

Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Igneous Activity

August 29-31, 2000
Las Vegas, Nevada

Introduction and Objectives

This Technical Exchange and Management Meeting on Igneous Activity (IA) is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on preclicensing consultations and a 1992 agreement with DOE, staff-level resolution can be achieved during preclicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket the license application. Resolution at the staff level does not preclude an issue being raised and considered during the licensing proceedings, nor does it prejudge what the NRC staff evaluation of that issue will be after its licensing review. Issue resolution at the staff level during preclicensing is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. Pertinent additional information could raise new questions or comments regarding a previously resolved issue.

Issues are **Aclosed** if the DOE approach and available information acceptably address staff questions such that no information beyond what is currently available will likely be required for regulatory decision making at the time of initial license application. Issues are **Aclosed-pending** if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues are **Aopen** if the NRC has identified questions regarding the DOE approach or information, and the DOE has not yet acceptably addressed the questions or agreed to provide the necessary additional information in the license application.

The objective of this meeting is to discuss and review the progress on resolving the IA KTI (see Attachment 1 for list of subissues). The quality assurance (QA) aspect of this KTI was determined to be outside the scope of the meeting and is being tracked in NRC's ongoing review of DOE's QA program.

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff stated that subissue 1 (probability of igneous activity) is closed and subissue 2 (consequence of igneous activity) is open. Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. The agenda and the attendance list are provided as Attachments 2 and 3, respectively. Copies of the presenters' slides are provided as Attachment 4. A copy of the draft meeting summary and draft matrix, which were handed out at the meeting, are included as Attachment 5. Highlights from the Technical Exchange and Management Meeting are listed below.

Highlights

1) Opening Comments

DOE stated that the intent of the meeting is to reach agreement on the current status and path forward for each of the IA subissues (see Igneous Activity Key Technical Issue@presentation given by Eric Smistad). During the April 25-26, 2000, KTI Technical Exchange, the NRC listed the two subissues as being open. During this meeting, DOE stated that it would provide additional details about how acceptance criterion and NRC concerns have been addressed and provide references to relevant information. DOE stated that it felt that the details provided during the meeting would be the basis for NRC to list both subissues as closed-pending.

The NRC stated that the acceptance criterion presented in Revision 1 of the IA Issue Resolution Status Report (IRSR) will be changing in Revision 2 of the IRSR (see ANRC Introductory Comments@presentation given by John Trapp). The change will provide uniformity with other KTIs and are being developed in parallel with Revision 1 of the Yucca Mountain Review Plan. The NRC stressed, however, that the technical concerns the staff has will not change with the new acceptance criterion. The NRC also discussed the relationship of the subissues to NRC abstractions. The probability subissue will be covered under scenario analysis. The consequence subissue will be covered under the following integrated subissues: (1) volcanic disruption of waste package, (2) airborne transport of radionuclides, (3) mechanical disruption of engineered barriers, (4) redistribution of radionuclides in soil, and (5) lifestyle of the critical group. The DOE requested that they be provided with a matrix correlation between the current acceptance criterion and the revised acceptance criterion, once the revision has completed.

Neither the State of Nevada nor the Affected Units of Local Government (AULG) had opening remarks.

2) Igneous Activity in the Total Performance Assessment

DOE presented the general outline and status of the Total System Performance Assessment - Site Recommendation (TSPA-SR) (see Igneous Activity in the Total System Performance Assessment - Site Recommendation: A Summary@presentation given by Peter Swift). The DOE stated that all TSPA-SR igneous disruption analyses (base case and sensitivity analyses) are based on a no backfill design. The results of the TSPA-SR will be summarized in the Site Recommendation Consideration Report, Revision 0. DOE then discussed the igneous intrusion groundwater transport and volcanic eruption ash fall pathways and the dose histories associated with each. The overall expected annual dose is the sum of the nominal dose history and the two igneous process dose histories, weighted by the annual probability of each event.

DOE's dose history showed that estimated dose from eruptive processes dominates for the first few thousand years and then the intrusive dose dominates out to 100,000 years. The NRC stated that its calculations, however, shows the eruptive dose dominates to 10,000 years. For eruptive events, DOE stated that the probability weighted mean annual dose rate peaks at 0.006 mrem/yr, and for the intrusive-dominated period, the mean annual peak dose rate in the

first 10,000 years is between 10^{-1} and 10^{-2} mrem/yr. DOE stated that it took no credit for either cladding or the waste packages intersected by an eruption or in close proximity to an intrusion in the IA calculations. DOE then discussed the TSPA-SR dose sensitivity analysis event for probability, showing the $10E-7$ intrusive event probability which raised the dose rates by about a factor of 6 over the base case probability to approximately 0.15 mrem/yr at 10,000 years. Using an approximately 10^{-8} probability for extrusive event, peak probability-weighted mean annual dose increased to 0.03 mrem/year with the DOE consequence model.

DOE concluded that the preliminary results show that the igneous disruption is the main contributor to dose in first 10,000 years and that the peak mean probability-weighted igneous doses are well below the EPA-proposed standard. The NRC pointed out that needs to see the results of a $10E-7$ extrusive event as agreed to by DOE.

3) Technical Discussion of the Consequence of Igneous Activity

Acceptance Criterion 1 through 4 - Eruptive Scenario Modeling

A discussion of acceptance criterion for the IA consequence subissue - eruptive scenario modeling was presented by the DOE (see Igneous Activity Consequences Subissue: Eruptive Scenario Modeling - Acceptance Criterion 1, 2, 3, 4, and 5" presentation given by Michael Sauer).

Under Acceptance Criterion #1, DOE stated that each extrusive igneous event is assumed to have a violent Strombolian phase that is modeled in the TSPA-SR using ASHPLUME v1.4LV. Strombolian and effusive eruption phases have been screened out due to low consequences and have not been incorporated into the TSPA-SR. DOE stated that high level waste entrainment is estimated via an incorporation ratio defined in ASHPLUME and is described in the igneous consequences Analysis and Model Report (AMR). DOE then presented the parameter inputs used in ASHPLUME (including ash particle size, event power, conduit diameter, violent eruptive phase volume, and waste particle diameter).

The NRC and Center for Nuclear Waste Regulatory Analyses (CNWRA) had a number of questions in this area: (1) how DOE accounted for the combined density of particles comprised of ash and waste in the eruption modeling, (2) the sensitivity of the grain size of waste, and (3) the technical basis for how the volumes from analog volcanos represent the likely range of volumes from Yucca Mountain volcanos. Mike Sheridan (Electric Power Research Institute representative) questioned why DOE selected violent Strombolian, given that it appears to be extremely conservative. DOE discussed evidence from southern Nevada. NRC discussed the Tolbachik analog as being useful for understanding the Crater Flat eruptive process.

As a result of additional discussions, NRC and DOE reached 3 agreements (see Attachment 1). With these agreements, the NRC stated that this Acceptance Criterion could be listed as closed-pending.

Under Acceptance Criterion #2, DOE stated that it is using ASHPLUME v1.4LV for the TSPA-SR and that it has compared ASHPLUME v1.4LV and v2.0 to the 1995 Cerro Negro eruption measured ashfall thickness (Hill et al. 1998). DOE concluded that both v1.4LV and v2.0 provide good agreement with the observed 1995 Cerro Negro ash layers and with each other.

As a result of additional discussions, NRC and DOE reached one agreement (see Attachment 1). With this agreement, the NRC stated that this Acceptance Criterion could be listed as closed-pending.

Under Acceptance Criterion #3, DOE stated that no credit was being taken for potential rotation of least principal stress to vertical during the thermal period and that this would be documented in the Igneous Consequence Modeling AMR. The NRC and the CNWRA expressed a concern that the current repository design, as shown in Sauer, 2000 (Igneous Activity Consequences Subissue: Intrusive Scenario presentation, slide 6), could result in an increased number of waste canisters being included in the conduit. This could result from the orientation of the repository drifts sub-perpendicular to the minimum in situ horizontal stress axis, resulting in conduit elongation or dike formation sub-parallel to the drifts. As a result of additional discussions, NRC and DOE reached one agreement (see Attachment 1). With this agreement, the NRC stated that this Acceptance Criterion could be listed as closed-pending.

Under Acceptance Criterion #4, DOE stated that the waste packages in the path of the eruptive conduit are assumed to be sufficiently damaged to provide no further protection and that this was documented in the Igneous Consequence Modeling for the TSPA-SR AMR (ANL-WIS PA000017). The NRC stated that it had no further questions in this area and that this Acceptance Criterion could be closed.

Acceptance Criterion 5 - Biosphere Modeling

Under Acceptance Criterion #5, the DOE stated that by conservatively fixing wind direction to the south and using transition phase Biosphere Dose Conversion Factors (BDCFs) for the full 10,000 years, that it bounds the expected range of doses and thus Acceptance Criterion #5 is addressed. The NRC requested a discussion of what DOE meant by remobilization in Amargosa and stated that DOE may not have adequately addressed uniform soil removal rates in the analyses. The NRC questioned whether DOE considers mechanical breakdown of particles (e.g., plowing). NRC discussed the process of soil removal and how it relates to agricultural or tilled land. William Melson (Nuclear Waste Technical Review Board (NWTRB) consultant) suggested that most ash gets slurried by overland water, getting into washes and in surface fractures/faults. DOE emphasized that by assigning the wind direction always to the south, uncertainties such as those associated with remobilization on variable slopes with variable thicknesses of ash are captured. NRC suggested that ash is continually being eroded and replenished by deposition of material eroded from locations nearer Yucca Mountain. John Stuckless (representing the USGS) disagreed, citing general observations, including the Jake Ridge area. The DOE stated that its present approach reasonably captures uncertainty associated with ash redistribution. The DOE stated that its analysis is sufficiently robust as to allow certain processes to be discounted. The NRC commented that DOE is not considering that through time incoming material would add to radionuclide inventory in the soils. As a result of additional discussions, NRC and DOE reached one agreement (see Attachment 1).

Under the Biosphere Modeling Eruptive Scenario, the DOE discussed the issues of (see Igneous Activity Consequences Subissue: Biosphere Modeling - Eruptive Scenario presentation given by Michael Sauer) mass loading, inhalation dose, soil removal and particle change, and self evacuation.

Under mass loading, the DOE provided information on the mass loading parameters and indicated that they were appropriate for the critical group. The NRC had no additional questions in this area and requested that DOE document the information. As a result of additional discussions, NRC and DOE reached one agreement (see Attachment 1).

Under inhalation dose, the DOE stated that it treats the inhalation of particles in the 10-100 micron range as additional soil ingestion. The NRC and CNWRA questioned this assumption and suggested that DOE might be underestimating the dose. The NRC stated that it needed additional justification regarding this assumption. As a result of additional discussions, NRC and DOE reached one agreement (see Attachment 1).

Under soil removal and particle change, the NRC noted that it discussed this issue previously (see above paragraph) and that it had no additional comments.

Under self evacuation, the DOE stated that it no longer assumes that the critical group self-evacuates during extrusive eruption and that this is documented in a calculation recently provided to the NRC (Scoping Calculation for Volcanic Eruption Biosphere Dose Conversion Factors). The NRC stated it had no further questions in this area.

The DOE then provided a brief discussion on wind characteristics and how they are being handled in TSPA-SR. The NRC expressed a concern that DOE's wind speed data is truncated at an altitude below the top of the possible tephra column. The NRC suggested that DOE evaluate new wind data and use the appropriate wind speeds with the height of the eruption column being modeled. The DOE stated it is looking into the speed-altitude relationships. As a result of additional discussions, NRC and DOE reached one agreement (see Attachment 1). With this agreement and the other agreements noted above, the NRC stated that this Acceptance Criterion could be listed as closed-pending.

Acceptance Criterion 1 through 4 - Intrusive Scenario Modeling

Under Acceptance Criterion #1, the DOE stated that the conceptual model of the intrusive event is consistent with the geologic record of basaltic igneous activity in Yucca Mountain region. The NRC had no further questions in this area (see Attachment 1 for overall status and agreements for Acceptance Criterion 1 through 4).

Under Acceptance Criterion #2, the DOE stated the models are verified against analog igneous system and therefore acceptance criterion 2 is addressed. The NRC had no further questions in this area (see Attachment 1 for overall status and agreements for Acceptance Criterion 1 through 4).

Under Acceptance Criterion #3, the DOE stated that it has addressed acceptance criterion 3 by incorporating the conceptual model for dike drift interaction in the TSPA intrusive model. The NRC requested that DOE provide instructions for accessing the database in this area. The DOE agreed to this request. The NRC had no further questions in this area (see Attachment 1 for overall status and agreements for Acceptance Criterion 1 through 4).

Under Acceptance Criterion #4, the DOE stated that it had addressed acceptance criterion 4 by conservatively neutralizing all engineered barriers near the dike and assuming damaged lid

welds on all remaining packages in intersected drifts. The DOE stated that packages intersected by the dike plus three packages on either side of the dike are assumed to be sufficiently damaged to provide no further protection (Zone 1) from influx of water and release of radionuclides. The waste in this zone is assumed to be instantly reduced in grain size and is available to be transported from the repository. The DOE stated that all additional packages in intersected drifts undergo lid weld failure (Zone 2). In this zone the drip shield, ground support, lid welds, and cladding of the waste will fail, but not the waste packages. All waste in Zone 1 is exposed to water flux in the drift as per the nominal case; in Zone 2 the waste packages need to be exposed to seepage to get water into the package. The DOE stated that there will be diffusional releases in Zone 2.

As a result of additional discussions, NRC and DOE reached one agreement (see Attachment 1). With this agreement the NRC stated that this was an acceptable path forward, but it did not have sufficient information to go to closed-pending. Therefore, this acceptance criterion is open.

4) Technical Discussion of Probability of Igneous Activity

The NRC began the discussions of the probability of igneous activity by discussing the overall status of the issue. The NRC understands that DOE plans on using a probability distribution derived from the Probabilistic Volcanic Hazard Assessment (PVHA) analysis having a mean value of approximately $1.6 \times 10E-8$ for its licensing case. The NRC disagrees with the use of that probability distribution and is more comfortable with a probability range of between $10E-8$ and $10E-7$. Therefore, the NRC has requested, and DOE has agreed that, in addition to its licensing case for SR and LA, DOE will provide, for informational purposes, the results of a single point sensitivity analysis for extrusive and intrusive igneous processes at $10E-7$. Based on this agreement, the NRC stated that this subissue is closed-pending. The NRC noted that the upcoming revision to the IRSR will reflect this agreement and also contain the staff's evaluation of DOE's analyses. The DOE stated that it agrees with the NRC approach. Both the NRC and DOE agreed that it would review and incorporate any new information, if applicable, into its calculations. NRC stated that when DOE establishes parameter values by applying weighting factors (probabilities) to alternative conceptual models, DOE needs to provide a technical basis for the probabilities.

The DOE then provided its approach to meeting Acceptance Criterion 1 through 4 and 6 through 8 (see the Igneous Activity Probability Subissue: Acceptance Criterion 1, 3, 4, 6, and 7 presentation given by Frank Perry, the Igneous Activity Probability Subissue: Acceptance Criterion #2 - Definition of Igneous Event presentation given by Robert Young, the Igneous Activity Probability Subissue: Acceptance Criterion #8 - Expert Elicitation Process presentation given by Kevin Coppersmith). As a result of additional discussions, NRC and DOE reached two agreements (see Attachment 1). With these agreements, the NRC stated that the probability subissue could be listed as closed-pending.

The CNWRA then provided a discussion on tectonic models (see the Vertical Axis Rotations and Normal Faults: Paleomagnetic and Geologic Evidence for the Development of Crater Flat, Nevada presentation given by John Stamatakos). The CNWRA summary is listed on page 2 of the presentation.

The DOE then provided its approach to Acceptance Criterion #5 (see Igneous Activity Probability Subissue: Acceptance Criterion #5: Tectonic Models). DOE stated that its models are consistent with tectonic models proposed for the Yucca Mountain region. Carl Stepp indicated that source zone boundaries were drawn primarily from volcano locations. The NRC had no further questions in this area and considers Acceptance Criteria #5 as closed-pending.

Although not directly related to this Igneous Activity KTI Technical Exchange, the Structural Deformation and Seismicity KTI item on tectonic models was discussed. Based on the discussions at this meeting, the SDS KTI item on tectonic models is closed regarding an apparent inconsistency in the application of tectonic models to the Probabilistic Seismic Hazard Assessment (PSHA) and the PVHA. DOE has indicated that the hinge line, as shown by Fredrich and others, is not a structural barrier that delimits a volcanic source zone. The PVHA volcanic source zone thus does not represent seismogenic sources as used in PSHA. However, the tectonic framework subissue is closed-pending, awaiting revisions to the DOE's Disruptive Events Features Events and Processes (FEPs) AMR. Resolution of this subissue will be formalized at the upcoming SDS Technical Exchange.

The CNWRA then provided an overview of NRC/CNWRA volcanism probability models (see Geologic Setting presentation given by Charles Connor). The presentation concluded that a uniform distribution between $10E-7$ to $10E-8$ annual probability of occurrence captures the range of uncertainty by considering relationships between tectonics, structural geology, geophysical information, and volcanism at Yucca Mountain. The conclusion concerning the concept of probability of volcanic crisis (2.5×10^{-4} /year) drew comment from DOE to the effect of being unnecessarily provocative because of its being an unfamiliar term and potentially misleading the public. CNWRA staff provided a definition and NRC indicated sensitivity to DOE's concern.

5) Update on Features, Events and Processes (FEPs).

The NRC stated, in general, that the justification for screening out biosphere FEPs were not based on present knowledge of current conditions, and that screening of critical group should be based on current conditions without regard for future changes in behavior (see Issue in the Biosphere presentation given by Christopher McKinley). The DOE stated that it was revising all the FEPs AMR and would have them completed by January 2001. The DOE further stated that it would revise the FEPs database after completion of the FEPs AMR revisions.

The NRC staff stated that two specific FEPs may need to be added to the list of FEPs considered by DOE. Specifically:

- (1) The re-entry of radionuclides that leach out of the soil back into the groundwater. This process is definitely negligible for the base case due to the low concentration of radionuclides in the soil and the large dilution volume due to pumping. However, for the volcanism scenario, there will be an ash deposit covering about 10s to 100s of square kilometers of land that are closer to Yucca Mountain than the critical group and could leach into the groundwater that flows to the critical group. This would not affect the peak dose from the volcanic event, but it may make a difference in the calculation of the expected annual dose.

(2) FEP 2.4.07.00.00 (Dwellings) should include an evaluation of the effects of evaporative coolers on the dose to the critical group.

6) Public Comments

Judy Treichel (Nevada Nuclear Waste Task Force) commented on the term "closed." She stated that it is a significant perception problem for concerned citizens. She stated that doing "tricky math" to get around the fact that there will be big doses when a volcanic eruption occurs is not perceived well. She cited the hearings associated with the proposed Private Fuel Storage Facility as relevant to the Yucca Mountain process.

Steve Frishman (Nevada Nuclear Waste Project Office) commented that no one can figure out how to calculate the redistribution factor. Everything deposited up gradient will pass through the critical group, but at an unknown rate. The rate needs to be determined (he suggested using the Lathrop Wells cone as an example). He stated that redistribution should not be dismissed by saying the analysis is conservative, unless the process is better understood.

William Melson (NWTRB) commented that issues related to Yucca Mountain and finding a repository is a societal issue which the NRC and DOE are trying to deal with.

Don Shettle (Nye County) commented on why volcanogenic thermal water has not been considered by DOE. A representative from USGS stated that the concept has been considered, but was not found to be significant for the Yucca Mountain site. The DOE stated that this was discussed in the Disruptive Events FEPs AMR and was excluded by low probability of occurrence and low magnitude of effect.

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