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**MAR 22 2000**

**U.S. DEPARTMENT OF ENERGY (DOE) REVIEW OF U.S. NUCLEAR REGULATORY COMMISSION'S (NRC) IGNEOUS ACTIVITY ISSUE RESOLUTION STATUS REPORT, REVISION 2**

The DOE has reviewed Revision 2 of the Issue Resolution Status Report (IRSR) on the Key Technical Issue of Igneous Activity developed by the NRC staff. The enclosed comments are directed at a broad range of concerns, including probability ranges and distributions, source zone models, and needed clarification and corrections.

In general, the DOE agrees with the risk-informed performance-based approach that the NRC has adopted in its development of the proposed 10 CFR Part 63. We believe that our approach to addressing igneous activity is fully consistent with the performance-based 10 CFR Part 63 approach. However, we are concerned that some of the discussions in the subject IRSR are not consistent. For example, proposed 10 CFR Part 63 endorses the concept of a probabilistic analysis. In accordance with this approach, the DOE intends to use the full distribution of the annual frequency of igneous intersection of a potential repository at Yucca Mountain including a proper and quantitative characterization of uncertainties. In contrast, the IRSR discussion uses a single value for the annual probability of volcanic disruption. Such an approach may be overly conservative and does not represent the range of interpretations and uncertainties that many experts on the subject judged appropriate for characterizing the volcanic hazard at Yucca Mountain.

DOE appreciates the opportunity to review the subject IRSRs and provide comments for our consideration. The enclosure contains both general and specific comments. We request that our comments be considered in the preparation of the next revision of the IRSR.

If you have any questions regarding our comments, please contact Tim Sullivan at (702) 794-5589 or Carol Hanlon at (702) 794-1324.

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Enclosure:  
Comments on Issue Resolution Status Report,  
Revision 2, Key Technical Issue:  
Igneous Activity

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Rec'd from  
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**COMMENTS ON SSIUE RESOLUTION STATUS REPORT  
REVISION 2, KEY TECHNICAL ISSUE  
IGNEOUS ACTIVITY**

**General Comments**

Section 5.1 of Revision 2 of the Igneous Activity IRSR states that the DOE and the NRC have not yet reached agreement on the appropriate range of volcanic and intrusive probability estimates to use in performance assessment. Section 5.1 also states that the NRC considers the DOE preferred value of  $1.5 \times 10^{-8}$  as, at best, representing the low end of acceptable probability values. As the NRC staff knows, we disagree with the statement. The value of  $1.5 \times 10^{-8}$  is the mean probability estimate from the Probabilistic Volcanic Hazards Assessment (PVHA) (CRWMS M&O 1996). DOE believes it is important and appropriate that the PVHA, and the analyses that build from the data provided by the PVHA experts, continue to provide the fundamental basis for the DOE probabilities used in performance assessments for Site Recommendation (SR) documentation.

The NRC's Iterative Performance Assessment Phase 2 uses a single value for the annual probability of volcanic disruption. The NRC believes this value is reasonably conservative. However, it does not represent the range of interpretations and uncertainties that many experts on the subject judged appropriate for characterizing the volcanic hazard at Yucca Mountain. In contrast to the NRC's approach, DOE intends to use the full distribution of the annual frequency of igneous intersection of a repository at Yucca Mountain, as determined from the elicitation of 10 volcanism experts (CRWMS M&O 1996). This distribution represents the uncertainties in assessing the likelihood of such a disruptive event. As a probabilistic analysis, the Total System Performance Assessment (TSPA) requires a proper and quantitative characterization of uncertainties. Any particular value of the distribution can be used in the TSPA (including the NRC's preferred estimate of  $10^{-7} \text{ yr}^{-1}$ ) to check for sensitivity. As described in the following sections, DOE plans to test the sensitivity of the TSPA to the NRC's preferred estimate in this manner. DOE believes that it is appropriate to use values that are representative of the PVHA expert elicitation while testing the sensitivity of the TSPA to the NRC's preferred estimate.

In addition, DOE strongly believes that the PVHA and supporting documents meet the acceptance criteria outlined by the NRC in the IRSR. Specific examples are provided in the comments that follow.

**Specific Comments**

1. Section 4.1.1.3, page 18, line 10: "It also is not clear why the 5-11 Ma volcanics were not considered by all experts to define spatial patterns or derive process models."

The 5-11 Ma centers were considered by all the PVHA experts in their assessments of the spatial distributions and recurrence. However, the 5-11 Ma volcanics were judged to provide poorer constraints on the locations and rate of future volcanism than data on younger volcanic centers. Therefore, they were given little or no weight in the hazard models. DOE suggests that the IRSR text be revised to correct this statement.

2. Section 4.1.2.3.3, page 22, paragraph 2: The IRSR states that, based on analogy with the San Rafael volcanic field, the number of Yucca Mountain Region (YMR) intrusive events may be a

factor of two or more greater than the number of volcanic events. A similar statement is also made in Section 5.1. "The staff will assume that the probability of an igneous intrusive event is a factor of 2 to 5 times higher than that of a volcanic event."

DOE found that the reference (Delaney and Gartner, 1997) provided in the IRSR does not address the ratio of extrusive to intrusive events. It would be helpful if the NRC could provide the interpretations and assumptions used to reach their conclusion about the probability of an igneous event being 2 to 5 times higher than that of a volcanic event. In the meantime, DOE plans to continue to use the probability for intrusive events as described in the PVHA. The PVHA provides the distribution for the annual frequency of intersection of an igneous dike with the potential repository footprint (intrusive event). The mean value of this distribution is  $1.5 \times 10^{-8}$ .

3. Section 5.1.2, page 133: The IRSR describes discussions between NRC and DOE staff at Appendix 7 meetings and DOE workshops. It states that future DOE models will assume a volcano will localize within the repository if the initiating dike penetrates the repository site.

This statement is incorrect. DOE plans to determine the probability of a volcanic vent through the repository based on interpretations of the volcanism experts in the PVHA. DOE does not plan to assume with a probability of 1.0 that a volcano will localize within the repository if the initiating dike penetrates the repository site. DOE assumes vent(s) somewhere on a dike. Even if the dike intersects the repository, the location of the vent on the dike will be random and may not coincide with the repository.

DOE requests that the IRSR text be revised to describe how DOE actually plans to model this scenario.

4. Sections 4.1.4.3.1 and 5.1.4 of the IRSR describe concerns that significant amounts of information developed after the PVHA elicitation have not been addressed. DOE acknowledges that new data have been collected since the PVHA assessments. In accordance with DOE procedures for conducting and documenting expert elicitation projects, the relevance of these data with respect to the assessments of the Expert Panel has been and will continue to be assessed using methods such as sensitivity analyses. DOE is monitoring new data and plans to incorporate significant new data into future technical and licensing documents. AP-AC.1Q, Expert Elicitation, was implemented for the post-elicitation studies by the Center for Nuclear Waste Regulatory Analysis (Stamatokos et. al., 1997; Connor et. al., 1997). These studies provided evidence to support the likelihood of greater volume for a volcanic center in the Crater Flat field and an additional igneous center in the Amargosa Valley. Sensitivity studies showed that these new data did not significantly impact the results of the PVHA (Brocoum, 1997). A preliminary review of other new data identified in the IRSR Rev. 2 (e.g., Wernicke et. al., 1998) suggests they also will not significantly impact the PVHA results. DOE currently is reviewing these data in more detail to determine if additional analyses are warranted.

In summary, DOE agrees that new and relevant information available after the completion of the expert elicitation needs to be assessed. DOE has a procedure for assessment of new data that is consistent with the guidance of NUREG-1563, *Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program* (Kotra, et. al., 1996). Per the procedure, the results of the assessment will be documented in a letter report. Delivery of this

letter report is currently scheduled for April 2000. DOE suggests that this perspective be reflected in the IRSR discussion.

5. Section 4.1.4.4, page 41, last paragraph: The second to last sentence states that "Staff concludes that the distribution of sparse events does not provide an accurate basis to conclude that spatial recurrence rate within the repository boundary is zero or a low background value."

The staff apparently believes that the PVHA developed a spatial recurrence rate of zero or near zero. DOE agrees with the staff that the spatial recurrence rate of volcanic events within the repository boundary is not zero. We do not, however, believe that the PVHA concluded it was. Rather, the PVHA experts addressed the issue of limited data by developing distributions for the spatial recurrence rate of volcanic events. Some of these distributions result in finite probabilities for very low occurrence rates in the repository area. These low rates cannot be precluded by the limited data available. The focus of the PVHA was to express the full range of uncertainty associated with the quantified hazard.

DOE suggests correction or clarification of the description on the methods employed by the PVHA experts be provided in the next revision of the IRSR.

6. Section 4.1.5.3, page 43, paragraph 2: The IRSR states that only source zones were used to compute inputs for the TSPA-VA and to restrict events to locations west of the site. The inputs to the TSPA-VA were computed using the full PVHA model, which in no case restricts events to locations west of the site. For those cases where source zones were used, in no instance were events precluded from occurring at the site.

DOE suggests the IRSR be revised to correct this statement.

7. Section 4.1.5.3, page 43, paragraph 3: In the IRSR, the NRC states that much of the confusion regarding volcanism source zones could be resolved if the relationships between volcanism and structure were considered mechanistically and in light of mapped structural features. However, there are also arguments against this approach. DOE believes that a strength of the PVHA was allowing the experts to provide their own conceptualizations rather than prescribing any particular conceptualization. This approach is consistent with our understanding of the intent of NUREG-1563, *Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program* (Kotra, et. al., 1996).

DOE suggests that the NRC either provide additional information and/or revise the statement to permit an approach that is consistent with the flexibility intended in NUREG 1563.

8. Section 4.1.8.3, page 65: The IRSR uses the phrase "utilizing the source zone models that preclude volcanoes from forming at the repository site, as was done repeatedly in Geomatrix (1996)." Source zone models presented in the PVHA do not preclude volcanic events at the repository site. No models developed by the experts resulted in a zero probability of volcanic events at the site. The deep crustal structural domain may place some spatial constraints on the

9. location of a deep source zone for the magma, but these constraints do not apply in the shallow crust. Magma that is constrained to originate deep below Crater Flat may still produce dikes kilometers long in the shallow crust. These dikes could cross the repository footprint and impact the repository. The deep crustal structure does not affect where the dikes go in the shallow crust (only where magma is coming from). They can cross an imaginary surface projection of the deep structural boundaries.

DOE did not exclude these models and suggests the IRSR be revised to correct this statement.

10. Section 4.1.9, page 66: Probability Criterion 9 states that "Estimates of the probability of future igneous activity in the YMR will be acceptable provided that: The collection, documentation, and development of data and models have been performed under acceptable QA procedures, or if data was not collected under an established QA program, it has been qualified under appropriate QA procedures." The IRSR states "Staff also note that none of the data, codes, or models used to support igneous activity analyses in the TSPA-VA were qualified." It also states the NRC staff is concerned that limited time remains for DOE to qualify these data.

Revision 2 of this IRSR was developed before the implementation of the Process Model Report (PMR) effort. In support of the PMR effort, verification/qualification of data, software, and models will be completed on an incremental basis. The results of this effort should help to alleviate NRC concerns in this area.

11. Section 4.2.1.3, page 69: The stated intent of this acceptance criterion is to ensure models are consistent with the geological record. The IRSR also states that physical conditions representative of violent strombolian activity should be used. DOE believes that it counter to the performance-based approach discussed in proposed 10 CFR Part 63 to prescribe the approach that must be used. This does not allow for varying scientific interpretations, nor does it afford DOE the opportunity to present technically and scientifically valid arguments for models that make a different case.

DOE recognizes that violent strombolian eruptions may have occurred in the past and includes these eruption types in the entire range of possible future activity. DOE models include violent strombolian activity as a part of the model and parameter ranges. The fraction of time that eruptions would be in a violent phase is not known for igneous activity at the Yucca Mountain region. Also, the IRSR often uses the term "expected" values to refer to maximum values, whereas DOE uses the term to describe the mean of a distribution. DOE use of the term is consistent with its usage in the term "expected annual dose" as defined in proposed 10 CFR Part 63.2.

DOE suggests the IRSR text be revised to remove the guidance that physical conditions representative of violent strombolian activity should be used. Removal of this guidance would make the criterion more consistent with the performance-based approach discussed in proposed 10 CFR Part 63.

12. Section 4.2.2.4, page 76: The IRSR concludes that there are no observations of the behavior of dense waste particles in ash plumes. It also explains that application of physically accurate models is a fundamental step in modeling of dose and risk to a critical group.

DOE suggests that the IRSR acknowledge that alternative approaches are available to address the distribution and deposition of dense waste particles in tephra deposits. As an example, instead of embarking on an extensive research and model development program, the processes may be bounded for modeling purposes according to current understanding of the relative contributions and effects of the different eruption styles.

13. Section 4.2.4.3.1, page 84: The IRSR takes issue with the TSPA-Viability Assessment (TSPA-VA) assumptions regarding waste packages and entrainment of waste during volcanic eruptions. This conclusion is reached in part because the alloy-22 used in the VA waste package design is a low-temperature alloy for which there are no data on the performance at temperatures expected during volcanism. In addition, the IRSR states that TSPA-VA calculations assume that the inner waste package barrier would not fail unless it had been reduced in thickness by approximately 50 percent, which would not occur until about 160,000 years postclosure.

The IRSR states that the TSPA-VA does not demonstrate that waste package survivability can be assumed. The IRSR also states that, because DOE safety case appears based on waste package and waste form resilience during igneous events, additional data and models will need to provide a reasonable basis that waste packages can indeed withstand exposure in an actively erupting volcanic conduit and that HLW will not be substantially entrained by such an eruption. The IRSR concludes the DOE modeling assumptions are not substantiated by information in the literature or independent DOE studies and will not meet acceptance criteria presented in the IRSR.

The NRC evaluations were performed against a waste package and repository design that has since been changed. Many of the observations provided by the NRC have been overtaken by design changes. Specifically, the waste package being analyzed will be the Site Recommendation (SR) design with an outer wall made of a corrosion resistant material with the inner wall selected to provide structural support. Also, the analyses to be performed for TSPA-SR as described in the TSPA-SR Methods and Assumptions Document (CRWMS M&O 1999) address the concerns described in the IRSR. The Methods and Assumptions document states that the analysis for the TSPA-SR postulates that igneous activity in the Yucca Mountain region results in magma intersecting the repository and an eruption occurs through the repository. It is assumed that the magma can neutralize the protection provided by the waste packages that it contacts, and the waste is entrained to the surface.

DOE suggests that the IRSR be revised to recognize the design changes and the analytical techniques described in the TSPA-SR Methods and Assumptions Document.

14. Section 4.2.5, page 86 and Section 5.2.5, page 141: The IRSR concludes that there is substantial agreement between the NRC and DOE on this criterion, and that most differences are not significant. However, it also notes that the modeling assumptions presented in the TSPA-VA related to wind speed and directions must either be modified or supported by data. The IRSR states that the wind velocity and direction used in TSPA-VA were chosen to minimize the dose at 20-km south. It states that these wind conditions are not applicable to the elevations at which the plume exists. The IRSR cites data for wind speed of ~6 m/s at an elevation of 2 km from the land surface. It also states that wind speeds increase to ~12 m/s at altitudes of 4 km (see p. 88) and that this is a reasonably conservative value to use in dose modeling. It also concludes that a "reasonably conservative" assumption is that the winds continually blow to the south.

The values used by the DOE reflect the "expected" case. The parameter values used by the NRC reflect a worst-case scenario. DOE acknowledges that the data used in the calculations must be justified and that the use and application of the data must be documented. DOE also believes that dose calculations should fairly and appropriately consider the important factors. Therefore, we suggest that the NRC consider acknowledging the appropriateness of different approaches in the next IRSR revision.

## References

Brocoum, S.J., 1997, *Evaluation of Data Provided at U. S. Department of Energy (DOE) and U. S. Nuclear Regulatory Commission (NRC) Igneous Activity Technical Exchange, February 25-26, 1997*, Las Vegas, Nevada: Yucca Mountain Site Characterization Office. ACC: MOL.19970722.0276.

Connor, C.B., S. Lane-Magsino, J.A. Stamatakos, R.H. Martin, P.C. La Femina, B.E. Hill, S. Lieber, *Magnetic Surveys Help Reassess Volcanic Hazards at Yucca Mountain, Nevada*, Eos, Transactions of the American Geophysical Union 78(7): 73-78, 1997. TIC: 234580.

CRWMS M&O 1996. *Probabilistic Volcanic Hazards Analysis for Yucca Mountain, Nevada*. BA0000000-1717-2200-00082, REV. 00. Las Vegas, Nevada: Author. ACC: MOL.19961119.0034.

CRWMS M&O 1998. *Synthesis of Volcanism Studies for the Yucca Mountain Site Characteristic Project*. Level 3 Deliverable 3781MR1. Las Vegas, Nevada: Author. ACC: MOL.19990511.0400.

CRWMS M&O 1999. *Total System Performance Assessment—Site Recommendation Methods and Assumptions*. TDR-MGR-MD-000001 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990916.0105.

Delaney, P.T., and A.E. Gartner, *Physical Processes of Shallow Mafic Dike Emplacement Near the San Rafael Swell, Utah*, Geological Society of America Bulletin 109: 1,177-1,192, 1997. TIC: 238031.

Kotra, J.P., Lee, M.P., Eisenburg, N.A. and DeWispelare, A.R. NRC 1996. *Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program*, NUREG-1563. Washington, D.C.: Division of Waste Management. MOL.19961216.0119.

Stamatakos, J.A., C.B. Connor, R.H. Martin, *Quaternary Basin Evolution and Basaltic Volcanism of Crater Flat, Nevada, From Detailed Ground Magnetic Surveys of the Little Cones*, Journal of Geology 105: 319-330, 1997. TIC: 245108.

Wernicke, B., J.L. Davis, R.A. Bennet, P. Elosegui, M.J. Abolins, R.J. Brady, M.A. House, N.A. Niemi, J.K. Snow, 1998. *Anomalous Strain Accumulation in the Yucca Mountain Area, Nevada*. Science, Vol. 279, p. 2096 – 2100, Washington, D.C.; National Association for the Advancement of Science. TIC: 235956.