Department of Energy
Office of Civilian Radioactive Waste Management
Yucca Mountain Site Characterization Office
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JUL 06 1994

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U. S. DEPARTMENT OF ENERGY (DOE) RESPONSES TO STATE OF NEVADA COMMENTS ON STUDY PLANS 8.3.1.4.2.2, REVISION 2 (CHARACTERIZATION OF STRUCTURAL FEATURES IN THE SITE AREA); 8.3.1.9.2.1 (MINERAL RESOURCE ASSESSMENT OF YUCCA MOUNTAIN, NYE COUNTY, NEVADA); 8.3.1.17.4.3 (QUATERNARY FAULTING WITHIN 100 KM OF YUCCA MOUNTAIN, INCLUDING THE WALKER LANE) (SCPB: 8.3.1.4.2.2, 8.3.1.9.2.1, 8.3.1.17.4.3)

Enclosed are responses to comments made by the State of Nevada on study plans in letters dated February 8, 1994, February 9, 1994, and February 28, 1994. Enclosures 1-3 contain DOE's responses to these comments.

For comments on DOE-approved study plans, the Yucca Mountain Site Characterization Office asks the responsible participant organization (the U.S. Geological Survey) and principal investigator to perform a review and assess the impact on the planned study. The assessment includes a determination as to whether or not a revision is warranted. If a revision is warranted, DOE's intention is stated in the responses. If a revision is not warranted, additional information is provided on how the concern is being addressed, why it is inappropriate, or where the concern is being addressed if another study plan is at issue.

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If you have any questions, please contact Thomas W. Bjerstedt at (702) 794-7590.

Robert M. Nelson, Jr.
Acting Project Manager

AMSL:TWB-3987

Enclosures:
1. DOE Responses to Comments on Study Plan 8.3.1.4.2.2
2. DOE Responses to Comments on Study Plan 8.3.1.9.2.1
3. DOE Responses to Comments on Study Plan 8.3.1.17.4.3

rec'd with letter dtd 9/6/94

BOB MILLER
Governor

STATE OF NEVADA

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I-353048

February 8, 1994

Dan Dreyfus, Director
Office of Civilian Radioactive
Waste Management
U. S. Department of Energy
Washington, D.C. 20545

Dear Dr. Dreyfus:

The State of Nevada has reviewed the DOE Study Plan for "Characterization of Structural Features in the Site Area" (Study Plan 8.3.1.4.2.2, Rev. 2) and its cited references, and is providing its comments in this letter and attachment. The State's comments address the adequacy, completeness, and technical accuracy of the Study Plan to meet the purposes of site characterization.

The State's primary concerns regarding the subject Study Plan are summarized as follows:

#1

1. The principal geologic map of the site area (Scott and Bonk, 1984) which has formed the basis for the Yucca Mountain project, the original ESF layout, and this Study Plan, has yet to be finalized or subject to a quality assurance review. Significant known structural and stratigraphic features which could have a major influence on the proposed repository layout are absent from the Scott and Bonk, 1984 map due to its small scale. This mapping at a scale of 1:12,000 has already been proven insufficient to provide the detail necessary for resolving the geometry of faulting at Yucca Mountain. This mapping needs to be expanded to a larger scale (1:6,000 or 1:3,000) to identify all the relevant structural features before proceeding further.

102.8

ENCLOSURE 1

#2

2. The Study Plan proposal to conduct five activities in parallel is inappropriate. Detailed surface mapping at a scale of 1:6,000 or larger in conjunction with geophysical surveys (Study Plan 8.3.1.4.2.1) should be followed sequentially by pavement mapping; layout and logging of boreholes; vertical seismic profiling (VSP); and finally, the layout and excavation of the ESF.

#3

3. The use of photogrammetry as the principal method of mapping the ESF tunnels will be inadequate to obtain all of the relevant data. Although photogrammetry has certain advantages insofar as accurately locating mapped features and providing a complete digitized database, it cannot replace crucial information that can only be obtained by conventional mapping.

#4

4. The pavement and outcrop methods to be employed in the surface-fracture network studies will probably produce some valuable, but limited data on the fracture characteristics of the Tiva Canyon formation. Mapping of only "two or more sites in each outcropping (map) unit" will probably not yield representative results at a repository scale.

Should you have any questions, this office is available to meet with the Department and discuss the State's comments at any time.

Sincerely,

Robert R. Loux
Executive Director

ATTACHMENT
cc: R. Nelson, DOE-YMPO
J. Cantlon, NWTRB
J. Youngblood, NRC
M. Steindler, NRC-ACNW
S. Kraft, EEI
D. Weigel, GAO

ATTACHMENT

State of Nevada comments on DOE Study Plan 8.3.1.4.2.2, Rev2, "Characterization of Structural Features in the Site Area."

GENERAL COMMENTS

#5

The Study Plan seems to represent a multi-faceted approach to understanding the three-dimensional distribution of fractures in the site area. In general, it appears that the activities described for this study will be sufficient to produce data on some aspects of the geometry, spatial distribution, and physical features of fault and fracture systems at Yucca Mountain. The approaches will provide information on location, orientation, geometry, and extent of fractures. However, it is unclear how information about chronology of structural features will be obtained. Also, no description is given on techniques to be used to determine the amount and direction of movement of faults and fractures. In addition, fracture continuity and length are not satisfactorily addressed. This is especially problematical for one-dimensional exposures of fracture traces in pavements or the ESF. To address this problem, the Study Plan needs to discuss what offset markers or piercing points will be used to determine amount of offset and what kinds of structural studies will be done to determine direction of movement? How will the fracture surfaces be revealed and what kinds of kinematic indicators will be used? Also, what are the key features of faults and fault zones to be recorded?

We also have concerns about whether the data will be representative, particularly in the case of cores. Cores provide information that is not available any other way, but it is unclear from this Study Plan exactly how much core will be available. Although the number and locations of existing and proposed drillholes are included, there is no discussion of when core (as opposed to cuttings) will be collected or how this decision will be made. The statement that looking at 10% of core should yield representative results is simplistic and, we think, statistically incorrect (even if all holes will be cored from top to bottom!).

#6

1. Study Plan Approach

Mapping at 1:12,000 scale has already proven to provide insufficient detail to resolve the geometry of faults responsible for strata tilts at Yucca Mountain (c.f. Scott and Bonk, 1984). Within the repository block and adjoining areas, surface structural mapping at scales such as 1:6,000 or 1:3,000 are suggested.

#1 again

Without access to in-house technical reports which form the basis of procedures for mapping within the ESF, we are unable to completely evaluate whether the planned techniques will be sufficient. We are aware, however, that mapping within smooth-walled tunnels with circular bores poses many special problems. For example, it is unlikely that undisturbed samples can be taken in most places without coring drills. Also, magnetic compasses cannot be used to measure orientations of features because of metal track and utility lines. The photogrammetric method described in the Study Plan may provide the capability to determine the orientation of planar, through-going features that intersect the complete circular bore of the tunnel, but it seems unlikely to provide the capability of measuring orientation of discontinuous, irregular, or poorly exposed features or those that parallel the tunnel. In addition, structurally damaged zones, which will be of critical importance to evaluation of the extent of the repository block disturbed zone, tend to require extensive rock bolting and netting, which will greatly restrict study access.

#3 again

2. Study Plan Data Collection Activities

Surface mapping activities will provide representative data on distribution of ash flow tuffs and other lithostratigraphic units only if mapping is done at a suitably large scale. Only then can surface faults be shown in any detail. However, regardless of the scale, mapping alone will not provide sufficient information to deduce the magnitude and orientation of slip along the faults. Some faults will have to be excavated to expose the fault surfaces for more detailed kinematic study. Mapping of surface pavements suffers from the same limitation as surface mapping in regards to magnitude and

#5 again

orientation of slip. Fault and fracture surfaces must first be exposed by cleaning or excavating.

#7 Insufficient information is provided in the Study Plan to make an informed judgment about the mapping plan for the ESF. Underground mapping should provide a representative sampling of structures intersected by the bore of the tunnel. What is unclear is the location and geometry of the various drifts relative to known mapped fault and fracture systems at the site. The proposed layout of drifts and ramps needs to be shown on a map of known and suspected geological and structural features to evaluate whether data to be obtained from the ESF mapping will be representative of the block as a whole.

#8 A serious State concern is about the proposed methods and the timing constraints for mapping in the ESF. Conventional geologic mapping provides data that cannot be obtained from photogrammetry, but the Study Plan suggests that conventional mapping will not be done everywhere. The reason for this decision seems to be to avoid interfering with excavation and other ESF test schedules. The criteria for deciding when and where conventional mapping will be used are not stated. It is also not clear whether other ESF tests and/or engineering decisions (e.g., casing or grouting parts of the ESF, etc.) will eliminate the possibility of geologic mapping, field checking, etc. at a later date.

3. **Study Plan Scope**

#9

The range of studies proposed, including mapping, pavement studies, borehole studies, underground mapping, and vertical seismic profiling, seems to provide a reasonable combination of techniques for evaluating the gross nature of structural features in the site area.

4. **Study Plan Schedule**

#10

Figure 5.1, page F-11, is difficult to interpret. Figure 5.1 shows that ESF construction begins two years after some undefined datum and that all other activities proceed after this datum. Most activities show report deadlines four or more years following construction of the ESF. Geologic mapping, stated elsewhere in the Study Plan as complete, is shown in the schedule as not complete until one year past the start of the ESF.

#2 again

The sequencing of this study seems entirely inappropriate. DOE appears to be proceeding with the excavation of the Exploratory Studies Facility (ESF), the most costly aspect of the entire Site Characterization Program, without the benefit of the results of appropriate geological and geophysical studies that should, in fact, be the basis for siting and designing the ESF. A rational sequence of activities should proceed from the least expensive, most accessible sorts of data gathering, to progressively more elaborate and expensive activities. This has the benefit of allowing the most careful planning of the most expensive activities. One logical sequence of activities could be as follows:

A. Complete all surface geologic and structural mapping. This would include mapping of pavements and uncleared outcrops. Since the 1:12,000 scale of geologic maps that have been completed has been shown to be inadequate, the key areas should be remapped at 1:6,000 or a larger scale to define critical structural features at the surface.

B. Existing boreholes should be logged, using the newest technology, televiewers, etc.

C. New boreholes should be sited on the basis of evaluation of data from 1 and 2. Estimates of costs, numbers of boreholes, and siting criteria should be provided.

D. Vertical seismic profiling should be attempted, utilizing a combination of existing and new boreholes, in order to define structural anomalies in the rock mass and obtain seismic velocities for follow on seismic surveys.

E. Geophysical seismic surveys should be conducted between the boreholes utilizing the boreholes to define stratigraphy and velocities.

F. The ESF should be planned and designed only after the results of A-E are available for review. Explicit criteria and rationales for the ESF need to be worked out on the basis of all available geologic and geophysical data before any major underground incursions are made.

5. Issues Resolution

A reasonably well thoughtout series of activities has been planned for characterization of structural features. However, the sequencing of activities appears completely inadequate (see above), and little thought has been given to making maximum use of existing and newly acquired geological information in siting and organizing the activities. Numerous questions are unanswered by the Study Plan about the process of selection of sites for stripped pavements and boreholes. How are sites chosen? What statistical tests are used? How will DOE ensure that sites are representative and that they cover the entire range of variation? It is of considerable importance to plot sites on a highly detailed topographic and geologic basemap to evaluate these questions. Furthermore, many problems of measurement and representativeness or spatial data have not been adequately addressed. Many critical scientific questions regarding the geometry, regularity, continuity, and dating of fractures and faults have not even been discussed. We consider it unlikely, therefore, that this study, as written, will

#11

resolve the issue of the characterization of the structural features of the site area.

#11 cont.

Based on the information available in this document, we consider it unlikely that the objective of complete characterization of the structural features will be met.

6. References

#12

The reference base, as it relates to topical studies around Yucca Mountain seems to be fairly complete. However, references are completely lacking in most of the recent literature on fractures and joints in rocks and there are no references from the Journal of Structural Geology.

SPECIFIC COMMENTS

#13

On page 2.1-1, Activity 8.3.1.4.2.2.1, geologic mapping of zonal features in the Paintbrush Tuff at a scale of 1:12,000 is discussed. Zonal features in tuffs can be distinctive and extensive enough to provide markers for recognizing fault offsets, however, they are planar (tabular) features, not linear features. They therefore show only an apparent offset. Kinematic indicators, or a cross-cutting planar structure that provides a piercing point, are needed to determine direction and amount of net slip.

An Open-File report by Scott and Bonk on the northeast part of the mapped area was published in 1984 as preliminary. That map, which has been the principal basis for the entire Yucca

Mountain repository program has never been subject to a quality assurance review or finalized. Also, it is our understanding that the rest of the mapping was completed, and compiled on topographic bases in FY 1987. Six years later, the remainder of the mapping has not yet been published. It is stated that 1:12000 scale is adequate to show the structural geometry necessary to construct structural and tectonic models of Yucca Mountain. This is inaccurate. Many fine-scale faults not mapped in field had to be postulated by Scott and Bonk to account for steep dips of lithostratigraphic units in the vicinity of large faults. The geometry of these small faults is critical to structural interpretations, yet was never evaluated in the field. A much larger mapping scale is clearly necessary. Local mapping at larger scales is proposed, but no details are provided.

#14

On page 2.2-1, Section 2.2.2.1, second paragraph, states that nine pavement sites have been completed, and that a total of approximately fifty sites will be studied by this method. Figure 2.2-1, however, shows only seven completed sites and twenty-seven potential sites. These need to be plotted on a much more detailed topographic base map, preferably with 1:12,000 scale geological information superimposed, in order to assess the usefulness of the existing and proposed sites. No map of the uncleared outcrop sites is given, therefore, we cannot judge whether systematic coverage can be obtained

#15

from the surface-fracture network studies. In addition, there needs to be some discussion of sample site selection strategy, and the statistical approaches that will be used, particularly fractals.

As part of Activity 8.3.1.4.2.2.2 Surface-fracture network studies, the pavement and outcrop methods discussed under Section 2.2, page 2.2-1, complement each other and both are necessary. The Study Plan states that nine pavement sites and fifty uncleared-outcrop sites have been completed. It is difficult to evaluate the choice of the number of sites without seeing the results of those studies first. However, "two or more sites in each outcropping unit" (p. 3.2-1) sounds low, particularly if "unit" refers to map units. A single tuff cooling unit typically comprises a non-welded base, a welded central zone, and a vapor-phase altered top. Each of these would be expected to have different primary fracture characteristics, and potentially different susceptibility to later tectonically-induced fracturing. A mappable member or formation may comprise more than one cooling unit. Two study sites in such a unit will probably not yield representative results.

#16

On page 2.2-3, Section 2.2.2.4 states that the timing of surface-fracture network studies is known to be dependent upon data from geologic mapping, yet mapping is said to have been

#17

finished in 1987. When and how will the Scott and Bonk 1984 preliminary map and the 1987 maps be finalized? What quality assurance data qualification process will be utilized?

On page 2.3-1, Section 2.3, borehole evaluation of faults and fractures is discussed. Previous studies of detailed logging of fractures and faults in the cores from UE17e on the NTS as part of other structural studies, used the existing fracture logs as a starting point. The main problems with these logs appear to be (1) the geologists did not, or could not, distinguish between faults, joints, and drilling-induced fractures; (2) the geologists did not note kinematic indicators on the faults even though some surfaces showed sense of slip and/or multiple slip direction; and (3) there was a noticeable difference in log descriptions between geologists who logged different parts of a single core. All of these problems can be alleviated in the proposed study by assuring that all geologists doing fracture logging have experience with the interpretation of small-scale structures and by duplicating enough of the logging to insure reproducibility of structural observations.

#18

In Section 2.3.1, page 2.3-1, first paragraph; Although we understand the rationale for the three logging methods and support the use of all three, we recommend that direct observation of cores be used as much as possible. This provides the kinds of information (e.g., nature of fractures, compositions of fracture fillings, kinematics of fault surfaces) that are not available from the other methods.

#19

In Section 2.3.1, page 2.3-1, we interpret the third paragraph to say that 10% of the total oriented core, if available, would be sufficient for measuring fracture orientations. We see several problems with this approach, primarily related to (a) how much core will be available for study, and (b) whether the available core is representative. How much of each hole will be cored? If only some of the hole is cored, how are the segments to be cored chosen? How much of this is oriented core? How and why is the decision made to collect oriented vs. unoriented core? All core collected as part of this and related studies should be oriented. Based on observations on UE17e (which was continuously cored for its entire 3000' length), there are several reasons to question the representativeness of observations on 10% of a core, First fracture density can change dramatically as a result of subtle compositional variations; second fracture density changes with proximity to faults, the location(s) of which will probably not be known when coring intervals are selected); and third, core recovery is commonly poorest in fault zones.

#20

#21 In Section 2.4.1, page 2.4-1, although there is an advantage in using photogrammetry for accurate location of the mapped features and for generating a complete digitized data base, virtually all other measurements should be made manually at the working face.

#22 On page 2.4-4, Section 2.4.2, second paragraph, we strongly disagree with the statement that "through photogrammetry the geologist is able to gather critical data which would be lost by conventional mapping". We think the opposite is true. Photogrammetry can probably provide fracture location, orientation, and extent more efficiently than sketching can, but it will miss the clues provided by subtle changes in color, texture, mineralogy, etc. that allow the geologist to interpret the origin of a given fracture, recognize which are the important faults, determine the number, sense(s) and relative age(s) of motion on a fault surface, etc. In addition, as have previously noted, many critical measurements (e.g., fracture aperture, composition of fracture filling, etc.) cannot be made from a photograph.

#23 On page 2.4-6, Section 2.4.2.2, second paragraph, hand-specimen petrographic descriptions should be done at the working face, not at the surface. Such descriptions are usually made on the basis of several samples, and are often supplemented by a look at surrounding rocks to confirm an unexpected observation, a check for how representative the hand specimen is, a look for systematic compositional variation with position in the bed, etc. None of this is possible to someone identifying a sample in a lab. The description of a simple sample under lab conditions may give more "reproducible" results, but that does not mean that they are more representative or accurate.

#24 On page 2.4-6, Section 2.4.2.3, the second paragraph states, "Where excavations expose unusual geologic features...the geologists should be allotted sufficient time and access to avoid a loss or irretrievable data". We agree, but why does this not read "...geologists <u>WILL</u> be allotted sufficient time>>>"?

#25 On page 2.4-7, under Section 2.4.3, why does there have to be a choice of methods? Photogrammetry (and the associated remote analysis of results) has some advantages, but it cannot replace the crucial observations made during conventional mapping. Crucial information such as fracture aperture, nature of fractures (joint or fault), fault kinematics, etc. can only be determined by conventional mapping methods.

#26 On page 2.4-9, Section 2.4.3.6 states that, "The mapping will be driven by the rate of excavation progress." Does this mean that the mapping must keep up with excavation, even if some important measurements must be omitted? Who will make the progress decision, the geologist or the engineer?

#27 On page 2.4-9, Section 2.4.3.8, the statement "Test methods selected for this activity are designed to reduce to a minimum the amount of time that geologists and associated technicians are required to spend underground..." in the concluding paragraph is an alarming example of misplaced priorities. The statement suggests that collection of site characterization data will be sacrificed for a perceived underground safety problem.

#28 On page 3.2-3, Section 3.2.1.1 and Table 2.2-1, the list of fracture parameters to be measured does not include sense of slip. Slickenside pitch, which is listed, provides a line along which slip occurred, but not the direction along that line. Other necessary measurements which are not specified include the relative ages of mineral coatings and different fault sets, joint sets, etc. It is important to distinguish between faults and joints before making relative age determinations, because cross-cutting relationships in joints give the opposite result of the same pattern in faults. The relative age determinations must be made in the field, not in the office.

#29 In Section 3.3.2.1, on page 3.3-2, how is the distinction between natural, coring-induced, and handling-induced fractures made? For natural fractures, how are joints distinguishable from faults?

#30 In Section 3.3.7, page 3.3-5, we note that fracture orientation data are most useful when presented as stereograms because these display both strike and dip for each data point. For Section 3.3.8, page 3.3-5, we note again that it is very important that fracture data for all three subsurface techniques be compared and that fracture data for several complete oriented cores be included in this comparison.

#31 On page 3.4-1, Section 3.4.1, in the second paragraph, the next to last sentence, states, "In reaches where conventional mapping is used..." This statement implies that there are places where it will not be used; how will each be chosen? How much of the ESF will not be mapped by conventional techniques?

#32 On page 3.4-3, in Section 3.4.1.2 (b), please clarify if data will be rechecked in the field as necessary, or rechecked from the photos? If a feature does not show well on the photos, no amount of rechecking in the lab will improve interpretation. On page F-11, "Figure 5-1, Schedule for Study 8.3.1.4.2.2": Why is there no required exchange of information between these studies relatively early in the project as opposed to schedule years four or five?

#33 On page T-18, "Table 2.4-2, Test characteristics of photogrammetric and conventional sketch methods of geologic mapping": This table omits the important consideration that the "conventional sketch" method results in data that cannot be obtained from the photogrammetric method (e.g., direction and sense of motion of faults, reactivation of fault surfaces, distinction between joints and faults, etc.).

U. S. Department of Energy Response to State of Nevada Comments on Study Plan 8.3.1.4.2.2 (Characterization of Structural Features in the Site Area)

Responses to Summary Comments:

1. Mapping of selected critical localities within the site area is being done at considerably larger scales than 1:12,000, but remapping the entire area at larger scales is not planned. (Experience has shown that mapping at a scale of 1:6,000 is not any more definitive than the 1:12,000 scale.)

2. The work plan as discussed in the study plan is considered adequate to achieve study objectives. Schedules are commonly based on funding and availability of personnel.

3. Mapping in the ESF will involve both conventional and photogrammetric methods, as is adequately and clearly stated in the study plan. (See response to Comment 8.)

4. The aim of the fracture network studies is to obtain data that are representative of the repository area; the numbers and locations of the study sites will be selected accordingly.

Responses to General Comments:

5. Fault data (chronology, displacements, slip rates, etc.) are being obtained in many other studies in the site characterization program (tectonic studies, surficial mapping, etc.), based on commonly accepted, standard methods and techniques. Fracture continuity and length, offsets, and other significant parameters will be addressed in the present study in sufficient detail to meet study objectives.

6. To reiterate what is stated in the study plan, it is anticipated that sufficient core will be examined to provide a representative sampling and to satisfactorily meet study objectives.

7. Appropriate maps will be prepared as excavation proceeds. The primary objectives of the ESF mapping are to provide a detailed characterization of the geologic features encountered in the ramp and drift excavations and to accurately portray these features on maps.

8. Current study plans call for conventional mapping to be performed for all excavations to the extent possible, with photogrammetry as a supplemental method. Mapping techniques are being tested in the first 400 feet of the excavation to determine viability of photogrammetry as a mapping technique. Because of changes in the size, length, and type of excavation, the ramps and drifts will not be obscured to the extent originally planned when the study plan was prepared, thus allowing for greater access and more time for conventional mapping of the underground features. The goal

of ESF excavation is to characterize the rock at the repository level as well as the rocks down to it. DOE intends to construct a safe facility in which this work takes place. If tunnel stability becomes an issue, such as in the Rainier Mesa tuff and associated units, DOE intends to do what is necessary to make the tunnel safe even if it makes characterization difficult or precludes it. When decisions are made that require trade-offs between safety and ability to characterize the site, both the testing staff and the design and safety engineers will be involved. They will recommend the trade-offs to DOE management on how best to support the needs of the characterization program and the need to deliver a safe tunnel to the testers.

9. The DOE also regards the combination as a reasonable approach.

10. Schedules of activities are commonly subject to change, depending on funding, availability of personnel, and other factors, many of which are beyond the control of the study staff. There is no requirement to modify study plans as these changes occur--current schedules can be determined through the project's Planning and Control System. Although Yucca Mountain and surrounding areas had previously been mapped geologically, there is a need (as discussed in the study plan) to map selected areas at larger scales and in greater detail. This mapping is now proceeding as part of this and related studies in the site characterization program.

11. As commented upon elsewhere, selected areas will be mapped at larger scales and in considerable detail. The areas selected for this kind of new mapping are carefully chosen as needs are identified during the course of study. For example, "strip" mapping along faults is considered necessary to establish slip rates and direction and recurrence of movement. Detailed mapping of surficial deposits is required to help in determining age of faulting; and large-scale mapping is needed to establish fracture patterns and characteristics. Sites for pavement study are chosen on the bases of: (1) there is an opportunity to collect data on fractures exposed in the Tiva Canyon or Topopah at places where work is being undertaken for other purposes; for example, the Large Block Experiment, and (2) the trade-offs for ease of construction or clearing, spatial representativeness, and geology available for examination render a given location as desirable.

12. References cited in study plans are not intended to be all inclusive, and study plans are not revised solely to include new information by reference. Why does not the comment include references thought to be relevant to the work.

Responses to Specific Comments:

13. Standard, widely-accepted methods will be used in mapping zonal features and determining fault offsets.

14. An updated version of Scott and Bonk's map is in final stages of review for publication as Open-File Report OFR 92-266. All faults relevant to site characterization will be studied in detail, as indicated in earlier responses. The Ghost Dance Fault strip mapping, for example, has been carried out at a scale of 1:240.

15. Reports on fracture studies, when completed, will contain locality maps. The current approach to fracture studies may not involve fractals because validity of fractal approach has not been firmly established.

16. Whether or not two sites for each outcropping unit are sufficient to meet study goals can only be determined as the investigation progresses.

17. Scott and Bonk's map reflects standard mapping methods and is nearing publication as Open-File Report 92-266. This mapping has proven to be accurate through peer review and by later field investigations. For this reason, a combination of confirmation and corroboration is the likely means by which a qualification exercise may proceed.

18. All facets of study will be conducted by fully qualified personnel, according to the quality assurance program. The ability to achieve consistency between investigators rests in establishing recognition and definition criteria, which has been done. There will always be some degree of subjectivity in this type of evaluation, but it can be reduced through explicit and consistent use of recognition criteria.

19. Direct study of cores will be done to the greatest possible extent.

20. Ten percent is only an estimate, and is not intended to be a fixed guideline for the entire core study. Variations in core characteristics are fully recognized by study personnel. The project's Sample Management Committee evaluates requests for core and mediates the sometimes conflicting needs of investigators who need sample material from specific holes.

21. The majority of fracture characteristics will be measured manually in the excavation.

22. The true comparison is that both techniques render representations of the same reality in different ways. Photogrammetric methods do result in very accurate location data, as well as other fracture characteristics, and may be used for these purposes. See the response to Comment 8.

23. Brief descriptions of rock samples will be made underground and notations made as to the setting from which the sample was collected. More detailed examination and analysis will be performed in appropriate laboratories.

24. Except when personal safety is concerned, geologists will have sufficient time to examine and map geologic features in the excavations. See the response to Comment 8.

25. See the response to Comment 22.

26. Given the excavation progress expected for the hard volcanic rock and a goal to adequately characterize the site, the penetration rates will be paced to ensure the tunnel is adequately mapped and that a safe tunnel is constructed.

27. We will provide adequate staffing underground to characterize geologic features in detail and to satisfactorily achieve study goals. With the advent of the mapping gantry to immediately follow the excavation equipment, the congestion issue, and hence the safety factor, is not as critical as once thought. See the responses to Comments 8 and 26.

28. Standard methods being applied in fracture studies will also result in data on sense of slip and relative ages.

29. See the response to Comment 18.

30. Stereonets will be used in portraying fracture data. Discussions in Sections 2.3.1 and 3.3.2.1 of the study plan indicate that oriented core samples will be used for comparisons with data obtained through logging of boreholes.

31. When significant geologic structures are penetrated, both methods will be used, but both methods are not to be used down the entire length of the ramp. There will be a rationale for why one or the other technique is fielded. See the responses to Comments 8 and 22.

32. Photogrammetry, as indicated in earlier responses, is now considered to be an alternate mapping method. Surface and underground mapping will be integrated and closely coordinated. Rechecking will be done as the need arises.

33. See the response to Comment 22.

BOB MILLER
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STATE OF NEVADA

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February 9, 1994

Dan Dreyfus, Director
Office of Civilian Radioactive
Waste Management
U. S. Department of Energy
Washington, D.C. 20545

Dear Dr. Dreyfus:

The State of Nevada has reviewed the DOE Study Plan, "Natural Resource Assessment of Yucca Mountain, Nye County, Nevada" (Study Plan 8.3.1.9.2.1, Rev.0) and its cited references, and is providing its comments in this letter and attachment. The State's comments address the adequacy, completeness, and technical accuracy of the Study Plan to meet the purposes of site characterization.

The State's primary concerns regarding the subject Study Plan are summarized as follows:

#1

1. The geochemical and geological activities of the Study Plan contain a fundamental conceptual oversight. The basic premise of the Study Plan is that the site area would present the same target to an explorationist in the future as it does today. Where, in fact, there will be residual thermal, radiation, and geochemical anomalies resulting from any long-term radioactive waste disposal that may be inherently attractive to future explorationists. Consideration of how the repository site might be disturbed in a hypothetical search for minerals could require major changes in how and when the study is carried out.

#2

2. The Study Plan does not explicitly include any program for detailed geochemical, petrographic and related analysis of the rocks intersected by the exploratory tunnels and deep boreholes as they might relate to early site suitability determinations of natural resource potential.

ENCLOSURE 2

#3

3. The authors of the Study Plan do not include consultation or participation of any U.S.G.S. geologists known for their work on the type of deposits most likely to be present in the Yucca Mountain site area.

#4

4. The Study Plan, as outlined, is not an exploration plan based on industry practice of systematic sampling followed by more detailed studies of anomalous areas. The subdivision of the work into a "geochemical assessment" activity and a "geophysical/geological appraisal" activity is highly artificial and contrary to standard mineral potential surveys.

It should be noted that concerns and comments contained in this letter are applicable only to geochemical and mineral resource assessments. Concerns and comments relative to geothermal and hydrocarbon resource assessments will be transmitted later.

Should you have any questions, this office is available to meet with the Department and discuss the State's comments at any time.

Sincerely,

Robert R. Loux
Executive Director

ATTACHMENT
cc: R. Nelson, DOE-YMPO
J. Youngblood, NRC
M. Steindler, NRC-ACNW
J. Cantlon, NWTRB
S. Kraft, EEI
D. Weigel, GAO

ATTACHMENT

State of Nevada Comments on DOE Study Plan 8.3.1.9.2.1, Rev. 0 - "Natural Resource Assessment of Yucca Mountain, Nye County, Nevada."

GENERAL COMMENTS

#5

The State believes that there exists a fundamental conceptual oversight in the formulation of the entire geochemical and geological program presented in this Study Plan. We believe that there are major fallacies in the ideas held by the Department and the authors as to how the repository site might come to be disturbed in a hypothetical future search for minerals. Recognition of these fallacies and consideration of their implications will require major changes in how and when the evaluation of the mineral potential of the Yucca Mountain repository site should be carried out.

#5

The principal concern of DOE seems to be that future exploratory drilling of the Yucca Mountain site area could intersect radioactive waste and introduce it into the environment. We believe, however, that drilling should not be the principal and only concern. To drill an exploratory hole that would intersect the repository horizon clearly requires both a technological capability more or less equivalent to that presently available and a social and economic infrastructure that would favor high-risk investments for mineral investigation. Economic geologists, mining engineers, etc., of such a future society would clearly have knowledge and understanding similar to that of modern mineral explorationists and miners. Specifically, future explorationists would recognize that major tunneling had taken place on the eastern flank of Yucca Mountain, even if all historical records had been lost and considerable time had elapsed. In short, it will be impossible to hide the large amounts of excavated rock material.

Moreover, future explorationists would clearly consider as one possibility that the tunneling had been undertaken for the extraction of minerals. This possibility would be reinforced by the clear presence of old mines (for example, the huge open pit of the Lac (formerly Bond) - Bullfrog mine in the Bare Mountain-Bullfrog Hills areas and the presence of a number of geophysical anomalies that would be created by the waste emplacement (e.g. thermal radioactive halos, gravity, magnetic, etc.). Undoubtedly, one of the first things that professionals of this hypothetical "new" society would do is to look at, and geochemically sample in a more or less systematic manner, the rock removed from the tunnels. This would unquestionably be done before any drill holes were placed into the repository area. It is clear that the principal indication to future generations of possible mineralization at Yucca Mountain would be the material removed from the exploration, haulage and repository tunnels. Irrespective of efforts to grade, smooth, cover, or otherwise conceal or obscure the waste removed from the repository tunnels, we feel that any society sufficiently advanced to carry out deep exploratory

#5

drilling would recognize and sample the rock waste dumps as a first step.

Following the above line of reasoning, we suggest that the most important rocks to sample will be those cut by the exploratory tunnels. The Study Plan for evaluation of mineral potential should, therefore, explicitly include a program of detailed geochemical, petrographic and related studies of the rocks intersected by the exploratory tunnels. Moreover, only when the exploratory tunnels are finished, and the geochemical, petrographic and other data that bear on mineral potential are available, can a reasoned assessment be made as to the degree to which the proposed repository would attract the attention of future mineral explorationists.

#5a

We do not believe that the logging, geochemical analysis, etc., of core from surface exploration holes can take the place of sampling the tunnels themselves. This is because the size of mineral deposits of the types that could be expected at Yucca Mountain is many times smaller than the average spacing of the existing and proposed drill holes. Indeed, even in areas of known mineralization, much more closely spaced drill holes commonly fail to intercept ore grade deposits.

#6

The above line of reasoning can easily be extended further. For example, if the rock removed from the tunnels, etc., were to show signs of hydrothermal activity, mineralization, etc., future explorationists could be tempted to reopen the tunnels leading to the repository in search of the mineralized rock. It would be very difficult and probably impossible, to hide the location of the tunnels from professionals having the technology to drill deep exploratory holes. Detailed seismic, air photo, shallow drilling, or other methods could be used to search out and discover the tunnels, which then could be reopened and rehabilitated. Reopening would clearly involve a first-order breach of the integrity of the repository.

#7

If rock with geochemical and/or mineralogical features suggestive of nearby mineralization were to be excavated, the repository tunnels could conceivably serve as a staging area for drilling, etc., to explore for nearby mineralization. Most likely, such hypothetical mineralization would be below, rather than above, the level of the proposed repository. If geochemical or other distal indications of possible mineralization are encountered in the tunnels and/or deep boreholes, consideration should be given to evaluating these possible deep targets by drilling or other means. If meaningful indications of potentially economic mineralization are found by such a program, then this would provide one more reason that the site should be disqualified.

#8

#9

A general impression from the review is that the sections on geochemical, geophysical and particularly, geological assessments relative to mineralization are weak and not as well thought out as are those sections for geothermal and hydrocarbon resources.

We are concerned that the authors of the Study Plan do not include any of the U.S. Geological Survey geologists who are known for their work on the types of mineral deposits, particularly low-grade bulk-mineable Au+/-Ag deposits, present in areas near Yucca

#3 Mountain or which might possibly be present beneath Yucca Mountain. Two of the authors are known to have worked for many years

Again formulating trade-tonnage models of various types of mineral deposits. While such expertise is important, extensive field or laboratory experience with mineral deposits of the type known or possibly present in the vicinity of Yucca is more important. The discussion intimates that the research group does not include an analytical geochemist.

An illustrative example of the obvious lack of general and local expertise and knowledge in economic geology by the USGS authors of this Study Plan is provided by Plate 1 of Bergquist and McKee (1991) which, in a modified form, was also presented to the

#10 Advisory Committee on Nuclear Waste in Las Vegas on October, 1992. On this plate, the Sterling mine, a well-known, producing sedimentary rock-hosted disseminated gold deposit, is shown as a polymetallic vein type deposit. Vein type epithermal Au-Ag deposits of low total sulfide adularia-sericite type in the southeastern Bullfrog Hills, including the major producing Lac (formerly Bond) - Bullfrog mine, are shown as hot-spring type Au-Ag deposits. Similar adularia-sericite type Au-Ag vein deposits in the northeastern Bullfrog Hills (Mayflower and Pioneer mines) are classified as polymetallic vein deposits. These are errors that experienced economic geologists would not commit.

The subdivision of work to assess the potential for mineralization and mineral resources into two parts "geochemical assessment" and "geophysical/geological appraisal" (p.2-1 - 2-5) is highly artificial and is contrary to the way that appraisals of the mineral potential of an area are normally carried out in the private sector. Geochemical data and geophysical/geological information clearly should not be segregated and evaluated independently of one another but rather must be closely integrated

#11 to arrive at a proper evaluation. Although the Study Plan clearly states that information will be closely shared between groups/tasks, this does not take the place of having a single group working with both geochemical and geological data. This artificial subdivision of efforts is underscored on page 3-2, where the various types of geochemical data that are to be obtained are listed. Many of these data, for example the petrographic, potassium-argon, argon-argon, and stable isotopic data are fundamentally geological in nature, and require a person with geological insight to both obtain the samples and interpret the data.

In addition proposed program of geochemical assessment is significantly outmoded relative to sampling methodology, analytical techniques, and interpretation. This appears to reflect: 1) an

#12 unfamiliarity, or at least a lack of practical experience, on the part of the authors with standard private-sector exploration geochemical methods and practice and 2) the fact that apparently none of the authors are practicing analytical geochemists.

The general design of the geochemical program as outlined in the Study Plan is focused on detailed surface sampling of rocks, soils, vegetation, etc. combined with the study of drill core and groundwater. As discussed above, we feel that the Study Plan is seriously flawed by the omission of any program of sampling of the exploratory tunnels. In addition, the program as outlined is not a cohesive plan to address the problem. A large percentage of the possible techniques that one can use for geochemical

#13 exploration, ranging from the use of panned concentrates to the sampling of certain plant species have been listed. No coherent plan for general systematic sampling followed by more detailed study in geochemically anomalous areas has been elucidated. Everything is going to be done using almost every possible technique that could be thought of. Finally, the discussion of the analysis of the data is typical of a research study and not a standard analysis of mineral exploration data collected and analyzed by an industry exploration team.

Perhaps more importantly, the program does not appear to explicitly take into account present geological knowledge. Although geochemical studies of the rocks exposed in the immediate area of the repository are far from systematic or comprehensive, many geologists have studied and sampled the area. From these observations it is reasonably clear that there is no evidence of hydrothermal alteration or other signs of hydrothermal activity visible at the surface. On the other hand, there is evidence for hydrothermal activity and mineralization in older rocks exposed in various areas both east and west of Yucca Mountain (e.g., Castor and Weiss, 1992). Also, a thin unit of siliceous sinter has recently been recognized on the northwest slope of Yucca Mountain between the Tram and Bullfrog Members of the Crater Flat Tuff (C. Fridrich, personal commun., 1993). For these reasons, we suggest that the surface studies focus on ash-flow and other units below the Topopah Springs Member of the Paintbrush Tuff.

#14

The Study Plan appears to confuse the determination of initial or original geochemical features of the various units with estimation of background values. The determination of initial values requires careful sampling of the various units and various parts of compositionally zones units in areas where they have undergone the least post-depositional modification. On the other hand, estimation of background values, for the purpose of evaluating mineral potential, requires more systematic areal sampling, because the concentration data sought will include any and all

#15

post-depositional changes unrelated to hydrothermal activity and mineralization.

#16 The amount of discussion devoted to geological studies is extremely modest compared to that for the geochemical and geophysical studies. We consider that geological considerations are of equal, or even greater, importance than are geochemistry and geophysics.

#17 The Study Plan fails to include any maps showing the location of mines, mineral deposits, prospects, etc., in the vicinity of Yucca Mountain. Nor is there a map showing other mines in the southern Great Basin equivalent to the ones given, for example, in the section on hydrocarbon potential.

#18 The Study Plan lacks an appropriate summary discussion of the mineral deposits present in the surrounding areas. A recent summary paper by Castor and Weiss (1992) appears to have been ignored, as are previous publications of the University of Nevada Reno that bear directly on geology and mineral deposits, for example, Noble et al(1992). Moreover, other types of mineral deposits such as non-metallic or aggregates that might be present at or near the repository site need to be discussed more completely.

In the Study Plan it is stated that it is impossible to indicate which mines and prospects will be visited for study. The reason given is that at present it is not known which mines will permit access to their properties. This is a specious argument, since all the mines in the area have in the past graciously granted access to any qualified group that asked. Moreover, even if access is at present not assured, it should in no way prohibit preparation of a list of deposits and prospects that should be examined.

#19

SPECIFIC COMMENTS

In Section 3.1, p.3-1, the Study Plan considers the elements gold, silver, copper, lead, zinc, tin, mercury, thorium and uranium as important commodities. Of these, gold, is, at present, the metal of greatest economic interest in the region. Uranium and thorium would appear to have little possible importance in the Yucca Mountain area. On the other hand, lithium and beryllium have been omitted. Lithium in the form of hectorite (a Li smectite) apparently is highly sought after for cosmetics. Beryllium, as bertradite, is presently produced from late Cenozoic volcanic rocks at Spor Mountain in western Utah.. Although the type of slightly peraluminous "topaz rhyolite" which hosts and is related to Be mineralization at Spor Mountain is apparently not present in the southwest Nevada volcanic field, the possibility for economic Be mineralization is at least as great as that for economic Th and U mineralization. In addition, because of rapid advances in technology, minerals that may have no significant economic value today, could become very valuable in the future.

#20

Under Section 3.1.1.1.1, p. 3-1 in the paragraph that addresses the surface sampling activity, the Study Plan mentions the collection of "grab" samples. As generally understood, "grab samples" consist of one or more pieces of rock taken from a given outcrop, etc.

#21 This is probably not the best way to carry out systematic surface rock sampling for mineral exploration or evaluation. What should probably be taken are so-called "chip samples", which consist of aggregates of small rock fragments taken from many outcrops over an area of from 25 to 500 square meters or more.

We are also concerned about the proposed program for the sampling of drill core. Typically, core sampling involves "splitting", that is subdividing the core (by diamond saw in the case of the Yucca Mountain core) and submitting a portion (typically one half or one

#22 fourth of the core) for analysis. Short, arbitrary lengths of the core, or portions of the core, are not normally taken in mineral exploration, although parts of the core may not be analyzed if the megascopically observable petrographic character of the rock strongly suggests that anomalous geochemical values are not present.

The last sentence in the first paragraph of Section 3.1.1.1, pg. 3-1, "For example, some of the silicic tuffs in the vicinity of Yucca Mountain may be sufficiently alkaline to warrant examination of their niobium, rare earth, uranium and thorium potential", seems to demonstrate lack of contemporary experience in applied economic geology. The Gold Flat Member of the Thirsty Canyon Tuff, is the most Nb, REE, U and Th rich unit of silicic tuff in the southwestern Nevada volcanic field (Noble, 1965). However, even this unit, which does not occur in the general vicinity of the repository site, does not contain nearly high enough concentrations of these elements to make it a potential economic source. In addition, the term "industrial minerals" is used several times without any details as to which of the large number of industrial minerals might be expected to occur at the repository site.

#23

Section 3.1.5, pages 3-2 - 3-4 discusses geochemical analytical methods. Although the analytical methods for geochemical analysis outlined appear suitable, there would appear to be a problem in how these techniques are to be applied. Specifically, it would seen that the ICP-AES multi-element procedure of Lichte et al. (1987) is going to be used to screen large numbers of samples. From the way the Study Plan is written, it would seem that more sensitive methods (e.g., Motooka, 1988) would only be used as needed. It should be emphasized that the ICP-AES method has been shown to be inappropriate for recognizing low-level geochemical anomalies of the type that must be looked for to find buried mineral bodies, particularly epithermal Au-Ag mineralization. The detection limits for gold and other important "pathfinders" elements appear to be too high. Instead, the most sensitive methods available for detecting such critical elements as Au, As, Sb, Tl, Hg and Bi (e.g. Motooka, 1988) should be used routinely for both background

#24

estimation and anomaly detection. Moreover, in addition to the elements listed, tellurium (Te) should be determined using methods that are sensitive to a few hundred parts per billion. Finally, no mention is given of evaluating the possible presence of ammonium, which is known to occur in many altered rocks of high-level hydrothermal systems. Ammonium can be readily detected by spectral methods, using either hand-held or airplane or helicopter instrumentation.

#25 Several sophisticated laboratory techniques, including K-Ar and Ar-Ar dating, fluid inclusion studies and stable isotope measurements are mentioned several times in the Study Plan. Although all are useful techniques with which to characterize and understand igneous and hydrothermal activity, nowhere in the Study Plan is any indication given as to how the methods are to be applied or how the resultant data will be utilized other than, implicitly, to "better characterize the site".

#26 In Section 3.2, beginning on pg.3-6, the discussion of geophysical data appears to be more credible than that of the geochemical and geological sections. The names of the individuals involved in the preparation of the report include several individuals well known for the quality of their geophysical work in the southern Great Basin and elsewhere.

In Section 3.2.1, on pg. 3-6, it is proposed in the Study Plan that the airborne radiometric data obtained as part of the NURE program be reanalyzed and interpreted. This study will add little to the mineral resource assessment. If an adequate knowledge of possible anomalous concentrations of U, Th and K are desired, the area should be reflown on a close grid pattern and at very low elevation, using a helicopter, to obtain detailed data. Care should be taken to utilize instrumentation that has the ability to discriminate the effects of short-lived radionuclides produced by NTS surface testing and other activities.

#27

It is stated in the second paragraph, last sentence on page 3-7: "Similarly, gold associated IP anomalies at Bare Mountain will also be traced eastward to Yucca Mountain, particularly in the vicinity of the magnetic anomalies near the proposed repository (Bath and Jahren, 1984)." The "gold associated IP anomalies" presumably refer to the Joshua Hollow gold occurrence. Considering the small size of disseminated gold deposits relative to the distance from Bare Mountain to Yucca Mountain, the above-quoted statement seems to demonstrate a lack of practical understanding of the geology involved.

#28

In Section 3.2.5 on pg. 3-8, deep induced potential (IP) and audio magnetotelluric (AMT) surveys are proposed as methods for locating possible buried gold and silver deposits. There may be some question as to whether IP measurements can be effective in locating local concentrations of disseminated sulfides at depths equivalent to those of the proposed repository. It is our understanding that there is a trade off between depth and resolution with IP methods. #29 It would seem likely that a deep, buried unoxidized deposit might not be resolvable. Moreover, it is our understanding that various magnetotelluric methods measure only resistivity, and that only IP methods can discern the chargeability produced by the presence of sulfides. The examples cited on p.3-8, particularly that at Joshua Hollow, are near-surface occurrences.

Even more troublesome is the fact that there are no IP anomalies related to gold mineralization at either the Mother Lode mine or the Joshua Hollow prospect. We have spoken to two geologists, S. Ristorcelli and S. Green, who have both worked in this area. (Steve Green is referenced as personal communication, 1987 on page 3-8, next to last paragraph.) Both are closely familiar with the #30 geophysical work done at Mother Lode and Joshua Hollow. Contrary to what the Study Plan implies, both geologists stated that the only IP response is a very weak anomaly that is probably related to carbonaceous material in the sedimentary rocks. There is no IP anomaly related to mineralization. The Mother Lode mine was discovered by drilling, which in turn was directed by surface geological information, and the Joshua Hollow occurrence was discovered accidentally during drilling for water.

Section 3.5. pg. 3-29 - 3-36, outlines the procedures that will be utilized to evaluate the mineral potential of the Yucca Mountain area. We believe that utilization of these methods may be inappropriate for several of the following reasons.

#31

First is the nature of the deposit models themselves. Certain models are oversimplified and/or incomplete. Some of the "standard" U.S.G.S. models (Cox and Singer, 1986; 1992), for example the Creede, Comstock and Sado types of epithermal precious metal deposits, are not utilized by most mineral deposits geologists (including many geologists of the U.S. Geological Survey).

#32

Second, the grade-tonnage models of the U.S. Geological Survey are also subject to serious criticism. Specifically, the average grade and tonnage of deposit is a complicated function of metal price, ease of mining, amenability of the ore to metallurgical treatment, other production costs, economic and political factors, etc. Grades and tonnages utilized by the U.S. Geological Survey have been obtained at various times from published sources, some of which are old, and from various mining companies. An example of such confusion is provided by the recent updating of the sedimentary rock-hosted (Carlin type) gold deposit model (Mosier et al., 1992). Deposits containing oxidized ores are lumped together with deposits consisting largely or entirely of unoxidized (refractory) ore. Refractory ores require expensive milling and oxidation by roasting, treatment with gaseous chlorine, or pressure autoclaving whereas many oxide ores can be treated by much less expensive heap leaching methods. Therefore, although both oxidized and unoxidized deposits formed by the same general ore-forming process, an all-important practical economic consideration and presence or absence of later oxidation in large part controls the grade-tonnage data reported by producers. Therefore, we think the grade-tonnage model of Mosier et al., may be highly distorted.

#33 Over the past several years the U.S. Geological Survey has received strong criticism and has been the subject of litigation from certain groups with regard to the application of its procedures for estimation of the size and number of undiscovered deposits of various types within potential wilderness areas (p.3-31 of the Study Plan). It would seen unwise to base such an important matter as the mineral potential of the repository on a procedure that is highly controversial.

REFERENCES

#34 In general, the references for the geochemical and geological parts of the Study Plan are inadequate. The geophysics and geothermal sections would appear to be much more adequately documented.

Major shortcomings include almost complete lack of primary citations for the mineral deposits of both the region surrounding the repository site and the entire southern Great Basin. Moreover, there is a conspicuous lack of citations of important specific and general papers on the types of precious metal and other types of deposits that might be present in the Yucca Mountain area. Virtually the only citations are to various descriptive and grade and tonnage models as presented in Mineral Deposits Models, U.S. Geol. Survey Bull. 1693, 1986, and subsequent additions and modifications. Although these short, summary publications contain useful information, they are in no way equivalent to the many important scientific contributions that have appeared in the scientific and professional literature over the past decades. As mentioned above, certain of the classes of deposits proposed by the U.S. Geological Survey are not in general use.

#34

A similar restriction to publications of the U.S. Geological Survey is apparent for geochemical analysis methods. However, this is perhaps not as serious because the personnel and analytical methods of the U.S. Geological Survey are, in general, of high quality.

#34

REFERENCES CITED IN STATE OF NEVADA COMMENTS

Bergquist, J. R., and McKee, E. H., 1991, Mines, prospects and mineral occurrences in Esmeralda and Nye Counties, Nevada, near Yucca Mountain: U. S. Geol. Survey Admin.Report, 385 p. plus two maps.

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Cox, D. P., and Singer, D. A., eds., 1986, Mineral deposit models: U.S. Geol. Survey Bull, 1693, 379 p.

Mosier, D. L., Singer, D. A., Bagby, W. C., and Menzie, W. D., 1992, Grade and tonnage model of sediment-hosted Au, in Bliss, J. D., ed., Developments in mineral deposit modeling: U.S. Geol. Survey Bull. 2044, 0. 26-28.

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Noble, D. C., Weiss, S. I., and McKee, E. H., 1991, Magmatic and hydrothermal activity, caldera geology, and regional extension in the western part of the southwestern Nevada volcanic field, in Raines, G. L., Lisle, R. E., Schafer, R. W., and Wilkinson, W. H., eds., Geology and Ore Deposits of the Great Basin, Vol. II: Reno, Geol. Soc. Nevada, p. 913-934.

U. S. Department of Energy Response to State of Nevada Comments on Study Plan 8.3.1.9.2.1 (Mineral Resource Assessment of Yucca Mountain, Nye County, Nevada)

Responses to Summary Comments:

1-4. Specific responses to Summary Comments 1-4 are given in later comments.

Responses to General Comments:

5. Study 8.3.1.9.2.1 represents an objective, state-of-the-art approach to assessing the natural resource potential of the repository site. Consideration of the extent to which the actual or inferred presence of resources at the site might influence the exploration activities of future generations is the responsibility of studies in Investigation 8.3.1.9.3, and is beyond the scope of the present study. The state's scenario, however, is completely based on the assumption that the hypothetical "new" society is in absolute ignorance of what took place at Yucca Mountain.

5a. Although no specific mention is made in Study Plan 8.3.1.9.2.1 for the collection of samples from the ESF, these excavations are not excluded from the extensive subsurface sampling program being planned in the site characterization program. Detailed sampling of soil and rocks in test pits, trenches, and borings (in connection with the ESF) will be conducted in Investigation 8.3.1.14.2 (Studies to Provide Soil and Rock Properties of Potential Locations of Surface and Subsurface Access Facilities), and these samples should be available for geochemical analysis and physical properties testing. In addition, rocks will be mapped, sampled, and examined petrographically for evidences of mineralization in Study 8.3.1.4.2.2 (Characterization of the Structural Features Within the Site Area). In this regard: (1) Study Plan 8.3.1.4.2.2, Revision 2, states that samples from the ESF will be collected for use in Study 8.3.1.3.2.2 (History of Mineralogic and Geochemical Alteration of Yucca Mountain), and (2) Study Plan 8.3.1.9.2.1 (Section 2.1.1.1) states that full use will be made of data collected by Study 8.3.1.3.2.2 because of the close relationship between the two studies.

6. Ideally, drill holes made specifically for mineral assessment should be more closely spaced; however, the selection and spacing of drill holes is the responsibility of the integrated drilling program. See the response to Comment 5.

7. See the response to Comment 5.

8. A survey to determine the presence or absence of "potentially economic mineralization" is the goal of Study 8.3.1.9.2.1. See the response to Comment 5.

9. DOE disagrees with the implications in this comment. As stated previously, Study 8.3.1.9.2.1 is being planned as an objective, state-of-the-art approach to mineral assessment. The comment lays out a criticism lacking specificity for a response.

10. The Sterling Mine deposit is accurately described by Bergquist and McKee (1991 Admin. Rpt., p. 320). Interpretations as to deposit type (e.g., epithermal vs. hot spring) may vary from one investigator to another. The DOE does not appreciate the *ad hominem* criticism in this and other comments.

11. Separating the "test" of geochemical assessment from the "test" of geophysical/geological appraisal is only done to more specifically identify different elements of work that are considered necessary to achieve study objectives and for decomposition of work scope for cost and schedule purposes. Such separation in no way implies that each "test" will be conducted independently; in this case, the two will be closely coordinated and will involve the same personnel, some of whom are acknowledged experts in the isotopic field.

12. Again, we strongly disagree with the implication in this comment. The USGS has a long and exemplary history in geochemical exploration, and has pioneered in many aspects of this field. The approach a field program might take to try to discover minerals is not the same as that which would be fielded to help make a case for evidence for absence.

13. See response to Comment 5a with regard to sampling in the ESF. The approach to assessing the mineral potential of the site area as presented in the study plan is considered to be as thorough and comprehensive as may be followed by an experienced exploration team. The comment that "no coherent plan for general systematic sampling followed by more detailed study in geochemically anomalous areas has been elucidated" suggests the reviewer simply did not carefully read the discussion in the first paragraph of the study plan's Section 3.1.1.1.

14. One of the primary purposes of the geophysical/geological appraisal (Activity 8.3.1.9.2.1.2) is to compile and synthesize all published data, as well as data from other ongoing studies in the site characterization program, that are relevant to a mineral resource appraisal of the Yucca Mountain area. It is explicitly stated (e.g., in Section 3.2.1) that the study will not be confined only to the immediate site, but will take into account evidences of mineralization in areas surrounding Yucca Mountain.

15. Reference sections are being sampled to obtain initial values, and systematic areal sampling is being done for background values.

16. There is nothing implied, and certainly not intended, to suggest that attention to geological studies will be secondary to geochemistry or geophysics in the study plan. The importance of geological relationships in mineral assessment is obvious, and well-recognized by all investigators.

17. The maps in Bergquist and McKee (1991) that the state received via letter from YMSCO dated December 28, 1993, certainly contain the type of data this comment requests. See the response to Comment 19.

18. In Section 3.2 of the study plan, it is stated that geologic and geophysical data pertinent to resource assessment will be combined and used to provide a basis for comparison of the geologic conditions at the site with analog environments of known mineralized rocks elsewhere in the region. Reference to the study of the occurrence, abundance, and quality of industrial minerals is made in the first paragraph in Section 3.1.1.1.

19. The specific mines and prospects to be visited and studied will be determined as the work progresses and access is established. A 1991 Administrative Report (USGS to DOE) by Bergquist and McKee (Mines, Prospects, and Mineral Occurrences in Esmeralda and Nye Counties, Nevada, near Yucca Mountain), which was prepared subsequent to the initial preparation of Study Plan 8.3.1.9.2.1, contains maps and deposit descriptions that will serve as a useful guide in selecting localities for study in the areas surrounding Yucca Mountain.

<u>Responses to Specific Comments</u>:

20. In Section 2.1.2.2, lithium and beryllium are both listed as elements to be analyzed for and for which occurrence maps will be prepared. If anomalous concentrations of these (or any other element) are detected, they will be followed up by additional studies of similar deposits elsewhere in the surrounding areas. The planned anomaly and residual maps should contain the kinds of information needed to evaluate mineral potential.

21. The characterization of the sampling methodology is accurate.

22. The core being gathered from boreholes since UZ-14 was spudded in April 1991 are being examined from the perspective of the goals of this study. Anomalous areas of mineralization are identified in field logging for subsequent inspection for sampling and detailed core log preparation. The planned sampling procedures are considered adequate to achieve study objectives.

23. As implied in the cited sentence in Section 3.1.1.1, further study of silicic tuffs will be conducted only if there is sufficient indication from an initial examination that there is a resource potential. It is not deemed necessary for purposes of study plan discussion to be more explicit about the kinds of industrial minerals that may be involved in resource assessment; this will be determined as the study progresses. Zeolites are specifically mentioned (Section 3.5.5), however, in addition to the silicic tuffs.

24-25. The analytical procedures being followed are state of the art and provide levels of detection necessary to achieve study objectives. Uses of the resulting analytical data are explicitly stated in several sections of the study plan. Current planning for the study does not include detection of ammonium. The K-Ar dating is being used to time and constrain mineralization events at some of the mineralized districts in the area around Yucca Mountain.

26. The geological, geochemical, and geophysical components of this study will assuredly all be of comparable quality, contrary to the implications given in this comment.

27. There are no current plans to obtain additional airborne radioactive data. The relative quality of the NURE data is well-recognized by study investigators.

28. The "gold-associated IP anomalies" are to be considered in the overall effort to identify all potential mineral occurrences in the site area, regardless of pre-conceived ideas as to whether further investigation is warranted.

29-30. IP and AMT methods may, or may not, provide meaningful data for assessing mineral potential in the Yucca Mountain area, but are listed as possible "tools" that could be used for this purpose. The extent to which they may be employed is yet to be determined.

31-33. In response to these comments, it should be strongly emphasized that study plans are not historical documents in the sense that they record the evolution of thinking that has taken place since the original document was prepared, or that takes place during the course of the study. The methodology for modeling mineral deposits discussed in Section 3.5 of the study plan reflects what was considered to be a reliable means for assessing the mineral potential of the site area, based on the forthcoming results of the combined geological, geochemical, and geophysical studies. If techniques have since been developed to better utilize this data base, then the approaches to modeling may be modified to better achieve study objectives.

34. The study plan reference list is not a bibliography. There is ample reference made in several sections of the study plan to the use of all available published data that relate to evaluating the mineral potential of the Yucca Mountain area. Although emphasis is given to the summary of mineral deposit models published by the USGS, this is not intended as the sole basis for the modeling effort.

BOB MILLER
Governor

STATE OF NEVADA

ROBERT R. LOUX
Executive Director

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February 28, 1994

Dan Dreyfus, Director
Office of Civilian Radioactive
Waste Management
U. S. Department of Energy
Washington, D.C. 20545

Dear Dr. Dreyfus:

The State of Nevada has reviewed the DOE Study Plan, "Quaternary Faulting Within 100KM of Yucca Mountain, Including the Walker Lane" (Study Plan 8.3.1.17.4.3, Rev.1) and its cited references, and is providing its comments in this letter and attachment. The State's comments address the adequacy, completeness, and technical accuracy of the Study Plan to meet the purposes of site characterization.

The State's primary concerns regarding the subject Study Plan are summarized as follows:

1. 1. No rational basis or justification is provided in the Study Plan for limiting the investigations area to what appears to be an arbitrary 100 km radius from the proposed Yucca Mountain site.

2. 2. The rationale and justification for the activities that are outlined in Study Plan 8.3.1.17.4.3 are vague, therefore, it is not reasonably possible to ascertain whether or not the scope, sequence, or timing is appropriate or likely to lead to useful or needed results.

3. 3. The amount of work that will be required to complete the activities as proposed in this Study Plan appears to be extensive. Given the actual level of funding that has been allocated for these programs to date, we have strong

ENCLOSURE 3

doubts that much of the work proposed can or will be completed, analyzed and assimilated in time to meet the present schedule proposed for license application.

4.
4. The new limited low sun angle (LSA) photographic coverage proposed in the Study Plan for only Jackass Flats, Crater Flats and parts of the Amargosa Desert, will be inadequate to effectively map all of the Quaternary faults that probably exist within a 100 km radius of the site.

5.
5. A major seismogenic source, the Pahrump - Stateline - Amargosa Valley fault, appears to have been completely overlooked in developing the Study Plan.

6.
6. The principal geophysical reference (Oliver et.al. 1990) which forms much of the basis for this Study Plan has yet to be finalized. None of the other USGS geophysical references listed as Open-file have been made publicly available.

7.
7. There are a number of notable references bearing on the Quaternary faulting element of the Study Plan that have been overlooked and omitted.

Should you have any questions, this office is available to meet with the Department and discuss the State's comments at any time.

Sincerely,

Robert R. Loux
Executive Director

ATTACHMENT
cc: R. Nelson, DOE/YMPO
J. Cantlon, NWTRB
J. Youngblood, NRC
M. Steindler, NRC-ACNW
S. Kraft, EEI
D. Weigel, GAO

ATTACHMENT

State of Nevada comments on DOE Study Plan 8.3.1.17.4.3 "Quaternary Faulting Within 100 km of Yucca Mountain, Including the Walker Lane".

GENERAL COMMENTS

Study Plan 8.3.1.17.4.3 outlines the approach and techniques to be used in assessing seismogenic sources lying within 100 km of Yucca Mountain. Five activities each having specific objectives are proposed (p.1-1): 1) Conduct and evaluate deep geophysical surveys along an east-west transect across Yucca Mountain, the Walker Lane, and the Furnace Creek fault; 2) Evaluate Quaternary faults within 100 km of Yucca Mountain; 3) Evaluate the Cedar Mountain earthquake zone and its bearing on wrench tectonics of the Walker Lane; 4) Evaluate the Bare Mountain fault zone; and 5) Evaluate structural domains and characterize the Yucca Mountain region with respect to regional patterns of faults and fractures. An additional, but separate part of the study includes an analysis of bedrock rotation along wrench faults based on rotation of paleomagnetic poles.

8.

Some of the activities listed above are generic in nature, while some are fault specific. Although not specifically spelled out in the Study Plan, our impression is that the relation between the planned activities and their bearing on the evaluation of the regional seismotectonic setting falls into four broad categories. We see these four broad categories as 1) reconnaissance level Quaternary fault investigations supplemented by selected site

8.

specific exploratory trenching; 2) detailed investigation of selected faults (Bare Mountain and Furnace Creek faults); 3) geophysical surveys along a Furnace Creek-Yucca Mountain-Walker Lane transect; and 4) evaluation of seismotectonic styles and evidence for Walker Lane wrench-fault tectonics. The generic activities, such as the preparation of photogeologic maps and the modeling of Walker Lane wrench tectonics, are difficult to evaluate since the discussion of these activities is so generalized and incomplete. The adequacy of any and all of these studies will be strongly dependent upon the level of effort that DOE will actually devote to the studies in terms of manpower and funding. Based upon the actual funding to date, the State has every reason to believe that most of the proposed activities will never be undertaken.

Our conclusion from reviewing the Study Plan is that if all of the planned activities are conducted as stated and at a level consistent with the implicit degree of proposed detail, the results could provide necessary representative data that might be adequate for characterizing the Quaternary seismotectonics of the region. 9. However, we note that these activities are all very labor-intensive, and based on the schedule shown in Figure 5-1 the proposed studies will require tens of person-years to adequately complete and assimilate. Even without the discovery of any major geologic surprises, the results will probably be unavailable in time to play any significant part in the site suitability and licensing decisions. For example, the activity to evaluate

Quaternary faults within 100 km of the site is scheduled to include mapping of all Quaternary faults and "verifying the tectonic origin of scarps, lineaments in the field, and for those found to have a tectonic origin, estimate their age, amount of displacement, and recurrence interval of surface faulting events" (p.2-8). Based on a preliminary compilation of Quaternary fault scarps and lineaments in the 100-km region by the U.S. Bureau of Reclamation, there are
10. tens, perhaps hundreds, of possible tectonic features in the region, making this one proposed activity a formidable task. Experience by the Nevada Bureau of Mines and Geology in other similar regional Quaternary fault studies has shown that characterizing the slip history of all Quaternary features within such a large area (33,000 km2) will require numerous years of focused research.

The State realizes that the Study Plan is based on a site characterization plan that does not necessarily require the testing of any hypotheses. Without some specific mention of the potential consequences of the findings within the context of the viability of the proposed repository, this Study Plan simply degrades into a litany of tasks. There is no substantive basis to decide (1) whether the area being covered is sufficient; (2) what the
11, potential consequence of the findings is to the viability of the proposed repository site, and (3) to what level (in both time and money) the activities should or will be pursued. For example, consider the Death Valley fault zone and its potential impact on

the proposed repository. An intensive mapping and possible trenching effort is proposed for this fault zone to provide information bearing on fault slip rates, recurrence times, and its role in the general tectonic framework. However, if DOE simply assumes a worst case scenario for the fault: very high slip rate and very frequent earthquakes of very large magnitude, will it make any difference in the ultimate decision regarding viability of the

11. proposed repository site? Seismic hazards and hydrogeological modeling should be able to determine the answer to that question now. If the answer is no, then it seems the need for further detailed study of many of the regional structures is obviated. If on the other hand the answer is yes, then a more suitable study can be designed to determine whether or not the fault model is correct and more specifically define the impact on design and performance parameters.

Another example is the planned reflection profiling. The justification for this activity apparently stems from the desire to provide evidence for the width, continuity, and depth of major faults, fault zones, and other structural features. Further on it is stated that "definition of faults in the subsurface by these

12. means will contribute significantly in efforts to constrain the location and character of potential sources of ground motion and rupture within 100 km of the potential site." Besides the fact that not all of the potentially significant sources will be evaluated as part of this study, there is no information provided

in this Study Plan stating how any of the resultant information will bear on the integrity of the proposed repository. With currently available information regarding the location of faults and possible fault models, the question should be asked and modeling efforts should take place early to determine whether or
12. not or how the different models would effect the proposed repository. There appears to be a good likelihood that there would be minimal difference in the impact of the different models, in which case discerning which is correct may not be all that important. If analysis shows that, for example, one of the models would impact the site critically, then an experiment could be designed to determine whether or not that model is viable.

As currently written, the rationale and justification for the tasks outlined in this Study Plan are so vague that it is not reasonably possible to ascertain whether or not the scope, sequence, or timing of programs is appropriate, cost effective, or likely to lead to useful or needed results. We suggest that each activity outlined in this and other Study Plans be accompanied by
13. a specific statement detailing (1) what hypotheses or models the activities are designed to address and (2) how the different model scenarios differ in their potential impact on the proposed repository. An outcome of this exercise should be a determination of whether or not it matters which model is correct and, hence, whether the motivation for the study and proposed attendant expenditures are realistic. DOE's present approach appears to be

to study everything and arrive at one universally accepted model of the Yucca Mountain system. It is well recognized that it is easier and less expensive to pose an experiment to confirm or deny a given hypothesis than it is to design a study to determine exactly how a system works. Indeed, in any given region, arguments of what is

13. the correct 'model' will always continue, whereas there are many models that can be ruled out with simple observation. Hence, with upfront analyses, the tasks of the DOE Study Plan(s) could be designed more efficiently to address those issues which represent the potentially greatest impact on determining the viability of the proposed repository system.

On the other hand if the results of this study are intended to provide some all encompassing basis for defining the geologic setting, as originally implied in the SCP and required as input to 10CFR60, then the plan does not go far enough geographically and is improperly sequenced. As the State has pointed out previously, there is no justification for limiting the investigation to a 100 Km radius. Any source, regardless of the distance, that could

14. generate strong ground motion in excess of 0.1g at the site needs to be considered in both the facilities design and in the post closure risk assessment. In addition, by limiting the study to a few specific features within a 100 Km radius, DOE will severely limit their ability to defend the tectonic models that they eventually use to support a site suitability determination and submit in a license application. The state is not suggesting that

the same level of investigatory effort proposed in this Study Plan be also applied to significant sources outside the arbitrary 100 Km radius but only that these sources be specifically considered in a scientific manner. A systematic compilation and analysis of data from existing literature may suffice in most cases. An exception might be distant but significant earthquake sources that occur within the regional boundaries of the Yucca Mountain geologic setting and either trend into the immediate site area, connect with other significant sources that do, or are possible analogs for sources that are closer to the immediate site. Once all of the potentially significant sources have been established, a more realistic plan could then be developed that would be both time and cost effective.

14.

We have not evaluated the adequacy of the planned geophysical surveys as proposed in this Study Plan since they are covered under separate study plans for the most part and the principal references (e.g. Oliver et. al. 1990) have not been made available. However the proposed geophysical surveys appear to be reasonable within the context of the need to define subsurface structural connections. The geophysical studies comprise a major portion of this Study Plan, but they are clearly necessary in order to resolve geologic uncertainties associated with regional tectonics. We therefore agree in concept with the geophysical activities as outlined in the Study Plan pending the public release of the so called geophysical "white paper" (Oliver et.al. 1990) and the other referenced

15.

"Open-file" and "In Press" studies. After a review of these released documents, further comments on the geophysical program may be warranted.

SPECIFIC COMMENTS

16. On page 1-3, under Section 1.2, "Rationale and justification for the information to be obtained," the general statement is made in the 1st paragraph that the information "is needed to assist in designing the repository and in evaluating its future performance." Without belaboring the point, explain how this information, once it becomes available, will be translated into repository design? Also explain why this important design information is not required for the underground portion of the ESF prior to the beginning of construction if the ESF is to be included as part of the final repository?

17. On page 2-2, in the "Rationale for Selecting the Study" paragraph it is stated that the Furnace Creek, Rock Valley, and Bare Mountain faults are the largest, most active faults in the Yucca Mountain region and that"...it is unlikely but still possible that one or more Quaternary faults that would fit into the above category have yet to be identified in the region." Since this conclusion will be proven or disproven by the proposed study, it is premature, and likely incorrect, to conclude that these faults comprise the principal seismogenic sources at or near Yucca Mountain. For example, the Pahrump-Stateline Amargosa Valley fault

system, first suggested by Lauren Wright of the U.S. Geological Survey, may extend north to the Crater Flat area and/or connect with the Rock Valley fault zone based on the studies of Hoffard (1991) and Donovan (1991). These studies document Holocene offset. Based on length-magnitude relations, this fault system is capable of maximum credible earthquakes of M>7, The lack of discussion of this fault zone in the Study Plan (except for a brief reference to it on p. 2-1) is a major omission since the zone may be more proximal to the site than many of the other major faults.

17.

On page 2-2, in the last sentence of the 1st paragraph under Section 2.1, the statement is made that "if the planned (geophysical) tests are successful, the results may provide sufficient data to meet the needs and objectives of several activities in Study 8.3.1.17.4.7, Subsurface geometry and concealed extensions of Quaternary faults." What alternatives will be used if the geophysics programs are not successful?

18.

On page 2-3, in the 2nd paragraph, the use of teleseismic P-wave residuals and Pv/Sv variations is discussed. The statement is made that the results of applying the technique on a limited basis has yielded controversial results. The paragraph goes on to state that the data and interpretations will be reviewed by Los Alamos National Laboratory before deciding on a future course of action. The distinct impression given is that since LANL has already decided that the results do not support their

19.

interpretation, therefore the technique is invalid. We are not optimistic that any further internal review by LANL and the USGS will alter that position. DOE needs to recognize that regardless
19. of how controversial the results may be, if they are permissive of adverse conditions that could impact the site suitability decision or performance, they must be addressed in a substantive manner.

On page 2-7, under Activity 8.3.1.17.4.3.2, the DOE proposes to conduct a variety of surficial geologic studies to provide the basis for a final map of Quaternary faults within 100 km of the site. A major element of this activity involves the preparation of a photogeologic map of Quaternary scarps using conventional and low-sun-angle (LSA) photographs (p. 3-10). Medium-scale LSA photographs will only be utilized for portions of Jackass Flats, Crater Flat, and the Amargosa Desert suggesting that the only LSA photographs to be used will be those previously provided by Nevada Bureau of Mines and Geology (NBMG) and that no new photography will
20. be flown. Given the level of detail proposed by the Study Plan, it is imperative that additional LSA photography be flown of the entire 100-km radius region. This area contains approximately 33,000 km2 which is comparable to two 1 degree x 2 degree sheets (1:250,000-scale), an area that can photographed at suitable scale (e.g., 1:40,000) at minimal costs relative to other parts of the proposed Study Plan. Similar studies by Bell (1984) have demonstrated the need to utilize comprehensive LSA coverage. We therefore regard the lack of such LSA coverage for the entire study

area as a major Study Plan deficiency.

On page 2-8, under Section 2.2.2, "Rationale for selecting the number, location, duration, and timing of the tests," the second paragraph states "studies....will probably be concentrated within approximately 45 km because faults in this area are considered to have the greatest potential for producing ground motions that may affect repository design and performance." How large does the vertical ground motion (VGM) have to be to affect repository design and performance? How will the VGM be translated into design and

21. performance? It seems that there is no basis for this statement since there is no more than a crude conceptual repository design under consideration at this time. Once basic design parameters including thermal loading are established by DOE, it may then be possible to determine more specifically the potential effects of strong ground motion. In the interim, the State suggests that the DOE broaden this study to include identification and consideration of all seismogenic sources that could produce VGM in excess of 0.1g, regardless of the distance from the proposed site.

On page 2-11, Activity 8.3.1.17.4.3.5 proposes to evaluate the nature of structural domains and regional fault and fracture patterns through the analysis of Landsat Thematic Mapper (TM) and side-looking airborne radar (SLAR) imagery. Fracture and fault

22. patterns and densities mapped from the imagery will apparently be used to evaluate the concentrated nature of faulting near the

repository site. We believe that it unlikely that the goal of this activity will be achieved if based solely on the use of TM and SLAR imagery. Such high-altitude imagery is best suited for enhancing large-scale structural features and lacks the resolution necessary for discriminating smaller scale features such as Quaternary fault scarps and fractures. In a similar study in the Walker Lake 2 degree sheet, Rowan and Purdy (1984) used Landsat MSRR imagery to map faults and fractures within the central Walker Lane. A
22. comparison of their map with the companion map of Cenozoic faults (Dohrenwend, 1982) and the geologic map of the Walker Lake 2 degree sheet (Stewart et al., 1982) indicates that Landsat imagery failed to detect numerous critical Quaternary faults, including the Benton Spring and Indian Head faults, as well as historic fault scarps associated with the 1932 Cedar Mountain and 1934 Excelsior Mountain earthquakes.

Under Section 2.5.1 on page 2-12, first paragraph, item (3) proposes to map "surfaces with a coating of desert varnish to aid in defining areas of tectonic stability." How are these data definitive of tectonic stability and what are the supporting references? Later in the same paragraph, the statement is made
23. that "the techniques involved are not well established, and additional feasibility studies may be required...." What kind of feasibility studies are being considered and how much time and money will be required to qualify the technique?

Beginning on page 3-1, a description is given of tests and analysis proposed to be carried out under the Activity 8.3.1.17.4.3.1: Conduct and evaluate deep geophysical surveys in an east-west transect crossing the Furnace Creek fault zone, Yucca Mountain, and the Walker Lane. It is our opinion that this activity could be one of the most important parts of the study in terms of the information that would result that bears on possible design and performance issues. We agree conceptually that geophysical tests will be necessary in order to resolve the geologic uncertainties associated with the regional tectonics. What concerns us however is that the type and extent of geophysical
24, tests proposed seems to be predicated more on the capabilities and bias of the authors rather than on any objective focused effort to identify all the relevant seismic source structures within the immediate geologic setting of Yucca Mountain. The proposed geophysics program seems to be predicated on the results of limited field tests that were conducted over ten years ago. These earlier feasibility tests were not always conducted under optimum conditions or necessarily in ideal locales. The geophysics part of the study needs to be refocused towards identifying all of the major potential tectonic features within the geologic setting that could be contributors to the seismic hazard. In order to accomplish this result, the DOE should focus the study in terms of using the best techniques and contractors/researchers available to solve the problem.

The list of references beginning on page R-1 is incomplete for a plan of this scope and contains numerous typographical errors (e.g., the Bender and Perkins (1987) citation is incomplete). There are numerous notable references missing that are important to the
25. Quaternary faulting elements. As previously noted, the theses by Donovan (1991) and Hoffard (1991) are important data sets not discussed in the Study Plan. Importantly, there are numerous other references relative to Walker Lane tectonics missing (c.f., Nielsen, 1965, Shawe, 1965, Walker, 1985). The omission, and lack of discussion, of Stewart (1988) is a major deficiency of the Study Plan.

We are also concerned that the principal references used in support of the geophysical programs (e.g. Oliver et.al. 1990 and Ponce, In Press (1992?)) have not been distributed outside of DOE, or finalized. In addition, the State feels that it is unacceptable
26. to use personal communication references (e.g. Mooney and Schapper, 1991; page 3-6, 2nd paragraph) and/or references to USGS Open-file reports that are not available outside of the DOE unless written copies of these documents accompany the Study Plan.

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Bell, J. W., 1984, Quaternary fault map of Nevada--Reno sheet: Nevada Bureau of Mines and Geology Map 79.

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U. S. Department of Energy Response to State of Nevada

Comments on Study Plan 8.3.1.17.4.3

(Quaternary Faulting within 100 km of Yucca Mountain, Including the Walker Lane)

Responses to Summary Comments:

1. The decision to focus investigations of Quaternary faults within 100 km of Yucca Mountain is not arbitrary, but rather is based in part on what is considered to be the "geologic setting" of Yucca Mountain, and in part on available ground motion attenuation relations. The "geologic setting" is described as including all of the geologic elements (structural, stratigraphic, volcanic, geomorphic) that characterize, affect, or contribute to the makeup and evolution of Yucca Mountain. Such a setting therefore encompasses all of the neighboring ranges and bounding basins, the proximal fault zones that distinguish the structural pattern of Yucca Mountain and surrounding areas (typical of the Southern Basin and Range), and all of the adjacent volcanic fields. Although specific boundaries cannot be drawn, most of these features, or significant portions of them, occur within 100 km of Yucca Mountain. It should be emphasized, however, that the 100 km radius in no way limits consideration of features at greater distances that may be relevant to the present study.

   With regard to ground motions, as the distance between an earthquake source and a given site increases, larger and larger magnitude earthquakes are required to produce significant ground motion at that site. Consequently, it is expected that the occurrence of earthquakes on faults beyond a 100 km radius of Yucca Mountain will contribute insignificantly to the ground motion hazard at the potential repository site. As seismic sources are identified, however, and ground motions determined, the validity of the 100 km distance will be evaluated and, if necessary, revised.

2. The rationale and justification for the proposed activities are intended only to describe what each activity is to accomplish and why some other activity was not chosen over the one described. As noted on page 1-1, the overall objective of the study is to supply information on Quaternary faulting history for potential seismic sources within 100 km of the site that could affect the performance of the site. The general rationale and justification for conducting this study is that possibly significant seismic sources are known to exist in the region, and should be studied.

3. Work that is proposed in Study Plan 8.3.1.17.4.3 will build upon a large base of previous work, and it is anticipated that the goals of the study will be reached in a timely fashion, including the input of relevant data for site suitability evaluations. Of course, the amount of work that will be completed during any given time period in the future will necessarily depend on the level of funding that is received.

4. Realistically, the goal is not to map all Quaternary faults within 100 km of Yucca Mountain, but, as stated in Section 1 of Study Plan 8.3.1.9.2.1, to focus primary attention on those faults that are known, expected, or inferred to be: (1) relevant earthquake sources (earthquakes that could generate severe ground motions at the potential site); (2) possible locations of future ground rupture at surface or underground facilities important to safety; (3) possible conduits for basaltic magmas at or related to Quaternary volcanic centers proximal to Yucca Mountain; and (4) possible sources of strain or offset which could materially affect the hydrology of the site. McConnell, Blackford, and Ibrahim of the NRC (NUREG-1451, July 1992) describe these features as those that "may affect the design and/or performance of structures, systems, and components important to safety, containment, or waste isolation, and/or may provide significant input into models used in design or assessment."

   Analysis of low sun-angle photos has been proposed for the areas that are thought to be most critical in the identification of such faults. These areas were chosen because they are proximal to the potential site, are likely areas where scarps may have formed that will be revealed by low sun-angle photos, or are areas that may contain fault zones (e.g., the southwestern extension of the Rock Valley fault zone, and the northern extension of the Pahrump-Stateline-Amargosa Valley fault zone).

5. The Pahrump-Stateline-Amargosa Valley fault zone is not discussed extensively in the study plan, but it has not been neglected during the actual studies being conducted by DOE and its contractors. Studies of this zone will include air photo analysis, field checking of results, and trenching on suspected fault traces.

6. The report, "Status of Data, Major Results, and Plans for Geophysical Activities, Yucca Mountain Project," by Oliver and others, was finalized by DOE in 1990 (Document YMP/90-38), and sent to the NRC, the State of Nevada, and other interested parties shortly after that time. A revised version of this report has been prepared as a USGS Professional Paper. It is currently in review and includes geophysical tests performed after completion of the 1990 paper. A copy will be sent to the State of Nevada when it is issued as part of routine transmittal of YMSCO participant technical products to those recipients on our mailing list. If the state needs another copy of Oliver and others (1990), please inform the contact indicated on the cover letter and arrangements will be made.

7. The references cited in study plans are not bibliographies that include all of the available literature that potentially bears on the study, nor is there any attempt to update the list of pertinent references as more recent ones become available. All references that are considered essential to the study, at the time the study plan is prepared, are cited, and more recent relevant references will also be utilized as appropriate.

<u>Responses to General Comments</u>:

8. Planned generic activities are intended as reconnaissance to help define areas that need more detailed investigation, such as is discussed in Sections 2.4, 3.2.1.2, and 3.2.1.3 of the study plan. The amount of detailed study which proceeds from these generic investigations certainly depends on the level of funding that the project receives.

9-10. See the responses to Comments 3 and 4.

11. The primary purpose of a study plan is to discuss the methods and procedures that will be used in a given study to achieve certain designated objectives by addressing prescribed parameters in a manner that produces reliable results. In this context, such documents are largely descriptions of work elements that will be followed in conducting and satisfactorily completing that study.

    With regard to the area being covered by Study 8.3.1.17.4.3, several statements are made in the study plan (e.g., Section 3.2.8) to the effect that the information being obtained is considered to be representative of the study area or of the individual feature being mapped and investigated.

The ultimate objective of Study 8.3.1.17.4.3 is to provide information to other studies, such as Tectonic Models and Synthesis (Study Plan 8.3.1.17.4.12) and Relevant Earthquake Sources (Study Plan 8.3.1.17.4.1), for use in evaluating the tectonic setting and seismic hazard at Yucca Mountain. Under these studies, the sensitivity and/or consequence analyses suggested in the comment are carried out. Feedback from tectonic synthesis, seismic hazard assessment, and postclosure tectonic effects studies will determine the level of detail and areal extent within which faults need to be studied.

12. As indicated in the response to Comment 11, data on Quaternary faults collected in Study 8.3.1.17.4.3 will be used in Study 8.3.1.17.4.12 to perform the modeling efforts mentioned in this comment. The extent to which seismic profiling will be conducted in the site characterization program (including the present study) is dependent on the results of the survey being planned in Activity 8.3.1.4.2.1.2 (Surface-based Geophysical Surveys), on the perceived need for additional surveys, and on future funding levels.

13. The overriding goal of the preclosure tectonics studies is to collect the kinds of data that are needed to select and portray the model that best suits the accumulated information. All reasonable alternatives (as listed in SCP Tables 8.3.1.17-7 and 8.3.1.17-8) need to be considered in the model selection process, and this effort is coordinated through Study 8.3.1.17.4.12, Tectonic Models and Synthesis. Study 8.3.1.17.4.3 is one of the studies that is collecting essential data for this purpose.

14. It should be reemphasized that features beyond 100 km of the potential repository site (e.g., Cedar Mountain to the northwest) will be included if relevant to the study, and that significant sources of ground motion will be considered in facilities design and postclosure risk assessment, regardless of their distance from the site. See also the response to Comment 4.

15. See the response to Comment 6.

Responses to Specific Comments:

16. Information on regional Quaternary faults will contribute to the assessment of seismic hazards at Yucca Mountain, which in turn will provide the basis for seismic design inputs for a potential repository. Available information to date has been considered in developing seismic design inputs for the ESF design. ESF design has to allow that it can be incorporated into a repository at a later date, not that it be designed as a repository today. Upgrade or replacement of some ESF items can be carried out to meet repository design items if the site is found suitable.

17. See the response to Comment 5.

18. While it is not anticipated that the geophysical programs will all be unsuccessful, there exist other approaches to gathering sufficient information on subsurface faults. These include direct evidence from seismic monitoring, analogs from other areas of the Basin and Range, and geologic models of the site constrained by available stratigraphic and structural data.

19. Teleseismic P-wave residuals and Pv/Sv variations will continue to be evaluated from data previously collected by LANL (chiefly underground nuclear explosions) and from data currently being collected by the University of Nevada, Reno, Southern Great Basin Seismic Monitoring Network. Results will be considered in the site suitability decision.

20. The goal of this study is to characterize regional faults that could affect design or performance of a potential repository at Yucca Mountain. Thus, the level of detail and scope of studies varies as a function of distance from the site. Analysis of low sun-angle photographs has been proposed for those areas that are most critical to this study.

21. Seismic design of a potential repository at Yucca Mountain will take into account an appropriate level of seismic hazard. In terms of Quaternary fault investigation, the guidance in NUREG 1451 (McConnell et al., 1992) specifies that faults that can produce an earthquake that generates a ground acceleration of 0.1 g or greater within the controlled area should be considered in investigations for seismic hazards. DOE's investigations are consistent with this guidance. However, there is no ground motion threshold below which seismic inputs would not be considered, although if the assessed ground motion inputs are low, the impact on design could be small to none. Given the appropriate seismic design inputs, reasonably available technology will be used to design a facility that meets specified evaluation

and acceptance criteria. Development of seismic design inputs and seismic design criteria, however, are not the subject of this study plan.

22. As noted in Section 2.5.1 of Study Plan 8.3.1.17.4.3, the analysis of remote sensing imagery will be supplemented by ground-truth studies and by data from fault maps based on air photo interpretation.

23. In a 1994 publication, "Relict Colluvial Boulder Deposits as Paleoclimatic Indicators in the Yucca Mountain Region, Southern Nevada" (Geological Society of America Bulletin, v. 105, p. 1008-1018), Whitney and Harrington conclude, from a study of rock varnish on hillslope deposits of early to middle Pleistocene age, that the topography of Yucca Mountain was little affected by Quaternary tectonic activity. Cation-ratio dating techniques were used in the study.

24. The DOE Geophysical Integration Team (GITF) has been formed to ensure that appropriate geophysical techniques will be used to provide sufficient information to address suitability and licensing issues. The design and scope of geophysical field tests is also subject to change based on results from other tests, and may not be performed exactly as described in the SCP or in the study plan. The study plans may be revised to reflect those changes, which would be documented in site characterization progress reports.

25. See the response to Comment 7.

26. References to personal communications and in-press documentation are being culled out and avoided in study plan revisions. USGS Open-File reports are available to the state, as indicated in the response to Comment 6.