June 11, 2009

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC AND SAFETY LICENSING BOARDS

In the Matter of	)	
	)	Docket No. 63-001-HLW
U.S. DEPARTMENT OF ENERGY	)	
	)	ASLBP Nos. 09-876-HLW-CAB01
(High-Level Waste Repository)	)	09-877-HLW-CAB02
	)	09-878-HLW-CAB03

NRC STAFF ANSWER TO STATE OF NEVADA'S NEW CONTENTIONS BASED ON FINAL NRC RULE

INTRODUCTION

Pursuant to 10 C.F.R. § 2.309(h)(1) and Case Management Order #1 issued by the Construction Authorization Boards, the Staff of the U.S. Nuclear Regulatory Commission (Staff) hereby files its answer to the State of Nevada's New Contentions Based on Final NRC Rule (NEV New Contentions), filed May 12, 2009. *U.S. Dep't of Energy* (High Level Waste Repository) (Jan. 29, 2009) (unpublished order at 4). For the reasons set forth below, the Staff does not oppose the admission of NEV-SAFETY-202 in part, but opposes the admission of NEV-SAFETY-203.

BACKGROUND

On June 3, 2008, the Department of Energy (DOE) submitted the Yucca Mountain Repository License Application (LA) to the NRC, seeking authorization to construct a geologic repository at a geologic repository operations area at Yucca Mountain, Nevada, in accordance with the provisions of 10 C.F.R. Part 63. *See* Yucca Mountain; Notice of Receipt and Availability of Application, 73 Fed. Reg. 34,348 (June 17, 2008); Yucca Mountain; Notice of Receipt and Availability of Application; Correction, 73 Fed. Reg. 40,883 (July 16, 2008). In

September 2008, the Staff determined that the application contained sufficient information, pursuant to 10 C.F.R. Part 2 and Part 63, to begin its detailed technical review and docketed the application. Department of Energy; Notice of Acceptance for Docketing of a License Application for Authority to Construct a Geologic Repository at a Geologic Repository Operations Area at Yucca Mountain, 73 Fed. Reg. 53,284 (Sept. 15, 2008). On October 17, 2008, the Commission issued a "Notice of Hearing and Opportunity to Petition for Leave to Intervene." *U.S. Dept' of Energy* (High-Level Waste Repository), CLI-08-25, 68 NRC __ slip op. (Oct. 17, 2008). The Notice of Hearing was subsequently published in the *Federal Register* on October 22, 2008. In the Matter of U.S. Department of Energy (High-Level Waste Repository); Notice of Hearing and Opportunity To Petition for Leave to Intervene on an Application for Authority To Construct a Geologic Repository at a Geologic Repository Operations Area at Yucca Mountain, 73 Fed. Reg. 63,029 (Oct. 22, 2008).

On December 19, 2008, the State of Nevada filed a petition for leave to intervene and request for hearing.[1] DOE filed an answer to the petition on January 16, 2009,[2] and the Staff filed its answer on February 9, 2009.[3] On February 24, 2009, Nevada filed timely replies to DOE and the Staff.[4]

Three licensing boards, referred to as the Construction Authorization Boards (CABs or Boards), were established to preside over the petitions to intervene and requests to participate

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[1] State of Nevada's Petition to Intervene as a Full Party, Dec. 19, 2008 (NEV Petition).

[2] Answer of the U.S. Department of Energy to the State of Nevada's Petition to Intervene (Jan. 16, 2009).

[3] NRC Staff Answer to Intervention Petitions (Feb. 9, 2009).

[4] State of Nevada's Reply to DOE's Answer to Nevada's Petition to Intervene as a Full Party, filed on Feb. 24, 2009; State of Nevada's Reply to NRC Staff's Answer to Nevada's Petition to Intervene as a Full Party, filed on Feb. 24, 2009.

in the high-level waste repository construction authorization application proceeding. Department of Energy; Establishment of Atomic Safety Licensing Boards, 74 Fed. Reg. 4477 (Jan. 26, 2009). The Commission's Notice of Hearing and the Boards' Case Management Order provided that contentions concerning EPA standards-related issues will be deemed timely if filed within 60 days after the NRC rules implementing the new EPA standards are published in the *Federal Register*. 73 Fed. Reg. at 63,032; Order at 4. The NRC published its final rule on March 13, 2009. Implementation of a Dose Standard After 10,000 Years, 74 Fed. Reg. 10,811 (Mar. 13, 2009). The Case Management Order established that answers shall be filed within 50 days after service of the contentions. Order at 4.

On May 12, 2009, Nevada filed two new contentions, NEV-SAFETY-202 and NEV-SAFETY-203. NEV-SAFETY-202 challenges DOE's treatment of climate change in the post-10,000 year period, and in the alternative, requests a waiver from the application of a Commission regulation, 10 C.F.R. § 63.342(c), pursuant to 10 C.F.R. § 2.335. NEV New Contentions at 2. NEV-SAFETY-203 also requests a waiver of the application of 10 C.F.R. § 63.342(c) as it relates to land surface erosion in the post-10,000 year period. *Id.* at 9. For the reasons discussed below, Nevada's rule waiver requests should be denied.

DISCUSSION

A. Legal Standards Governing Requests for Rule Waiver

Section 2.335 provides that unless a waiver or exception from a regulation has been granted, a party may not attack any Commission regulation in any adjudicatory proceeding under Part 2. 10 C.F.R. § 2.335(a). An attack on a Commission regulation is only permitted where a waiver is explicitly granted or an exception is made for a particular proceeding. 10 C.F.R. § 2.335(a),(b). The regulation specifies that "[t]he sole ground for petition of waiver or exception is that special circumstances with respect to the subject matter of the particular proceeding are such that the application of the rule or regulation . . . would not serve the

purposes for which the rule or regulation was adopted." 10 C.F.R. § 2.335(b). The Commission requires that any request for such waiver or exception "be accompanied by an affidavit that identifies . . . the subject matter of the proceeding as to which application of the rule or regulation . . . would not serve the purposes for which the rule or regulation was adopted." *Id.* Additionally, "[t]he affidavit must state with particularity the special circumstances alleged to justify the waiver or exception requested." *Id.* Other parties may file responses, including counter affidavits, to the waiver request. *Id.*

Further, if after considering the petition, affidavits, and any responses, the presiding officer finds that the *prima facie* requirement in section 2.335(b) is satisfied, prior to ruling on the petition, the waiver request issue must be certified directly to the Commission for determination. 10 C.F.R. § 2.335(d).

B. NEV Proffered Contentions

In its answer to Nevada's petition, the Staff addressed contention admissibility requirements generally and will not repeat them here. *See* Staff Answer at 34-39. The Staff's discussion of Nevada's two new contentions, NEV-SAFETY-202 and NEV-SAFETY-203, is below.

NEV-SAFETY-202 – CONTINUATION OF CLIMATE CHANGE FEPS

> As provided in SAR Subsections 2.2.1.2 and 2.3.1.1, and as reflected in related SAR subsections, climate-change processes included as FEPs in the TSPA for the first 10,000 years are neither carried forward for the next 990,000 years, as the rule requires, nor represented by NRC's specified deep percolation rate for that subsequent period.
>
> If the climate change processes addressed by this contention are not included as FEPs for the first 10,000 years, and not taken into account beyond 10,000 years for that reason, or if the climate change processes addressed by this contention are included as FEPs for the first 10,000 years, but 10 C.F.R. § 63.342 (c) is construed so that climate-change processes included as FEPs in the TSPA for the first 10,000 years are not carried forward for the next 990,000 years, then there are special circumstances with respect to the subject matter of this proceeding such that application of 10 C.F.R. § 63.342(c), which places limits on features, events and processes to be considered in the post-10,000-year period, does not serve the purposes for which it was adopted, and this contention is a rule challenge under 10 C.F.R. § 2.335.

NEV New Contentions at 2. Nevada asserts that climate-change processes included as features, events, and processes (FEPs)[5] in the total systems performance assessment (TSPA) for the first 10,000 years are improperly excluded from the post-10,000 year analysis. *Id.* In addition, NEV-SAFETY-202 asserts that the climate-change processes included as FEPs in the TSPA for the first 10,000 years are not represented by NRC's specified deep percolation rate for the next 990,000 years. *Id.* Nevada argues in the alternative that, if DOE's interpretation of section 63.342(c) is correct and these climate change processes are not carried forward for the post-10,000 year period because of 10 C.F.R. § 63.342(c), then the rule does not serve the purposes for which it was adopted and, therefore, Nevada challenges the rule under 10 C.F.R.

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[5] Section 63.114(a)(4) directs DOE to consider only FEPs consistent with the limits on performance assessment specified at 10 C.F.R. § 63.342. 74 Fed. Reg. at 10,828.

§ 2.335. *Id.*

Staff Response

The Staff does not oppose admission of NEV-SAFETY-202 insofar as it alleges that "DOE's TSPA fails to include the deep percolation in NRC's final rule, which is different from the one NRC proposed."[6] *See id.* at 3.

To the extent that Nevada argues the rule requires DOE to carry forward the climate-change process FEPs into the post-10,000 year period, the Staff opposes the admissibility of the contention because it fails to raise a genuine dispute regarding the application under 10 C.F.R. § 2.309(f)(1)(vi). *See* NEV New Contentions at 2. Insofar as NEV-SAFETY-202 is a challenge to 10 C.F.R. § 63.342(c), the Staff opposes its admissibility because it constitutes a challenge to an existing regulation and does not meet the standards of 10 C.F.R. § 2.335(b).

10 C.F.R. § 2.309(f)(1)(vi): Genuine Dispute Regarding the Application

The petitioner bears the burden of demonstrating that its contention meets the admissibility standards. *See, e.g., Progress Energy Carolinas, Inc.* (Shearon Harris Nuclear Power Plant, Units 2 & 3), CLI-09-08, 69 NRC __ (May 18, 2009) (slip op. at 9). Pursuant to 10 C.F.R. § 2.309(f)(1)(vi), the contention must "provide *sufficient information to show* that a genuine dispute exists with the applicant/licensee on a material issue of law or fact." 10 C.F.R. § 2.309(f)(1)(vi) (emphasis added). Further, "if the petitioner believes that the application fails to contain information on a relevant matter as required by law, [the contention must include] the identification of each failure *and the supporting reasons for the petitioner's belief*." *Id.* (emphasis added).

[6] The Staff notes that, on May 7, 2009, it issued a request for additional information (RAI) asking DOE to address its compliance with the requirements of the final rule. *See* ADAMS Accession Nos. ML091270461 (LSN# NRC000030179), ML091270353 (LSN# NRC000030166). On June 5, 2009, DOE responded to this request. ADAMS Accession No. ML091590581.

In support of its contention, Nevada argues that 10 C.F.R. § 63.342 requires climate change FEPs included for the first 10,000 years to be carried through the next 990,000 years. NEV New Contentions at 5. However, contrary to section 2.309(f)(1)(vi), NEV-SAFETY-202 does not provide any explanation or supporting reasons for this assertion. It appears that Nevada misinterprets the rule. Section 63.342 provides the manner in which climate change should be addressed in the post-10,000 year period, and it does not require DOE to carry its FEP analysis for climate change for the first 10,000 year period through the subsequent 990,000 year period. The rule allows DOE to limit its analysis of climate change to the effects of increased water flow through the repository, which can be represented by using a constant-in-time value deep percolation rate based on a truncated lognormal distribution with an arithmetic mean of 41 mm/year and a standard deviation of 33 mm/year, resulting in deep percolation rates between 10 and 100 mm/year. 74 Fed. Reg. at 10,829-30 (to be codified at 10 C.F.R § 63.342(c)(2)).

When EPA proposed the standards for the period after 10,000 years, EPA intended to constrain the performance assessment by limiting the climate change analysis to a specific effect:

> To address climate change, we required DOE to focus on the effects of increased water flow through the repository, which is the climatic effect with the most influence on release and transport of radionuclides. We determined that such a focus would provide the basis for a reasonable test of the disposal system, and that climate change beyond 10,000 years could be represented by constant conditions reflecting precipitation levels that differ from current conditions, which eliminates unresolvable speculation regarding the timing, magnitude, and duration of climatic cycles over this time frame. We also directed that NRC establish the exact nature of future climate characteristics to be used in performance assessments.

Environmental Protection Agency, Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada, 73 Fed. Reg. 61,256, 61,261 (Oct. 15, 2008). In

adopting the final rule, the NRC intended to make its rules consistent with the EPA's standards for a geologic repository at Yucca Mountain. 74 Fed. Reg. at 10,813. As EPA intended to limit the climate change analysis in the post-10,000 year period, so did the NRC. *See id.* ("EPA's rule requires DOE to assess the effects of climate change in the period after 10,000 years. This assessment is limited to the effects of increased water flow through the repository."). Section 63.342(c)(2) establishes the specific manner in which DOE may represent climate change in its performance assessment. Thus, Nevada incorrectly interprets section 63.342.

In developing 10 C.F.R. § 63.342, the NRC considered various processes and effects related to climate change and concluded that the climate change analysis could be limited to the effects of increased water flow through the repository. *See id.* at 10,818-20, 10,829. Nevada argues that the rule requires consideration, in the post-10,000 year period, of any climate change FEPs that were included in the first 10,000 years. NEV New Contentions at 2. Nevada identifies three specific climate change FEPs that it believes should be continued in the performance assessment after 10,000 years. NEV New Contentions at 5. However, the deep percolation values specified by the rule incorporate the FEPs identified by Nevada: Climate Change (74 Fed. Reg. at 10,818-19), Climate Modification Increases Recharge (*id*. at 10,819-20), and Infiltration and Recharge (*id*. at 10,821-22). *See also* Attachment 1, Affidavit of Eugene Peters at ¶ 8. These deep percolation values also incorporate additional processes and effects related to climate change, such as net infiltration (74 Fed. Reg. at 10,819), anthropogenic influences (*id.*), including an increase in the number and intensity of storm events (*id.*), natural climate change (*id.* at 10,818), and temporal variability in climate conditions (*id*. at 10,818-19). Because the Commission chose a range of deep percolation values that already incorporates the climate change FEPs identified by Nevada, it would be unnecessary to require DOE to carry forward any climate change effects related to these FEPs from the initial 10,000 year period. As discussed below, the EPA and NRC rulemakings limited what DOE was

required to consider with respect to climate change FEPs to that described in 40 C.F.R. § 197.36(c) and 10 C.F.R. § 63.342(c) for the post-10,000 year period.

To the extent that NEV-SAFETY-202 argues that section 63.342(c) should be interpreted to require climate change FEPs used for the first 10,000 years be carried through the next 990,000 years, it should be rejected because it fails to provide sufficient information to establish a genuine dispute under 10 C.F.R. § 2.309(f)(1)(vi).

Nevada's Waiver Claim under 10 C.F.R. § 2.335

Section 2.335 provides in relevant part that, unless a waiver or exception from a regulation has been granted, a party may not attack any Commission regulation in any adjudicatory proceeding under Part 2. 10 C.F.R. § 2.335(a). This section also provides that the only ground for a waiver or exception is that "special circumstances with respect to the subject matter of the particular proceeding are such that the application of the rule or regulation (or a provision of it) would not serve the purposes for which the rule or regulation was adopted." 10 C.F.R. § 2.335(b). This same subsection requires that any such petition be accompanied by an affidavit that "state[s] with particularity the special circumstances alleged to justify the waiver or exception requested." *Id.*

In NEV-SAFETY-202, Nevada argues that, if section 63.342(c) is interpreted to limit the consideration of climate-change processes in the post 10,000 years, then Nevada is challenging the regulation under 10 C.F.R. § 2.335 because it does not serve the purposes for which it was adopted. NEV New Contentions at 2. Nevada claims that special circumstances exist, pursuant to 10 C.F.R. § 2.335(b). *Id.* at 6-7. Nevada states that because the Commission has not accounted for "the range of climatic conditions that could apply in the post-10,000-year period," section 63.342(c) should not be applied to this proceeding. *Id.* at 7. According to Nevada, waiver of the rule is justified because the specified deep percolation values do not adequately represent the effects of climate change in the post-10,000 year period. *See id.* Nevada claims

that its petition for a waiver is supported by the attached affidavits of Dr. Michael C. Thorne and Dr. Jonathan Overpeck. These same affidavits were originally attached to Nevada's December 19, 2008 Petition to Intervene. As discussed below, Nevada has not made a *prima facie* showing that the application of 10 C.F.R. § 63.342(c) would not serve the purposes for which the rule or regulation was adopted. Therefore, Nevada's petition for rule waiver should be denied, and NEV-SAFETY-202 (except as described above) should be rejected as an impermissible attack upon Commission regulations. *See* 10 C.F.R. § 2.335(a).

Nevada claims that application of section 63.342(c) will not serve the purpose for which it was adopted in this case because the regulation is not supported by recent advances in scientific knowledge, resulting in a performance assessment that does not contribute meaningfully to the Commission's safety findings. NEV New Contentions at 7. But a failure to consider more recent evidence, by itself, does not satisfy the high burden of section 2.335, and does not show that application of the rule would not serve the purpose for which it was adopted. In promulgating the final rule, the Commission noted that scientific progress is expected to continue. 74 Fed. Reg. at 10,823. The Commission stated "[t]he intention of the rule is to specify a reasonable basis for evaluating safety using current knowledge. Given the current approach for estimating deep percolation, it would take a *major shift in scientific understanding* for the deep percolation rates to change significantly." *Id.* (emphasis added). The Commission then provides the example that, even if there were a 100,000 year period with no rainfall at Yucca Mountain, it would have a limited effect on the average deep percolation rate for the million-year period, and dose estimates are not expected to change significantly. *Id.* at 10,823-24. Thus, Nevada must do more than simply assert that there is new evidence not considered at the time of the rulemaking; Nevada must demonstrate that "future scientific advances show the regulation is no longer sufficiently protective of public health and safety and the environment." *Id.* at 10,824.

As an initial matter, Nevada does not point to any specific new evidence, but suggests that studies similar to ones being performed in Europe need to be done for Yucca Mountain to determine the range of climatic conditions that could apply in the post 10,000 year period. *See* NEV New Contentions at 6-7. However, the authors of the study cited by Nevada acknowledge that the application of their model to a performance assessment has limitations. Attachment 1, Affidavit of Eugene Peters at ¶ 9.[7] In addition, the NRC did consider many of the same factors as the authors of the study, in terms of orbital effects on climate and water balance. *Id.* Consequently, Nevada fails to demonstrate how this study demonstrates the regulation is no longer protective of public health and safety and the environment.

Moreover, in developing 10 C.F.R. § 63.342, the NRC considered various processes and effects related to climate change and concluded that the climate change analysis in DOE's performance assessment "'may be limited to the effects of increased water flow through the repository as a result of climate change, and the resulting transport and release of radionuclides to the accessible environment.'" Attachment 1, Affidavit of Eugene Peters at ¶ 5 (quoting 74 Fed. Reg. at 10,829). Nevada asserts that the specified deep percolation values used to represent this increased water flow are not based on recent scientific understanding because neither the DOE nor NRC used a regional- or global-scale circulation model to predict climate conditions in the vicinity of Yucca Mountain, and did not consider "complex, changing interactions between insolation changes driven by orbital characteristics…, natural variations…and slow reduction in greenhouse-gas concentrations…, and internal variability

[7] The affidavits included in the Staff's response are included only to respond to Nevada's challenges to an NRC regulation, pursuant to 10 C.F.R. § 2.335(b). This Staff is not here, nor in the attached affidavits, addressing the merits of Nevada's proffered contentions beyond the content of their rule challenge petition.

within the climate system at sub-orbital timescales." NEV New Contentions at 6. However, the NRC did consider these factors, among others, in developing the range of deep percolation values specified in the final rule. Attachment 1, Affidavit of Eugene Peters at ¶¶ 10, 11. The Commission received comments on the proposed rule that were similar to the concerns raised in NEV-SAFETY-202. *See* 74 Fed. Reg. at 10,818-24; *see also* Attachment 1, Affidavit of Eugene Peters at ¶¶ 6, 7, 10, 11. The Commission considered and responded to these comments in the promulgation of the final rule; therefore, NEV-SAFETY-202 does not present special circumstances that warrant waiver or exception. *See id.* Because the NRC considered the factors raised in NEV-SAFETY-202 before promulgating the final rule, and because Nevada has not shown a "major shift in scientific understanding" that demonstrates the regulation to be insufficiently protective of public health and safety and the environment, Nevada fails to establish a *prima facie* showing that the application of the rule would not serve the purpose for which it was adopted.

Further, the affidavits Nevada provides are inadequate to make the *prima facie* showing required by 10 C.F.R. § 2.335(b). Section 2.335(d) requires that an affidavit to request a waiver from a regulation "must state with particularity the special circumstances alleged to justify the waiver or exception requested." "It is not . . . enough merely to allege the existence of special circumstances; such circumstances must be set forth with particularity. The petition should be supported by proof, in affidavit or other appropriate form, sufficient for the Licensing Board to determine whether the petitioning party has made a prima facie showing for waiver." *Carolina Power & Light Co.* (Shearon Harris Nuclear Power Plant, Units 1 & 2), LBP-82-119A, 16 NRC 2069, 2073 (1982). Here, the affidavits provided by Nevada make no mention of this

contention[8] or its waiver petition; nor do they articulate that special circumstances exist. The two referenced affidavits, dated December 8, 2008 (Thorne) and December 12, 2008 (Overpeck), were signed prior to the publication of the implicated regulation and Nevada's new contentions. Rather, as admitted by Nevada, these affidavits were prepared and submitted in support of its initial intervention petition. *See* NEV New Contentions at 7. Even if there is some factual overlap between NEV-SAFETY-202 and the contentions Nevada filed in December 2008, neither the affidavits nor the original contentions address the special circumstances justifying waiver of section 63.342(c).

Therefore, Nevada has not supported its waiver claim by affidavit, and has not made a *prima facie* showing that application of 10 C.F.R. § 63.342(c) would not serve the purpose for which it was adopted. Accordingly, Nevada's waiver request should be denied, and, to the extent NEV-SAFETY-202 challenges section 63.342(c), it should be rejected as an impermissible attack upon Commission regulations. *See* 10 C.F.R. § 2.335(a).

As discussed above, NEV-SAFETY-202 is admissible in part to the extent that it asserts that DOE's TSPA fails to include the deep percolation values specified in the NRC final rule. However, to the extent that NEV-SAFETY-202 alleges that 10 C.F.R. § 63.342 requires DOE to carry forward its climate change FEPs into the post-10,000 year period, it should be rejected because it fails to provide sufficient information to establish a genuine dispute under 10 C.F.R. § 2.309 (f)(1)(vi).

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[8] Attachments to the affidavits list the contentions adopted by the affiant. NEV-SAFETY-202 is not listed among those contentions adopted by either Dr. Thorne or Dr. Overpeck.

NEV-SAFETY-203 – EROSION FEP SCREENING AFTER 10,000 YEARS

> Even if DOE's exclusion of land-surface erosion (FEP 1.2.07.01.0A), as reflected in SAR Subsections 2.2.1.1 and 2.2.1.2 and similar subsections, were correct for the first 10,000 years (but see NEV-SAFETY-41), land surface corrosion [sic] cannot be excluded from the TSPA in the period between 10,000 years and 1,000,000 years because topography modifications will continue to the point that topography is grossly altered. Within this latter period, portions of the Paintbrush Tuff may become completely eroded, with significant affects on infiltration and seepage, and the emplacement drifts may be exposed to the earth's surface, eliminating the upper geologic barrier entirely, with the result that doses to the RMEI will be increased significantly. Therefore, there are special circumstances with respect to the subject matter of this proceeding such that application of 10 C.F.R. § 63.342(c), which places limits on features, events and processes to be considered in the post-10,000-year period, does not serve the purposes for which it was adopted. This is a rule challenge under 10 C.F.R. § 2.335.

NEV New Contentions at 9. NEV-SAFETY-203 challenges 10 C.F.R. § 63.342(c) pursuant to 10 C.F.R. § 2.335. *Id.* Nevada argues that special circumstances exist such that the section 63.342(c) limits on features, events, and processes to be considered in the post-10,000 year period do not serve the purposes for which the rule was adopted. *Id.* Nevada asserts that land surface erosion during the post-10,000 year period can grossly alter the topography and may completely erode portions of the Paintbrush Tuff thereby eliminating the upper geologic barrier and increasing doses to the reasonably maximally exposed individual. *Id.*

Staff Response

The Staff opposes the admission of NEV-SAFETY-203 because it is a direct attack upon an NRC regulation, and it fails to meet the standards of 10 C.F.R. § 2.335(b).

Nevada's Waiver Claim under 10 C.F.R. § 2.335

Section 2.335 provides in relevant part that, unless a waiver or exception from a regulation has been granted, a party may not attack any Commission regulation in any adjudicatory proceeding under Part 2. 10 C.F.R. § 2.335(a). As indicated earlier, this section

also provides that the only ground for a waiver or exception is that "special circumstances with respect to the subject matter of the particular proceeding are such that the application of the rule or regulation (or a provision of it) would not serve the purposes for which the rule or regulation was adopted." 10 C.F.R. § 2.335(b). This same subsection requires that any such petition be accompanied by an affidavit that "state[s] with particularity the special circumstances alleged to justify the waiver or exception requested." *Id.*; *see also Shearon Harris*, LBP-82-119A, 16 NRC at 2073.

Nevada argues that the Commission in its rulemaking neglected evidence that erosion will "affect (1) the infiltration flux by changing the surface morphology and soil thickness, (2) the seepage and operation of the postulated natural barrier systems . . ., and (3) the emplacement drifts may be exposed at the Earth's surface in 500,000 years." NEV New Contentions at 13. Nevada claims that its petition for a rule waiver is supported by the affidavits of Dr. Michael C. Thorne and Dr. Stephan K. Matthai that were provided in support of Nevada's Petition to Intervene. Those affidavits are dated December 8, 2008 and December 15, 2008, respectively. As discussed below, Nevada has not made a *prima facie* showing that the application of 10 C.F.R. § 63.342(c) would not serve the purposes for which the rule was adopted. Therefore, Nevada's petition for waiver should be denied, and NEV-SAFETY-203 should be rejected as an impermissible attack upon Commission regulations. *See* 10 C.F.R. § 2.335(a).

Nevada claims there is new scientific evidence to support its rule challenge. NEV New Contentions at 10-11. Nevada cites two articles in support of its position that debris flows at Yucca Mountain after thunderstorms in 1984 and 2003 removed more material than suggested by the studies upon which DOE relied. *Id.* at 11 (citing Coe, J.A., Glancy, P.A., Whitney, J.W. (1997) "Volumetric Analysis and Hydrologic Characterization of a Modern Debris Flow Near Yucca Mountain, Nevada" GEOMORPHOLOGY, Vol. 20 at 11-28; and Syed, K.H., Goodrich, D.C., Myers, D.E., and Sorooshiah, S. (2003) "Spatial Characteristics of Thunderstorm Rainfall Fields

and Their Relation to Runoff," JOURNAL OF HYDROLOGY, Vol. 271, Issue 1-4). However, these studies were published in 1997 and 2003 and are not new evidence, and as discussed below, the NRC was aware of the information at the time of the rulemaking. *See* Attachment 2, Affidavit of Brittain Hill, Philip Justus, and Timothy McCartin (Affidavit of NRC Staff) at ¶¶ 12, 14.

When the rule was proposed and finalized, the NRC was aware of the process of erosion and the information Nevada cited relating to debris flows after thunderstorms in 1984 and 2003 (*see* NEV New Contentions at 11). Attachment 2, Affidavit of NRC Staff at ¶¶ 17,18. However, the NRC did not believe it was necessary to include erosion as a process with significance that called for special treatment such as the EPA and NRC did for other processes. *Id.* With respect to the Stuewe et al. model, "it does not represent a scientific advance in the understanding of erosion at the Yucca Mountain." *Id.* at ¶ 18. Moreover, even if these studies were new, Nevada fails to show how erosion observed during these short-term events has special significance to the average erosion rates during the 10,000 year period used by DOE to exclude land-surface erosion. *Id.* at ¶¶ 14, 16. The purpose of the regulation is to provide an approach for considering features, events, and processes that provide a reasonable test for repository performance over the one million year period. *See id.* at ¶ 18 (citing Environmental Protection Agency, Public Health and Environmental Radiation Protection Standards for Yucca Mountain, NV, 70 Fed. Reg. 49,014, 49,048 (proposed Aug. 22, 2005). Nothing in NEV-SAFETY-203 demonstrates that its application would have any other effect.

Nevada also cites a study that was not published when NEV-SAFETY-203 was drafted, but has since been published. NEV New Contentions at 11 (citing Stuewe, K., Robi, J. and Matthai, S. (2008) "Erosional Decay of the Yucca Mountain Crest," GEOMORPHOLOGY (in press), LSN# NEV000005187)). The version of the study cited in NEV-SAFETY-203 does not contain a discussion of a critical limitation of this model, but such discussion is present in the published version of the study. Attachment 2, Affidavit of NRC Staff at ¶ 15. As the Staff's affidavit more

fully explains, the model described in the paper on which Nevada relies to justify its rule challenge " 'may break down for catchments smaller than about 5 km^2 in size…and that smaller gullies may therefore not be well described by our model.' " *Id.* (citing Stüwe et al. 2009 at 207). These smaller catchments and gullies are the types of catchments and gullies found at Yucca Mountain. *Id*. Because of the significant limitations this model has, especially as it relates to the conditions actually found at Yucca Mountain, it does not establish special circumstances that justify Nevada's request to waive section 63.342. *Id.*

In support of its waiver request, Nevada refers to the affidavits of Dr. Michael C. Thorne and Dr. Stephan K. Matthai that were provided in support of Nevada's Petition to Intervene and dated December 8, 2008 and December 15, 2008, respectively. However, these affidavits are not supportive of Nevada's petition for waiver.[9] Section 2.335(b) requires a petition for waiver to be accompanied by an affidavit that sets forth "with particularity the special circumstances alleged to justify the waiver or exception requested." 10 C.F.R. § 2.335(b). Even if there is some factual overlap between NEV-SAFETY-203 and the contentions Nevada filed in December 2008, neither the affidavits nor the original contentions address the special circumstances justifying waiver of section 63.342(c). The Staff notes that NEV-SAFETY-41 states that "current rates of erosion and the long-term effects of erosion both demonstrate that the ongoing erosion process will be of significance to safety assessment both in the period before 10,000 years and in the longer term." NEV Petition at 241. However, the proposed rule was available at the time Nevada's initial petition was filed, and the proposed rule also limited consideration of FEPs in the post-10,000 year period. Implementation of a Dose Standard After

[9] Attachments to the affidavits list the contentions adopted by the affiant. NEV-SAFETY-203 is not listed among those contentions adopted by either Dr. Thorne or Dr. Matthai.

10,000 Years, 70 Fed. Reg. 53,313 (proposed Sept. 8, 2005). But, NEV-SAFETY-41 did not assert that the proposed rule did not adequately provide for a performance assessment that would be a reasonable test of repository performance over the period of geologic stability. Therefore, the affidavits used to support NEV-SAFETY-41 cannot be interpreted, today, as setting forth "with particularity the special circumstances alleged to justify the waiver." 10 C.F.R. § 2.335(b). Nevada has not supported its petition for waiver by affidavit, as required, and has not made a *prima facie* showing that application of 10 C.F.R. § 63.342(c) would not serve the purpose for which it was adopted. Accordingly, NEV-SAFETY-203 should be rejected as an impermissible attack upon Commission regulations. *See* 10 C.F.R. § 2.335(a).

CONCLUSION

For the reasons set forth above, NEV-SAFETY-202 should be admitted to the extent it alleges that DOE's TSPA fails to include the deep percolation values specified in the NRC final rule. However, NEV-SAFETY-202 should be rejected insofar as it argues that 10 C.F.R. § 63.342 requires DOE to carry forward its climate change FEPs into the post-10,000 year period and insofar as it challenges that rule under 10 C.F.R. § 2.335. The Boards should deny Nevada's petition for waiver of the Commission rule and reject NEV-SAFETY-203.

/Signed (electronically) by/
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Counsel for NRC Staff
U.S. Nuclear Regulatory Commission
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alc1@nrc.gov

/Executed in accord with 10 C.F.R. § 2.304(d)/
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ATTACHMENT 1

AFFIDAVIT OF EUGENE PETERS

June 11, 2009

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC AND SAFETY LICENSING BOARDS

In the Matter of	)	
	)	Docket No. 63-001-HLW
U.S. DEPARTMENT OF ENERGY	)	
	)	ASLBP Nos. 09-876-HLW-CAB01
(High-Level Waste Repository)	)	09-877-HLW-CAB02
	)	09-878-HLW-CAB03

AFFIDAVIT OF EUGENE PETERS, M.S., P.G., C.E.M.
CONCERNING NRC STAFF'S RESPONSE TO NEV-SAFETY-202

This affidavit is provided in response to Nevada's challenge to an NRC regulation. I, Eugene Peters, do hereby state as follows:

Introduction

1. I am employed as Chief, Repository Site Branch, Division of High Level Waste Repository Safety, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission. In this capacity, I am responsible for evaluation of post-closure high level radioactive waste repository performance in the areas of engineered barrier degradation, unsaturated and saturated water flow, radionuclide transport, and disruptive geologic events.

2. I have approximately 18 years experience in broad areas of geosciences and environmental engineering. I contributed to the development of the Final Rule at 10 C.F.R. 63 in the areas of climate change, infiltration, and groundwater flow.

3. I have a Bachelor of Arts Degree, with Distinction, in Geological Sciences from the University of Rochester, a Master of Science degree in Environmental Science and Engineering from Johns Hopkins University, and have been admitted to PhD candidacy in geology at the George Washington University. I am also licensed as a Professional Geologist in the State of Tennessee and am a Certified Environmental Manager by the State of Nevada.

4. My curriculum vita is Attachment A to this affidavit.

5. In developing 10 C.F.R. § 63.342, the NRC considered various processes and

effects related to climate change in the post-10,000 year period and concluded that "[t]he climate change analysis may be limited to the effects of increased water flow through the repository as a result of climate change, and the resulting transport and release of radionuclides to the accessible environment." Implementation of a Dose Standard After 10,000 Years, 74 Fed. Reg. 10,811, 10,829 (Mar. 13, 2009). The deep percolation values specified by rule in 10 C.F.R. § 63.342(c)(2) incorporate the effects of both anthropogenic and natural climate change – and, as a result of those effects, increase the amount of water reaching the repository horizon relative to the preceding 10,000 years. The DOE performance assessment is required to consider the effects of increased water flow through the repository from climate change pursuant to 10 C.F.R. § 63.342(c)(2).

Incorporation of climate change effects:

6. Regarding anthropogenic climate change, the NRC stated that:

> NRC considered the effects of anthropogenic influences on climate change. Based on that evaluation, the NRC believes the range of values specified for deep percolation rates adopted in the final rule captures the range of temporal variability, uncertainty, and magnitude of deep percolation expected as a consequence of future climate change. The magnitude and timing of the anthropogenic effects…are likely to be more pronounced during the first 10,000 years. The final regulation addresses… the 10,000 to 1 million year time period, during which any anthropogenic effects are anticipated to diminish. Anthropogenic effects…might persist for 100,000-year time periods, but do not fluctuate periodically and decrease with time after an initial peak. Therefore, NRC believes that these effects can be captured by the long-term average infiltration values adopted in the final regulation because the range of values for the sampled population bounds these effects in an appropriately conservative manner.

74 Fed. Reg. at 10,819.

7. Regarding natural climate change, the NRC stated that:

> The Commission believes the future climatic regime can be bounded by the observed range of conditions over past glacial-interglacial cycles. All climate predictions are based on and calibrated to evidence of past climates contained in the geologic record. The values specified for deep percolation rates adopted in

> the final regulation capture the range of temporal variability, uncertainty, and magnitude of deep percolation expected as a consequence of future climate change….The NAS (1995) indicated there is a reasonable data base from which to infer past changes and noted that ‘‘(a)lthough the range of climatic conditions has been wide, paleoclimate research shows that the bounding conditions, the envelope encompassing the total climatic range, have been fairly stable’’ and that ‘‘(b)ased on this record, it seems plausible that the climate will fluctuate between glacial and interglacial stages during the period suggested for the performance assessment calculations.’’ Further, in its 1995 findings, the NAS stated that ‘‘enough of the important aspects [of climate change] can be known within reasonable limits of uncertainty, and these properties and processes are sufficiently understood and stable over the long time scales of interest to make calculations possible.

Id. at 10,818.

8. In summary, DOE is required to include the effects of climate change-related FEPs. In accordance with 10 C.F.R. § 63.342(c), DOE may limit its analyses to the effects of increased water flow. This is because relevant climate change processes, including those identified in the FEPs cited in NEV-SAFETY-202, were considered by the NRC in development of the Final Rule deep percolation values (74 Fed. Reg. 10,811-30).

Nevada's claim that NRC values do not include "recent scientific understanding:"

9. Nevada asserts, in its challenge to the NRC's Final Rule (74 Fed. Reg. 10,811-30), that the specified deep percolation values are not based on recent scientific understanding because neither the DOE nor NRC used a regional- or global-scale circulation model to predict climate conditions in the vicinity of Yucca Mountain, and did not consider "complex, changing interactions between insolation changes driven by orbital characteristics…, natural variations…and slow reduction in greenhouse-gas concentrations…, and internal variability within the climate system at sub-orbital timescales." NEV New Contentions at 6. In fact, the NRC did consider these factors, and more, in developing the range of deep percolation values specified in its 2009 Final Rule. Nevada cites a European study (BIOCLIM 2004; NEV New

Contentions at 6) as an example for using regional- or global-scale circulation models to predict climate conditions in radioactive waste disposal performance assessment (PA). The authors of the BIOCLIM study acknowledge both the subjective judgment for including such a model in a PA ("…the first question to be addressed is whether biosphere system change has to be considered;" BIOCLIM 2004 at 25) as well as the considerable "cascade of uncertainty" (BIOCLIM, 2004 at 38) entailed in such an endeavor. Therefore, the authors acknowledge that the application of their model to a performance assessment has limitations. As stated above, the NRC did consider many of the same factors as the authors of the BIOCLIM study, in terms of orbital effects on climate and water balance. The NRC 2009 Final Rule incorporates reasonably conservative assumptions about and analyses of many factors and uncertainty related to climate change effects.

10. In the development of the Final Rule, the Commission addressed and discussed in detail in the Statement of Considerations (SOC) the concerns raised by Nevada in NEV-SAFETY-202. *See* 74 Fed. Reg. 10,811-26. Specifically, the constant-in-time deep percolation values specified in the Final Rule adequately capture temporally variant conditions associated with orbital and sub-orbital timescales. During the development of the regulations, the NRC evaluated implications of temporal variations in climate scenarios (i.e., variation cycle of 100,000 years) and found a small effect on overall dose estimates compared with the approach finalized in the regulations (i.e., generally wetter conditions are assumed over to be constant over the entire million year period with a minimal effect on dose). The NRC summarized as follows:

> Specifically, simulations done by the NRC using its performance assessment code (TPA Version 4.1j) exhibited similar repository performance, in terms of dose, under constant and non-constant climate scenarios (''Regulatory Perspective on Implementation of a Dose Standard for a One-Million Year Compliance Period,'' T. McCartin, Proceedings of the 2006 Materials Research Society Fall Meeting, Volume 985 from the Materials Research Society Proceedings Series). In these simulations, the non-constant climate scenarios were developed using cyclic variations caused

> by orbital parameters. Also, the constant climate scenarios used deep percolation values specified in NRC's proposed regulations.

Id. at 10,820. In addition, the Commission noted that it

> believes the future climatic regime can be bounded by the observed range of conditions over past glacial-interglacial cycles. All climate predictions are based on and calibrated to evidence of past climates contained in the geologic record. The values specified for deep percolation rates adopted in the final regulation capture the range of temporal variability, uncertainty, and magnitude of deep percolation expected as a consequence of future climate change….

Id. at 10,818. Further, the Commission stated

> Anthropogenic effects, as represented in…GCMs…, might persist for 100,000 year time periodically and they decrease with time after an initial peak. Therefore, NRC believes that these effects can be captured by the long-term average infiltration values adopted in the final regulation because the range of values for the sampled population bounds these effects in an appropriately conservative manner. Atmospheric reorganization and increased frequency and magnitude of extreme events might result from natural or anthropogenic climate change. However, extreme 10-to 20-year events effectively become long-term averages that are incorporated into the range specified for deep percolation in the final regulation, when simulating a time period of 1 million years. The Paintbrush non-welded tuff unit (PTn unit) overlying the potential repository dampens the effects of transient phenomena associated with shorter time frames (Manepally, C., et al., ''The Nature of Flow in the Faulted and Fractured Paintbrush Non-welded Hydrogeologic Unit,'' San Antonio, TX: Center for Nuclear Waste Regulatory Analyses, April 2007) in the system's response to external hydrologic events. The [National Academy of Sciences] also recognized that long-term net infiltration averages can bound and describe Yucca Mountain hydrology adequately, stating that ''the subsurface location of the repository would provide a temporal filter for climate change effects on hydrologic processes.'' …Cohen [2005 observed that], ''no evidence shows that high-frequency fluctuations (a few years or shorter) penetrate to the depth of the potential repository'' (Cohen, S., ''Assumptions, Conservatisms, and Uncertainties in Yucca Mountain Performance Assessments,'' S. Cohen & Associates, prepared for U.S. Environmental Protection Agency, August 8, 2005). Flow simulations have shown that the non-welded PTn rock unit effectively damps out decadal flow transients. Also, …'frequent events' are mitigated by evapotranspiration. If high-precipitation events occur more frequently, the concomitant increases in soil formation and vegetation likely will mitigate the potential for increased infiltration, because net infiltration correlates inversely with soil thickness and extent of vegetative cover. Given the

> expected ratios of infiltration to precipitation, infiltration estimates of 15 to 60 mm (0.6 to 2.4 in.) per event would result if all precipitation were to infiltrate. In reality, a substantial fraction of such high precipitation will run off or evapotranspire. Accordingly, long-term deep percolation as specified in the proposed rule captures these events in an appropriately conservative manner.…The natural and anthropogenic effects associated with climate change are uncertain at this [Yucca Mountain regional] scale. Predictions will vary in timing, frequency, and magnitude of climatic variables such as temperature and precipitation, and therefore, net infiltration and deep percolation. …Cohen (2005) also notes that ''(a)nthropogenic climate changes could reduce possibility of future glacial climates, lowering long-term infiltration rates and reducing dose.'' In conclusion, the range of uncertainty and variability in predictions of future climate, including that associated with anthropogenic changes, and the resulting deep percolation are captured by the range of values specified in the final regulation.

Id. at 10,819.

11. These excerpts from the Final Rule SOC illustrate NRC's in-depth consideration of future climate change processes due to anthropogenic effects and natural variability. The NRC did consider changes in orbital characteristics, climate forcing functions, and present-day anthropogenic contributions of greenhouse gas emissions, based on current scientific understanding and adopted reasonably conservative approaches in specifying deep percolation values at the proposed repository horizon. Therefore, Nevada's assertion that NRC did not consider "recent scientific understanding" is not correct.

12. I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge, information and belief.

/RA/

_____

Eugene Peters

Executed in Rockville, MD
this 11th day of June, 2009

ATTACHMENT A

CURRICULUM VITA OF EUGENE PETERS

Curriculum Vita
Eugene M. Peters

U.S. Nuclear Regulatory Commission
Mail Stop E-2B2
Washington, D.C.

Chief, Repository Site Branch, Division of High Level Radioactive Waste Repository Safety (2008-Present)

- Member NRC Groundwater Technical Advisory Group
- Responsible for evaluation of DOE License Application with respect to high level radioactive waste repository post-closure performance in the areas of engineered barrier degradation, unsaturated and saturated water flow, radionuclide transport, and disruptive geologic events.
- Supervise up to 10 direct-report and 40 indirect-report NRC and contractor staff

Chief, Performance Assessment Branch, Division of High Level Radioactive Waste Repository Safety (2007-2008)

- Member NRC Groundwater Technical Advisory Group
- Responsible for preparing for evaluation DOE License Application with respect to performance assessment and overall compliance.
- Responsible for development of code TPA 5.1b

Hydrogeologist, Repository Site Branch, Division of High Level Radioactive Waste Repository Safety (2005-2007)

- Member NRC Groundwater Technical Advisory Group
- Technical lead for portions of the proposed geologic repository for high-level waste radioactive waste at Yucca Mountain, Nevada, including Climate and Infiltration and alternate technical lead for teams addressing diverse technical issues such as Saturated Zone Flow, Unsaturated Zone Radionuclide Transport, and Quantity and Chemistry of Water Reaching Waste Packages.
- As hydrogeologist in Repository Site Branch, responsible program element manager for portions of TPA code related to Climate and Infiltration and supporting process models. Responsible for ensuring NRC and CNWRA staff are familiar with structure of DOE TSPA and supporting process-level models.

- Review DOE publications, analyses, computer models, etc., related to effects of climate change on natural systems and infiltration of water into subsurface environment at Yucca Mountain.
- Independently assess effects of climate change and various infiltration scenarios as alternative conceptual models; assess risk significance of climate change and magnitude/timing of infiltrating water to Yucca Mountain system performance and dose.
- Project Officer for CNWRA efforts related to Climate and Infiltration
- Liaise with developers of U.S. NRC Total System Performance Assessment (TPA v. 5.1) code with respect to physical processes and parameter values used for Climate and Infiltration.
- Support QA activities in general and specifically to Climate and Infiltration topics.
- Maintain awareness of current research and developments related to Climate and Infiltration.

- Technical analyst for a former uranium recovery facility. Analyzed hydrologic and geochemical data to determine if conclusions reached and decisions made or recommended by licensee and Agreement State (Colorado) were technically well-founded and supportable.

- Technical review of fuel cycle sites' groundwater and geochemical data to determine if licensee was in compliance with plans and license requirements. Technical review required Requests for Additional Information to explain significant gaps in the groundwater flow and contaminant transport models and inadequate technical bases.

Senior Consultant, CH_2M Hill (2003-2005)

- Corporate director for characterization technologies

- Designated corporate subject matter expert for contaminated site management and remediation

- Senior consultant and technical reviewer for 10-year, $120 million contract with Navy. Responsible for technical oversight and final review of all deliverables at ten bases (Superfund and RCRA sites) in mid-Atlantic region. Includes all aspects of remedial investigation, interpretation of groundwater and contaminant data, human health and ecological risk assessment, feasibility studies, and remedial design under CERCLA and RCRA. Significant interaction with State and Federal regulatory agencies

- Expert witness for lawsuit involving contamination in estuarine system in New Jersey. Developed expert opinions on nature, extent , timing, and provenance of contamination.

- Indian Head Naval Surface Warfare Center: Senior consultant. Responsible for all technical work on extensive metals, inorganics, organic chemical, and explosives contamination at multiple sites across facility. Designed and oversaw investigations, feasibility studies and remediation system design. Conducted tidal influence study. Negotiated with State and Federal regulatory agencies.

- White Oak Naval Surface Warfare Center, Maryland: Senior consultant. Designed 21-well groundwater extraction system for RCRA/BRAC site in Maryland contaminated with organic chemicals. Conducted extensive aquifer testing program to minimize hydraulic interference

with remedies at adjacent sites and streams. Responsible for RFI and CMS development for soil and groundwater contamination by explosives, inorganic, and organic chemicals. Designed aquifer testing and geophysical investigation program at fractured bedrock site.

- Coordinated extensive and comprehensive review of hydrogeologic data at Washington Navy Yard Superfund site in Washington DC, including aquifer tests and slug tests on more than 120 wells, analyses of tidal effects on near-shore groundwater, and hydrologic data for Anacostia River.
- Manager and senior consultant for redevelopment of former phosphate fertilizer plant with radionuclide contamination in Virginia as propane peak-shaving plant. Managed all aspects of due diligence, including negotiations with seller and obtaining prospective purchaser status, removal actions, investigation, risk assessment, and participation in voluntary remediation program.
- Senior consultant for redevelopment of metals-contaminated site in Virginia as high-profile recreational facility. Responsible for technical oversight on all due diligence, investigation, risk assessment, remedial design, and cost allocation/recovery, and insurance documents. Prepared briefings for County management and political leadership.
- Dahlgren Naval Surface Warfare Center, Virginia: Resposible for investigation, corrective measures studies, and remediation of chromium-contaminated sites.

Senior Manager, ENVIRON International Corporation (1997-2003)

- Designed, implemented, and managed investigation in support of a human health risk assessment at a former 100-acre chemical/metallurgical plant effluent pond complex in Nevada intended for residential and governmental redevelopment. Significant interaction with NDEP over scope of work and findings.
- Served as expert witness in several cases regarding pollution conditions under secured creditor-impaired property insurance policies. Managed simultaneous investigations of pollution at portfolios of up to 60 sites under rigorous deadlines. Prepared claims packages on portfolios of up to 330 properties. Successfully defended claims on portfolio of 35 sites with 100% success rate. Actively defended claims on 700-site portfolio.
- Served as expert witness in cost recovery case under New York State navigation laws for soil and groundwater contamination at a major international airport. Developed opinions as to timing, source, and nature of release, regulatory oversight and requirements, and magnitude of damages.
- Developed expert witness report and opinions regarding estimation of future environmental liabilities at portfolios of sites including 51 manufactured gas plants, 11 fly-ash landfills, a 19,000-mile natural gas pipeline system with more than 330 compressor stations, 13 large-scale chemical plants, 4 coal mines, a shipyard, several hazardous waste disposal facilities, and several ore-processing and smelting plants, as part of insurance cost recovery claims.

- Prepared expert witness reports and cost allocation models for CERCLA cost recovery actions at a chrome-plating plant and at several manufactured gas plant, tar recovery plants, and coke battery sites for soil, groundwater, and sediment contamination. Developed extensive forensic database of gas-related waste management and manufacturing processes.
- Served as expert witness in two cases regarding chlorinated solvent transport and fate in ground water at sites in Texas. Developed opinions on NCP consistency, nature, extent, transport, and environmental fate of contamination, timing and causes of release, necessity of remediation, analysis of TNRCC requirements, and magnitude of damages.
- Provided litigation support in numerous toxic tort, property damage, and CERCLA cost allocation/recovery cases involving municipal well fields, a petroleum refinery, landfills, and regional groundwater contamination. Included historical regulatory analyses.
- Evaluated regautlary environmental and possible cleabnup standards for radionuclides in soil and groundwater at a phosphate mine tailings pile in Florida for litigation. Modeled residual radioactivity using RESRAD v. 5.8.2.
- Designed, implemented, and managed simultaneous, full-scale investigations at ten chemical manufacturing plants in the USA and Canada on behalf of a potential purchaser and provided technical assistance during negotiations. Entire project completed in less than 30 days and resulted in a greater than 10% purchase price adjustment in client's favor.
- Designed, implemented, and managed all aspects of investigation and remediation of nine chlorinated solvent sites using chemical oxidation, bioremediation, and conventional methods in seven states, including participation in voluntary cleanup and reimbursement fund programs in Virginia, Maryland, Tennessee, and North Carolina; managed remediation of a hydrocarbon chemical spill from a rail car at a Maryland chemical plant.
- Independent review and critique of complex density-dependent ground water flow and solute transport model for chlorinated solvents at a Puerto Rico Superfund site in karst terrain
- Conducted extensive critical review of ground water flow and contaminant transport models and assessing affects of varying input parameters and model construction for litigation purposes at an Arizona NPL Site, involving multiple property-damage and bodily-injury suits. Reviews used in successful summary judgment motions.
- Developed groundwater flow at contaminant transport models at numerous State and Federal Superfund sites.

Adjunct Faculty, George Washington University, Department of Earth Sciences (1999-2001)

- Taught lecture and lab courses in physical and historical geology

Director, Technical Programs & Senior Hydrogeologist, Clean Sites, Inc. (1994-1997)

- Led $2.0 million in grants from USEPA and Sandia National Lab to assist DOD and DOE NPL sites with innovative characterization and remedial technologies for contaminated groundwater. Served on technical advisory panels to assist Federal RPMs in remedy selection, design, implementation, and evaluation at DOD and DOE facilities in CA, MA, and FL. Provided technical assistance to DOE for treating uranium and nitrates in groundwater usng innovatiev rmedaition and characterization technologies at UMTRA site in Arizona; plutonium in soil at processing plants in Ohio.
- Served as member of binding arbitration panels for soil and groundwater contamination at chemical plant in New Jersey, a carbon black plant in Texas, and a municipal landfill in Michigan.
- Conducted senior-level independent technical peer review of all proposed ground water plume remedies and several soil remedies at Rocky Mountain Arsenal NPL Site.
- Provided technical assistance to citizen's group in understanding technical issues associated with radionuclide remediation and in responding to DOE's environmental impact statement for closure/cleanup of the West Valley Nuclear Services Center.
- Participated in high-profile, independent strategic-level review of DOD Environmental Management Program on behalf of the Deputy Undersecretary of Defense for Environmental Security.
- Provided final technical review of verification reports for signing parties (five major petrochemical companies) to an agreement with U.S. EPA and Indiana DEM to reduce migration of subsurface contaminants to the Calumet River.

Staff Geologist, General Physics Corporation (1991-1994)

- Led RI at Army Airfield to support prevention of listing as a NPL site. Participated in three other RIs as a field geologist, installing more than 250 monitoring wells and deep exploratory borings.
- Coordinated integrity testing of over 150 USTs and 5 miles of underground pipeline testing at Army and Navy facilities using non-volumetric and tracer methods, ground water extraction, air sparging/soil vapor extraction, and free product recovery systems.

U. S. Marine Corps (1987-1991; Reserve service until 1996)

EDUCATION:

Candidate	Ph.D.	Geology, George Washington University (University Research Fellow 1999-2000)
1996	M.S.	Environmental Engineering & Science, Johns Hopkins University
1987	B.A.	Geological Sciences, University of Rochester, with Distinction

PROFESSIONAL LICENSES

Professional Geologist, State of Tennessee (TN-2314)
Certified Environmental Manager, State of Nevada (EM-1768)

AWARDS

University Research Fellowship, George Washington University
Meridian Society, University of Rochester
Joseph C. Wilson Fellowship, University of Rochester
NROTC Midshipman Life Award, University of Rochester
USEPA Partner in Innovation Award

PROFESSIONAL MEMBERSHIPS AND ACTIVITIES

- Advisory Panel, Massachusetts Environmental Technology Center (1998-2000)
- Federal Advisory Committee to USEPA for Environmental Justice (1997-1998)
- National Ground Water Association Safety Committee (1997-2001)
- Technical Advisory Committee, Lake Michigan Federation (1996-1998)
- ACS, AGU, AGWSE, GSA, GSW, IAGC, IAMG, MCA

INVITED PRESENTATIONS

- Presentation to the USNRC Advisory Committee on Nuclear Waste (ACNW) on climate and infiltration studies
- State Voluntary Cleanup Programs – Environmental Issues for Energy Generation n the Non-Utility Sector Conference, sponsored by A&WMA, CIBO, IDEA, and USCHPA –2005
- U.S. Navy Remediation Innovation Technology Seminar Series – Presentation at Navy Engineering Regional Centers in Honolulu, Seattle, San Diego, Philadelphia, Charleston, Norfolk, and Washington DC. -- 2005
- U.S. EPA- U. S. Navy-Virginia DEQ Joint Installation Restoration Conference – 2004
- CH2M HILL Technology Exchanges: Presentations at to Northeast, Southeast, Northwest, Southwest, and Asia-Pacific Regions – 2004
- CH2M HILL – Site Characterization and Remediation Practice Seminars, Northeast Region -- 2003
- American Institute of Chemical Engineers - Center for Waste Reduction Technologies Annual Meeting, 1996
- DOE/HWAC Conference on Eliminating Barriers to Innovative Technologies Annual

Meeting, 1996 (Breakout Session Moderator)

- Federal Remedial Technologies Round Table Annual Meeting, 1996, 1997
- Massachusetts Environmental Technology Center Annual Meeting 1996
- Federal Remedial Technologies Development Forum Annual Meeting, 1995, 1996, 1997
- Western Governors Association - Interstate Regulatory Technology Cooperative Annual Meeting, 1997
- Public Workshop, Indiana Harbor Ship Canal Dredge and Confined Disposal Facility Project, Whiting, Indiana, 1996 – Invited panelist

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Peters, G. and E. Clark. 1996. Public-Private Partnerships, *Proceedings, 1996 World Environmental Congress*.

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Peters, G. Hydrogeologic Model of a Superfund Site Landfill using *Visual* Modflow and the HELP Model. (Master's Thesis, Johns Hopkins University)

Peters, G., and D. McClure. 1995. Effects of Large-Scale Hydraulic Control Measures for Landfills on Surrounding Groundwater Hydrology, *Proceedings, Focus on Eastern Regional Groundwater Issues Conference.*

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McNelly, G., E. Peters, D. Powell, D. Nehoda, E. Fitzpatrick, and M. Holland. 1994. Public-Private Partnerships to Stimulate Use of Innovative Hazardous Waste Site Technologies *Journal of Environmental Law and Practice*, October 1994.

ATTACHMENT 2

AFFIDAVIT OF BRITTAIN HILL, PHILIP JUSTUS, and TIMOTHY MCCARTIN

June 11, 2009

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC AND SAFETY LICENSING BOARDS

In the Matter of	)	
	)	Docket No. 63-001-HLW
U.S. DEPARTMENT OF ENERGY	)	
	)	ASLBP Nos. 09-876-HLW-CAB01
(High-Level Waste Repository)	)	09-877-HLW-CAB02
	)	09-878-HLW-CAB03

AFFIDAVIT OF BRITTAIN HILL, Ph.D., PHILIP JUSTUS, Ph.D., L.G., AND TIMOTHY MCCARTIN, CONCERNING NRC STAFF'S RESPONSE TO NEV-SAFETY-203

This affidavit is provided in response to Nevada's challenge to an NRC regulation. The initials of the individual(s) providing the statements in the paragraph are given in parentheses. We, Brittain Hill (BH), Philip Justus (PJ), and Timothy McCartin (TM), do hereby state as follows:

Introduction

1. (BH) I am employed as a Senior Advisor for Repository Science in the Division of High-Level Waste Repository Safety, Office of Nuclear Materials Safety and Safeguards at the U.S. Nuclear Regulatory Commission. I have over 25 years of professional experience in geological sciences. My experience includes conducting field and laboratory investigations of geologic phenomena, developing numerical models to help explain geologic processes, applying numerical models to evaluate geologic hazards, and using scientific information to support development of U.S. Nuclear Regulatory Commission policies and regulations. I hold a Bachelor of Arts in Geological Sciences from the University of California, Santa Barbara (1981), and a Master of Science (1984) and Doctor of Philosophy (1991) in Geology from Oregon State University

2. (BH) I provided technical support for the Staff's response to contention

NEV-SAFETY-203. In this regard, I reviewed the contention, the documents cited in the contention, and relevant portions of DOE's License application. With respect to contention NEV-SAFETY-203, I note that the contention argues DOE's basis for screening land-surface erosion (FEP 1.2.07.01.0A) uses average long-term erosion rates that (1) are inconsistent with erosion rates observed during two thunderstorms on or near Yucca Mountain and (2) are inconsistent with results from the numerical model in Stuewe et al. (2008).

3. (BH) My curriculum vita is Attachment A to this affidavit.

4. (PJ) I am employed as a Senior Geologist in the Division of High-Level Waste Repository Safety in the Office of Nuclear Material Safety and Safeguards at the U.S. Nuclear Regulatory Commission. In this capacity, I am responsible for the Staff's review of Yucca Mountain site characteristics, and alternative conceptual models of geologic, tectonic, hydrologic and environmental processes and conditions. I have approximately 29 years of experience in geology; primarily in high-level waste repository projects. I drafted acceptance criteria and license review guidance for seismotectonic, faulting and fracturing issues for the Yucca Mountain repository. This included compliance criteria for 10 C.F.R. Part 63. I hold a Bachelor of Science in Geology from the City College of City University of New York (1962), a Master of Science in Geology (1966) and a Doctor of Philosophy in Geology (1971) from the University of North Carolina, Chapel Hill. I have been a Licensed Geologist in Washington State since 2002.

5. (PJ) I provided technical support for the Staff's response to contention NEV-SAFETY-203. In this regard, I reviewed the contention, the documents cited in the contention, and relevant portions of DOE's License application.

6. (PJ) My résumé is Attachment B to this affidavit, and my list of publications is Attachment C.

7. (TM) I am employed as a Senior Level Advisor for Performance Assessment in

the Division of High Level Waste Repository Safety in the Office of Nuclear Materials Safety and Safeguards, U.S. Nuclear Regulatory Commission. In this capacity, I am responsible for ensuring the implementation of technically sound performance assessment approaches and concepts in the review of license applications of waste management facilities. I have approximately 28 years of experience in the development and implementation of approaches and concepts for conducting and evaluating performance assessments for geologic disposal of high level radioactive waste. I was the technical lead in the development of 10 C.F.R. Part 63, the regulatory criteria that govern a U.S. Department of Energy license application for a high level waste repository at Yucca Mountain. I was also the technical lead for NRC regulations governing high level waste disposal at Yucca Mountain for the period after 10,000 years (final regulations published March 13, 2009). I hold a Bachelor of Science in Physics from Xavier University (1973) and a Master of Science in Physics from Wayne State University (1976).

8. (TM) I provided technical support for the Staff's response to contention NEV-SAFETY-203. In this regard, I reviewed the contention, the documents cited in the contention, and relevant portions of DOE's License application. I also reviewed the contention's claims against the background, intent, statements of consideration and language of 10 C.F.R. Part 63.

9. (TM) My curriculum vita is Attachment D to this affidavit.

Geologic Perspective

10. (PJ) Yucca Mountain comprises a sequence of volcanic ash layers, deposited more than 11 million years ago. These layers were subsequently compacted, hardened into rock, uplifted by tectonic activity, and, throughout geologic time, subjected to erosion and deposition -- creating Yucca Mountain in its current state.

11. (PJ) Erosion and deposition continue today and will continue. Topographically high areas and slopes erode by the action of running water, wind, gravity, and man-induced

activities which collectively act to reduce higher elevations and fill, through deposition, lower elevation areas. Yucca Mountain is oriented approximately north-south and is cut by erosional gullies primarily on its east side. These gullies focus erosion on the side slopes of Yucca Mountain, transporting eroded material down to the base of the mountain, depositing it there, where it could be subsequently transported downgradient. Erosion and deposition also occur on the steeper west flank of Yucca Mountain, adjoining Crater Flat, but this steeper slope overlies very little of the proposed repository footprint, as designated by DOE.

12. (PJ) Surface processes, including erosion, at Yucca Mountain have been studied over the past 20 years using a variety of approaches. For example, studies were conducted to determine the rate at which ephemeral streams in the gullies on the Yucca Mountain east slope incise ground surface (BSC, 2004, Sections 3.3.7.5, para.2, p.3-44, para.5, p.3-45; 3.4.6, p.3-56). Studies were conducted to determine the erosion history of the hillslopes between the gullies. (BSC, 2004, Sections 3.2.2.1, pp.3-3 to 3-4; 3.3.7.5. p.3-44; 3.4.6, p.3-54; 3.4.6.2 and 3.4.6.3, pp.3-55-56). Studies of tectonic uplift rates (BSC, 2004, Sections 3.2.1.1, p.3-2; 4.3, paras. 2,3, pp.4-29-30; 4.3.2 thru 4.3.2.1, 4.3.2.2, pp.4-40-44) also provide information on the extent to which vertical displacement on the faults bounding Yucca Mountain and the adjacent valleys affect the stream gradients and local topographic relief. Climate change in the region over the geologic past and infiltration rates have been studied and provide insight on the amount of water available to cause erosion by gullying, overland flow and stream transport, by wind, and by freeze-thaw and snowmelt cycles, as well as rates of deposition and soil accumulation (BSC, 2004, Sections 3.4.6.3, pp.3-55 to 56; 3.4.2, pp. 3-46 to 47; 3.4.9, pp.3-59 to 60). Geological and geophysical studies conducted to understand the earthquake and volcanic history of the region, contributed to the understanding of rates of erosion and of burial (deposition) of faults and volcanoes as old as Yucca Mountain (BSC, 2004, Sections 3.4.6.5, pp.3-56 to 57; 4.3.2, pp.4-40 to 44; 4.3.2.4, pp.4-46 to 47; 4.3.3.4,, pp.4-56 to 57). Studies of

erosion rates of mountains in similar geological, tectonic and climatologic settings as Yucca Mountain - natural analogs - have been applied to Yucca Mountain erosion scenarios (BSC. 2004, Section 3.4.2, paras. 1,3, p. 3-56). Satellite imagery, digital terrain mapping, and computer technology has improved the accuracy and precision of detection of changes in surface elevations, stream bed gradients, hillslope retreat, volumetric measurements of debris, and migration of surface features such as stream courses (BSC, 2004, Section 3.4.6.4, p.3-56). NEV-SAFETY-203 does not introduce new data regarding erosion or deposition of surface materials or of rates of erosion or deposition of Yucca Mountain that are derived from measurements, samples of surface materials, field investigations of materials or processes, or monitoring erosion or deposition rates.

Reasonableness of Model and Erosion Rates

13. (BH) Nevada's technical basis for the special circumstances for challenging the application of section 2.335(b) hinges on two arguments (NEV New Contentions at 13): (1) DOE's long-term erosion rates are not consistent with observations during short-term erosion events, and (2) the presumed extent of erosion calculated with the numerical model in Stuewe et al. (2008) is greater than DOE's erosion estimates.

14. (BH) In the first argument, Nevada fails to present a reasoned basis as to how erosion observed during less-than-1-year-long thunderstorms in 1984 and 2003 (NEV New Contentions at 11) represents special significance to estimates of average long-term erosion rates. An average erosion rate based on the long-term recurrence of past events may include smaller intervals of time where erosion is either higher or lower than the average rate. However, Nevada has not presented any information to suggest that short-term erosion rates observed during rare thunderstorm events would recur frequently, such that these rates would be representative of thousands of years or longer. In addition, the short-term erosion observations cited by Nevada (NEV New Contentions at 11) were available for consideration

during the post-10,000 year rulemaking process and do not represent new scientific information.

15. (BH) Nevada's second argument presents the results of the numerical model in Stuewe et al. (2008) as evidence that erosion "will be of special significance to safety assessment in the long term, between 10,000 and 1,000,000 years" (NEV New Contentions at 13). A critical limitation of this model is not discussed in Stuewe et al. (2008, pp. 9-10), cited by Nevada, but is discussed in the published version of Stüwe et al. (2009, p. 207). The authors now note that "the stream power model may break down for catchments smaller than about 5 km^2 in size (e.g., Wobus et al., 2006) and that the smaller gullies may therefore not be well described by our model." Such "smaller gullies" are, in fact, the gullies that overlie the proposed repository footprint, which is approximately 5 km^2 in total size. Most individual gullies sloping eastward from Yucca Mountain crest are short and small with drainage basins around or less than 1 km^2, which is much less than the 5 km^2 threshold below which the stream power model is deemed to break down. In addition, the Stuewe et al. (2008) model depends on the relationship between stream power and erosion rate to calculate the formation of gullies. However, the authors state "there is not enough information on their time dependent evolution to constrain this relationship" (Stuewe et al. 2008, p. 4). To overcome this lack of information, the authors simply assume that erosion rate is proportional to the square of stream power (Stuewe et al. 2008, p. 5). No technical basis is provided to support why this proportionality, as opposed to one yielding lower erosion rates, is appropriate for representing the "not well described" smaller gullies on the 5 km^2 topographic footprint of the repository. These statements by the authors undermine the presumed reliability of this model in determining erosion rates on Yucca Mountain itself. Therefore, such an equivocal model does not constitute a showing of special circumstances such that the application of § 63.342(c) would not serve the purposes for which it was adopted.

16. (BH) Straightforward observations of erosion processes at Yucca Mountain call

into question the Stuewe et al. (2008) model results. The authors acknowledge that, at most, approximately 200 m of additional rock strata might have overlain Yucca Mountain (Stuewe et al. 2008, p. 8) prior to erosion beginning 11.6 Myr ago. Topographic maps show the maximum depth of gullies overlying Yucca Mountain is approximately 100 m. Thus, no more than 300 m of erosion occurred to create these gullies during the last 11.6 Myr, which gives an average erosion rate of approximately 26 m/Myr. However, in order to create 300 m of future erosion in the next 0.5 to 5 Myr (NEV New Contentions at 12), Nevada relies on a model that requires erosion rates of 1,000 to 10,000 m/Myr (i.e., 1 mm/yr; Stuewe et al. 2008, p. 5). Nevada has not presented a reasoned basis to explain how the same amount of erosion that took 11.6 Myr to develop in the past will somehow occur in less than one million years in the future. By way of example, I note that the approximately 1,800 m of vertical erosion that formed the Grand Canyon in Arizona is generally thought to have occurred over 5 to 6 Myr, giving an average erosion rate of 300—360 m/Myr. I also note that erosive features equivalent to the Colorado River have not formed on Yucca Mountain. Eroded features at Yucca Mountain show that the Stuewe et al. (2008) model relies on unsupportable assumptions that are inconsistent with current scientific understanding of erosion processes at Yucca Mountain, such as factors of 40-400 increase in observed erosion rates. As such, these model results do not constitute a showing of special circumstances such that the application of § 63.342(c) would not serve the purposes for which it was adopted.

Regulatory Perspective

17. (TM) In the final regulations for the period after 10,000 years, the Commission specified how certain events and processes were to be treated after 10,000 years up to the period of geologic stability (i.e., one million years) to provide a reasonable test of repository safety. As discussed above, the NRC was aware of the process of erosion and certainly the

observational information cited by Nevada (e.g., debris flows in 1984 and 2003) when the regulations were proposed and finalized, and did not consider it necessary to include erosion as a process with significance that called for special treatment such as that specified in the EPA standards and adopted in NRC regulations at 10 CFR Part 63.342(c) for other processes such as general corrosion.

18. (TM) As discussed above, the information in NEV-SAFETY-203 and the information underlying the Stuewe et al. (2008) model have been available for, in some cases, years if not decades. The development of a model, which the authors acknowledge uses questionable technical assumptions and relies on extraordinary erosion rates, does not represent a scientific advance in the understanding of erosion at the Yucca Mountain site. The intent of this portion of the regulations, which was adopted from the EPA standards, was clearly articulated by EPA in its standards. EPA explained that the goal of the performance assessment

> is to design an assessment that is a reasonable test of the disposal system under a range of conditions that represents the expected case, as well as relatively less likely (but not wholly speculative) scenarios with potentially significant consequences. The challenge is to define the parameters of the assessment so that they demonstrate whether or not the disposal system is resilient and safe in response to meaningful disruptions, while avoiding extremely speculative (and in some cases, fantastical) events.

Environmental Protection Agency, Public Health and Environmental Radiation Protection Standards for Yucca Mountain, NV, 70 Fed. Reg. 49,014, 49,048 (proposed Aug. 22, 2005).

References

19. (BH, PJ, TM) The following is a list of references cited in this affidavit.

BSC, 2004, Yucca Mountain Site Description: TDR-CRW-GS-000001 REV 02 ICN 01, 2 vols., Bechtel SAIC Company, Las Vegas, Nevada [ACC: DOC.20040504.0008], LSN# DN2002066045.

Stuewe, K., Robi, J. and Matthai, S., 2008, Erosional Decay of the Yucca Mountain Crest, *Geomorphology*, (in press), LSN# NEV000005187.

Stüwe, K., Robi, J. and Matthai, S., 2009, Erosional Decay of the Yucca Mountain Crest, *Geomorphology*, vol. 108, p 200-208. doi: 10.1016/j.geomorph.2009.01.008.

20. (BH, PJ, TM) We declare under penalty of perjury that the foregoing is true and correct to the best of our knowledge, information and belief.

/RA/

Brittain Hill, Ph.D

Executed in Rockville, MD
this 11th day of June, 2009

/RA/

Philip Justus, Ph.D, L.G.

Executed in Rockville, MD
this 11th day of June, 2009

/RA/

Timothy McCartin

Executed in Bethany Beach, DE
this 11th day of June, 2009

ATTACHMENT A

CURRICULUM VITA OF BRITTAIN HILL

Brittain Eames Hill, Ph.D.

U.S. Nuclear Regulatory Commission, MS EBB-02-02, Washington DC 20555-0001

EDUCATION

Ph.D. in Geology, Oregon State University, Corvallis, June 1991
M.S. in Geology, Oregon State University, Corvallis, June 1984
B.A. in Geological Sciences, University of California, Santa Barbara, June 1981

EMPLOYMENT

September, 2005–Present: Senior Technical Advisor for Repository Science, Office of Nuclear Materials Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington DC.

September 1997–July 2005: Principal Scientist (3/05–7/05); Senior Research Scientist (9/97–3/05), Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, Texas. Senior technical lead on volcanism and risk assessment for the U.S. Nuclear Regulatory Commission's high-level radioactive waste program.

September 1992–September 1997: Research Scientist, Center for Nuclear Waste Regulatory Analyses, Southwest Research Institute, Texas. Co-principal investigator on volcanism for the U.S. Nuclear Regulatory Commission's high-level radioactive waste program.

June 1990–July 1992: Geologist III, Oregon Department of Geology & Mineral Industries, Portland. Science coordinator and well-site geologist for a geothermal research drilling program in the Oregon Cascade Range.

March 1992–June 1992: Instructor, Oregon State University, Corvallis, Oregon. Taught an introductory engineering geology class to approximately 35 engineering students.

March 1986–June 1990: Independent Consultant for a variety of geothermal, precious metal, and petroleum resource companies.

September 1986–June 1991: Teaching Assistant, Oregon State University. Taught summer field camp (1988, 1989, 1991), mineralogy, lithology, and optical mineralogy labs and occasional lectures.

June 1984–December 1985: Assistant Geologist, UNOCAL Geothermal, California. Conducted geothermal research and exploration California, Nevada, and Utah, including field mapping, computer programming, drilling program management, and geochemical exploration techniques.

PROFESSIONAL SERVICE & MEMBERSHIPS

Expert Panel Member, Bristol University Risk Assessment Group, 2009-Present
Oregon State University, Board of Geoscience Advisors, 2006-Present
Consultant, International Atomic Energy Agency, 2006-Present
Elected Associate Member of Sigma Xi, the Scientific Research Society, 1989
Member of the International Association for Volcanology and Chemistry of the Earth's Interior
Member of the American Geophysical Union and the Geological Society of America
Co-chair, IAVCEI Working Group on Modeling Tephra Hazards, 2002–2005
Corresponding Member, International Volcanic Health Hazards Network, 2003–Present
Divisional Management Advisory Committee, Southwest Research Institute, 1994–1995
Institute Management Advisory Committee, Southwest Research Institute, 1995
Institute Services Committee, Southwest Research Institute, 2003–2005

MAJOR FIELD INVESTIGATIONS

Schell Creek Range, NV: 1980. Mapping of faulted Paleozoic sediments and Tertiary volcanics.
Bend Highlands, OR: 1982–84. Mapping and physical volcanology of Quaternary pyroclastic deposits.
Geysers Geothermal field, CA: 1983–85. Spring, soil, and soil-gas sampling, mapping Franciscan Fm.
Medicine Lake Highlands, CA: 1983–84. Soil-gas and spring sampling, mapping Quaternary volcanics.
Black Rock Volcanic Field, UT: 1984. Geothermal drilling, mapping and petrology of Quaternary basalt.
Sparks, NV: 1984. Geothermal wildcat drilling program.
Regional NV, CA, UT: 1984–85. Geothermal reconnaissance of springs, volcanics, field mapping.
Mist Oilfield, OR: 1986. Soil and vegetation surveys.
Three Sisters–Broken Top volcanoes, OR: 1986–90. Mapping, physical volcanology, petrology.
E. Oregon volcanics: 1988–90. Field mapping, physical volcanology of Neogene volcanics.
Santiam Pass, OR: 1989–90. Deep geothermal drilling, core studies, downhole geophysics.
Central NV Volcanic Field: 1992–2002. Petrology, physical volcanology, potential field geophysics.
Western Great Basin Volcanic Fields: 1993–99. Reconnaissance of physical volcanology, petrology.
Tolbachik Volcanoes, Kamchatka: 1994–95. Physical volcanology, petrology, potential field geophysics.
San Rafael volcanic field, UT: 1998–99. Physical volcanology, mapping, potential field geophysics.
Cerro Negro volcano, Nicaragua: 1995–99. Eruption monitoring, volcanology, petrology, geophysics.

SUPPLEMENTAL EDUCATION

Introduction to Arc/Info. Environmental Systems Research Institute: 12/1992
Advanced GIS with Arc/Info. Environmental Systems Research Institute: 11/1993
Physics of Explosive Volcanism. A. Freundt & M. Rosi, IAVCEI: 1/1997
Gravity-Driven Flows of Volcanic Origin. K. Scott & M. Sheridan, IAVCEI: 1/1997
Analyzing Risk: Science, Assessment and Managemnt. Harvard School of Public Health, 10/1998
Hazard Analysis: Qualitative/Quantitative Analysis Methods. Process Safety Institute, 9/1999
Technical Specialist Audit Observation Training. Nuclear Regulatory Commission, 1/2000
Principles and Techniques for Communicating Effectively about High Concern, Sensitive, or Controversial Issues. Dr. Vincent Covello, Center for Risk Communication: 2/2000
Real-time Volcano Monitoring from Space. A. Harris, IAVCAI: 7/2000
Reviewing a NRC Integrated Safety Analysis. Process Safety Institute: 10/2000
Science and Effective Media Communications. V. Yannacone, GSA: 11/2000
Scope Creep: Preventing and Resolving. S. Walesh, Am Soc. Civil Eng.: 4/2003
Introductory and Advanced Modeling with GOLDSIM. Golder Associates: 8/2004
High-Level Waste Health Physics. NRC, R. Reed & J. Ricci: 9/2004

ADDITIONAL PROFESSIONAL SKILLS

Detailed planning and safe conduct of multidisciplinary field investigations in remote areas, including active volcanoes. Strong project management skills, including integrated operations planning and budgeting. Intermediate to advanced skills in Geographic Information Systems for UNIX and Windows environments, including Arc/Info, ArcView, and ERDAS Imagine. Advanced petrographic analysis of igneous and sedimentary rocks, electron microprobe operations (Cameca SX-50), instrumental neutron activation analysis, and standard x-ray fluorescence and x-ray diffraction techniques. Basic skills in spoken Spanish, rudimentary knowledge of French and German languages.

PROFESSIONAL PUBLICATIONS

This publication list demonstrates how I've worked collaboratively over the past twenty years with a large group of scientists investigating a variety of topics related to volcanism, igneous petrology, structural geology, and risk analyses.

Peer-reviewed Papers (27):

Hill, B.E., W. Aspinall, C. B. Connor, J.-C. Komorowski, and S. Nakada. 2009. Recommendations for Assessing Volcanic Hazards at Sites of Nuclear Installations. *In* C. Connor, N. Chapman, and L. Connor, eds. *Volcanism, Tectonism, and Siting Nuclear Facilities*. New York, NY: Cambridge University Press.

Lejeune, A.-M., B.E. Hill, A.W. Woods, R.S.J. Sparks, and C.B. Connor. 2009. Intrusion Dynamics for Volatile-Poor Basaltic Magma Into Subsurface Nuclear Installations. *In* C. Connor, N. Chapman, and L. Connor, eds. *Volcanism, Tectonism, and Siting Nuclear Facilities*. New York, NY: Cambridge University Press.

Woods, A.W., O. Bokhove, A. deBoer, and B. Hill. 2006. Compressible Magma Flow in a Two-dimensional Elastic-walled Conduit. *Earth and Planetary Science Letters*, 246 (3-4): 241–250.

Heggy, E., S.M. Clifford, R.E. Grimm, C.L. Dinwiddie, D.Y. Wyrick, and B.E. Hill. 2006. Ground-penetrating radar sounding in mafic lava flows: Assessing attenuation and scattering losses in Mars-analog volcanic terrains. *Journal of Geophysical Research,* 111, E06S04, DOI:10.1029/2005JE002589.

La Femina, P.C., C.B. Connor, B.E. Hill, W. Strauch, and J.A. Saballos. 2004. Magma-tectonic interactions in Nicaragua: The 1999 seismic swarm and eruption of Cerro Negro volcano. *Journal of Volcanology and Geothermal Research,* 137 (1-3): 187–199 DOI: 10.1016/j.jvolgeores.2004.05.006.

Dunne, W.M., D.A. Ferrill, J.G. Crider, B. Hill, P. La Femina, D. Waiting, A.P. Morris, and R. Fedors. 2003. Orthogonal jointing during coeval igneous degassing and normal faulting, Yucca Mountain, Nevada. *Geological Society of America Bulletin,* 115: 1492–1509.

Woods, A.W., S. Sparks, O. Bokhove, A-M. LeJeune, C.B. Connor, and B.E. Hill. 2002. Modeling magma-drift interaction at the proposed high-level radioactive waste repository at Yucca Mountain, Nevada, U.S.A. *Geophysical Research Letters*. [DOI 10.1029/2002GL014665].

Connor, C.B., B.E. Hill, B. Winfrey, N. Franklin, and P.C. La Femina. 2001. Estimation of volcanic hazards from tephra fallout. *Natural Hazards Review* 2(1): 33–42.

Connor, C.B., J.A. Stamatakos, D.A. Ferrill, B.E. Hill, G. Ofoegbu, F.M. Conway, B. Sagar, and J.S. Trapp. 2000. Geologic factors controlling patterns of small-volume basaltic volcanism: Application to a volcanic hazards assessment at Yucca Mountain, Nevada. *Journal of Geophysical Research* 105: 417–432.

Doubik, P.Yu., and B.E. Hill. 1999. Magmatic and hydromagmatic conduit development during the 1975 Tolbachik Eruption, Kamchatka, with implications for hazards assessment at Yucca Mountain, Nevada. *Journal of Volcanology and Geothermal Research*, 91: 43–64.

Hill, B.E., C.B. Connor, M.S. Jarzemba, P.C. La Femina, M. Navarro, and W. Strauch. 1998. 1995 eruptions of Cerro Negro volcano, Nicaragua, and risk assessment for future eruptions. *Geological Society of America Bulletin*, 10: 1231–1241.

Connor, C.B., J.A. Stamatakos, D.A. Ferrill, and B.E. Hill. 1998. Technical Comment on anomalous strain rates in the Yucca Mountain area, Nevada, by Wernicke, et al. *Science*, 282: 1007b–1009b.

Conway, F.M., C.B. Connor, B.E. Hill, C.D. Condit, K. Mullaney, and C.M. Hall. 1998. Recurrence rates of basaltic volcanism in SP Cluster, San Francisco volcanic field, Arizona. *Geology* 26: 655–658.

Connor, C.B., P.C. Licthner, F.M. Conway, B.E. Hill, A.A. Ovsyannikov, I. Federchenko, Yu. Doubik, V.N. Shapar and Yu. Taran. 1997. Cooling of an igneous dike twenty years after intrusion. *Geology* 25: 711–714.

Connor, C.B., S. Lane-Magsino, J.A. Stamatakos, R.H. Martin, P.C. La Femina, B.E. Hill, and S. Lieber. 1997. Magnetic surveys help reassess volcanic hazards at Yucca Mountain, Nevada. *EOS, Transactions of the American Geophysical Union* 78(7): 73–78.

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Connor, C.B., and B.E. Hill. 1995. Three nonhomogeneous Poisson models for the probability of basaltic volcanism: Application to the Yucca Mountain Region, Nevada, U.S.A. *Journal of Geophysical Research* 100(B6): 10,107–10,125.

Connor, C.B., and B.E. Hill. 1993. Estimating the probability of volcanic disruption of the candidate Yucca Mountain repository using spatially and temporally nonhomogeneous poisson models. *Proceedings, American Nuclear Society Focus '93 Meeting.* La Grange Park, IL: American Nuclear Society. 174–181.

Hill, B.E. editor, 1992. *Geology and geothermal resources of the Santiam Pass area of the Oregon Cascade Range, Deschutes, Jefferson, and Linn Counties, Oregon*: Oregon Department of Geology & Mineral Industries Open-file report O-92-3, 61 p.

Hill, B.E. 1992. Stratigraphy and petrology of the Santiam Pass 77-24 drill core *in* Hill, B.E., ed., *Geology and geothermal resources of the Santiam Pass area of the Oregon Cascade Range, Deschutes, Jefferson, and Linn Counties, Oregon*: Oregon Department of Geology & Mineral Industries Open-file report O-92-3, p. 19-36.

Hill, B.E., and G.R. Priest. 1992. Geologic setting of the Santiam Pass area, central Cascade Range, Oregon, *in* Hill, B.E., ed., *Geology and geothermal resources of the Santiam Pass area of the Oregon Cascade Range, Deschutes, Jefferson, and Linn Counties, Oregon*: Oregon Department of Geology & Mineral Industries Open-file report O-92-3, p. 5-18.

Hill, B.E., G. Priest, D.D. Blackwell, and D. Benoit. 1991. Scientific results of the Santiam Pass 77-24 Geothermal Drilling Program: *Transactions, Geothermal Resource Council*, v. 15, p. 171-176.

Hill, B.E., G.R., Priest, and D.D. Blackwell. 1991. Initial results from the 1990 geothermal drilling program at Santiam Pass, Cascade Range, Oregon: *Oregon Geology*, v. 53, p. 101-103.

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Hill, B.E., S.J. Lynton, and J.F. Luhr. 1995. Amphibole in Quaternary basalts of the Yucca Mountain region: significance to volcanism models. *Proceedings, Sixth Annual International High–Level Radioactive Waste Management Conference*. La Grange Park, IL: American Nuclear Society. 132–134.

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Hill, B.E. 1991. Development of petrogenetically distinct silicic magma systems in the Three Sisters region of the Oregon Cascade Range since 400 ka. *EOS, Transactions, American Geophysical Union* 72–44: 524.

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Hill, B.E. 1989. Significance of distinct rhyodacitic provinces within the Three Sisters region of the Oregon central High Cascades. *New Mexico Bureau of Mines and Mineral Resources*, IAVCEI Bulletin 131: 130.

Hill, B.E. 1988. The Bull Springs Inlier and its significance to Oregon central High Cascade tectonics. *Proceedings of the Oregon Academy of Science* 24: 62.

Hill, B.E. 1988. The Tumalo Volcanic Center: A large Pleistocene vent complex on the east flank of the Oregon central High Cascades. *Geological Society of America Abstracts with Programs* 20–7: 398.

Hill, B.E. 1987. The widespread Loleta ash and its proximal equivalents had an Oregon central High Cascade source. *Geological Society of America Abstracts with Programs* 19–7: 703.

Hill, B.E. 1984. Petrology of the Bend pumice and Tumalo tuff; A Pleistocene Cascade eruption involving magma mixing. *Proceedings of the Oregon Academy of Science* 20: 52.

ATTACHMENT B

RÉSUMÉ OF PHILIP JUSTUS

Résumé

PHILIP STANLEY JUSTUS, Ph.D, L.G.

Division of High-Level Waste Repository Safety, Mailstop E2-B2
U.S. Nuclear Regulatory Commission
Washington, DC 20555

EMPLOYMENT

Senior Geologist — 1994 to date

Office of Nuclear Material Safety and Safeguards, U.S. NRC — Washington, DC

[High-Level Waste Management]. Technical reviewer and coordinator of NRC staff reviews of Yucca Mountain (YM) License Application (LA) since June 3, 2008 in fields that require knowledge of site characteristics and alternative conceptual models of geologic, tectonic, hydrologic and environmental processes and conditions. Reviewed Supplemental Final Environmental Impact Statement, Safety Analysis Report, and Requests for Additional Information and respective responses and proposed contentions on geoscience subjects ancillary to LA. Co-leader of geology-hydrology site visits and co-author of guidebook to YM and vicinity for Staff orientation. Drafter acceptance criteria and license review guidance for seismotectonic, faulting and fracturing issues associated with proposed repository at Yucca Mountain, NV, NRC regulation 10 CFR Part 63, using risk-informed and performance-based approach. Manage NRC's Yucca Mountain structural deformation and seismicity team to focus DOE on licensing issue resolution. Manage and direct the geology-geophysics technical experts at NRC's Center for Nuclear Waste Regulatory Analyses in San Antonio, TX. Conducted independent analyses of Basin and Range neotectonics and discussed with DOE how the results apply to resolution of licensing issues at Yucca Mountain in the pre-license consultation phase of the YM project. Seek to educate peers and public about regulatory geology using results of NRC actions through public and professional society presentations and publications. Office Director's Liaison to Commissioner's Advisory Committee on Nuclear Waste to smooth protocols and ensure value-added to interactions.

Occasionally, evaluate applications to reclaim uranium mills and tailings with regard to geologic and seismologic stability requirements. Consult with licensee's management and state officials to ensure that rockfall and subsidence stability issues are identified and addressed early. Prepare input to EIS and licensing decisions and defend their geologic bases. Wrote Technical and Safety Evaluation Reports that consider geologic hazards. Independently determined whether faults at a nuclear site are seismogenic and headward erosion of a stream were hazards (e.g., Moab, UT; Gore, OK). Consulted with State of Washington on geologic stability issues to assist with its (the nation's first state) acceptance of a Reclamation Plan for a uranium-mill tailings site (near Spokane, WA). I've been a Licensed Geologist in Washington State since 2002.

Senior On-Site Licensing Representative — 1992 - 1994

Division of High-Level Waste Repository Safety, U.S. NRC — Las Vegas, Nevada

Represented NRC Headquarters management to DOE and its contractors, and Nevada state, local and tribal government officials while managing NRC's Nevada office providing oversight to Yucca Mountain project. Effected two-way communication between NRC and DOE staff's to help ensure that site characteristics and evidence of natural disruptive events were thoroughly investigated by DOE. Identified concerns that affected DOE's ability to develop a complete and high-quality license application, such as inconsistencies in stratigraphic nomenclature and unexplained length-limits on mapping fractures in surface exposures and tunnel walls. Kept NRC HQ's management in close contact with changing DOE-YM management, at the cutting-edge of DOE's surface-based testing program, and with its tunnel-boring-machine operation start-up.

Section Leader **1981 - 1992**
Office of Nuclear Material Safety and Safeguards, U.S. NRC Washington, DC

Helped develop the Division of Waste Management's capability to evaluate DOE's detailed environmental assessments, site characterization reports and preliminary licensing conclusions which relied on results of core drilling, geophysical surveys, geological mapping, hydrologic testing, seismotectonic modeling and computerized tectonic models. Managed and directed geologists, hydrologists, geochemists, seismologists, geophysicists, environmental scientists, hydraulic engineers and computer modelers of groundwater flow and contaminant transport to initiate, develop and communicate regulatory guidance and technical evaluations. Helped set 10 CFR Part 60 standards for DOE's characterization of seismotectonic, volcanologic, geomorphic and natural resources for first-of-a-kind geologic repository program. The Section and its contractors helped persuade DOE to redirect part of its site characterization program to establish a pervasive quality assurance program and to integrate its field investigations (such as core logging quality assurance at Hanford, WA; and the integration of geophysical surveying, drilling and decision analysis of the location of exploratory shafts at Yucca Mountain). Managed multi-million dollar technical assistance contracts at DOE labs, government agencies, universities and private companies. Served on source evaluation panel for NRC's first Federally Funded Research and Development Center procurement. Was **Acting Branch Chief, Geosciences Branch, for one year,** 1986. Supervised technical and secretarial professionals; administered budget, contracts, training and individual development programs. Recruited, trained, rewarded and retained staff. Made licensing decisions, produced technical reviews and internal quality assurance procedures. Focused structural geology and volcanism research on licensing needs.

Geologist **1980 – 1981**
Office of Nuclear Reactor Regulation, U.S. NRC Washington, DC

Evaluated geologic stability of several nuclear reactor sites in western U.S. Prepared and presented testimony in court to defend NRC's decision to allow a nuclear test reactor to restart after it was found to be within a zone of capable faults. This was the first case wherein NRC staff considered a probabilistic fault hazard analysis as a supplement to a deterministic analysis. Assisted staff attorneys with discovery, stipulations, cross examinations of licensee's and intervenor's technical experts and findings. Coordinated staff's panel of geoscience experts in its appearance before Atomic Safety and Licensing Board. Represented NRC in public outreach opportunities to explain significance of capable faults discovered by applicant near proposed power reactor site at Hanford, WA.

Associate Professor **1970-1980**
Fairleigh Dickinson University (FDU) Madison, New Jersey

[Began as Instructor; tenured]. Helped start the Department of Earth Sciences at FDU and its West Indies Laboratory, a marine research station on St. Croix, from scratch. Recruited and educated students some of whom were employed as geoscientists. Taught college courses in structural geology-tectonics, igneous and metamorphic petrology, geomorphology, mineralogy and crystallography, field mapping, oceanography and environmental science. Engaged undergraduate geology majors in field research by applying for and receiving funds from the NJ Geological Survey. Conducted research and published results on Appalachian Mountains geology. Consulted for local citizen's association and businesses. Promoted earth science education by publishing newspaper items and field trip guidebooks. Was Editor-In-Chief, NJ Academy of Sciences Bulletin, 25th anniversary issue. Was President, American Assoc. of University Professors FDU-Madison Chapter. Was a Post-Doctoral Fellow at Rice University studying western U.S. volcanism. Was an Honorary Research Fellow at University College London studying propagation-arrest of cooling cracks in Tertiary basaltic lava flows of Scotland.

Major and Assistant Professor **1967-1970**
Army Corps of Engineers, U.S. Military Academy West Point, New York

[Began as 1st Lt and Instructor]. Active duty assignment was to redevelop and expand the geology program at the U.S. Military Academy. Taught physical geology, physical geography, terrain analysis and astronomy-astronautics. Co-edited and updated the West Point Atlas of Landforms to include earth and planetary landforms from satellite imagery, sea-floor topography, and lunar and planetary surface photos and maps. Wrote geology field guide to the West Point Reservation. Returned in summers to teach new instructors and update course materials. Received Army commendation medal for Atlas and related educational efforts.

EDUCATION

Ph.D. **1971**
University of North Carolina Chapel Hill, North Carolina
Major: Structural Geology, Tectonics and Metamorphism in Appalachian Mtns

M.S. **1966**
University of North Carolina Chapel Hill, North Carolina
Major: Basaltic Dike Crystallization, Mesozoic Dike-Swarm Tectonics.

B.S. **1962**
City College of City University of New York New York, New York
Major: Geology Minor: Military Science and Engineering.

PUBLIC SERVICE

* NRC Volunteers in Schools Program, charter member, continuing
* Chesapeake Research Consortium, Inc., Scientific and Technical Advisory Comm., observer, 1995-1997
* Montgomery County (MD) Solid Waste Advisory Committee, member, and Water Quality Committee, chairman, 1986-1992
* Montgomery County (MD) Science Fair Association, advisor, 1991
* Morristown (NJ) Environmental Committee, vice chairman, 1976-1977

MEMBERSHIPS

* Geological Society of America
* American Geophysical Union
* American Association for the Advancement of Science
* Sigma Xi Scientific Research Society
* Geological Society of Washington (DC)
* The Planetary Society

PUBLICATIONS

List of publications on aspects of regulatory geology, radioactive waste management, fault evaluations at nuclear facilities, Appalachian tectonics, basalt crystallization and jointing, landforms, and field trip guides, is available separately.

#

ATTACHMENT C

LIST OF PUBLICATIONS OF PHILIP JUSTUS

Philip S. Justus .

PUBLICATIONS

2009 McKague, H.L. and Justus, P.S., **Yucca Mountain Region Field Guide**: Center for Nuclear Waste Regulatory Analyses, San Antonio, TX [June 2009, supercedes previous editions]

2004 Justus, P.S., Leslie, B.W., Grossman, C.J., Danna, J.G., and McCartin, T.J.**, Geologic, Hydrologic and Geochemical Features, Events and Processes (FEPs) That Could Affect Isolation at the Proposed Yucca Mountain Repository: U.S. Nuclear Regulatory Commission 's (NRC's) Risk-Insights Baseline Study** (abs.): Geological Society of America Abstracts with Programs, v. 36, no. 5, p. 281

2004 Justus, P.S., Stamatakos, J.A., Ferrill, D.A., Waiting, D.J., Morris, A.P., Sims, D.W., and Ghosh, A., **Methods Developed by the U.S. Nuclear Regulatory Commission to Evaluate Risk from Fault Displacements Through a Potential Waste Repository, Yucca Mountain, Nevada, USA:** 32nd International Geological Congress, Proceedings, Florence, Italy (in press)

2003 Waiting, D.J., Stamatakos, J.A., Ferrill, D.A., Sims, D.W., Morris, A. P., Justus, P.S., and A-b.K. Ibrahim, **Methodologies for the Evaluation of Faulting at Yucca Mountain, Nevada**: American Nuclear Soc., Proceedings of the International High-Level Radioactive Waste Management Conf., Las Vegas, NV, March 2003, p. 377-387

2002 Justus, P.S., Stamatakos, J.A., McCartin, T.J., and Firth, J.R., **Evaluating Radiological Risks From Seismotectonic Hazards at the Proposed Radioactive Waste Repositotry at Yucca Mountain, Nevada: U.S. Nuclear Regulatory Commission's Risk-Informed and Performance-Based Approach**: Geological Soc. of America, Abs. With Programs, v. 34, no. 6, p. 106, October 2002

2002 Justus, P.S., Leslie, B.W., and J.A. Stamatakos, **Evaluating Geological Issues at a Potential High-Level Radioactive Waste Repository at Yucca Mountain, Nevada** (abs.): Association of Engineering Geologists-American Institute of Professional Geologists Joint Meeting, Reno, v.45, p.71, September 2002

2000 Justus, P.S., Stamatakos, J.A., Ghosh, A., Hsiung, S., Miklas, M., Chen, R, Ibrahim, Ab.K., and J.Firth, **Risk-Informed and Performance-Based Evaluation of Seismotectonic Processes at the Candidate High-Level Nuclear Waste Repository, Yucca Mountain, Nevada** (Abs.): Geological Society of America, Proceedings of Annual Meeting

1999 Justus, P.S., Stamatakos, J.A., Firth, J., Ghosh, A., Hsiung, S. and Ab.K. Ibrahim, **Incorporation of Tectonic Processes in Probabilistic Risk Assessments of the Proposed High-Level Radioactive Waste Repository at Yucca Mountain, Nevada: Nuclear Regulatory Staff Approach** (Abs.): Transactions of American Geophysical Union, v. 80, p. S1

1999 U.S. Nuclear Regulatory Commission, **Issue Resolution Status Report, Key Technical Issue: Structural Deformation and Seismicity, Rev. 2**, Division of Waste Management, September (P. Justus, J. Stamatakos, et al.)

1998 Justus, P.S., Stamatakos, J.A., Ferrill, D.A. and L.H. McKague, **U.S. Nuclear Regulatory Commission's Resolution Report on Type I Faults and Tectonic Models**: American Nuclear Society's Eighth International High-Level Radioactive Waste Management Conference Proceedings, May, p. 233-235

1997 Stamatakos, J.A., Connor, C.B., Hill, B.E., Magsino, S. L., Ferrill, D.A., Kodama, K. P., and Justus, P.S., **The Carrara Fault in Southwest Nevada Revealed From Detailed Gravity and Magnetic Results: Implications for Seismicity, Volcanism, and Tectonics Near Yucca Mountain, Nevada** (abs): American Geophysica Union, Dec 1997

1997 U.S. Nuclear Regulatory Commission, **Final Technical Evaluation Report for the Proposed Revised Reclamation Plan fo the Atlas Corporation Moab Mill (UT), Source Material License. No. SUA 917, Docket No. 40-3453, Atlas Corp.**: NUREG-1532, Chapter 2, Geologic Stability, pp. 2-1 to 2-31, March (P.Justus - geology; A-b. K. Ibrahim - seismicity)

1996 Justus, P.S., Olig, S and H.H. Doelling, **Stop 5, Atlas Tailings Pond**, in, A.C. Huffman, Jr., et al., eds., Utah Geological Association 1996 Fall Field Trip Road and River Log, Utah Geol. Assoc. Guidebook 25, p. 411

1996 Stamatakos, J.A., P.S. Justus, et al., **Center for Nuclear Waste Regulatory Analyses, Nuclear Regulatory Commission Radioactive Waste Program Annual Progress Report - FY 1996, Chapter 3, Structural Deformation and Seismicity**,: U.S. NRC NUREG/CR-6513, no. 1, pp. 3-1 to 3-33

1994 Justus, P.S. and Gilray, J., **Role of U.S. Nuclear Regulatory Commission's On- Site Representatives in Pre-Licensing Activities for a High-Level Radioactive Waste Repository**: Proc. 5th Int'l Conf. High-Level Radioactive Waste Mgmt, American Nuclear Soc., Las Vegas, NV, 1712-1715

1993 Justus, P.S. and Gilray, J., **Role of U.S. Nuclear Regulatory Commission's On-Site Representativies in the High-Level Radioactive Waste Program Pre-Licensing Activities** (abs.): American Soc. Quality Control Engineers, Knoxville, TN

1993 McConnell, K.I., Ibrahim, A-B. K., and Justus, P.S., **U.S. Nuclear Regulatory Commission Staff Technical Position on Investigations to Identify Fault Displacement Hazards and Seismic Hazards at a Geologic Repository**: Proc. 4th Int'l. Conf. High-Level Radioactive Waste Mgmt., American Nuclear Soc., Las Vegas, NV, 175-181

1992 Justus, P.S. and Stockey, J.R., **Introductory Remarks for the International High-Level Radioactive Waste Conference Technical Session on Site Characterization: Approaches, Concepts, Concerns**: Proc. 3rd Int'l. Conf. High-Level Radioactive Waste Mgmt., American Nuclear Soc., Las Vegas, NV, 746-747

1992 Trapp, J.S., and Justus, P.S., **Regulatory Requirements to Address Issues Related to Volcanism and Magmatism: Code of Federal Regulations, Title 10, Part 60, Disposal of High-Level Radioactive Wastes in Geologic Repositories**: Proc. 3rd Int'l. Conf., High-Level Radioactive Waste Mgmt., American Nuclear Soc., Las Vegas, NV, 2039-2046

1991 Justus, P.S., **EDITORIAL - Regulatory Geology and Regulatory Hydrology: Site and System Performance Evaluations in the Face of Uncertainty**: Environmental Geology Water Science, v. 18, no.3, 157

1991 Browning, R.E., Justus, P.S., and Johnson, R.L., **U.S. Nuclear Regulatory Commission's Strategy for Identifying and Reducing Uncertainties Important to Licensing a High-Level Radioactive Waste Repository: Geological Examples Applicable to the Yucca Mountain Site, Nevada**; in, Geological Problems in Radioactive Waste Isolation - A Worldwide View; P.A. Witherspoon, ed., Lawrence Berkeley Labs Publ. LB29703, 191-196

1989 Fortuna, S.L. and Justus, P.S., **U.S. Nuclear Regulatory Commission's Federally Funded**

Research and Development Center for the High-Level Waste Disposal Program: the Center for Nuclear Waste Regulatory Analyses: Proc. Of Waste Management '89, Univ. Of Arizona, Tucson, AZ, 161-165

1989 Trapp, J.S. and Justus, P.S., **U.S. Nuclear Regulatory Commission (NRC) Proposed Classification of 10CFR60: Definition and Use of the Terms 'Anticipated Processes and Events' and 'Unanticipated Processes and Events:'** American Nuclear Soc., Focus '89, Nuclear Waste Isolation in the Unsaturated Zone, Las Vegas, NV, 207-212

1989 Justus, P.S. and Stablein, N.K., **Geoscientists Help Make 10,000-Year Decisions: U.S. Nuclear Regulatory Commission**: Geotimes, v. 34, no. 1, 14-15 (invited article)

1987 Gupta, D.C., Nataraja, M.S., and Justus, P.S., **Site Characterization Information Needs for a High-Level Waste Repository**: Proc. Of Waste Management '87, Univ of Arizona, Tucson, AZ, 165-168

1986 Justus, P.S., **Book Reviews: Scientific Basis for Nuclear Waste Management VII, edited by G.L. McVay, Materials Research Soc., v. 26, Elsevier, N.Y., 1099pp; and VIII, edited by C.M. Jantzen, J.A. Stone and R.C. Ewing**, v. 44, ibid., 991 pp: Geology, v. 14, no. 2, 192

1985 Justus, P.S., Trapp, J.S., Westbrook, K.B., Lee, R., Blackford, M.E., and Rice, B., **Geologic Repositories for Radioactive Waste: the Nuclear Regulatory Commission Geologic Comments on the Environmental Assessments** (abs.): Geological Soc. America Abastracts with Programs, Ann. Mtg., Orlando, FL, 621

1984 Curran, H.A., Justus, P.S., Young, D. And Garver, J.B., Jr., **Atlas of Landforms, 3rd ed**: John Wiley and Sons, N.Y., 165 pp.

1983 Justus, P.S., **Nuclear Regulatory Commission's Requirements for High-Level Radioactive Waste Repositories: Regulatory Procedures, Technical Criteria and Standards Associated with Geological Characteristics of a Site** (abs.): Geological Soc. America Abstracts with Programs, v. 15, no. 6, 60

1982 Justus, P.S., **The Role of the Geological Sciences in the Siting of High-Level Radioactive Waste Repositories: the Nuclear Regulatory Commission Perspective** (abs.): Bull. American Physical Soc., v. 27, no. 4, 589

1981 Justus, P.S. and Jackson, R.E., **The Role of the U.S. Nuclear Regulatory Commission in the Development of Engineering Geology: Effect of Regulations on Engineering Geology Investigations** (abs.): Geological Soc. America Abstracts with Programs, v. 13, no. 7, 481-482

1979 Justus, P.S., **Geological Constraints to Land Use in New Jersey: a Checklist for Environmental Managers** (abs.): Bull. New Jersey Academy of Science, v. 24, no. 2

1978 Justus, P.S., **Origin of Curvi-Columnar Joints in Basalt Cooling Units by Fracture-Controlled Quenching** (abs.): EOS, Trans. American Geophysical Union, v. 59, no. 4, 379

1978 Sturchio, N.C. and Justus, P.S., **Columnar Structures in John O'Rourkes Quarry, West Orange, New Jersey** (abs.): Bull. New Jersey Acad. Of Science, v. 23, no. 2, 96

Philip S. Justus Publications, continued

1978 Justus, P.S., Meyer, D. And Sturchio, N.C., **Systematic Curvi-Columnar Jointing in First Watchung Mountain Basalt, New Jersey: Reinterpretation of Origin and Significance** (abs.): Abstracts with Programs, Geological Soc. America, v. 10, no. 2, 49

1977 Justus, P.S., **Excavations in Morristown Unearth History**: Daily Record (Newspaper), Morris County, New Jersey, magazine sect., full-page H6, Sunday 20 March 1977

1976 Justus, P.S., Cadwell, D.H., Naylor, R.A., Shenker, A.E., Fedosh, M.S. and Schoenmaker, J.A., **Geology of Jenny Jump Mountain Area On the Highlands-Great Valley Border, Blairstown, Washington and Belvidere Quadrangles, New Jersey** (abs.): Bull. New Jersey Academy of Science, V. 21, no. 1, 27

1975 Justus, P.S., **Guidelines for a Geology Field Trip to Any Very Old Cemetary**: New Jersey Science Teachers Assoc. Bull., v. 22, no. 2, 31-33

1975 Justus, P.S., **Folded Silurian Metasedimentary Rocks of Kanouse Mountain, Newfoundland, New Jersey - a Field Trip Stop of Exceptional Educational Value** (abs.): Bull. New Jersey Acad. Science, v. 20, no. 1, 40-41

1974 Justus, P.S. and Butler, J.R., **Classsification of Cataclastic and Dislocation Metamorphic Rocks** (abs.): Abstracts with Programs, Geological Soc. America, v. 6, no. 4, 369-370

1974 Curran, H.A., Justus, P.S., Perdew, E.L. and Prothero, M.B., eds., **Atlas of Landforms, 2nd ed**: John Wiley and Sons, N.Y., 140 pp.

1974 Justus, P.S., **Field Trip Guide: Geology of the Folded Silurian Rocks and Unconformity at Kanouse Mountain, Newfoundland, Passaic County, New Jersey**: N.J. Science Teachers Assoc. Bull., v. 21, no. 2, 18-25

1974 Justus, P.S., ed., **Contributions to the Geology of Eastern St. Croix: Part 1 - Grass Point, Part 2 - Isaac Point, Part 3 - East Point**, p. 165-185, in H.G. Multer and L.C. Gerhard, eds., Guidebook to the Geology and Ecology of Some Marine and Terrestrial Environments, St. Croix, U.S. Virgin Islands: Spec. Publ. 5, West Indies Lab, Fairleigh Dickinson Univ., Christiansted, St. Croix, 303pp.

1973 Justus, P.S., Editorial: **The Preservation of an Outdoor Science Laboratory at Lake Valhalla Glen, Morris County, New Jersey**: New Jersey Science Teachers Assoc. Bull., v. 20, no. 3, 26, 27, 30

1973 Roper, P.J. and Justus, P.S., **Polytectonic Evolution of the Brevard Zone**: American Jour. Science, Cooper Volume 273-A, 105-132

1973 Justus, P.S. and Roper, P.J., **Structural Development of the Brevard Zone, Part I: Theories of Origin and Comparative Tectonics** (abs.): Abstracts with Programs, Geological Soc. America, v. 5., no. 5., 408

1973 Roper, P.J. and Justus, P.S., **Structural Development of the Brevard Zone, Part II: Tectonic Synthesis**: ibid., 430

1970 Justus, P.S., Thayer, P.A., and Weigand, P., **Comparative Geochemistry and Petrology of Diabase Dikes in the North Carolina Triassic Basins** (abs.): Abstracts with Programs, Geological Soc. America, v. 2, 223

1969 Justus, P.S., **Paleogeographic Aspects of Continental Drift**: Proc. Assoc. American Geographers, N.Y. - N.J. Sect., 10th Ann. Mtg., 133-146

1968 Ragland, P.C., Rogers, J.J.W., and Justus, P.S., **Origin and Differentiation of Triassic Dolerite Magmas, North Carolina, U.S.A.**: Contributions to Mineralogy and Petrology, v. 20,

57-80

1968 Ragland, P.C., Rogers, J.J.W. and Justus, P.S., **Chemical Composition of Triasssic Dolerite Magmas From North Carolina and Their Possible Tectonic Significance** (abs.): Program Geological Soc. America Ann. Mtg., 244-245

1968 Dunn, D.E., Butler, J.R. and Justus, P.S., **Discussion: Brevard Zone Compared to Alpine Root Zones**: American Jour. Science, v. 266, 215-219

1968 Dunn, D.E., Butler, J.R., Weigand, P. and Justus, P.S., **Lithology and Structural Style of the Brevard Zone, N.C.** (Abs.): Program Geological Soc. America, SE Sect. Mtg., 33-34

1967 Justus, P.S., **Evidence of Volcanism or Shallow Intrusion in the Triassic Pekin Formation of the Deep River Basin North Carolina** (abs.): Jour. Elisha Mitchell Scientific Soc., v. 83, no. 3, 176-177

1967 Justus, P.S., **Occurrence of chlorite +/- actinolite +/- talc schist along the Brevard Zone in Wilkes and Caldwell Counties, North Carolina** (abs.): ibid., 178

1967 Justus, P.S., **Sequence of Development of Microscopic Textures in Diabase Dikes in Deep River Basin, North Carolina** (abs.): Program Geological Soc. America Ann. Mtg., 113-114

1966 Justus, P.S. and Butler, J.R., **Modal and Textural Zonation of Diabase Dikes in Deep River Basin, North Carolina** (abs.): Geological Soc. America Spec. Paper 101, 363

ATTACHMENT D

CURRICULUM VITA OF TIMOTHY MCCARTIN

Timothy J. McCartin

Education:

Master of Science in Physics - 1976
Wayne State University; Detroit, Michigan

Bachelor of Science in Physics - 1973
Xavier University; Cincinnati, Ohio

Professional Experience:

U.S. Nuclear Regulatory Commission, 1981- Present
Current Position: Senior Level Advisor for Performance Assessment
Division of High Level Waste Repository Safety
Office of Nuclear Materials Safety and Safeguards

- Responsible for ensuring technically sound performance assessment approaches and concepts are implemented at the NRC in the review of license applications of waste management facilities and the development of performance assessments of waste management facilities

- Technical lead for the development of 10 CFR Part 63, the regulatory criteria that govern any U.S. Department of Energy license application for a high level waste repository at Yucca Mountain

- Technical lead for development of NRC's regulations for high level waste disposal at Yucca Mountain for the period after 10,000 years (final regulations published March 13, 2009)

- Technical lead for development of NRC's regulation specifying probability for unlikely feature, events and processes for high level waste disposal at Yucca Mountain (final regulations published October 8, 2002)

- Technical lead for development of NRC's regulations for high level waste disposal at Yucca Mountain for the initial 10,000 years (final regulations published November 2, 2001)

- Technical lead for development of analyses relevant to dose-based performance measures for a proposed geologic repository at Yucca Mountain in support of NRC regulations

- Technical lead for development of NRC's Total System Performance Assessment code (TPA versions 3 and 4)

- Technical lead for development of unsaturated and saturated zone flow and radionuclide transport computer modules for NRC's TPA code

- U.S. NRC representative to the International Atomic Energy Agency to assist development of international safety standards for geologic disposal (Safety Requirements No. WS-R-4, Geological Disposal of Radioactive Waste published 2006)

- U.S. NRC representative to the International Atomic Energy Agency to assist development of guidance supporting international safety standards for geologic disposal

- U.S. NRC participant and NRC task leader in international studies for evaluating ground water flow (HYDRCOIN), radionuclide transport (INTRACOIN), and validation of models of transport of radioactive substances through groundwater in the geosphere (INTRAVAL) coordinated by the Swedish Nuclear Power Inspectorate

Relevant Publications:

McCartin, Timothy; ‘‘Regulatory Perspective on Implementation of a Dose Standard for a One-Million Year Compliance Period,’’, Proceedings of the 2006 Materials Research Society Fall Meeting, Volume 985 from the Materials Research Society Proceedings Series

McCartin, T.; J. Danna, C. Grossman, and G. Wittmeyer; Development of Risk Insights in the U.S. Nuclear Regulatory Commission’s High-Level Waste Program; in Proceedings of the Waste Management-04 Conference; February 29 - March, 2004; Tucson Arizona.

McCartin, T. et al; Understanding Performance Assessment Results; The 10th International High-Level Radioactive Waste Management Conference (American Nuclear Society); March 26 – April 3, 2003; Las Vegas, Nevada

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC AND SAFETY LICENSING BOARDS

In the Matter of	)	
	)	Docket No. 63-001-HLW
U.S. DEPARTMENT OF ENERGY	)	
	)	ASLBP Nos. 09-876-HLW-CAB01
(High-Level Waste Repository)	)	09-877-HLW-CAB02
	)	09-878-HLW-CAB03

CERTIFICATE OF SERVICE

I hereby certify that copies of the "NRC STAFF ANSWER TO STATE OF NEVADA'S NEW CONTENTIONS BASED ON FINAL NRC RULE" in the above-captioned proceeding have been served on the following persons this 11th of June, 2009, by Electronic Information Exchange.

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