



## Department of Energy

Washington, DC 20585

August 21, 2023

Dr. Nathan Siu  
Chair  
Nuclear Waste Technical Review Board  
2300 Clarendon Boulevard  
Suite 1300  
Arlington, VA 22201-3367

Dear Dr. Siu,

The U.S. Department of Energy's (DOE) Office of Nuclear Energy appreciates your letter of December 14<sup>th</sup>, 2022, which summarized the Nuclear Waste Technical Review Board's 2022 Summer Meeting. In that meeting, held on September 13-14, 2022 in Arlington, Virginia, information was presented by DOE and national laboratory participants on DOE's research and development (R&D) activities related to the geologic disposal of spent nuclear fuel (SNF) and high-level radioactive waste (HLW) in argillaceous host rocks and R&D on clay-based engineered barriers.

The Board's letter provided findings and recommendations on these DOE's activities. DOE appreciates the Board's input to our program and looks forward to its future insights on DOE's activities related to the management and disposal of SNF and HLW.

The enclosure provides the DOE's responses to the Board's specific findings and recommendations. If you have any questions on the responses, please contact Timothy Gunter at [timothy.gunter@nuclear.energy.gov](mailto:timothy.gunter@nuclear.energy.gov).

Sincerely,

A handwritten signature in black ink that reads "Kathryn Huff". The signature is fluid and cursive.

Kathryn Huff  
Assistant Secretary  
For Nuclear Energy

Enclosure

## **U.S. Department of Energy (DOE) Response to the Nuclear Waste Technical Review Board (NWTRB) Report from the NWTRB 2022 Summer Meeting**

### **NWTRB findings and recommendations, and DOE responses:**

#### **Board Comment #1:**

*The Board finds that DOE has a technically valid approach to developing its modeling capability that will enable it to evaluate the post-closure performance of a potential SNF and HLW repository in an argillaceous host rock.*

*The Board encourages DOE to continue its R&D efforts related to argillaceous host rocks and clay-based engineered barriers, including leveraging the experience of disposal programs in other countries.*

#### **DOE Response #1:**

Investigations of deep geologic disposal in argillaceous host rocks, and clay-based engineered barriers, are fundamental components of the DOE Spent Fuel and Waste Science and Technology (SFWST) disposal research program and are planned to continue. These activities necessarily leverage the experience and expertise developed in international disposal research efforts. The SFWST R&D program, combined with international collaboration in related research areas, brings to bear a broad and multi-faceted range of expertise and experience to the DOE disposal research program.

#### **Board Comment #2:**

*The Board finds that DOE has not clearly articulated the progress of its R&D activities related to argillaceous host rocks and clay-based engineered barriers toward achieving its program objectives and addressing the technical gaps.*

*The Board recommends that DOE assess the overall progress of its R&D activities relative to achieving the stated objectives and addressing the identified technical gaps and how each R&D task contributed to understanding processes in the natural and engineered barrier systems and to developing DOE's argillite reference case. This self-assessment could also serve as a tool for knowledge management and for clear and effective communication on its disposal options, including disposal in argillaceous rocks. Ongoing and future assessments could help refine the focus of DOE's R&D activities documented in the disposal R&D 5-year plan.*

#### **DOE Response #2:**

Since the end of fiscal year 2022, a concerted effort has been made to more clearly articulate progress made, significance of activities undertaken, outstanding technical challenges, and prospective work in major SFWST work package milestone reports. Going forward, major milestone reports will contain a more detailed Executive Summary section that includes an Executive Summary abstract. This abstract will describe the importance of the corresponding work, accomplishments for the most recent year, key

findings of the work, and future R&D activities envisioned for both the near and far-term. For milestones with limited scope, the abstract may be the entire Executive Summary. For milestones with extensive scope and/or results, the body of the Executive Summary will cover further details of the work executed and results accomplished. The development and rollout of the milestone report abstract in the Executive Summary is due to a request from DOE-NE leadership that such a detailed abstract be included in major milestone report deliverables. It also results in part from a comment from the NWTRB at the July 2022 fact-finding meeting at Sandia National Laboratories. It is the intention of the DOE that progress, importance, key findings, and prospective work are more readily apparent by the inclusion of the Executive Summary abstract in major milestone report deliverables.

The detailed summaries will be useful when research priorities, and associated resource allocations, are developed and assessed each year, and will also form a basis for the progress in control accounts reported in updates to the Disposal Research 5-year Plan. Having concise summaries of R&D activities, challenges, accomplishments, and potential future work will further enable the assessment of program progress and the development of practical research goals for the near and far-term. These aspects are expected to prove useful, particularly for activities supporting disposal research in argillaceous rocks and clay-based engineered barriers.

### **Board Comment #3:**

*The Board finds insufficient integration between DOE activities related to consent-based siting of federal consolidated interim storage facilities and those related to geologic disposal.*

*The Board recommends integration of DOE activities related to consent-based siting of federal consolidated interim storage facilities and those related to geologic disposal to enable effective public and stakeholder engagement.*

### **DOE Response #3:**

The work being done in DOE's Disposal R&D program assumes that a geologic disposal facility is an integral part of any waste management program, supports the future use of a consent-based siting approach for future siting of a geologic disposal facility, and communicates about the ongoing R&D activities in Disposal Research. The DOE Disposal R&D program focuses on generic disposal concepts and the technical bases and constraints of these generic repository concepts to develop the tools for evaluating the post-closure safety of such systems. The SFWST Storage and Transportation R&D program and the Disposal Research R&D program maintain awareness of activities focused on consent-based siting for consolidated interim storage, both in the U.S. program and in international nuclear waste management efforts. Activities supporting the International Collaborations Disposal Research work package aim to stay abreast of approaches and outcomes in other countries so that those lessons learned can be applied to the U.S. program.

DOE management and staff leads in the Office of Integrated Waste Management (which includes Consent-Based Siting) and the Office of Spent Fuel and Waste Science and Technology (including Storage, Transportation and Disposal R&D) meet weekly or more often to maintain awareness and integrate activities between the two offices. DOE and SFWST staff are considering how consent-based siting could be adapted for siting deep geologic repositories in the future. However, because Congress has not authorized DOE to pursue consent-based siting for disposal, the primary focus currently remains on federal consolidated interim storage.

#### **Board Comment #4:**

*The Board commends DOE for recognizing the importance of URLs in training the next generation of scientists and engineers.*

*The Board recommends that DOE further consider how URLs and other DOE facilities could play a role in public information and community engagement efforts and in training programs. As DOE proceeds with its consent-based siting process for federal consolidated interim storage facilities, systematic consideration should be given to how URLs and other facilities might contribute. This should include systematically reviewing and learning from the experiences by other countries.*

#### **DOE Response #4:**

The use and leveraging of Underground Research Laboratories (URLs), both internationally and at the U.S. Waste Isolation Pilot Plant (WIPP) (a geologic disposal facility for transuranic defense waste), are fundamental aspects of the U.S. geologic disposal R&D program. DOE utilizes the WIPP facility for public outreach activities, such as tours of the site and the underground, although this can only be done in a limited fashion because site visits must be scheduled around WIPP operations. This results in somewhat limited opportunity for visits to the site by the public. But as an example, the Fall 2022 DECOVALEX (DEvelopment of COupled models and their VALidation against EXperiments) workshop held in Albuquerque, New Mexico, included a site visit to the WIPP site with a tour of the underground.

To evaluate the potential uses of a U.S. URL for geologic disposal R&D, as well as for public outreach, a new 2023 SFWST disposal research work package has been established to investigate the range of issues related to establishing a new U.S. URL. There are two components of this work package. The first component, led by Sandia National Laboratories, will evaluate the potential of a generic URL for the U.S. waste disposal program. This evaluation will include an assessment of the resource needs in establishing a URL, its maintenance requirements and operating costs once established, as well as optimal development timing for the facility within the disposal program evolution paradigm. Such a URL, located in the U.S., could prove advantageous for public outreach, communication, and information sharing.

The second component of the new URL work package, led by Lawrence Berkley National Laboratory, will consist of a detailed review of international collaborative activities in existing URLs. Although the U.S. is currently participating in numerous international URL activities throughout the world, this review will evaluate the involvement in additional URL testing and modeling activities. It will also consider primary disposal R&D benefits and associated costs, as well as ancillary benefits such as public outreach, of such additional activities.

**Board Comment #5:**

*The Board finds that additional analysis is required to clarify the relative importance of the bentonite buffer on the performance of a repository in an argillaceous host rock.*

*The Board recommends that DOE assess the performance of argillite repositories with no buffer or with a crushed host rock buffer.*

**DOE Response #5:**

Several performance assessment (PA) activities under the Geologic Disposal Safety Assessment (GDSA) framework are focused on developing a set of sensitivity analyses and virtual tracers that can be used to help quantify the performance contributions for specific Features, Events, and Processes (FEPs). GDSA evaluations could be done to quantify the performance contribution of a range of backfill/buffer materials, including crushed host rock, with respect to peak annual dose. However, because the answer would also depend to a large extent on the site-specific properties of the host rocks, with self-healing clays likely having less reliance on the bentonite buffer than a fractured brittle argillite formation, the Board's recommended assessment would be more relevant at a point where the program moves into a focus on specific sites. The primary objectives of PA development to date have been 1) adding capabilities to the PFLOTRAN model so that more FEPs are included in reference cases, 2) developing the reference cases to simulate nominal repository designs, 3) developing methods and techniques for including and propagating uncertainty in models, 4) developing sensitivity analyses for specific input parameters, and 5) performance quantification associated with specific FEPs, such as waste packages, waste forms, buffer, repository, geosphere, dispersion, decay, etc. The SFWST program is adjusting how FEPs for each generic repository concept are integrated with the R&D control accounts, defining the technical bases for each concept such that additional analyses of barrier function/reliance would be facilitated.

**Board Comment #6:**

*The Board notes that DOE previously developed additional models to represent non-Darcian flow in both argillites and bentonite buffers. The Board suggests that DOE clearly articulate the technical basis for the assumptions made in its numerical models for flow in the bentonite buffer and argillite host rock. DOE is planning to update features, events, and processes for generic repositories and the Board suggests that the applicability of Darcy's Law to low permeability media like argillites and bentonite buffers be evaluated as a part of this update.*

**DOE Response #6:**

Recent GDSA activities have supported the development of two reduced-order models in PFLOTRAN aimed at investigating the impact of fluid/rock interactions beyond traditional Darcy-law modeling. The two reduced-order models aim to represent the impact of bentonite swelling on disturbed rock zone permeability and rock-material dependent permeability for rocks that transform type (e.g., smectite to illite). Temperature-dependent capillary pressure and relative-permeability functions have also been implemented in PFLOTRAN. However, these have not yet been widely utilized in PA reference cases as their implementations are quite recent and there is significant additional computational overhead

associated with them for tightly coupled systems. An assessment of the applicability and suitability of Darcy's Law to low permeability media is a priority of PFLOTRAN FEPs analysis activities.

GDSA activities for the argillite case have been focused on the development of sensitivity analysis and uncertainty quantification for geological parameters, waste package degradation, and waste package breach time distribution.