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# A PRELIMINARY ASSESSMENT OF EARTHQUAKE GROUND SHAKING HAZARD AT YUCCA MOUNTAIN, NEVADA AND IMPLICATIONS TO THE LAS VEGAS REGION

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## ABSTRACT

As part of early design studies for the potential Yucca Mountain nuclear waste repository, we have performed a preliminary probabilistic seismic hazard analysis of ground shaking. A total of 88 Quaternary faults within 100 km of the site were considered in the hazard analysis.

They were characterized in terms of their probability of occurring, fault geometry, maximum earthquake magnitude, recurrence model, and slip rates. Individual faults were characterized by maximum earthquakes that ranged from  $M_w$  5.1 to 7.6. Fault slip rates ranged from a very low 0.00001 mm/yr to as much as 4 mm/yr. An areal source zone representing background earthquakes up to  $M_w$   $6\frac{1}{4} \pm \frac{1}{4}$  was also included in the analysis. Recurrence for these background events was based on the 1904-1994 historical record, which contains events up to  $M_w$  5.6.

Based on this analysis, the peak horizontal rock accelerations are 0.16, 0.28, and 0.50 g for return periods of 500, 1,000, 2,000, and 10,000 years, respectively. The Basin and Range faults are the dominant contributor to the ground shaking hazard at Yucca Mountain because of the low slip rates of the Basin and Range faults. The reduction in peak accelerations on the probabilistic ground motions is due to the inclusion of a new attenuation relation developed specifically for earthquakes in extensional tectonic regimes (Spudich *et al.*, 1996). This relation gives significantly lower peak accelerations than five other California-based relations used in the analysis, possibly due to the low slip rates of extensional earthquakes compared to California events. Because Las Vegas is in the same tectonic regime as Yucca Mountain, the seismic sources and parameters are similar.

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affecting the seismic hazard at Yucca Mountain also have implications to Las Vegas. These ~~implications are discussed in this paper.~~

## INTRODUCTION

Yucca Mountain is located about 130 km northwest of Las Vegas (Figure 1) in the southern Great Basin of the Basin and Range province. As the proposed site of the nation's first nuclear waste repository, it has been the focus of extensive geological, seismological, and geophysical investigations for more than a decade. An objective of these studies is to provide basic information and data for the evaluation of potential seismic hazards and the development of appropriate seismic design criteria for facilities at Yucca Mountain. Based on the results of these studies, a *preliminary* probabilistic seismic hazard analysis of earthquake ground shaking has been performed. A final assessment of seismic hazards for Yucca Mountain is currently ongoing involving an evaluation of seismic sources, ground motions, and fault displacement by a panel of experts.

Because of their proximity, Yucca Mountain and the city of Las Vegas share some similarities with regard to potential seismic hazards. Specifically, some of the seismic sources that could generate ground shaking at Yucca Mountain could also affect Las Vegas. Additionally, the rate at which ground motions attenuate with distance should be similar for both areas. In this paper, we describe the results of our *preliminary* probabilistic seismic hazard analysis of Yucca Mountain and discuss its implications to Las Vegas and the surrounding vicinity.

### Approach

The probabilistic analysis described herein revises an earlier study performed for the

seismic sources and other input are included in the probabilistic analysis using log  
Discrete values of the source input parameters have been included along with an assessment of

## SEISMIC SOURCE CHARACTERIZATION

Two types of seismic sources were characterized in this analysis: Quaternary faults and an areal source representing "background" earthquakes not associated with the faults specifically modeled in this study.

### Quaternary Faults

Available geologic data show that 88 faults having known or suspected Quaternary ( $\leq 2$  Ma) activity are located within about 100 km of Yucca Mountain (Pezzopane, 1996; Keefer and Pezzopane, 1996) (Table 1; Figure 1). Within about 15 km of the site, 19 "local" faults have been identified of which 10 exhibit definitive evidence for Quaternary activity. Some of the faults may be structurally related, such that they may rupture together in a future event. In these cases, we have evaluated their structural settings and assigned weights to characterize this capability (see following section).

In general, the seismic source characterization of the local Yucca Mountain faults was the result of detailed paleoseismic investigations (Whitney *et al.*, 1996). Parameters for most of the regional faults (beyond a distance of 15 km) are from map compilations, literature reviews, and reconnaissance investigations (Piety, 1995; Anderson *et al.*, 1995a; 1995b) (Table 1).

### Seismogenic Capability

In this analysis, all known faults having documented or suspected geologic evidence of Quaternary displacement were considered as potential seismic sources. For the most part, the association of seismicity has not been a definitive criteria to classify faults as being seismogenic. To evaluate the range of possible seismic sources in the region, we have characterized the seismogenic capability for each fault. In this study, we have assessed seismogenic capability

based on two factors: 1) whether the fault is considered an independent seismogenic source one that is responsible for the principal seismic energy release; and 2) whether the fault is active or has been recently active, as determined by historical seismicity, fault offsets or a sharp geomorphic expression in young surficial deposits, or direct structural relation and kinematic connection with another active fault. These two factors, as explained below, were assessed for each fault using a weighting scheme wherein the product of the weights is the value in Table 1.

The structural setting and mapped length were the primary basis to weight each fault as to whether it could form an independent, co-dependent, or co-independent rupture. Independent and cumulative seismogenic sources are characterized by mapped traces longer than 15 km a

throws of hundreds of meters or more in Tertiary or younger deposits. These faults probably penetrate to seismogenic depths of 5 to 15 km. Independent seismic sources are commonly range-bounding or block-bounding faults that show repeated displacements in late Quaternary time. Co-dependent faults have continuous mapped lengths less than 5 km; sporadic, if any, evidence of Quaternary activity, and traces that usually merge with, and/or strike parallel to, and are in the immediate vicinity of a much longer (> 15 km) independent fault. Co-dependent faults probably move in structural association with and only when the nearby independent fault ruptures. Co-independent faults are characterized by mapped lengths ranging from 5 to 15 km and traces that usually merge with or form a smaller geometric fault segment of a much longer (independent) fault. Co-independent faults are thought to occasionally rupture simultaneously with the independent fault, and sometimes rupture randomly on their own.

According to this subjective structural evaluation, independent and likely co-independent faults were assigned weights ranging from 0.5 to 1.0 (Table 1). Co-dependent faults were assigned lower weights ranging from 0.1 to 0.5 because they are not likely to be principal sources of earthquakes. The weighting factor of independent versus co-dependent seismic sources accounts for possible fault segmentation models and thus, the relative likelihood that the fault

The main advantage of this scheme is to allow the possibility that short (< 10 km) faults within 10 km of Yucca Mountain could be

seismogenic capability is whether the fault has been active. For many of the regional faults, evaluation of whether they have not been mapped in detail or recognized from interpretations of aerial photography in the field. Even given detailed studies of fault activity, it is difficult to determine whether a fault is active in Quaternary time because complete stratigraphic sections including the fault traces are not preserved over the fault traces. Consequently, this study is based on the state of evidence for Quaternary fault activity.

Faults having documented Quaternary displacement are assigned a probability of activity of 1.0 if there is evidence to suspect but not conclusively demonstrate activity and probabilities of activity ranging from 0.1 to 0.9 based on geological evidence of young activity. These faults have clear displacements as seen on aerial photography and appear to offset topographic features. However, the faults or photolineaments have commonly been investigated in the field, which leads to equivocal interpretations of their activity. Faults that lack youthful-looking displacements or a sharp geomorphic signature, but for which no clear evidence of activity can be proved are assigned probabilities of activities less than 0.5 on the basis of the geological evidence of activity.

source could produce an earthquake independently allow the possibility that short (< 10 km) faults within 10 km of Yucca Mountain could be independent earthquake sources.

The second factor considered in the evaluation of whether a fault has been active. For some of the local and middle range faults, Quaternary movement is more uncertain because they have not been mapped in detail or recognized from interpretations of aerial photography in the field. Even given detailed studies of fault activity, it is difficult to determine whether a fault is active in Quaternary time because complete stratigraphic sections including the fault traces are not preserved over the fault traces. Consequently, this study is based on the state of evidence for Quaternary fault activity.

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## Fault Geometry and Sense of Slip

The mapped locations of local Yucca Mountain faults were generally adopted from Simonds *et al.* (1995). Although some of the faults were modified from their original geometry, the hazard calculations modeled all faults as single planes along-strike and downdip. The downdip geometry of almost all of the faults was used in this analysis. In all cases, three values of dip were chosen on the basis of the dominant sense of slip of the fault as seen from surface offsets and inferred from its tectonic setting. Predominantly normal-slip faults were assigned dips of 30°, 40°, and 50°, respectively (Table 1). Most strike-slip faults were assigned dips of 60°, 75°, and 90°; whereas some strike-slip and most normal-slip faults were assigned dips of 60°, 75°, and 90°, all weighted 0.3, 0.4, and 0.3, respectively. This also accounts for possible differences in the style of slip as reflected in different downdip geometries. Except for seismic events located within a few tens of km from the Yucca Mountain site, dip uncertainties contribute to variations in maximum magnitude values, which indirectly affect the ground motion values.

## Maximum Magnitudes

Maximum magnitude was derived from an empirical relation between surface rupture length and  $M_w$  determined by Wells and Coppersmith (1994) for all-slip events. The upper and lower maximum magnitude values in Table 1 account for the standard deviation of the empirical relation, taken here as  $\pm 0.3$  moment magnitude unit from the preferred value.

In determining maximum magnitudes for this analysis, we use the entire mapped length for each fault. This is a conservative choice because Quaternary displacement rarely is documented along the entire fault length and faults rarely rupture along their entire length. Thus, the maximum magnitudes determined for this analysis are likely conservative. For example, if a fault can rupture at most one-half of its length in an individual earthquake, the maximum magnitudes may be about 0.4 magnitude units too high. While conservatism is not normally appropriate in a probabilistic seismic hazard analysis, the preliminary nature of the study and our desire to simplify the calculations justify this choice.

The local Yucca Mountain faults permit many different interpretations of their rupture lengths and how they may connect and behave seismogenically (see "Seismogenic Capability"). Thus although maximum fault lengths of some of the shorter ( $\leq 5$  km) faults are proportional to  $M_w$  5.5 to 6.0 events (Table 1), it seems unlikely that they continue to seismogenic depths and act as independent seismogenic structures,

Simonds *et al.* (1995), and regional faults show slight curvature in many areas. The maximum magnitude for each fault is uncertain; hence a range of maximum magnitudes were chosen on the basis of the surface offsets and inferred from its tectonic setting. Dips of 45°, 60°, and 75°, and weights of 0.3, 0.4, and 0.3, respectively. The range of dip values was chosen insofar as the style of faulting is related to the source.

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given their relatively short lengths, close spacings, and possible terminations against the more prominent Quaternary faults.

### Earthquake Recurrence and Fault Slip Rates

Earthquake recurrence for the faults is assessed using both the truncated exponential (Gutenberg-Richter) and characteristic earthquake models. The seismic moment approach of Molnar (1979) and Anderson (1979) is employed with fault slip rates as a proxy for seismic moment rate to arrive at the recurrence for the truncated exponential model. We used the numerical model of Youngs and Coppersmith (1985) for the characteristic model.

In cases for which paleoseismic investigations indicate the characteristic recurrence model is more appropriate than the exponential model, we weight the characteristic model either 0.6 or 0.7 (Table 1). For many faults, however, no paleoseismic data are available. In these cases, the two recurrence models are assumed to be equally valid (weighted 0.5 each; Table 1).

Three values of fault slip rate were characterized for each fault (Table 1) on the basis of available geologic and paleoseismic studies: a preferred rate and an upper- and lower-bound. The preferred slip rate was assigned a weight of 0.6, whereas the upper- and lower-bound values were weighted 0.2 each. Yucca Mountain faults have been trampled at numerous sites, and the number, size, and age of displacement for events have been determined for all of the longer faults. Paleoseismic studies have been performed for two more distant seismic sources, the Rock Valley and Furnace Creek faults. The results of many different absolute and relative dating techniques, including hundreds of uranium-series, thermoluminescence, ash lithology "fingerprinting", and geochronologic analyses, have helped to assess the age of paleoearthquakes and fault slip rates. The most up-to-date and complete summary of the paleoseismic study results for all Quaternary faults in the site vicinity is contained in Whitney *et al.* (1996). Most of the known Quaternary faults in the Yucca Mountain vicinity have slip rates on the order of 0.001 to 0.01 mm/yr, whereas regional faults have rates ranging from a presumed low of 0.00001 mm/yr to as much as a well-determined 4 mm/yr.

The level of study of known and suspected Quaternary faults at distances greater than about 25 km from Yucca Mountain decreases with increasing distance from Yucca Mountain, except for several of the longer and potentially more significant faults, including the Death Valley and Furnace Creek faults (within 55 km of Yucca Mountain) and the Rock Valley-Springs fault system. Reconnaissance studies of several of these faults as available data from previous studies are described in Anderson *et al.* (1995b), and Piety (1995). Slip rate information for these faults are described in Whitney *et al.* (1996).

Faults for which no slip rate information is available, either because the fault may not be active or there have been no field studies, were assigned slip rates on the basis of interpretations of aerial photographs and geomorphic comparisons to other faults for which some slip rate data exist. In many cases, the uncertainty in slip rate ranges over two orders of magnitudes. Included in this category are some of the local faults that do not show evidence of Quaternary displacement but may have a small probability of seismogenic capability (e.g., Ghost Dance and Sundance faults), as well as some that are buried (e.g., Midway Valley, Drill Hole Wash faults) and some that may not even be faults (e.g., Yucca Wash fault?). Many more regional faults appear on air photos to have scarps in Quaternary deposits, but they simply lack detailed studies and, hence, slip rate data. In many cases, the overall minimum to maximum slip rate values range between two orders of magnitude (Table 1). As will be discussed below, only a few of these regional faults contribute to the probabilistic hazard at Yucca Mountain at return periods less than 100,000 years.

### Background Earthquakes

To account for the hazard from background earthquakes that are not associated with the known mapped faults already considered in the study, an areal source encompassing the region within 100 km of Yucca Mountain was incorporated into the hazard analysis (Figure 2). This background source also includes the seismicity that may be associated with shorter (<10 km long) known regional faults that have not been specifically included in the probabilistic analysis because of their small contribution to hazard (due to their greater distance and smaller maximum magnitude).

In characterizing the background source, the 100-km radius area around Yucca Mountain was considered to be, to first order, uniform in terms of its tectonic, geologic, and seismologic

characteristics. A uniform distribution of events in the depth range of 0 to 15 km was also assumed. This depth distribution is consistent with observations from the Southern Great Basin seismographic network (Rogers *et al.*, 1991).

### Historical Seismicity

A historical catalogue of 16,115 earthquakes within 100 km of the site and covering the time period from 1904, the date of the first reported event, through January 1994 was used (Figure 2) to characterize the earthquake recurrence for the background seismic source. The largest known earthquake in this region was the 1910 surface wave magnitude ( $M_s$ ) 5.7 Goldfield event.

All known or suspected mining blasts and underground NTS nuclear explosions, cavity collapses, and induced aftershocks were removed from the catalogue. The latter were identified by assuming that all events that occurred within 12 months and within a radius of 6 km of a

nuclear explosion were induced. The distance criteria was based on the observations of Rogers *et al.* (1977). Removal of the NTS-induced aftershocks resulted in a catalogue of 3,358 earthquakes.

### Maximum Magnitude

In the Basin and Range province and most regions of the western U.S., the threshold for surface faulting, and hence the upper limit for the background earthquake without surface rupture, usually ranges between Richter magnitude ( $M_L$ ) 6 to  $6\frac{1}{2}$  (Doser, 1985; Arabasz *et al.*, 1992; dePolo, 1994; Pezzopane and Dawson, 1996). Earthquakes larger than these magnitudes are usually accompanied by surface rupture and thus repeated events of this size will produce recognizable fault or fold-related features at the earth's surface. On the basis of these observations, a maximum magnitude of  $M_w$   $6\frac{1}{4} \pm \frac{1}{4}$  has been adopted for the background source.

The maximum magnitude range for a background source overlaps with the range of magnitudes determined for some faults on the basis of paleoseismic investigations and earthquake rupture scenarios at Yucca Mountain (Whitney *et al.*, 1996; Pezzopane *et al.*, 1996). Thus, in the Yucca Mountain vicinity, the maximum magnitude selected for the background zone may be too high. This is also suggested by results from an empirical and theoretical approach to estimating the maximum magnitude specifically for the Yucca Mountain setting (Pezzopane and Dawson, 1996). This study suggests the value for the background zone is  $M_w$   $6.1 \pm 0.1$ . The broader range, nevertheless, is used in this analysis to encompass a greater range of uncertainty and to account for possible hidden seismic sources, mainly east and south of Yucca Mountain.

### Earthquake Recurrence

The portion of the historical seismicity catalogue that can be used to evaluate background earthquake recurrence rates depends on the completeness of the catalogue for different magnitude ranges. In this analysis, the catalogue completeness was generally adopted from the analysis by Rogers *et al.* (1991). The completeness intervals represent the period of time for which earthquakes within that magnitude ( $M_L$ ) range are completely reported in the catalogue. This information is used in the evaluation of recurrence relation parameters following the maximum-likelihood procedure developed by Weichert (1980).

For the catalogue used in this study, the vast majority of earthquakes have assigned  $M_L$  or equivalent  $M_w$  values. We have assumed that  $M_w$  is equivalent to  $M_L$  in the range  $M_L$  2.5 to 5.6

The recurrence relation is given in the form of a truncated exponential distribution for the occurrence of independent earthquakes (Figure 3). Dependent events, either foreshocks, aftershocks, or smaller events within an earthquake swarm (the largest swarm event is assumed to be a mainshock) were identified using empirical criteria for the size in time and space of mainshock-foreshock-aftershock sequences in a procedure adopted from Youngs *et al.* (1992). If an event was identified as dependent by two of three criteria, it was not used in the assessment of recurrence parameters.

Adjusting the catalogue database for dependent events and incompleteness, 329 earthquakes remained in the range  $M_w$  2.5 to 5.6 from which to assess recurrence for the background areal source (Figure 3). The number of earthquakes in the areal source was normalized on an annual basis and per  $\text{km}^2$ . Events were placed into 0.5 magnitude unit bins and the regression was performed on the resulting data points as described in Weichert (1980).

Assuming the usual form of the Gutenberg-Richter relationship ( $\log N = a - bM$ ), the calculated  $b$ -value was  $0.87 \pm 0.04$  and the  $a$ -value  $-1.08 \pm 0.03$  (Figure 3). For the probabilistic analysis,  $a$ - and  $b$ -values are treated as dependent on each other. Uncertainty in the  $a$ -value is taken from the calculated standard deviation; for the  $b$ -value, the uncertainty is estimated to be  $\pm 0.1$  which is larger than the calculated standard deviation. This accounts for model uncertainties related to the ability of the exponential relationship to describe future earthquake occurrence.

An important assumption in basing the recurrence of background seismicity on the historical earthquake record is that the events within the record are not associated with any of the faults considered as seismic sources in the analyses. Within the uncertainties of the epicentral locations shown in Figure 1, this assumption appears to be generally valid. Possible exceptions are the 1992 Little Skull Mountain  $M_w$  5.6 earthquake and its aftershocks which may have occurred on the Mine Mountain fault (Meremonte *et al.*, 1995) and a sequence of shallow earthquakes along the Rock Valley fault zone in 1993 (Shields *et al.*, 1996). For this analysis we assume they are not.

## GROUND MOTION ATTENUATION

Six empirically-based relationships describing the attenuation of peak horizontal acceleration and spectral acceleration at a period of 1.0 sec were used to evaluate the attenuation of ground motions in the Yucca Mountain region: Abrahamson and Silva (1997); Sadigh *et al.* (1993); Boore *et al.* (1993) (Class B); Campbell and Bozorgnia (1994) (Campbell [1993] for spectral accelerations); Idriss (1991; 1994); and Spudich *et al.* (1996). These relationships are appropriate for rock sites. With the exception of the last relationship, they are based primarily on strong motion recordings of California earthquakes. The Spudich *et al.* (1996) relationship



ground motions (e.g., 1.0 sec spectral acceleration), the Furnace Creek and Death Valley faults are almost as significant as the background earthquakes (Figure 5).

In addition to looking at the marginal contribution of each seismic source to the total hazard results, the contribution from different magnitude and distance ranges can also be examined, independent of seismic source. The contributions to the total peak horizontal acceleration and

1.0 sec spectral acceleration hazard for different magnitude and distance ranges, and for return periods of 2000 and 10,000 years is shown in Figure 6. At 2,000 years, the peak acceleration hazard is dominated by background earthquakes of  $M_w$  5 to  $6\frac{1}{2}$  at short distances ( $< 10$  km) with a small contribution from the distant active faults. At a 10,000-year return period, the contribution of the Paintbrush Canyon fault becomes more significant and the dominant magnitude range shifts to slightly higher values (Figure 6). For the 1.0 sec spectral acceleration, background earthquakes continue to dominate, but the Furnace Creek and Death Valley faults also contribute significantly, particularly at return periods less than about 5,000 years (Figure 6).

Comparison of the peak acceleration hazard computed using each of the six attenuation relationships individually indicates that four of the five western U.S. empirical relationships give nearly the same peak acceleration hazard results (Figure 7). The fifth relationship, that of Moore *et al.* (1993), gives lower peak accelerations. Most significantly, as discussed earlier, the Studich *et al.* (1996) relationship which was weighted 0.5, gives the lowest peak values, significantly lower than the five western U.S. relationships.

## IMPLICATIONS TO THE LAS VEGAS REGION

The locations of both Yucca Mountain and Las Vegas in the southern Great Basin portion of the Basin and Range province suggest that the potential sources and level of seismic hazards might be similar. Within 100 km of both locations are numerous Quaternary faults characterized by maximum earthquakes of  $M_w$   $6\frac{1}{2}$  to  $7\frac{1}{2}$  and slip rates of 0.00001 to 4 mm/yr. At Yucca Mountain, the relatively short local faults pose a low probabilistic ground shaking hazard because of their very low slip rates (less than 0.01 mm/yr). Although fewer in number, the local faults within the Las Vegas area such as the Eglington and Frenchman Mountain faults may pose a relatively greater hazard to this locale because of their higher slip rates (up to 0.1 mm/yr or more; Slemmons, 1996). Longer, more active but more distant faults ( $M_{max}$  7 to  $7\frac{1}{2}$  and 1 to 4 mm/yr), such as Pahrump Valley and Death Valley faults, will contribute to the long-period seismic hazard at both locations.

Background earthquakes will contribute significantly to the hazard at both locations particularly at short return periods. The level of background seismicity in the Las Vegas area, however, appears to be lower than at Yucca Mountain (although this may not be real given the short and

incomplete historical record) and thus the contribution to hazard may be lower in Las Vegas from this source.

Given that both sites are in the southern Great Basin, the attenuation of seismic waves will probably be similar. In contrast, other path and site factors that may increase ground shaking will be more significant in Las Vegas than Yucca Mountain. Specifically, because Las Vegas is located within an alluvial valley, basin effects and the presence of low-velocity unconsolidated

low frequencies. In summary, comparable to Las Vegas on rock, the latter will be subjected to seismic hazard is likely greater

sediments will likely amplify ground shaking at both high and low the probabilistic ground motions at Yucca Mountain may be comparable to sites at return periods less than 10,000 years. However, because of enhanced ground shaking due to the above effects, the level of seismic hazard in the Las Vegas area than at Yucca Mountain.

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TABLE 1  
 KNOWN AND SUSPECTED QUATERNARY FAULTS IN THE YUCCA MOUNTAIN REGION MODELED IN THE SEISMIC HAZARD ANALYSIS

Fault	Closest Distance (km)	Capability	Length (km)	Dip (degrees)	Maximum Magnitude (M <sub>w</sub> )	Recurrence Model	Fault Slip Rate mm/yr
Ghost Dance (GD)	0	0.1	3	45 (0.3)	5.3 (0.2)	Exponential (0.5)	0.00001 (0.2)
				60 (0.4)	5.6 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				75 (0.3)	5.9 (0.2)		0.001 (0.2)
Sundance (SD)	0	0.1	1	60 (0.3)	4.8 (0.2)	Exponential (0.5)	0.00001 (0.2)
				75 (0.4)	5.1 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				90 (0.3)	5.4 (0.2)		0.001 (0.2)
Solitario Canyon (SC)	1	1	20	45 (0.3)	6.3 (0.2)	Exponential (0.3)	0.005 (0.2)
				60 (0.4)	6.6 (0.6)	Characteristic (0.7)	0.01 (0.6)
				75 (0.3)	6.9 (0.2)		0.03 (0.2)
Drill Hole Wash (DHW)	1.5	0.1	4	60 (0.3)	5.6 (0.2)	Exponential (0.5)	0.00001 (0.2)
				75 (0.4)	5.9 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				90 (0.3)	6.2 (0.2)		0.001 (0.2)
Dune Wash (DW)	2	0.1	3	60 (0.3)	5.3 (0.2)	Exponential (0.5)	0.00001 (0.2)
				75 (0.4)	5.6 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				90 (0.3)	5.9 (0.2)		0.001 (0.2)
Bow Ridge (BR)	2.5	0.5	10	45 (0.3)	5.9 (0.2)	Exponential (0.4)	0.0005 (0.2)
				60 (0.4)	6.2 (0.6)	Characteristic (0.6)	0.003 (0.6)
				75 (0.3)	6.5 (0.2)		0.005 (0.2)
Pagany Wash (PW)	2.5	0.1	4	60 (0.3)	5.6 (0.2)	Exponential (0.5)	0.00001 (0.2)
				75 (0.4)	5.9 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				90 (0.3)	6.2 (0.2)		0.001 (0.2)
Iron Ridge (IR)	2.5	0.5	9	45 (0.3)	5.9 (0.2)	Exponential (0.5)	0.0005 (0.2)
				60 (0.4)	6.2 (0.6)	Characteristic (0.5)	0.003 (0.6)
				75 (0.3)	6.5 (0.2)		0.01 (0.2)
Boomerang Point (BP)	2.5	0.1	5	45 (0.3)	5.6 (0.2)	Exponential (0.5)	0.00001 (0.2)
				60 (0.4)	5.9 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				75 (0.3)	6.2 (0.2)		0.001 (0.2)
Midway Valley (MV)	3	0.1	8	45 (0.3)	5.8 (0.2)	Exponential (0.5)	0.00001 (0.2)
				60 (0.4)	6.1 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				75 (0.3)	6.4 (0.2)		0.001 (0.2)
Sever Wash (SW)	3	0.1	4	60 (0.3)	5.6 (0.2)	Exponential (0.5)	0.00001 (0.2)
				75 (0.4)	5.9 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				90 (0.3)	6.2 (0.2)		0.001 (0.2)
Fatigue Wash (FW)	3.5	0.5	17	45 (0.3)	6.2 (0.2)	Exponential (0.4)	0.0005 (0.2)
				60 (0.4)	6.5 (0.6)	Characteristic (0.6)	0.002 (0.6)
				75 (0.3)	6.8 (0.2)		0.01 (0.2)

TABLE 1  
 KNOWN AND SUSPECTED QUATERNARY FAULTS IN THE YUCCA MOUNTAIN REGION MODELED IN THE SEISMIC HAZARD ANALYSIS

Fault	Closest Distance (km)	Capability	Length (km)	Dip (degrees)	Maximum Magnitude (M <sub>x</sub> )	Recurrence Model	Fault Slip Rate mm/yr
Paintbrush Canyon (PC)	4	1	24	45 (0.3)	6.4 (0.2)	Exponential (0.3)	0.002 (0.2)
				60 (0.4)	6.7 (0.6)	Characteristic (0.7)	0.01 (0.6)
				75 (0.3)	7.0 (0.2)		0.04 (0.2)
Windy Wash (WW)	4.5	1	25	45 (0.3)	6.4 (0.2)	Exponential (0.3)	0.001 (0.2)
				60 (0.4)	6.7 (0.6)	Characteristic (0.7)	0.01 (0.6)
				75 (0.3)	7.0 (0.2)		0.03 (0.2)
Yucca Wash (YW)	5	0.1	9	60 (0.3)	5.9 (0.2)	Exponential (0.5)	0.00001 (0.2)
				75 (0.4)	6.2 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				90 (0.3)	6.5 (0.2)		0.001 (0.2)
Crater Flat (CRF)	6	0.7	18	45 (0.3)	6.2 (0.2)	Exponential (0.5)	0.0005 (0.2)
				60 (0.4)	6.5 (0.6)	Characteristic (0.5)	0.002 (0.6)
				75 (0.3)	7.0 (0.2)		0.01 (0.2)
Wagonwheel Road (WWR)	10	0.7	9	45 (0.3)	6.7 (0.2)	Exponential (0.5)	0.001 (0.2)
				60 (0.4)	7.0 (0.6)	Characteristic (0.5)	0.01 (0.6)
				75 (0.3)	7.3 (0.2)		0.03 (0.2)
Bore Mountain (BM)	14	1	10	45 (0.3)	6.7 (0.2)	Exponential (0.5)	0.001 (0.2)
				60 (0.4)	7.0 (0.6)	Characteristic (0.5)	0.01 (0.6)
				75 (0.3)	7.3 (0.2)		0.03 (0.2)
Mine Mountain (MM)	18	0.5	27	70 (0.3)	6.4 (0.2)	Exponential (0.5)	0.0001 (0.2)
				80 (0.4)	6.7 (0.6)	Characteristic (0.5)	0.001 (0.6)
				90 (0.3)	7.0 (0.2)		0.01 (0.2)
Rocket Wash-Beatty Wash (RWBW)	19	0.3	17	45 (0.3)	6.2 (0.2)	Exponential (0.5)	0.00001 (0.2)
				60 (0.4)	6.5 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				75 (0.3)	6.8 (0.2)		0.001 (0.2)
Wahmonia (WAH)	22	0.5	15	70 (0.3)	6.1 (0.2)	Exponential (0.5)	0.0001 (0.2)
				80 (0.4)	6.4 (0.6)	Characteristic (0.5)	0.001 (0.6)
				90 (0.3)	6.7 (0.2)		0.01 (0.2)
Oasis Valley (OSV)	24	0.4	20	45 (0.3)	6.3 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.6 (0.6)	Characteristic (0.5)	0.003 (0.6)
				75 (0.3)	6.9 (0.2)		0.01 (0.2)
Rock Valley (RV)	27	1	65	70 (0.3)	6.9 (0.2)	Exponential (0.4)	0.001 (0.2)
				80 (0.4)	7.2 (0.6)	Characteristic (0.6)	0.01 (0.6)

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<u>Fault</u>	<u>Closest Distance</u> <u>(km)</u>	<u>Capability</u>	<u>Length</u> <u>(km)</u>	<u>Dip</u> <u>(degrees)</u>	<u>Maximum</u> <u>Magnitude</u> <u>(M<sub>w</sub>)</u>	<u>Recurrence Model</u>	<u>Fault Slip Rate</u> <u>mm/yr</u>
				90 (0.3)	7.5 (0.2)		0.1 (0.2)
Cane Spring (CS)	29	0.3	27	70 (0.3)	6.4 (0.2)	Exponential (0.5)	0.00001 (0.2)
				80 (0.4)	6.7 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				90 (0.3)	7.0 (0.2)		0.001 (0.2)
West Specter Range (WSR)	33	1	9	45 (0.3)	5.9 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.2 (0.6)	Characteristic (0.5)	0.004 (0.6)
				75 (0.3)	6.5 (0.2)		0.01 (0.2)
Ash Meadows (AM)	34	1	60	45 (0.3)	6.8 (0.2)	Exponential (0.4)	0.001 (0.2)
				60 (0.4)	7.1 (0.6)	Characteristic (0.6)	0.04 (0.6)
				75 (0.3)	7.4 (0.2)		0.1 (0.2)
Yucca Lake (YCL)	36	0.6	17	45 (0.3)	6.2 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.5 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	6.8 (0.2)		0.01 (0.2)
Eleana Range (ER)	37	1	13	45 (0.3)	6.1 (0.2)	Exponential (0.5)	0.001 (0.2)
				60 (0.4)	6.4 (0.6)	Characteristic (0.5)	0.01 (0.6)
				75 (0.3)	6.7 (0.2)		0.1 (0.2)
Amargosa River (AR)	38	1	15	60 (0.3)	6.1 (0.2)	Exponential (0.5)	0.0001 (0.2)
				75 (0.4)	6.4 (0.6)	Characteristic (0.5)	0.001 (0.6)
				90 (0.3)	6.7 (0.2)		0.01 (0.2)
Bullfrog Hills (BUL)	38	0.6	7	45 (0.3)	5.8 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.1 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	6.4 (0.2)		0.01 (0.2)
Yucca (YC)	40	1	32	45 (0.3)	6.5 (0.2)	Exponential (0.4)	0.00005 (0.2)
				60 (0.4)	6.8 (0.6)	Characteristic (0.6)	0.005 (0.6)
				75 (0.3)	7.1 (0.2)		0.05 (0.2)
Tolicha Peak (TOL)	42	0.6	22	60 (0.3)	6.3 (0.2)	Exponential (0.5)	0.0001 (0.2)
				75 (0.4)	6.6 (0.6)	Characteristic (0.5)	0.001 (0.6)
				90 (0.3)	6.9 (0.2)		0.01 (0.2)
Carpetbag (CB)	43	0.8	30	45 (0.3)	6.5 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.8 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.1 (0.2)		0.01 (0.2)
Keane Wonder (KW)	43	0.5	25	45 (0.3)	6.4 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.7 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.0 (0.2)		0.01 (0.2)
Area Three (AT)	44	0.6	12	45 (0.3)	6.0 (0.2)	Exponential (0.5)	0.0001 (0.2)

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Fault	Closest Distance (km)	Capability	Length (km)	Dip (degrees)	Maximum Magnitude (M <sub>w</sub> )	Recurrence Model	Fault Slip Rate mm/yr	
Checkpoint Pass (CP)	44	0.3	7	60 (0.4)	6.3 (0.6)	Characteristic (0.5)	0.001 (0.6)	
				75 (0.3)	6.6 (0.2)		0.01 (0.2)	
				45 (0.3)	5.8 (0.2)		Exponential (0.5)	0.00001 (0.2)
Plutonium Valley-North Halfpint Ridge (PVNH)	46	0.3	26	60 (0.4)	6.1 (0.6)	Characteristic (0.5)	0.0001 (0.6)	
				75 (0.3)	6.4 (0.2)		0.001 (0.2)	
				45 (0.3)	6.4 (0.2)		Exponential (0.5)	0.00001 (0.2)
Crossgrain Valley (CGV)	48	0.6	9	60 (0.4)	6.7 (0.6)	Characteristic (0.5)	0.0001 (0.6)	
				75 (0.3)	7.0 (0.2)		0.001 (0.2)	
				45 (0.3)	5.9 (0.2)		Exponential (0.5)	0.0001 (0.2)
Pahute Mesa (PM)	48	0.6	9	60 (0.4)	6.2 (0.6)	Characteristic (0.5)	0.001 (0.6)	
				75 (0.3)	6.5 (0.2)		0.01 (0.2)	
				45 (0.3)	5.9 (0.2)		Exponential (0.5)	0.0001 (0.2)
Mercury Ridge (MER)	48	0.3	10	60 (0.4)	6.2 (0.6)	Characteristic (0.5)	0.0001 (0.6)	
				75 (0.3)	6.5 (0.2)		0.001 (0.2)	
				45 (0.3)	5.9 (0.2)		Exponential (0.5)	0.00001 (0.2)
Ranger Mountain	49	0.6	5	60 (0.4)	6.2 (0.6)	Characteristic (0.5)	0.001 (0.6)	
				75 (0.3)	6.2 (0.2)		0.01 (0.2)	
				45 (0.3)	5.6 (0.2)		Exponential (0.5)	0.0001 (0.2)
Furnace Creek (FC)	50	1	145	70 (0.3)	7.3 (0.2)	Exponential (0.3)	0.2 (0.2)	
				80 (0.4)	7.6 (0.6)		Characteristic (0.7)	4.0 (0.6)
				90 (0.3)	7.9 (0.2)			12.0 (0.2)
South Ridge (SOU)	50	0.6	19	70 (0.3)	6.3 (0.2)	Exponential (0.5)	0.0001 (0.2)	
				80 (0.4)	6.6 (0.6)		Characteristic (0.5)	0.001 (0.6)
				90 (0.3)	6.9 (0.2)			0.01 (0.2)
Boundary	51	1	7	45 (0.3)	5.8 (0.2)	Exponential (0.5)	0.0005 (0.2)	
				60 (0.4)	6.1 (0.6)		Characteristic (0.5)	0.005 (0.6)
				75 (0.3)	6.4 (0.2)			0.05 (0.2)
Sarcobatus Flat (SF)	52	0.6	51	45 (0.3)	6.8 (0.2)	Exponential (0.5)	0.0001 (0.2)	
				60 (0.4)	7.1 (0.6)		Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.4 (0.2)			0.01 (0.2)
West Springs Mountain (WSM)	53	1	60	45 (0.3)	6.8 (0.2)	Exponential (0.3)	0.001 (0.2)	
				60 (0.4)	7.1 (0.6)		Characteristic (0.7)	0.05 (0.6)
				75 (0.3)	7.4 (0.2)			0.1 (0.2)

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<u>Fault</u>	<u>Closest Distance</u> <u>(km)</u>	<u>Capability</u>	<u>Length</u> <u>(km)</u>	<u>Dip</u> <u>(degrees)</u>	<u>Maximum</u> <u>Magnitude</u> <u>(M<sub>w</sub>)</u>	<u>Recurrence Model</u>	<u>Fault Slip Rate</u> <u>mm/yr</u>
Buried Hills (BH)	53	0.6	26	45 (0.3)	6.4 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.7 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.0 (0.2)		0.01 (0.2)
Cockeyed Ridge-Papoose Lake (CRPL)	53	0.6	21	45 (0.3)	6.3 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.6 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	6.9 (0.2)		0.01 (0.2)
Death Valley (DV)	55	1	100	45 (0.3)	7.1 (0.2)	Exponential (0.3)	1.0 (0.2)
				60 (0.4)	7.4 (0.6)	Characteristic (0.7)	3.0 (0.6)
				75 (0.3)	7.7 (0.2)		6.0 (0.2)
Belted Range (BLR)	55	1	54	45 (0.3)	6.8 (0.2)	Exponential (0.5)	0.001 (0.2)
				60 (0.4)	7.1 (0.6)	Characteristic (0.5)	0.01 (0.6)
				75 (0.3)	7.4 (0.2)		0.1 (0.2)
Kawich Range (KR)	57	1	84	45 (0.3)	7.0 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	7.3 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.6 (0.2)		0.01 (0.2)
Oak Spring Butte (OAK)	57	0.6	21	45 (0.3)	6.3 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.6 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	6.9 (0.2)		0.01 (0.2)
Grapevine (GV)	58	0.7	20	45 (0.3)	6.3 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.6 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	6.9 (0.2)		0.01 (0.2)
Spotted Range (SPR)	59	0.6	30	45 (0.3)	6.5 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.8 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.1 (0.2)		0.01 (0.2)
Cactus Springs	59	0.6	14	45 (0.3)	6.1 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.4 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	6.7 (0.2)		0.01 (0.2)
Emigrant Valley North (EVN)	60	0.6	28	45 (0.3)	6.5 (0.2)	Exponential (0.5)	0.001 (0.2)
				60 (0.4)	6.8 (0.6)	Characteristic (0.5)	0.01 (0.6)
				75 (0.3)	7.1 (0.2)		0.1 (0.2)
Gold Flat	60	0.6	16	45 (0.3)	6.2 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.5 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	6.8 (0.2)		0.01 (0.2)
Kawich Valley (KV)	61	0.3	43	45 (0.3)	6.7 (0.2)	Exponential (0.5)	0.0001 (0.2)

TABLE 1  
 KNOWN AND SUSPECTED QUATERNARY FAULTS IN THE YUCCA MOUNTAIN REGION MODELED IN THE SEISMIC HAZARD ANALYSIS

<u>Fault</u>	<u>Closest Distance</u> (km)	<u>Capability</u>	<u>Length</u> (km)	<u>Dip</u> (degrees)	<u>Maximum</u> <u>Magnitude</u> (M <sub>w</sub> )	<u>Recurrence Model</u>	<u>Fault Slip Rate</u> mm/yr
Chert Ridge	65	0.3	14	60 (0.4)	7.0 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.3 (0.2)		0.01 (0.2)
				45 (0.3)	6.1 (0.2)		Exponential (0.5)
Emigrant Valley South	66	0.6	20	60 (0.4)	6.4 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				75 (0.3)	6.7 (0.2)		0.001 (0.2)
				45 (0.3)	6.3 (0.2)		Exponential (0.5)
Indian Springs Valley (ISV)	67	0.5	28	60 (0.4)	6.6 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	6.9 (0.2)		0.01 (0.2)
				45 (0.3)	6.5 (0.2)		Exponential (0.5)
Grapevine Mountains (GM)	67	0.7	31	60 (0.4)	6.8 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.1 (0.2)		0.1 (0.2)
				45 (0.3)	6.5 (0.2)		Exponential (0.5)
Pahrump (PRP)	70	1	70	70 (0.3)	6.9 (0.2)	Exponential (0.5)	0.001 (0.2)
				80 (0.4)	7.2 (0.6)		0.01 (0.6)
				90 (0.3)	7.5 (0.2)		0.05 (0.2)
Fallout Hills	70	0.3	8	45 (0.3)	5.8 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.1 (0.6)		0.001 (0.6)
				75 (0.3)	6.4 (0.2)		0.01 (0.2)
Bonnie Claire	74	0.5	27	45 (0.3)	6.4 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.7 (0.6)		0.001 (0.6)
				75 (0.3)	7.0 (0.2)		0.01 (0.2)
Stumble	74	0.5	33	45 (0.3)	6.5 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.8 (0.6)		0.001 (0.6)
				75 (0.3)	7.1 (0.2)		0.01 (0.2)
West Pintwater Range (WPR)	76	1	60	45 (0.3)	6.8 (0.2)	Exponential (0.5)	0.001 (0.2)
				60 (0.4)	7.1 (0.6)		0.01 (0.6)
				75 (0.3)	7.4 (0.2)		0.1 (0.2)
Towne Pass	76	1	38	45 (0.3)	6.6 (0.2)	Exponential (0.5)	0.001 (0.2)
				60 (0.4)	6.9 (0.6)		0.01 (0.6)
				75 (0.3)	7.2 (0.2)		0.1 (0.2)
Jumbled Hills	77	0.4	27	45 (0.3)	6.4 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.7 (0.6)		0.001 (0.6)
				75 (0.3)	7.0 (0.2)		0.01 (0.2)

TABLE 1  
 KNOWN AND SUSPECTED QUATERNARY FAULTS IN THE YUCCA MOUNTAIN REGION MODELED IN THE SEISMIC HAZARD ANALYSIS

Fault	Closest Distance (km)	Capability	Length (km)	Dip (degrees)	Maximum Magnitude (M <sub>w</sub> )	Recurrence Model	Fault Slip Rate mm/yr
Cactus Flat-Mellan	80	0.5	35	45 (0.3)	6.6 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.9 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.2 (0.2)		0.01 (0.2)
East Pintwater Range (EPR)	81	0.6	58	45 (0.3)	6.8 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	7.1 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.4 (0.2)		0.01 (0.2)
North Desert Range	81	0.5	24	45 (0.3)	6.4 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.7 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.0 (0.2)		0.01 (0.2)
La Madre	82	0.6	33	45 (0.3)	6.5 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.8 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.1 (0.2)		0.01 (0.2)
Groom Range Central	82	0.3	31	45 (0.3)	6.5 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.8 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.1 (0.2)		0.01 (0.2)
Cactus Flat	84	0.6	50	45 (0.3)	6.8 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	7.1 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.4 (0.2)		0.01 (0.2)
Three Lakes Valley	84	0.3	27	45 (0.3)	6.4 (0.2)	Exponential (0.5)	0.00001 (0.2)
				60 (0.4)	6.7 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				75 (0.3)	7.0 (0.2)		0.001 (0.2)
Groom Range East	85	0.3	20	45 (0.3)	6.3 (0.2)	Exponential (0.5)	0.00001 (0.2)
				60 (0.4)	6.6 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				75 (0.3)	6.9 (0.2)		0.001 (0.2)
Cactus Range-Wellington Hills	87	0.3	29	45 (0.3)	6.5 (0.2)	Exponential (0.5)	0.00001 (0.2)
				60 (0.4)	6.8 (0.6)	Characteristic (0.5)	0.0001 (0.6)
				75 (0.3)	7.1 (0.2)		0.001 (0.2)
Chalk Mountain	87	0.5	20	45 (0.3)	6.3 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.6 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	6.9 (0.2)		0.01 (0.2)
Chicago Valley	90	1	20	45 (0.3)	6.3 (0.2)	Exponential (0.5)	0.001 (0.2)
				60 (0.4)	6.6 (0.6)	Characteristic (0.5)	0.01 (0.6)
				75 (0.3)	6.9 (0.2)		0.1 (0.2)
Tin Mountain	90	1	29	45 (0.3)	6.5 (0.2)	Exponential (0.5)	0.001 (0.2)
				60 (0.4)	6.8 (0.6)	Characteristic (0.5)	0.01 (0.6)
				75 (0.3)	7.1 (0.2)		0.1 (0.2)

TABLE 1  
 KNOWN AND SUSPECTED QUATERNARY FAULTS IN THE YUCCA MOUNTAIN REGION MODELED IN THE SEISMIC HAZARD ANALYSIS

Fault	Closest Distance (km)	Capability	Length (km)	Dip (degrees)	Maximum Magnitude ( $M_w$ )	Recurrence Model	Fault Slip Rate mm/yr
Tikaboo	92	1	33	45 (0.3)	6.5 (0.2)	Exponential (0.5)	0.0001 (0.2)
				60 (0.4)	6.8 (0.6)	Characteristic (0.5)	0.001 (0.6)
				75 (0.3)	7.1 (0.2)		0.01 (0.2)
Stonewall Mountain	92	1	22	45 (0.3)	6.3 (0.2)	Exponential (0.5)	0.001 (0.2)
				60 (0.4)	6.6 (0.6)	Characteristic (0.5)	0.01 (0.6)
				75 (0.3)	6.9 (0.2)		0.1 (0.2)
Panamint Valley (PV)	95	1	100	60 (0.3)	7.1 (0.2)	Exponential (0.3)	1.5 (0.2)
				75 (0.4)	7.4 (0.6)	Characteristic (0.7)	2.5 (0.6)
				90 (0.3)	7.7 (0.2)		3.5 (0.2)
Hunter Mountain (HM)	95	1	85	70 (0.3)	7.0 (0.2)	Exponential (0.3)	1.5 (0.2)
				80 (0.4)	7.3 (0.6)	Characteristic (0.7)	2.5 (0.6)
				90 (0.3)	7.6 (0.2)		3.5 (0.2)
Panover	97	1	56	45 (0.3)	6.8 (0.2)	Exponential (0.5)	0.001 (0.2)

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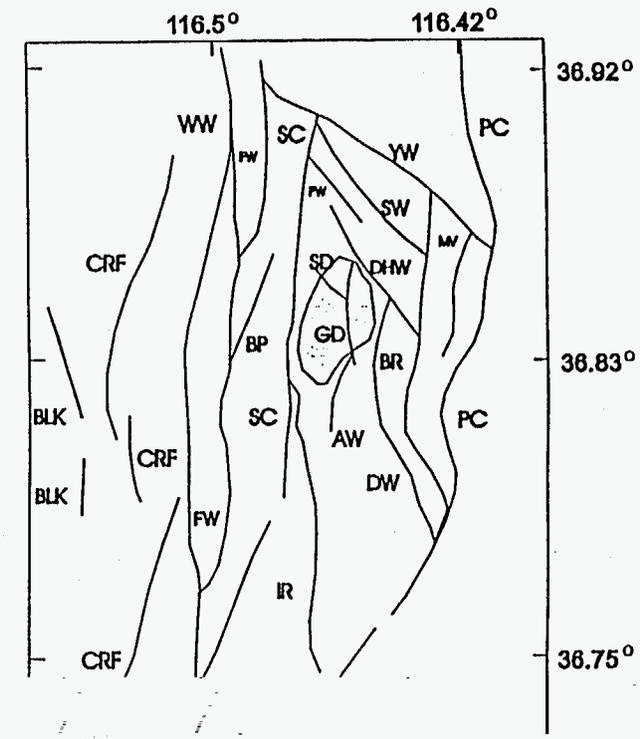
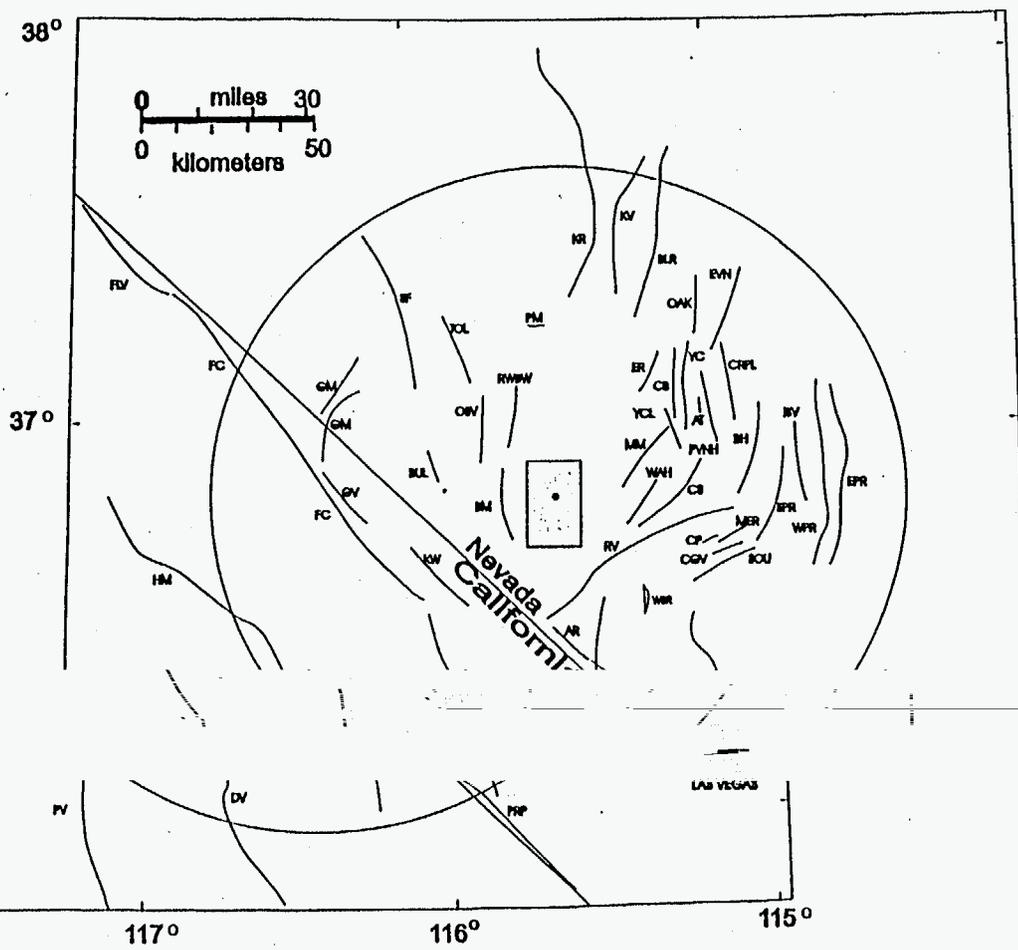
60 (0.4)  
60 (0.4)  
60 (0.4)

60 (0.4)  
60 (0.4)  
60 (0.4)

Exponential  
Characteristic

0.5  
0.5  
0.5

0.001  
0.001  
0.001



- |      |             |     |                       |      |                                   |      |                         |      |             |
|------|-------------|-----|-----------------------|------|-----------------------------------|------|-------------------------|------|-------------|
| AM   | Ash Meadows | CRF | Cane Spring           | KR   | Kawich Range                      | RV   | Rock Valley             | AM   | Ash Meadows |
| AR   | Arden       | DV  | Death Valley          | KV   | Kawich Valley                     | RWBW | Rocket Wash-Beatty Wash | AR   | Arden       |
| AT   | Atlatlan    | EPR | East Pintwater Range  | KW   | Keane Wonder                      | SF   | Sarcobatus Flat         | AT   | Atlatlan    |
| BH   | Bullhead    | ER  | Eleana Range          | MER  | Mercury Ridge                     | SOU  | South Ridge             | BH   | Bullhead    |
| BLR  | Bull Run    | EVN | Emigrant Valley North | MM   | Mine Mountain                     | SPR  | Spotted Range           | BLR  | Bull Run    |
| BM   | Boreas      | FC  | Furnace Creek         | OAK  | Oak Spring Butte                  | TOL  | Tolcha Peak             | BM   | Boreas      |
| BUL  | Bullfrog    | FLV | Fish Lake Valley      | OSV  | Oasis Valley                      | WAH  | Wahmonie                | BUL  | Bullfrog    |
| CB   | Carpenter   | GM  | Grapevine Mountains   | PM   | Pahute Mesa                       | WPR  | West Pintwater Range    | CB   | Carpenter   |
| CGV  | Crocker     | GV  | Grapevine             | PRP  | Pahrump                           | WSM  | West Springs Mountain   | CGV  | Crocker     |
| CP   | Crocker     | HM  | Hunter Mountain       | PV   | Panamint Valley                   | WSR  | West Specier Range      | CP   | Crocker     |
| CRPL | Crocker     | ISV | Indian Springs Valley | PVNH | Plutonium Valley-N Halfpint Range | YC   | Yucca                   | CRPL | Crocker     |
|      |             |     |                       |      |                                   | YCL  | Yucca Lake              |      |             |

Figure 1 Known or suspected Quaternary faults within 100 km of Yucca Mountain. Local faults are shown in greater detail on right.

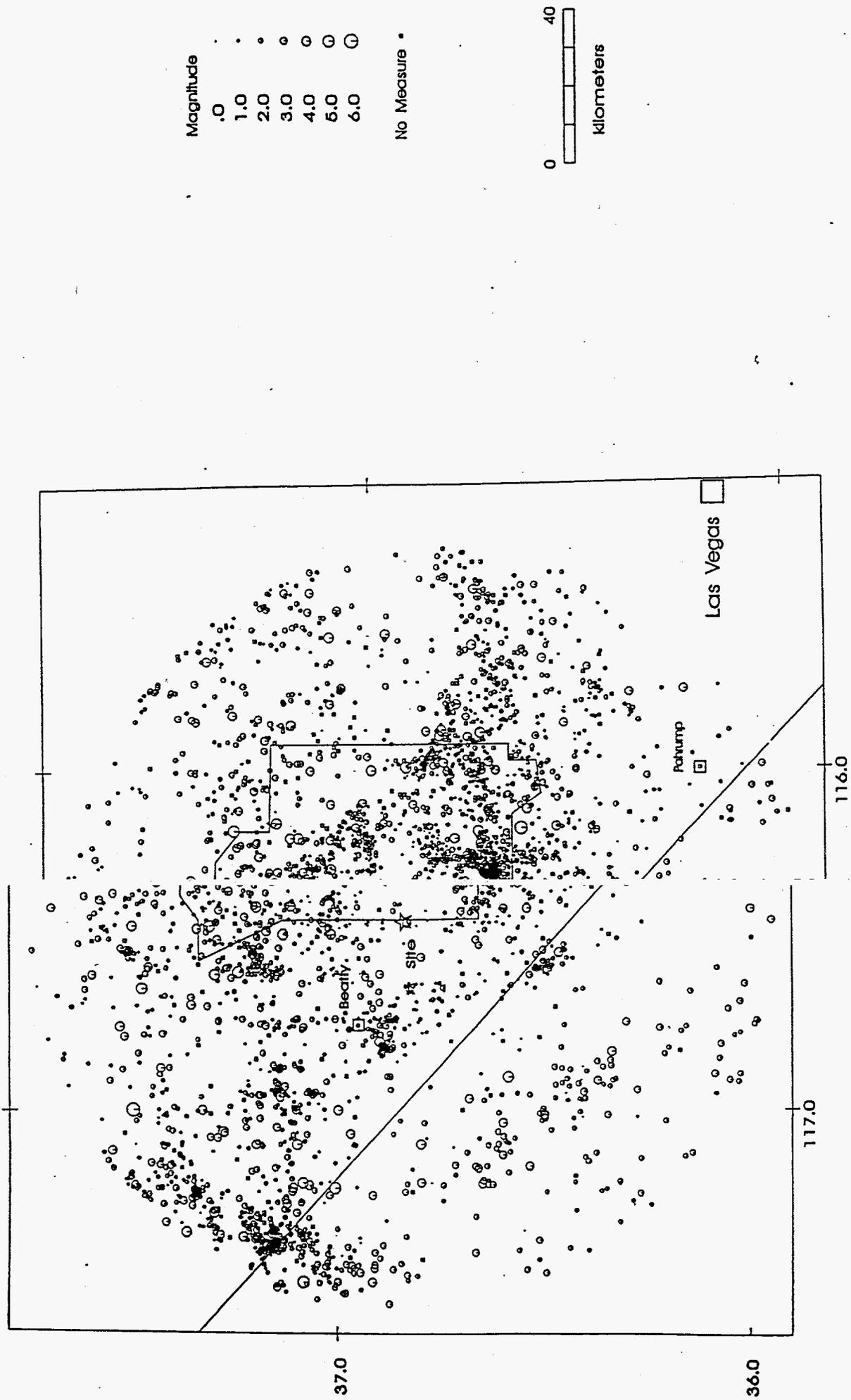


Figure 2 Historical Seismicity (1904-1996) within 100 km of the Yucca Mountain site used in recurrence.

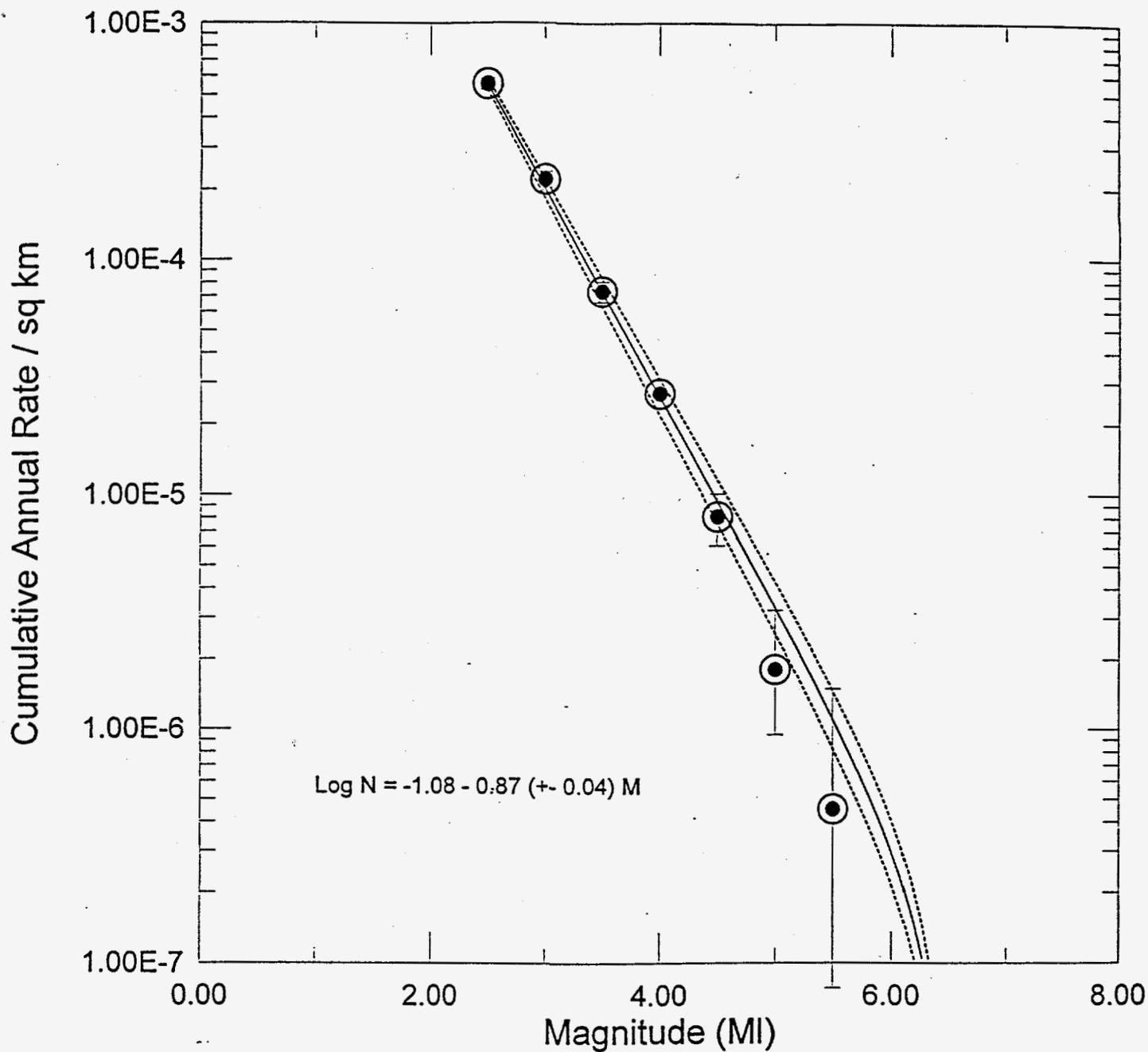
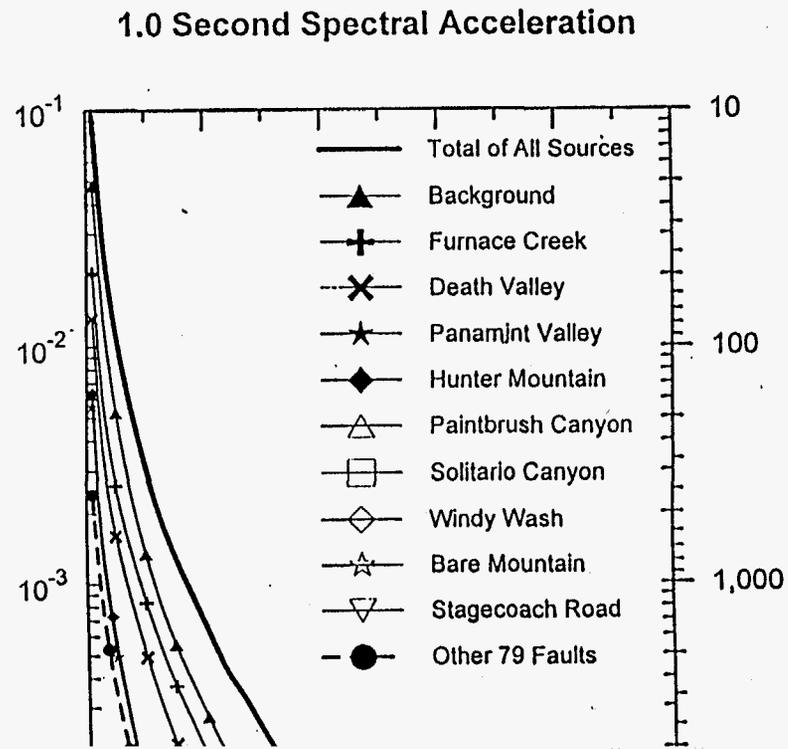
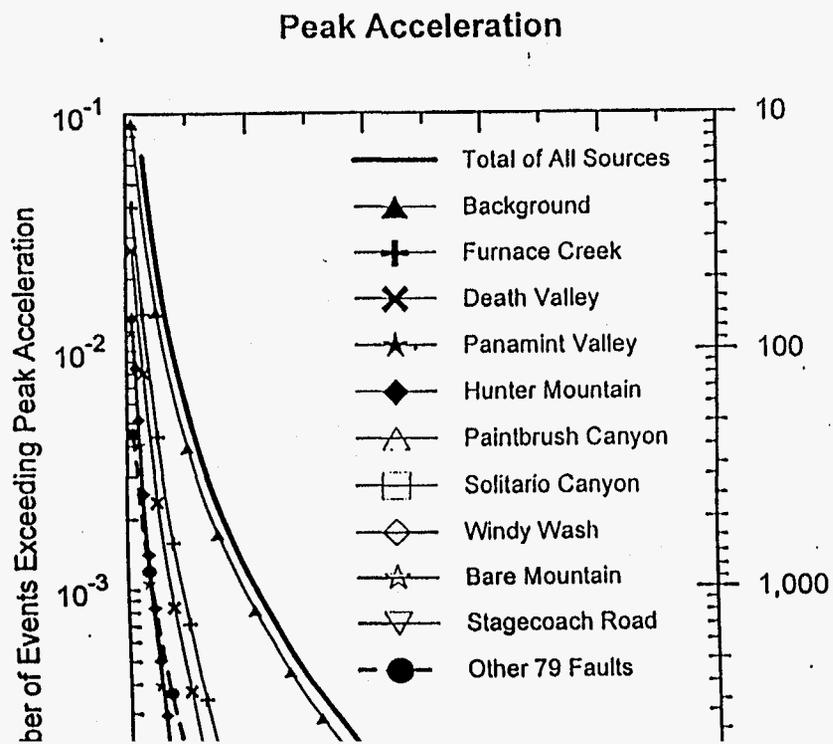


Figure 3 Truncated exponential earthquake recurrence relationship for the Yucca Mountain region. Data points are shown with their standard errors.



Figure 4. Mean, med

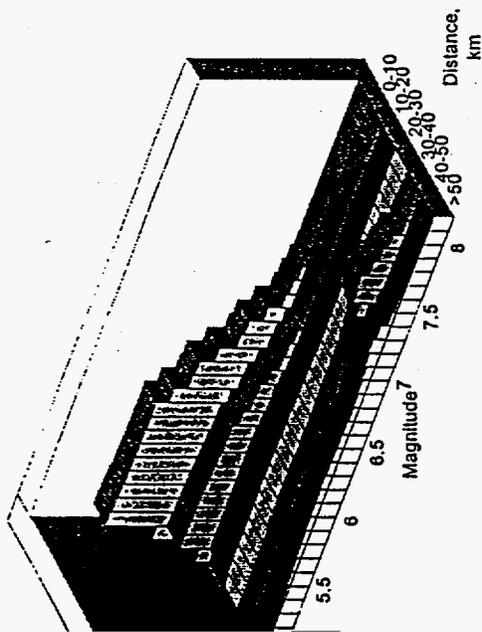


Peak Acceleration, g's

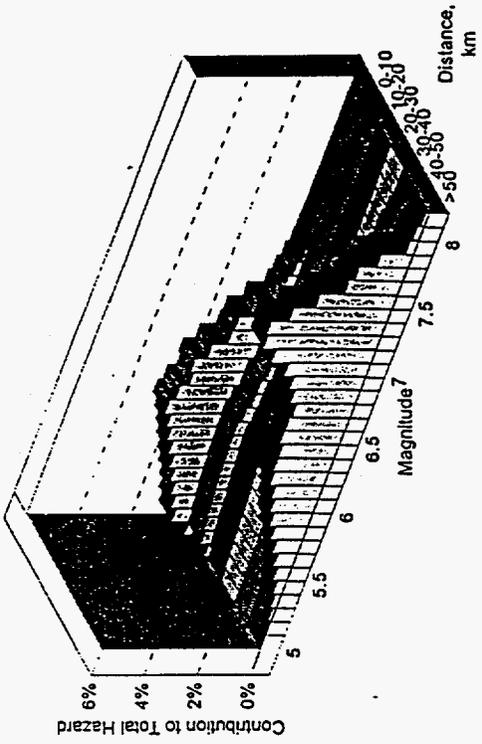
Figure 5. Mean peak horizontal acceleration and 1.0 second spectral acceleration hazard curves and contributions of seismic sources

Contribution to Total Hazard  
 8%  
 6%  
 4%  
 2%  
 0%

Contributions to Peak Acceleration  
 Return Period = 2,000 years

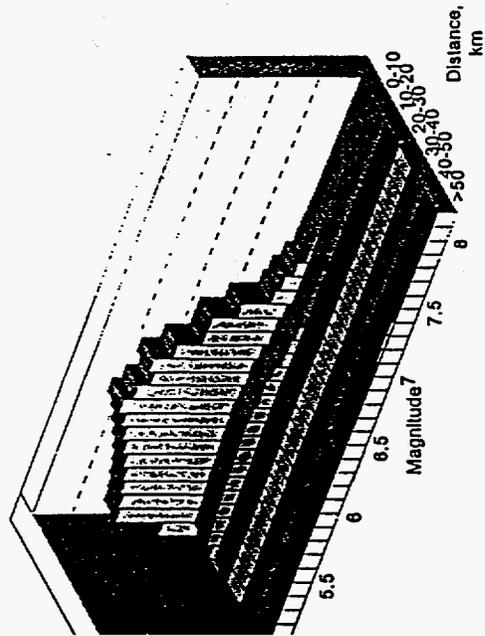


Contributions to 1.0 sec Spectral Acc  
 Return Period = 2,000 years

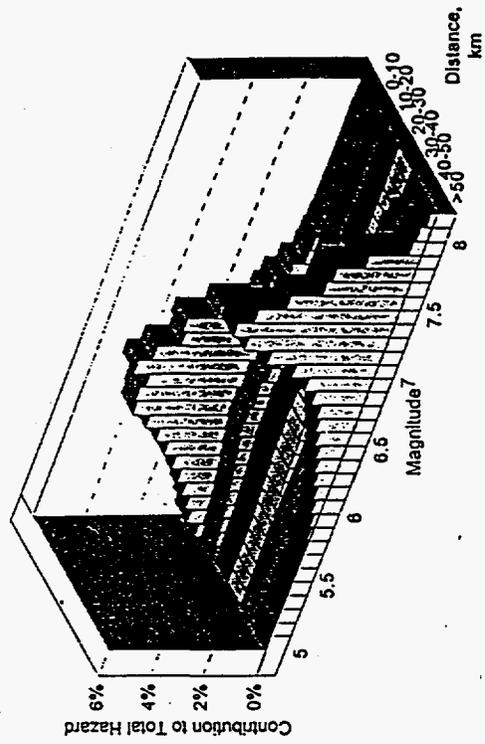


Contribution to Total Hazard  
 8%  
 6%  
 4%  
 2%  
 0%

Contributions to Peak Acceleration  
 Return Period = 10,000 years



Contributions to 1.0 sec Spectral Acc  
 Return Period = 10,000 years



Figure

magnitude and distance contributions to the mean peak horizontal acceleration and 1.0 second spectral acceleration hazard at return periods of 2,000 and 10,000 years

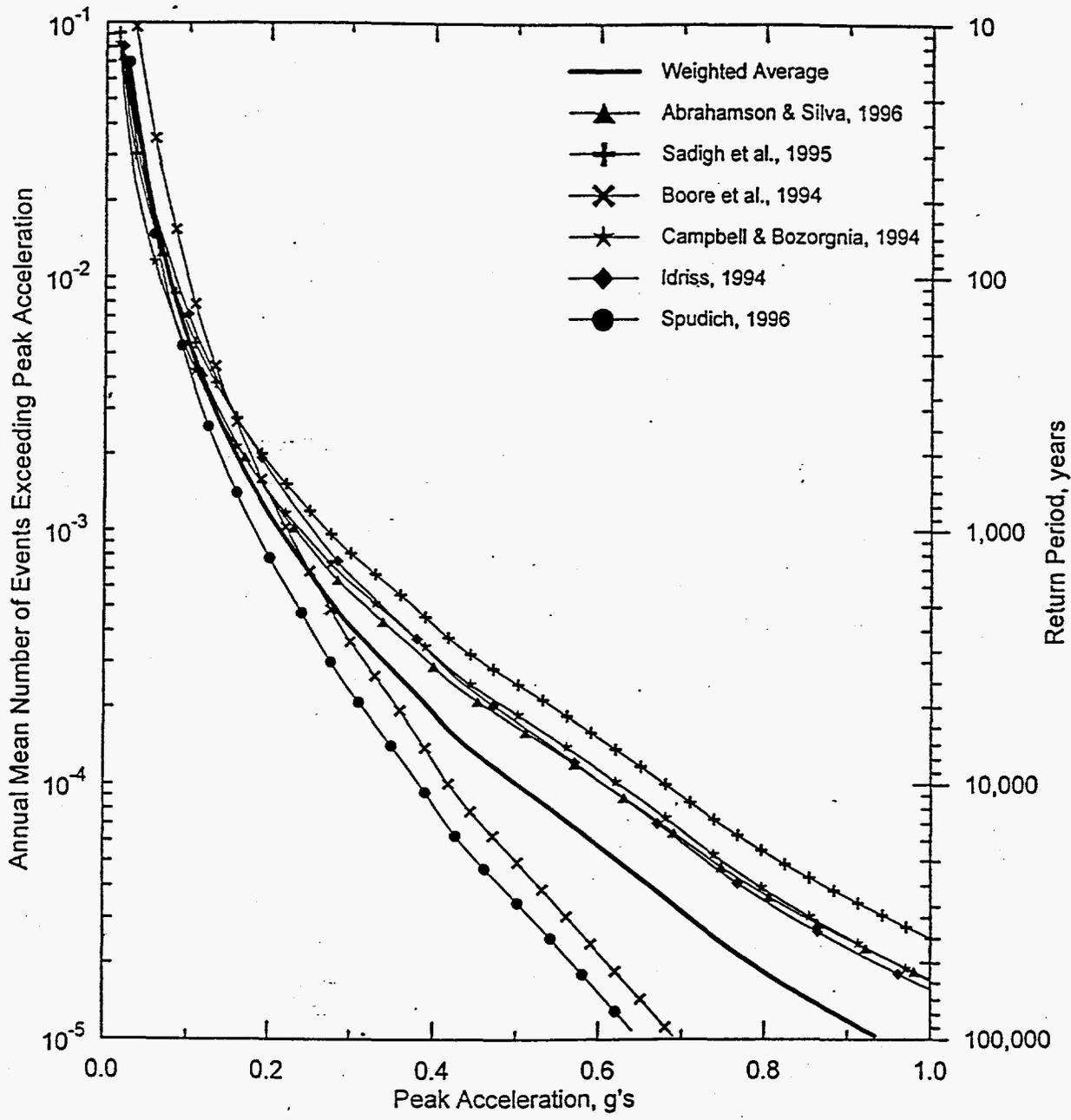


Figure 7. Sensitivity of mean peak horizontal acceleration hazard to selection of empirical attenuation relationship. Each relationship is shown when used individually in hazard calculations.