UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD
2300 Clarendon Boulevard, Suite 1300
Arlington, VA 22201

January 29, 2014

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

Dear Dr. Lyons:

The U.S. Nuclear Waste Technical Review Board appreciates the participation of U.S. Department of Energy (DOE) Office of Nuclear Energy (NE) officials and technical experts from the national laboratories in the Board's public meeting held in Washington, D.C., on November 20, 2013. The major topics discussed at the meeting were DOE-NE's research and development (R&D) activities being supported by the Office of Used Fuel Disposition R&D (NE-53) and studies on advanced separations and waste form technologies being supported by the Office of Fuel Cycle R&D (NE-52). The presentations by DOE personnel provided the Board with a solid overview of many of the activities being undertaken by DOE-NE, while supplementary information provided by Dr. Monica Regalbuto at various points throughout the meeting was especially helpful in addressing questions that were raised.

The Board also thanks you and the other DOE officials and technical experts who participated in the "Technical Workshop on the Impacts of Dry-Storage Canister Designs on Future Handling, Storage, Transportation, and Geologic Disposal of Spent Nuclear Fuel in the United States," which preceded the Board meeting. The Board considers the disposition of spent nuclear fuel (SNF) in dry-storage systems to be an important issue that requires DOE's continuous attention. The Board is preparing a report on the subject matter of the workshop that it plans to publish in 2014.

This letter conveys Board comments and recommendations related to the DOE activities discussed at the November 20 public meeting.

Activities Sponsored by the Office of Used Nuclear Fuel Disposition Research and Development

Three topics were discussed at the meeting:

- Experiments and a field demonstration to collect data on the properties of high-burnup SNF and storage systems during long-term dry storage
- Evaluation of SNF and high-level radioactive waste (HLW) inventory and waste form/disposal options
- Integrating standardization of SNF and HLW canister system design into the nuclear waste management system

Experiments and a field demonstration to collect data on the properties of high-burnup SNF and storage systems during long-term dry storage

Almost all the fuel that is being discharged from U.S. nuclear power plants today, and that which will be discharged in the future, is high-burnup SNF [irradiation levels greater than 45 gigawatt days per metric ton uranium (GWD/MTU)]. This high-burnup SNF likely will be stored in dry-storage canisters at commercial nuclear utility sites for decades. Dr. Michael Billone's presentation on laboratory testing of high-burnup fuel cladding alloys provided useful data on the properties of high-burnup fuel cladding. However, apparently due to funding limitations, the tests he described were limited in scope and number, were spread over a broad range of experimental conditions, and had not been repeated to investigate statistical variations in the results for the same set of conditions. These factors may limit the usefulness of the test results as the basis for predicting changes in cladding performance during transport after extended storage. Consequently, the Board encourages DOE to consider both how it can extend the work it is supporting in this area, for example by conducting more tests using cladding samples irradiated in research reactors to study the impact of high burnups, and how it can gain access to the results of work that has been done in this area by other national and international R&D programs.

During his presentation, Dr. Billone indicated that the nuclear industry has a substantial amount of additional data on the characteristics of high-burnup fuel (e.g., fuel rod end-of-life internal gas pressures that determine cladding hoop stresses, and cladding oxide-layer thickness and hydrogen pickup), but these data generally are proprietary and not currently accessible to DOE. The Board is pleased that Dr. Billone is working on projects with the nuclear industry that enables him to obtain additional data on these properties. However, given the importance of understanding how high-burnup fuel and cladding properties could change during prolonged periods of SNF storage, the Board encourages DOE to focus particular effort on gaining access to more data from the nuclear industry related to this issue.

The Board commends DOE for initiating the "Cask Demonstration Project (CDP)," presented by Dr. William Boyle, which is intended to provide much needed data on changes in the properties of high-burnup fuel and potential degradation of storage system materials during dry storage. However, the Board is concerned that the CDP does not include a more extensive program of monitoring and testing SNF and dry-storage systems during extended storage. Following the decommissioning of the Test Area North Hot Shop at the Idaho National Laboratory, DOE has no facility that can be used to open a dry-storage cask or canister in a dry environment (i.e., without submersion in a water pool) to inspect SNF following a period of dry storage. The CDP assumes the availability of such a facility, but not until ten years after the fuel has been loaded into a cask at the North Anna site, i.e., in about the year 2026. The Board recommends that DOE make it a priority to develop a more extensive program to inspect and examine, using advanced analytical techniques, the condition of SNF with a range of designs, burnups, and storage histories and establish the capability to open large dry-storage casks and canisters in a dry facility, possibly at the Idaho National Laboratory as indicated in the report "*Viability of Existing INL Facilities for Dry Storage Cask Handling*" [FCRD-UFD-2013-000027]. The Board also urges DOE to increase its R&D efforts to develop sensors and instrumentation that can operate in the extreme environments that exist in storage systems so that

additional data on the condition of SNF and dry-storage systems can be collected over long storage periods.

Evaluations of SNF and HLW inventory and waste form/disposal options

The presentations by Dr. David Sassani and Dr. Peter Swift described work that DOE is doing to evaluate the attributes of potential geologic media that might be suitable for the disposal of the full inventory of SNF and HLW waste forms. However, the Board felt the waste form/disposal options evaluation lacked the in-depth analysis that would be expected from a study involving 44 individuals from 14 organizations. The final outcome of this exercise seems to indicate that the three host rock types considered for a mined geologic repository (salt, crystalline rock, and clay/shale) show similar performance, which the Board found to be surprising and questionable. At this point, the waste form/disposal options evaluation is based on qualitative metrics and appears to not address a number of issues: (1) temperature dependence of corrosion rate and mechanism for different waste forms, (2) matching waste forms to geochemical conditions in order to improve waste form performance, and (3) matching waste form performance to the half-life and radiotoxicity of different waste streams. Perhaps a useful and objective approach to improving this evaluation would be to analyze in more detail the results available in other countries: (1) Sweden for granite, (2) France and Switzerland for clay, and (3) Germany for salt. It also would have been interesting to compare the performance assessment results for each of the different geologies for a single waste form (most importantly SNF).

Given the considerable effort that went into assessing an unsaturated site in volcanic tuff at Yucca Mountain, the Board suggests that relevant results from that work should be included in the current evaluation to increase the range of the study. In addition, the Board encourages DOE to make the SNF and HLW inventory data available to the public in a more accessible format, for example in spreadsheet form.

According to Dr. Sassani's presentation, DOE's sodium-bonded fuel currently does not have a clear path for disposition. As you know, the Board is preparing a report on the management of DOE's SNF and will clarify its understanding of the potential disposition options for this fuel with DOE's Office of Environmental Management.

DOE's position with regard to the potential use of deep borehole disposal remains unclear based on the presentations and recent DOE documents. In Dr. Boyle's overview of the NE-53 R&D program, he described DOE's R&D program related to developing deep borehole disposal technology and suggested it may be used for disposal of *both SNF and HLW*. However, Dr. Swift's presentation indicated that DOE's waste form/disposal options evaluation suggests that emplacing SNF and HLW at depths of from 3 to 5 km beneath the surface is not operationally feasible because of the size of the disposal containers. The study concluded that deep borehole disposal would not be possible for large size waste packages (e.g., existing vitrified HLW containers and commercial SNF in dual-purpose canisters) and, in other cases, significant modification of waste forms would be required (e.g., rod consolidation for SNF or redesign of canisters for HLW). Prior to embarking on an expensive, full-scale demonstration, it would be prudent to have an explicit understanding of the types of waste that are realistic candidates for deep borehole disposal.

As you know, the Board provided recommendations and an updated factsheet on deep borehole disposal in its July 30, 2013, letter to you. The Board will continue to follow with great interest the deep borehole disposal R&D plans, such as described in "*Deep Borehole Disposal Research: Demonstration Site Selection Guidelines, Borehole Seals Design, and RD&D Needs*" [FCRD-USED-2013-000409] and in "*Research, Development, and Demonstration Roadmap for Deep Borehole Disposal*" [FCRD-USED-2012-000269]. At present, it appears that the current plan does not address many of the technical concerns expressed by the Board or issues raised in other critical reviews of deep borehole disposal. For example, the plan does not present the rationale for using a full-scale borehole for testing seals rather than an incremental approach beginning with laboratory-scale tests and does not indicate why the potential test program does not include drilling a pilot borehole, which was a unanimous recommendation of the drilling engineers involved in the deep borehole disposal workshop sponsored by Sandia National Laboratory in January 2013. According to the evaluation presented by Dr. Swift, deep borehole disposal has no real prospect of replacing mined geologic disposal of SNF and HLW, but it could be used to dispose of a limited class of waste forms. Thus, the use of deep borehole disposal should be expected to increase the total cost of the U.S. nuclear waste disposal program, rather than offsetting some of the cost of disposal in a mined repository. Consequently, the Board believes that DOE activities related to evaluating the potential of deep borehole disposal should not divert funding or technical effort away from work related to the storage of SNF and the development of a deep geologic repository. If DOE envisions that deep borehole disposal might be appropriate for some small volume, "niche" waste, then any borehole research program should be designed with disposal of that waste form in mind and justified on the basis of a cost-benefit and safety analysis.

Integrating standardization of SNF and HLW canister system design into the nuclear waste management system

The Board was encouraged by the effort described in Dr. Joshua Jarrell's presentation on integrating standardization into the nuclear waste management system. As you know, the Board supported the development of the transportation-aging-disposal canister for the proposed Yucca Mountain repository, and it believes now, as it did then, that the use of standardized canisters potentially may have important advantages related to safety, handling, system simplification, and cost savings. The Board strongly supports the work DOE has initiated to draw on the perspective and experience of the nuclear industry, including the cask vendors, in developing a standardized approach and looks forward to receiving further information and updates on this work as it progresses.

Activities Sponsored by the Office of Fuel Cycle Research and Development

Mr. Andrew Griffith provided an overview of NE-52, including its mission, near- to long-term program objectives, and R&D activities related to materials recovery and waste forms. However, it was not clear from Mr. Griffith's presentation how DOE establishes R&D priorities to guide the allocation of its limited funding in this area. For example, the presentation on developing the technology for uranium separation from seawater was technically interesting but, given the significant challenges facing DOE (e.g., investigating how the characteristics of high-burnup SNF change during extended periods of dry storage), and the abundance of uranium that is readily available for extraction using conventional technologies at reasonable cost, it is

difficult for the Board to understand why separating uranium from seawater should be a high priority. The Board recommends that the DOE Fuel Cycle Technologies R&D program establish its priorities based on work needed to provide information on the most important issues related to managing and disposing of SNF and HLW.

Mr. Griffith highlighted DOE's support of university research through its Nuclear Energy University Program (NEUP). The Board believes that NEUP is an extremely important investment that aids in leveraging DOE funding to make technical progress and in educating the next generation of nuclear science and technology researchers. The Board strongly endorses DOE's continued support of this program.

Thank you again, on behalf of the Board, for your participation and the participation of DOE-NE staff and technical experts from the national laboratories at our November meeting and the workshop held the same week. We look forward to continuing our ongoing review of DOE's technical activities related to managing and disposing of SNF and HLW.

Sincerely,

{Signed by}

Rodney C. Ewing
Chairman

cc:
Mr. D. Huizenga, DOE-EM