UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD
2300 Clarendon Boulevard, Suite 1300
Arlington, VA 22201
703-235-4473

AGENDA

International Technical Workshop on Deep Borehole Disposal of Radioactive Waste

Embassy Suites
1250 22nd Street NW
Washington, DC 20037

Tuesday, October 20, 2015 (Ballroom)

8:00 a.m. **Call to Order and Introductory Statements**
Rod Ewing, Board Chairman
Mary Lou Zoback, Board Member

8:15 a.m. **DOE's Strategy for Management and Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste, Including Deep Borehole Disposal of Smaller DOE-Managed Waste Forms**
Franklin Orr, Under Secretary for Science and Energy, U.S. Department of Energy

9:00 a.m. **DOE's Deep Borehole Disposal Research Program**
Timothy Gunter, U.S. Department of Energy, Office of Nuclear Energy

QUESTIONS TO BE ADDRESSED:
What is the rationale for deep borehole disposal? What wastes would be, or might be, disposed of via deep boreholes? What are the objectives of the program and which research activities address the objectives? What is being assumed concerning post-closure standards and regulations for deep borehole disposal? What is the safety case for deep borehole disposal? What features, events, or processes are crucial to the concept? What needs to be completed to achieve a proof-of-concept? What is the timeline for the research program, siting, licensing, and implementation of disposal of radioactive wastes?

10:00 a.m. **Break**

10:15 a.m. **DOE Deep Borehole Field Test: Site Characterization and Design Requirements**
David Sassani and Ernest Hardin, Sandia National Laboratories

QUESTIONS TO BE ADDRESSED:
What geological, hydrological, geomechanical, geochemical, and thermal data will be collected? How will the data test the assumptions of the concept and previous modeling? What is the design for testing the proof-of-concept for emplacement and retrieval of surrogate waste canisters? How will the activities of the deep borehole test allow DOE to assess the feasibility of the deep borehole disposal concept?

11:45 a.m. **Public Comments**

12:00 p.m. **Break**

12:15 p.m. **Lunchtime Presentation: International Perspective on Deep Borehole Disposal**
Fergus Gibb, University of Sheffield, United Kingdom

1:00 p.m. **Break**

1:15 p.m. **Panel #1 Experience in Deep Drilling in Crystalline Rocks**
Moderator: Mary Lou Zoback, Board Member
Panelists: Stephen Hickman (U.S. Geological Survey), Claus Chur (CCConsulting, Germany), Eric van Oort (University of Texas at Austin)

QUESTIONS TO BE ADDRESSED:
In the context of DOE's plans to drill a 5 km deep hole in crystalline rock, with a bottom-hole diameter of up to 17" and with an emplacement zone for surrogate sealed waste canisters between 3-5 km depth:

- What are the technical/geomechanical challenges for drilling and completing such a borehole?
- What lessons have been learned during drilling deep boreholes in crystalline rock?
- What lessons have been learned in implementing downhole characterization programs, including cross-hole testing?
- What is the ultimate bottom-hole diameter with foreseeable technological advances?

2:30 p.m. **Break**

2:45 p.m. **Panel #2 Emplacement Mode**
Moderator: Allen Croff, Board Member
Panelists: Wesley Patrick (Southwest Research Institute), Mark MacGlashan (MacGlashan Engineering Consulting), Douglas Minnema (Defense Nuclear Facilities Safety Board), Ernest Hardin (Sandia National Laboratories)

QUESTIONS TO BE ADDRESSED:
In the context of DOE's plan to dispose of highly radioactive wastes in ~5 km deep boreholes in crystalline rock:

- Emplacement mode selection
  - What are the current and foreseeable options for the emplacement mode?
  - What is the recommended/preferred emplacement mode for deep borehole disposal implementation and what is the basis for the recommendation/preference?
  - How do (a) experience from non-waste-related package emplacement in deep boreholes and (b) the impacts of emplacing highly radioactive wastes in normal and off-normal situations affect the selection of the preferred emplacement mode?
- How does the safety of potential emplacement options compare in terms of operational impacts to the public and workers in normal and off-normal conditions?
- What data will be required to evaluate human health and technical risks, costs, and design implications of deep borehole disposal in the context of developing a safety case for borehole disposal?
- How will the Deep Borehole Field Test be designed to elucidate human health and technical risks associated with deep borehole disposal emplacement of highly radioactive wastes?

4:00 p.m. **Panel #3 Borehole Seals**

Moderator: Gerald Frankel, Board Member
Panelists: Paul Bommer (University of Texas at Austin), Nick Collier (University of Sheffield, United Kingdom), Roland Pusch (Luleå University of Technology, Sweden)

QUESTIONS TO BE ADDRESSED:
In the context of DOE's plans to drill a 5 km deep hole in crystalline rock and dispose of sealed waste canisters between 3-5 km depth, while relying extensively on geology for containment as well as sealing of the disposal zone and upper 3 km of the borehole:

- What materials and processes have been developed for sealing, and used to seal, boreholes under representative conditions?
- What evidence is there for the long-term effectiveness of borehole seals?
- How can we predict the long-term performance of seals?
- What level of performance of a borehole seal is critical to the safety of deep borehole disposal?

5:15 p.m. **Public Comments**

5:35 p.m. **Adjourn Public Meeting**

Poster Session (Embassy Room)

Wednesday, October 21, 2015 (Ballroom)

8:00 a.m. **Call to Order and Introductory Statements**
Rod Ewing, Board Chairman
Mary Lou Zoback, Board Member

8:15 a.m. **U.S. Environmental Protection Agency Perspectives on Deep Borehole Disposal**
Dan Schultheisz, U.S. Environmental Protection Agency

9:00 a.m. **Panel #4 Hydrogeology at Depth: Anticipated Conditions and Characterizing the Conditions**
Moderator: Jean Bahr, Board Member
Panelists: Mark Person (New Mexico Tech), Mark Zoback (Stanford University), Kent Novakowski (Queen's University, Canada)

QUESTIONS TO BE ADDRESSED:
In the context of DOE's concept for borehole disposal using 5 km deep boreholes in crystalline rock, with disposal of sealed waste canisters between 3-5 km depth, relying extensively on geology for containment:

- What does the global experience tell us about subsurface conditions and hydraulic properties at 3-5 km in crystalline rock?
- What characterization techniques are best suited to determine in situ conditions and properties at depth prior to and after drilling?
- Will it be possible, within the relatively short time available for tests in the pilot hole, to adequately quantify hydraulic heads, gradients and permeability of fractures, fault zones and the rock matrix?
- How do the conditions at borehole depths compare with conditions at mined repository depths (~1 km) with respect to potential for transport from the disposal site to the accessible environment?

10:00 a.m. **Break**

10:15 a.m. **Panel #5 Geochemistry of Fluids at Depth: Anticipated Conditions and Characterizing the Conditions**
Moderator: Susan Brantley, Board Member
Panelists: D. Kirk Nordstrom (U.S. Geological Survey), Shaun Frape (University of Waterloo, Canada), Jennifer McIntosh (University of Arizona)

QUESTIONS TO BE ADDRESSED:
In the context of DOE's concept for borehole disposal using 5 km deep boreholes in crystalline rock, with disposal of sealed waste canisters between 3-5 km depth, and relying extensively on geology for containment:

- What does the global experience from geochemistry of fluids, fracture mineralogy, and fluid inclusions tell us about subsurface conditions and parameters at 3-5 km in crystalline rock?
- What characterization techniques are best suited to determine the geochemistry of fluids at depth?
- What are the implications of the expected saline and reducing groundwater conditions at 3-5 km for solubilities of minerals and retardation factors of radionuclides?

11:15 a.m. **Panel #6 Multiple Barriers: Waste Forms and Canister Materials**
Moderator: Rod Ewing, Board Chairman
Panelists: David Sassani (Sandia National Laboratories), Neil Hyatt (University of Sheffield, United Kingdom), Narasi Sridhar (DNV GL)

QUESTIONS TO BE ADDRESSED:
In the context of DOE's concept for borehole disposal using 5 km deep boreholes in crystalline rock, with disposal of sealed waste canisters between 3-5 km depth, and relying extensively on geology for containment as well as sealing of the disposal zone and upper 3 km of the borehole:

- How much reliance will be placed on engineered barrier components as compared to natural barriers?
- What waste form and package characteristics (e.g., resistance to corrosion, strength to withstand the column of waste above it, ability to be retrieved) are needed for deep borehole disposal?
- How well known are the characteristics of wastes (waste form per se, current packaging, potential future packaging) that are or might be disposed of in deep boreholes?

12:15 p.m. **Public Comments**

12:30 p.m. **Lunch Break (1 hour)**

1:30 p.m. **Panel #7 Efficacy of Deep Borehole Disposal and Risk Analysis**
Moderator: Rod Ewing, Board Chairman
Panelists: Peter Swift (Sandia National Laboratories), Bertil Grundfeldt (Kamakta Konsult AB, Sweden), Richard Garwin (IBM Fellow Emeritus)

QUESTIONS TO BE ADDRESSED:

- What are the advantages and disadvantages of deep borehole disposal relative to other disposal options?
- What is the projected post-closure dose from a deep borehole disposal program and how does it compare to projected doses from a conventional geologic repository for disposal of the same waste quantities and forms?
- What are the key uncertainties with the expected performance from a deep borehole disposal facility?
- What is the effect of sustained elevated temperatures on the performance of deep borehole disposal?
- How will the lack of international experience in implementing a deep borehole disposal program affect DOE's approach?

2:30 p.m. **Break**

2:45 p.m. **Key Observations from Panels**
One panelist from each panel summarizes the panel's key points based on what has been presented at the workshop (5 minutes each and Board questions)

4:00 p.m. **Closing Speaker**
Andrew Griffith, Associate Deputy Assistant Secretary for Fuel Cycle Technologies, U.S. Department of Energy

QUESTIONS TO BE ADDRESSED:
What does DOE need to do to make its deep borehole disposal research program a success? What external factors (e.g., lack of applicable regulations) and current waste storage site factors (e.g., need to build bulk packaging facility for calcine waste or timing of removal of cesium and strontium capsules from pool storage) impact the timeframe for implementation of deep borehole option? What other activities must DOE complete to determine whether deep borehole disposal is a viable option?

4:45 p.m. **Public Comments**

5:00 p.m. **Adjourn Public Meeting**