U.S. NUCLEAR REGULATORY COMMISSION STAFF PERSPECTIVES ON THE ACNW DRAFT WHITE PAPER ON *IGNEOUS ACTIVITY AT YUCCA MOUNTAIN*

The following comments by U.S. Nuclear Regulatory Commission (NRC) staff identify areas, in the Advisory Committee on Nuclear Waste (ACNW) draft White Paper, where relevant NRC information which provides important programmatic context for the technical investigations conducted by staff, has not been fully nor accurately cited or discussed. The comments are grouped into four general areas of concern, with specific examples provided for each area. These comments and examples are not intended as a complete list of information that staff considers relevant to these concerns.

The draft White Paper is focused on the presentation of ACNW's analysis of igneous activity (e.g., Section 3). The ACNW analyses include extensive discussion of work presented by the Electric Power Research Institute (2004, 2005). Staff has recently developed an independent technical assessment of this work (Basu, et al., 2007), and suggests that the ACNW consider this assessment in revising its White Paper.

1. Misunderstanding or Misapplication of Staff Information Regarding Part 63 Analysis

The draft White Paper provides perspectives on risk calculations that are confusing and, do not acknowledge key staff documents. For example, in Lines 5531–5537, ACNW writes: "By the quantitative definition of how risk is calculated - the product of probability and consequence for the igneous scenario - this could be considered a risk. However, the significance of a 'probability weighted dose' is not clear. Since probabilities are always fractions, a probability-weighted dose will be smaller than the corresponding inhalation dose. From the receptor's point of view, this can be confusing and perhaps misleading. NRC should be encouraged to clarify the meaning of the expression."

The NRC staff has taken steps to ensure that the representation of the probability-weighted dose for the igneous scenario could be understood. NRC's most recent published report on its performance assessment results (Mohanty, et al., 2004) displayed the probability-weighted dose curve and conditional dose curves (i.e., dose when the event is assumed to occur) show the difference between these two doses (page 3-84, Figures 3-44 and 3-45). Similar analyses were presented in, for example, NRC (1999). The staff believes these documents clearly present the probability weighted dose concept.

Lines 5310–5314 of the draft states "Events that occur more than 1,000 years after repository closure would result in essentially no dose from even the longer-lived fission products like Cs-137 and Sr-90. Because any significant dose would be a gamma dose from these fission products, such events would not result in an external dose."

Such assertions under the heading "NRC Analyses," do not accurately describe NRC analyses. To the best of our knowledge, the NRC staff has never stated there is "essentially no dose" after 1,000 years. For example, NRC's most recent published report on its performance assessment results (Mohanty, et al., 2004) clearly shows that while the dose for an event that

occurs at 1,000 years is approximately four times less than an event that occurs at 100 years, this dose is not insignificant (page 3-84, Figure 3-44).

Although external doses are calculated as part of the total expected dose equivalent, external doses have not been an NRC staff concern for the igneous scenario (e.g., Mohanty, et al., 2004). Thus, it is unclear why the external dose from fission products is referenced as an NRC staff analysis in the draft White Paper.

- The NRC staff recommends that sections in the White Paper that discuss NRC staff analyses only present information that is transparent and traceable to cited NRC reports or publications. Presentation of ACNW perspectives and analyses in these sections is a misunderstanding or misapplication of NRC staff information.

2. Incomplete Regulatory Context for Staff Technical Investigations

The draft White Paper does not provide a regulatory or programmatic context for the evolution of igneous activity issues. This omission fails to recognize that the NRC staff has systematically developed focused technical investigations to enhance review capabilities in areas of potential risk significance, probe risk-significant areas of U.S. Department of Energy (DOE) information, gain risk insights for alternative conceptual models, and integrate technical information into an independent total-system performance assessment.

In response to questions and concerns with the DOE program for igneous activity, NRC developed technical investigation programs to provide an independent assessment and review capability for igneous activity issues. Early results from these programs provided a technical basis for evaluating uncertainties in, for example, probability models (e.g., Connor and Hill, 1993; Connor and Hill, 1995; Condit and Connor, 1996); use of historically active volcanoes to help interpret characteristics of past activity in the Yucca Mountain region (e.g., Connor, 1993; Connor and Hill, 1994; Hill, et al., 1995), and modeling airborne transport from basaltic volcanoes (e.g., Jarzemba, et al., 1997; Hill, et al., 1996).

The NRC staff has produced numerous reports and held detailed interactions with the DOE. This information provides a detailed record of how the available information, including the NRC staff's independent information, was synthesized and applied to understanding and resolution of technical uncertainties in the DOE information. The draft White Paper, however, does not present this programmatic context for how the staff used available information to understand risk-significant uncertainties in the DOE program and provide early identification of potentially significant issues.

For example, external review of the Center for Nuclear Waste Regulatory Analysis (CNWRA) program (McKague, 1998) identified the potential risk significance of magma-drift interaction processes, which supported the identification of this issue as significant in NRC staff comments on the DOE Viability Assessment (Travers, 1999) and Site Recommendation (Meserve, 2001). Initial results from first-order models for gas-bearing (Bokhove and Woods, 2000; Woods, et al., 2002) and gas-absent (Lejeune, et al., 2002) flows supported numerous technical exchanges with DOE, which resulted in a DOE agreement to provide additional support for the information used in the Site Recommendation (Reamer, 2001). The independent NRC staff information provided a technical basis for determining the high significance of this issue to repository performance (Mohanty, et al., 2004; NRC, 2004), and for resolving technical concerns with DOE information (Kokajko, 2005a; NRC, 2005). The draft White Paper, however, presents

NRC staff investigations without indicating of how this information was developed to probe the DOE program and respond to NRC staff and other stakeholder concerns with the DOE program, nor how this and other relevant information was used to evaluate new DOE information.

- Staff recommends that the White Paper be revised to acknowledge the full range of NRC staff technical investigations, their programmatic context, and the interactions between NRC, DOE, and other stakeholders, that show how independent information has been used to risk-inform technical issues, understand the effects of alternative conceptual models, and identify and resolve technical concerns about the DOE program.

3. Incomplete Presentation of NRC Information in Areas Identified as NRC Positions or Views

Technical sections of the draft White Paper that focus on NRC staff positions (i.e., Sections 5–6) do not cite nor discuss important NRC staff technical investigations. In addition, information developed in these investigations gives additional perspective to the information used by ACNW to develop its analysis of igneous activity in the draft White Paper (e.g., Section 3). The following examples highlight areas where additional information could be discussed in the relevant sections of the draft White Paper.

Independent reviews of the CNWRA igneous activity program were conducted in 1994 (Hill, 1995) and 1997 (McKague, 1998). These reviews evaluated many of the risk-significant areas associated with potential igneous events, and assessed planned and ongoing NRC/CNWRA technical investigations in these areas. Section 1.7 of the White Paper should recognize that the NRC staff igneous activity program has undergone and responded to two independent, external reviews.

NRC staff has developed an independent understanding of the tectonic and magmatic framework for basaltic volcanism in the Yucca Mountain region, which is the foundation for evaluating the likelihood of future igneous activity in this region. Only three papers were cited in the draft White Paper, and information from Connor and Hill (1994); Stirewalt, et al. (1995); Hill and Connor (1996); Stamatakos and Ferrill (1998); Stamatakos, et al. (1998); and Waiting, et al. (2001) which supplies part of the technical basis NRC staff has developed in this area, is not cited nor discussed in the draft White Paper (e.g., lines 3309–3354).

Consideration of NRC perspectives on the probability of igneous activity in Sections 4 and 5 should also address work done to understand methods to evaluate probability-model utility in forecasting future igneous events, effects of potential buried volcanoes, and uncertainties in recurrence rate estimates for basaltic volcanic fields, in such papers as Condit and Connor (1996); Connor and Sanders (1994); Connor et al. (1997); Magsino, et al. (1998); Connor and Hill (1994b, 1995a); Hill, et al. (1994); Conway, et al. (1997; 1998); Connor and Conway (2000). Although the draft White Paper cites probability models for the Yucca Mountain region developed by NRC staff, it fails to acknowledge that these models have emphasized the development of review capabilities for probability issues. By focusing on only a limited selection of the staff's model papers (i.e., Connor and Hill, 1995b; Connor et al., 2000), the draft White Paper incorrectly implies that the NRC staff has developing a fixed "position," on probability.

In the area of igneous-event consequences, Section 6.2 ("Intrusive Event") does not discuss work by Bokhove and Woods (2000), Lejeune, et al. (2002), Bokhove, et al. (2005), Woods, et al. (2006) and Menand and Philips (2005), which support staff understanding of

potential magma-repository interactions. Analyses presented by Smart (2004) are relevant to understanding thermo-mechanical response of drift walls and the potential for magma-drift interactions. In addition to the above papers, NRC (2005) presents important information on waste package response to potential igneous events, which supports the models used in Mohanty, et al. (2004). Information provided in NRC (1999), Jarzemba, et al. (1997) and Codell (2004) supports the consideration of waste form response to potential intrusive igneous events. The discussion of igneous event consequences would be much more complete if the White Paper also consider the information presented in the key technical issue (KTI) resolution process (e.g., Schlueter, 2003; Kokajko, 2005b).

For the section on effects from extrusive events (Section 6.3), Hill (1996), Doubik and Hill (1999), NRC (2005) and Woods, et al. (2005), for example, provide significant information relevant to understanding NRC staff perspectives on subvolcanic conduit development, and the formation of secondary breakouts (i.e., the "dogleg scenario") beyond that discussed in Woods, et al., 2002, and should be discussed. As with intrusive events, the extrusive event discussion should address information presented in the KTI resolution process (e.g., Kokajko, 2005a). Information relevant to understanding the modeling of airborne transport of radionuclides (e.g., Jarzemba, et al., 1997; Jarzemba, 1997; Hill, et al., 1998; Connor, et al., 2001; Mohanty, et al., 2004) and development of associated parameters (1998; Hill and Connor, 2000; Mohanty, et al., 2004; Hill, 2004) is either not cited or addressed when discussing the NRC analysis. NRC staff information relevant to understanding significance or limitations in alternative conceptual models (e.g., Codell, 2004; Spradley, 2006) warrants consideration in this section as does information on the characteristics of volcanic deposits and associated airborne mass loads as discussed in, for example, Hill and Connor (1995); Hill, et al. (1995,1996, 2001); Jarzemba (1997); and McKague (1998).

Information developed for NRC staff perspectives on post-volcanic redistribution effects (Section 6.4) includes analyses, in Hill and Connor (2000), and NRC (2004), that discuss the potential significance of this issue to risk. Initial models and associated information relevant to understanding long-term redistribution processes also are discussed in Hooper (2004) and Mohanty, et al. (2005), with additional information presented in Hooper and Benke (2006) and Benke, et al. (2006).

- In addition to including the relevant programmatic documents (item 2), NRC staff recommends the draft White Paper be revised to include a more complete range of NRC technical investigations in each of the sections that describe NRC staff positions.

4. Absence of Risk Insights to Evaluate Significance of ACNW Assessments

The NRC staff is aware of technical areas where ACNW has expressed interpretations that differ from those of NRC staff. Like ACNW, the NRC staff recognizes that limited data for difficult-to-observe igneous processes can lead to alternative views on the probability and consequences of potential igneous events. Although conclusions are not presented in the draft White Paper, apparent conclusions are reached throughout Sections 2–6, regarding ACNW's agreement, or lack of agreement, with information developed by NRC. The significance of these disagreements for repository performance, however, cannot be determined unless the draft White Paper includes a discussion of the risk significance of the process being evaluated.

The NRC staff has developed an integrated program that uses quantitative modeling and professional judgment to evaluate the risk significance of technical issues and associated uncertainties. Examples of these risk insights are provided in, for example, NRC (2004, 2005), and Mohanty, et al. (2004, 2005). Additionally, risk information has been used by NRC staff to

focus, and at times resolve, key technical uncertainties using DOE information. For example, igneous activity KTI Agreement 2.02 used a DOE sensitivity analysis to conclude that existing uncertainties in particle-size distributions were not significant to risk (Schlueter, 2003). The influence of risk insights on the evolution of many other uncertainties can also be determined by consideration of the information in NRC (2005).

- The NRC staff recommends that the draft White Paper be revised to include a discussion of the significance of apparent disagreements or alternative interpretations. Based on the information presented in NRC (2004), use of relative risk significance would provide a transparent basis for evaluating the significance of areas of apparent disagreement or alternative views.

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