Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Unsaturated and Saturated Flow Under Isothermal Conditions

August 16-17, 2000
Berkeley, California

Introduction and Objectives

This Technical Exchange and Management meeting on Unsaturated and Saturated Flow Under Isothermal Conditions (USFIC) 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 prelicensing consultations and a 1992 agreement with DOE, staff-level resolution can be achieved during prelicensing 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 prelicensing 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 “closed” 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 “closed-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 “open” 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 unsaturated zone issues under the USFIC 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 will be 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 agreed with DOE that subissue 1 and 2 are still closed. Subissue 3 is open. Subissues 4 and 6 (UZ portion) are closed-pending. Subissue 5, which relates to the saturated zone (SZ) and Subissue 6 (SZ portion) will be discussed in an upcoming KTI technical exchange and management meeting.

Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. The DOE Action Plan for Net Infiltration Issues is included as Attachment 2. The DOE ongoing and planned testing synopsis (Testing and Modeling Activity Description) is provided as Attachment 3. The agenda and the attendance list are provided as Attachments 4 and 5, respectively.

Copies of the presenters' slides are provided as Attachment 6. Highlights from the Technical Exchange and Management Meeting are listed below.

Highlights

1) Technical Discussion of Climate Change and Hydrologic Effects of Climate Change

Climate Change Subissue

A summary of the current status of resolution was presented (see attachment on "Unsaturated Zone (UZ) Flow Under Isothermal Conditions" by Claudia Newbury). There are six acceptance criteria; five of which are considered closed both in the NRC USFIC Issue Resolution Status Report (IRSR) and by the DOE. The sixth acceptance criterion pertains to QA and was determined to be outside the scope of the meeting and will be tracked in NRC's ongoing review of DOE's QA program. DOE presented its current approach to climate change (see attachment on "Unsaturated Zone (UZ) Flow Under Isothermal Conditions: Climate Change and Hydrologic Effects" by Claudia Newbury). DOE's approach to future climate for the Site Recommendation (SR) is based on paleoclimate data. No expert elicitation will be used and no additional work is planned for a potential License Application (LA). They use three future climate states (i.e., modern, monsoon, and glacial transition) based on analog climate sites. The DOE SR approach is different than that used in their Viability Assessment (VA), but is acceptable. Questions by Center for Nuclear Waste Regulatory Analyses (CNWRA) and NRC staff focused on predictions of climate states and the infiltration used for periods beyond 10,000 years. A glacial transition is assumed after 2000 years from present. NRC staff concluded that they had no further questions and that the subissue remains closed.

Hydrologic Effects of Climate Change

A summary of the current status of resolution was presented (see attachment on "Unsaturated Zone (UZ) Flow Under Isothermal Conditions" by Claudia Newbury). There are five acceptance criteria; four of which are considered closed both in the NRC USFIC IRSR and by DOE. The fifth acceptance criterion pertains to QA and was determined to be outside the scope of the meeting and will be tracked in NRC's ongoing review of DOE's QA program. DOE presented its current approach to hydrologic effects on climate change (see attachment on "Unsaturated Zone (UZ) Flow Under Isothermal Conditions: Climate Change and Hydrologic Effects" by Claudia Newbury). DOE's SR approach assumes a rise in the water table of 120 meters [(documented in the Unsaturated Zone Process Model Report (PMR)]. No expert elicitation will be used and no additional work is planned for a potential LA. NRC staff indicated that information obtained from the Nye County wells suggests that DOE's approach is acceptable, but conservative. NRC staff concluded that they had no further questions and that the subissue remains closed.

2) Technical Discussion of Present-Day Shallow Infiltration

A summary of the current status of resolution was presented (see attachment on "Unsaturated Zone (UZ) Flow Under Isothermal Conditions" by Claudia Newbury). There are six acceptance criteria; five of which were previously considered closed by both NRC and DOE. The sixth acceptance criterion pertains to QA and was determined to be outside the scope of the meeting and will be tracked in NRC's ongoing review of DOE's QA program. Although DOE proposed that the subissue should remain closed, their estimates of shallow infiltration have been revised

downward since TSPA-VA, thus prompting NRC to reexamine the status of resolution. In addition to discussing the acceptance criteria DOE indicated that NRC still had questions. DOE presented its current approach to estimating shallow infiltration for present and future climate conditions (see attachment on "Estimated Shallow Infiltration..." by Joe Hevesi). NRC staff expressed concern that DOE upper-bound estimates of shallow infiltration for present and future climates may not be high enough to encompass the uncertainty inherent in the many infiltration model parameters and assumptions. NRC staff indicated that one acceptable approach would be to perform Monte Carlo analyses, similar to that performed for the glacial transition climate in the Analysis of Infiltration Uncertainty AMR (ANL-NBS-HS-000027), and base upper-bound infiltration estimates for each climate state on, for example, the upper 90th percentile. DOE staff proposed that another acceptable approach would be to provide additional model validation through an analysis of site geochemical, isotopic, and borehole temperature data. At the end of the meeting, DOE provided an Action Plan for the open net infiltration issues (See Attachment 2). The NRC stated that the subissue remains open pending its review of a DOE plan and schedule that provides additional justification that the proposed infiltration values are appropriate. This plan is to be provided during October 2000. The NRC also stated that, if the DOE approach is acceptable, this subissue will be considered as closed-pending at the November 2000 saturated zone meeting.

3) Technical Discussion of Matrix Diffusion

A summary of the current status of resolution was presented (see attachment on "Unsaturated Zone (UZ) Flow Under Isothermal Conditions" by Claudia Newbury). Currently NRC considers the subissue open and DOE proposed that the subissue should be closed "pending." There are four acceptance criteria; one of which is considered closed both in the NRC USFIC IRSR and by DOE. One acceptance criterion relates to the saturated zone and is not applicable to this meeting. The third acceptance criterion requires that if credit is taken for matrix diffusion then the transport predictions must be consistent with site geochemical and isotopic data. The fourth acceptance criterion pertains to QA and was determined to be outside the scope of the meeting and will be tracked in NRC's ongoing review of DOE's QA program. In addition to discussing the acceptance criteria DOE indicated that NRC still had three questions regarding matrix diffusion. DOE presented evidence to support its current approach to matrix diffusion (see attachment on "Matrix Diffusion" by Clifford Ho). Data from the Alcove 1 seepage experiments were presented with the conclusion that observed breakthrough of the bromide tracer was difficult to explain without assuming a relatively high rate of matrix diffusion (i.e., effective matrix diffusion coefficient of 2×10^{-9} m^2/s). It should be noted that the bromide breakthrough data available for review in the supporting AMR (MDL-NBS-HS-000006) consisted of only two data points representing the only very early part of the tracer breakthrough curve. However, Hui Hai Liu presented recent data and model results covering a two-year time period that yielded a similar conclusion. Data and model results were also presented by DOE that showed the conceptual model of matrix diffusion in the UZ is not inconsistent with observations of chloride concentration in matrix pore waters in the ESF and ECRB. DOE also presented plans for additional testing specifically designed to validate the matrix diffusion conceptual model wherein tracers will be introduced into ECRB Alcove 8 and monitored 20 m below in ESF Niche 3. NRC staff concluded that this subissue could be considered "closed, pending" if the DOE could agree to (i) provide an analysis with the Site Recommendation showing TSPA model sensitivity to matrix diffusion in the UZ, (ii) provide for NRC comment a work plan for the Alcove 8/Niche 3 study, and (iii) document results of the Alcove 8/Niche 3 study pertaining to matrix diffusion in AMR or other DOE-approved document.

4) Technical Discussion of Deep Percolation - UZ Flow and Transport Beneath the Repository

A summary of the current status of resolution was given in two presentations (see attachments on “Discussion of Deep Percolation - Seepage Into Drifts” by Joe Wang and “Discussion of Deep Percolation - Unsaturated Zone Flow” by Bo Bodvarsson). Currently NRC considers the subissue open and DOE proposed that the subissue should be closed-pending. There are six acceptance criteria; one of which is considered closed both in the NRC USFIC IRSR and by DOE. The sixth acceptance criterion pertains to QA and was determined to be outside the scope of the meeting and will be tracked in NRC’s ongoing review of DOE’s QA program.

Seepage Into Drifts

The DOE presented the ongoing and planned testing and modeling activities to evaluate seepage into drifts (Slide #2). In addition to discussing the acceptance criteria DOE indicated that NRC still had a number of questions in this area. The DOE then discussed the ongoing passive monitoring and active seepage characterizations. Questions by CNWRA and NRC staff focused on the east-west drift and the need for the drift to equilibrate to pre-ventilation conditions. The NRC staff indicated one reason to continue the passive monitoring, including a drip cloth, is that this approach would allow for an evaluation of the alternate conceptual model of film flow leading to dripping under low flux conditions. The next point addressed was the need to demonstrate for all niche and alcove hydraulic tests that ventilation has not biased the test results. Details on niche studies which attempt to overcome ventilation effects were discussed. The relative importance of micro-fractures on matrix porosity interpretations and concepts of flow was presented by M. Morganstern (Consultant to Nye County). The importance of measuring effects of ventilation in all testing, as is now being conducted in some tests, was mentioned by NRC staff. The use of natural analogs to support short term predictions of long-term seepage estimates was addressed. Finally, results from recent testing in the lower lithophysal unit indicate that the unit has stronger capillarity and higher permeability than middle nonlithophysal tuff. Detailed fracture surveys, where the cutoff for mapping features was 10 cm, support the measured permeability. As a result of measured hydrologic characteristics the predicted seepage threshold for the lithophysal unit is higher than in other units. The next point of discussion was evaluation of the steady-state deep percolation assumption. Information on seepage calibration models matching a sequence of pulses was offered as one line of evidence that the effects are already considered. The importance of the Paintbrush Tuff non-welded unit in damping transient effects was also offered as a line of evidence why transient effects do not need to be considered. NRC staff pointed out the importance of potential high angle fault features that intersect the unit as a way to bypass the dampening effect. In addition, preliminary results by CNWRA staff applying the approach used in the Technical Basis Document for the Viability Assessment indicated that transient effects may not be completely dampened. The next point discussed was the analysis of alternate scenarios of waste-package or drip shield wetting over the performance period. DOE indicated that alternative scenarios are being performed for the TSPA-SR. The final point of discussion was that the effect of drift collapse on seepage rates should account for the scale of asperities in drift geometry caused by rockfall. Information was provided that the effects of both rockfall and drift collapse are being evaluated. CNWRA staff stressed that the scale of those studies is not sufficiently small to address the technical concern. Scales comparable to the inverse van Genuchten alpha parameter are appropriate, so that seepage would not be under-predicted for small scale asperities. During the summary of this topic the importance of the discrepancy between the observation of secondary mineralization in lithophysal cavities at fluxes below the seepage threshold was discussed. The CNWRA staff suggested that this was evidence for the

alternate conceptual model of film flow under low flux conditions and this line of evidence of alternate approach needs to be reconciled.

Unsaturated Zone Flow

The importance of the calibrated properties model to derive parameter sensitivities and uncertainties used in modeling unsaturated flow fields was presented. The chloride and temperature calibrations were described as important constraints on infiltration rates. Perched water calibrations were addressed. The water potential data from the cross-drift was presented. Discussion of the information focused on how different conceptual models of flow (dual permeability and the active-fracture) might lead to different interpretations for matrix saturations. Additional information on the effective damping of episodic transient pulses of surface infiltration was presented and the importance of varying properties sets was discussed. The CNWRA reservations on transient events, presented in the previous discussion on the seepage, were re-iterated. Flow patterns and lateral diversion in the Calico Hills non-welded unit was the next point of discussion. The average quantity of water laterally diverted in DOE models which would then flow down faults and bypass sorptive units was presented. The average value was 50 percent for glacial transition conditions and a lower percent under current climate conditions. CNWRA staff indicated that information only on averages for the whole model was insufficient to assess the current approach. The fraction of diversion under the repository and ranges of diversion in different portions of the model was necessary for the CNWRA assessment. The amount of credit for retardation of radionuclide transport was stated to be highest for the lowest Topopah Spring unit, less for the vitric non-welded portion of the Calico Hills, and still less for the zeolitic Calico Hills unit. CNWRA staff indicated that the information on the geochemistry of perched water, and the pore water adjacent to the perched zones, was not addressed in the presentation and may not be in an analysis and model report (AMR). NRC staff stated that this information is needed to complete their assessment of DOE's approach for flow beneath the repository. The NRC staff stated that the subissue is closed-pending if the DOE would agree to the items listed in Attachment 1.

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

The DOE stated that it was revising the FEPs AMR and would have it completed by December 2000. Following the FEPs AMR revision, the DOE stated that it would revise the FEPs database. The DOE also stated that it was developing a FEPs cross-walk between the UZ FEPs and the USFIC KTI.

The NRC staff stated that two specific FEPs may need to be added to the list of FEPs considered by DOE. Linda Lehman's (consultant to State of Nevada) discussion of the potential for lateral flow in the Topopah Spring tuff resulting from infiltration along the eastern side of the Solitario Canyon Fault is one FEP that should be considered. The other FEP that DOE needs to consider concerns the potential for film flow occurring under low flux rates (see item number 2 under subissue 4 in Attachment 1).

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