



**UNITED STATES  
NUCLEAR WASTE TECHNICAL REVIEW BOARD**

2300 Clarendon Boulevard, Suite 1300  
Arlington, VA 22201-3367

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Dr. Peter B. Lyons  
Assistant Secretary for Nuclear Energy  
U.S. Department of Energy  
1000 Independence Avenue, SW  
Washington, DC 20585

Mr. David Huizenga  
Senior Advisor for Environmental Management  
U.S. Department of Energy  
1000 Independence Avenue, SW  
Washington, DC 20585

Dear Dr. Lyons and Mr. Huizenga:

On March 19, 2014, the U.S. Nuclear Waste Technical Review Board held a public meeting in Albuquerque, New Mexico. The main topic of the meeting was the U.S. Department of Energy (DOE) Office of Nuclear Energy (NE) research and development (R&D) activities related to salt as a geologic medium for disposing of spent nuclear fuel (SNF) and high-level radioactive waste (HLW). Technical experts from Los Alamos National Laboratory (LANL) and Sandia National Laboratories (SNL) presented the results of work supported by the DOE-NE Office of Used Fuel Disposition R&D on a range of salt-related topics. These topics included the technical basis for SNF and HLW disposal in salt, performance assessment (PA) modeling of a generic salt disposal system for SNF and HLW, coupled models for thermal-hydrological-chemical and thermal-hydrological-mechanical processes in a salt repository, brine migration experimental studies in salt, and the U.S./German collaboration on R&D investigations on salt as a repository medium for SNF and HLW disposal.

Because the meeting was held in New Mexico, the Board took advantage of the opportunity to learn about the experience gained in the development and operation of the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico, that might inform consideration of salt as a geologic medium for the disposal of SNF and HLW. A DOE Office of Environmental Management (DOE-EM) Carlsbad Field Office staff member discussed lessons learned from managing remote-handled radioactive wastes at WIPP and from past "generic" heater tests at WIPP that may be relevant to SNF and HLW disposal in salt. In addition, a former Director of the New Mexico Environmental Evaluation Group (EEG), which conducted independent technical evaluations of WIPP from 1978 to 2004, reviewed the history of the development of the WIPP project and discussed technical issues relevant to the construction of a repository for SNF and HLW in salt.

After discussing and evaluating the information presented at the meeting, the Board has a number of specific comments and recommendations related to the individual presentations that are recorded in the body of this letter. In addition, the Board offers three broader observations and recommendations below based on issues that cut across the presentations.

### **General Observations**

- The Board is impressed with the advances that DOE has made in modeling coupled processes, but believes this program would benefit from a closer coordination of effort between the national laboratories. *The Board recommends that DOE develop a framework for bringing together the different modeling groups to encourage model comparison, integration, and computational performance improvement, which are essential elements for further advances in understanding coupled processes and in increasing confidence in these models for repository site performance evaluation.*
- The Board also was impressed with the large number of published experimental studies that have been conducted in underground salt mines and repositories in the U.S. and other countries, the results of which were summarized comprehensively in one of the presentations. *Consequently, the Board recommends that DOE continue its efforts on coupled-process model validation using published laboratory and in situ field-scale test data.*
- Overall the presentations emphasized the potentially positive qualities of salt as a geologic medium for SNF and HLW disposal. The Board notes that there may be potential disadvantages associated with locating a repository for SNF and HLW in salt, such as inadvertent human intrusion due to exploration for natural resources (e.g., oil and gas), brine migration along clay seams, and accelerated plastic flow due to the presence of heat-generating waste. *The Board recommends that attention be given to these factors in order to ensure a balanced evaluation of the performance of salt as a medium for a geologic repository.*

### **DOE-NE Presentations**

Dr. Kristopher Kuhlman (SNL) made a presentation on the technical basis for SNF and HLW disposal in salt. The presentation was very informative in that it summarized the large number of *in situ* studies in salt that previously were undertaken in the U.S. and other countries, mostly during the 1960s through the 1990s. These studies provide a wealth of data for understanding, modeling, and benchmarking the behavior of salt, including mechanical behavior, in a thermal field. The Board was impressed with the extent of the data already available for salt as a medium for geologic disposal. However, the conclusion of the talk indicated the need for data on bedded salt with waste canisters emplaced on the drift floor and covered by crushed salt backfill. *Because this emplacement strategy is one that DOE may study for SNF and HLW disposal in a U.S. repository in salt, the Board recommends collecting such in situ test data.*

Dr. Florie Caporuscio (LANL) described experimental studies on brine migration in salt under a thermal gradient and on thermal dehydration of accessory clay and sulfate minerals

present in salt deposits. He also showed videos of liquid and gas-phase migration in single salt crystals under a thermal gradient. The phenomenon of brine migration by the movement of fluid inclusions up the thermal gradient was recognized many decades ago and is well documented in the literature as far back as the 1960s. In order to advance the understanding of how this would affect the performance of a salt repository, it seems appropriate to consider issues, such as the maximum amount of brine that might accumulate around a waste package as a result of fluid inclusion migration or mineral dehydration and whether any field studies have monitored migration of brine inclusions. *The Board recommends that issues of brine migration and accumulation around waste packages be addressed by initially making relatively simple calculations of the amount of water that might accumulate around a waste package due to fluid inclusion migration within the thermal gradient of a waste package.*

Dr. Philip Stauffer (LANL) described efforts to simulate coupled thermal–hydrological–chemical processes occurring within a reference HLW repository in bedded salt. The simulations used the Finite Element Heat and Mass transfer (FEHM) code, a porous-medium flow and mass-transport simulator for multiphase thermal problems that was developed at LANL. FEHM simulations were described for a generic waste disposal concept in which canisters are emplaced on the drift floor and then covered by run-of-mine salt backfill. The simulations investigated the effects of backfill saturation, backfill porosity, clay content of the salt, and heat load on in-drift temperature, porosity, and saturation. The Board considers this work to be well done, and the information presented indicates that the FEHM code will be useful in providing insights into the dominant heat and mass transport processes resulting from disposal of SNF and HLW in bedded salt. *The Board recommends expanding the application of the FEHM code to evaluate other processes, such as the effects of thin clay beds within “intact” salt on fluid and heat transport.*

Dr. Guadalupe Argüello (SNL) discussed an ongoing effort to develop a capability to simulate coupled thermal–hydrological–mechanical processes in a HLW repository in salt. The effort involves adapting for geologic repository applications the SIERRA Mechanics code suite, which is a family of finite-element, multiphysics codes developed at SNL as a simulation tool to support U.S. nuclear weapons stockpile stewardship. Dr. Argüello also described the current collaboration between DOE and German investigators to study the thermo-mechanical behavior and sealing/healing of salt and provided examples of comparisons between field data from the Asse salt mine in Germany and simulation results. He also described a scoping thermal–mechanical simulation using SIERRA Mechanics that evaluated room closure in a generic HLW salt repository. *The Board commends DOE for the significant progress that has been made in developing a state-of-the-art thermal–hydrological–mechanical model for repository applications and urges the group to continue its efforts in model improvement, including incorporation of thin clay beds that can have significant impact on mechanical performance, and, most importantly, in model validation using field data available from U.S. and international sites.*

Dr. David Sevougian (SNL) described the development of a PA modeling and analysis capability. He also explained the PA methodology (including analysis of features, events, and processes) and the PA code construction and capabilities. As there is no site-specific or design-specific information available for a U.S. repository in salt, Dr. Sevougian discussed the results of

applying the PA code to a generic salt repository reference case. The generic PA analysis, however, did not include consideration of the potential consequences of human intrusion. As salt bodies often are located in regions rich in resources such as oil and gas, the potential for release of radionuclides from a repository as a result of human intrusion also is critically important. Other potential problems related to disposal in salt of SNF and HLW that were not included in the PA analysis include the ingress of water from sources external to the salt body, as has occurred at the Asse site in Germany, as well as the presence of pressurized brine pockets, such as those that have been found in the Castile Formation that underlies the WIPP repository. Critical issues in this regard are the cumulative volume, distribution, and properties of all the brines associated with salt deposits, from the scale of fluid inclusions to large brine pockets. *The Board recommends that the issues of human intrusion and ingress of water from sources external to the salt body be included also in a PA analysis of SNF and HLW disposal in salt.*

Dr. Frank Hansen (SNL) described the accomplishments and ongoing activities of the U.S./German collaboration on R&D investigations related to salt as a repository medium for HLW disposal. Dr. Hansen explained that U.S. and German collaboration on research, development, and demonstration activities over nearly 50 years has contributed to the comprehensive knowledge and sound expertise in salt repository science and engineering. In particular, noteworthy progress has been made on safety assessments for heat-generating waste disposal and multiphysics modeling to capture physical processes using the next generation of computational capabilities. The Board commends this collaboration in salt repository science with German investigators and other international groups such as the Salt Club, which also includes Poland and the Netherlands. The Board believes this collaboration can help DOE leverage many of its ongoing efforts, particularly the testing and modeling of WIPP salt. Drs. Hansen, Kuhlman, and Argüello discussed in their presentations the various tests that have been conducted at the Asse mine in Germany, but did not mention the flooding that has occurred there. *The Board recommends that information on the flooding that has occurred at the Asse site should be evaluated for any lessons that can inform the consideration of salt as a geologic medium for SNF and HLW disposal.*

## **DOE-EM Presentation**

Within the scope of lessons that could be learned related to a repository for SNF and HLW in salt, Dr. Abe Van Luik (DOE Carlsbad Field Office) discussed the method of emplacement of transuranic waste at WIPP. Presently, remote-handled wastes are emplaced in pre-drilled boreholes in disposal room walls and the boreholes are then plugged with concrete shields. Using this method, the handling of one canister takes ten to twelve hours from receipt to emplacement. Also, the large equipment used to emplace the remote-handled waste blocks access to the drift, which prevents the emplacement of contact-handled waste in the open area of the same room. Because the volume of contact-handled waste that requires disposal is much greater than that of remote-handled waste, some of the boreholes for remote-handled wastes have had to be passed over and have gone unused. Dr. Van Luik indicated that DOE is looking at disposing of remote-handled waste in disposal rooms dedicated to this waste type using a simpler and more efficient single-pass mining and emplacement method. Using this method, a disposal room would be opened, remote-handled waste would be emplaced on the floor, and then the room would be backfilled with run-of-mine salt. The next disposal room would be opened only

after backfilling of the preceding one has started. DOE is currently considering requesting permission from the Environmental Protection Agency and the State of New Mexico to use this new emplacement method at WIPP.

Dr. Van Luik also described the heater tests that were conducted in the 1980s at WIPP, which served as a surrogate for the Deaf Smith County, Texas site that at the time was being considered as a potential site for a SNF and HLW repository. The heater test results indicated that emplacement of heat-generating waste in vertical boreholes causes a steep and very localized temperature and pressure gradient to form and brine to flow into the borehole. The brine inflow was due to the pressure gradient, and the brine came from the dehydration of water-bearing clays that are interbedded with the salt. Dr. Van Luik indicated that the pressure gradient that drives brine flow can be reduced by emplacing the waste on the disposal room floor in such a way as to not cut across the clay beds. He concluded that the operational and heater test experiences at WIPP suggest that hot, higher radioactivity wastes can be disposed of safely and efficiently on a drift floor with run-of-mine salt backfill as shielding. From an operational perspective there appear to be advantages to the waste emplacement method Dr. Van Luik described. *However, the Board notes that an evaluation would be needed of whether this emplacement strategy would have any adverse impacts on the long-term performance of a SNF and HLW repository in salt.*

The Board noted that an important lesson learned from the discussion of potentially changing the emplacement method at WIPP is that during the operational phase of a geologic repository, there is still the opportunity to improve operations and, perhaps, even the long-term performance of the repository. *Thus, it is important to maintain flexibility in the design of a geologic repository and, to the extent feasible, keep options open to introduce changes after the start of operations.* This principle is important in the development of a SNF and HLW repository in any geologic medium.

### **New Mexico EEG Presentation**

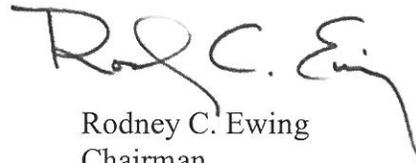
Robert Neill, Director Emeritus of EEG, provided his perspective on the history of the WIPP project and some of the technical issues that had to be dealt with during the development of WIPP as a repository. Mr. Neill emphasized that part of the success of WIPP was due to the public confidence engendered by EEG's independent evaluation of the impact of WIPP on public health and the environment. The EEG earned public confidence because it was seen as an objective, independent organization that represented the interests of the State of New Mexico. EEG published 90 reports on its analyses, made presentations at public and professional meetings, testified before the State legislature and the U.S. Congress, and encouraged its staff to play key roles in professional societies. Mr. Neill also stated that WIPP benefited from the strong support of local officials and from the commitment of the governor and the State legislature to give the project a fair review. He discussed some of the technical issues that came up during EEG's review of the WIPP project, including the need to consider the implications of the brine reservoir that was found underneath the WIPP site, mineral dissolution, and breccia pipe formation. Mr. Neill also made some observations related to SNF and HLW disposal in the U.S.

## Public Discussion

At its meetings, the Board always provides the opportunity for members of the public to comment on issues of concern related to the management and disposal of SNF and HLW. As anticipated by the Board, there was also considerable public interest at the meeting in the status of DOE activities related to the release of radioactivity from the WIPP repository on February 14. Several members of the public commented that by not having a spokesperson attend the meeting, DOE missed an opportunity to provide an update on the situation at WIPP and to respond to questions on this topic, about which many people were keenly interested.

The Board appreciates the efforts of DOE-NE and DOE-EM to prepare detailed technical presentations, and we thank all for their participation in the meeting. We look forward to continuing our ongoing review of DOE's technical activities related to managing and disposing of SNF and HLW.

Sincerely,

A handwritten signature in black ink that reads "Rodney C. Ewing". The signature is written in a cursive style with a long, sweeping tail on the final letter.

Rodney C. Ewing  
Chairman