

AUG 23 1993

NOTE TO: Joseph J. Holonich, HLPD

FROM: Ronald L. Ballard, HLGE

SUBJECT: DETAILED REVIEW OF DOE STUDY PLAN 8.3.1.9.2.1, REV. 0
"NATURAL RESOURCE ASSESSMENT OF YUCCA MOUNTAIN, NYE COUNTY, NEVADA"

Enclosed with this note are the results of the detailed review of the subject study plan. The review was conducted in accordance with the procedures presented in the "Review Plan for NRC Staff Review of DOE Study Plans," Rev. 2, dated March 4, 1993. The detailed review was conducted by the Center, with NRC oversight, as requested by K. McConnell in the study plan review task description letter of March 22, 1993, to the Center's Dr. L. McKague. The NRC staff review was limited, consisting of (1) an assessment of the Center's comments and questions in order to identify those concerns of such significance that they should be transmitted to the DOE and (2) an identification of several concerns of its own. The combined CNWRA\NRC study plan detailed review has resulted in the identification of one comment and seven questions (see Attachment A).

DOE also indicated in its December 17, 1992, letter transmitting the subject study plan, that it had addressed several SCA open items. In a follow-up letter of February 5, 1993, DOE clarified its earlier letter by providing further information relative to three SCA open items (Comment 53 and Questions 14 and 15). DOE indicated that, based upon information presented in the letters and in the study plan, it considered these open items resolved. The NRC staff evaluated the DOE's responses to the open items. As a result of its evaluation of the three SCA open items, the NRC staff considers the two questions resolved and the comment partially resolved (see below and Attachment B).

DOE has made considerable progress with respect to the resolution of the subject open items by providing sufficient detailed information to enable the NRC staff to completely resolve two of the three SCA open items (Questions 14 and 15) and to partially resolve the third concern (Comment 53). Of the multiple bases (six) underlying Comment 53 four bases remain unresolved. The first open basis focuses on the overall integration of natural resources-related activities with other elements of the site characterization program. The second open basis addresses the placement of drill holes with respect to an assessment of the natural resources within the controlled area. The third open basis addresses drill hole coverage of the Paleozoic and other subsurface stratigraphic units. The fourth open basis, which was not addressed by the DOE in its response, relates to DOE's citation of out-of-date models and references in support of various elements of its program. With respect to the first open basis (integration of activities including the identification of studies dependent upon, and supportive of, the natural resources study plan), DOE has made some progress since initial identification of the concern in mid-1989. The geophysical investigations portion of the first basis is resolved. With respect to the second open basis, the DOE response is extremely limited by proposing that the subsurface natural resources assessment of vertical to near-vertical faults/mineralized zones within the controlled area will be accommodated through the direct sampling of such features within the Exploratory Studies Facility.

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Facility. Regarding the third open basis, the DOE plans to characterize the site and the area within the perimeter drift outline by means of deep core holes located beyond the site. This does not resolve the Staff concern. Regarding the fourth open basis, which has not been addressed by DOE in its response, DOE continues to use out-dated references and neglects to mention current model codes and critical references. Additional details relative to these four open bases are included within the staff's evaluation of these concerns (see Attachment B).

An additional observation is that the study plan, in providing a basis for certain statements, cites references as "in press", "in preparation", or "personal communication". Such citations are not acceptable as references in study plans per the 1993 DOE/NRC Level of Detail Agreement and Review Process for Study Plans. Specific examples of unacceptable citations are: Section 3.2.5, p. 3-8 (Steve Green, Gexa Gold Corp., personal communication, 1987); and in the References Section: p. R-3 (Brocher et al., 1989, in preparation), p. R-4 (Cox, 1992, in press), and p. R-8 (Mosier, et al., 1992, in press).

The CNWRA review was conducted by Dr. David R. Turner and Michael P. Miklas, Jr. The lead NRC reviewer was H. E. Lefevre (504-3464) of the Geology and Geophysics Section. Assisting in the NRC review were Drs. A. K. Ibrahim (504-2523) and J. S. Trapp (504-2509) of the Geology and Geophysics Section and Dr. J. W. Bradbury (504-2535) of the Hydrologic Transport Section.

Ronald L. Ballard, HLGE

Enclosures: As stated

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COMMENT AND QUESTIONS
July 12, 1993

Study Plan 8.3.1.9.2.1 Natural Resource Assessment of Yucca Mountain, Nye County, Nevada

COMMENT 1

Consider deepening one or more of the proposed Systematic Drilling Program drill holes that are to be located within the perimeter drift outline in order to obtain site-specific mineral and energy resources data.

BASIS

- There are no existing drill holes within the perimeter drift outline that penetrate Paleozoic rocks and none are proposed (DOE, 1992, Fig. 2-1).
- Existing drill hole UE25p#1, located 2.0 miles southeast of the perimeter drift outline (DOE, 1992, Figs. 2-1 and 2-2), penetrates approximately 1,800 ft of the Paleozoic rock.
- Three deep drill holes (G-5, G-6, and G-7) extending into the Paleozoic section are proposed as part of the mineral and energy resource assessment of the site (DOE, 1992, Section 2.1.2.1, p. 2-3).
- The three proposed deep geologic exploratory drill holes (G-5, G-6, and G-7) are located outside of the controlled area and are approximately 2.5 to 6.0 miles outside the perimeter drift outline (DOE, 1992, Fig. 2-1).
- The purpose of the three G-series deep drill holes is to acquire regional stratigraphic information (DOE, 1993, Table 2.1, p. 12).
- "These holes (G-series) are located too far from the repository block to provide much geostatistical data" (DOE, 1993, Table 2.1, p. 12).
- Although the justification given in the Natural Resource Study Plan (DOE, 1992, Section 2.5.1, p. 2-12) for not drilling deep holes within the perimeter drift is that the holes would be "too costly and too damaging to the repository block itself", DOE is nevertheless proposing, in the Systematic Drilling Program (1993, Section 1.2, p. 4) that twelve drill holes, ranging in depth from 1,700 ft to 3,000 ft be drilled inside the perimeter drift outline.
- DOE (1993, Section 2.4.1, pp. 21 and 22) indicates that the SCP (DOE, 1988, p. 8.4.3-43) presents analyses demonstrating that drilling activities (including a drill hole into the

water table within the perimeter drift outline) do not impact the site adversely.

RECOMMENDATION

For mineral and energy resources purposes, rather than relying solely upon information derived from either existing or planned drill holes that are remote (2.0 to 6.0 miles) from the perimeter drift outline, consider extending (to below the Tertiary/Paleozoic contact) one or more of the proposed deep drill holes that are to be located within the conceptual design repository (DOE, 1993, Fig. 1.3, p. 5).

REFERENCES

DOE (U.S. Department of Energy), 1988. "Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada". Office of Civilian Radioactive Waste Management, DOE RW-0199. 9 Volumes.

DOE (U.S. Department of Energy), 1992. Study Plan 8.3.1.9.2.1, Natural Resource Assessment of Yucca Mountain, Nye County, Nevada, Rev. 0, dated September 15, 1992.

DOE (U.S. Department of Energy), 1993. Study Plan 8.3.1.4.3.1, Systematic Acquisition of Site Specific Subsurface Information, Rev. 1, dated June 4, 1993.

NRC (U.S. Nuclear Regulatory Commission), 1992. Staff Technical Position on Investigations to identify Fault Displacement Hazards and Seismic Hazards at a Geologic Repository, NUREG-1451, dated April 1992.

Study Plan 8.3.1.9.2.1 Natural Resource Assessment of Yucca Mountain, Nye County, Nevada

QUESTION 1

How will "surrounding areas" be selected and sampled?

BASIS

- In Section 2.1.1.1 (DOE, 1992, p. 2-2), it is mentioned that the chemical composition of rocks from the site will be "...compared and contrasted with samples from surrounding areas that are known to be mineralized."
- According to Section 3.1.1.1 (DOE, 1992, p. 3-2), samples will be collected from areas with "...potential or suspected mineralization, such as Calico Hills, Wahmonie-Salyer district, and from prospects and currently or previously active mines."
- In Section 3.2.8 (DOE, 1992, p. 3-11), it is stated that "The synthesis of data will take into account altered and mineralized rocks known to occur in nearby areas outside the site area..."
- In Section 3.4.1.1 (DOE, 1992, p. 3-20 and Fig. 2-1), with respect to determining the presence or absence of hydrocarbon source rocks, the organic content of potential source rocks will be addressed by "...sampling Paleozoic stratigraphy cored in boreholes adjacent to the site and exposed in outcrops in nearby areas . . ."
- The idea involving investigation of areas with established resource potential and looking for correlations with the findings at Yucca Mountain is a sound one. It is not clear as to how these sampled areas are to be compared with the Yucca Mountain site area. Discussion of how these areas are to be (or have been) selected, mapped, drilled, sampled, and interpreted is critical in ensuring that any comparison with Yucca Mountain is justified. Also, identifying what features are to be compared and contrasted is important.

RECOMMENDATION

Study Plan Section 3.5.1 should provide some indication of the type of mineral deposits that will be considered. References to recent reports by Bergquist and McKee (1991) and Tingley (1992) would also be useful for identifying a number of possible comparison sites. The Study Plan should demonstrate how these surrounding areas are to be mapped, sampled, and interpreted to validate any comparisons.

REFERENCES

Bergquist, J.R., and McKee, E.H., 1991. Mines, Prospects, and Mineral Occurrences in Esmeralda and Nye Counties, Nevada, Near Yucca Mountain, Administrative Report. U.S. Geological Survey.

DOE (U.S. Department of Energy), 1992. Study Plan 8.3.1.9.2.1, Natural Resource Assessment of Yucca Mountain, Nye County, Nevada, Rev. 0, dated September 15, 1992.

NRC (U.S. Nuclear Regulatory Commission), 1992. Staff Technical Position on Investigations to Identify Fault Displacement Hazards and Seismic Hazards at a Geologic Repository, NUREG-1451, 19 pp., July 1992.

Tingley, J.V., 1992. Mining Districts of Nevada. Report 47. Nevada Bureau of Mines and Geology. Reno, NV.

Study Plan 8.3.1.9.2.1 Natural Resource Assessment of Yucca Mountain, Nye County, Nevada

QUESTION 2

Why are there no plans for utilizing geochemical information from existing drill holes that are located within the conceptual design repository ?

BASIS

- In Section 2.1.2.1 (DOE, 1992a, p. 2-3), it is stated that the "...subsurface sampling program will include a sufficient number of drill cores selected so as to adequately cover the study area."
- The subsurface sampling program (DOE, 1992a, Section 2.1.2.1, p. 2-3; Section 3.1.1.1, p. 3-1 and Fig. 2-1) includes no plan or figure specifically demonstrating that subsurface sampling is to be conducted within the controlled area.
- There are a number of existing deep drill holes (USW G-4, USW H-4, USW H-5, and USW WT-2) within the conceptual design repository ranging in depth from 2,060 to 4,000 ft from which mineralogical samples have been obtained (DOE, 1992b).
- The subsurface sampling program (DOE, 1992a, Section 3.1.1.1, p. 3-1) although indicating that a sufficient number of drill holes will be selected to adequately cover the site area, neither describes nor depicts (DOE, 1992a, Section 3.1.1.1, p. 3-1 and Fig. 2-1) drill holes either existing or planned that are closer than two miles to the conceptual design repository.

RECOMMENDATION

The study plan should consider using both existing subsurface information and subsurface information that can be obtained from drill holes currently proposed within the controlled area. In order to adequately address the natural resources potential within the controlled area consider utilizing existing geochemical analyses of samples obtained from drill holes located within the controlled area. In addition, subsurface natural resources information can be obtained from deep drill holes to be located within the conceptual design repository as a part of the Systematic Drilling Program (DOE, 1993, Fig. 1.3, p. 5).

REFERENCES

DOE (U.S. Department of Energy), 1992a. Study Plan 8.3.1.9.2.1, Natural Resource Assessment of Yucca Mountain, Nye County, Nevada, Rev. 0, dated September 15, 1992.

DOE (U.S. Department of Energy), 1992b. Yucca Mountain Site Characterization Project, Existing and Proposed Drillholes Within 10 Km of the Site, Map YMP-92-081.0, EG&G/EM Remote Sensing Laboratory.

DOE (U.S. Department of Energy), 1993. Study Plan 8.3.1.4.3.1, Systematic Acquisition of Site Specific Subsurface Information, Rev. 1, dated June 4, 1993.

Study Plan 8.3.1.9.2.1 Natural Resource Assessment of Yucca Mountain, Nye County, Nevada

QUESTION 3

Remote sensing is not mentioned as a possible test. Given the usefulness of such methods in determining surface alteration and regional structural trends, why has the analysis of remote sensing imagery not been included?

BASIS

- Section 2.2 (DOE, 1992) considers a number of geological and geophysical analyses but does not mention the use of remote sensing technology.
- Remote sensing imagery has been used to identify zones of clay and iron oxide hydrothermal alteration in semi-arid and arid regions of the western U.S. (e.g., Mouat et al., 1986; Magee et al., 1986; Taranik, 1987).
- Landsat TM and SPOT imagery was also used by Castor et al. (1990) to identify and compare fault patterns and zones of alteration in the mineral evaluation of the Yucca Mountain Addition.
- The resolution of satellite images approaches 10 to 20 m and would be useful in identifying zones of hydrothermal alteration both inside and outside the perimeter outline.
- Appropriate filters may also be useful for directional edge enhancement in order to identify possible lineaments and fault patterns associated with mineralization, hydrocarbon and geothermal resources.

RECOMMENDATION

Include a plan to use remote sensing (satellite imagery, aerial photography) imagery to delineate areas of alteration and regional structural trends and lineaments.

REFERENCES

Castor, S.B., Feldman, S.C., and Tingley, J.V., 1990. Mineral Evaluation of the Yucca Mountain Addition, Nye County, Nevada. Nevada Bureau of Mines and Geology, Open File Report 90-4, 80 pp.

DOE (U.S. Department of Energy), 1992. Study Plan 8.3.1.9.2.1, Natural Resource Assessment of Yucca Mountain, Nye County, Nevada, Rev. 0, dated September 15, 1992.

Magee, R.W., Moore, J.M., and Brunner, 1986. Thematic Mapper Data Applied to Mapping Hydrothermal Alteration in Southwest New Mexico: Proceedings of the 5th Thematic Conference on Remote Sensing for Exploration Geology, Reno NV.

Mouat, D.A., Myers, J.S., and Miller, N. L., 1986. An Integrated Approach to the Use of LANDSAT TM Data for Gold Exploration in West Central Nevada: Proceedings of the 5th Thematic Conference on Remote Sensing for Exploration Geology, Reno NV.

Taranik, J.V., 1987. Application of Aerospace Remote Sensing Technology to Exploration for Precious Metals in the Western United States: Proceedings of the Bulk Minable Precious Metals Symposium, Geologic Society of Nevada. p. 551-576.

Study Plan 8.3.1.9.2.1 Natural Resource Assessment of Yucca Mountain, Nye County, Nevada

QUESTION 4

Are there plans to consider the effects of extrusive/intrusive ratios outside of the range of about 1 to 10 and to identify the source of additional parameters necessary for input into the Finite Element Heat and Mass Transfer Code?

BASIS

- In Section 3.3.1.3 (DOE, 1992, p. 3-14), it is stated that extrusive/intrusive ratios of "...about 1 to 6 for the basaltic type and 10 or greater for the silicic type..." of volcanoes will be used to approximate the size of inferred intrusions. This inferred size will be used as input into the FEHMN (Finite Element Heat and Mass Transfer Code) (Zyvoloski et al., 1991) heat and mass transfer model.
- The extrusive/intrusive ratios that are used in DOE, 1992 (Section 3.3.1.3, p. 3-14) are empirical values. Values as low as 1:200 for basalt and 1:100 for rhyolites have been reported at the Coso Volcanic field (Bacon, 1982) to the southwest of Yucca Mountain. Since intrusion size is one type of input into the FEHMN program (Zyvoloski et al., 1991), varying this ratio could have significant effects on any modeling study results.

RECOMMENDATION

Include plans in geothermal modeling for sensitivity analysis and propagation of uncertainty related to extrusive/intrusive ratios.

REFERENCES

- Bacon, C.R., 1982. Time-predictable bimodal volcanism in the Coso Range, California. *Geology*: pp. 65-69.
- DOE (U.S. Department of Energy), 1992. Study Plan 8.3.1.9.2.1, Natural Resource Assessment of Yucca Mountain, Nye County, Nevada, Rev. 0, dated September 15, 1992.
- Zyvoloski, G., Dash, Z., and Keldar, S., 1991. FEHMN 1.0: Finite Element Heat and Mass Transfer Code: LA-12062-MS, Los Alamos National Laboratory, Los Alamos, NM.

Study Plan 8.3.1.9.2.1 Natural Resource Assessment of Yucca Mountain, Nye County, Nevada

QUESTION 5

Are there any plans to consider comparison areas in the context of 10 CFR 60.21(c)(13) and 10 CFR 60.122(c)(17)?

BASIS

- Although the consideration of comparison areas is mentioned in the Study Plan (DOE, 1992, Sections 2.1.1.1, 3.1.1.1, 3.2.8, and 3.5), what is actually proposed in the different activities is the comparison of the Yucca Mountain area to areas of known mineralization (or proven geothermal/hydrocarbon potential). While this is extremely useful in terms of determining the types of models that are appropriate to the Yucca Mountain setting, it is not apparent that the proposed comparison satisfies the provisions of 10 CFR Part 60.
- The three separate components of the requirement (10 CFR 60.21(c)(13) for the comparison areas to be investigated include: (1) similar size, (2) representative of the geologic setting and (3) within the geologic setting.

RECOMMENDATION

Address the differences between the comparison described in this Study Plan with comparison areas as defined in 10 CFR 60.21(c)(13) and 10 CFR 60.122(c)(17). Include a statement describing how DOE's comparison area approach satisfies these NRC rule provisions.

REFERENCE

DOE (U.S. Department of Energy), 1992. Study Plan 8.3.1.9.2.1, Natural Resource Assessment of Yucca Mountain, Nye County, Nevada, Rev. 0, dated September 15, 1992.

Study Plan 8.3.1.9.2.1 Natural Resource Assessment of Yucca Mountain, Nye County, Nevada

QUESTION 6

What techniques will be used to estimate the size and number of undiscovered deposits?

BASIS

- The 10 CFR Part 60 evaluation of the probability of inadvertent human intrusion associated with the exploration for natural resources requires a quantitative evaluation of mineral and energy (hydrocarbon and geothermal) resources at the site. In Study Plan Section 3.5.1 (DOE, 1992, page 3-31), a general, three-step methodology is described for obtaining a "...probabilistic, quantitative estimate of mineral endowment of a given area..." While the methodology is reasonable, it is very broad, and there is quite a large leap between Step Two - Delineation of favorable areas and Step Three - Estimate the size and number of undiscovered deposits of each type. It is not clear how this leap will be made, and no references are provided to point the way. Not surprisingly, it seems that a significant amount of subjective interpretation will be necessary, but there is no clear indication of how this will be used to obtain a probabilistic and quantitative estimate. Will expert judgement be proposed? Techniques are available for quantitatively delineating potential targets and estimating reserves of some types of mineral deposits (e.g., Harris and Pan, 1991; Pan and Harris, 1990; Chung et al., 1988; 1992).

RECOMMENDATION

Provide detail on techniques that may be used to quantify the size and number of undiscovered deposits. Provide information on uncertainties, sensitivity analysis, and error propagation. For subjective interpretation, discussion of the expert elicitation process is appropriate.

REFERENCES

Chung, C.F., Fabbri, A. G., and Sinding-Larsen, R. (eds.), 1988. Quantitative Analysis of Mineral and Energy Resources. Dordrecht, Netherlands: Reidel.

Chung, C.F., Singer, D. A., and Menzie, W. D., 1992. Predicting Sizes of Undiscovered Mineral Deposits: An Example Using Mercury Deposits in California. Economic Geology, Vol. 87: pp. 1174-1179.

DOE (U.S. Department of Energy), 1992. Study Plan 8.3.1.9.2.1, Natural Resource Assessment of Yucca Mountain, Nye County, Nevada, Rev. 0, dated September 15, 1992.

Harris, D.P., and Pan, G., 1991. Consistent Geologic Areas for Epithermal Gold-silver Deposits in the Walker Lake Quadrangle of Nevada and California: Delineated by Quantitative Methods. Economic Geology, Vol. 86, pp. 142-165.

Pan, G., and Harris, D. P., 1990. Quantitative Analysis of Anomalous Sources and Geochemical Signatures in the Walker Lake Quadrangle of Nevada and California. Journal of Geochemical Exploration, Vol. 38, pp. 299-321.

Study Plan 8.3.1.9.2.1 Natural Resource Assessment of Yucca Mountain, Nye County, Nevada

QUESTION 7

What form will the results from the Study Plan (DOE, 1992, p. 4-1) take for input into Investigation 8.3.1.9.3 (DOE, 1988 - Studies to Provide the Information Required on Potential Effects of Exploiting Natural Resources on Hydrologic, Geologic, and Rock Characteristics)?

BASIS

- Data from this Study Plan (DOE, 1992, p. 4-1) will be used in Investigation 8.3.1.9.3 "by providing the basis for probabilistic calculations for determining inadvertent human interference and (or) intrusion . . . at Yucca Mountain in the postclosure period . . ." (DOE, 1988, p. 8.3.1.9-45).
- The specific ways in which the results from this Study Plan (DOE, 1992) will be used to provide a basis for probabilistic calculations are not discussed. It is not clear how this study will provide other than qualitative results, and in fact this is stated in Section 3.5.4 (DOE, 1992, p. 3-32).

RECOMMENDATION

Expand the discussion in Study Plan Section 4.0 to provide information on the form which the results may be expected to take and how this information will be used to provide quantitative input into probabilistic calculations. A discussion of possible expert elicitation methods may be appropriate.

REFERENCES

DOE (U.S. Department of Energy), 1988. "Site Characterization Plan: Yucca Mountain site, Nevada Research and Development Area, Nevada". Office of Civilian Radioactive Waste Management, DOE RW-0199. 9 Volumes, p. 8.3.1.9-45.

DOE (U.S. Department of Energy), 1992. Natural Resource Assessment of Yucca Mountain, Nye County, Nevada, Rev. 0, dated September 15, 1992.

EVALUATION OF SCA OPEN ITEMS
July 12, 1993

Study Plan 8.3.1.9.2.1 Natural Resource Assessment of Yucca Mountain, Nye County, Nevada

SCA COMMENT 53

The program of investigations for natural resources assessment as presented in the SCP appears to be unsatisfactory for consideration of potential natural resources and natural resource models at the site.

EVALUATION OF DOE RESPONSE

SCA Comment 53, Basis 1 - Conceptual Models

- Although conceptual models directed toward natural resource occurrence in tuffs have now been considered in the SCP, alternative natural resource models to include hosts other than tuffs appear not to be considered. For example, the resource assessment program does not specifically provide for testing structures as potential ore hosts, nor does it provide for testing of possible tactites on the margin of the hypothesized Crater Flat caldera complex.

Evaluation of SCA Comment 53, Basis 1

- The DOE (1993a) response, coupled with numerous study plan citations, indicate that DOE will be considering a number of natural resource occurrence models in addition to that of the repository host rock - tuff.
- DOE indicates (1992a, Section 3.2.1, p. 3-6) that "geologic features such as structures, altered zones, and different lithologies . . . will be used as selective criteria in obtaining samples . . . for geochemical analyses" in its natural resources assessment program.
- In its response DOE (1993a) indicates that "particular attention will be given to geophysical boundaries associated with faults and lithologic variations in bedrock" in its mineral resources study.
- DOE (1993a) further indicates that "the possible presence of faults, including detachment and thrust faults, and (or) a metamorphic core complex beneath Yucca Mountain . . . will be evaluated."

- DOE has planned tests (both geophysical and deep geological drill holes) that both define the Paleozoic/Tertiary boundary (DOE, 1993a) and penetrate (by deep drill hole) the Paleozoic rock sequence (DOE, 1992a, Section 2.1.2.1, p. 2-3).
- Examples of planned geophysics tests yielding data from lithologies other than tuff include: magnetotelluric (2 to 5 km depth); geoelectric methods providing depth to Paleozoic basement; and magnetics yielding data regarding possible intrusive bodies (DOE, 1992a, Section 3.2.5, p. 3-10).
- DOE's response (DOE, 1993a) further indicates that three deep cored boreholes (G-5, G-6, and G-7) are proposed. These boreholes are planned to penetrate a representative portion of the Paleozoic rock sequence below the volcanic tuff (DOE, 1992a, Section 2.1.2.1, p. 2-3 and Fig. 2-1).
- With respect to the testing of possible tactites on the margin of the hypothesized Crater Flat caldera complex the DOE (1993a) response indicates that pending mapping-derived evidence of contact metamorphism "near what would be the eastern limb of this hypothesized structure . . . such evidence can be factored into final siting criteria for presently planned drillholes." Based on this statement, the NRC staff assumes the DOE intends to weigh this evidence in reassessing both the location and scope of planned drillholes.
- The NRC staff considers this portion of the comment resolved.

SCA Comment 53, Basis 2 - Geochemical Analyses of Samples

- The suite of elements selected for analysis in the geochemical sampling program is limited to those commodities known to exist in silicic tuff (p. 8.3.1.9-30) and excludes those elements or commodities associated with resources in tactites (skarn), carbonate and other sedimentary rocks, and possible plutonic rocks that may be present beneath the site.

Evaluation of SCA Comment 53, Basis 2

- The response (DOE, 1993a) indicates that geochemical testing is planned for "all of the elements of interest in assessing the mineral potential of Yucca Mountain."
- DOE's response (1993a) indicates that the standard analytical package shown on the table in Section 3.1.5 (DOE, 1992a, p. 3-4) identifies 44 elements to be tested at moderate to low concentrations.
- With respect to elements concentrated or associated with tactites (skarn), the Staff observes that Rose and Burt (1979) indicate that there are four additional elements (tungsten,

boron, fluorine and tantalum) not included on the table on p. 3-4 (DOE, 1992a) that are concentrated in, or associated with, these types of deposits.

- Tungsten, although apparently not specifically identified in the Study Plan as an element to be determined, will be considered since tungsten skarn has been listed (DOE, 1992a, p, 3-33) as an example of a type of mineral deposit that may be applicable to Yucca Mountain.
- In addition to those elements identified in the Study Plan response (DOE, 1992a, Section 3.1.5, table on p. 3-4), the Study Plan (Section 2.1.2.2, p. 2-3), indicates that additional elements (tellurium, zinc, fluorine, barium and the rare-earth elements) will be determined.
- Boron and fluorine are among those elements to be analyzed as part of the spring and well water analysis effort (DOE, 1992a, Section 3.3.1.2, p. 3-13).
- Although not identified in DOE's response (1993a), the Study Plan contains numerous instances where additional elements (not listed on the table on p. 3-4) are to be analyzed. To cite a few examples, the following Study Plan citations are given: Section 2.1.1.1, p. 2-1; Section 2.1.2.2, p. 2-3; and Section 3.3.1.2, p. 3-13.
- In addition to the Natural Resource Assessment Study Plan, element analyses are to be conducted under a number of other studies (DOE, 1992a, Section 2.1.1.1, p. 2-1).
- The suite of elements identified for analyses in the Site Characterization Plan (DOE, 1988) has been expanded considerably and is no longer limited to those commodities known to exist in silicic tuff. The suite now includes the analyses of a host of elements found in a number of mineral deposit types (DOE, 1992a, p. 3-33).
- The DOE response, coupled with additional tests identified in a number of Study Plan sections, has satisfactorily addressed the Staff's SCA concern.
- The NRC staff considers this portion of the comment resolved.

SCA Comment 53, Basis 3 - Integration of Investigations and Consideration of Geophysical Investigations

- Proposed investigations still appear to lack integration with other geological, geophysical, and geochemical investigations and pre-existing data. No geophysical investigations directed toward natural resources assessment and evaluation appear to be considered as recommended in CDSCP Comment 39. Results of

geologic/geophysical activities planned for other purposes may provide a portion of the information to delineate areas for more detailed study.

Evaluation of SCA Comment 53, Basis 3

- Although the DOE (1993a) response relative to the integration of activities conducted under the Natural Resource Study Plan (8.3.1.9.2.1) with other geological, geophysical, and geochemical investigations, studies, and activities captures the majority of the Study Plan "input from" and "output to" elements of the natural resources program, it is incomplete. The overall, but incomplete, integration is shown on Study Plan Table 5-1 (DOE, 1992a).
- Investigation 8.3.1.9.2 (DOE, 1988, Figure 8.3.1.9-3, p. 8.3.1.9-22) which integrates the mineral, energy (hydrocarbon and geothermal), and water resources studies of Yucca Mountain is not shown as "output to" on Study Plan Table 5-1 and is not cited in the study plan text (DOE, 1992a).
- Activity 8.3.1.2.1.3 (DOE, 1991, Fig. 3.2-1, p. 3.2-2) is not identified on Table 5-1 (DOE, 1992a). Tests conducted include, among others, a general reconnaissance for mine shafts and the use of mining company boreholes. This information should be integrated into the Natural Resource Study (DOE, 1992a).
- Studies 8.3.1.5.2.1, 8.3.1.8.5.2, 8.3.1.15.2.2.1, and Activities 8.3.1.4.1.1, 8.3.1.4.3.1.1, and 8.3.1.8.1.1.3 are cited in the Natural Resource Study Plan (8.3.1.9.2.1) text as providing input into various study plan activities but are not identified on Study Plan Table 5-1 (DOE, 1992a).
- Investigation 8.3.1.2.2 and Study 8.3.1.8.5.1 are listed on Natural Resource Study Plan Table 5-1 but are not cited in the study plan text (DOE, 1992a).
- The following are either misidentified and/or mislabeled in the Natural Resource Study Plan (DOE, 1992a): (1) Activity 8.3.1.4.3.1.1 (systematic drilling program), is apparently incorrectly identified (p. 2-3) as the integrated drilling program (Activity 8.3.1.4.1.1); (2) Investigation 8.3.1.17.4 is misidentified as 9.3.1.17.4 (p. 2-4); (3) Study 8.3.1.4.2.1 is misidentified as 8.3.1.17.4.2.1 (p. 3-7); Study 8.3.1.5.2.1 is misidentified as 8.3.1.5.1.2.1 (p. 3-12); and Study 8.3.1.8.5.2 is misidentified as 8.3.1.6.5.2 (p. 3-24).
- Internal integration of the five activities within the Natural Resource Study Plan (DOE, 1992a) is necessary in order to effectively meet the objectives and goal of the study. The potential for feedback between the study plan activities while

work is ongoing is not discussed in detail.

- Regarding geophysical investigations, the response (DOE, 1993a) indicated (DOE 1992a, Section 3.2.1, p. 3-7) that two important methods for locating gold and silver sulfide deposits are now being planned, both on and off-site. These two tests (deep induced polarization and audio magnetotelluric surveys) had not been previously planned as site characterization activities.
- DOE further indicates (DOE, 1992a, Section 3.2.1, p.3-7) that "geophysical signatures of known mineral deposits in similar geologic settings will be especially useful in locating areas of potential mineralization" and that geophysical surveys planned for another study (DOE, 1992c) "will be evaluated for structures and strata that bear on the evaluation of mineralized zones."
- The DOE response (DOE, 1992a, Section 3.2.1, p. 3-7) indicates that "additional geophysical surveys beyond those planned for this activity (Activity 8.3.1.9.2.1.2, Geophysical/geologic appraisal of the site relative to mineral resources) may subsequently be recommended if anomalies (as a result of DOE's evaluation of existing/previously planned geophysical surveys) are detected and there is a need to define them more completely."
- The NRC staff considers the integration portion of this comment open and the geophysical investigations portion of the comment resolved.

SCA Comment 53, Basis 4 - Drill Holes May Not be Designed to Investigate High-Angle Faults or Mineralized Zones

- Drill holes proposed for other tests may not uniformly cover the controlled area and may not be directed at or intersect features favorable to mineralization such as high-angle fault zones, detachment zones, or veins. Drill holes as planned may not be favorably placed or extend to the depth necessary to provide sufficient information to assess resource potential of pre-Cenozoic rocks and volcanic rocks underlying the proposed repository. A large degree of uncertainty exists that vertical drill holes would intersect vertical to near vertical faults or mineralized zones (see Comment 34).

Evaluation of SCA Comment 53, Basis 4

- DOE's response (DOE, 1993a) indicates that, with respect to adequate characterization of near-vertical structural features for suggestions of mineralization, that underground access by means of the excavations for the Exploratory Studies Facility (ESF) will provide the opportunity to directly sample rocks at

the location of vertical discontinuities.

- Since examination, sampling, and testing of high-angle fault zones (and veins) exposed within the ESF excavations would represent only a portion of the geologic section that is located within the perimeter drift outline, the Staff is concerned that only limited information regarding potential mineralization would be acquired if data from this single source alone were to be acquired. Sampling within the ESF could be supplemented by including the analysis of samples taken from drill holes considered under the Systematic Drilling Program (DOE, 1992a, Fig. 1.3, p. 5).
- The Study Plan does not reference the Exploratory Studies Facility as a source for geochemical samples or geologic information.
- The NRC Staff acknowledges that the response (DOE, 1993a) indicates that "the possible presence of faults, including detachment and thrust faults . . . beneath Yucca Mountain . . . will be evaluated".
- Additionally, the response (DOE, 1993a) indicates that deep geological drill holes will define the Paleozoic/Tertiary boundary (considered by some to represent a postulated detachment zone) as well as penetrate the Paleozoic rock sequence.
- With respect to the three planned deep geological drill holes (G-5, G-6, and G-7), the DOE (1993b, Section 2.1.1, Table 2.1, p. 12) indicates that "These holes are located too far from the repository block to provide much geostatistical data". Since the three planned deep core holes are to be located outside of the site area (DOE, 1992a, Fig. 2-1), the Staff questions the usefulness of the holes for natural resources evaluation purposes within either the site area or within the perimeter drift outline.
- Since the studies identified in the Systematic Drilling Program (DOE, 1993b, Table 2.1, pp. 12-13) do not indicate that information will be acquired for natural resources evaluation purposes, the Staff assumes that drill holes acquired under these studies are to be located independent of the needs of the natural resource evaluation. Given this apparent absence of natural resources considerations in the Systematic Drilling Program, significant mineralization, if present, may not be detected.
- The NRC staff considers the drill hole location and depth portion of Comment 53, Basis 4, open.

SCA Basis 5 - Drill Hole Coverage to Include Testing of the Paleozoic and Other Units

- Mineral and/or hydrocarbon resource potential of pre-Cenozoic rocks cannot be adequately assessed based on surface samples. Drill holes that penetrate the Paleozoic rocks, postulated detachment zone (Scott, 1986), and lowermost volcanic rocks are necessary to test for possible mineral resources in light of gold discoveries and mines near Yucca Mountain associated with low-angle faulting, Paleozoic rocks and the lower Tram Member of the Crater Flat Tuff (Sterling Mine at Bare Mountain, Bullfrog District, and GEXA gold claims in northern Crater Flat).

Evaluation of SCA Comment 53, Basis 5

- DOE's response indicates (DOE, 1992a, Section 3.1.1.1, p. 3-1) that the subsurface sampling program, including deep holes, will adequately cover the site area. The planned sampling interval within cores will range between 50 and 300 feet, but will include biased samples taken from altered or mineralized zones.
- DOE indicates that the area lying within 5 km of the center of the surface projection of the perimeter drift will receive a detailed evaluation of oil and gas resources. Furthermore, because of a paucity of hydrocarbon-related data in the immediate vicinity of Yucca Mountain, DOE indicates that a regional study will be required to adequately assess the hydrocarbon potential of the site (1992a, Section 2.4.2.2, p. 2-10).
- This regional hydrocarbon study will include an evaluation of selected exploration holes drilled by the petroleum industry to determine if information relative to the site can be obtained (DOE, 1992a, Section 2.4.2.2, p. 2-10).
- DOE has planned three deep geological drill holes (G-5, G-6, and G-7) that are designed to define the lowermost volcanic rocks as well as the postulated Paleozoic/Tertiary detachment zone. These deep boreholes will penetrate substantial thicknesses of the Paleozoic strata (DOE, 1993a).
- Biased samples will be collected from three planned deep drill holes (G-5, G-6 and G-7) for the purposes of the identification of rock types, contacts, and alteration zones that might be associated with mineralization (DOE, 1992a, Section 2.1.2.1, p. 2-3).
- DOE (1993b, Section 2.1.1, Table 2.1, p. 12) indicates that "These holes (G-5, G-6 and G-7) are located too far from the repository block to provide much geostatistical data." Since

the three deep drill holes are to be located outside of the site area, the Staff questions the applicability of the planned deep core holes for natural resources evaluation purposes within either the site area or, more specifically, within the perimeter drift outline.

- The NRC staff considers this portion of the comment open.

SCA Basis 6 - Outdated References

- Information in Chapter 1 and Section 8.3.1.9.2.1 does not reflect recent publications, models, and discoveries (see NRC, 1986 and CDSCP Comment 38; see information in Raney, 1988 and Price, 1988). Reliance has been placed on out-of-date models, parameters (production figures in dollars rather than tonnage and grade), and references (e.g., McKee, 1979 and Hewitt, 1968).

Evaluation of SCA Basis 6

- DOE's responses (1992b and 1993a) do not address this portion of SCA Comment 53.
- The NRC staff considers this portion of the comment open.

REFERENCES

Bergquist, J.R. and E. H. McKee, 1991. Mines, Prospects, and Mineral Occurrences in Esmeralda and Nye Counties, Nevada, Near Yucca Mountain: U.S. Geological Survey Administrative Report to the U.S. Department of Energy Yucca Mountain Project.

Castor, S. B., Feldman, S.C., and Tingley, J. V., 1990. Mineral Evaluation of the Yucca Mountain Addition, Nye County, Nevada: Nevada Bureau of Mines and Geology, Open-File Report 90-4, 80 pp.

DOE (U.S. Department of Energy), 1988. "Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada". Office of Civilian Radioactive Waste Management, DOE RW-0199. 9 Volumes.

DOE (U.S. Department of Energy), 1991. Study Plan 8.3.1.2.1.3, Characterization of the Yucca Mountain Regional Ground-Water Flow System, Rev. 0, dated January 25, 1991.

DOE (U.S. Department of Energy), 1992a. Study Plan 8.3.1.9.2.1, Natural Resource Assessment of Yucca Mountain, Nye County, Nevada, Rev. 0, dated September 15, 1992.

DOE (U.S. Department of Energy), 1992b. Letter from John P. Roberts, DOE, to Joseph J. Holonich, NRC; Subject: Submittal of Study Plan 8.3.1.9.2.1 "Natural Resource Assessment of Yucca

Mountain, Nye County, Nevada" to the U. S. Nuclear Regulatory Commission, December 17, 1992, 2 pp. plus 2 enclosures, including DOE's addressing of four SCA open items.

DOE (U.S. Department of Energy), 1992c. Study Plan 8.3.1.4.2.1, Characterization of the Vertical and Lateral Distribution of Stratigraphic Units within the Site Area, Rev. 0, dated Feb. 3, 1992.

DOE (U.S. Department of Energy), 1993a. Letter from John P. Roberts, DOE, to Joseph J. Holonich, NRC; Subject: Submittal of updated responses to three SCA open items to the U.S. Nuclear Regulatory Commission, February 5, 1993, one page, plus 3 enclosures.

DOE (U.S. Department of Energy), 1993b. Study Plan 8.3.1.4.3.1, Systematic Acquisition of Site Specific Subsurface Information, Rev. 1, dated June 4, 1993.

Harris, A.G., Repetski, J. E., Clayton, J. L., Grow, J. A., Carr, M. D., and Daw, T. A., 1992. Results from 1991 Wildcat Wells Near Yucca Mountain, Nevada: Geological Society of America, Abstract, Rocky Mountain Section, May 13-15, 1992, p.17.

Rose, A. W. and Burt, D. M., 1979. Hydrothermal Alteration in Geochemistry of Hydrothermal Ore Deposits, H. L. Barnes, ed., Holt, Rinehart and Winston, Inc., New York.

Study Plan 8.3.1.9.2.1 Natural Resource Assessment of Yucca Mountain, Nye County, Nevada

SCP Section 8.3.1.9 Human Intrusion

SCP Section 1.6.1 Drilling and Excavation History

SCA QUESTION 14

The SCP does not appear to consider historical records of claims and/or leases in its evaluation of previous drilling or excavation at Yucca Mountain. What consideration has been given to historical maps and claim and lease information in establishing the position that "no further investigation of previous drilling or mining is needed" (p. 1-213) in the proposed repository area?

EVALUATION OF DOE RESPONSE

- The DOE response (DOE, 1993) indicates that the NRC's concerns relative to the DOE's consideration of historical records in its evaluation of previous drilling or excavation at, and in the vicinity of Yucca Mountain, are, and will continue, to be addressed during site characterization activities.
- On-going and future surface mapping activities conducted by the U.S. Geological Survey are following technical procedure GP-01, "Geologic Mapping" which directs that all mines, prospects, . . . , and drill holes be plotted on general purpose geologic maps (DOE, 1993).
- A recent U.S. Geological Survey report (Bergquist and McKee, 1991), sponsored by DOE, demonstrates that historical records are being utilized as part of its site characterization activities (DOE, 1993).
- The NRC staff considers this question resolved.

REFERENCES

Bergquist, J.R. and E. H. McKee, 1991. Mines, Prospects, and Mineral Occurrences in Esmeralda and Nye Counties, Nevada, Near Yucca Mountain. U.S. Geological Survey Administrative Report to the U.S. Department of Energy Yucca Mountain Project.

DOE (U.S. Department of Energy), 1993. Letter from John P. Roberts, DOE, to Joseph J. Holonich, NRC; Subject: Submittal of updated responses to three SCA open items to the U.S. Nuclear Regulatory Commission, February 5, 1993, one page, plus 3 enclosures.

Study Plan 8.3.1.9.2.1 Natural Resource Assessment of Yucca Mountain, Nye County, Nevada

SCA QUESTION 15

What is the basis for SCP statements with respect to resource exploration and mineral resource potential? The following statements are inconsistent and/or fail to consider or integrate alternative information.

EVALUATION OF DOE RESPONSE

- The response (DOE, 1993) clarifies, through referral to Study Plan Section 3.2.5 (p. 3-8) the SCP statement regarding the low mineral resources potential of the site. On p. 3-8 DOE states that there is presently no known field evidence of ore mineralization at Yucca Mountain, hence the origin of "low" mineral resources potential.
- DOE's (1993) response states that its natural resources assessment program is broadly based, comprehensive, and objective and has made no prior assumptions "as to the nature of the evidence that will be found with regard to the presence or absence of mineral deposits."
- The response (DOE, 1993) further states that the basis of the NRC staff's perception of the mineral resource potential of the site is understood and that Yucca Mountain's proximity to mineralized areas and the presence of faults and other potentially mineralized zones will be taken into account. Study Plan Section 3.2.1, p. 3-6 (DOE, 1992a) bears out this statement.
- The DOE response (DOE, 1993) clarifies the SCP statement that it is "standard practice to exclude evaluation of mineral resources below 1 km" by indicating that this depth limitation was not meant to apply to DOE's natural resources assessment of Yucca Mountain.
- DOE has demonstrated (DOE, 1992a, Section 3.2.5, pp. 3-8 thru 3-10) that 1 km is not a depth limitation since a number of geophysical investigations are to be conducted and will provide mineral resources potential data at depths exceeding one kilometer.
- Examples of planned geophysics tests yielding data below one kilometer include: magnetotelluric (2 to 5 km depth); geoelectric methods providing depth to Paleozoic basement; and magnetics yielding data regarding possible intrusive bodies (DOE, 1992a, Section 3.2.5, p 3-10).

- The response further indicates that three deep cored drill holes (G-5, G-6, and G-7) are proposed (DOE, 1993). These drill holes (all anticipated to exceed the one kilometer depth) are planned to penetrate a representative portion of the Paleozoic rock sequence below the volcanic tuff (DOE, 1992b, Section 2.1.1.2, p. 2-3 and Fig. 2.1-2).
- The DOE response (DOE, 1993) clarifies the apparent SCP inconsistency regarding potential exploration of the Paleozoic by indicating that the natural resources assessment program is not constrained by depth and that Paleozoic exploration for precious metals cannot be dismissed.
- In support of the above statement, DOE has planned tests (both geophysical and deep geological drill holes) that are designed (by geophysical means) to identify the Paleozoic/Tertiary boundary (DOE, 1993) and to penetrate (by deep drill hole) the Paleozoic rock sequence (DOE, 1992b, Section 2.2.1.2, p. 2-3 and Fig. 2.1-2).
- The NRC staff considers this question resolved.

REFERENCES

- DOE (U.S. Department of Energy), 1992a. Study Plan 8.3.1.9.2.1, Natural Resource Assessment of Yucca Mountain, Nye County, Nevada, Rev. 0, dated September 15, 1992.
- DOE (U.S. Department of Energy), 1992b. Study Plan 8.3.1.4.2.1, Characterization of the Vertical and Lateral Distribution of Stratigraphic Units Within the Site Area, Rev. 0, dated February 3, 1992.
- DOE (U.S. Department of Energy), 1993. Letter from John P. Roberts, DOE, to Joseph J. Holonich, NRC; Subject: Submittal of updated responses to three SCA open items to the U.S. Nuclear Regulatory Commission, February 5, 1993, one page, plus 3 enclosures.