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Overview of the Deep Borehole Field Test

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U.S. Nuclear Waste Technical Review Board Briefing

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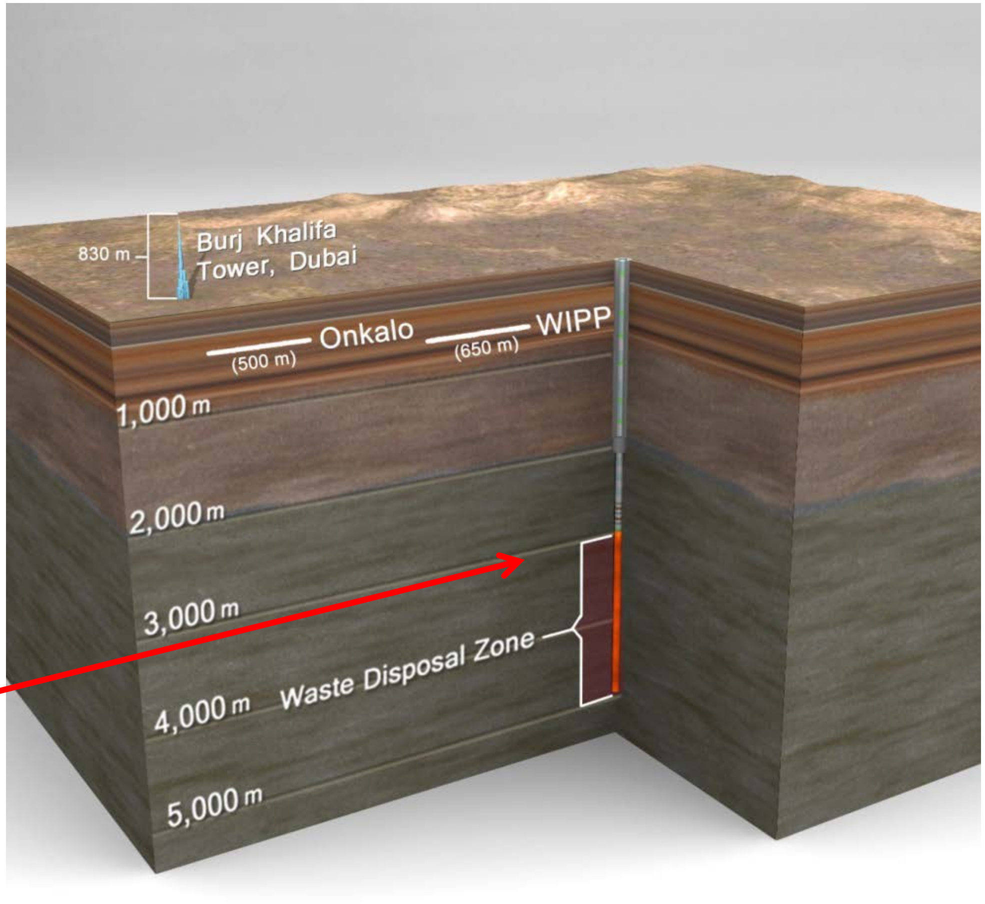
Overview of the Deep Borehole Disposal Field Test: Outline

- Deep Borehole Disposal Concept
- Safety and Feasibility Considerations
- Why Deep Borehole Disposal?
- Wastes being considered for Deep Borehole Disposal
- Previous work related to the deep borehole disposal concept
- Objectives of the Deep Borehole Field Test (DBFT)
- Planned Activities that will Establish Feasibility of the Deep Borehole Disposal Concept
- Elements and Organization of the Field Test
- DOE Procurement of Site and Contracting Services and Status
- Schedule and Key Milestones
- International, Nuclear Energy University Program, Small Business Innovative Research (SBIR), and SubTER Activities

Deep Borehole Disposal Concept

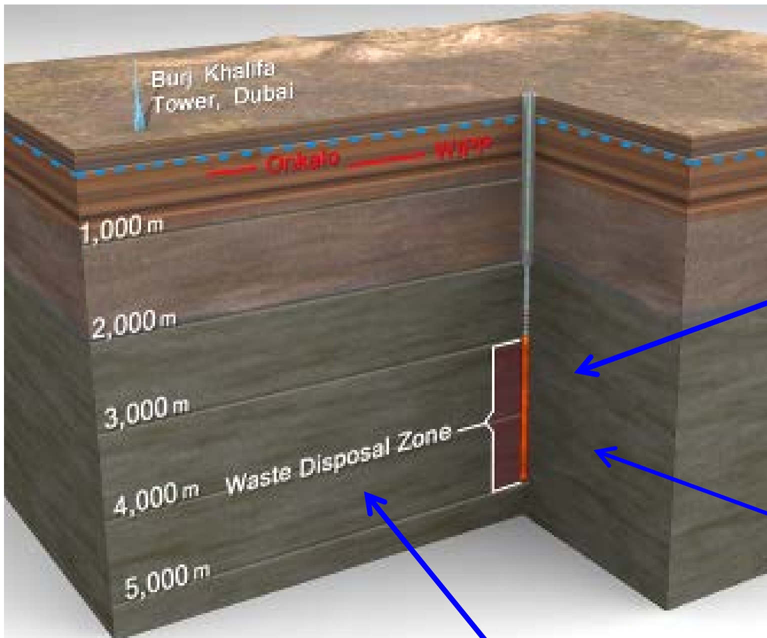
- **5,000 m deep borehole in crystalline basement rock, well below fresh groundwater resources**
  - **Waste canisters in bottom 2,000 m**
  - **Seals in upper 3,000 m**

Potential for Robust Isolation



Deep Borehole Disposal Concept – Safety and Feasibility Considerations

Long-Term Waste Isolation (hydrogeochemical characteristics)



Waste emplacement is deep in crystalline basement

- at least 1,000 m of crystalline rock (seal zone) overlying the waste disposal zone
- Crystalline basement within 2,000 m of the surface is common in many stable continental regions

Crystalline basement has very low permeability – limits flow and transport

Deep groundwater in the crystalline basement:

- has very long residence times – isolated from shallow groundwater
- has high salinity and is geochemically reducing – limits the solubility and enhances the sorption of many radionuclides in wastes
- exhibits density stratification (saline groundwater underlying fresh groundwater) – opposes thermally-induced upward groundwater convection

Deep Borehole Disposal Concept – Safety and Feasibility Considerations

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Operational Safety and Feasibility (engineering factors)

Drilling Technology exists to drill and case larger-diameter boreholes to 5,000 m depth in crystalline rock at acceptable cost

Emplacement System Design provides assurance the waste canisters can be safely surface-handled and emplaced at depth

Borehole and Casing Design maintains borehole integrity and minimizes probability of waste canisters becoming stuck during emplacement

Waste Canister Design maintains structural integrity and prevents leakage of radioactive materials during operations

Borehole Seals maintain a low-permeability barrier, at least over the time scale of thermally-induced upward flow

Why Deep Borehole Disposal?

- **Potential for robust isolation**
- **Gives DOE the flexibility to consider options for disposal of smaller waste forms in deep boreholes (DOE 2014a)**
  - Potentially earlier disposal of some wastes than might be possible in a mined repository
  - Reduce costs associated with projected treatments of some wastes

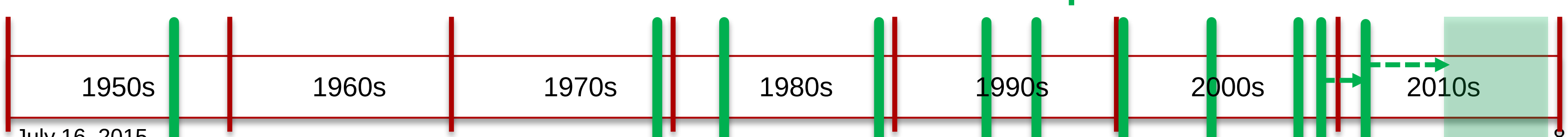
Wastes Being Considered for Deep Borehole Disposal

- **DOE-Managed small waste forms are candidates for deep borehole disposal (SNL 2014a)**
  - Cesium and strontium capsules stored at the Hanford Site
  - Untreated calcine HLW currently stored at INL in sets of stainless steel bins within concrete vaults
  - Salt wastes from electrometallurgical treatment of sodium-bonded fuels could be packaged in small canisters as they are produced
  - Some DOE-managed SNF currently stored in pools at INL and SRS
  - Vitrified HLW that has not yet been made could be redesigned and packaged for deep borehole disposal

Deep Borehole Disposal History

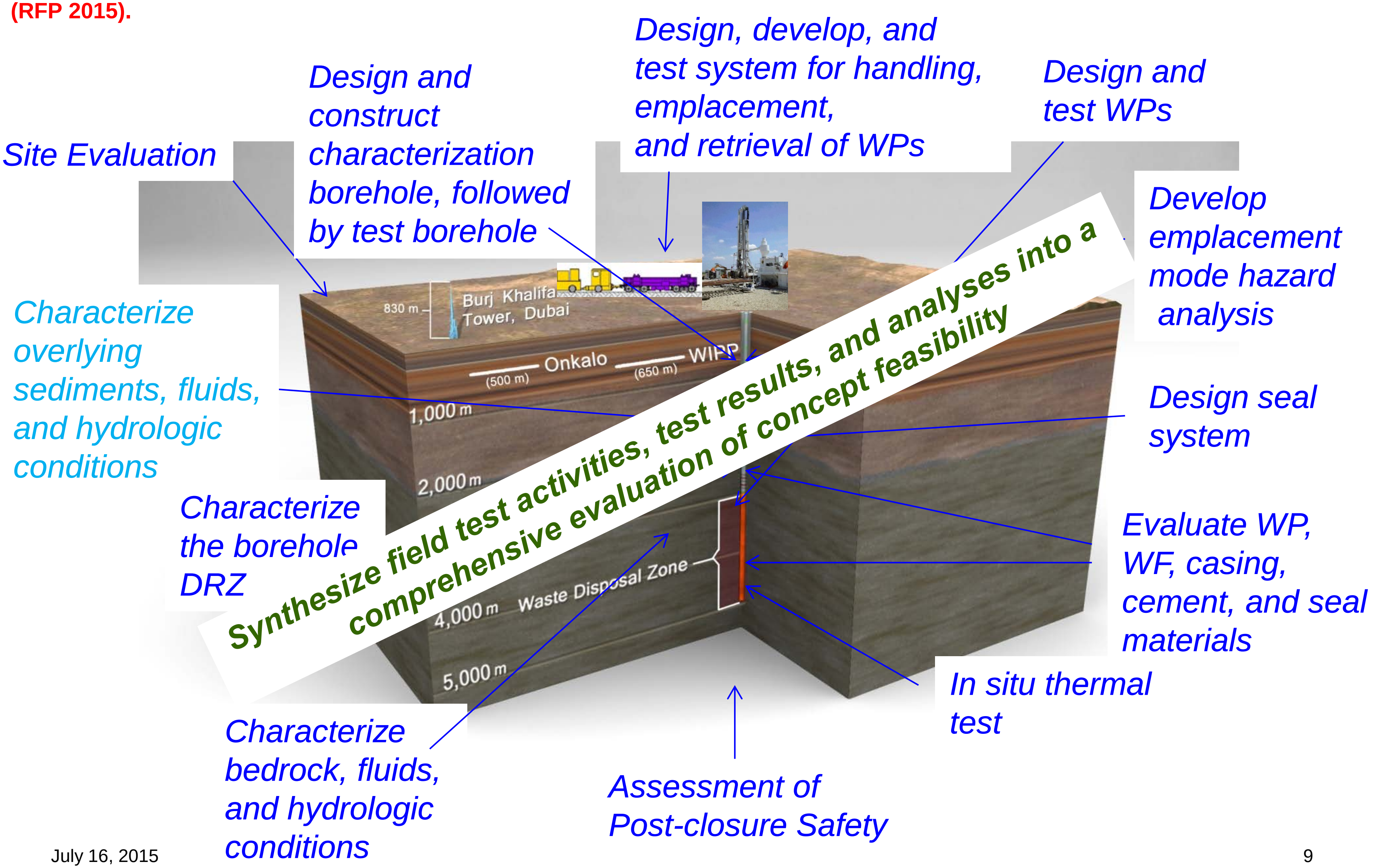
- **Hess et al. (1957) NAS Publication 519**
  - *The Disposal of Radioactive Waste on Land. Appendix C: Committee on Deep Disposal*
- **Obrien et al. (1979) LBL-7089**
  - *The Very Deep Hole Concept: Evaluation of an Alternative for Nuclear Waste disposal*
- **Woodward-Clyde (1983) ONWI-226**
  - *Very Deep Hole Systems Engineering Studies*
- **Juhlin and Sandstedt (1989) SKB 89-39**
  - *Storage of Nuclear Waste in Very Deep Boreholes*
- **Ferguson (1994) SRNL WSRC-TR-94-0266**
  - *Excess Plutonium Disposition: The Deep Borehole Option*
- **Halsey et al (1996) LLNL UCRL-LR-119735**
  - *Deep Borehole Disposal Facility PEIS Data Input Report for Immobilized Disposal*
- **Heiken et al. (1996) LANL LA-13168-MS**
  - *Disposition of Excess Weapon Plutonium in Deep Borehole: Site Selection Handbook*
- **Harrison (2000) SKB-R-00-35**
  - *Very Deep Borehole – Deutag's Opinion on Boring, Canister Emplacement and Retrievability*
- **Nirex (2004) N/108**
  - *A Review of the Deep Borehole Disposal Concept*
- **Beswick (2008) EPS International**
  - *Status of Technology for Deep Borehole Disposal*
- **Sapiie and Driscoll (2009) MIT-NFC-TR-109**
  - *A Review of Geology-Related Aspects of Deep Borehole Disposal of Nuclear Wastes*
- **Brady et al. (2009) SNL SAND2009-4401**
  - *Deep Borehole Disposal of High-Level Radioactive Waste*
- **Arnold et al. (2011) SNL SAND2011-6749**
  - Reference Design and Operations
- **DOE UFD Reports 2012 - 2015**

Deep Borehole Field Test DBFT



Objectives of the Deep Borehole Field Test

In no case will the US Government place or otherwise have nuclear material, waste, or other waste disposal material on the property (RFP 2015).



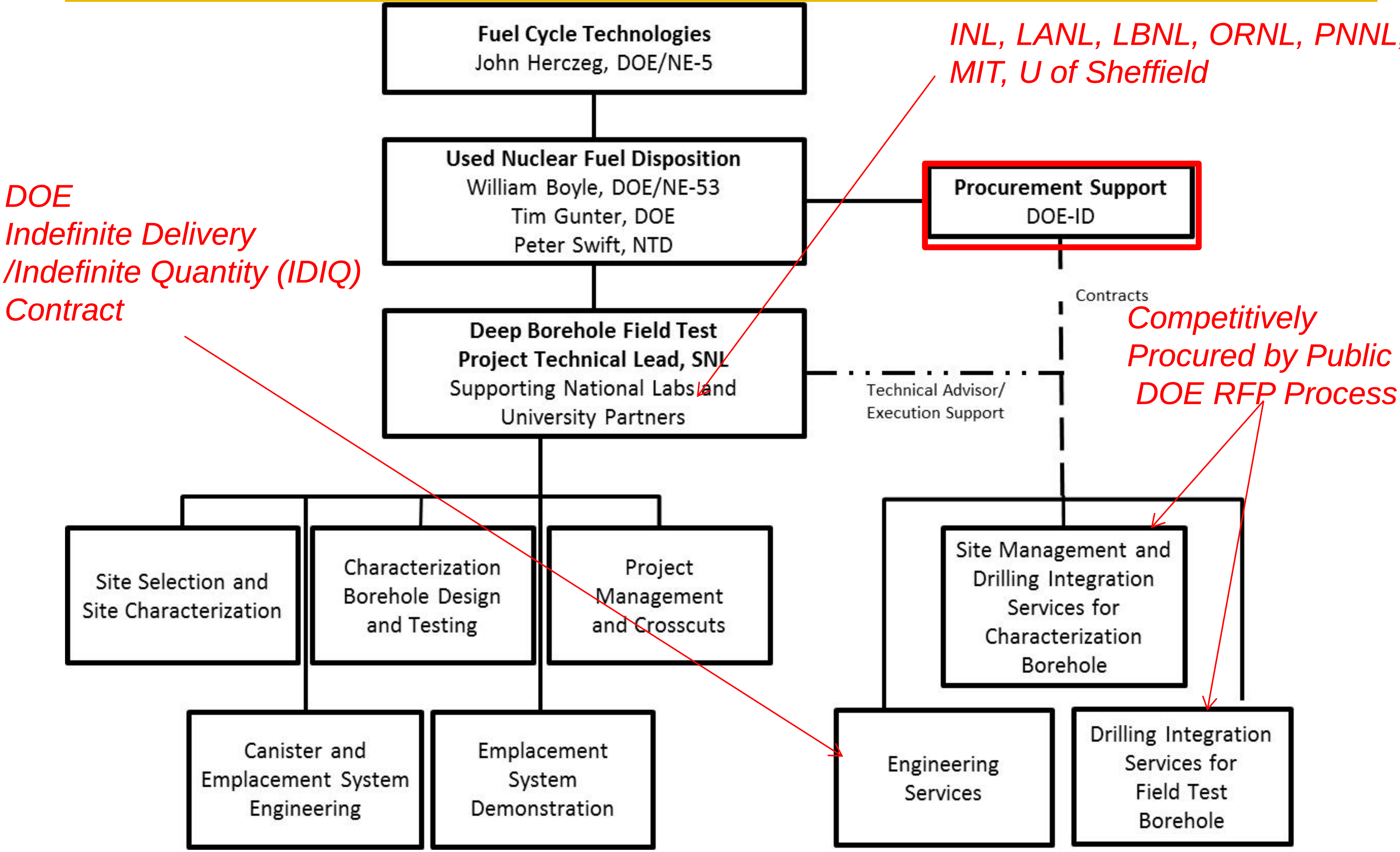
Planned Activities that will Establish Feasibility of the Deep Borehole Disposal Concept

- Select a suitable site
- Design, drill, and construct the characterization borehole (CB) to requirements
- Collect data in the CB needed to characterize crystalline basement conditions and confirm, with acceptable uncertainty, expected hydrogeochemical conditions
- Design, drill, and construct the field test borehole (FTB) to requirements
- Design and develop surface handling and emplacement systems and operational methods for safe canister/WP handling and emplacement
- Verify through hazard analysis that handling and emplacement operations canister/WP handling and emplacement have sufficiently low risk

Planned Activities that will Establish Feasibility of the Deep Borehole Disposal Concept (continued)

- Demonstrate safe surface handling, and emplacement and retrieval operations in the FTB
- Conduct laboratory studies of engineered materials under representative downhole conditions to provide a technical basis, with acceptable uncertainties, for predicting evolution of the system
- Conduct subsystem analyses and a post-closure safety assessment, including quantification of uncertainties, and demonstrate understanding of key processes and safety of the concept
- Conduct a cost analysis verifying acceptable costs of concept implementation
- Synthesize above elements into a comprehensive and transparent evaluation of the feasibility of the Deep Borehole Concept

DBFT Project Organization (SNL 2014b)



DBFT FY15/FY16 Timeline

- **09/30/14 – Final Project Plan Rev. 0 Submitted**
  - FCRD-UFD-2014-000592, SAND2014-18559R
- **10/24/14 – Siting RFI Issued**
- **12/08/14 – Siting RFI Responses Received**
- **04/07/15 – Draft RFP Issued for Site Management and Drilling CB**
- **05/05/15 – Draft RFP Responses Received**
- **06/22/15 – Pre-solicitation notice for the Deep Borehole Field Test**
- **06/25/15 – Awarded Engineering Services task contract to AREVA**
- **07/09/15 – Issued RFP for Site Management and Drilling CB**
- **09/09/15 – RFP Responses Due**
- **02/05/16 – Award Contract for Site Management & Drilling CB**
- **09/01/16 – Start Drilling CB**

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Deep Borehole Field Test Schedule

	FY15	FY16	FY17	FY18	FY19
Site Management and Drilling Integration Services (SM&D) Draft RFP – Issued	◆ 04/07/15				
Field Test – Award Engineering Services Contract	◆ 06/25/15				
SM&D Final RFP – Issue	◆ 07/09/15				
SM&D RFP – Proposals Due	◆ 09/09/15				
SM&D – Award Contract		◆ 02/05/16			
Field Test Borehole Services – RFP Issued		◆ 06/03/16			
Field Test Borehole Services – Proposals Due		◆ 08/05/16			
Characterization Borehole – Start Drilling		◆ 09/01/16			
Field Test Borehole Services – Award Contract			◆ 01/13/17		
Characterization Borehole – Completed			◆ 02/27/17		
Field Test Borehole – Start Drilling			◆ 07/07/17		
Field Test Borehole – Completed				◆ 01/05/18	
Field Test – Start Emplacement Demonstration				◆ 01/17/18	
Field Test – Complete Emplacement Demonstration					01/17/19 ◆
Documentation – Field Test Analyses and Evaluation					09/30/19 ◆

DBFT Estimated Project Budget

- **~ $80M over 5-year duration (FY15-FY19)**
  - FY15: ~ $5M planning, procurements, R&D
  - FY16-FY18: ~$20M, $25M, $25M per year, significant drilling and engineering costs
  - FY19: ~ $5M Complete field testing, analyses and synthesis, and documentation

DBFT FY15 Milestones

- **06/04/15 - Site Selection Evaluation for Deep Borehole Field Test**
  - SNL, LANL, LBNL, ORNL, FCRD-UFD-2015-000130
- **06/04/15 - Deep Borehole Field Test: Characterization Borehole Science Objectives**
  - SNL, LANL, LBNL, FCRD-UFD-2015-000131
- **09/15/15 - Deep Borehole Field Test Specifications**
  - SNL, LBNL
- **09/29/15 - Conceptual Design and Requirements for Characterization and Field Test Boreholes**
  - SNL, LANL, LBNL

DBH International, NEUP, SBIR Projects

- **International**
  - KAERI – Borehole tracer test in granite
  - U. of Sheffield - R&D to Support the DBFT (FTBH Design, BH Seal Design and Performance Criteria)
  - Uppsala University – Swedish Deep Drilling Program - Collisional Orogeny in the Scandinavian Caledonides (COSC)
- **NEUP**
  - MIT – Optimization of Deep Borehole Systems for HLW Disposal
- **SBIR**
  - RESPEC - Rock Melt Borehole Sealing System (Electric Heater)
  - OLYMPIC RESEARCH - Development of thermally formed plugs for deep borehole waste disposal applications (Thermite formula Heat Source and Sealant)
  - IMPACT TECHNOLOGIES / Massachusetts Institute of Technology / DoD AFRL- Deep Bore Storage of Nuclear Waste using MMW (Millimeter Wave) Technology
  - CIMENTUM - Unique Cimentum Cement for Cementing & Grout in Deep Boreholes for Radioactive Waste Disposal
  - Kapteyn-Murnane Labs - Laser technologies for ultrasensitive groundwater dating using long-lived isotopes
- **SubTER/Geothermal/UFD**
  - SNL/BNL/UNM - Fit-for-Purpose Cement for Rock-Cement Interfaces in SubTER Applications

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