LAWRENCE LIVERMORE LABORATORY

WM DOCKET CONTROL
CENTER

September 7, 1984

Mr. Michael E. Blackford
Project Manager, MS-623ss
Geotechnical Branch, WMGT
Division of Waste Management
Office of Nuclear Material Safety & Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: Transmittal of EA Review on the NNWSI Site, Nye County, Nevada

Reference: NRC FIN A0294

Dear Mr. Blackford:

The purpose of this letter is to transmit the subject EA review.

Our review and evaluation of this EA was requested in your communication dated July 1984. We have successfully accomplished our review on this EA.

If you have any questions, please let us know.

Sincerely yours,

H. Lawrence McKague FOR
Dae H. Chung
Leader
NRC Nuclear Waste Management Project

DHC:HLMcK:be

Attachment: as stated

xc: P. S. Justus, WMGT
B. J. Rice, WMGT
J. S. Trapp, WMGT
K. B. Westbrook, WMGT

WM-RES
WM Record File A0294
LLL

WM Project 10, 11, 16
Docket No.
PDR ✓
LPDR ✓(B, N, S)

Distribution:
MBlackford

(Return to WM, 623-SS) C2

8409190252 840907
PDR WMRES EXILLL
A-0294 PDR

This report is a preliminary review of a draft of the statutory Environmental Assessment for the Nevada Nuclear Waste Storage Investigations Project (NNWSI).

This review was made without access to some of the references listed in the text of the EA. Accordingly, it should be considered as preliminary and the final review may have important changes and additions. The paragraph number indicated in the comments below refer to paragraph order on the indicated page.

Sections of the Draft EA for NTS include topics of concern to us. The rationale is included with possible methods of investigation that could assist in resolving or mitigating these concerns.

Chapter 2

General Comments

No general comments at this time.

Specific Comments

2-1 Section 2.1 Regional setting of Yucca Mountain
Page 2-5, Paragraph 2
Incorrect data

Oldest volcanic related rocks on NTS are 29 MY old Horse Spring formation (Barnes et al. 1982).

2-2 Section 2.1 Regional Setting of Yucca Mountain
Page 2-5, Paragraph 2
Incorrect data

Youngest siliceous volcanic rocks on NTS are associated with the Black Mountain caldera which has a K-Ar age of 6.3 $\pm$ 0.2 MY (Noble et al. 1983).

2-3 Section 2.1 Regional Setting of Yucca Mountain
Page 2-5, Paragraph 3
Missing information

Stewart (1978) is not listed in bibliography. Therefore cannot check reference in order to determine if conclusion reached is correct.

2-4 Section 2.1 Regional setting of Yucca Mountain
Page 2-6 and 2-7, Figures 2-3a and 2-3b
Missing and/or conflicting information

Although cross sections are schematic they do not show caldera beneath Yucca Mountain as is indicated in Figure 3-3. Understanding the deeper structures beneath Yucca Mountain is an important part of evaluating the geologic stability of the area.

2-5 Section 2.1 Regional setting of Yucca Mountain
Page 2-8, paragraph 1
Missing reference

The conclusion that most, if not all, precipitation evaporates before it is able to seep deeply into the rocks has important implications for a repository beneath Yucca Mountain, yet there is neither data nor reference to support this conclusion on page 2-8.

Chapter 3

General comments

The use of blanket references, as on page 3-5, paragraph 2, makes it difficult to determine specific sources of information, how some conclusions were reached, and if all differing interpretations were considered.

Specific comments

3-1 Section 3.1.2.1 Stratigraphy and Volcanic History of Yucca Mountain Area
Page 3-11, paragraph 1, sentence 3
Incorrect information

Vitrophyre is a dense black glassy rock in which the glassy fragments have completely coalesced (welded) eliminating all pore space. The vitrophyre zone or zone of dense welding does not occur at top of an ash flow and only rarely at the bottom of flow emplaced at high temperatures (Smith, 1960, p. 154-155). Rapid cooling by the atmosphere or earth results in a vitric non to partially welded tuff. Most single ash-flow cooling units have a nonwelded top and bottom (Smith 1960, p. 154).

3-2 Section 3.1.2.1 Stratigraphy and Volcanic History of Yucca Mountain Area
Page 3-11, paragraph 2
Incorrect information

Bedded tuffs generally imply the volcanic material has been reworked, i.e. eroded and redeposited, after the initial deposition and may have originated as either an ash fall or an ash flow, or both, prior to erosion and redeposition. For an example see Maldonado and Koether (1983, p. 58). Ash falls are the more common source for bedded material because of their nonwelded nature. However, ash falls can be identified and are commonly listed in USGS lithologic descriptions as such (Maldonado and Koether (1983, p. 66)..

3-3 Section 3.1.2.1 Stratigraphy and Volcanic History of Yucca Mountain Area
Page 3-12, paragraph 1
Data allows a different interpretation

The absence of Rainier Mesa tuff on high standing blocks can occur as the result of geologic process other than non deposition on high standing fault blocks. The most obvious one is erosion, subsequent to faulting. Ekren et al. (1968) offer evidence that the topography was "very subdued during the eruption of the Timber Mountain tuff." Thus the initiation of significant faulting may be several million years more recent than implied in this report.

3-4 Section 3.1.2.2 Structure
Page 3-16, Paragraph 1
Interpretation disagrees with published literature

The last sentence in this paragraph states that the Death Valley and Owens Valley shear zones "might still be active". This disagrees with published literature and the historic record, which clearly indicate these fault zones to be active. The 1872 Owens Valley earthquake is a well documented earthquake that was accompanied by extensive and large surface faulting within the Owens Valley fault zone (Oakeshott and others, 1972). The Death Valley fault zone has been described as active and shows Holocene displacements (Butler and others, 1983 and Brogan, 1979, unpublished). There is strong evidence that these fault zones should be considered to be active.

3-5 Section 3.1.2.2 Structure
Page 3-16 & 3-18, Paragraph 4
Data allows for a different interpretation

There is no evidence or basis presented for the interpretation of residual stress being responsible for structural deformation between the Walker Lane and the Las Vegas shear zone. Residual implies waning tectonic activity and a low probability for extended continuation of deformation into the future. Based on the data presented, stress could be accumulating as a result of a low slip-rate or incipient reactivation of an older system. The range of possibilities for this activity contains significantly different implications for interpretation of future fault behavior. The distinction between residual and low rate of tectonic activity is not discussed or resolved. A low deformation rate model includes a higher potential for earthquakes and for fault rupturing.

3-6 Section 3.1.2.2 Structure
Page 3-17, Figure 3-4
Insufficient information is presented

Figure 3-4 does not have sufficient discussion of the caption to allow the reader to understand the figure. The figure shows major strike-slip fault zones in Nevada and California. However, the age and activity of these faults are not presented. Many of the fault representations are not clear. For example, a strikeslip fault of 80 km length is shown at a distance of about 15 to 20 km southwest of the site. The fault's age, activity, and seismic hazard to the site is not discussed for possible impact on the seismotectonic characterization of the site. This figure should be redrafted and clearly labelled with characterization and accurate delineation of faults.

3-7 Section 3.1.2.2 Structure
Page 3-18, paragraph 3
Not enough information presented

The EA mentions an area of very closely spaced faults that trend northeast. There is no discussion or reference to this work. Figure 3-8 shows several areas of closely spaced faults in the central block. However, these trend north-north-west. Lack of information on these faults does not permit their evaluation. These zones would seem to be an unusual feature not recognized elsewhere in southern Nevada.

3-8 Section 3.1.2.2 Structure
Page 3-19, Figure 3-5
Information disagrees with other parts of the EA

Figure 3-5 shows disagreement with Figure 3-3. Tram and Older Tuffs calderas are omitted; Crater Flat is not indicated to be a caldera; and the eastern edge of Silent Canyon caldera is unspecified. Interpretation of the Calico Hills area is confusing because it is listed under "Calderas" but is called the "Calico Hills Dome". Diagrammatical representation of caldera/fault relations should be a useful tool in understanding the regional tectonics. Geologic features such as faults and calderas must be related and understanding what these relations are necessary to predict future settings. Figure 3-5 should be updated to represent present knowledge of the geologic setting. A larger scale map would be easier to interpret.

3-9 <u>Section 3.1.2.2. Structure</u>
<u>Page 3-23. Paragraph 3</u>
<u>Data disagrees with other parts of the EA</u>

The discussion of Quaternary fault scarps near the site indicates a distance range of 10-20 km. Conversion to English units is given as 5 - 10 miles. Which units were used in measurements? Accurate conversion of units is needed.

3-10 <u>Section 3.1.1.2.2 Structure</u>
<u>Page 3-23, Paragraph 3</u>
<u>Insufficient information is presented</u>

The report states that trenches across faults with small, degraded scarps within about 10-20 km of the site, show "no unequivocal" evidence that movement has occurred in the last 35,000 years. The terminology "no unequivocal" is also used in similar statements about faulting near the site on pages 6-225, 6-228, 6-231, and 6-298. On page 6-297, the terminology is changed to say "There is no confirmed evidence of surface displacements in deposits considered to be younger than 35,000 years". This statement refers to faults "on and near Yucca Mountain". The terminology "no unequivocal" is an unclear, double negative phrase, and can be interpreted as equivocal evidence of faulting within the last 35,000 years existing within 10 to 20 km of the site. Not enough information is presented to allow the reader to know whether these faults should be considered seismic hazards or not. For example, there is no discussion of the possibility of lateral faulting, causing only low scarps, which could degrade relatively quickly. If "no confirmed evidence" is being used in the same context, it would be more clear to use it throughout. Evidence for active faulting should be evaluated and the basis for dismissing this evidence should be provided. The fault map of Nakata and others (1982) indicates the Bare Mountain fault to have Holocene activity at a distance of about 15 km (not 10 to 20 km).

3-11 Section 3.1.2.3 Seismicity
Page 3-24, Paragraph 1
Interpretation disagrees with other published literature

In this section it is stated that "Yucca Mountain lies in an area of relatively low historic seismicity just south of the Southern Nevada East West Seismic Belt " (SNEWSB). This is schematically illustated in Figure 3-9 (pages 3-25) of the EA. Insufficient data or discussion is presented to evaluate whether a southern boundary of the SNEWSB can be delineated and the site be excluded from this seismic belt. The SNEWSB is characterized by seismicity in a region where north-south trending normal blocks are transected by east to southeast zones of lateral faulting (Smith, 1978). Two seismicity maps of the area around the NTS (Rogers and others, 1981, Figure 7 -Seis. 1981) show a shotgun pattern of seismicity, with local areas of more concentrated seismicity. From these seismicity maps it seems more likely that the Yucca Mountain site be interpreted as lying within the SNEWSB. At least one publication (Carr and Rogers, 1982, p. 9) delineate the extent of the "East - West Zone" to include the Yucca Mountain site. A higher degree of tectonic and seismic activity is implied if the site is included within the SNEWSB. If the site is to be excluded from the SNEWSB, further discussion and characterization of the southern boundary of the SNEWSB is needed.

The same comments, needs, and concerns exist on the useage of Rogers and others (1977) for the maximum ground acceleration as outlined in comments for Section 6.3.3.4, Page 6-296 (comment 6-21).

3-12 Section 3.1.2.3 Seismicity
Page 3-24, Paragraph 2
Data disagrees with other published literature

The same needs and concerns exist as outlined in comments on conversion of units in Section 3.1.2.2, pages 3-23 (comment 3-9), this time concerning the units of the site to the Bare Mountain fault (i.e. 15 km, or 10 mi).

The same comments, needs, and concerns exist on the usage of Rogers and others (1977) for the maximum ground acceleration as outlined in comments for Section 6.3.3.3.4, page 6-296 (comment 6-21).

Chapter 4

General Comments

None at this time.

Specific Comments

4-1 Section 4.1.1 Field Studies
Page 4-2 to 4-6
Insufficient information

Because of the descriptive and general nature of this section it is impossible to determine if many of the tasks outlined are justified and suitable to fill information gaps in the seismological and tectonic elements of present geologic data.

4-2 Section 4.1.3.4 Tectonics, seismicity, and volcanism studies
Page 4-29, Paragraph 2
Tasks outlined probably will not provide the required data

"Monitoring and interpreting present seismicity [and] studies [of] the history of Pliocene and Pleistocene activity" will not necessarily result in adequate assessment of seismic hazards at the site. As outlined in comments on Section 6.3.1.7 (comment 6-9) the faulting history may be a poor representation of potential future fault behavior. Likewise, present (and historical) seismicity is commonly non-representative of long term seismicity. Utilization of all available data and concepts are needed to make the best estimations for future seismic activity. No mention is made of intent for remote sensing analyses or low-sun-angle aerial photography projects, which are needed for fault delineation.

Chapter 5

No comments at this time.

Chapter 6

General comments

None at this time

Specific comments

6-1 Section 6.2.1.6 Environmental Quality
Page 6-54, paragraph 1
Incomplete sentence

Cannot assess conclusion.

6-2 Section 6.2.1.6 Environmental Quality
Page 6-54, paragraph 3
Not enough information presented

Information presented does not allow determination of effects of flash floods crossing alluvial fan at base of Sheep Range on rail line and potential for accident. This is not considered in Chapter 5, p. 5-14 and 5-15.

6-3 Section 6.3.1.1 Geohydrology
Page 6-97, paragraphs 4, 5
Data unavailable

Reference used in text including Spengler and Chornach (1984), Lahoud et al. (1984), Craig and Robinson (1984) and Scott and Bonk (1984) are not available. Without these references not enough information is presented to allow reader to determine how the conclusions were reached.

6-4 Section 6.3.1.1 Geohydrology
Page 6-98, paragraph 1
Incomplete information

Emphasis in discussions concerning faults is on vertical displacement. However, strike-slip displacement has been observed on a number of historical faults in Nevada (Stewart, 1980, p. 117). Without considering horizontal displacement, rates of displacement and timing of last movement displacements could be wrong.

6-5 Section 6.3.1.1 Geohydrology
Page 6-105, paragraph 1 and 2
Unavailable information

Paper by Montazer and Wilson (1984) is unavailable. Without reference not enough information is available to assess conclusions.

6-6 Section 6.3.1.3 Rock Characteristics
Page 6-187, paragraph 2
Incomplete sentence

Last sentence of paragraph is incomplete. Reader cannot determine conclusion.

6-7 Section 6.3.1.4 Climatic Changes
Page 6-190
Unavailable references

Reader cannot determine how conclusions were reached without Spaulding et al. (1984)..

6-8 Section 6.3.1.4 Climatic Changes
Page 6-196, paragraph 3
Missing data

A statement is made that "Some evidence indicates that the climate in Nevada during each of the alluvials was similar." Neither evidence or reference is given. Reader cannot determine how conclusion was reached.

6-9 Section 6.3.1.7 Tectonics
Page 6-223, Paragraph 1
Information in chapters 3 and 6 allow a different interpretation

Three tectonic processes and events are evaluated for adverse effects on a waste location site: 1) faulting affecting groundwater, 2) uplift or subsidence affecting erosion rates, and 3) transport of waste to the surface by volcanic activity. A fourth tectonic process that should be evaluated for Yucca Mountain site is surface and subsurface faulting at the site, possibly rupturing the repository. The EA contains some discussion of faulting at the site, but that discussion is confusing and inadequate (see review, Sec. 6.3.1.7, Page 6-225, comment 6-12). "Faulting affecting groundwater" may have a different emphasis in analysis than faulting of the site, which might adversely affect engineered or natural barriers of the waste containment.

The reasons that faulting at the Yucca Mountain site is an important consideration at include the following. The stress regime at Yucca Mountain is at least roughly known. Healy and others (1982) report a least principle stress direction of N70W + 10 degrees based on hydraulic fracturing techniques. Various authors have concluded that faults in the Yucca Mountain area which have a north or northeast trend, are potentially active based on the stress regime, orientation of the faults, and type of faults (e.g., normal) (Rogers and others (1982); Healy and others, 1982; this EA, page 3-26, 2nd paragraph). Further, on page 6-225 (3rd paragraph) of this EA, it states, "In addition, stress measurements suggst that the rocks may be extensionlly stressed to near the point of failure along certain faults (Healy et al., 1982).", and, as stated from Carr (1984) on page 6-232 (EA): "Although none of these data or arguments are conclusive, a combination of the stress data, the historic seismicity of the region, and the indication from current seismicity that fault activity depends more on fault orientation than fault age, suggests that a potential exists for renewed movement on faults near Yucca Mountain, despite geologic evidence of relatively tectonic stability in the Quaternary period".

Faults at the Yucca Mountain site are shown on pages 3-20 and 3-22 of this EA (figures 3-6 and 3-8, respectively, and are discussed on pages 3-23 and 3-24). These faults have the potential for rupturing if there is sufficient strain and/or the accumulation the local state-of-stress along the faults is changed (e.g., change of groundwater level due to a climatic change). These are considerations for primary rupture. The possibility of secondary or subsidary rupture should also be considered at the site (e.g., adjustments to a faulting event on the Bare Mountain fault). The host rock (Tonopah Springs member of the Paintbrush Tuff) has been described as being "densely fractured" in the lower part of the unit (page 3-13, paragraph 4). In addition to faults, these fractures should also be considered for potential adjustments during a faulting event. Direct rupture of the repository could cause many conceivable adverse situations, including release of radioactive gases into the atmosphere and destruction of access to waste storage areas.

To resolve this issue, the possibility of surface and subsurface faulting at the site needs to be directly addressed. If the faults in the site area are close to a failure state, the scenarios of fault rupture events should be discussed.

6-10 Section 6.3.1.7 Tectonic
Page 6-225, paragraph 1
Data allows a different interpretation

See comment 6-4

6-11 Section 6.3.1.7 Tectonics
Page 6-225 Paragraph 3
Insufficient information is presented

The same comments, needs, and concerns exist as outlined in comments on the usage of "no unequivocal' in Section 3.1.2.2, page 3-23 (comment 3-10).

6-12 Section 6.3.1.7 Tectonics
Page 6-225 Paragraph 4
The interpretation disagrees with other sections of the report

In the fourth paragraph on page 6-225 it is stated, "Therefore, neither major tectonic activity nor the resumption of large scale silicic volcanic activity in the area near Yucca Mountain is likely in the next 10,000 years because these kinds of events have not taken place for several million years (Carr, 1984)". This statement has three major conflicts: 1) Tectonic activity has taken place in the Quaternary (page 6-225, 3rd paragraph, "more than one episode of movement during Quaternary on faults within 10km of Yucca Mountain"), contrary to the fore statement which indicates "major" tectonic activity has not occurred near Yucca Mountain for several million years.; 2) Although silicic volcanism seems to have ceased for the last several million years, basaltic volcanism has continued, with the last eruption about 300,000 years ago (page 6-225, 1st paragraph); 3) A statement from page 6-232 also appears to disagree somewhat with the statement in question.

The statement from page 6-232 is, "Although none of these data or arguments are conclusive, a combination of the stress data, the historic seismicity of the region, and the indication from current seismicity that fault activity depends more on fault orientation than fault age, suggests that a potential exists for renewed movement on faults near Yucca Mountain, despite geologic evidence of relative tectonic stability in the Quaternary period (Carr, 1984).". It is important that a proper, reasonable, consistent, tectonic characterization of the site be determined and clearly addressed. To resolve this issue, the statement in question should be taken out of the EA.

6-13 Section 6.3.1.7 Tectonics
Page 6-226, paragraph 1
Alternate interpretations of data are possible

Several points in this paragraph are open to alternate interpretations.

(1) Most of the fault movement could have taken place after the eruption of Timber Mountain tuffs. See comment 3-3.

(2) The fact that the basalt lava flows are not faulted is not surprising given their location in a fault bound graben. Additional geophysical evidence establishing a fault in the subsurface beneath the flows would be needed for this statement to be significant.

(3) That lava flows as old as 3.75 million years are not extensively buried is not surprising given the general aridity of the area in the past (section 6.3.1.4).

(4) The conclusion that the west side of Crater Flat only appears to be "morphologically active, but has actually undergone only minor tectonic adjustment in the last 10 million years" is based on the assumption that most of the fault displacement in the region took place between 12.9 and 11.6 million years ago. Ekren (1968) has presented data the faulting took place between 11.6 and 7.6 million years ago (comment 3-3).

The effects of these conclusions in the EA is to under assess the role of faulting in the more recent history of Yucca Mountain.

Two referenced papers which are important to these discussions are Swadley et al. (1984) and Carr (1984) both are currently unavailable.

6-14 Section 6.3.1.7 Tectonics
Page 6-227, Paragraph 3
Insufficient information is presented

On page 6-277 it is stated that the probability of surface faulting in the site area is less than 1 in 35,000 for the next 35,000 years based on an approach that is described as being "too simplistic" in the same sentence. If this approach is "too simplistic" no usable conclusions can be made. An approach to surface rupture probability should be made that is not "too simplistic" (i.e. one which reasonably determines surface rupture probability at the site).

6-15 Section 6.3.1.7 Tectonics
Page 6-228, Paragraph 3
Insufficient information is presented

The same comments, needs, and concerns exist as outlined in comments on the usage of "no unequivocal" in Section 3.1.2.2, page 3-23 (comment 3-10).

6-16 Section 6.3.1.7 Tectonics
Page 6-231 Paragraph 1
Insufficient information is presented

In the first paragraph on this page, it is again stated that the Yucca Mountain site is situated adjacent to the Southern Nevada East - West Seismic Belt. The problem and basis, importance to EA findings, and recommendations are the same as that of section 3.1.2.3, page 3-24 (comment 3-11).

6-17 Section 6.3.1.7 Tectonics
Page 6-231, paragraph 1
Not enough information presented to allow reader to determine how conclusion was reached.

The conclusion is reached that the probability of a magnitude 6 or larger earthquake in the Yucca Mountain area is low. This conclusion is based on the occurrence of two historic earthquakes. This conclusion is also based on the work (unavailable) of Swadley et al. (1984) that states there is no unequivocal evidence of surface faulting in the last 35,000 years. As noted in comment 6-4 horizontal displacement does not seem to be considered, and may not be recognizable. Also see comments 3-10, 4-2 and 6-22.

The recognization of post 35,000 year horizontal movement on faults and a longer record of historical earthquakes could change estimate of probability of future earthquakes.

6-18 Section 6.3.1.7 Tectonics
Page 6-231, Paragraph 2
Insufficient information is presented

The same comments, needs, and concerns exist as outlined in comments on the usage of "no unequivocal" in Section 3.1.2.2, Page 3-23 (comment 3-10).

6-19 Section 6.3.1.7 Tectonics
Page 6-235, Table 6.3.1.7 -2
Interpretation disagrees with other published literature

Table 6.3.1.7 - 2 shows vertical tectonic uplift rates for various locations in the Great Basin. One location is the "Sierra Nevada Owens Valley - White -Inyo Mountains", and a 0.4m/1000 yr vertical rate is ascribed to this location. The reference listed for this vertical rate is an "average of 9 estimates from the literature. This is hard to evaluate because it is not clear why the Sierra Nevada and the White Mountains are grouped together, and the data for the estimate is not presented. The Sierra Nevada and the White Mountains are separate blocks, and should be considered as separate entities in the tectonic analysis. Although 0.4 m/1000yr may be a good approximation for the Sierra Nevada (Huber, 1981 estimates an uplift rate of

0.3m/1000yr for the Sierra Nevada at 38 degree north latitude), the White Mountains have been estimated to have an uplift rate of 0.8 m/1000yr (Wallace, 1978) at the northern end. To resolve this the Sierra Nevada and White Mountains vertical tectonic rates should be evaluated separately and this should be indicated in the EA.

6-20 <u>Section 6.3.1.7 Tectonics</u>
<u>Page 6-237, Paragraph 2</u>
<u>Insufficient information is presented</u>

Under "Plans for site characterization", only one plan is presented for studying faults directly. This is "dating of past fault displacements". This investigation is critical to future evalua'ions of the site, but this investigation alone is not adequate for characterization of faults in the Yucca Mountain area. Other fault parameters, including fault dimensions, sense of displacement, role, if any, of detachment faulting, degree of branching and shattering of faults, etc., need to also be determined. This statement should be modified to include a more complete analysis of the faults.

6-21 <u>Section 6.3.3.4 Tectonics</u>
<u>Page 6-296, Paragraph 8</u>
<u>Information disagrees with other published literature</u>

Item 2 under the Evaluation on page 6-296 states that "The predicted maximum ground motion at Yucca Mountain caused by credible maximum earthquakes ... is 0.4g (Rogers et al., 1977)". This statement is highly out of date. A number of things are questionable about Rogers and others (1977) study, mostly because of post 1977 studies and earthquakes. Some of the lengths from Rogers and others (1977) differ from later representations (e.g., Yucca fault is reported as 25 km in Rogers and others (1977) and is shown as possibly 30+ km in Carr and Rogers (1982); the Bare Mountain fault is preported as 8 km long in Rogers and others (1977) which differs from later representations of 15km as shown by Carr and Rogers in 1982. The terminology "credible maximum earthquake" is unusual. Estimations of maximum credible earthquakes from the length parameter were based on Bonilla and Buchanan (1970) which has been greatly revised and improved (Slemmons, 1984;

Bonilla and others, 1984). Rogers and others (1977) use Schnabel and Seed's (1973) attenuation relations to estimate maximum ground motions. These relationships have been revised by Seed and Idriss (1982) incorporating data from the well recorded 1979 and 1980 earthquakes in California. Rogers and others (1977) Figure 9 (contoured maximum acceleration) does not show the influence of the Bare Mountain fault, a critical fault in the seismic hazard analysis of the Yucca Mountain site. Estimation of the ground motion parameters is a vital link between seismic hazard and seismic safety. Considerations of ground motion parameters should be derived from Present state-of-knowledge. Parameters such as fault lengths should be defined and discussed, incorporating the most recent studies. Maximum credible earthquake magnitude estimations using fault lengths should utilize the more recent (Slemmons, 1984) relationships. Seed and Idriss (1982) relations should be used instead of Schnabel and Seed (1973). Separate faults such as the Bare Mountain fault should be considered specific sources, and be individually treated in a more sophisticated seismic hazard analysis.

6-22 <u>Section 6.3.3.4 Tectonics, Subheading V Potentially Adverse Conditions</u>
<u>Page 6-298, Paragraph 2</u>
<u>Insufficient information is presented to indicate how conclusions were reached</u>

"Sufficient to indicate that no important fault scarps are undetected" has not been demonstrated. Glass and Slemmons (1978) indicate that the single most effective method of delineating scarps is by use and study of low-sun angle aerial photographs. No mention is made for having done (or planning to do) any low-sun-angle aerial photography work. This type of study is extremely useful for fault scarp delineation. Considering the scope and importance of this study, generation of low-sun-angle aerial photography of the entire area around Yucca Mountain should be completed to delineate and assist in characterizing the faults of this region.

The same comments, needs, and concerns exist as outlined in comments on the usage of "no unequivocal" in Section 3.1.2.2, page 3-24 (comment 3-10).

References

Barnes, H., Ekren, E. B., Rogers, C. L., and Hedlund, D. C. (1982) Geologic and Tectonic Maps of the Mercury Quadrangle, Nye and Clark Counties, Nevada, USGS Map I-1197.

Bonilla, M. G. and Buchanan, J. M., 1970, Interim report on worldwide historic surface faulting: U.S. Geological Survey, Open-File Report (December).

Bonilla, M. G., Mark, R. K., and Lienkaemper, J. J., 1984, Statistical relations among earthquake magnitude, surface rupture length, and surface fault displacement: U. S. Geological Survey, Open-File Report 84-256.

Butler, P. R., Troxel, B. W., Verosub, K. L., 1983, Varying styles of deformation associated with strike slip on the Death Valley fault zone, southern Death Valley, California: American Geophysical Union, EOS, v. 64, p. 865.

Carr, W. J., 1982, Volcano-tectonic history of Crater Flat, southwestern Nevada, as suggested by new evidence from Drill Hole USW-VH-1 and vicinity.

Carr, W. J., and Rogers, A. M., 1982, Tectonics, seismicity, volcanism, and erosion rates in the southern Great Basin, in U.S. Geological Survey Research in Radioactive Waste Disposal - Fiscal Year 1979: U.S. Geological Survey, Circular 847.

Ekren, E. B., Rogers, C. L., Anderson, R. E., and Orkild, P.P. (1968) Age of Basin and Range North Faulting in Nevada Test Site and Nellis Air Force Range, Nevada, Geol. Soc. America Mem. 110.

Glass, C. E., and Slemmons, D. B., 1978, State-of-the-art for assessing earthquake hazards in the United States, Report 11, Imagery in earthquake analysis: U. S. Army Engineer Waterways Experiment Station, Miscellaneous Paper S-73-1.

Healy, J. M., Hickman, S. H., Zoback, M. D., and Ellis, W. L., 1982, Deep borehole stress measurements at the Nevada Test Site: American Geophysical Union, EOS, v. 63, p. 1099.

Huber, N. K., 1981, Amount and timing of late Cenozoic uplift and tilt of the central Sierra Nevada, California - evidence from the upper San Joaquin River basin: U. S. Geological Survey Professional Paper 1197.

Maldonado, F., and Koether, S. L. (1983), Stratigraphic, structure, and some petrographic features of Tertiary volcanic rocks at the USW G-2 drill hole, Yucca Mountain, Nye County, Nevada, U. S. Geol. Surv. Open File Rept. 83-732.

Nakata, J. K., Wentworth, C. M., Machette, M. N., 1982, Quaternary fault map of the Basin and Range and Rio Grande Rift Provinces, western United States: U. S. Geological Survey, Open-File Rept. 82-579.

Noble, D. C., Vogel, T. A., Weiss, S. I., Erwin, J. W., McKee E. H. and Younker, L. W. (1983) Stratigraphic Relations and Source Areas of Ash Flow Sheets of the Black Mountain and Stonewall Mountain Volcanic Centers, Nevada, Lawrence Livermore National Laboratory, UCRL-90132.

Oakeshott, G. B., Greensfelder, R. W., and Kahle, J., 1872-1972, One hundred years later: Calif. Div. of Mines and Geology, California Geology, V. 25, p. 55.

Rogers, A. M., Perkins, D. M. and McKeown, F. A., 1977, A preliminary assessment to the seismic hazard of the Nevada Test Site region: Seismological Soc. of America, Bulletin, v. 67, p. 1587.

Rogers, A. M., Harmsen, S. C., and Carr, W. J. 1981, Southern Great Basin seismological data report for 1980 and preliminary data analysis: U.S. Geological Survey, Open File Rept. 81-1086.

Rogers, A. M., Carr., W. J., and Harmsen, S. C., 1982, Relations between observed seismic activity and structure in the southern Great Basin of Nevada and California: American Geophysical Union, EOS, v. 63, p. 1033

Rogers, A. M., Harmsen, S. C., Carr, W. J., and Spence, W., 1983, Southern great Basin seismological data report for 1981 and preliminary data analysis: U.S. Geological Survey, Open File Rept. 83-669.

Schnabel, P. B., and Seed, H. B., 1973, Accelerations in rock for earthquakes in western United States: Seismological Society of America Bulletin, v. 63, p. 501.

Seed, H. B., and Idriss, I. M., 1982, Ground motions and soil liquifaction during earthquakes: Earthquake Engineering Research Institute, Monograph, 134 p.

Slemmons, D. Burton, 1984, Evaluation of seismic hazards in earthquake resistant design; identification and characterization of active faults, <u>in</u> Evaluation of Seismic Hazards in Earthquake Resistant Design: EERI, specialty Seminars on Earthquake Engineerings, July 20, 1984.

Smith, R. B., 1978, Seismicity, crustal structure, and intraplate tectonics of the interior of the western Cordillera, <u>in</u> Cenozoic Tectonics and Regional Geophysics of the Western Cordillera: Geological Soc. of America, Memoir 152, p. 111.

Smith, R. L. (1960) Zones and Zonal Variations in Welded Ash Flows, U.S. Geol. Surv. Prof. Paper 354-F.

Stewart, J. H. (1980) Geology of Nevada, Nevada Bureau of Mines and Geology, SP Pub. 4.

Wallace, R. E., 1978, Patterns of faulting and seismic gaps in the Great Basin Province: U. S. Geological Survey, Open File Rept. 78-943.