



**UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD**

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

January 7, 2022

Dr. Kathryn Huff
Principal Deputy Assistant Secretary for Nuclear Energy
U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585

Dear Dr. Huff:

On behalf of the U.S. Nuclear Waste Technical Review Board (Board), I want to thank you and your staff, as well as the staff from the national laboratories, for supporting the Board's 2021 Fall Meeting, which was held virtually on November 3–4, 2021. The purpose of the meeting was to review information on the U.S. Department of Energy, Office of Nuclear Energy (DOE-NE) research and development (R&D) activities related to the Geologic Disposal Safety Assessment (GDSA) Framework. This letter presents the Board's observations, findings, and recommendations resulting from the meeting. The agenda, presentation materials, and an archived recording of the webcast for the meeting are posted on the Board's website at <https://www.nwtrb.gov/meetings/past-meetings/fall-2021-virtual-board-meeting---november-3-4-2021>. A meeting transcript is also available there.

The Board also thanks the staff from DOE and the national laboratories for supporting a technical fact-finding meeting, which was held virtually on October 13–14, 2021. This fact-finding meeting enabled the Board to prepare for the November 2021 public meeting.

Background

Over the past several years, DOE has been developing a modeling capability for evaluating the post-closure performance of potential repositories for spent nuclear fuel (SNF) and high-level radioactive waste (HLW). According to DOE, the suite of computational models and codes called the GDSA Framework is part of its efforts to develop a sound technical basis for evaluating geologic disposal in the United States in different host rocks and different disposal options.¹ The Board sees DOE's efforts as having the capability to address several recommendations the Board made in its Six Recommendations Report,² issued in April 2021,

¹ DOE uses the term "disposal option" to refer to the collection of specific repository features including engineered barriers, such as buffer or backfill, the type of disposal waste package, and the waste emplacement geometry (vertical or horizontal with respect to the orientation of emplacement tunnels).

² NWTRB. 2021. *Six Overarching Recommendations for How to Move the Nation's Nuclear Waste Management Program Forward*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. April.

namely, to anticipate the required high-performance computing and data management infrastructure required for a multi-decade waste management program and to facilitate application of iterative and adaptive approaches to development of a geologic repository. The Board's meeting examined DOE's R&D activities related to the GDSA Framework. Although DOE presentations in previous Board meetings have touched upon some aspects of the GDSA Framework and the Board has commented on those in Board reports or letters to DOE,^{3,4} the November 2021 meeting was an opportunity for the Board to conduct a high-level review focused on DOE's GDSA efforts.

At the meeting, the Board received a brief update from William Boyle (DOE-NE) on DOE's Spent Fuel and Waste Disposition Program. Alisa Trunzo (DOE-NE) then described DOE's current efforts on a consent-based approach to siting a federal interim storage facility for SNF, and also summarized the work DOE-NE has been conducting to prepare for an integrated waste management system. Ms. Trunzo stated that DOE is committed to a consent-based approach to siting a federal interim storage facility that fully embraces principles of openness, transparency, public engagement, equity, environmental justice, and broad participation including that of historically underrepresented groups and communities. She noted also that DOE is incorporating expertise in the social sciences and resources from the national laboratory system to help move the program forward. She stated that DOE is funding an integrated research project for up to three years and \$3 million for a university-led team to perform research that will inform how DOE implements a consent-based siting process. Further, she noted that DOE's approach is aligned with the recommendations in the Board's Six Recommendations Report for how to move the nation's nuclear waste management program forward.

The Board then heard several presentations from the national laboratory researchers who are conducting the work for DOE. These presentations included an overview of R&D activities related to developing the GDSA Framework and descriptions of several GDSA Framework components, including the multiphase flow and reactive transport code PFLOTRAN, the uncertainty quantification and sensitivity analysis code DAKOTA, the discrete fracture network model dfnWorks, the Fuel Matrix Degradation Model for commercial SNF, and a biosphere model. Other presentations by national laboratory researchers described the uncertainty and sensitivity analysis tools being applied in the GDSA Framework, the application of the GDSA Framework to generic repository reference cases in bedded salt, shale, and crystalline host rocks, and a case study in integrating insight and experience from the international community into geologic disposal safety assessments.

The Board also heard a presentation by two U.S. Nuclear Regulatory Commission (NRC) staff members and another by a representative from the Radioactive Waste Management organization in the United Kingdom (U.K.). The NRC staff members discussed their

³ NWTRB. 2020. *Filling the Gaps: The Critical Role of Underground Research Laboratories in the U.S. Department of Energy Geologic Disposal Research and Development Program*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. January.

⁴ Bahr, J.M. 2021. Board letter to Dr. Kathryn Huff with comments from December 2020 Board meeting (December 30, 2021). <https://www.nwtrb.gov/docs/default-source/correspondence/jmb028.pdf?sfvrsn=4>. (Accessed January 6, 2022)

perspectives on developing and applying performance assessment computer codes based on their collective experiences in these activities at the NRC and their participation in international programs. The U.K. representative described the development of environmental safety case models that will support geologic disposal of the U.K.'s radioactive waste.

Board Observations, Findings, and Recommendations

After discussing and examining the information presented at the fact-finding meeting and the public meeting, the Board has several observations, findings, and recommendations on DOE's program and GDSA R&D activities, which are provided below. The Board notes that all the meeting presentations were well done and addressed the questions the Board posed in the meeting agenda. A positive aspect of the meeting was hearing from a variety of staff and researchers, which the Board understands is important to DOE's efforts on knowledge management and human capacity building.

DOE's Consent-Based Process for an Interim Storage Facility

The Board commends DOE for starting a new effort on consent-based siting of an interim storage facility⁵ and for recognizing the crucial importance of effective risk communication, full public engagement, and inclusiveness in the siting process. The Board supports DOE's commitment to transparency, openness, and effectively engaging stakeholders, including historically underrepresented communities, in any consent-based siting process. The Board is pleased DOE noted that its path forward for a consent-based siting process is well-aligned with the recommendations in the Board's Six Recommendations Report.

The Board also commends DOE for its plan to support its future risk communication efforts with social science expertise. At the same time, the Board observes that a great deal of relevant knowledge and expertise on risk communication, public engagement, and inclusiveness may be found in other fields, including behavioral science and the public health sciences. The Board notes that including these other fields would provide DOE a significantly broader and stronger knowledge base upon which to draw insights and expertise. Further, the Board supports DOE funding of a university-led team to conduct research on consent-based siting as the Board believes universities are well equipped to conduct multidisciplinary research that includes experts in the social and behavioral sciences, public health, and other relevant fields, and may enhance public confidence in DOE's efforts to improve risk communication.

At the meeting, in response to a Board member comment, the DOE representative stated that DOE is open to learning from experiences in other countries on the consent-based process for siting nuclear waste facilities. The Board notes that experiences in other countries, such as Sweden, Switzerland, and Canada, suggest that effective risk communication, public engagement, and inclusiveness in the siting process can be central to the success of any siting effort. The Board is encouraged by DOE's willingness to consider international experience. Although no two countries are identical, valuable insights can be gained by reviewing siting

⁵ On December 1, 2021, DOE issued a Request for Information in the *Federal Register* (Vol. 86, No. 228) to collect comments and opinions about using a consent-based siting process to identify sites to consolidate and temporarily store the nation's SNF.

experiences elsewhere.⁶ The Board notes that as DOE further develops its strategy for communication, engagement, and inclusiveness, it would be beneficial to systematically review key lessons that have been learned from siting processes in other nations. Ideally, this should include not only a review of literature on siting experiences in other countries, but direct interaction with government agencies, stakeholder organizations, and community groups that have been part of siting processes. The Board looks forward to hearing more in the future about DOE activities in this area.

Although DOE's current effort is focused on siting an interim storage facility, the Board notes that DOE previously worked on a consent-based process for both storage and disposal facilities for SNF and HLW.^{7,8} The Board observes that strategies for effective communication, public engagement, and inclusiveness that DOE applies or develops in its current effort could be applicable to a future siting of a geologic repository for SNF and HLW.

The Board also observes that there may be lessons that could be learned from the challenges that arose with the proposal in 2016 to conduct a deep borehole experiment in Rugby, North Dakota. The Board noted in its Six Recommendations Report that this proposal encountered difficulties partly due to a lack of sufficient transparency and early engagement with the public. The Board suggests that as a follow-on to that project, DOE could do a detailed analysis of how the project was developed and the strategies for public engagement identified, and produce a candid "lessons learned" document that might be used for future consent-based siting and stakeholder engagement activities.

DOE's GDSA R&D Activities

The Board commends DOE for its R&D activities related to developing and enhancing its geologic disposal safety assessment capability. The Board notes that DOE is using state-of-the-art models, modeling approaches, and methods of analysis to develop and expand the GDSA Framework. There is a focused and excellent effort on uncertainty quantification and sensitivity analysis, which the Board believes can help increase the overall confidence in the results generated using the GDSA Framework. The Board also notes that DOE is actively applying lessons learned from the Waste Isolation Pilot Plant and Yucca Mountain projects, the international community, and publicly available sources.

- *The Board finds that DOE has a technically valid approach to developing its geologic disposal safety assessment capability that will enable it to evaluate the post-closure*

⁶ NWTRB. 2015. *Designing a Process for Selecting a Site for a Deep-Mined, Geologic Repository for High-Level Radioactive Waste and Spent Nuclear Fuel: A Detailed Analysis*. Arlington, Virginia: U.S. Nuclear Waste Technical Review Board. January.

⁷ DOE. 2016. *Designing a Consent-based Siting Process. Summary of Public Input Final Report*. December. <https://www.energy.gov/sites/prod/files/2016/12/f34/Summary%20of%20Public%20Input%20Report%20FINAL.pdf>. (Accessed January 6, 2022)

⁸ DOE. 2017. *Draft Consent-Based Siting Process for Consolidated Storage and Disposal Facilities for Spent Nuclear Fuel and High-Level Radioactive Waste*. January. <https://www.energy.gov/sites/prod/files/2017/01/f34/Draft%20Consent-Based%20Siting%20Process%20and%20Siting%20Considerations.pdf>. (Accessed January 6, 2022)

performance of potential SNF and HLW repositories in different host rocks and with different disposal options. DOE is competently carrying out the development of the GDSA Framework and is making great progress in this effort while recognizing some of the challenges.

The Board encourages DOE to continue its GDSA Framework development efforts.

The Board notes that the GDSA Framework can be applied at various stages of the repository program, including site selection and evaluation, assessment of disposal options, and, eventually, to support a license application to construct a geologic repository. The repository performance modeling requirements will evolve as the repository program progresses through its various stages. The performance assessment models and codes should also evolve and improve as the repository program progresses — simpler during the early stages and later becoming more complex as more features, events, and processes are considered and advances in models and codes are made. Hence, the iterative nature of performance assessment code development. The Board believes that continued improvements in the GDSA Framework can be facilitated by applying it systematically to a broad suite of reference cases to begin exploration of the needed changes to the framework, to understand better the performance of the total system and that of the various engineered and natural barriers, and to assess the various disposal options. For example, a set of simulations for a crystalline host rock can evaluate what disposal options can lead to poor, mid-range, and good repository performance. The disposal options considered could explore various waste package designs, near-field configurations, far-field configurations, and biosphere assumptions. The Board acknowledges that DOE is currently using the GDSA Framework to simulate the performance of a small set of generic reference cases, but believes a strategy and intended outcome of the simulations need to be clearly defined and the GDSA Framework systematically applied.

- *The Board finds that DOE needs to more clearly define and articulate the near-term goals and applications of the GDSA Framework in order to better prioritize what needs to be incorporated into the software framework at different stages of the repository program.*

The Board recommends that DOE define a clear strategy and intended outcome for the use of the GDSA Framework in the near term and systematically apply it to a broad suite of reference cases.

The Board notes that an important component of repository performance assessments, as well as evaluation of different disposal options, is the performance modeling and evaluation of engineered barriers, including waste forms, waste packages, and buffer materials. Performance assessment codes need to have a robust capability to assess the performance of engineered barriers, particularly for disposal options that are likely to rely heavily on those barriers. The GDSA Framework currently has limited capability to represent engineered barriers, such as fuel cladding and waste package materials, and to model their degradation. This limits DOE's ability to assess different disposal options, to determine engineered barrier importance, and to prioritize its R&D portfolio related to engineered barrier performance. The Board notes DOE indicated that it plans to improve the representation of the evolution of buffer and backfill behavior and waste package degradation in its numerical models.

- *The Board finds that the GDSA Framework currently does not have an adequate capability to assess the performance of engineered barriers, which may be necessary for evaluating engineered barrier capability and different disposal options.*

The Board recommends that DOE expedite the development of the GDSA Framework such that it has sufficient capability to assess the performance of different engineered barriers. This capability is needed to assess different disposal options and to apply the GDSA Framework systematically to a broad suite of reference cases. The Board notes that in developing this capability, DOE also needs to take account of near-field processes that could affect the performance of engineered barriers.

The Board notes that there is great value in independent assessments, evaluations, and critiques of major code systems such as the GDSA Framework. The Board acknowledges that components of DOE R&D activities related to the GDSA Framework, such as modeling and laboratory work, are being peer-reviewed as part of journal and conference publication processes, as well as by technical experts in the national laboratories and entities such as the NWTRB. However, the Board believes that input from a broader set of stakeholders, including the public and regulators, on the development of the GDSA Framework can help improve the transparency of the processes being modeled (e.g., assumptions, conceptual models) and the modeling results. This improved transparency can be in the form of a clearer and simpler display of results and an ability to show how different components of a multibarrier system contribute to long-term safety. Transparency is important when interacting with stakeholders at all stages of the repository program, and is particularly important when interacting with regulators during the implementer's preparation of and the regulator's review of a license application to construct a repository. The NRC speakers at the meeting stated that stakeholder engagement was an important component of NRC's development of its performance assessment capability.

- *The Board finds that the development of the GDSA Framework can be improved by peer reviews by a broader spectrum of stakeholders.*

The Board recommends that DOE solicit input on the development of the GDSA Framework from a broader spectrum of stakeholders, including the public and the regulator.

The Board observes that, although DOE has applied its own quality assurance (QA) program, the GDSA Framework, PFLOTRAN, and DAKOTA codes have not been developed under a Nuclear Quality Assurance (NQA-1)⁹ or equivalent QA program. Yet this will be an important requirement for any future submission of a license to the NRC for repository construction. The Board believes that qualifying the computer codes using an acceptable QA program will be more costly, challenging, and time consuming the longer the implementation of the QA program is delayed. The Board notes that it would be appropriate for DOE to start an assessment of what needs to be done to have all the components of the GDSA Framework NQA-1 qualified (or equivalent). Moreover, it appears to the Board that the capabilities of the DAKOTA code are not being utilized in model calibration to determine the values and associated uncertainties of parameters that appear in various models. If that is the case, the Board notes it would be useful

⁹ ASME NQA-1-2019, "Quality Assurance Requirements for Nuclear Facility Applications," American Society of Mechanical Engineers, New York, NY.

for the GDSA Framework team, including the process model developers, to work with the DAKOTA code team to identify how the DAKOTA capabilities can be used in model calibration.

Thank you again, on behalf of the Board, for the participation of DOE-NE staff and technical experts from the national laboratories at our November meeting. 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}

Jean M. Bahr
Chair

cc: Dr. Kimberly Petry, DOE-NE
Dr. William Boyle, DOE-NE
Mr. Timothy Gunter, DOE-NE