REVIEW OF DOE STUDY PLAN 8.3.1.9.2.1 - NATURAL RESOURCE ASSESSMENT OF YUCCA MOUNTAIN, NYE COUNTY, NEVADA

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1.0 INTRODUCTION

One way to minimize the likelihood of inadvertent human intrusion in the future at a high-level waste (HLW) geologic repository is to avoid areas that have either known resources or indications of untapped resource potential that might attract exploration and exploitation. Therefore, assessment of the natural resource potential at Yucca Mountain is of interest with regard to determining the possibility of inadvertent human intrusion at the proposed HLW repository during the postclosure period.

2.0 REVIEW CRITERIA

The review of this Study Plan (SP) is based on the "Review Plan for NRC Staff Review of DOE Study Plans, Revision 2" (NRC, 1993). The portion of the Review conducted at the Center for Nuclear Waste Regulatory Analyses (CNWRA) is concerned with the ability of the activities, tests, and analyses proposed in the SP to provide the data for licensing that the study plan was designed to provide.

3.0 SUMMARY OF STUDY PLAN 8.3.1.9.2.1 GENERAL CONCERNS

Study Plan 8.3.1.9.2.1 follows the outline presented in the Site Characterization Plan (SCP; DOE, 1988), and is divided into five activities. These include:

- Activity 8.3.1.9.2.1.1 - Geochemical Assessment of Yucca Mountain in Relation to the Potential for Mineralization;
- Activity 8.3.1.9.2.1.2 - Geophysical/Geologic Appraisal of the Site Relative to Mineral Resources;
- Activity 8.3.1.9.2.1.3 - Assessment of the Potential for Geothermal Energy at Yucca Mountain;
- Activity 8.3.1.9.2.1.4 - Assessment of Hydrocarbon Resources at or Near the Site; and
- Activity 8.3.1.9.2.1.5 - Mineral and Energy Assessment of the Site, Comparison to Known Mineralized Areas, and the Potential for Undiscovered Resources and Future Exploration.

The SP is comprehensive and generally broad in nature and is likely to provide the information needed for evaluating the mineral and energy resource potential of Yucca Mountain. However, the SP does not provide much detail on the specific type of work to be performed. To some extent, this is justified because much of the outlined work depends on input from other studies (e.g., Activity 8.3.1.8.5.1 - Characterization of Volcanic Features, and others listed in Table 5-1); as a result, the state of knowledge

of resource potential at the Yucca Mountain site is too limited to warrant great detail at this point in time. Nevertheless, it should be possible to define the problem more closely than has been done, and outline integration among different activities in more detail given the amount of information currently available. Ongoing integration among the different activities listed in the SP is not always clear, for example (Fig. 5-1); in some cases, possible integration is not discussed until the final activity (Activity 8.3.1.9.2.1.5). References to specific geologic mapping activities need to be strengthened (Question 3). There are also references in the text to other site characterization investigations, studies, and activities that are not listed in Table 5-1, and activities cited in the table that do not appear in the text (Comment 2). These suggest that full advantage is not being taken of other site characterization studies. Other than references to a few publications, there are few indications in any activity as to what types of analytical procedures will be followed, and what types of tolerances, accuracy, and precision are to be required of laboratory and field analyses. Also, although existing data are mentioned frequently, there is little discussion of how these data will be selected, reviewed, evaluated, and compiled in a systematic manner, even though these data may be used to define geologic areas of particular interest.

3.1 Geochemical Assessment (Activity 8.3.1.9.2.1.1)

Activities involving general geologic field mapping are not specifically mentioned, and few references are made to other SPs, activities, or existing data which may provide needed information. It is stated that biased "grab" samples will be collected from stratigraphic and structural features favorable to mineralization, but how these features will be identified is not defined. Sampling intervals are discussed, but mapping scales are only mentioned in the context of sample locations, not in terms of geologic mapping (Question 3). Also, although emphasis is placed on drill hole sampling, these boreholes will be sited under the integrated drilling program (Activity 8.3.1.4.1.1); it is not clear from the discussion that drill holes will be sited to intersect potential localized mineralization zones or that all well logs will be carefully reviewed to identify key features. Finally, the ESF is not mentioned as a source for geochemical samples or geologic information.

Although existing geochemical data for similar geologic environments are mentioned in Section 2.1.1.2, there is little discussion of existing data at Yucca Mountain or of how a systematic literature review will be undertaken to compile and evaluate these data. Test methods and procedures are only discussed for sampling methods. Analytical methods are not described, and technical procedures which are relevant to these methods are not identified. Although references are given where analytical methods are reported, they may not be appropriate. For example, Valley et al. (1986) is mentioned in Section 3.1.2, page 3-3 as a source for stable isotope analytical procedures. Although this reference describes data interpretation in detail, it does not address sample extraction/analysis procedures.

3.2 Geophysical/Geologic Appraisal (Activity 8.3.1.9.2.1.2)

The importance of existing geologic and geophysical data is emphasized, but this activity does not provide a systematic plan for acquiring, evaluating, and compiling these data. The SP makes clear that interpretation of the geophysical data under this activity will be dependent on the understanding of the geology of the area, and existing geologic and geophysical maps are discussed and several site characterization activities are identified as sources for these data. Activity 8.3.1.9.2.1.2 makes reference to geophysical/geological logging of drill holes without identifying how these drill holes will be sited or selected. It is indicated that this will be accomplished as part of the integrated drilling program, but the relationship is not discussed at any length. Also, although input from Activity 8.3.1.9.2.1.1 is discussed on page 2-4, there is no mention here of integrating work done in this activity with activities

8.3.1.9.2.1.3 - Assessing Geothermal Potential and 8.3.1.9.2.1.4 - Assessing Hydrocarbon Potential (Question 6).

3.3 Assessment of Geothermal Potential (Activity 8.3.1.9.2.1.3)

This is the only activity that presents a systematic plan for reviewing and evaluating the existing literature. The types of equipment that will be used and the analytical precision that can be expected under normal operating conditions are specified. Reference to specific geologic studies is also made, in contrast to other sections of the SP. Modeling studies are discussed in Sections 2.3.1 (page 2-6) and 3.3.1.3 (page 3-14), and the FEHM heat and mass transfer model is mentioned as a tool to determine geothermal potential of the study area. However, this code requires a number of rock and water properties as input parameters; sources for these parameters are not defined (Question 8). In addition, modeling will rely on estimates of intrusive/extrusive ratios of 1 to about 10 for the types of rocks found at Yucca Mountain. These ratios are empirical in nature and ratios as high as 200 have been reported for volcanic rocks in the Coso volcanic field to the southwest. It is not clear that the uncertainties inherent in such input parameters will be taken into account for the modeling exercise. Finally, there is a more recent reference for FEHMN which meets Department of Energy/Yucca Mountain Project (DOE/YMP) software QA requirements (Zyvoloski et al., 1991). This should be referenced in the SP rather than the older version reported (Question 7) in Zyvoloski et al. (1988).

3.4 Assessment of Hydrocarbon Resources (Activity 8.3.1.9.2.1.4)

This activity is well organized and proceeds logically through the different elements necessary to evaluate hydrocarbon potential. Identification of reservoir rocks, traps, and seals is reliant on geophysical techniques, however, and desirable correlation with geologic mapping is not described in any detail. Again, there is no systematic discussion of the identification, compilation, and evaluation of existing data. Specific methods are discussed with regard to maturation studies, thermal history modeling, and geophysical investigations. However, similar specifics are lacking as to what types of geological techniques will be used to define stratigraphy and structures underlying the repository. Also, as with the previous three activities, there is no substantive discussion of drill hole siting and its relation to key features. It appears that three drill holes near the site will penetrate the Paleozoic section. Given the amount of drilling undertaken in exploratory operations such as Railroad Valley (e.g., Garside et al., 1988), it is not clear from the discussion that this is sufficient to define hydrocarbon potential. Other drill holes and well logs may be available, but are not mentioned here.

3.5 Mineral and Energy Assessment (Activity 8.3.1.9.2.1.5)

Data produced by the preceding four activities are synthesized here. However, the type of synthesis that will be performed and the types of quantitative results that are expected for input into performance assessment calculations are not clear. Presumably, the synthesis will provide some qualitative insight on the drilling scenarios and drilling rates that can be expected at Yucca Mountain, but it may also be used to identify trends where this drilling is likely to occur. Such drilling may affect performance calculations. How information of this type will contribute quantitatively to performance assessment calculations is not discussed specifically. In addition, human interference is only referred to in the context of drilling into a waste package or a volume of contaminated rock, and bringing the material to the surface. An additional concern is the possibility of drilling providing zones of enhanced flow and transport from the repository to the water table and out to the accessible environment. Comparison areas, required by 10 CFR 60.21(c)(13) and 10 CFR 60.122(c)(17), are mentioned, but what is actually discussed is genetic

models for areas with established resource potential and how they might relate to conditions at Yucca Mountain. While this is certainly a viable strategy and will provide valuable information, it is not clear that this approach satisfies the regulation as it is currently worded (Question 10). Although comparison with genetic models will be made on the scale of Yucca Mountain, there is a general lack of discussion on how regional features such as metallogenic provinces or large-scale structural trends will factor into the analysis. Also, although the SP states that much of the information will be "qualitative and inferential" (page 3-32) in nature, there is no mention of the types of uncertainties that may be found, sensitivity analyses to determine the degree to which these uncertainties might affect interpretation, or how these uncertainties will be propagated through performance assessment calculations.

3.6 References

Department of Energy (DOE). 1988. *Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada.* Office of Civilian Radioactive Waste Management (OCRWM), DOE/RW-0199. Washington, D.C.

Garside, L.J., R.H. Hess, K.L. Fleming, and B.S. Weimer. 1988. *Oil and Gas Developments in Nevada.* Nevada Bureau of Mines Geol. Bulletin 104. Reno, NV.

Nuclear Regulatory Commission (NRC). 1993. *Review Plan for NRC Staff Review of DOE Study Plans, Revision 2, March 10, 1993.* Division of High-Level Waste Management, Office of Nuclear Material Safety and Safeguards. Washington, D.C.

Valley, J.W., H.P. Taylor, Jr., and J.R. O'Neil, eds. 1986. *Reviews in Mineralogy, Vol. 16: Stable Isotopes in High Temperature Geological Processes.* Mineralogical Society of America. 569 p.

Zyvoloski, G., Z. Dash, and S. Kelkar. 1988. *FEHM: Finite Element Heat and Mass Transfer Code.* LA-11224-MS, Los Alamos National Laboratory, Los Alamos, NM.

Zyvoloski, G., Z. Dash, and S. Kelkar. 1991. *FEHMN 1.0: Finite Element Heat and Mass Transfer Code.* LA-12062-MS, Los Alamos National Laboratory, Los Alamos, NM.

4 SPECIFIC OBJECTIONS, COMMENTS, AND QUESTIONS

4.1 Objections

There are no objections to this Study Plan

4.2 Comments

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

Comment 1

> The reference to a 1987 personal communication cited on in Section 3.2.5, page 3-8 is inappropriate.

Basis

Attachment 2 of the "1993 DOE/NRC Level of Detail Agreement and Review Process for Study Plans" (NRC, 1993) states that personal and oral communications are not acceptable references unless documented in letter reports.

Recommendation

Provide reference to the appropriate letter report if available; if no letter report exists, remove the personal communication cited on page 3-8.

Reference

Nuclear Regulatory Commission (NRC). 1993. *Review Plan for NRC Staff Review of DOE Study Plans, Revision 2, March 10, 1993.* Division of High-Level Waste Management, Office of Nuclear Material Safety and Safeguards. Washington, D.C.

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

Comment 2

Identification of investigations, studies, and activities that are relevant to the planned work is inconsistent, and in some instances incorrect.

Basis

- 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, 8.3.1.8.1.1.3 are cited in the text as providing input into the planned activities but are not included in Table 5-1.

- Investigation 8.3.1.2.2 and Study 8.3.1.8.5.1 are listed in Table 5-1 as providing input but are not cited in the text. All of these plans are appropriately included, but referencing should be consistent.

- Some studies are misidentified and/or mislabeled in the text:

  --page 2-3 - Activity 8.3.1.4.3.1.1 (Systematic Drilling Program), is incorrectly identified as the Integrated Drilling Program (Activity 8.3.1.4.1.1);
  --page 2-4, Investigation 8.3.1.17.4 is misidentified as 9.3.1.17.4;
  --page 3-7, Study 8.3.1.4.2.1 is misidentified as 8.3.1.17.4.2.1;
  --page 3-24, Study 8.3.1.8.5.2 is misidentified as 8.3.1.6.5.2).

Recommendation

Make sure that all relevant investigations, studies, and activities are included and correctly and consistently referenced. This is especially true for references to planned drilling activities.

4.3 Questions

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

Question 1

Is the possibility considered that drilling for exploration and/or exploitation may provide enhanced pathways for groundwater flow and transport?

Basis

- In Section 1.2 on page 1-3, the possibility of exploratory drilling intercepting a waste package and bringing the waste to the surface in the drill cuttings and fluids is mentioned.

- In addition to direct releases, the Site Characterization Plan (SCP) considers the possibility that human activities related to natural resources could "...affect isolation in other ways, such as a shortening of travel pathways by groundwater removal..." (DOE, 1988; p. 8.3.5.18-19).

Recommendation

In addition to direct release to the surface include the possibility of exploratory drilling providing shorter travel pathways to the accessible environment.

References

Department of Energy (DOE). 1988. *Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada*. Office of Civilian Radioactive Waste Management (OCRWM), DOE/RW-0199. Washington, D.C.

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

Question 2

How will "surrounding areas" be selected and sampled?

Basis

- In Section 2.1.1.1 on page 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 on page 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 on page 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 on page 3-20, 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 (Fig. 2-1)..."

The idea is a sound one involving investigation of areas with established resource potential and looking for correlations with the findings at Yucca Mountain. However, in the absence of an operational definition of "geologic setting," it is not clear to what these areas are to be compared. Where possible it should be stated what surrounding areas are appropriate, perhaps by referring to Fig. 2-1, Section 3.5.1. Discussion of how these areas are to be (or have been) selected mapped, drilled, sampled, and interpreted is critical in making sure that any comparison with Yucca Mountain is justified. Also, identifying what features are to be compared and contrasted is important.

Recommendation

A reference to Section 3.5.1 will provide some indication of what type of mineral deposits will be considered. References to recent reports by Berquist and McKee (1991) and Tingley (1992) would be useful for identifying a number of possible comparison sites. Also, indicate the types of features that are to be compared. Indicate how these surrounding areas are to be mapped, sampled, and interpreted to validate any comparisons.

References

Berquist, J.R., and McKee, E.H. 1991. *Mines, Prospects, and Mineral Occurrences in Esmeralda and Nye Counties, Nevada, Near Yucca Mountain*. Administrative Report. US Geol. Survey.

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 3

Sampling densities, sample location, and geochemical data interpretation are to be related to site geology. What field mapping activities and sampling strategies are being planned or will be used in relationship to this activity?

Basis

- In Section 2.1.2.1 on page 2-2, sample location and density will be based on "... the geology, known and expected mineral occurrences, topography, and boundaries of the perimeter drift (fig. 2-1)."

- In Section 3.1.1.1 on page 3-1, "The surface sampling program for geochemical analyses will be based on the geology of Yucca Mountain..."

As stated in Section 2.1.2.1, geologic mapping is critical to determining sampling density, sample location, and data interpretation. Geology of the parent material is an important aspect of the interpretation of geochemical surveys and surface sampling (e.g., Thompson, 1986; Sinclair, 1986; Einaudi, 1992). Although Yucca Mountain has been mapped in detail, there is no real discussion of how either existing field data (e.g., Scott and Bonk, 1984) or field/alteration mapping associated with this or other activities, will relate to the sampling program. Also, while numbers of samples are preliminary, the total number of samples to be collected seems fairly small, especially considering that areas outside of the perimeter drift will also be sampled. Sample size (e.g. channel sampling) is not discussed, and the difficulty in collecting representative samples to avoid possible nugget effects is not mentioned. Finally, establishing baselines for background values and defining key regional geochemical trends may require sampling areas outside of the perimeter drift that are unmineralized.

Recommendation

Include more detailed references to site characterization activities or existing data that include geologic field mapping. Provide information on possible sampling strategies. Include references to sampling specific areas outside the site to determine regional trends.

References

Einaudi, M.T. 1992. In *Report of the Peer Review Panel on the Early Site Suitability Evaluation of the Potential Repository Site at Yucca Mountain, Nevada.* SAIC-91/8001. Science Applications International Corporation: 247-321.

Scott, R.B., and Bonk, J. 1984. *Preliminary Geologic Map of Yucca Mountain, Nye County, Nevada, with Geologic Sections.* USGS-OFR-84-494, Open-File Report. US Geol. Survey.

Sinclair, A.J. 1986. Statistical interpretation of soil geochemical data. J.M. Robertson (ed.) *Reviews in Economic Geology, vol. 3, Exploration Geochemistry: Design and Interpretation of Soil Surveys*. Society of Economic Geology. pp.97-115.

Thompson, I. 1986. Getting it Right. J.M. Robertson (ed.) *Reviews in Economic Geology, vol. 3, Exploration Geochemistry: Design and Interpretation of Soil Surveys*. Society of Economic Geology. pp.1-18.

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

Question 4

How will the "sufficient number of drill hole cores" be selected? Will all drill holes be examined for such features or only a few chosen *a priori*?

Basis

- In Section 2.1.2.1 on page 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."

Since the integrated and systematic drilling programs (Activities 8.3.1.4.1.1 and 8.3.1.4.3.1.1, respectively) will apparently site boreholes independent of the needs of natural resource evaluation, selection of suitable samples from existing drill core will require careful evaluation of all available well logs and drill core for features indicating mineralization. Since exploratory drilling often involves siting boreholes on fairly close centers (e.g., 200 ft), it is not clear that it is possible to select a sufficient number of samples from the available drill hole core. Also, sampling intervals in boreholes (50-300 ft; Section 3.1.1.1) are fairly coarse and may miss significant mineralized intervals. Finally, no provision is made for subsurface sampling from boreholes outside the study area.

Recommendation

Include criteria that will be used to select drill holes for sampling. Also include plans for careful evaluation of all well logs and drill core. A shorter sampling interval for analysis may be necessary to reduce the likelihood of missing mineralized intervals.

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

Question 5

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

Basis

- Section 2.2 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. (1989) 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; selecting appropriate band ratios (e.g., TM band 5/TM band 7 for clays and TM band 3/TM band 1 for iron oxides) will be useful in identifying zones of hydrothermal alteration both inside and outside the perimeter drift. Appropriate band-pass filters may also be useful for directional edge enhancement 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. One appropriate place would be in Sections 2.2 and 3.2 related to geophysical/geologic appraisal of the site.

References

Castor, S.B., Feldman, S.C., and Tingley, J.V. 1989. *Mineral Evaluation of the Yucca Mountain Addition, Nye County, Nevada.* Science Applications International Corporation. Las Vegas, 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.

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.

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 6

Are there plans for the careful integration of ongoing work between activities?

Basis

- Section 2.2, page 2-4 mentions combining results from Activity 8.3.1.9.2.1.1-Geochemical Assessment and Activity 8.3.1.9.2.1.2-Geophysical/geologic appraisal.

- Input from Activity 8.3.1.9.2.1.2 into the assessment of hydrocarbon potential (Activity 8.3.1.9.2.1.4) is mentioned briefly in Section 2.4.2.3 on page 2-10.

Integration among activities is generally mentioned in terms of end results providing some input into a few other activities. However, the potential for feedback among these different activities while work is ongoing is not discussed in detail. For example, findings from Activity 8.3.1.9.2.1.2 could help to direct sampling strategies undertaken in Activity 8.3.1.9.2.1.1. Activity 8.3.1.9.2.1.2 could also provide information relevant to Activities 8.3.1.9.2.1.3 and 8.3.1.9.2.1.4. Linkages among activities are not clearly shown in Figure 5-1. In general, ongoing integration among all of the different activities needs to be laid out more clearly.

Recommendation

Include references as to where the different activities might provide input to or receive output from other each other. An appropriate way to display this would be to include these linkages on Figure 5-1.

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

Question 7

Are there plans to consider the effects of intrusive/extrusive ratios outside of the range of about 1 to 10?

Basis

- In Section 3.3.1.3 on page 3-14, it is stated that intrusive/extrusive ratios of "...about 1 to 6 for the basaltic type and 10 or greater silicic type..." of volcanoes will be used to approximate the size of inferred intrusions. This inferred size will be used as input into the FEHM heat and mass transfer model.

The intrusive/extrusive ratio that is used in this section is an empirical value. Values as high as 200 for basalt and 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 FEHM program, 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 intrusive/extrusive ratios.

References

Bacon, C.R. 1982. Time-predictable bimodal volcanism in the Coso Range, California. *Geology*: 65-69.

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

Question 8

Where will the other parameters necessary for input into the FEHM program come from?

Basis

- Section 3.3.1.3, page 3-14 describes the use of the FEHM model to calculate "...2-D and 3-D transient heat conduction and heat and mass transfer of hydrothermal convection around intrusives. The results...will be used in evaluating thermal gradients and temperatures..."

The FEHM (and FEHMN) heat and mass transfer code requires a number of rock and fluid properties as input in setting up a problem. These include permeability, porosity, density, saturation, and initial pressure (Zyvoloski et al., 1991). These properties are not discussed, nor are possible sources for these properties mentioned.

Recommendation

Give existing or likely sources for these values. Include plans for sensitivity analysis of models to variations in these parameters.

References

Zyvoloski, G., Z. Dash, and S. Kelkar. 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 9

Are there any plans to consider regional geothermal potential more than 5 km from Yucca Mountain?

Basis

It is stated that the planned tests are "...designed to provide data that are representative of the existing geothermal regime within 5 km of Yucca Mountain." (Section 3.3.8, page 3-19). Since most of the water samples and boreholes deep enough to penetrate the water table (Figure 3-1) are located within 5 km of the perimeter drift (Figure 3-1), it seems unlikely that this plan will consider regional geothermal potential other than by sampling of several springs 20 to 60 km away (page 3-13).

Recommendation

Do not limit the discussion of geothermal assessment to a 5 km radius. Since planned tests will be conducted to include springs and wells beyond the 5 km radius, modify wording on page 3-19 to read "...designed to provide data that are representative of the existing geothermal regime <u>in the vicinity</u> of Yucca Mountain." Also, the possibility of large-scale pumping outside of 5 km which might affect regional groundwater should be discussed.

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

Question 10

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 Section 3.5, page 3-30 and in other areas (see Question 2), what is actually proposed in the different activities is the comparison of Yucca Mountain to areas of known mineralization (or proven geothermal/hydrocarbon potential). While this is extremely useful in terms of determining the types of genetic models that are appropriate to the Yucca Mountain setting, it is not apparent that the proposed comparison satisfies the regulation as it is currently worded.

Recommendation

Address the differences between the comparison described in this SP with comparison areas as defined in 10 CFR 60.21(c)(13) and 10 CFR 60.122(c)(17), as well as including a statement describing how DOE's comparison area approach satisfies this NRC rule provision.

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

Question 11

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

Basis

Evaluating the probability of inadvertent human intrusion associated with the exploration for natural resources, 10 CFR Part 60 requires a quantitative evaluation of mineral and energy resources at the site. In this SP, Section 3.5.1, 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., A.G. Fabbri, and R. Sinding-Larsen (eds.). 1988. *Quantitative Analysis of Mineral and Energy Resources*. Dordrecht, Netherlands: Reidel.

Chung, C.F., D.A. Singer, and W.D. Menzie. 1992. Predicting sizes of undiscovered mineral deposits: An example using mercury deposits in California. *Economic Geology 87*: 1174-1179.

Pan, G., and D.P. Harris. 1990. Quantitative analysis of anomalous sources and geochemical signatures in the Walker Lake quadrangle of Nevada and California. *Journal of Geochemical Exploration 38*: 299-321.

Harris, D.P., and G. Pan. 1991. Consistent geologic areas for epithermal gold-silver deposits in the Walker Lake quadrangle of Nevada and California: Delineated by quantitative methods. *Economic Geology 86*: 142-165.

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

Question 12

What form will the results from the study take for input into Investigation 8.3.1.9.3 (Studies to Provide the Information Required on Potential Effects of Exploiting Natural Resources on Hydrologic, Geologic, and Rock Characteristics)?

Basis

The specific ways in which the results from this study 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, page 3-32.

Recommendation

This is related to Question 11, and may be addressed in a similar fashion. Expand the discussion in Section 4 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. As with Question 11, a discussion of possible expert elicitation methods may be appropriate.