

RAI Volume 3, Chapter 2.2.1.2.2, Third Set, Number 1:

Please, address why DOE has not provided a basis to exclude igneous event probability models published since 2000 (i.e., Ho et al., 2006) from consideration in SAR section 2.2.2.2.3.2. Address why published probability models in Ho and Smith (1997) and Ho et al. (2006), were not discussed in SAR section 2.2.2.2.3.2. This information is needed to determine compliance with 10 CFR 63.114.

Basis: In SAR section 2.2.2.2.3.2, DOE concluded that alternative probability models published between 1982 and 2000 (Tables 2.2-18 and 2.3.11-4) “cluster at slightly greater than 10^{-8} per year.” DOE concluded that this “clustering” in published models provides confidence that the DOE probability estimate is robust. However, Ho and Smith (1997) and Ho et al. (2006) published probability estimates for future igneous events at Yucca Mountain, which are not included in SAR Tables 2.2-18 and 2.3.11-4 and are not discussed in SAR section 2.2.2.2.3.2.

1. RESPONSE

The fundamental basis for igneous probability estimates in the SAR is the Probabilistic Volcanic Hazard Analysis (PVHA) (CRWMS M&O 1996). Although “clustering” of published models, discussed in SAR Section 2.2.2.2.3.2, is not the primary basis for igneous probability estimates, it increases confidence in that basis. As noted in Update #1 of the license application (LA) (SAR Section 5.4.1, p. 5.4-6), the differences between the PVHA and updated PVHA (PVHA-U) (SNL 2008) probability distributions would not significantly affect the estimates of repository performance for either 10,000 years or 1,000,000 years, demonstrating that the PVHA-U results confirm the original PVHA technical basis.

SAR Tables 2.2-18 and 2.3.11-4 present the results of published probability estimates, not models or approaches to modeling. Confidence in the robustness of the disruption probability results comes from: (1) the expert elicitation process that was followed in both the PVHA and the PVHA-U is consistent with NUREG-1563 (Kotra et al. 1996) and other guidance (Budnitz et al. 1997); (2) the consideration by experts in both the PVHA and the PVHA-U of a wide range of available data and probability models in making their assessments, including those cited in the RAI; and (3) consistency between the two disruption probability estimates resulting from the PVHA and the PVHA-U.

SAR Tables 2.2-18 and 2.3.11-4 include Ho and Smith’s 1998 paper, which subsumes and incorporates the approaches and concepts given in their 1997 paper. The 2006 paper by Ho et al. was not included in SAR Tables 2.2-18 and 2.3.11-4 because it does not present disruption probability results; however, that paper was provided to the PVHA-U experts and was part of the experts’ considerations.

1.1 LICENSING BASIS FOR IGNEOUS PROBABILITY ESTIMATES

The fundamental licensing basis for igneous probability estimates in the SAR is the PVHA (CRWMS M&O 1996), an expert elicitation carried out consistent with NUREG-1563 (Kotra et al. 1996) and other guidance (Budnitz et al. 1997). Subsequent to the LA submittal, the PVHA-U (SNL 2008) was completed and submitted to the NRC (Boyle 2008). Update #1 of the LA refers to the PVHA-U (SAR Section 5.4.1, p. 5.4-6) and concludes that differences between the PVHA and the PVHA-U probability distributions would not significantly affect the estimates of repository performance for 10,000 years or 1,000,000 years, demonstrating that the PVHA-U results confirm the original PVHA technical basis.

The expert elicitation process followed in both the PVHA and PVHA-U provided experts with a wide range of data and models for their consideration. The process calls for the identification of applicable data, existing models, published interpretations, etc., and presentation to the panel for their consideration (Kotra et al. 1996, pp. 25 and 26). In this context, the expert “consideration” of data and models refers to (1) the evaluation of models relative to their credibility in light of available data, (2) the development of PVHA input parameters (e.g., recurrence rates) in light of models and data, and (3) the quantification of uncertainties in conceptual models and parameters. In addition to the databases developed for the PVHA and PVHA-U studies, multiple workshops and field trips were held to allow proponents of alternative models to present their interpretations and findings. This also allowed the experts to probe the technical support for alternative models in order to evaluate the credibility of alternative models, which could be used to assign weights to alternatives in logic trees. Databases considered by the PVHA and the PVHA-U experts included not only the data and models given in the two references cited in the RAI along with Ho and Smith’s 1998 paper, but also a full range of credible models from the larger technical community.

The information and interpretations comprising the references cited in this RAI were provided to the experts for their consideration and evaluation. Although Ho and Smith’s 1997 and 1998 papers were published after completion of the PVHA in 1996, Dr. Eugene Smith participated at the Workshop on Data Needs on February 23, 1995 (CRWMS M&O 1996, p. C-3), the Workshop on Alternative Hazard Models on March 31, 1995 (CRWMS M&O 1996, pp. C-8 and C-9), and the Crater Flat Field Trip on March 29, 1995 (CRWMS M&O 1996, pp. D-1 and D-2). Dr. Chih-Hsaing Ho participated in the Workshop on Alternative Hazard Models on March 30, 1995 (CRWMS M&O 1996, p. C-8). Peer review was part of the expert elicitation process. Peer Review Panel member Dr. Allin Cornell met with Drs. Ho and Smith to improve his understanding of their temporal and spatial models and to ensure that these models were represented to the experts as possible models for their use (CRWMS M&O 1996, p. 2-19).

As part of the PVHA-U, the three references cited in the RAI were provided to the PVHA-U expert panel (SNL 2008, p. B-9). Dr. Smith’s models were presented at Workshop #2, Alternative Models, on February 17, 2005 (SNL 2008, p. C-22), and he participated in discussions of his and other models at Workshop #3, Preliminary Assessments, on September 27, 2006 (SNL 2008, pp. C-45 and C-46). Thus, the data, models, and approaches advocated by Drs. Ho and Smith were made available to both the PVHA and the PVHA-U expert panels for their consideration.

Despite the passage of 12 years between the PVHA and the PVHA-U and the development of new data and models within the igneous technical community during that period, the results of the PVHA-U and PVHA are consistent, and evaluations show that updated disruption probability distributions would not significantly affect the PVHA-based estimates of repository performance for 10,000 years or 1,000,000 years (Boyle 2008). Based on these results, Update #1 of the LA (SAR Section 5.4.1, p. 5.4-6) indicates that the basis for the igneous probability estimates remains the PVHA. The consistency of the probability estimates between the two studies provides a fundamental basis for confidence in the robustness of the PVHA results.

In summary, the fundamental bases for confidence in the probability estimates are: (1) the expert elicitation process that was followed, consistent with NUREG-1563 (Kotra et al. 1996) and other guidance (Budnitz et al. 1997); (2) the consideration by experts in both studies of a wide range of available data and probability models in making their assessments, including those cited in this RAI; and (3) consistency between the two disruption probability estimates that result from the PVHA and the PVHA-U. Observations such as made in SAR Section 2.2.2.2.3.2 regarding the clustering of existing probability estimates increase that confidence.

1.2 INCLUSION OF HO AND SMITH 1997 IN SAR TABLES 2.2-18 AND 2.3.11-4

As noted in the RAI, SAR Tables 2.2-18 and 2.3.11-4 do not include Ho and Smith's 1997 paper. However, those tables do include a reference to Ho and Smith's 1998 paper. Ho and Smith's 1997 methodology paper presents a Bayesian approach to assessing probabilities. The paper's focus is alternative approaches to assessing the prior distribution for the Bayesian analysis, given as either prior distributions selected for mathematical convenience (Ho and Smith 1997, p. 621) or motivated by expert knowledge (Ho and Smith 1997, p. 622). The calculations given in the paper are termed sensitivity analyses and their purpose is to illustrate the sensitivity of calculated hazard to alternative approaches to selecting the prior distribution (Ho and Smith 1997, p. 624). As such, the results are examples to illustrate the Bayesian methodology and its sensitivity to the selection of prior distributions.

Ho and Smith's 1998 paper includes the Bayesian approach discussed in their 1997 paper and further presents a method for incorporating models based on a homogeneous Poisson process and a non-homogeneous Poisson process. Hence, the approach and concepts given in Ho and Smith's 1997 paper are included and subsumed in their 1998 paper. Hazard results expressed as disruption probabilities are given for the Bayesian, homogeneous Poisson, and non-homogeneous Poisson models (Ho and Smith 1998, p. 508), and these appear to represent the authors' incorporation of what they deem to be applicable data and model inputs. Therefore, it was concluded that the Bayesian approach presented in Ho and Smith's 1997 paper is captured in the probability estimates for the three alternative models presented in their 1998 paper, and these estimates are included in SAR Tables 2.2-18 and 2.3.11-4.

1.3 EXCLUSION OF HO ET AL. 2006 FROM SAR TABLES 2.2-18 AND 2.3.11-4

Ho et al.'s 2006 paper (Ho et al. 2006, p. 118) presents a strategy for the evaluation and use of a "hazards area" based on a model developed for licensing commercial space launch and reentry operations in the space transportation industry. Alternative approaches or site disruption scenarios that may result in different probabilities are considered, but the scenarios are not followed by specific calculations of disruption probability. Ho et al.'s 2006 paper is not included in SAR Tables 2.2-18 and 2.3.11-4 because it does not present disruption probability results. However, the paper was considered by the PVHA-U experts.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

Boyle, W.J. 2008. "Transmittal of Report: Probabilistic Volcanic Hazard Analysis Update (PVHA-U) for Yucca Mountain, Nevada." Letter from W. Boyle (DOE) to NRC, October 17, 2008, Project No. WM-00011, Docket Number 63-001, with enclosures. BSC Correspondence Log # 1021084046, CCU.20081021.0009.

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CRWMS (Civilian Radioactive Waste Management System) M&O (Management and Operating Contractor) 1996. *Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada*. BA0000000-01717-2200-00082 REV 0. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971201.0221.

Ho, C.-H., and E.I. Smith 1997. "Volcanic Hazard Assessment Incorporating Expert Knowledge: Application to the Yucca Mountain Region, Nevada, U.S.A." *Mathematical Geology*, 29, 615-627. New York, New York: Plenum Publishing Corporation.

Ho, C.-H. and Smith, E.I. 1998. "A Spatial-Temporal/3-D Model for Volcanic Hazard Assessment: Application to the Yucca Mountain Region, Nevada." *Mathematical Geology*, 30, (5), 497-510. New York, New York: Plenum Publishing Corporation.

Ho, C.-H., E.I. Smith, and D.L. Keenan 2006. "Hazard Area and Probability of Volcanic Disruption of the Proposed High-Level Radioactive Waste Repository at Yucca Mountain, Nevada, USA." *Bulletin of Volcanology*, 69, 117-123. New York, New York: Springer-Verlag.

ENCLOSURE 1

Response Tracking Number: 00500-00-00

RAI: 3.2.2.1.2.2-3-001

Kotra, J.P.; Lee, M.P.; Eisenberg, N.A.; and DeWispelare, A.R. 1996. *Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program*. NUREG-1563. Washington, D.C.: U.S. Nuclear Regulatory Commission.

SNL (Sandia National Laboratories) 2008. *Probabilistic Volcanic Hazard Analysis Update (PVHA-U) for Yucca Mountain, Nevada*. TDR-MGR-PO-000001 REV 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080905.0006.^a

NOTE: ^aProvided as an enclosure to letter from Boyle to Director, Division HLWRS, dtd 11/06/08, "Second Transmittal of Report: Probabilistic Volcanic Hazard Analysis Update (PVHA-U) for Yucca Mountain, Nevada."