>

- BJF94, site class A and B: more recent relations in terms of shear-wave velocity are available.

- Blast-Based Models: I expect that the attenuation from a surface source differs from an earthquake source.
- Campbell's early models: more recent models are available
- Campbell's hard rock model: other relations are for "soft" rock; few hard rock data are available.
- Idriss 93 (pga): more recent relation is available
- Sabetta & Pugliese: not up-to-date; uses S triggered data

	Proponent Model	Model Weight	
		Spectral Acceleration, PGA	PGV
Joyner-Boore Distance	BJF94	1.0 (0.5 for M=5); 0 for PGA	–
	SEA97	1.0	–
	JB88	0.0	1.0
All Other Distance Measures	AS97	1.0	–
	C97	0.6	1.0
	Idriss 97	0.2	–
	Sadigh 97	0.2	–
	McGarr 84	0.0	1.0

F2-2.4.2 Point Source Weights. The validations for the point source model show that there is a significant bias (over prediction) for this model at long periods ($T \geq 2$ sec). Since no correction was made for this bias, I gave the point source model zero weight for periods greater than or equal to 2 sec. At periods less than 1 sec, there is not a significant bias so I gave the point source model full weight for short periods.

- $T \geq 2.0$ sec: weight = 0.0 (because of uncorrected bias)
- $T = 1.0$ sec: weight = 0.5 (transition to periods with no bias)
- $T < 1.0$ sec: weight = 1.0

F2-2.4.3 Finite Fault Weights. I consider all three finite fault models to be equally credible so I gave equal weight to all three. Only Zeng and Anderson provided estimates at M = 5. To avoid giving much larger weight to this model for magnitude 5 events, I gave it zero weight. This ensures that all models have equal impact on the estimates.

- Zeng and Anderson: weight = 1, except = 0 for M = 5 (the only finite fault model for M = 5)
- Silva: weight = 1
- Somerville: weight = 1

F2-2.5 Conversions

Use same source and path corrections for horizontal and vertical motions.

F2-2.5.1 Empirical Models.

- Source differences: all empirical except Abrahamson & Silva (1997) and SEA96 need corrections for differences in source. Use Silva's corrections.
- Site differences: Campbell CA-->YM300
- pgv: For those proponent models lacking pgv use pgv/Sa(T=1.0s) from the point source model to scale the Sa(T=1.0s) estimates. Apply the conversion to the Sa(T=1.0s) AFTER conversions to YM300 and normal fault source.
- Sa(T=0.05s): For those proponent models lacking Sa at T = 0.05 s (20 Hz), use the following factor: Sa(T=0.05s)/Sa(T=0.10s) = 0.7 See the Appendix F2-A for the derivation of this factor. Apply the conversion factor to the Sa(T=0.1s) results before applying the source and YM300 conversion factors.
- Point source model: use stress = 45 bars, sigma(lnStress) = 0.5 (these numbers will probably be updated after receiving the new Becker results).

F2-2.5.2 Finite Fault Models.

- Source differences: apply the source correction, as in the empirical proponent models.
- Site differences: the simulations accounted for the YM site condition, so no corrections are needed.

F2-3 SIGMAS

F2-3.1 Aleatory

Find the average of the sigma from the empirical proponent models, using the same in-class weights used for finding the median ground motions. Include component-to-component 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.

F2-6 REFERENCES

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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

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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 Bennett and others (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 and others (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 and others (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 and others (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 and others (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 and others (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 and others (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 and others (1997) with those of Boore and others (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.

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.

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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 (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
7	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

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APPENDIX F4
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APPENDIX F4

EXPERT REPORT ON YUCCA MOUNTAIN GROUND MOTION ATTENUATION

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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; Abrahamson, 1993; Boore et at., 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

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, 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 (Bennett et al. 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 (Yucca Mountain Ground Motion Data Package, 1997).

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 (1991 and 1997, written communication). 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

Class, Model	Class Wt.	Wt.	CA to YM300	Stress Drop
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
Sadigh		1	Y	Y	N
Empirical (ext.)	1				
A&S 97 (N)		1	Y	N	N

Class. Model	Class Wt.	Wt.	CA to YM300	Stress Drop	Z/H
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_0 from $\log M_0=16.05+1.5M$.

(2) Distribute M_0 evenly among multiple faults, $M_0=nM_{0f}$.

(3) Calculate $M_f=(\log M_{0f}-16.05)/1.5$, 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.

F4-8 REFERENCES

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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

TABLE F4-5
A. McGARR: 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	0.09408	0.78921	0.35494	0.08239
2	5.00	1	0.12759	0.77760	0.40561	0.07818
3	5.00	5	0.03808	0.78688	0.33888	0.08116
4	5.00	5	0.05581	0.77991	0.32861	0.07863
5	5.80	10	0.09734	0.73214	0.18824	0.09231
6	5.80	20	0.08215	0.73295	0.21058	0.09277
7	6.50	1	0.49629	0.70629	0.23021	0.09949
8	6.50	1	0.53565	0.70663	0.32029	0.10017
9	6.50	1	0.44392	0.70995	0.23537	0.10176
10	6.50	5	0.45438	0.70738	0.30880	0.10006
11	6.50	5	0.28673	0.70640	0.19241	0.09954
12	6.50	50	0.04446	0.70948	0.24497	0.10147
13	6.50	50	0.04821	0.70496	0.25579	0.09899
14	7.00	10	0.33018	0.68942	0.26958	0.11298
15	7.50	50	0.10581	0.69089	0.22371	0.12148
16	7.50	50	0.12022	0.68679	0.25248	0.11918
17	5.00	1	0.03887	0.78921	0.58915	0.08239
18	5.80	5	0.15795	0.73360	0.18515	0.09309
19	5.80	5	0.08856	0.73374	0.24305	0.09325
20	5.00	10	0.04359	0.77760	0.19409	0.07818
21	5.00	10	0.05966	0.77298	0.26170	0.07790
22	5.00	50	0.00674	0.77529	0.26470	0.07794
23	5.00	50	0.00769	0.77760	0.22716	0.07818
24	5.00	160	0.00155	0.77068	0.41756	0.07807
25	5.80	1	0.26897	0.73044	0.28280	0.09134
26	5.80	5	0.24327	0.73129	0.31881	0.09176
27	5.80	5	0.13833	0.72709	0.21590	0.09044
28	5.80	10	0.11971	0.73307	0.22512	0.09282
29	5.80	10	0.17139	0.73077	0.29279	0.09171
30	5.80	10	0.08471	0.73030	0.26780	0.09157
31	5.80	50	0.01728	0.73081	0.47267	0.09154
32	5.80	50	0.01802	0.73239	0.56708	0.09285
33	6.50	5	0.36574	0.70542	0.26328	0.09914
34	6.50	10	0.24055	0.70747	0.26598	0.10021
35	6.50	10	0.37022	0.70704	0.33527	0.10001
36	6.50	10	0.18834	0.70535	0.21757	0.09912
37	6.50	20	0.12470	0.70642	0.21653	0.09955
38	6.50	20	0.17731	0.70980	0.29052	0.10167
39	6.50	20	0.10509	0.70571	0.17444	0.09925
40	6.50	100	0.02213	0.70631	0.29387	0.09950
41	6.50	160	0.01144	0.70845	0.40268	0.10121
42	7.00	1	0.62292	0.69025	0.22411	0.11339
43	7.00	10	0.51173	0.68994	0.30369	0.11320
44	7.00	10	0.26018	0.68938	0.17538	0.11296
45	7.00	50	0.07252	0.68813	0.21359	0.11223
46	7.00	50	0.08304	0.69105	0.27230	0.11386
47	7.50	1	0.75940	0.69782	0.28949	0.12824
48	5.00	10	0.42137	0.69464	0.29154	0.12506
49	5.00	10	0.61968	0.69063	0.40666	0.12131
50	8.00	50	0.13952	0.70611	0.25434	0.11343
51	8.00	160	0.04306	0.70202	0.36680	0.11172

TABLE F4-6
A. McGARR: 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	0.04141	0.82412	0.30516	0.07128
2	5.00	1	0.05545	0.82182	0.39650	0.07107
3	5.00	5	0.01665	0.81952	0.36408	0.07110
4	5.00	5	0.02459	0.81952	0.43752	0.07110
5	5.80	10	0.05043	0.78845	0.20197	0.08301
6	5.80	20	0.04207	0.78654	0.21934	0.08614
7	6.50	1	0.29217	0.76628	0.21096	0.09875
8	6.50	1	0.30525	0.76701	0.31509	0.10181
9	6.50	1	0.25518	0.76217	0.23163	0.09985
10	6.50	5	0.26587	0.76567	0.31860	0.10119
11	6.50	5	0.16142	0.76262	0.25448	0.09977
12	6.50	50	0.02959	0.76286	0.28559	0.09762
13	6.50	50	0.02986	0.76291	0.34876	0.09986
14	7.00	10	0.20101	0.74890	0.25864	0.11597
15	7.50	50	0.07470	0.75033	0.25503	0.12649
16	7.50	50	0.08269	0.74842	0.29251	0.12758
17	5.00	1	0.01676	0.81722	0.72014	0.07134
18	5.80	5	0.08104	0.79407	0.36904	0.09110
19	5.80	5	0.04537	0.79209	0.34173	0.08900
20	5.00	10	0.01813	0.81722	0.14918	0.07134
21	5.00	10	0.02417	0.81722	0.21981	0.07134
22	5.00	50	0.00293	0.81493	0.41534	0.07180
23	5.00	50	0.00320	0.82182	0.37162	0.07107
24	5.00	160	0.00090	0.81952	0.41360	0.07110
25	5.80	1	0.13781	0.79135	0.30971	0.08489
26	5.80	5	0.12383	0.78401	0.34350	0.08432
27	5.80	5	0.06911	0.78985	0.31612	0.08716
28	5.80	10	0.06058	0.78968	0.22683	0.08392
29	5.80	10	0.08685	0.78479	0.29479	0.08466
30	5.80	10	0.04437	0.79050	0.29278	0.08874
31	5.80	50	0.01007	0.78400	0.48317	0.08137
32	5.80	50	0.01065	0.78646	0.53086	0.08526
33	6.50	5	0.20543	0.76853	0.26516	0.09979
34	6.50	10	0.14143	0.76614	0.26065	0.09874
35	6.50	10	0.21626	0.76409	0.32505	0.10033
36	6.50	10	0.10926	0.76232	0.24306	0.09968
37	6.50	20	0.07419	0.76271	0.24685	0.09751
38	6.50	20	0.10122	0.76615	0.33036	0.10150
39	6.50	20	0.06206	0.76340	0.24613	0.10003
40	6.50	100	0.01580	0.76339	0.28697	0.09772
41	6.50	160	0.00878	0.76388	0.43595	0.09797
42	7.00	1	0.36811	0.74990	0.32675	0.11649
43	7.00	10	0.31315	0.75058	0.35191	0.11855
44	7.00	10	0.16192	0.74645	0.23605	0.11695
45	7.00	50	0.04928	0.74880	0.29796	0.11595
46	7.00	50	0.05339	0.74706	0.36957	0.11711
47	7.50	1	0.48414	0.75679	0.41763	0.12961
48	5.00	10	0.27547	0.75406	0.31417	0.12864
49	5.00	10	0.40973	0.75064	0.49681	0.12841
50	8.00	50	0.10475	0.75795	0.25976	0.12604
51	8.00	160	0.03921	0.76188	0.33445	0.12695

TABLE F4-7
A. McGARR: 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	0.01170	0.91687	0.44990	0.07130
2	5.00	1	0.01556	0.91228	0.37888	0.07193
3	5.00	5	0.00542	0.90544	0.54983	0.07446
4	5.00	5	0.00738	0.90544	0.51380	0.07446
5	5.80	10	0.02039	0.88529	0.31735	0.10388
6	5.80	20	0.01603	0.88198	0.34426	0.11280
7	6.50	1	0.13624	0.86561	0.26294	0.12915
8	6.50	1	0.13756	0.86033	0.32083	0.13460
9	6.50	1	0.11574	0.86217	0.21271	0.13531
10	6.50	5	0.11617	0.86312	0.40839	0.13601
11	6.50	5	0.07994	0.86301	0.25717	0.13577
12	6.50	50	0.01503	0.86272	0.43598	0.12849
13	6.50	50	0.01473	0.86013	0.50787	0.13438
14	7.00	10	0.10475	0.85316	0.35852	0.15056
15	7.50	50	0.04270	0.85226	0.50795	0.16212
16	7.50	50	0.04513	0.84361	0.57992	0.16507
17	5.00	1	0.00486	0.91000	0.89805	0.07257
18	5.80	5	0.03228	0.87676	0.33589	0.11027
19	5.80	5	0.01972	0.87801	0.35255	0.11071
20	5.00	10	0.00636	0.90544	0.25571	0.07446
21	5.00	10	0.00778	0.90771	0.31558	0.07341
22	5.00	50	0.00117	0.90544	0.46521	0.07446
23	5.00	50	0.00112	0.90544	0.55630	0.07446
24	5.00	160	0.00047	0.90544	0.48000	0.07446
25	5.80	1	0.05435	0.89000	0.24463	0.10599
26	5.80	5	0.04744	0.87569	0.33961	0.10984
27	5.80	5	0.03023	0.87722	0.27912	0.11036
28	5.80	10	0.02407	0.88939	0.29054	0.10784
29	5.80	10	0.03153	0.88555	0.35098	0.11678
30	5.80	10	0.01896	0.87611	0.35654	0.11000
31	5.80	50	0.00458	0.88163	0.64329	0.10248
32	5.80	50	0.00459	0.88026	0.66741	0.11234
33	6.50	5	0.10013	0.86505	0.27767	0.12876
34	6.50	10	0.06675	0.86542	0.28345	0.12887
35	6.50	10	0.09241	0.86336	0.39798	0.13647
36	6.50	10	0.05269	0.86061	0.31857	0.13459
37	6.50	20	0.03809	0.86773	0.28966	0.12992
38	6.50	20	0.04730	0.85792	0.34860	0.13363
39	6.50	20	0.03039	0.85997	0.37785	0.13437
40	6.50	100	0.00874	0.86403	0.36371	0.12863
41	6.50	160	0.00511	0.86858	0.59103	0.13045
42	7.00	1	0.19363	0.85316	0.30861	0.15056
43	7.00	10	0.14430	0.84904	0.46045	0.15547
44	7.00	10	0.08445	0.85029	0.36053	0.15645
45	7.00	50	0.02789	0.85108	0.39784	0.14990
46	7.00	50	0.02908	0.84582	0.47628	0.15417
47	7.50	1	0.24850	0.85676	0.45266	0.16441
48	5.00	10	0.14675	0.85170	0.49999	0.16193
49	5.00	10	0.19363	0.84570	0.64907	0.16566
50	8.00	50	0.06564	0.86234	0.30079	0.16399
51	8.00	160	0.02777	0.86352	0.41672	0.16411

TABLE F4-8
A. McGARR: 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	0.00407	0.95631	0.55928	0.07796
2	5.00	1	0.00493	0.94932	0.53335	0.07431
3	5.00	5	0.00170	0.94932	0.48334	0.07431
4	5.00	5	0.00215	0.94932	0.50607	0.07431
5	5.80	10	0.00940	0.89777	0.34842	0.11603
6	5.80	20	0.00646	0.89363	0.34813	0.12481
7	6.50	1	0.07791	0.87968	0.24975	0.15548
8	6.50	1	0.07449	0.86199	0.26963	0.14763
9	6.50	1	0.06375	0.86630	0.24394	0.15104
10	6.50	5	0.06215	0.86799	0.34984	0.15240
11	6.50	5	0.04552	0.87061	0.29508	0.15501
12	6.50	50	0.00885	0.87424	0.53610	0.14787
13	6.50	50	0.00787	0.86615	0.59643	0.15083
14	7.00	10	0.06460	0.85716	0.36724	0.17276
15	7.50	50	0.03205	0.85189	0.43624	0.18038
16	7.50	50	0.02976	0.84587	0.57781	0.18362
17	5.00	1	0.00151	0.95165	0.73524	0.07532
18	5.80	5	0.01297	0.89723	0.33121	0.12813
19	5.80	5	0.00809	0.89644	0.37226	0.12728
20	5.00	10	0.00220	0.94468	0.39526	0.07290
21	5.00	10	0.00241	0.94700	0.35118	0.07349
22	5.00	50	0.00046	0.94237	0.34346	0.07252
23	5.00	50	0.00042	0.94237	0.30143	0.07252
24	5.00	160	0.00015	0.94237	0.33319	0.07252
25	5.80	1	0.02572	0.89960	0.30701	0.11755
26	5.80	5	0.02062	0.89663	0.33583	0.12785
27	5.80	5	0.01392	0.89325	0.33091	0.12448
28	5.80	10	0.01153	0.89923	0.33671	0.11707
29	5.80	10	0.01252	0.89141	0.36938	0.12303
30	5.80	10	0.00808	0.89481	0.47855	0.12568
31	5.80	50	0.00216	0.89940	0.63111	0.11716
32	5.80	50	0.00196	0.89456	0.68478	0.12568
33	6.50	5	0.05887	0.87914	0.24520	0.15359
34	6.50	10	0.03783	0.87673	0.29971	0.15063
35	6.50	10	0.04436	0.86747	0.38968	0.15216
36	6.50	10	0.02779	0.86963	0.41675	0.15418
37	6.50	20	0.02094	0.87233	0.35747	0.14617
38	6.50	20	0.02253	0.87122	0.41900	0.15569
39	6.50	20	0.01613	0.86394	0.47096	0.14906
40	6.50	100	0.00476	0.86915	0.51889	0.14370
41	6.50	160	0.00329	0.87857	0.58656	0.15219
42	7.00	1	0.12487	0.85491	0.28151	0.17065
43	7.00	10	0.07585	0.84840	0.46087	0.17388
44	7.00	10	0.04878	0.84914	0.43370	0.17437
45	7.00	50	0.01845	0.85394	0.44843	0.16989
46	7.00	50	0.01743	0.84947	0.52519	0.17476
47	7.50	1	0.17502	0.85792	0.38368	0.18555
48	5.00	10	0.09741	0.85630	0.51116	0.18411
49	5.00	10	0.11032	0.84693	0.64831	0.18444
50	8.00	50	0.05303	0.87160	0.25135	0.18110
51	8.00	160	0.02409	0.87208	0.31114	0.18150

TABLE F4-9
A. McGARR: HORIZONTAL POINT ESTIMATES
PEAK GROUND VELOCITY

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	5.76892	0.77513	0.42153	0.07727
2	5.00	1	8.96000	0.77513	0.37607	0.07727
3	5.00	5	2.01906	0.77513	0.30275	0.07727
4	5.00	5	3.34081	0.76900	0.38084	0.07375
5	5.80	10	5.59918	0.74832	0.18514	0.09661
6	5.80	20	4.59678	0.74679	0.18488	0.09881
7	6.50	1	33.93066	0.75161	0.18533	0.11509
8	6.50	1	37.32352	0.74897	0.31358	0.11705
9	6.50	1	28.89401	0.74897	0.21364	0.11705
10	6.50	5	33.16038	0.74696	0.30885	0.11576
11	6.50	5	18.36356	0.74540	0.18142	0.11522
12	6.50	50	2.47847	0.74552	0.33705	0.11290
13	6.50	50	2.55408	0.74445	0.37580	0.11482
14	7.00	10	23.59593	0.74789	0.24704	0.12606
15	7.50	50	7.44233	0.74841	0.38578	0.13626
16	7.50	50	8.47371	0.74335	0.45892	0.13663
17	5.00	1	1.84080	0.76900	0.71942	0.07375
18	5.80	5	9.73234	0.74761	0.34306	0.09896
19	5.80	5	5.20978	0.74667	0.31641	0.09860
20	5.00	10	2.42389	0.76594	0.12511	0.07232
21	5.00	10	3.50263	0.76900	0.10771	0.07375
22	5.00	50	0.27286	0.76289	0.20093	0.07113
23	5.00	50	0.30460	0.76594	0.19567	0.07232
24	5.00	160	0.05448	0.75681	0.24571	0.06949
25	5.80	1	17.18606	0.74999	0.31394	0.09721
26	5.80	5	16.38807	0.74456	0.31007	0.09789
27	5.80	5	8.45280	0.74601	0.22597	0.09840
28	5.80	10	6.95378	0.75164	0.22147	0.09773
29	5.80	10	10.82250	0.74683	0.21336	0.09882
30	5.80	10	4.81959	0.74561	0.29965	0.09829
31	5.80	50	0.80705	0.74895	0.52645	0.09675
32	5.80	50	0.86779	0.74884	0.56224	0.09952
33	6.50	5	24.09546	0.75074	0.19797	0.11468
34	6.50	10	15.56801	0.74954	0.19304	0.11421
35	6.50	10	24.93648	0.74728	0.31349	0.11589
36	6.50	10	11.51401	0.74482	0.21603	0.11506
37	6.50	20	7.54828	0.74832	0.23254	0.11375
38	6.50	20	10.65791	0.74782	0.27492	0.11613
39	6.50	20	5.98332	0.74287	0.25458	0.11431
40	6.50	100	1.20417	0.74701	0.35479	0.11354
41	6.50	160	0.53600	0.75174	0.58288	0.11601
42	7.00	1	45.19347	0.74891	0.29994	0.12675
43	7.00	10	37.40738	0.74592	0.41376	0.12772
44	7.00	10	17.71020	0.74322	0.30764	0.12672
45	7.00	50	4.61680	0.74404	0.32868	0.12495
46	7.00	50	5.17090	0.74223	0.40715	0.12641
47	7.50	1	60.57650	0.75566	0.50900	0.14015
48	5.00	10	33.02724	0.75068	0.42410	0.13735
49	5.00	10	48.64212	0.74540	0.67888	0.13727
50	8.00	50	12.06421	0.75608	0.36087	0.13408
51	8.00	160	3.71883	0.76042	0.45514	0.13457

TABLE F4-10
A. McGARR: VERTICAL POINT ESTIMATES
PEAK GROUND ACCELERATION

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.08773	0.65788	0.61424	0.07873
2	5.00	1	0.10244	0.66188	0.31600	0.07940
3	5.00	5	0.02608	0.65788	0.40156	0.07873
4	5.00	5	0.03042	0.66063	0.22121	0.07912
5	5.80	10	0.05001	0.60510	0.26502	0.09930
6	5.80	20	0.04325	0.59898	0.36240	0.09243
7	6.50	1	0.29021	0.56190	0.28457	0.11353
8	6.50	1	0.32237	0.56528	0.24609	0.11759
9	6.50	1	0.26248	0.56140	0.21735	0.11298
10	6.50	5	0.27964	0.56003	0.31306	0.11152
11	6.50	5	0.16792	0.56140	0.24414	0.11298
12	6.50	50	0.01241	0.56040	0.29642	0.11191
13	6.50	50	0.01493	0.55953	0.28418	0.11102
14	7.00	10	0.15156	0.53819	0.19367	0.14253
15	7.50	50	0.02606	0.53671	0.26060	0.15077
16	7.50	50	0.03198	0.53646	0.36468	0.15046
17	5.00	1	0.02872	0.65338	0.46575	0.07871
18	5.80	5	0.07677	0.59810	0.37503	0.09164
19	5.80	5	0.04600	0.60160	0.36352	0.09510
20	5.00	10	0.03355	0.66463	0.28174	0.08020
21	5.00	10	0.05823	0.65013	0.29962	0.07917
22	5.00	50	0.00275	0.65563	0.16842	0.07862
23	5.00	50	0.00281	0.64913	0.15459	0.07940
24	5.00	160	0.00030	0.65688	0.24926	0.07866
25	5.80	1	0.17892	0.59998	0.46725	0.09339
26	5.80	5	0.17016	0.59810	0.38014	0.09164
27	5.80	5	0.09041	0.59998	0.26397	0.09339
28	5.80	10	0.06710	0.60210	0.29646	0.09565
29	5.80	10	0.10974	0.59948	0.33714	0.09290
30	5.80	10	0.05089	0.60048	0.26298	0.09390
31	5.80	50	0.00514	0.59898	0.55375	0.09243
32	5.80	50	0.00604	0.60098	0.50851	0.09442
33	6.50	5	0.21342	0.55953	0.20921	0.11102
34	6.50	10	0.12410	0.56240	0.17870	0.11410
35	6.50	10	0.22048	0.56403	0.32217	0.11602
36	6.50	10	0.09872	0.56040	0.23381	0.11191
37	6.50	20	0.05555	0.56140	0.17455	0.11298
38	6.50	20	0.09089	0.56465	0.31443	0.11680
39	6.50	20	0.04323	0.55953	0.25315	0.11102
40	6.50	100	0.00468	0.56290	0.35610	0.11468
41	6.50	160	0.00169	0.56040	0.46202	0.11191
42	7.00	1	0.32060	0.54069	0.22876	0.14549
43	7.00	10	0.25173	0.54107	0.32693	0.14596
44	7.00	10	0.11848	0.53957	0.20036	0.14413
45	7.00	50	0.01822	0.53932	0.21504	0.14383
46	7.00	50	0.02303	0.53932	0.38217	0.14383
47	7.50	1	0.42540	0.54283	0.34844	0.15906
48	5.00	10	0.18229	0.53671	0.24519	0.15077
49	5.00	10	0.29286	0.53958	0.39797	0.15451
50	8.00	50	0.03734	0.54292	0.29347	0.14981
51	8.00	160	0.00781	0.54392	0.34952	0.15101

TABLE F4-11
A. McGARR: 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	0.19611	0.66776	0.74679	0.07405
2	5.00	1	0.22714	0.66776	0.40246	0.07405
3	5.00	5	0.05487	0.66651	0.58540	0.07425
4	5.00	5	0.06538	0.67226	0.34465	0.07387
5	5.80	10	0.09962	0.61616	0.40006	0.09436
6	5.80	20	0.08278	0.61191	0.32080	0.08956
7	6.50	1	0.59513	0.57615	0.41567	0.11001
8	6.50	1	0.65188	0.57777	0.37186	0.11213
9	6.50	1	0.49860	0.57515	0.31546	0.10876
10	6.50	5	0.57174	0.57515	0.40572	0.10876
11	6.50	5	0.30783	0.57415	0.36895	0.10756
12	6.50	50	0.01997	0.57565	0.36803	0.10938
13	6.50	50	0.02442	0.57615	0.31693	0.11001
14	7.00	10	0.28825	0.55289	0.30716	0.13788
15	7.50	50	0.04088	0.55102	0.27650	0.14468
16	7.50	50	0.05064	0.55127	0.35364	0.14502
17	5.00	1	0.06152	0.66876	0.62732	0.07394
18	5.80	5	0.15471	0.61453	0.50509	0.09239
19	5.80	5	0.08652	0.61741	0.46528	0.09598
20	5.00	10	0.07164	0.68151	0.45203	0.07604
21	5.00	10	0.12523	0.66776	0.22462	0.07405
22	5.00	50	0.00513	0.66651	0.23809	0.07425
23	5.00	50	0.00560	0.67226	0.21339	0.07387
24	5.00	160	0.00039	0.66876	0.37943	0.07394
25	5.80	1	0.37618	0.61741	0.61769	0.09598
26	5.80	5	0.34437	0.61391	0.51263	0.09168
27	5.80	5	0.17400	0.61391	0.39888	0.09168
28	5.80	10	0.13601	0.61803	0.44266	0.09682
29	5.80	10	0.21540	0.61341	0.46138	0.09112
30	5.80	10	0.09348	0.61291	0.42610	0.09059
31	5.80	50	0.00893	0.61291	0.62613	0.09059
32	5.80	50	0.01039	0.61678	0.63282	0.09516
33	6.50	5	0.42971	0.57565	0.32267	0.10938
34	6.50	10	0.24185	0.57952	0.29392	0.11456
35	6.50	10	0.43085	0.57727	0.40965	0.11147
36	6.50	10	0.17916	0.57665	0.34712	0.11065
37	6.50	20	0.10371	0.57665	0.24709	0.11065
38	6.50	20	0.17143	0.57952	0.32035	0.11456
39	6.50	20	0.07476	0.57465	0.34334	0.10815
40	6.50	100	0.00624	0.57665	0.42745	0.11065
41	6.50	160	0.00213	0.57377	0.49972	0.10713
42	7.00	1	0.65060	0.55626	0.31494	0.14236
43	7.00	10	0.48672	0.55751	0.40088	0.14412
44	7.00	10	0.21085	0.55464	0.27340	0.14015
45	7.00	50	0.02975	0.55389	0.26624	0.13916
46	7.00	50	0.03755	0.55351	0.37479	0.13867
47	7.50	1	0.85022	0.55902	0.34831	0.15653
48	5.00	10	0.34681	0.55077	0.33709	0.14435
49	5.00	10	0.56548	0.55427	0.46742	0.14925
50	8.00	50	0.05744	0.56270	0.29045	0.14875
51	8.00	160	0.00856	0.56070	0.42310	0.14628

TABLE F4-12
A. McGARR: 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	0.17932	0.70108	0.54242	0.08433
2	5.00	1	0.21198	0.70608	0.24608	0.08744
3	5.00	5	0.05854	0.70608	0.33249	0.08744
4	5.00	5	0.06892	0.71158	0.15364	0.09168
5	5.80	10	0.10659	0.63343	0.23175	0.11105
6	5.80	20	0.09024	0.62955	0.41739	0.10506
7	6.50	1	0.58532	0.58992	0.29588	0.11368
8	6.50	1	0.64442	0.59192	0.30262	0.11687
9	6.50	1	0.51292	0.59192	0.28156	0.11687
10	6.50	5	0.53488	0.58992	0.39294	0.11368
11	6.50	5	0.32512	0.59092	0.24212	0.11525
12	6.50	50	0.02516	0.58992	0.35971	0.11368
13	6.50	50	0.02998	0.59042	0.33795	0.11446
14	7.00	10	0.29998	0.56768	0.27498	0.14037
15	7.50	50	0.05144	0.56669	0.32701	0.14950
16	7.50	50	0.06150	0.56519	0.39521	0.14697
17	5.00	1	0.06380	0.70108	0.39876	0.08433
18	5.80	5	0.16259	0.63005	0.30390	0.10580
19	5.80	5	0.09609	0.63005	0.33024	0.10580
20	5.00	10	0.07437	0.71008	0.22507	0.09045
21	5.00	10	0.12434	0.69758	0.35532	0.08262
22	5.00	50	0.00624	0.70883	0.22066	0.08946
23	5.00	50	0.00649	0.69983	0.21479	0.08367
24	5.00	160	0.00054	0.70358	0.39052	0.08579
25	5.80	1	0.36638	0.62855	0.37523	0.10363
26	5.80	5	0.33337	0.63005	0.39968	0.10580
27	5.80	5	0.17546	0.62805	0.23318	0.10293
28	5.80	10	0.13695	0.63218	0.31612	0.10905
29	5.80	10	0.22037	0.63218	0.41889	0.10905
30	5.80	10	0.10064	0.62855	0.24779	0.10363
31	5.80	50	0.01126	0.63280	0.52392	0.11004
32	5.80	50	0.01231	0.63218	0.59821	0.10905
33	6.50	5	0.42559	0.59092	0.23559	0.11525
34	6.50	10	0.25479	0.59142	0.22340	0.11606
35	6.50	10	0.42767	0.59142	0.41362	0.11606
36	6.50	10	0.19632	0.59042	0.23794	0.11446
37	6.50	20	0.11288	0.59042	0.23139	0.11446
38	6.50	20	0.18205	0.59354	0.39339	0.11957
39	6.50	20	0.08684	0.58904	0.22634	0.11233
40	6.50	100	0.00838	0.58792	0.44726	0.11064
41	6.50	160	0.00287	0.58954	0.48917	0.11309
42	7.00	1	0.64614	0.56968	0.26616	0.14368
43	7.00	10	0.48712	0.57281	0.41971	0.14909
44	7.00	10	0.22972	0.56768	0.19058	0.14037
45	7.00	50	0.03653	0.56681	0.29672	0.13895
46	7.00	50	0.04542	0.56793	0.39735	0.14077
47	7.50	1	0.84681	0.57044	0.43931	0.15609
48	5.00	10	0.36351	0.56582	0.34873	0.14802
49	5.00	10	0.57576	0.56844	0.48598	0.15253
50	8.00	50	0.07132	0.58777	0.35881	0.15898
51	8.00	160	0.01038	0.58827	0.44070	0.15966

TABLE F4-13
A. McGARR: 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	0.11264	0.69996	0.43327	0.08494
2	5.00	1	0.12451	0.70996	0.27520	0.08623
3	5.00	5	0.04017	0.70846	0.16527	0.08581
4	5.00	5	0.04299	0.70596	0.17344	0.08529
5	5.80	10	0.07777	0.63319	0.17111	0.11102
6	5.80	20	0.06835	0.63107	0.50257	0.10845
7	6.50	1	0.44086	0.59667	0.20892	0.11293
8	6.50	1	0.45906	0.59554	0.25431	0.11116
9	6.50	1	0.38845	0.59504	0.24801	0.11039
10	6.50	5	0.41591	0.59392	0.34828	0.10870
11	6.50	5	0.25808	0.59292	0.25631	0.10724
12	6.50	50	0.02274	0.59067	0.38503	0.10413
13	6.50	50	0.02725	0.59392	0.41687	0.10870
14	7.00	10	0.24849	0.57241	0.27143	0.12883
15	7.50	50	0.05116	0.56905	0.36987	0.13407
16	7.50	50	0.06091	0.57017	0.42926	0.13592
17	5.00	1	0.04230	0.70846	0.24675	0.08581
18	5.80	5	0.11510	0.62944	0.30366	0.10665
19	5.80	5	0.07245	0.63157	0.34337	0.10904
20	5.00	10	0.04468	0.71121	0.23177	0.08663
21	5.00	10	0.08317	0.70596	0.52475	0.08529
22	5.00	50	0.00520	0.70996	0.36602	0.08623
23	5.00	50	0.00505	0.69496	0.24330	0.08561
24	5.00	160	0.00059	0.70471	0.33462	0.08511
25	5.80	1	0.25224	0.62994	0.32370	0.10719
26	5.80	5	0.23759	0.63382	0.37464	0.11181
27	5.80	5	0.13329	0.63157	0.20669	0.10904
28	5.80	10	0.10175	0.63632	0.20110	0.11518
29	5.80	10	0.16022	0.63507	0.44697	0.11346
30	5.80	10	0.07741	0.62994	0.22574	0.10719
31	5.80	50	0.00957	0.63319	0.49152	0.11102
32	5.80	50	0.01146	0.63319	0.50075	0.11102
33	6.50	5	0.32166	0.59292	0.21526	0.10724
34	6.50	10	0.19259	0.59067	0.20637	0.10413
35	6.50	10	0.32625	0.59504	0.40591	0.11039
36	6.50	10	0.16182	0.59292	0.24749	0.10724
37	6.50	20	0.09331	0.59392	0.27914	0.10870
38	6.50	20	0.14895	0.59904	0.47863	0.11683
39	6.50	20	0.07684	0.59342	0.30506	0.10796
40	6.50	100	0.00916	0.59604	0.50193	0.11194
41	6.50	160	0.00362	0.59442	0.48893	0.10944
42	7.00	1	0.49837	0.57241	0.24831	0.12883
43	7.00	10	0.39984	0.57666	0.42799	0.13597
44	7.00	10	0.20125	0.57316	0.27225	0.13004
45	7.00	50	0.03542	0.57103	0.33009	0.12664
46	7.00	50	0.04434	0.57141	0.46095	0.12723
47	7.50	1	0.65472	0.57405	0.44585	0.14258
48	5.00	10	0.31265	0.57155	0.33984	0.13823
49	5.00	10	0.47565	0.57280	0.46870	0.14038
50	8.00	50	0.07163	0.59740	0.38540	0.14792
51	8.00	160	0.01378	0.59240	0.49521	0.14131

TABLE F4-14
A. McGARR: 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	0.04395	0.73405	0.53915	0.08267
2	5.00	1	0.05306	0.73530	0.28672	0.08279
3	5.00	5	0.01460	0.74155	0.42222	0.08422
4	5.00	5	0.01800	0.73405	0.21245	0.08267
5	5.80	10	0.04496	0.65847	0.15653	0.11556
6	5.80	20	0.04200	0.65959	0.52128	0.11676
7	6.50	1	0.25877	0.62705	0.18034	0.11553
8	6.50	1	0.29198	0.62593	0.18759	0.11393
9	6.50	1	0.25345	0.62643	0.18413	0.11463
10	6.50	5	0.25351	0.62343	0.27599	0.11058
11	6.50	5	0.17452	0.62493	0.19850	0.11255
12	6.50	50	0.01834	0.62255	0.30791	0.10948
13	6.50	50	0.02291	0.62218	0.33268	0.10902
14	7.00	10	0.17743	0.60420	0.27592	0.12911
15	7.50	50	0.04542	0.60433	0.36211	0.13916
16	7.50	50	0.05128	0.60283	0.32687	0.13694
17	5.00	1	0.01682	0.75405	0.37923	0.09095
18	5.80	5	0.06376	0.66122	0.26159	0.11859
19	5.80	5	0.04010	0.65659	0.23231	0.11371
20	5.00	10	0.01965	0.73180	0.22403	0.08260
21	5.00	10	0.03358	0.72980	0.44269	0.08269
22	5.00	50	0.00253	0.74155	0.20988	0.08422
23	5.00	50	0.00280	0.73180	0.22509	0.08260
24	5.00	160	0.00043	0.73655	0.35657	0.08296
25	5.80	1	0.12219	0.65897	0.46511	0.11608
26	5.80	5	0.12624	0.66609	0.35400	0.12484
27	5.80	5	0.07854	0.65797	0.16988	0.11505
28	5.80	10	0.05937	0.66234	0.17839	0.11994
29	5.80	10	0.09163	0.66347	0.40558	0.12135
30	5.80	10	0.04646	0.66409	0.19000	0.12215
31	5.80	50	0.00621	0.65797	0.59425	0.11505
32	5.80	50	0.00777	0.66059	0.52415	0.11787
33	6.50	5	0.20274	0.62868	0.17454	0.11793
34	6.50	10	0.13198	0.62755	0.26996	0.11625
35	6.50	10	0.22523	0.62705	0.38873	0.11553
36	6.50	10	0.11414	0.62493	0.27476	0.11255
37	6.50	20	0.06598	0.62705	0.30271	0.11553
38	6.50	20	0.10799	0.62930	0.48456	0.11888
39	6.50	20	0.05427	0.62493	0.22832	0.11255
40	6.50	100	0.00861	0.62543	0.41112	0.11323
41	6.50	160	0.00400	0.62493	0.42565	0.11255
42	7.00	1	0.33300	0.60995	0.18651	0.13831
43	7.00	10	0.28411	0.60795	0.40194	0.13498
44	7.00	10	0.14843	0.60533	0.25427	0.13082
45	7.00	50	0.02866	0.60420	0.25382	0.12911
46	7.00	50	0.03688	0.60458	0.41774	0.12967
47	7.50	1	0.41407	0.60883	0.30230	0.14627
48	5.00	10	0.22150	0.60370	0.27594	0.13822
49	5.00	10	0.33432	0.60533	0.37385	0.14068
50	8.00	50	0.06706	0.63650	0.41892	0.14094
51	8.00	160	0.01758	0.63825	0.46570	0.14290

TABLE F4-15
A. McGARR: 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	0.01926	0.75468	0.47268	0.07644
2	5.00	1	0.02190	0.76593	0.25586	0.07572
3	5.00	5	0.00632	0.75893	0.43968	0.07558
4	5.00	5	0.00756	0.75293	0.19447	0.07699
5	5.80	10	0.02214	0.69853	0.26455	0.09747
6	5.80	20	0.01985	0.69573	0.32964	0.10305
7	6.50	1	0.14190	0.67160	0.35861	0.10753
8	6.50	1	0.15766	0.66745	0.24439	0.10972
9	6.50	1	0.13288	0.66632	0.22151	0.10836
10	6.50	5	0.13989	0.66695	0.34171	0.10910
11	6.50	5	0.09722	0.66345	0.10304	0.10519
12	6.50	50	0.01084	0.66985	0.43326	0.10539
13	6.50	50	0.01416	0.66257	0.37913	0.10432
14	7.00	10	0.10003	0.65427	0.22631	0.13014
15	7.50	50	0.02989	0.65060	0.23696	0.13700
16	7.50	50	0.03523	0.64751	0.40349	0.13880
17	5.00	1	0.00654	0.75368	0.56634	0.07674
18	5.80	5	0.03187	0.69673	0.34070	0.10398
19	5.80	5	0.02193	0.69836	0.30981	0.10562
20	5.00	10	0.00713	0.74943	0.45917	0.07844
21	5.00	10	0.01160	0.75293	0.25261	0.07699
22	5.00	50	0.00101	0.75368	0.32419	0.07674
23	5.00	50	0.00130	0.75468	0.15191	0.07644
24	5.00	160	0.00023	0.75693	0.52079	0.07589
25	5.80	1	0.06369	0.70778	0.49307	0.10816
26	5.80	5	0.06223	0.69948	0.42074	0.10685
27	5.80	5	0.04029	0.69523	0.17231	0.10260
28	5.80	10	0.02950	0.70053	0.20974	0.09936
29	5.80	10	0.04451	0.69436	0.33898	0.10186
30	5.80	10	0.02707	0.69886	0.21488	0.10616
31	5.80	50	0.00355	0.70391	0.69121	0.10311
32	5.80	50	0.00467	0.69523	0.47841	0.10260
33	6.50	5	0.10896	0.67097	0.24016	0.10675
34	6.50	10	0.07436	0.67047	0.17102	0.10614
35	6.50	10	0.10899	0.66170	0.29556	0.10349
36	6.50	10	0.06783	0.66382	0.17906	0.10558
37	6.50	20	0.03546	0.67097	0.27290	0.10675
38	6.50	20	0.05674	0.66257	0.28752	0.10432
39	6.50	20	0.03495	0.66170	0.22112	0.10349
40	6.50	100	0.00572	0.66697	0.35020	0.10223
41	6.50	160	0.00285	0.67047	0.58308	0.10614
42	7.00	1	0.17745	0.65740	0.38601	0.13460
43	7.00	10	0.15936	0.64906	0.34746	0.12935
44	7.00	10	0.09235	0.64906	0.17421	0.12935
45	7.00	50	0.01881	0.65027	0.31589	0.12501
46	7.00	50	0.02359	0.64618	0.43099	0.12572
47	7.50	1	0.24116	0.66735	0.37247	0.16095
48	5.00	10	0.13286	0.65122	0.27302	0.13771
49	5.00	10	0.19815	0.64813	0.41587	0.13954
50	8.00	50	0.04350	0.67995	0.15722	0.14612
51	8.00	160	0.01488	0.67545	0.40442	0.14211

TABLE F4-16
A. McGARR: 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	0.00590	0.82151	0.39748	0.07480
2	5.00	1	0.00668	0.81651	0.35261	0.07724
3	5.00	5	0.00185	0.82001	0.47369	0.07544
4	5.00	5	0.00215	0.81701	0.22194	0.07695
5	5.80	10	0.00852	0.76922	0.31030	0.12524
6	5.80	20	0.00685	0.76425	0.34775	0.14192
7	6.50	1	0.07216	0.74340	0.22998	0.14956
8	6.50	1	0.07920	0.73013	0.30401	0.15463
9	6.50	1	0.06482	0.72875	0.15843	0.15347
10	6.50	5	0.06912	0.73163	0.44399	0.15599
11	6.50	5	0.04605	0.72875	0.21209	0.15347
12	6.50	50	0.00548	0.73903	0.35622	0.14537
13	6.50	50	0.00721	0.72963	0.73295	0.15420
14	7.00	10	0.04717	0.72099	0.38391	0.16836
15	7.50	50	0.01551	0.72417	0.58840	0.18468
16	7.50	50	0.02011	0.71422	0.86965	0.18993
17	5.00	1	0.00173	0.81876	0.76101	0.07603
18	5.80	5	0.01311	0.75725	0.32002	0.13617
19	5.80	5	0.00769	0.75925	0.41478	0.13758
20	5.00	10	0.00199	0.81651	0.55549	0.07724
21	5.00	10	0.00369	0.81501	0.36171	0.07814
22	5.00	50	0.00029	0.81751	0.56535	0.07668
23	5.00	50	0.00053	0.81501	0.55390	0.07814
24	5.00	160	0.00006	0.82751	1.13750	0.07314
25	5.80	1	0.02792	0.77885	0.27050	0.13547
26	5.80	5	0.02615	0.76212	0.46622	0.13994
27	5.80	5	0.01649	0.76425	0.33324	0.14192
28	5.80	10	0.01064	0.76872	0.32389	0.12483
29	5.80	10	0.01499	0.76587	0.49498	0.14356
30	5.80	10	0.01031	0.76262	0.47282	0.14039
31	5.80	50	0.00140	0.76510	0.65362	0.12223
32	5.80	50	0.00206	0.76362	0.74810	0.14132
33	6.50	5	0.05061	0.74115	0.23864	0.14731
34	6.50	10	0.03409	0.74215	0.16407	0.14829
35	6.50	10	0.04842	0.73563	0.48882	0.16002
36	6.50	10	0.03144	0.73500	0.37211	0.15935
37	6.50	20	0.01702	0.74115	0.23276	0.14731
38	6.50	20	0.02454	0.73225	0.54022	0.15658
39	6.50	20	0.01593	0.72963	0.48470	0.15420
40	6.50	100	0.00267	0.74053	0.51410	0.14672
41	6.50	160	0.00166	0.74215	0.63519	0.14829
42	7.00	1	0.09153	0.72286	0.40551	0.17014
43	7.00	10	0.07365	0.71591	0.52759	0.17886
44	7.00	10	0.04352	0.71541	0.39336	0.17833
45	7.00	50	0.00962	0.72074	0.49261	0.16814
46	7.00	50	0.01348	0.71179	0.75641	0.17471
47	7.50	1	0.11313	0.73129	0.49443	0.19224
48	5.00	10	0.06513	0.72967	0.51407	0.19037
49	5.00	10	0.10136	0.72484	0.66017	0.20165
50	8.00	50	0.02830	0.76211	0.29458	0.19185
51	8.00	160	0.01195	0.76436	0.52852	0.19349

TABLE F4-17
A. McGARR: 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	0.00199	0.86897	0.58471	0.08812
2	5.00	1	0.00239	0.86347	0.56624	0.08745
3	5.00	5	0.00066	0.86547	0.58288	0.08758
4	5.00	5	0.00091	0.86197	0.51706	0.08744
5	5.80	10	0.00404	0.80443	0.29218	0.15407
6	5.80	20	0.00323	0.79421	0.45921	0.16547
7	6.50	1	0.03715	0.78276	0.21028	0.18037
8	6.50	1	0.04356	0.76849	0.39428	0.18396
9	6.50	1	0.03677	0.76686	0.34242	0.18232
10	6.50	5	0.04027	0.76886	0.57489	0.18435
11	6.50	5	0.02405	0.76611	0.29248	0.18159
12	6.50	50	0.00283	0.78164	0.34175	0.17903
13	6.50	50	0.00363	0.77386	0.72255	0.18998
14	7.00	10	0.02839	0.77047	0.25707	0.20706
15	7.50	50	0.00981	0.76746	0.50584	0.21467
16	7.50	50	0.01194	0.75538	0.78796	0.21833
17	5.00	1	0.00061	0.86822	0.83448	0.08797
18	5.80	5	0.00672	0.79458	0.54608	0.16581
19	5.80	5	0.00393	0.79321	0.46905	0.16459
20	5.00	10	0.00068	0.86722	0.67584	0.08780
21	5.00	10	0.00141	0.86197	0.60323	0.08744
22	5.00	50	0.00010	0.86822	0.63733	0.08797
23	5.00	50	0.00022	0.86222	0.93270	0.08744
24	5.00	160	0.00003	0.87847	0.70783	0.09164
25	5.80	1	0.01230	0.80593	0.30922	0.15559
26	5.80	5	0.01303	0.79546	0.60522	0.16663
27	5.80	5	0.00723	0.79346	0.44067	0.16481
28	5.80	10	0.00480	0.80318	0.31641	0.15287
29	5.80	10	0.00663	0.79583	0.56525	0.16698
30	5.80	10	0.00465	0.79783	0.57046	0.16897
31	5.80	50	0.00064	0.80281	0.57289	0.15252
32	5.80	50	0.00095	0.79858	0.79828	0.16976
33	6.50	5	0.02960	0.77914	0.20062	0.17617
34	6.50	10	0.01720	0.77464	0.15228	0.17157
35	6.50	10	0.02369	0.77224	0.47767	0.18807
36	6.50	10	0.01545	0.76936	0.41252	0.18488
37	6.50	20	0.00889	0.78389	0.19476	0.18176
38	6.50	20	0.01136	0.76974	0.46478	0.18528
39	6.50	20	0.00882	0.77174	0.65561	0.18749
40	6.50	100	0.00131	0.77914	0.56415	0.17617
41	6.50	160	0.00090	0.77914	0.56231	0.17617
42	7.00	1	0.05357	0.76534	0.39249	0.20056
43	7.00	10	0.03962	0.75927	0.55596	0.21178
44	7.00	10	0.02477	0.75577	0.52185	0.20744
45	7.00	50	0.00571	0.76797	0.51771	0.20381
46	7.00	50	0.00745	0.75927	0.79249	0.21178
47	7.50	1	0.07725	0.77471	0.29861	0.22386
48	5.00	10	0.03848	0.76633	0.53179	0.21336
49	5.00	10	0.05754	0.76201	0.72542	0.22623
50	8.00	50	0.02032	0.81560	0.50803	0.21526
51	8.00	160	0.00826	0.81735	0.51294	0.21677

TABLE F4-18
A. McGARR: VERTICAL POINT ESTIMATES
PEAK GROUND VELOCITY

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	3.51791	0.65369	0.63598	0.08446
2	5.00	1	4.54194	0.65469	0.28625	0.08515
3	5.00	5	0.84525	0.65469	0.45857	0.08515
4	5.00	5	1.16534	0.65369	0.16207	0.08446
5	5.80	10	2.54933	0.62518	0.18207	0.13171
6	5.80	20	2.38133	0.61594	0.41413	0.12905
7	6.50	1	15.68956	0.61778	0.22500	0.15041
8	6.50	1	20.80833	0.61258	0.24880	0.15108
9	6.50	1	8.58214	0.61375	0.89385	0.15224
10	6.50	5	19.51708	0.60975	0.30496	0.14840
11	6.50	5	5.92469	0.61191	0.85398	0.15043
12	6.50	50	0.82693	0.61245	0.37987	0.14562
13	6.50	50	1.26487	0.61075	0.56537	0.14932
14	7.00	10	10.58788	0.61933	0.21741	0.17205
15	7.50	50	2.62447	0.61442	0.40242	0.18642
16	7.50	50	3.69140	0.61114	0.68314	0.18811
17	5.00	1	0.92577	0.65369	0.52421	0.08446
18	5.80	5	4.20172	0.61511	0.30767	0.12820
19	5.80	5	2.53698	0.61711	0.42130	0.13029
20	5.00	10	1.09262	0.65869	0.34852	0.08812
21	5.00	10	2.40898	0.65003	0.21098	0.08205
22	5.00	50	0.11739	0.65603	0.06887	0.08611
23	5.00	50	0.15247	0.63869	0.17117	0.07638
24	5.00	160	0.01701	0.66469	0.49392	0.09305
25	5.80	1	8.53003	0.62268	0.44687	0.12888
26	5.80	5	9.66733	0.61594	0.34810	0.12905
27	5.80	5	2.65836	0.61378	0.91903	0.12688
28	5.80	10	3.42054	0.62384	0.21454	0.13018
29	5.80	10	5.95535	0.61661	0.34049	0.12975
30	5.80	10	2.92209	0.61711	0.29270	0.13029
31	5.80	50	0.27576	0.62318	0.66480	0.12943
32	5.80	50	0.42276	0.61711	0.60964	0.13029
33	6.50	5	12.42783	0.61845	0.17451	0.15106
34	6.50	10	7.69370	0.61445	0.15610	0.14732
35	6.50	10	12.85128	0.61441	0.37841	0.15292
36	6.50	10	4.06735	0.60825	0.81126	0.14708
37	6.50	20	3.44543	0.61211	0.19834	0.14535
38	6.50	20	5.72157	0.61075	0.39690	0.14932
39	6.50	20	3.28365	0.60975	0.39781	0.14840
40	6.50	100	0.37168	0.61661	0.31329	0.14929
41	6.50	160	0.14707	0.61345	0.55159	0.14646
42	7.00	1	19.08100	0.62033	0.28288	0.17304
43	7.00	10	17.78589	0.61588	0.43819	0.17382
44	7.00	10	5.71387	0.61355	0.77096	0.17145
45	7.00	50	1.56797	0.61683	0.35194	0.16967
46	7.00	50	2.38716	0.61355	0.66397	0.17145
47	7.50	1	26.74642	0.62525	0.37924	0.19758
48	5.00	10	14.02704	0.61575	0.32293	0.18766
49	5.00	10	22.31861	0.61530	0.58960	0.19236
50	8.00	50	4.99881	0.64678	0.30704	0.19667
51	8.00	160	1.34581	0.66178	0.53584	0.20831

APPENDIX F5

ESTIMATION OF STRONG GROUND MOTIONS AT YUCCA MOUNTAIN

Walter Silva

APPENDIX F5
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APPENDIX F5

ESTIMATION OF STRONG GROUND MOTIONS AT YUCCA MOUNTAIN

Walter Silva

Pacific Engineering and Analysis

August 15, 1997

F5-1 INTRODUCTION

The process used to develop appropriate site-specific attenuation relations for both probabilistic and deterministic applications to Yucca Mountain is by the use of multiple expects. A total of seven strong ground motion experts were given the task of developing a suite of scaling rules and weights to apply to an expert selected suite of strong ground motion empirical and/or numerical models. Fifty-one specific cases of magnitude, source mechanism, source depth, and site distance (Table 3-3) were specified for which 4 ground motion parameters were requested: median (μ), aleatory uncertainty (σ), standard error of the median estimate (σ_μ), and uncertainty of the aleatory uncertainty (σ_σ). These estimates were requested for both horizontal (random component) and vertical components at seven frequencies: 0.33, 0.50, 1.00, 2.00, 5.00, 10.00 and 20.00 Hz as well as peak ground acceleration (PGA) and peak ground velocity (PGV). The 3,672 point estimates were then used to develop smoothed models over magnitude, source mechanism, and site location (distance and hanging wall/foot wall) for each expert. The suite of expert models then represent the expected epistemic uncertainty for strong ground motion estimation on a site specific-basis at Yucca Mountain.

The magnitude range is M 5.0 to 8.0 with a horizontal distance range of 1 to 160 km (Yucca Mountain Data Package, Volume 1, Table 3-3). The specific cases selected by the facilitation team were based on sources expected to be major contributors to the seismic hazard at Yucca Mountain. Both strike-slip and normal-slip mechanisms are considered with normal faults representing 25 of 51 cases in Table 3-3. In addition to the 51 cases, two additional cases or scenarios were specified: 1) nearly simultaneous (triggered) multiple ruptures on parallel or possibly sub-parallel faults; and 2) a low angle normal fault.

The evaluation, specification, and defense of appropriate empirical and numerical point estimates and their associated uncertainties for all of these cases is a formidable task, particularly in view of the relatively "new" parameters requested: $\sigma\mu$ and $\sigma\sigma$. The consideration and use of these parameters does not reflect state-of-the-practice and considerable uncertainty exists regarding appropriate methods to estimate their values. As a result they should be regarded in the context of development rather than mature and stable practice. In addition, there are several issues, site

specific and general, which were controlling factors in the selection of empirical and numerical models and their associated weights. These issues are discussed below.

F5-2 SITE-SPECIFIC ISSUES

The site-specific issues at Yucca Mountain requiring special consideration are: 1) the definition of the free-surface; 2) crustal, kappa, and Q(f) differences between California and the Yucca Mountain region of the Basin and Range province; and 3) the large contribution of normal fault sources to the seismic hazard.

F5-2.1 Free Surface At -300m

The free surface at which the ground motions are defined for Yucca Mountain was at a depth of -300m, the average depth (or horizon) of the repository. The shear-wave velocity at this depth is about 6,000 ft/sec (1.9 km/sec), much greater than shear-wave velocities of about 1,000 ft/sec which are typical of soft rock sites near the surface. Since empirical attenuation relations for rock are dominated by soft California rock, a significant (≥ 20%) site-specific adjustment factor is necessary. At rock sites, over the frequency range of 0.33 to 20.00 Hz, horizontal motions are dominated by vertically propagating shear-waves (Silva et al., 1997) and vertical motions are comprised of inclined compression- and shear-waves (EPRI, 1993; Silva, et al., 1997). As a result, separate adjustment factors are warranted for horizontal and vertical motions.

F5-2.2 Yucca Mountain Regional Crustal Structure

The differences between the regional crustal structure containing the site and those representative of the empirical strong motion database (largely California) are large and represent differences in shear-wave velocity, deep crustal damping (Q(f)), and shallow crustal damping (as expressed by kappa in the top 1 to 2 km). These parameters have large and predictable effects on strong ground motions (EPRI, 1993; Silva and Darragh, 1995; Silva, 1992; Silva et al., 1997) and substantial (± 20%) differences in these parameters should be accommodated in scale factors for the empirical (largely California based) attenuations relations. Both the definition of -300m outcropping as the reference point of free field motions as well as the differences in regional crustal models is accommodated in a single set of frequency-dependent scale factors for horizontal motions. For numerical simulations, use of the site and regional-specific parameters precludes the use of these adjustment factors.

F5-2.3 Normal Faulting Sources

It has long been recognized that normal faulting sources produce strong ground motions that are generally lower than those expected for reverse fault sources. More recently, evidence suggests that strong ground motions from normal fault ruptures in extensional regimes are also lower than those from comparable strike-slip ruptures in compressional regimes, suggesting that this observation should be incorporated into the Yucca Mountain ground motion point estimates.

Because of sparse normal faulting strong motion data available for WUS sources, currently available empirical attenuation relations do not distinguish between strike-slip and normal-slip mechanisms. As a result, the USGS recently acquired world-wide strong motion data from normal faulting earthquakes, added these to existing data for extensional regime strike-slip earthquakes, and developed an attenuation relation appropriate for extensional regime sources (Spudich et al., 1997). They also made the data available to the Yucca Mountain project and normal fault adjustment factors to the predominately compressional strike-slip attenuation relation of Abrahamson and Silva (1997) were developed by N. Abrahamson. Because the combination of both strike-slip and normal-slip data into the relation of Spudich et al. (1997) makes applying their relation somewhat ambiguous, the normal-slip adjustment factors of Abrahamson for horizontal and vertical motions are applied to each empirical relation selected. As a result, each selected relation is implemented for strike-slip mechanism and the normal-slip factors applied as appropriate (see Table F5-1). Because the adjustment factors of Abrahamson are large, particularly at low frequencies, only 50% of the factors are implemented. This is a judgmental assessment since there are still too few data to unambiguously constrain the adjustment factors. Both more earthquakes and a larger number of sites, particularly at close distances ($D \leq 20$ km) are needed.

F5-3 GENERAL ISSUES

The general issues are those which are faced for most seismic hazard assessments: the magnitude and distance ranges exceed those used in developing empirical attenuation relations and exceed the magnitudes and distances used in validating the numerical models as well. To address the ranges in magnitudes and distances appropriate for implementing the empirical relations, only the ranges specified by the authors are used. The relations receive a substantially lower weight outside their respective M and D ranges (Table F5-1).

For the numerical simulations, a wide range in degree of validation exists between the four proponent models. The Anderson finite-fault model currently has had only limited validations ($M > 5.0$) in the form of comparisons to recorded data. Formal validations resulting in statistically significant estimates of model variability are not available. The Silva point- and finite-source models have recently been validated for horizontal motions for 15 earthquakes for the finite-source (M 5.7 to 7.4) and 18 earthquakes for the point-source (M 4.2 to 7.4) at about 500 sites (Silva et al., 1997) over the fault distance range of 1 to 218 km (460 km for the Saguenay earthquake). For vertical motions, which are only computed for the point-source model, validations to-date consist of five earthquakes (M 6.4 to 7.2) at about 200 sites. As a result, the modeling variability is well constrained for horizontal motions and reasonably well constrained for the vertical component.

For the Somerville finite-fault model, reasonably extensive validations have also been performed Approximately four earthquakes have model variability estimates: Loma Prieta, Nahanni, Saguenay, and Northridge but with few sites exceeding source-to-site distances of about 30 km

(EPRI, 1993; Somerville et al., 1995). As a result, the model variability estimates are most appropriate for close-in conditions. For WUS crustal conditions, model variability increases sharply for distances exceeding about 50 km (Silva et al., 1997) suggesting that close-in model variability estimates may result in values which are too low for applications to larger distances.

For vertical motions, neither the Anderson nor Somerville models have validation results which produced model variability estimates. As a result, the point-source vertical component model variability estimates were applied to both the Anderson and Somerville point estimates. For the horizontal components, because the Somerville validations covered a limited distance range and the values given by Somerville appeared low compared to published results (EPRI, 1993; Somerville et al., 1995) and since no estimates were available for the Anderson model, the finite-source model uncertainty estimates of Silva were used for their simulations.

F5-4 PROPONENT GROUND MOTION MODELS AND WEIGHTING SCHEME

The proponent models were selected from two general classes: empirical and numerical.

F5-4.1 Empirical Models

The empirical models chosen were those considered to generally reflect the most recent analyses of data, represent different functional forms, be appropriate for crustal earthquakes, and use a consistent data set for soft rock site conditions. To represent empirical attenuation relations the following models were selected: Abrahamson and Silva (1997), Boore et al. (1997), Campbell (1997), and Sadigh et al. (1997). Because few of the relations specify peak ground velocity, Joyner and Boore (1988) was added for PGV only since it has the same functional form as Boore et al. (1997). The selected empirical relations, ground motion parameters, and magnitude and distance ranges specified by the authors are listed in Table F5-1. The class weight for the empirical is 0.4 and the within class (proponent model) weights are generally equal at 1.0 (Table F5-1). Exceptions to the weights of 1.0 are cases outside the specified ranges (weight of 0.25) and the case-specific weights which are listed in Table F5-2. These case-specific weights reflect a judgmental assessment that the ground motion point estimates were unrealistic. For the empirical relations (BJF97, CP97, and SD97), this may be an artifact of smoothing of coefficients or simply cases outside the range of applicability which are poorly constrained by little or no data.

F5-4.1.1 Scale Factors for the Empirical Models. For the empirical models up to four scale factors are used depending upon which parameters are available. The first scale factor adjusts the empirical rock (soft rock for CP97) horizontal motion estimates to Yucca Mountain crustal conditions and to a depth of 300m outcropping. This scale factor is termed "crust" in Table F5-1 and is the factor developed by Campbell. This factor is distance dependent due to the difference in Q(f) models between California and the Yucca Mountain region of the Basin and Range province. This factor is preferred to the distance independent crustal factor of Silva.

The second scale factor is the normal faulting factors of Abrahamson for horizontal and vertical motions. This is applied to normal slip (NS in Table F5-1) sources and, as previously stated, only 50% of the factor is implemented. The third scale factor is the PGV/PGA (VOA) point-source scale factor of Silva for horizontal and vertical components. The fourth factor is related to the third and is the vertical-to-horizontal (VOH) point-source scale factor of Silva. These last two factors are site-specific. Because a crustal adjustment factor is not available for vertical components, appropriate vertical component motions are estimated by applying the VOH scale factor to the horizontal motions adjusted to a 300m depth at Yucca Mountain. This approach is considered preferable to directly using the empirical vertical component estimates combined with the horizontal component crustal factor.

F5-4.2 Numerical Models

The numerical models available were the finite-fault models of Anderson, Silva, and Somerville and the point-source model of Silva. This suite of models generally reflects the range in currently viable approaches to kinematic (specification of slip) numerical simulations. The finite-source models share common features in that they sum small earthquakes to construct a large earthquake. The Silva and Somerville models use asperity slip distributions and an empirical constant rise time model which determines the number of events to sum for each subfault. Both approaches use $M \approx 5$ subevents to model crustal earthquakes. The models differ in their wave propagation algorithms as well as subevent source spectra (Silva et al., 1997; Somerville et al., 1995). The Anderson model uses a distinctly different subevent source description (Zeng et al., 1994) with a wave propagation algorithm similar to that of Somerville.

The inclusion of the point-source model, which has been demonstrated over the years to reliably predict strong ground motions (Boore, 1983; 1986; Schneider et al., 1993; Silva and Darragh, 1995; Silva et al., 1997) completes the suite of numerical models. The point-source model is an important adjunct to the suite of numerical models as it has been implemented on numerous seismic hazard evaluations and is the model which forms the basis for evaluating strong ground motions in the CEUS. As a result, the point-source model provides base-case site-specific predictions.

For the numerical models, the class weight is 0.6 as compared to the class weight of 0.4 for the empirical models (Table F5-1). The higher weight for the numerical models reflects the preference in their fundamentally site-specific nature as well as the degree of validation, particularly for the Silva and Somerville models. In adjusting the empirical (i.e. California) models for Yucca Mountain, essentially doubling the parametric assumptions and model computations are necessary compared to direct site-specific simulations.

Table F5-1 also lists the M and D ranges of applicability for which simulations were available as well as the proponent model's weights. For the Anderson model, although simulations were available, the M 5.0 simulations were not used as validations were not available for $M \leq 5.7$ (1992 Little Skull Mountain earthquake). Also, for this model, because model variability

estimates were not available, it was given a weight of 0.7 compared to the equal weights of 1.0 assigned to the other numerical models. This lower weight is not intended to reflect the expectation that it will perform less well than the other finite-fault models in statistically significant validations over a large range in M and D, but simply indicates less confidence in its predictions at this time.

As with the empirical model estimates, case-specific weights are listed in Table F5-2. The M 5.0 exclusion of the Anderson model was addressed earlier. The case and frequency exclusions of the Somerville model reflect unreasonable values possibly due to computational errors (i.e. deterministic radiation pattern nodes).

F5-4.2.1 Scale Factors for the Numerical Models. As with the empirical models, scale factors were applied to the numerical models (Table F5-1). Because the simulations were site specific, the crustal factor is not necessary resulting in direct use of the horizontal and vertical components for strike-slip earthquakes. This also applies to the point-source model. For the latter, a constant stress drop of 60 bars was used, the appropriate average value for strike-slip earthquakes (Silva et al., 1997). The remaining scale factors; the Abrahamson normal slip factor for vertical and horizontal components, the VOA, and the VOH factors were all applied in a manner analogous to the empirical estimates (Table F5-1).

F5-5 ESTIMATES OF UNCERTAINTY

The estimates of uncertainty provided for each median ground motion estimate include: 1) the uncertainty about the median estimate (aleatory, σ), uncertainty of the median estimate (epistemic, σ_μ), and the uncertainty of the aleatory uncertainty σ (epistemic, σ_σ). Table F5-3 summarizes the partition of uncertainty for both the empirical and numerical model.

F5-5.1 Aleatory Uncertainty

The aleatory uncertainties (σ_j) for the empirical models are given by each proponent for an average horizontal component and vertical component (if available). If the vertical component median estimate is computed using the average horizontal component estimate, the average horizontal component aleatory is increased by the σ_{VOH} factor in Table F5-3. A similar approach is applied to peak ground velocity (PGA). These increases in aleatory uncertainty were computed based on the increase in aleatory uncertainty for the vertical component over the average horizontal component for σ_{VOH} and the increase of 1 sec aleatory uncertainty for response spectral acceleration over peak ground acceleration for the σ_{VOA} (Table F5-3). For the numerical point-source aleatory uncertainty, an uncertainty in stress drop ($\sigma_{\Delta\sigma}$) of 0.5 was specified. This value is considered appropriate for the expected variability in stress drop for large ($M \geq 5$) earthquakes located within a tectonic province.

The total aleatory uncertainty (σ_j^T) for the jth proponent model is computed as the vector sum of the various contributions. The σ_{MECH} is included for the potential case of higher aleatory

uncertainty for normal-slip earthquakes over strike-slip earthquakes. Since not enough data are available to constrain the normal-slip aleatory uncertainty, this increase is set to zero. The σ_{CRUST} is the increase in aleatory uncertainty due to a possible larger variability in crustal structure in the Yucca Mountain region (within about 200 km of the site) than exists in California. The potential increased variability in crustal structure, evidenced by a suite of measured shear-wave velocities at Yucca Mountain, would result in a larger contribution of ground motion variations due to path and site variations than exists in California. As a result, the modeling uncertainty, based almost entirely on California data (Silva et al., 1997) would not reflect this potentially higher uncertainty. The value of 0.2 is based on judgment from parametric analyses on the effects of variations in crustal and site parameters on estimated ground motions (Roblee et al., 1997).

The final two aleatory component, σ_{MOD} and σ_{RANDOM}, are the modeling uncertainties estimated for the Silva finite-fault model (Silva et al., 1997) and the increase in aleatory uncertainty for a random horizontal component (Boore et al., 1997). A previously discussed, because the modeling uncertainty computed for the Silva finite-source covers a large distance and magnitude range, it is applied to both the Anderson and Somerville models. This approach is justified by direct comparisons in limited validation exercises (Northridge and Landers earthquakes at about 20 sites) which showed comparable model uncertainties and bias estimate for all three finite-source models. Interestingly, comparison exercises between the point-source model and the Somerville finite-source model also showed similar uncertainties and bias estimates for frequencies of 1 Hz and greater (EPRI, 1993). At lower frequencies, the point-source model tendency to overpredict (particularly at close distances) is reflected in negative bias estimates (EPRI, 1993; Silva et al., 1997).

F5-5.2 Epistemic Uncertainty

For the epistemic uncertainties of each proponent model, σ_μ's of 0.1 and 0.2 were assumed for the empirical and numerical finite-source models, respectively. For the point-source model, using the law of propagation of errors combined with the sensitivity of the point-source ground motion estimates to variations in stress drop ($\sigma_{\text{ground motion}} \approx 0.7\ \sigma_{\Delta\sigma}$, Silva, 1991), estimates of $\sigma_{\sigma\Delta\sigma}$ and $\sigma_{\mu\Delta\mu}$ of 0.2 were obtained. The partition for the jth model's epistemic uncertainties is listed in Table F5-3. These estimates reflect uncertainties in the median scale factors or transfer functions due to parametric uncertainties and are based on judgement. The model component is assumed to be contained in the proponent model epistemic uncertainties on the first page of Table F5-3.

F5-5.3 Median And Uncertainty Estimates

The rules for computing the point estimates are given in Table F5-3. The median estimate (lognormal) is simply the weighted median with the combined class and proponent model weights normalized to sum to unity. The aleatory uncertainty is computed in a similar manner simply as the mean of weighted variances. For the uncertainty of the median (σ_μ), a double sum is used with the first contribution due to the weighted variance about the median and the second

due to a weighted average of the proponent models epistemic uncertainties In a similar manner, the uncertainty of the aleatory uncertainty (σ_σ) is computed as a double sum: a weighted variation about the mean σ in addition to a weighted average of the proponent models total aleatory uncertainties. These relations reflect a consensus opinion at the April 1997 ground motion workshop. More development work is necessary in characterizing appropriate methods to estimate σ_μ and σ_σ and this current relation with both contributions is appealing but certainly not definitive. Tables F5-4 through F5-21 list the point estimates for all 51 cases.

F5-6 MULTIPLE RUPTURE ON PARALLEL FAULTS

Based on the results of the multiple rupture deterministic scenarios of Somerville and the incoherent or SRSS (Square Root Sum Squares) results of Silva, the recommendation is to apply the SRSS approach. The SRSS approach should be applied to the Fourier amplitude spectra and the response spectra subsequently estimated from the SRSS Fourier amplitude spectra. However, in view of all the uncertainties inherent in the multiple rupture scenario, computing the SRSS response spectra directly is a reasonable approach. Because the SRSS is most appropriate at high frequencies, it is recommended to increase the low frequency ($\leq$ 1 Hz SRSS) by 25%. This value is based on the coherent verses incoherent (SRSS) sum results presented by Silva at the April, 1997 ground motion workshop.

F5-7 LOW ANGLE FAULT

Because of the lack of empirical strong motion data from low angle normal faults and no modeling results to provide guidance, it is recommended that this scenario should be treated as a normal fault.

F5-8 REGRESSION MODEL

For the regression model, the distance metric of shortest site-to-rupture surface distance was specified. The regression model for motions was specified to reflect hanging/foot-wall effects while the regression model on aleatory uncertainty was specified to reflect effects of magnitude and period. For the epistemic uncertainties, $\sigma\mu$ and $\sigma\sigma$, the regression model was specified to be magnitude independent and to vary monotomically with distance. All four regression models (μ, σ, σ_μ, σ_σ) reflect appropriate fits to the point estimates and capture stable features of magnitude, distance, and period dependencies.

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TABLE F5-1
PROPONENT MODELS, WEIGHTS, AND SCALE FACTORS

EMPIRICAL RELATIONS

Relation	Parameters	M Range	D Range (km)	WT
AS97	H,V	5 - 8	0 - 200	1.0
BJF97	H	5.5 - 7.5	0 - 80	1.0
CP97	H, V, PGV	5 - 8	3 - 60	1.0
SD97	H, V	4 - 8	0 - 100	1.0
JB88	PGV (only)	5 - 7.5	0 - 100	1.0

Class weights: Empirical 0.4
Numerical 0.6
For cases outside ranges WT = 0.25

TABLE F5-1 CONT.
EMPIRICAL SCALE FACTORS

Parameter	Scale Factor	σ_μ	σ	WT all
H Spectra	Crust	0.15	0.20	1.0
	Normal H (NS)	0.00	0.00	
H PGA	Crust	0.15	0.20	1.0
	Normal H (NS)	0.00	0.00	
H PGV (V available)	Crust	0.15	0.20	1.0
	Normal H (NS)	0.00	0.00	
H PGV (V not available use PGA)	Crust	0.15	0.20	0.5
	Normal H (NS)	0.00	0.00	
	VOA H	0.15	0.30	
V Spectra (use horizontal)	Crust	0.15	0.20	1.0
	Normal V (NS)	0.00	0.00	
	VOH	0.20	0.20	
V PGA (use horizontal)	Crust	0.15	0.20	1.0
	Normal V (NS)	0.00	0.00	
	VOH	0.20	0.20	
V PGV (use horizontal PGA)	Crust	0.15	0.00	0.5
	Normal V (NS)	0.00	0.00	
	VOA V	0.15	0.30	
	VOH	0.20	0.20	

TABLE F5-1 CONT.
NUMERICAL RELATIONS

Relation	Parameters	M Range	D Range(km)	WT
AND	H, V, PGV	5.8 - 8.0	ALL	0.7
POINT	H, VOH, VOA	ALL	ALL	1.0
SIL	H, PGV	ALL	ALL	1.0
SOM	H, V, PGV	ALL	ALL	1.0

TABLE F5-1 CONT.
NUMERICAL SCALE FACTORS

Parameter	Scale Factor	σ_μ	σ	WT all
H Spectra	Normal H (NS)	0.00	0.00	1.0
H PGA	Normal H (NS)	0.00	0.00	1.0
H PGV (V available)	Normal H (NS)	0.00	0.00	1.0
H PGV (V not available use PGA)	Normal H (NS)	0.00	0.00	0.5
	VOA H	0.15	0.30	
V Spectra (available)	Normal V (NS)	0.00	0.00	1.0
	VOH*, 0.00	0.20	0.20	
V Spectra (not available use H)	Normal V (NS)	0.00	0.00	1.0
	VOH	0.20	0.20	
V PGA (available)	Normal V (NS)	0.00	0.00	1.0
	VOH*, 0.00	0.20	0.20	
V PGA (not available use H)	Normal V (NS)	0.00	0.00	1.0
	VOH	0.20	0.20	
V PGV (available)	Normal V (NS)	0.00	0.00	1.0
	VOH*, 0.00	0.20	0.20	
V PGV (not available use H)	VOH	0.20	0.20	0.5
	VOA V	0.15	0.30	

*Use scale factor of 0.0 and σln of 0.20 to increase variability for vertical components

N.B. Normal Faulting Scale Factor: Use 0.5 of scale factor for horizontal and vertical components.

TABLE F5-2
CASE SPECIFIC WEIGHTS

Relation	Component	F (Hz)	Case
Anderson	H, V	ALL	ALL M 5.0
Somerville	H, V	0.3, 0.5	5, 6
	H, V	0.3, 0.5, 1.0	12, 13, 14, 15, 16, 38, 39, 40, 41
	H, V	ALL	31, 32
	H, V	1.0	42
	H, V	0.3, 0.5, 1.0	44, 45, 46, 47, 48, 49
Silva PT	H, V	ALL	51
BJF97	H	0.5	ALL
	H	ALL	24, 42, 47, 48
CMP 97	H	ALL	40, 41
SAD 97	H	ALL	40, 41

TABLE F5-3
APPROACH TO COMPUTING POINT ESTIMATES

<u>Given</u> μ_j, σ_j, $\sigma_{\mu j}$, WT_j for j^{th} relation

Empirical σ_j = aleatory for average component
$\sigma_\mu = 0.1$

Numerical (Point) σ_j = aleatory modeling plus parametric for average component
$\sigma_\mu = 0.2$

Numerical (Finite) σ_j = aleatory parametric for average component
$\sigma_\mu j = 0.2$

<u>Compute Total Aleatory</u>

$$\sigma_j^{T2} = \sigma_j^2 + \sigma_{MECH}^2 + \sigma_{CRUST}^2 + \sigma_{VOA}^2 + \sigma_{VOH}^2 + \sigma_{MOD}^2 + \sigma_{RANDOM}^2$$

Where σ_{MECH} = increase in aleatory due to mechanism
= 0

σ_{CRUST} = increase in aleatory due to YM crust at -300m
= 0.2

σ_{VOA} = increase in aleatory for larger PGV than PGA aleatory
= 0.3

σ_{VOH} = increase in aleatory for larger vertical than horizontal aleatory
= 0.2

σ_{MOD} = modeling aleatory
= $\sigma_{MOD}(f)$

σ_{RANDOM} = increase in aleatory for random component (JBF 97)

Compute Total Epistemic

$$\sigma_{\mu j}^{T2} = \sigma_{\mu j}^{2} + \sigma_{\mu CRUST}^{2} + \sigma_{\mu VOA}^{2} + \sigma_{\mu VOH}^{2}$$

Where $\sigma_{\mu CRUST}$ = epistemic uncertainty in median crustal transfer function
= 0.15

$\sigma_{\mu VOA}$ = epistemic uncertainty in median peak velocity/peak acceleration transfer function
= 0.15

$\sigma_{\mu VOH}^{2}$ = epistemic uncertainty in median vertical/horizontal transfer function
= 0.2

Then

$$\mu' = \sum \mu_j WT_j$$

$$\sigma = \sqrt{\sum \sigma_j^{T2}\ WT_j}$$

$$\sigma_{\mu}^{2} = \sum WT_j (\mu'_j - \bar{\mu})^2 - \sum WT_j \sigma_{\mu j}^{2}$$

$$\sigma_{\sigma}^{2} = \sum WT_j (\sigma'_j - \bar{\sigma})^2 - \sum WT_j \sigma_{\sigma j}^{2}$$

TABLE F5-4
W. J. SILVA: HORIZONTAL POINT ESTIMATES
PEAK GROUND ACCELERATION

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.18154	0.69272	0.33829	0.09780
2	5.00	1	0.16407	0.69790	0.35660	0.09664
3	5.00	5	0.05301	0.69142	0.30515	0.09733
4	5.00	5	0.05273	0.69404	0.32525	0.09694
5	5.80	10	0.09850	0.64265	0.28714	0.12739
6	5.80	20	0.07220	0.64150	0.30682	0.12754
7	6.50	1	0.44361	0.63259	0.35821	0.13041
8	6.50	1	0.44822	0.63454	0.47015	0.13169
9	6.50	1	0.40568	0.63572	0.42342	0.13101
10	6.50	5	0.38053	0.62620	0.39716	0.13056
11	6.50	5	0.25263	0.63550	0.37082	0.13102
12	6.50	50	0.03212	0.62533	0.28341	0.13052
13	6.50	50	0.02886	0.62489	0.30835	0.13051
14	7.00	10	0.25534	0.61246	0.29294	0.13619
15	7.50	50	0.06446	0.61457	0.26442	0.14042
16	7.50	50	0.06725	0.61118	0.30051	0.13935
17	5.00	1	0.05988	0.69272	0.31289	0.09780
18	5.80	5	0.14463	0.64362	0.36724	0.12730
19	5.80	5	0.08764	0.64587	0.37996	0.12697
20	5.00	10	0.06253	0.69142	0.27819	0.09733
21	5.00	10	0.08381	0.68884	0.31447	0.09788
22	5.00	50	0.00627	0.68884	0.30815	0.09788
23	5.00	50	0.00647	0.68629	0.32103	0.09860
24	5.00	160	0.00082	0.68479	0.31645	0.10058
25	5.80	1	0.28355	0.64688	0.39176	0.12727
26	5.80	5	0.23086	0.64201	0.38387	0.12747
27	5.80	5	0.13760	0.64521	0.36858	0.12706
28	5.80	10	0.12277	0.64761	0.29022	0.12838
29	5.80	10	0.16273	0.64233	0.33084	0.12742
30	5.80	10	0.07790	0.64636	0.40005	0.12735
31	5.80	50	0.01366	0.63860	0.36519	0.12722
32	5.80	50	0.01308	0.64289	0.43421	0.12736
33	6.50	5	0.32732	0.62743	0.32643	0.13068
34	6.50	10	0.20988	0.62944	0.30294	0.13110
35	6.50	10	0.28650	0.62878	0.37365	0.13102
36	6.50	10	0.15940	0.62928	0.34808	0.12992
37	6.50	20	0.10365	0.62543	0.27592	0.13052
38	6.50	20	0.13123	0.63010	0.34906	0.13119
39	6.50	20	0.07799	0.62631	0.32867	0.12961
40	6.50	100	0.01536	0.62875	0.32606	0.13088
41	6.50	160	0.00692	0.63373	0.47604	0.13417
42	7.00	1	0.50973	0.62110	0.30018	0.13682
43	7.00	10	0.34653	0.61999	0.36376	0.13793
44	7.00	10	0.19675	0.61444	0.35980	0.13565
45	7.00	50	0.04820	0.61044	0.28756	0.13590
46	7.00	50	0.05004	0.61234	0.29839	0.13617
47	7.50	1	0.53874	0.63507	0.40136	0.14863
48	5.00	10	0.31386	0.62399	0.33627	0.14593
49	5.00	10	0.37202	0.61523	0.50832	0.14039
50	8.00	50	0.08215	0.62024	0.30312	0.12008
51	8.00	160	0.02067	0.62010	0.35827	0.11416

TABLE F5-5
W. J. SILVA: 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	0.38075	0.69545	0.33018	0.09939
2	5.00	1	0.34394	0.69805	0.34951	0.09873
3	5.00	5	0.10251	0.69548	0.29638	0.09736
4	5.00	5	0.10245	0.69812	0.30720	0.09693
5	5.80	10	0.16409	0.63976	0.30585	0.12667
6	5.80	20	0.11575	0.63497	0.31270	0.12610
7	6.50	1	0.75712	0.62015	0.35657	0.12836
8	6.50	1	0.76219	0.62146	0.43611	0.12976
9	6.50	1	0.68812	0.61987	0.43093	0.12822
10	6.50	5	0.66534	0.61581	0.42085	0.12742
11	6.50	5	0.43674	0.61751	0.43627	0.12761
12	6.50	50	0.04384	0.61474	0.31454	0.12693
13	6.50	50	0.03978	0.61417	0.36969	0.12690
14	7.00	10	0.41711	0.59704	0.31474	0.13136
15	7.50	50	0.08330	0.59945	0.31441	0.13590
16	7.50	50	0.08779	0.59570	0.36204	0.13439
17	5.00	1	0.11669	0.69545	0.29720	0.09939
18	5.80	5	0.23822	0.63580	0.38003	0.12552
19	5.80	5	0.14207	0.63612	0.41122	0.12621
20	5.00	10	0.12277	0.70626	0.29028	0.09669
21	5.00	10	0.16854	0.69548	0.33278	0.09736
22	5.00	50	0.01000	0.69028	0.30905	0.09874
23	5.00	50	0.01042	0.69028	0.32072	0.09874
24	5.00	160	0.00099	0.68274	0.40870	0.10417
25	5.80	1	0.49887	0.63682	0.42044	0.12612
26	5.80	5	0.40840	0.64025	0.41323	0.12735
27	5.80	5	0.23339	0.63927	0.46608	0.12701
28	5.80	10	0.20516	0.64232	0.33043	0.12788
29	5.80	10	0.27113	0.63597	0.36271	0.12594
30	5.80	10	0.13033	0.63472	0.49343	0.12591
31	5.80	50	0.01944	0.63522	0.40813	0.12605
32	5.80	50	0.01836	0.63740	0.50336	0.12632
33	6.50	5	0.55790	0.61308	0.32780	0.12628
34	6.50	10	0.35724	0.62170	0.30464	0.12893
35	6.50	10	0.49397	0.61682	0.40082	0.12716
36	6.50	10	0.26690	0.61819	0.40799	0.12832
37	6.50	20	0.16394	0.61881	0.29092	0.12870
38	6.50	20	0.21231	0.62052	0.36935	0.12833
39	6.50	20	0.12355	0.61327	0.40765	0.12707
40	6.50	100	0.01847	0.61249	0.30872	0.12709
41	6.50	160	0.00845	0.61438	0.33375	0.12670
42	7.00	1	0.87614	0.60436	0.35197	0.13442
43	7.00	10	0.59235	0.60776	0.41121	0.13462
44	7.00	10	0.31968	0.59715	0.43808	0.13237
45	7.00	50	0.06437	0.59479	0.30839	0.13092
46	7.00	50	0.06837	0.59726	0.33628	0.13141
47	7.50	1	0.91498	0.62010	0.47839	0.14962
48	5.00	10	0.49585	0.61084	0.39232	0.14368
49	5.00	10	0.59665	0.60023	0.58079	0.13592
50	8.00	50	0.10607	0.61548	0.37871	0.11540
51	8.00	160	0.02092	0.60722	0.42481	0.10915

TABLE F5-6
W. J. SILVA: 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	0.39383	0.72685	0.33473	0.10557
2	5.00	1	0.35579	0.72097	0.35847	0.10343
3	5.00	5	0.11568	0.72462	0.26049	0.10507
4	5.00	5	0.11509	0.72165	0.28142	0.10385
5	5.80	10	0.19650	0.65992	0.28205	0.13387
6	5.80	20	0.14256	0.66057	0.33892	0.13396
7	6.50	1	0.90812	0.64863	0.36622	0.13818
8	6.50	1	0.94720	0.64780	0.51587	0.13834
9	6.50	1	0.85388	0.65031	0.45483	0.13872
10	6.50	5	0.77595	0.64005	0.42035	0.13486
11	6.50	5	0.52081	0.64671	0.37779	0.13702
12	6.50	50	0.05912	0.64148	0.34010	0.13524
13	6.50	50	0.05319	0.64058	0.32424	0.13469
14	7.00	10	0.51271	0.62640	0.32021	0.13898
15	7.50	50	0.11119	0.63247	0.33855	0.14576
16	7.50	50	0.11615	0.62514	0.36698	0.14221
17	5.00	1	0.13068	0.71520	0.25901	0.10197
18	5.80	5	0.29465	0.66162	0.38624	0.13415
19	5.80	5	0.17510	0.66122	0.40895	0.13372
20	5.00	10	0.13621	0.72462	0.27916	0.10507
21	5.00	10	0.18229	0.71293	0.35210	0.10121
22	5.00	50	0.01295	0.71872	0.29561	0.10280
23	5.00	50	0.01345	0.71293	0.31691	0.10121
24	5.00	160	0.00126	0.70502	0.44366	0.10370
25	5.80	1	0.57206	0.66483	0.42477	0.13536
26	5.80	5	0.48805	0.66094	0.38818	0.13402
27	5.80	5	0.27315	0.66422	0.40810	0.13591
28	5.80	10	0.23716	0.66235	0.30539	0.13556
29	5.80	10	0.31674	0.66046	0.37521	0.13395
30	5.80	10	0.15342	0.65687	0.40971	0.13262
31	5.80	50	0.02554	0.65979	0.35464	0.13385
32	5.80	50	0.02426	0.66105	0.42436	0.13466
33	6.50	5	0.67664	0.64466	0.34330	0.13634
34	6.50	10	0.42901	0.64384	0.32123	0.13631
35	6.50	10	0.59590	0.64228	0.42454	0.13587
36	6.50	10	0.32047	0.64369	0.34451	0.13621
37	6.50	20	0.20817	0.63857	0.30495	0.13410
38	6.50	20	0.26145	0.64250	0.37121	0.13537
39	6.50	20	0.15332	0.64148	0.33919	0.13520
40	6.50	100	0.02454	0.64086	0.34071	0.13350
41	6.50	160	0.01037	0.63794	0.35233	0.13329
42	7.00	1	1.05138	0.63215	0.34290	0.14156
43	7.00	10	0.69986	0.63435	0.41723	0.14262
44	7.00	10	0.39947	0.62794	0.36645	0.13986
45	7.00	50	0.08577	0.62346	0.35112	0.13785
46	7.00	50	0.09091	0.62737	0.35685	0.13936
47	7.50	1	1.09550	0.64992	0.43579	0.15738
48	5.00	10	0.61825	0.63865	0.37085	0.15098
49	5.00	10	0.74590	0.63125	0.54426	0.14507
50	8.00	50	0.14082	0.64910	0.35904	0.12581
51	8.00	160	0.02399	0.64110	0.45416	0.11630

TABLE F5-7
W. J. SILVA: 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	0.29847	0.74854	0.33926	0.10165
2	5.00	1	0.27594	0.75429	0.35347	0.10372
3	5.00	5	0.09593	0.74013	0.26000	0.09958
4	5.00	5	0.09702	0.73735	0.27983	0.09905
5	5.80	10	0.18766	0.69017	0.27809	0.13316
6	5.80	20	0.14310	0.68225	0.34102	0.13009
7	6.50	1	0.84001	0.66866	0.35835	0.13145
8	6.50	1	0.87850	0.67736	0.48194	0.13556
9	6.50	1	0.80461	0.68506	0.43649	0.13906
10	6.50	5	0.74158	0.66924	0.40238	0.13282
11	6.50	5	0.51119	0.67238	0.34014	0.13271
12	6.50	50	0.06646	0.66760	0.35420	0.13159
13	6.50	50	0.05943	0.66320	0.30521	0.12992
14	7.00	10	0.50960	0.65322	0.31623	0.13472
15	7.50	50	0.13073	0.65530	0.35163	0.13935
16	7.50	50	0.13931	0.65062	0.34940	0.13712
17	5.00	1	0.10735	0.73740	0.26197	0.09953
18	5.80	5	0.26423	0.68548	0.41272	0.13139
19	5.80	5	0.17504	0.68595	0.34558	0.13095
20	5.00	10	0.11123	0.74013	0.27116	0.09958
21	5.00	10	0.14790	0.73735	0.33823	0.09905
22	5.00	50	0.01282	0.74578	0.29048	0.10114
23	5.00	50	0.01350	0.73188	0.30896	0.09853
24	5.00	160	0.00162	0.73894	0.40344	0.10244
25	5.80	1	0.50229	0.68656	0.39079	0.13152
26	5.80	5	0.43108	0.68415	0.36844	0.13129
27	5.80	5	0.25756	0.68728	0.34025	0.13158
28	5.80	10	0.22041	0.68861	0.31411	0.13235
29	5.80	10	0.29702	0.68292	0.35859	0.13018
30	5.80	10	0.15331	0.69036	0.33123	0.13313
31	5.80	50	0.02768	0.68619	0.31997	0.13148
32	5.80	50	0.02781	0.68572	0.35820	0.13142
33	6.50	5	0.63007	0.66524	0.32814	0.13051
34	6.50	10	0.39870	0.67092	0.29532	0.13289
35	6.50	10	0.54925	0.66848	0.38074	0.13171
36	6.50	10	0.32403	0.66557	0.31994	0.13012
37	6.50	20	0.20155	0.66839	0.29263	0.13214
38	6.50	20	0.26532	0.66606	0.35180	0.13119
39	6.50	20	0.16082	0.66835	0.29726	0.13114
40	6.50	100	0.03067	0.66895	0.34597	0.13063
41	6.50	160	0.01402	0.66932	0.35415	0.13206
42	7.00	1	0.97826	0.65818	0.31707	0.13641
43	7.00	10	0.69059	0.65687	0.39630	0.13634
44	7.00	10	0.40746	0.65219	0.32591	0.13408
45	7.00	50	0.09853	0.65130	0.37144	0.13404
46	7.00	50	0.10531	0.65191	0.35123	0.13424
47	7.50	1	1.08750	0.67163	0.40961	0.14898
48	5.00	10	0.64133	0.66709	0.35800	0.14740
49	5.00	10	0.74593	0.65166	0.49921	0.13756
50	8.00	50	0.16533	0.67096	0.32923	0.11557
51	8.00	160	0.03379	0.66753	0.51995	0.10831

TABLE F5-8
W. J. SILVA: 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	0.13522	0.81449	0.34956	0.08523
2	5.00	1	0.12851	0.80047	0.38467	0.08003
3	5.00	5	0.04671	0.80668	0.27762	0.08473
4	5.00	5	0.04856	0.79821	0.34027	0.08112
5	5.80	10	0.11628	0.75054	0.29414	0.13229
6	5.80	20	0.09467	0.75207	0.34893	0.13297
7	6.50	1	0.58368	0.73321	0.26841	0.13433
8	6.50	1	0.60411	0.73395	0.38593	0.13521
9	6.50	1	0.55182	0.74010	0.35849	0.13733
10	6.50	5	0.50889	0.73200	0.34874	0.13580
11	6.50	5	0.34953	0.73341	0.34083	0.13440
12	6.50	50	0.05392	0.73599	0.28677	0.13772
13	6.50	50	0.05286	0.72752	0.35419	0.13421
14	7.00	10	0.37911	0.71835	0.27366	0.14163
15	7.50	50	0.12512	0.72211	0.29990	0.14947
16	7.50	50	0.13674	0.71435	0.36390	0.14608
17	5.00	1	0.05212	0.81449	0.29750	0.08523
18	5.80	5	0.17702	0.75327	0.35948	0.13344
19	5.80	5	0.10319	0.75708	0.41754	0.13324
20	5.00	10	0.05319	0.79545	0.27832	0.08032
21	5.00	10	0.07100	0.79000	0.37147	0.07933
22	5.00	50	0.00767	0.79271	0.28738	0.07972
23	5.00	50	0.00820	0.79545	0.32952	0.08032
24	5.00	160	0.00147	0.78732	0.40005	0.08107
25	5.80	1	0.31193	0.75088	0.33225	0.13058
26	5.80	5	0.27107	0.74893	0.39535	0.13150
27	5.80	5	0.15949	0.74482	0.35737	0.12900
28	5.80	10	0.14424	0.75229	0.27727	0.13305
29	5.80	10	0.20182	0.74800	0.36465	0.13134
30	5.80	10	0.09329	0.75069	0.40305	0.13084
31	5.80	50	0.01998	0.74803	0.34683	0.13116
32	5.80	50	0.01998	0.75110	0.45120	0.13298
33	6.50	5	0.44536	0.72836	0.30158	0.13445
34	6.50	10	0.29824	0.73219	0.31326	0.13599
35	6.50	10	0.42055	0.73139	0.39146	0.13570
36	6.50	10	0.22780	0.73149	0.35711	0.13380
37	6.50	20	0.14717	0.73021	0.26420	0.13507
38	6.50	20	0.19826	0.73660	0.36628	0.13799
39	6.50	20	0.12344	0.73213	0.31473	0.13399
40	6.50	100	0.02976	0.73583	0.31874	0.13449
41	6.50	160	0.01669	0.73377	0.33919	0.13607
42	7.00	1	0.71694	0.72297	0.29790	0.14164
43	7.00	10	0.56484	0.71932	0.39154	0.14196
44	7.00	10	0.30914	0.72136	0.34770	0.14104
45	7.00	50	0.08734	0.71590	0.30747	0.14054
46	7.00	50	0.09732	0.72142	0.38978	0.14289
47	7.50	1	0.77911	0.73938	0.35015	0.15766
48	5.00	10	0.47774	0.72965	0.31895	0.15448
49	5.00	10	0.61504	0.72161	0.50614	0.14922
50	8.00	50	0.15956	0.73746	0.29987	0.12457
51	8.00	160	0.04859	0.73704	0.47048	0.11943

TABLE F5-9
W. J. SILVA: 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	0.05203	0.83787	0.33457	0.06192
2	5.00	1	0.04591	0.83512	0.35431	0.06111
3	5.00	5	0.01892	0.82674	0.27351	0.06286
4	5.00	5	0.01826	0.82674	0.33637	0.06286
5	5.80	10	0.05763	0.79957	0.31238	0.11302
6	5.80	20	0.04397	0.79678	0.32987	0.11642
7	6.50	1	0.32106	0.78624	0.25789	0.11892
8	6.50	1	0.29904	0.78822	0.39454	0.12328
9	6.50	1	0.27001	0.77927	0.38985	0.11987
10	6.50	5	0.26325	0.78181	0.32625	0.12470
11	6.50	5	0.17052	0.78005	0.40892	0.11982
12	6.50	50	0.03584	0.77602	0.26291	0.11923
13	6.50	50	0.03203	0.77663	0.29929	0.12232
14	7.00	10	0.23790	0.76702	0.27533	0.13051
15	7.50	50	0.08908	0.76888	0.25013	0.14030
16	7.50	50	0.09139	0.76585	0.29240	0.14164
17	5.00	1	0.02107	0.82972	0.31377	0.06033
18	5.80	5	0.07935	0.81109	0.50249	0.12427
19	5.80	5	0.04668	0.81133	0.52346	0.11902
20	5.00	10	0.02130	0.82403	0.25282	0.06236
21	5.00	10	0.02592	0.82403	0.31780	0.06236
22	5.00	50	0.00358	0.82135	0.25850	0.06213
23	5.00	50	0.00353	0.82948	0.28079	0.06362
24	5.00	160	0.00088	0.82812	0.34767	0.06361
25	5.80	1	0.14750	0.80923	0.41946	0.11373
26	5.80	5	0.12206	0.79191	0.43336	0.11339
27	5.80	5	0.06975	0.80703	0.46860	0.11635
28	5.80	10	0.06974	0.80192	0.29376	0.11445
29	5.80	10	0.09338	0.79338	0.35029	0.11406
30	5.80	10	0.04458	0.80848	0.41368	0.11847
31	5.80	50	0.01163	0.79135	0.30733	0.10972
32	5.80	50	0.01153	0.79645	0.32481	0.11528
33	6.50	5	0.23284	0.78651	0.28756	0.12327
34	6.50	10	0.16994	0.78207	0.28843	0.12143
35	6.50	10	0.22677	0.77882	0.33715	0.12321
36	6.50	10	0.11742	0.77950	0.37156	0.11965
37	6.50	20	0.08398	0.77574	0.27473	0.11904
38	6.50	20	0.11220	0.78272	0.37362	0.12522
39	6.50	20	0.06715	0.78147	0.34645	0.12031
40	6.50	100	0.02052	0.78236	0.28705	0.11735
41	6.50	160	0.01231	0.77855	0.33980	0.11842
42	7.00	1	0.40718	0.77270	0.29120	0.12910
43	7.00	10	0.30266	0.77069	0.36690	0.13461
44	7.00	10	0.18086	0.76678	0.36592	0.12942
45	7.00	50	0.06159	0.76684	0.26528	0.13046
46	7.00	50	0.06109	0.76410	0.30338	0.13191
47	7.50	1	0.49178	0.78510	0.36727	0.14289
48	5.00	10	0.32253	0.77606	0.32670	0.14407
49	5.00	10	0.39192	0.77000	0.54056	0.14326
50	8.00	50	0.11448	0.77401	0.32558	0.12702
51	8.00	160	0.04251	0.78754	0.40197	0.12370

TABLE F5-10
W. J. SILVA: 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	0.01406	0.92404	0.42119	0.06278
2	5.00	1	0.01107	0.91864	0.45775	0.06215
3	5.00	5	0.00534	0.90504	0.33300	0.07094
4	5.00	5	0.00452	0.90504	0.38411	0.07094
5	5.80	10	0.02254	0.88033	0.36006	0.12220
6	5.80	20	0.01450	0.87633	0.35129	0.13360
7	6.50	1	0.15787	0.87063	0.28618	0.13191
8	6.50	1	0.13059	0.86266	0.37284	0.13922
9	6.50	1	0.11571	0.86616	0.40327	0.14100
10	6.50	5	0.10370	0.86381	0.43998	0.14671
11	6.50	5	0.07706	0.86779	0.46418	0.14204
12	6.50	50	0.01743	0.86100	0.32579	0.13444
13	6.50	50	0.01411	0.85796	0.43034	0.14294
14	7.00	10	0.12817	0.85880	0.30973	0.15059
15	7.50	50	0.05667	0.85606	0.26936	0.16020
16	7.50	50	0.05058	0.84152	0.36750	0.16231
17	5.00	1	0.00584	0.91597	0.34412	0.06224
18	5.80	5	0.02839	0.86626	0.46777	0.12729
19	5.80	5	0.01749	0.87317	0.53078	0.12467
20	5.00	10	0.00605	0.90504	0.31070	0.07094
21	5.00	10	0.00643	0.90768	0.35738	0.07062
22	5.00	50	0.00114	0.90504	0.25700	0.07094
23	5.00	50	0.00100	0.90504	0.30806	0.07094
24	5.00	160	0.00036	0.90830	0.28989	0.06864
25	5.80	1	0.06006	0.89372	0.36848	0.12242
26	5.80	5	0.04238	0.86420	0.46849	0.12606
27	5.80	5	0.02746	0.87165	0.47769	0.12376
28	5.80	10	0.02488	0.88859	0.41456	0.12971
29	5.80	10	0.02692	0.88372	0.46276	0.14089
30	5.80	10	0.01612	0.86955	0.53698	0.12268
31	5.80	50	0.00509	0.87340	0.43792	0.11835
32	5.80	50	0.00419	0.87310	0.46872	0.13212
33	6.50	5	0.11307	0.86528	0.31075	0.13578
34	6.50	10	0.07464	0.86598	0.33687	0.13610
35	6.50	10	0.08162	0.86436	0.41815	0.14753
36	6.50	10	0.04834	0.86317	0.50868	0.13930
37	6.50	20	0.04150	0.87040	0.35369	0.13861
38	6.50	20	0.04650	0.85374	0.39565	0.14080
39	6.50	20	0.02984	0.86195	0.46623	0.13871
40	6.50	100	0.01212	0.86763	0.31010	0.13130
41	6.50	160	0.00794	0.87394	0.37731	0.13736
42	7.00	1	0.21378	0.86289	0.32864	0.14619
43	7.00	10	0.12100	0.85301	0.46195	0.15766
44	7.00	10	0.08697	0.85968	0.47307	0.15572
45	7.00	50	0.03527	0.85486	0.24972	0.14881
46	7.00	50	0.03042	0.84679	0.36692	0.15434
47	7.50	1	0.25659	0.86919	0.46354	0.16075
48	5.00	10	0.18127	0.85499	0.37731	0.15969
49	5.00	10	0.17889	0.84550	0.57756	0.16411
50	8.00	50	0.07454	0.86928	0.34933	0.15550
51	8.00	160	0.03223	0.87951	0.46998	0.14636

TABLE F5-11
W. J. SILVA: 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	0.00420	0.97945	0.70348	0.08419
2	5.00	1	0.00331	0.97092	0.70624	0.08009
3	5.00	5	0.00164	0.96419	0.62818	0.09238
4	5.00	5	0.00139	0.96419	0.64245	0.09238
5	5.80	10	0.01035	0.91179	0.41614	0.13882
6	5.80	20	0.00595	0.90654	0.45226	0.15049
7	6.50	1	0.07607	0.92510	0.39247	0.16939
8	6.50	1	0.06318	0.89224	0.40895	0.15739
9	6.50	1	0.05735	0.90074	0.44846	0.16294
10	6.50	5	0.05340	0.89866	0.43180	0.17082
11	6.50	5	0.04196	0.90939	0.50174	0.16919
12	6.50	50	0.00909	0.90816	0.41315	0.16399
13	6.50	50	0.00643	0.89498	0.62048	0.16829
14	7.00	10	0.07079	0.90413	0.34909	0.18306
15	7.50	50	0.03483	0.89336	0.30628	0.18730
16	7.50	50	0.02856	0.88420	0.39667	0.19274
17	5.00	1	0.00178	0.97374	0.64340	0.08126
18	5.80	5	0.01226	0.91376	0.48884	0.15597
19	5.80	5	0.00723	0.91824	0.57367	0.14853
20	5.00	10	0.00184	0.95857	0.59693	0.09042
21	5.00	10	0.00195	0.96137	0.56138	0.09131
22	5.00	50	0.00037	0.95580	0.49356	0.08972
23	5.00	50	0.00032	0.95580	0.51509	0.08972
24	5.00	160	0.00013	0.96222	0.39776	0.08295
25	5.80	1	0.02612	0.92146	0.46384	0.13440
26	5.80	5	0.01879	0.91262	0.49037	0.15547
27	5.80	5	0.01292	0.91193	0.50451	0.14394
28	5.80	10	0.01142	0.91462	0.51200	0.14059
29	5.80	10	0.01059	0.90217	0.55810	0.14740
30	5.80	10	0.00656	0.91498	0.72348	0.14594
31	5.80	50	0.00218	0.91495	0.52901	0.14075
32	5.80	50	0.00170	0.90841	0.61821	0.15194
33	6.50	5	0.05961	0.91832	0.38728	0.17282
34	6.50	10	0.03622	0.91329	0.45475	0.16829
35	6.50	10	0.03636	0.89769	0.48008	0.17043
36	6.50	10	0.02250	0.90745	0.65839	0.16791
37	6.50	20	0.01892	0.90435	0.51072	0.16133
38	6.50	20	0.01976	0.90529	0.48632	0.17602
39	6.50	20	0.01412	0.89605	0.60252	0.15974
40	6.50	100	0.00534	0.90352	0.47216	0.15104
41	6.50	160	0.00411	0.92051	0.44715	0.16635
42	7.00	1	0.12247	0.90447	0.41650	0.17410
43	7.00	10	0.06150	0.88952	0.50200	0.18536
44	7.00	10	0.04636	0.89592	0.55029	0.18100
45	7.00	50	0.02004	0.89763	0.29794	0.17858
46	7.00	50	0.01626	0.89166	0.40332	0.18676
47	7.50	1	0.14939	0.91067	0.51679	0.18968
48	5.00	10	0.10758	0.90229	0.44994	0.19330
49	5.00	10	0.09822	0.88634	0.66807	0.19411
50	8.00	50	0.04955	0.92324	0.37824	0.18569
51	8.00	160	0.02100	0.93330	0.38988	0.17415

TABLE F5-12
W. J. SILVA: HORIZONTAL POINT ESTIMATES
PEAK GROUND VELOCITY

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	6.75385	0.81085	0.37484	0.06924
2	5.00	1	5.99852	0.81085	0.40353	0.06924
3	5.00	5	2.20889	0.79932	0.29676	0.07699
4	5.00	5	2.16783	0.79367	0.36090	0.07371
5	5.80	10	6.41480	0.77058	0.29603	0.12615
6	5.80	20	4.72000	0.76895	0.32184	0.12815
7	6.50	1	36.87325	0.79058	0.31082	0.13466
8	6.50	1	34.80685	0.78758	0.41903	0.13697
9	6.50	1	31.54553	0.78758	0.40525	0.13697
10	6.50	5	29.80575	0.76841	0.35401	0.14279
11	6.50	5	20.57563	0.78262	0.39351	0.13520
12	6.50	50	3.55206	0.76596	0.32155	0.13970
13	6.50	50	3.10300	0.76493	0.42666	0.14154
14	7.00	10	27.12796	0.76862	0.28271	0.15155
15	7.50	50	10.19356	0.76800	0.32316	0.16046
16	7.50	50	10.09783	0.76142	0.39706	0.16018
17	5.00	1	2.49106	0.80528	0.32710	0.06657
18	5.80	5	9.50616	0.77004	0.45049	0.12836
19	5.80	5	5.56210	0.78316	0.45409	0.12334
20	5.00	10	2.50309	0.79089	0.25802	0.07237
21	5.00	10	3.20192	0.79367	0.32364	0.07371
22	5.00	50	0.34513	0.78813	0.30167	0.07124
23	5.00	50	0.34398	0.79089	0.33098	0.07237
24	5.00	160	0.07450	0.78271	0.27826	0.06964
25	5.80	1	17.09039	0.78720	0.40421	0.12170
26	5.80	5	14.08704	0.76587	0.41538	0.12703
27	5.80	5	8.62235	0.78228	0.36726	0.12318
28	5.80	10	7.67284	0.77511	0.29585	0.12750
29	5.80	10	10.12376	0.76901	0.32817	0.12816
30	5.80	10	4.95588	0.78175	0.43091	0.12310
31	5.80	50	1.15414	0.77143	0.39779	0.12634
32	5.80	50	1.07340	0.77176	0.47901	0.12902
33	6.50	5	26.36674	0.77316	0.28155	0.14206
34	6.50	10	17.64168	0.77149	0.27097	0.14146
35	6.50	10	23.35256	0.76886	0.34837	0.14296
36	6.50	10	12.82736	0.78185	0.40468	0.13506
37	6.50	20	8.80323	0.76980	0.30778	0.14087
38	6.50	20	11.50766	0.76962	0.35509	0.14326
39	6.50	20	7.06512	0.77919	0.41324	0.13434
40	6.50	100	1.98055	0.78436	0.48392	0.13330
41	6.50	160	1.04059	0.77473	0.81491	0.14353
42	7.00	1	51.16418	0.78763	0.34450	0.14320
43	7.00	10	34.06840	0.76640	0.41122	0.15307
44	7.00	10	20.53811	0.78031	0.43224	0.14345
45	7.00	50	6.50598	0.76331	0.29957	0.14991
46	7.00	50	6.28715	0.76124	0.37082	0.15121
47	7.50	1	60.22858	0.79663	0.53296	0.15441
48	5.00	10	38.05346	0.77125	0.41266	0.16193
49	5.00	10	45.09637	0.76428	0.64673	0.16116
50	8.00	50	14.52860	0.75883	0.44569	0.15123
51	8.00	160	5.25501	0.78261	0.51865	0.14299

TABLE F5-13
W. J. SILVA: VERTICAL POINT ESTIMATES
PEAK GROUND ACCELERATION

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.14263	0.71377	0.26693	0.09726
2	5.00	1	0.11105	0.71879	0.24455	0.09616
3	5.00	5	0.03515	0.71251	0.22334	0.09680
4	5.00	5	0.03051	0.71505	0.21837	0.09643
5	5.80	10	0.06150	0.66528	0.21279	0.12683
6	5.80	20	0.03778	0.66417	0.20327	0.12698
7	6.50	1	0.31936	0.65557	0.30171	0.12965
8	6.50	1	0.28471	0.65745	0.41510	0.13085
9	6.50	1	0.25684	0.65859	0.36583	0.13020
10	6.50	5	0.24171	0.64940	0.32700	0.12978
11	6.50	5	0.15153	0.65838	0.31198	0.13021
12	6.50	50	0.01385	0.64857	0.20923	0.12974
13	6.50	50	0.01107	0.64814	0.22976	0.12973
14	7.00	10	0.15922	0.63617	0.21993	0.13496
15	7.50	50	0.02709	0.63820	0.18196	0.13884
16	7.50	50	0.02581	0.63494	0.19160	0.13784
17	5.00	1	0.04034	0.71377	0.23381	0.09726
18	5.80	5	0.08192	0.66622	0.29552	0.12675
19	5.80	5	0.04689	0.66839	0.30947	0.12644
20	5.00	10	0.04276	0.71251	0.18479	0.09680
21	5.00	10	0.05266	0.71000	0.17666	0.09733
22	5.00	50	0.00290	0.71000	0.22927	0.09733
23	5.00	50	0.00266	0.70752	0.21046	0.09801
24	5.00	160	0.00035	0.70608	0.37176	0.09988
25	5.80	1	0.21469	0.66937	0.34117	0.12672
26	5.80	5	0.15049	0.66466	0.30822	0.12691
27	5.80	5	0.08290	0.66776	0.30482	0.12652
28	5.80	10	0.08075	0.67007	0.21695	0.12776
29	5.80	10	0.09919	0.66498	0.23584	0.12687
30	5.80	10	0.04324	0.66887	0.34508	0.12680
31	5.80	50	0.00606	0.66137	0.31170	0.12668
32	5.80	50	0.00515	0.66551	0.38120	0.12681
33	6.50	5	0.22548	0.65059	0.26313	0.12988
34	6.50	10	0.13380	0.65253	0.23334	0.13028
35	6.50	10	0.17455	0.65190	0.30783	0.13020
36	6.50	10	0.08781	0.65238	0.28239	0.12918
37	6.50	20	0.05811	0.64866	0.19711	0.12974
38	6.50	20	0.06808	0.65316	0.28287	0.13036
39	6.50	20	0.03766	0.64951	0.25732	0.12890
40	6.50	100	0.00541	0.65186	0.37589	0.13009
41	6.50	160	0.00213	0.65667	0.48793	0.13318
42	7.00	1	0.33592	0.64448	0.27881	0.13555
43	7.00	10	0.20452	0.64341	0.29173	0.13658
44	7.00	10	0.10528	0.63807	0.29202	0.13446
45	7.00	50	0.02045	0.63423	0.21446	0.13468
46	7.00	50	0.01939	0.63605	0.19216	0.13494
47	7.50	1	0.36054	0.65796	0.36353	0.14665
48	5.00	10	0.18868	0.64728	0.29507	0.14406
49	5.00	10	0.21813	0.63883	0.46153	0.13881
50	8.00	50	0.03435	0.64366	0.22474	0.11784
51	8.00	160	0.00753	0.64353	0.29907	0.11230

TABLE F5-14
W. J. SILVA: 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	0.32913	0.72253	0.26056	0.09849
2	5.00	1	0.25614	0.72504	0.27708	0.09787
3	5.00	5	0.07623	0.72256	0.21682	0.09661
4	5.00	5	0.06638	0.72511	0.24464	0.09620
5	5.80	10	0.11650	0.66910	0.24507	0.12596
6	5.80	20	0.06895	0.66452	0.26000	0.12544
7	6.50	1	0.62225	0.65037	0.30533	0.12750
8	6.50	1	0.55190	0.65162	0.40169	0.12880
9	6.50	1	0.49672	0.65011	0.40029	0.12737
10	6.50	5	0.48176	0.64624	0.38088	0.12664
11	6.50	5	0.29948	0.64786	0.41146	0.12681
12	6.50	50	0.02167	0.64521	0.26048	0.12619
13	6.50	50	0.01750	0.64467	0.33797	0.12616
14	7.00	10	0.30078	0.62838	0.25551	0.13015
15	7.50	50	0.04026	0.63067	0.25970	0.13424
16	7.50	50	0.03888	0.62710	0.31031	0.13286
17	5.00	1	0.08802	0.72253	0.21783	0.09849
18	5.80	5	0.15295	0.66531	0.34661	0.12491
19	5.80	5	0.08643	0.66562	0.37986	0.12553
20	5.00	10	0.09387	0.73294	0.20810	0.09597
21	5.00	10	0.11758	0.72256	0.25656	0.09661
22	5.00	50	0.00527	0.71756	0.23949	0.09789
23	5.00	50	0.00487	0.71756	0.26193	0.09789
24	5.00	160	0.00042	0.71030	0.37677	0.10294
25	5.80	1	0.42365	0.66628	0.37800	0.12546
26	5.80	5	0.29851	0.66957	0.37427	0.12659
27	5.80	5	0.15870	0.66863	0.44430	0.12627
28	5.80	10	0.15300	0.67154	0.27469	0.12709
29	5.80	10	0.18635	0.66548	0.31770	0.12529
30	5.80	10	0.08210	0.66428	0.47496	0.12526
31	5.80	50	0.00986	0.66476	0.36860	0.12540
32	5.80	50	0.00827	0.66684	0.48261	0.12564
33	6.50	5	0.43965	0.64364	0.27121	0.12559
34	6.50	10	0.26128	0.65185	0.24291	0.12803
35	6.50	10	0.34379	0.64720	0.36684	0.12640
36	6.50	10	0.16864	0.64851	0.38052	0.12747
37	6.50	20	0.10572	0.64909	0.22651	0.12782
38	6.50	20	0.12654	0.65073	0.33767	0.12748
39	6.50	20	0.06861	0.64382	0.38013	0.12632
40	6.50	100	0.00685	0.64307	0.42320	0.12634
41	6.50	160	0.00257	0.64488	0.48597	0.12598
42	7.00	1	0.67555	0.63533	0.31513	0.13294
43	7.00	10	0.40369	0.63857	0.37286	0.13313
44	7.00	10	0.19781	0.62848	0.40817	0.13106
45	7.00	50	0.03137	0.62624	0.25257	0.12976
46	7.00	50	0.03049	0.62858	0.28179	0.13020
47	7.50	1	0.71179	0.65033	0.44942	0.14702
48	5.00	10	0.34660	0.64150	0.36092	0.14149
49	5.00	10	0.40781	0.63141	0.55684	0.13426
50	8.00	50	0.05108	0.64592	0.33134	0.11287
51	8.00	160	0.00762	0.63806	0.38179	0.10712

TABLE F5-15
W. J. SILVA: 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	0.27664	0.75810	0.26051	0.10417
2	5.00	1	0.23919	0.75246	0.28073	0.10217
3	5.00	5	0.07494	0.75596	0.15498	0.10372
4	5.00	5	0.07184	0.75312	0.17885	0.10258
5	5.80	10	0.12440	0.69419	0.20526	0.13244
6	5.80	20	0.08505	0.69480	0.26899	0.13253
7	6.50	1	0.63025	0.68346	0.31031	0.13636
8	6.50	1	0.63765	0.68268	0.47277	0.13652
9	6.50	1	0.57386	0.68506	0.40652	0.13686
10	6.50	5	0.52237	0.67533	0.36571	0.13332
11	6.50	5	0.34010	0.68164	0.32059	0.13529
12	6.50	50	0.02888	0.67668	0.28501	0.13367
13	6.50	50	0.02558	0.67583	0.25383	0.13316
14	7.00	10	0.33041	0.66240	0.25490	0.13695
15	7.50	50	0.05352	0.66815	0.28297	0.14306
16	7.50	50	0.05632	0.66121	0.30074	0.13981
17	5.00	1	0.08537	0.74694	0.15233	0.10082
18	5.80	5	0.18414	0.69580	0.32870	0.13269
19	5.80	5	0.10588	0.69542	0.35489	0.13229
20	5.00	10	0.08969	0.75596	0.18428	0.10372
21	5.00	10	0.11857	0.74476	0.27212	0.10013
22	5.00	50	0.00658	0.75030	0.21443	0.10160
23	5.00	50	0.00669	0.74476	0.22890	0.10013
24	5.00	160	0.00058	0.73719	0.42514	0.10240
25	5.80	1	0.40122	0.69885	0.37748	0.13380
26	5.80	5	0.32775	0.69515	0.32843	0.13258
27	5.80	5	0.17644	0.69828	0.35648	0.13432
28	5.80	10	0.15473	0.69650	0.23570	0.13400
29	5.80	10	0.20583	0.69470	0.31347	0.13251
30	5.80	10	0.09478	0.69129	0.35915	0.13128
31	5.80	50	0.01268	0.69407	0.30225	0.13243
32	5.80	50	0.01183	0.69526	0.37432	0.13317
33	6.50	5	0.45851	0.67969	0.28295	0.13467
34	6.50	10	0.27799	0.67892	0.25602	0.13465
35	6.50	10	0.39243	0.67744	0.37250	0.13425
36	6.50	10	0.19935	0.67878	0.28027	0.13455
37	6.50	20	0.12420	0.67393	0.23645	0.13263
38	6.50	20	0.15674	0.67765	0.31224	0.13378
39	6.50	20	0.08766	0.67668	0.27364	0.13363
40	6.50	100	0.00957	0.67609	0.47979	0.13209
41	6.50	160	0.00343	0.67333	0.54178	0.13190
42	7.00	1	0.69735	0.66784	0.31823	0.13929
43	7.00	10	0.45750	0.66992	0.36290	0.14028
44	7.00	10	0.24611	0.66386	0.30452	0.13774
45	7.00	50	0.04151	0.65962	0.29789	0.13591
46	7.00	50	0.04428	0.66332	0.28879	0.13729
47	7.50	1	0.73641	0.68468	0.41024	0.15387
48	5.00	10	0.38802	0.67400	0.34704	0.14792
49	5.00	10	0.49067	0.66699	0.50409	0.14243
50	8.00	50	0.06758	0.68391	0.30118	0.12225
51	8.00	160	0.00973	0.67632	0.42190	0.11351

TABLE F5-16
W. J. SILVA: 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	0.16623	0.76178	0.26270	0.10111
2	5.00	1	0.16199	0.76743	0.28750	0.10312
3	5.00	5	0.04871	0.75352	0.14763	0.09910
4	5.00	5	0.05230	0.75079	0.18493	0.09859
5	5.80	10	0.09349	0.70451	0.19398	0.13254
6	5.80	20	0.07421	0.69675	0.27561	0.12957
7	6.50	1	0.45824	0.68345	0.29757	0.13087
8	6.50	1	0.51346	0.69196	0.43561	0.13484
9	6.50	1	0.46945	0.69950	0.38340	0.13823
10	6.50	5	0.43343	0.68402	0.34698	0.13220
11	6.50	5	0.28962	0.68709	0.26637	0.13209
12	6.50	50	0.02649	0.68242	0.29653	0.13101
13	6.50	50	0.02560	0.67811	0.21906	0.12940
14	7.00	10	0.25797	0.66835	0.24582	0.13398
15	7.50	50	0.05175	0.67039	0.29353	0.13841
16	7.50	50	0.06070	0.66581	0.28383	0.13626
17	5.00	1	0.05500	0.75084	0.15097	0.09905
18	5.80	5	0.14346	0.69992	0.35708	0.13082
19	5.80	5	0.09197	0.70038	0.27953	0.13039
20	5.00	10	0.05748	0.75352	0.16619	0.09910
21	5.00	10	0.08345	0.75079	0.27046	0.09859
22	5.00	50	0.00520	0.75907	0.20063	0.10061
23	5.00	50	0.00588	0.74542	0.22589	0.09808
24	5.00	160	0.00068	0.75235	0.38876	0.10187
25	5.80	1	0.27852	0.70098	0.33556	0.13095
26	5.80	5	0.25274	0.69861	0.30785	0.13073
27	5.80	5	0.14472	0.70168	0.26777	0.13101
28	5.80	10	0.11315	0.70298	0.24236	0.13175
29	5.80	10	0.16797	0.69741	0.29676	0.12965
30	5.80	10	0.08228	0.70470	0.25614	0.13250
31	5.80	50	0.01111	0.70061	0.25437	0.13091
32	5.80	50	0.01206	0.70015	0.29026	0.13085
33	6.50	5	0.33549	0.68010	0.26048	0.12996
34	6.50	10	0.20322	0.68567	0.21796	0.13226
35	6.50	10	0.31385	0.68328	0.31830	0.13112
36	6.50	10	0.17502	0.68043	0.24130	0.12960
37	6.50	20	0.09519	0.68319	0.21524	0.13155
38	6.50	20	0.13839	0.68091	0.28174	0.13062
39	6.50	20	0.08034	0.68315	0.21020	0.13058
40	6.50	100	0.01036	0.68374	0.48396	0.13009
41	6.50	160	0.00434	0.68410	0.55763	0.13147
42	7.00	1	0.50485	0.67321	0.29286	0.13561
43	7.00	10	0.39013	0.67192	0.33821	0.13554
44	7.00	10	0.21771	0.66734	0.25092	0.13336
45	7.00	50	0.03909	0.66648	0.31692	0.13333
46	7.00	50	0.04598	0.66707	0.28590	0.13352
47	7.50	1	0.56438	0.68636	0.38940	0.14775
48	5.00	10	0.31461	0.68191	0.33624	0.14621
49	5.00	10	0.42183	0.66682	0.45360	0.13668
50	8.00	50	0.06538	0.68571	0.25757	0.11434
51	8.00	160	0.01310	0.68235	0.48849	0.10734

TABLE F5-17
W. J. SILVA: 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	0.06918	0.80988	0.27202	0.08554
2	5.00	1	0.07209	0.79577	0.31859	0.08029
3	5.00	5	0.02158	0.80202	0.17040	0.08503
4	5.00	5	0.02479	0.79350	0.25960	0.08140
5	5.80	10	0.05260	0.74552	0.21185	0.13264
6	5.80	20	0.04638	0.74707	0.27491	0.13332
7	6.50	1	0.29052	0.72808	0.17585	0.13465
8	6.50	1	0.33587	0.72883	0.31340	0.13554
9	6.50	1	0.30622	0.73501	0.27566	0.13769
10	6.50	5	0.28293	0.72686	0.27042	0.13614
11	6.50	5	0.18792	0.72828	0.24892	0.13472
12	6.50	50	0.01939	0.73088	0.20570	0.13808
13	6.50	50	0.02140	0.72235	0.26496	0.13453
14	7.00	10	0.17407	0.71311	0.18499	0.14201
15	7.50	50	0.04474	0.71690	0.22490	0.14991
16	7.50	50	0.05605	0.70908	0.28730	0.14648
17	5.00	1	0.02431	0.80988	0.20112	0.08554
18	5.80	5	0.09107	0.74827	0.28423	0.13380
19	5.80	5	0.05126	0.75211	0.35384	0.13360
20	5.00	10	0.02504	0.79072	0.17138	0.08059
21	5.00	10	0.03811	0.78523	0.30658	0.07959
22	5.00	50	0.00280	0.78796	0.18815	0.07998
23	5.00	50	0.00335	0.79072	0.24234	0.08059
24	5.00	160	0.00056	0.78254	0.37505	0.08134
25	5.80	1	0.15843	0.74587	0.26178	0.13091
26	5.80	5	0.15162	0.74391	0.33178	0.13183
27	5.80	5	0.08515	0.73976	0.27529	0.12931
28	5.80	10	0.06737	0.74729	0.18741	0.13340
29	5.80	10	0.10850	0.74297	0.29807	0.13168
30	5.80	10	0.04740	0.74567	0.33063	0.13117
31	5.80	50	0.00723	0.74300	0.28230	0.13149
32	5.80	50	0.00813	0.74609	0.38602	0.13333
33	6.50	5	0.21599	0.72319	0.22329	0.13477
34	6.50	10	0.13806	0.72705	0.23895	0.13633
35	6.50	10	0.22819	0.72625	0.32066	0.13604
36	6.50	10	0.11640	0.72634	0.27251	0.13412
37	6.50	20	0.06291	0.72506	0.17026	0.13540
38	6.50	20	0.09765	0.73150	0.28313	0.13836
39	6.50	20	0.05813	0.72699	0.21349	0.13430
40	6.50	100	0.00937	0.73072	0.39342	0.13481
41	6.50	160	0.00491	0.72864	0.47901	0.13641
42	7.00	1	0.34965	0.71777	0.21799	0.14201
43	7.00	10	0.30226	0.71408	0.32281	0.14234
44	7.00	10	0.15601	0.71615	0.26259	0.14142
45	7.00	50	0.03128	0.71064	0.23434	0.14091
46	7.00	50	0.03995	0.71620	0.31916	0.14329
47	7.50	1	0.38815	0.73429	0.28690	0.15817
48	5.00	10	0.21752	0.72449	0.25019	0.15497
49	5.00	10	0.32892	0.71640	0.45235	0.14966
50	8.00	50	0.05702	0.73235	0.21460	0.12502
51	8.00	160	0.01737	0.73194	0.42710	0.11980

TABLE F5-18
W. J. SILVA: 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	0.02745	0.82591	0.25041	0.06267
2	5.00	1	0.02465	0.82312	0.29666	0.06185
3	5.00	5	0.00898	0.81462	0.16021	0.06363
4	5.00	5	0.00889	0.81462	0.27468	0.06363
5	5.80	10	0.02642	0.78702	0.23362	0.11356
6	5.80	20	0.02020	0.78419	0.27523	0.11706
7	6.50	1	0.16186	0.77348	0.15726	0.11945
8	6.50	1	0.15613	0.77549	0.34897	0.12393
9	6.50	1	0.14069	0.76640	0.34309	0.12043
10	6.50	5	0.13744	0.76898	0.27069	0.12542
11	6.50	5	0.08595	0.76719	0.36428	0.12038
12	6.50	50	0.01262	0.76309	0.16742	0.11979
13	6.50	50	0.01181	0.76371	0.23447	0.12297
14	7.00	10	0.10983	0.75394	0.18632	0.13128
15	7.50	50	0.03101	0.75583	0.15012	0.14122
16	7.50	50	0.03399	0.75275	0.22785	0.14260
17	5.00	1	0.01010	0.81764	0.22202	0.06104
18	5.80	5	0.03841	0.79873	0.46808	0.12509
19	5.80	5	0.02177	0.79898	0.49020	0.11971
20	5.00	10	0.01032	0.81187	0.12140	0.06313
21	5.00	10	0.01330	0.81187	0.25308	0.06313
22	5.00	50	0.00131	0.80915	0.13478	0.06289
23	5.00	50	0.00134	0.81739	0.20213	0.06441
24	5.00	160	0.00033	0.81601	0.31068	0.06439
25	5.80	1	0.07637	0.79684	0.36441	0.11427
26	5.80	5	0.06448	0.77925	0.39343	0.11396
27	5.80	5	0.03511	0.79460	0.43053	0.11697
28	5.80	10	0.03308	0.78941	0.20789	0.11503
29	5.80	10	0.04734	0.78074	0.30039	0.11464
30	5.80	10	0.02130	0.79608	0.37001	0.11914
31	5.80	50	0.00416	0.77868	0.22815	0.11017
32	5.80	50	0.00431	0.78386	0.26680	0.11589
33	6.50	5	0.11422	0.77376	0.20232	0.12394
34	6.50	10	0.07933	0.76924	0.20364	0.12205
35	6.50	10	0.11541	0.76594	0.28383	0.12388
36	6.50	10	0.05606	0.76663	0.32223	0.12021
37	6.50	20	0.03594	0.76281	0.18409	0.11960
38	6.50	20	0.05149	0.76990	0.32520	0.12595
39	6.50	20	0.02933	0.76864	0.29279	0.12089
40	6.50	100	0.00649	0.76953	0.29099	0.11784
41	6.50	160	0.00365	0.76567	0.38606	0.11894
42	7.00	1	0.20248	0.75971	0.21248	0.12981
43	7.00	10	0.15152	0.75767	0.31863	0.13550
44	7.00	10	0.08502	0.75370	0.31658	0.13014
45	7.00	50	0.02152	0.75375	0.17285	0.13123
46	7.00	50	0.02280	0.75097	0.24155	0.13273
47	7.50	1	0.25246	0.77232	0.33480	0.14385
48	5.00	10	0.14744	0.76313	0.25761	0.14509
49	5.00	10	0.19612	0.75697	0.50909	0.14427
50	8.00	50	0.03984	0.76105	0.24821	0.12827
51	8.00	160	0.01464	0.77481	0.34613	0.12482

TABLE F5-19
W. J. SILVA: 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	0.00704	0.89820	0.35586	0.06486
2	5.00	1	0.00509	0.89264	0.39207	0.06420
3	5.00	5	0.00239	0.87864	0.32160	0.07331
4	5.00	5	0.00189	0.87864	0.38563	0.07331
5	5.80	10	0.00965	0.85316	0.30034	0.12441
6	5.80	20	0.00572	0.84903	0.30794	0.13642
7	6.50	1	0.07311	0.84314	0.20464	0.13430
8	6.50	1	0.05694	0.83492	0.30551	0.14203
9	6.50	1	0.05042	0.83853	0.34035	0.14390
10	6.50	5	0.04624	0.83610	0.36984	0.14995
11	6.50	5	0.03248	0.84021	0.40580	0.14498
12	6.50	50	0.00549	0.83320	0.25192	0.13705
13	6.50	50	0.00419	0.83006	0.38802	0.14601
14	7.00	10	0.05412	0.83092	0.22875	0.15389
15	7.50	50	0.01735	0.82809	0.17710	0.16376
16	7.50	50	0.01506	0.81306	0.29836	0.16597
17	5.00	1	0.00266	0.88989	0.34623	0.06428
18	5.80	5	0.01192	0.83863	0.42428	0.12985
19	5.80	5	0.00691	0.84577	0.49268	0.12704
20	5.00	10	0.00274	0.87864	0.24988	0.07331
21	5.00	10	0.00282	0.88135	0.29047	0.07300
22	5.00	50	0.00038	0.87864	0.24859	0.07331
23	5.00	50	0.00031	0.87864	0.30003	0.07331
24	5.00	160	0.00012	0.88199	0.30993	0.07092
25	5.80	1	0.02889	0.86697	0.27701	0.12454
26	5.80	5	0.01925	0.83651	0.38926	0.12856
27	5.80	5	0.01166	0.84420	0.41410	0.12609
28	5.80	10	0.01095	0.86168	0.34965	0.13219
29	5.80	10	0.01178	0.85665	0.40160	0.14395
30	5.80	10	0.00647	0.84204	0.49653	0.12496
31	5.80	50	0.00169	0.84600	0.43147	0.12039
32	5.80	50	0.00131	0.84570	0.47628	0.13487
33	6.50	5	0.05096	0.83763	0.22390	0.13847
34	6.50	10	0.03167	0.83834	0.25521	0.13880
35	6.50	10	0.03564	0.83667	0.34676	0.15079
36	6.50	10	0.01906	0.83544	0.45647	0.14212
37	6.50	20	0.01595	0.84291	0.27997	0.14142
38	6.50	20	0.01762	0.82570	0.32829	0.14377
39	6.50	20	0.01061	0.83419	0.41498	0.14150
40	6.50	100	0.00317	0.84004	0.23808	0.13369
41	6.50	160	0.00195	0.84656	0.32968	0.14006
42	7.00	1	0.09830	0.83516	0.25573	0.14916
43	7.00	10	0.05294	0.82494	0.40598	0.16131
44	7.00	10	0.03390	0.83183	0.41487	0.15917
45	7.00	50	0.01090	0.82685	0.13988	0.15202
46	7.00	50	0.00913	0.81851	0.30127	0.15784
47	7.50	1	0.12076	0.84166	0.42006	0.16419
48	5.00	10	0.07745	0.82698	0.31553	0.16322
49	5.00	10	0.07944	0.81717	0.53232	0.16787
50	8.00	50	0.02283	0.84175	0.27730	0.16013
51	8.00	160	0.00975	0.85231	0.41325	0.15042

TABLE F5-20
W. J. SILVA: 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	0.00199	0.95511	0.66765	0.08674
2	5.00	1	0.00143	0.94635	0.67180	0.08255
3	5.00	5	0.00067	0.93945	0.58778	0.09531
4	5.00	5	0.00053	0.93945	0.60584	0.09531
5	5.80	10	0.00407	0.88558	0.35777	0.14182
6	5.80	20	0.00210	0.88018	0.39800	0.15406
7	6.50	1	0.03373	0.89929	0.33183	0.17323
8	6.50	1	0.02626	0.86544	0.34640	0.16105
9	6.50	1	0.02377	0.87420	0.39537	0.16679
10	6.50	5	0.02219	0.87207	0.36849	0.17510
11	6.50	5	0.01666	0.88311	0.45333	0.17325
12	6.50	50	0.00256	0.88185	0.35650	0.16792
13	6.50	50	0.00172	0.86827	0.59301	0.17248
14	7.00	10	0.02800	0.87769	0.28168	0.18775
15	7.50	50	0.00966	0.86660	0.22911	0.19211
16	7.50	50	0.00771	0.85716	0.33488	0.19780
17	5.00	1	0.00074	0.94925	0.60402	0.08375
18	5.80	5	0.00463	0.88761	0.43498	0.15971
19	5.80	5	0.00260	0.89223	0.53284	0.15190
20	5.00	10	0.00078	0.93368	0.55425	0.09330
21	5.00	10	0.00080	0.93655	0.51483	0.09421
22	5.00	50	0.00011	0.93083	0.44106	0.09257
23	5.00	50	0.00009	0.93083	0.47153	0.09257
24	5.00	160	0.00004	0.93742	0.33057	0.08557
25	5.80	1	0.01201	0.89554	0.41220	0.13709
26	5.80	5	0.00795	0.88644	0.43409	0.15919
27	5.80	5	0.00513	0.88573	0.45429	0.14717
28	5.80	10	0.00469	0.88850	0.46577	0.14365
29	5.80	10	0.00425	0.87567	0.51365	0.15087
30	5.80	10	0.00244	0.88887	0.69480	0.14923
31	5.80	50	0.00063	0.88884	0.48476	0.14382
32	5.80	50	0.00046	0.88211	0.58969	0.15556
33	6.50	5	0.02551	0.89231	0.32568	0.17700
34	6.50	10	0.01455	0.88713	0.40360	0.17234
35	6.50	10	0.01462	0.87106	0.42702	0.17469
36	6.50	10	0.00833	0.88112	0.62728	0.17193
37	6.50	20	0.00680	0.87793	0.46583	0.16516
38	6.50	20	0.00696	0.87889	0.43904	0.18046
39	6.50	20	0.00467	0.86937	0.56852	0.16349
40	6.50	100	0.00128	0.87707	0.32936	0.15434
41	6.50	160	0.00092	0.89456	0.36242	0.17023
42	7.00	1	0.05271	0.87805	0.36182	0.17832
43	7.00	10	0.02417	0.86263	0.44904	0.19021
44	7.00	10	0.01681	0.86923	0.50555	0.18556
45	7.00	50	0.00558	0.87100	0.21565	0.18312
46	7.00	50	0.00441	0.86485	0.34612	0.19166
47	7.50	1	0.06418	0.88443	0.47484	0.19437
48	5.00	10	0.04243	0.87580	0.40109	0.19831
49	5.00	10	0.03853	0.85936	0.62662	0.19922
50	8.00	50	0.01373	0.89737	0.31251	0.19152
51	8.00	160	0.00575	0.90771	0.32797	0.17932

TABLE F5-21
W. J. SILVA: VERTICAL POINT ESTIMATES
PEAK GROUND VELOCITY

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	4.02063	0.79848	0.30458	0.07021
2	5.00	1	3.63480	0.79848	0.36422	0.07021
3	5.00	5	1.14604	0.78677	0.20089	0.07814
4	5.00	5	1.15680	0.78103	0.31448	0.07480
5	5.80	10	2.95145	0.75756	0.21252	0.12718
6	5.80	20	2.16782	0.75590	0.27688	0.12924
7	6.50	1	18.33007	0.77789	0.23189	0.13585
8	6.50	1	18.03647	0.77484	0.38526	0.13822
9	6.50	1	16.30184	0.77484	0.36980	0.13822
10	6.50	5	15.44497	0.75535	0.31362	0.14426
11	6.50	5	10.16407	0.76980	0.35621	0.13641
12	6.50	50	1.12685	0.75285	0.24686	0.14109
13	6.50	50	1.03599	0.75181	0.39181	0.14298
14	7.00	10	11.70002	0.75556	0.19073	0.15328
15	7.50	50	3.04512	0.75493	0.24510	0.16241
16	7.50	50	3.25418	0.74824	0.36079	0.16211
17	5.00	1	1.30940	0.79282	0.24350	0.06750
18	5.80	5	4.66900	0.75701	0.41940	0.12945
19	5.80	5	2.60342	0.77035	0.42310	0.12426
20	5.00	10	1.33212	0.77820	0.13735	0.07344
21	5.00	10	1.82780	0.78103	0.27279	0.07480
22	5.00	50	0.13110	0.77540	0.20902	0.07228
23	5.00	50	0.13645	0.77820	0.27836	0.07344
24	5.00	160	0.02898	0.76989	0.36336	0.07066
25	5.80	1	9.22932	0.77445	0.34759	0.12257
26	5.80	5	7.76950	0.75277	0.38225	0.12809
27	5.80	5	4.45780	0.76946	0.32784	0.12410
28	5.80	10	3.68903	0.76217	0.21218	0.12857
29	5.80	10	5.28468	0.75596	0.28505	0.12925
30	5.80	10	2.39286	0.76892	0.39736	0.12401
31	5.80	50	0.39300	0.75842	0.34091	0.12738
32	5.80	50	0.38397	0.75876	0.44868	0.13013
33	6.50	5	12.63204	0.76018	0.19084	0.14352
34	6.50	10	7.91494	0.75849	0.17495	0.14290
35	6.50	10	11.68760	0.75581	0.30629	0.14443
36	6.50	10	5.89662	0.76901	0.36829	0.13626
37	6.50	20	3.53467	0.75676	0.22792	0.14229
38	6.50	20	5.02494	0.75658	0.31304	0.14474
39	6.50	20	2.89825	0.76631	0.37765	0.13552
40	6.50	100	0.56912	0.77157	0.39061	0.13445
41	6.50	160	0.27961	0.76178	0.70186	0.14502
42	7.00	1	23.17708	0.77489	0.28343	0.14461
43	7.00	10	16.27792	0.75330	0.37647	0.15483
44	7.00	10	9.02237	0.76745	0.39894	0.14486
45	7.00	50	1.98927	0.75016	0.21559	0.15158
46	7.00	50	2.07269	0.74806	0.33142	0.15292
47	7.50	1	27.14126	0.78404	0.47213	0.15608
48	5.00	10	15.80830	0.75823	0.35217	0.16392
49	5.00	10	21.18422	0.75114	0.62516	0.16312
50	8.00	50	4.29233	0.74560	0.38614	0.15378
51	8.00	160	1.47492	0.76979	0.46899	0.14528

APPENDIX F6

YUCCA MOUNTAIN PROBABILISTIC SEISMIC HAZARD ANALYSIS DOCUMENTATION OF EXPERT MODEL GROUND MOTIONS

Paul G. Somerville
Woodward-Clyde Federal Services

APPENDIX F6
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APPENDIX F6

YUCCA MOUNTAIN PROBABILISTIC SEISMIC HAZARD ANALYSIS DOCUMENTATION OF EXPERT MODEL GROUND MOTIONS

Paul G. Somerville
Woodward-Clyde Federal Services

F6-1 INTRODUCTION

This report documents the decisions that I made in developing a ground motion model for use at Yucca Mountain. The model pertains to a hypothetical rock surface that is produced by excavating the top 300 meters of overburden at the site.

F6-2 WEIGHTING SCHEME

The overall weight, W, for each model is developed by scaling four weights:

$$W = B \times M \times D \times F$$

where

B = base level weight
M = magnitude applicability weight
D = distance applicability weight
F = frequency applicability weight

The base level weights represent my general evaluation of the applicability of the models within each class to the prediction of ground motion at Yucca Mountain. The magnitude, distance, and frequency weights reflect how well the models are expected to predict ground motions at specific magnitudes, distances and frequencies, respectively

F6-2.1 Model Classes

I divided the proponent models into four classes: 1) finite fault numerical simulations, 2) explosion, 3) empirical, and 4) point source stochastic. The model classes and their base level weights are shown in Table F6-1.

The finite fault numerical simulations are generally well validated against recorded data and thus are expected to have the capacity to predict ground motions for Yucca Mountain specific conditions.

The explosion models contain region-specific distance attenuation information, however the distance attenuation has not been adjusted for differences in the source depth of explosions and earthquakes. Since the explosions are at shallower depths than are representative of earthquake source depths, they will contain more surface waves which may significantly affect the distance attenuation.

The empirical models are based on strong motion data that span the relevant ranges of magnitude, distance, and period that are considered in this study. The adjustment factors for the empirical model account for Yucca Mountain specific conditions. The empirical model class is given the largest weight.

The point source stochastic model has been extensively validated against data; however it does not include finite fault effects such as rupture directivity at low frequencies.

F6-2.2 Model Weights - Horizontal Component

Model classes 1, 2, and 3 contain multiple proponent models. The relative weights that I assigned to these models are listed in Table F6-1. The same weights are used for both the median (μ) and the aleatory uncertainty (σ) for all of the models.

F6-2.2.1 Finite Fault Models. All three finite source models have been validated against recorded data. The Silva and Somerville models have been validated against a larger number of earthquakes than the Zeng and Anderson model. The Zeng and Anderson model uses an unconventional source model. The Somerville and Zeng and Anderson models include rupture directivity effects at low frequencies, but these effects are not fully included in the Silva model. Since all three models have been validated against data, I specified equal weight for the three finite source models.

F6-2.2.2 Explosion Models. There are three proponent models based on explosion data. The first model (Blast 1) is based on an explosion source that is not relevant for earthquakes. The third model (Blast 3) is based on the Little Skull Mountain source that is not generally applicable to other earthquakes. Therefore, these two models were given zero weight.

The second model (Blast 2), uses an empirical response spectra shape that is attenuated based on the observed NTS attenuation. This model has a reasonable spectral shape and includes information on the regional attenuation. Of the three proponent explosion models, I consider this to be the only applicable model. Therefore, I assigned it a model weight of 1.0.

F6-2.2.3 Empirical Models. I included the empirical models listed below. I gave higher weight to those models that incorporate magnitude dependent attenuation rates and different attenuation rates for soil and rock sites. Models that were not based on recent data or current regression methods were down weighted. The specific models are discussed below.

Abrahamson and Silva (1997): This model includes recent data and incorporates distance dependent magnitude scaling and different attenuation rates for soil and rock. It includes near fault effects such footwall/hanging wall effects. It includes style-of-faulting factors for normal faulting earthquakes so it does not need scaling for stress drop. Due to the inclusion of near fault effects, I increased the weight on this model to 0.3.

Joyner and Boore (1988): This model is not based on recent data. It uses the same attenuation shape for rock and soil and for different magnitudes which I consider to be unrealistic. Its distance metric (Joyner-Boore distance) makes it unsuitable for use in the near source region of dipping faults. Due to these disadvantages, I down weighted this model to 0.1. This model does include peak velocity which only a few models include.

Campbell (1997), soft rock: This model includes recent data and incorporates distance dependent magnitude scaling and different attenuation rates for soil and rock. I assigned a weight of 0.2 to this model.

Idriss (1997, written communication): This model includes recent data and incorporates distance dependent magnitude scaling and different attenuation rates for soil and rock. It is not based on current regression methods. Due to the regression methods used in this model, I reduced the weight to 0.1.

Sadigh et al (1997): This model includes recent data and incorporates distance dependent magnitude scaling and different attenuation rates for soil and rock. I assigned a weight of 0.2 to this model.

Spudich et al (1997): This model is specific for events in extensional regimes so it does not require scaling for stress drop difference. The use of the same attenuation shape for rock and soil sites and for different magnitudes is unrealistic. Its distance metric (Joyner-Boore distance) makes it unsuitable for use in the near source region of dipping faults. I reduced the weight for this model to 0.1.

The following empirical models were excluded (given zero weight) for the reasons given.

McGarr (1984) : The theoretically based dependence of ground motions on faulting mechanism is not borne out in recorded data.

Sabetta and Pugliese (1996): This model is based on Italian data. The Italian data that are relevant to Yucca Mountain is included in the Spudich et al (1996) model.

Campbell (1990, 1993, 1994): These Campbell models have been superseded by Campbell (1997).

Boore et al (1997): The assumption of a constant, distance-independent relation between soil and rock causes this model to underpredict rock motions at close distances.

F6-2.2.4 Point Source Stochastic Model. The point source proponent model was provided with the median and uncertainties in the point source stress drop to be specified by each expert. I specified the following values to be used:

Median stress drop = 60 bars
Standard deviation of stress drop = 0.7 (natural log units)
Standard error of the median stress drop = 0.3
Standard error of the standard deviation of stress drop = 0.3

F6-2.2.5 Magnitude Weights. The magnitude weights reflect how well the models are expected to predict ground motions as a function of magnitude; Table F6-2 summarizes these factors. The weights for the explosion model reflect the decreasing constraint on the explosion attenuation model with increasing magnitude. The weights on the point source stochastic model reflect the decreasing physical realism of the point source model with increasing magnitude.

F6-2.2.6 Distance Weights. The distance weights (Table F6-3) reflect how well the models are expected to predict ground motions as a function of distance. For the Silva models (finite source and point source), the weights are different for two frequency ranges: less than 1 Hz and greater than 1 Hz. The weights for the Silva finite fault reflect the decreasing physical realism of the homogeneous radiation pattern with decreasing distance for frequencies of 1 Hz and less. The weights for the point source stochastic model reflect the decreasing physical realism of the homogeneous radiation pattern with decreasing distance for frequencies of 1 Hz and less and of the point source model with decreasing distance. The need to calibrate the point source stochastic model against empirical models makes it more like an empirically based algorithm. The weights for the explosion model reflect the decreasing appropriateness of the attenuation function with decreasing distance.

F6-2.2.7 Frequency Weights. These weights (Table F6-4) reflect how well the models are expected to predict ground motions as a function of frequency. The weights for the point source stochastic model represent the decreasing physical realism of the point source model with decreasing frequency; it contains no physical representation of source finiteness and rupture directivity effects. The weights for the Silva finite fault stochastic model represents the decreasing physical realism of the homogeneous radiation pattern with decreasing frequency.

F6-2.2.8 Horizontal Component Variability. The proponent models for the horizontal component all predict the average of the two horizontal components. This project is using the random horizontal component, so the component-to-component variability needs to be added to the aleatory uncertainty. The two available proponent models are Boore et al (1997) and Spudich et al (1997). These two models are very similar. I selected the horizontal component to component variability from the Boore et al (1997) model.

F6-2.3 Model Weights - Vertical Component

The weighting scheme described for the horizontal component is also used for the vertical component.

F6-3 ADJUSTMENTS TO WEIGHTED POINT ESTIMATES

The weighting scheme described above assumed that predictions were available for each model in a given model class. However, for the class of numerical simulation models, predictions were available for only some of the models for the largest and smallest magnitudes (magnitude 5 and 8). In some instances, the predictions of the one or two available numerical models were quite different from those of the other classes of models and from available recorded data. In these cases, the point estimates were modified to give a lower weight to the class of numerical models.

In particular, for the magnitude 5 case, the Zeng and Anderson model was the only finite fault model that was run. I did not want to give a weight of 0.4 to that single simulation so I modified the point estimates for those cases by hand.

F6-4 EPISTEMIC UNCERTAINTY

Estimates of epistemic uncertainties in the median ground motion values and their aleatory variability were based principally on the variations among the estimates of different models. Most of the proponent models did not provide epistemic uncertainties. The exceptions were the Somerville numerical simulation and the point source stochastic model. The epistemic

uncertainties from these proponent models were included in the total epistemic uncertainty. The epistemic uncertainties were computed by the facilitation team.

I made the following modifications to these statistical estimates of the epistemic uncertainty: For the epistemic uncertainty in sigma (σ_σ), I set a minimum value of 0.05 natural log units and a maximum value of 0.2 natural log units.

F6-5 FINAL POINT ESTIMATES

The final point estimates were checked for consistency and found to be mutually consistent. My final point estimates of μ, σ, σ_μ, and σ_σ for the horizontal component for the 51 cases are given in Tables F6-5 to F6-13 for the nine ground motion parameters. The corresponding point estimates for the vertical component are given in Tables F6-14 to F6-22.

F6-6 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 10F of the Data Package.

F6-6.1 Mu

The point estimates of the median ground motion are well fit by the regression fits. The point estimates for each magnitude cluster around the regression fits, and point estimates for different magnitudes are generally well separated. Based on review of residual plots (Vol. 10F of the Ground Motion Data Package), the regression fit is judged to be an appropriate representation of my point estimates.

F6-6.2 Sigma

The sigma values are well modeled by a functional form in which sigma decreases with increasing magnitude until it reaches a minimum value at magnitude 7. The sigma values vary from about 0.6 for peak acceleration to about 0.8 for 0.3 Hz spectral acceleration. This degree of variation is not very much larger than that of empirical attenuation relations derived

for a specified region, and for this reason is considered to be a realistic representation of the aleatory variation of ground motion at Yucca Mountain.

F6-6.3 Sigma Mu

There are wide variations in the values of sigma mu. They have a systematic variation with distance, tending to have a minimum at a distance of about 20 km. This variation is modeled using a quadratic equation in distance. The values of sigma mu also have a magnitude dependence which is highly variable. This was fit by a linear magnitude dependence, which was allowed to vary from frequency to frequency. This variation is quite large with the magnitude dependence having a minimum at 5 Hz and larger values at both lower and higher frequencies. Based on review of the residual plots (Vol. 10F of the Ground Motion Data Package), these models were judged to be an appropriate representation of my sigma Mu estimates.

F6-6.4 Sigma Sigma

The values of sigma sigma have small variations with magnitude. They also have small variations with distance, except for the lower frequencies and for the vertical component. The regression model is judged to be an appropriate representation of my sigma sigma estimates.

F6-7 SPECIAL CASES

Adjustments for two special fault rupture cases were developed using ground motion simulations. These two scenarios are described below. The simulations used the high frequency part of Woodward-Clyde's simulation procedure (i.e. same method as Somerville simulations) to predict the ground motion for the special cases and for the base cases. The ratios of the predicted ground motions were used to guide the recommendation of adjustment factors to use for the special cases. These simulations are unbiased for frequencies above 1 Hz. At frequencies less than 1 Hz, the simulations tend to underpredict recorded data. However, as described below, the adjustments are based on the ratio of the two simulations and not on their absolute values, so I have also based my estimates on the computed ratios at frequencies less than 1 Hz.

F6-7.1 Multiple Parallel Faults

The response spectral ratios were computed for the case of three parallel faults dipping 60 degrees (separated by 2 and 3 km) rupturing simultaneously compared to a single fault rupture. The total moment for both cases corresponds to a moment magnitude 6.82 (each of the three parallel faults had moment corresponding to magnitude 6.5). The resulting ratios are given in the Ground Motion Data Package (Vol. 1b). Based on these computed ratios, my estimates of the adjustment factors for simultaneous rupture on parallel faults are given in Table F6-23. These adjustments include additional aleatory and epistemic uncertainty.

F6-7.2 Low Angle Fault

The second case is one of a low angle fault with a dip of about 30 degrees beneath the site, together with a set of three more steeply dipping conjugate faults. The total moment for both cases corresponds to magnitude 6.8. The resulting ratios are given in the Ground Motion Data Package (Vol. 1b). Based on these computed ratios, my estimates of the adjustment factors for simultaneous rupture are given in Table F6-24. These adjustments include additional aleatory and epistemic uncertainty.

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TABLE F6-1
WEIGHTS FOR MODEL CLASSES
(BASE LEVEL WEIGHT B)

MODEL	CLASS	WEIGHT
Finite Fault Numerical	1	0.4
Explosion (NTS)	2	0.05
Empirical	3	0.5
Point Source Stochastic	4	0.05

TABLE F6-2
MAGNITUDE FACTORS M

MODEL	M 5.0	M 5.8	M 6.5	M 7.0	M 7.5
Zeng and Anderson	1	1	1	1	1
Silva Finite Fault	1	1	1	1	1
Somerville	1	1	1	1	1
Explosion	1	1	0.9	0.8	0.7
Empirical	1	1	1	1	1
Point Source Stochastic	1	0.9	0.8	0.7	0.6

TABLE F6-3
DISTANCE FACTORS D (APPLIED TO RUPTURE DISTANCE)

MODEL	1 KM	5 KM	10 KM	20 KM	50 KM
Zeng and Anderson	1	1	1	1	1
Silva Finite Fault	0.5 (f<1 Hz) 1.0 (f >1 Hz)	0.7 (f<1 Hz) 1.0 (f >1 Hz)	0.8 (f<1 Hz) 1.0 (f >1 Hz)	0.9 (f<1 Hz) 1.0 (f >1 Hz)	1.0 (f<1 Hz) 1.0 (f >1 Hz)
Somerville	1	1	1	1	1
Blast 2	0	0	0.75	1	1
Empirical	1	1	1	1	1
Point Source Stochastic	0.2 (f<1 Hz) 0.5 (f >1 Hz)	0.4 (f<1 Hz) 0.7 (f >1 Hz)	0.6 (f<1 Hz) 0.8 (f >1 Hz)	0.8 (f<1 Hz) 0.9 (f >1 Hz)	1.0 (f<1 Hz) 1.0 (f >1 Hz)

TABLE F6-4
FREQUENCY FACTORS F

MODEL	0.3 HZ	0.5 HZ	1.0 HZ, PGV	2-20 HZ	PGA
Zeng and Anderson	1	1	1	1	1
Silva Finite Fault	0.4	0.6	0.8	1	1
Somerville	1	1	1	1	1
Explosion	1	1	1	1	1
Empirical	1	1	1	1	1
Point Source Stochastic	0.25	0.5	0.75	1	1

TABLE F6-5
P. G. SOMERVILLE: HORIZONTAL POINT ESTIMATES
PEAK GROUND ACCELERATION

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.12685	0.66211	0.34401	0.17028
2	5.00	1	0.20004	0.67019	0.46825	0.16916
3	5.00	5	0.04871	0.66711	0.32421	0.16981
4	5.00	5	0.07955	0.67110	0.39932	0.16929
5	5.80	10	0.09769	0.60725	0.22804	0.16059
6	5.80	20	0.07441	0.60700	0.27123	0.16107
7	6.50	1	0.42450	0.57421	0.30895	0.16175
8	6.50	1	0.45352	0.57590	0.44710	0.16307
9	6.50	1	0.40468	0.57327	0.35879	0.15956
10	6.50	5	0.35922	0.57225	0.31859	0.16200
11	6.50	5	0.24893	0.57305	0.23152	0.15953
12	6.50	50	0.02844	0.57185	0.29228	0.16329
13	6.50	50	0.02874	0.57143	0.25031	0.16324
14	7.00	10	0.25219	0.54359	0.27775	0.16772
15	7.50	50	0.05831	0.54086	0.24524	0.17343
16	7.50	50	0.06337	0.53782	0.23715	0.17194
17	5.00	1	0.04215	0.66211	0.61112	0.17028
18	5.80	5	0.15546	0.60692	0.30883	0.16036
19	5.80	5	0.09311	0.60105	0.31775	0.15643
20	5.00	10	0.06646	0.66987	0.21914	0.16989
21	5.00	10	0.08515	0.66605	0.27478	0.17056
22	5.00	50	0.00619	0.66772	0.33520	0.17069
23	5.00	50	0.00623	0.66399	0.38635	0.17150
24	5.00	160	0.00076	0.66028	0.53082	0.17243
25	5.80	1	0.26746	0.60578	0.30810	0.15966
26	5.80	5	0.22324	0.60528	0.27648	0.16047
27	5.80	5	0.13839	0.60036	0.23796	0.15646
28	5.80	10	0.12035	0.61178	0.23646	0.16143
29	5.80	10	0.16267	0.60694	0.28490	0.16062
30	5.80	10	0.07877	0.60147	0.29348	0.15679
31	5.80	50	0.01163	0.60503	0.48840	0.16126
32	5.80	50	0.01200	0.60901	0.50764	0.16137
33	6.50	5	0.30989	0.57347	0.27315	0.16224
34	6.50	10	0.20335	0.57463	0.26236	0.16318
35	6.50	10	0.28016	0.57401	0.32126	0.16304
36	6.50	10	0.15880	0.56687	0.23014	0.15748
37	6.50	20	0.10034	0.57119	0.23849	0.16276
38	6.50	20	0.13590	0.57548	0.30907	0.16380
39	6.50	20	0.07770	0.56387	0.20893	0.15668
40	6.50	100	0.01201	0.57202	0.41962	0.16360
41	6.50	160	0.00473	0.58008	0.48846	0.16752
42	7.00	1	0.46160	0.54927	0.29043	0.16799
43	7.00	10	0.33444	0.55053	0.31262	0.17045
44	7.00	10	0.19492	0.53863	0.20610	0.16217
45	7.00	50	0.04389	0.54249	0.27267	0.16829
46	7.00	50	0.04717	0.54425	0.25900	0.16883
47	7.50	1	0.50761	0.55646	0.34719	0.18185
48	5.00	10	0.28777	0.54833	0.28260	0.17857
49	5.00	10	0.36600	0.54105	0.38566	0.17251
50	8.00	50	0.07351	0.55289	0.25562	0.18382
51	8.00	160	0.01859	0.54634	0.42745	0.18045

TABLE F6-6
P. G. SOMERVILLE: 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	0.23556	0.67213	0.50631	0.16613
2	5.00	1	0.35471	0.67621	0.26888	0.16530
3	5.00	5	0.08473	0.67707	0.38640	0.16543
4	5.00	5	0.12255	0.68112	0.26846	0.16472
5	5.80	10	0.16379	0.61207	0.27084	0.15854
6	5.80	20	0.11618	0.60838	0.27001	0.15864
7	6.50	1	0.74006	0.57360	0.29435	0.15886
8	6.50	1	0.77949	0.57461	0.35631	0.16011
9	6.50	1	0.69017	0.56929	0.31567	0.15548
10	6.50	5	0.62012	0.57031	0.32786	0.15909
11	6.50	5	0.42881	0.56699	0.31483	0.15471
12	6.50	50	0.03927	0.56955	0.35488	0.16028
13	6.50	50	0.03968	0.56902	0.33133	0.16022
14	7.00	10	0.40569	0.53667	0.26482	0.16408
15	7.50	50	0.07920	0.53438	0.29135	0.17008
16	7.50	50	0.08491	0.53108	0.27838	0.16836
17	5.00	1	0.07255	0.67213	0.66627	0.16613
18	5.80	5	0.25176	0.60754	0.31705	0.15754
19	5.80	5	0.15041	0.60238	0.35176	0.15407
20	5.00	10	0.12032	0.69470	0.24836	0.16328
21	5.00	10	0.15528	0.67917	0.25124	0.16544
22	5.00	50	0.00908	0.67292	0.40172	0.16738
23	5.00	50	0.00891	0.67292	0.44778	0.16738
24	5.00	160	0.00101	0.66165	0.58586	0.17105
25	5.80	1	0.49351	0.60686	0.32597	0.15681
26	5.80	5	0.40211	0.61159	0.27547	0.15891
27	5.80	5	0.24027	0.60546	0.36690	0.15478
28	5.80	10	0.20613	0.61425	0.28229	0.15942
29	5.80	10	0.26987	0.60860	0.27723	0.15810
30	5.80	10	0.13220	0.60100	0.41634	0.15381
31	5.80	50	0.01637	0.60930	0.57855	0.15902
32	5.80	50	0.01654	0.61128	0.59802	0.15913
33	6.50	5	0.53572	0.56783	0.28093	0.15797
34	6.50	10	0.34849	0.57482	0.26659	0.16122
35	6.50	10	0.46808	0.57049	0.34531	0.15949
36	6.50	10	0.26252	0.56752	0.30668	0.15539
37	6.50	20	0.15998	0.57228	0.26549	0.16135
38	6.50	20	0.21731	0.57398	0.33571	0.16119
39	6.50	20	0.12109	0.56271	0.30574	0.15380
40	6.50	100	0.01428	0.56807	0.49650	0.16014
41	6.50	160	0.00585	0.56868	0.58154	0.16019
42	7.00	1	0.80673	0.54469	0.31693	0.16514
43	7.00	10	0.54141	0.54639	0.35894	0.16810
44	7.00	10	0.31455	0.53358	0.28527	0.15887
45	7.00	50	0.06028	0.53540	0.31849	0.16472
46	7.00	50	0.06482	0.53766	0.29889	0.16542
47	7.50	1	0.85600	0.55313	0.39192	0.18094
48	5.00	10	0.46037	0.54323	0.30558	0.17678
49	5.00	10	0.55923	0.53466	0.41191	0.16909
50	8.00	50	0.09699	0.54969	0.32081	0.18063
51	8.00	160	0.02039	0.53952	0.47171	0.17578

TABLE F6-7
P. G. SOMERVILLE: 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	0.26627	0.72587	0.30872	0.16689
2	5.00	1	0.41922	0.71752	0.56245	0.16623
3	5.00	5	0.10108	0.72620	0.23935	0.16687
4	5.00	5	0.16962	0.72206	0.46122	0.16648
5	5.80	10	0.19342	0.63565	0.24279	0.16280
6	5.80	20	0.14547	0.63668	0.31630	0.16308
7	6.50	1	0.83758	0.60363	0.34411	0.16750
8	6.50	1	0.92271	0.60277	0.52665	0.16759
9	6.50	1	0.81708	0.60185	0.41828	0.16558
10	6.50	5	0.70440	0.59789	0.35826	0.16542
11	6.50	5	0.49557	0.59853	0.23690	0.16381
12	6.50	50	0.05084	0.59820	0.34842	0.16708
13	6.50	50	0.05128	0.59748	0.26587	0.16661
14	7.00	10	0.48458	0.56810	0.31459	0.17257
15	7.50	50	0.09807	0.56838	0.35769	0.18113
16	7.50	50	0.10788	0.56212	0.32674	0.17742
17	5.00	1	0.09171	0.70918	0.44310	0.16611
18	5.80	5	0.31077	0.63703	0.35302	0.16296
19	5.80	5	0.18390	0.63153	0.37054	0.15918
20	5.00	10	0.14000	0.72669	0.29136	0.16665
21	5.00	10	0.18111	0.71089	0.34593	0.16603
22	5.00	50	0.01180	0.71936	0.30093	0.16602
23	5.00	50	0.01172	0.71165	0.34041	0.16601
24	5.00	160	0.00113	0.70011	0.57071	0.16700
25	5.80	1	0.52907	0.63783	0.34188	0.16286
26	5.80	5	0.46096	0.63638	0.28735	0.16289
27	5.80	5	0.27090	0.63412	0.26397	0.16106
28	5.80	10	0.23132	0.63761	0.25615	0.16405
29	5.80	10	0.31414	0.63614	0.32321	0.16284
30	5.80	10	0.15332	0.62729	0.28296	0.15831
31	5.80	50	0.02140	0.63652	0.46335	0.16339
32	5.80	50	0.02147	0.63753	0.51396	0.16396
33	6.50	5	0.61894	0.60216	0.31541	0.16686
34	6.50	10	0.40442	0.59967	0.29965	0.16719
35	6.50	10	0.56217	0.59827	0.39534	0.16676
36	6.50	10	0.31055	0.59561	0.21021	0.16285
37	6.50	20	0.19614	0.59505	0.28443	0.16562
38	6.50	20	0.25581	0.59849	0.32972	0.16680
39	6.50	20	0.14720	0.59356	0.20680	0.16180
40	6.50	100	0.01784	0.59481	0.56710	0.16584
41	6.50	160	0.00640	0.59523	0.68033	0.16595
42	7.00	1	0.92215	0.57375	0.35370	0.17315
43	7.00	10	0.64438	0.57500	0.37483	0.17636
44	7.00	10	0.37921	0.56626	0.20668	0.16845
45	7.00	50	0.07569	0.56589	0.36236	0.17238
46	7.00	50	0.08315	0.56929	0.32682	0.17398
47	7.50	1	0.96213	0.58391	0.38809	0.19009
48	5.00	10	0.54278	0.57316	0.33028	0.18513
49	5.00	10	0.68498	0.56732	0.40738	0.17953
50	8.00	50	0.11749	0.59142	0.37641	0.19357
51	8.00	160	0.01992	0.57948	0.75236	0.18723

TABLE F6-8
P. G. SOMERVILLE: 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	0.20496	0.74800	0.31892	0.16234
2	5.00	1	0.32023	0.75617	0.55911	0.16285
3	5.00	5	0.07769	0.74023	0.23264	0.16235
4	5.00	5	0.12930	0.73621	0.39891	0.16258
5	5.80	10	0.18434	0.66914	0.24758	0.16336
6	5.80	20	0.14387	0.66279	0.32779	0.16157
7	6.50	1	0.79685	0.62831	0.33769	0.16327
8	6.50	1	0.86816	0.63618	0.49054	0.16704
9	6.50	1	0.78611	0.64023	0.41777	0.16880
10	6.50	5	0.68378	0.63114	0.35506	0.16510
11	6.50	5	0.49115	0.62859	0.23777	0.16257
12	6.50	50	0.05720	0.62913	0.35788	0.16484
13	6.50	50	0.05860	0.62532	0.24486	0.16344
14	7.00	10	0.49293	0.60051	0.31422	0.16971
15	7.50	50	0.12167	0.59775	0.37504	0.17575
16	7.50	50	0.13486	0.59373	0.34083	0.17351
17	5.00	1	0.06626	0.73174	0.52280	0.16294
18	5.80	5	0.27529	0.66444	0.37614	0.16241
19	5.80	5	0.17928	0.65960	0.31658	0.15977
20	5.00	10	0.11052	0.74162	0.27433	0.16224
21	5.00	10	0.14044	0.73777	0.32602	0.16249
22	5.00	50	0.01228	0.74986	0.24322	0.16206
23	5.00	50	0.01083	0.73108	0.32822	0.16335
24	5.00	160	0.00162	0.73857	0.52835	0.16245
25	5.80	1	0.47160	0.66292	0.33285	0.16185
26	5.80	5	0.40567	0.66314	0.29076	0.16241
27	5.80	5	0.25115	0.66083	0.21331	0.16028
28	5.80	10	0.21509	0.66782	0.28684	0.16280
29	5.80	10	0.29150	0.66285	0.33711	0.16146
30	5.80	10	0.15017	0.66366	0.20506	0.16151
31	5.80	50	0.02232	0.66670	0.49040	0.16261
32	5.80	50	0.02484	0.66627	0.40043	0.16260
33	6.50	5	0.59066	0.62763	0.30157	0.16310
34	6.50	10	0.38428	0.63144	0.28040	0.16537
35	6.50	10	0.52735	0.62934	0.35164	0.16437
36	6.50	10	0.31420	0.62215	0.22346	0.15992
37	6.50	20	0.19461	0.62917	0.26755	0.16497
38	6.50	20	0.27263	0.62716	0.34790	0.16416
39	6.50	20	0.15878	0.62480	0.19867	0.16097
40	6.50	100	0.02251	0.62733	0.53137	0.16439
41	6.50	160	0.00902	0.62994	0.65107	0.16573
42	7.00	1	0.88557	0.60483	0.32568	0.17012
43	7.00	10	0.65355	0.60370	0.36173	0.17132
44	7.00	10	0.40028	0.59587	0.22543	0.16537
45	7.00	50	0.09106	0.59920	0.37087	0.16977
46	7.00	50	0.09930	0.59974	0.32289	0.16998
47	7.50	1	1.01131	0.61181	0.41856	0.18346
48	5.00	10	0.59450	0.60735	0.37395	0.18268
49	5.00	10	0.71661	0.59447	0.39673	0.17323
50	8.00	50	0.14508	0.61914	0.36173	0.18322
51	8.00	160	0.02856	0.61121	0.74180	0.17934

TABLE F6-9
P. G. SOMERVILLE: 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	0.09150	0.81820	0.35807	0.11651
2	5.00	1	0.15592	0.79811	0.54214	0.11576
3	5.00	5	0.03637	0.81384	0.29882	0.11592
4	5.00	5	0.06318	0.80192	0.39047	0.11545
5	5.80	10	0.11233	0.72973	0.26054	0.16404
6	5.80	20	0.09283	0.73164	0.29147	0.16373
7	6.50	1	0.57048	0.69005	0.23564	0.16926
8	6.50	1	0.60408	0.69062	0.35060	0.17001
9	6.50	1	0.54719	0.69347	0.29477	0.17306
10	6.50	5	0.47555	0.69307	0.26573	0.16977
11	6.50	5	0.33672	0.68723	0.22342	0.17011
12	6.50	50	0.04810	0.69664	0.31576	0.17025
13	6.50	50	0.05156	0.68937	0.30935	0.16727
14	7.00	10	0.39010	0.66504	0.30204	0.17609
15	7.50	50	0.11930	0.66328	0.32425	0.18392
16	7.50	50	0.13247	0.65656	0.32840	0.18035
17	5.00	1	0.03323	0.81820	0.55906	0.11651
18	5.80	5	0.17997	0.73100	0.27433	0.16606
19	5.80	5	0.10319	0.72866	0.34550	0.17100
20	5.00	10	0.04654	0.80005	0.22366	0.11571
21	5.00	10	0.06256	0.79249	0.26854	0.11676
22	5.00	50	0.00646	0.79687	0.24879	0.11608
23	5.00	50	0.00758	0.80057	0.24584	0.11563
24	5.00	160	0.00134	0.78950	0.52214	0.11750
25	5.80	1	0.29417	0.72485	0.28678	0.16543
26	5.80	5	0.25563	0.72709	0.31633	0.16471
27	5.80	5	0.15236	0.71695	0.25123	0.16779
28	5.80	10	0.13898	0.73125	0.25558	0.16453
29	5.80	10	0.19236	0.72750	0.32545	0.16345
30	5.80	10	0.08929	0.72259	0.30048	0.16916
31	5.80	50	0.01640	0.72856	0.52114	0.16210
32	5.80	50	0.01655	0.73108	0.61930	0.16330
33	6.50	5	0.42564	0.68972	0.27307	0.16855
34	6.50	10	0.29008	0.69268	0.29561	0.16919
35	6.50	10	0.40129	0.69197	0.34186	0.16893
36	6.50	10	0.22010	0.68538	0.26278	0.16946
37	6.50	20	0.14499	0.69118	0.24339	0.16811
38	6.50	20	0.20260	0.69663	0.31729	0.17059
39	6.50	20	0.12046	0.68600	0.20392	0.16967
40	6.50	100	0.02362	0.69155	0.47442	0.16796
41	6.50	160	0.01099	0.69499	0.62162	0.16987
42	7.00	1	0.70091	0.66658	0.26716	0.17661
43	7.00	10	0.54131	0.66590	0.34128	0.17644
44	7.00	10	0.30141	0.66167	0.21693	0.17500
45	7.00	50	0.08183	0.66354	0.30611	0.17524
46	7.00	50	0.09179	0.66829	0.35469	0.17757
47	7.50	1	0.78365	0.67552	0.28380	0.19197
48	5.00	10	0.46638	0.66913	0.28560	0.18822
49	5.00	10	0.59559	0.66245	0.36648	0.18310
50	8.00	50	0.15150	0.68582	0.35736	0.19604
51	8.00	160	0.04286	0.67904	0.70696	0.19366

TABLE F6-10
P. G. SOMERVILLE: 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	0.03684	0.83469	0.33193	0.08148
2	5.00	1	0.06206	0.83067	0.60540	0.08165
3	5.00	5	0.01457	0.82650	0.26743	0.08192
4	5.00	5	0.02506	0.82650	0.44080	0.08192
5	5.80	10	0.05252	0.77721	0.23950	0.15479
6	5.80	20	0.04284	0.77375	0.28050	0.15604
7	6.50	1	0.29635	0.74215	0.18465	0.16585
8	6.50	1	0.29795	0.74257	0.33535	0.16913
9	6.50	1	0.26623	0.73288	0.28143	0.16849
10	6.50	5	0.24537	0.74086	0.22083	0.16696
11	6.50	5	0.16304	0.73328	0.23493	0.16839
12	6.50	50	0.02948	0.73676	0.33435	0.16061
13	6.50	50	0.02857	0.73621	0.36707	0.16286
14	7.00	10	0.21064	0.71277	0.19504	0.17229
15	7.50	50	0.07496	0.70823	0.30571	0.17979
16	7.50	50	0.08091	0.70462	0.32346	0.18029
17	5.00	1	0.01255	0.82266	0.61964	0.08275
18	5.80	5	0.08015	0.78508	0.43353	0.16412
19	5.80	5	0.04604	0.78072	0.44976	0.17009
20	5.00	10	0.01740	0.82507	0.21418	0.08270
21	5.00	10	0.02264	0.82507	0.24977	0.08270
22	5.00	50	0.00239	0.82203	0.36740	0.08359
23	5.00	50	0.00264	0.83320	0.30942	0.08132
24	5.00	160	0.00070	0.82947	0.52026	0.08183
25	5.80	1	0.13136	0.78076	0.34181	0.16064
26	5.80	5	0.11392	0.76917	0.34941	0.15745
27	5.80	5	0.06605	0.77734	0.33776	0.16841
28	5.80	10	0.06332	0.77894	0.23340	0.15560
29	5.80	10	0.08897	0.77117	0.34175	0.15610
30	5.80	10	0.04217	0.77745	0.27790	0.16945
31	5.80	50	0.00868	0.77161	0.51785	0.15059
32	5.80	50	0.00905	0.77464	0.57520	0.15439
33	6.50	5	0.21089	0.74657	0.21098	0.16627
34	6.50	10	0.15596	0.74104	0.24869	0.16352
35	6.50	10	0.21720	0.73750	0.32650	0.16479
36	6.50	10	0.11297	0.73283	0.21914	0.16824
37	6.50	20	0.07793	0.73589	0.20854	0.16093
38	6.50	20	0.10511	0.74032	0.35329	0.16554
39	6.50	20	0.06245	0.73445	0.20333	0.16883
40	6.50	100	0.01547	0.73751	0.44519	0.16081
41	6.50	160	0.00758	0.73845	0.59921	0.16123
42	7.00	1	0.34316	0.71578	0.27740	0.17388
43	7.00	10	0.29263	0.71453	0.31788	0.17550
44	7.00	10	0.16508	0.70645	0.19392	0.17339
45	7.00	50	0.04968	0.71282	0.36017	0.17192
46	7.00	50	0.05178	0.70948	0.42042	0.17260
47	7.50	1	0.41974	0.71955	0.29846	0.18445
48	5.00	10	0.27324	0.71321	0.23654	0.18272
49	5.00	10	0.35357	0.70820	0.39652	0.18182
50	8.00	50	0.10447	0.71589	0.32365	0.19499
51	8.00	160	0.03703	0.72344	0.64636	0.19765

TABLE F6-11
P. G. SOMERVILLE: 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	0.00935	0.89172	0.49082	0.07346
2	5.00	1	0.01588	0.88361	0.57965	0.07156
3	5.00	5	0.00424	0.87199	0.42286	0.07095
4	5.00	5	0.00695	0.87199	0.45999	0.07095
5	5.80	10	0.01734	0.83440	0.34705	0.16632
6	5.80	20	0.01304	0.82725	0.31630	0.17233
7	6.50	1	0.13040	0.79967	0.29657	0.17861
8	6.50	1	0.12585	0.79124	0.31512	0.18592
9	6.50	1	0.11443	0.78346	0.24399	0.18540
10	6.50	5	0.09634	0.79442	0.30664	0.18535
11	6.50	5	0.07563	0.78346	0.22409	0.18540
12	6.50	50	0.01255	0.80184	0.49514	0.17480
13	6.50	50	0.01162	0.79359	0.51534	0.17977
14	7.00	10	0.09182	0.78090	0.31233	0.18956
15	7.50	50	0.03627	0.77257	0.61321	0.19429
16	7.50	50	0.03656	0.75720	0.67174	0.19306
17	5.00	1	0.00321	0.87957	0.81982	0.07103
18	5.80	5	0.02974	0.81767	0.42108	0.17328
19	5.80	5	0.01613	0.81468	0.43387	0.18124
20	5.00	10	0.00564	0.87375	0.32829	0.07002
21	5.00	10	0.00659	0.87757	0.34831	0.06986
22	5.00	50	0.00089	0.87503	0.40978	0.06988
23	5.00	50	0.00080	0.87503	0.43352	0.06988
24	5.00	160	0.00038	0.87503	0.67053	0.06988
25	5.80	1	0.04779	0.83937	0.29572	0.17496
26	5.80	5	0.04019	0.81765	0.38144	0.17326
27	5.80	5	0.02605	0.81267	0.33872	0.17996
28	5.80	10	0.02066	0.83756	0.32523	0.16963
29	5.80	10	0.02601	0.82820	0.35891	0.17768
30	5.80	10	0.01499	0.81065	0.36414	0.17876
31	5.80	50	0.00324	0.83232	0.70135	0.15990
32	5.80	50	0.00316	0.82608	0.68550	0.16912
33	6.50	5	0.09168	0.80289	0.28001	0.17827
34	6.50	10	0.06077	0.80252	0.29024	0.17778
35	6.50	10	0.07721	0.79323	0.32399	0.18391
36	6.50	10	0.04671	0.78145	0.24919	0.18392
37	6.50	20	0.03449	0.80536	0.31726	0.17839
38	6.50	20	0.04115	0.78951	0.36495	0.17917
39	6.50	20	0.02517	0.77944	0.35264	0.18250
40	6.50	100	0.00736	0.80333	0.49687	0.17544
41	6.50	160	0.00375	0.81024	0.71032	0.17996
42	7.00	1	0.17833	0.78134	0.28807	0.18974
43	7.00	10	0.11726	0.76955	0.34867	0.19232
44	7.00	10	0.07280	0.75719	0.31483	0.18813
45	7.00	50	0.02407	0.77831	0.47644	0.18647
46	7.00	50	0.02391	0.76752	0.52341	0.18875
47	7.50	1	0.20165	0.77358	0.25862	0.19437
48	5.00	10	0.12130	0.77014	0.46233	0.19296
49	5.00	10	0.14380	0.75932	0.51746	0.19531
50	8.00	50	0.06298	0.78669	0.41537	0.19320
51	8.00	160	0.02673	0.78818	0.71781	0.19390

TABLE F6-12
P. G. SOMERVILLE: 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	0.00374	0.92730	0.58312	0.09756
2	5.00	1	0.00590	0.91491	0.50987	0.08801
3	5.00	5	0.00166	0.91521	0.41817	0.08808
4	5.00	5	0.00270	0.91521	0.37529	0.08808
5	5.80	10	0.00818	0.83867	0.40845	0.17568
6	5.80	20	0.00548	0.82797	0.39025	0.18281
7	6.50	1	0.06993	0.80856	0.31632	0.19199
8	6.50	1	0.06577	0.78857	0.27741	0.18916
9	6.50	1	0.06095	0.78495	0.23834	0.19035
10	6.50	5	0.05266	0.79868	0.31813	0.19668
11	6.50	5	0.04578	0.78903	0.28735	0.19460
12	6.50	50	0.00658	0.81892	0.68448	0.19413
13	6.50	50	0.00557	0.80189	0.66287	0.19465
14	7.00	10	0.04984	0.79348	0.44755	0.20000
15	7.50	50	0.02366	0.78296	0.62152	0.20000
16	7.50	50	0.02061	0.76972	0.72085	0.20000
17	5.00	1	0.00128	0.91903	0.80692	0.09107
18	5.80	5	0.01352	0.82829	0.36323	0.18747
19	5.80	5	0.00707	0.81654	0.42916	0.18526
20	5.00	10	0.00231	0.90732	0.31295	0.08259
21	5.00	10	0.00247	0.91141	0.31563	0.08528
22	5.00	50	0.00045	0.90390	0.28857	0.08035
23	5.00	50	0.00042	0.90390	0.23381	0.08035
24	5.00	160	0.00014	0.90390	0.44023	0.08035
25	5.80	1	0.02187	0.84211	0.37290	0.18271
26	5.80	5	0.01919	0.82662	0.39827	0.18624
27	5.80	5	0.01446	0.81451	0.32315	0.18351
28	5.80	10	0.01057	0.84091	0.40847	0.17743
29	5.80	10	0.01075	0.82595	0.40321	0.18302
30	5.80	10	0.00716	0.81654	0.55838	0.18526
31	5.80	50	0.00159	0.84453	0.75672	0.17671
32	5.80	50	0.00134	0.83035	0.80990	0.18290
33	6.50	5	0.05362	0.81462	0.33815	0.19526
34	6.50	10	0.03180	0.81477	0.39268	0.19346
35	6.50	10	0.03487	0.79757	0.30877	0.19399
36	6.50	10	0.02312	0.78699	0.46158	0.19245
37	6.50	20	0.01700	0.81292	0.40440	0.18977
38	6.50	20	0.01701	0.80450	0.42581	0.19931
39	6.50	20	0.01283	0.78495	0.50653	0.19035
40	6.50	100	0.00316	0.80945	0.59371	0.18525
41	6.50	160	0.00208	0.82167	0.69273	0.19709
42	7.00	1	0.11074	0.78821	0.38796	0.20000
43	7.00	10	0.05961	0.77543	0.34455	0.20000
44	7.00	10	0.03930	0.76712	0.48181	0.20000
45	7.00	50	0.01376	0.79471	0.62554	0.20000
46	7.00	50	0.01248	0.78081	0.65245	0.20000
47	7.50	1	0.14308	0.78140	0.35964	0.20000
48	5.00	10	0.07049	0.79079	0.59501	0.20000
49	5.00	10	0.07945	0.76750	0.52931	0.20000
50	8.00	50	0.04597	0.81706	0.45953	0.20000
51	8.00	160	0.01879	0.81578	0.58322	0.20000

TABLE F6-13
P. G. SOMERVILLE: HORIZONTAL POINT ESTIMATES
PEAK GROUND VELOCITY

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	6.19240	0.75430	0.48845	0.11281
2	5.00	1	10.98591	0.75430	0.44195	0.11281
3	5.00	5	2.13188	0.75475	0.29240	0.11259
4	5.00	5	3.96052	0.74672	0.38568	0.10788
5	5.80	10	5.73685	0.70714	0.23293	0.17259
6	5.80	20	4.46827	0.70587	0.25751	0.17196
7	6.50	1	33.83729	0.69455	0.23259	0.19018
8	6.50	1	35.56729	0.69278	0.36673	0.19230
9	6.50	1	32.10643	0.68924	0.30448	0.19336
10	6.50	5	29.22446	0.69089	0.20506	0.18875
11	6.50	5	19.66437	0.68321	0.16941	0.18943
12	6.50	50	2.32895	0.69468	0.34012	0.18354
13	6.50	50	2.35763	0.69286	0.30174	0.18464
14	7.00	10	22.72798	0.68570	0.21177	0.19698
15	7.50	50	7.06813	0.68144	0.34854	0.20000
16	7.50	50	7.84944	0.67493	0.39502	0.20000
17	5.00	1	1.81194	0.74619	0.73224	0.10803
18	5.80	5	10.64026	0.70322	0.39214	0.17548
19	5.80	5	5.30738	0.69587	0.40784	0.17855
20	5.00	10	2.57144	0.74327	0.23137	0.10563
21	5.00	10	3.52047	0.74724	0.20853	0.10773
22	5.00	50	0.27154	0.74046	0.19880	0.10353
23	5.00	50	0.30210	0.74435	0.19384	0.10539
24	5.00	160	0.05051	0.73270	0.22300	0.10031
25	5.80	1	16.37890	0.70654	0.33392	0.17749
26	5.80	5	15.12992	0.69995	0.29071	0.17411
27	5.80	5	8.61951	0.69587	0.27074	0.17855
28	5.80	10	6.92135	0.71078	0.26388	0.17417
29	5.80	10	10.22196	0.70459	0.25593	0.17381
30	5.80	10	4.64371	0.69587	0.32568	0.17855
31	5.80	50	0.72668	0.71013	0.50384	0.16922
32	5.80	50	0.77207	0.70909	0.51733	0.17102
33	6.50	5	23.37201	0.69623	0.18464	0.18913
34	6.50	10	15.43033	0.69673	0.21861	0.18767
35	6.50	10	21.77278	0.69291	0.25140	0.18804
36	6.50	10	11.93642	0.68321	0.18789	0.18943
37	6.50	20	7.37069	0.69655	0.22603	0.18593
38	6.50	20	10.05950	0.69514	0.28043	0.18750
39	6.50	20	5.93595	0.67921	0.21433	0.18716
40	6.50	100	1.10247	0.69685	0.42514	0.18468
41	6.50	160	0.43038	0.70314	0.49181	0.18840
42	7.00	1	44.13552	0.68544	0.31694	0.19959
43	7.00	10	32.65550	0.68215	0.36959	0.19730
44	7.00	10	18.28486	0.67107	0.26776	0.19578
45	7.00	50	4.39625	0.68437	0.33475	0.19421
46	7.00	50	4.78176	0.68145	0.36190	0.19458
47	7.50	1	55.89795	0.67939	0.47824	0.20000
48	5.00	10	30.25994	0.68017	0.34578	0.20000
49	5.00	10	39.85450	0.67402	0.59017	0.20000
50	8.00	50	11.98477	0.68782	0.30368	0.20000
51	8.00	160	3.31111	0.69414	0.47062	0.20000

TABLE F6-14
P. G. SOMERVILLE: VERTICAL POINT ESTIMATES
PEAK GROUND ACCELERATION

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.07378	0.68879	0.60833	0.16487
2	5.00	1	0.09796	0.69571	0.38181	0.16406
3	5.00	5	0.02559	0.68912	0.41014	0.16484
4	5.00	5	0.03143	0.69383	0.25717	0.16424
5	5.80	10	0.05484	0.66131	0.29139	0.16307
6	5.80	20	0.05205	0.65132	0.48094	0.15984
7	6.50	1	0.31880	0.61061	0.28922	0.16555
8	6.50	1	0.34340	0.61640	0.20069	0.16863
9	6.50	1	0.33587	0.60731	0.20631	0.16382
10	6.50	5	0.28387	0.60837	0.21197	0.16464
11	6.50	5	0.21082	0.60731	0.20044	0.16382
12	6.50	50	0.01650	0.61043	0.37978	0.16558
13	6.50	50	0.01988	0.60896	0.33968	0.16502
14	7.00	10	0.18538	0.61075	0.19717	0.17078
15	7.50	50	0.03757	0.61342	0.26064	0.17526
16	7.50	50	0.04418	0.61299	0.38933	0.17499
17	5.00	1	0.02721	0.68100	0.47680	0.16622
18	5.80	5	0.08101	0.64918	0.43419	0.15918
19	5.80	5	0.05844	0.65283	0.44034	0.15927
20	5.00	10	0.03367	0.70077	0.26507	0.16368
21	5.00	10	0.06272	0.67609	0.47126	0.16747
22	5.00	50	0.00379	0.68582	0.21681	0.16543
23	5.00	50	0.00353	0.67487	0.20705	0.16789
24	5.00	160	0.00040	0.68792	0.45153	0.16507
25	5.80	1	0.16573	0.65169	0.44521	0.15950
26	5.80	5	0.16104	0.64918	0.34511	0.15918
27	5.80	5	0.10091	0.64999	0.29685	0.15841
28	5.80	10	0.06959	0.65626	0.28642	0.16110
29	5.80	10	0.11272	0.65184	0.37393	0.15985
30	5.80	10	0.05912	0.65086	0.30619	0.15866
31	5.80	50	0.00593	0.65165	0.72426	0.16001
32	5.80	50	0.00695	0.65499	0.64679	0.16083
33	6.50	5	0.24040	0.60752	0.20043	0.16431
34	6.50	10	0.14494	0.61287	0.19855	0.16664
35	6.50	10	0.23415	0.61562	0.33336	0.16804
36	6.50	10	0.12774	0.60556	0.20593	0.16302
37	6.50	20	0.06978	0.61164	0.22117	0.16607
38	6.50	20	0.11311	0.61711	0.42433	0.16881
39	6.50	20	0.05738	0.60403	0.26757	0.16237
40	6.50	100	0.00635	0.61462	0.42089	0.16746
41	6.50	160	0.00194	0.61043	0.57122	0.16558
42	7.00	1	0.38450	0.61379	0.23054	0.17269
43	7.00	10	0.28262	0.61563	0.30664	0.17356
44	7.00	10	0.16071	0.60976	0.21314	0.17056
45	7.00	50	0.02533	0.61346	0.23752	0.17214
46	7.00	50	0.03102	0.61346	0.44565	0.17214
47	7.50	1	0.56608	0.62222	0.34497	0.18242
48	5.00	10	0.22360	0.61272	0.20075	0.17500
49	5.00	10	0.32582	0.61763	0.32960	0.17837
50	8.00	50	0.05658	0.62428	0.25618	0.18716
51	8.00	160	0.01068	0.62600	0.39057	0.18808

TABLE F6-15
P. G. SOMERVILLE: 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	0.15772	0.70749	0.76790	0.16445
2	5.00	1	0.20636	0.70749	0.41530	0.16445
3	5.00	5	0.04953	0.70556	0.60813	0.16506
4	5.00	5	0.06307	0.71540	0.34975	0.16229
5	5.80	10	0.10625	0.68165	0.46289	0.16527
6	5.80	20	0.09462	0.67475	0.39269	0.16364
7	6.50	1	0.67470	0.63947	0.49673	0.15854
8	6.50	1	0.70605	0.64225	0.32958	0.15997
9	6.50	1	0.70342	0.63577	0.29604	0.15662
10	6.50	5	0.59567	0.63853	0.27704	0.15815
11	6.50	5	0.41764	0.63402	0.37116	0.15585
12	6.50	50	0.02526	0.64049	0.46268	0.15908
13	6.50	50	0.03119	0.64133	0.36746	0.15946
14	7.00	10	0.35760	0.63993	0.38624	0.16145
15	7.50	50	0.05804	0.64166	0.29617	0.16428
16	7.50	50	0.06865	0.64208	0.33342	0.16455
17	5.00	1	0.05422	0.70922	0.65489	0.16394
18	5.80	5	0.15984	0.67869	0.59931	0.16438
19	5.80	5	0.11461	0.68203	0.51714	0.16521
20	5.00	10	0.06652	0.73120	0.44195	0.15945
21	5.00	10	0.12529	0.70780	0.32486	0.16437
22	5.00	50	0.00629	0.70590	0.30308	0.16497
23	5.00	50	0.00655	0.71558	0.27563	0.16223
24	5.00	160	0.00049	0.70968	0.52859	0.16381
25	5.80	1	0.34670	0.68313	0.65271	0.16574
26	5.80	5	0.31565	0.67763	0.43895	0.16411
27	5.80	5	0.20463	0.67590	0.44077	0.16327
28	5.80	10	0.13755	0.68481	0.47950	0.16640
29	5.80	10	0.20970	0.67702	0.45211	0.16402
30	5.80	10	0.11064	0.67415	0.47794	0.16286
31	5.80	50	0.00969	0.67667	0.77705	0.16403
32	5.80	50	0.01110	0.68313	0.77305	0.16578
33	6.50	5	0.49492	0.63937	0.37995	0.15853
34	6.50	10	0.28340	0.64630	0.36624	0.16217
35	6.50	10	0.45400	0.64250	0.39416	0.16005
36	6.50	10	0.24953	0.63840	0.33306	0.15790
37	6.50	20	0.12885	0.64181	0.32264	0.15969
38	6.50	20	0.21089	0.64665	0.42316	0.16232
39	6.50	20	0.10462	0.63490	0.34463	0.15622
40	6.50	100	0.00825	0.64217	0.47322	0.15986
41	6.50	160	0.00263	0.63735	0.57091	0.15778
42	7.00	1	0.82059	0.64473	0.40287	0.16449
43	7.00	10	0.55246	0.64778	0.38121	0.16632
44	7.00	10	0.31272	0.64028	0.31713	0.16189
45	7.00	50	0.04108	0.64226	0.30352	0.16268
46	7.00	50	0.04971	0.64163	0.40652	0.16232
47	7.50	1	1.18734	0.65404	0.34735	0.17433
48	5.00	10	0.43726	0.64068	0.37812	0.16377
49	5.00	10	0.64258	0.64665	0.40857	0.16789
50	8.00	50	0.08547	0.66203	0.29039	0.17689
51	8.00	160	0.01236	0.65859	0.43773	0.17525

TABLE F6-16
P. G. SOMERVILLE: 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	0.16010	0.74611	0.57763	0.16184
2	5.00	1	0.22337	0.75476	0.35306	0.16219
3	5.00	5	0.05690	0.75452	0.29900	0.16220
4	5.00	5	0.07365	0.76393	0.20953	0.16329
5	5.80	10	0.11966	0.69210	0.23728	0.17931
6	5.80	20	0.11051	0.68580	0.50707	0.17535
7	6.50	1	0.73823	0.64401	0.30713	0.16749
8	6.50	1	0.81988	0.64744	0.18027	0.17011
9	6.50	1	0.81870	0.64556	0.18794	0.16913
10	6.50	5	0.62633	0.64477	0.23455	0.16788
11	6.50	5	0.48760	0.64381	0.18300	0.16774
12	6.50	50	0.03099	0.64588	0.39884	0.16841
13	6.50	50	0.03811	0.64672	0.36705	0.16902
14	7.00	10	0.38956	0.64615	0.22586	0.17258
15	7.50	50	0.07112	0.64937	0.27952	0.17817
16	7.50	50	0.08301	0.64682	0.33218	0.17576
17	5.00	1	0.06011	0.74611	0.37151	0.16184
18	5.80	5	0.18698	0.68620	0.38200	0.17567
19	5.80	5	0.13471	0.68460	0.37525	0.17492
20	5.00	10	0.07480	0.76120	0.19357	0.16293
21	5.00	10	0.14081	0.73993	0.50731	0.16195
22	5.00	50	0.00726	0.75879	0.25986	0.16267
23	5.00	50	0.00723	0.74363	0.23044	0.16185
24	5.00	160	0.00060	0.74995	0.50419	0.16196
25	5.80	1	0.38666	0.68319	0.37642	0.17407
26	5.80	5	0.35789	0.68620	0.34186	0.17567
27	5.80	5	0.22123	0.68109	0.30115	0.17299
28	5.80	10	0.14538	0.69000	0.30249	0.17792
29	5.80	10	0.24753	0.69000	0.43017	0.17792
30	5.80	10	0.12627	0.68197	0.30673	0.17345
31	5.80	50	0.01192	0.69144	0.59903	0.17871
32	5.80	50	0.01278	0.69039	0.69742	0.17803
33	6.50	5	0.53015	0.64647	0.19864	0.16914
34	6.50	10	0.31970	0.64768	0.20723	0.16996
35	6.50	10	0.51149	0.64768	0.37936	0.16996
36	6.50	10	0.29303	0.64294	0.17847	0.16706
37	6.50	20	0.14115	0.64636	0.23173	0.16885
38	6.50	20	0.23712	0.65162	0.47233	0.17299
39	6.50	20	0.12456	0.64053	0.20182	0.16526
40	6.50	100	0.01040	0.64253	0.48776	0.16611
41	6.50	160	0.00327	0.64526	0.48243	0.16796
42	7.00	1	0.88551	0.64860	0.21343	0.17525
43	7.00	10	0.61710	0.65486	0.33202	0.18076
44	7.00	10	0.35691	0.64348	0.18161	0.17130
45	7.00	50	0.04823	0.64532	0.27453	0.17159
46	7.00	50	0.05975	0.64721	0.39348	0.17321
47	7.50	1	1.28060	0.65447	0.31953	0.18430
48	5.00	10	0.47984	0.64734	0.23851	0.17655
49	5.00	10	0.73446	0.65181	0.32953	0.18095
50	8.00	50	0.10233	0.68628	0.30746	0.19296
51	8.00	160	0.01305	0.68714	0.46111	0.19349

TABLE F6-17
P. G. SOMERVILLE: 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	0.09737	0.70790	0.46283	0.15812
2	5.00	1	0.12227	0.72519	0.39050	0.15806
3	5.00	5	0.04052	0.72272	0.18015	0.15790
4	5.00	5	0.04497	0.71844	0.20833	0.15778
5	5.80	10	0.08398	0.66224	0.18203	0.18448
6	5.80	20	0.08352	0.65903	0.65002	0.18247
7	6.50	1	0.49988	0.63131	0.17124	0.17447
8	6.50	1	0.51212	0.62938	0.18859	0.17289
9	6.50	1	0.51422	0.62618	0.23132	0.17140
10	6.50	5	0.46260	0.62753	0.32639	0.17104
11	6.50	5	0.33509	0.62246	0.25549	0.16853
12	6.50	50	0.02766	0.62344	0.45348	0.16774
13	6.50	50	0.03472	0.62889	0.50463	0.17147
14	7.00	10	0.30345	0.63424	0.27424	0.17130
15	7.50	50	0.06965	0.63346	0.37064	0.17292
16	7.50	50	0.08244	0.63537	0.43457	0.17464
17	5.00	1	0.04035	0.72260	0.19173	0.15791
18	5.80	5	0.12461	0.65555	0.37005	0.18102
19	5.80	5	0.09263	0.65653	0.44917	0.18261
20	5.00	10	0.04271	0.72746	0.18553	0.15821
21	5.00	10	0.09779	0.71852	0.74214	0.15778
22	5.00	50	0.00690	0.72542	0.44304	0.15803
23	5.00	50	0.00621	0.70016	0.24477	0.15911
24	5.00	160	0.00072	0.71658	0.49537	0.15778
25	5.80	1	0.24341	0.65564	0.32974	0.18135
26	5.80	5	0.24503	0.66296	0.42537	0.18511
27	5.80	5	0.15421	0.65653	0.28785	0.18261
28	5.80	10	0.10607	0.66751	0.19628	0.18788
29	5.80	10	0.17645	0.66540	0.55566	0.18646
30	5.80	10	0.09044	0.65368	0.29935	0.18107
31	5.80	50	0.01039	0.66293	0.58305	0.18449
32	5.80	50	0.01318	0.66293	0.61210	0.18449
33	6.50	5	0.36537	0.62583	0.22202	0.16980
34	6.50	10	0.22157	0.62249	0.22821	0.16739
35	6.50	10	0.36529	0.62989	0.45026	0.17263
36	6.50	10	0.21717	0.62246	0.25934	0.16853
37	6.50	20	0.11352	0.62844	0.34263	0.17133
38	6.50	20	0.18856	0.63707	0.61682	0.17837
39	6.50	20	0.10412	0.62334	0.35721	0.16918
40	6.50	100	0.01150	0.63245	0.60045	0.17420
41	6.50	160	0.00411	0.62972	0.54124	0.17209
42	7.00	1	0.60068	0.63310	0.19069	0.17094
43	7.00	10	0.47908	0.64146	0.43190	0.17788
44	7.00	10	0.28186	0.63245	0.29635	0.17142
45	7.00	50	0.04658	0.63267	0.34077	0.16961
46	7.00	50	0.05956	0.63330	0.51532	0.17013
47	7.50	1	0.85330	0.64043	0.44020	0.18075
48	5.00	10	0.38870	0.63707	0.28920	0.17668
49	5.00	10	0.56272	0.63921	0.38650	0.17877
50	8.00	50	0.10036	0.68291	0.37053	0.18694
51	8.00	160	0.01642	0.67430	0.53252	0.18193

TABLE F6-18
P. G. SOMERVILLE: 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	0.03422	0.72666	0.54012	0.10665
2	5.00	1	0.04993	0.72882	0.41620	0.10695
3	5.00	5	0.01232	0.73947	0.35201	0.10923
4	5.00	5	0.01741	0.72663	0.21465	0.10662
5	5.80	10	0.04662	0.65851	0.24269	0.18656
6	5.80	20	0.05016	0.66082	0.72138	0.18736
7	6.50	1	0.26071	0.62923	0.17557	0.18081
8	6.50	1	0.30714	0.62730	0.24440	0.17909
9	6.50	1	0.29822	0.62503	0.26336	0.18029
10	6.50	5	0.25551	0.62428	0.34690	0.17539
11	6.50	5	0.20449	0.62240	0.30592	0.17795
12	6.50	50	0.02245	0.62466	0.41703	0.17416
13	6.50	50	0.03038	0.62403	0.45203	0.17368
14	7.00	10	0.20587	0.62996	0.42429	0.17897
15	7.50	50	0.06178	0.63173	0.46813	0.18414
16	7.50	50	0.06727	0.62919	0.42753	0.18167
17	5.00	1	0.01432	0.76125	0.30912	0.11776
18	5.80	5	0.06382	0.66273	0.31794	0.19017
19	5.80	5	0.04414	0.65166	0.32333	0.18853
20	5.00	10	0.01813	0.72279	0.22900	0.10622
21	5.00	10	0.03611	0.71939	0.64392	0.10603
22	5.00	50	0.00319	0.73923	0.29197	0.10918
23	5.00	50	0.00357	0.72281	0.30218	0.10620
24	5.00	160	0.00052	0.73081	0.56655	0.10723
25	5.80	1	0.10242	0.65806	0.45303	0.18849
26	5.80	5	0.12047	0.67098	0.44117	0.19668
27	5.80	5	0.08359	0.65407	0.29963	0.19000
28	5.80	10	0.06043	0.66503	0.29652	0.19111
29	5.80	10	0.09647	0.66693	0.58754	0.19256
30	5.80	10	0.05001	0.66479	0.29310	0.19770
31	5.80	50	0.00650	0.65852	0.75795	0.18518
32	5.80	50	0.00892	0.66290	0.69756	0.18809
33	6.50	5	0.21349	0.63320	0.31690	0.18321
34	6.50	10	0.14788	0.63188	0.44315	0.18135
35	6.50	10	0.23830	0.63103	0.59458	0.18058
36	6.50	10	0.14073	0.62240	0.40740	0.17795
37	6.50	20	0.07789	0.63162	0.45983	0.18051
38	6.50	20	0.13040	0.63541	0.70133	0.18403
39	6.50	20	0.06610	0.62240	0.34585	0.17795
40	6.50	100	0.01098	0.62948	0.51170	0.17806
41	6.50	160	0.00465	0.62865	0.47417	0.17735
42	7.00	1	0.37356	0.63806	0.24628	0.18873
43	7.00	10	0.31077	0.63633	0.55801	0.18526
44	7.00	10	0.18731	0.62710	0.37192	0.17995
45	7.00	50	0.03612	0.63112	0.34425	0.17919
46	7.00	50	0.04877	0.63175	0.54639	0.17978
47	7.50	1	0.47227	0.63670	0.34192	0.19122
48	5.00	10	0.25397	0.62957	0.37017	0.18263
49	5.00	10	0.34902	0.63234	0.40330	0.18541
50	8.00	50	0.09759	0.68433	0.52539	0.19740
51	8.00	160	0.02225	0.68735	0.52815	0.19908

TABLE F6-19
P. G. SOMERVILLE: 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	0.01487	0.72396	0.59915	0.06096
2	5.00	1	0.02009	0.74355	0.52136	0.06759
3	5.00	5	0.00514	0.73143	0.46037	0.06258
4	5.00	5	0.00709	0.72107	0.28922	0.06060
5	5.80	10	0.02063	0.68152	0.24850	0.16501
6	5.80	20	0.02121	0.67694	0.45973	0.16960
7	6.50	1	0.12704	0.65261	0.33598	0.17161
8	6.50	1	0.14949	0.64528	0.23075	0.17320
9	6.50	1	0.13288	0.64060	0.26323	0.17300
10	6.50	5	0.12916	0.64549	0.36728	0.17189
11	6.50	5	0.10138	0.63557	0.18932	0.16874
12	6.50	50	0.01184	0.65215	0.56161	0.16763
13	6.50	50	0.01778	0.63964	0.51927	0.16506
14	7.00	10	0.09980	0.65692	0.19090	0.17820
15	7.50	50	0.03706	0.64962	0.33361	0.17571
16	7.50	50	0.04440	0.64416	0.54776	0.17808
17	5.00	1	0.00498	0.72222	0.57960	0.06073
18	5.80	5	0.03013	0.67793	0.40827	0.17218
19	5.80	5	0.02336	0.67826	0.41718	0.18000
20	5.00	10	0.00561	0.71512	0.46046	0.06052
21	5.00	10	0.01065	0.72115	0.40098	0.06060
22	5.00	50	0.00109	0.72258	0.54108	0.06072
23	5.00	50	0.00164	0.72429	0.31752	0.06093
24	5.00	160	0.00027	0.72813	0.84266	0.06164
25	5.80	1	0.05079	0.69639	0.51719	0.17954
26	5.80	5	0.05576	0.68263	0.52813	0.17563
27	5.80	5	0.04016	0.67278	0.28952	0.17625
28	5.80	10	0.02737	0.68492	0.21740	0.16725
29	5.80	10	0.04364	0.67425	0.48164	0.16882
30	5.80	10	0.02979	0.67913	0.34723	0.18065
31	5.80	50	0.00354	0.69126	0.90359	0.17011
32	5.80	50	0.00544	0.67645	0.65565	0.16837
33	6.50	5	0.10058	0.65256	0.22116	0.17007
34	6.50	10	0.07520	0.65221	0.24430	0.16905
35	6.50	10	0.09753	0.63706	0.31782	0.16436
36	6.50	10	0.07775	0.63622	0.30979	0.16927
37	6.50	20	0.03587	0.65356	0.31777	0.16953
38	6.50	20	0.06067	0.63910	0.44461	0.16526
39	6.50	20	0.04127	0.63250	0.33262	0.16636
40	6.50	100	0.00668	0.64728	0.42363	0.16373
41	6.50	160	0.00300	0.65321	0.66840	0.16854
42	7.00	1	0.16517	0.66079	0.34362	0.18386
43	7.00	10	0.15615	0.64781	0.41130	0.17729
44	7.00	10	0.10686	0.64346	0.27268	0.17740
45	7.00	50	0.02192	0.65112	0.41624	0.17186
46	7.00	50	0.02905	0.64397	0.57490	0.17276
47	7.50	1	0.23897	0.67597	0.31835	0.20000
48	5.00	10	0.13373	0.64966	0.20006	0.17622
49	5.00	10	0.18746	0.64416	0.36136	0.17863
50	8.00	50	0.05750	0.69457	0.26407	0.20000
51	8.00	160	0.01873	0.68676	0.37409	0.19792

TABLE F6-20
P. G. SOMERVILLE: 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	0.00528	0.75061	0.58970	0.05000
2	5.00	1	0.00737	0.74177	0.55608	0.05000
3	5.00	5	0.00163	0.74874	0.58722	0.05000
4	5.00	5	0.00221	0.74347	0.27709	0.05000
5	5.80	10	0.00829	0.71014	0.38829	0.17663
6	5.80	20	0.00728	0.70218	0.42240	0.19370
7	6.50	1	0.07362	0.67633	0.35637	0.19223
8	6.50	1	0.08710	0.65272	0.37668	0.19073
9	6.50	1	0.07256	0.64898	0.27299	0.18843
10	6.50	5	0.07212	0.65664	0.51043	0.19334
11	6.50	5	0.05199	0.64898	0.31616	0.18843
12	6.50	50	0.00603	0.67365	0.52647	0.18233
13	6.50	50	0.00952	0.65708	0.96688	0.18877
14	7.00	10	0.04515	0.66836	0.36952	0.18848
15	7.50	50	0.01758	0.67308	0.77941	0.19735
16	7.50	50	0.02587	0.65546	1.14281	0.20000
17	5.00	1	0.00132	0.74575	0.89256	0.05000
18	5.80	5	0.01465	0.68790	0.40234	0.18453
19	5.80	5	0.00813	0.68909	0.51553	0.19023
20	5.00	10	0.00163	0.74340	0.65642	0.05000
21	5.00	10	0.00406	0.74077	0.50402	0.05000
22	5.00	50	0.00030	0.74672	0.88321	0.05000
23	5.00	50	0.00085	0.74239	0.55950	0.05000
24	5.00	160	0.00006	0.76401	1.58506	0.05895
25	5.80	1	0.02657	0.72484	0.42309	0.19681
26	5.80	5	0.02763	0.69635	0.60058	0.19235
27	5.80	5	0.01876	0.69785	0.43628	0.19876
28	5.80	10	0.00988	0.70928	0.37559	0.17583
29	5.80	10	0.01468	0.70392	0.58568	0.19781
30	5.80	10	0.01200	0.69500	0.60653	0.19588
31	5.80	50	0.00136	0.70513	0.90701	0.16811
32	5.80	50	0.00261	0.70217	1.00268	0.19151
33	6.50	5	0.04904	0.67365	0.28416	0.18732
34	6.50	10	0.03521	0.67660	0.23218	0.18886
35	6.50	10	0.04713	0.66486	0.54750	0.20000
36	6.50	10	0.03764	0.65992	0.49680	0.20000
37	6.50	20	0.01769	0.67608	0.32514	0.18656
38	6.50	20	0.02765	0.66031	0.71023	0.19400
39	6.50	20	0.01883	0.65051	0.65120	0.19011
40	6.50	100	0.00272	0.67622	0.65840	0.18507
41	6.50	160	0.00165	0.67900	0.76614	0.18814
42	7.00	1	0.09073	0.66920	0.46200	0.19194
43	7.00	10	0.07471	0.65909	0.53847	0.20000
44	7.00	10	0.04910	0.65445	0.48829	0.20000
45	7.00	50	0.01057	0.67032	0.66237	0.18831
46	7.00	50	0.01771	0.65447	0.98430	0.19427
47	7.50	1	0.10482	0.68098	0.41106	0.20000
48	5.00	10	0.06140	0.68036	0.50301	0.20000
49	5.00	10	0.10125	0.67152	0.66516	0.20000
50	8.00	50	0.04051	0.73228	0.37460	0.20000
51	8.00	160	0.01646	0.73621	0.55947	0.20000

TABLE F6-21
P. G. SOMERVILLE: 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	0.00212	0.80009	0.81491	0.08029
2	5.00	1	0.00328	0.79034	0.67230	0.06965
3	5.00	5	0.00070	0.79434	0.73290	0.07391
4	5.00	5	0.00128	0.78815	0.42549	0.06727
5	5.80	10	0.00473	0.73397	0.37989	0.19519
6	5.80	20	0.00416	0.71640	0.49586	0.20000
7	6.50	1	0.04135	0.70526	0.41153	0.20000
8	6.50	1	0.05512	0.67985	0.38815	0.20000
9	6.50	1	0.04824	0.67626	0.31782	0.20000
10	6.50	5	0.05056	0.68124	0.58873	0.20000
11	6.50	5	0.02963	0.67494	0.23803	0.20000
12	6.50	50	0.00340	0.70604	0.64597	0.20000
13	6.50	50	0.00514	0.69210	0.92433	0.20000
14	7.00	10	0.02949	0.71144	0.32946	0.20000
15	7.50	50	0.01158	0.70415	0.75431	0.20000
16	7.50	50	0.01515	0.68269	1.01080	0.20000
17	5.00	1	0.00056	0.79876	1.07275	0.07883
18	5.80	5	0.00977	0.71573	0.47570	0.20000
19	5.80	5	0.00530	0.71199	0.45211	0.20000
20	5.00	10	0.00066	0.79787	0.86940	0.07761
21	5.00	10	0.00200	0.78862	0.60788	0.06777
22	5.00	50	0.00012	0.80051	1.02821	0.08014
23	5.00	50	0.00049	0.78999	0.69468	0.06919
24	5.00	160	0.00004	0.81848	1.25153	0.09937
25	5.80	1	0.01358	0.73535	0.50251	0.19959
26	5.80	5	0.01754	0.71726	0.65394	0.20000
27	5.80	5	0.00938	0.71243	0.42227	0.20000
28	5.80	10	0.00517	0.73180	0.44532	0.19274
29	5.80	10	0.00753	0.71857	0.68221	0.20000
30	5.80	10	0.00626	0.72009	0.60544	0.20000
31	5.80	50	0.00073	0.73238	0.96513	0.19074
32	5.80	50	0.00144	0.72463	1.01649	0.20000
33	6.50	5	0.03435	0.69963	0.26675	0.20000
34	6.50	10	0.01888	0.69250	0.25079	0.19993
35	6.50	10	0.02501	0.68785	0.50129	0.20000
36	6.50	10	0.01916	0.68064	0.44058	0.20000
37	6.50	20	0.01007	0.70926	0.35489	0.20000
38	6.50	20	0.01324	0.68423	0.57333	0.20000
39	6.50	20	0.01179	0.68480	0.78724	0.20000
40	6.50	100	0.00135	0.70171	0.90168	0.20000
41	6.50	160	0.00095	0.70171	0.87878	0.20000
42	7.00	1	0.05691	0.70119	0.58391	0.20000
43	7.00	10	0.04173	0.69145	0.52428	0.20000
44	7.00	10	0.02888	0.68326	0.62865	0.20000
45	7.00	50	0.00684	0.70838	0.79110	0.20000
46	7.00	50	0.01008	0.69281	0.99900	0.20000
47	7.50	1	0.07796	0.71433	0.33975	0.20000
48	5.00	10	0.03502	0.70094	0.63890	0.20000
49	5.00	10	0.05615	0.69292	0.71565	0.20000
50	8.00	50	0.03083	0.78137	0.47685	0.20000
51	8.00	160	0.01107	0.78445	0.51313	0.20000

TABLE F6-22
P. G. SOMERVILLE: VERTICAL POINT ESTIMATES
PEAK GROUND VELOCITY

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	2.65124	0.66362	0.39808	0.07893
2	5.00	1	3.68688	0.66494	0.17883	0.07975
3	5.00	5	0.66013	0.66561	0.26741	0.07994
4	5.00	5	0.96828	0.66430	0.21965	0.07914
5	5.80	10	2.37668	0.61922	0.17473	0.16909
6	5.80	20	2.24397	0.60845	0.60395	0.16487
7	6.50	1	13.68076	0.59985	0.23627	0.17461
8	6.50	1	18.01303	0.59288	0.45881	0.17465
9	6.50	1	15.20432	0.59298	0.39291	0.17667
10	6.50	5	16.30697	0.59062	0.49712	0.17078
11	6.50	5	10.52329	0.59058	0.33527	0.17433
12	6.50	50	0.97511	0.59841	0.41709	0.16702
13	6.50	50	1.57279	0.59607	0.62754	0.17095
14	7.00	10	10.41637	0.59929	0.21922	0.18707
15	7.50	50	3.50694	0.59006	0.45058	0.19379
16	7.50	50	4.83217	0.58567	0.75462	0.19531
17	5.00	1	0.70917	0.66362	0.32042	0.07893
18	5.80	5	3.98799	0.60486	0.34393	0.16629
19	5.80	5	2.55361	0.60488	0.50608	0.17134
20	5.00	10	0.83952	0.67145	0.18448	0.08344
21	5.00	10	1.90272	0.66019	0.60964	0.07667
22	5.00	50	0.12397	0.66922	0.17214	0.08150
23	5.00	50	0.16313	0.64709	0.30707	0.07142
24	5.00	160	0.01747	0.68029	0.51732	0.08893
25	5.80	1	6.76514	0.61360	0.27080	0.16883
26	5.80	5	7.65992	0.60594	0.42510	0.16721
27	5.80	5	4.52524	0.60051	0.27394	0.16761
28	5.80	10	3.00607	0.61751	0.21426	0.16750
29	5.80	10	4.84362	0.60806	0.52434	0.16673
30	5.80	10	2.78572	0.60488	0.40269	0.17134
31	5.80	50	0.28533	0.61897	0.71864	0.16443
32	5.80	50	0.45959	0.61114	0.69462	0.16512
33	6.50	5	11.37272	0.60207	0.27895	0.17491
34	6.50	10	7.50399	0.59826	0.26593	0.16980
35	6.50	10	10.45618	0.59804	0.48593	0.17606
36	6.50	10	7.18017	0.58576	0.37996	0.16991
37	6.50	20	3.59531	0.59663	0.25990	0.16697
38	6.50	20	5.69562	0.59471	0.55034	0.17124
39	6.50	20	3.72142	0.58773	0.50517	0.17167
40	6.50	100	0.44705	0.60370	0.23614	0.17149
41	6.50	160	0.16347	0.59968	0.46234	0.16805
42	7.00	1	16.95840	0.59794	0.28176	0.18852
43	7.00	10	15.26860	0.59464	0.52837	0.18866
44	7.00	10	10.35549	0.58749	0.39525	0.18548
45	7.00	50	1.99607	0.59869	0.38269	0.18393
46	7.00	50	3.03759	0.59432	0.72999	0.18558
47	7.50	1	23.05415	0.59902	0.42991	0.20000
48	5.00	10	13.34890	0.58922	0.22836	0.19484
49	5.00	10	18.30014	0.58844	0.59026	0.20000
50	8.00	50	7.36929	0.62780	0.24077	0.20000
51	8.00	160	1.95719	0.64728	0.35007	0.20000

TABLE F6-23
ADJUSTMENT FACTORS FOR SIMULTANEOUS RUPTURE ON PARALLEL FAULTS

FREQUENCY (HZ)	HANGING WALL SCALE FACTOR	FOOTWALL SCALE FACTOR	ADDITIONAL ALEATORY UNC.	ADDITIONAL EPISTEMIC UNC.
PGV	1.5	1.75	0.3	0.2
20	1.5	1.75	0.3	0.2
10	1.5	1.75	0.3	0.2
5	1.5	1.75	0.3	0.2
2	1.4	1.75	0.3	0.2
1	1.4	1.6	0.3	0.2
0.5	1.4	1.6	0.3	0.2
0.3	1.4	1.6	0.3	0.2
PGV	1.4	1.6	0.3	0.2

TABLE F6-24
ADJUSTMENT FACTORS FOR SIMULTANEOUS RUPTURES ON PARALLEL FAULTS AND A DEEP DETACHMENT SURFACE

FREQUENCY (HZ)	SCALE FACTOR	ADDITIONAL ALEATORY UNC.	ADDITIONAL EPISTEMIC UNC.
PGA	1.0	0.3	0.2
20	1.0	0.3	0.2
10	1.0	0.3	0.2
5	1.0	0.3	0.2
2	1.2	0.3	0.2
1	2.2	0.3	0.2
0.5	2.2	0.3	0.2
0.3	1.7	0.3	0.2
PGV	2.2	0.3	0.2

APPENDIX F7

ESTIMATION OF GROUND MOTION ATTENUATION FOR THE YUCCA MOUNTAIN PROBABILISTIC SEISMIC HAZARD ASSESSMENT

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APPENDIX F7

ESTIMATION OF GROUND MOTION ATTENUATION FOR THE YUCCA MOUNTAIN PROBABILISTIC SEISMIC HAZARD ASSESSMENT

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F7-1 INTRODUCTION

One aspect of the evaluation of Yucca Mountain, Nevada as a potential geological repository for high-level radioactive waste is assessment of seismic hazards at the site. The selected approach to probabilistic seismic hazard assessment uses two panels, seismic source characterization and ground motion evaluation, to provide expert opinion on the likely sizes and probabilities of earthquakes in the region and the ground motions that these sources would produce at Yucca Mountain. The ground motion estimates combined with the likelihood of occurrence of the various seismic sources provide information on the site seismic hazard as a function of time.

Members of the ground motion expert panel were asked to provide point estimates of ground motion for 51 different combinations of magnitude, source distance, and source mechanism. These combinations included moment magnitudes of 5.0, 5.8, 6.5, 7.0, 7.5, and 8.0. The distances considered were horizontal separations of 1, 5, 10, 20, 50, and 160 km. Strike-slip and normal faulting (both foot wall and hanging wall) source mechanisms were included. The ground motions were not calculated for all possible combinations of these parameters, but rather for those combinations selected by the ground motion facilitation team as the most appropriate for hazard at Yucca Mountain. For each of the identified seismic sources, the experts calculated spectral acceleration at 7 frequencies (0.33, 0.5, 1.0, 2.0, 5.0, 10.0, and 20.0 Hz) plus peak ground acceleration (PGA) and peak ground velocity (PGV) for both

horizontal and vertical motion components. Each ground motion estimate consists of four (4) numbers: the median ground motion (μ), the aleatory uncertainty in the median (σ), the epistemic uncertainty in the median (σ_μ) and the epistemic uncertainty in the aleatory uncertainty (σ_σ). Thus the experts have calculated a total of 3672 parameters relevant to ground motion at a site called "YM300", which is a surface site but has velocities representative of Yucca Mountain at a depth of 300 m. The ground motion facilitation team for the project regressed the point estimates using standard techniques to develop continuous models of the ground motion attenuation at Yucca Mountain as functions of magnitude and distance.

F7-2 WEIGHTING SCHEME FOR PROPONENT GROUND MOTION MODELS

The ground motion facilitation team provided the experts with a suite of proponent models that were to be considered for their applicability to ground motions at Yucca Mountain. Each expert was required to evaluate each model and decide on its applicability in each of the 918 earthquake-frequency-component combinations. The typical approach was to develop estimates based on a weighted median of the proponent models. Each expert divided the proponent models into different classes, with each class assigned a weight, and then assigned a relative weight to each candidate model within each class. The various classes of proponent models and their weights are discussed in detail in the following sections.

F7-2.1 Classes Of Proponent Models

I chose to define three classes of proponent models: empirical, point source numerical simulation, and finite fault numerical simulation. The empirical models considered include several attenuation relations based on data primarily from California (e.g., Abrahamson and Silva, 1997; Boore et al., 1997; Campbell, 1997; Idriss, 1993, 1997 (written comm.); Sadigh et al., 1997), the Spudich et al. (1996) model for extensional regime data, the Sabetta and Pugliese (1996) model based on Italian earthquakes, and the McGarr (1984) relation for peak ground acceleration and velocity for close-in, extensional data. Also in this category are the explosion models developed for the Yucca Mountain Project by Bennett, et al. (1997) and the Campbell hybrid empirical model (Yucca Mountain Ground Motion Data Package, 1997). The single model of the point source numerical simulation class was developed by W. Silva.

Three different approaches to finite fault simulation were also exercised for the YM300 structure; these are the work of Zeng and Anderson; P. Somerville, and W. Silva. The Yucca Mountain Ground Motion Data Package (1997) contains information documenting all four of the numerical simulation models.

F7-2.2 Model Weights: Horizontal Components

All of the proponent models were available for making predictions of the horizontal component data. Many of the empirical models provide estimates for spectral acceleration and peak ground acceleration only, so there were only limited choices in models for the peak ground velocity estimates. A few of the empirical models (Boore et al., 1997; Spudich et al., 1996) did not provide high-frequency (20 Hz spectral acceleration) ground motion values.

In most cases, adjustments were made to the raw horizontal model estimates to make them applicable for the YM300 site. The adjustments that I chose to include were the effects of 1) crustal structure, 2) source differences (chiefly due to stress drop), 3) compensation for the difference between the average horizontal component (applicable for most proponent models) and the random horizontal component (the required estimate), and 4) interpolation for 20 Hz estimates when needed.

Two crustal adjustment factors were available for use by the experts: these were similar, but not identical, band-limited-white-noise-random-vibration theory estimates from Ken Campbell and Walt Silva (Yucca Mountain Ground Motion Data Package, 1997). These corrections account for the difference between a "California" crust and the YM300 velocity structure. I chose to apply the Campbell crustal correction to the appropriate empirical models as detailed below. The point source model and the three finite fault simulations were calculated directly for the YM300 model and did not require crustal transfer functions.

Some recent studies (Abrahamson and Silva, 1997; Spudich et al., 1996) have determined that the ground motions expected from normal-faulting earthquakes and also strike-slip earthquakes in extensional regimes may be lower than that expected for "typical" California strike slip and thrust earthquakes. The lower ground motions could be due to lower stress drop parameters for extensional-regime earthquakes. Becker and Abrahamson (1997) studied stress drops for extensional regime earthquakes and found an average stress drop of 45 bars

for a limited set of normal faulting earthquakes, and a value near 55 bars for extensional strike-slip earthquakes. These values are lower than those found for typical California events by Silva et al.(1996). Because Yucca Mountain is in an extensional regime, and the expected earthquakes are either normal or strike slip in nature, one might expect lower stress drops for these events and therefore lower ground motions than for the equivalent California events, which have an average stress drop of about 60 bars. This source effect was included in the ground motion estimates by using a source correction based on the same theory as the crustal correction, and coded by Ken Campbell. I chose to use source corrections for all models except those developed specifically for extensional regimes (Spudich et al., 1997; McGarr, 1984). Strike-slip events were assigned a stress drop parameter of 55 bars, and the normal events were assigned 45 bars. The numerical simulations were given the same source corrections as the empirical models.

Most of the empirical models and all of the numerical simulations were calculated for an average horizontal component. Because the desired attenuation relationships were for a random horizontal component, I incorporated additional aleatory uncertainty into the horizontal estimates for the appropriate models using the frequency-varying values of Boore et al. (1993).

Two of the empirical models do not provide coefficients applicable for calculating the spectral acceleration at 20 Hz (Boore et al. 1997 (BJF); Spudich et al., 1996 (SEA)). In order to avoid biasing the overall spectral shape for the event, I incorporated the interpolation scheme of Boore (Yucca Mountain Ground Motion Data Package, 1997) to estimate 20 Hz values for the BJF and SEA models.

F7-2.2.1 Empirical Models. In an overall sense, I favor the empirical models over the numerical simulations, thus I typically assigned a class weight of 0.6 or 0.7 (out of 1.0) to the empirical class. Slight variations occurred from case to case and even for various frequencies within each case due to different availability of applicable models. For example, there are few empirical models which provide peak ground velocity estimates, so the numerical simulations often received a relatively higher weight for PGV estimates. Generally, however, the empirical models were always assigned a class weight of 0.5 or higher.

The general rules as applied to each model are discussed below. Models within the empirical class ordinarily receive equal weight; exceptions are noted for each model.

Abrahamson and Silva (1997) (AS97). This model is applicable for the entire range of distance (0-160 km) and magnitude (5-8) considered here. AS97 does not provide peak ground velocity estimates, therefore this model was not used for PGV. AS97 has an available adjustment for normal faulting, however for consistency among the models instead of using the AS97-specific normal faulting corrections I applied the Campbell version of the source correction discussed above. For the strike-slip earthquakes, I assigned the stress drop to be 55 bars; 45 bars was chosen for the normal events. The AS97 model was a "workhorse" as it was included in the vast majority of the calculations. It is a modern model based on a good data set using state-of-the-art regression methods.

Boore, Joyner, and Fumal (1997) (BJF). The BJF model was developed using a carefully selected data set and the two-step regression approach (Joyner and Boore, 1993) to model the data. It has few data at small magnitudes and an unusual attenuation shape for large distances. I applied the BJF model in the range recommended by Boore et al. (1997); magnitudes greater than or equal to 5.5 and distances less than 100 km. The BJF model also does not include any magnitude saturation at short ranges. Because I believe that some magnitude saturation does occur, I gave the BJF model a lower weight within the empirical class for large events at short distances. I applied crustal and source corrections as detailed above to the BJF model, and applied the Boore (Yucca Mountain Ground Motion Data Package, 1997) interpolation scheme to provide 20 Hz spectral values. The model was calculated for a shear wave velocity of 620 m/s, consistent with California 'rock'. This Vs is lower than for the YM300 site, however the crustal transfer function should account for average velocity differences between typical California rock sites and the YM300 site.

Boore, Joyner, and Fumal (1994, class A). I did not use this model in the calculations. Boore (personal communication, 1997) recommended use of the BJF 1997 model.

Boore, Joyner, and Fumal (1997, class B). I did not use this model in the calculations. Boore (personal communication, 1997) recommended use of the BJF 1997 model.

Campbell, 1997 (soft rock) (C97). This model was used for most of the events at distances of 50 km or less. This model has a large degree of magnitude saturation; I gave it a lesser weight in some cases at close distance. Also, the Campbell model predicts higher amplitudes at low frequencies than the other models. In cases where the spectral shape was significantly different from my preference, I gave it a lower weight at .33, .5, and 1. Hz. The soft rock parameters are consistent with use of the Campbell crustal transfer function described above.

Campbell, 1997 (hard rock). I did not use this model in the calculations. According to Campbell (personal communication, 1997) the soft rock 1997 model is better suited for use in this study, coupled with the crustal and source transfer functions that he developed.

Campbell, 1993-1994 (hard rock). This model was not used. Campbell (personal communication) confirmed that the more recent 1997 model is more applicable.

Campbell, 1990-1994 (soft rock). This model was not used. Campbell (personal communication) confirmed that the more recent 1997 model is more applicable.

Campbell, 1990 (soil/soft rock). This model was not used. Campbell (personal communication) confirmed that the more recent 1997 model is more applicable.

Idriss, 1993 and 1997 (written comm.) (rock/stiff soil). This model was used, in combination with the appropriate crustal and source corrections, for magnitudes of 7.0 and less and distances of less than 100 km. It was generally given equal weight with the other applicable models. Both crustal and source corrections were applied to this model.

Joyner and Boore, 1988 (JB88). This older model uses similar methodology to BJF, but with a smaller data set. It was not used for the spectral acceleration or PGA estimates, but it does provide peak velocity predictions (PGV) and was used for PGV estimates for events in the magnitude range 5.5 to 7.5 and distances closer than 100 km.

Sadigh et al., 1997 (Sa97). I used this model for spectral acceleration and PGA estimates for the events of all magnitudes. Its stated distance limit is 100 km, however I also used it for the 160 km estimates for the magnitude 6.5 and 8.0 cases, as the data distribution illustrations in Sadigh et al. (1997) show significant amounts of data beyond 100 km at the higher magnitudes. The Sa97 model was, however, assigned a relatively lower weight for the distant events. The usual crustal and source corrections were applied to this model.

Sabetta and Pugliese, 1996 (SP96). This model is based on data from Italy and does include some normal faulting recordings. The data set is small, however, and the regression method is not as sophisticated as for some of the California models. I used it only for peak velocity estimates. Because the data set included some normal faulting data, I did not apply the source correction to the SP96 model, however I did apply the crustal transfer function. Due to uncertainty in the comparative crustal structure of California and the Italian sites, I added an additional 0.1 of epistemic uncertainty in the median each time the SP96 model was used. Also, this model received a lower weight (typically half) within the empirical class for the peak velocity estimates. It was not used for events larger than magnitude 7.0, or for distances larger than 100 km.

Spudich et al., 1996 (SEA96). This model is the first to be developed specifically for extensional regime data (strike-slip and normal faulting). The data were carefully selected and are applicable to the Yucca Mountain exercise without source correction. Because of the few data available, however, Spudich et al. were forced to place additional constraints on their regression that makes the shape of their model with frequency very similar to that of the BJF model. I used the SEA96 model for events from magnitude 5.5 through 7.0, and for distances less than 100 km. The crustal transfer function was applied, although its applicability to this worldwide data set is not as well known; I made the assumption that the crustal structure for the worldwide data (which included significant data from California) is similar to the generic California structure used in the transfer function. The SEA96 model did not provide 20 Hz spectral acceleration values, and the method proposed by Boore was used to interpolate a 20 Hz value for use in the point estimates.

McGarr, 1984. I used McGarr's model for horizontal PGV estimates only, in the distance range of 20 km and less and for magnitudes of 7 and less (McGarr, 1984 and McGarr,

personal communication, 1997). As it was developed for extensional regime data, no source correction was applied to this model, but the crustal transfer function was applied since McGarr's data set includes several California events.

Bennett, Murphy, and Barker, 1997 (Model 1). This model was developed using the underground nuclear explosion (UNE) data from the Nevada Test Site. Because Yucca Mountain is located in the immediate vicinity, the UNE data should be appropriate for the local crustal structure. UNE sources, however, differ from earthquake sources in a number of important ways. One difference is the large amount of surface wave energy generated in UNE data as a consequence of the shallow UNE burial. I do not believe that the spectral shape for this model is appropriate for earthquakes and therefore did not incorporate it into the calculations.

Bennett, Murphy, and Barker, 1997 (Model 2). Bennett et al., cognizant of the potential problems associated with Model 1, provided a model that is scaled to the spectral shape of Sadigh et al. (1997) at 10 km. This Bennett et al. Model 2 also contain the NTS-appropriate crustal attenuation. I judged this model to be the most applicable of the three Bennett et al. UNE models and applied it to a subset of the calculations, limited to certain magnitudes that most closely match the UNE yields. Bennett et al. provided a yield-magnitude relation; it shows that the UNE data are applicable for magnitude range less than 6. Due to the lack of close-in data in the UNE database, I chose to apply Model 2 to only the magnitude 5.8 events at distances of 20 km or greater (while UNE data are available at 10 km, this Model 2 is identical to the Sadigh et al. 1997 model at 10 km, and therefore would provide only redundant data). No crustal correction was applied, but a source correction was applied to the calculations. Typically, I gave this model half of the weight of the other empirical models.

Bennett, Murphy, and Barker, (Model 3). This version of the Bennett et al. models used the Little Skull Mountain earthquake spectrum to scale the UNE attenuation. I chose not to use this model due to this event's small size (not much long-period energy) and somewhat unusual spectral shape.

Campbell Hybrid Empirical Model (1997). Campbell developed a methodology to combine estimates from different empirical models with varying weights, including theoretical crustal

and source corrections as outlined above. I chose not to use this model directly, although the concept of weighting the empirical models within the class and applying crustal and source corrections is quite similar to this model. The hybrid empirical model does not include any models that are not outlined above, therefore no information is lost by combining the various models in the way I chose as opposed to the perhaps more elegant hybrid empirical approach.

F7-2.2.2 Numerical Simulations. There are two types of proponent models that are numerical simulations of ground motion at the YM300 site. Silva developed a stochastic point source approach which can be viewed as a baseline for comparison to the more sophisticated finite-fault simulations. My use of these models in the ground motion calculations is outlined below.

F7-2.2.2.1 Point Source Simulation. Silva (Yucca Mountain Ground Motion Data Package, 1997) developed a band limited white noise/random vibration theory (BLWN/RVT) stochastic point source method for calculating ground motions from a point source. The methodology combines the effects of the point source, path operator, and site operator to predict site-specific ground motion. He provided spectral accelerations, PGA, and PGV values for the full suite of 51 cases, using the YM300 crustal model. I generally assigned the stochastic point source model a class weight of about 0.1. It received a lower weight for the cases of large magnitude and short distances, where it would tend to overpredict the ground motion, and for the long period (0.33 Hz, 0.5 Hz) estimates for most cases. This model did receive weight up to 0.2, however, in cases where there were few other numerical simulations to include in the point estimate. For example, only the Zeng/Anderson finite fault model provided estimates for magnitude 5.0 earthquakes, so the point source model received a higher class weight for those cases. Because this model was the only one in its class, its relative weight within the class is always 1.0. I applied the source correction factors for stress drop to this model, but did not apply a crustal correction. This model requires a stress drop variability which I assigned to be 0.5 natural log units based on the studies of stress drop variability by Becker (Ground Motion Data Package). The model also incorporates the epistemic uncertainties in the median stress drop and standard deviation which I assigned to be 0.2 natural log units for both based on the results from Becker and on judgment.

F7-2.2.2.2 Finite-Fault Simulations. There are three proponent models that use finite fault simulations of ground motions. In all three cases, these simulations were performed for the YM300 structure directly and no crustal correction was applied. This class of models generally received a class weight of 0.3 or 0.35, depending on the other available models and their limitations for the particular case. If only one finite fault simulation was available for a particular case, it was assigned a class weight of 0.2.

Zeng and Anderson, 1997 (ZA). The estimates from this model (described in the Yucca Mountain Ground Motion Data Package, 1997) were developed from the composite fractal finite fault source method developed and described by Zeng et al. (1994). Its validation has not included any normal faulting earthquakes, and like the other finite fault models, it has also not been thoroughly validated for vertical data. Zeng and Anderson provided predictions for the full suite of events and distances. I used the results for this model in all cases, although in some instances it received a lower weight than the other finite fault simulations. If no other finite fault simulation was available for a particular case, the ZA model received a weight of 1.0 and its overall contribution was controlled by the class weight for the finite fault class. In my judgment, this model produced excessively high predictions for normal faulting events on the hanging wall, and as Anderson (personal communication, 1997) agreed that many of them seemed high and did not offer an explanation as to the cause, I weighted the ZA model at half weight for all hanging wall estimates. In other specific cases, this model also received a lower weight because it was an outlier, that is, different from all of the other model predictions by a factor of 2 or more. I applied the source corrections (stress drops of 55 and 45 bars for strike-slip and normal events, respectively) with a median stress drop uncertainty of 0.2.

Somerville (1997). This model uses a combination of theoretical (at long period) and empirical (at short periods) Green's functions to calculate ground motions from a specified finite fault (Yucca Mountain Ground Motion Data Package, 1997). Due to limitations on the available empirical Green's functions, Somerville provided estimates for the events of magnitudes 5.8, 6.5, 7.0, and 7.5 only. Thus his model was not included in estimates for the magnitude 5.0 or 8.0 events. This model generally was weighted equally with the others within the class with the exception of outlier predictions. For this model, some very low ground motions were obtained at low frequencies for some events. I decreased the relative

weight of the Somerville model for those instances to half, or occasionally to 1/4, of the other finite fault models. In one or two cases this model was not included at all in the calculations because its prediction over the entire spectrum was extremely different from the other models (cases 31 and 32). The source corrections were applied as in the Anderson model.

Silva (1997). This model is an extension of the point-source stochastic method to finite faults (Yucca Mountain Ground Motion Data Package, 1997). Simulations were provided for all events except for the M5.0 cases. In general, the Silva model received a relative weight equal to the other finite fault simulations. Source corrections were also applied to this model in an analogous fashion to the other models.

F7-2.3 Model Weights: Vertical Models

The application of model weights for the vertical models was very similar to that of the horizontal models. The vertical ground motion at the desired frequency was calculated and crustal and source corrections applied. I used only models that included vertical motions and did not use vertical/horizontal motion ratios in order to include models developed only for horizontal motions. This practice resulted in a generally smaller number of models contributing to each weighted median ground motion estimate. In particular, there were often only a few models applicable for vertical PGV.

The crustal correction developed by Campbell is applicable to horizontal motions only, so I developed an alternative approach for calculating the vertical ground motions while incorporating the crustal transfer function. In this procedure, the horizontal ground motions were scaled by the crustal correction factors and then scaled by the Yucca Mountain point source vertical/horizontal ratios. This method was applied to empirical models only (because the numerical simulations were done directly for the YM300 structure), and will be described in section 2.3.1.

The class weights for the vertical motions are generally the same as for the horizontal motions. Because there are fewer available data and models, the epistemic uncertainty is typically higher for the vertical; this will be discussed below in the uncertainty section.

F7-2.3.1 Empirical Models. There are four proponent empirical models that provide vertical attenuation relations: Abrahamson and Silva (1997), Campbell (1997), Sadigh et al. (1997) and Sabetta and Pugliese (1996). The SP96 model was used only for peak ground velocity. The Campbell model also provides PGV but the AS97 and Sa97 models do not, thus the number of empirical models used for vertical PGV was small.

The class weight for the empirical models is typically 0.6 - 0.7.

To apply the Campbell crustal correction, developed for horizontal motions, to the vertical data, I used the following simple method. Silva provided the ground motion experts with vertical to horizontal (z/h) ratios for the stochastic point source calculations. I started with the *horizontal* prediction for the empirical model and multiplied it by the horizontal crustal correction and then the appropriate point source z/h ratio to produce a crust-corrected vertical ground motion estimate. Both the aleatory and epistemic uncertainties were increased for model estimates obtained with this procedure; more explanation is given in the uncertainty section below.

The AS97, Campbell, and Sadigh models generally received equal weights within the empirical class. Exceptions are similar to those for the horizontals as described above. Each model's range of applicability is the same for vertical motions as it is for horizontal motions.

F7-2.3.2 Numerical Simulations. Three of the four numerical simulation proponent models provided vertical ground motion estimates. These were used as the horizontals, with source corrections but no crustal corrections. The class weights were assigned in a manner analogous to the horizontal estimates.

F7-2.3.2.1 Point Source Simulation. Silva provided z/h ratios for the stochastic point source simulations to convert the horizontal to vertical estimates. The class weight for the point source model is typically 0.1 as discussed above. This model is applicable to all of the spectral amplitudes, PGA, and PGV. Deviations from the standard weighting scheme are as for the horizontal components.

F7-2.3.2.2 Finite Fault Simulations. The Zeng and Anderson and Somerville models provided vertical component estimates, while the Silva model did not. The ZA and Somerville model weights were applied as for the horizontal estimates described above. The Somerville model is not applicable for magnitude 5.0 or 8.0 events, therefore for these event sizes the ZA model is alone in this model class. In these cases, the class weights were adjusted so that typically the empirical model class would receive a relative weight of 0.6 with the point source and ZA models assigned 0.2 each. Exceptions to the general weighting scheme are chiefly for data outliers as discussed above for the horizontal components.

F7-3 ADJUSTMENTS TO WEIGHTED ESTIMATES

Case-specific adjustments to the weighted estimates were made based on judgement.

F7-4 ESTIMATES OF UNCERTAINTIES

Three types of uncertainty were calculated for each median ground motion estimate. The FORTRAN program WT_AVE (Yucca Mountain Ground Motion Data Package, 1997) was used to provide statistical calculations of all three uncertainty values. The expert was provided the opportunity in the input file to WT_AVE to add additional uncertainty to that provided by the model proponent in any of the three uncertainty categories. These additions will be discussed below.

F7-4.1 Aleatory Uncertainty: σ

The aleatory uncertainty for each point estimate was calculated as a weighted average of the stated uncertainty for each model. The effect of the random horizontal component was included in this uncertainty for the appropriate model using the method recommended by Boore et al. (1993). The finite fault simulations include both parametric and modeling uncertainty in this term, while the empirical models typically provide a single number for uncertainty.

For the vertical component empirical and stochastic point source estimates, additional aleatory uncertainty associated with the regression fit to the point source z/h ratios was added (assuming no correlation) to the aleatory uncertainty. The proponents of the numerical

simulations did not provide uncertainty estimates specific for the vertical components. To convert the horizontal aleatory uncertainty to a value appropriate for the vertical component, I used the horizontal uncertainty value (without random effect) and multiplied it by an average vertical/horizontal uncertainty ratio determined from the applicable empirical relationships.

F7-4.2 Epistemic Uncertainty For Median Point Estimate: σ_μ

The FORTRAN program WT_AVE calculates statistical values of the epistemic uncertainty on the median point estimate. For the horizontal components, I assigned epistemic uncertainty to have several components: 1) effect of uncertainty in crustal correction, 2) effect of uncertainty in source correction (as quantified by an uncertainty in median stress drop of 0.2) and 3) additional added uncertainty for some models. This additional assigned epistemic uncertainty included 0.1 for the SP97 model due to increased uncertainty in crustal structure, and 0.2 assigned to the numerical simulations that did not provide epistemic uncertainty estimates: stochastic point source, ZA, and Silva finite fault. The 0.2 value is similar to that obtained for the empirical models and is the same as Somerville value assigned from his expert judgment.

Each model thus has an epistemic uncertainty value assigned to it. In addition, the effect of the weighted deviation of each individual model from the median is included using standard statistics. The weighted individual model epistemic uncertainty estimates and the deviation effect are combined as documented by N. Abrahamson at the April, 1997 ground motion workshop. I have additionally defined a floor value for epistemic uncertainty of 0.2, such that if the calculation produces a value of less than 0.2, it is adjusted upward to 0.2.

For the vertical estimates, I included all of the above uncertainties, with some additions. I defined the σ_μ for the finite fault and point source simulations to be 0.3 rather than the 0.2 used for the horizontals, because due to lack of data and modeling efforts for vertical ground motions there is more uncertainty associated with these estimates that could be reduced given additional information. I also assigned additional epistemic uncertainty of 0.2 above the statistical crustal and source corrections to the empirical models. This is meant to incorporate the additional uncertainty of applying the point source z/h ratio and the horizontal crustal transfer function. The deviation from the median part of the epistemic uncertainty

was included in the vertical estimate as well, with a total floor of 0.3 for any vertical σ_μ value.

F7-4.3 Epistemic Uncertainty In Aleatory Uncertainty: σ_σ

The epistemic uncertainty associated with the aleatory uncertainty was also calculated via the FORTRAN program WT_AVE. Here the main component is the variability in the σ estimates from model to model. A component was also included to allow inclusion of individual σ_σ estimates for each model, however only the Somerville finite fault model provided a σ_σ estimate, so in order to avoid model bias I did not include a contribution in this term. The vertical σ_σ computations were done in a manner analogous to the horizontal σ_σ.

F7-5 FINAL POINT ESTIMATES OF GROUND MOTION FOR THE 51 CASES

Tables F7-1 to F7-9 contain my horizontal component point estimates for the 51 cases, 9 frequencies. Tables F7-10 to F7-18 contain my vertical component point estimates. For each of the 918 event-frequency-component combinations, the four ground motion parameters (median and three uncertainties) are presented.

F7-6 EVALUATION OF REGRESSION FIT TO POINT ESTIMATES

The facilitation team applied regression models to all four ground motion parameters for each case, frequency, and component and provided plots of the regression results for my approval. In general, the regression fits were very satisfactory representations of my point estimates.

F7-6.1 Median Estimate: μ

Illustrations and tables elsewhere in this report present the results of the regressions on the 918 median ground motion estimates. In general, these regression lines are a good representation of my results. The regression lines for the peak velocity values do not always fit the data as well as the other spectral points; this could reflect greater uncertainty in the peak velocity values themselves due to fewer contributing models and less experience in predicting peak velocities.

With my approval, the effects of the hanging wall and foot wall were included in the normal faulting regressions. The hanging wall effect is a "bump" between 3 and 20 km, which increases with increasing magnitude. The foot wall effect is a more subtle trough in the regression relation at the same distance. There were no foot wall calculations for the magnitude 5.0 events. The hanging wall effect for magnitude 5.8 events is rather small and increases rapidly with size. The effect at magnitude 8.0, however, is unknown because no point estimates were made for normal faulting earthquakes at this large magnitude.

F7-6.2 Aleatory Uncertainty: σ

The facilitation team also provided regressions for the aleatory uncertainty. In all cases, the σ values decrease with increasing magnitude, and are generally tightly clustered for the horizontal estimates, with more scatter evident for the vertical estimates. In all cases the regressions provide a good representation of my σ estimates.

F7-6.3 Epistemic Uncertainty In The Median: σ_μ

The epistemic uncertainty regressions provide the most challenge in the regression process, as the statistical values are generally quite scattered. Each expert was offered the opportunity to specify σ_μ values as functions of magnitude and distance and/or to specify the functional form used in the regression. Generally, the epistemic uncertainty values are higher at small and large distance, and have a minimum around 10-20 km distance. This may reflect the larger body of data available for developing experience in the medium distance range. A magnitude dependence is not well defined therefore I chose a magnitude-independent regression. A quadratic distance dependence is appropriate for these data. In general, the σ_μ value for a given event-frequency-component combination has a fairly large uncertainty associated with it due to the large scatter around the regression curve.

F7-6.4 Epistemic Uncertainty In The Aleatory Uncertainty: σ_σ

The regressions for the uncertainty in the aleatory uncertainty are simple in form and generally have tightly clustered data that adequately define the regression line. The σ_σ values generally increase with magnitude, and, like the σ values themselves, there is considerably more scatter in the vertical σ_σ values than the horizontal values. The effect of distance is very small on this parameter. The regression lines are a good representation of the σ_σ estimates.

F7-7 SPECIAL CASE FAULT RUPTURE SCENARIOS

The experts were asked to provide rule revisions for two special cases of fault rupture: multiple parallel faults and a low-angle normal fault.

F7-7.1 Multiple Parallel Faults

The multiple parallel fault scenario consists of three or more parallel normal faults dipping at 60 degrees that all rupture essentially simultaneously. One example would be three magnitude 6.5 events that would have a combined moment magnitude of about 6.8. Paul Somerville provided a simulation of peak ground acceleration (Yucca Mountain Ground Motion Data Package, 1997) using his finite fault model for evaluating the effects of the multiple fault rupture. He determined that in all cases the three faults rupturing simultaneously resulted in higher ground motions than one magnitude 6.8 at the closest equivalent distance. Unfortunately, no simulation data is available for evaluating frequencies other than PGA.

As a distance measure for parallel multiple faults, I recommend using the rupture distance modified to be the distance to the closest fault rupture of all the available faults.

For predicting ground motion amplitudes, I recommend summing the ground motions for the multiple events incoherently (square root of the sum of the squares, or SRSS). In coming to this conclusion, I examined the relative ground motions at the relevant frequencies for a multiple fault scenario using the AS97 model. I compared the SRSS for a magnitude 6.5 at 1 km (foot wall), a magnitude 6.5 at 1 km (hanging wall) and a magnitude 6.5 at 5 km (hanging wall) to a single magnitude 6.8 event at 1 km (hanging wall). I also examined coherently adding the ground motions of these three events, which resulted in very high ground motions. The PGA for the single 6.8 event is about 35% lower than the SRSS combined amplitudes. This is quite similar to the Somerville prediction for a similar situation. The difference between the single 6.8 and the SRSS of the three 6.5s decreased with decreasing frequency, however the SRSS value is still significantly higher than that of the single 6.8 down to 0.33 Hz, by about 25-30%. Thus using the SRSS-combined events is consistent with the available modeling, and because the degree of coherency expected among the multiple faults at low

frequencies is unknown and certain to vary due to interevent timing differences, the SRSS approach should provide an adequate estimate of expected ground motion amplitudes.

I also recommend increasing the epistemic uncertainty for such a calculation by 0.1 at frequencies at and above 1 Hz, and by 0.2 for frequencies below 1 Hz.

F7-7.2 Low Angle Fault

A low angle normal fault rupture could occur in an area where a detachment fault exists. Unfortunately, while there are very few actual ground motion data for normal faults in general, there are none of which I am aware for low-angle normal faults. While thrust faults have shallower dips than normal faults, they are widely known to produce higher ground motions than strike-slip events, thus it is unlikely that a thrust-fault-based estimate would be appropriate for a low-angle normal fault in an extensional regime.

I recommend using the Yucca Mountain attenuation relations as they stand for a low-angle normal fault. The distance measure can also remain the same. Due to the high level of uncertainty stemming from lack of data, it is appropriate to increase the epistemic uncertainty on the median by 0.25 for all frequencies for the case of a low-angle normal fault.

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TABLE F7-1
M. C. WALCK: HORIZONTAL POINT ESTIMATES
PEAK GROUND ACCELERATION

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.15747	0.69327	0.35738	0.16200
2	5.00	1	0.14893	0.69514	0.35111	0.16200
3	5.00	5	0.05358	0.68368	0.32129	0.16400
4	5.00	5	0.05457	0.68461	0.32675	0.16400
5	5.80	10	0.09241	0.59828	0.25933	0.16400
6	5.80	20	0.06166	0.59607	0.26755	0.16400
7	6.50	1	0.38852	0.57062	0.36402	0.16900
8	6.50	1	0.35251	0.56816	0.41030	0.16900
9	6.50	1	0.33806	0.57273	0.39394	0.16900
10	6.50	5	0.30374	0.56602	0.36025	0.16800
11	6.50	5	0.21798	0.57258	0.32663	0.16900
12	6.50	50	0.02796	0.56754	0.29064	0.16800
13	6.50	50	0.02521	0.56492	0.29747	0.16700
14	7.00	10	0.23732	0.53881	0.29775	0.17400
15	7.50	50	0.05798	0.53528	0.25147	0.18000
16	7.50	50	0.05518	0.53230	0.25711	0.17900
17	5.00	1	0.06367	0.68896	0.29045	0.16500
18	5.80	5	0.13394	0.59970	0.30801	0.16400
19	5.80	5	0.08310	0.60148	0.30195	0.16400
20	5.00	10	0.06425	0.67839	0.27113	0.16300
21	5.00	10	0.07225	0.68274	0.27208	0.16400
22	5.00	50	0.00604	0.69758	0.30799	0.16000
23	5.00	50	0.00591	0.70637	0.32378	0.15900
24	5.00	160	0.00073	0.69766	0.32037	0.16300
25	5.80	1	0.25740	0.59919	0.37730	0.16500
26	5.80	5	0.19424	0.59512	0.33244	0.16400
27	5.80	5	0.12500	0.59805	0.32680	0.16400
28	5.80	10	0.11239	0.60162	0.27836	0.16500
29	5.80	10	0.13403	0.59540	0.28374	0.16400
30	5.80	10	0.07770	0.59884	0.33817	0.16500
31	5.80	50	0.01418	0.61013	0.33151	0.16200
32	5.80	50	0.01352	0.61205	0.38770	0.16200
33	6.50	5	0.28357	0.56900	0.33092	0.16800
34	6.50	10	0.18387	0.57035	0.30849	0.16900
35	6.50	10	0.22646	0.56756	0.34523	0.16800
36	6.50	10	0.13907	0.56837	0.30764	0.16800
37	6.50	20	0.09308	0.56761	0.27556	0.16800
38	6.50	20	0.10799	0.56864	0.30814	0.16800
39	6.50	20	0.06954	0.56632	0.28629	0.16800
40	6.50	100	0.01204	0.57210	0.36945	0.16200
41	6.50	160	0.00530	0.57536	0.46762	0.17000
42	7.00	1	0.44383	0.53927	0.30919	0.17300
43	7.00	10	0.27758	0.54277	0.34186	0.17600
44	7.00	10	0.17595	0.53825	0.29134	0.17400
45	7.00	50	0.04299	0.53911	0.27352	0.17000
46	7.00	50	0.04130	0.54645	0.25922	0.17400
47	7.50	1	0.49124	0.53707	0.35613	0.18800
48	5.00	10	0.27890	0.52712	0.29747	0.18300
49	5.00	10	0.31205	0.52791	0.41191	0.18100
50	8.00	50	0.07557	0.54384	0.27652	0.18200
51	8.00	160	0.01943	0.53130	0.35089	0.17800

TABLE F7-2
M. C. WALCK: 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	0.32745	0.69777	0.41292	0.16100
2	5.00	1	0.30646	0.69872	0.27924	0.16100
3	5.00	5	0.10396	0.69224	0.37626	0.16100
4	5.00	5	0.10347	0.69318	0.30920	0.16100
5	5.80	10	0.15904	0.60472	0.29881	0.16400
6	5.80	20	0.10212	0.59889	0.29471	0.16400
7	6.50	1	0.67480	0.57475	0.35986	0.16900
8	6.50	1	0.61859	0.57152	0.38692	0.16900
9	6.50	1	0.58774	0.57457	0.38506	0.16900
10	6.50	5	0.54050	0.56827	0.37543	0.16800
11	6.50	5	0.38410	0.57301	0.38250	0.16900
12	6.50	50	0.03878	0.57064	0.33608	0.16800
13	6.50	50	0.03524	0.56754	0.36609	0.16800
14	7.00	10	0.38863	0.53927	0.30178	0.17500
15	7.50	50	0.07473	0.53857	0.31567	0.17700
16	7.50	50	0.07176	0.53858	0.32265	0.17700
17	5.00	1	0.12690	0.69842	0.31469	0.16100
18	5.80	5	0.22890	0.60281	0.33491	0.16300
19	5.80	5	0.14020	0.60523	0.33843	0.16400
20	5.00	10	0.12307	0.69364	0.30121	0.16000
21	5.00	10	0.14356	0.69224	0.28780	0.16100
22	5.00	50	0.01023	0.69524	0.40966	0.16200
23	5.00	50	0.01022	0.70547	0.42930	0.16100
24	5.00	160	0.00111	0.69842	0.35969	0.16700
25	5.80	1	0.46464	0.60265	0.41041	0.16400
26	5.80	5	0.35141	0.60075	0.36053	0.16500
27	5.80	5	0.22026	0.60424	0.42546	0.16500
28	5.80	10	0.19522	0.60634	0.32292	0.16500
29	5.80	10	0.23177	0.59910	0.31638	0.16400
30	5.80	10	0.13811	0.60313	0.43254	0.16400
31	5.80	50	0.02068	0.61316	0.38131	0.16300
32	5.80	50	0.02015	0.61135	0.46664	0.16300
33	6.50	5	0.49601	0.56957	0.31995	0.16800
34	6.50	10	0.32009	0.57524	0.30129	0.17000
35	6.50	10	0.39796	0.56974	0.37291	0.16800
36	6.50	10	0.23872	0.57337	0.36340	0.16900
37	6.50	20	0.15103	0.57323	0.28855	0.16900
38	6.50	20	0.17874	0.57152	0.33335	0.16900
39	6.50	20	0.11310	0.57009	0.36390	0.16200
40	6.50	100	0.01441	0.56538	0.42257	0.16200
41	6.50	160	0.00658	0.56838	0.52760	0.16700
42	7.00	1	0.76340	0.54120	0.33536	0.17500
43	7.00	10	0.47397	0.54504	0.39241	0.17800
44	7.00	10	0.29186	0.54010	0.35777	0.17500
45	7.00	50	0.05792	0.53954	0.31750	0.17100
46	7.00	50	0.05688	0.54780	0.31097	0.17500
47	7.50	1	0.82750	0.53667	0.40126	0.18700
48	5.00	10	0.45640	0.54122	0.34733	0.18400
49	5.00	10	0.50871	0.53438	0.47077	0.17800
50	8.00	50	0.09575	0.54949	0.34048	0.18000
51	8.00	160	0.02069	0.52843	0.43869	0.17900

TABLE F7-3
M. C. WALCK: 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	0.33655	0.71877	0.29022	0.15900
2	5.00	1	0.31895	0.71684	0.32724	0.15800
3	5.00	5	0.11180	0.71040	0.26946	0.16000
4	5.00	5	0.11507	0.70944	0.32592	0.16000
5	5.80	10	0.16513	0.62111	0.30300	0.16700
6	5.80	20	0.11928	0.61750	0.29574	0.16700
7	6.50	1	0.76878	0.59229	0.38578	0.17400
8	6.50	1	0.71468	0.58667	0.44479	0.17300
9	6.50	1	0.68548	0.59338	0.42280	0.17500
10	6.50	5	0.60124	0.58317	0.38448	0.17100
11	6.50	5	0.43719	0.59112	0.32329	0.17400
12	6.50	50	0.05011	0.58826	0.33069	0.17300
13	6.50	50	0.04542	0.58423	0.30204	0.17200
14	7.00	10	0.41550	0.55633	0.31393	0.17900
15	7.50	50	0.09523	0.55001	0.33531	0.18400
16	7.50	50	0.09276	0.54336	0.32893	0.18000
17	5.00	1	0.13085	0.70790	0.23968	0.16000
18	5.80	5	0.24562	0.62428	0.31138	0.16600
19	5.80	5	0.14893	0.62740	0.30640	0.16600
20	5.00	10	0.13666	0.71290	0.25060	0.15900
21	5.00	10	0.15192	0.70654	0.27228	0.15900
22	5.00	50	0.01282	0.72578	0.30656	0.15600
23	5.00	50	0.01252	0.72608	0.32780	0.15600
24	5.00	160	0.00135	0.72545	0.36412	0.15900
25	5.80	1	0.46931	0.62363	0.38041	0.16800
26	5.80	5	0.37000	0.61710	0.29742	0.16700
27	5.80	5	0.24561	0.62312	0.34714	0.16800
28	5.80	10	0.19745	0.62256	0.29084	0.16800
29	5.80	10	0.24013	0.61671	0.24891	0.16700
30	5.80	10	0.13956	0.61803	0.36625	0.16600
31	5.80	50	0.02105	0.64240	0.44083	0.16500
32	5.80	50	0.02420	0.63434	0.37988	0.16500
33	6.50	5	0.56819	0.59033	0.34507	0.17300
34	6.50	10	0.36498	0.58976	0.32182	0.17300
35	6.50	10	0.45543	0.58429	0.39613	0.17200
36	6.50	10	0.27384	0.58913	0.29071	0.17300
37	6.50	20	0.17989	0.58640	0.31475	0.17100
38	6.50	20	0.20550	0.58572	0.31885	0.17200
39	6.50	20	0.13300	0.58773	0.27961	0.16900
40	6.50	100	0.01894	0.58413	0.43051	0.16300
41	6.50	160	0.00783	0.58750	0.49137	0.16800
42	7.00	1	0.82210	0.55754	0.31198	0.18600
43	7.00	10	0.50176	0.55891	0.35060	0.18200
44	7.00	10	0.31152	0.55683	0.27988	0.18000
45	7.00	50	0.06652	0.55849	0.36973	0.17700
46	7.00	50	0.06517	0.56111	0.31139	0.17900
47	7.50	1	0.93462	0.55758	0.38943	0.19400
48	5.00	10	0.52804	0.55146	0.35314	0.18800
49	5.00	10	0.58427	0.54481	0.44174	0.19000
50	8.00	50	0.11668	0.56637	0.37581	0.18800
51	8.00	160	0.02374	0.55357	0.41943	0.18400

TABLE F7-4
M. C. WALCK: 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	0.25013	0.74571	0.30485	0.15000
2	5.00	1	0.23865	0.74760	0.34933	0.15000
3	5.00	5	0.08854	0.73459	0.26480	0.15100
4	5.00	5	0.09155	0.73365	0.29509	0.15200
5	5.80	10	0.16983	0.65616	0.25248	0.16300
6	5.80	20	0.11554	0.64789	0.29625	0.16100
7	6.50	1	0.70354	0.62146	0.39807	0.17000
8	6.50	1	0.64469	0.62205	0.44509	0.17100
9	6.50	1	0.62409	0.63182	0.43766	0.17500
10	6.50	5	0.55352	0.61791	0.39052	0.17000
11	6.50	5	0.41151	0.62389	0.31071	0.17100
12	6.50	50	0.05527	0.62160	0.34725	0.17000
13	6.50	50	0.05048	0.61559	0.28077	0.16900
14	7.00	10	0.44910	0.58967	0.32624	0.17700
15	7.50	50	0.11225	0.58207	0.35640	0.17800
16	7.50	50	0.10926	0.57658	0.33698	0.17600
17	5.00	1	0.10364	0.73607	0.22682	0.15300
18	5.80	5	0.23346	0.65466	0.32112	0.16100
19	5.80	5	0.15447	0.65819	0.29528	0.16100
20	5.00	10	0.10765	0.73311	0.24164	0.15000
21	5.00	10	0.12641	0.73365	0.27240	0.15200
22	5.00	50	0.01218	0.75535	0.25559	0.14700
23	5.00	50	0.01121	0.75333	0.30631	0.14800
24	5.00	160	0.00158	0.76487	0.32903	0.15100
25	5.80	1	0.43968	0.65283	0.40415	0.16200
26	5.80	5	0.33978	0.64741	0.33800	0.16200
27	5.80	5	0.22173	0.65332	0.29380	0.16200
28	5.80	10	0.19720	0.65519	0.29763	0.16300
29	5.80	10	0.23340	0.64770	0.31001	0.16200
30	5.80	10	0.14015	0.65486	0.26688	0.16200
31	5.80	50	0.02748	0.67622	0.28952	0.15900
32	5.80	50	0.02646	0.66936	0.31769	0.15900
33	6.50	5	0.52459	0.62010	0.35504	0.16900
34	6.50	10	0.33960	0.62373	0.31006	0.17100
35	6.50	10	0.41266	0.61916	0.36050	0.17000
36	6.50	10	0.26587	0.61950	0.28059	0.16900
37	6.50	20	0.17721	0.62207	0.29211	0.17200
38	6.50	20	0.21091	0.61666	0.33768	0.16900
39	6.50	20	0.13709	0.62130	0.25582	0.17000
40	6.50	100	0.02370	0.61930	0.39592	0.16500
41	6.50	160	0.01064	0.62699	0.44743	0.16600
42	7.00	1	0.82620	0.59000	0.35074	0.17700
43	7.00	10	0.52239	0.58988	0.37419	0.17800
44	7.00	10	0.34447	0.58827	0.28105	0.17600
45	7.00	50	0.08668	0.59385	0.37181	0.17500
46	7.00	50	0.08283	0.59424	0.31205	0.17700
47	7.50	1	0.94092	0.58805	0.41872	0.18600
48	5.00	10	0.54929	0.58670	0.37104	0.18500
49	5.00	10	0.58369	0.57502	0.43161	0.17700
50	8.00	50	0.13717	0.59726	0.36255	0.18000
51	8.00	160	0.03448	0.59114	0.38604	0.17700

TABLE F7-5
M. C. WALCK: 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	0.11039	0.80160	0.34495	0.12700
2	5.00	1	0.11046	0.79695	0.38764	0.12700
3	5.00	5	0.04213	0.78831	0.27237	0.13000
4	5.00	5	0.04489	0.78552	0.28880	0.13000
5	5.80	10	0.10526	0.71665	0.25882	0.15500
6	5.80	20	0.07631	0.71435	0.27086	0.15600
7	6.50	1	0.51424	0.68397	0.27234	0.16900
8	6.50	1	0.46582	0.67902	0.30448	0.16900
9	6.50	1	0.44663	0.68836	0.29872	0.17200
10	6.50	5	0.39892	0.68177	0.27747	0.17000
11	6.50	5	0.28652	0.68411	0.26640	0.16900
12	6.50	50	0.04598	0.68780	0.29308	0.17100
13	6.50	50	0.04260	0.67773	0.28831	0.16900
14	7.00	10	0.35757	0.65225	0.30192	0.17900
15	7.50	50	0.11236	0.64437	0.27670	0.17900
16	7.50	50	0.10653	0.63609	0.27229	0.17600
17	5.00	1	0.04925	0.78572	0.23161	0.13200
18	5.80	5	0.15782	0.72325	0.27443	0.15400
19	5.80	5	0.09331	0.72727	0.28783	0.15400
20	5.00	10	0.04873	0.78347	0.23432	0.12700
21	5.00	10	0.05659	0.78275	0.27918	0.13000
22	5.00	50	0.00661	0.80633	0.23097	0.12100
23	5.00	50	0.00677	0.81342	0.22079	0.12100
24	5.00	160	0.00141	0.80973	0.24169	0.12300
25	5.80	1	0.27984	0.71461	0.31148	0.15400
26	5.80	5	0.22026	0.71142	0.31178	0.15600
27	5.80	5	0.13672	0.71060	0.28586	0.15300
28	5.80	10	0.12722	0.71777	0.27544	0.15600
29	5.80	10	0.15738	0.71011	0.29657	0.15300
30	5.80	10	0.08649	0.71536	0.30012	0.15300
31	5.80	50	0.02041	0.74643	0.27397	0.14500
32	5.80	50	0.01931	0.74361	0.32748	0.14600
33	6.50	5	0.37861	0.68293	0.30669	0.16900
34	6.50	10	0.25004	0.69312	0.30991	0.16900
35	6.50	10	0.30967	0.68854	0.32048	0.16900
36	6.50	10	0.18707	0.68285	0.28680	0.16900
37	6.50	20	0.13079	0.68413	0.28848	0.16600
38	6.50	20	0.15485	0.68360	0.29918	0.17100
39	6.50	20	0.10309	0.68327	0.24284	0.16900
40	6.50	100	0.02357	0.68660	0.35592	0.16600
41	6.50	160	0.01203	0.68935	0.50722	0.16300
42	7.00	1	0.65664	0.65013	0.27392	0.17800
43	7.00	10	0.42928	0.64941	0.33614	0.17900
44	7.00	10	0.26343	0.65221	0.26255	0.17900
45	7.00	50	0.07800	0.65740	0.29966	0.17800
46	7.00	50	0.07419	0.66071	0.30133	0.18100
47	7.50	1	0.73800	0.64770	0.29866	0.18800
48	5.00	10	0.44275	0.64566	0.28266	0.18400
49	5.00	10	0.48336	0.63731	0.38897	0.17900
50	8.00	50	0.14844	0.66084	0.27606	0.17700
51	8.00	160	0.05004	0.66096	0.37236	0.17200

TABLE F7-6
M. C. WALCK: 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	0.04240	0.90227	0.26394	0.12400
2	5.00	1	0.04511	0.89384	0.38188	0.12900
3	5.00	5	0.01702	0.82882	0.21964	0.10700
4	5.00	5	0.01845	0.82882	0.25495	0.10700
5	5.80	10	0.05194	0.77611	0.24690	0.13600
6	5.80	20	0.03915	0.76766	0.26170	0.14000
7	6.50	1	0.29071	0.74524	0.21867	0.16000
8	6.50	1	0.26180	0.74327	0.31514	0.16300
9	6.50	1	0.25574	0.74499	0.28978	0.16400
10	6.50	5	0.22943	0.74246	0.28014	0.16200
11	6.50	5	0.15551	0.74085	0.33034	0.16100
12	6.50	50	0.02961	0.73550	0.29476	0.16000
13	6.50	50	0.02758	0.74207	0.30795	0.16200
14	7.00	10	0.20999	0.70235	0.25464	0.17600
15	7.50	50	0.07920	0.69302	0.27814	0.17800
16	7.50	50	0.07820	0.69742	0.28205	0.18000
17	5.00	1	0.01966	0.83187	0.20000	0.11000
18	5.80	5	0.08207	0.78980	0.41204	0.14400
19	5.80	5	0.04702	0.78768	0.34359	0.14100
20	5.00	10	0.01882	0.82546	0.20000	0.10500
21	5.00	10	0.02314	0.81392	0.22509	0.11300
22	5.00	50	0.00283	0.83808	0.30103	0.09800
23	5.00	50	0.00306	0.84839	0.21956	0.09700
24	5.00	160	0.00087	0.85116	0.20000	0.09700
25	5.80	1	0.13646	0.77959	0.32270	0.13800
26	5.80	5	0.11043	0.76846	0.34796	0.13700
27	5.80	5	0.06594	0.77779	0.36178	0.14000
28	5.80	10	0.06103	0.77758	0.25363	0.13700
29	5.80	10	0.07928	0.76959	0.28937	0.13200
30	5.80	10	0.04523	0.76876	0.31707	0.14300
31	5.80	50	0.01093	0.78853	0.25215	0.12900
32	5.80	50	0.01124	0.79169	0.23834	0.13200
33	6.50	5	0.20133	0.74794	0.26541	0.16100
34	6.50	10	0.14162	0.74507	0.29900	0.16000
35	6.50	10	0.18376	0.74018	0.31947	0.16100
36	6.50	10	0.10475	0.74050	0.30865	0.16000
37	6.50	20	0.07433	0.74096	0.26036	0.15900
38	6.50	20	0.08610	0.74314	0.32253	0.16300
39	6.50	20	0.05877	0.74179	0.29597	0.16700
40	6.50	100	0.01558	0.73628	0.31868	0.16000
41	6.50	160	0.00966	0.73900	0.54121	0.14500
42	7.00	1	0.36082	0.70909	0.28703	0.17500
43	7.00	10	0.25392	0.70719	0.33867	0.17700
44	7.00	10	0.15837	0.70422	0.30564	0.17500
45	7.00	50	0.05020	0.71254	0.33456	0.17600
46	7.00	50	0.05052	0.71948	0.31899	0.17900
47	7.50	1	0.44211	0.69949	0.36243	0.18000
48	5.00	10	0.28308	0.69870	0.28780	0.18000
49	5.00	10	0.31676	0.69201	0.43455	0.17700
50	8.00	50	0.11233	0.69906	0.28918	0.18100
51	8.00	160	0.04627	0.71335	0.40257	0.17700

TABLE F7-7
M. C. WALCK: 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	0.01223	0.90638	0.34180	0.10000
2	5.00	1	0.01321	0.89520	0.36787	0.10800
3	5.00	5	0.00528	0.88594	0.29770	0.10900
4	5.00	5	0.00570	0.89246	0.26458	0.10800
5	5.80	10	0.02067	0.85748	0.35377	0.13500
6	5.80	20	0.01499	0.85396	0.36901	0.14300
7	6.50	1	0.13034	0.82080	0.25445	0.16100
8	6.50	1	0.11916	0.80747	0.25991	0.16400
9	6.50	1	0.11032	0.81599	0.27063	0.16700
10	6.50	5	0.09622	0.81345	0.29630	0.16900
11	6.50	5	0.07555	0.81716	0.31728	0.16700
12	6.50	50	0.01519	0.82594	0.35863	0.16000
13	6.50	50	0.01340	0.82717	0.47154	0.16400
14	7.00	10	0.10179	0.78901	0.29082	0.18900
15	7.50	50	0.04994	0.76822	0.38285	0.19700
16	7.50	50	0.04513	0.75873	0.48182	0.19400
17	5.00	1	0.00641	0.88717	0.22050	0.11100
18	5.80	5	0.03367	0.84574	0.37031	0.13800
19	5.80	5	0.02093	0.85015	0.36627	0.13800
20	5.00	10	0.00617	0.88416	0.20623	0.10700
21	5.00	10	0.00719	0.87819	0.24130	0.11900
22	5.00	50	0.00104	0.90441	0.27672	0.08900
23	5.00	50	0.00104	0.91271	0.31086	0.08900
24	5.00	160	0.00046	0.91556	0.20328	0.08900
25	5.80	1	0.05259	0.85720	0.26004	0.13900
26	5.80	5	0.04239	0.83249	0.31911	0.13900
27	5.80	5	0.02943	0.83930	0.33057	0.14700
28	5.80	10	0.02336	0.85634	0.31988	0.14100
29	5.80	10	0.02839	0.84907	0.34359	0.14900
30	5.80	10	0.02035	0.84789	0.33901	0.13900
31	5.80	50	0.00455	0.86675	0.51464	0.12300
32	5.80	50	0.00495	0.87496	0.41651	0.12900
33	6.50	5	0.09457	0.82003	0.25276	0.16000
34	6.50	10	0.06361	0.82054	0.26612	0.16100
35	6.50	10	0.07657	0.81449	0.29887	0.17000
36	6.50	10	0.04914	0.82363	0.36406	0.16500
37	6.50	20	0.03670	0.82377	0.28893	0.16300
38	6.50	20	0.04119	0.81470	0.33250	0.16200
39	6.50	20	0.02837	0.82255	0.40192	0.16800
40	6.50	100	0.00822	0.81432	0.40052	0.15200
41	6.50	160	0.00593	0.82032	0.63580	0.14600
42	7.00	1	0.18443	0.78293	0.26410	0.18400
43	7.00	10	0.11318	0.77324	0.34169	0.18700
44	7.00	10	0.07903	0.78909	0.36750	0.19100
45	7.00	50	0.02956	0.80019	0.31635	0.18800
46	7.00	50	0.02724	0.79772	0.40272	0.19000
47	7.50	1	0.22501	0.76600	0.34122	0.19800
48	5.00	10	0.14676	0.76436	0.40618	0.19400
49	5.00	10	0.15075	0.76181	0.46627	0.19400
50	8.00	50	0.07127	0.76747	0.32439	0.21300
51	8.00	160	0.03580	0.78183	0.47097	0.20500

TABLE F7-8
M. C. WALCK: 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	0.00464	0.93238	0.50526	0.10800
2	5.00	1	0.00501	0.90893	0.52239	0.11400
3	5.00	5	0.00205	0.92002	0.50603	0.11600
4	5.00	5	0.00224	0.92535	0.47386	0.11500
5	5.80	10	0.00966	0.85902	0.38489	0.13600
6	5.80	20	0.00619	0.85366	0.42506	0.14400
7	6.50	1	0.06970	0.82151	0.32286	0.18300
8	6.50	1	0.06360	0.79051	0.30294	0.16200
9	6.50	1	0.05945	0.80278	0.33343	0.17100
10	6.50	5	0.05077	0.79863	0.31533	0.17100
11	6.50	5	0.04285	0.80882	0.38311	0.17800
12	6.50	50	0.00829	0.83501	0.45752	0.17800
13	6.50	50	0.00639	0.81328	0.53040	0.17400
14	7.00	10	0.05767	0.79810	0.37422	0.20900
15	7.50	50	0.03143	0.78632	0.38707	0.22200
16	7.50	50	0.02608	0.78038	0.52036	0.22200
17	5.00	1	0.00270	0.89832	0.40974	0.11500
18	5.80	5	0.01369	0.86042	0.33063	0.15200
19	5.80	5	0.00861	0.86169	0.40556	0.14700
20	5.00	10	0.00256	0.91218	0.36592	0.11200
21	5.00	10	0.00282	0.90356	0.44487	0.12900
22	5.00	50	0.00048	0.93104	0.28253	0.08800
23	5.00	50	0.00044	0.93795	0.34788	0.09200
24	5.00	160	0.00017	0.94864	0.23141	0.08300
25	5.80	1	0.02510	0.85231	0.37156	0.13700
26	5.80	5	0.01938	0.84373	0.35537	0.15700
27	5.80	5	0.01446	0.84342	0.36839	0.14200
28	5.80	10	0.01138	0.85178	0.41367	0.13600
29	5.80	10	0.01132	0.83432	0.43811	0.13900
30	5.80	10	0.00935	0.84617	0.47177	0.14100
31	5.80	50	0.00222	0.88998	0.40918	0.12600
32	5.80	50	0.00217	0.87671	0.47531	0.12700
33	6.50	5	0.05288	0.82075	0.32841	0.18000
34	6.50	10	0.03385	0.81739	0.37672	0.17500
35	6.50	10	0.03492	0.79906	0.35211	0.17200
36	6.50	10	0.02619	0.81421	0.49206	0.17600
37	6.50	20	0.01845	0.81122	0.42856	0.16800
38	6.50	20	0.01848	0.82092	0.47534	0.18400
39	6.50	20	0.01482	0.80742	0.54931	0.16900
40	6.50	100	0.00381	0.82571	0.49493	0.15900
41	6.50	160	0.00321	0.86096	0.62653	0.16500
42	7.00	1	0.10849	0.78395	0.34419	0.19700
43	7.00	10	0.05689	0.76936	0.34807	0.19600
44	7.00	10	0.04346	0.78952	0.48616	0.20300
45	7.00	50	0.01778	0.79403	0.38366	0.20700
46	7.00	50	0.01515	0.79208	0.49211	0.21100
47	7.50	1	0.14280	0.78764	0.37969	0.21900
48	5.00	10	0.08623	0.79609	0.49034	0.22200
49	5.00	10	0.07976	0.79161	0.50733	0.21900
50	8.00	50	0.04748	0.79218	0.35157	0.24000
51	8.00	160	0.02279	0.82752	0.40694	0.22100

TABLE F7-9
M. C. WALCK: HORIZONTAL POINT ESTIMATES
PEAK GROUND VELOCITY

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	6.41921	0.69059	0.46971	0.14800
2	5.00	1	7.17257	0.67002	0.42351	0.14200
3	5.00	5	2.72278	0.67002	0.34900	0.14200
4	5.00	5	3.22851	0.66818	0.42848	0.14000
5	5.80	10	6.37310	0.71422	0.27348	0.16100
6	5.80	20	4.74515	0.71000	0.32044	0.16100
7	6.50	1	34.15452	0.71099	0.22892	0.17600
8	6.50	1	31.37688	0.70490	0.29075	0.17500
9	6.50	1	29.34413	0.70861	0.29551	0.17600
10	6.50	5	29.49820	0.70438	0.25267	0.17500
11	6.50	5	19.29887	0.70540	0.27023	0.17500
12	6.50	50	2.52660	0.70551	0.30546	0.17300
13	6.50	50	2.29040	0.70223	0.33963	0.17400
14	7.00	10	26.38220	0.70314	0.28532	0.18300
15	7.50	50	7.79752	0.70844	0.33204	0.19300
16	7.50	50	7.81732	0.70389	0.38956	0.19200
17	5.00	1	3.37499	0.64944	0.36703	0.13300
18	5.80	5	10.67598	0.71629	0.37579	0.16200
19	5.80	5	5.97682	0.71689	0.33199	0.16200
20	5.00	10	2.65139	0.68508	0.20743	0.14300
21	5.00	10	3.39941	0.66818	0.20000	0.14000
22	5.00	50	0.33848	0.68465	0.33390	0.15200
23	5.00	50	0.35234	0.68694	0.36638	0.15300
24	5.00	160	0.07464	0.71030	0.44988	0.14600
25	5.80	1	16.54418	0.71572	0.33990	0.16800
26	5.80	5	14.28111	0.70869	0.30680	0.16000
27	5.80	5	8.32652	0.71214	0.27402	0.16100
28	5.80	10	7.22272	0.71721	0.25563	0.16200
29	5.80	10	9.66396	0.71004	0.21227	0.16100
30	5.80	10	5.15102	0.70542	0.30981	0.16400
31	5.80	50	0.97198	0.76116	0.22495	0.15400
32	5.80	50	0.96185	0.76103	0.29571	0.15700
33	6.50	5	24.71942	0.71020	0.20000	0.17500
34	6.50	10	16.56292	0.70913	0.23266	0.18100
35	6.50	10	22.35008	0.70473	0.25199	0.17500
36	6.50	10	12.19726	0.70487	0.30020	0.17400
37	6.50	20	8.44397	0.70803	0.31167	0.17400
38	6.50	20	10.15552	0.70531	0.31577	0.17500
39	6.50	20	6.44230	0.70312	0.36365	0.17400
40	6.50	100	1.17220	0.70684	0.34623	0.17300
41	6.50	160	0.53879	0.76270	0.55741	0.15700
42	7.00	1	48.69814	0.70194	0.31744	0.18200
43	7.00	10	36.54720	0.69952	0.42746	0.18300
44	7.00	10	19.71888	0.69893	0.39890	0.18200
45	7.00	50	4.65942	0.69683	0.30272	0.18000
46	7.00	50	4.57622	0.69608	0.36163	0.18100
47	7.50	1	63.97175	0.71327	0.56319	0.19600
48	5.00	10	34.96797	0.71049	0.37695	0.19400
49	5.00	10	39.83652	0.71226	0.71809	0.18700
50	8.00	50	13.10689	0.71306	0.32048	0.19300
51	8.00	160	3.43297	0.81055	0.43466	0.13300

TABLE F7-10
M. C. WALCK: VERTICAL POINT ESTIMATES
PEAK GROUND ACCELERATION

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	0.11369	0.69558	0.53612	0.16269
2	5.00	1	0.10072	0.69861	0.40954	0.16195
3	5.00	5	0.03309	0.68234	0.42608	0.16493
4	5.00	5	0.03093	0.68631	0.37652	0.16399
5	5.80	10	0.05344	0.63373	0.38506	0.17229
6	5.80	20	0.03846	0.62149	0.45259	0.16608
7	6.50	1	0.29473	0.58699	0.35841	0.17957
8	6.50	1	0.28070	0.59398	0.33916	0.18452
9	6.50	1	0.27565	0.58956	0.34846	0.18100
10	6.50	5	0.23629	0.58800	0.35774	0.17989
11	6.50	5	0.17714	0.58956	0.34939	0.18100
12	6.50	50	0.01308	0.59100	0.44465	0.18161
13	6.50	50	0.01304	0.58519	0.41643	0.17825
14	7.00	10	0.15579	0.56803	0.33335	0.19961
15	7.50	50	0.02728	0.56205	0.41914	0.20807
16	7.50	50	0.02610	0.55440	0.34875	0.20224
17	5.00	1	0.03642	0.67848	0.45772	0.16576
18	5.80	5	0.07518	0.63065	0.45167	0.16811
19	5.80	5	0.05282	0.63597	0.44772	0.17111
20	5.00	10	0.03811	0.68934	0.39280	0.16461
21	5.00	10	0.05303	0.67942	0.37081	0.16479
22	5.00	50	0.00292	0.71091	0.35426	0.15724
23	5.00	50	0.00271	0.70601	0.33233	0.15803
24	5.00	160	0.00029	0.71185	0.38931	0.15715
25	5.80	1	0.17897	0.64061	0.49009	0.16742
26	5.80	5	0.15631	0.63065	0.40182	0.16811
27	5.80	5	0.09711	0.63350	0.38638	0.16964
28	5.80	10	0.07000	0.63673	0.38964	0.17159
29	5.80	10	0.10067	0.62598	0.39387	0.17385
30	5.80	10	0.05514	0.63426	0.37744	0.17008
31	5.80	50	0.00677	0.66025	0.34001	0.16372
32	5.80	50	0.00718	0.66480	0.38273	0.16559
33	6.50	5	0.21483	0.58743	0.32670	0.17950
34	6.50	10	0.12825	0.59070	0.32432	0.18186
35	6.50	10	0.17978	0.59255	0.41881	0.18333
36	6.50	10	0.10448	0.58843	0.33840	0.18019
37	6.50	20	0.05851	0.58956	0.34824	0.18100
38	6.50	20	0.07648	0.58908	0.44404	0.18130
39	6.50	20	0.04509	0.58743	0.36445	0.17950
40	6.50	100	0.00470	0.60003	0.51108	0.17858
41	6.50	160	0.00159	0.59461	0.51825	0.17519
42	7.00	1	0.31765	0.57089	0.33933	0.20213
43	7.00	10	0.20531	0.57132	0.41746	0.20252
44	7.00	10	0.12475	0.56960	0.34178	0.20097
45	7.00	50	0.01876	0.56932	0.38307	0.20072
46	7.00	50	0.01992	0.56753	0.46811	0.19930
47	7.50	1	0.41683	0.56908	0.49259	0.21532
48	5.00	10	0.18278	0.56205	0.34225	0.20807
49	5.00	10	0.23210	0.56535	0.44386	0.21133
50	8.00	50	0.03980	0.56913	0.44882	0.21311
51	8.00	160	0.00768	0.57462	0.52849	0.21196

TABLE F7-11
M. C. WALCK: 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	0.26123	0.70187	0.58070	0.16050
2	5.00	1	0.22206	0.69952	0.45254	0.16004
3	5.00	5	0.06932	0.69299	0.49648	0.16103
4	5.00	5	0.06365	0.69575	0.43193	0.16052
5	5.80	10	0.10045	0.64158	0.46330	0.16851
6	5.80	20	0.06939	0.63017	0.43620	0.16401
7	6.50	1	0.58764	0.59623	0.44450	0.17630
8	6.50	1	0.54414	0.60327	0.41898	0.18064
9	6.50	1	0.54237	0.60024	0.41497	0.17817
10	6.50	5	0.46094	0.60024	0.40963	0.17817
11	6.50	5	0.33347	0.59909	0.43621	0.17730
12	6.50	50	0.01966	0.60579	0.46599	0.18109
13	6.50	50	0.01999	0.59623	0.44919	0.17630
14	7.00	10	0.28363	0.57958	0.38466	0.19667
15	7.50	50	0.04045	0.57321	0.41686	0.20393
16	7.50	50	0.04023	0.56036	0.39218	0.19403
17	5.00	1	0.07736	0.69004	0.51735	0.16289
18	5.80	5	0.14307	0.64724	0.53519	0.16869
19	5.80	5	0.10098	0.65166	0.47942	0.17164
20	5.00	10	0.07836	0.70283	0.47674	0.16167
21	5.00	10	0.11311	0.69347	0.34895	0.16101
22	5.00	50	0.00541	0.70938	0.36916	0.15902
23	5.00	50	0.00531	0.71376	0.36499	0.15861
24	5.00	160	0.00037	0.71109	0.50776	0.15880
25	5.80	1	0.36625	0.65418	0.61403	0.17107
26	5.80	5	0.29600	0.64628	0.47649	0.16810
27	5.80	5	0.18958	0.64628	0.47061	0.16810
28	5.80	10	0.13519	0.65262	0.47398	0.17233
29	5.80	10	0.19882	0.63719	0.46799	0.17151
30	5.80	10	0.10210	0.64474	0.48033	0.16721
31	5.80	50	0.01126	0.66486	0.37545	0.16697
32	5.80	50	0.01228	0.67379	0.40207	0.17146
33	6.50	5	0.41413	0.60082	0.38354	0.17862
34	6.50	10	0.23822	0.60529	0.37354	0.18244
35	6.50	10	0.33179	0.60269	0.44762	0.18015
36	6.50	10	0.19440	0.60197	0.39894	0.17955
37	6.50	20	0.10381	0.60197	0.37245	0.17955
38	6.50	20	0.13728	0.59883	0.45039	0.17866
39	6.50	20	0.07944	0.59967	0.40135	0.17773
40	6.50	100	0.00596	0.59813	0.57919	0.18078
41	6.50	160	0.00191	0.59482	0.61728	0.17816
42	7.00	1	0.62677	0.58348	0.38877	0.20036
43	7.00	10	0.37784	0.58492	0.43654	0.20182
44	7.00	10	0.22890	0.58160	0.37566	0.19854
45	7.00	50	0.02725	0.58073	0.40219	0.19772
46	7.00	50	0.03087	0.57669	0.47324	0.19462
47	7.50	1	0.81120	0.58247	0.46988	0.21405
48	5.00	10	0.33461	0.57292	0.38328	0.20365
49	5.00	10	0.42845	0.57697	0.45942	0.20781
50	8.00	50	0.05783	0.58663	0.43421	0.21341
51	8.00	160	0.00801	0.57451	0.61532	0.21599

TABLE F7-12
M. C. WALCK: 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	0.22257	0.71774	0.45873	0.16014
2	5.00	1	0.20359	0.72606	0.34144	0.16161
3	5.00	5	0.06819	0.70912	0.35947	0.16227
4	5.00	5	0.06621	0.72128	0.31819	0.16531
5	5.80	10	0.10969	0.65167	0.33890	0.17800
6	5.80	20	0.07294	0.62565	0.44565	0.16730
7	6.50	1	0.59360	0.59764	0.39359	0.17725
8	6.50	1	0.55396	0.60904	0.38729	0.18458
9	6.50	1	0.55181	0.60904	0.41502	0.18458
10	6.50	5	0.44102	0.60671	0.40894	0.18216
11	6.50	5	0.34787	0.60788	0.37240	0.18336
12	6.50	50	0.02516	0.61579	0.50244	0.18651
13	6.50	50	0.02471	0.59802	0.45734	0.17768
14	7.00	10	0.29918	0.58552	0.36855	0.20086
15	7.50	50	0.05142	0.57999	0.46136	0.21044
16	7.50	50	0.05044	0.55033	0.41485	0.18425
17	5.00	1	0.07590	0.70214	0.39009	0.16340
18	5.80	5	0.15377	0.65987	0.38453	0.17652
19	5.80	5	0.10943	0.65987	0.42844	0.17652
20	5.00	10	0.07982	0.72012	0.33161	0.16468
21	5.00	10	0.10474	0.70583	0.39178	0.16092
22	5.00	50	0.00664	0.74176	0.33983	0.15899
23	5.00	50	0.00628	0.73478	0.32934	0.15700
24	5.00	160	0.00053	0.73769	0.49384	0.15768
25	5.80	1	0.35946	0.66184	0.40616	0.17357
26	5.80	5	0.29806	0.65987	0.40200	0.17652
27	5.80	5	0.18920	0.65676	0.36647	0.17397
28	5.80	10	0.13979	0.66317	0.36152	0.17942
29	5.80	10	0.19493	0.64487	0.45157	0.17584
30	5.80	10	0.10868	0.65754	0.37187	0.17459
31	5.80	50	0.01416	0.70133	0.35690	0.17885
32	5.80	50	0.01447	0.69987	0.37130	0.17780
33	6.50	5	0.41821	0.60788	0.34647	0.18336
34	6.50	10	0.25621	0.60846	0.35544	0.18396
35	6.50	10	0.33891	0.60846	0.49280	0.18396
36	6.50	10	0.20996	0.60730	0.36038	0.18276
37	6.50	20	0.11406	0.60730	0.37715	0.18276
38	6.50	20	0.14591	0.60045	0.50022	0.18049
39	6.50	20	0.09063	0.60570	0.36312	0.18115
40	6.50	100	0.00829	0.60479	0.57721	0.17993
41	6.50	160	0.00269	0.60669	0.59005	0.18176
42	7.00	1	0.63139	0.58786	0.37876	0.20362
43	7.00	10	0.38649	0.59151	0.47925	0.20817
44	7.00	10	0.24426	0.58552	0.36133	0.20086
45	7.00	50	0.03583	0.58450	0.44241	0.19969
46	7.00	50	0.03792	0.57709	0.47672	0.19451
47	7.50	1	0.81662	0.58438	0.56737	0.21612
48	5.00	10	0.35482	0.57897	0.39824	0.20916
49	5.00	10	0.44539	0.58204	0.50211	0.21304
50	8.00	50	0.07230	0.60438	0.48122	0.22485
51	8.00	160	0.01006	0.59918	0.57261	0.22875

TABLE F7-13
M. C. WALCK: 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	0.11915	0.74433	0.46099	0.15222
2	5.00	1	0.11711	0.75668	0.35199	0.15036
3	5.00	5	0.04525	0.73523	0.31430	0.15387
4	5.00	5	0.04276	0.73607	0.31617	0.15257
5	5.80	10	0.08215	0.66781	0.31789	0.17158
6	5.80	20	0.05601	0.64832	0.48157	0.16777
7	6.50	1	0.43463	0.62042	0.35342	0.17432
8	6.50	1	0.38876	0.63068	0.36436	0.17789
9	6.50	1	0.38907	0.63011	0.39949	0.17733
10	6.50	5	0.34692	0.62883	0.43720	0.17609
11	6.50	5	0.26044	0.62769	0.39517	0.17503
12	6.50	50	0.02324	0.63441	0.54840	0.17535
13	6.50	50	0.02210	0.61833	0.51736	0.17207
14	7.00	10	0.25064	0.60924	0.41303	0.19042
15	7.50	50	0.05149	0.60135	0.53266	0.19615
16	7.50	50	0.04785	0.57198	0.42092	0.17459
17	5.00	1	0.04978	0.72934	0.34039	0.15551
18	5.80	5	0.11164	0.67566	0.39388	0.16775
19	5.80	5	0.08028	0.67889	0.47775	0.16994
20	5.00	10	0.04987	0.74005	0.33575	0.15345
21	5.00	10	0.06689	0.74659	0.48302	0.15230
22	5.00	50	0.00540	0.76547	0.45873	0.14813
23	5.00	50	0.00483	0.75416	0.34783	0.14895
24	5.00	160	0.00058	0.76150	0.44249	0.14803
25	5.80	1	0.25883	0.68229	0.35921	0.16723
26	5.80	5	0.21636	0.68819	0.44543	0.17131
27	5.80	5	0.14038	0.67889	0.35944	0.16994
28	5.80	10	0.10689	0.68612	0.31807	0.17562
29	5.80	10	0.13886	0.67016	0.47128	0.17194
30	5.80	10	0.08159	0.67642	0.37356	0.16825
31	5.80	50	0.01247	0.72315	0.38009	0.16311
32	5.80	50	0.01377	0.72315	0.49615	0.16311
33	6.50	5	0.31946	0.62769	0.36472	0.17503
34	6.50	10	0.19532	0.62514	0.36132	0.17279
35	6.50	10	0.26109	0.63011	0.52854	0.17733
36	6.50	10	0.16446	0.62769	0.38885	0.17503
37	6.50	20	0.09588	0.62883	0.44118	0.17609
38	6.50	20	0.11907	0.62223	0.57674	0.17642
39	6.50	20	0.07675	0.62826	0.44514	0.17556
40	6.50	100	0.00908	0.62450	0.56489	0.17302
41	6.50	160	0.00354	0.63396	0.55902	0.17563
42	7.00	1	0.48332	0.60924	0.39263	0.19042
43	7.00	10	0.31922	0.61411	0.55553	0.19605
44	7.00	10	0.20255	0.61010	0.42556	0.19138
45	7.00	50	0.03515	0.60767	0.50128	0.18872
46	7.00	50	0.03689	0.59903	0.55346	0.18347
47	7.50	1	0.59964	0.59538	0.56119	0.19448
48	5.00	10	0.30787	0.60421	0.45452	0.19951
49	5.00	10	0.36676	0.60565	0.55797	0.20126
50	8.00	50	0.07284	0.63330	0.54117	0.21369
51	8.00	160	0.01423	0.62612	0.55591	0.20965

TABLE F7-14
M. C. WALCK: 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	0.05254	0.79817	0.49726	0.13044
2	5.00	1	0.05047	0.79709	0.39457	0.12836
3	5.00	5	0.01809	0.78444	0.40182	0.13411
4	5.00	5	0.01817	0.78201	0.32900	0.13091
5	5.80	10	0.04862	0.70898	0.32493	0.16448
6	5.80	20	0.03522	0.68355	0.49364	0.16595
7	6.50	1	0.26046	0.66311	0.31076	0.17141
8	6.50	1	0.25599	0.67514	0.32902	0.17372
9	6.50	1	0.25030	0.67570	0.34003	0.17426
10	6.50	5	0.21875	0.67234	0.37300	0.17117
11	6.50	5	0.17562	0.67402	0.34578	0.17267
12	6.50	50	0.01727	0.67899	0.40296	0.16882
13	6.50	50	0.02007	0.65947	0.47511	0.16778
14	7.00	10	0.18989	0.65343	0.42984	0.18477
15	7.50	50	0.04685	0.63512	0.49617	0.18548
16	7.50	50	0.04191	0.60962	0.35319	0.16940
17	5.00	1	0.02069	0.78229	0.39086	0.13604
18	5.80	5	0.06261	0.72751	0.37420	0.16513
19	5.80	5	0.04214	0.72060	0.37315	0.16033
20	5.00	10	0.02157	0.78034	0.33218	0.13074
21	5.00	10	0.02888	0.78008	0.44162	0.13339
22	5.00	50	0.00251	0.82298	0.34002	0.12094
23	5.00	50	0.00254	0.81573	0.34006	0.12160
24	5.00	160	0.00039	0.81926	0.44692	0.12106
25	5.80	1	0.12397	0.73377	0.46365	0.16056
26	5.80	5	0.11968	0.73483	0.43466	0.17129
27	5.80	5	0.08098	0.72265	0.34352	0.16165
28	5.80	10	0.06269	0.72920	0.32493	0.16646
29	5.80	10	0.07990	0.71914	0.44963	0.16347
30	5.80	10	0.04784	0.73182	0.34934	0.16863
31	5.80	50	0.00820	0.77517	0.35071	0.14141
32	5.80	50	0.00935	0.78105	0.49730	0.14395
33	6.50	5	0.21049	0.67822	0.34638	0.17679
34	6.50	10	0.13791	0.69044	0.40088	0.17810
35	6.50	10	0.16898	0.67096	0.47860	0.16861
36	6.50	10	0.11383	0.66152	0.38903	0.16974
37	6.50	20	0.06886	0.66311	0.43389	0.17141
38	6.50	20	0.08859	0.65348	0.53994	0.16899
39	6.50	20	0.05327	0.67402	0.37758	0.17267
40	6.50	100	0.00857	0.67613	0.51114	0.16707
41	6.50	160	0.00381	0.68825	0.52168	0.16865
42	7.00	1	0.33895	0.65991	0.35161	0.19225
43	7.00	10	0.23344	0.64425	0.51943	0.18264
44	7.00	10	0.14661	0.64228	0.38422	0.18017
45	7.00	50	0.02874	0.64144	0.40444	0.17916
46	7.00	50	0.03161	0.64172	0.51339	0.17949
47	7.50	1	0.40965	0.65294	0.43353	0.19822
48	5.00	10	0.23162	0.64716	0.40666	0.19133
49	5.00	10	0.26688	0.63587	0.45521	0.18643
50	8.00	50	0.06587	0.65451	0.52987	0.19284
51	8.00	160	0.01910	0.69134	0.52989	0.19626

TABLE F7-15
M. C. WALCK: 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	0.02251	0.82804	0.46249	0.11372
2	5.00	1	0.02162	0.83488	0.36788	0.10950
3	5.00	5	0.00788	0.81083	0.40687	0.11886
4	5.00	5	0.00790	0.80683	0.32138	0.11478
5	5.80	10	0.02338	0.74780	0.38817	0.14346
6	5.80	20	0.01840	0.73324	0.40292	0.14699
7	6.50	1	0.13153	0.71625	0.41345	0.15660
8	6.50	1	0.14071	0.72165	0.32905	0.16053
9	6.50	1	0.13355	0.73078	0.35747	0.16117
10	6.50	5	0.12701	0.73171	0.39018	0.16190
11	6.50	5	0.09859	0.71721	0.31007	0.15688
12	6.50	50	0.01109	0.72501	0.45279	0.16362
13	6.50	50	0.01210	0.69576	0.42580	0.15553
14	7.00	10	0.10564	0.70855	0.32721	0.18648
15	7.50	50	0.03093	0.68810	0.37006	0.18806
16	7.50	50	0.02795	0.67171	0.36903	0.18290
17	5.00	1	0.00800	0.80548	0.53900	0.11542
18	5.80	5	0.03312	0.75813	0.43764	0.14630
19	5.80	5	0.02428	0.76054	0.42325	0.14803
20	5.00	10	0.00845	0.80315	0.45959	0.11574
21	5.00	10	0.01200	0.80507	0.32359	0.11546
22	5.00	50	0.00108	0.85685	0.33059	0.09833
23	5.00	50	0.00128	0.84866	0.30000	0.09884
24	5.00	160	0.00021	0.85072	0.52215	0.09788
25	5.80	1	0.06203	0.78386	0.51717	0.14895
26	5.80	5	0.05985	0.77411	0.46828	0.14523
27	5.80	5	0.04261	0.75590	0.33461	0.14483
28	5.80	10	0.03090	0.76114	0.34215	0.14477
29	5.80	10	0.04244	0.75289	0.38668	0.14543
30	5.80	10	0.02904	0.76129	0.35133	0.14859
31	5.80	50	0.00455	0.82066	0.30000	0.12692
32	5.80	50	0.00573	0.80867	0.44832	0.12181
33	6.50	5	0.11199	0.72668	0.33152	0.16498
34	6.50	10	0.07813	0.71656	0.32849	0.16174
35	6.50	10	0.09479	0.70703	0.35995	0.15821
36	6.50	10	0.07016	0.69993	0.32895	0.15772
37	6.50	20	0.03809	0.72668	0.36417	0.16498
38	6.50	20	0.05025	0.69901	0.40078	0.15694
39	6.50	20	0.03421	0.69836	0.34980	0.15642
40	6.50	100	0.00557	0.73882	0.42781	0.15057
41	6.50	160	0.00259	0.74653	0.59736	0.15446
42	7.00	1	0.19294	0.70481	0.38614	0.18404
43	7.00	10	0.13571	0.68314	0.40176	0.17496
44	7.00	10	0.09317	0.68314	0.33263	0.17496
45	7.00	50	0.01894	0.69873	0.38136	0.17908
46	7.00	50	0.02135	0.69583	0.48485	0.17897
47	7.50	1	0.24159	0.72152	0.38300	0.21899
48	5.00	10	0.13607	0.68880	0.33792	0.18873
49	5.00	10	0.16174	0.67551	0.42032	0.18432
50	8.00	50	0.04540	0.69122	0.32018	0.19859
51	8.00	160	0.01538	0.70538	0.47162	0.18755

TABLE F7-16
M. C. WALCK: 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	0.00678	0.88549	0.46852	0.11450
2	5.00	1	0.00705	0.87631	0.42081	0.11343
3	5.00	5	0.00237	0.86803	0.47049	0.12583
4	5.00	5	0.00250	0.85719	0.36052	0.12271
5	5.80	10	0.00886	0.79801	0.46183	0.14454
6	5.80	20	0.00727	0.81344	0.33804	0.15070
7	6.50	1	0.07251	0.76337	0.33918	0.15573
8	6.50	1	0.07745	0.76214	0.36434	0.16170
9	6.50	1	0.06760	0.76037	0.30883	0.15981
10	6.50	5	0.06404	0.74678	0.44093	0.15909
11	6.50	5	0.04945	0.76037	0.33229	0.15981
12	6.50	50	0.00535	0.77626	0.38745	0.16491
13	6.50	50	0.00621	0.74366	0.65569	0.16232
14	7.00	10	0.04862	0.75534	0.41696	0.18841
15	7.50	50	0.01718	0.75305	0.66741	0.21330
16	7.50	50	0.01527	0.72573	0.46999	0.21606
17	5.00	1	0.00247	0.86758	0.63817	0.12585
18	5.80	5	0.01447	0.81085	0.39998	0.14838
19	5.80	5	0.00922	0.81158	0.41625	0.14896
20	5.00	10	0.00248	0.86179	0.56762	0.12443
21	5.00	10	0.00374	0.86622	0.35662	0.12600
22	5.00	50	0.00036	0.91215	0.46018	0.08829
23	5.00	50	0.00047	0.91124	0.42230	0.08891
24	5.00	160	0.00011	0.92172	0.38971	0.08684
25	5.80	1	0.02713	0.84228	0.38846	0.15603
26	5.80	5	0.02661	0.77117	0.49684	0.15336
27	5.80	5	0.01983	0.81219	0.42325	0.15853
28	5.80	10	0.01067	0.81180	0.47696	0.14521
29	5.80	10	0.01604	0.82565	0.46240	0.16092
30	5.80	10	0.01108	0.81283	0.40427	0.15009
31	5.80	50	0.00169	0.84566	0.45976	0.10900
32	5.80	50	0.00247	0.87637	0.61765	0.12119
33	6.50	5	0.05162	0.77992	0.34342	0.16857
34	6.50	10	0.03555	0.76717	0.32074	0.16505
35	6.50	10	0.04262	0.74065	0.48919	0.16670
36	6.50	10	0.03273	0.74970	0.42895	0.16294
37	6.50	20	0.01794	0.77992	0.34190	0.16857
38	6.50	20	0.02280	0.77295	0.43695	0.17419
39	6.50	20	0.01647	0.77198	0.40151	0.17324
40	6.50	100	0.00263	0.81180	0.51824	0.15910
41	6.50	160	0.00157	0.81300	0.64078	0.16017
42	7.00	1	0.09206	0.73172	0.43005	0.17722
43	7.00	10	0.06411	0.71896	0.48616	0.18208
44	7.00	10	0.04760	0.76282	0.44026	0.20344
45	7.00	50	0.00971	0.76625	0.49027	0.19859
46	7.00	50	0.01151	0.75081	0.66155	0.19843
47	7.50	1	0.11826	0.76896	0.47227	0.22853
48	5.00	10	0.06665	0.76261	0.49973	0.22342
49	5.00	10	0.08976	0.75221	0.58175	0.22755
50	8.00	50	0.02813	0.75332	0.43307	0.23856
51	8.00	160	0.01338	0.80370	0.66215	0.23060

TABLE F7-17
M. C. WALCK: 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	0.00241	0.90833	0.66442	0.11871
2	5.00	1	0.00277	0.90426	0.55143	0.11727
3	5.00	5	0.00094	0.89903	0.57642	0.12042
4	5.00	5	0.00108	0.90315	0.46535	0.11697
5	5.80	10	0.00426	0.83225	0.40409	0.15340
6	5.80	20	0.00321	0.84909	0.40232	0.15410
7	6.50	1	0.03634	0.78356	0.35702	0.17110
8	6.50	1	0.04273	0.78651	0.43780	0.17901
9	6.50	1	0.03870	0.78438	0.37080	0.17622
10	6.50	5	0.03914	0.76508	0.59273	0.17178
11	6.50	5	0.02519	0.78340	0.32541	0.17496
12	6.50	50	0.00274	0.81220	0.41241	0.19414
13	6.50	50	0.00311	0.76463	0.63762	0.17965
14	7.00	10	0.02779	0.80165	0.37850	0.23034
15	7.50	50	0.00993	0.78826	0.63386	0.24121
16	7.50	50	0.00860	0.74546	0.45127	0.22953
17	5.00	1	0.00087	0.91422	0.76265	0.12259
18	5.80	5	0.00637	0.84923	0.49327	0.15425
19	5.80	5	0.00413	0.84872	0.43662	0.15372
20	5.00	10	0.00088	0.91044	0.70143	0.12040
21	5.00	10	0.00136	0.91191	0.52932	0.12201
22	5.00	50	0.00014	0.93455	0.54743	0.08650
23	5.00	50	0.00019	0.93234	0.61792	0.08622
24	5.00	160	0.00003	0.94559	0.67308	0.08926
25	5.80	1	0.01215	0.85398	0.44284	0.16412
26	5.80	5	0.01384	0.79933	0.57890	0.16080
27	5.80	5	0.00860	0.84047	0.45190	0.15874
28	5.80	10	0.00481	0.84917	0.45811	0.15302
29	5.80	10	0.00657	0.86264	0.50811	0.16649
30	5.80	10	0.00473	0.85045	0.45738	0.15562
31	5.80	50	0.00078	0.87094	0.44210	0.11855
32	5.80	50	0.00109	0.90785	0.69911	0.13429
33	6.50	5	0.03042	0.78883	0.35740	0.18087
34	6.50	10	0.01731	0.78293	0.34091	0.17305
35	6.50	10	0.02206	0.78088	0.52409	0.19043
36	6.50	10	0.01512	0.76552	0.44788	0.17245
37	6.50	20	0.00915	0.81616	0.34224	0.19917
38	6.50	20	0.01088	0.79579	0.39062	0.18952
39	6.50	20	0.00849	0.79654	0.47104	0.19049
40	6.50	100	0.00123	0.84113	0.58334	0.17460
41	6.50	160	0.00080	0.84113	0.60910	0.17460
42	7.00	1	0.05222	0.75311	0.49502	0.19450
43	7.00	10	0.03658	0.80251	0.49129	0.22854
44	7.00	10	0.02523	0.79074	0.51698	0.22303
45	7.00	50	0.00532	0.79930	0.53770	0.22316
46	7.00	50	0.00598	0.77920	0.67899	0.22049
47	7.50	1	0.07115	0.79929	0.39738	0.25134
48	5.00	10	0.03541	0.78628	0.55567	0.23882
49	5.00	10	0.04708	0.76023	0.56543	0.23797
50	8.00	50	0.01743	0.78519	0.58667	0.26068
51	8.00	160	0.00803	0.84737	0.65950	0.25360

TABLE F7-18
M. C. WALCK: VERTICAL POINT ESTIMATES
PEAK GROUND VELOCITY

CASE NO.	MAGNITUDE	DISTANCE (KM)	MU	SIGMA	SIGMA MU	SIGMA SIGMA
1	5.00	1	4.51356	0.66047	0.53075	0.14023
2	5.00	1	4.29438	0.67793	0.38538	0.14361
3	5.00	5	1.33613	0.66075	0.49131	0.14046
4	5.00	5	1.54938	0.67738	0.57971	0.14321
5	5.80	10	2.69191	0.65374	0.31002	0.15986
6	5.80	20	2.13480	0.63642	0.43392	0.15093
7	6.50	1	17.03227	0.63830	0.30000	0.16385
8	6.50	1	19.31325	0.64194	0.33219	0.16810
9	6.50	1	17.14802	0.64291	0.31767	0.16917
10	6.50	5	18.23540	0.63959	0.36093	0.16561
11	6.50	5	11.03472	0.64139	0.30343	0.16750
12	6.50	50	0.90034	0.64793	0.40357	0.16787
13	6.50	50	1.06003	0.63207	0.53879	0.16160
14	7.00	10	10.69709	0.64638	0.30000	0.18118
15	7.50	50	2.73714	0.61448	0.45160	0.19726
16	7.50	50	2.56927	0.59904	0.39884	0.18716
17	5.00	1	1.60177	0.67650	0.64331	0.14313
18	5.80	5	5.25829	0.65530	0.47390	0.15895
19	5.80	5	2.82126	0.65751	0.45774	0.16116
20	5.00	10	1.19757	0.68012	0.38232	0.14528
21	5.00	10	2.00067	0.65947	0.30000	0.13940
22	5.00	50	0.14050	0.68443	0.32431	0.15158
23	5.00	50	0.16511	0.67262	0.34160	0.14482
24	5.00	160	0.02683	0.69038	0.70235	0.15590
25	5.80	1	8.41111	0.66134	0.42743	0.16207
26	5.80	5	9.35552	0.65622	0.38035	0.15986
27	5.80	5	4.93251	0.65383	0.32411	0.15754
28	5.80	10	3.26196	0.66237	0.33981	0.16340
29	5.80	10	5.24598	0.65690	0.35237	0.16526
30	5.80	10	2.93759	0.65751	0.38580	0.16116
31	5.80	50	0.40833	0.70338	0.30830	0.17142
32	5.80	50	0.59621	0.73215	0.54833	0.16423
33	6.50	5	12.35000	0.64661	0.30216	0.16952
34	6.50	10	7.42157	0.64329	0.33021	0.16604
35	6.50	10	11.62291	0.64346	0.39110	0.16979
36	6.50	10	6.71575	0.63835	0.34967	0.16436
37	6.50	20	3.34907	0.64137	0.34078	0.16416
38	6.50	20	4.75040	0.63207	0.43228	0.16160
39	6.50	20	3.16873	0.63959	0.46847	0.16561
40	6.50	100	0.43082	0.67610	0.31885	0.16552
41	6.50	160	0.19098	0.70913	0.58774	0.16540
42	7.00	1	22.95208	0.65020	0.36876	0.19157
43	7.00	10	18.73886	0.64368	0.51185	0.18170
44	7.00	10	9.81755	0.64174	0.38473	0.17944
45	7.00	50	1.60028	0.64429	0.40706	0.17889
46	7.00	50	1.92625	0.64085	0.52861	0.17896
47	7.50	1	26.02660	0.65398	0.41984	0.21336
48	5.00	10	13.98912	0.64336	0.34566	0.20143
49	5.00	10	18.11451	0.64312	0.59717	0.20581
50	8.00	50	5.24948	0.65526	0.43019	0.21662
51	8.00	160	2.16459	0.86826	0.45761	0.14152

APPENDIX G

HISTORICAL SEISMICITY CATALOGUE FOR YUCCA MOUNTAIN

HISTORICAL SEISMICITY CATALOGUE FOR YUCCA MOUNTAIN

by
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HISTORICAL SEISMICITY CATALOGUE FOR YUCCA MOUNTAIN

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HISTORICAL SEISMICITY CATALOGUE FOR YUCCA MOUNTAIN

INTRODUCTION

A historical earthquake catalogue of all known events within a 300-km radius circular region centered on the Yucca Mountain site was compiled for use in the: (1) characterization of the regional seismicity; (2) evaluation of the seismicity for any possible associations with geologic structures, particularly late-Quaternary faults; and (3) computation of earthquake recurrence parameters for the various seismotectonic provinces that make up the Yucca Mountain region. These activities are all part of the Probabilistic Seismic Hazard Analysis Project for Yucca Mountain.

The Yucca Mountain catalogue, which covers the time period from 1868 to 1996, was compiled from all available regional and national earthquake catalogues. Two catalogues for the Yucca Mountain region compiled prior to this study were used as a basis for this work (Meremonte and Rogers, 1987; Gross and Jaume, 1995). The catalogue described in this report differs from the previous catalogues in that it covers a much larger geographical region in order to satisfy the U.S. Nuclear Regulatory Commission's regulatory standards. Also, unlike the other catalogues, the Yucca Mountain catalogue lists all known magnitudes assigned to each event to derive values using a common magnitude scale. A best-estimate moment magnitude (M_W) value was calculated for each earthquake for this project. All known Nuclear Test Site (NTS) blasts were identified and were removed along with the associated dependent events using declustering algorithms. The historical catalogue was declustered using two different approaches, the results of which were compared for their effectiveness.

DATA SOURCES

The Yucca Mountain catalogue was compiled from the following regional and national catalogues (abbreviations for each catalogue are listed in parentheses):

- Catalogue for the Southern Great Basin network for the period 1978 to 1992 (Rogers *et al.*, 1987) (SGB)
- Seismological Laboratory of the University of Nevada, Reno catalogue for Nevada, 1874 to 1994 including the Southern Great Basin network data for 1992 to 1996 (UNR)
- California Institute of Technology Seismological Laboratory and U.S. Geological Survey catalogue for southern California, 1932 to 1996 (CIT)
- University of California at Berkeley Seismographic Station catalogue for northern California, 1910 to 1972 (UCB)
- U.S. Geological Survey catalogue for northern and central California, 1969 to 1996 (USGS)
- Catalogue of Southern Great Basin earthquakes, 1868 to 1978, compiled by Meremonte and Rogers (1987) (MER)
- University of Utah Seismographic Stations catalogue for Utah, 1881 to 1996 (UUTAH)
- California Division of Mines and Geology catalogue for California, 1868 to 1932 (CDMG)
- Stover, Reagor and Algermissen state catalogues for Utah and Arizona compiled by the National Earthquake Information Center (NEIC), 1881 to 1985 (SRA)
- NEIC Preliminary Determination of Epicenters catalogue for Utah and Arizona, 1938 to 1996 (PDE)
- Northern Arizona University catalogue for Arizona, 1891 to 1992 (NAU)
- Decade of North American Geology catalogue, 1868 to 1985 (Engdahl and Rinehart, 1988) (DNAG)

CATALOGUE COMPILATION

In the compilation of the Yucca Mountain catalogue, only specific time periods of several catalogues were used due to the availability of higher quality data from other networks. For example, only data prior to 1972 was used from the UCB catalogue, because the USGS network has provided much wider and denser seismographic coverage for northern and central California since 1972. Only earthquakes prior to 1932 were extracted from the CDMG catalogue, since the CIT, UCB, and USGS catalogues are more complete for

California after 1932. All available magnitude and intensity estimates, however, were extracted from each catalogue used in the compilation.

All events from the source catalogues within the 300-km Yucca Mountain region were combined into a single catalogue. This catalogue was then subdivided into seven subregions to remove duplicate events: southwestern Utah, northwestern Arizona, north-central Nevada, southern Nevada, east-central California, Mammoth Lakes, and southeastern California (Figure G-1). Each region had a different constituent catalogue hierarchy to retain the most precise location for each earthquake (Table G-1). The seven subregions overlap to retain events that may straddle the boundaries (Figure G-1).

In each subregion catalogue, multiple entries for the same earthquake were removed. The duplicate removal procedure compares the inter-event time and distances to user-specified time and distance windows to identify multiple entries for the same earthquake. If two earthquakes from the same source catalogue (e.g., CIT) occur within the user-specified time window, the time window is automatically reduced to just less than this inter-event time. If the inter-event times and distances of earthquakes from other source catalogues are small enough (i.e., lie within the user-specified time and distance windows or the adjusted time window), the events are identified as belonging to a duplicate group. The most accurate entry for each event within the group is then selected according to the specified catalogue hierarchy for that region (Table G-1). The allowable time and distance windows are greater for the historical period (1868 to 1964), and are reduced for the instrumental period (1965 to 1996). We used a time window of 1.5 minutes and a distance window of 1° for the period 1868 to 1964 and time and distance windows of 1.25 minutes and 0.75°, respectively, for the period 1965 to 1992. For the period 1993 to date, the parameters were 1.0 minute and 0.55°, respectively.

Duplicate entries were checked visually because the computer algorithm may not always identify every duplicate. This often occurs for historical earthquakes which may have uncorrected origin times or for earthquakes which occurred on the edge of or outside a network and may have significantly different locations. In some cases, referral to the original data sources (e.g., Townley and Allen, 1939 or U.S. Earthquakes) was necessary to discern

whether the entries were duplicate sets or not. The events within each duplicate group were examined, and if a different entry was preferred to the event flagged by the computer algorithm based on azimuthal gap, minimum station distance, or standard errors, then this event was flagged manually as the preferred event. The file of flagged preferred events was then used to produce the final subregion catalogues.

The subregion catalogues were combined sequentially and duplicate events were removed for overlap regions. In the duplicate removal procedure, all available magnitudes were extracted and kept in the final catalogue, along with their associated magnitude scale and data source. The final catalogue was truncated at August 31, 1996, the end date of the component catalogue CIT, to produce uniform coverage in space and time. The resulting catalogue contains 271,223 earthquakes of approximately M 0.5 and greater, from 1868 to 1996 (Figure G-2).

MAGNITUDE ESTIMATES AND CONVERSION TO MOMENT MAGNITUDE

Since the Yucca Mountain catalogue was compiled from several source catalogues, a uniform magnitude scale for all earthquakes was required in order to properly compute the earthquake recurrence for the region. In addition, it was necessary to assign magnitudes to historical earthquakes that occurred prior to calibrated seismographic instrumentation. Such magnitude estimates are usually based on the felt area or the maximum Modified Mercalli (MM) intensity. This is particularly problematic in the Basin and Range province where settlement and population growth have been erratic and sparse due to the boom and bust nature of mining operations and the rugged environment.

For each earthquake within the Yucca Mountain catalogue, a M_W was calculated from the best available magnitude estimate. Published relationships between seismic moment (M_o) and M_W or local magnitude (M_L) (or other magnitude scale) were used when available (Table G-2), and previously determined M_w values (Stover and Coffman, 1993; Doser and Smith, 1989) were added to the catalogue. Otherwise, magnitudes were first converted to M_L, from which an M_W was derived. The M_W conversion employed depended upon the source catalogue from which the earthquake was derived and upon the type and source of the

magnitude. A hierarchy of magnitude types and sources were developed for each catalogue (Tables G-3 and G-4). The procedures used for each source catalogue are described below

We have not addressed the issue of the standard errors in converting the magnitudes to M_W, but there is uncertainty in all the relationships used that can be incorporated into the recurrence estimates. Standard errors in converting maximum MM intensity into M_W are much larger due to the larger uncertainty.

Southern Great Basin Network Catalogue

The USGS SGB catalogue lists an M_L (USGS Digital Recording; USGSDR) magnitude for the majority of earthquakes recorded by the digital network. Other magnitude types listed include M_V (USGSDR), a local magnitude derived from the vertical records, M_C (USGSDR) the coda-amplitude magnitude and M_D (USGSDR), the duration magnitude, all of which are described in detail in Rogers *et al.* (1987). Both M_C and M_D were originally calibrated to the USGS M_L. The digital network was operated by the USGS from October 1981 to September 1992, when the responsibility was relinquished to the University of Nevada, Reno (UNR). During the handover in September of 1992, M_L computed by both the USGS and UNR (CUSP), were collected and a comparison (D. von Seggern, UNR, written communication, 1996; Figure G-3) indicates that the two are essentially equivalent in the range M_L 1.5 to 4. This is the only direct comparison of the two methodologies for computing M_L within the SGB.

Von Seggern (UNR, written communication, 1996) also compared M_o with M_L for the Southern Great Basin region (Figure G-4). The M_L's are derived from both the Southern Great Basin Seismic Network (SGBSN) from before and after 1992 and from Savage and Anderson (1995). The seismic moments are from Mayeda and Walter (1996) and other unpublished data computed by Ken Smith and Feng Su (UNR). Von Seggern concluded that above M 3, the moment-magnitude relation was essentially the same as that from Hanks and Kanamori (1979) relationship $\log M_o = {}^3/_2 M_L + 16$ (Figure G-4). For $M_L < 3$, the moment-magnitude relation has a slope of 1 and was fixed to the Hanks and Kanamori (1979) curve at M_L 3 (D. Von Seggern, UNR, written communication, 1996). The relationship for $M_L < 3$ is

$\log M_o = M_L + 17.55$. The relation between M_o and M_W (Hanks and Kanamori, 1979) of $M_W = {}^2/_3 \log M_o - 10.7$ was used to calculate M_W from M_L. The relations are $M_W = M_L$ for $M_L \geq 3$ and $M_W = {}^2/_3 M_L + 1$ for $M_L < 3$.

All earthquakes recorded by the SGB digital network for the period October 1981-September 1992 assigned M_L values were converted to M_W using the above relationships. However, many earthquakes within the catalogue only have M_C, M_V and/or M_D designations. For these earthquakes, a M_L value was first estimated from regressions developed in this study (Figures G-5 to G-7; Table G-2). The magnitude conversions, which are only valid for ranges indicated by the regressions, were used in a few cases for magnitudes just outside the specified ranges. M_L estimated from M_V was considered the best estimate followed in order by M_L estimates from M_C and M_D.

For the period prior to installation of the digital network, August 1978 to September 1981, and after 1981 in the event of computer failure, a M_D was computed from develocorder records. M_D (USGS Develocorder; USGSDV) was regressed with M_D values from UNR (Figure G-8; Table G-2). UNR M_D values were calibrated to M_L from UNR and BRK. M_W was estimated assuming the same relationships between M_W and M_L as were used for the Southern Great Basin.

University of Nevada, Reno Catalogue

All M_L magnitudes from UNR prior to September 1992 were converted to M_W using the same relationships between M_W and M_L as discussed above for the Southern Great Basin. M_D is calibrated to M_L for the range $1.5 \leq M_L \leq 5.7$ and is assumed to be equivalent to M_L UNR. After September 1992, magnitudes were determined by UNR from the CUSP (Caltech USGS Processing) system for the Southern Great Basin and are mostly M_D values. The relationship between M_D and M_L from CUSP for the period 1993-1995 is $M_L = -1.244 + 1.31 M_D$ (Figure G-9), where $M_L = M_D$ at a value of 4.0 (D. von Seggern, UNR, written communication, 1996). M_D values were first converted to M_L and then to M_W using the Southern Great Basin relationships between M_W and M_L.

California Institute of Technology Catalogue

Most earthquakes from the CIT catalogue have a M_L PAS designation which was converted to M_W assuming that $M_L = M_W$ for $M_L \geq 3$ (L. Wald, USGS, personal communication, 1996). All $M_L < 3$ were converted to M_W using the relationship of Chung and Bernreuter (1981) for California (Table G-2) since no regressions have been performed for this magnitude range for the region of interest (L. Wald, USGS, K. Hutton and L. Jones, California Institute of Technology, personal communications, 1996).

University of California, Berkeley Catalogue

Most of the earthquakes from the UCB catalogue give a M_L BRK (also designated BERK and UCB) and were converted to M_W directly using a relationship developed by R. Uhrhammer (UCB, personal communication, 1996) for $3.6 \leq M_L \leq 6.8$. Below M_L 3.6 the relationship was assumed to be the same (R. Uhrhammer, UCB, personal communication, 1996).

USGS Northern California Catalogue

Most earthquake magnitudes listed in the USGS catalogue are a M_L or M_D. Relationships between M_L and M_W developed for the Mammoth region (Chavez and Priestly, 1985) were used to convert the M_L values (Table G-2). These are valid for ranges of $1 \leq M_L \leq 6$ and $½ \leq M_L \leq 3$ respectively. Since the second equation is less reliable (Chavez and Priestly, 1985), it was only used for $M_L < 1$. If M_L was not available for a particular earthquake, the preferred alternative was M_D which has been calibrated to M_L. Other magnitudes were used if necessary (Tables G-2 and G-3).

Southern Great Basin Historical Earthquake Catalogue

The Southern Great Basin historical catalogue compiled by Meremonte and Rogers (1987) lists many magnitude data sources, many of which are unknown (UK). The catalogue includes the results from several microearthquake surveys conducted in the vicinity of the NTS which were assigned M_D values. These M_D values were assumed to be the same as M_D

computed by UNR. All M_L values from UNR, PAS and BRK were converted to M_W using the appropriate relationships (Table G-2). Surface-wave magnitudes (M_S) were converted using the formula $M_W = 0.79M_S + 1.24$ (Jost and Herrmann, 1990). Body-wave magnitudes (m_b) were assumed to be equivalent to M_L and then converted to M_W (Boore and Joyner, 1982) Other unspecified magnitudes were assumed to be equivalent to M_L for the Southern Great Basin and then converted to M_W. The magnitude conversion hierarchy (Table G-3) was based on the reliability of each magnitude type (Meremonte and Rogers, 1987).

University of Utah Catalogue

Most earthquakes from the University of Utah catalogue were assigned an M_L (UVUTAH, UU or SLC) and were converted to M_W directly using relationships developed by Shemeta and Pechmann (1989; unpublished work). These relationships are similar to the California relationships. Alternatively, M_D values (UVUTAH) calibrated to M_L for $M_D < 2.5$, were used when M_L was not available.

CDMG, SRA and PDE Catalogues

The CDMG, SRA, and PDE catalogues list magnitudes from a variety of sources. Relations between M_L and M_W for original sources were used where possible (i.e., UCB, CIT, UNR, and USGS). m_b or m_{bLg} magnitudes were converted to M_L using the m_b-M_L formula described in the MER catalogue section. M_L values from Arizona were assumed to be equivalent to M_L for the SGB catalogue. Any magnitudes of unknown origin from the CDMG catalogue were assumed to be equivalent to M_L from UCB.

Northern Arizona University Catalogue

A small number of earthquakes came from the NAU catalogue, which in most cases gives adopted magnitudes. M_L (AE) values were assumed to be equivalent to M_L for the Southern Great Basin. Conversions of other magnitudes used in the NAU catalogue (Table G-3) are described elsewhere in this section.

Decade of North American Geology Catalogue

Adopted magnitudes from UCB, CIT, UNR, and USGS contained in the DNAG catalogue were converted using the appropriate M_w relations. Unknown magnitudes and intensity-based magnitudes (M_I) from UCB and CIT were assumed to be equivalent to an M_L from the same institution, and UK or M_I magnitudes were assumed to be equivalent to M_L for the Southern Great Basin.

Maximum Modified Mercalli Intensity

Earthquakes with no magnitude but an assigned maximum MM intensity (I_0) were converted to M_L from I_0 depending on the location of the earthquake. For California and Nevada earthquakes, the Toppozada (1975) relation was used and for earthquakes in Arizona and Utah, the Gutenberg and Richter (1956) relation was used.

REMOVAL OF NTS EXPLOSIONS AND ASSOCIATED DEPENDENT EVENTS

For 40 years, the U.S. government conducted unannounced underground nuclear weapons tests at the Nevada Test Site (NTS) near the Yucca Mountain site. Many unannounced tests were detected by regional seismograph networks but were often not distinguished from earthquakes. A catalogue of 742 nuclear explosions conducted at or near the NTS (Figure G-10, Table G-5) was compiled and used to identify all blasts in the Yucca Mountain catalogue. The list was also used to remove events from the Yucca Mountain catalogue induced by or associated with the NTS explosions.

Underground nuclear tests were conducted at the NTS from 26 July 1957 to 23 September 1992. Atmospheric tests conducted from 1951 to 1957 were excluded from this catalogue. Testing at the NTS was halted on 2 October 1992. In 1994, DOE released data all nuclear tests conducted at the NTS (U.S. DOE, 1994).

Several data sources were combined to create a comprehensive nuclear explosion catalogue containing date and time, location, and equivalent magnitude. The most complete list of blasts came from the California Institute of Technology (Riley, CIT,

written communication, 1996). However, many tests announced by the DOE were not included in this list or did not contain pertinent information such as location or magnitude. Additional information was obtained from the Lawrence Livermore National Laboratory (LLNL) Containment Database (G. Pawloski, LLNL, personal communication, 1997) and Seismological Database (T. Hauk, LLNL, personal communication, 1997), and from the UCB Seismograph Stations (Collins and Uhrhammer, 1988; Becker *et al.*, 1990). These data sources were cross-referenced to create as complete a record as possible for each blast. The depths of burial given by the DOE were all significantly less than 1 km, so all blasts were assigned a zero depth.

To remove nuclear blast-induced aftershocks and possible cavity collapses from the Yucca Mountain catalogue, the events were removed using the Youngs *et al.* (1987) declustering algorithm described in the next section. Time and distance windows created by the declustering algorithm are a function of magnitude, so each nuclear blast with no recorded magnitude was assigned a calculated value.

Magnitudes for most of the tests were given in the original data sources, but many blasts had no magnitude, particularly blasts prior to 1963. For the approximately 225 blasts without recorded magnitudes, we calculated a magnitude based on yield (total effective energy released in a nuclear explosion), using the equation

$$M_L=3.603+0.3774\ ln W$$

where M_L is the local magnitude and W is the yield in equivalent kilotons of TNT (M. Walck, Sandia Laboratories, personal communication, 1997). Blasts with both a known magnitude and yield were used to compare the calculated M_L with recorded body-wave magnitudes. The average difference between recorded m_b and calculated M_L magnitudes was 0.29.

Although recorded blast magnitudes and magnitude-yield relationships are not classified by the U.S. government, nuclear test yields are classified information. For some tests, an exact yield has been released by the DOE and for some, no information has been released.

For most events, however, yield information was released as a range of values (e.g., 12-20 kt).

For approximately 35 blasts with an exact yield released by the DOE, M_L values were calculated. Approximately 13 blasts with a yield range of 20 to 200 kt were assigned M_L 5.15, the average of the maximum (M_L 5.6) and minimum (M_L 4.7) possible magnitudes for this yield range. Approximately 160 blasts with a yield range given by the DOE as "less than 20 kt" or "12 - 20 kt" were assigned a value of M_L 4.7, which corresponds to the maximum possible yield of 20 kt. Blasts with an assigned yield value of "$\leq$ 1 kt" or for which yield was listed as "sparse" without elaboration were assigned a value of M_L 3.6, the minimum magnitude from this equation. Approximately 11 events with neither known magnitude nor listed yield range were assigned M_L 3.6.

DECLUSTERING OF THE HISTORICAL SEISMICITY CATALOGUE

To assess the hazard from "background" earthquakes, estimates of earthquake recurrence are required. The background earthquake is defined as an event that can occur without an apparent association with a known tectonic feature. Recurrence is estimated from a catalogue of independent earthquakes which are assumed to follow a Poissonian distribution of earthquake occurrence. Dependent events (foreshocks and aftershocks or smaller events within an earthquake swarm) are identified using various criteria and then removed from the catalogue.

The 300-km catalogue was declustered using procedures developed by Youngs *et al.* (1987) and Veneziano and Van Dyck (1985). In the Youngs *et al.* (1987) method, dependent events were identified using empirical criteria for the size in time and space of foreshock-mainshock-aftershock sequences developed by Arabasz and Robinson (1976), Gardner and Knopoff (1974), and Uhrhammer (1986). If an event was identified as dependent by two of the three criteria, it was deleted from the catalogue.

The Veneziano and Van Dyck (1985) procedure is more sophisticated than that of Youngs *et al.* (1987) and allows for spatial nonhomogeneities and apparent nonstationarity caused by

catalogue incompleteness. The method first sorts earthquakes by size and then date. Each earthquake in turn is statistically tested from largest to smallest for clustering. To accomplish this testing, the seismicity rates of a local temporal and spatial window are compared with that for an extended temporal and spatial window. Cluster dimensions are then estimated based on this comparison, and all identified secondary events (dependent events) within the cluster are deleted from the catalogue. The procedure is repeated iteratively until no secondary events are removed.

The declustering algorithm of Reasenberg (1985) was not used to decluster the 300-km catalogue based on discussions with M. Savage (Victoria University, written communication, 1997). The Reasenberg code uses California-specific parameters which are not suitable for Nevada, a region with lower rates of earthquake occurrence. Savage has modified the Reasenberg code as part of a study to determine foreshock probabilities for Nevada (Savage and dePolo, 1993), but met with limited success (M. Savage, Victoria University, written communication, 1997).

Only 26,250 and 31,147 earthquakes remained in the 300-km catalogue after declustering with the Youngs *et al.* (1987) and Veneziano and Van Dyck (1985) methods, respectively (see Figures G-11 and G-12 for plots of declustered catalogues within 100 km of Yucca Mountain).

Distance-time plots for the 100 km catalogue before and after declustering (Figures G-13 to G-15) were used to test the effectiveness of the declustering procedures. In addition, earthquakes in the vicinity of Little Skull Mountain were plotted as a function of time after declustering (Figures G-16a-g and G-17a-g). The Youngs *et al.* (1987) procedure appears to miss some aftershocks that occurred up to four years after the 1992 mainshock. Two of the three methods used in the Youngs *et al.* (1987) procedure were developed for California and therefore may be inappropriate for the lower rates of seismicity of the Southern Great Basin. In comparison, the more sophisticated Veneziano and Van Dyck (1985) procedure produced a more even temporal distribution without the large year-to-year differences seen in the Youngs *et al.* declustered catalogue, particularly from 1993 to 1994 (Figures G-16d-e and G-17d-e). Both approaches, however, leave in aftershocks, particularly a year after the 1992

mainshock. The Little Skull Mountain fault zone as defined by the aftershock distribution is somewhat less pronounced in the plots of the Veneziano declustered catalogue (Figures G-16a and G-17a).

LAKE MEAD RESERVOIR-INDUCED SEISMICITY

Since the early 1940's, reservoir-induced-seismicity has occurred at Lake Mead, the reservoir impounded by Hoover Dam (Rogers and Lee, 1976). One of the issues to be addressed in the Probabilistic Seismic Hazard Analysis Project is whether such seismicity will contribute to the hazard at the Yucca Mountain site in the future and if so, if it should be incorporated into the hazard analysis. The reservoir-induced earthquakes at Lake Mead were retained in the Yucca Mountain catalogue and it was left to the judgments of the experts to keep or delete the events for their analysis.

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TABLE G-1
HIERARCHIES FOR REMOVAL OF DUPLICATE EVENTS IN SUBREGION CATALOGUES

SUBREGION CATALOGUES (LISTED IN ORDER OF PREFERENCE)						
North-Central Nevada	**Northwestern Arizona**	**Southern Nevada**	**Southeastern California**	**Mammoth Lakes**	**East-Central California**	**Southwestern Utah**
UNR	MER	SGB	CIT	USGS*	USGS	UUTAH
SGB	SGB	MER	CDMG	UNR	UCB	DNAG
MER	UNR	UNR	UNR	UCB	CDMG	MER
DNAG	NAU	COMG	UCB	CDMG	UNR	SGB
CDMG	SRA	DNAG	NAU	CIT	CIT	UNR
CIT	PDE	CIT	SRA	DNAG	DNAG	PDE
USGS	DNAG	UCB				SRA
UCB	UUTAH	USGS				NAU
UUTAH	CIT	PDE				CIT
	USGS	NAU				USGS
		SRA				
		UUTAH				

* The USGS location was exclusively used for all Mammoth Lakes events after 1982

Table G-2
MAGNITUDE CONVERSIONS FOR THE YUCCA MOUNTAIN CATALOGUE (MAJOR CONTRIBUTORS)

Catalogue	Magnitude Scale	MW-ML and Other Magnitude Relationships, Their Ranges of Validity, and References
CIT	ML PAS	MW = ML for $3 \le ML \le 6.8$ (L. Wald, USGS, personal communication, 1996; Hanks and Kanamori, 1979; Thatcher and Hanks, 1973) MW = 0.887 ML + 0.633 for ML < 3 for California (Chung and Bernreuter, 1981)
UCB	ML BRK	MW = (0.997± 0.02) ML - 0.05 (±0.131) for $3.6 \le ML \le 6.8$ (R. Uhrhammer, UCB, written communication, 1996) For ML < 3.6 assume same as above (R. Uhrhammer, UCB, oral communication, 1997)
USGS_CA	ML USGS MD USGS	For Mammoth region MW = 0.8 ML + 0.96 for $1 \le ML \le 6$ and MW = 0.54 ML + 1.55 for $½ \le ML \le 3$ (Chavez and Priestly, 1985) Coda duration magnitude equivalent to ML for $0.5 \le ML \le 5.5$ (Eaton, 1992) so use above conversions
SGB	ML USGSDR MC USGSDR MV USGSDR MD USGSDR MD USGSDV	MW = ML for $ML \ge 3$; Use MW = 0.667 ML + 1 for ML < 3 (D. von Seggern, UNR, written communication, 1996) Coda amplitude magnitude - convert to ML using ML =1.05 MC -0.01 for $1.0 \le MC \le 3.0$ (Figure G-6) then to MW ML from vertical record - convert to ML using ML =1.01 MV + 0.22. Valid for $0.5 \le MV \le$ ~3.0 (Figure G-5) then to MW Coda duration magnitude - convert to ML using ML =1.01 MD + 0.06 for $0.5 \le MD \le 2.25$ (Figure G-7) then to MW Coda duration magnitude from develocorder - convert to MD UNR using MD (UNR) = 0.82MD (USGS)+ 1.07 for $1.25 \le$ MD (USGS)≤ 2.5 (Figure G-8) then to MW
UNR	ML UNRENO MD UNRENO MD CUSP	Using same Mo-ML relation as for SGB MW = ML for $3 \le ML \le 6.8$; and MW = 0.667 ML + 1.0 for ML < 3 MD calibrated to ML (UNR or UCB) for $1.5 \le ML \le 5.7$. Use equations above Convert to ML CUSP using ML = -1.24 + 1.31 MD for $0.5 \le MD \le 4$ (D. von Seggern, UNR, written communication, 1996) then to MW
MER	ML MD MB MS	Adopted from UCB, CIT or UNR - use appropriate conversion Adopted from UNR or NTS related seismic research, e.g., HSF, ROW and FPH - Assume equivalent to MD UNR mb = ML for mb < 5.5 and then convert to MW (Boore and Joyner, 1982) MW = 0.79MS + 1.24 (Jost and Herrmann, 1990)
UU	ML MD	MW = 0.8 ML + 0.5 for $2.3 \le ML \le 3.5$ and MW = ML - 0.17 for $3.5 \le ML \le 6.0$ (Shemeta and Pechmann, 1989 and unpublished work): Calibrated to ML for $1.5 \le ML \le 2.5$

TABLE G-3
HIERARCHIES FOR MAGNITUDE CONVERSION FOR SUB-CATALOGUES OF THE 300 KM YUCCA MOUNTAIN CATALOGUE

CATALOGUE	MAGNITUDE SCALE	MAGNITUDE CONVERSION
CIT	ML PAS	See Table G-2
UCB	ML BRK/BERK/UCB	See Table G-2
	ML PAS	See Table G-2
	MI CDMG	=ML BRK (See Table G-2)
	MI BRK	=ML BRK (See Table G-2)
	UK MAK	=ML BRK (See Table G-2)
USGS_CA	ML USGS	See Table G-2
	MD USGS	See Table G-2
	MX USGS	=ML USGS (See Table G-2)
	MD UNRCSP	See Table G-2
	ML BRK/BERK	See Table G-2
	MD UNRENO	See Table G-2
	ML PAS	See Table G-2
	ML CCN	=ML USGS (See Table G-2)
SGB	ML USGSDR	See Table G-2
	MV USGSDR	See Table G-2
	MC USGSDR	See Table G-2
	MD USGSDR	See Table G-2
	MD USGSDV	See Table G-2
	MD UNRENO	See Table G-2
	MD SGB	=MD USGSDR (See Table G-2)
UNR	ML UNRENO	See Table G-2
	MD UNRENO	See Table G-2
	MD UNRCSP	See Table G-2
	ML BRK	See Table G-2
	ML USGSDR	See Table G-2
	MV USGSDR	See Table G-2
	MD USGS	See Table G-2
	ML PAS	See Table G-2

TABLE G-3
HIERARCHIES FOR MAGNITUDE CONVERSION FOR SUB-CATALOGUES OF THE 300 KM YUCCA MOUNTAIN CATALOGUE

CATALOGUE	MAGNITUDE SCALE	MAGNITUDE CONVERSION
MER	ML BRK	See Table G-2
	ML PAS	See Table G-2
	ML UNRENO	See Table G-2
	MD UNR	See Table G-2
	MD HSF, ROW, FPH, RWL, PHM, SHJ, RYN	=MD UNRENO (See Table G-2)
	ML KKG, RYN, PDX, RWL, NOS	=ML USGSDR (See Table G-2)
	UK ALX, RYC, KKG, ERS, PDX, GDY, ISC	=ML USGSDR (See Table G-2)
	ML ISC	=ML USGSDR (See Table G-2)
	MI UVUTAH	=ML UVUTAH(See Table G-2)
	MX UVUTAH	=ML UVUTAH (See Table G-2)
	MB	See Table G-2
	MS	See Table G-2
UVUTAH	ML UVUTAH/SLC	See Table G-2
	MD UVUTAH/SLC	See Table G-2
	ML PAS	See Table G-2
	ML UNRENO	See Table G-2
	MI UVUTAH	=ML UVUTAH (See Table G-2)
	MD UNRENO	See Table G-2
	MX UVUTAH	=ML UVUTAH (See Table G-2)
DNAG	ML BRK	See Table G-2
	ML PAS	See Table G-2
	ML GS	=ML USGSDR (See Table G-2)
	ML CCN	=ML USGSDR (See Table G-2)
	MB DNAG	See Table G-2
	MD UNRENO	See Table G-2
	MD SGB	See Table G-2
	ML UNV	=ML UNRENO (See Table G-2)
	UK BRK	=ML BRK (See Table G-2)
	UK PAS	=ML PAS (See Table G-2)
	UK	=ML USGSDR (See Table G-2)
	MI BRK, CDMG	=ML BRK

TABLE G-3
HIERARCHIES FOR MAGNITUDE CONVERSION FOR SUB-CATALOGUES OF THE 300 KM YUCCA MOUNTAIN CATALOGUE

CATALOGUE	MAGNITUDE SCALE	MAGNITUDE CONVERSION
DNAG (Cont.)	MI GS	=ML USGSDR (See Table G-2)
	MI SGB	=ML USGSDR (See Table G-2)
NEIC - CDMG	MW H&K	No conversion needed
	ML RI	=ML BRK (See Table G-2)
	ML EH	=ML BRK (See Table G-2)
	UK TO	=ML BRK (See Table G-2)
	UK DMG	=ML BRK (See Table G-2)
NEIC - SRA	MD UU	See Table G-2
	LG AE	=mb (See Table G-2)
NEIC - PDE	ML GS	=ML USGSDR (See Table G-2)
	ML AE	=ML USGSDR (See Table G-2)
	MB NEIC	See Table G-2
NAU	ML UNRENO	See Table G-2
	ML AE	=ML USGSDR (See Table G-2)
	ML GS	=ML USGSDR (See Table G-2)
	LG AE	=mb (See Table G-2)

TABLE G-4
EXPLANATION OF MAGNITUDE DATA SOURCES IN THE YUCCA MOUNTAIN CATALOGUE

ABE1	Abe and Noguchi (1983)
ALX	U.S. Army Corps of Engineers, Alexandria Laboratories
BDA	Unknown
BRK, BERK	University of California at Berkeley, California
BRP	Basin and Range Province
CALT1	Caltech
CCN	USGS Central California Network
CDMG	California Division of Mines and Geology
CGS	U.S. Coast and Geodetic Survey
CIT	California Institute of Technology
DMG	California Department of Mines and Geology
DNAG	Decade of North American Geology
DOSSM1	Doser and Smith (1989)
DW	Dewey
DWR	California Department of Water Resources
EQH	Earthquake History of the United States
ERL	Environmental Research Laboratory 1971-1973
ERS	Hays *et al.* (1975)
FPH	Fischer *et al.* (1972)
GDY	W. Gawthrop and J. Dewey, USGS, written communication, 1980
GTR1	Gutenberg-Richter magnitude from intensity
HSF	Hamilton *et al.* (1971)
H&K	Hanks and Kanamori
ISC	International Seismological Centre
KKG	King *et al.* (1971), Bayer *et al.* (1972) and Bayer (1973a; 1973b; 1974)
MAK	Unknown
MER	Meremonte and Rogers (1987)
NAU	Northern Arizona University
NEIC	National Earthquake Information Center
NOS	Unknown
OTT	Ottawa
PAS	Pasadena, California
PDE	Preliminary Determination of Epicenters

TABLE G-4
EXPLANATION OF MAGNITUDE DATA SOURCES IN THE YUCCA MOUNTAIN CATALOGUE

PDX	National Oceanic and Atmospheric Administration
PHM	Papanek and Hamilton (1972)
REN	Reno, Nevada
ROW	Rogers *et al.* (1977)
RPM	Unknown
RWL	Rogers and Lee (1976)
RYC	F. Ryall, UNR, written communication, 1980
RYN	Historical catalogue data, update of Slemmons *et al* (1965)
SGB	Southern Great Basin Network
SHJ	Smith *et al.* (1971)
SLC	Salt Lake City, Utah
SRA	Stover, Reagor, Algermissen catalogue from NEIC
STOCOFF	Stover and Coffman
TOPO	Toppozada magnitude from intensity
UCB, UCBMLT	University of California, Berkeley
USE	U.S. Earthquakes, U.S. Coast and Geodetic Survey
USGS, NEIC, GS	National Earthquake Information Center, USGS
USGSDR	USGS SGB catalogue magnitude from digital recordings
USGSDV	USGS SGB catalogue magnitude from develocorders
UNRCSP	University of Nevada, Reno, from UNRSL CUSP system
UNW	Unknown
USN	Hays *et al.* (1975)
UU, UVUTAH	University of Utah
VSB	Von Seggern and Brune (1996)
WCFS1	Woodward-Clyde Federal Services
XXX	Unknown

TABLE G-5
CATALOGUE OF UNDERGROUND NUCLEAR BLASTS AT THE NEVADA TEST SITE, 1957 TO 1992

Explanation of abbreviations:

Cat. No. Event number

Date Date of blast, GMT year, month, day

Time Time of blast, GMT hour, minute, second

Latitude Latitude, decimal degrees

Longitude Longitude, decimal degrees

Depth Depth of event, kilometers (all were assumed to be zero)

Magnitude 1 Magnitude, two-letter magnitude scale, magnitude source

Magnitude scales:

- M_L Local magnitude
- M_B Body-wave magnitude
- M_D Coda-duration magnitude
- M_W Moment magnitude

Magnitude sources:

WCFS	Woodward-Clyde Federal Services, calculated from yield
UNRENO	University of Nevada, Reno
RIL, RILEY OPP	Riley, California Institute of Technology
ISC	International Seismological Centre
ALX	U.S. Army Corps of Engineers, Alexandria Laboratories
RYN	Historical catalogue data, update of Slemmons *et al.* (1965)
UCB	University of California, Berkeley
MVDSDR	Calculated from USGS develocorder

Magnitude 2 Secondary magnitude

Intensity (MM) Modified Mercalli intensity

Agency Source

LLNL	Data from Lawrence Livermore National Laboratory
UNRENO	Data from University of Nevada, Reno
RILEY OPP	Data from Riley, CIT, provided by David Oppenheimer, USGS (1996)
MER	Meremonte and Rogers (1987)

TABLE G-5
ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
1	1957	JUL	26	00:00.0	37.052	-116.03	0	3.60MLWCFS		LLNL
2	1957	AUG	27	35:00.0	37.049	-116.03	0	3.60MLWCFS		LLNL
3	1957	SEP	19	59:00.6	37.196	-116.2	0	3.80MLWCFS		LLNL
4	1957	DEC	6	15:00.0	37.05	-116.03	0	3.60MLWCFS		LLNL
5	1958	FEB	22	00:00.0	0	0	0	3.60MLWCFS		LLNL
6	1958	MAR	14	00:00.0	0	0	0	3.60MLWCFS		LLNL
7	1958	SEP	12	00:00.0	37.05	-116.03	0	4.80MLWCFS		LLNL
8	1958	SEP	17	30:00.0	37.05	-116.03	0	4.40MLWCFS		LLNL
9	1958	SEP	21	00:00.0	37.049	-116.03	0	3.76MLWCFS		LLNL
10	1958	SEP	23	00:00.0	0	0	0	3.60MLWCFS		LLNL
11	1958	SEP	26	00:00.0	37.05	-116.03	0	3.86MLWCFS		LLNL
12	1958	SEP	26	00:00.0	37.193	-116.2	0	3.86MLWCFS		LLNL
13	1958	OCT	5	15:00.0	37.049	-116.03	0	4.24MLWCFS		LLNL
14	1958	OCT	8	00:00.0	37.195	-116.2	0	5.21MLWCFS		LLNL
15	1958	OCT	14	00:00.0	37.194	-116.2	0	5.39MLWCFS		LLNL
16	1958	OCT	16	00:00.0	37.184	-116.2	0	4.21MLWCFS		LLNL
17	1958	OCT	16	00:00.0	37.18	-116.2	0	4.50MDUNRENO		UNRENO
18	1958	OCT	20	30:00.0	37.05	-116.03	0	3.60MLWCFS		LLNL
19	1958	OCT	29	00:00.0	37.195	-116.21	0	5.10MLWCFS		LLNL
20	1958	OCT	30	00:00.0	37.186	-116.2	0	3.60MLWCFS		LLNL
21	1961	SEP	15	00:00.0	37.188	-116.21	0	3.96MLWCFS		LLNL
22	1961	SEP	16	45:00.0	37.048	-116.03	0	4.70MLWCFS		LLNL
23	1961	OCT	1	30:00.0	37.048	-116.04	0	4.70MLWCFS		LLNL
24	1961	OCT	10	00:00.0	37.194	-116.21	0	4.70MLWCFS		LLNL
25	1961	OCT	29	30:00.0	37.049	-116.03	0	4.70MLWCFS		LLNL
26	1961	DEC	3	04:00.6	37.046	-116.03	0	4.60MLWCFS		LLNL
27	1961	DEC	10	00:00.0	32.264	-103.87	0	4.00MLWCFS		LLNL
28	1961	DEC	13	00:00.0	37.127	-116.05	0	3.60MLWCFS		LLNL
29	1961	DEC	17	35:00.0	37.043	-116.03	0	4.70MLWCFS		LLNL
30	1961	DEC	22	30:00.0	37.195	-116.21	0	4.70MLWCFS		LLNL
31	1962	JAN	9	30:00.0	37.045	-116.04	0	4.20MLWCFS		LLNL
32	1962	JAN	18	00:00.0	37.047	-116.03	0	4.30MLWCFS		LLNL
33	1962	JAN	30	00:00.0	37.047	-116.04	0	4.70MLWCFS		LLNL

E G-5
ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
34	1962	FEB	8	00:00.0	37.127	-116.05	0	4.00MLWCFS		LLNL
35	1962	FEB	9	30:00.0	37.044	-116.04	0	4.30MLWCFS		LLNL
36	1962	FEB	15	00:00.0	37.226	-116.06	0	4.25MLWCFS		LLNL
37	1962	FEB	19	30:00.0	37.049	-116.03	0	3.85MLWCFS		LLNL
38	1962	FEB	19	50:00.0	37.127	-116.04	0	4.70MLWCFS		LLNL
39	1962	FEB	23	00:00.0	37.129	-116.05	0	4.50MLWCFS		LLNL
40	1962	FEB	24	30:00.0	37.048	-116.03	0	4.70MLWCFS		LLNL
41	1962	MAR	1	10:00.0	37.041	-116.03	0	4.70MLWCFS		LLNL
42	1962	MAR	5	15:00.0	37.111	-116.37	0	3.60MLWCFS		LLNL
43	1962	MAR	6	30:00.0	37.048	-116.03	0	4.70MLWCFS		LLNL
44	1962	MAR	8	00:00.0	37.122	-116.05	0	4.40MLWCFS		LLNL
45	1962	MAR	15	30:00.0	37.044	-116.03	0	4.70MLWCFS		LLNL
46	1962	MAR	28	00:00.0	37.124	-116.03	0	4.10MLWCFS		LLNL
47	1962	MAR	31	00:00.0	37.047	-116.04	0	4.70MLWCFS		LLNL
48	1962	APR	5	00:00.0	37.045	-116.02	0	4.50MLWCFS		LLNL
49	1962	APR	6	00:00.0	37.118	-116.04	0	4.70MLWCFS		LLNL
50	1962	APR	12	00:00.0	37.127	-116.05	0	4.70MLWCFS		LLNL
51	1962	APR	14	00:00.0	37.222	-116.16	0	3.84MLWCFS		LLNL
52	1962	APR	21	40:00.0	37.119	-116.03	0	4.70MLWCFS		LLNL
53	1962	APR	27	00:00.0	37.118	-116.04	0	4.70MLWCFS		LLNL
54	1962	MAY	7	33:00.0	37.047	-116.03	0	4.70MLWCFS		LLNL
55	1962	MAY	10	00:00.0	37.128	-116.05	0	4.70MLWCFS		LLNL
56	1962	MAY	12	00:00.0	37.065	-116.03	0	5.00MLWCFS		LLNL
57	1962	MAY	19	00:00.0	37.123	-116.05	0	4.70MLWCFS		LLNL
58	1962	MAY	25	00:00.0	37.125	-116.05	0	4.70MLWCFS		LLNL
59	1962	JUN	1	00:00.0	37.046	-116.03	0	4.70MLWCFS		LLNL
60	1962	JUN	6	00:00.0	37.046	-116.04	0	4.70MLWCFS		LLNL
61	1962	JUN	13	00:00.0	37.222	-116.16	0	4.70MLWCFS		LLNL
62	1962	JUN	21	00:00.0	37.043	-116.03	0	4.70MLWCFS		LLNL
63	1962	JUN	27	00:00.0	37.042	-116.04	0	5.20MLWCFS		LLNL
64	1962	JUN	28	00:00.0	37.009	-116.2	0	4.70MLWCFS		LLNL
65	1962	JUN	30	30:00.0	37.117	-116.05	0	4.70MLWCFS		LLNL
66	1962	JUL	6	00:00.0	37.177	-116.05	0	5.40MLWCFS		LLNL

TABLE G-5
ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
67	1962	JUL	13	00:00.2	37.055	-116.03	0	5.15MLWCFS		LLNL
68	1962	JUL	27	00:00.0	37.13	-116.06	0	4.70MLWCFS		LLNL
69	1962	AUG	24	00:00.0	37.119	-116.04	0	4.70MLWCFS		LLNL
70	1962	AUG	24	00:00.0	37.046	-116.02	0	4.70MLWCFS		LLNL
71	1962	SEP	6	00:00.0	37.13	-116.05	0	4.70MLWCFS		LLNL
72	1962	SEP	14	10:00.0	37.044	-116.02	0	4.70MLWCFS		LLNL
73	1962	SEP	20	00:00.0	37.055	-116.03	0	4.70MLWCFS		LLNL
74	1962	SEP	29	00:00.0	37.117	-116.03	0	4.70MLWCFS		LLNL
75	1962	OCT	5	00:00.0	37.139	-116.05	0	5.40MLWCFS		LLNL
76	1962	OCT	12	00:00.0	37.123	-116.05	0	4.70MLWCFS		LLNL
77	1962	OCT	12	00:00.0	37.049	-116.03	0	4.70MLWCFS		LLNL
78	1962	OCT	18	00:00.0	37.129	-116.04	0	4.70MLWCFS		LLNL
79	1962	OCT	19	00:00.0	37.04	-116.02	0	4.70MLWCFS		LLNL
80	1962	OCT	27	00:00.0	37.149	-116.05	0	4.70MLWCFS		LLNL
81	1962	NOV	9	00:00.0	37.164	-116.07	0	4.70MLWCFS		LLNL
82	1962	NOV	15	30:00.0	37.042	-116.02	0	4.70MLWCFS		LLNL
83	1962	NOV	27	00:00.0	37.123	-116.03	0	4.70MLWCFS		LLNL
84	1962	DEC	4	00:00.0	37.128	-116.05	0	4.70MLWCFS		LLNL
85	1962	DEC	7	00:00.0	37.052	-116.03	0	4.70MLWCFS		LLNL
86	1962	DEC	12	25:00.0	37.172	-116.2	0	4.70MLWCFS		LLNL
87	1962	DEC	12	45:00.0	37.046	-116.02	0	4.70MLWCFS		LLNL
88	1962	DEC	14	00:00.0	37.124	-116.04	0	4.70MLWCFS		LLNL
89	1963	FEB	8	00:00.2	37.149	-116.05	0	4.70MLWCFS		LLNL
90	1963	FEB	8	30:00.1	37.058	-116.03	0	4.70MLWCFS		LLNL
91	1963	FEB	15	00:00.0	37.049	-116.03	0	4.70MLWCFS		LLNL
92	1963	FEB	21	47:00.0	37.12	-116.05	0	4.70MLWCFS		LLNL
93	1963	MAR	1	00:00.0	37.045	-116.03	0	4.70MLWCFS		LLNL
94	1963	MAR	15	22:00.5	37.126	-116.05	0	4.70MLWCFS		LLNL
95	1963	MAR	29	49:00.0	37.042	-116.02	0	4.70MLWCFS		LLNL
96	1963	APR	5	52:00.0	37.037	-116.02	0	4.70MLWCFS		LLNL
97	1963	APR	10	01:00.3	37.049	-116.03	0	4.70MLWCFS		LLNL
98	1963	APR	11	03:00.0	37.157	-116.07	0	4.70MLWCFS		LLNL
99	1963	APR	24	09:30.1	37.121	-116.04	0	4.70MLWCFS		LLNL

ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT)	Latitude	Longitude	Depth	Magnitude 1	Magnitude 2	Agency
				hr:min.sec			(km)			Source
100	1963	MAY	9	19:00.3	37.049	-116.02	0	4.70MLWCFS		LLNL
101	1963	MAY	17	55:00.1	37.048	-116.03	0	4.70MLWCFS		LLNL
102	1963	MAY	22	40:00.0	37.111	-116.04	0	5.15MLWCFS		LLNL
103	1963	MAY	29	03:00.3	37.128	-116.04	0	4.70MLWCFS		LLNL
104	1963	JUN	5	00:00.0	37.196	-116.21	0	4.70MLWCFS		LLNL
105	1963	JUN	6	00:00.0	37.044	-116.04	0	4.70MLWCFS		LLNL
106	1963	JUN	6	58:00.0	37.125	-116.04	0	4.70MLWCFS		LLNL
107	1963	JUN	14	10:00.0	37.046	-116.02	0	4.70MLWCFS		LLNL
108	1963	JUN	25	00:00.0	37.131	-116.07	0	4.70MLWCFS		LLNL
109	1963	AUG	12	45:00.0	37.04	-116.02	0	4.70MLWCFS		RILEY OPP
110	1963	AUG	15	00:00.0	37.15	-116.08	0	4.70MLWCFS		RILEY OPP
111	1963	AUG	23	20:00.0	37.13	-116.04	0	4.70MLWCFS		RILEY OPP
112	1963	SEP	13	53:00.0	37.16	-116.08	0	4.70MLWCFS		RILEY OPP
113	1963	SEP	13	00:00.0	37.06	-116.02	0	5.70MLWCFS		RILEY OPP
114	1963	SEP	27	20:00.0	0	0	0	3.00MBRIL		RILEY OPP
115	1963	OCT	11	00:00.0	37.037	-116.02	0	4.70MLWCFS		RILEY OPP
116	1963	OCT	11	00:00.0	37.12	-116.03	0	4.70MLWCFS		RILEY OPP
117	1963	OCT	16	00:00.0	37.2	-116.23	0	5.15MLWCFS		RILEY OPP
118	1963	OCT	26	00:00.0	39.2	-118.38	0	4.80MLWCFS		RILEY OPP
119	1963	NOV	14	00:00.0	37.04	-116.02	0	4.70MLWCFS		RILEY OPP
120	1963	NOV	15	00:00.0	37.13	-116.05	0	4.70MLWCFS		RILEY OPP
121	1963	NOV	22	30:00.0	37.12	-116.05	0	5.15MLWCFS		RILEY OPP
122	1963	DEC	4	38:30.0	37.04	-116.03	0	4.70MLWCFS		RILEY OPP
123	1963	DEC	12	02:00.0	37.13	-116.04	0	4.70MLWCFS		RILEY OPP
124	1964	JAN	16	00:00.0	37.142	-116.05	0	5.20MBISC		LLNL
125	1964	JAN	23	00:00.0	37.126	-116.04	0	4.20MBRIL		RILEY OPP
126	1964	JAN	30	00:00.0	37.1	-115.9	0	4.10MBRIL		RILEY OPP
127	1964	FEB	12	37:59.5	37.03	-116.12	0	4.70MLWCFS		RILEY OPP
128	1964	FEB	13	30:00.0	37.2	-115.9	0	4.00MBRIL		RILEY OPP
129	1964	FEB	18	37:19.0	37.1	-116	0	4.80MBRIL	4.40MBRIL	RILEY OPP
130	1964	FEB	20	30:00.0	37.15	-116.04	0	5.10MBRIL		RILEY OPP
131	1964	MAR	12	00:07.0	37.3	-116.2	0	3.30MBRIL		RILEY OPP
132	1964	MAR	13	02:00.0	37.05	-116.01	0	4.70MLWCFS		RILEY OPP

TABLE G-5
ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
133	1964	APR	14	40:00.0	37.129	-116.03	0	4.70MLWCFS		RILEY OPP
134	1964	APR	15	30:00.0	37.044	-116.02	0	4.70MLWCFS		RILEY OPP
135	1964	APR	24	10:00.0	37.15	-116.06	0	5.20MBRIL		RILEY OPP
136	1964	APR	29	47:00.0	37.04	-116.03	0	4.10MBRIL		RILEY OPP
137	1964	MAY	14	40:00.0	37.12	-116.04	0	4.70MLWCFS		RILEY OPP
138	1964	MAY	15	15:00.0	37.04	-116.01	0	4.70MLWCFS		RILEY OPP
139	1964	JUN	11	45:00.0	37.15	-116.08	0	4.70MLWCFS		RILEY OPP
140	1964	JUN	12	01:00.0	36.8	-116.2	0	3.60MBRIL		RILEY OPP
141	1964	JUN	18	30:00.0	37.3	-115.6	0	3.20MBRIL		RILEY OPP
142	1964	JUN	24	06:12.0	36.8	-116.7	0	3.20MBRIL		RILEY OPP
143	1964	JUN	25	30:00.0	37.11	-116.03	0	4.70MLWCFS		RILEY OPP
144	1964	JUN	30	33:00.0	37.17	-116.06	0	4.70MLWCFS		RILEY OPP
145	1964	JUL	16	15:00.0	37.18	-116.05	0	5.15MLWCFS		RILEY OPP
146	1964	JUL	17	18:30.0	37.02	-116.03	0	4.70MLWCFS		RILEY OPP
147	1964	AUG	19	00:00.0	37.16	-116.08	0	4.70MLWCFS		RILEY OPP
148	1964	AUG	22	17:00.0	37.07	-116.02	0	4.70MLWCFS		RILEY OPP
149	1964	AUG	28	06:00.0	37.07	-116.02	0	4.70MLWCFS		RILEY OPP
150	1964	SEP	4	15:00.0	37.02	-116.02	0	4.70MLWCFS		RILEY OPP
151	1964	SEP	11	00:00.0	37.2	-114.8	0	3.30MBRIL		RILEY OPP
152	1964	OCT	2	03:00.0	37.08	-116.01	0	4.00MBISC		LLNL
153	1964	OCT	9	00:00.0	37.15	-116.08	0	4.80MBRIL		RILEY OPP
154	1964	OCT	16	59:30.0	37.04	-116.02	0	4.70MLWCFS		RILEY OPP
155	1964	OCT	22	00:00.0	31.14	-189.57	0	5.30MBRIL	4.60MBRIL	RILEY OPP
156	1964	OCT	31	04:59.0	37.11	-116.03	0	4.70MLWCFS		RILEY OPP
157	1964	NOV	5	00:00.0	37.17	-116.07	0	4.80MBRIL		RILEY OPP
158	1964	DEC	5	15:00.0	37.11	-116.05	0	4.80MBRIL		RILEY OPP
159	1964	DEC	5	15:00.0	37.13	-116.07	0	5.15MLWCFS		RILEY OPP
160	1964	DEC	16	00:00.0	37.03	-116.01	0	3.70MLWCFS		RILEY OPP
161	1964	DEC	16	10:00.0	37.18	-116.07	0	4.00MLWCFS		RILEY OPP
162	1964	DEC	18	35:00.0	37.08	-116.34	0	3.60MLWCFS		RILEY OPP
163	1964	DEC	23	43:00.0	37.3	-115.1	0	2.90MBRIL		RILEY OPP
164	1965	JAN	14	00:00.0	37.119	-116.03	0	4.70MLWCFS		RILEY OPP
165	1965	JAN	29	22:00.0	37	-116	0	3.60MBRIL		RILEY OPP

TABLE G-5

ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT)	Latitude	Longitude	Depth	Magnitude 1	Magnitude 2	Agency
				hr:min.sec			(km)			Source
166	1965	FEB	4	30:00.0	37.131	-116.06	0	4.70MLWCFS		RILEY OPP
167	1965	FEB	12	10:30.0	37.165	-116.08	0	4.70MLWCFS		RILEY OPP
168	1965	FEB	16	30:00.0	37.052	-116.02	0	4.50MLWCFS		RILEY OPP
169	1965	FEB	18	18:47.0	36.82	-115.95	0	4.70MLWCFS		RILEY OPP
170	1965	MAR	3	13:00.0	37.065	-116.04	0	5.15MLWCFS		RILEY OPP
171	1965	MAR	20	23:50.0	37	-116.3	0	3.60MBRIL		RILEY OPP
172	1965	MAR	26	34:08.0	37.148	-116.04	0	5.15MLWCFS		RILEY OPP
173	1965	APR	5	00:00.0	37.026	-116.02	0	4.70MLWCFS		RILEY OPP
174	1965	APR	14	14:00.0	37.28	-116.52	0	4.30MBRIL		RILEY OPP
175	1965	APR	21	00:00.0	37.01	-116.2	0	5.00MBRIL		RILEY OPP
176	1965	APR	22	39:00.0	37.1	-115.9	0	3.90MBRIL		RILEY OPP
177	1965	APR	23	44:00.0	37.02	-116	0	3.70MBRIL		RILEY OPP
178	1965	MAY	7	47:11.0	37.14	-116.07	0	4.70MLWCFS		RILEY OPP
179	1965	MAY	12	15:00.0	37.24	-116.43	0	4.70MLWCFS		RILEY OPP
180	1965	MAY	14	57:52.0	36.82	-115.97	0	4.70MLWCFS		RILEY OPP
181	1965	MAY	14	32:36.0	37.06	-116.01	0	4.70MLWCFS		RILEY OPP
182	1965	MAY	21	08:52.0	37.119	-116.03	0	4.70MLWCFS		RILEY OPP
183	1965	JUN	11	45:00.0	37.043	-116.02	0	3.70MLWCFS		RILEY OPP
184	1965	JUN	11	28:38.0	37.116	-116.02	0	3.60MBRIL		RILEY OPP
185	1965	JUN	16	30:00.0	36.82	-115.96	0	4.70MLWCFS		RILEY OPP
186	1965	JUN	17	00:00.0	37.22	-116.06	0	4.70MLWCFS		RILEY OPP
187	1965	JUL	22	21:10.1	37.2	-115.98	0	2.40UKALX		MER
188	1965	JUL	23	00:00.0	37.1	-116.03	0	5.40MBRIL		RILEY OPP
189	1965	AUG	6	23:30.0	37.02	-116.04	0	4.70MLWCFS		RILEY OPP
190	1965	AUG	21	43:09.0	37.113	-116.03	0	3.40MBRIL		RILEY OPP
191	1965	AUG	27	51:13.0	37.14	-116.07	0	4.70MLWCFS		RILEY OPP
192	1965	SEP	1	08:00.0	37.02	-116.01	0	4.20MBRIL		RILEY OPP
193	1965	SEP	10	12:00.0	37.08	-116.02	0	5.10MBRIL		RILEY OPP
194	1965	SEP	17	08:23.0	37.11	-116.03	0	4.70MLWCFS		RILEY OPP
195	1965	NOV	12	00:00.0	37.05	-116.02	0	4.70MLWCFS		RILEY OPP
196	1965	NOV	23	17:33.0	37.162	-116.07	0	3.60MBRIL		RILEY OPP
197	1965	DEC	3	13:02.0	37.165	-116.05	0	5.60MBRIL		RILEY OPP
198	1965	DEC	16	39:18.0	37.14	-116.06	0	4.70MLWCFS		RILEY OPP

TABLE G-5
ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
199	1965	DEC	16	15:00.0	37.07	-116.03	0	5.30MBRIL		RILEY OPP
200	1965	DEC	25	59:53.0	37	-116.3	0	4.10MBRIL	3.60MBRIL	RILEY OPP
201	1966	JAN	13	37:43.0	37.12	-116.03	0	4.70MLWCFS		RILEY OPP
202	1966	JAN	18	35:00.0	37.09	-116.02	0	5.20MBRIL		RILEY OPP
203	1966	JAN	21	28:00.0	37.03	-116.02	0	4.70MLWCFS		RILEY OPP
204	1966	JAN	22	17:20.0	36.5	-114.7	0	3.20MBRIL		RILEY OPP
205	1966	FEB	3	17:37.0	37.13	-116.07	0	4.30MBRIL		RILEY OPP
206	1966	FEB	24	55:07.0	37.27	-116.43	0	4.80MBRIL		RILEY OPP
207	1966	MAR	5	15:00.0	37.17	-116.21	0	4.70MLWCFS		RILEY OPP
208	1966	MAR	7	41:00.0	37.04	-116.03	0	4.70MLWCFS		RILEY OPP
209	1966	MAR	12	04:13.0	37.14	-116.05	0	4.70MLWCFS		RILEY OPP
210	1966	MAR	18	00:00.0	37.01	-116.01	0	4.70MLWCFS		RILEY OPP
211	1966	MAR	24	55:28.0	37.11	-116.03	0	4.70MLWCFS		RILEY OPP
212	1966	APR	1	40:00.0	37.1	-116.02	0	4.70MLWCFS		RILEY OPP
213	1966	APR	6	57:17.0	37.14	-116.14	0	4.40MBRIL		RILEY OPP
214	1966	APR	7	27:30.0	37.02	-115.99	0	4.70MLWCFS		RILEY OPP
215	1966	APR	14	13:43.0	37.24	-116.43	0	5.40MBRIL		RILEY OPP
216	1966	APR	23	55:26.0	37.161	-116.08	0	3.30MBRIL		RILEY OPP
217	1966	APR	25	38:00.0	36.89	-115.94	0	4.50MBRIL		RILEY OPP
218	1966	MAY	4	32:17.0	37.14	-116.14	0	5.50MBRIL		RILEY OPP
219	1966	MAY	5	00:00.0	37.05	-116.04	0	4.20MBRIL		RILEY OPP
220	1966	MAY	6	00:00.0	37.35	-116.32	0	5.50MBRIL		RILEY OPP
221	1966	MAY	12	37:26.0	37.13	-116.07	0	4.20MBRIL		RILEY OPP
222	1966	MAY	13	30:00.0	37.09	-116.03	0	5.60MBRIL		RILEY OPP
223	1966	MAY	19	56:28.0	37.11	-116.06	0	5.80MBRIL		RILEY OPP
224	1966	MAY	27	00:00.0	37.18	-116.1	0	5.10MBRIL		RILEY OPP
225	1966	JUN	2	30:00.0	37.23	-116.06	0	5.60MBRIL		RILEY OPP
226	1966	JUN	3	00:00.0	37.07	-116.04	0	5.70MBRIL		RILEY OPP
227	1966	JUN	10	30:00.0	37.06	-116.04	0	4.70MLWCFS		RILEY OPP
228	1966	JUN	15	00:00.0	37.01	-116.2	0	4.70MLWCFS		RILEY OPP
229	1966	JUN	15	02:47.0	37.17	-116.05	0	5.15MLWCFS		RILEY OPP
230	1966	JUN	25	13:00.0	37.16	-116.07	0	4.40MLWCFS		RILEY OPP
231	1966	JUN	30	15:00.0	37.32	-116.3	0	6.10MBRIL		RILEY OPP

ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
232	1966	JUL	28	33:30.0	37.14	-116.13	0	4.70MLWCFS		RILEY OPP
233	1966	AUG	10	16:00.0	37.17	-116.05	0	4.70MLWCFS		RILEY OPP
234	1966	SEP	12	30:00.0	36.88	-115.95	0	4.60MBRIL		RILEY OPP
235	1966	SEP	23	00:00.0	37.1	-116.04	0	4.70MLWCFS		RILEY OPP
236	1966	SEP	29	45:30.0	37.17	-116.05	0	4.10MBRIL		RILEY OPP
237	1966	NOV	5	45:00.0	37.17	-116.05	0	4.70MLWCFS		RILEY OPP
238	1966	NOV	11	00:00.0	37.13	-116.05	0	4.70MLWCFS		RILEY OPP
239	1966	NOV	18	02:00.0	37.04	-116.01	0	4.70MLWCFS		RILEY OPP
240	1966	DEC	13	50:00.0	37.035	-116.01	0	3.90MBRIL		RILEY OPP
241	1966	DEC	13	00:00.0	36.88	-115.94	0	4.60MBRIL		RILEY OPP
242	1966	DEC	20	30:00.0	37.3	-116.41	0	6.30MBRIL		RILEY OPP
243	1967	JAN	18	55:00.0	37.165	-116.05	0	3.20MBRIL		RILEY OPP
244	1967	JAN	19	45:00.0	37.14	-116.14	0	5.40MBRIL		RILEY OPP
245	1967	JAN	20	40:04.0	37.1	-116	0	5.20MBRIL		RILEY OPP
246	1967	JAN	26	30:00.0	37.165	-116.05	0	3.80MBRIL		RILEY OPP
247	1967	FEB	8	15:00.0	37.17	-116.05	0	4.80MBRIL		RILEY OPP
248	1967	FEB	23	34:00.0	37.02	-116.02	0	4.40MBRIL		RILEY OPP
249	1967	FEB	23	50:00.0	37.13	-116.07	0	5.80MBRIL		RILEY OPP
250	1967	MAR	2	00:00.0	37.17	-116.05	0	4.20MBRIL		RILEY OPP
251	1967	MAR	3	19:00.0	37.039	-116.01	0	3.70MBRIL		RILEY OPP
252	1967	APR	7	00:00.0	37.05	-116.02	0	3.90MBRIL		RILEY OPP
253	1967	APR	21	09:00.0	37.02	-116.04	0	4.30MBRIL		RILEY OPP
254	1967	APR	27	45:00.0	37.14	-116.06	0	3.80MBRIL		RILEY OPP
255	1967	MAY	10	40:00.0	37.08	-116	0	5.00MBRIL		RILEY OPP
256	1967	MAY	20	00:00.0	37.13	-116.06	0	5.90MBRIL		RILEY OPP
257	1967	MAY	23	00:00.0	37.28	-116.37	0	5.70MBRIL		RILEY OPP
258	1967	MAY	26	00:00.0	37.25	-116.48	0	5.50MBRIL		RILEY OPP
259	1967	JUN	22	10:00.0	37.13	-116.03	0	4.70MLWCFS		RILEY OPP
260	1967	JUN	26	00:00.0	37.2	-116.21	0	5.10MBRIL		RILEY OPP
261	1967	JUN	29	25:00.0	37.03	-116.02	0	4.60MBRIL		RILEY OPP
262	1967	JUL	27	00:00.0	37.15	-116.05	0	5.00MBRIL		RILEY OPP
263	1967	AUG	4	00:00.0	37.01	-116.15	0	4.00MBRIL		RILEY OPP
264	1967	AUG	10	10:00.0	37.16	-116.05	0	4.70MLWCFS		RILEY OPP

TABLE G-5
ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
265	1967	AUG	18	12:30.0	37.01	-116.04	0	4.60MBRIL		RILEY OPP
266	1967	AUG	24	30:00.0	37.163	-116.07	0	4.70MLWCFS		RILEY OPP
267	1967	AUG	31	30:00.0	37.18	-116.21	0	5.00MBRIL		RILEY OPP
268	1967	SEP	7	45:00.0	37.15	-116.05	0	5.00MBRIL		RILEY OPP
269	1967	SEP	21	45:00.0	37.17	-116.04	0	3.90MLWCFS		RILEY OPP
270	1967	SEP	27	00:00.0	37.1	-116.05	0	5.70MBRIL		RILEY OPP
271	1967	OCT	18	30:00.0	37.12	-116.06	0	5.70MBRIL		RILEY OPP
272	1967	OCT	25	30:00.0	37.03	-116.03	0	4.70MLWCFS		RILEY OPP
273	1967	NOV	8	00:00.0	37.09	-116.04	0	5.10MBRIL		RILEY OPP
274	1967	DEC	6	00:00.0	37.159	-116.05	0	4.70MLWCFS		RILEY OPP
275	1967	DEC	10	30:00.0	36.68	-107.21	0	4.90MLWCFS		RILEY OPP
276	1967	DEC	15	00:00.0	37.04	-116	0	4.70MLWCFS		RILEY OPP
277	1968	JAN	18	30:00.0	37.15	-116.07	0	4.40MLWCFS		RILEY OPP
278	1968	JAN	19	00:00.0	37.16	-116.05	0	5.15MLWCFS		RILEY OPP
279	1968	JAN	19	15:00.0	38.63	-116.22	0	6.30MBRIL		RILEY OPP
280	1968	JAN	26	00:00.0	37.28	-116.51	0	2.30MBRIL		RILEY OPP
281	1968	JAN	31	30:01.0	36.89	-116.12	0	4.70MLWCFS		RILEY OPP
282	1968	FEB	21	30:00.0	37.12	-116.05	0	5.80MBRIL		RILEY OPP
283	1968	FEB	29	08:30.0	37.18	-116.21	0	5.00MBRIL		RILEY OPP
284	1968	MAR	12	04:00.0	37.01	-116.37	0	5.40MBRIL	4.00MBRIL	RILEY OPP
285	1968	MAR	14	19:00.0	37.05	-116.01	0	1.50MBRIL		RILEY OPP
286	1968	MAR	22	00:00.0	37.33	-116.31	0	5.60MBRIL		RILEY OPP
287	1968	MAR	25	44:27.0	36.87	-115.93	0	4.70MLWCFS		RILEY OPP
288	1968	APR	10	00:00.0	37.15	-116.08	0	4.60MBRIL		RILEY OPP
289	1968	APR	18	05:00.0	37.15	-116.04	0	4.90MBRIL		RILEY OPP
290	1968	APR	23	01:30.0	37.34	-116.38	0	4.10MBRIL		RILEY OPP
291	1968	APR	26	00:00.0	37.3	-116.46	0	6.30MBRIL		RILEY OPP
292	1968	MAY	3	00:01.0	37	-115.99	0	4.10MBRIL		RILEY OPP
293	1968	MAY	8	10:00.0	37.157	-116.04	0	3.90MBRIL		RILEY OPP
294	1968	MAY	17	00:00.0	37.12	-116.06	0	4.70MBRIL		RILEY OPP
295	1968	JUN	5	21:30.0	37.035	-116.02	0	4.00MBRIL		RILEY OPP
296	1968	JUN	6	30:00.0	37.17	-116.04	0	4.70MLWCFS		RILEY OPP
297	1968	JUN	15	00:00.0	37.26	-116.31	0	5.90MBRIL		RILEY OPP

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ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
298	1968	JUN	28	22:00.0	37.25	-116.48	0	5.30MBRIL		RILEY OPP
299	1968	JUL	17	00:00.0	37.001	-116	0	4.00MBRIL		RILEY OPP
300	1968	JUL	30	00:00.0	37.12	-116.08	0	5.15MLWCFS		RILEY OPP
301	1968	AUG	9	00:00.0	37.162	-116.08	0	3.50MBRIL		RILEY OPP
302	1968	AUG	15	00:00.0	37.124	-116.05	0	3.90MBRIL		RILEY OPP
303	1968	AUG	27	30:00.0	36.88	-115.93	0	4.70MLWCFS		RILEY OPP
304	1968	AUG	29	45:00.0	37.25	-116.35	0	5.90MBRIL		RILEY OPP
305	1968	SEP	6	00:00.0	37.14	-116.05	0	5.60MBRIL		RILEY OPP
306	1968	SEP	12	00:00.0	37.03	-116.01	0	4.70MLWCFS		RILEY OPP
307	1968	SEP	17	00:00.0	37.12	-116.13	0	5.10MBRIL		RILEY OPP
308	1968	SEP	24	05:00.0	37.2	-116.21	0	5.00MBRIL		RILEY OPP
309	1968	OCT	3	29:00.0	37.03	-115.99	0	4.70MLWCFS		RILEY OPP
310	1968	OCT	10	30:00.0	37.133	-116.04	0	3.90MBRIL		RILEY OPP
311	1968	OCT	29	36:01.0	37.1	-116	0	3.40MBRIL		RILEY OPP
312	1968	OCT	31	30:00.0	37.047	-116.03	0	3.90MBRIL		RILEY OPP
313	1968	NOV	4	15:00.0	37.13	-116.09	0	5.00MBRIL		RILEY OPP
314	1968	NOV	15	30:00.0	37.048	-116	0	3.90MBRIL		RILEY OPP
315	1968	NOV	15	45:00.0	37.03	-116.03	0	4.70MLWCFS		RILEY OPP
316	1968	NOV	20	00:00.0	37.01	-116.21	0	4.90MBRIL		RILEY OPP
317	1968	NOV	22	19:00.0	37.14	-116.04	0	4.70MLWCFS		RILEY OPP
318	1968	DEC	8	00:00.0	37.34	-116.57	0	4.80MBRIL		RILEY OPP
319	1968	DEC	12	10:01.0	37.12	-116.08	0	4.70MLWCFS		RILEY OPP
320	1968	DEC	12	20:00.0	37	-116.1	0	3.90MBRIL		RILEY OPP
321	1968	DEC	19	30:00.0	37.23	-116.47	0	6.30MBRIL		RILEY OPP
322	1969	JAN	15	00:00.0	37.15	-116.07	0	4.50MLWCFS		RILEY OPP
323	1969	JAN	15	30:00.0	37.21	-116.23	0	5.15MLWCFS		RILEY OPP
324	1969	JAN	22	00:02.0	36.96	-116.03	0	4.60MBRIL		RILEY OPP
325	1969	JAN	30	00:00.0	37.05	-116.03	0	4.80MBRIL	4.90MBRIL	RILEY OPP
326	1969	FEB	4	00:00.0	37	-116	0	3.70MBRIL		RILEY OPP
327	1969	FEB	12	18:21.0	37.17	-116.21	0	4.70MLWCFS		RILEY OPP
328	1969	MAR	18	40:02.0	37.1	-116	0	4.40MBRIL	4.10MBRIL	RILEY OPP
329	1969	MAR	20	12:00.0	37.02	-116.03	0	4.60MBRIL	4.50MBRIL	RILEY OPP
330	1969	MAR	21	30:00.0	37.13	-116.09	0	4.90MBRIL	4.85MBRIL	RILEY OPP

TABLE G-5
ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
331	1969	APR	24	04:00.0	37.1	-116.1	0	3.80MBRIL		RILEY OPP
332	1969	APR	30	00:00.0	37.08	-116.01	0	5.30MBRIL	5.25MBRIL	RILEY OPP
333	1969	APR	30	00:00.0	37.09	-116.01	0	5.15MLWCFS		RILEY OPP
334	1969	MAY	7	45:00.0	37.283	-116.5	0	5.50MBISC		LLNL
335	1969	MAY	7	45:00.0	37.28	-116.5	0	5.80MBRIL	5.75MBRIL	RILEY OPP
336	1969	MAY	15	00:00.0	37	-116	0	4.50MBRIL	4.05MBRIL	RILEY OPP
337	1969	MAY	27	15:00.0	37.08	-116	0	5.00MBRIL	4.95MBRIL	RILEY OPP
338	1969	JUN	12	00:00.0	37.01	-116.03	0	4.40MBRIL	4.50MBRIL	RILEY OPP
339	1969	JUN	26	00:00.0	37.1	-116	0	4.40MBRIL	4.10MBRIL	RILEY OPP
340	1969	JUL	16	02:30.0	37.12	-116.06	0	4.70MBRIL	4.60MBRIL	RILEY OPP
341	1969	JUL	16	55:00.0	37.14	-116.09	0	5.60MBRIL	5.55MBRIL	RILEY OPP
342	1969	AUG	14	30:00.0	37.16	-116.06	0	4.70MLWCFS		RILEY OPP
343	1969	AUG	27	45:00.0	37.02	-116.04	0	4.70MBRIL	4.75MBRIL	RILEY OPP
344	1969	SEP	10	00:00.0	39.36	-107.95	0	5.30MBRIL		RILEY OPP
345	1969	SEP	12	02:23.0	36.88	-115.93	0	4.50MBRIL	4.40MBRIL	RILEY OPP
346	1969	SEP	16	30:00.0	37.31	-116.46	0	6.20MBRIL	6.25MBRIL	RILEY OPP
347	1969	SEP	20	30:01.0	37.1	-116.1	0	4.30MBRIL	3.90MBRIL	RILEY OPP
348	1969	OCT	8	30:00.0	37.26	-116.44	0	5.50MBRIL	5.50MBRIL	RILEY OPP
349	1969	OCT	28	35:00.0	37.3	-116.4	0	3.10MBRIL		RILEY OPP
350	1969	OCT	29	30:00.0	37.12	-116.13	0	5.10MBRIL	4.80MBRIL	RILEY OPP
351	1969	OCT	29	00:00.0	37.14	-116.14	0	5.00MBRIL	4.80MBRIL	RILEY OPP
352	1969	OCT	29	01:51.0	37.14	-116.06	0	5.70MBRIL	5.65MBRIL	RILEY OPP
353	1969	NOV	13	15:00.0	37.16	-116.07	0	3.80MLWCFS		RILEY OPP
354	1969	NOV	21	52:00.0	37.03	-116	0	5.00MBRIL	4.95MBRIL	RILEY OPP
355	1969	DEC	5	00:00.0	37.18	-116.21	0	5.00MBRIL	5.00MBRIL	RILEY OPP
356	1969	DEC	10	30:00.0	37.1	-116	0	4.20MBRIL		RILEY OPP
357	1969	DEC	17	00:00.0	37.08	-116	0	5.50MBRIL	5.45MBRIL	RILEY OPP
358	1969	DEC	17	15:00.0	37.01	-116.02	0	4.80MBRIL	4.70MBRIL	RILEY OPP
359	1969	DEC	18	00:00.0	37.12	-116.03	0	5.20MBRIL	5.10MBRIL	RILEY OPP
360	1970	JAN	23	30:00.0	37.14	-116.04	0	4.60MBRIL	4.30MBRIL	RILEY OPP
361	1970	JAN	30	00:00.0	37.03	-116.03	0	4.60MBRIL	4.55MBRIL	RILEY OPP
362	1970	FEB	4	00:00.0	37.1	-116.03	0	5.60MBRIL	5.60MBRIL	RILEY OPP
363	1970	FEB	5	00:00.0	37.16	-116.04	0	4.40MBRIL	4.75MBRIL	RILEY OPP

TABLE G-5

ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
364	1970	FEB	11	15:00.0	37.2	-116.21	0	4.60MBRIL	4.60MBRIL	RILEY OPP
365	1970	FEB	25	28:38.0	37.04	-116	0	5.20MBRIL	5.15MBRIL	RILEY OPP
366	1970	FEB	26	30:00.0	37.12	-116.06	0	5.30MBRIL	5.20MBRIL	RILEY OPP
367	1970	MAR	6	24:01.0	37.17	-116.09	0	4.50MBRIL	4.45MBRIL	RILEY OPP
368	1970	MAR	6	00:00.0	37.14	-116.04	0	4.30MBRIL	4.00MBRIL	RILEY OPP
369	1970	MAR	19	03:30.0	37	-116.02	0	4.10MBRIL	4.30MBRIL	RILEY OPP
370	1970	MAR	23	05:00.0	37.09	-116.02	0	5.50MBRIL	5.50MBRIL	RILEY OPP
371	1970	MAR	26	00:00.0	37.3	-116.53	0	6.50MBRIL	6.50MBRIL	RILEY OPP
372	1970	APR	21	30:00.0	37.05	-115.99	0	4.60MBRIL	4.65MBRIL	RILEY OPP
373	1970	APR	21	00:00.0	37.12	-116.08	0	4.80MBRIL	4.80MBRIL	RILEY OPP
374	1970	MAY	1	13:00.0	37.06	-116.03	0	4.20MBRIL	4.10MBRIL	RILEY OPP
375	1970	MAY	1	40:00.0	37.13	-116.03	0	4.50MBRIL	4.30MBRIL	RILEY OPP
376	1970	MAY	5	30:00.0	37.22	-116.18	0	5.20MBRIL	5.00MBRIL	RILEY OPP
377	1970	MAY	12	00:00.0	37.01	-116.2	0	4.70MLWCFS		RILEY OPP
378	1970	MAY	15	30:00.0	37.16	-116.04	0	5.30MBRIL	5.15MBRIL	RILEY OPP
379	1970	MAY	21	00:00.0	37.01	-115.99	0	3.50MBRIL	3.95MBRIL	RILEY OPP
380	1970	MAY	21	15:00.0	37.07	-116.01	0	5.10MBRIL	5.00MBRIL	RILEY OPP
381	1970	MAY	26	16:00.0	37.18	-116.21	0	5.00MBRIL	4.80MBRIL	RILEY OPP
382	1970	MAY	26	00:00.0	37.11	-116.06	0	5.60MBRIL	5.60MBRIL	RILEY OPP
383	1970	MAY	28	00:00.0	37.1	-116	0	4.20MBRIL	3.90MBRIL	RILEY OPP
384	1970	JUN	26	00:00.0	37.11	-116.09	0	4.30MBRIL	4.20MBRIL	RILEY OPP
385	1970	OCT	13	05:00.0	37.1	-116.1	0	3.90MBRIL		RILEY OPP
386	1970	OCT	14	30:00.0	37.07	-116.01	0	5.50MBRIL	5.50MBRIL	RILEY OPP
387	1970	OCT	28	30:00.0	37.3	-116	0	3.90MBRIL		RILEY OPP
388	1970	NOV	5	00:00.0	37.03	-116.01	0	4.90MBRIL	4.75MBRIL	RILEY OPP
389	1970	NOV	19	00:00.0	37	-116	0	4.10MBRIL		RILEY OPP
390	1970	DEC	3	07:00.0	37.12	-116.27	0	3.10MBRIL		RILEY OPP
391	1970	DEC	16	00:00.0	37.1	-116.01	0	5.10MBRIL	5.10MBRIL	RILEY OPP
392	1970	DEC	16	00:00.0	37.14	-116.03	0	4.70MLWCFS		RILEY OPP
393	1970	DEC	17	05:00.0	37.13	-116.08	0	5.70MBRIL	5.80MBRIL	RILEY OPP
394	1970	DEC	18	30:00.0	37.17	-116.1	0	5.20MBRIL	5.05MBRIL	RILEY OPP
395	1971	APR	29	00:00.0	37.12	-116.33	0	4.70MLWCFS		RILEY OPP
396	1971	JUN	16	50:00.0	37.03	-116.01	0	4.90MBRIL	4.60MBRIL	RILEY OPP

TABLE G-5
ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
397	1971	JUN	23	30:00.0	37.02	-116.02	0	4.80MBRIL	4.70MBRIL	RILEY OPP
398	1971	JUN	24	00:00.0	37.15	-116.07	0	5.20MBRIL	5.10MBRIL	RILEY OPP
399	1971	JUN	29	30:00.0	37.18	-116.21	0	4.90MBRIL		RILEY OPP
400	1971	JUL	1	00:00.0	37.01	-116.2	0	4.70MLWCFS		RILEY OPP
401	1971	JUL	8	00:00.0	37.11	-116.05	0	5.50MBRIL	5.50MBRIL	RILEY OPP
402	1971	JUL	9	00:00.0	37	-116.1	0	3.40MBRIL		RILEY OPP
403	1971	JUL	21	33:00.0	0	0	0	4.70MLWCFS		RILEY OPP
404	1971	AUG	18	00:00.0	37.06	-116.04	0	5.40MBRIL	5.30MBRIL	RILEY OPP
405	1971	SEP	22	00:00.0	37.1	-116	0	3.60MBRIL		RILEY OPP
406	1971	SEP	29	00:00.0	37.01	-116.01	0	4.40MBRIL	4.10MBRIL	RILEY OPP
407	1971	OCT	8	30:00.0	37.11	-116.04	0	4.70MBRIL	4.55MBRIL	RILEY OPP
408	1971	OCT	14	30:00.0	37.2	-116.1	0	4.40MBRIL	4.15MBRIL	RILEY OPP
409	1971	NOV	24	15:00.0	36.88	-115.93	0	3.80MBRIL		RILEY OPP
410	1971	NOV	30	45:00.0	37.1	-116.1	0	4.70MBRIL	4.44MBRIL	RILEY OPP
411	1971	DEC	14	09:59.0	37.12	-116.09	0	4.70MBRIL	4.50MBRIL	RILEY OPP
412	1972	FEB	3	45:00.0	37	-115.8	0	4.10MBRIL		RILEY OPP
413	1972	FEB	17	02:00.0	37.1	-116	0	4.60MBRIL	4.25MBRIL	RILEY OPP
414	1972	MAR	30	00:00.0	37	-116	0	4.60MBRIL	4.40MBRIL	RILEY OPP
415	1972	MAR	30	00:17.8	37.684	-116.96	0	4.30MLRYN	4.30MDUNRENO	MER
416	1972	APR	19	32:00.0	37.12	-116.08	0	4.60MBRIL	4.30MBRIL	RILEY OPP
417	1972	MAY	2	15:00.0	37.21	-116.21	0	5.00MBRIL	5.05MBRIL	RILEY OPP
418	1972	MAY	11	00:00.0	37.2	-116.1	0	3.60MBRIL		RILEY OPP
419	1972	MAY	17	10:00.0	37.12	-116.09	0	4.40MBRIL	4.35MBRIL	RILEY OPP
420	1972	MAY	19	00:00.0	37.06	-116	0	4.90MBRIL	4.55MBRIL	RILEY OPP
421	1972	JUN	7	20:00.0	0	0	0	3.80MBRIL		RILEY OPP
422	1972	JUN	28	30:00.0	37.1	-116.1	0	3.70MBRIL		RILEY OPP
423	1972	JUL	20	16:00.0	37.21	-116.18	0	5.00MBRIL	5.00MBRIL	RILEY OPP
424	1972	JUL	25	30:00.0	36.9	-116	0	4.00MBRIL	3.70MBRIL	RILEY OPP
425	1972	SEP	21	30:00.0	37.08	-116.04	0	5.70MBRIL	5.60MBRIL	RILEY OPP
426	1972	SEP	26	30:00.0	37.12	-116.09	0	4.40MBRIL	4.45MBRIL	RILEY OPP
427	1972	NOV	9	15:00.0	37.2	-116.3	0	3.70MBRIL		RILEY OPP
428	1972	NOV	9	15:00.0	0	0	0	3.70MBRIL		RILEY OPP
429	1972	DEC	12	30:00.0	37.081	-116.04	0	3.30MBRIL		RILEY OPP

ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
430	1972	DEC	21	15:00.0	37.14	-116.08	0	5.00MBRIL	5.00MBRIL	RILEY OPP
431	1973	MAR	8	10:00.0	37.1	-116.03	0	5.40MBRIL	5.40MBRIL	RILEY OPP
432	1973	MAR	23	15:00.0	0	0	0	3.30MBRIL		RILEY OPP
433	1973	APR	25	25:00.0	37	-116.03	0	4.70MBRIL	4.70MBRIL	RILEY OPP
434	1973	APR	26	15:00.0	37	-116	0	4.10MBRIL	3.80MBRIL	RILEY OPP
435	1973	APR	26	15:00.0	37.12	-116.06	0	5.60MBRIL	5.50MBRIL	RILEY OPP
436	1973	MAY	17	00:00.0	39.79	-108.37	0	5.40MBRIL		RILEY OPP
437	1973	MAY	24	30:00.0	37.2	-116.1	0	4.80MBRIL	4.35MBRIL	RILEY OPP
438	1973	JUN	5	00:00.0	37.18	-116.22	0	5.10MBRIL	5.10MBRIL	RILEY OPP
439	1973	JUN	6	00:00.0	37.25	-116.35	0	6.10MBRIL	6.20MBRIL	RILEY OPP
440	1973	JUN	21	45:00.0	37.1	-116	0	5.30MBRIL	5.40MBRIL	RILEY OPP
441	1973	JUN	28	15:12.0	37.15	-116.09	0	4.90MBRIL	5.00MBRIL	RILEY OPP
442	1973	JUN	28	45:00.0	37.1	-116	0	4.70MLWCFS		RILEY OPP
443	1973	OCT	2	15:00.0	37.2	-115.8	0	3.90MBRIL		RILEY OPP
444	1973	OCT	12	00:00.0	37.2	-116.2	0	4.80MBRIL	4.65MBRIL	RILEY OPP
445	1973	NOV	28	30:00.0	37.01	-116.02	0	4.40MBRIL	4.40MBRIL	RILEY OPP
446	1973	DEC	12	00:00.0	36.9	-116	0	4.50MBRIL	4.45MBRIL	RILEY OPP
447	1973	DEC	19	16:01.4	37.013	-116.03	0	3.50MDUNRENO	3.20MDRYN	MER
448	1974	FEB	27	00:00.0	37.1	-116.05	0	5.80MBRIL	5.60MBRIL	RILEY OPP
449	1974	APR	23	13:00.0	37.1	-116.1	0	3.40MLRIL		RILEY OPP
450	1974	MAY	22	15:00.0	37.1	-116.1	0	4.40MBRIL	4.30MBRIL	RILEY OPP
451	1974	MAY	23	38:30.0	37.12	-116.08	0	4.80MBRIL	4.80MBRIL	RILEY OPP
452	1974	JUN	6	40:00.0	37	-116	0	4.40MBRIL	4.30MBRIL	RILEY OPP
453	1974	JUN	19	00:00.0	37.21	-116.21	0	5.00MBRIL	4.90MBRIL	RILEY OPP
454	1974	JUL	10	00:00.0	37.08	-116.03	0	5.70MBRIL	5.70MBRIL	RILEY OPP
455	1974	JUL	18	00:00.0	37.1	-116.1	0	4.10MBRIL	3.90MBRIL	RILEY OPP
456	1974	AUG	14	00:00.0	37.02	-116.04	0	4.60MBRIL	4.45MBRIL	RILEY OPP
457	1974	AUG	30	00:00.0	37.15	-116.08	0	5.80MBRIL	5.70MBRIL	RILEY OPP
458	1974	SEP	25	00:00.0	37	-116	0	4.40MBRIL	4.20MBRIL	RILEY OPP
459	1974	SEP	26	30:00.0	0	0	0	3.30MBRIL		RILEY OPP
460	1974	SEP	26	05:00.0	37.13	-116.07	0	5.60MBRIL	5.50MBRIL	RILEY OPP
461	1974	OCT	28	00:00.0	37.2	-137.2	0	4.70MLWCFS		RILEY OPP
462	1974	DEC	16	30:00.0	36.9	-116	0	4.30MBRIL		RILEY OPP

TABLE G-5
ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
463	1975	FEB	6	30:00.0	37.259	-115.91	0	3.50MBRIL		RILEY OPP
464	1975	FEB	6	13:00.0	37	-116	0	4.50MBRIL		RILEY OPP
465	1975	FEB	28	15:00.0	37.11	-116.06	0	5.70MBRIL	5.70MBRIL	RILEY OPP
466	1975	MAR	7	00:00.0	37.13	-116.08	0	5.50MBRIL	5.60MBRIL	RILEY OPP
467	1975	APR	5	45:00.0	37.19	-116.21	0	4.80MBRIL	5.00MBRIL	RILEY OPP
468	1975	APR	24	10:00.0	37.12	-116.09	0	4.60MBRIL	4.50MBRIL	RILEY OPP
469	1975	APR	30	00:00.0	37.11	-116.03	0	5.20MBRIL	5.10MBRIL	RILEY OPP
470	1975	MAY	14	00:00.0	37.22	-116.47	0	6.00MBRIL	6.00MBRIL	RILEY OPP
471	1975	JUN	3	20:00.0	37.34	-116.52	0	5.90MBRIL	5.80MBRIL	RILEY OPP
472	1975	JUN	3	40:00.0	37.09	-116.04	0	5.70MBRIL	5.65MBRIL	RILEY OPP
473	1975	JUN	19	00:00.0	37.35	-116.32	0	6.10MBRIL	6.05MBRIL	RILEY OPP
474	1975	JUN	26	30:00.0	37.28	-116.37	0	6.20MBRIL	6.15MBRIL	RILEY OPP
475	1975	AUG	30	12:00.0	37.28	-116.21	0	3.10MBRIL		RILEY OPP
476	1975	SEP	6	00:00.0	37.02	-116.03	0	4.60MBRIL	4.65MBRIL	RILEY OPP
477	1975	OCT	24	11:26.0	37.22	-116.18	0	4.70MBRIL	4.80MBRIL	RILEY OPP
478	1975	OCT	28	30:00.0	37.29	-116.41	0	6.40MBRIL	6.30MBRIL	RILEY OPP
479	1975	NOV	18	30:00.0	37	-116	0	4.40MBRIL	4.45MBRIL	RILEY OPP
480	1975	NOV	20	00:00.0	37.22	-116.37	0	6.00MBRIL	5.85MBRIL	RILEY OPP
481	1975	NOV	26	30:00.0	37.12	-116.02	0	5.00MBRIL	4.35MBRIL	RILEY OPP
482	1975	DEC	20	00:00.0	37.13	-116.06	0	5.70MBRIL	5.70MBRIL	RILEY OPP
483	1976	JAN	3	15:00.0	37.3	-116.33	0	6.20MBRIL	6.25MBRIL	RILEY OPP
484	1976	FEB	4	20:00.0	37.07	-116.03	0	5.80MBRIL	5.65MBRIL	RILEY OPP
485	1976	FEB	4	40:00.0	37.11	-116.04	0	5.70MBRIL	5.65MBRIL	RILEY OPP
486	1976	FEB	12	45:00.0	37.27	-116.49	0	6.30MBRIL	6.20MBRIL	RILEY OPP
487	1976	FEB	14	30:00.0	37.24	-116.42	0	6.00MBRIL	5.85MBRIL	RILEY OPP
488	1976	FEB	26	50:00.0	37	-116	0	4.20MBRIL	4.25MBRIL	RILEY OPP
489	1976	MAR	9	00:00.0	37.31	-116.36	0	6.00MBRIL	6.05MBRIL	RILEY OPP
490	1976	MAR	14	30:00.0	37.31	-116.47	0	6.30MBRIL	6.40MBRIL	RILEY OPP
491	1976	MAR	17	15:00.0	37.26	-116.33	0	6.10MBRIL	6.05MBRIL	RILEY OPP
492	1976	MAR	17	45:00.0	37.11	-116.05	0	5.80MBRIL	5.90MBRIL	RILEY OPP
493	1976	MAY	12	50:00.0	37.21	-116.21	0	4.90MBRIL		RILEY OPP
494	1976	MAY	20	30:00.0	37.1	-116	0	3.70MBRIL		RILEY OPP
495	1976	JUL	27	30:00.0	37.08	-116.04	0	5.30MBRIL	5.40MBRIL	RILEY OPP

ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
496	1976	AUG	26	30:00.0	37.13	-116.08	0	5.30MBRIL	5.30MBRIL	RILEY OPP
497	1976	OCT	6	30:00.0	0	0	0	3.70MBRIL		RILEY OPP
498	1976	NOV	23	15:00.0	37.17	-116.05	0	4.70MLWCFS		RILEY OPP
499	1976	DEC	8	49:30.0	37.08	-116	0	4.90MBRIL	4.70MBRIL	RILEY OPP
500	1976	DEC	21	09:00.0	37.12	-116.07	0	4.70MLWCFS		RILEY OPP
501	1976	DEC	28	00:00.0	37.1	-116.04	0	5.50MBRIL	5.45MBRIL	RILEY OPP
502	1977	FEB	16	53:00.0	37	-116	0	4.80MBRIL	4.35MBRIL	RILEY OPP
503	1977	MAR	8	24:00.0	37.2	-116.3	0	3.80MBRIL		RILEY OPP
504	1977	APR	5	00:00.0	37.12	-116.06	0	5.60MBRIL	5.65MBRIL	RILEY OPP
505	1977	APR	27	00:00.0	37.09	-116.03	0	5.40MBRIL	5.30MBRIL	RILEY OPP
506	1977	MAY	25	00:00.0	37.09	-116.04	0	5.30MBRIL	5.25MBRIL	RILEY OPP
507	1977	JUL	28	07:00.0	37.1	-115.9	0	3.70MBRIL		RILEY OPP
508	1977	AUG	4	40:00.0	37.09	-116.01	0	5.00MBRIL	5.05MBRIL	RILEY OPP
509	1977	AUG	16	41:00.0	37.2	-115.9	0	3.70MBRIL		RILEY OPP
510	1977	AUG	16	49:00.0	37.2	-116	0	4.00MBRIL		RILEY OPP
511	1977	AUG	19	32:00.0	37	-116	0	3.30MBRIL		RILEY OPP
512	1977	AUG	19	55:00.0	37.11	-116.05	0	5.60MBRIL	5.60MBRIL	RILEY OPP
513	1977	SEP	15	36:30.0	37.03	-116.04	0	4.50MBRIL	4.50MBRIL	RILEY OPP
514	1977	SEP	27	00:00.0	37.15	-116.07	0	4.80MBRIL	4.80MBRIL	RILEY OPP
515	1977	OCT	26	15:00.0	37.01	-116.02	0	4.40MBRIL	4.35MBRIL	RILEY OPP
516	1977	NOV	1	06:00.0	37.19	-116.21	0	4.70MBRIL		RILEY OPP
517	1977	NOV	9	00:00.0	37.07	-116.05	0	5.70MBRIL	5.70MBRIL	RILEY OPP
518	1977	NOV	17	30:00.0	37.02	-116.03	0	4.70MBRIL	4.70MBRIL	RILEY OPP
519	1977	DEC	14	00:00.0	37	-116.1	0	3.80MBRIL		RILEY OPP
520	1977	DEC	14	30:00.0	37.14	-116.09	0	5.70MBRIL	5.65MBRIL	RILEY OPP
521	1978	FEB	13	53:00.0	37.13	-116.03	0	3.80MBRIL	3.95MBRIL	RILEY OPP
522	1978	FEB	23	00:00.0	37.12	-116.06	0	5.60MBRIL	5.65MBRIL	RILEY OPP
523	1978	MAR	16	00:00.0	37.1	-116.1	0	3.90MBRIL	4.05MBRIL	RILEY OPP
524	1978	MAR	23	30:00.0	37.1	-116.05	0	5.60MBRIL	5.60MBRIL	RILEY OPP
525	1978	APR	11	30:00.0	37.3	-116.33	0	5.30MBRIL	5.40MBRIL	RILEY OPP
526	1978	APR	11	45:00.0	37.23	-116.37	0	5.50MBRIL	5.50MBRIL	RILEY OPP
527	1978	JUN	1	00:00.0	37	-116	0	3.70MBRIL		RILEY OPP
528	1978	JUL	7	00:00.0	37.1	-116	0	4.00MBRIL	4.00MBRIL	RILEY OPP

TABLE G-5
ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT)	Latitude	Longitude	Depth	Magnitude 1	Magnitude 2	Agency
				hr:min.sec			(km)			Source
529	1978	JUL	12	00:00.0	37.08	-116.04	0	5.50MBRIL	5.60MBRIL	RILEY OPP
530	1978	AUG	31	00:00.0	37.28	-116.36	0	5.60MBRIL	5.60MBRIL	RILEY OPP
531	1978	SEP	13	15:00.0	37.21	-116.21	0	4.60MBRIL	4.65MBRIL	RILEY OPP
532	1978	SEP	27	30:00.0	38.825	-115.98	0	3.40MBRIL		RILEY OPP
533	1978	SEP	27	00:00.0	37.07	-116.02	0	5.00MBRIL	5.05MBRIL	RILEY OPP
534	1978	SEP	27	20:00.0	37.08	-116.05	0	5.70MBRIL	5.80MBRIL	RILEY OPP
535	1978	NOV	2	25:00.0	37.29	-116.3	0	4.20MBRIL	4.25MBRIL	RILEY OPP
536	1978	NOV	18	00:00.0	37.13	-116.08	0	5.10MBRIL	5.20MBRIL	RILEY OPP
537	1978	DEC	1	07:30.0	37	-116	0	3.70MBRIL		RILEY OPP
538	1978	DEC	16	30:00.0	37.27	-116.41	0	5.50MBRIL	5.55MBRIL	RILEY OPP
539	1979	JAN	24	00:00.0	37.11	-116.01	0	4.50MBRIL	4.50MBRIL	RILEY OPP
540	1979	FEB	8	00:00.0	37.1	-116.05	0	5.50MBRIL	5.55MBRIL	RILEY OPP
541	1979	FEB	15	05:00.0	37.15	-116.07	0	4.80MBRIL	4.90MBRIL	RILEY OPP
542	1979	MAR	14	30:00.0	37.03	-116.04	0	4.30MBRIL	4.50MBRIL	RILEY OPP
543	1979	MAY	11	00:00.0	37	-116	0	4.40MBRIL		RILEY OPP
544	1979	JUN	11	00:00.0	37.29	-116.46	0	5.50MBRIL	5.50MBRIL	RILEY OPP
545	1979	JUN	20	00:14.0	37.11	-116.02	0	4.00MBRIL	4.15MBRIL	RILEY OPP
546	1979	JUN	28	44:00.0	37.14	-116.09	0	5.00MBRIL	5.05MBRIL	RILEY OPP
547	1979	AUG	3	07:30.0	37.08	-116.07	0	4.50MBRIL	4.55MBRIL	RILEY OPP
548	1979	AUG	8	00:00.0	37.01	-116.01	0	4.80MBRIL	4.75MBRIL	RILEY OPP
549	1979	AUG	29	08:00.0	37.12	-116.07	0	4.70MBRIL	4.90MBRIL	RILEY OPP
550	1979	SEP	6	00:00.0	37.09	-116.05	0	5.80MBRIL	5.80MBRIL	RILEY OPP
551	1979	SEP	8	02:00.0	37.16	-116.04	0	3.50MBRIL		RILEY OPP
552	1979	SEP	26	00:00.0	37.23	-116.36	0	5.60MBRIL	5.60MBRIL	RILEY OPP
553	1979	NOV	29	00:00.0	36.99	-116.02	0	3.80MBRIL	3.95MBRIL	RILEY OPP
554	1979	DEC	14	00:00.0	37.14	-116.06	0	3.70MBRIL		RILEY OPP
555	1980	FEB	28	00:00.0	37.13	-116.09	0	4.40MBRIL		RILEY OPP
556	1980	MAR	8	35:00.0	37.18	-116.08	0	3.90MBRIL		RILEY OPP
557	1980	APR	3	00:00.0	37.15	-116.08	0	4.70MBRIL		RILEY OPP
558	1980	APR	16	00:00.0	37.1	-116.03	0	5.30MBRIL		RILEY OPP
559	1980	APR	26	00:00.0	37.25	-116.42	0	5.40MBRIL		RILEY OPP
560	1980	MAY	2	46:30.0	37.06	-116.02	0	4.40MBRIL		RILEY OPP
561	1980	MAY	22	00:00.0	37	-116.03	0	3.50MBRIL		RILEY OPP

ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
562	1980	JUN	12	15:00.0	37.28	-116.45	0	5.60MBRIL		RILEY OPP
563	1980	JUN	24	10:00.0	37.02	-116.03	0	4.40MBRIL		RILEY OPP
564	1980	JUL	25	05:00.0	37.26	-116.48	0	5.50MBRIL		RILEY OPP
565	1980	JUL	31	19:00.0	37.01	-116.02	0	4.30MBRIL		RILEY OPP
566	1980	SEP	25	45:00.0	37.06	-116.05	0	4.60MBRIL		RILEY OPP
567	1980	SEP	25	26:30.0	37.12	-116.06	0	3.40MBRIL		RILEY OPP
568	1980	OCT	24	15:00.0	37.07	-116	0	4.40MBRIL		RILEY OPP
569	1980	OCT	31	00:00.0	37.24	-116.21	0	4.70MBRIL		RILEY OPP
570	1980	NOV	14	50:00.0	37.11	-116.02	0	4.10MBRIL		RILEY OPP
571	1980	DEC	17	10:00.0	37.32	-116.32	0	5.10MBRIL		RILEY OPP
572	1981	JAN	15	25:00.0	37.09	-116.04	0	5.60MBRIL		RILEY OPP
573	1981	FEB	5	00:00.0	37.01	-116.03	0	3.20MLRIL		RILEY OPP
574	1981	FEB	25	00:00.0	37.18	-116.08	0	3.00MLRIL		RILEY OPP
575	1981	APR	30	35:00.0	37.18	-116.08	0	3.20MBRIL		RILEY OPP
576	1981	MAY	29	00:00.0	37.1	-116	0	4.20MBRIL	4.30MBRIL	RILEY OPP
577	1981	JUN	6	00:00.0	37.303	-116.33	0	5.60MBISC		LLNL
578	1981	JUN	6	00:00.0	37.3	-116.33	0	5.50MBRIL	5.50MBRIL	RILEY OPP
579	1981	JUL	10	00:00.0	37.13	-116.03	0	4.10MBRIL		RILEY OPP
580	1981	JUL	16	00:00.0	37.09	-116.02	0	3.30MLRIL		RILEY OPP
581	1981	AUG	5	41:00.0	37.15	-116.04	0	2.80MLRIL		RILEY OPP
582	1981	AUG	27	31:00.0	37.16	-116.07	0	3.80MBRIL		RILEY OPP
583	1981	SEP	4	00:00.0	37.06	-116.05	0	3.80MBRIL		RILEY OPP
584	1981	SEP	24	00:00.0	37.01	-116.02	0	3.50MLRIL		RILEY OPP
585	1981	OCT	1	00:00.0	37.08	-116.01	0	4.90MBRIL	5.00MBRIL	RILEY OPP
586	1981	NOV	11	00:00.0	37.08	-116.07	0	4.80MBRIL	4.80MBRIL	RILEY OPP
587	1981	NOV	12	00:00.0	37.11	-116.05	0	5.30MBRIL	5.35MBRIL	RILEY OPP
588	1981	DEC	3	00:00.0	37.15	-116.07	0	4.60MBRIL	4.75MBRIL	RILEY OPP
589	1981	DEC	16	05:00.0	37.11	-116.12	0	4.40MBRIL	4.35MBRIL	RILEY OPP
590	1982	JAN	28	00:00.0	37.09	-116.05	0	5.90MBRIL	5.90MBRIL	RILEY OPP
591	1982	FEB	12	55:00.0	37.22	-116.46	0	5.40MBRIL	5.50MBRIL	RILEY OPP
592	1982	FEB	12	25:00.0	37.35	-116.32	0	5.60MBRIL	5.60MBRIL	RILEY OPP
593	1982	APR	17	00:00.0	37.02	-116.01	0	4.50MBRIL	4.50MBRIL	RILEY OPP
594	1982	APR	25	05:00.0	37.26	-116.42	0	5.40MBRIL	5.45MBRIL	RILEY OPP

TABLE G-5
ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
595	1982	MAY	6	00:00.0	37.12	-116.13	0	4.30MBRIL	4.10MBRIL	RILEY OPP
596	1982	MAY	7	17:00.0	37.07	-116.05	0	5.70MBRIL	5.70MBRIL	RILEY OPP
597	1982	JUN	16	00:00.0	37.11	-116.02	0	3.90MBRIL		RILEY OPP
598	1982	JUN	24	15:00.0	37.24	-116.37	0	5.60MBRIL	5.70MBRIL	RILEY OPP
599	1982	JUL	29	05:00.0	37.1	-116.07	0	4.50MBRIL	4.45MBRIL	RILEY OPP
600	1982	AUG	5	00:00.0	37.08	-116.01	0	5.70MBRIL	5.70MBRIL	RILEY OPP
601	1982	AUG	11	00:00.0	37.19	-116.05	0	3.30MLRIL		RILEY OPP
602	1982	SEP	2	00:00.0	37.02	-116.02	0	3.30MLRIL		RILEY OPP
603	1982	SEP	23	00:00.0	37.21	-116.21	0	4.90MBRIL	5.00MBRIL	RILEY OPP
604	1982	SEP	23	00:00.0	37.17	-116.09	0	4.90MBRIL	4.95MBRIL	RILEY OPP
605	1982	SEP	29	30:00.0	37.09	-116.04	0	3.80MBRIL		RILEY OPP
606	1982	NOV	12	17:00.0	37.02	-116.03	0	4.40MBRIL	4.50MBRIL	RILEY OPP
607	1982	DEC	10	20:00.0	37.03	-116.07	0	4.60MBRIL	4.70MBRIL	RILEY OPP
608	1983	FEB	11	00:00.0	37.05	-116.05	0	3.70MBRIL	4.20MLUCB	RILEY OPP
609	1983	FEB	17	00:00.0	37.16	-116.06	0	4.00MBRIL	3.90MBRIL	RILEY OPP
610	1983	MAR	26	20:00.0	37.3	-116.46	0	5.10MBRIL	5.25MBRIL	RILEY OPP
611	1983	APR	14	05:00.0	37.07	-116.05	0	5.70MBRIL	5.70MBRIL	RILEY OPP
612	1983	APR	22	53:00.0	37.11	-116.02	0	4.00MBRIL	4.00MBRIL	RILEY OPP
613	1983	MAY	5	20:00.0	37.01	-116.09	0	4.50MBRIL	4.55MBRIL	RILEY OPP
614	1983	MAY	26	30:00.0	0	0	0	4.70MLWCFS		RILEY OPP
615	1983	MAY	26	00:00.0	37.1	-116.01	0	4.40MBRIL	4.65MBRIL	RILEY OPP
616	1983	JUN	9	10:00.0	37.16	-116.09	0	4.50MBRIL	4.50MBRIL	RILEY OPP
617	1983	AUG	3	33:00.0	37.12	-116.09	0	4.20MBRIL	4.20MBRIL	RILEY OPP
618	1983	AUG	11	00:00.0	37	-116	0	4.40MBRIL	4.40MBRIL	RILEY OPP
619	1983	AUG	27	00:00.0	37.2	-116	0	4.10MBRIL		RILEY OPP
620	1983	SEP	1	00:00.0	37.27	-116.36	0	5.40MBRIL	5.45MBRIL	RILEY OPP
621	1983	SEP	21	00:00.0	37.21	-116.21	0	3.70MBRIL		RILEY OPP
622	1983	SEP	21	25:00.0	37.1	-116	0	3.70MBRIL		RILEY OPP
623	1983	SEP	22	00:00.0	37.11	-116.05	0	4.00MBRIL		RILEY OPP
624	1983	DEC	9	00:00.0	37	-116	0	4.00MBRIL		RILEY OPP
625	1983	DEC	16	30:00.0	37.14	-116.07	0	5.10MBRIL	5.10MBRIL	RILEY OPP
626	1984	JAN	31	30:00.0	37.11	-116.12	0	4.10MBRIL	4.40MBRIL	RILEY OPP
627	1984	FEB	15	00:00.0	37.22	-116.18	0	5.00MBRIL	5.05MBRIL	RILEY OPP

ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
628	1984	MAR	1	45:00.0	37.07	-116.05	0	5.90MBRIL	5.85MBRIL	RILEY OPP
629	1984	MAR	31	30:00.0	37.15	-116.08	0	4.10MBRIL	4.35MBRIL	RILEY OPP
630	1984	MAY	1	05:00.0	37.11	-116.02	0	5.30MBRIL	5.40MBRIL	RILEY OPP
631	1984	MAY	2	50:00.0	37.2	-116	0	3.40MBRIL		RILEY OPP
632	1984	MAY	16	00:00.0	37.1	-116	0	3.80MBRIL		RILEY OPP
633	1984	MAY	31	04:00.0	37.1	-116.05	0	5.80MBRIL	5.75MBRIL	RILEY OPP
634	1984	JUN	20	15:00.0	37	-116.04	0	4.60MBRIL	4.75MBRIL	RILEY OPP
635	1984	JUL	12	00:00.0	37.2	-116.1	0	3.60MBRIL		RILEY OPP
636	1984	JUL	25	30:00.0	37.27	-116.41	0	5.30MBRIL	5.40MBRIL	RILEY OPP
637	1984	AUG	2	00:00.0	37.02	-116.01	0	4.70MBRIL	4.65MBRIL	RILEY OPP
638	1984	AUG	30	45:00.0	37.09	-115.99	0	4.50MBRIL	4.65MBRIL	RILEY OPP
639	1984	SEP	13	00:00.0	37.09	-116.07	0	5.00MBRIL	5.10MBRIL	RILEY OPP
640	1984	OCT	2	14:00.0	37.1	-116	0	4.20MBRIL		RILEY OPP
641	1984	NOV	10	40:00.0	37	-116.02	0	4.50MBRIL	4.50MBRIL	RILEY OPP
642	1984	DEC	9	40:00.0	37.27	-116.49	0	5.50MBRIL	5.50MBRIL	RILEY OPP
643	1984	DEC	15	45:00.0	37.28	-116.31	0	5.40MBRIL	5.45MBRIL	RILEY OPP
644	1984	DEC	20	20:00.0	37	-116	0	4.20MBRIL		RILEY OPP
645	1985	MAR	15	31:00.0	37.06	-116.05	0	4.80MBRIL	4.80MBRIL	RILEY OPP
646	1985	MAR	23	30:00.0	37.18	-116.09	0	5.30MBRIL	5.35MBRIL	RILEY OPP
647	1985	APR	2	00:00.0	37.1	-116.03	0	5.70MBRIL	5.75MBRIL	RILEY OPP
648	1985	APR	6	15:00.0	37.2	-116.21	0	4.80MBRIL	4.90MBRIL	RILEY OPP
649	1985	MAY	2	20:00.0	37.25	-116.33	0	5.70MBRIL	5.65MBRIL	RILEY OPP
650	1985	JUN	12	15:00.0	37.25	-116.49	0	5.50MBRIL	5.50MBRIL	RILEY OPP
651	1985	JUN	12	30:00.0	37.01	-116.08	0	4.40MBRIL	4.30MBRIL	RILEY OPP
652	1985	JUN	26	03:00.0	37.12	-116.12	0	4.30MBRIL	4.10MBRIL	RILEY OPP
653	1985	JUL	25	00:00.0	37.3	-116.44	0	5.20MBRIL	5.25MBRIL	RILEY OPP
654	1985	AUG	14	00:00.0	0	0	0	4.70MLWCFS		RILEY OPP
655	1985	AUG	17	25:00.0	37	-116.04	0	4.60MBRIL	4.50MBRIL	RILEY OPP
656	1985	SEP	27	15:00.0	37.09	-116	0	4.60MBRIL	4.65MBRIL	RILEY OPP
657	1985	OCT	9	40:00.0	0	0	0	4.70MLWCFS		RILEY OPP
658	1985	OCT	9	20:00.0	37.21	-116.21	0	4.20MBRIL	4.30MBRIL	RILEY OPP
659	1985	OCT	16	35:00.0	37.11	-116.12	0	4.60MBRIL	4.60MBRIL	RILEY OPP
660	1985	DEC	5	00:00.0	37.05	-116.05	0	5.70MBRIL	5.65MBRIL	RILEY OPP

TABLE G-5
ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
661	1985	DEC	28	01:00.0	37.24	-116.47	0	5.30MBRIL	5.35MBRIL	RILEY OPP
662	1986	MAR	22	15:00.0	37.08	-116.07	0	5.10MBRIL	5.25MBRIL	RILEY OPP
663	1986	APR	10	08:30.0	37.22	-116.18	0	4.90MBRIL	5.00MBRIL	RILEY OPP
664	1986	APR	20	12:30.0	37	-116	0	4.00MBRIL		RILEY OPP
665	1986	APR	22	30:00.0	37.26	-116.44	0	5.30MBRIL	5.35MBRIL	RILEY OPP
666	1986	MAY	21	59:00.0	37.13	-116.06	0	4.00MBRIL		RILEY OPP
667	1986	JUN	5	04:00.0	37.1	-116.02	0	5.30MBRIL	5.35MBRIL	RILEY OPP
668	1986	JUN	25	27:45.0	37.27	-116.5	0	5.50MBRIL		RILEY OPP
669	1986	JUL	17	00:00.0	37.28	-116.36	0	5.70MBRIL	5.70MBRIL	RILEY OPP
670	1986	JUL	24	05:00.0	37.14	-116.07	0	4.40MBRIL	4.45MBRIL	RILEY OPP
671	1986	SEP	4	09:00.0	37.2	-116.4	0	3.50MLRIL		RILEY OPP
672	1986	SEP	11	57:00.0	37.07	-116.05	0	3.20MLRIL		RILEY OPP
673	1986	SEP	30	30:00.0	37.3	-116.31	0	5.50MBRIL	5.50MBRIL	RILEY OPP
674	1986	OCT	16	25:00.0	37.22	-116.46	0	5.60MBRIL	5.60MBRIL	RILEY OPP
675	1986	NOV	14	00:00.0	37.1	-116.05	0	5.80MBRIL	5.75MBRIL	RILEY OPP
676	1986	DEC	13	50:05.0	37.26	-116.41	0	5.50MBRIL	5.55MBRIL	RILEY OPP
677	1987	FEB	3	20:00.0	37.18	-116.05	0	2.20MLRIL		RILEY OPP
678	1987	FEB	11	45:00.0	37.01	-116.05	0	4.50MBRIL	4.40MBRIL	RILEY OPP
679	1987	MAR	18	28:00.0	37.21	-116.21	0	4.30MBRIL		RILEY OPP
680	1987	APR	18	40:01.0	37.25	-116.51	0	5.50MBRIL		RILEY OPP
681	1987	APR	22	00:00.0	36.983	-116.01	0	4.20MLUCB		UC BERK
682	1987	APR	22	00:00.0	36.98	-116.01	0	4.20MBRIL		RILEY OPP
683	1987	APR	30	30:00.0	37.23	-116.42	0	5.50MBRIL		RILEY OPP
684	1987	JUN	18	20:00.0	37.19	-116.04	0	4.70MLWCFS		RILEY OPP
685	1987	JUN	20	00:00.0	37.22	-116.18	0	3.50MLRIL		RILEY OPP
686	1987	JUN	30	05:00.0	36.99	-116.04	0	4.60MBRIL		RILEY OPP
687	1987	JUL	16	00:00.0	37.1	-116.02	0	4.80MBRIL		RILEY OPP
688	1987	AUG	13	00:00.0	37.06	-116.05	0	5.90MBRIL		RILEY OPP
689	1987	SEP	24	00:00.0	37.23	-116.38	0	5.70MBRIL		RILEY OPP
690	1987	OCT	23	00:00.0	37.14	-116.08	0	5.20MBRIL		RILEY OPP
691	1987	DEC	1	30:00.0	37	-116	0	4.70MLWCFS		RILEY OPP
692	1987	DEC	2	30:00.0	37.24	-116.16	0	4.10MBRIL		RILEY OPP
693	1988	FEB	15	10:00.0	37.31	-116.47	0	5.30MBRIL		RILEY OPP

ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
694	1988	APR	7	15:00.0	37.01	-116.04	0	4.10MBRIL		RILEY OPP
695	1988	MAY	13	35:00.0	37.12	-116.07	0	4.80MBRIL		RILEY OPP
696	1988	MAY	21	30:00.0	37.03	-115.99	0	4.30MBRIL		RILEY OPP
697	1988	JUN	2	00:00.0	37.26	-116.44	0	5.30MBRIL		RILEY OPP
698	1988	JUN	22	00:00.0	37.17	-116.07	0	3.10MLRIL		RILEY OPP
699	1988	JUL	7	05:30.0	37.25	-116.38	0	5.60MBRIL		RILEY OPP
700	1988	AUG	17	00:00.0	37.3	-116.31	0	5.50MBRIL		RILEY OPP
701	1988	AUG	23	30:00.0	36.99	-116.01	0	4.10MBRIL		RILEY OPP
702	1988	AUG	30	00:00.0	37.09	-116.07	0	5.00MBRIL		RILEY OPP
703	1988	OCT	13	00:00.0	37.09	-116.05	0	5.90MBRIL		RILEY OPP
704	1988	NOV	9	15:00.0	36.98	-116.01	0	3.60MLRIL		RILEY OPP
705	1988	DEC	10	30:00.0	37.2	-116.21	0	5.00MBRIL		RILEY OPP
706	1989	FEB	10	06:00.0	37.08	-116	0	5.20MBRIL		RILEY OPP
707	1989	FEB	24	15:00.0	37.13	-116.12	0	4.40MBRIL		RILEY OPP
708	1989	MAR	9	05:00.0	37.14	-116.07	0	4.90MBRIL		RILEY OPP
709	1989	MAY	15	10:00.0	37.11	-116.12	0	4.40MBRIL	4.70MBRIL	RILEY OPP
710	1989	MAY	26	07:00.0	37.09	-116.06	0	3.70MLRIL	3.9	RILEY OPP
711	1989	JUN	22	15:00.0	37.28	-116.41	0	5.30MBRIL	5.60MBRIL	RILEY OPP
712	1989	JUN	27	30:00.0	37.28	-116.35	0	4.90MBRIL		RILEY OPP
713	1989	SEP	14	00:00.0	37.236	-116.16	0	4.40MLUCB		UC BERK
714	1989	SEP	14	00:00.0	37.24	-116.16	0	3.80MBRIL		RILEY OPP
715	1989	OCT	31	30:00.0	37.263	-116.49	0	5.40MLUCB		UC BERKRK
716	1989	OCT	31	30:00.0	37.26	-116.49	0	5.70MBRIL	5.70MBRIL	RILEY OPP
717	1989	NOV	15	20:00.0	37.11	-116.01	0	3.40MLRIL	3.50MBRIL	RILEY OPP
718	1989	DEC	8	00:00.0	37.23	-116.41	0	5.50MBRIL		RILEY OPP
719	1989	DEC	20	00:00.0	37.03	-116.03	0	4.70MLWCFS		RILEY OPP
720	1990	MAR	10	00:00.0	37.11	-116.06	0	5.00MBRIL	5.00MBRIL	RILEY OPP
721	1990	APR	6	00:00.0	37	-116.05	0	3.10MBRIL		RILEY OPP
722	1990	JUN	13	00:00.0	37.26	-116.42	0	5.70MBRIL	5.80MBRIL	RILEY OPP
723	1990	JUN	21	15:00.0	36.99	-116	0	4.00MBRIL	4.50MBRIL	RILEY OPP
724	1990	JUL	25	00:00.0	37.21	-116.21	0	4.80MBRIL		RILEY OPP
725	1990	SEP	20	15:00.0	0	0	0	4.70MLWCFS		RILEY OPP
726	1990	SEP	27	02:00.0	37.004	-116.05	0	2.27MwMVGSDR		RILEY OPP

TABLE G-5
ANNOUNCED UNITED STATES NUCLEAR TESTS AT THE NEVADA TEST SITE

Cat. No.	Year	Mo.	Day	Time (GMT) hr:min.sec	Latitude	Longitude	Depth (km)	Magnitude 1	Magnitude 2	Agency Source
727	1990	OCT	12	30:00.0	37.25	-116.49	0	5.60MBRIL	5.70MBRIL	RILEY OPP
728	1990	NOV	14	17:00.0	37.23	-116.37	0	5.40MBRIL	5.40MBRIL	RILEY OPP
729	1991	MAR	8	02:00.0	37.1	-116.07	0	4.30MBRIL		RILEY OPP
730	1991	APR	4	00:00.0	37.3	-116.31	0	5.60MBRIL		RILEY OPP
731	1991	APR	16	30:00.0	37.24	-116.44	0	5.40MBRIL		RILEY OPP
732	1991	AUG	15	00:00.0	37.09	-116	0	4.20MBRIL		RILEY OPP
733	1991	SEP	14	00:00.0	37.23	-116.43	0	5.50MBRIL		RILEY OPP
734	1991	SEP	19	30:00.0	37.24	-116.17	0	4.00MBRIL		RILEY OPP
735	1991	OCT	18	12:00.0	37.06	-116.04	0	5.20MBRIL		RILEY OPP
736	1991	NOV	26	35:00.0	37.1	-116.07	0	4.60MBRIL		RILEY OPP
737	1992	MAR	26	30:00.0	37.27	-116.36	0	5.50MBRIL		RILEY OPP
738	1992	APR	30	30:00.0	37.2	-116.2	0	4.70MLWCFS		RILEY OPP
739	1992	JUN	19	45:00.0	37	-116.01	0	3.00MBRIL		RILEY OPP
740	1992	JUN	23	00:00.0	37.12	-116.03	0	3.90MBRIL		RILEY OPP
741	1992	SEP	18	00:00.0	37.2	-116.2	0	4.20MBRIL		RILEY OPP
742	1992	SEP	23	04:00.0	37	-116	0	4.40MBRIL		RILEY OPP
743	1993	SEP	22	01:00.0	37.2	-116.1	0	4.30MBRIL		RILEY OPP

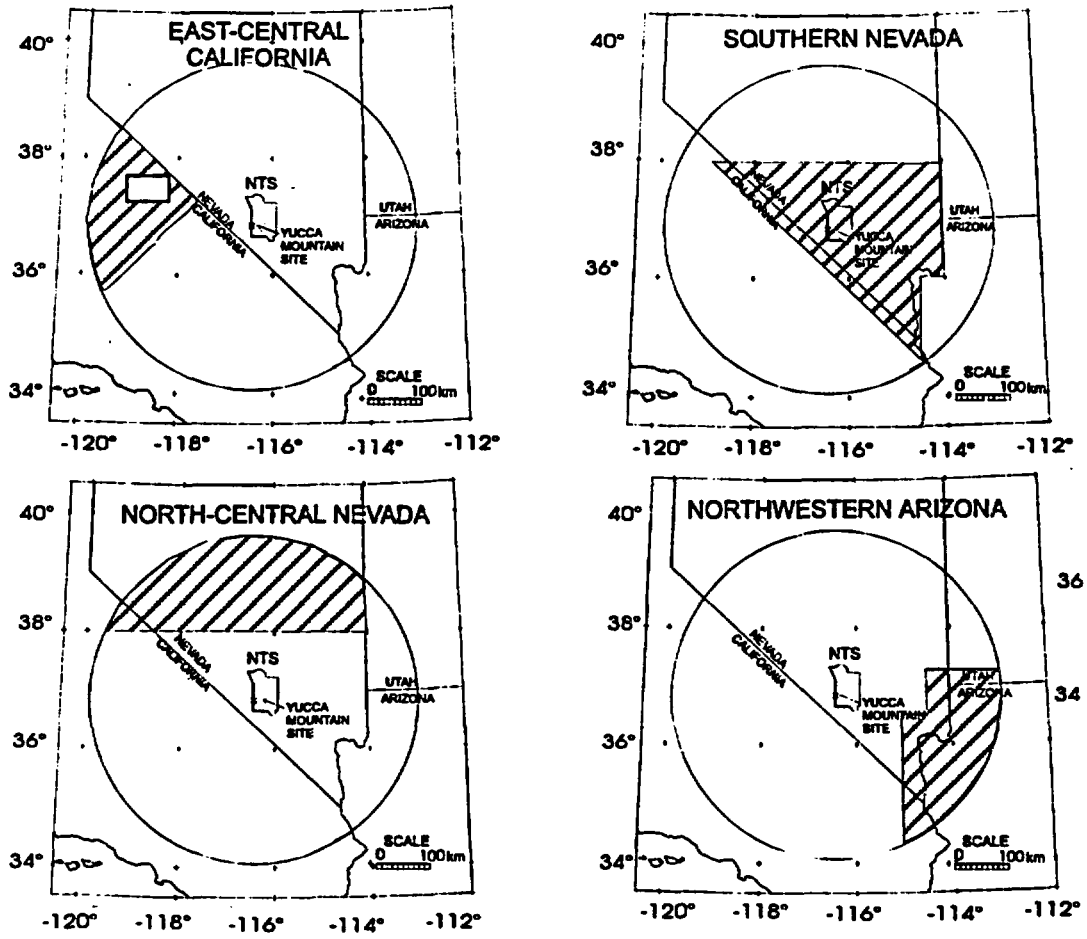


Figure G-1 Subregions that comprise the 300-km radius Yucca Mountain catalogue

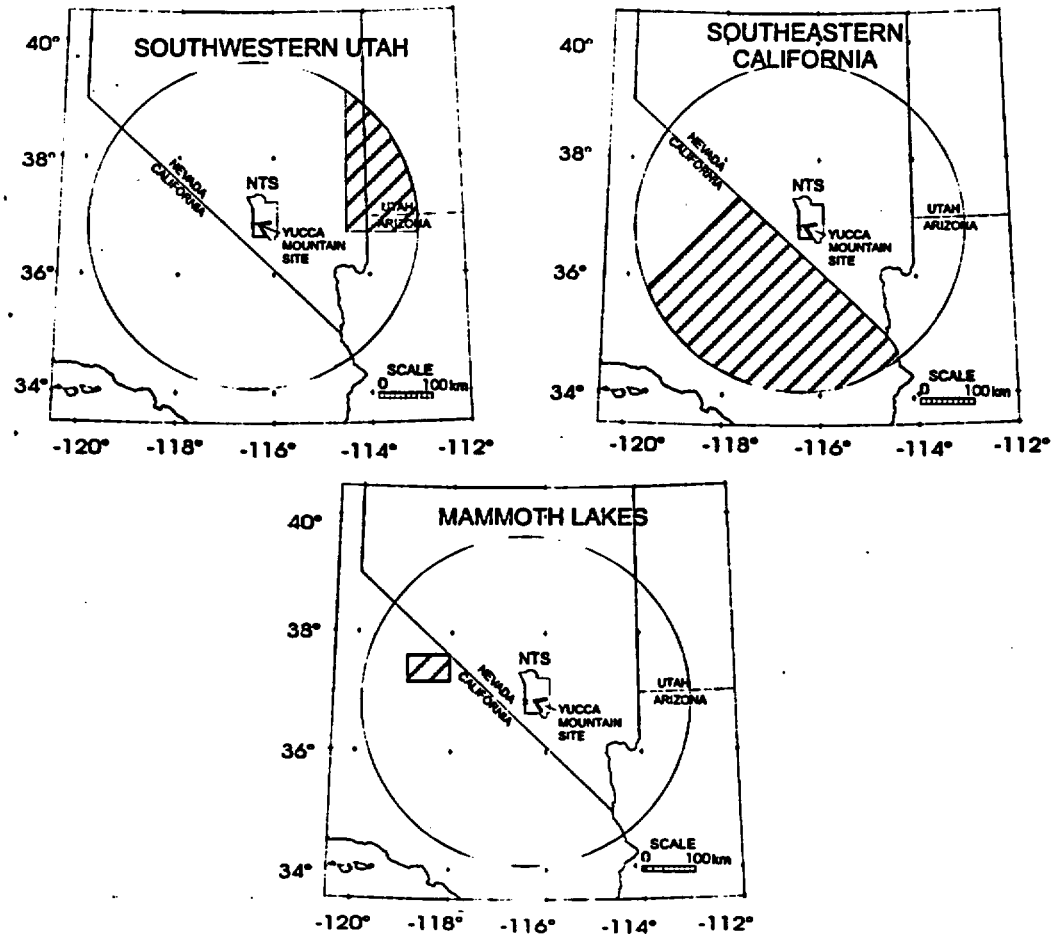


Figure G-1(continued) Subregions that comprise the 300-km radius Yucca Mountain catalogue

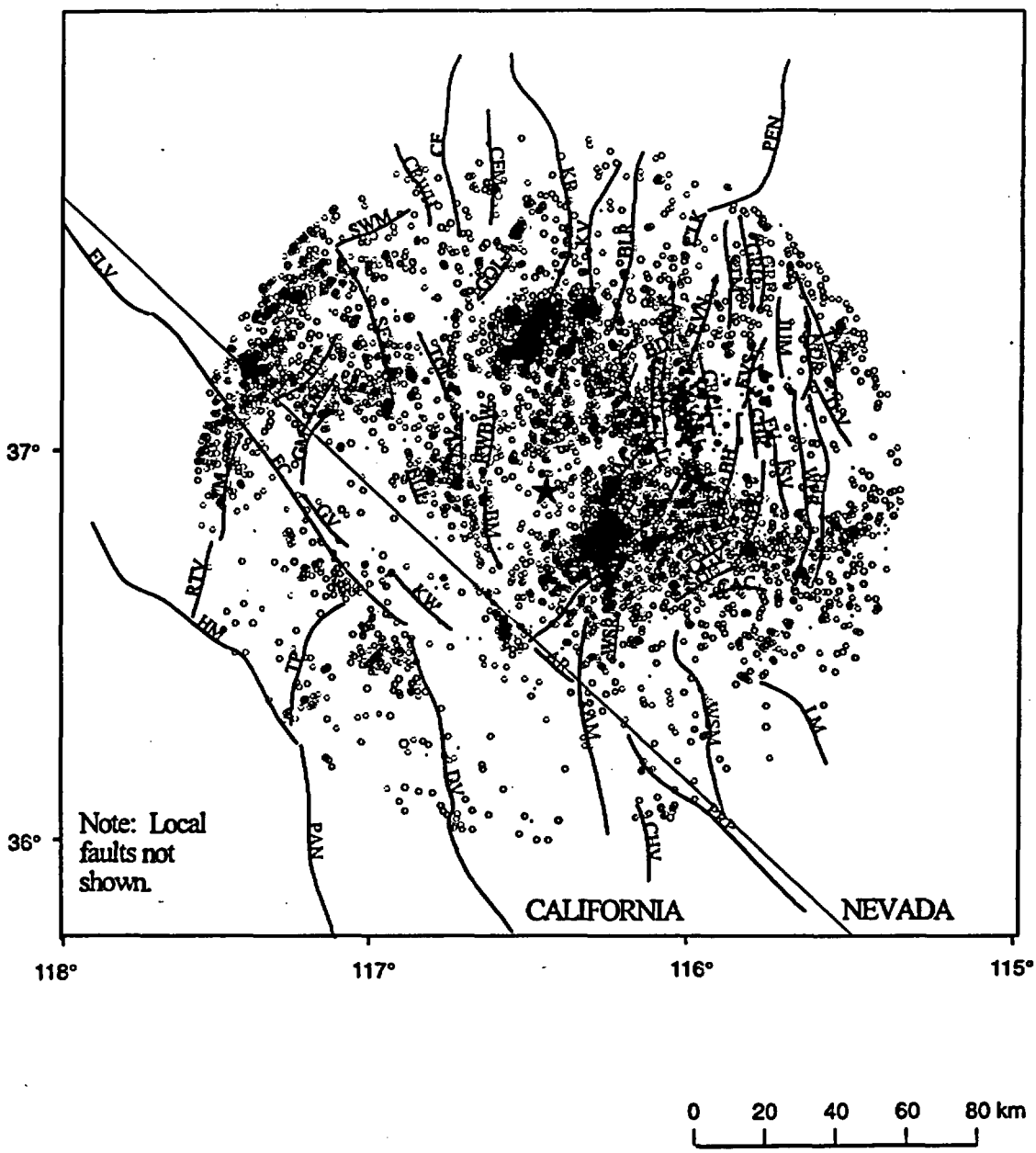


Figure G-2 Historical seismicity (1904 - 1996) and faults within the 300-km radius Yucca Mountain catalogue

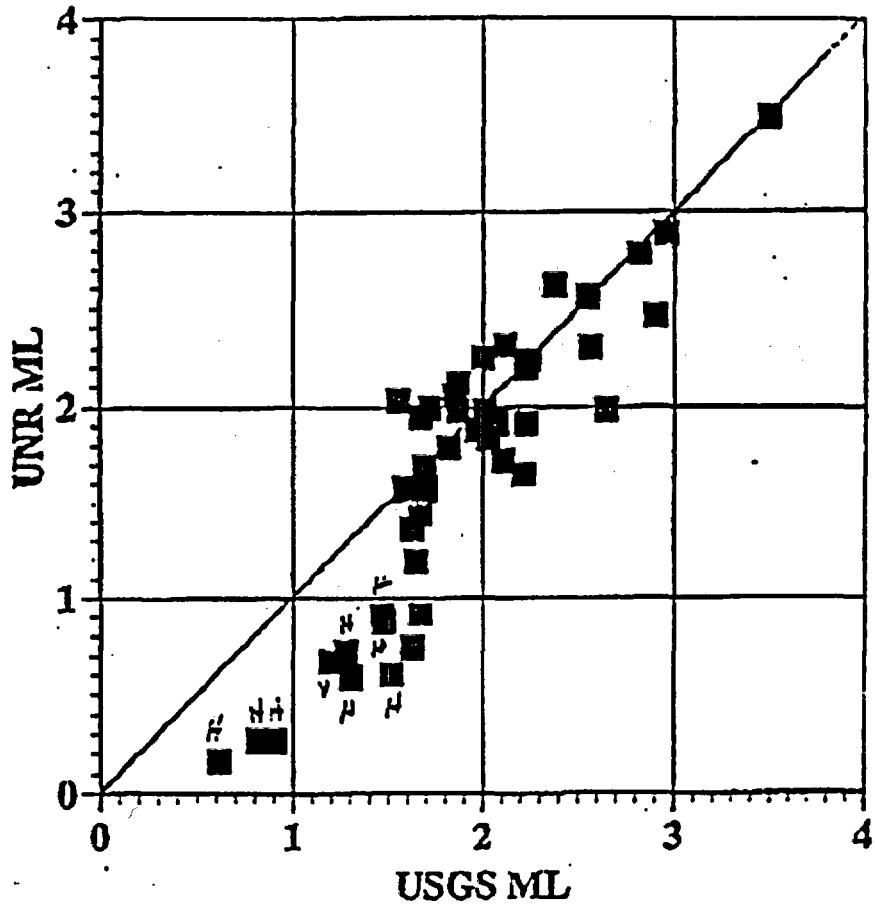


Figure G-3 M_L (UNR CUSP) vs. M_L (USGSDR) for the Southern Great Basin for common events in September 1992. From von Seggern (UNR, written communication, 1996).

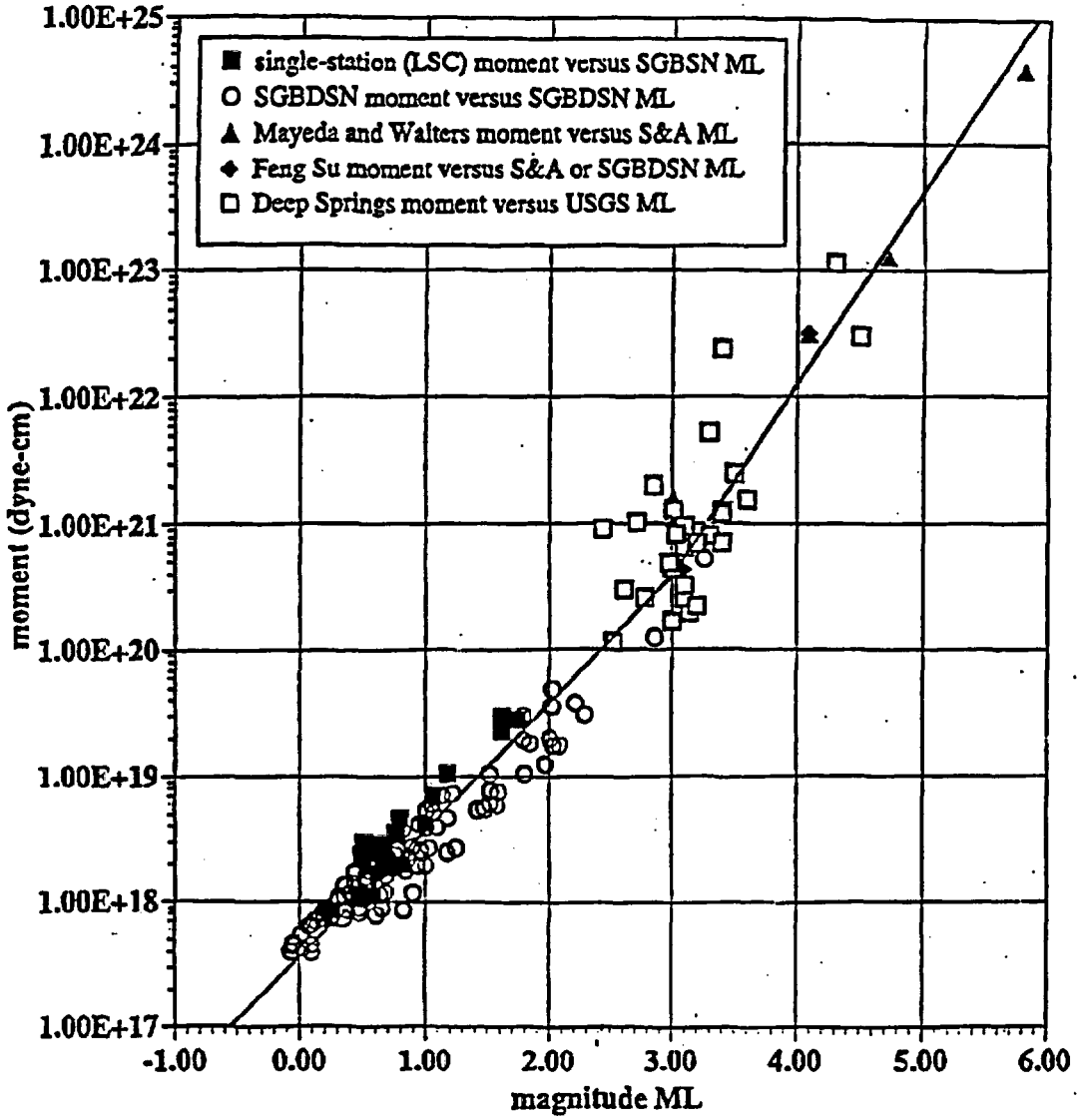
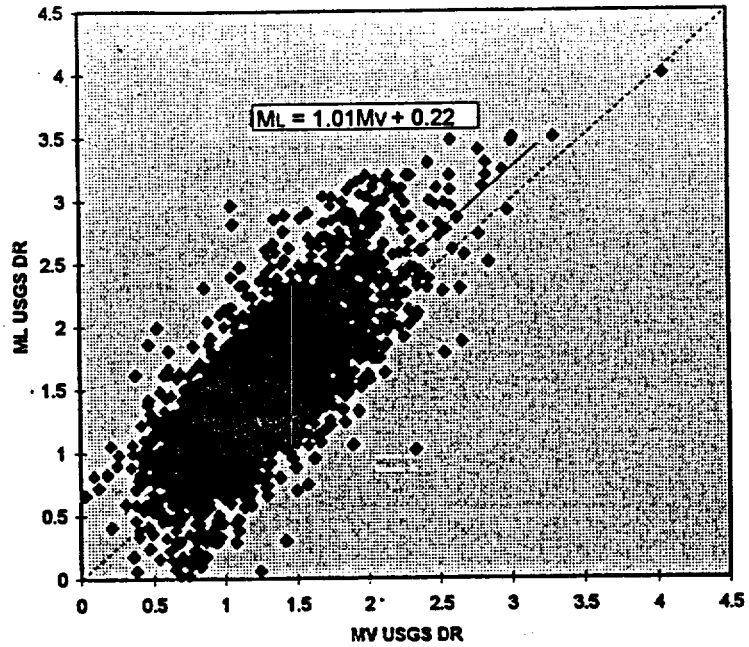


Figure G-4 Moment vs. M_L for the Southern Great Basin-selected data. From von Seggern (UNR, written communication, 1996).



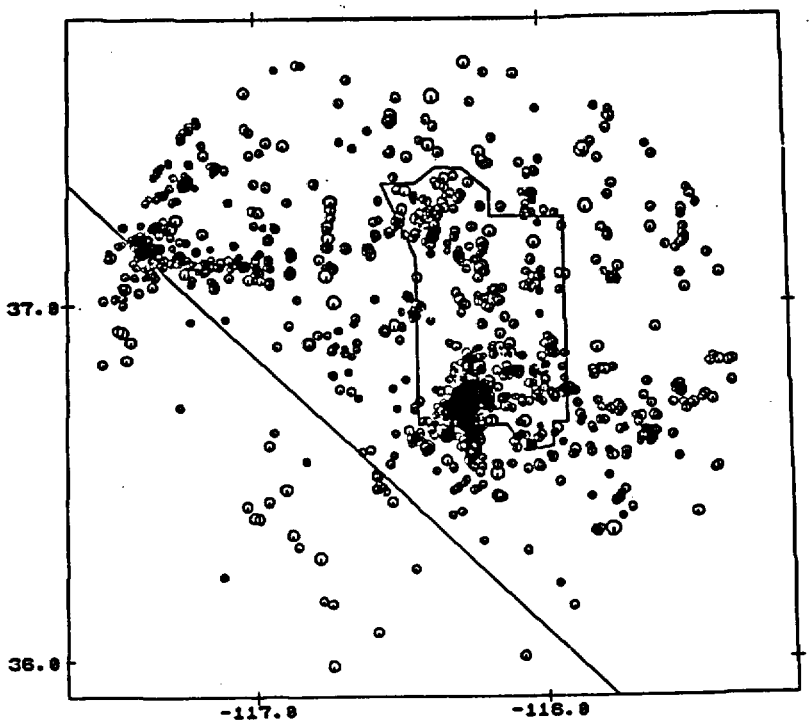
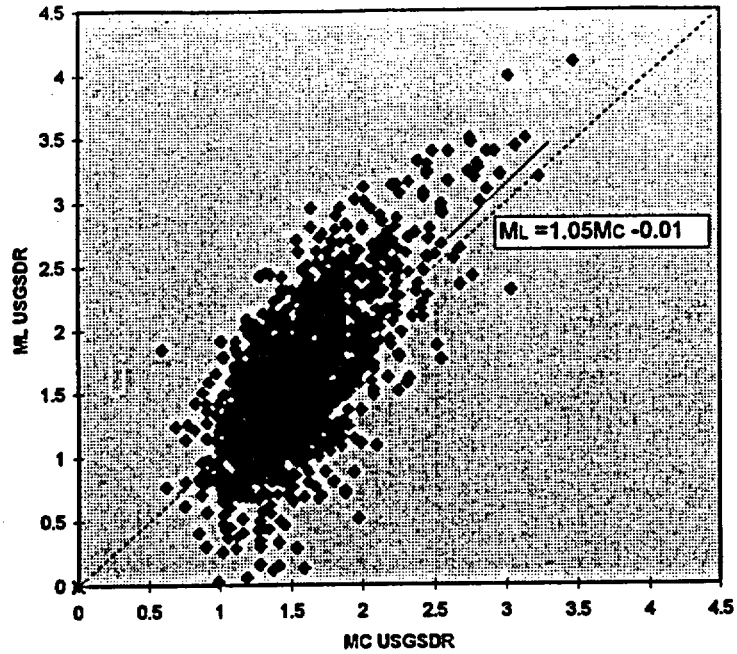


Figure G-5 Regression of M_L (USGSDR) on M_V (USGSDR) for the SGB catalogue and locations of earthquakes used (1985 to 1991)



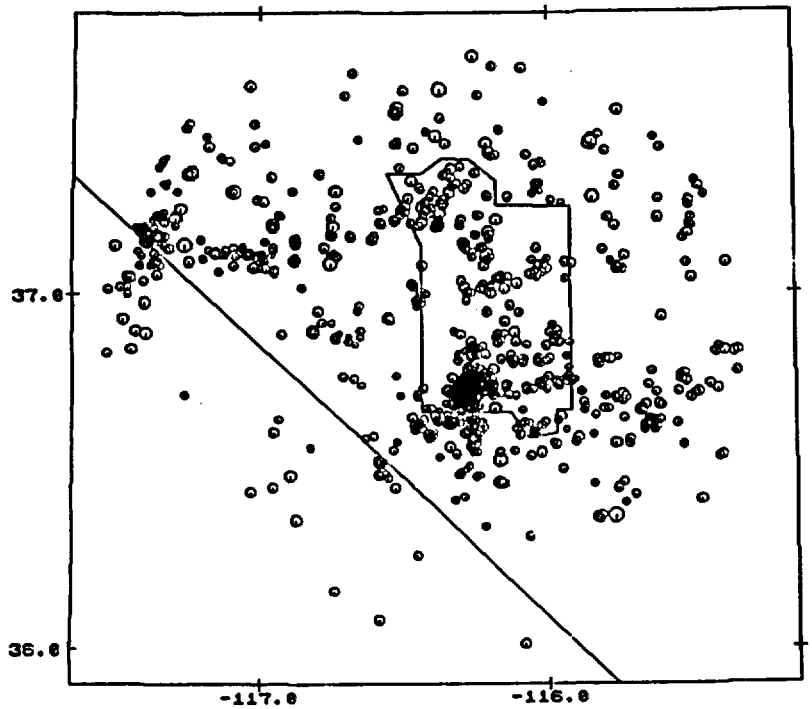
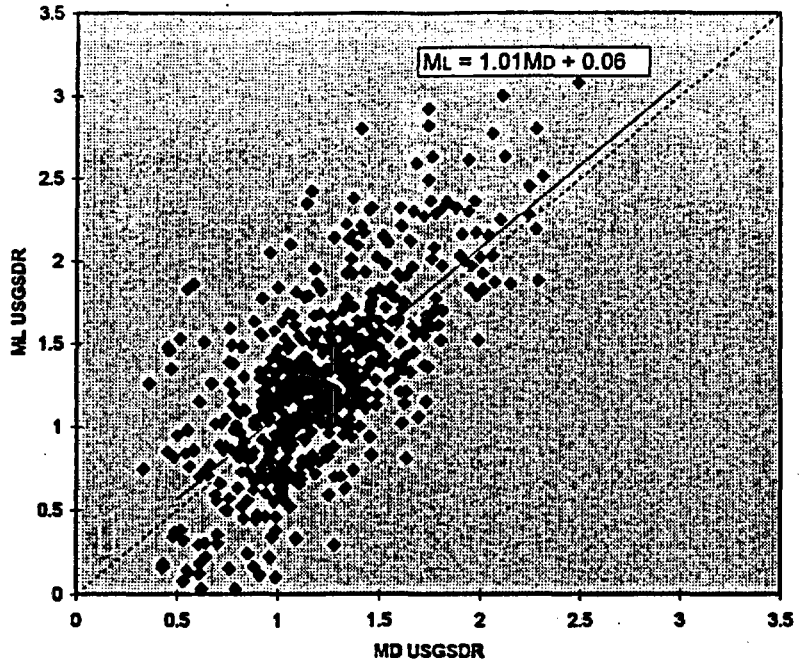


Figure G-6 Regression of M_L (USGSDR) on M_C (USGSDR) for the SGB catalogue and locations of earthquakes used (1985 to 1992)



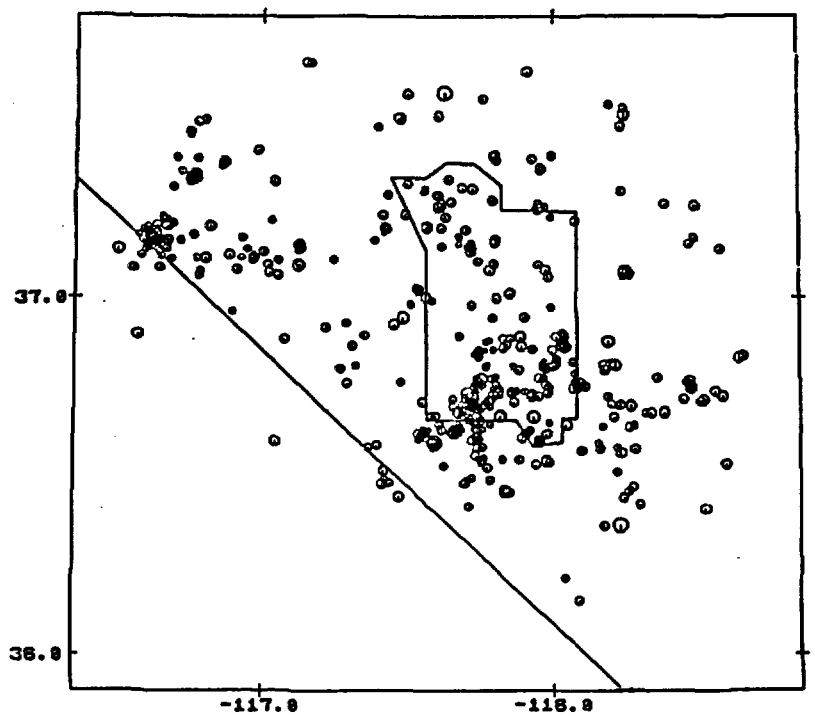
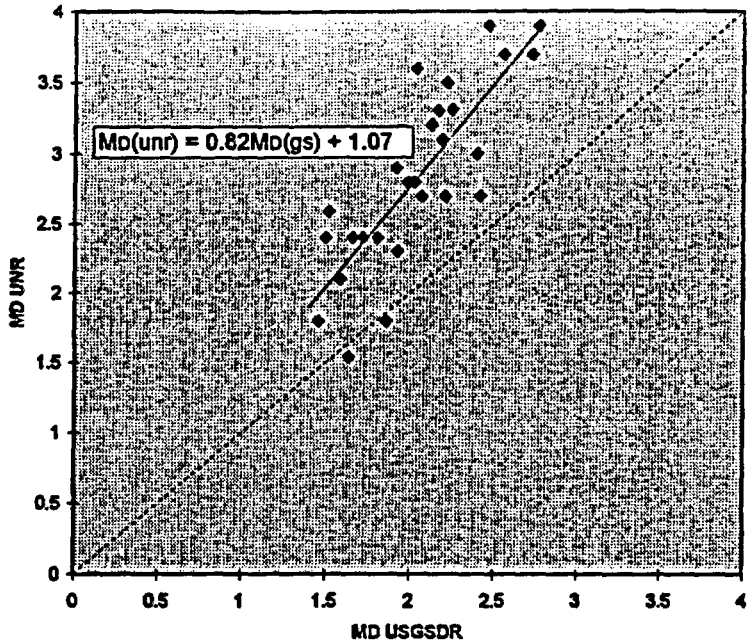


Figure G-7 Regression of M_L (USGSDR) on M_D (USGSDR) for the SGB catalogue and locations of earthquakes used (1984 to 1992)



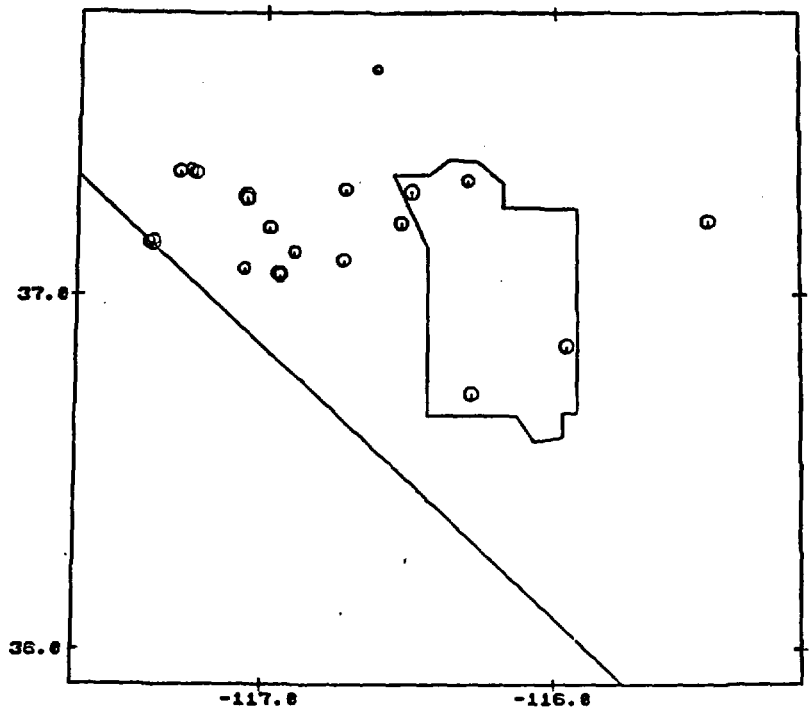


Figure G-8 Regression of M_D (UNR) on M_D (USGSDV) for the SGB catalogue and locations of earthquakes used (1978 to 1992)

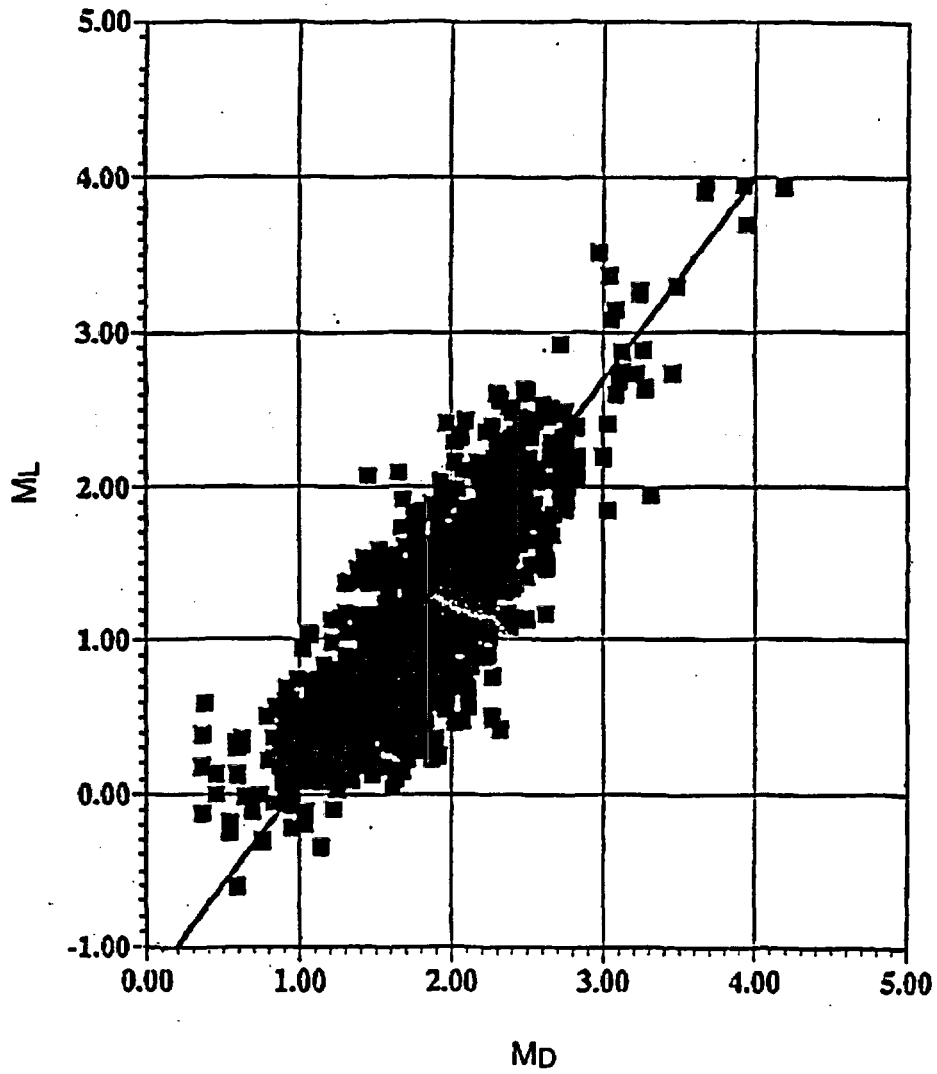


Figure G-9 M_L (CUSP) vs. M_D (CUSP) for the Southern Great Basin (1993 to 1995). From von Seggern (UNR, written communication, 1996).

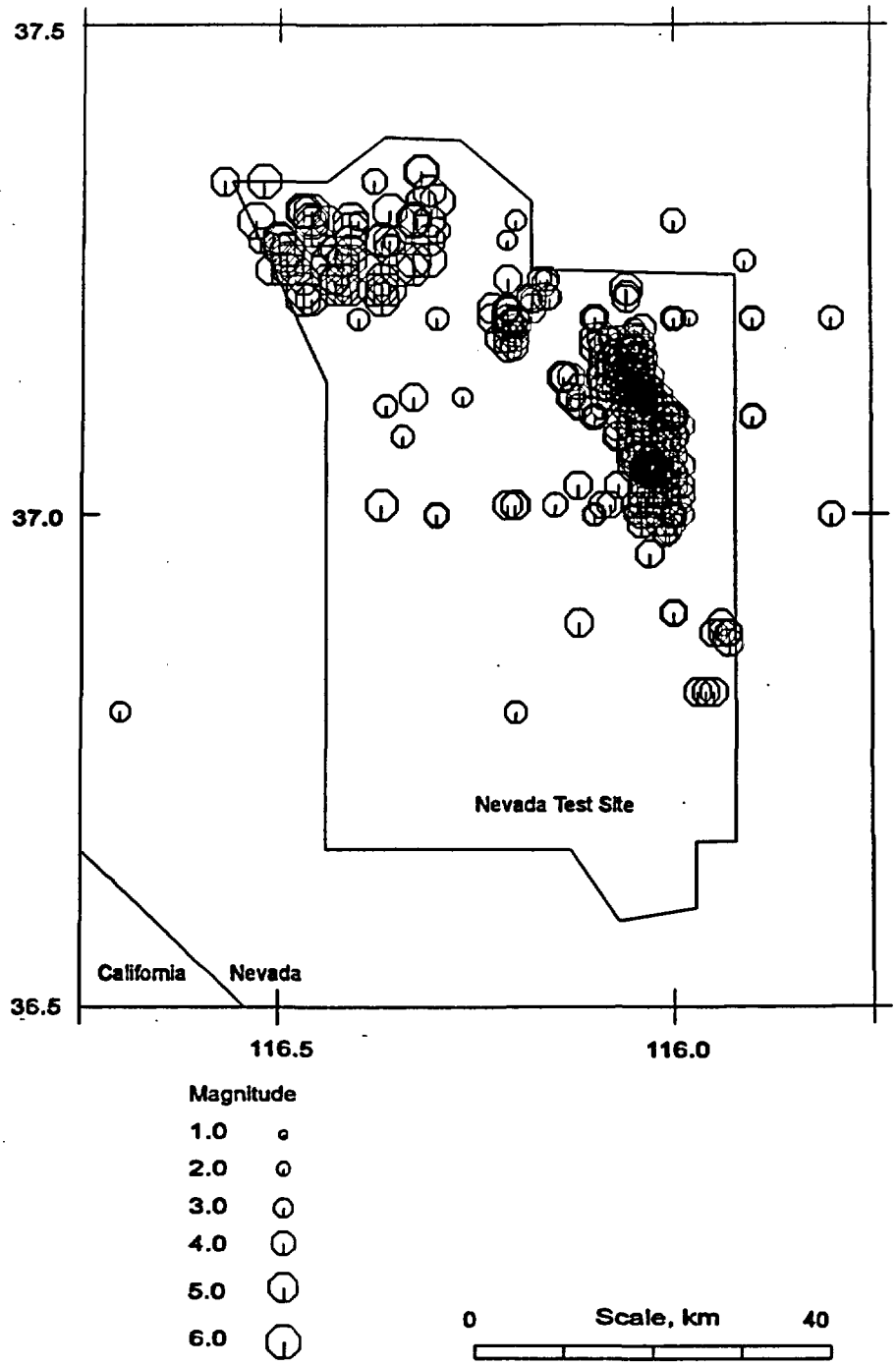


Figure G-10 Announced United States underground nuclear tests, 1957 to 1992

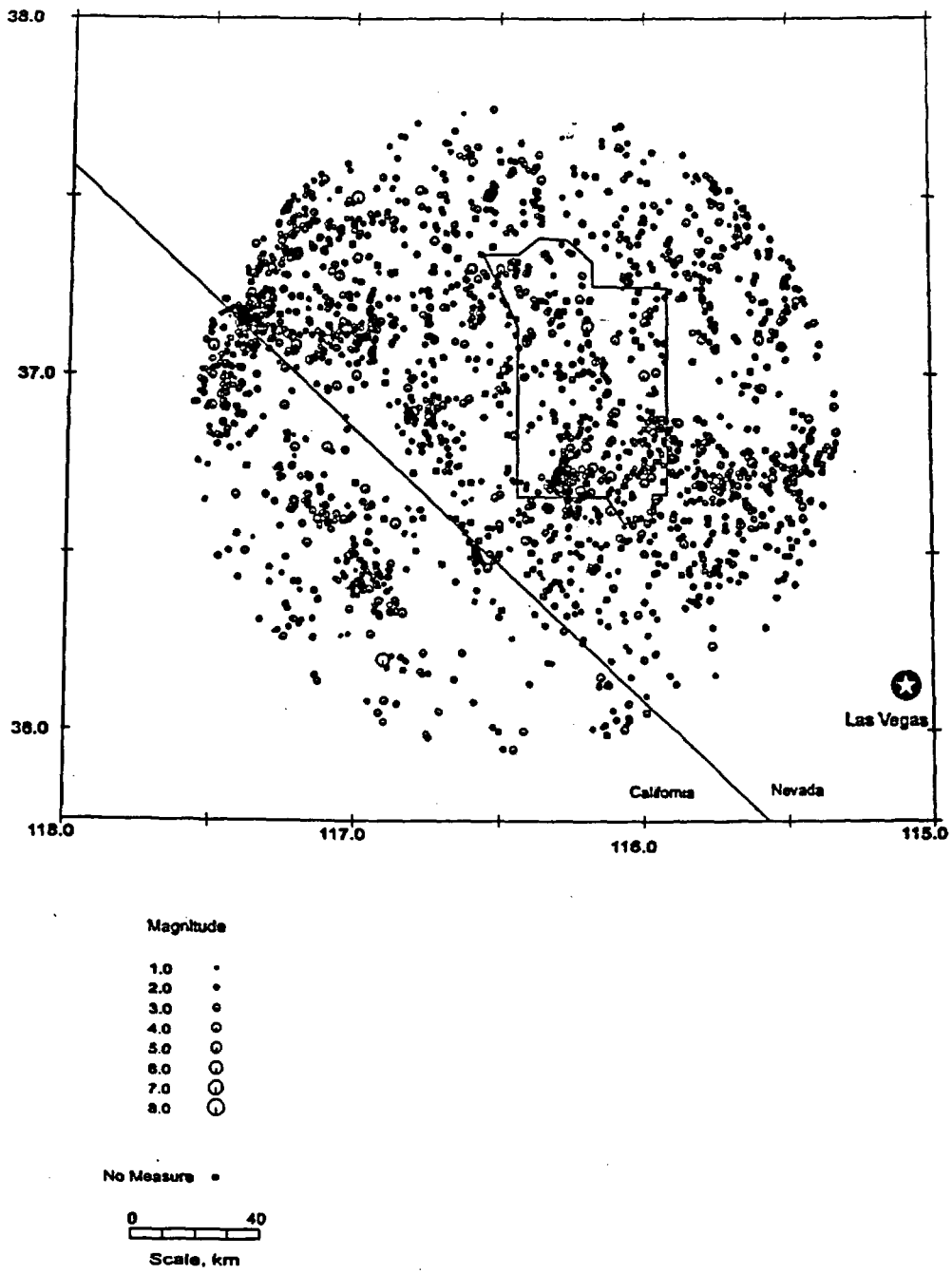


Figure G-11 Historical seismicity (1868 to 1996) after declustering with the Youngs *et al.* approach

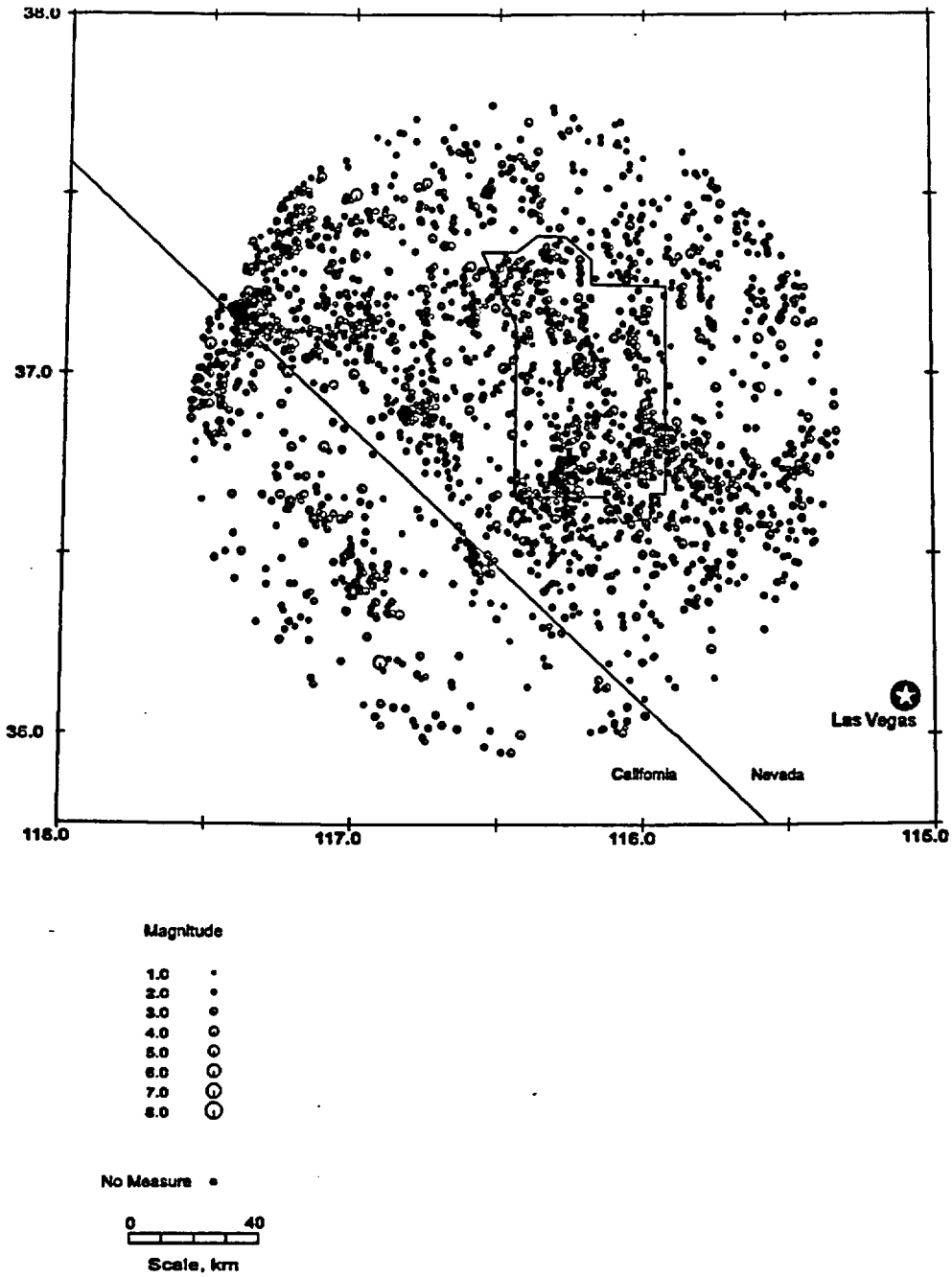


Figure G-12 Historical seismicity (1868 to 1996) after declustering with the Veneziano and van Dyck approach

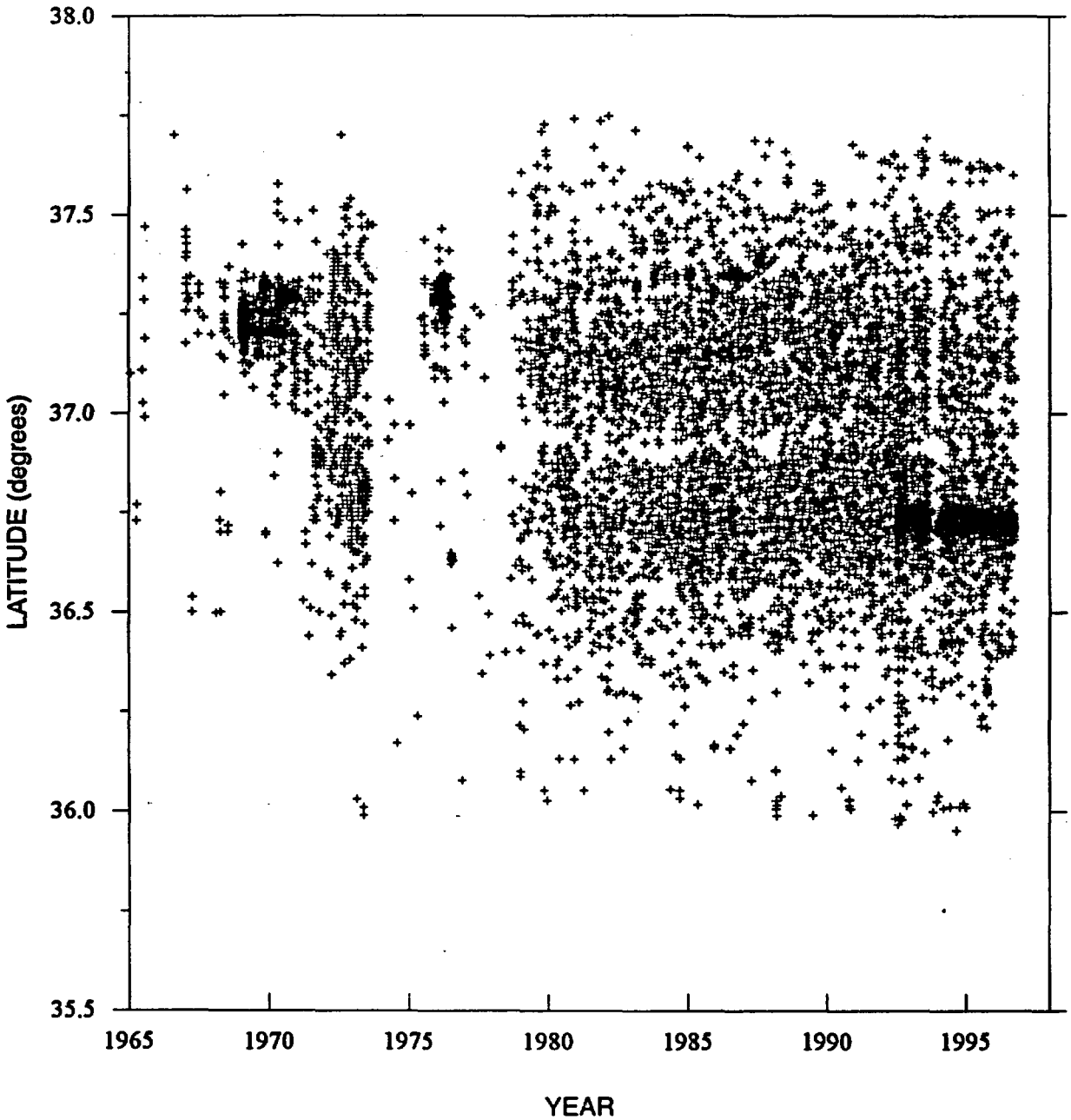


Figure G-13 Earthquakes in the 100 km catalogue as a function of latitude and time prior to declustering

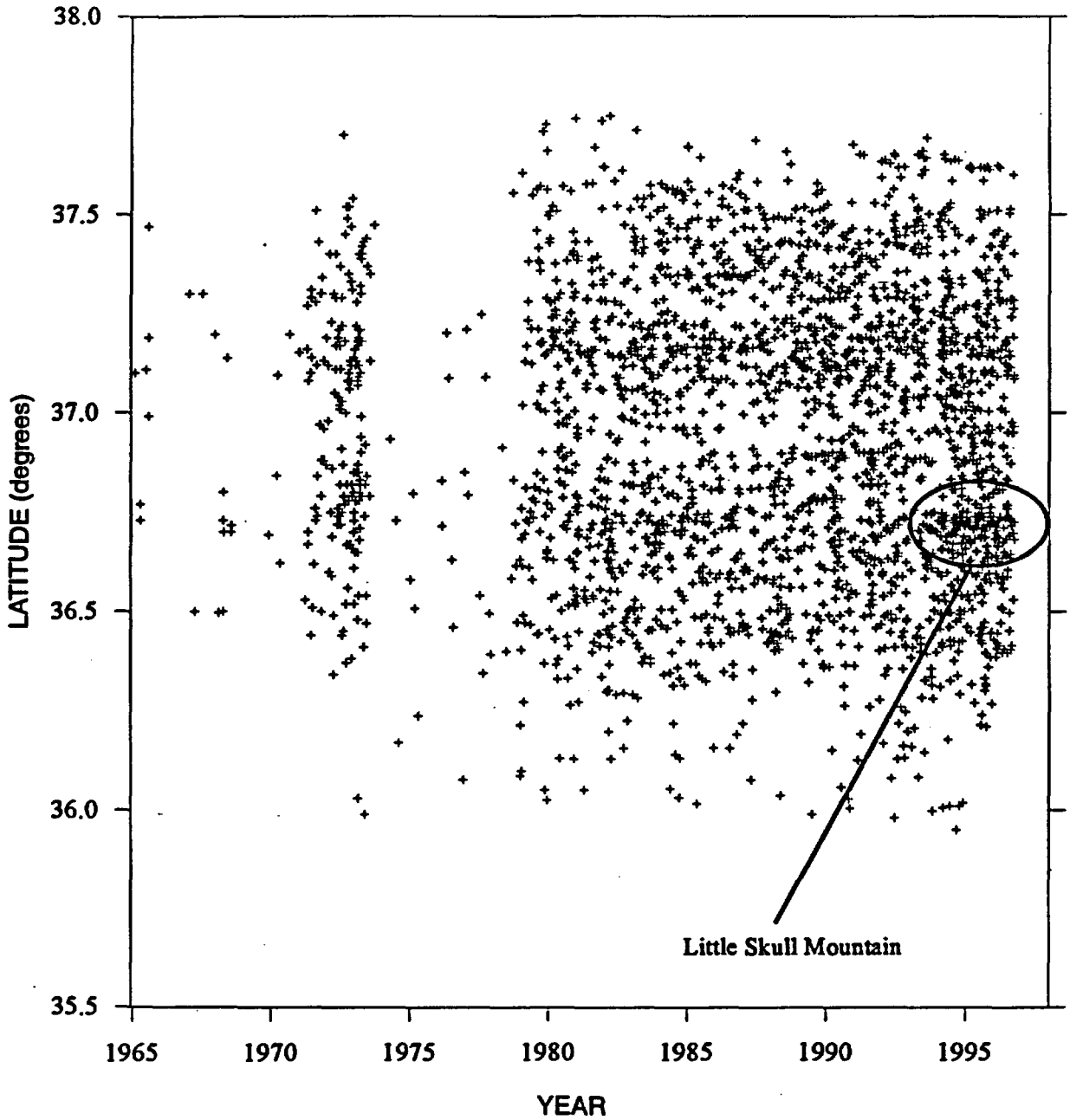


Figure G-14 Earthquakes in the 100 km catalogue as a function of latitude and time after declustering with the Youngs *et al.* approach

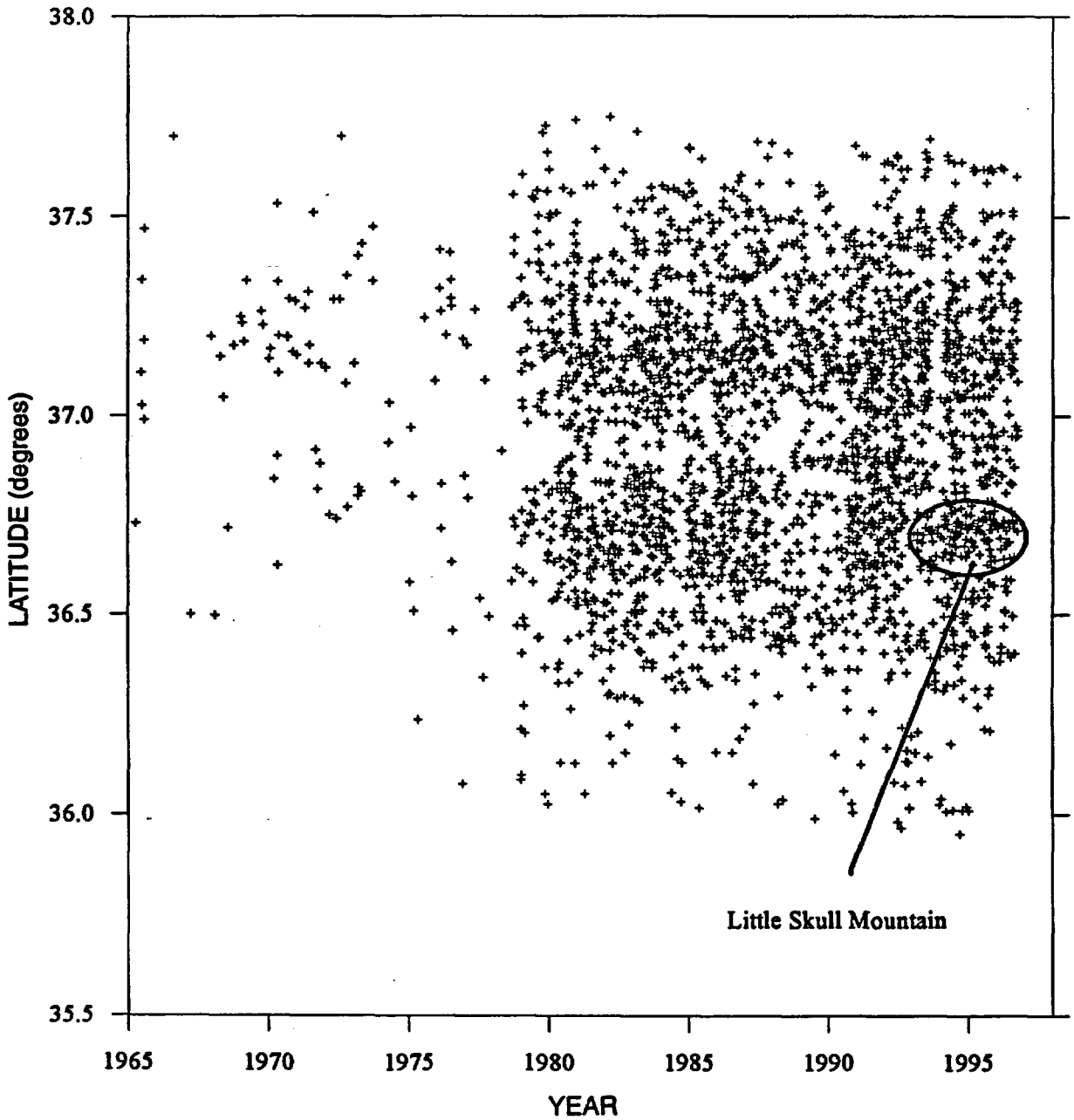


Figure G-15 Earthquakes in the 100 km catalogue as a function of latitude and time after declustering with the Veneziano and van Dyck approach

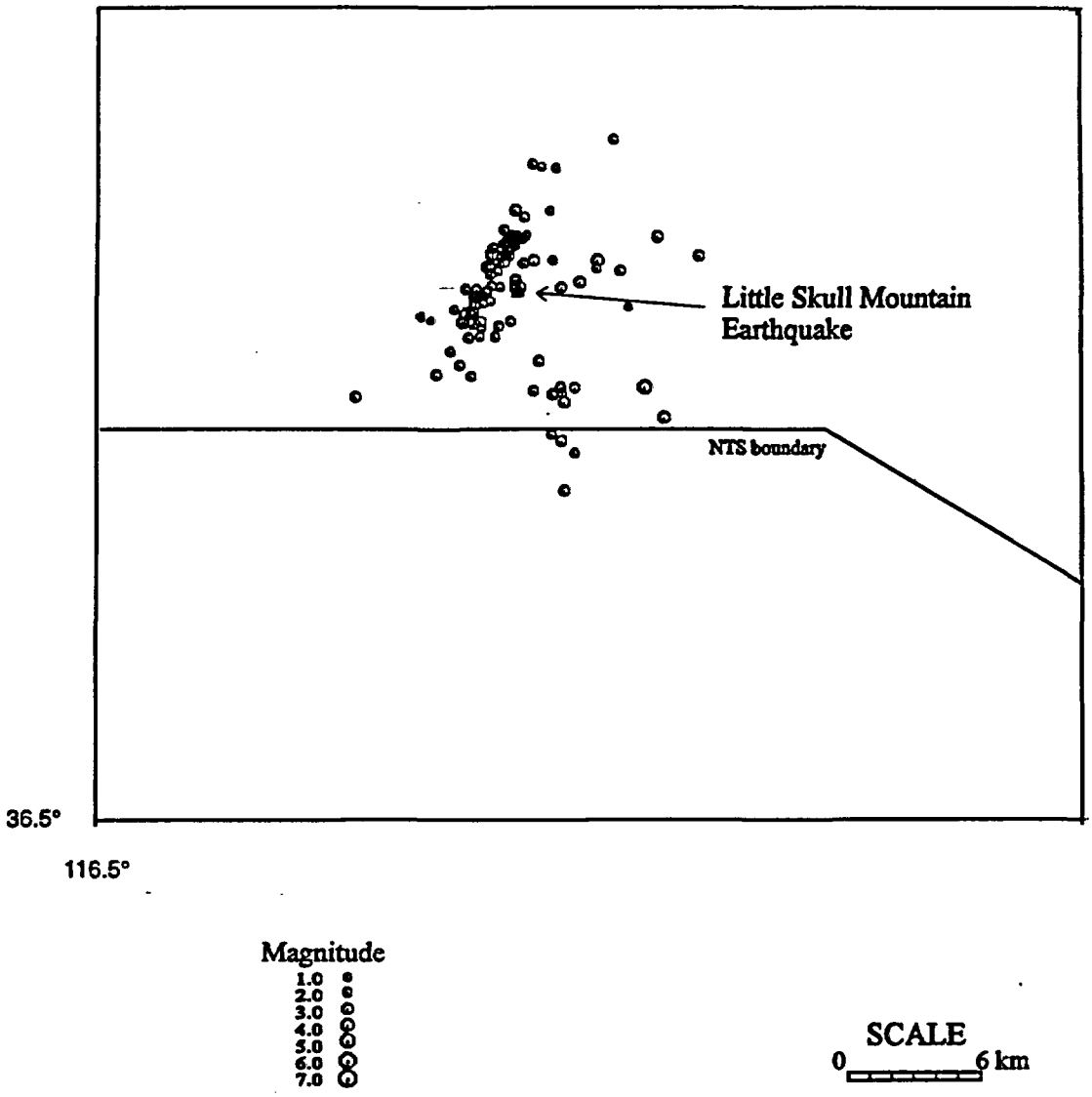


Figure G-16a Earthquakes from 1965 to 1996 within 10 km of Little Skull Mountain after declustering with the Youngs *et al.* approach

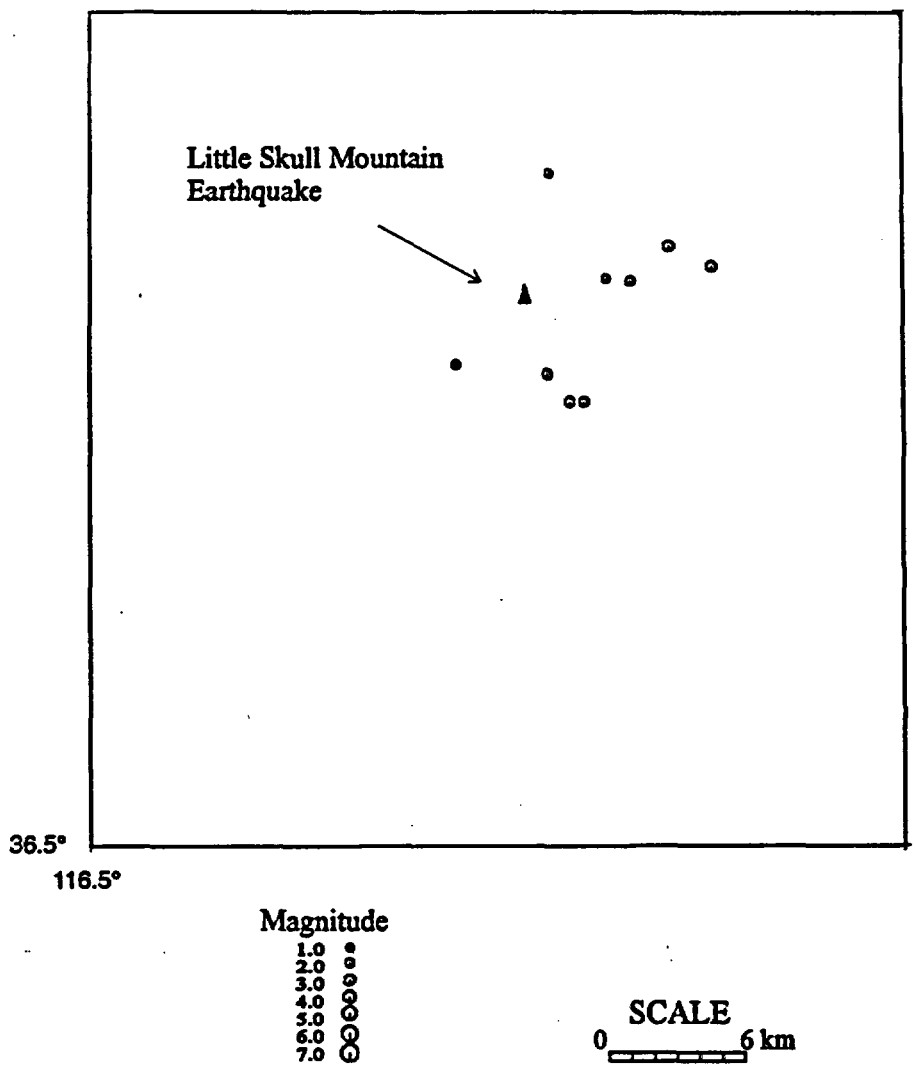


Figure G-16b Earthquakes in 1991 within 10 km of Little Skull Mountain after declustering with the Youngs *et al.* approach

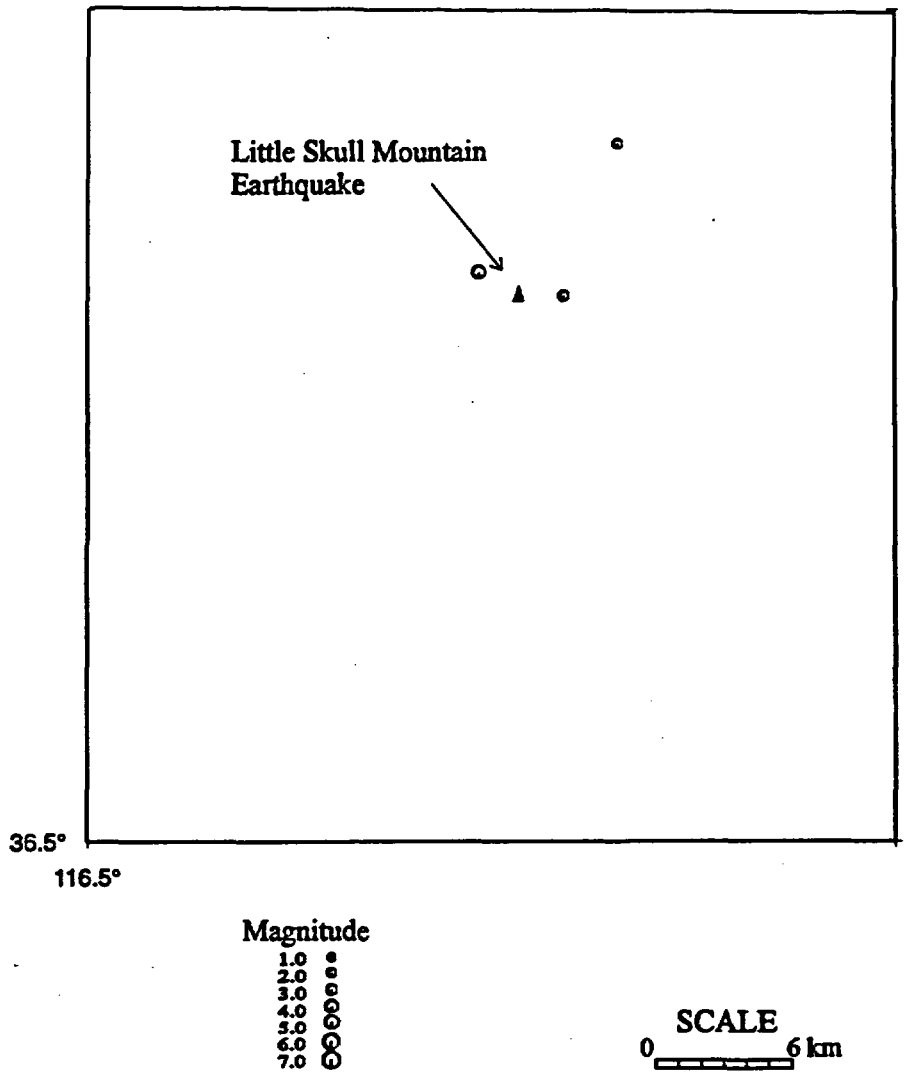


Figure G-16c Earthquakes in 1992 within 10 km of Little Skull Mountain after declustering with the Youngs *et al.* approach

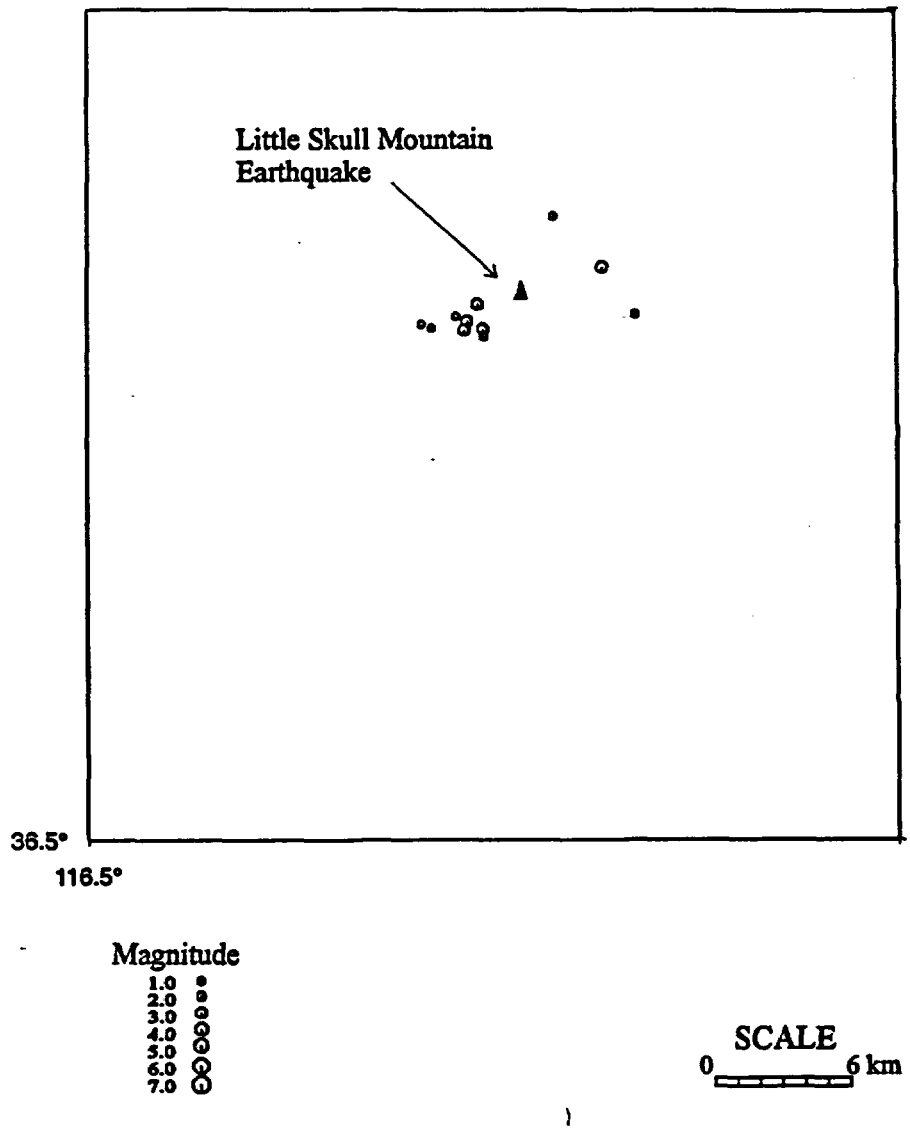


Figure G-16d Earthquakes in 1993 within 10 km of Little Skull Mountain after declustering with the Youngs *et al.* approach

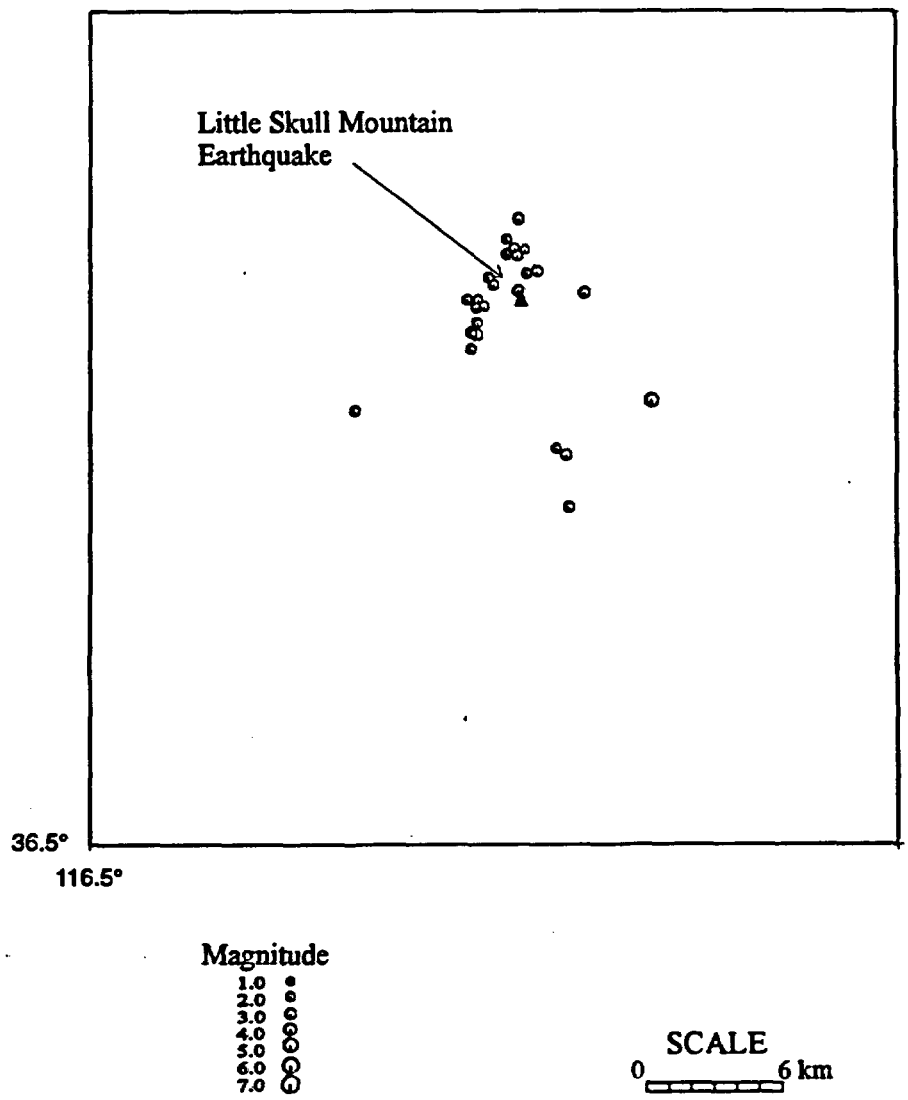


Figure G-16e Earthquakes in 1994 within 10 km of Little Skull Mountain after declustering with the Youngs *et al.* approach

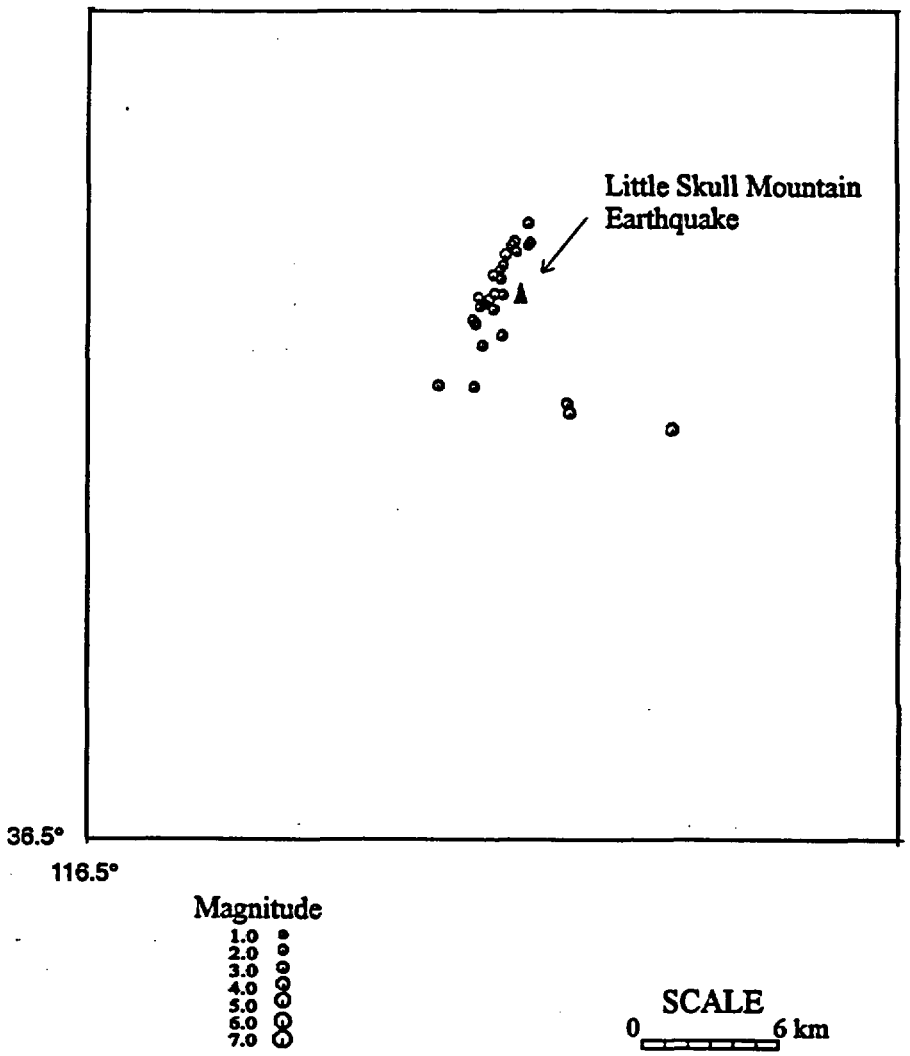


Figure G-16f Earthquakes in 1995 within 10 km of Little Skull Mountain after declustering with the Youngs *et al.* approach

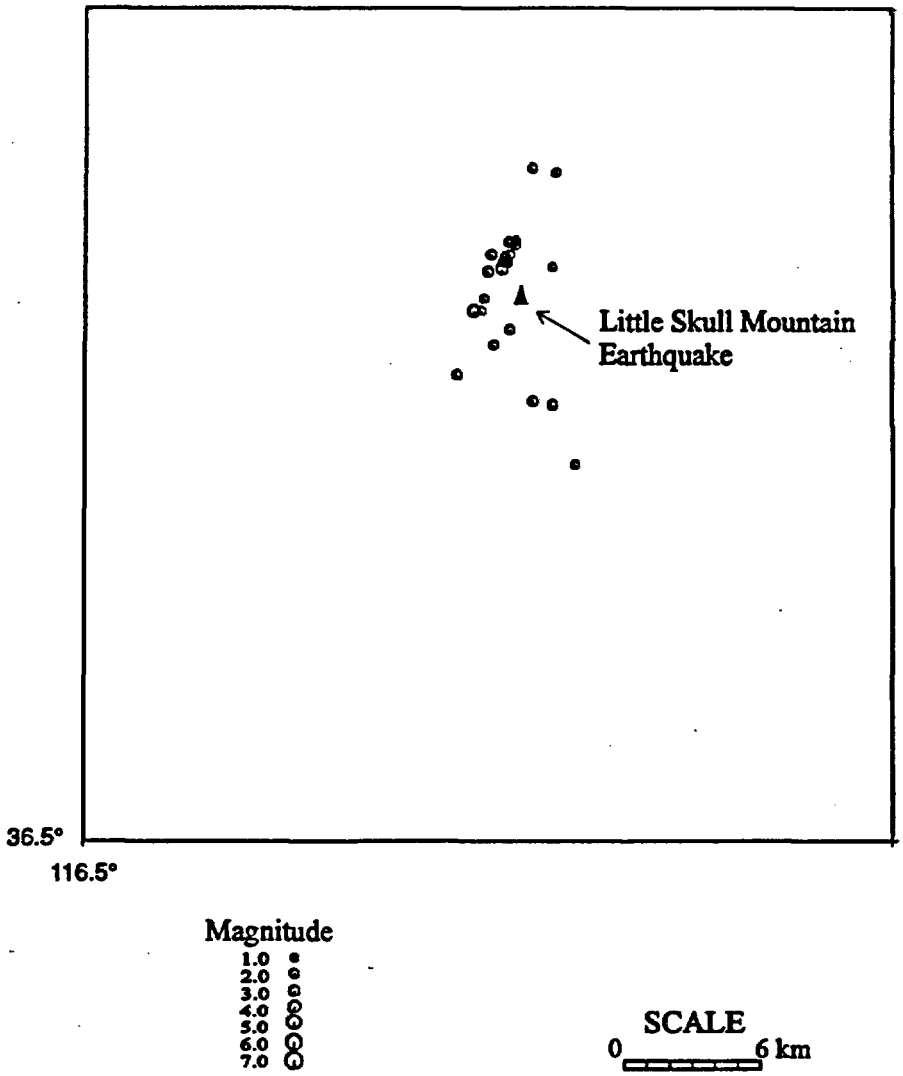


Figure G-16g Earthquakes in 1996 within 10 km of Little Skull Mountain after declustering with the Youngs *et al.* approach

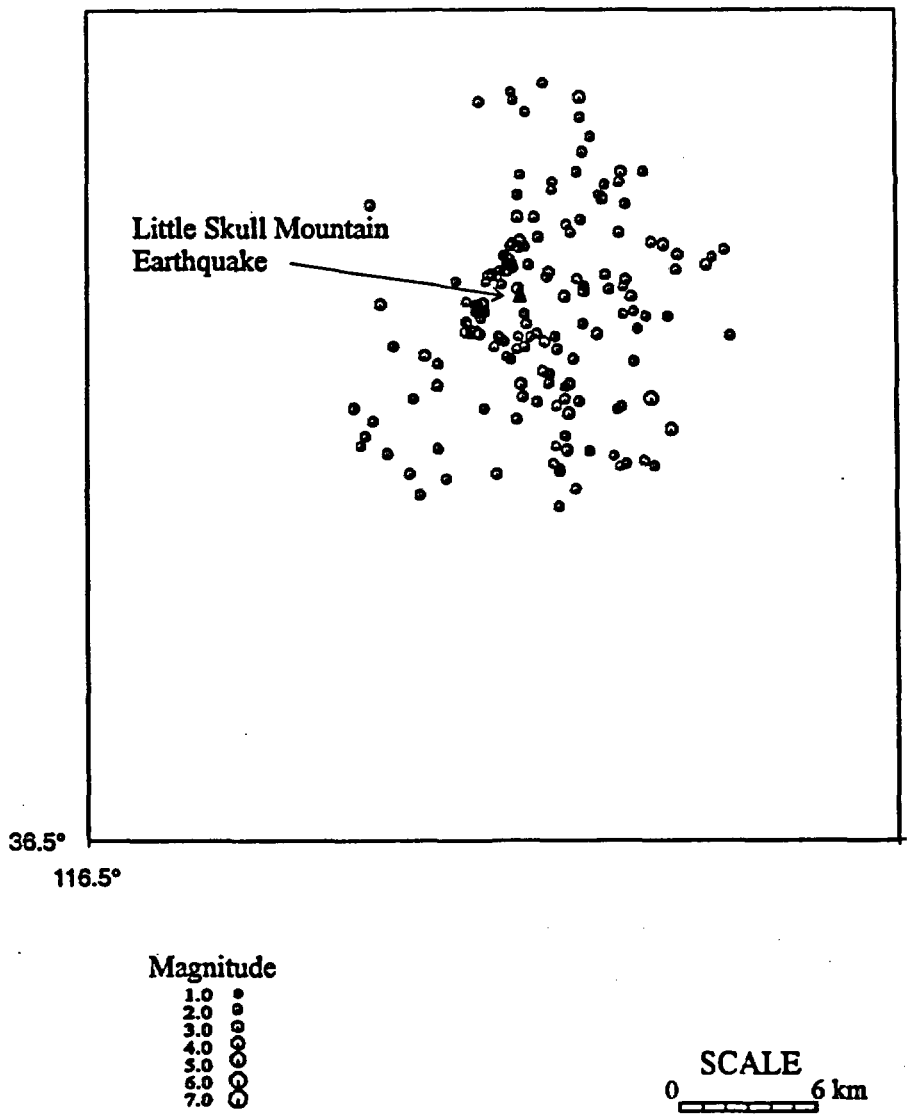


Figure G-17a Earthquakes from 1965 to 1996 within 10 km of Little Skull Mountain after declustering with the Veneziano and van Dyck approach

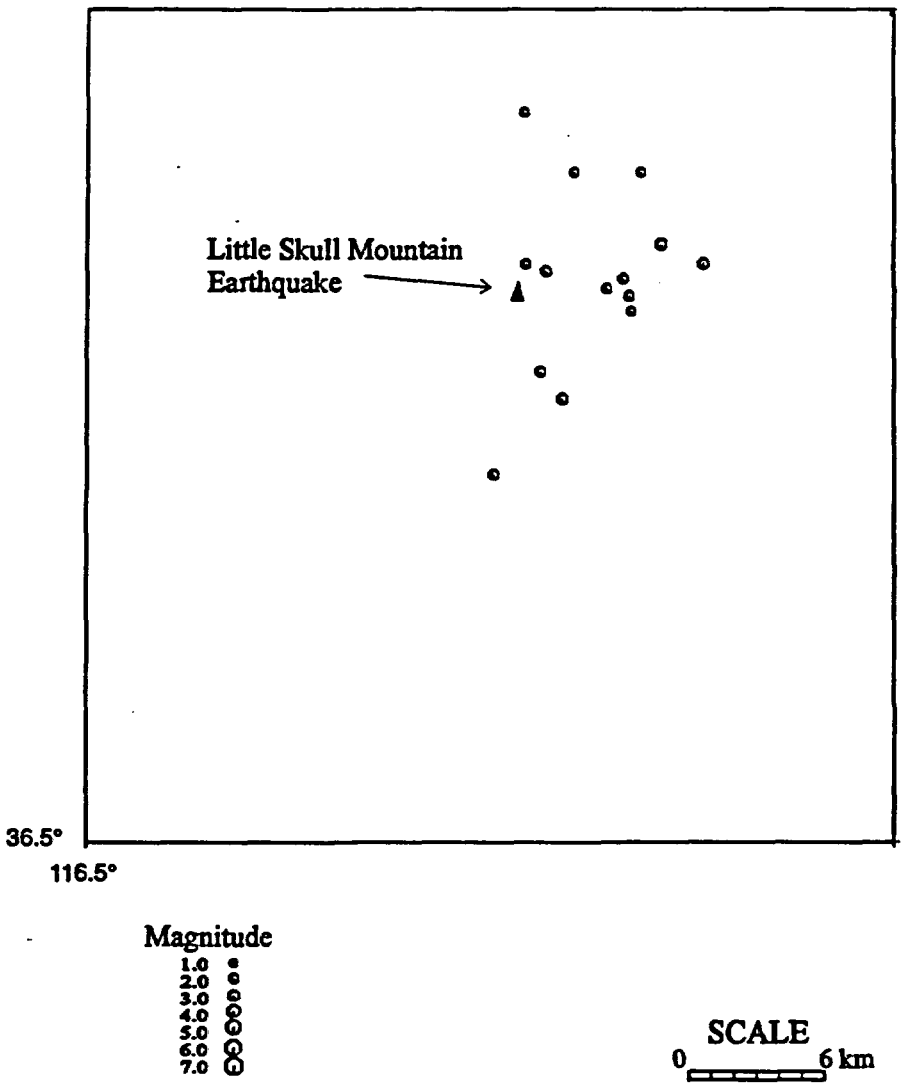


Figure G-17b Earthquakes in 1991 within 10 km of Little Skull Mountain after declustering with the Veneziano and van Dyck approach

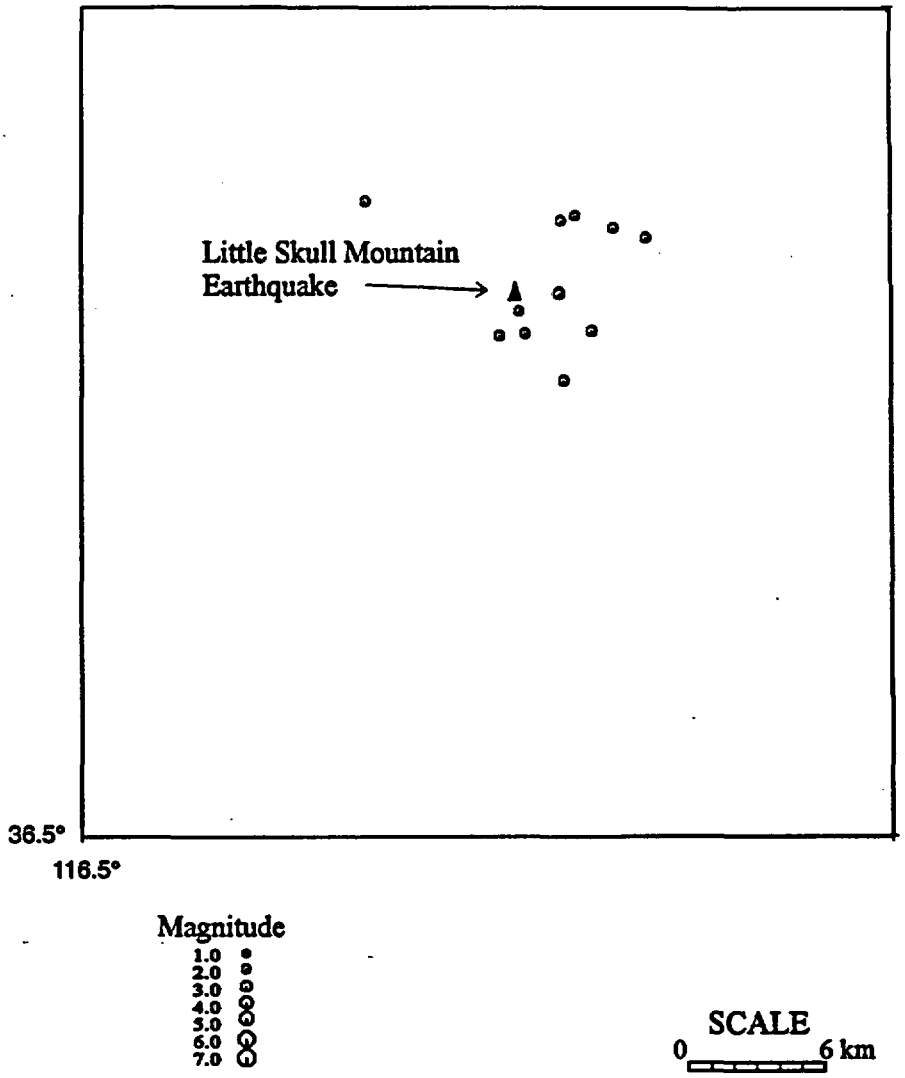


Figure G-17c Earthquakes in 1992 within 10 km of Little Skull Mountain after declustering with the Veneziano and van Dyck approach

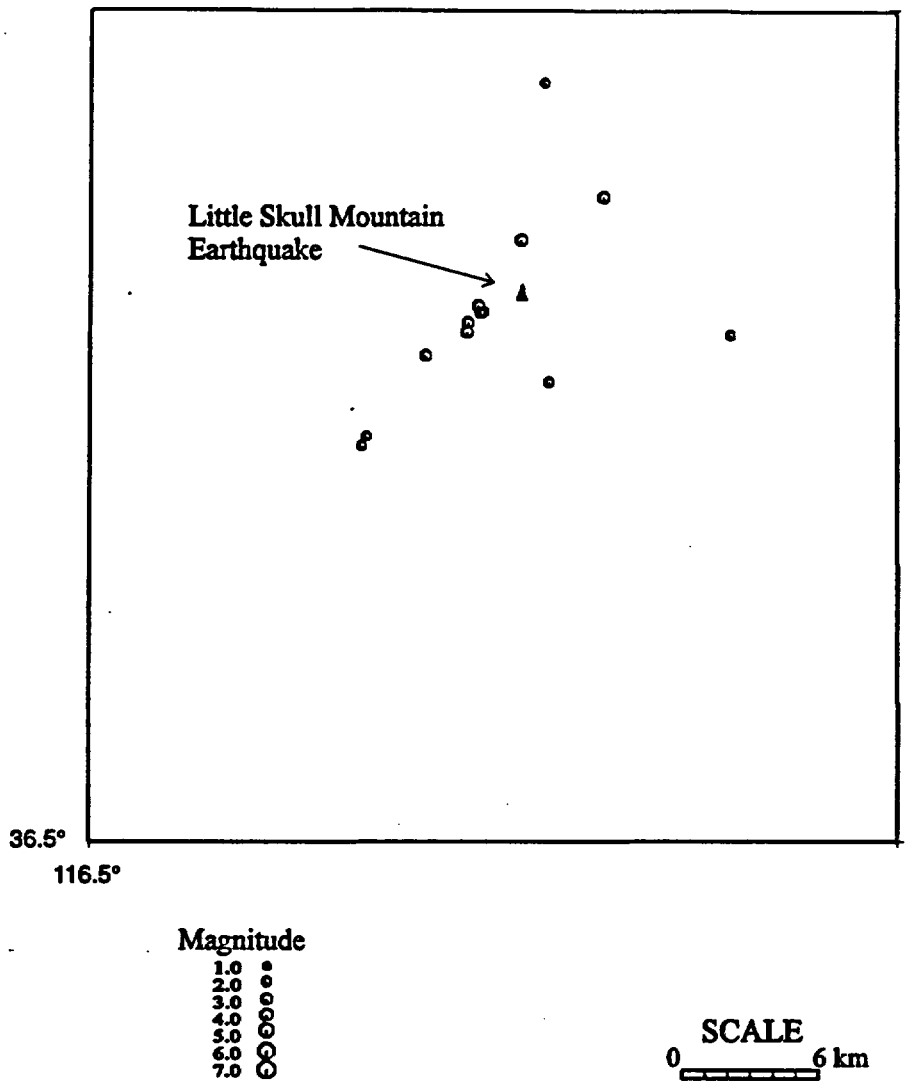


Figure G-17d Earthquakes in 1993 within 10 km of Little Skull Mountain after declustering with the Veneziano and van Dyck approach

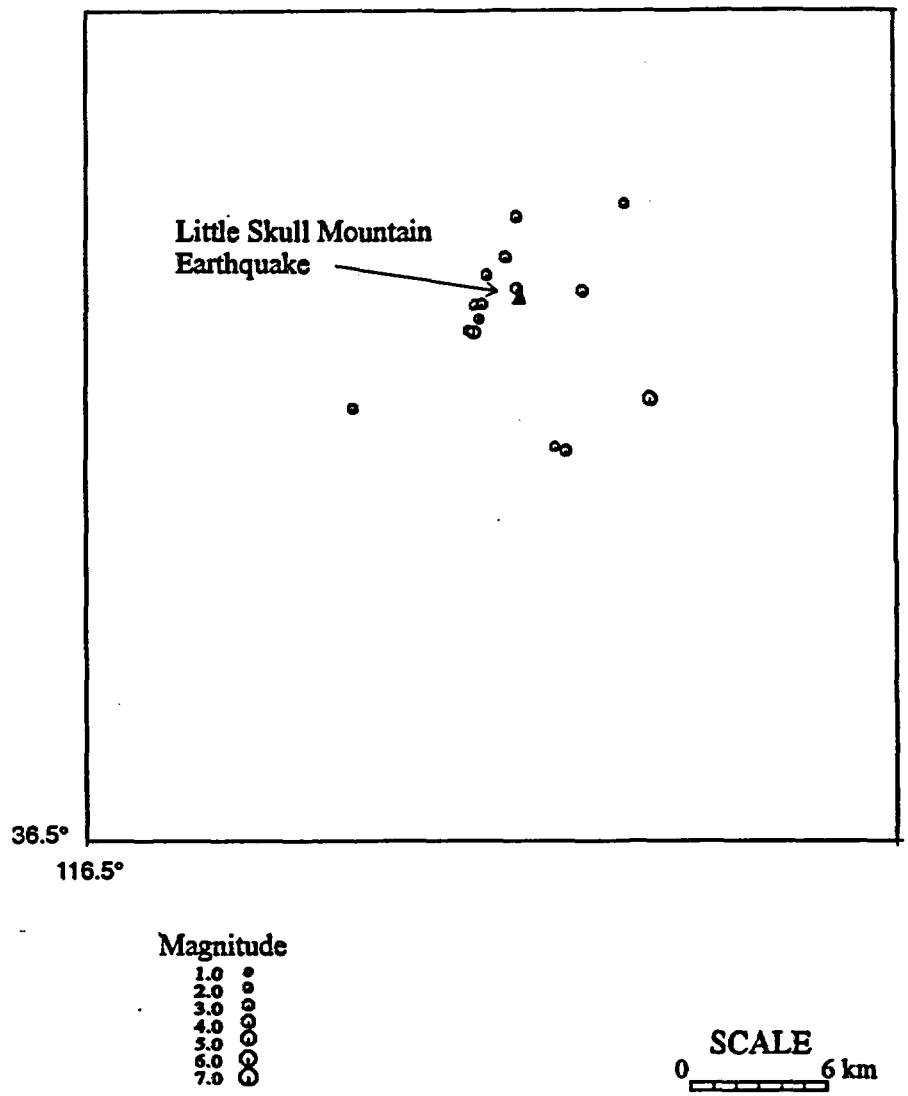


Figure G-17e Earthquakes in 1994 within 10 km of Little Skull Mountain after declustering with the Veneziano and van Dyck approach

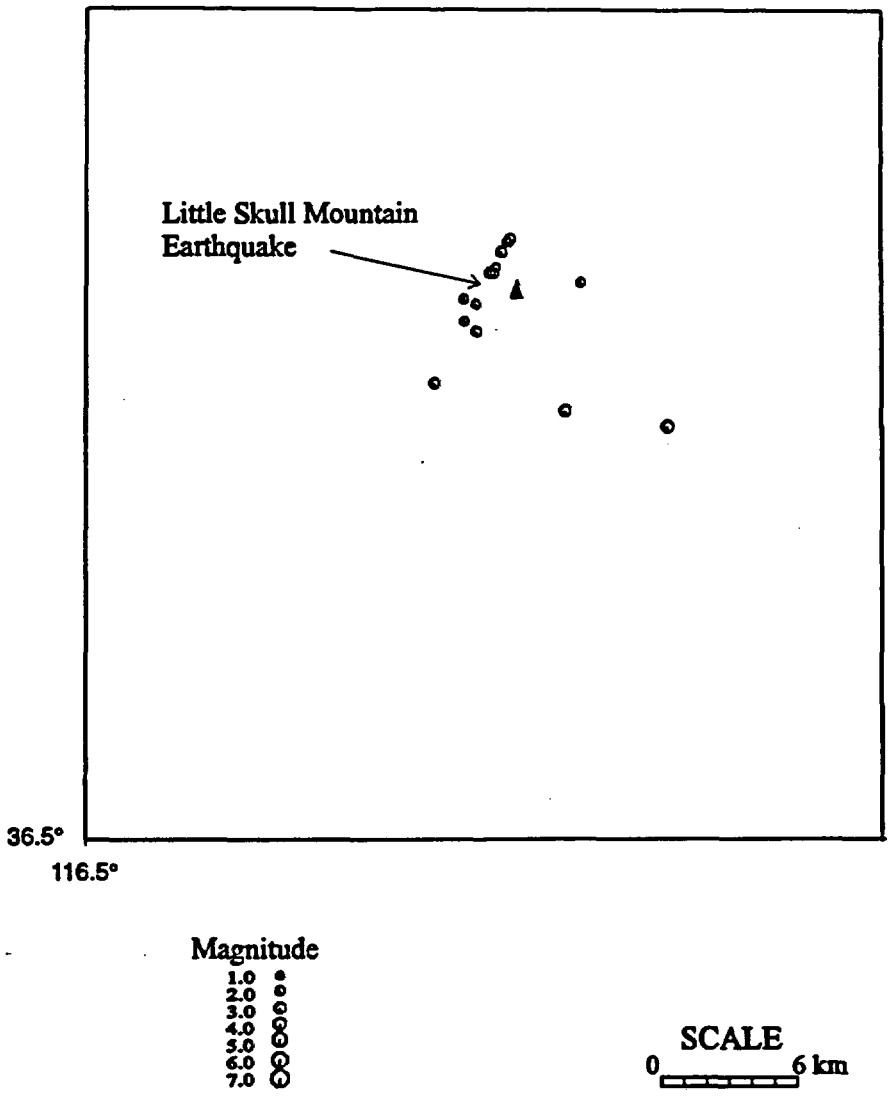


Figure G-17f Earthquakes in 1995 within 10 km of Little Skull Mountain after declustering with the Veneziano and van Dyck approach

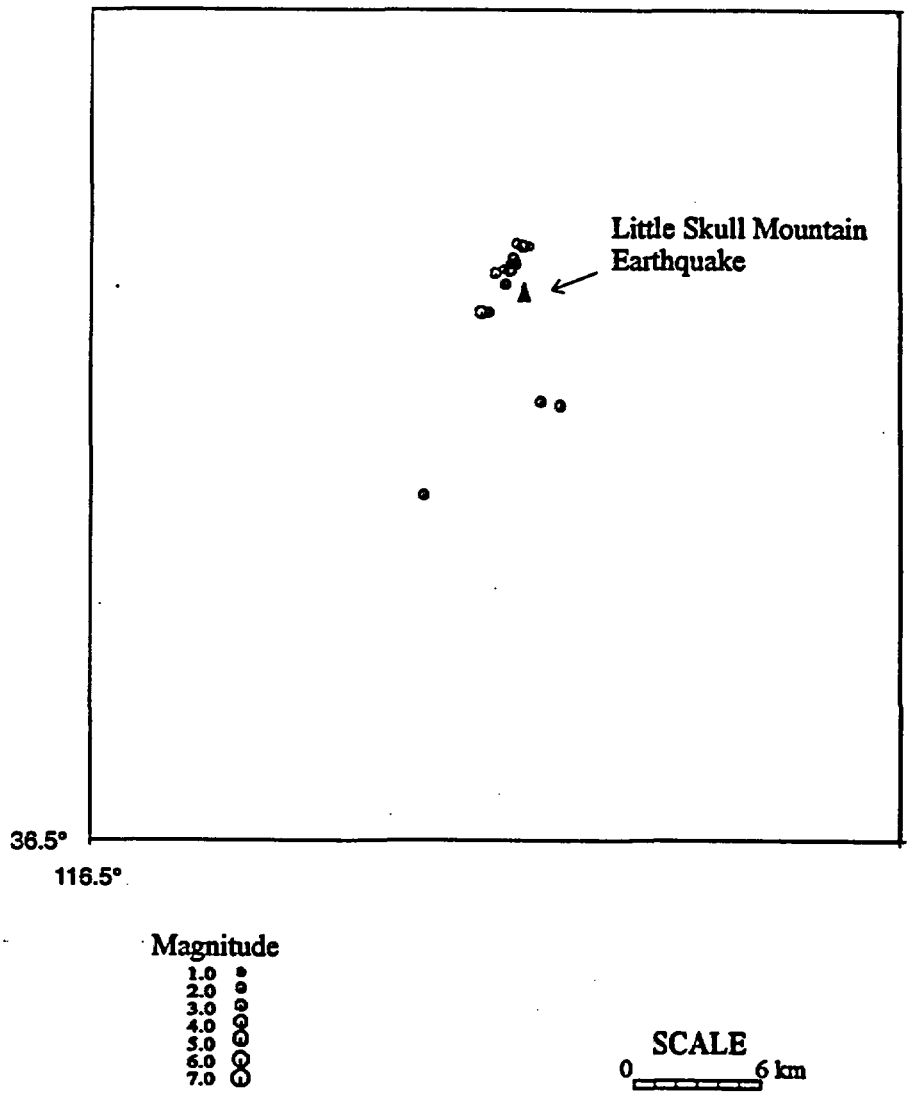


Figure G-17g Earthquakes in 1996 within 10 km of Little Skull Mountain after declustering with the Veneziano and van Dyck approach

APPENDIX H

DEVELOPMENT OF FAULT DISPLACEMENT HAZARD PARAMETER DISTRIBUTIONS

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Figure H-8 Beta distribution parameters *a* and *b* developed at specific values of *x/L* from the "Wheeler" curves shown on the left of Figure H-7 and the smooth curves fit to these parameters.

Figure H-9 Probability distributions for *D/MD* as a function of normalized location, *x/L*, along a principal rupture developed by the SBK team using numerical simulations of slip with fractal fault roughness.

Figure H-10 Beta distribution parameters *a* and *b* developed at specific values of *x/L* from the simulation results shown on Figure H-9 and the smooth curves fit to these parameters.

Figure H-11 CDFs for simulations of *D/MD* as a function of normalized location, *x/L*, from Figure H-9 compared to CDFs for beta distributions computed using the beta parameters from the smooth curves shown on Figure H-10.

Figure H-12 Logistic regression models for the probability of surface rupture as a function of moment magnitude developed from three data sets presented in Pezzopane and Dawson (1996). GB = Great Basin post 1930, NB&R = northern Basin and Range post 1930, and EC = extensional Cordillera.

Figure H-13a Frequency of distributed rupture as a function of distance from principal rupture. The plot on the left shows hanging wall data; the plot on the right shows footwall data. Data include hanging wall cracking from 1988 Chalfant Valley earthquake. Points along bottom of plot represent distances for individual earthquakes where observed frequency was zero. The data for the three magnitude intervals are offset for clarity.

Figure H-13b Frequency of distributed rupture as a function of distance from principal rupture. The plot on the left shows hanging wall data; the plot on the right shows footwall data. Data do not include hanging wall cracking from 1988 Chalfant Valley earthquake. Points along bottom of plot represent distances for individual earthquakes where observed frequency was zero. The data for the three magnitude intervals are offset for clarity.

Figure H-13c Frequency of distributed rupture as a function of distance from principal rupture developed for the AAR and SDO teams. The plot on the left shows hanging wall data, the plot on the right shows footwall data. Data do not include hanging wall cracking from the 1988 Chalfant Valley earthquake or data from the 1980 Mammoth earthquake. Points along bottom of plot represent distances for individual earth quakes where observed frequency was zero. The data for the three magnitude intervals are offset for clarity.

Figure H-14 Example of fitting straight line (dashed line) to digitized rupture trace (solid points) to determine the average strike azimuth.

Figure H-15 Frequency distribution for angle between average strike of principal rupture and strike of individual distributed rupture traces. Parameter n denotes the number of digitization points along an individual rupture trace. Top plot shows the data from Table H-3 presented in terms of fraction of total ruptures. Bottom plot shows exponential fits to the data normalized to unity at a relative angle of 0°.

APPENDIX H
DEVELOPMENT OF FAULT DISPLACEMENT HAZARD PARAMETER DISTRIBUTIONS

H.1 INTRODUCTION

The approaches for assessing fault displacement hazard developed by the SSFD expert teams include a number of empirical models for the distribution of various parameters. To assist in translating the teams' assessments into quantitative methods for use in computing the fault displacement hazard, the SSFD facilitation Team fit statistical distributions to the various empirical data sets specified by the teams. This appendix documents the development of these fault displacement hazard parameter distributions.

H.2 DISTRIBUTIONS FOR NORMALIZED DISPLACEMENT DATA FROM YUCCA MOUNTAIN TRENCHING STUDIES

The assessment of fault displacement hazard requires a model for the conditional probability of exceeding a specified displacement, d, given the occurrence of a displacement event, $P(D>d)$. The SSFD expert teams developed a number of empirical models to compute this probability. These models were based on data for displacement in individual events obtained from the Yucca Mountain paleoseismic trenching studies. The data from the various trenches were typically pooled together by normalizing the data from each trench using a normalizing parameter related to the location where they were obtained. The SSFD Facilitation Team then developed a statistical model for the distribution of D/D_{norm} that can be used to compute $P(D>d)$. These various data sets and the fitted statistical models are described below.

H.2.1 Normalization by Average Displacement at a Point

The DFS team developed a pooled set of displacement data by normalizing the displacements from each trench by the average of all of the displacements measured in the trench, designated AD. They used only data from trenches with three or more displacement events. Figure H-1 shows the cumulative distribution function (CDF) of the normalized data (the data are listed in Table DFS-12 in Appendix E). The DFS team developed a triangular distribution for D/AD by setting the mode of the distribution at 1.0 and placing the lower and upper limits for D/AD at 0 and 2.6, respectively. However, the

resulting CDF does not provide a good fit to the empirical CDF, as indicated in the upper left-hand plot on Figure H-1. In addition, it was judged more appropriate to fit a statistical model to the data that does not have a fixed upper limit. Because *D/AD* is restricted to non-negative values and the data indicate that the distribution is skewed to the right, three reasonable distributions are the exponential, lognormal, and gamma distributions. The exponential distribution has the form

$$F(x) = 1 - e^{-x/\mu_x} \tag{H-1}$$

where $F(x)$ is the CDF (the probability that the variable X is less than or equal to a value x) and parameter μ_x is the mean value of x. Setting x equal to *D/AD*, the mean value of *D/AD* is 1.0.

The lognormal distribution has the form

$$F(x) = \frac{1}{\sqrt{2\pi}\sigma_{\ln(x)}} \int_{-\infty}^{\ln(x)} e^{-1/2\left(\frac{z-\mu_{\ln(x)}}{\sigma_{\ln(x)}}\right)^2} dz \tag{H-2}$$

Setting x equal to *D/AD*, the resulting parameters are $\mu_{\ln(D/AD)} = -0.267$ and $\sigma_{\ln(D/AD)} = 0.839$.

The gamma distribution has the form

$$F(x) = \frac{1}{\Gamma(a)} \int_0^{x/b} e^{-t} t^{a-1} dt \tag{H-3}$$

where $\Gamma(a)$ is the gamma function. Setting x equal to *D/AD* and using the moments of the data, the resulting parameters of the gamma distribution are $a = 2.78$ and $b = 0.36$.

Two other types of distributions that provide skewed-to-the-right density functions and a positive mode are the Type I and II extreme value distributions, although the Type I distribution is not limited to non-negative values.

The Type I distribution has the form

$$F(x) = e^{-e^{-a(x-u)}} \tag{H-4}$$

where $a = 1.282/\sigma_x$ and $u = \mu_x - 0.577/a$ (Benjamin and Cornell, 1970). Setting x equal to *D/AD* and using the moments of the data, the resulting parameters of the Type I distribution are $a = 2.11$ and $u = 0.726$.

The Type II distribution has the form

$$F(x) = e^{-(u/x)^k} \tag{H-5}$$

where $\mu_x = u\Gamma(1-1/k)$ and $\sigma^2_x = u^2[\Gamma(1-2/k) - \Gamma^2(1-1/k)]$ (Benjamin and Cornell, 1970). Setting x equal to *D/AD* and using the moments of the data, the resulting parameters of the Type II distribution are $u = 0.757$ and $k = 3.19$.

Shown on Figure H-1 are the resulting CDFs for the exponential, lognormal, gamma, Type I, and Type II distributions fit to the data for *D/AD*. The best fits are obtained using the gamma and Type I distributions. The fit of the Type I distribution (as measured by the χ^2 and Kolmogorov-Smirnov goodness of fit tests) is slightly better than the gamma distribution. However, the fitted Type I distribution has a small tail (0.01 probability) of negative values for *D/AD*. Therefore, the gamma distribution with parameters $a = 2.78$ and $b = 0.36$ is preferable to model the distribution of *D/AD*.

H.2.2 Normalization by Average Paleoseismic Displacement for a Fault

The SBK team also developed a pooled set of displacement data by normalizing the displacements from each trench by an estimate of the average displacement per event for paleoseismic events, designated AD_{paleo}, for the fault on which the trench was located. These data are listed in Table SBK-6 in Appendix E. Figure H-2 shows the resulting CDFs for fits of exponential, lognormal, gamma, and Type I distributions to the D/AD_{paleo} data. The best fits are obtained using the gamma and Type I distributions, with the Type I distribution providing better goodness of fit statistics. However, as was the case for the

data shown on Figure H-1, the fitted Type I distribution has a small tail (0.02 probability) of negative values for $D/AD_{\text{-}paleo}$. Therefore, the gamma distribution with parameters a = 2.17 and b = 0.46 is preferable to model the distribution of $D/AD_{\text{-}paleo}$.

H.2.3 Normalization by Average Displacement as a Function of Fault Rupture Length

The SBK team also developed a pooled set of displacement data by normalizing the displacements from each trench by the average displacement per event based on an empirical relationship between average displacement and fault rupture length, designated $AD_{\text{-}F(RL)}$, for the fault on which the trench was located. These data are listed in Table SBK-6 in Appendix E. Figure H-3 shows the resulting CDFs for fits of exponential, lognormal, gamma, and Type I distributions to the $D/AD_{\text{-}F(RL)}$ data. The best fit is obtained using the gamma distribution with parameters a = 0.82 and b = 1.77.

H.2.4 Normalization by Maximum Displacement as a Function of Fault Rupture Length

The SBK team developed a pooled set of displacement data by normalizing the displacements from each trench by the maximum displacement per event based on an empirical relationship between maximum displacement and fault rupture length, designated $MD_{\text{-}F(RL)}$, for the fault on which the trench was located. These data are listed in Table SBK-6 in Appendix E. Figure H-4 shows the resulting CDFs for fits of exponential, lognormal, gamma, and Type I distributions to the $D/MD_{\text{-}F(RL)}$ data. The best fit is obtained using the gamma distribution with parameters a = 0.69 and b = 1.05.

H.2.5 Normalization by Expected Maximum Displacement

The AAR team developed a pooled set of displacement data by normalizing the displacements from each trench by the expected maximum displacement for a feature, designated M/MD, for the fault on which the trench was located. These data are listed in Table AAR-10 in Appendix E. Figure H-4 shows the resulting CDFs for fits of exponential, lognormal, gamma, and Type I distributions to these data. Good fits were obtained for the exponential distribution with μ_{MD}^{max} = 0.83, and for the gamma distribution with parameters a = 1.41 and b = 0.59. The goodness of fit statistics were slightly better for the gamma distribution. Because the gamma distribution has two parameters, one would expect it to provide a better fit than the single parameter exponential model. The statistical significance of the improvement in the fit can be evaluated using the likelihood ratio test (e.g. Seber and Wild, 1989, p. 196). The

likelihood of observing a particular data set, x_i (i = 1 to n), given a gamma distribution with parameters a and b is

$$L(a,b) = \prod_{i=1}^{n} \frac{(x_i/b)^{a-1} e^{-x_i/b}}{b\Gamma(a)} \tag{H-6}$$

The likelihood ratio statistic, LR, defined as

$$LR = 2\ln[L(\hat{\theta})/L(\theta_o)] \tag{H-7}$$

is used to test the hypothesis that the parameters $\hat{\theta}$ are equal to specified values θ_o. In this case, the exponential distribution is a special case of the gamma distribution with a = 1.0. The hypothesis that a is different from 1.0 is tested by setting $\hat{\theta}$={1.41, 0.59} and θ_o={1.0, 0.83} (for the exponential case $b = \mu_x$). The resulting value of LR is 2.93. The LR statistic is approximately χ_r^2 distributed with the degrees of freedom, r, equal to the number of additional free parameters in going from parameter set θ_o to parameter set $\hat{\theta}$. For this case, r = 1, and $P(\chi_1^2 > 2.93) = 0.09$. Thus, the improved fit of the gamma distribution over the exponential distribution is only marginally statistically significant.

H.2.6 Normalization by Cumulative Displacement

The SBK team developed a pooled set of displacement data by normalizing the displacements from each trench by the cumulative displacement, designated D_{cum}, for the fault on which the trench was located. These data are listed in Table SBK-7in Appendix E. Figure H-6 shows the resulting CDFs for fits of exponential, lognormal, gamma, and Type I distributions to the D/D_{cum} data. The best fits are obtained with the gamma and Type I distributions, with the fit of the Type I distribution producing better goodness of fit statistics. However, the fitted Type I distribution has a small tail (0.04 probability) of negative values for $D/AD_{\text{-}paleo}$. Therefore, the gamma distribution with parameters a = 1.79 and b = 0.00098 is preferable to model the distribution of D/D_{cum}.

H.3 DISTRIBUTIONS FOR DISPLACEMENT AT A POINT ALONG A PRINCIPAL RUPTURE

The SSFD expert teams developed an approach for assessing the variability of the displacement at a point along a principal rupture as a fraction of the maximum displacement on the rupture. These assessments were based on empirical data or simulations using fault roughness. The SSFD Facilitation Team then developed statistical models for the distribution of *D/MD* as a function of location along the principal rupture that can be used to compute $P(D_E>d)$. These models are described below.

H.3.1 Empirical Distribution for *D/MD* Along a Fault Rupture

Wheeler (1989) presented displacement profiles normalized by peak displacement for five large Basin and Range earthquake ruptures. The ASM team smoothed these data to develop curves defining the minimum, median, and maximum values of *D/MD* at a point as a function of normalized location along strike. The normalized point location is specified as x/L, where x is measured from one end of the rupture and L is the length of rupture. The data were smoothed to make the curves symmetric about $x/L = 0.5$. Shown at the left of Figure H-7 are the resulting normalized displacement curves. These curves were interpreted to represent a low percentile, the median value, and a high percentile for *D/MD*, and were used to construct a cumulative distribution function for *D/MD*.

The ratio *D/MD* is limited to the range of 0 to 1.0. A very flexible distribution form for modeling variables that have a fixed range is the beta distribution. When the variable y is limited to the range $0 \le y \le 1$, the beta distribution has the form

$$F(y) = \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)} \int_0^y z^{a-1}(1-z)^{b-1}\,dz \qquad \text{(H-8)}$$

Setting $y = D/MD$ and interpreting the minimum and maximum curves to be the 5th and 95th percentiles of the CDF for *D/MD*, beta distributions were developed at increments of $0.05x/L$. The resulting a and b parameters are plotted on Figure H-8. Relationships were developed for the parameters a and b as a function of x/L; specifically, $a = 3.73+3.98x/L$ and $b = 5.28+46.28e^{-16.7x/L}$, with $0 \le x/L \le 0.5$. The CDFs shown on the right of Figure H-7 were obtained using values of a and b from these relationships.

H.3.2 Numerical Simulations of *D/MD* Along a Fault Rupture

The SBK team presented in Workshop #5 the results of numerical simulations of the displacement pattern along a fault based on a fractal modeling of fault roughness. Figure H-9 shows the resulting CDFs for *D/MD* as a function of *x/L* computed from 100 simulations. These simulated CDFs were fit with beta distributions. The resulting values of parameters *a* and *b* as a function of *x/L* are shown on Figure H-10. Relationships were developed for the parameters *a* and *b* as a function of *x/L*; specifically, $a = \exp[0.6064+21.83x/L - 108.0(x/L)^2 + 136.6(x/L)^3]$ and $b = \exp[2.027+12.21x/L - 87.90(x/L)^2 + 115.5(x/L)^3]$, with $0 \leq x/L \leq 0.5$. Figure H-11 shows a comparison of the simulated CDFs to those obtained using values of *a* and *b* from these relationships.

H.4 DISTRIBUTIONS FOR PROBABILITY OF NEAR SURFACE RUPTURE

The SSFD teams developed approaches for assessing the probability the rupture will occur near the surface, given the occurrence of an earthquake, using data sets developed from mapping of historical ruptures. These models are described below.

H.4.1 Empirical Distribution for Probability of Principal Fault Rupture

Pezzopane and Dawson (1996) present a data base of historical ruptures that have occurred in the extensional Cordillera of the western U.S. On their Figures 9-4A, 9-6, and 9-8A they present histograms that list the number of earthquakes that have reported principal rupture near the surface and the number of earthquakes that have no reported principal rupture near the surface. These histograms show data on 105 earthquakes from the extensional Cordillera (their Figure 9-4A), 47 earthquakes in the northern Basin and Range Province that occurred post-1930 (their Figure 9-6), and 32 earthquakes in the Great Basin province that occurred post-1930 (their Figure 9-8A). These data, summarized in Table H-1, can be used to develop a model for the probability of near-surface rupture given the occurrence of an earthquake.

Wells and Coppersmith (1995) used a *logistic regression* model to analyze these types of data. The logistic regression model (e.g., Hosmer and Lemeshow, 1989) is a commonly used model for assessing the outcome of a dichotomous variable; in this case given the occurrence of an earthquake, surface rupture either occurs or does not occur. The

probability of a positive outcome (the occurrence of principal faulting given the occurrence of the event) is given by the expression

$$P(rupture|event) = \frac{e^{f(x)}}{1+e^{f(x)}} \qquad \text{(H-9)}$$

where $f(x)$ is a function of a set of variables characterizing the event. Wells and Coppersmith (1995) used magnitude to characterize the earthquake, defining $f(x)$ to be:

$$f(x) = a + bM \qquad \text{(H-10)}$$

Using this functional form, logistic regression functions were fit to the three data sets listed in Table H-11 using a maximum likelihood approach. The resulting models for the probability of principal surface faulting are shown on Figure H-12 and the parameters of the models are listed below.

Coefficients of Equation (H-9)

Data Set	a	b
32 Great Basin events	-16.02	2.685
47 Northern Basin & Range events	-18.71	3.041
105 extensional Cordillera events	-12.53	1.921

H.4.2 Empirical Distribution for Probability of Distributed Fault Rupture

Pezzopane and Dawson (1996) present a set of maps (their Plate 21) of historical ruptures that have occurred in the extensional Cordillera of the western U.S. indicating the location of distributed (secondary) ruptures around the principal (primary) fault rupture. Silvio Pezzopane presented in Workshop #3 an analysis of these data that showed the length of distributed rupture as a function of the distance from the principal rupture. His analysis was performed by constructing a raster scan of each map with a 0.5 km pixel size. The length of distributed faulting was set equal to 0.5 km times the number of pixels containing distributed rupture at a given distance from the principal rupture.

These data were used in the assessment of the distributed faulting hazard to develop an empirical model for the probability of the occurrence of distributed faulting at a point given the occurrence of an earthquake. Dr. Pezzopane extended his analysis of the mapping data

to also count the number of pixels that did not contain distributed faulting as a function of distance from the principal rupture. These data are presented in Table H-2. Figures H-13a and H-13b show these data in terms of the frequency of occurrence of distributed faulting. The frequencies plotted for each earthquake and distance from the principal rupture were computed by dividing the number of pixels with surface rupture by the total number of pixels. The row of data plotted at the bottom of the figures represent data points for which the observed frequency is zero. Figure H-13a shows the data including the hanging wall cracking that was observed in the 1988 Chalfant Valley, California earthquake and Figure H-13b shows the data without the Chalfant Valley hanging wall cracking observations.

The data for observations of the occurrence of distributed faulting listed in Table H-2 also represent the outcome of a dichotomous variable; distributed rupture either occurs or does not occur at each point (pixel). The logistic model [Equation (H-9)] was used to compute the probability of distributed rupturing occurring at a point. The data indicate a decrease in the frequency of occurrence with increasing distance, a decrease in frequency with decreasing magnitude, and lower frequencies in the footwall than in the hanging wall. The functional form used to represent these trends is

$$f(x) = C_1 + (C_2 + C_3 m + C_4 h) \cdot \ln(r + C_5) \qquad \text{(H-11)}$$

where m is earthquake magnitude, r is the distance to the principal rupture (in km), and h = 1 for the hanging wall side of the rupture and $h = 0$ for the footwall side of the rupture. Equation (H-11) was fit to the data listed in Table H-2 considering the two cases shown on Figures H-13a and H-13b. The resulting maximum likelihood parameters are listed below, including a case specified by the AAR team.

Coefficients of Equation (H-11)

Data Set	C_1	C_2	C_3	C_4	C_5
Table H-2 with Chalfant Valley Cracking	-0.891	-2.93	0.0065	0.957	1.48
Table H-2 without Chalfant Valley Cracking	2.06	-4.62	0.118	0.682	3.32
Table H-2 without Chalfant Valley Cracking and Mammoth (AAR)	2.04	-4.60	0.118	0.705	3.38

Shown on Figures H-13a and H-13b are curves indicating the probability of distributed rupture at a point, give the occurrence of an earthquake of M_w 5.5, 6.5, and 7.5. These relationships indicate that when the hanging wall cracking data from the 1988 Chalfant Valley earthquake are included in the data set, the resulting relationship shows no dependence on magnitude. If these data are not considered appropriate, then a significant magnitude effect is observed. The AAR and SDO teams considered an additional case exluding the hanging wall cracking data from Chalfant Valley and data from the 1980 Mammoth earthquake. The resulting parameters of Equation (H-11) are listed above and the data and logistic regression model are shown on Figure H-13c

H.4.3 Empirical Distribution for Probability of Distributed Rupture as a Function of Fault Orientation

The SBK and SDO teams considered a model for the probability that distributed rupture could occur on a feature based on data on the relative orientation between the principal and distributed ruptures in historical earthquakes. The data used for this assessment were the maps of historical ruptures presented on Plate 21 of Pezzopane and Dawson (1996). The digitized faulting maps were analyzed to calculate the strike azimuths of the principal faulting trace and the individual distributed faulting traces. Figure H-14 shows an example of how a straight line was fit to a digitized fault trace. The average strike line was found by minimizing the squared distance from the fault trace digitization points measured normal to the strike line. Table H-3 summarizes the data for the angle between the principal fault trace and the individual distributed fault traces in terms of the number of distributed ruptures with relative angles within 5° intervals. Figure H-15 shows the data for all of the historical ruptures in terms of frequency of ruptures in each 5° relative angle increment (the number of ruptures in each increment divided by the total number of ruptures). The data are presented in terms of the number of digitization points for each distributed rupture trace. It is expected that the average strike for traces with more digitization points are somewhat better defined.

The frequency data plotted at the top of Figure H-15 were fit with the functional form:

$$\ln(frequency) = C_1 + C_2 \,\mathrm{int}[\theta/5] + C_3 \,\mathrm{int}[\theta/5]^2 \qquad \text{(H-12)}$$

where θ is the angle between the average strike of the principal and distributed rupture and int[ ] is the integer function (i.e., int[4/5] = 0, int[7/5] = 1). The following table lists the coefficients of the individual fits to the data.

Coefficients of Equation (H-12)

Data Set	C_1	C_2	C_3
n ≥ 2	-2.09	-0.0732	-0.00546
n ≥ 3	-1.84	-0.130	-0.00415
n ≥ 4	-1.73	-0.173	-0.00226
n ≥ 5	-1.72	-0.186	-0.00132
n ≥ 6	-1.86	-0.0734	-0.0117

These relationships can be used to assess the relative likelihood of rupture by normalizing them to produce unity at θ = 0 [i.e., setting C_1 to 0 in Equation (H-12)]. The resulting relationships are shown on the bottom plot of Figure H-15.

H.5 REFERENCES

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Table H-1
Summary of Data Presented in Pezzopane and Dawson (1996) For the Occurrence of Principal Faulting During Historical Ruptures

Moment Magnitude (M_w)	Extensional Cordillera		Northern Basin & Range Post-1930		Great Basin Post-1930	
	Number of Events with:		Number of Events with:		Number of Events with:	
	Surface Rupture	No Surface Rupture	Surface Rupture	No Surface Rupture	Surface Rupture	No Surface Rupture
4.5	1	0				
4.6						
4.7						
4.8						
4.9	1	0	1	0	1	0
5.0	0	1	0	1		
5.1						
5.2	1	0				
5.3	0	1	0	1	0	1
5.4						
5.5	1	17	0	7	0	4
5.6	1	4	1	4	1	2
5.7	0	4	0	3	0	2
5.8	2	3	2	2	2	1
5.9	0	3	0	3	0	1
6.0	5	23	2	2	2	2
6.1	2	6	2	5	2	3
6.2	1	3	1	0	1	0
6.3	1	3	1	1	1	0
6.4	1	1				
6.5	1	4				
6.6	3	0	2	0	2	0
6.7						
6.8	3	0	3	0	2	0
6.9						
7.0						
7.1	1	0	1	0	1	0
7.2	1	0	1	0	1	0
7.3	2	0				
7.4	3	0	1	0		
7.5						
7.6	1	0				

Table H-2
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Distributed Faulting
(Page 1 of 12)

Distance from Principal Rupture (km)	Hanging Wall		Footwall	
	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture
1992 M_w 7.4 Landers, CA				
0.5	88	396	58	426
1.0	28	300	18	310
1.5	42	281	0	323
2.0	48	439	10	477
2.5	6	332	6	332
3.0	2	422	2	422
3.5	2	347	0	349
4.0	4	407	0	411
4.5	2	452	0	454
5.0	2	357	0	359
5.5	2	435	2	435
6.0	4	366	2	368
6.5	0	474	0	474
7.0	4	411	0	415
7.5	2	383	0	385
8.0	2	494	0	496
8.5	0	464	0	464
9.0	2	449	0	451
9.5	2	436	0	438
10.0	0	412	0	412
10.5	0	525	0	525
11.0	0	482	0	482
11.5	0	481	0	481
12.0	0	465	0	465
12.5	0	534	0	534
13.0	0	493	0	493
13.5	0	479	0	479
14.0	0	540	0	540
14.5	0	489	0	489
15.0	0	562	0	562
15.5	0	506	0	506
16.0	0	485	0	485
16.5	0	521	0	521
17.0	0	546	0	546
1887 M_w 7.4 Sonora, Mexico				
0.5	0	375	0	375
1.0	6	299	0	305
1.5	4	298	0	302
2.0	2	403	0	405
2.5	4	306	0	310
3.0	0	345	0	345
3.5	0	322	0	322
4.0	0	339	0	339
4.5	0	418	0	418
5.0	0	333	0	333
5.5	0	367	0	367

Table H-2
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Distributed Faulting
(Page 2 of 12)

Distance from Principal Rupture (km)	Hanging Wall		Footwall	
	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture
6.0	0	345	0	345
6.5	0	403	0	403
7.0	0	378	0	378
7.5	0	361	0	361
8.0	6	426	0	432
8.5	10	414	0	424
9.0	12	383	0	395
9.5	6	395	0	401
10.0	0	387	0	387
10.5	0	454	0	454
11.0	0	437	0	437
11.5	0	428	0	428
12.0	0	426	0	426
12.5	0	489	0	489
13.0	0	452	0	452
13.5	0	439	0	439
14.0	0	482	0	482
14.5	0	451	0	451
15.0	0	507	0	507
15.5	0	474	0	474
16.0	0	467	0	467
16.5	0	490	0	490
17.0	0	537	0	537
1959 M_w 7.4 Hebgen Lake, MT				
0.5	14	185	12	187
1.0	4	135	10	129
1.5	6	125	4	127
2.0	10	185	0	195
2.5	0	117	4	113
3.0	0	157	2	155
3.5	0	128	0	128
4.0	0	159	0	159
4.5	0	179	0	179
5.0	2	141	0	143
5.5	4	183	0	187
6.0	6	150	0	156
6.5	20	187	0	207
7.0	6	179	0	185
7.5	2	168	0	170
8.0	0	229	0	229
8.5	16	196	0	212
9.0	16	201	0	217
9.5	0	211	0	211
10.0	4	193	0	197
10.5	0	263	0	263
11.0	2	233	0	235
11.5	14	237	0	251

Table H-2
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Distributed Faulting
(Page 3 of 12)

Distance from Principal Rupture (km)	Hanging Wall		Footwall	
	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture
12.0	0	238	0	238
12.5	8	269	0	277
13.0	4	257	0	261
13.5	4	248	0	252
14.0	2	291	0	293
14.5	0	265	0	265
15.0	0	308	0	308
15.5	0	288	0	288
16.0	0	280	0	280
16.5	0	315	0	315
17.0	0	321	0	321
1932 M_w 7.2 Cedar Mtn., NV				
0.5	4	169	0	173
1.0	6	184	4	186
1.5	4	197	2	199
2.0	14	289	0	303
2.5	4	229	0	233
3.0	0	275	6	269
3.5	4	244	6	242
4.0	6	264	18	252
4.5	10	335	2	343
5.0	2	274	0	276
5.5	0	322	0	322
6.0	6	288	0	294
6.5	6	330	2	334
7.0	0	315	2	313
7.5	0	295	4	291
8.0	0	367	2	365
8.5	0	346	0	346
9.0	0	331	0	331
9.5	0	336	0	336
10.0	0	318	0	318
10.5	0	378	0	378
11.0	0	367	0	367
11.5	0	361	0	361
12.0	0	359	0	359
12.5	0	403	0	403
13.0	0	384	0	384
13.5	0	370	2	368
14.0	0	410	2	408
14.5	0	381	0	381
15.0	0	429	0	429
15.5	0	407	0	407
16.0	0	397	0	397
16.5	0	411	0	411
17.0	0	433	0	433

Table H-2
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Distributed Faulting
(Page 4 of 12)

Distance from Principal Rupture (km)	Hanging Wall		Footwall	
	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture
1954 M_w 7.1 Fairview Peak, NV				
0.5	4	291	10	285
1.0	8	219	6	221
1.5	6	228	2	232
2.0	12	315	2	325
2.5	6	250	6	250
3.0	8	288	2	294
3.5	8	273	4	277
4.0	8	294	2	300
4.5	22	363	4	381
5.0	28	282	4	306
5.5	4	350	0	354
6.0	2	332	0	334
6.5	4	393	0	397
7.0	2	377	0	379
7.5	2	364	0	366
8.0	0	441	0	441
8.5	0	411	0	411
9.0	0	391	0	391
9.5	2	386	0	388
10.0	0	374	0	374
10.5	0	436	0	436
11.0	0	425	0	425
11.5	0	413	0	413
12.0	0	407	0	407
12.5	0	466	0	466
13.0	0	431	0	431
13.5	0	420	0	420
14.0	0	463	0	463
14.5	0	429	0	429
15.0	0	482	0	482
15.5	0	451	0	451
16.0	0	442	0	442
16.5	0	473	0	473
17.0	0	506	0	506
1954 M_w 6.8 Dixie Valley, NV				
0.5	16	243	4	255
1.0	18	178	0	196
1.5	36	164	0	200
2.0	32	257	0	289
2.5	24	183	0	207
3.0	26	220	0	246
3.5	4	215	0	219
4.0	6	236	0	242
4.5	6	290	0	296
5.0	2	232	0	234
5.5	0	269	0	269

Table H-2
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Distributed Faulting
(Page 5 of 12)

Distance from Principal Rupture (km)	Hanging Wall		Footwall	
	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture
6.0	0	246	0	246
6.5	0	295	0	295
7.0	0	277	0	277
7.5	0	260	0	260
8.0	0	325	0	325
8.5	0	308	0	308
9.0	0	300	0	300
9.5	0	299	0	299
10.0	0	286	0	286
10.5	0	346	0	346
11.0	0	330	0	330
11.5	0	332	0	332
12.0	0	325	0	325
12.5	0	373	0	373
13.0	0	348	0	348
13.5	0	340	0	340
14.0	0	379	0	379
14.5	0	352	0	352
15.0	0	394	0	394
15.5	0	374	0	374
16.0	0	367	0	367
16.5	0	394	0	394
17.0	0	417	0	417
1983 M_w 6.8 Borah Peak, ID				
0.5	14	152	22	144
1.0	6	122	10	118
1.5	4	129	4	129
2.0	12	200	4	208
2.5	2	152	2	152
3.0	6	186	4	188
3.5	8	153	4	157
4.0	14	174	4	184
4.5	10	214	4	220
5.0	8	166	2	172
5.5	8	209	4	213
6.0	6	180	0	186
6.5	2	238	0	240
7.0	0	218	0	218
7.5	0	202	0	202
8.0	0	266	0	266
8.5	0	252	0	252
9.0	0	246	0	246
9.5	0	243	0	243
10.0	0	230	0	230
10.5	0	295	0	295
11.0	0	276	0	276
11.5	0	276	0	276

Table H-2
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Distributed Faulting
(Page 6 of 12)

Distance from Principal Rupture (km)	Hanging Wall		Footwall	
	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture
12.0	0	271	0	271
12.5	0	314	0	314
13.0	0	297	0	297
13.5	0	287	0	287
14.0	0	320	0	320
14.5	0	299	0	299
15.0	0	344	0	344
15.5	0	323	0	323
16.0	0	315	0	315
16.5	0	338	0	338
17.0	0	372	0	372
1954 M_w 6.8 Stillwater, NV				
0.5	4	146	2	148
1.0	4	126	6	124
1.5	8	128	0	136
2.0	10	190	0	200
2.5	10	140	0	150
3.0	6	172	0	178
3.5	0	162	0	162
4.0	0	179	0	179
4.5	0	213	0	213
5.0	0	178	0	178
5.5	0	203	0	203
6.0	0	190	0	190
6.5	0	223	0	223
7.0	0	215	0	215
7.5	6	200	0	206
8.0	6	245	0	251
8.5	0	245	0	245
9.0	0	236	0	236
9.5	0	243	0	243
10.0	0	234	0	234
10.5	4	271	0	275
11.0	2	270	0	272
11.5	2	266	0	268
12.0	0	269	0	269
12.5	0	305	0	305
13.0	0	291	0	291
13.5	0	285	0	285
14.0	0	313	0	313
14.5	0	297	0	297
15.0	0	330	0	330
15.5	0	318	0	318
16.0	0	313	0	313
16.5	0	331	0	331
17.0	0	359	0	359

Table H-2
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Distributed Faulting
(Page 7 of 12)

Distance from Principal Rupture (km)	Hanging Wall		Footwall	
	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture
1954 M_w 6.6 Rainbow Mtn., NV				
0.5	12	75	26	61
1.0	12	68	0	80
1.5	2	84	2	84
2.0	2	116	0	118
2.5	0	96	0	96
3.0	0	108	0	108
3.5	0	108	0	108
4.0	0	116	0	116
4.5	0	150	0	150
5.0	0	124	0	124
5.5	0	140	0	140
6.0	0	136	0	136
6.5	0	160	0	160
7.0	0	156	0	156
7.5	0	152	0	152
8.0	0	190	0	190
8.5	0	184	0	184
9.0	0	180	0	180
9.5	0	184	0	184
10.0	0	180	0	180
10.5	0	215	0	215
11.0	0	211	0	211
11.5	0	212	0	212
12.0	0	212	0	212
12.5	0	247	0	247
13.0	0	232	0	232
13.5	0	228	0	228
14.0	0	255	0	255
14.5	0	240	0	240
15.0	0	272	0	272
15.5	0	260	0	260
16.0	0	256	0	256
16.5	0	276	0	276
17.0	0	298	0	298
1986 M_w 6.2 Chalfant Valley, CA				
0.5	12	55	10	57
1.0	0	66	0	66
1.5	0	68	0	68
2.0	0	96	0	96
2.5	0	80	0	80
3.0	0	93	0	93
3.5	0	92	0	92
4.0	0	101	0	101
4.5	0	127	0	127
5.0	0	108	0	108
5.5	0	125	0	125

Table H-2
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Distributed Faulting
(Page 8 of 12)

Distance from Principal Rupture (km)	Hanging Wall		Footwall	
	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture	Number of 0.5 km^2 Pixels with Distributed Rupture	Number of 0.5 km^2 Pixels without Distributed Rupture
6.0	0	120	0	120
6.5	0	141	0	141
7.0	0	140	0	140
7.5	0	136	0	136
8.0	0	172	0	172
8.5	0	164	0	164
9.0	0	165	0	165
9.5	0	168	0	168
10.0	0	164	0	164
10.5	0	197	0	197
11.0	0	193	0	193
11.5	0	197	0	197
12.0	0	196	0	196
12.5	0	227	0	227
13.0	0	216	0	216
13.5	0	212	0	212
14.0	0	238	0	238
14.5	0	224	0	224
15.0	0	253	0	253
15.5	0	244	0	244
16.0	0	240	0	240
16.5	0	261	0	261
17.0	0	277	0	277
17.5	0	277	0	277
18.0	0	286	0	286
18.5	0	277	0	277
19.0	0	300	0	300
19.5	0	288	0	288
20.0	0	317	0	317
20.5	0	301	0	301
21.0	0	317	0	317
21.5	0	328	0	328
22.0	0	316	0	316
22.5	0	341	0	341
23.0	0	328	0	328
23.5	0	357	0	357
24.0	0	356	0	356
24.5	0	372	0	372

Table H-2
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Distributed Faulting
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1986 M_w 6.2 Chalfant Valley, CA with hanging wall cracking				
0.5	12	55	10	57
1.0	0	66	0	66
1.5	0	68	0	68
2.0	0	96	0	96
2.5	0	80	0	80
3.0	0	93	0	93
3.5	0	92	0	92
4.0	0	101	0	101
4.5	0	127	0	127
5.0	0	108	0	108
5.5	0	125	0	125
6.0	0	120	0	120
6.5	0	141	0	141
7.0	0	140	0	140
7.5	0	136	0	136
8.0	0	172	0	172
8.5	0	164	0	164
9.0	0	165	0	165
9.5	2	166	0	168
10.0	0	164	0	164
10.5	0	197	0	197
11.0	8	185	0	193
11.5	4	193	0	197
12.0	10	186	0	196
12.5	2	225	0	227
13.0	0	216	0	216
13.5	8	204	0	212
14.0	10	228	0	238
14.5	10	214	0	224
15.0	20	233	0	253
15.5	10	234	0	244
16.0	8	232	0	240
16.5	2	259	0	261
17.0	10	267	0	277
17.5	2	275	0	277
18.0	0	286	0	286
18.5	2	275	0	277
19.0	6	294	0	300
19.5	2	286	0	288
20.0	2	315	0	317
20.5	0	301	0	301
21.0	2	315	0	317
21.5	0	328	0	328
22.0	2	314	0	316
22.5	0	341	0	341
23.0	0	328	0	328
23.5	0	357	0	357
24.0	0	356	0	356

Table H-2
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Distributed Faulting
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24.5	0	372	0	372
1980 M_w 6.1 Mammoth Lake, CA				
0.5	8	108	2	114
1.0	20	74	8	86
1.5	22	70	2	90
2.0	8	129	6	131
2.5	2	92	0	94
3.0	0	121	0	121
3.5	0	105	0	105
4.0	0	122	0	122
4.5	0	153	0	153
5.0	0	120	0	120
5.5	0	149	0	149
6.0	0	133	0	133
6.5	0	168	0	168
7.0	0	158	0	158
7.5	0	148	0	148
8.0	0	194	0	194
8.5	0	186	0	186
9.0	0	183	0	183
9.5	0	185	0	185
10.0	0	175	0	175
10.5	0	223	0	223
11.0	0	213	0	213
11.5	0	215	0	215
12.0	0	212	0	212
12.5	0	244	0	244
13.0	0	234	0	234
13.5	0	228	0	228
14.0	0	257	0	257
14.5	0	238	0	238
15.0	0	277	0	277
15.5	0	261	0	261
16.0	0	254	0	254
16.5	0	279	0	279
17.0	0	299	0	299
1950 M_w 5.6 Fort Sage, CA				
0.5	2	46	0	48
1.0	0	46	0	46
1.5	0	50	0	50
2.0	0	72	0	72
2.5	0	62	0	62
3.0	0	74	0	74
3.5	0	74	0	74
4.0	0	82	0	82
4.5	0	106	0	106
5.0	0	90	0	90
5.5	0	106	0	106
6.0	0	102	0	102
6.5	0	122	0	122
7.0	0	122	0	122

Table H-2
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Distributed Faulting
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7.5	0	118	0	118
8.0	0	150	0	150
8.5	0	146	0	146
9.0	0	146	0	146
9.5	0	150	0	150
10.0	0	146	0	146
10.5	0	178	0	178
11.0	0	174	0	174
11.5	0	178	0	178
12.0	0	178	0	178
12.5	0	206	0	206
13.0	0	198	0	198
13.5	0	194	0	194
14.0	0	218	0	218
14.5	0	206	0	206
15.0	0	234	0	234
15.5	0	226	0	226
16.0	0	222	0	222
16.5	0	242	0	242
17.0	0	260	0	260
1979 M_w 5.5 Homestead Valley, CA				
0.5	0	28	6	22
1.0	0	26	0	26
1.5	0	30	0	30
2.0	0	52	0	52
2.5	4	38	0	42
3.0	2	53	0	55
3.5	0	54	0	54
4.0	0	63	0	63
4.5	0	87	0	87
5.0	0	70	0	70
5.5	0	87	0	87
6.0	0	82	0	82
6.5	0	107	0	107
7.0	0	102	0	102
7.5	0	98	0	98
8.0	0	128	0	128
8.5	0	130	0	130
9.0	0	127	0	127
9.5	0	130	0	130
10.0	0	126	0	126
10.5	0	163	0	163
11.0	0	155	0	155
11.5	0	159	0	159
12.0	0	158	0	158
12.5	0	187	0	187
13.0	0	178	0	178
13.5	0	174	0	174
14.0	0	200	0	200
14.5	0	186	0	186
15.0	0	219	0	219

Table H-2
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Distributed Faulting

15.5	0	206	0	206
16.0	0	202	0	202
16.5	0	223	0	223
17.0	0	242	0	242

Table H-3
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Angle Between Strikes of Principal and Distributed Ruptures

	n = 2		n = 3		n = 4		n = 5		n = 6	
θ	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
1983 M_w 6.8 Borah Peak, ID										
0 to 5	20	0.049	5	0.051	3	0.047	1	0.023	0	0
5 to 10	11	0.027	5	0.051	3	0.047	2	0.045	2	0.077
10 to 15	6	0.015	4	0.041	3	0.047	3	0.068	2	0.077
15 to 20	69	0.169	12	0.122	7	0.109	4	0.091	1	0.038
20 to 25	6	0.015	6	0.061	4	0.062	3	0.068	3	0.115
25 to 30	70	0.172	10	0.102	6	0.094	3	0.068	2	0.077
30 to 35	9	0.022	7	0.071	5	0.078	3	0.068	1	0.038
35 to 40	24	0.059	8	0.082	6	0.094	6	0.136	4	0.154
40 to 45	13	0.032	8	0.082	3	0.047	2	0.045	2	0.077
45 to 50	7	0.017	3	0.031	2	0.031	2	0.045	2	0.077
50 to 55	9	0.022	6	0.061	6	0.094	3	0.068	2	0.077
55 to 60	8	0.020	8	0.082	5	0.078	3	0.068	1	0.038
60 to 65	98	0.240	5	0.051	4	0.062	4	0.091	2	0.077
65 to 70	0	0	0	0	0	0	0	0	0	0
70 to 75	32	0.078	0	0	0	0	0	0	0	0
75 to 80	8	0.020	6	0.061	3	0.047	3	0.068	1	0.038
80 to 85	7	0.017	3	0.031	3	0.047	2	0.045	1	0.038
85 to 90	11	0.027	2	0.020	1	0.016	0	0	0	0
1932 M_w 7.2 Cedar Mtn, NV										
0 to 5	1	0.029	0	0	0	0	0	0	0	0
5 to 10	2	0.059	0	0	0	0	0	0	0	0
10 to 15	2	0.059	2	0.200	0	0	0	0	0	0
15 to 20	2	0.059	1	0.100	1	0.333	1	0.333	0	0
20 to 25	5	0.147	2	0.200	0	0	0	0	0	0
25 to 30	3	0.088	1	0.100	0	0	0	0	0	0
30 to 35	3	0.088	0	0	0	0	0	0	0	0
35 to 40	3	0.088	1	0.100	1	0.333	1	0.333	1	1.0
40 to 45	1	0.029	0	0	0	0	0	0	0	0
45 to 50	55	0.147	1	0.100	0	0	0	0	0	0
50 to 55	3	0.088	1	0.100	0	0	0	0	0	0
55 to 60	0	0	0	0	0	0	0	0	0	0
60 to 65	1	0.029	1	0.100	1	0.333	1	0.333	0	0
65 to 70	0	0	0	0	0	0	0	0	0	0
70 to 75	0	0	0	0	0	0	0	0	0	0
75 to 80	1	0.029	0	0	0	0	0	0	0	0
80 to 85	0	0	0	0	0	0	0	0	0	0
85 to 90	2	0.059	0	0	0	0	0	0	0	0
1986 M_w 6.2 Chalfant Valley, CA										
0 to 5	23	0.291	5	0.312	4	0.667	1	0.500	1	1.0
5 to 10	20	0.253	2	0.125	0	0	0	0	0	0
10 to 15	17	0.215	5	0.312	1	0.167	1	0.500	0	0
15 to 20	10	0.127	0	0	0	0	0	0	0	0
20 to 25	4	0.051	2	0.125	0	0	0	0	0	0
25 to 30	2	0.025	1	0.062	0	0	0	0	0	0
30 to 35	1	0.013	0	0	0	0	0	0	0	0
35 to 40	2	0.025	1	0.062	1	0.167	0	0	0	0
40 to 45	0	0	0	0	0	0	0	0	0	0
45 to 50	0	0	0	0	0	0	0	0	0	0

Table H-3
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Angle Between Strikes of Principal and Distributed Ruptures

	n = 2		n = 3		n = 4		n = 5		n = 6	
θ	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.
50 to 55	0	0	0	0	0	0	0	0	0	0
55 to 60	0	0	0	0	0	0	0	0	0	0
60 to 65	0	0	0	0	0	0	0	0	0	0
65 to 70	0	0	0	0	0	0	0	0	0	0
70 to 75	0	0	0	0	0	0	0	0	0	0
75 to 80	0	0	0	0	0	0	0	0	0	0
80 to 85	0	0	0	0	0	0	0	0	0	0
85 to 90	0	0	0	0	0	0	0	0	0	0
1954 M_w 6.8 Dixie Valley, NV										
0 to 5	46	0.162	34	0.183	26	0.173	16	0.163	12	0.154
5 to 10	42	0.148	34	0.183	32	0.213	24	0.245	20	0.256
10 to 15	54	0.190	28	0.151	20	0.133	12	0.122	10	0.128
15 to 20	36	0.127	34	0.183	28	0.187	18	0.184	16	0.205
20 to 25	24	0.085	8	0.043	8	0.053	4	0.041	4	0.051
25 to 30	16	0.056	8	0.043	2	0.013	0	0	0	0
30 to 35	18	0.063	10	0.054	8	0.053	6	0.061	4	0.051
35 to 40	8	0.028	8	0.043	6	0.040	6	0.061	6	0.077
40 to 45	10	0.035	6	0.032	6	0.040	2	0.020	2	0.026
45 to 50	6	0.021	2	0.011	2	0.013	2	0.020	2	0.026
50 to 55	2	0.007	2	0.011	2	0.013	0	0	0	0
55 to 60	10	0.035	4	0.022	4	0.027	4	0.041	2	0.026
60 to 65	4	0.014	2	0.011	2	0.013	0	0	0	0
65 to 70	2	0.007	2	0.011	2	0.013	2	0.020	0	0
70 to 75	0	0	0	0	0	0	0	0	0	0
75 to 80	6	0.021	4	0.022	2	0.013	2	0.020	0	0
80 to 85	0	0	0	0	0	0	0	0	0	0
85 to 90	0	0	0	0	0	0	0	0	0	0
1993 M_w 6.1 Eureka Valley,CA										
0 to 5	0	0	0	0	0	0	0	0	0	0
5 to 10	2	0.020	0	0	0	0	0	0	0	0
10 to 15	2	0.020	0	0	0	0	0	0	0	0
15 to 20	1	0.010	0	0	0	0	0	0	0	0
20 to 25	1	0.010	0	0	0	0	0	0	0	0
25 to 30	7	0.070	1	0.059	0	0	0	0	0	0
30 to 35	12	0.120	2	0.118	0	0	0	0	0	0
35 to 40	20	0.200	2	0.118	1	0.167	0	0	0	0
40 to 45	8	0.080	4	0.235	2	0.333	0	0	0	0
45 to 50	14	0.140	4	0.235	1	0.167	0	0	0	0
50 to 55	19	0.190	0	0	0	0	0	0	0	0
55 to 60	4	0.040	2	0.118	0	0	0	0	0	0
60 to 65	3	0.030	0	0	0	0	0	0	0	0
65 to 70	2	0.020	0	0	0	0	0	0	0	0
70 to 75	2	0.020	1	0.059	1	0.167	0	0	0	0
75 to 80	2	0.020	0	0	0	0	0	0	0	0
80 to 85	1	0.010	1	0.059	1	0.167	1	1.000	0	0
85 to 90	0	0	0	0	0	0	0	0	0	0

Table H-3
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Angle Between Strikes of Principal and Distributed Ruptures
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1954 M_w 7.1 Fairview Peak, NV										
0 to 5	25	0.181	17	0.191	13	0.197	12	0.245	9	0.231
5 to 10	35	0.254	22	0.247	17	0.258	11	0.224	10	0.256
10 to 15	12	0.087	10	0.112	9	0.136	4	0.082	4	0.103
15 to 20	18	0.130	10	0.112	7	0.106	6	0.122	5	0.128
20 to 25	19	0.138	13	0.146	8	0.121	6	0.122	5	0.128
25 to 30	8	0.058	3	0.034	3	0.045	2	0.041	2	0.051
30 to 35	6	0.043	6	0.067	4	0.061	4	0.082	1	0.026
35 to 40	9	0.065	4	0.045	2	0.030	2	0.041	2	0.051
40 to 45	0	0	0	0	0	0	0	0	0	0
45 to 50	3	0.022	2	0.022	2	0.030	2	0.041	1	0.026
50 to 55	1	0.007	0	0	0	0	0	0	0	0
55 to 60	0	0	0	0	0	0	0	0	0	0
60 to 65	1	0.007	1	0.011	0	0	0	0	0	0
65 to 70	1	0.007	1	0.011	1	0.015	0	0	0	0
70 to 75	0	0	0	0	0	0	0	0	0	0
75 to 80	0	0	0	0	0	0	0	0	0	0
80 to 85	0	0	0	0	0	0	0	0	0	0
85 to 90	0	0	0	0	0	0	0	0	0	0
1950 M_w 5.6 Fort Sage, CA										
0 to 5	1	1.0	1	1.0	0	0	0	0	0	0
5 to 10	0	0	0	0	0	0	0	0	0	0
10 to 15	0	0	0	0	0	0	0	0	0	0
15 to 20	0	0	0	0	0	0	0	0	0	0
20 to 25	0	0	0	0	0	0	0	0	0	0
25 to 30	0	0	0	0	0	0	0	0	0	0
30 to 35	0	0	0	0	0	0	0	0	0	0
35 to 40	0	0	0	0	0	0	0	0	0	0
40 to 45	0	0	0	0	0	0	0	0	0	0
45 to 50	0	0	0	0	0	0	0	0	0	0
50 to 55	0	0	0	0	0	0	0	0	0	0
55 to 60	0	0	0	0	0	0	0	0	0	0
60 to 65	0	0	0	0	0	0	0	0	0	0
65 to 70	0	0	0	0	0	0	0	0	0	0
70 to 75	0	0	0	0	0	0	0	0	0	0
75 to 80	0	0	0	0	0	0	0	0	0	0
80 to 85	0	0	0	0	0	0	0	0	0	0
85 to 90	0	0	0	0	0	0	0	0	0	0
1975 M_w 5.2 Galway Valley										
0 to 5	1	0.143	0	0	0	0	0	0	0	0
5 to 10	0	0	0	0	0	0	0	0	0	0
10 to 15	0	0	0	0	0	0	0	0	0	0
15 to 20	1	0.143	0	0	0	0	0	0	0	0
20 to 25	3	0.429	1	1.0	1	1.0	0	0	0	0
25 to 30	0	0	0	0	0	0	0	0	0	0
30 to 35	0	0	0	0	0	0	0	0	0	0
35 to 40	0	0	0	0	0	0	0	0	0	0
40 to 45	0	0	0	0	0	0	0	0	0	0
45 to 50	0	0	0	0	0	0	0	0	0	0
50 to 55	0	0	0	0	0	0	0	0	0	0

Table H-3
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Angle Between Strikes of Principal and Distributed Ruptures

55 to 60	0	0	0	0	0	0	0	0	0	0
60 to 65	1	0.143	0	0	0	0	0	0	0	0
65 to 70	1	0.143	0	0	0	0	0	0	0	0
70 to 75	0	0	0	0	0	0	0	0	0	0
75 to 80	0	0	0	0	0	0	0	0	0	0
80 to 85	0	0	0	0	0	0	0	0	0	0
85 to 90	0	0	0	0	0	0	0	0	0	0
1959 M_w 7.4 Hebgen Lake, MT										
0 to 5	13	0.143	8	0.151	5	0.135	5	0.156	3	0.130
5 to 10	6	0.066	5	0.094	3	0.081	3	0.094	3	0.130
10 to 15	18	0.198	12	0.226	7	0.189	6	0.187	4	0.174
15 to 20	3	0.033	1	0.019	0	0	0	0	0	0
20 to 25	0	0	0	0	0	0	0	0	0	0
25 to 30	6	0.066	5	0.094	5	0.135	5	0.156	4	0.174
30 to 35	14	0.154	3	0.057	3	0.081	2	0.062	1	0.043
35 to 40	4	0.044	4	0.075	3	0.081	2	0.062	1	0.043
40 to 45	3	0.033	0	0	0	0	0	0	0	0
45 to 50	8	0.088	6	0.113	5	0.135	3	0.094	3	0.130
50 to 55	5	0.055	4	0.075	2	0.054	2	0.062	1	0.043
55 to 60	6	0.066	4	0.075	3	0.081	3	0.094	2	0.087
60 to 65	1	0.011	1	0.019	1	0.027	1	0.031	1	0.043
65 to 70	0	0	0	0	0	0	0	0	0	0
70 to 75	1	0.011	0	0	0	0	0	0	0	0
75 to 80	1	0.011	0	0	0	0	0	0	0	0
80 to 85	1	0.011	0	0	0	0	0	0	0	0
85 to 90	1	0.011	0	0	0	0	0	0	0	0
1979 M_w 5.5 Homestead Valley, CA										
0 to 5	6	0.120	0	0	0	0	0	0	0	0
5 to 10	6	0.120	0	0	0	0	0	0	0	0
10 to 15	5	0.100	2	0.667	0	0	0	0	0	0
15 to 20	25	0.100	0	0	0	0	0	0	0	0
20 to 25	11	0.220	1	0.333	1	1.000	1	1.000	0	0
25 to 30	4	0.080	0	0	0	0	0	0	0	0
30 to 35	2	0.040	0	0	0	0	0	0	0	0
35 to 40	1	0.020	0	0	0	0	0	0	0	0
40 to 45	2	0.040	0	0	0	0	0	0	0	0
45 to 50	1	0.020	0	0	0	0	0	0	0	0
50 to 55	3	0.060	0	0	0	0	0	0	0	0
55 to 60	2	0.040	0	0	0	0	0	0	0	0
60 to 65	1	0.020	0	0	0	0	0	0	0	0
65 to 70	1	0.020	0	0	0	0	0	0	0	0
70 to 75	0	0	0	0	0	0	0	0	0	0
75 to 80	0	0	0	0	0	0	0	0	0	0
80 to 85	0	0	0	0	0	0	0	0	0	0
85 to 90	0	0	0	0	0	0	0	0	0	0
1992 M_w 7.4 Landers, CA										
0 to 5	11	0.143	8	0.136	6	0.200	6	0.353	4	0.333
5 to 10	7	0.091	5	0.085	1	0.033	0	0	0	0
10 to 15	6	0.078	4	0.068	4	0.133	2	0.118	1	0.083
15 to 20	8	0.104	4	0.068	3	0.100	3	0.176	2	0.167
20 to 25	7	0.091	6	0.102	4	0.133	2	0.118	1	0.083

Table H-3
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Angle Between Strikes of Principal and Distributed Ruptures
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25 to 30	6	0.078	6	0.102	3	0.100	1	0.059	1	0.083
30 to 35	2	0.026	1	0.017	0	0	0	0	0	0
35 to 40	4	0.052	2	0.034	1	0.033	0	0	0	0
40 to 45	2	0.026	2	0.034	1	0.033	0	0	0	0
45 to 50	55	0.065	3	0.051	2	0.067	1	0.059	1	0.083
50 to 55	4	0.052	4	0.068	2	0.067	1	0.059	1	0.083
55 to 60	1	0.013	1	0.017	0	0	0	0	0	0
60 to 65	3	0.039	3	0.051	0	0	0	0	0	0
65 to 70	2	0.026	2	0.034	0	0	0	0	0	0
70 to 75	3	0.039	2	0.034	1	0.033	1	0.059	1	0.083
75 to 80	3	0.039	3	0.051	0	0	0	0	0	0
80 to 85	1	0.013	1	0.017	1	0.033	0	0	0	0
85 to 90	2	0.026	2	0.034	1	0.033	0	0	0	0
1980 M_w 6.1 Mammoth Lake, CA										
0 to 5	8	0.061	3	0.120	1	0.143	0	0	0	0
5 to 10	11	0.083	3	0.120	1	0.143	0	0	0	0
10 to 15	17	0.129	1	0.040	1	0.143	1	0.250	0	0
15 to 20	4	0.030	3	0.120	1	0.143	1	0.250	0	0
20 to 25	19	0.144	7	0.280	2	0.286	2	0.500	1	1.000
25 to 30	11	0.083	1	0.040	0	0	0	0	0	0
30 to 35	8	0.061	1	0.040	0	0	0	0	0	0
35 to 40	31	0.235	4	0.160	1	0.143	0	0	0	0
40 to 45	1	0.008	1	0.040	0	0	0	0	0	0
45 to 50	0	0	0	0	0	0	0	0	0	0
50 to 55	10	00.076	0	0	0	0	0	0	0	0
55 to 60	3	0.023	1	0.040	0	0	0	0	0	0
60 to 65	2	0.015	0	0	0	0	0	0	0	0
65 to 70	75	0.038	0	0	0	0	0	0	0	0
70 to 75	0	0	0	0	0	0	0	0	0	0
75 to 80	2	0.015	0	0	0	0	0	0	0	0
80 to 85	0	0	0	0	0	0	0	0	0	0
85 to 90	0	0	0	0	0	0	0	0	0	0
1872 M_w 7.6 Owens Valley, CA										
0 to 5	29	0.266	8	0.229	6	0.250	4	0.250	4	0.286
5 to 10	20	0.183	5	0.143	4	0.167	3	0.187	2	0.143
10 to 15	4	0.037	4	0.114	1	0.042	1	0.062	1	0.071
15 to 20	27	0.248	4	0.114	2	0.083	1	0.062	1	0.071
20 to 25	5	0.046	5	0.143	4	0.167	2	0.125	2	0.143
25 to 30	8	0.073	5	0.143	3	0.125	2	0.125	1	0.071
30 to 35	8	0.073	2	0.057	2	0.083	1	0.062	1	0.071
35 to 40	45	0.046	2	0.057	2	0.083	2	0.125	2	0.143
40 to 45	1	0.009	0	0	0	0	0	0	0	0
45 to 50	1	0.009	0	0	0	0	0	0	0	0
50 to 55	1	0.009	0	0	0	0	0	0	0	0
55 to 60	0	0	0	0	0	0	0	0	0	0
60 to 65	0	0	0	0	0	0	0	0	0	0
65 to 70	0	0	0	0	0	0	0	0	0	0
70 to 75	0	0	0	0	0	0	0	0	0	0
75 to 80	0	0	0	0	0	0	0	0	0	0
80 to 85	0	0	0	0	0	0	0	0	0	0
85 to 90	0	0	0	0	0	0	0	0	0	0

Table H-3
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Angle Between Strikes of Principal and Distributed Ruptures
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1915 M_w 7.3 Pleasant Valley, CA										
0 to 5	4	0.200	1	0.111	1	0.167	0	0	0	0
5 to 10	1	0.050	1	0.111	0	0	0	0	0	0
10 to 15	1	0.050	1	0.111	1	0.167	0	0	0	0
15 to 20	1	0.050	1	0.111	1	0.167	1	0.500	1	0.500
20 to 25	1	0.050	1	0.111	0	0	0	0	0	0
25 to 30	1	0.050	1	0.111	0	0	0	0	0	0
30 to 35	6	0.300	2	0.222	2	0.333	1	0.500	1	0.500
35 to 40	2	0.100	0	0	0	0	0	0	0	0
40 to 45	0	0	0	0	0	0	0	0	0	0
45 to 50	2	0.100	0	0	0	0	0	0	0	0
50 to 55	1	0.050	1	0.111	1	0.167	0	0	0	0
55 to 60	0	0	0	0	0	0	0	0	0	0
60 to 65	0	0	0	0	0	0	0	0	0	0
65 to 70	0	0	0	0	0	0	0	0	0	0
70 to 75	0	0	0	0	0	0	0	0	0	0
75 to 80	0	0	0	0	0	0	0	0	0	0
80 to 85	0	0	0	0	0	0	0	0	0	0
85 to 90	0	0	0	0	0	0	0	0	0	0
1954 M_w 6.6 Rainbow Mtn., NV										
0 to 5	5	0.098	2	0.100	1	0.111	1	0.143	1	0.500
5 to 10	4	0.078	2	0.100	1	0.111	0	0	0	0
10 to 15	13	0.255	1	0.050	1	0.111	0	0	0	0
15 to 20	4	0.078	1	0.050	0	0	0	0	0	0
20 to 25	1	0.020	0	0	0	0	0	0	0	0
25 to 30	2	0.039	0	0	0	0	0	0	0	0
30 to 35	7	0.137	2	0.100	1	0.111	1	0.143	0	0
35 to 40	2	0.039	1	0.050	1	0.111	1	0.143	0	0
40 to 45	1	0.020	1	0.050	0	0	0	0	0	0
45 to 50	2	0.039	1	0.050	1	0.111	1	0.143	1	0.500
50 to 55	0	0	0	0	0	0	0	0	0	0
55 to 60	3	0.059	2	0.100	1	0.111	1	0.143	0	0
60 to 65	5	0.098	5	0.250	1	0.111	1	0.143	0	0
65 to 70	1	0.020	1	0.050	0	0	0	0	0	0
70 to 75	1	0.020	1	0.050	1	0.111	1	0.143	0	0
75 to 80	0	0	0	0	0	0	0	0	0	0
80 to 85	0	0	0	0	0	0	0	0	0	0
85 to 90	0	0	0	0	0	0	0	0	0	0
1887 M_w 7.4 Sonora, Mexico										
0 to 5	25	0.145	18	0.161	16	0.188	8	0.154	3	0.091
5 to 10	24	0.140	16	0.143	13	0.153	12	0.231	7	0.212
10 to 15	18	0.105	14	0.125	12	0.141	6	0.115	4	0.121
15 to 20	19	0.110	15	0.134	13	0.153	8	0.154	3	0.091
20 to 25	11	0.064	9	0.080	7	0.082	5	0.096	4	0.121
25 to 30	14	0.081	7	0.062	5	0.059	5	0.096	5	0.152
30 to 35	13	0.076	7	0.062	5	0.059	2	0.038	2	0.061
35 to 40	12	0.070	8	0.071	4	0.047	1	0.019	1	0.030
40 to 45	14	0.081	8	0.071	4	0.047	2	0.038	2	0.061
45 to 50	9	0.052	5	0.045	3	0.035	2	0.038	1	0.030
50 to 55	6	0.035	2	0.018	2	0.024	1	0.019	1	0.030
55 to 60	2	0.012	2	0.018	0	0	0	0	0	0

Table H-3
Summary of Data from Pezzopane and Dawson (1996, Plate 21) for Frequency of Angle Between Strikes of Principal and Distributed Ruptures
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60 to 65	2	0.012	0	0	0	0	0	0	0	0
65 to 70	1	0.006	0	0	0	0	0	0	0	0
70 to 75	1	0.006	0	0	0	0	0	0	0	0
75 to 80	0	0	0	0	0	0	0	0	0	0
80 to 85	1	0.006	1	0.009	1	0.012	0	0	0	0
85 to 90	0	0	0	0	0	0	0	0	0	0
1954 M_w 6.8 Stillwater, NV										
0 to 5	7	0.159	3	0.097	3	0.187	2	0.286	1	0.200
5 to 10	7	0.159	4	0.129	0	0	0	0	0	0
10 to 15	7	0.159	4	0.129	3	0.187	1	0.143	1	0.200
15 to 20	25	0.114	5	0.161	0	0	0	0	0	0
20 to 25	5	0.114	5	0.161	3	0.187	1	0.143	1	0.200
25 to 30	3	0.068	3	0.097	3	0.187	1	0.143	0	0
30 to 35	1	0.023	1	0.032	1	0.062	0	0	0	0
35 to 40	4	0.091	2	0.065	1	0.062	1	0.143	1	0.200
40 to 45	2	0.045	2	0.065	1	0.062	0	0	0	0
45 to 50	2	0.045	1	0.032	0	0	0	0	0	0
50 to 55	1	0.023	1	0.032	1	0.062	1	0.143	1	0.200
55 to 60	0	0	0	0	0	0	0	0	0	0
60 to 65	0	0	0	0	0	0	0	0	0	0
65 to 70	0	0	0	0	0	0	0	0	0	0
70 to 75	0	0	0	0	0	0	0	0	0	0
75 to 80	0	0	0	0	0	0	0	0	0	0
80 to 85	0	0	0	0	0	0	0	0	0	0
85 to 90	0	0	0	0	0	0	0	0	0	0
Combined Statistics										
0 to 5	225	0.125	113	0.148	85	0.166	56	0.167	38	0.160
5 to 10	198	0.110	104	0.136	75	0.147	55	0.164	44	0.186
10 to 15	182	0.101	92	0.120	63	0.123	37	0.110	27	0.114
15 to 20	213	0.119	91	0.119	63	0.123	43	0.128	29	0.122
20 to 25	122	0.068	66	0.086	42	0.082	26	0.078	21	0.089
25 to 30	161	0.090	52	0.068	30	0.059	19	0.057	15	0.063
30 to 35	110	0.061	44	0.058	31	0.061	20	0.060	11	0.046
35 to 40	131	0.073	47	0.061	30	0.059	22	0.066	18	0.076
40 to 45	58	0.032	32	0.042	17	0.033	6	0.018	6	0.025
45 to 50	65	0.036	28	0.037	18	0.035	13	0.039	11	0.046
50 to 55	65	0.036	21	0.027	16	0.031	8	0.024	6	0.025
55 to 60	39	0.022	24	0.031	13	0.025	11	0.033	5	0.021
60 to 65	122	0.068	18	0.024	9	0.018	7	0.021	3	0.013
65 to 70	16	0.009	6	0.008	3	0.006	2	0.006	0	0
70 to 75	40	0.022	4	0.005	3	0.006	2	0.006	1	0.004
75 to 80	23	0.013	13	0.017	5	0.010	5	0.015	1	0.004
80 to 85	11	0.006	6	0.008	6	0.012	3	0.009	1	0.004
85 to 90	16	0.009	4	0.005	2	0.004	0	0	0	0

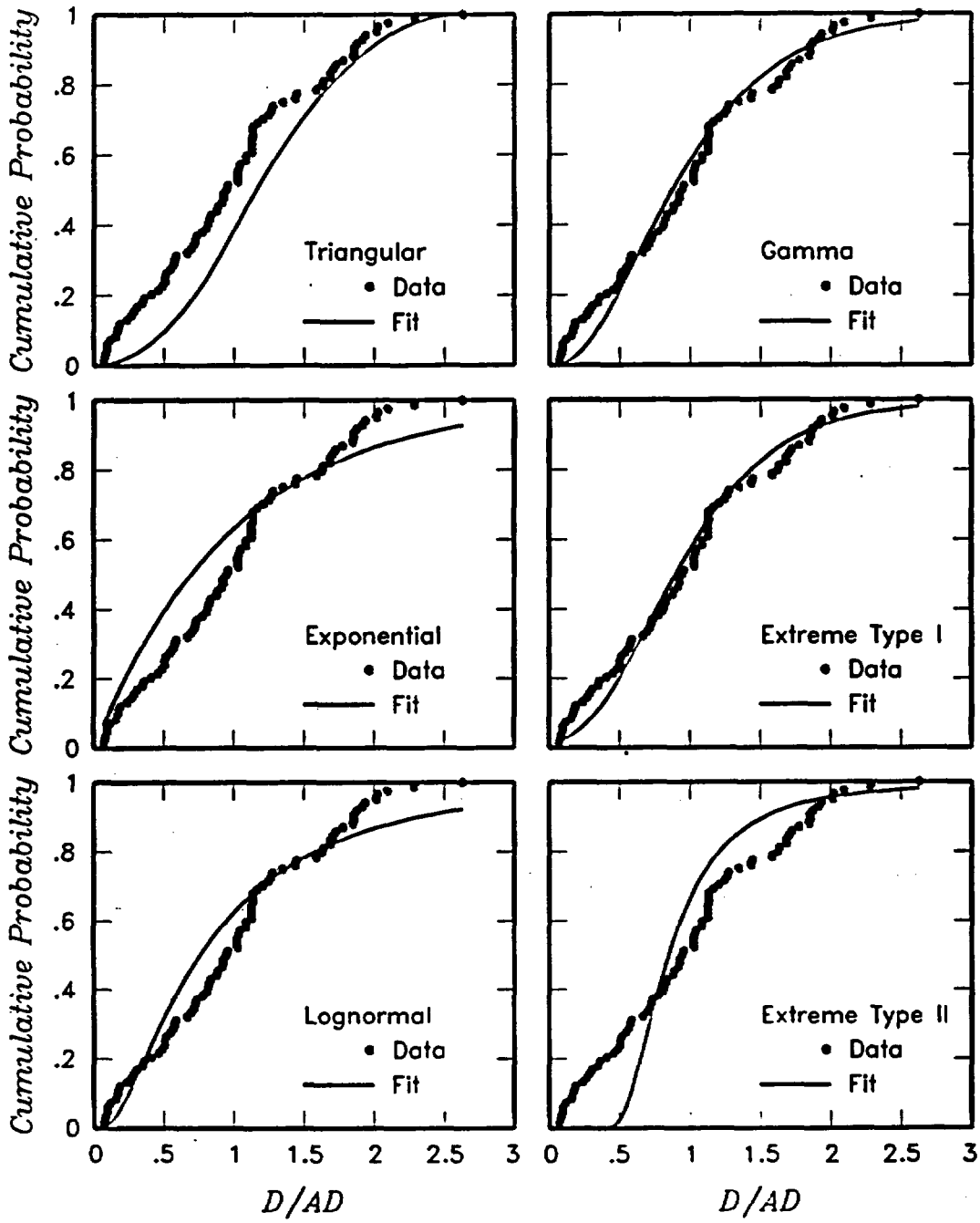

Figure H-1 Comparison of empirical CDF for the ratio D/D_{avg} developed by the DFS team with the CDFs for various statistical distributions fit to the data

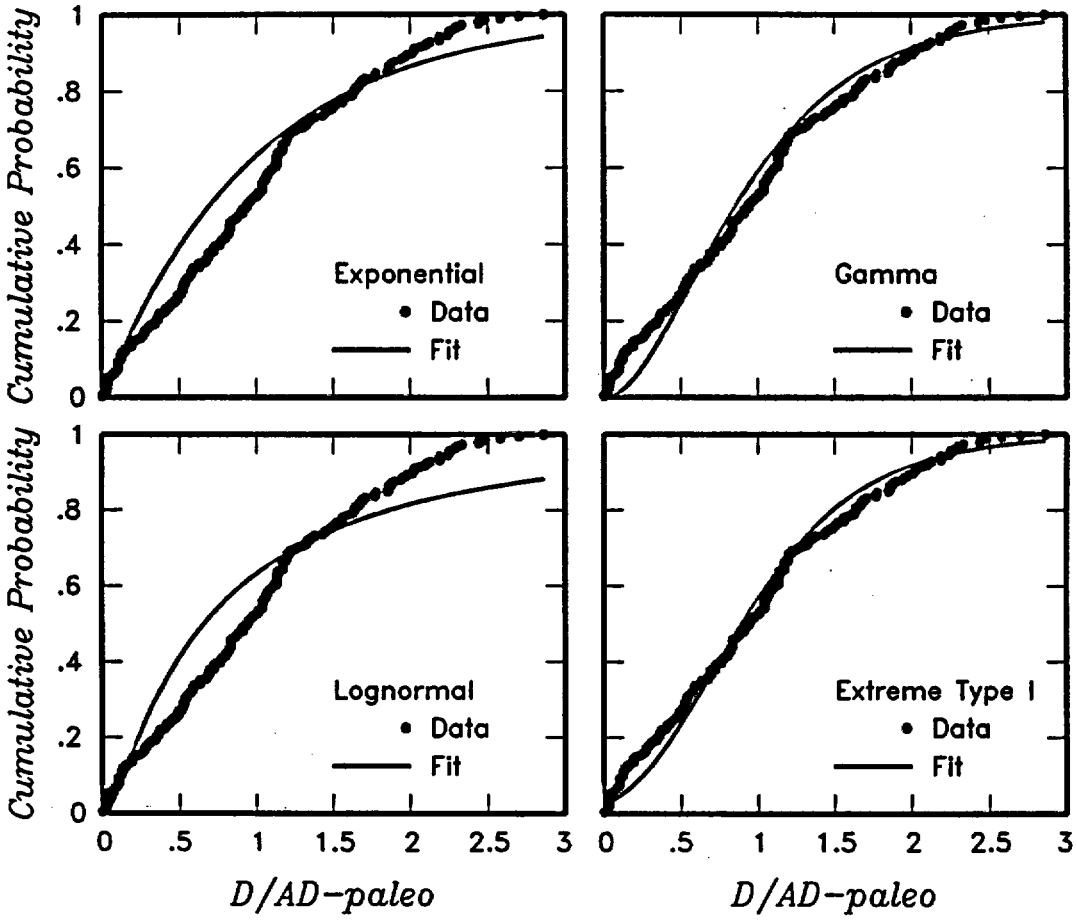

Figure H-2 Comparison of empirical CDF for the ratio $D/D_{avg\text{-}paleo}$ developed by the SBK team with the CDFs for various statistical distributions fit to the data

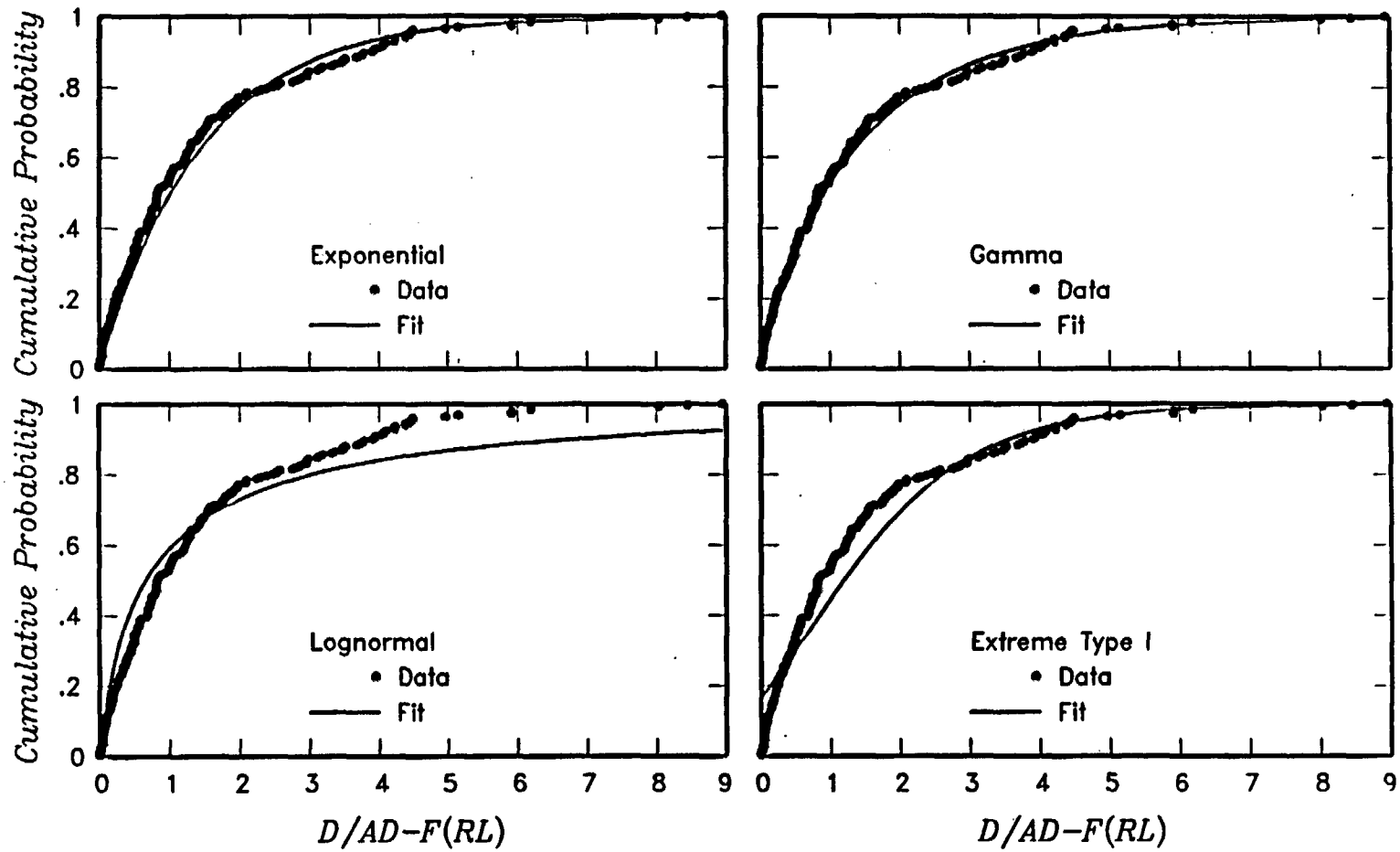

Figure H-3 Comparison of empirical CDF for the ratio $D/D_{avg\text{-}F(RL)}$ developed by the SBK team with the CDFs for various statistical distributions fit to the data

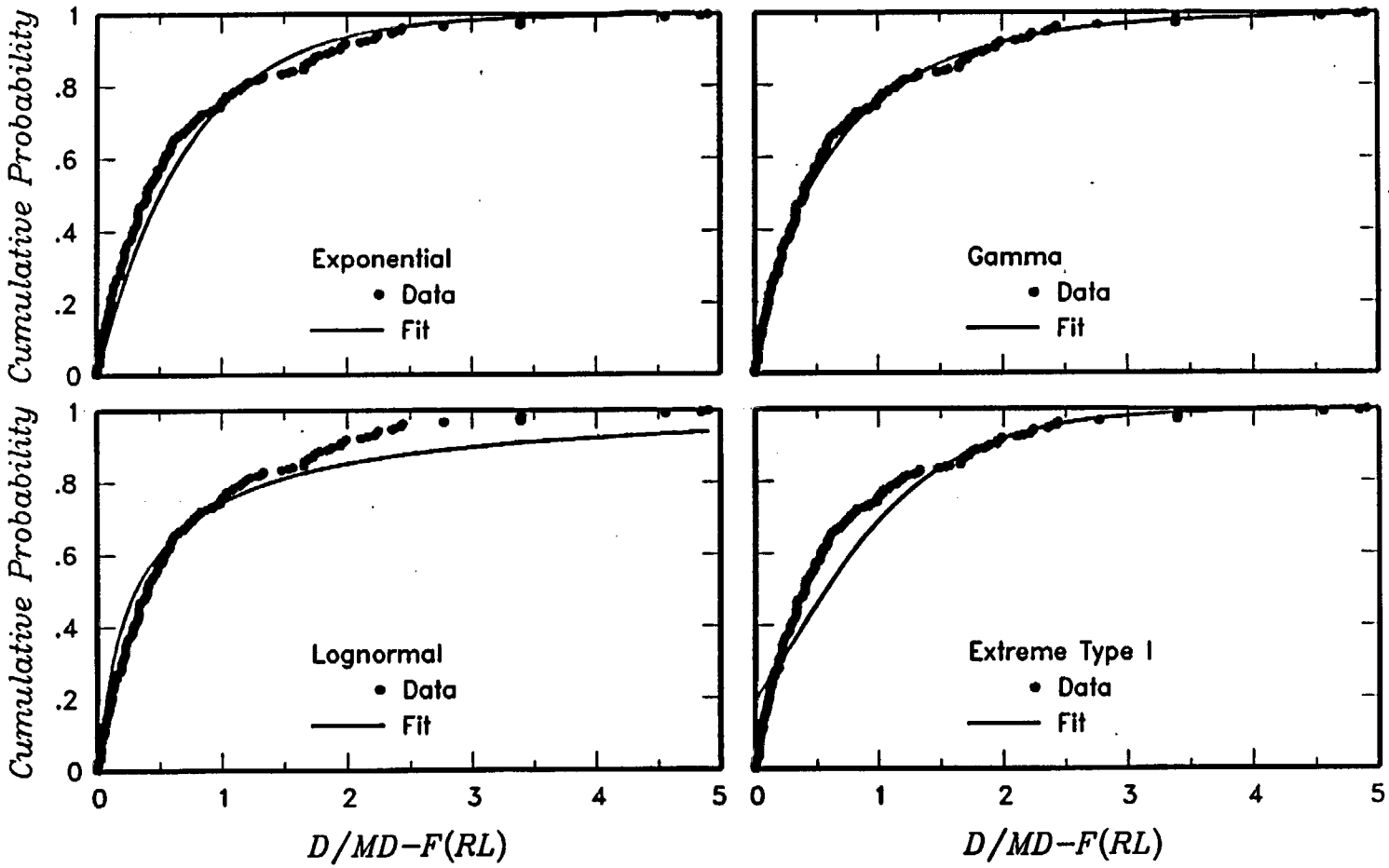

Figure H-4 Comparison of empirical CDF for the ratio D/D_{max}-F(RL) developed by the SBK team with the CDFs for various statistical distributions fit to the data

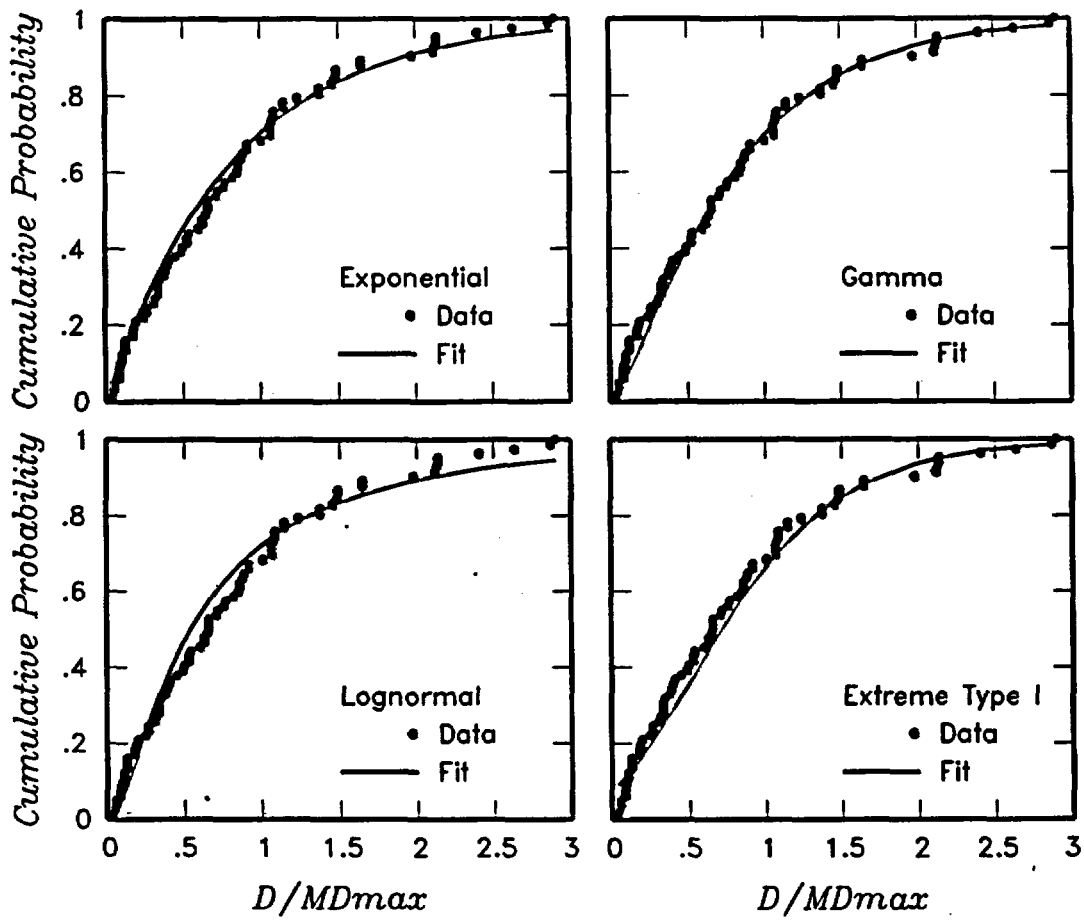

Figure H-5 Comparison of empirical CDF for the ratio D/D^{max} developed by the AAR team with the CDFs for various statistical distributions fit to the data

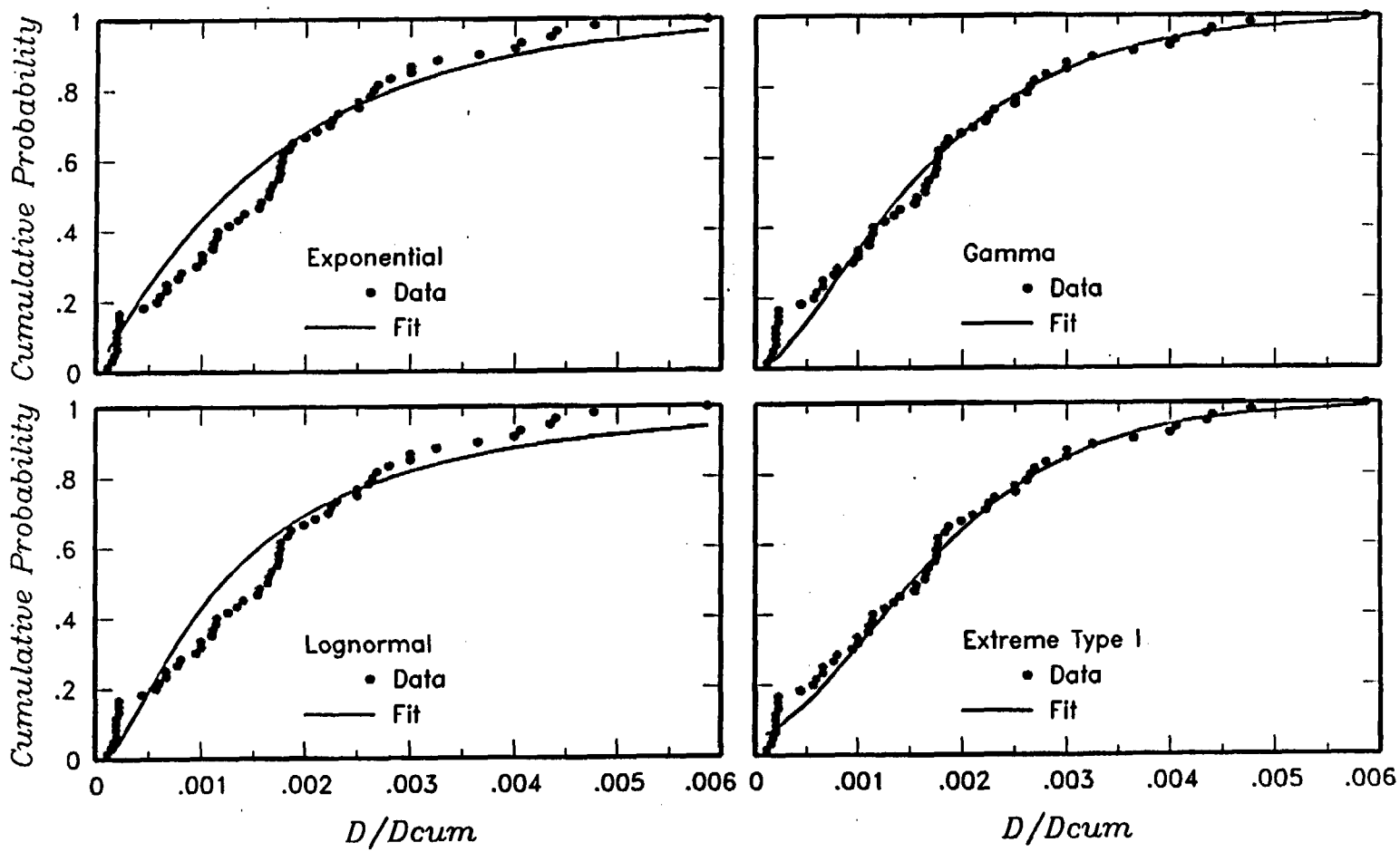

Figure H-6 Comparison of empirical CDF for the ratio D/Dcum developed by the SBK team with the CDFs for various statistical distributions fit to the data

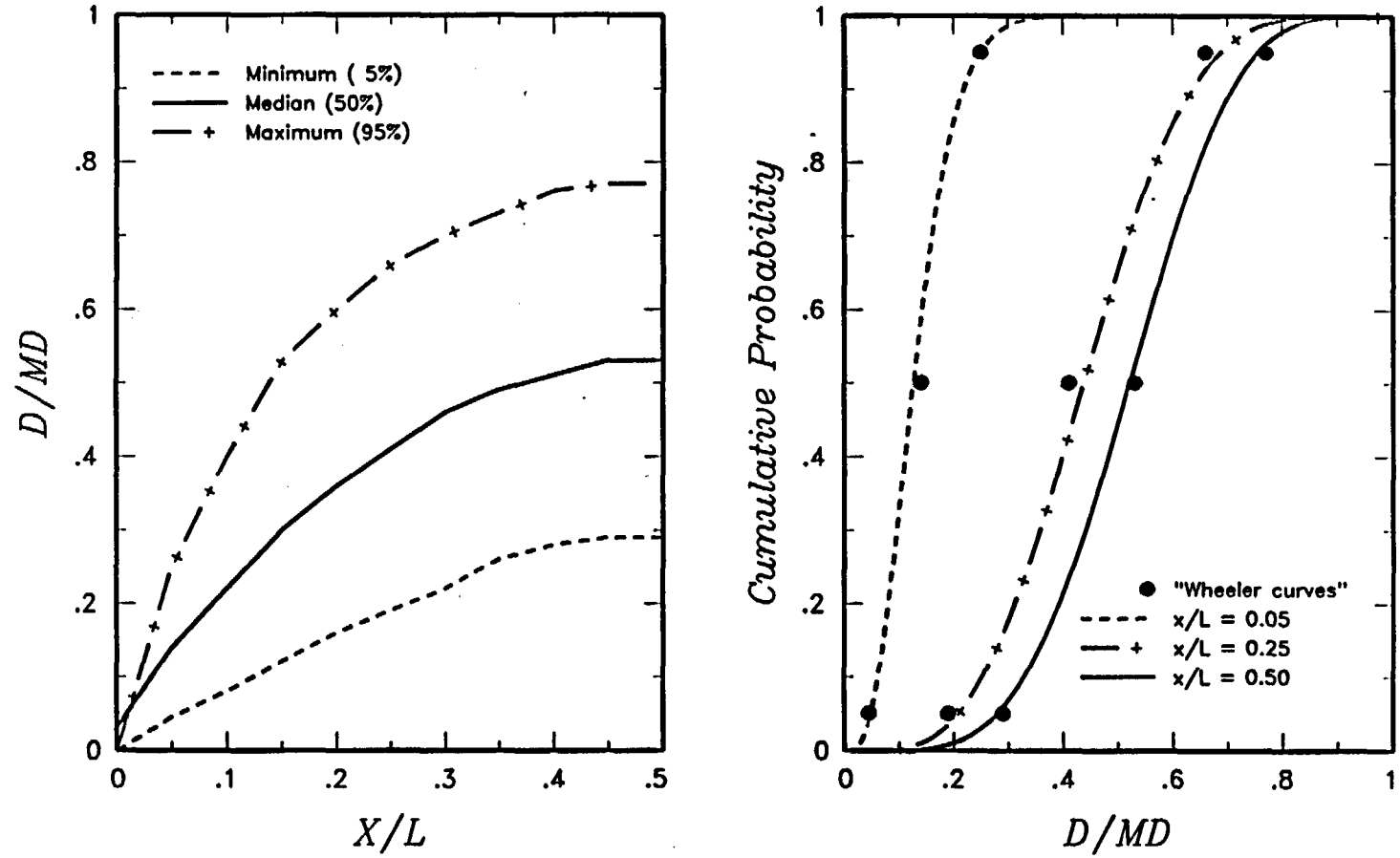

Figure H-7 Probability distributions for D/D_{max} as a function of normalized location, x/L, along a principal rupture. Left, smooth curves for minimum, median, and maximum values of D/D_{max} developed by the ASM team from analysis of historical ruptures presented in Wheeler (1989). Right, CDFs for beta distributions computed using the beta parameters from the smooth curves shown on Figure H-8.

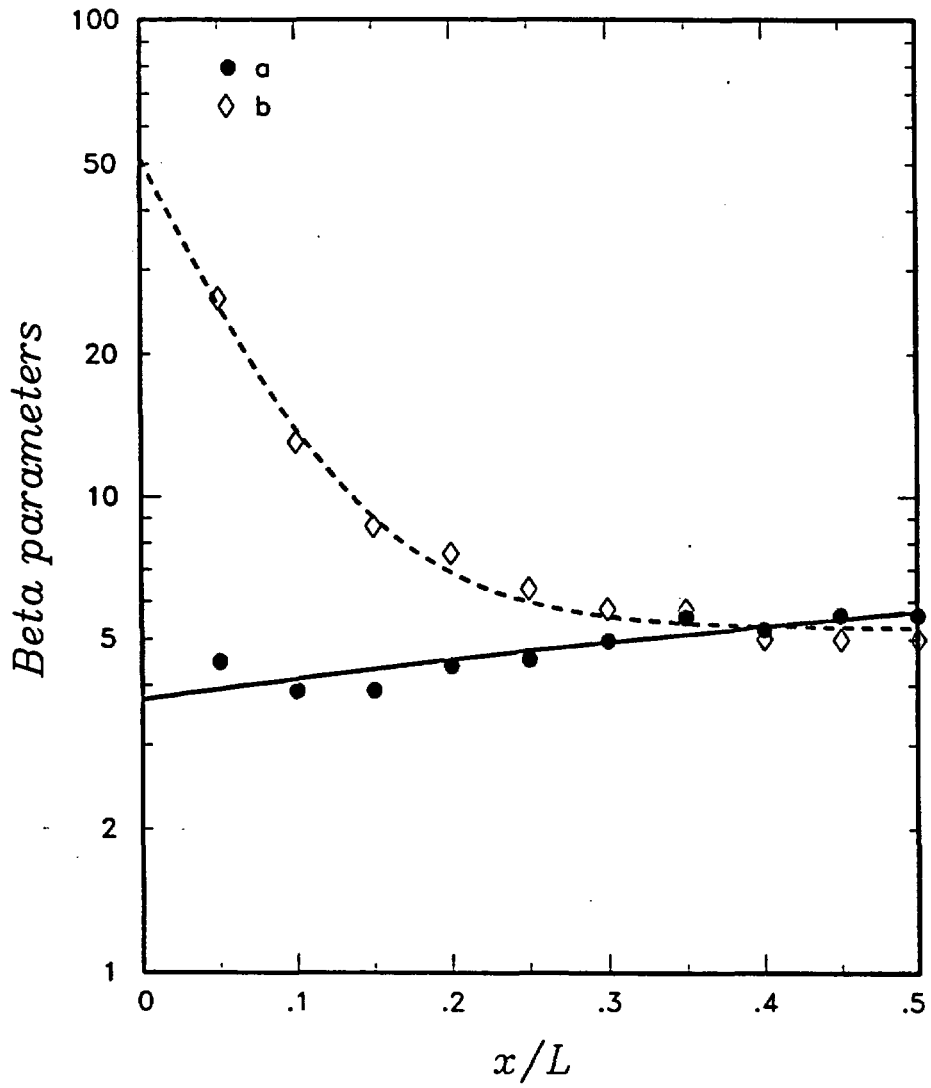

Figure H-8 Beta distribution parameters a and b developed at specific values of x/L from the "Wheeler" curves shown on the left of Figure H-7 and the smooth curves fit to these parameters

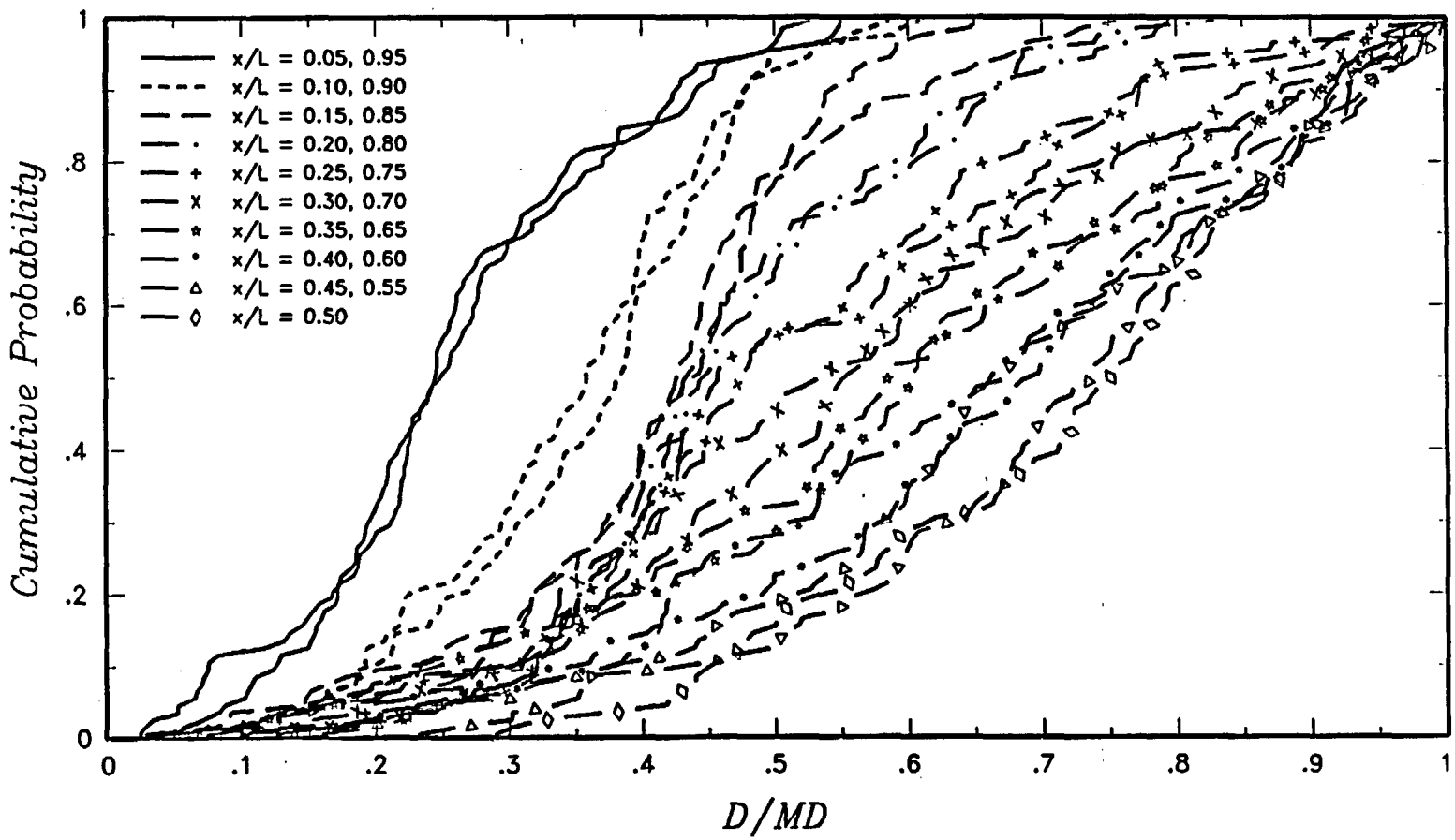

Figure H-9 Probability distributions for D/D_{max} as a function of normalized location, x/L, along a principal rupture developed by the SBK team using numerical simulations of slip with fractal fault roughness

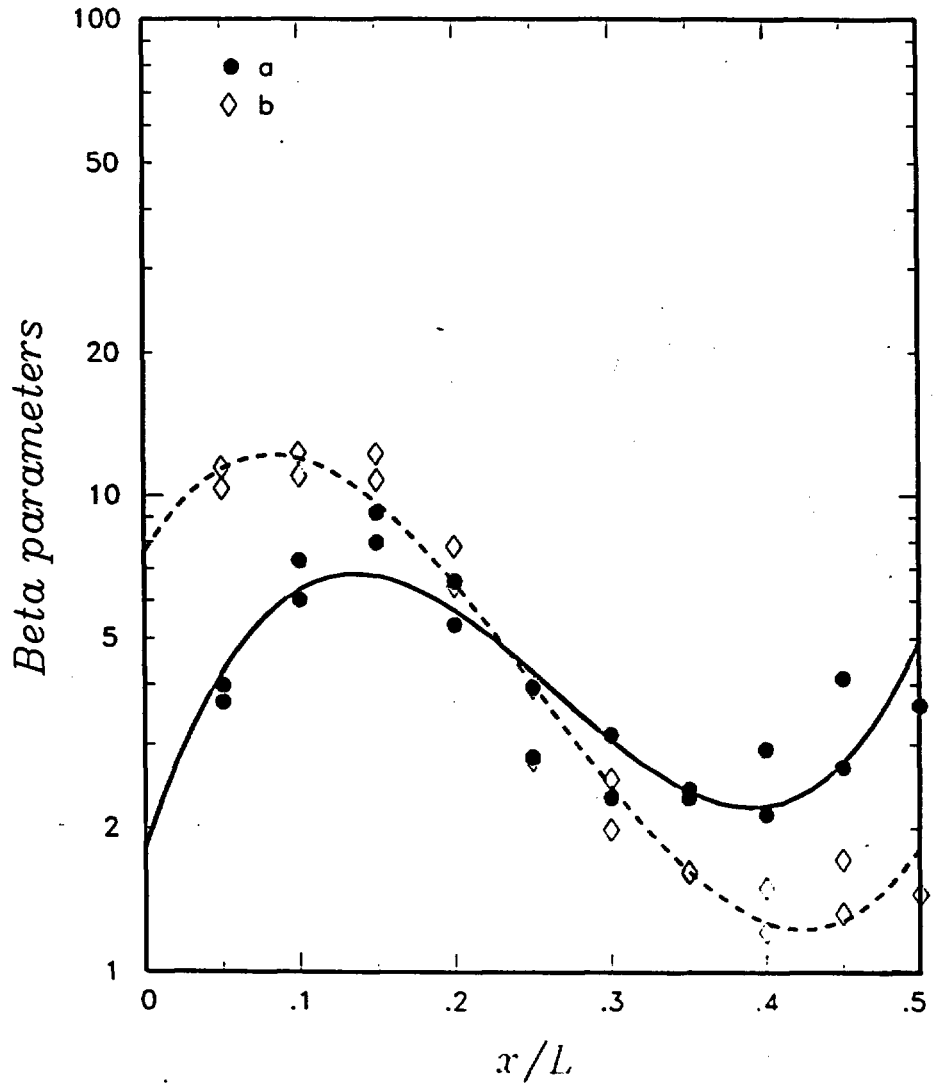

Figure H-10 Beta distribution parameters a and b developed at specific values of x/L from the simulation results shown on Figure H-9 and the smooth curves fit to these parameters

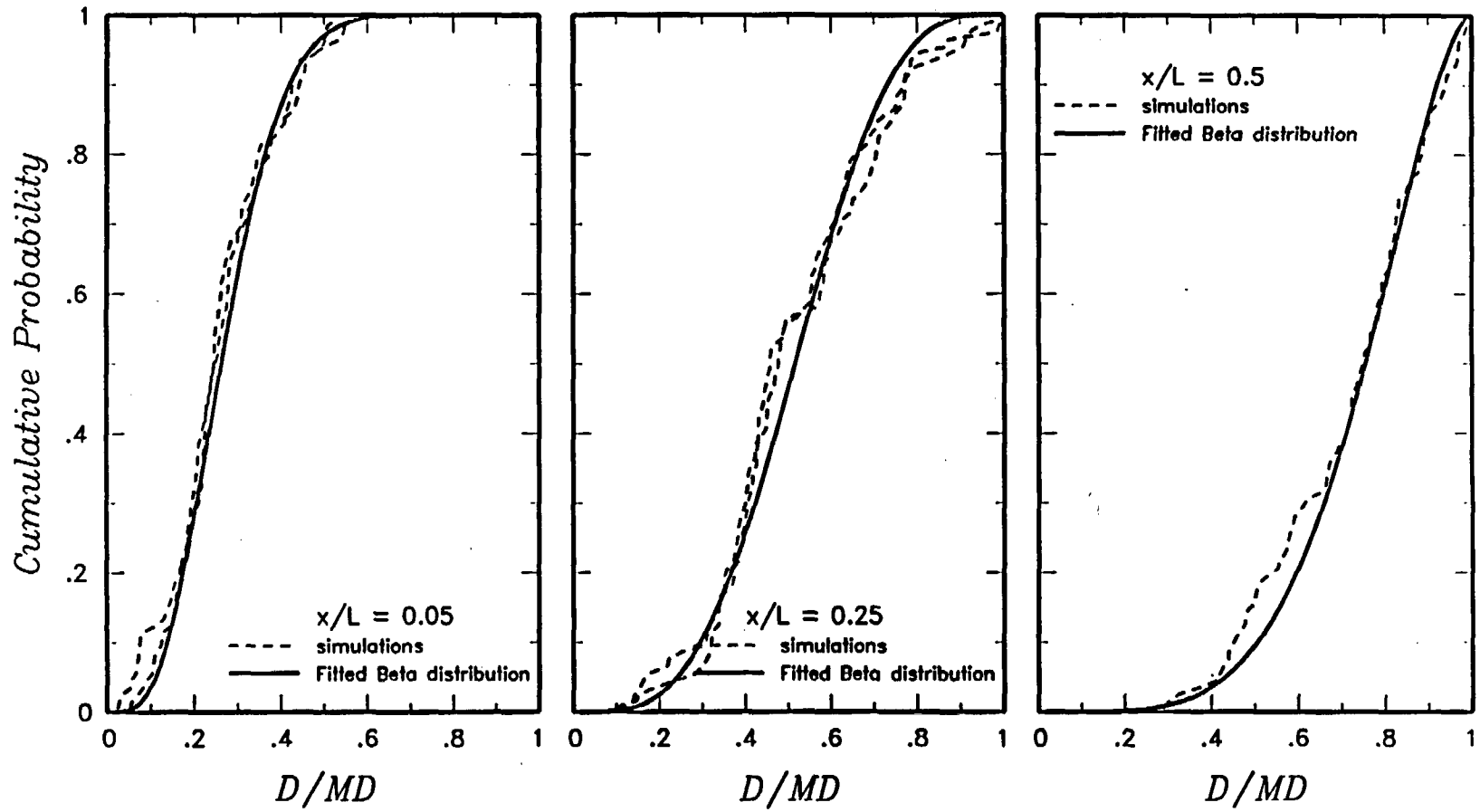

Figure H-11 CDFs for simulations of D/D_{max} as a function of normalized location, x/L, from Figure H-9 compared to CDFs for beta distributions computed using the beta parameters from the smooth curves shown on Figure H-10

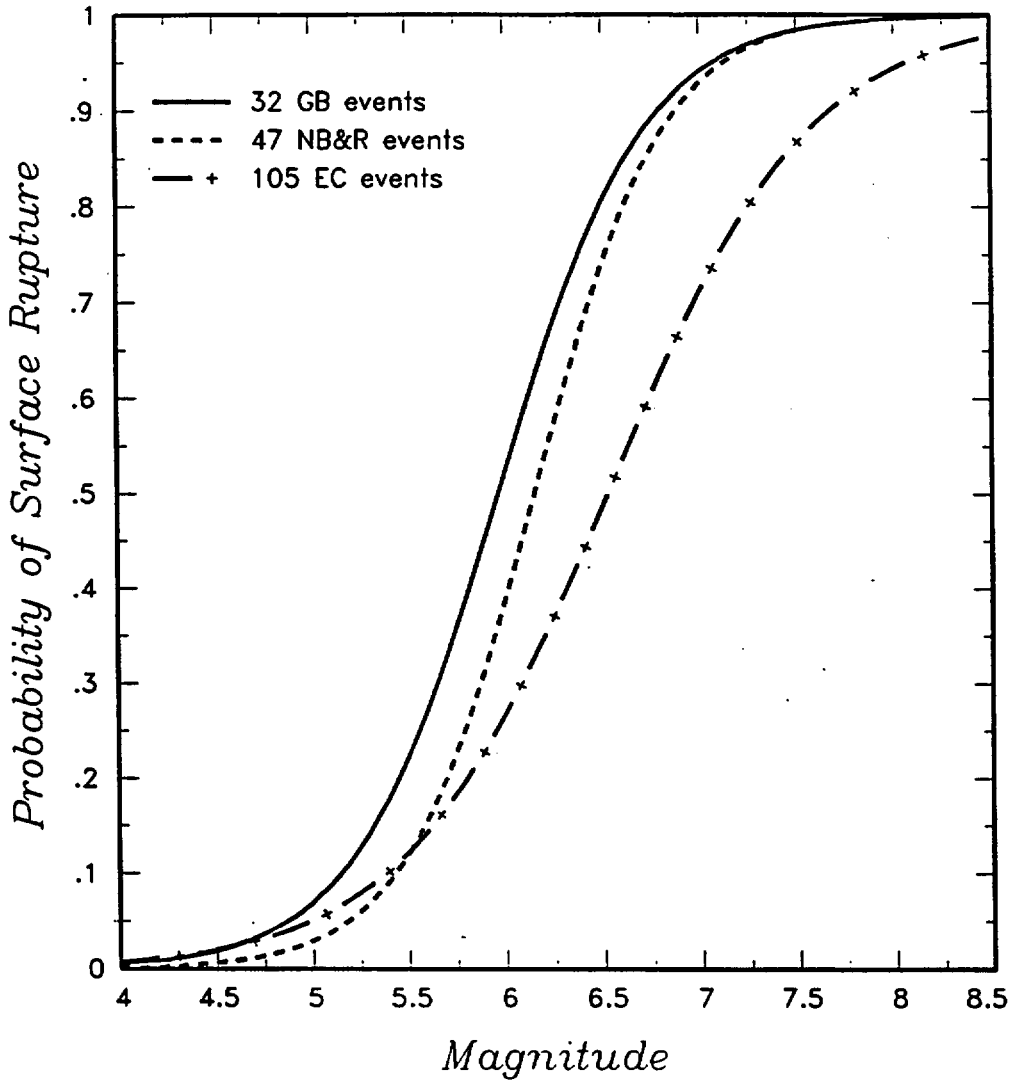

Figure H-12 Logistic regression models for the probability of surface rupture as a function of moment magnitude developed from three data sets presented in Pezzopane and Dawson (1996). GB = Great Basin post 1930, NB&R = northern Basin and Range post 1930, and EC = extensional cordillera.

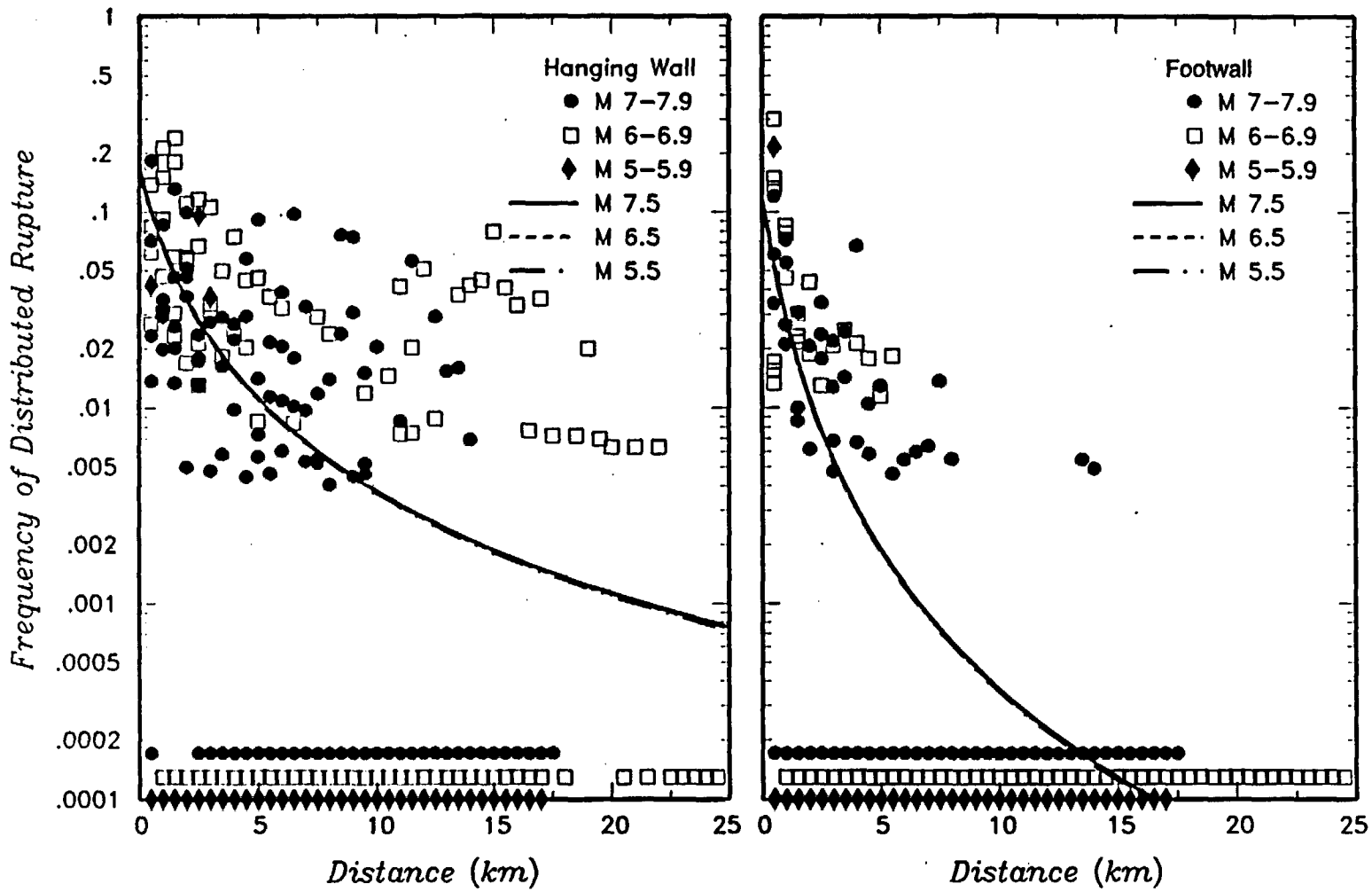

Figure H-13a Frequency of distributed rupture as a function of distance from principal rupture. Data include hanging wall cracking from 1988 Chalfant Valley earthquake. Points along bottom of plot represent distances for individual earthquakes where observed frequency was zero. The data for the three magnitude intervals are offset for clarity.

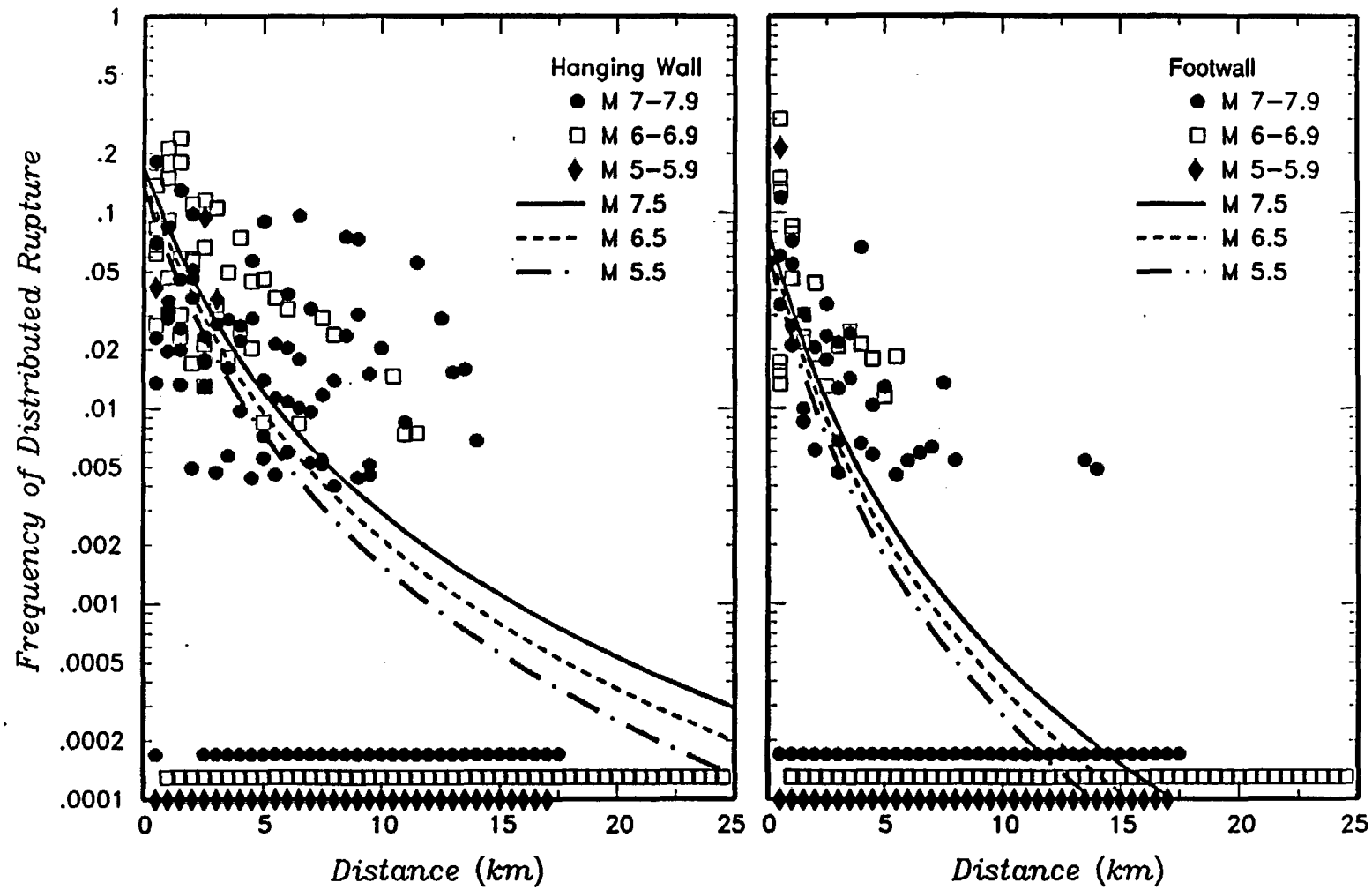

Figure H-13b Frequency of distributed rupture as a function of distance from principal rupture. Data do not include hanging wall cracking from 1988 Chalfant Valley earthquake. Points along bottom of plot represent distances for individual earthquakes where observed frequency was zero. The data for the three magnitude intervals are offset for clarity.

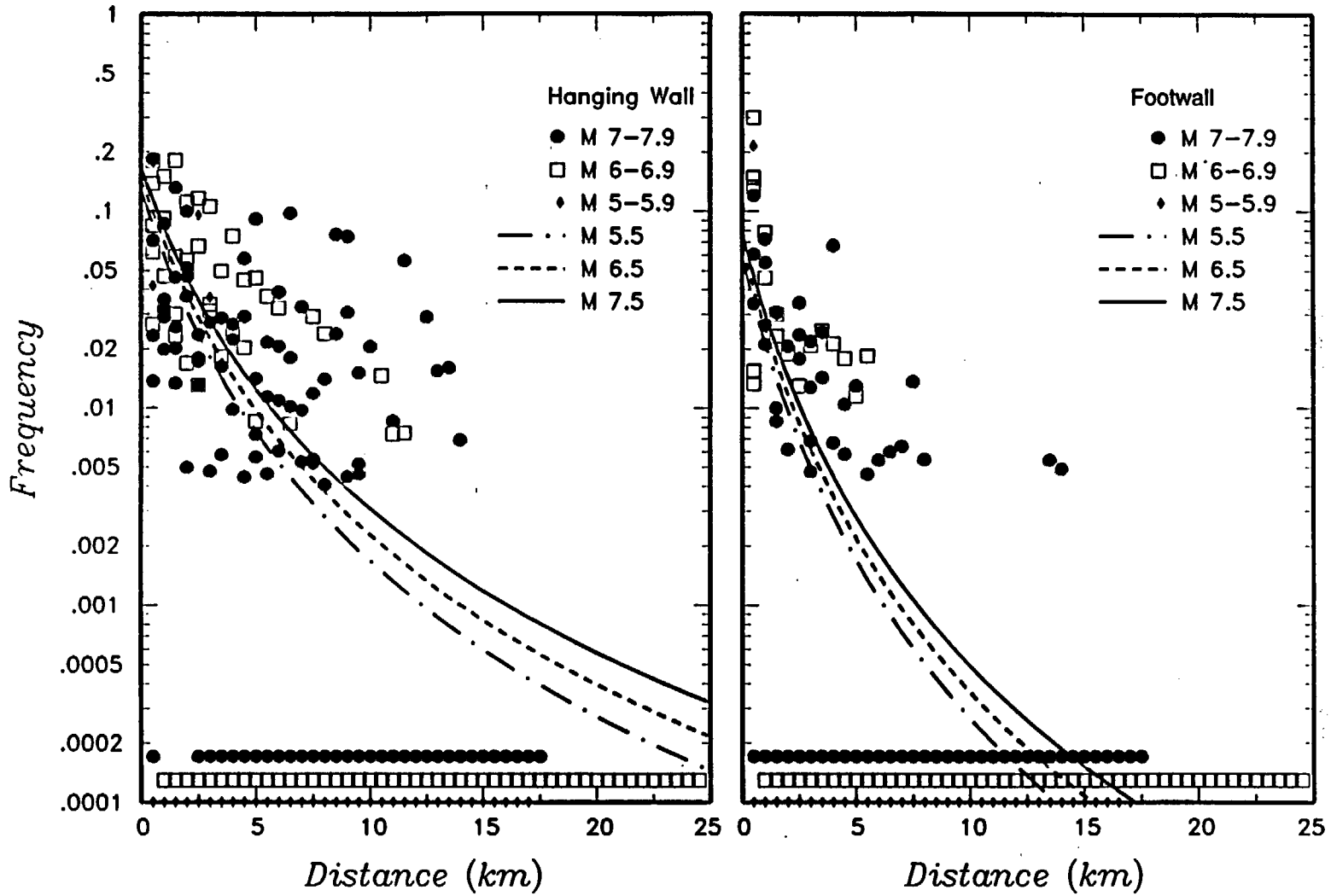

Figure H-13c Frequency of distributed rupture as a function of distance from principal rupture developed for thr AAR and SDO teams. The plot on the left shows hanging wall data, the plot on the right shows footwall data. Data do not include hanging wall cracking from the 1988 Chalfant Valley earthquake or data from the 1980 Mammoth earthquake. Points along bottom of plot represent distances for individual earthquakes where observed frequency was zero. The data for the three magnitude intervals are offset for clarity.

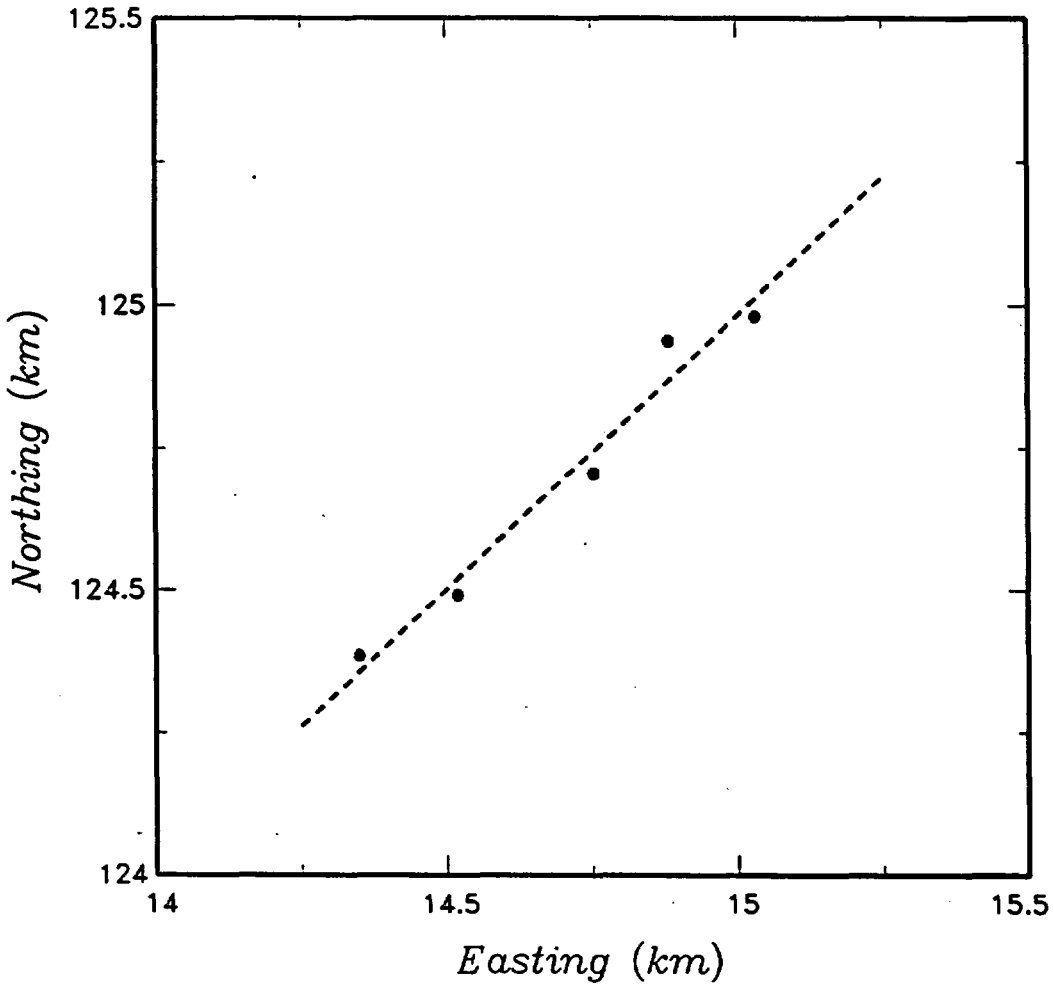

Figure H-14 Example of fitting straight line (dashed line) to digitized rupture trace (solid points) to determine the average strike azimuth

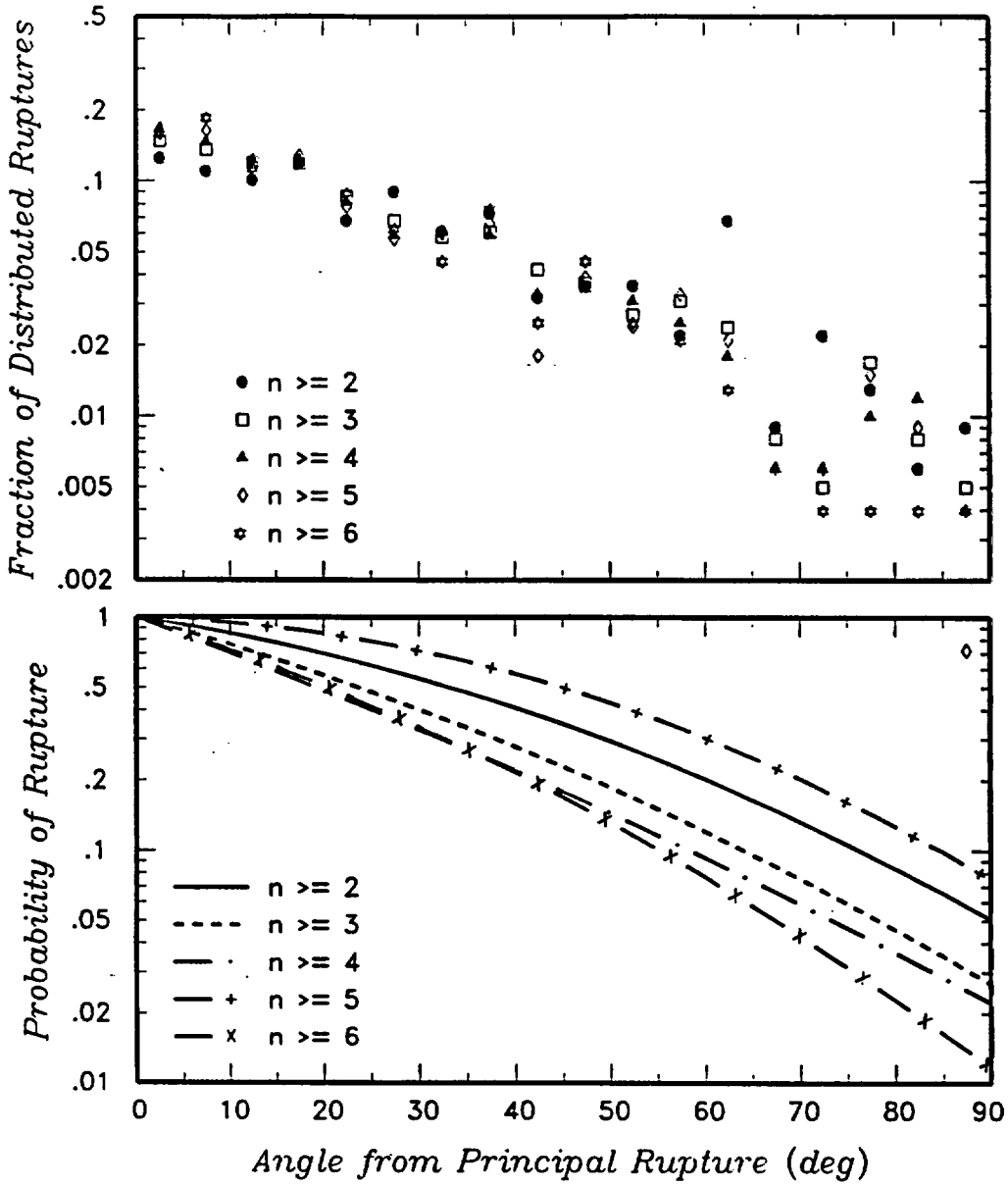

Figure H-15 Frequency distribution for angle between average strike of principal rupture and strike of individual distributed rupture traces. Parameter n denotes the number of digitization points along an individual rupture trace. Top plot shows the data from Table H-3 presented in terms of fraction of total ruptures. Bottom plot shows exponential fits to the data normalized to unity at a relative angle of 0°.

APPENDIX I

RESULTS OF REGRESSION ATTENUATION ANALYSES

APPENDIX I

RESULTS OF REGRESSION ATTENUATION ANALYSES

The following tables summarize the regression coefficients developed from each experts' point estimates. The equation forms adopted for the regressions are discussed in Chapter 6.

TABLE I-1A
J. G. ANDERSON: REGRESSION COEFFICIENTS
MEDIAN MODEL

COMPONENT	FREQUENCY (HZ)	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}	SIGMA FIT
Horiz	PGA	1.9771	0.4586	-1.4197	-0.3066	0.2303	0.0000	0.0076	6.7	0.2144	-0.3545	5.2	6.0	0.1493
	20	2.8264	0.4586	-1.5590	-0.3066	0.2303	0.0136	-0.0263	7.4	0.2236	-0.3492	5.0	6.1	0.1455
	10	3.0127	0.4586	-1.5426	-0.3066	0.2303	0.0123	0.0354	7.4	0.1317	-0.3955	5.0	5.9	0.1631
	5	2.5847	0.4586	-1.3715	-0.3066	0.2303	-0.0100	0.0220	6.7	0.2009	-0.3174	5.3	6.0	0.1598
	2	1.7055	0.4586	-1.1607	-0.2628	0.2303	-0.0469	0.0382	5.8	0.2553	-0.3625	5.3	5.9	0.1521
	1	0.7983	0.4586	-1.0296	-0.2628	0.2303	-0.0803	-0.0330	5.0	0.3555	-0.2645	5.0	6.1	0.1557
	0.5	-0.5006	0.4586	-0.8625	-0.1752	0.2303	-0.1139	-0.1220	2.9	0.3861	-0.0211	5.0	6.5	0.1889
	0.3	-1.0946	0.4586	-0.8745	-0.0876	0.2303	-0.1407	-0.1366	3.0	0.2769	-0.0830	5.0	6.7	0.1992
	PGV	6.0533	0.4586	-1.2687	-0.1752	0.2303	-0.0476	0.0217	5.9	0.2551	-0.3154	5.1	6.0	0.1696
Vert	PGA	1.8132	0.7399	-1.5441	0.2825	0.1375	0.0000	0.1492	7.8	0.3229	-0.2993	5.1	6.5	0.1728
	20	2.7352	0.7399	-1.6777	0.2825	0.1375	0.0066	0.1284	7.6	0.3390	-0.2740	5.5	6.3	0.1668
	10	3.1549	0.7399	-1.6122	-0.1412	0.1375	-0.0364	0.1170	7.7	0.3135	-0.3205	5.1	6.5	0.2131
	5	2.5230	0.7399	-1.4196	-0.1695	0.1375	-0.0475	0.1274	8.2	0.3532	-0.2886	5.2	6.5	0.2079
	2	1.7173	0.7399	-1.2318	-0.1695	0.1375	-0.1003	0.1907	8.0	0.3075	-0.2739	5.0	6.2	0.2090
	1	0.5757	0.7399	-1.0973	-0.1695	0.1375	-0.1243	0.2956	6.9	0.2498	-0.1456	5.4	7.0	0.1679
	0.5	-0.0541	0.7399	-1.0697	-0.1695	0.1375	-0.1933	0.5981	5.8	-0.1117	-0.3472	5.0	5.5	0.2462
	0.3	-0.7565	0.7399	-0.9967	-0.1695	0.1375	-0.2338	0.6419	4.7	-0.1892	-0.5016	5.3	6.5	0.2554
	PGV	6.0353	0.7399	-1.3048	-0.1695	0.1375	-0.1137	0.4000	7.7	0.0160	-0.4243	5.0	5.9	0.2679

TABLE I-1B
J. G. ANDERSON: REGRESSION COEFFICIENTS
SIGMA MODEL

COMPONENT	FREQUENCY (HZ)	b_1	b_2	b_3	b_4	SIGMA FIT
Horiz	PGA	0.5590	-0.0543	0.0	6.8	0.0094
	20	0.5598	-0.0597	0.0	6.8	0.0105
	10	0.5756	-0.0680	0.0	6.9	0.0155
	5	0.6074	-0.0659	0.0	6.9	0.0148
	2	0.6603	-0.0637	0.0	7.0	0.0158
	1	0.7316	-0.0456	0.0	7.0	0.0091
	0.5	0.8199	-0.0392	0.0	6.9	0.0159
	0.3	0.8646	-0.0901	0.0	6.1	0.0224
	PGV	0.7201	-0.0202	0.0	7.0	0.0102
Vert	PGA	0.6326	-0.0205	0.0	6.2	0.0081
	20	0.6528	-0.0182	0.0	6.5	0.0082
	10	0.6742	-0.0636	0.0	5.9	0.0103
	5	0.6530	-0.0606	0.0	5.8	0.0146
	2	0.6573	-0.0691	0.0	5.8	0.0148
	1	0.6838	-0.0453	0.0	5.8	0.0169
	0.5	0.7221	-0.0156	0.0	5.8	0.0183
	0.3	0.7640	-0.0382	0.0	5.8	0.0219
	PGV	0.6299	-0.0370	0.0	5.8	0.0173

TABLE I-1C
J. G. ANDERSON: REGRESSION COEFFICIENTS
SIGMA-MU MODEL

COMPONENT	FREQUENCY (HZ)	c_1	c_2	c_3	c_4	c_5	c_6	MINIMUM	SIGMA FIT
Horiz	PGA	0.9620	0.0	-0.3323	0.0516	0.0304	6.0	0.2	0.0989
	20	0.9291	0.0	-0.2891	0.0434	0.0100	6.0	0.2	0.1008
	10	0.9696	0.0	-0.3295	0.0496	0.0386	6.0	0.2	0.0968
	5	0.9489	0.0	-0.3064	0.0457	0.0260	6.0	0.2	0.0996
	2	0.9234	0.0	-0.2859	0.0425	0.0240	6.0	0.2	0.0961
	1	0.9467	0.0	-0.3018	0.0465	0.0394	6.0	0.2	0.1025
	0.5	0.8838	0.0	-0.2370	0.0393	0.0071	6.0	0.2	0.1059
	0.3	0.8841	0.0	-0.1975	0.0327	-0.0180	6.0	0.2	0.1128
	PGV	0.9170	0.0	-0.2645	0.0412	0.0060	6.0	0.2	0.1081
Vert	PGA	0.9061	0.0	-0.2806	0.0480	0.0242	6.0	0.2	0.1220
	20	0.9655	0.0	-0.2351	0.0349	-0.0417	6.0	0.2	0.1257
	10	0.8968	0.0	-0.2670	0.0438	0.0269	6.0	0.2	0.1131
	5	0.8608	0.0	-0.2251	0.0366	0.0584	6.0	0.2	0.1058
	2	0.8496	0.0	-0.1971	0.0315	0.0232	6.0	0.2	0.1073
	1	0.9472	0.0	-0.2968	0.0551	-0.0050	6.0	0.2	0.1308
	0.5	0.8773	0.0	-0.2503	0.0602	0.0613	6.0	0.2	0.2003
	0.3	0.8719	0.0	-0.1939	0.0476	0.0375	6.0	0.2	0.1721
	PGV	0.8580	0.0	-0.2441	0.0483	0.0259	6.0	0.2	0.1412

TABLE I-1D
J. G. ANDERSON: REGRESSION COEFFICIENTS
SIGMA-SIGMA MODEL

COMPONENT	FREQUENCY (HZ)	d_1	d_2	d_3	d_4	SIGMA FIT
Horiz	PGA	0.1147	0.0	0.0	0.0	0.0
	20	0.1095	0.0	0.0	0.0	0.0
	10	0.1262	0.0	0.0	0.0	0.0
	5	0.1221	0.0	0.0	0.0	0.0
	2	0.1322	0.0	0.0	0.0	0.0
	1	0.1325	0.0	0.0	0.0	0.0
	0.5	0.1539	0.0	0.0	0.0	0.0
	0.3	0.1549	0.0	0.0	0.0	0.0
	PGV	0.1197	0.0	0.0	0.0	0.0
Vert	PGA	0.1310	0.0	0.0	0.0	0.0
	20	0.1153	0.0	0.0	0.0	0.0
	10	0.1419	0.0	0.0	0.0	0.0
	5	0.1411	0.0	0.0	0.0	0.0
	2	0.1473	0.0	0.0	0.0	0.0
	1	0.1390	0.0	0.0	0.0	0.0
	0.5	0.1702	0.0	0.0	0.0	0.0
	0.3	0.1929	0.0	0.0	0.0	0.0
	PGV	0.1240	0.0	0.0	0.0	0.0

TABLE I-2A
D. M. BOORE: REGRESSION COEFFICIENTS
MEDIAN MODEL

COMPONENT	FREQUENCY (HZ)	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}	SIGMA FIT
Horiz	PGA	1.5497	0.3084	-1.3607	0.0428	0.1679	0.0000	-0.0091	6.6	0.3143	-0.1556	5.0	6.6	0.0652
	20	2.6166	0.3084	-1.5608	0.0428	0.1679	0.0060	-0.0008	7.2	0.3150	-0.1482	5.2	6.5	0.0745
	10	2.8493	0.3084	-1.5616	0.0428	0.1679	-0.0015	0.0202	7.8	0.2528	-0.1906	5.0	6.4	0.0891
	5	2.4108	0.3084	-1.4094	0.0428	0.1679	-0.0139	0.0240	7.5	0.2560	-0.1443	5.0	6.5	0.0880
	2	1.5149	0.3084	-1.1710	0.0428	0.1679	-0.0522	-0.0020	5.8	0.3720	-0.1352	5.0	6.6	0.0779
	1	0.7658	0.3084	-1.0502	0.0428	0.1679	-0.0864	-0.0353	5.0	0.4619	-0.1113	5.0	6.8	0.0812
	0.5	-0.2483	0.3084	-0.9440	0.0428	0.1679	-0.1015	-0.1290	4.8	0.3628	-0.0287	5.1	6.7	0.0939
	0.3	-0.5903	0.3084	-0.9312	0.0428	0.1679	-0.1629	-0.2092	4.1	0.1632	-0.0246	5.1	6.5	0.0825
	PGV	5.8882	0.3084	-1.1710	0.0428	0.1679	-0.1051	-0.0677	5.5	0.3161	-0.2053	5.0	6.1	0.1341
Vert	PGA	1.6973	0.5387	-1.5373	0.2029	0.1404	0.0000	-0.0580	6.4	0.3991	-0.0696	5.6	6.4	0.0707
	20	3.1350	0.5387	-1.7786	0.2029	0.1404	0.0058	-0.0629	7.0	0.3832	-0.0957	5.7	6.3	0.0799
	10	3.0993	0.5387	-1.7441	0.2029	0.1404	-0.0027	-0.0034	7.3	0.3445	-0.1193	5.6	6.4	0.0872
	5	1.9869	0.5387	-1.4854	0.2029	0.1404	-0.0142	0.0407	6.7	0.3542	-0.0831	5.6	6.3	0.0852
	2	0.6682	0.5387	-1.1881	0.2029	0.1404	-0.0404	0.0537	5.3	0.3557	-0.0107	5.5	6.4	0.0934
	1	-0.1466	0.5387	-1.0425	0.2029	0.1404	-0.0646	0.0188	4.4	0.3217	0.0840	5.5	6.5	0.0963
	0.5	-1.0320	0.5387	-0.9188	0.2029	0.1404	-0.0963	-0.0472	3.4	0.3081	0.1089	5.6	6.5	0.1120
	0.3	-1.3453	0.5387	-0.9122	0.2029	0.1404	-0.1313	-0.0431	3.3	0.2441	0.0609	5.2	6.5	0.1209
	PGV	5.0911	0.5387	-1.2405	0.2029	0.1404	-0.0725	0.1002	6.3	0.0365	-0.1530	5.0	6.2	0.1720

TABLE I-2B
D. M. BOORE: REGRESSION COEFFICIENTS
SIGMA MODEL

COMPONENT	FREQUENCY (HZ)	b_1	b_2	b_3	b_4	SIGMA FIT
Horiz	PGA	0.5060	-0.0601	0.0	7.1	0.0004
	20	0.5246	-0.0607	0.0	7.1	0.0004
	10	0.5399	-0.0616	0.0	7.1	0.0003
	5	0.5855	-0.0598	0.0	7.1	0.0004
	2	0.6540	-0.0573	0.0	7.1	0.0005
	1	0.7089	-0.0540	0.0	7.1	0.0004
	0.5	0.7786	-0.0498	0.0	7.1	0.0004
	0.3	0.6838	-0.0839	0.0	7.1	0.0006
	PGV	0.5048	-0.0588	0.0	7.2	0.0021
Vert	PGA	0.5577	-0.0807	0.0	7.0	0.0049
	20	0.5954	-0.0770	0.0	7.0	0.0044
	10	0.5954	-0.0770	0.0	7.0	0.0044
	5	0.5954	-0.0576	0.0	7.0	0.0044
	2	0.5954	-0.0576	0.0	7.0	0.0044
	1	0.5954	-0.0576	0.0	7.0	0.0044
	0.5	0.5954	-0.0576	0.0	7.0	0.0044
	0.3	0.6121	-0.0576	0.0	7.0	0.0044
	PGV	0.4924	-0.0600	0.0	7.2	0.0022

TABLE I-2C
D. M. BOORE: REGRESSION COEFFICIENTS
SIGMA-MU MODEL

COMPONENT	FREQUENCY (HZ)	c_1	c_2	c_3	c_4	c_5	c_6	MINIMUM	SIGMA FIT
Horiz	PGA	0.5471	-0.0146	-0.1968	0.0337	0.0358	6.0	0.2	0.0659
	20	0.5194	0.0186	-0.1558	0.0269	0.0384	6.0	0.2	0.0691
	10	0.5976	0.0331	-0.1950	0.0323	0.0330	6.0	0.2	0.0660
	5	0.6248	0.0482	-0.2179	0.0361	0.0192	6.0	0.2	0.0603
	2	0.3572	0.0034	-0.0872	0.0187	0.0305	6.0	0.2	0.0543
	1	0.2909	-0.0070	-0.0330	0.0090	0.0523	6.0	0.2	0.0652
	0.5	0.2121	-0.0561	0.0153	0.0123	0.0502	6.0	0.2	0.0891
	0.3	0.2584	-0.0061	0.0870	-0.0082	0.0773	6.0	0.2	0.1139
	PGV	0.3575	0.0070	-0.1036	0.0271	0.0050	6.0	0.2	0.0840
Vert	PGA	0.3162	-0.0271	-0.0839	0.0201	0.0411	6.0	0.2	0.0726
	20	0.4047	-0.0043	-0.0734	0.0157	0.0076	6.0	0.2	0.0808
	10	0.2951	-0.0211	-0.0745	0.0187	0.0451	6.0	0.2	0.0679
	5	0.3058	-0.0036	-0.0760	0.0213	0.0599	6.0	0.2	0.0858
	2	0.2463	0.0210	-0.0090	0.0123	0.0444	6.0	0.2	0.0874
	1	0.3998	-0.0363	-0.1366	0.0329	0.0324	6.0	0.2	0.0847
	0.5	0.3062	0.0196	-0.0457	0.0207	0.0741	6.0	0.2	0.1323
	0.3	0.4412	-0.0852	-0.0048	0.0092	0.0306	6.0	0.2	0.1680
	PGV	0.1711	0.0371	0.0060	0.0035	0.1135	6.0	0.2	0.0744

TABLE I-2D
D. M. BOORE: REGRESSION COEFFICIENTS
SIGMA-SIGMA MODEL

COMPONENT	FREQUENCY (HZ)	d_1	d_2	d_3	d_4	SIGMA FIT
Horiz	PGA	0.1	0.0	0.0	7.1	0.0
	20	0.1	0.0	0.0	7.1	0.0
	10	0.1	0.0	0.0	7.1	0.0
	5	0.1	0.0	0.0	7.1	0.0
	2	0.1	0.0	0.0	7.1	0.0
	1	0.1	0.0	0.0	7.1	0.0
	0.5	0.1	0.0	0.0	7.1	0.0
	0.3	0.1	0.0	0.0	7.1	0.0
	PGV	0.1	0.0	0.0	7.1	0.0
Vert	PGA	0.1	0.0	0.0	7.1	0.0
	20	0.1	0.0	0.0	7.1	0.0
	10	0.1	0.0	0.0	7.1	0.0
	5	0.1	0.0	0.0	7.1	0.0
	2	0.1	0.0	0.0	7.1	0.0
	1	0.1	0.0	0.0	7.1	0.0
	0.5	0.1	0.0	0.0	7.1	0.0
	0.3	0.1	0.0	0.0	7.1	0.0
	PGV	0.1	0.0	0.0	7.1	0.0

TABLE I-3A
K. W. CAMPBELL: REGRESSION COEFFICIENTS
MEDIAN MODEL

COMPONENT	FREQUENCY (HZ)	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}	SIGMA FIT
Horiz	PGA	1.8960	0.2126	-1.4434	-0.2258	0.2412	0.0000	0.0399	6.5	0.0000	0.0000	0.0	0.0	0.1105
	20	2.7450	0.2126	-1.5910	-0.2258	0.2412	0.0132	0.0291	6.9	0.0000	0.0000	0.0	0.0	0.1168
	10	2.7735	0.2126	-1.5481	-0.2032	0.2412	0.0144	0.0483	7.0	0.0000	0.0000	0.0	0.0	0.1180
	5	2.3798	0.2126	-1.3963	-0.1806	0.2412	-0.0011	0.0574	6.8	0.0000	0.0000	0.0	0.0	0.1230
	2	1.7052	0.2126	-1.2043	-0.1671	0.2412	-0.0496	0.0483	5.7	0.0000	0.0000	0.0	0.0	0.1487
	1	1.0160	0.2126	-1.1143	-0.1671	0.2412	-0.0885	0.0519	5.2	0.0000	0.0000	0.0	0.0	0.1519
	0.5	0.1935	0.2126	-1.0324	-0.1671	0.2412	-0.1418	0.0549	4.7	0.0000	0.0000	0.0	0.0	0.1782
	0.3	-0.2184	0.2126	-1.0371	-0.1671	0.2412	-0.2034	0.0269	4.6	0.0000	0.0000	0.0	0.0	0.1910
	PGV	6.0095	0.2126	-1.2345	-0.1671	0.2412	-0.0840	0.0469	4.9	0.0000	0.0000	0.0	0.0	0.1305
Vert	PGA	1.9650	0.4014	-1.6105	0.0000	0.2009	0.0000	0.1042	6.8	0.0000	0.0000	0.0	0.0	0.1308
	20	3.2137	0.4014	-1.8135	0.0000	0.2009	0.0040	0.0972	7.3	0.0000	0.0000	0.0	0.0	0.1464
	10	3.0633	0.4014	-1.7233	0.0000	0.2009	0.0001	0.1022	7.3	0.0000	0.0000	0.0	0.0	0.1405
	5	2.0716	0.4014	-1.4754	0.0000	0.2009	-0.0101	0.0949	7.0	0.0000	0.0000	0.0	0.0	0.1262
	2	1.0862	0.4014	-1.2540	0.0000	0.2009	-0.0531	0.1019	6.1	0.0000	0.0000	0.0	0.0	0.1309
	1	0.4391	0.4014	-1.1841	0.0000	0.2009	-0.0920	0.1647	5.7	0.0000	0.0000	0.0	0.0	0.1077
	0.5	-0.2319	0.4014	-1.1386	0.0000	0.2009	-0.1564	0.2868	4.7	0.0000	0.0000	0.0	0.0	0.1118
	0.3	-0.6304	0.4014	-1.1370	0.0000	0.2009	-0.2225	0.3577	4.3	0.0000	0.0000	0.0	0.0	0.1582
	PGV	5.4130	0.4014	-1.3230	0.0000	0.2009	-0.0702	0.1917	6.7	0.0000	0.0000	0.0	0.0	0.1153

TABLE I-3B
K. W. CAMPBELL: REGRESSION COEFFICIENTS
SIGMA MODEL

COMPONENT	FREQUENCY (HZ)	b_1	b_2	b_3	b_4	SIGMA FIT
Horiz	PGA	0.4952	-0.0718	0.0	7.1	0.0107
	20	0.5000	-0.0756	0.0	7.1	0.0095
	10	0.5180	-0.0759	0.0	7.1	0.0097
	5	0.5518	-0.0743	0.0	7.1	0.0094
	2	0.6156	-0.0722	0.0	7.1	0.0090
	1	0.6611	-0.0697	0.0	7.1	0.0090
	0.5	0.7137	-0.0666	0.0	7.1	0.0087
	0.3	0.7203	-0.0649	0.0	7.1	0.0087
	PGV	0.5657	-0.0789	0.0	7.1	0.0032
Vert	PGA	0.5842	-0.0642	0.0	6.8	0.0134
	20	0.6238	-0.0628	0.0	6.7	0.0124
	10	0.6287	-0.0644	0.0	6.7	0.0124
	5	0.6327	-0.0550	0.0	6.7	0.0123
	2	0.6475	-0.0586	0.0	6.7	0.0121
	1	0.6596	-0.0584	0.0	6.8	0.0121
	0.5	0.6838	-0.0603	0.0	6.8	0.0128
	0.3	0.6929	-0.0603	0.0	6.8	0.0128
	PGV	0.5989	-0.0652	0.0	6.8	0.0137

TABLE I-3C
K. W. CAMPBELL: REGRESSION COEFFICIENTS
SIGMA-MU MODEL

COMPONENT	FREQUENCY (HZ)	c_1	c_2	c_3	c_4	c_5	c_6	MINIMUM	SIGMA FIT
Horiz	PGA	0.7267	0.0	-0.3005	0.0535	0.0173	6.0	0.2	0.0800
	20	0.7021	0.0	-0.2571	0.0486	0.0132	6.0	0.2	0.0829
	10	0.8492	0.0	-0.3861	0.0691	0.0222	6.0	0.2	0.0660
	5	0.9030	0.0	-0.4097	0.0721	0.0007	6.0	0.2	0.0601
	2	0.5303	0.0	-0.1899	0.0395	0.0131	6.0	0.2	0.0843
	1	0.4384	0.0	-0.1203	0.0273	0.0477	6.0	0.2	0.0992
	0.5	0.2665	0.0	0.0325	0.0096	0.0263	6.0	0.2	0.1223
	0.3	0.2476	0.0	0.1379	-0.0106	0.0240	6.0	0.2	0.1341
	PGV	0.7873	0.0	-0.3460	0.0620	0.0272	6.0	0.2	0.1085
Vert	PGA	0.6835	0.0	-0.2488	0.0476	0.0222	6.0	0.2	0.1022
	20	0.7763	0.0	-0.2297	0.0423	0.0085	6.0	0.2	0.1093
	10	0.7307	0.0	-0.3015	0.0569	0.0342	6.0	0.2	0.0964
	5	0.8226	0.0	-0.3631	0.0677	0.0620	6.0	0.2	0.0944
	2	0.5424	0.0	-0.1390	0.0318	0.0378	6.0	0.2	0.1164
	1	0.7375	0.0	-0.2475	0.0475	-0.0049	6.0	0.2	0.1283
	0.5	0.5831	0.0	-0.1478	0.0433	0.0501	6.0	0.2	0.1541
	0.3	0.5651	0.0	-0.0052	0.0136	0.0817	6.0	0.2	0.1910
	PGV	0.8300	0.0	-0.3837	0.0728	0.1044	6.0	0.2	0.1112

TABLE I-3D
K. W. CAMPBELL: REGRESSION COEFFICIENTS
SIGMA-SIGMA MODEL

COMPONENT	FREQUENCY (HZ)	d_1	d_2	d_3	d_4	SIGMA FIT
Horiz	PGA	0.1	0.0	0.0	7.1	0.0
	20	0.1	0.0	0.0	7.1	0.0
	10	0.1	0.0	0.0	7.1	0.0
	5	0.1	0.0	0.0	7.1	0.0
	2	0.1	0.0	0.0	7.1	0.0
	1	0.1	0.0	0.0	7.1	0.0
	0.5	0.1	0.0	0.0	7.1	0.0
	0.3	0.1	0.0	0.0	7.1	0.0
	PGV	0.1	0.0	0.0	7.1	0.0
Vert	PGA	0.1	0.0	0.0	7.1	0.0
	20	0.1	0.0	0.0	7.1	0.0
	10	0.1	0.0	0.0	7.1	0.0
	5	0.1	0.0	0.0	7.1	0.0
	2	0.1	0.0	0.0	7.1	0.0
	1	0.1	0.0	0.0	7.1	0.0
	0.5	0.1	0.0	0.0	7.1	0.0
	0.3	0.1	0.0	0.0	7.1	0.0
	PGV	0.1	0.0	0.0	7.1	0.0

TABLE I-4A
A. F. McGARR: REGRESSION COEFFICIENTS
MEDIAN MODEL

COMPONENT	FREQUENCY (HZ)	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}	SIGMA FIT
Horiz	PGA	1.6594	0.2412	-1.4068	-0.1238	0.2153	0.0000	0.0166	6.8	0.0000	0.0000	0.0	0.0	0.1588
	20	2.6292	0.2412	-1.5697	-0.1238	0.2153	0.0074	-0.0037	7.3	0.0000	0.0000	0.0	0.0	0.1796
	10	2.8002	0.2412	-1.5646	-0.1238	0.2153	0.0050	0.0153	7.7	0.0000	0.0000	0.0	0.0	0.1764
	5	2.3506	0.2412	-1.4123	-0.0825	0.2153	-0.0088	0.0439	7.4	0.0000	0.0000	0.0	0.0	0.1633
	2	1.5042	0.2412	-1.1972	-0.0413	0.2153	-0.0471	0.0690	6.1	0.0000	0.0000	0.0	0.0	0.1648
	1	0.7751	0.2412	-1.0911	0.0000	0.2153	-0.0819	0.0620	5.4	0.0000	0.0000	0.0	0.0	0.1687
	0.5	-0.0836	0.2412	-0.9972	0.0413	0.2153	-0.1217	0.0304	5.1	0.0000	0.0000	0.0	0.0	0.1765
	0.3	-0.5679	0.2412	-0.9422	0.0413	0.2153	-0.1860	-0.0560	4.4	0.0000	0.0000	0.0	0.0	0.1545
	PGV	5.9472	0.2412	-1.2788	0.0413	0.2153	-0.0740	0.0723	5.7	0.0000	0.0000	0.0	0.0	0.1747
Vert	PGA	1.8472	0.3457	-1.6393	-0.1253	0.2179	0.0000	0.0630	6.8	0.0000	0.0000	0.0	0.0	0.1728
	20	3.0364	0.3457	-1.8353	-0.1253	0.2179	0.0115	0.0401	7.5	0.0000	0.0000	0.0	0.0	0.1927
	10	2.8984	0.3457	-1.7478	-0.1253	0.2179	0.0100	0.0391	7.8	0.0000	0.0000	0.0	0.0	0.1796
	5	2.2051	0.3457	-1.5680	-0.0835	0.2179	-0.0082	0.0592	7.4	0.0000	0.0000	0.0	0.0	0.1683
	2	1.3797	0.3457	-1.3725	-0.0418	0.2179	-0.0555	0.1148	6.9	0.0000	0.0000	0.0	0.0	0.1712
	1	0.5173	0.3457	-1.2524	0.0000	0.2179	-0.0879	0.1526	6.2	0.0000	0.0000	0.0	0.0	0.1494
	0.5	-0.4559	0.3457	-1.1451	0.0418	0.2179	-0.1399	0.2048	5.0	0.0000	0.0000	0.0	0.0	0.1516
	0.3	-1.0476	0.3457	-1.1063	0.0418	0.2179	-0.1827	0.2133	4.6	0.0000	0.0000	0.0	0.0	0.1560
	PGV	5.4176	0.3457	-1.4111	0.0418	0.2179	-0.0483	0.1238	6.4	0.0000	0.0000	0.0	0.0	0.2830

TABLE I-4B
A. F. McGARR: REGRESSION COEFFICIENTS
SIGMA MODEL

COMPONENT	FREQUENCY (HZ)	b_1	b_2	b_3	b_4	SIGMA FIT
Horiz	PGA	0.5670	-0.0441	0.0	6.9	0.0034
	20	0.5714	-0.0462	0.0	6.9	0.0041
	10	0.5895	-0.0543	0.0	6.8	0.0055
	5	0.6240	-0.0520	0.0	6.8	0.0053
	2	0.6939	-0.0486	0.0	6.7	0.0056
	1	0.7523	-0.0370	0.0	6.8	0.0032
	0.5	0.8528	-0.0302	0.0	6.8	0.0045
	0.3	0.8541	-0.0494	0.0	6.8	0.0070
	PGV	0.7480	-0.0256	0.0	5.8	0.0041
Vert	PGA	0.5404	-0.0636	0.0	6.8	0.0036
	20	0.5557	-0.0625	0.0	6.8	0.0036
	10	0.5716	-0.0754	0.0	6.7	0.0069
	5	0.5757	-0.0735	0.0	6.7	0.0075
	2	0.6194	-0.0986	0.0	6.2	0.0090
	1	0.6572	-0.0593	0.0	6.6	0.0074
	0.5	0.7320	-0.0665	0.0	6.3	0.0097
	0.3	0.7732	-0.0849	0.0	6.1	0.0109
	PGV	0.6176	-0.0454	0.0	5.8	0.0089

TABLE I-4C
A. F. McGARR: REGRESSION COEFFICIENTS
SIGMA-MU MODEL

COMPONENT	FREQUENCY (HZ)	c_1	c_2	c_3	c_4	c_5	c_6	MINIMUM	SIGMA FIT
Horiz	PGA	0.4361	0.0	-0.1255	0.0231	0.0170	6.0	0.2	0.0944
	20	0.4444	0.0	-0.0793	0.0147	0.0093	6.0	0.2	0.0933
	10	0.5028	0.0	-0.1443	0.0256	0.0145	6.0	0.2	0.0833
	5	0.5358	0.0	-0.1647	0.0283	-0.0043	6.0	0.2	0.0829
	2	0.3175	0.0	-0.0454	0.0106	0.0012	6.0	0.2	0.0858
	1	0.3177	0.0	-0.0251	0.0075	0.0198	6.0	0.2	0.0943
	0.5	0.2482	0.0	0.0727	-0.0044	0.0056	6.0	0.2	0.1191
	0.3	0.2057	0.0	0.1263	-0.0157	0.0154	6.0	0.2	0.1098
	PGV	0.3386	0.0	-0.0486	0.0133	0.0072	6.0	0.2	0.1265
Vert	PGA	0.3355	0.0	-0.0288	0.0061	-0.0004	6.0	0.2	0.0977
	20	0.4595	0.0	-0.0238	0.0019	-0.0302	6.0	0.2	0.1128
	10	0.3773	0.0	-0.0699	0.0165	0.0148	6.0	0.2	0.0919
	5	0.2906	0.0	-0.0434	0.0157	0.0613	6.0	0.2	0.0899
	2	0.2361	0.0	0.0213	0.0027	0.0069	6.0	0.2	0.1045
	1	0.4178	0.0	-0.0855	0.0194	-0.0507	6.0	0.2	0.1106
	0.5	0.2854	0.0	-0.0087	0.0196	0.0659	6.0	0.2	0.1487
	0.3	0.2291	0.0	0.0702	0.0018	0.1555	6.0	0.2	0.1379
	PGV	0.4553	0.0	-0.1333	0.0277	0.1640	6.0	0.2	0.1883

TABLE I-4D
A. F. McGARR: REGRESSION COEFFICIENTS
SIGMA-SIGMA MODEL

COMPONENT	FREQUENCY (HZ)	d_1	d_2	d_3	d_4	SIGMA FIT
Horiz	PGA	0.1010	0.0073	0.0	7.2	0.0045
	20	0.1015	0.0097	0.0	7.2	0.0046
	10	0.1072	0.0102	0.0	7.2	0.0046
	5	0.1040	0.0092	0.0	7.2	0.0038
	2	0.1156	0.0171	0.0	7.2	0.0035
	1	0.1207	0.0239	0.0	7.2	0.0042
	0.5	0.1620	0.0396	0.0	7.2	0.0034
	0.3	0.1818	0.0496	0.0	7.1	0.0047
	PGV	0.1347	0.0273	0.0	7.2	0.0022
Vert	PGA	0.1435	0.0324	0.0	7.2	0.0072
	20	0.1402	0.0322	0.0	7.2	0.0065
	10	0.1431	0.0271	0.0	7.2	0.0074
	5	0.1322	0.0207	0.0	7.2	0.0071
	2	0.1364	0.0215	0.0	7.2	0.0082
	1	0.1332	0.0257	0.0	7.2	0.0079
	0.5	0.1893	0.0477	0.0	7.2	0.0095
	0.3	0.2130	0.0609	0.0	6.9	0.0111
	PGV	0.1858	0.0449	0.0	7.2	0.0066

TABLE I-5A
W. J. SILVA: REGRESSION COEFFICIENTS
MEDIAN MODEL

COMPONENT	FREQUENCY (HZ)	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}	SIGMA FIT
Horiz	PGA	1.8005	0.3153	-1.3837	-0.2558	0.2277	0.0000	-0.1026	6.5	0.2448	-0.2330	5.3	6.1	0.1025
	20	2.7125	0.3153	-1.5541	-0.2558	0.2277	0.0167	-0.1075	7.0	0.2384	-0.2658	5.2	6.2	0.1244
	10	2.9773	0.3153	-1.5532	-0.2558	0.2277	0.0107	-0.0789	7.5	0.1681	-0.2994	5.1	6.0	0.1266
	5	2.6009	0.3153	-1.4075	-0.2558	0.2277	-0.0054	-0.0685	7.2	0.1991	-0.2360	5.3	6.1	0.1167
	2	1.6999	0.3153	-1.1745	-0.2345	0.2277	-0.0455	-0.0619	5.9	0.3161	-0.1954	5.1	6.2	0.1026
	1	0.9533	0.3153	-1.0575	-0.2131	0.2277	-0.0823	-0.1434	5.6	0.3724	-0.1700	5.3	6.2	0.1075
	0.5	0.0547	0.3153	-0.9277	-0.2131	0.2277	-0.1430	-0.2633	4.5	0.3164	-0.0652	5.4	6.3	0.1123
	0.3	-0.4523	0.3153	-0.9075	-0.2345	0.2277	-0.2005	-0.2867	4.3	0.3268	-0.0615	5.0	7.4	0.1246
	PGV	5.9145	0.3153	-1.1166	-0.2558	0.2277	-0.0938	-0.1484	5.5	0.3349	-0.1934	5.0	6.7	0.1001
Vert	PGA	1.8504	0.2013	-1.6070	-0.3040	0.2360	0.0000	-0.2461	6.3	0.3630	-0.2009	5.1	6.5	0.1031
	20	3.1590	0.2013	-1.8481	-0.3040	0.2360	0.0138	-0.2468	7.3	0.3313	-0.2651	5.2	6.5	0.1239
	10	3.0835	0.2013	-1.7702	-0.2606	0.2360	0.0090	-0.1158	7.8	0.2430	-0.2923	5.1	6.2	0.1238
	5	2.1817	0.2013	-1.5370	-0.2606	0.2360	-0.0083	-0.0119	6.9	0.3048	-0.1845	5.2	6.5	0.1094
	2	1.1944	0.2013	-1.2980	-0.2606	0.2360	-0.0514	0.0302	5.6	0.4316	-0.1490	5.0	6.6	0.1045
	1	0.5178	0.2013	-1.1971	-0.2606	0.2360	-0.0885	-0.1312	5.4	0.4854	-0.1251	5.1	6.6	0.1141
	0.5	-0.4204	0.2013	-1.0913	-0.2606	0.2360	-0.1457	-0.3447	4.5	0.4766	-0.0200	5.2	6.7	0.1182
	0.3	-0.9693	0.2013	-1.0845	-0.2823	0.2360	-0.2036	-0.3732	4.3	0.4332	0.0053	5.0	7.2	0.1408
	PGV	5.3774	0.2013	-1.2790	-0.2823	0.2360	-0.0798	-0.1293	5.2	0.4871	-0.1266	5.0	6.9	0.1054

TABLE I-5B
W. J. SILVA: REGRESSION COEFFICIENTS
SIGMA MODEL

COMPONENT	FREQUENCY (HZ)	b_1	b_2	b_3	b_4	SIGMA FIT
Horiz	PGA	0.6246	-0.0606	0.0	6.1	0.0062
	20	0.6107	-0.0696	0.0	6.2	0.0072
	10	0.6391	-0.0722	0.0	6.1	0.0066
	5	0.6648	-0.0696	0.0	6.1	0.0071
	2	0.7288	-0.0584	0.0	6.2	0.0069
	1	0.7716	-0.0311	0.0	6.8	0.0058
	0.5	0.8620	-0.0439	0.0	6.1	0.0081
	0.3	0.9044	-0.0671	0.0	5.9	0.0098
	PGV	0.7744	-0.0278	0.0	5.8	0.0091
Vert	PGA	0.6479	-0.0586	0.0	6.1	0.0060
	20	0.6414	-0.0667	0.0	6.2	0.0069
	10	0.6744	-0.0688	0.0	6.1	0.0062
	5	0.6797	-0.0683	0.0	6.1	0.0069
	2	0.7237	-0.0588	0.0	6.2	0.0070
	1	0.7586	-0.0316	0.0	6.8	0.0059
	0.5	0.8342	-0.0453	0.0	6.1	0.0084
	0.3	0.8780	-0.0690	0.0	5.9	0.0101
	PGV	0.7614	-0.0283	0.0	5.8	0.0093

TABLE I-5C
W. J. SILVA: REGRESSION COEFFICIENTS
SIGMA-MU MODEL

COMPONENT	FREQUENCY (HZ)	c_1	c_2	c_3	c_4	c_5	c_6	MINIMUM	SIGMA FIT
Horiz	PGA	0.3235	0.0	0.0	0.0	0.0415	6.0	0.2	0.0489
	20	0.3439	0.0	0.0	0.0	0.0585	6.0	0.2	0.0567
	10	0.3432	0.0	0.0	0.0	0.0442	6.0	0.2	0.0543
	5	0.3372	0.0	0.0	0.0	0.0233	6.0	0.2	0.0532
	2	0.3141	0.0	0.0	0.0	0.0606	6.0	0.2	0.0417
	1	0.3046	0.0	0.0	0.0	0.0705	6.0	0.2	0.0580
	0.5	0.3462	0.0	0.0	0.0	0.0929	6.0	0.2	0.0610
	0.3	0.4627	0.0	0.0	0.0	0.0756	6.0	0.2	0.0959
	PGV	0.3673	0.0	0.0	0.0	0.0344	6.0	0.2	0.0954
Vert	PGA	0.2695	0.0	0.0	0.0	0.0167	6.0	0.2	0.0710
	20	0.3043	0.0	0.0	0.0	0.0591	6.0	0.2	0.0759
	10	0.3016	0.0	0.0	0.0	0.0240	6.0	0.2	0.0830
	5	0.2917	0.0	0.0	0.0	0.0012	6.0	0.2	0.0847
	2	0.2500	0.0	0.0	0.0	0.0489	6.0	0.2	0.0669
	1	0.2294	0.0	0.0	0.0	0.0945	6.0	0.2	0.0757
	0.5	0.2881	0.0	0.0	0.0	0.0996	6.0	0.2	0.0689
	0.3	0.4034	0.0	0.0	0.0	0.0888	6.0	0.2	0.1069
	PGV	0.2940	0.0	0.0	0.0	0.0700	6.0	0.2	0.0990

TABLE I-5D
W. J. SILVA: REGRESSION COEFFICIENTS
SIGMA-SIGMA MODEL

COMPONENT	FREQUENCY (HZ)	d_1	d_2	d_3	d_4	SIGMA FIT
Horiz	PGA	0.1335	0.0354	0.0	6.0	0.0050
	20	0.1298	0.0345	0.0	5.9	0.0054
	10	0.1379	0.0383	0.0	5.9	0.0054
	5	0.1326	0.0403	0.0	5.8	0.0056
	2	0.1384	0.0631	0.0	5.9	0.0059
	1	0.1275	0.0649	0.0	6.0	0.0065
	0.5	0.1469	0.0711	0.0	6.1	0.0081
	0.3	0.1855	0.0508	0.0	6.8	0.0090
	PGV	0.1454	0.0669	0.0	6.1	0.0066
Vert	PGA	0.1317	0.0383	0.0	5.9	0.0049
	20	0.1287	0.0342	0.0	5.9	0.0053
	10	0.1360	0.0375	0.0	5.9	0.0053
	5	0.1319	0.0400	0.0	5.8	0.0056
	2	0.1388	0.0632	0.0	5.9	0.0059
	1	0.1282	0.0648	0.0	6.0	0.0066
	0.5	0.1499	0.0720	0.0	6.1	0.0084
	0.3	0.1900	0.0519	0.0	6.8	0.0092
	PGV	0.1468	0.0674	0.0	6.1	0.0068

TABLE I-6A
P. G. SOMERVILLE: REGRESSION COEFFICIENTS
MEDIAN MODEL

COMPONENT	FREQUENCY (HZ)	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}	SIGMA FIT
Horiz	PGA	1.9958	0.4419	-1.4672	-0.0696	0.1873	0.0000	0.0474	7.4	0.1137	-0.3247	5.2	6.0	0.1357
	20	2.8175	0.4419	-1.6032	-0.0696	0.1873	0.0088	0.0192	7.5	0.1163	-0.3085	5.0	6.1	0.1331
	10	3.2424	0.4419	-1.6657	-0.0696	0.1873	0.0115	0.0692	8.6	0.0472	-0.3688	5.1	5.9	0.1415
	5	2.7528	0.4419	-1.4804	-0.0696	0.1873	-0.0101	0.0698	7.9	0.0888	-0.3043	5.1	6.0	0.1419
	2	1.8591	0.4419	-1.2335	-0.0696	0.1873	-0.0592	0.0723	6.4	0.1728	-0.2919	5.3	5.9	0.1362
	1	0.9851	0.4419	-1.1037	-0.0696	0.1873	-0.0981	0.0358	5.7	0.2394	-0.2533	5.1	6.0	0.1408
	0.5	-0.2631	0.4419	-0.9365	-0.0696	0.1873	-0.1388	-0.0296	4.0	0.2554	-0.1006	5.0	6.2	0.1682
	0.3	-0.7669	0.4419	-0.9285	-0.0696	0.1873	-0.1725	-0.0665	3.8	0.1646	-0.1141	5.0	7.0	0.1806
	PGV	6.1419	0.4419	-1.2895	-0.0696	0.1873	-0.0818	0.0720	6.0	0.1300	-0.3366	5.2	5.9	0.1831
Vert	PGA	1.7975	0.7212	-1.5779	0.3965	0.1132	0.0000	0.0977	7.2	0.1952	-0.2478	5.1	6.5	0.1377
	20	2.9792	0.7212	-1.7716	0.3965	0.1132	0.0048	0.0938	7.6	0.1789	-0.2697	5.2	6.5	0.1366
	10	3.0338	0.7212	-1.7444	0.3965	0.1132	0.0036	0.1249	7.7	0.1519	-0.2566	5.1	6.3	0.1380
	5	2.2087	0.7212	-1.5319	0.3965	0.1132	-0.0066	0.1270	7.7	0.1861	-0.2233	5.1	6.3	0.1346
	2	1.2175	0.7212	-1.2841	0.3965	0.1132	-0.0595	0.1763	7.2	0.1857	-0.1821	5.1	6.0	0.1521
	1	0.1031	0.7212	-1.1187	0.3965	0.1132	-0.0900	0.2377	6.1	0.1295	-0.0242	5.1	6.0	0.1248
	0.5	-0.7137	0.7212	-1.0516	0.3965	0.1132	-0.1418	0.3920	4.9	0.0000	-0.3000	6.5	7.4	0.1833
	0.3	-1.3183	0.7212	-1.0035	0.3965	0.1132	-0.1706	0.4636	4.2	0.0000	-0.4000	6.2	7.4	0.2021
	PGV	5.3412	0.7212	-1.3183	0.3965	0.1132	-0.0770	0.3185	7.0	0.0000	-0.3000	5.0	7.4	0.1912

TABLE I-6B
P. G. SOMERVILLE: REGRESSION COEFFICIENTS
SIGMA MODEL

COMPONENT	FREQUENCY (HZ)	b_1	b_2	b_3	b_4	SIGMA FIT
Horiz	PGA	0.5454	-0.0613	0.0	6.9	0.0059
	20	0.5396	-0.0694	0.0	6.9	0.0071
	10	0.5714	-0.0767	0.0	6.8	0.0094
	5	0.6028	-0.0732	0.0	6.8	0.0089
	2	0.6665	-0.0721	0.0	6.8	0.0090
	1	0.7130	-0.0597	0.0	6.9	0.0046
	0.5	0.7717	-0.0538	0.0	6.9	0.0096
	0.3	0.7958	-0.1063	0.0	6.1	0.0134
	PGV	0.6876	-0.0535	0.0	6.1	0.0072
Vert	PGA	0.6137	-0.0504	0.0	6.5	0.0058
	20	0.6436	-0.0465	0.0	6.5	0.0062
	10	0.6492	-0.0785	0.0	6.3	0.0089
	5	0.6337	-0.0701	0.0	6.2	0.0109
	2	0.6336	-0.0895	0.0	6.1	0.0126
	1	0.6502	-0.0533	0.0	6.4	0.0115
	0.5	0.6701	-0.0545	0.0	6.4	0.0161
	0.3	0.7010	-0.0963	0.0	6.0	0.0197
	PGV	0.5972	-0.0676	0.0	6.0	0.0103

TABLE I-6D
P. G. SOMERVILLE: REGRESSION COEFFICIENTS
SIGMA-SIGMA MODEL

COMPONENT	FREQUENCY (HZ)	d_1	d_2	d_3	d_4	SIGMA FIT
Horiz	PGA	0.1648	-0.0070	0.0	5.8	0.0062
	20	0.1619	-0.0055	0.0	5.8	0.0062
	10	0.1748	0.0062	0.0	7.2	0.0060
	5	0.1715	0.0055	0.0	7.2	0.0043
	2	0.1759	0.0593	0.0	6.0	0.0064
	1	0.1713	0.0992	0.0	5.9	0.0078
	0.5	0.1858	0.1278	0.0	5.9	0.0055
	0.3	0.1957	0.1219	0.0	5.9	0.0044
	PGV	0.1924	0.0850	0.0	6.0	0.0048
Vert	PGA	0.1727	0.0057	0.0	7.2	0.0052
	20	0.1626	-0.0010	0.0	6.5	0.0042
	10	0.1741	0.0148	0.0	5.8	0.0056
	5	0.1763	0.0228	0.0	5.8	0.0056
	2	0.1843	0.0952	0.0	5.8	0.0060
	1	0.1741	0.1405	0.0	5.8	0.0078
	0.5	0.1919	0.1762	0.0	5.8	0.0067
	0.3	0.1995	0.1538	0.0	5.8	0.0044
	PGV	0.1805	0.1120	0.0	5.9	0.0088

TABLE I-7A
M. C. WALCK: REGRESSION COEFFICIENTS
MEDIAN MODEL

COMPONENT	FREQUENCY (HZ)	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}	SIGMA FIT
Horiz	PGA	1.9092	0.2170	-1.4495	-0.1943	0.2237	0.0000	-0.1331	7.4	0.1574	-0.2079	5.1	6.3	0.0721
	20	2.7014	0.2170	-1.5881	-0.1943	0.2237	0.0216	-0.1501	7.6	0.2096	-0.1813	5.5	6.2	0.0775
	10	2.7707	0.2170	-1.5581	-0.1943	0.2237	0.0171	-0.1007	7.8	0.1045	-0.2559	5.0	6.0	0.0982
	5	2.5077	0.2170	-1.4277	-0.1943	0.2237	-0.0054	-0.1224	7.7	0.1503	-0.1854	5.0	6.4	0.0829
	2	1.6685	0.2170	-1.1947	-0.1943	0.2237	-0.0550	-0.1270	6.2	0.2306	-0.1506	5.1	6.1	0.0732
	1	0.8069	0.2170	-1.0454	-0.1943	0.2237	-0.0956	-0.1003	5.3	0.2657	-0.1260	5.3	6.0	0.0816
	0.5	-0.1650	0.2170	-0.9097	-0.1943	0.2237	-0.1406	-0.1338	4.5	0.2454	0.0210	5.0	6.0	0.1039
	0.3	-0.5989	0.2170	-0.9200	-0.1943	0.2237	-0.1764	-0.1613	4.6	0.1336	-0.0249	5.3	7.0	0.1074
	PGV	6.3192	0.2170	-1.3065	-0.1943	0.2237	-0.0782	-0.1320	6.8	0.3225	-0.2042	5.0	6.7	0.1270
Vert	PGA	2.0111	0.3076	-1.6747	-0.0548	0.1979	0.0000	-0.0856	7.2	0.2393	-0.1406	5.5	6.5	0.0876
	20	3.1584	0.3076	-1.8811	-0.0548	0.1979	0.0171	-0.0874	7.8	0.2197	-0.1740	5.6	6.3	0.1029
	10	2.9870	0.3076	-1.7765	-0.0548	0.1979	0.0118	-0.0870	8.0	0.1850	-0.1570	5.6	6.3	0.0990
	5	2.2835	0.3076	-1.5785	-0.0548	0.1979	-0.0102	-0.0954	7.7	0.2268	-0.1040	5.7	6.2	0.0838
	2	1.5135	0.3076	-1.3836	-0.0548	0.1979	-0.0632	-0.0658	7.0	0.2301	-0.0831	5.5	6.4	0.0842
	1	0.7035	0.3076	-1.2693	-0.0548	0.1979	-0.0958	-0.0031	6.5	0.2117	0.0130	5.5	6.3	0.0898
	0.5	-0.5457	0.3076	-1.0812	-0.0548	0.1979	-0.1405	0.0455	4.5	0.2538	0.1001	5.1	6.5	0.1082
	0.3	-0.9148	0.3076	-1.1201	-0.0548	0.1979	-0.1834	0.0927	4.7	0.1565	-0.0677	5.7	6.2	0.1171
	PGV	5.1786	0.3076	-1.2816	-0.0548	0.1979	-0.0599	0.0255	5.1	0.3538	-0.0906	5.0	6.8	0.1381

TABLE I-7B
M. C. WALCK: REGRESSION COEFFICIENTS
SIGMA MODEL

COMPONENT	FREQUENCY (HZ)	b_1	b_2	b_3	b_4	SIGMA FIT
Horiz	PGA	0.5377	-0.0799	0.0	6.8	0.0116
	20	0.5398	-0.0817	0.0	6.8	0.0109
	10	0.5556	-0.0842	0.0	6.8	0.0112
	5	0.5895	-0.0813	0.0	6.8	0.0116
	2	0.6509	-0.0731	0.0	6.9	0.0108
	1	0.6993	-0.0675	0.0	7.1	0.0144
	0.5	0.7753	-0.0558	0.0	7.2	0.0099
	0.3	0.7917	-0.0705	0.0	6.8	0.0152
	PGV	0.7140	0.0446	0.0	5.8	0.0204
Vert	PGA	0.5681	-0.0698	0.0	6.8	0.0086
	20	0.5793	-0.0684	0.0	6.8	0.0075
	10	0.5838	-0.0769	0.0	6.8	0.0131
	5	0.6052	-0.0784	0.0	6.8	0.0135
	2	0.6472	-0.0830	0.0	6.8	0.0176
	1	0.6921	-0.0696	0.0	6.9	0.0183
	0.5	0.7536	-0.0753	0.0	6.7	0.0221
	0.3	0.7861	-0.0813	0.0	6.6	0.0224
	PGV	0.6522	-0.0154	0.0	6.5	0.0360

TABLE I-7C
M. C. WALCK: REGRESSION COEFFICIENTS
SIGMA-MU MODEL

COMPONENT	FREQUENCY (HZ)	c_1	c_2	c_3	c_4	c_5	c_6	MINIMUM	SIGMA FIT
Horiz	PGA	0.4410	0.0	-0.1066	0.0180	0.0220	6.0	0.2	0.0342
	20	0.4270	0.0	-0.0826	0.0166	0.0273	6.0	0.2	0.0457
	10	0.4561	0.0	-0.1182	0.0225	0.0151	6.0	0.2	0.0423
	5	0.4926	0.0	-0.1386	0.0237	0.0138	6.0	0.2	0.0398
	2	0.3457	0.0	-0.0568	0.0111	0.0133	6.0	0.2	0.0430
	1	0.3454	0.0	-0.0684	0.0136	0.0424	6.0	0.2	0.0575
	0.5	0.2627	0.0	-0.0027	0.0073	0.0447	6.0	0.2	0.0684
	0.3	0.2924	0.0	0.0682	-0.0086	0.0274	6.0	0.2	0.0724
	PGV	0.4004	0.0	-0.0878	0.0184	0.0292	6.0	0.2	0.0909
Vert	PGA	0.4292	0.0	-0.0364	0.0085	-0.0061	6.0	0.2	0.0533
	20	0.5320	0.0	-0.0759	0.0148	-0.0112	6.0	0.2	0.0598
	10	0.4840	0.0	-0.0941	0.0209	0.0126	6.0	0.2	0.0555
	5	0.4053	0.0	-0.0295	0.0112	0.0358	6.0	0.2	0.0693
	2	0.3742	0.0	-0.0048	0.0054	0.0125	6.0	0.2	0.0605
	1	0.4533	0.0	-0.0666	0.0142	-0.0085	6.0	0.2	0.0592
	0.5	0.3733	0.0	0.0239	0.0027	-0.0032	6.0	0.2	0.0845
	0.3	0.4412	0.0	0.0000	0.0074	0.0124	6.0	0.2	0.0973
	PGV	0.3698	0.0	-0.0176	0.0088	0.0322	6.0	0.2	0.0902

TABLE I-7D
M. C. WALCK: REGRESSION COEFFICIENTS
SIGMA-SIGMA MODEL

COMPONENT	FREQUENCY (HZ)	d_1	d_2	d_3	d_4	SIGMA FIT
Horiz	PGA	0.1757	0.0072	0.0	7.2	0.0035
	20	0.1757	0.0075	0.0	7.2	0.0034
	10	0.1826	0.0115	0.0	7.2	0.0035
	5	0.1794	0.0131	0.0	7.2	0.0022
	2	0.1786	0.0281	0.0	6.8	0.0036
	1	0.1779	0.0343	0.0	7.0	0.0057
	0.5	0.1956	0.0423	0.0	7.2	0.0075
	0.3	0.2137	0.0505	0.0	7.2	0.0105
	PGV	0.1826	0.0202	0.0	6.9	0.0088
Vert	PGA	0.2010	0.0203	0.0	7.2	0.0066
	20	0.1990	0.0197	0.0	7.2	0.0063
	10	0.2036	0.0205	0.0	7.2	0.0077
	5	0.1933	0.0192	0.0	7.2	0.0061
	2	0.1885	0.0264	0.0	7.1	0.0075
	1	0.1877	0.0350	0.0	7.2	0.0082
	0.5	0.2058	0.0446	0.0	7.2	0.0150
	0.3	0.2305	0.0567	0.0	7.2	0.0141
	PGV	0.1860	0.0194	0.0	7.2	0.0108

APPENDIX J

HYPOCENTRAL DISTANCE METRIC: DEVELOPMENT OF MODELS FOR AREAL SOURCES

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APPENDIX J

HYPOCENTRAL DISTANCE METRIC: DEVELOPMENT OF MODELS FOR AREAL SOURCES

J.1 INTRODUCTION

The attenuation relations developed directly from the experts' point estimates were formulated to describe ground motions from planar seismogenic sources (faults). However, most hazard models - including those proposed for the Yucca Mountain PSHA project - incorporate areal sources over which uniform seismic activity is expected. These areal sources typically model background seismic activity (activity which cannot be assigned to known faults) or activity arising from a laterally distributed source zone. In the hazard analysis, areal sources are typically treated as point sources. The distance measure for a point source is hypocentral distance as opposed to the 'closest distance to the fault' measures used by the experts in this study.

In this appendix, a conversion from hypocentral distance to "closest distance" is developed that accounts for the finite dimension of the fault rupture. This conversion affects both the median ground motion and the aleatory variability and, to a lesser extent, the epistemic uncertainty in both.

J.2 MEDIAN GROUND MOTION

We consider a fault rupture dimension as given by the Wells and Coppersmith (1994)[1] magnitude-area and magnitude-width scaling relations for all fault types. For this study, we only used the mean relations for the rupture dimension scaling relations. (This will tend to underestimate the aleatory variability impact; however, it is a small effect). For each magnitude, the hypocenter is located at various locations on the rupture plane along-strike and down-dip (Figure J-1). Since hypocenters tend to be located near the bottom of fault ruptures, a minimum depth (in terms of the fraction of the fault width) is used to constrain the depth distribution of the hypocenters. Note that this constraint is in terms of the location of the hypocenter on the rupture plane, which is not the same as the depth distribution of the hypocenters. The top of the hypocenters is defined by the parameter T, where T=0

[1] Wells, D.L. and Coppersmith, K.J., 1994, New empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacement: Bulletin of the Seismological Society of America, v. 84, p. 974-1002.

corresponds to the top of the rupture and T=1 corresponds to the bottom of the rupture (Figure J-1).

For each hypocenter, sites were located in a circle around the hypocenter (sites with constant hypocentral distance, Figure J-2). For each site, the rupture distance was computed. The mean and standard deviation of the rupture distance for the ith hypocenter are denoted R_i and σ_{R_i}, respectively. This process was applied for both vertical faults and 60 degree dipping faults (no distinction is made for the difference due to fault dip).

The resulting correlation between hypocentral distance and mean rupture distance (R_i) for T=0.25 is shown on Figure J-3 for magnitude 6.5. Based on the trends on Figure J-3, the following functional form was adopted

For $H \leq 30$ km,

$$\overline{R}(H,M,T) = H\left(1 + e_1 + \left(e_2 + e_9(T-0.25)\right)(M-5)\right) + H^2\left(e_3 + \left(e_4 + e_{10}(T-0.25)\right)(M-5)\right) \quad \text{(J-1a)}$$

and for $H > 30$ km,

$$\overline{R}(H,M,T) = H + 30\left(e_1 + \left(e_2 + e_9(T-0.25)\right)(M-5)\right) + 900\left(e_3 + \left(e_4 + e_{10}(T-0.25)\right)(M-5)\right)$$
(J-1b)

where $\overline{R}$ is the mean rupture distance (in km), M is moment magnitude, H is hypocentral distance (in km), and T is the top of the hypocenter zone on the fault rupture (in fraction of fault width). An ordinary least-squares regression analyses was performed. The resulting coefficients are listed in Table J-1; the standard deviation of the fit is $\sigma_{\overline{R}}$ = 1.2 km.

The mean $\overline{R}$ is plotted versus hypocentral distance on Figures J-4a, J-4b, and J-4c for magnitudes 5.0, 5.8, and 6.5, respectively. This model can be used to convert the hypocentral distance for a given magnitude to a closest-distance measure.

J.3 ALEATORY VARIABILITY

The correlation of the aleatory variability of the individual estimates of R_i with hypocentral distance is shown on Figure J-5 for M = 6.5 and T = 0.25. This correlation suggests a relation of the form

$$\sigma_{Ri}(H,M,T) = \left(e_5 + \left(e_6 + e_{11}(T-0.25)\right)(M-5)\right)\tanh\left\{H\left(e_7 + e_8(M-5)\right)\right\} \quad \text{(J-2)}$$

The estimated coefficients resulting from an ordinary least-squares regression are listed in Table J-1. The aleatory variability for magnitude 5.0, 5.8 and 6.5 are plotted versus hypocentral distance on Figures J-6a, J-6b, and J-6c, respectively.

The total aleatory variability is the combination of σ_{Ri} and the equation fitting variability of the $\overline{R}_i$

$$\sigma_R(H,M,T)=\sqrt{\sigma^2_{R_i}(H,M,T)+\sigma^2_{\overline{R}}} \tag{J-3}$$

The effect of variability of rupture distance (given H, M and T) on the resulting ground motion is computed by standard propagation of errors:

$$\sigma_{Hypo}(H,M,T)=\sqrt{\left(\frac{\partial Y}{\partial R}\right)^2\cdot\sigma^2_R(H,M,T)} \tag{J-4}$$

where Y is the natural log ground motion attenuation relation. For the functional form used in this study (Eq. 6-1 in Section 6; without hanging wall and footwall effects)

$$\frac{\partial Y}{\partial R}=\left(a_3+a_5(M-6.25)\right)\frac{R(H,M,T)}{R^2(H,M,T)+a_8^2} \tag{J-5}$$

where a_3, a_5, and a_8 are coefficients in the regression equations for each expert (Appendix I).

Substituting Equations J-5 and J-3 into Equation J-4 leads to:

$$\sigma_{Hypo}(H,M,T)=\left(\left(a_3+a_5(M-6.25)\right)\frac{R(H,M,T)}{R^2(H,M,T)+a_8^2}\right)\sqrt{\sigma^2_{R_i}(H,M,T)+\sigma^2_{\overline{R}}} \tag{J-6}$$

This additional aleatory variability should be added (using square-root-sum-squares) to the aleatory variability of the experts models (σ_{Total}) given in Equation 6-6. The σ_{hypo} is plotted on Figure J-7.

J.4 EPISTEMIC UNCERTAINTY

The epistemic uncertainty was estimated by considering the uncertainty in the model resulting from uncertainty in T given by σ_T,.

The epistemic uncertainty in the median is given by

$$\sigma_{\mu}^{Hypo}(H,M,T)=\sqrt{\left(\frac{\partial Y}{\partial T}\right)^2\cdot\sigma_T^2} \tag{J-7}$$

where

$$\frac{\partial Y}{\partial T}=\frac{\partial Y}{\partial R}\frac{\partial R}{\partial T} \tag{J-8}$$

and

$$\frac{\partial R(H,M)}{\partial T}=\begin{cases} e_9 H(M-5)+e_{10}H^2(M-5) & \text{for } H \le 30\text{ km} \\ e_9 30(M-5)+e_{10}900(M-5) & \text{for } H > 30\text{ km} \end{cases} \tag{J-9}$$

The epistemic uncertainty in the aleatory variability is expressed as

$$\sigma_{\sigma}^{Hypo}=\sqrt{\left(\frac{\partial\sigma_{Hypo}}{\partial T}\right)^2\sigma_T^2} \tag{J-10}$$

$$=\left|\frac{\partial Y}{\partial R}\right|\frac{\partial\sigma_R}{\partial T}\sigma_T \tag{J-11}$$

where

$$\frac{\partial\sigma_R}{\partial T}=e_{11}(M-5)\tanh\left\{H\left(e_7+e_8(M-5)\right)\right\} \tag{J-12}$$

For this study, we assumed that $\sigma_T = 0.15$ (i.e., 15% of the down-dip width).

The resulting epistemic uncertainty in the median variability is plotted on Figure J-8 for M_w 6.5 and 5.8. The epistemic uncertainty in the aleatory variability is negligible.

J.5 CONCLUSIONS

If the hypocentral distance is simply applied to the attenuation equations developed in Section 6 in place of the "closest distance to the fault rupture," the resulting median ground motion will be overestimated and the aleatory variability will be underestimated. The factors developed in this appendix provide an approximate correction for these effects so that the hazard for areal sources can be easily evaluated using the attenuation relations developed in Section 6.

TABLE J-1
REGRESSION MODEL COEFFICIENTS

COEFFICIENT	ESTIMATE
e_1	-0.207
e_2	-0.323
e_3	0.0058
e_4	0.0059
e_5	1.894
e_6	3.854
e_7	0.0116
e_8	0.0094
e_9	-0.177
e_{10}	0.0055
e_{11}	0.0111

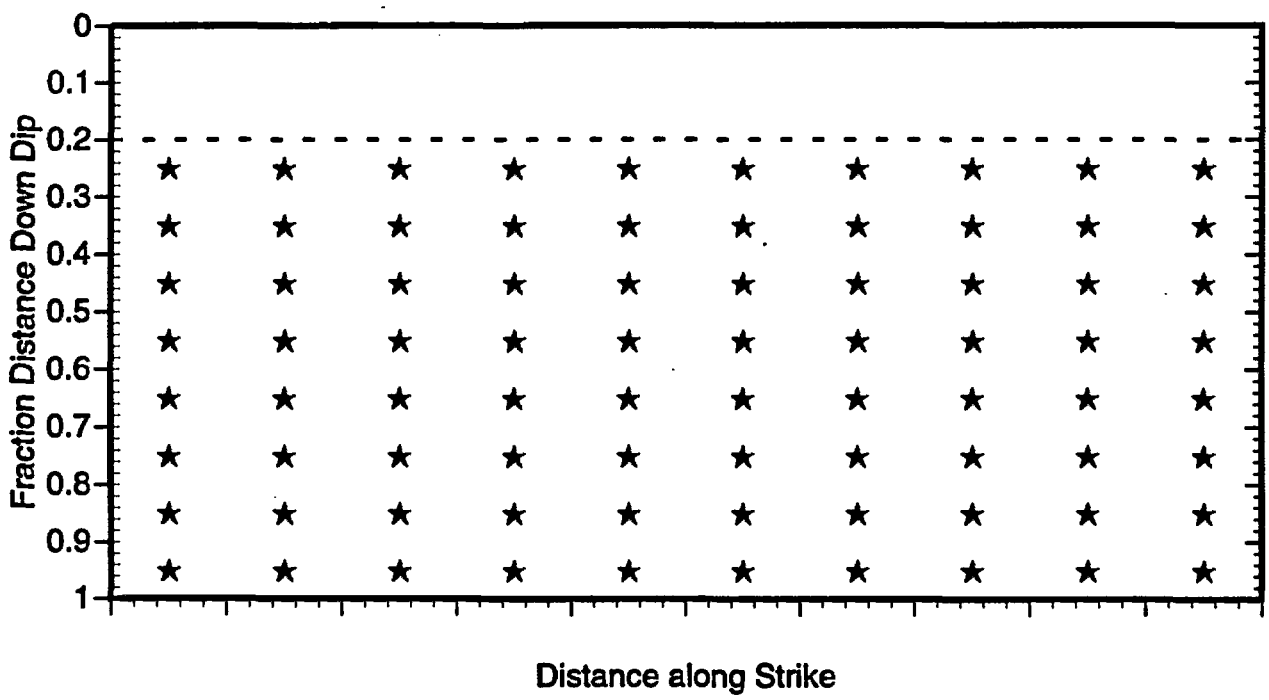

Figure J-1 Example distribution of hypocenters (stars) on the rupture plane for T = 0.2. If T = 0, then hypocenters would be uniformly distributed over the rupture plane. If T = 0.5, then the hypocenters would be uniformly distributed over the lower half of the rupture plane.

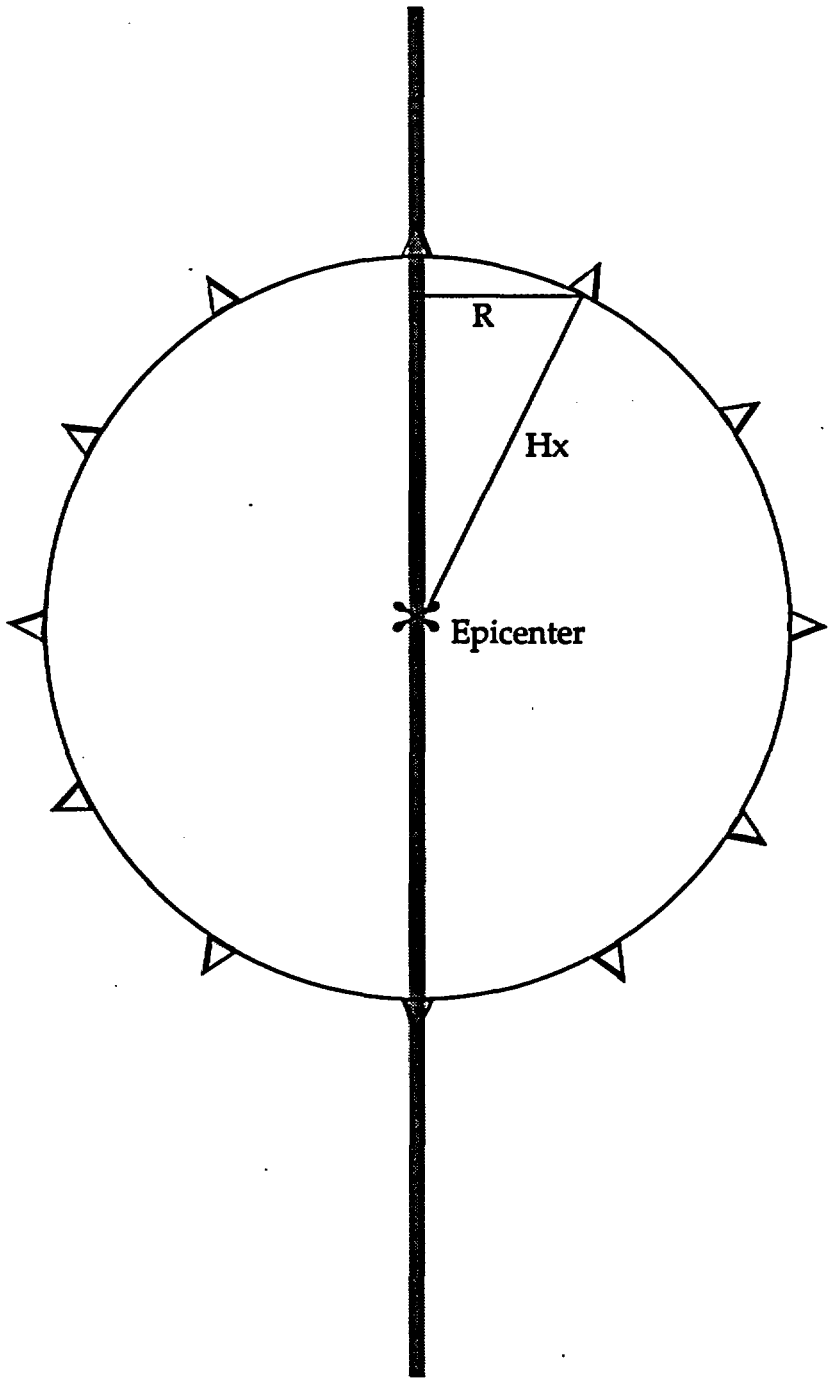

Figure J-2 Map view of a vertical fault rupture plane. For each hypocenter on the rupture plane, a suite of locations (shown by the triangles) is used for each hypocentral distance. The closest distance is then computed for each location to produce a set of hypocentral distance-rupture distance pairs.

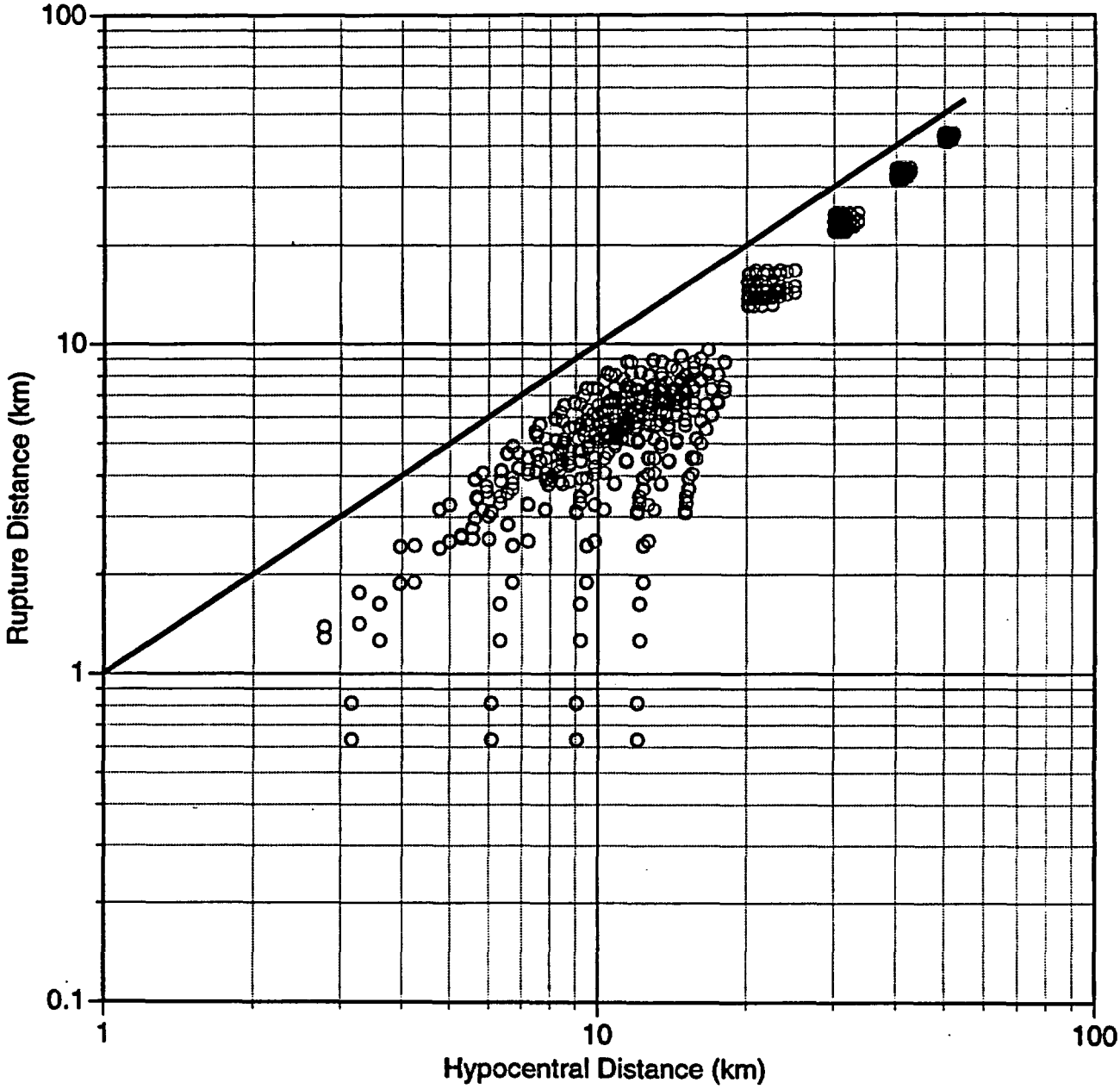

Figure J-3 Mean rupture distance versus hypocentral distance for M_W 6.5 for T = 0.25. The rupture distance is less than the hypocentral distance (the points all plot below the R = H line).

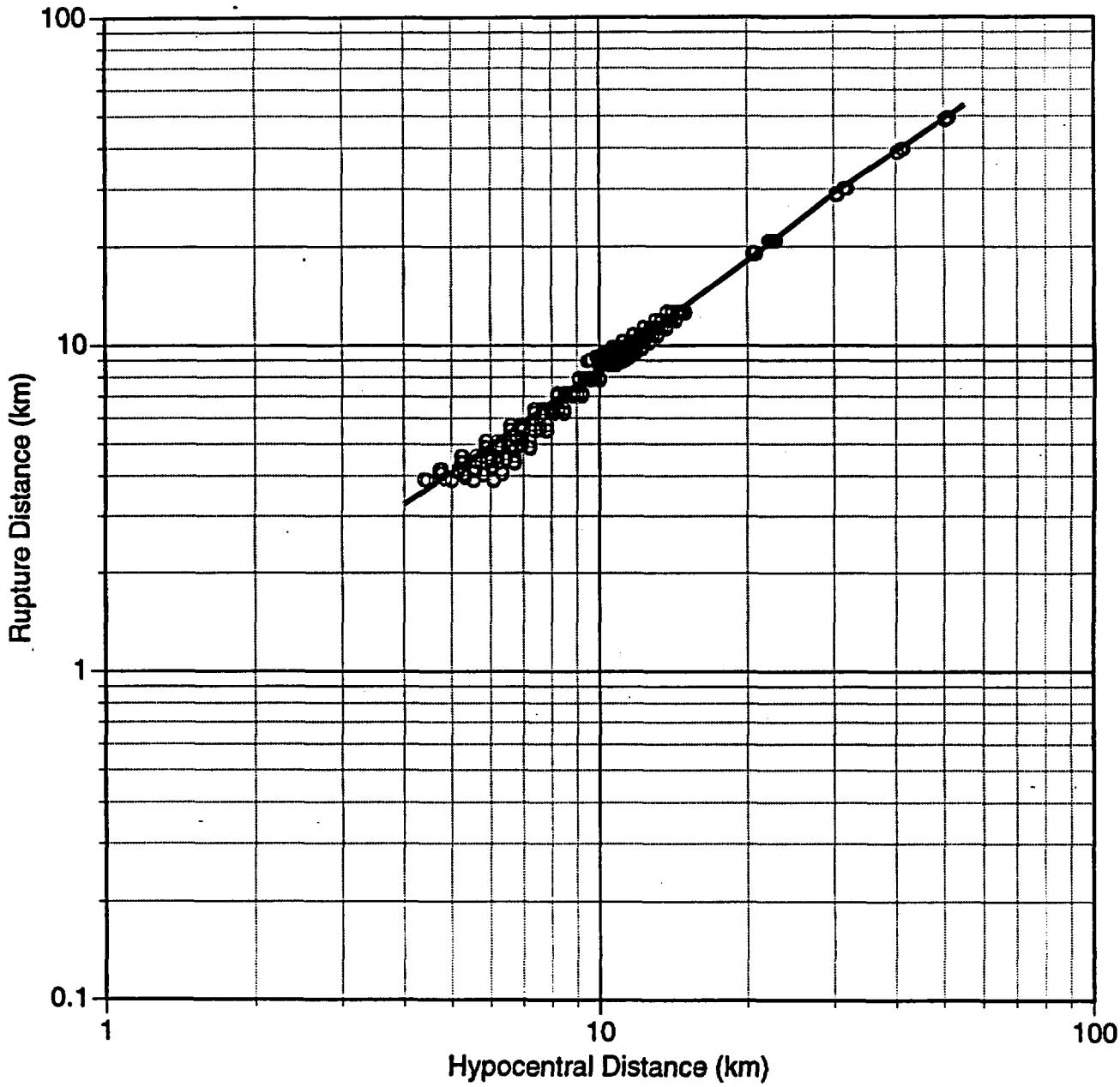

Figure J-4a Model of the mean rupture distance versus hypocentral distance for M_W 5.0 for T = 0.25

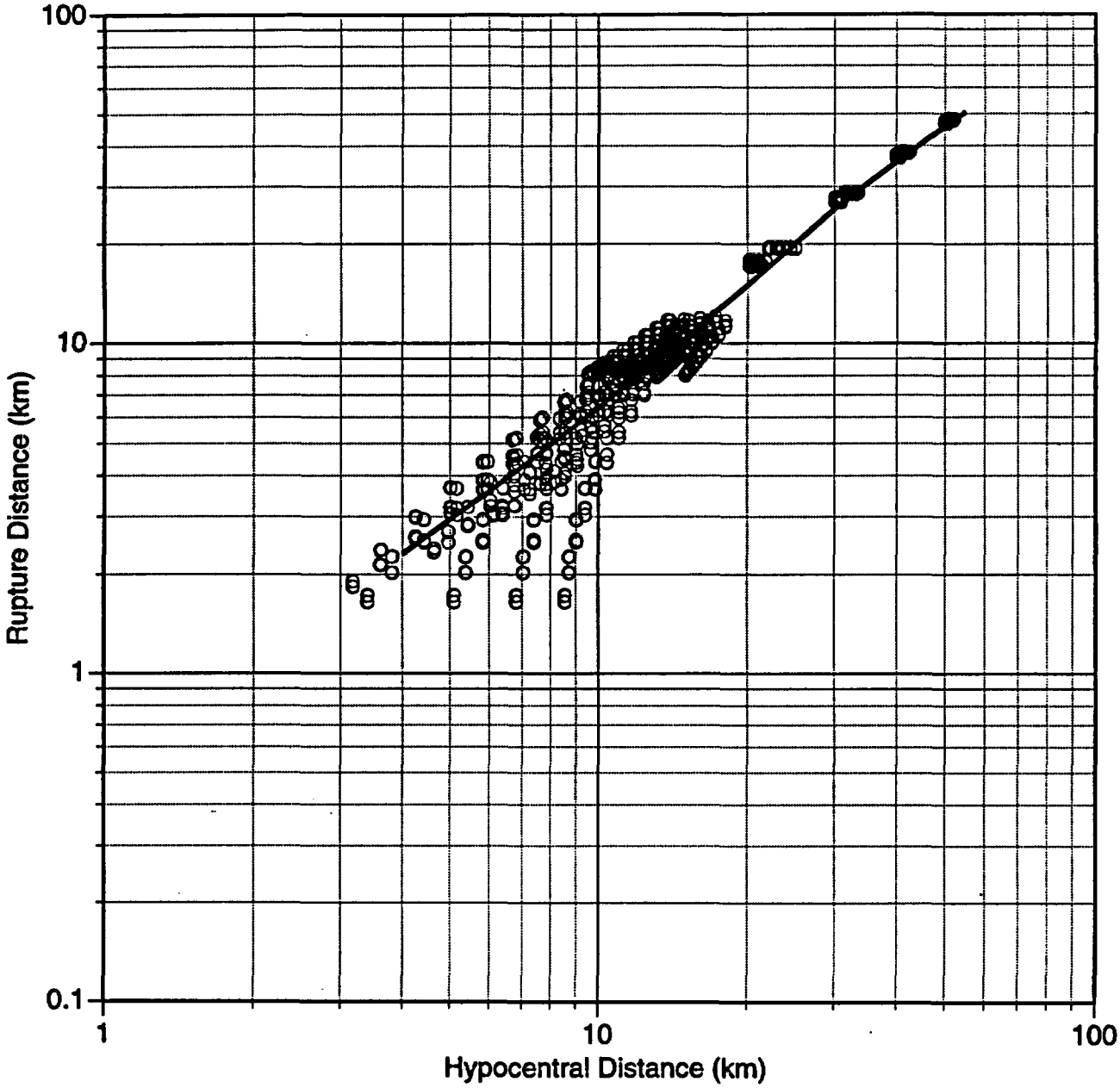

Figure J-4b Model of the mean rupture distance versus hypocentral distance for M_W 5.0 for T = 0.25

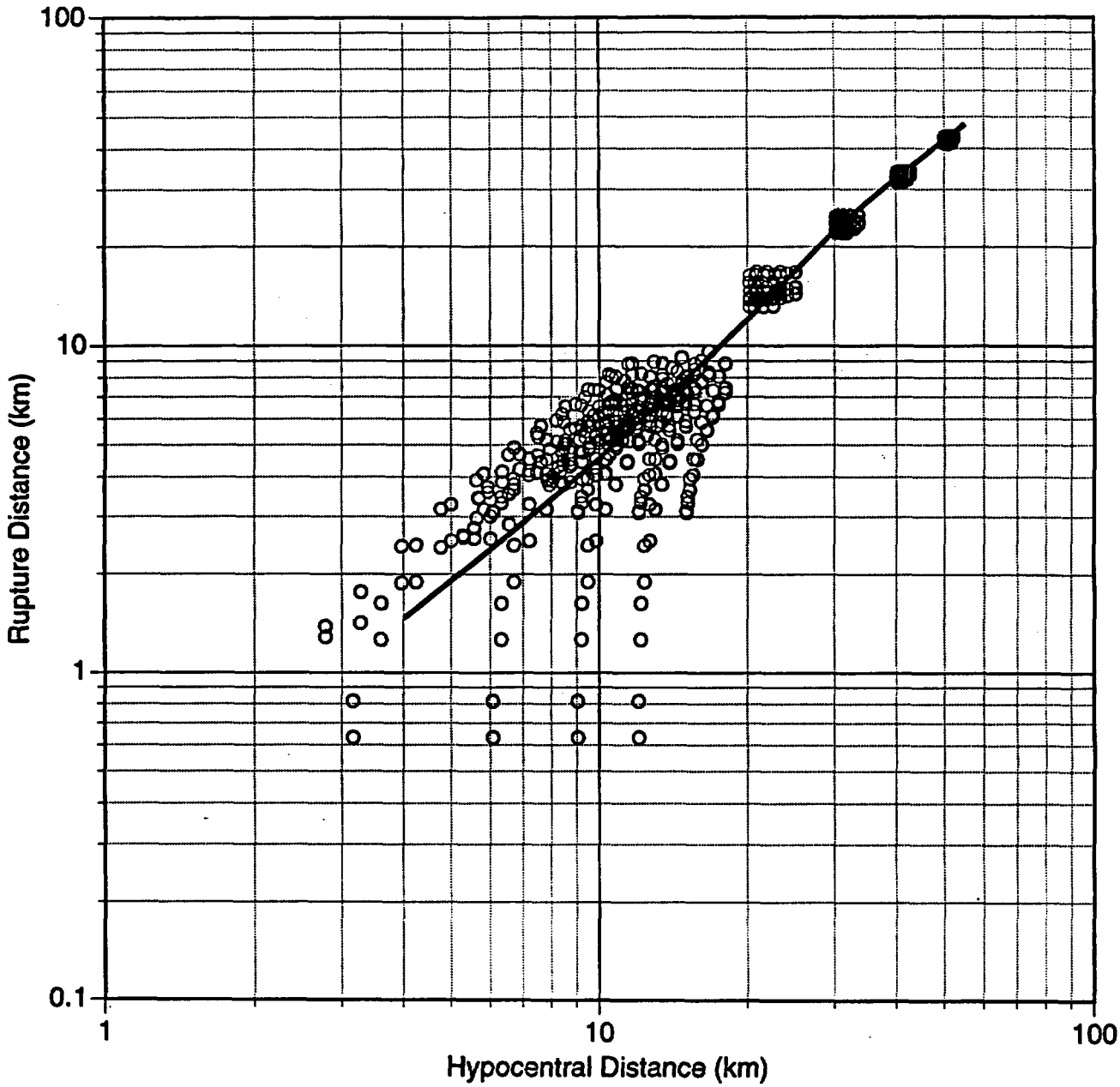

Figure J-4c Model of the mean rupture distance versus hypocentral distance for M_W 6.5 for T = 0.25

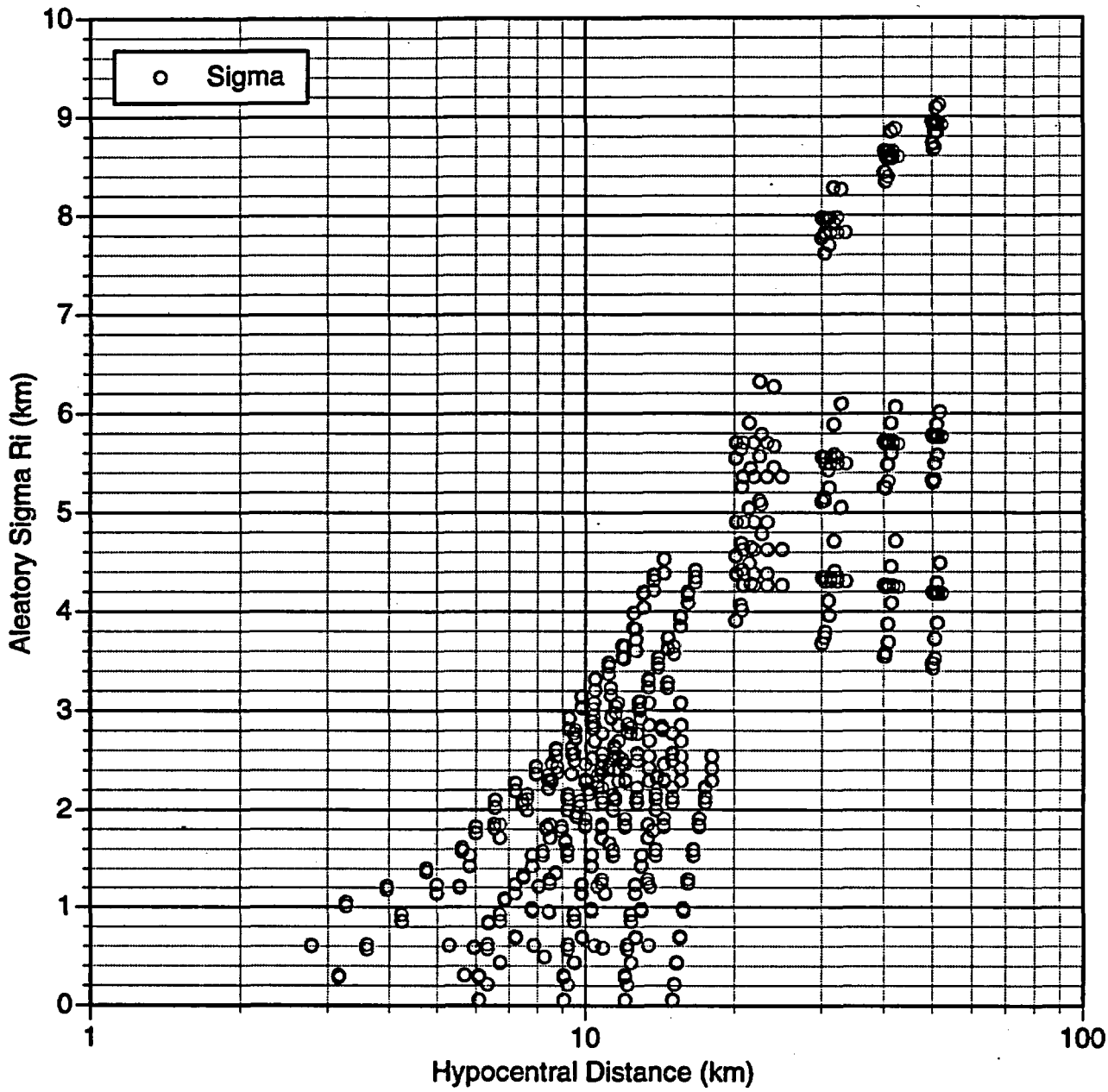

Figure J-5 Aleatory variability of the individual estimates of Ri given a hypocentral distance and M_W 6.5 and T = 0.25

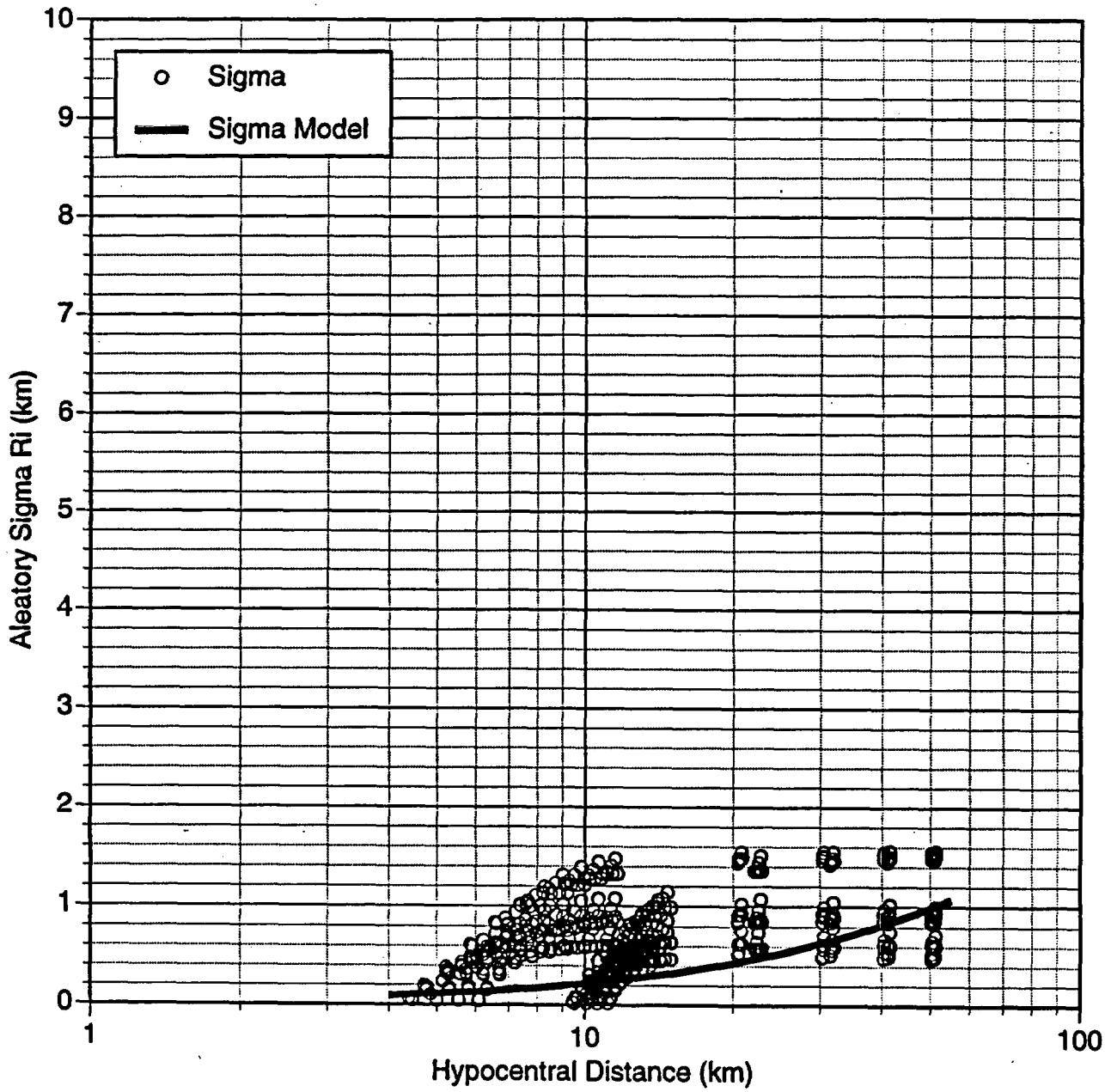

Figure J-6a Aleatory variability of the individual estimates of Ri given a hypocentral distance and M_W 5.0 and T = 0.25

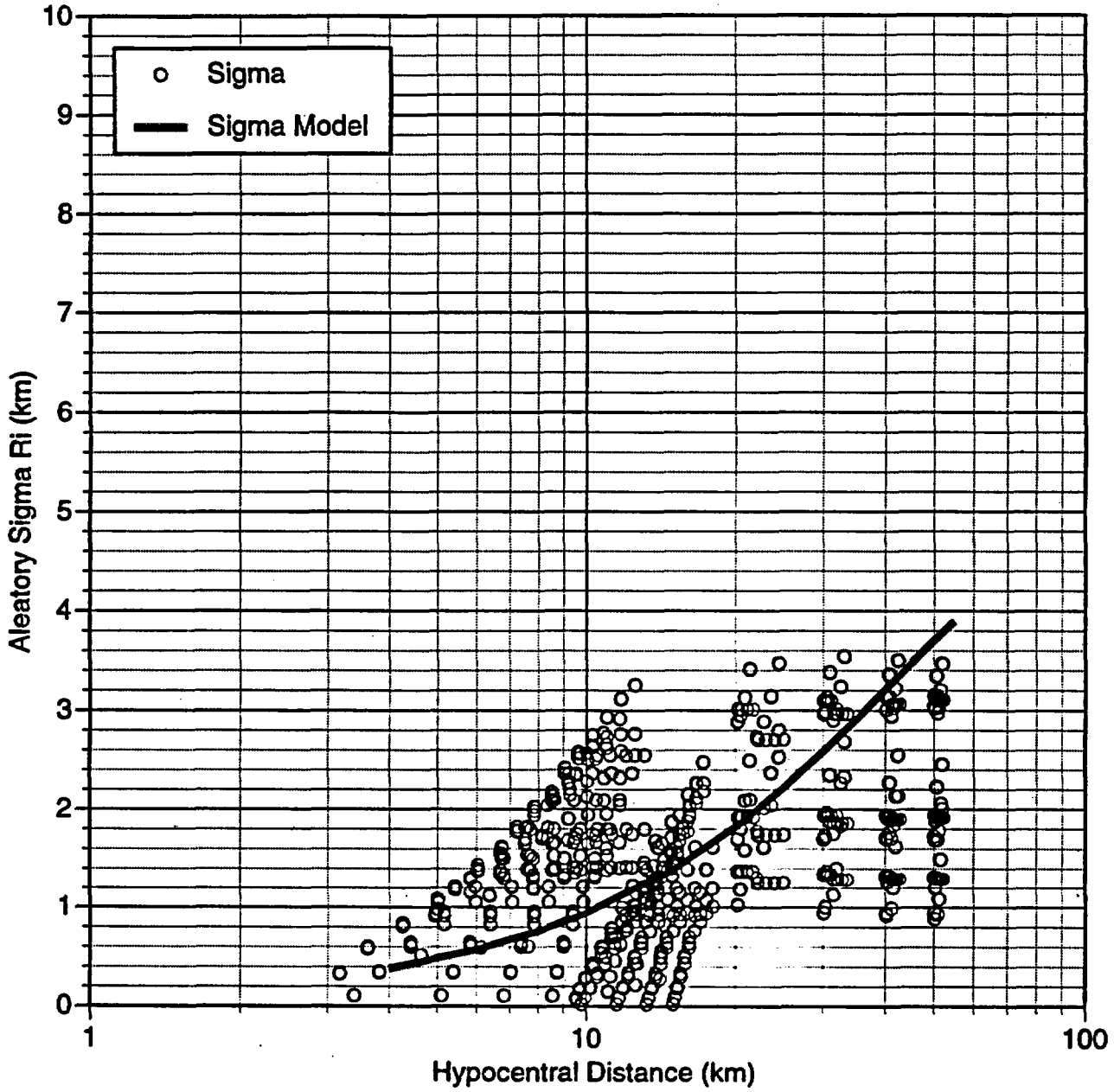

Figure J-6b Aleatory variability of the individual estimates of Ri given a hypocentral distance and M_W 5.8 and T = 0.25

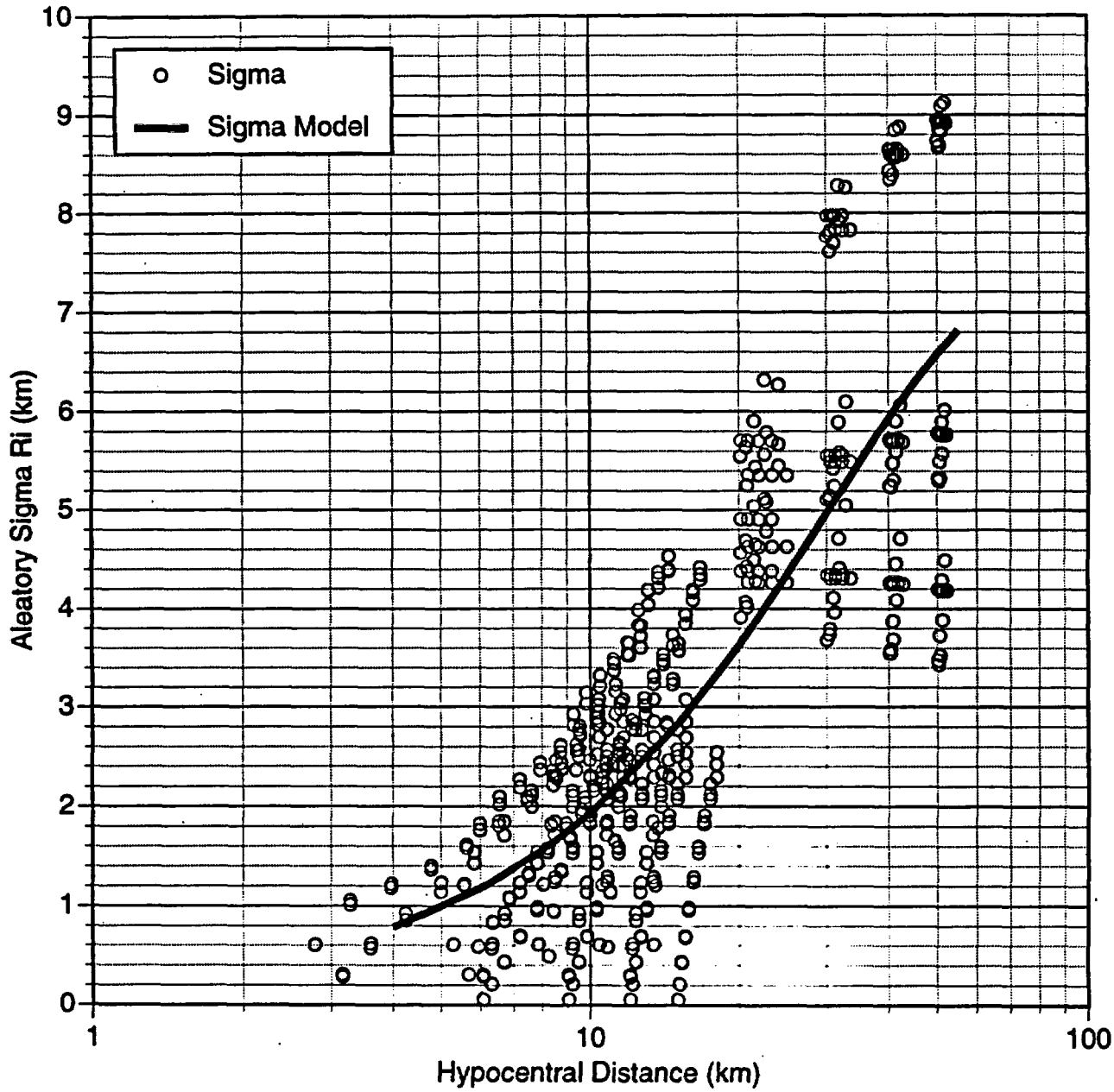

Figure J-6c Aleatory variability of the individual estimates of Ri given a hypocentral distance and M_W 6.5 and T = 0.25

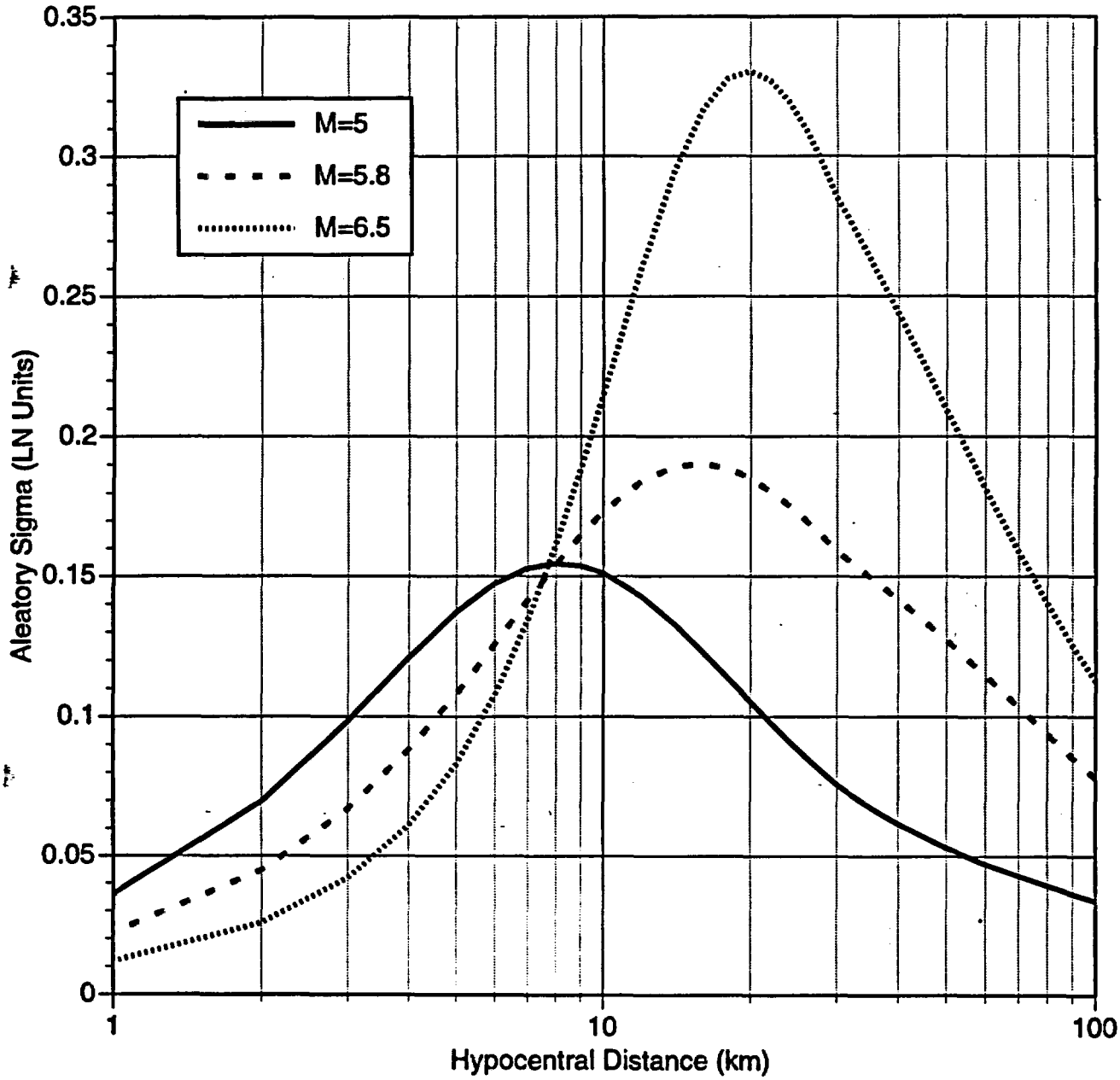

Figure J-7 Example of additional aleatory variability (Sigma hypo) in the natural log ground motion due to hypocentral distance. This is added (using SRSS) to the aleatory variability given by the experts. This example is for horizontal PGA using the Anderson model

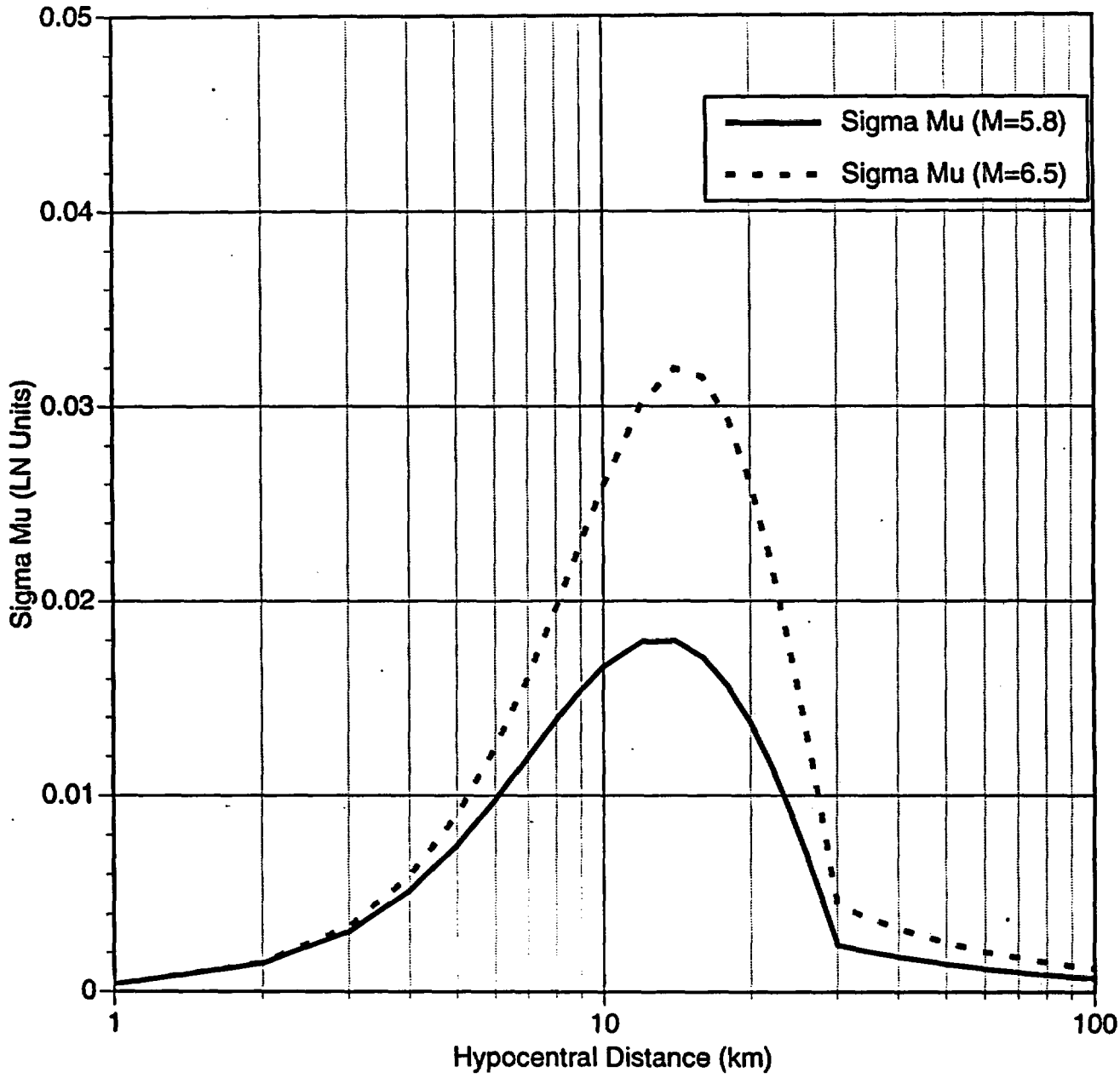

Figure J-8 Example of epistemic uncertainty in the median natural log ground motion due to uncertainty in the T value (depth distribution of hypocenters). This example is for horizontal PGA using Anderson's results. This additional epistemic uncertainty is negligible.

APPENDIX K

YUCCA MOUNTAIN PROJECT RECORDS AND DATA TRACKING INFORMATION FOR DATA USED AND CITED WITHIN THE REPORT

APPENDIX K

YUCCA MOUNTAIN PROJECT RECORDS AND DATA TRACKING INFORMATION FOR DATA USED AND CITED WITHIN THE REPORT

Planning documentation for the U.S. Department of Energy Level 3 Milestone, SP32IM3, *PSHA Final Report*, contained milestone description/completion criteria that governed the report's technical and regulatory content. A complete listing of these criteria is found in Appendix L, Table L-1. Appendix K was created to respond specifically to two criteria excerpted from Table L-1: (1) The Q status of the data used and cited in the report will be appropriately noted and (2) within the report's Reference Section, references to data used in the report will include record Accession Numbers or Data Tracking Numbers, when available. Since the report is organizationally complex and is structured to contain multiple reference sections within the chapters and appendices the references from all sections were examined for identification of data used and those identified were compiled into a single reference section. This reference section, Appendix K, simplifies a user's search for data information.

Once the data references were compiled, the Yucca Mountain Project Records Information System (RIS) and Automated Technical Data Tracking (ATDT) system data bases were searched to determine if a reference resided in the YMP records and/or data archives. Based on the information found for each reference the Q or non-Q status of the data was determined. Appendix K contains the results of the RIS and ATDT data base searches. The data information in the section is formatted so that the first number recorded after a reference is the record's accession number. An accession number is in the form, XXX.NNNNNNNN.NNNN, where X is a letter and N is a number. The data tracking number (DTN) follows the accession number. The DTN is always 18 characters (including the decimal located fourth place from the left) of varied alpha-numeric combinations. Multiple accession and/or data tracking numbers for one reference are possible. The DTN is followed by the Q status of the reference. No numbers are recorded if a reference could not be located in either database. Such a reference is assigned a non-Q status. Where a reference contains no identifying numbers and it is known to have been a Yucca Mountain Project

investigation controlled under a quality assurance program, the status is designated Q followed by a question mark. Question marks are also associated with identification numbers for which the data base information had a strong relation to but did not correspond exactly with the given reference.

Multiple citations were found within the seismic source fault displacement expert elicitation summaries (Appendix E) that referred to data obtained from PSHA workshop presentations. Such citations are not clearly defined references and do not contain enough information to perform a successful database search. The PSHA report contains several sections of information pertaining to the workshops and presentations (Chapters 2.0 and 3.0, and Appendices C and D). All material handed out to the experts as part of the workshop presentations has been compiled for submittal to the YMP Reports Processing Center (RPC) as a record. After processing, accession numbers will be assigned to the records by the RPC.

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APPENDIX L

MILESTONE SP32IM3
DESCRIPTION/COMPLETION CRITERIA
COMPLIANCE LOCATION

APPENDIX L

MILESTONE SP32IM3 DESCRIPTION/COMPLETION CRITERIA COMPLIANCE LOCATION

Delivery of this report, *Probabilistic Seismic Hazard Analyses for Fault Displacement and Vibratory Ground Motion at Yucca Mountain*, to the U.S. Department of Energy fulfills the requirements of Level 3 Milestone, SP32IM3, PSHA Final Report. The determination of ground motion and fault displacement hazards coupled with the technical and regulatory requirements of the milestone ensured that the report would be of sizable length and complex organization. In recognition of these factors, Table L-1 has been prepared to assist the DOE with the performance of a timely review and approval process for the deliverable report. The table presents the original milestone description/completion criteria for the deliverable excerpted from the 1996 *Yucca Mountain Site Characterization Project Planning and Control System Summary Account Planning Sheet* for Summary Account 0G32836FB1, *Conduct Probabilistic Seismic Hazards Analysis*. Text location information is proviided in the table to assist in determining report compliance with the identified criteria. Attachments L-1 and L-2 of this appendix are copies of forms and letters requested by the DOE as evidence of further compliance with Milestone SP32IM3 criteria. Attachment L-3 is a copy of the letter submitted to DOE citing completion of 1998 Level 3 Milestone SPG28MM3 relating to the completion of this report.

TABLE L-1
MILESTONE DESCRIPTION/COMPLETION CRITERIA
For Level 3 Milestone SP32IM3
Probabilistic Seismic Hazard Analyses Final Report

Milestone Description/Completion Criteria	Compliance Location
The report will provide quantitative hazard results that will form the basis for developing seismic design inputs for the potential repository and that will support assessments of its long-term performance with respect to waste containment and isolation.	This report, *Probabilistic Seismic Hazard Analyses for Fault Displacement and Vibratory Ground Motion at Yucca Mountain, Nevada,* provides quantitative hazard results and was developed to support assessments of long-term performance with respect to waste containment and isolation.
The hazard results will be in the form of annual probabilities with which various levels of fault displacement and vibratory ground motion are expected to be exceeded for a rock site at the surface.	**Chap. 7.0, Sec. 7.3,** Integrated Results **Chap. 8.0, Sec. 8.2** Note: The "rock site at the surface" is a reference rock outcrop at the ground surface.
The report will describe the process used in carrying out the probabilistic seismic hazard assessment including the selection process for experts, the workshop process to facilitate review of data and interpretations, and the elicitation process to formally document interpretations.	**Chap. 2.0,** Process for Eliciting Expert Evaluations **Chap. 3.0, Secs. 3.2,** Seismic Source and Fault Displacement Workshops, and **3.3,** Elicitation of SSFD Experts **Chap. 5.0, Sec. 5.3,** Ground Motion Workshops and Meetings **Appendix C,** Summaries of Seismic Source and Fault Displacement Characterization Workshops **Appendix D.** Summaries of Ground Motion Characterization Workshops **Chap. 5.0, Sec. 5.1,** Expert Elicitation Process

TABLE L-1
MILESTONE DESCRIPTION/COMPLETION CRITERIA
For Level 3 Milestone SP32IM3
Probabilistic Seismic Hazard Analyses Final Report

Milestone Description/Completion Criteria	Compliance Location
The report and process will be consistent with the PSHA Project Plan.	The PSHA process and the final report were developed consistent with the Project Plan, YMP-USGS-EE-9701, R0, *Probabilistic Analysis of Fault Displacement and Vibratory Ground Motion and the Development of Seismic Design Basis for Yucca Mountain.* Feedback workshops in addition to those outlined in the Project Plan were found to be necessary to accommodate difficulties with characterization of fault displacement.
The report will include documentation of interpretations and uncertainties used as input to the hazard calculation including the data, analyses, and reasoning upon which they are based.	**Appendix E,** Seismic Source and Fault Displacement Expert Elicitation Summaries **Appendix F,** Ground Motion Expert Elicitation Summaries
The fault displacement and seismic source characterization interpretations will include: a. the spatial distribution of active faults or seismic source zones b. the rate of occurrence and relative size distribution of future earthquakes c. the relation of fault displacement and secondary faulting to magnitude d. the dependency among seismic sources, if any	Items a, b, and d: **Chap. 4.0, Sec. 4.3.1,** Seismic Source Characterization Item c: **Chap. 4.0, Sec. 4.3.2,** Fault Displacement Characterization All items: **Appendix E,** Seismic Source and Fault Displacement Expert Elicitation Summaries
For ground motion characterization, the interpretations will describe the expected amplitude of ground motion as a function of magnitude and source-to-site distance.	**Chap. 5.0,** Ground Motion Characterization Facilitation Approach **Chap. 6.0,** Ground Motion Attenuation Relations **Appendix F,** Ground Motion Expert Elicitation Summaries

TABLE L-1
MILESTONE DESCRIPTION/COMPLETION CRITERIA
For Level 3 Milestone SP32IM3
Probabilistic Seismic Hazard Analyses Final Report

Milestone Description/Completion Criteria	Compliance Location
Documentation of the interpretations and uncertainty evaluations for each expert or team of experts will be included as appendices to the report.	**Chap. 4.0, Sec. 4.3,** Expert Team Models **Chap. 5.0, Sec. 5.6,** Experts Point Estimates **Appendix E,** Seismic Source and Fault Displacement Expert Elicitation Summaries **Appendix F,** Ground Motion Expert Elicitation Summaries **Appendix I,** Results of Attenuation Regression Analyses
The report will include documentation of the computational procedures used to calculate the hazard, the hazard results, and discussion of hazard curves, including the mean curve and various percentiles of the distribution.	**Chap. 7.0, Secs. 7.1,** Basic PSHA Model, **7.2,** Implementation of Methodology In This Study, **7.3,** Integrated Results, and **7.4,** Sensitivity Results **Chap. 8.0, Sec. 8.2**
The report will be accompanied by a letter recommending which Site Characterization Analysis comments and Topical Report open items might be closed or partially addressed by results of the PSHA. QA controls involved in the PSHA process will also be described in the letter or in the report itself.	**Attachment L-1 of Appendix L,** Milestone SP32IM3 Description/Completion Criteria Compliance Location QA controls: **Chap. 1.0, Sec. 1.6,** Quality Assurance
This deliverable will be prepared in accordance with OCRWM-approved QA procedures implementing requirements of the Quality Assurance Requirements Description.	**Chap. 1.0, Sec. 1.6,** Quality Assurance

TABLE L-1
MILESTONE DESCRIPTION/COMPLETION CRITERIA
For Level 3 Milestone SP32IM3
Probabilistic Seismic Hazard Analyses Final Report

Milestone Description/Completion Criteria	Compliance Location
The report will be developed on the basis of the best technical data, including both Q and non-Q data. The Q status of data used and cited in the report will be appropriately noted.	The SSFD expert teams and GM experts were provided with the best technical data available as summarized in **Appendix B**, Data Packages Distributed to Experts, and provided during workshop presentations (**Appendix C**, Summaries of Seismic Source and Fault Displacement Characterization Workshops, and **D**, Summaries of Ground Motion Characterization Workshops). The Q status of the data used and cited in the report is noted in **Appendix K, YMP** Records and Data Tracking Information for Data Used and Cited Within the Report.
Stratigraphic nomenclature used will be consistent with the Reference Information Base Section 1.12 (a): Stratigraphy - Geologic Lithologic Stratigraphy.	Stratigraphic nomenclature where cited within the report adheres to Reference Information Base Section 1.12 (a): Stratigraphy – Geologic Lithologic Stratigraphy.
Within the report's Reference Section, references to data used in the report will include record Accession Numbers or Data Tracking Numbers, when available.	Because of its organizational complexity, the PSHA report is structured to contain multiple reference sections within the chapters and appendices. Chapter 9 is a limited reference list applicable only to the main body of the report and does not incorporate references from the appendices. To simplify the search for the required information **Appendix K, YMP** Records and Data Tracking Information for Data Used and Cited Within the Report, was developed. Appendix K compiles the appropriate references for the data used within the report with their Accession and Data Tracking Numbers, where available.

TABLE L-1
MILESTONE DESCRIPTION/COMPLETION CRITERIA
For Level 3 Milestone SP32IM3
Probabilistic Seismic Hazard Analyses Final Report

Milestone Description/Completion Criteria	Compliance Location
Technical data contained within the deliverable and not already incorporated in GENISES will be submitted for incorporation in accordance with YAP-SIII.3Q. Verification of technical data submittal compliance will be demonstrated by including as part of the deliverable: a) a copy of the Technical Data Information Form generated identifying the data in the Automated Technical Data Tracking system and b) a copy of the transmittal letter attached to the technical data transmittal to GENISES Administrator.	The technical data contained within the deliverable and not incorporated in GENISES was examined by the USGS YMPB Data Coordinator. Based on this examination and discussions with the PSHA Management Team the Data Coordinator determined that the data were not appropriate candidates for incorporation in GENISES. A Technical Data Information Form was generated to track the data, however, and a copy of the TDIF is located in **Attachment L-2 of Appendix L,** Milestone SP32IM3 Description/Completion Criteria Compliance Location. The data have been identified as appropriate for submittal to the Reference Information Base in accordance with YAP-SIII.3Q and the process for submittal has been initiated.
Deliverable will be processed in accordance with YAP-5.1Q.	The USGS Yucca Mountain Project Branch Project Control Group has prepared a Document Action Request (DAR) in accordance with YAP-5.1Q. The DAR accompanies the submittal of this report to the U.S. Department of Energy. Further processing of the deliverable in compliance with the YAP is the responsibility of the DOE.

APPENDIX L

ATTACHMENT L-1

SITE CHARACTERIZATION ANALYSIS COMMENTS AND TOPICAL REPORT OPEN ITEMS ADDRESSED BY THE RESULTS OF THE PSHA

ATTACHMENT L-1

SITE CHARACTERIZATION ANALYSIS COMMENTS AND TOPICAL REPORT OPEN ITEMS ADDRESSED BY RESULTS OF PSHA

Introduction

This response to Level 3 Milestone SP32IM3 description/completion criteria (see Table L-1) recommends closure of certain Site Characterization Analysis (SCA) comments and Topical Report (TR) open items posed to the U.S. Department of Energy (DOE), Yucca Mountain Project, regarding Key Technical Issue on Structural Deformation and Seismicity at the potential repository, Yucca Mountain, Nevada. Bases for closure are results of recently completed assessments including, but not limited to, (1) the U.S. Geological Survey (USGS) report *Seismotectonic Framework of Yucca Mountain* (1996), which compiles and synthesizes geologic and seismotectonic data collected over the many years of site characterization studies at Yucca Mountain; (2) all of the workshops, field trips, and proceedings associated with the Probabilistic Seismic Hazard Analysis (PSHA), Expert Elicitation Project, particularly what is referred to here as the PSHA Report; and (3) the Deterministic Seismic Hazard Analysis (DSHA) Report by Menges et al. (1997).

The scope pertains to five open items within the subissue Fault Slip, which is one of four subissues of importance to total system performance assessment as outlined by staff of the U.S. Nuclear Regulatory Commission (NRC) (NUREG-1347, 1989). Items are organized numerically by Comment and Question according to certain unresolved comments listed in the Issue Resolution Status Report (Key Technical Issue: Structural Deformation and Seismicity), Revision 0, dated November 12, 1997. Numbers in parentheses refer to page numbers cited from NUREG-1347, NRC Staff Site Characterization Analysis of the DOE's Site Characterization Plan, Yucca Mountain Site, Nevada, 1989. Cited references can be found in the bibliographies of the USGS Seismotectonic Framework Report, the PSHA or DSHA Reports.

Comments and Issues Addressed

COMMENT 59 Sequencing Fault Investigations

"The information presented for the program of investigations for faulting does not allow the NRC staff to determine what investigations will actually be conducted. In addition, the sequencing of many geophysical and geologic activities related to faulting may lead to data collection activities that are inadequate to support assessments of performance and design bases." (p. 4-53)

Nearly all planned and relevant geologic and geophysical investigations outlined in the SCP have been completed, and the sequencing of fault investigations and related activities was continually reexamined as site characterization activities proceeded. As new information was available, or, as supplemental data were developed from other studies, certain investigations of the preclosure tectonic program (Section 8.3.1.17) were revised. Revisions in the strategy and sequencing of planned activities have been, and continue to be, published in semiannual site characterization Progress Reports.

Appendix A of Progress Report #16 describes some of the changes to the site characterization program, including Integration of Geophysical Activities (App. A, page A-38). A comprehensive geophysical testing program was conducted in Study 8.3.1.4.1.2 (formerly Study 8.3.1.4.2.1.6 in the SCP) as presented in the 1990 and 1995 Geophysics White Paper (DOE, 1990; Oliver et al., 1995). Most of the standard and prototype testing programs outlined by the DOE (1990) were conducted, including some enhancements to the original plans, for example vertical seismic profiling. The DOE has collected, analyzed, and synthesized nearly 23 miles of deep seismic reflection profiling, 35 miles of high-resolution shallow reflection profiling, and coincident magnetic and gravity data. These investigations are summarized in Majer et al. (1996) and Brocher et al. (in press). In addition, the Center for Nuclear Waste Regulatory Analyses (CNWRA) has collected and analyzed gravity and magnetic data in the vicinity of Yucca Mounntain as described in various reports by lead authors of the CNWRA, such as D.A. Ferrill or J.A. Stamatakos.

The PSHA expert elicitation made special efforts to ensure all expert teams had full access to all available data and existing interpretations in the published and unpublished literature. Specifically, investigators from many different organizations having data or interpretations pertaining to the identification or characterization of potential seismic and volcanic sources presented their analyses and distributed resource materials at each of the PSHA workshops, field trips, and meetings. In addition, several local and regional fault compilations have been examined iteratively in efforts to identify and characterize accurately all potential seismic sources in the region. This inventory of all known and suspected Quaternary faults was, and continues to be, analyzed with deterministic methods to identify seismic sources relevant to the PSHA and other assessments. The results were provided to the PSHA expert teams as they integrated and synthesized available data for each fault during the process of seismic source characterization. These efforts are described in the PSHA Report as well as the USGS Seismotectonic Framework Report and DSHA Report.

COMMENT 61 Location of New Faults

"The program of investigations for faulting appears to assume that any future faulting will follow old faulting patterns. The NRC staff considers that this is not a reasonably conservative assumption, and does not consider that this assumption is technically justified." (p. 4-55)

The PSHA project has two parts: seismic source characterization (SSC) related to vibratory ground motion analysis and SSC related to fault displacement analysis. The PSHA project consulted the expert teams to develop methodologies for assessing the total probability of faulting at any site, including one in which there is no pre-existing fault (see logic trees in PSHA Report). Methodologies are developed for assessing the amounts and probabilities of displacement associated with both principal and distributed fault ruptures. Several discussions during PSHA workshops and field trips considered the potential for hidden faults, the validity of distributed rupture scenarios, and the potential for new faulting. These efforts are described in the PSHA Report.

COMMENT 63 Integrating Fault Data

"The information presented for the program of investigations for study of faulting at the surface facilities does not appear to have integrated pre-existing information and makes assumptions about pre-existing information and ongoing investigations which the NRC cannot evaluate because the NRC has not seen the background information." (p. 4-56)

Appendix A of Progress Report #16 states that existing geological and geophysical data were evaluated and used to plan the location and character of future data-gathering activities, both at the site and in the region nearby. For example, on the basis of existing data near prospective surface facilities (Gibson et al., 1990, 1992), an ambitious program of trenching, mapping, and other investigations was conducted (USGS Seismotectonic Framework Report; Simonds et al., 1995; Swan et al., in press). The PSHA expert teams evaluated fault displacement probabilities (at several sites, many near-potential repository surface facilities) by integrating and analyzing all of the results and data available from remote sensing, geologic mapping, trenching, drilling, seismicity and geophysical investigations, as well as from other studies, both local and regional in scope, by a variety of technical experts. Available and requested additional data used by the PSHA experts to evaluate fault displacement at the prospective surface facility, as well as other sites, are documented in the PSHA Report.

COMMENT 69 Northwest-Trending Faults

"The SCP does not appear to integrate and synthesize data resulting from the planned activities characterizing northwest-trending faults." (p. 4-61)

Several investigations involved compilation, mapping, and selected trenching of all faults within the site area that have known or suspected Quaternary movements, including northwest-trending faults; and those that have been trenched lack evidence for Quaternary slip (USGS Seismotectonic Framework Report). The structural geology and Neogene activity of all faults in the Yucca Mountain block have been repeatedly mapped and examined closely (Christiansen and Lipman, 1965; Lipman and McKay, 1965; Scott and Bonk, 1984; Simonds et al., 1995; Day et al., 1996; Potter et al., 1996; Swan et al., in press), including correlations of surface mapping with fault and fracture zones exposed in the subsurface exploratory drifts (Sweetkind et al., 1996). In addition, regional studies and

compilations examined and characterized such faults over wide areas within a 100-km radius of the Yucca Mountain site (Anderson, Bucknam et al., 1995; Anderson, Crone et al., 1995; Klinger and Piety, 1996; Piety, 1996). The PSHA expert teams integrated and analyzed data from these and other studies during the seismic source characterization of all known and suspected Quaternary faults, including local and regional northwest-trending faults. The DSHA report includes a complete inventory of such faults and their potential deterministic ground motions at the Yucca Mountain site.

COMMENT 71 Significant Fault

"The tentative goal, design parameter, and expected value relating faulting (e.g., "significant Quaternary fault") and performance allocation for System Element 1.1.2 are not sufficient for adequately characterizing the hazard posed by faulting in the repository." (p. 4-61)

The probabilistic fault displacement analyses for sites within the repository block are based on several different methods that utilized several different data sets having interdependent relations, such as displacement per event, interevent recurrence interval, and fault slip rate, as well as fault length, width, and structural setting (PSHA Report). The different data sets and methodologies are synthesized into alternative tectonic models with which the PSHA expert teams account for uncertainties in the existing data, such as for different estimates of the lateral components of fault displacement and, hence, slip rates. The experts interpretations of the interrelationships among local faults and of alternative tectonic models are accounted for in the hazard curves (see logic trees in PSHA Report). The actual repository design and construction are in part based on the geologic and geophysical characterization of that particular fault zone (DOE Seismic Topical Reports I, II, and III).

APPENDIX L

ATTACHMENT L-2

Copy of the Technical Data Information Form identifying the data contained within the deliverable in the Automated Technical Data Tracking system.

YMP-023-R4
05/06/96

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
TECHNICAL DATA INFORMATION

(Check one): [X] ACQUIRED DATA *(complete Parts I and II)*
Data Tracking Number (DTN): GS980283117362.001

[ ] DEVELOPED DATA *(complete Parts I, II and III)*
Data Tracking Number (DTN): _____

PART I Identification of Data

Title/Description of Data: PROBABILISTIC SEISMIC HAZARD ANALYSES FOR FAULT DISPLACEMENT AND VIBRATORY GROUND MOTION AT YUCCA MOUNTAIN, NEVADA. I.G. WONG AND J.C. STEPP, REPORT COORDINATORS - TECHNICAL REPORT 1

Principal Investigator (PI): WHITNEY, J W
Last Name First and Middle Initials

PI Organization: U.S. GEOLOGICAL SURVEY

Are Data Qualified?: [X] Yes [ ] No Governing Plan: SCP

SCPB Activity Number(s): 8.3.1.17.3.6.1

WBS Number(s): 1.2.3.2.8.3.6

PART II Data Acquisition/Development Information

Method: NUREG-1563, BRANCH TECHNICAL POSITION ON THE USE OF EXPERT ELICITATION IN THE HIGH-LEVEL RADIOACTIVE WASTE PROGRAM, AND YMP-USGS-QMP-3.16.R0, SCIENTIFIC EXPERT ELICITATION. CALCULATIONS FOR EXPERT INTERPRETATIONS AND FINAL SEISMIC HAZARD CURVES FOR THE YUCCA MOUNTAIN SITE WERE DEVELOPED THROUGH THE USE OF RISK ENGINEERING INC. SOFTWARE PROGRAMS FRISK88, PREP88, POST88, AND MRE88.

Location(s): USGS, DENVER, CO

Period(s): 4/1/95 to 2/19/98
From: MM/DD/YY To: MM/DD/YY

Sample ID Number(s): _____

PART III Source Data DTN(s)

_____ _____ _____
_____ _____ _____
_____ _____ _____

Comments

SUBJECT TO REVISION

Checked by: Patricia G. Sheaffer 2/20/98
Signature Date

YAP-SIII.3Q.1

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
TECHNICAL DATA INFORMATION
CONTINUATION SHEET

SCPB Activity Number(s) (continued)

8.3.1.17.3.6.2

Location(s) (continued)

WOODWARD-CLYDE FEDERAL SERVICES, OAKLAND, CA

APPENDIX L

ATTACHMENT L-3

Copy of letter to the U.S. Department of Energy fulfilling completion requirements of Level 3 Milestone, SPG28MM3, *Letter to DOE: PSHA Final Report Completed.*

United States Department of the Interior

U.S. GEOLOGICAL SURVEY

Yucca Mountain Project Branch
1180 Town Center Drive
Las Vegas, NV 89134

WBS#: 1.2.3.2.8.3.6
INFORMATION ONLY
February 23, 1998

Stephan J. Brocoum
Assistant Manager for Licensing
Yucca Mountain Site Characterization Office
U.S. Department of Energy
P.O. Box 30307
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Attention: Tim Sullivan

Subject: Completion of Fiscal Year 1997 Level 3 Milestone SP32IM3: PSHA Final Report and Completion of Fiscal Year 1998 Level 3 Milestone SPG28MM3: Letter to DOE: PSHA Final Report Completed

Fiscal Year 1997 Level 3 Milestone, SP32IM3, baseline date 8/29/97, has been completed. The PSHA Final Report titled, *Probabilistic Seismic Hazard Analyses for Fault Displacement and Vibratory Ground Motion at Yucca Mountain, Nevada,* was submitted to DOE on February 23, 1998. The milestone report has not received USGS Director's approval at this time. Therefore, the document should not be distributed outside of the Yucca Mountain Project nor should it be cited. Obtaining Director's approval is the subject of 1998 Level 3 Milestone SPG28NM3: Director's Approval PSHA Final Report, due 7/17/98.

Submittal of the PSHA final report concurrent with the submittal of this letter to the DOE meets the milestone requirements for completion of Fiscal Year 1998 Level 3 Milestone SPG28MM3.

If you have any questions, please call me at 295-5456.

Sincerely

Robert W. Craig

Robert W. Craig
Technical Project Officer
U.S. Geological Survey
Yucca Mountain Project Branch

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