The Critical Role of Underground Research Laboratories to Geologic Disposal Programs

Presented to:

INMM 35rd Spent Fuel Management Seminar

Presented By:

Bret Leslie, Senior Professional Staff

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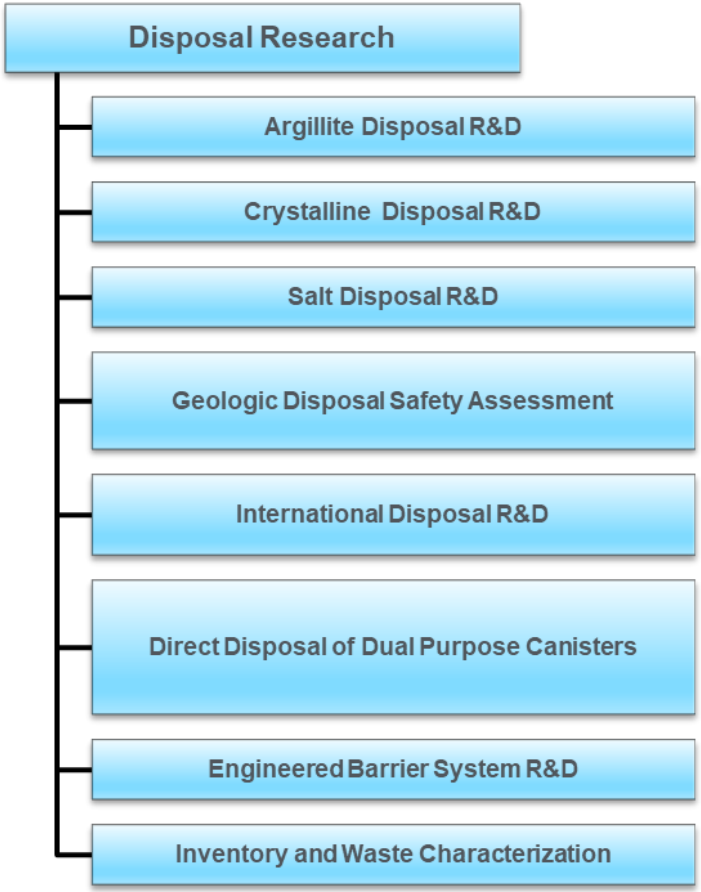
Board Workshop

- April 2019 workshop focused on underground research laboratories (URLs), U.S. Department of Energy's (DOE's) disposal R&D program, and DOE's international collaborations
  - Three speakers from countries with operating URLs (France, Sweden, and Switzerland) and one speaker from a country without a URL (United Kingdom) described the integration and contribution of URL science to their respective country's radioactive waste management program
- Presenters emphasized that URLs are used to
  - Develop and test technology and methods for site characterization, construction, and monitoring
  - Test the disposal design concept and alternatives, operational options (e.g., waste package emplacement), and demonstrate the industrial-scale project to the public

DOE Disposal R&D Program

- In 2010, DOE began generic research on alternative host rocks (crystalline, clay, and salt) and repository environments very different from that at Yucca Mountain
  - Focused on postclosure safety
- DOE reprioritized its geologic disposal R&D activities and updated their priorities in 2019
  - State-of-the-art level and importance to safety case metrics used for update

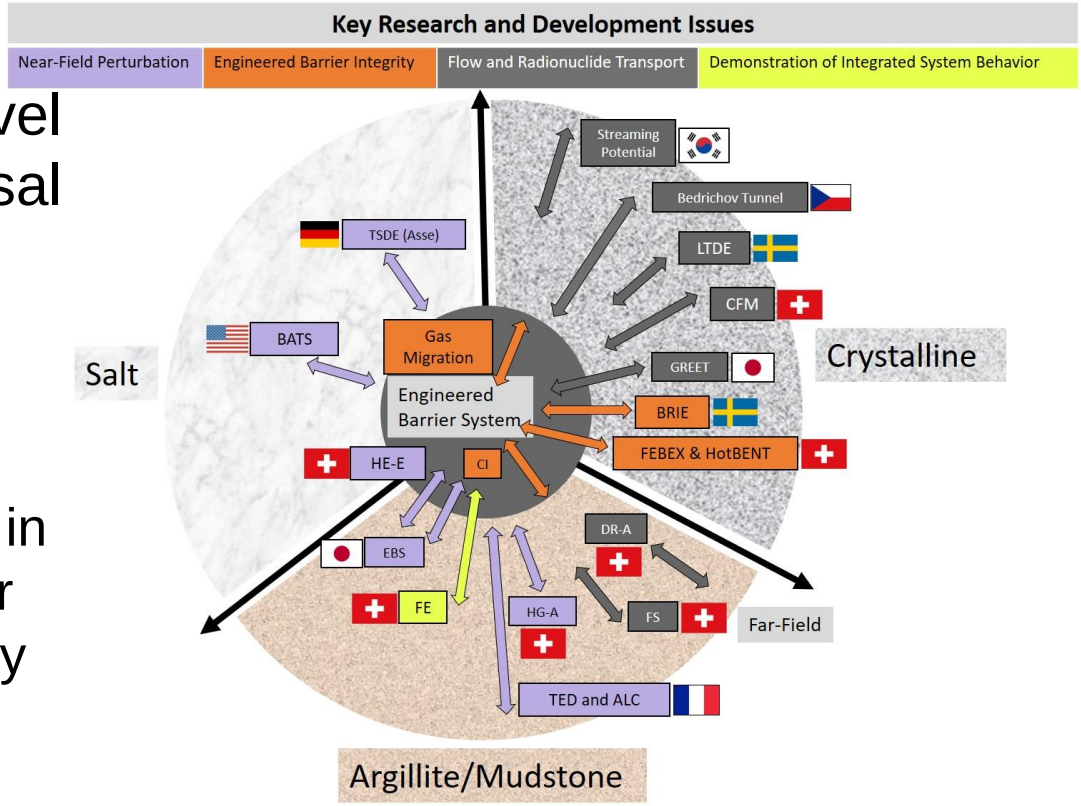
DOE's R&D Program



W. Boyle, DOE Collaboration and Underground Research Program: Overall Program and Approach (NWTRB 2019)

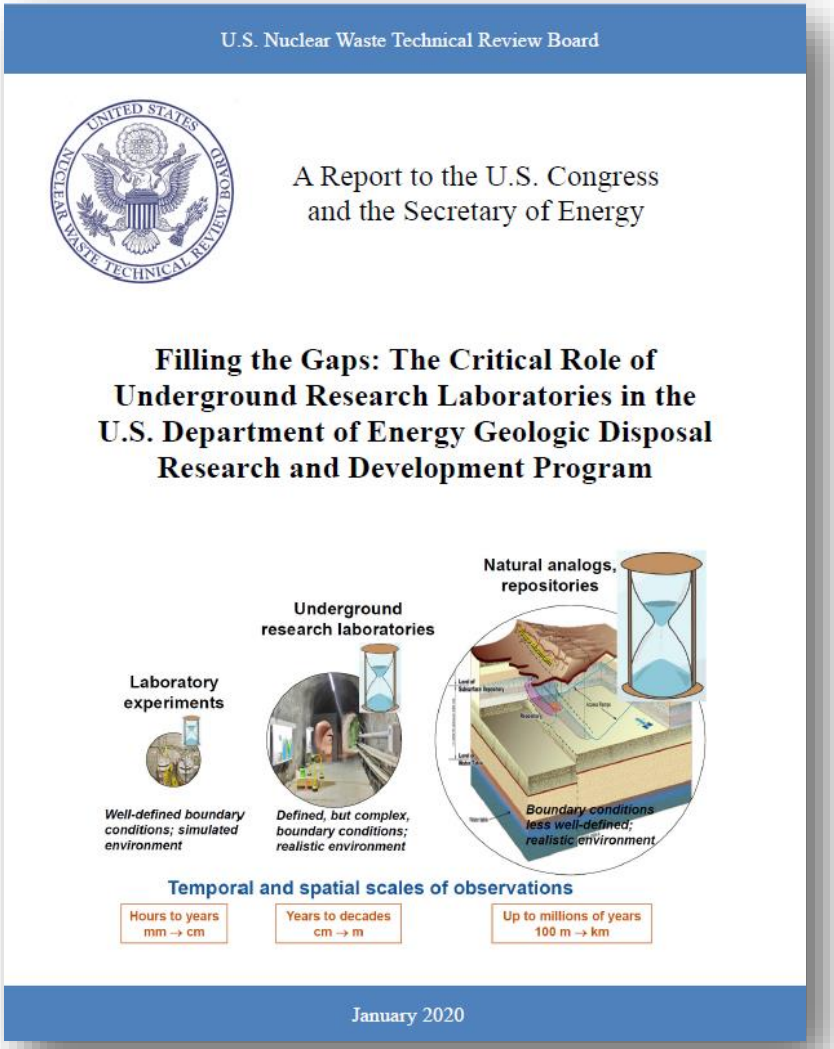
DOE Disposal R&D Program (cont.)

- DOE has collaborated in research conducted in several URLs located in Europe and Asia since 2012
- Collaborations have been beneficial to its spent nuclear fuel and high-level radioactive waste disposal research program
  - Access to data and to decades of experience gained in various disposal environments in a cost-effective manner and enabled their timely participation in URL-related studies



Board Review and Report

- Board reviewed the technical and scientific validity of DOE's URL-related R&D activities using
  - Workshop and fact-finding meeting with DOE
  - Reports published by DOE and others
- Board report has findings and recommendations
  - Specific findings and recommendations
  - Four principal findings and recommendations



Principal Findings and Recommendations

- *Finding #1*: DOE participation in URL-related international research greatly benefits the U.S. geologic disposal R&D program by furthering its understanding of generic and site-specific disposal issues relevant to alternative repository host rocks and environments. DOE-funded R&D activities also are benefiting the URL-related research of other countries, especially in the area of complex analytical and numerical model/software development.

- *Recommendation #1:* DOE should expand its collaborative international URL activities to enhance its capacity for R&D of geologic repositories.

Principal Recommendation #1 (Cont.)

To obtain maximum benefit from its international programs, DOE should consider

- (i) making use of R&D in URLs to address the technical needs for the design, licensing, construction, and operation of geologic repositories in different host rocks that consider the types of waste in the U.S. inventory;
- (ii) pursuing international URL R&D partnerships, including those involving non-nuclear waste applications (e.g., carbon sequestration) that require underground knowledge and operations, in which DOE could participate in the design, construction, and operational phases of the collaborations; and
- (iii) compiling best practices, innovative approaches, and notable successes and failures in public outreach, engagement, and risk communication from the experiences of URL programs in other countries.

Principal Findings and Recommendations (cont.)

- *Finding #2*: The more developed repository programs in other countries have focused on creating and strengthening their safety cases and making them transparent to the public. Repository programs in other countries use URLs to explain the technical bases underlying their safety cases, periodically reassess knowledge gaps and define new activities to strengthen the technical bases, and demonstrate the technology that will allow implementation of the proposed safety concept.

- *Recommendation #2:* DOE should make systematic use of URL R&D results to regularly update generic repository safety cases that can be easily understood by and demonstrated to the public, including safety cases relevant to direct disposal of dual-purpose canisters in different host rocks.

Principal Findings and Recommendations (cont.)

- *Finding #3*: Countries with more developed geologic disposal programs have found domestic URLs essential to their repository programs. DOE needs domestic URLs to advance geologic disposal efforts over the next decades and further its ability to train the next generation of scientists, engineers, and skilled technical workers.
- *Recommendation #3:* DOE should pursue one or more domestic URLs to advance the development and demonstration of disposal concepts and provide a platform for training the next generation of U.S. scientists, engineers, and skilled technical workers. DOE should evaluate whether underground sites in the U.S. with existing infrastructure could be used as generic URLs and whether use of existing facilities could be broadened (e.g., for more underground experiments or as training facilities) without impacting their primary missions.

Principal Recommendation #3 (Cont.)

If DOE expands its domestic URL program in this way, then it should consider

- (i) broadening its URL R&D program from one focused on the technical issues relevant to post-closure repository performance to one that includes developing and demonstrating the construction and operational concepts for disposal;
- (ii) supporting larger, more formal training opportunities in underground disposal research in disciplines needed for the waste disposition mission; and
- (iii) making domestic URLs broadly accessible to researchers from the U.S. and other countries, including those outside the DOE geologic disposal R&D program.

Principal Findings and Recommendations (cont.)

- *Finding #4*: DOE's international URL collaborations have advanced its generic disposal R&D program, including development of modeling capabilities recognized internationally as state-of-the-art, but further work on its coupled thermal-hydrological-mechanical-chemical models and URL- and laboratory-based research can strengthen its program.

- *Recommendation #4:* DOE should continue advancing its thermal-hydrological-mechanical-chemical-based research and model development and pursue more URL- and laboratory-based studies, particularly at elevated temperatures.

Principal Recommendation #4 (Cont.)

In doing so, DOE should consider

- (i) designing and conducting technical activities in URLs to test hypotheses and assumptions, while at the same time remaining open to unexpected processes or behaviors;
- (ii) employing an iterative process involving laboratory experiments focused on fundamental processes, modeling, and field experiments and observations;
- (iii) including geomechanical constraints and thermal effects in fracture flow and transport models; and
- (iv) focusing on bedded salts and using the heater tests at the Waste Isolation Pilot Plant to improve the constitutive models of salt behavior.