SAND2016-11761PE

Used Fuel Disposition R&D Campaign

U.S. Used Fuel Disposition Research and Development Campaign

Kevin McMahon

Sandia National Laboratories
Used Fuel Disposition R&D Campaign
December 6, 2016

2016 AIT-TECRO Joint Standing Committee Meeting
on Civil Nuclear Cooperation
December 6 – December 8, 2016
Albuquerque, New Mexico, USA

Sandia National Laboratories is a multi-mission laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND2017-XXXX PE

Used Fuel Disposition

Used Nuclear Fuel Disposition (UFD) Research and Development Campaign Overview

- **Background**
  - Administration Strategy for Used/Spent Nuclear Fuel (U/SNF) and High Level Waste
  - US DOE Office of Nuclear Energy (NE) Structure (FY2017)
- **UFD R&D Campaign (UFDC) Focus Areas and Structure**
  - Mission and Participants
  - US Spent Fuel (SNF/UNF) and High-Level Waste (HLW) Inventories
  - Long-term Objectives of the UFD Campaign
  - Campaign Structure
  - Short-term (next 3 years) R&D Objectives
- **UFD R&D Campaign Projects Summaries**
  - Storage and Transportation
  - Defense Waste Repository
  - Disposal Research

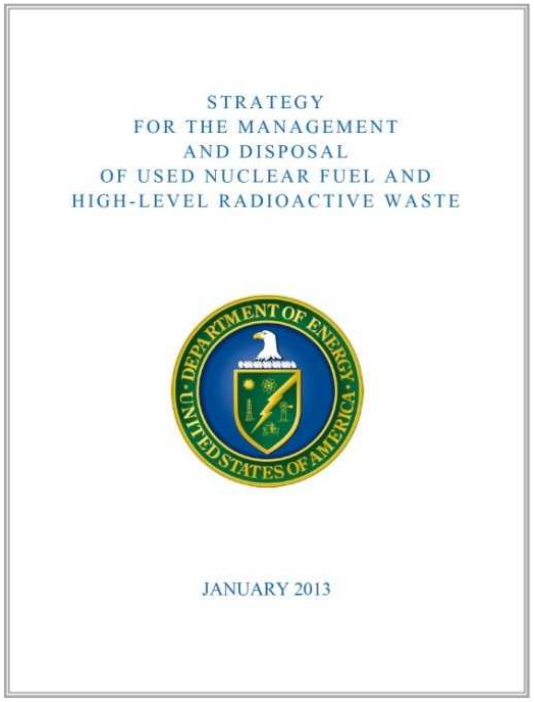
Used Fuel Disposition

Summary of the Administration's UNF and HLW Strategy

Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste **issued January 2013**

The Strategy is:

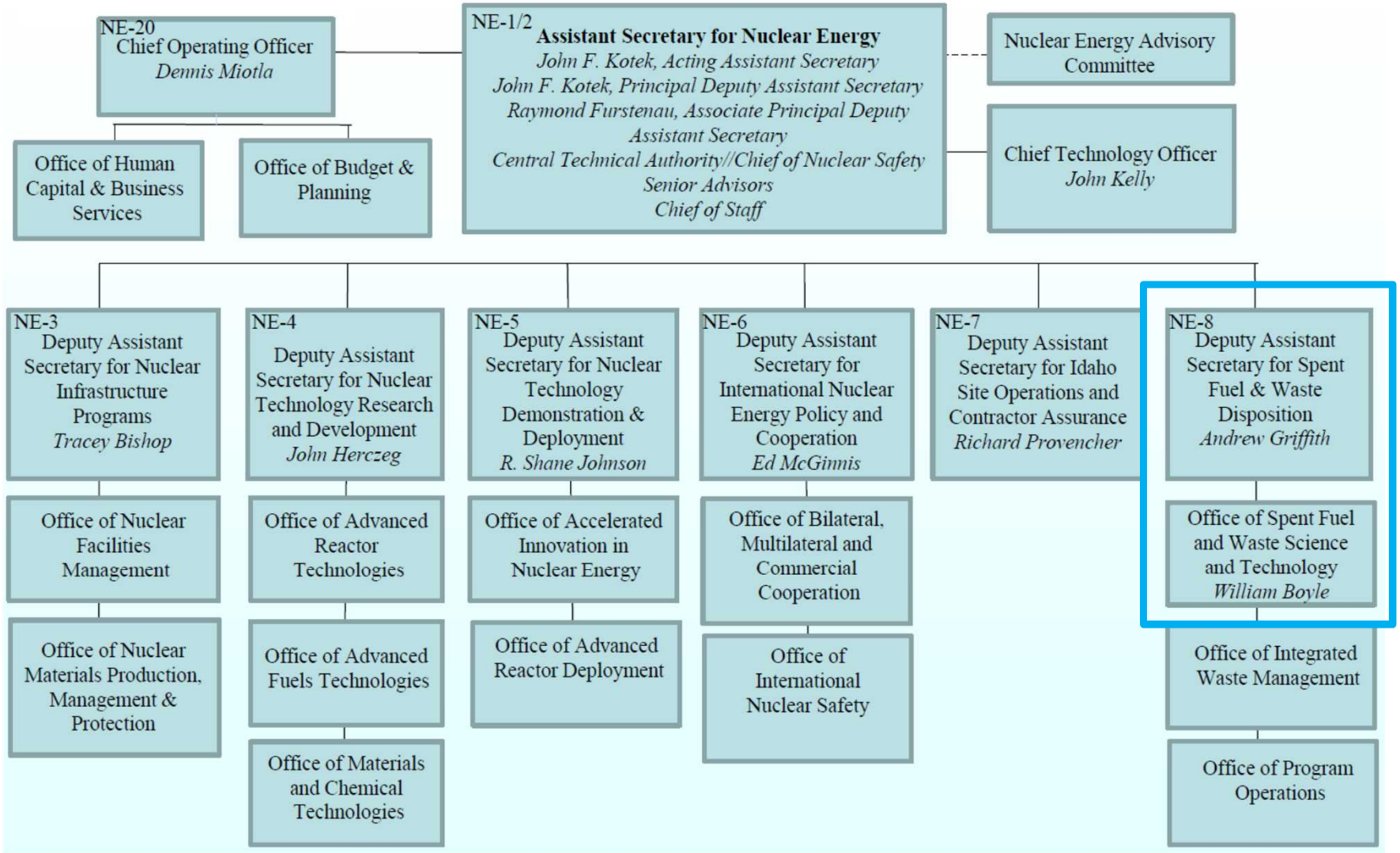
- **A statement of Administration policy regarding the importance of addressing the disposition of used nuclear fuel and high-level radioactive waste**
- **The response to the final report and recommendations made by the *Blue Ribbon Commission on America's Nuclear Future***
- **The initial basis for discussions among the Administration, Congress and other stakeholders**



- **The Strategy outlines a 10-year program of work that:**
  - Sites, designs, licenses, constructs and begins operations of a pilot interim storage facility
  - Advances toward the siting and licensing of a larger interim storage facility
  - Makes demonstrable progress on the siting and characterization of repository sites

DOE-NE Organization Chart

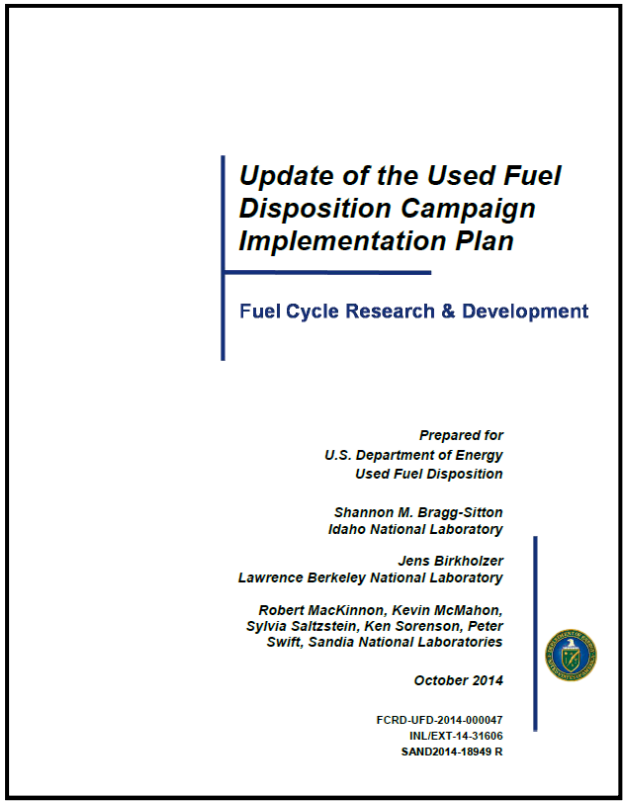
(http://www.energy.gov/ne/organization)



Used Fuel Disposition

UFD R&D Campaign Mission

The MISSION of the Used Fuel Disposition Campaign is to identify alternatives and conduct scientific research and technology development to enable storage, transportation and disposal of used nuclear fuel and wastes generated by existing and future nuclear fuel cycles.



Update of the Used Fuel Disposition Campaign Implementation Plan

FCRD-UFD-2014-000047, October 2014

Used Fuel Disposition

Used Fuel Disposition R&D National Laboratories and Campaign Challenge

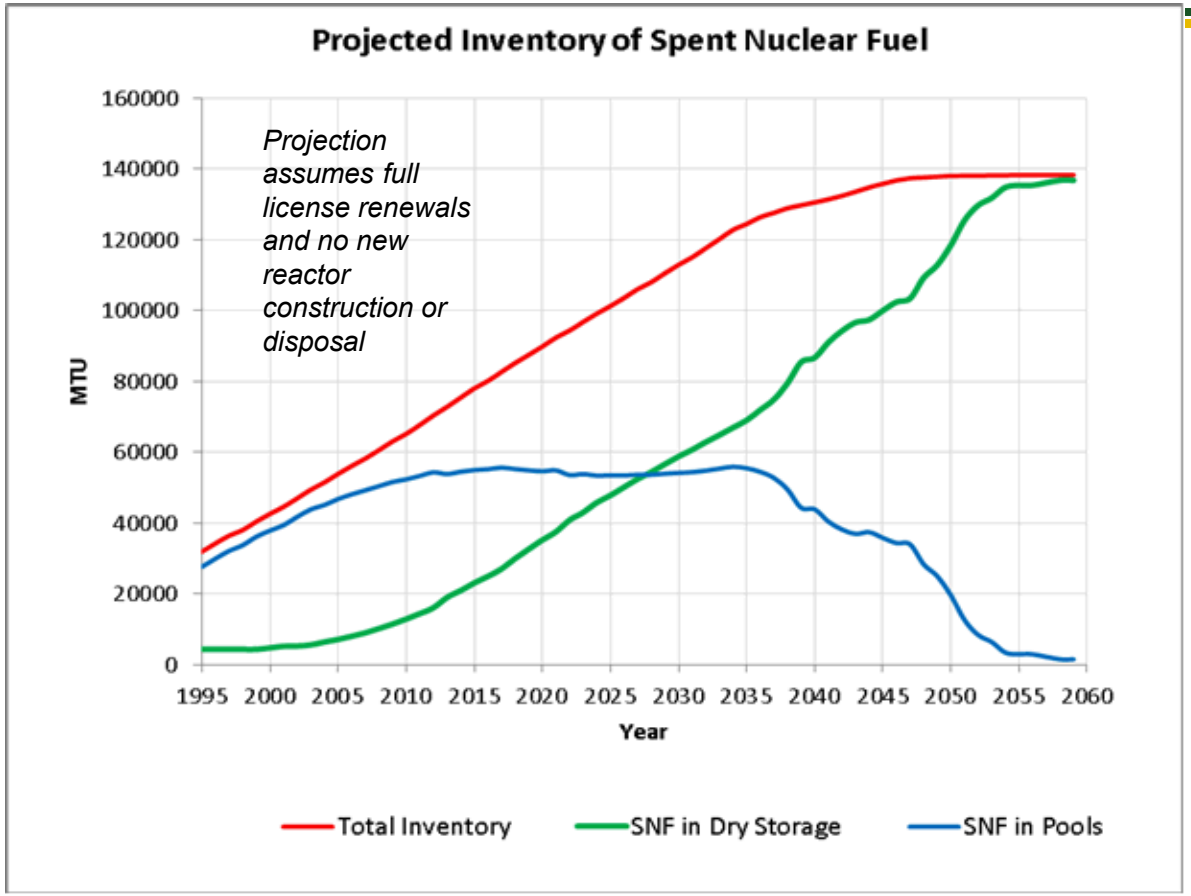
The DOE Office of Used Nuclear Fuel Disposition Research and Development and ***nine national laboratories*** participate in the DOE Office of Nuclear Energy's "Used Fuel Disposition Campaign"

Campaign challenge: to provide a sound technical basis for supporting the current DOE strategy for managing the back end of the nuclear fuel cycle…

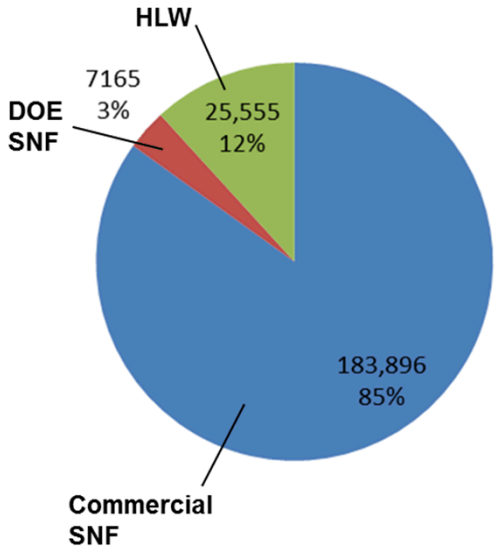
Update of the *Used Fuel Disposition Campaign Implementation Plan, FCRD-UFD-2014-0000474, October 2014*

Used Fuel Disposition

Historical and Projected Commercial Spent Nuclear Fuel (SNF) Discharges and High-Level Radioactive Waste (HLW) in the United States



Projected Volumes of SNF and HLW in 2048



Volumes shown in m^3, assuming constant rate of nuclear power generation and packaging of future commercial SNF in existing designs of dual-purpose canisters

Approx. 80,150 MTHM (metric tons heavy metal) of SNF in storage in the US today

- 25,400 MTHM in dry storage at reactor sites, in approximately 2,080 cask/canister systems
- Balance in pools, mainly at reactors

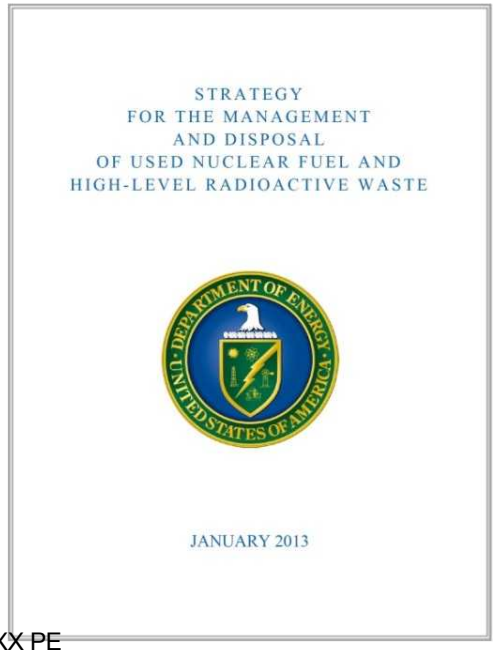
Approx. 2200 MTHM of SNF generated nationwide each year

- Approximately 160 new DPCs are loaded each year because reactor pools are essentially at capacity

Long-Term UFD R&D Campaign Objectives

- Support the implementation of a full-scale NRC-licensed confirmatory storage demonstration facility, in collaboration with industry
- Develop the technical basis necessary to support eventual transportation of used nuclear fuel, including high-burnup fuel
- Support the Nuclear Fuel Storage and Transportation Planning Project with implementation of integrated storage, transportation, and disposal concepts

Support the Administration's 2013 *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste*



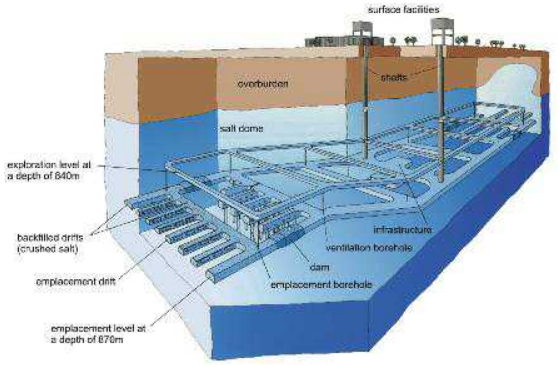
Used Fuel Disposition

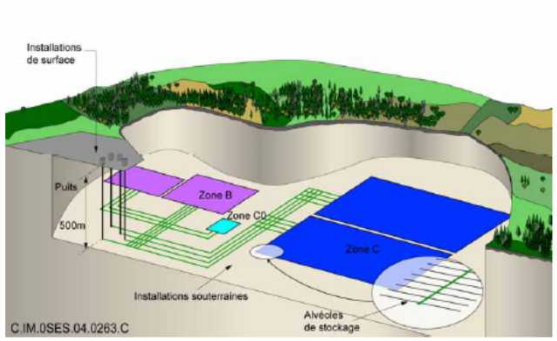
Storage and Transportation R&D Objectives

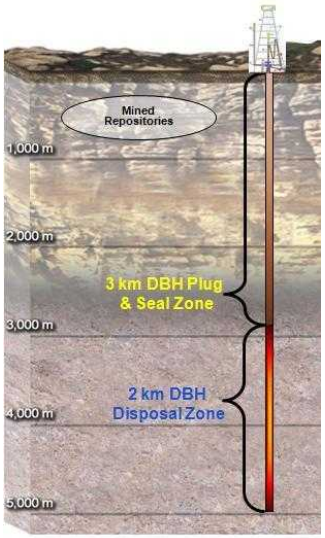
1. **Support the development of the technical bases to demonstrate used fuel integrity for extended storage periods**
2. **Support the development of the technical bases for fuel retrievability and transportation after long term storage**
3. **Support the development of the technical bases for transportation of high burnup fuel**

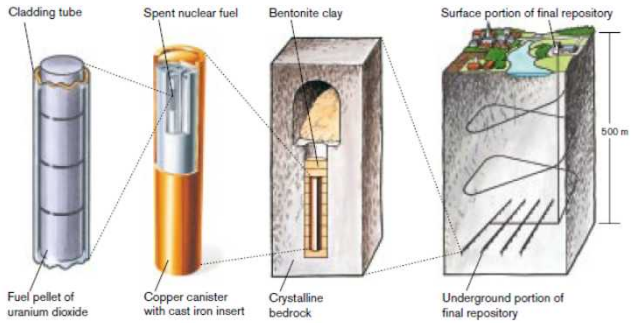
DOE's R&D Focus for UNF and HLW Disposal

- **Provide a sound technical basis for multiple viable disposal options in the US**
- **Increase confidence in the robustness of generic disposal concepts**
- **Develop the science and engineering tools needed to support disposal concept implementation**



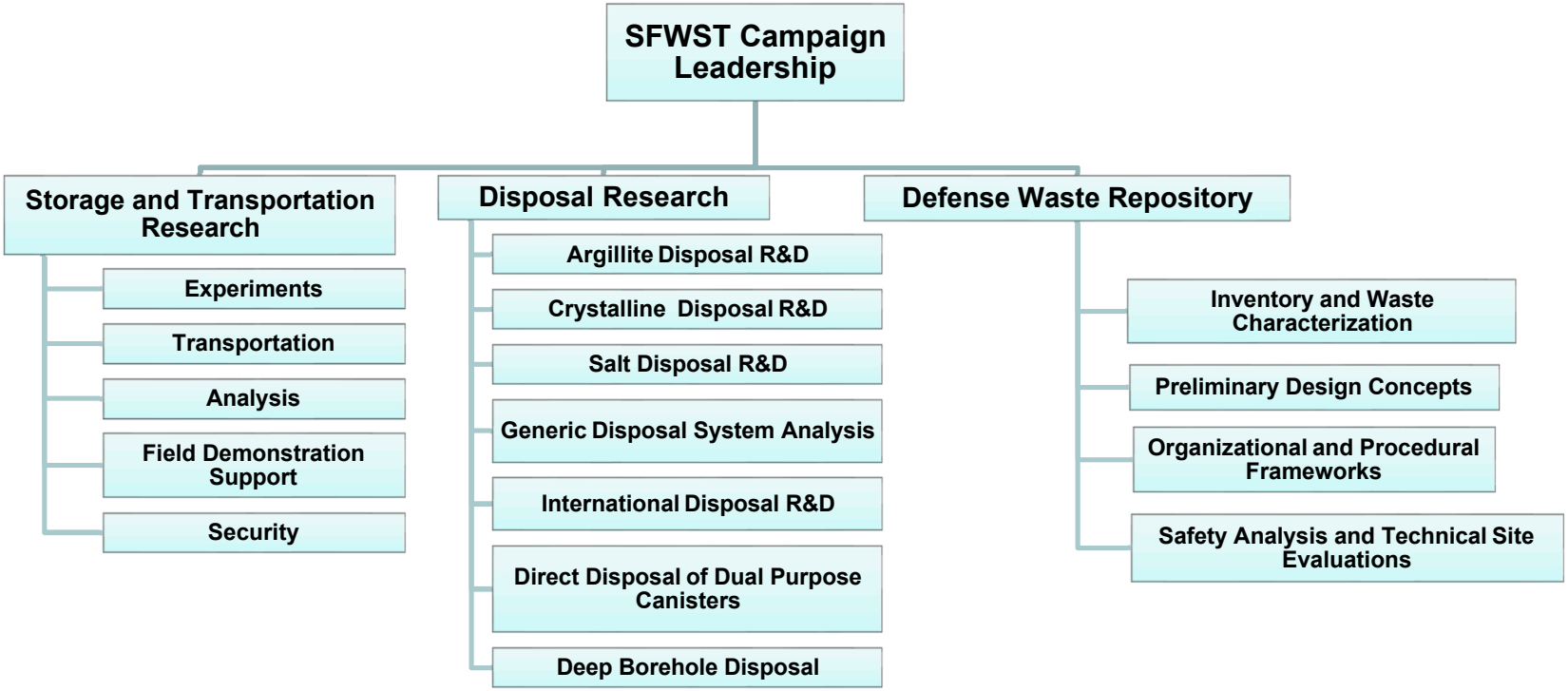






Used Fuel Disposition

Organization of the Used Fuel Disposition Campaign (Spent Fuel & Waste Science & Technology: FY2017)



High-burnup Confirmatory Data Project (industry-led, managed directly by DOE)

Deep Borehole Field Test (procurement managed directly by DOE)

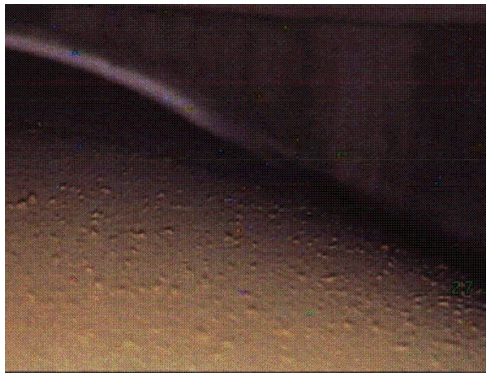
Used Fuel Disposition

Three-Year UFD Campaign Objectives (2017-2019)

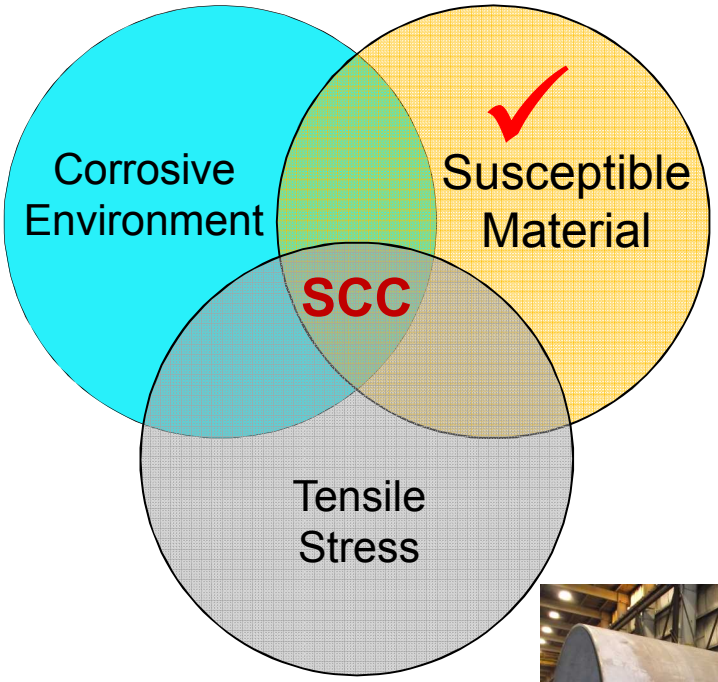
- **Storage and Transportation R&D**
  - Support the high burn-up (HBU) fuel full-scale ***storage demonstration*** project
  - Develop understanding of temperature/pressure affect cladding integrity in HBU UNF
    - *Predictive modeling and Experimentation*
  - Develop understanding of how corrosion and stress corrosion cracking affect ***performance of stainless steel dry storage canisters***
    - *Material and environmental data; predictive modeling*
  - Characterize external loadings on UNF during normal conditions of transport
- **Defense Waste Repository R&D**
  - Initiate a ***defense waste repository*** program for disposal of defense HLW and some DOE-managed SNF (cooler)
- **Disposal R&D**
  - Field a ***deep borehole test***
    - *Current US DOE Procurement Process – award early January 2017*
    - *Initiate drilling in ~2017, complete testing in 2020*
  - Complete evaluation of the direct disposal of dual-purpose canisters
  - Develop reference cases for ***generic disposal concepts***
  - Develop experimental and modeling basis for understanding long-term ***performance of disposal systems*** in argillaceous rock, salt, crystalline rock, and deep boreholes
    - *Leverage **international disposal R&D***

Storage R&D - Understanding Canister Performance

- **Primary Concern is Stress Corrosion Cracking (SCC), which requires three concurrent conditions:**



Dust on canister surface at Calvert Cliffs (EPRI 2014)



Weld zone, 304 SS plate.
Photo: Ranor

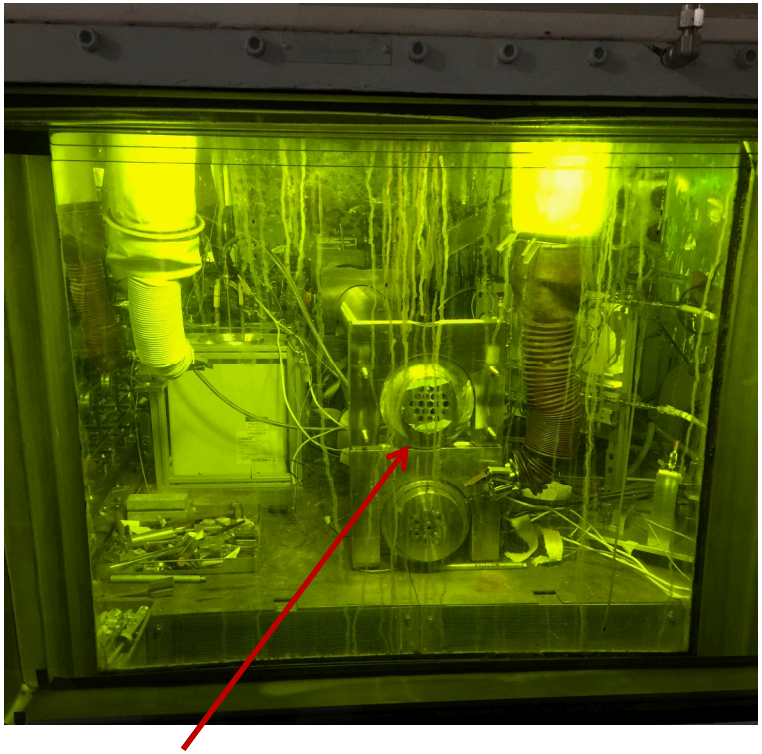
Mock-up Canister
Photo: Enos, SNL

High Burnup Confirmatory Data Project – Obtaining *Baseline* Data

25 fuel rods with similar histories will be tested now to document properties before 10 years of storage.

"Sister Rod" Acquisition and Testing

- Areva and Westinghouse rods pulled in June and January 2015 from different assemblies
  - *AREVA M5™ rods*
  - *Westinghouse Zirlo™ rods*
  - *Westinghouse Low-tin Zircaloy-4 rods*
  - *Westinghouse standard Zircaloy-4 rods*
- All 25 sister rods currently at Oak Ridge National Laboratory
- Draft Sister Rod Test Plan in peer review



25 Sister Rods in ORNL Hot Cell.
Photo: Saltzstein, SNL

Observations from Current Storage and Transportation R&D

1. *Spent fuel integrity*

- Current test and analyses indicate that spent fuel is ***more*** robust than was previously thought.
- The *DOE/EPRI High Burnup Confirmatory Data Project* will obtain data after 10 years of dry storage to confirm current test and analysis results.

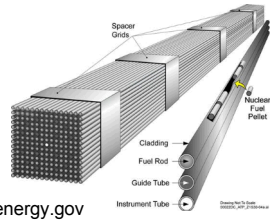


Photo: energy.gov

2. *Storage system integrity*

- *Stress corrosion cracking of canisters may be a concern in some parts of the country. More work is needed in analysis and detection.*
- *Monitoring and Aging Management practices at storage sites will be important to confirm storage system performance during extended service.*

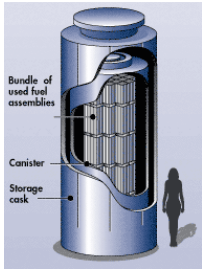
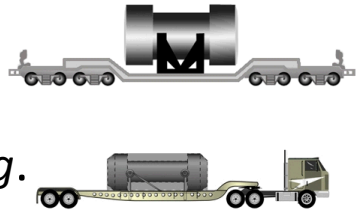


Photo: nrc.gov

3. *Spent fuel transportability following extended storage*

- *The realistic stresses fuel experiences due to vibration and shock during normal transportation are far below yield and fatigue limits for cladding.*



Energy.gov/pictures

The March 24, 2015 Decision and Resulting Campaign Structure

The White House

Office of the Press Secretary

E-Mail Tweet Share +

For Immediate Release March 24, 2015

Presidential Memorandum -- Disposal of Defense High-Level Radioactive Waste in a Separate Repository

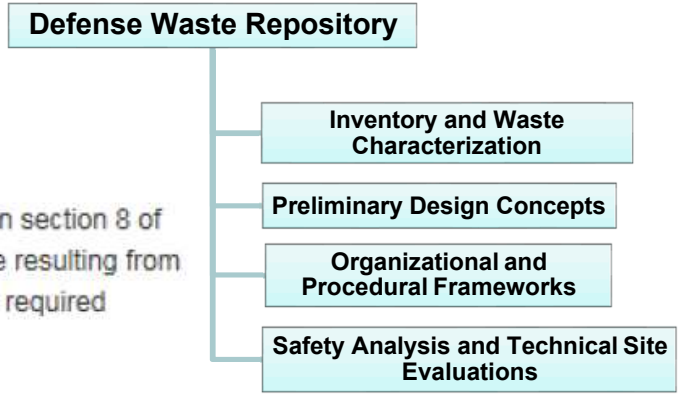
MEMORANDUM FOR THE SECRETARY OF ENERGY

SUBJECT: Disposal of Defense High-Level Radioactive Waste in a Separate Repository

Your memorandum and accompanying report of January 9, 2015, analyze the factors enumerated in section 8 of the Nuclear Waste Policy Act of 1982 (the "Act") concerning disposal of high-level radioactive waste resulting from atomic energy defense activities, conclude that a strong basis exists to find a separate repository is required pursuant to section 8 of the Act, and recommend that I make this finding.

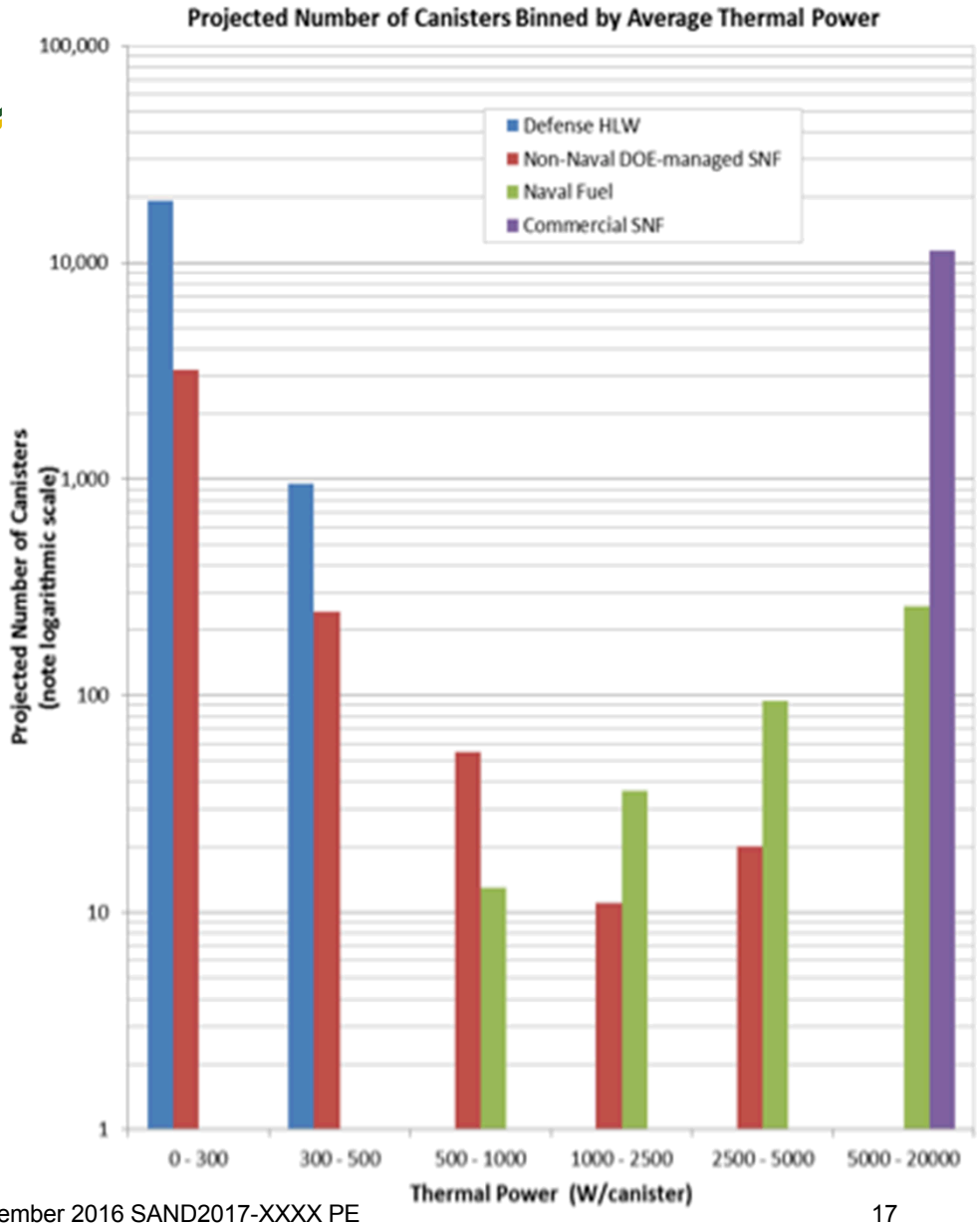
In accordance with the Act, I find the development of a repository for the disposal of high-level radioactive waste resulting from atomic energy defense activities only is required.

BARACK OBAMA



Thermal Characteristics of HLW and SNF Affect Disposal Strategies

- All defense HLW is relatively cold: less than 500 W per canister
- Most DOE-managed SNF is relatively cold: less than 1000 W per canister
- All commercial SNF has comparatively high thermal output
- Some naval SNF is comparable in thermal power to commercial SNF
- Repository designs and operational concepts can be engineered to address waste form thermal characteristics



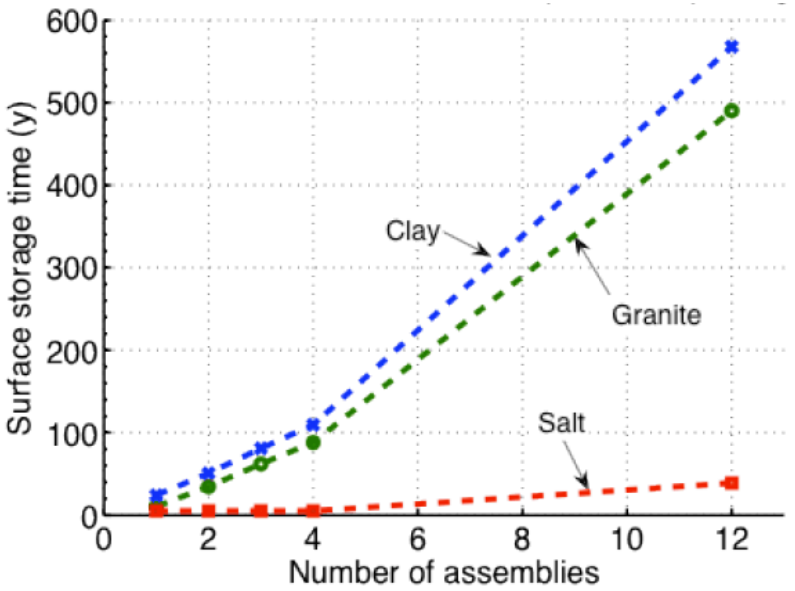
Repository Considerations: Thermal Management

Temperature limits based on current international and previous US concepts:

- 100°C for clay buffers and clay/shale media (e.g., SKB 2006)
- 200°C for salt (e.g., Salt Repository Project, Fluor 1986)

Final temperature constraints will be site- and design-specific

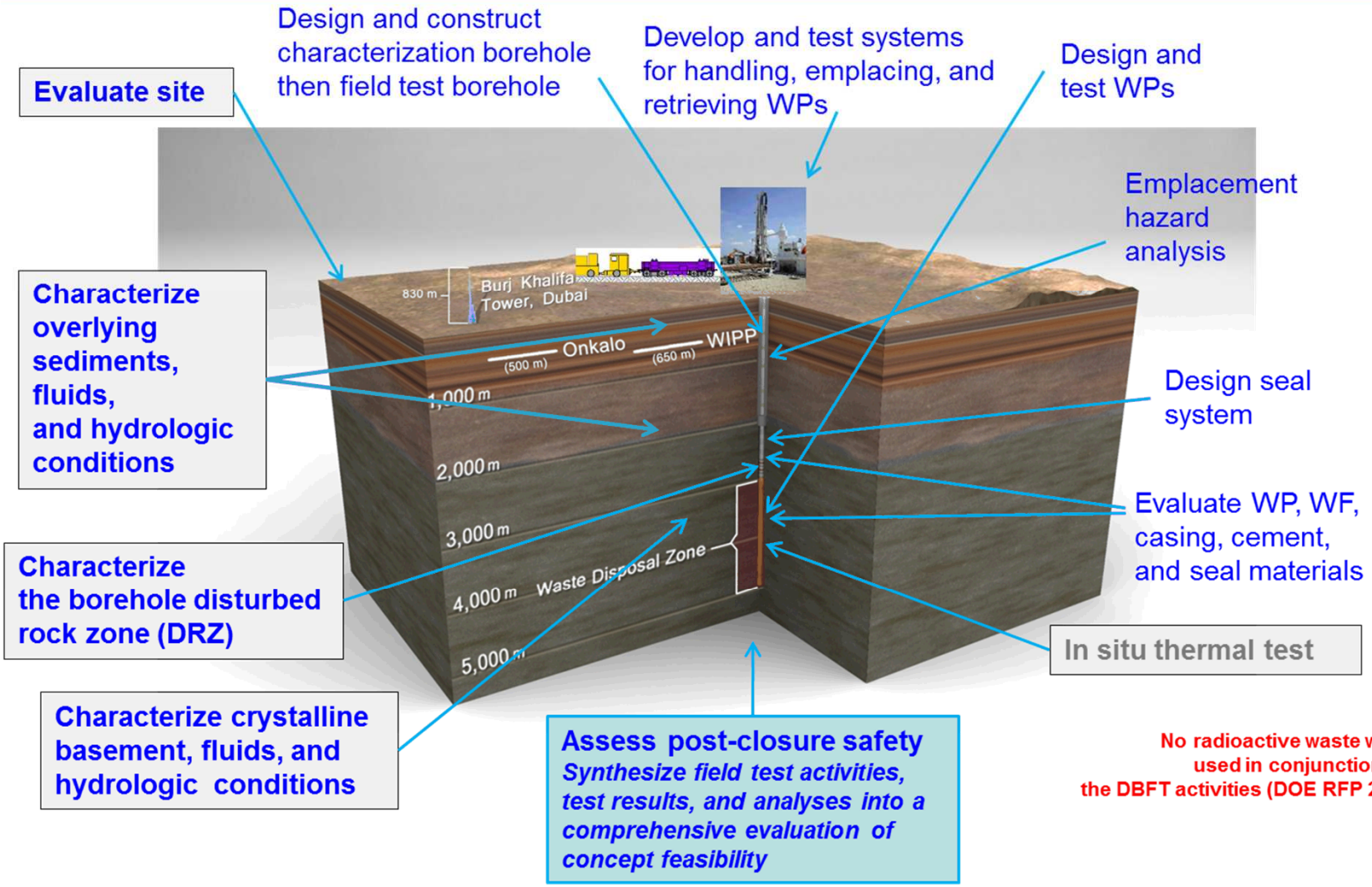
Decay Storage Needed to Meet WP Surface Temperature Limits vs. WP Size or Capacity (PWR Assemblies; 60 GWd/MT Burnup)



Repository thermal constraints can be met by

1) Aging
2) Ventilation in the repository
3) Decreasing package thermal output (size and burn-up)
4) Increasing package and drift spacing in the repository

Deep Borehole Field Test Objectives



Current Disposal Collaboration in International Partnerships/Activities

Multinational Initiatives

- **Mont Terri Project**
  - *Participate in experiments at Mont Terri clay URL in Switzerland*
- **DECOVALEX Project**
  - *Participate in model comparison initiative for several URL related tasks in different host rocks*
- **Colloid Formation and Migration Project**
  - *Participate in colloid research at Grimsel granite URL in Switzerland*
- **SKB Task Forces (New)**
  - *Participate in crystalline rock research centered around Äspö HRL in Sweden*
- **FEBEX DP (New)**
  - *Participate in FEBEX dismantling project, which will analyze bentonite-rock behavior after 17 years of heating*
- **Nuclear Energy Agency (NEA)**
  - *Thermochemical Database Project*
  - *Salt Club*
  - *Clay Club*

Bilateral Agreements

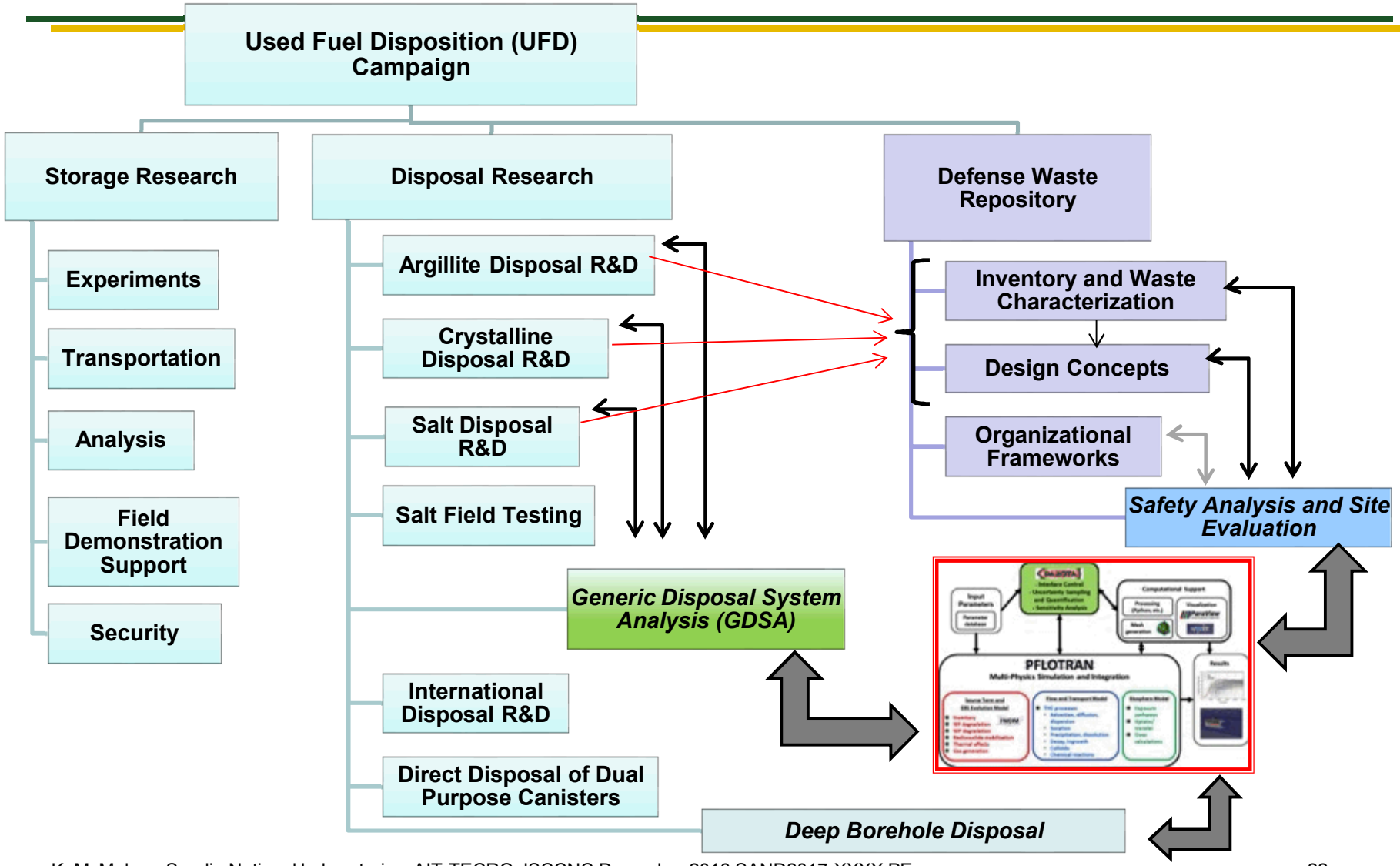
- **US-China**
  - Bilateral Civil Nuclear Energy Cooperative Action Plan (BCNECAP) with working group in Spent Fuel Storage and Repository Science
- **US-Germany benchmarking study for salt**
  - Participate in model comparison for TM behavior of domal and bedded salt
- **US-Republic of Korea (ROK)**
  - KAERI Underground Research Tunnel (KURT), experiments in crystalline rock
  - Joint Fuel Cycle Study (JFCS), information exchange in used fuel disposal
- **Other Potential Opportunities**
  - Explore use of existing Memorandum of Understanding (MoU) between DOE and Spain (ENRESA), France (ANDRA), Japan (JNEAP) and Belgium

International Underground Research Laboratory (URL) Collaborations in UFDC Disposal Research

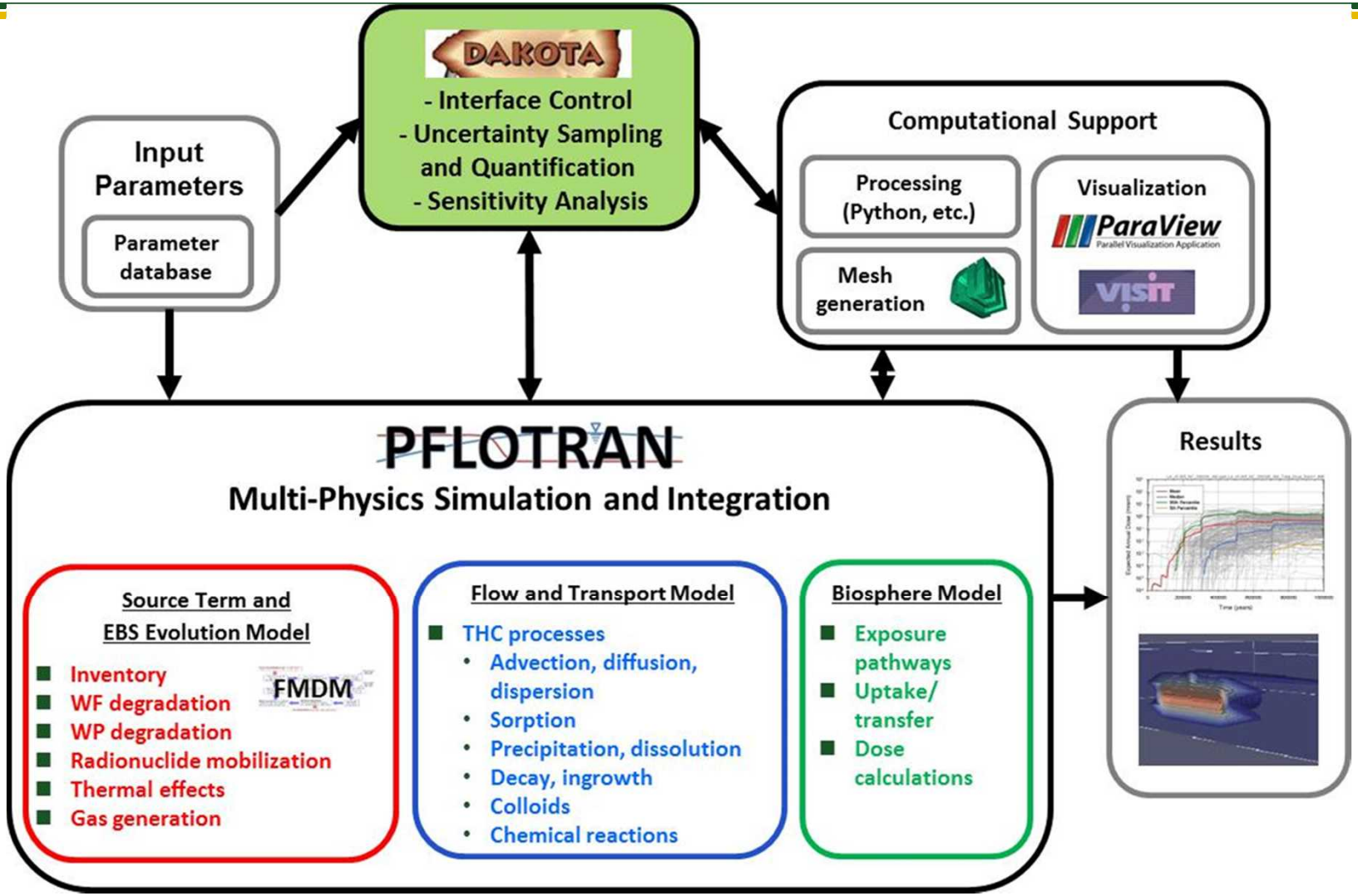
URL	Relevant Ongoing or Planned Experiments (Selected)	Cooperation Mode	UFD Participation
Mont Terri, Switzerland (Opalinus Clay)	• FE: Full-scale heater test demonstration experiment	• Mont Terri Project	• LBNL (Ongoing)
	• HE-E: Half-scale heater test in VE test section	• DECOVALEX-2015	• LBNL (Complete)
	• HG-A: Gas path host rock and seals	• Mont Terri Project	• LBNL (Complete)
	• EB: Engineered Barrier Experiment	• DECOVALEX-2019	• LBNL (Planned)
	FS: Fault Slip Experiment	• DECOVALEX-2019	• LBNL (Planned)
Grimsel Test Site, Switzerland (Granite)	• CFM: RN tracer test and RN-doped plug experiment	• CFM	• LANL, LLNL (Complete)
	• FEBEX-DP: full-scale heater test dismantling	• FEBEX-DP	• SNL, LBNL (Ongoing)
	• HotBENT: high-temperature heater test	• HotBENT	• LBNL (Planned)
Äspö Hard Rock Laboratory, Sweden (Granite)	• BRIE: Bentonite rock interaction experiment	• SKB Task Forces	• LANL (Complete)
	• LTDE-SD and REPRO (Diffusion-Advection-Sorption)	• SKB Task Forces	• LANL (Ongoing)
Mizunami, Japan (Granite)	• GREET: Groundwater Recovery Experiment	• DECOVALEX-2019	• SNL (Planned)
Bedrichov Tunnel, Czech Rep. (Granite)	• Flow patterns and tracer transport in fractured granite	• DECOVALEX-2015	• SNL (Complete)
Horonobe URL, Japan (Sedimentary rock)	• EBS experiment: Vertical heater and buffer test (planned)	• DECOVALEX-2015	• LBNL (Complete)
KURT URL, Korea (Crystalline rock)	• Streaming potential (SP) testing	• MoU KAERI	• SNL (Complete)
	• Techniques for *in situ* borehole characterization	• MoU KAERI	• SNL (Ongoing)
LSMHM URL, France (COX Clay)	• TED Heater Test	• DECOVALEX-2019	• LBNL (Planned)
	• ALC Heater Test	• DECOVALEX-2019	• LBNL (Planned)
WIPP, U.S. (Bedded Salt)	• Room B and D experiments	• MoU BMWi, Germ.	• SNL (Ongoing)
Asse Mine, Germany (Domal Salt)	• TDSE Heater Test	• Bilateral Coll.	• LBNL (Completed)

Used Fuel Disposition

Integration Linkages



Enhanced GDSA Computational Model Architecture for Performance Assessment



Used Fuel Disposition

Contact Information

Kevin McMahon
Sandia National Laboratories
MS 0779, PO Box 5800
Albuquerque, NM 87185-0779
Office: +1 505 844 5184
Mobile: +1 505 944 6511
Email: kamcmah@sandia.gov

Backup Slides

Used Fuel Disposition Campaign External Collaborations

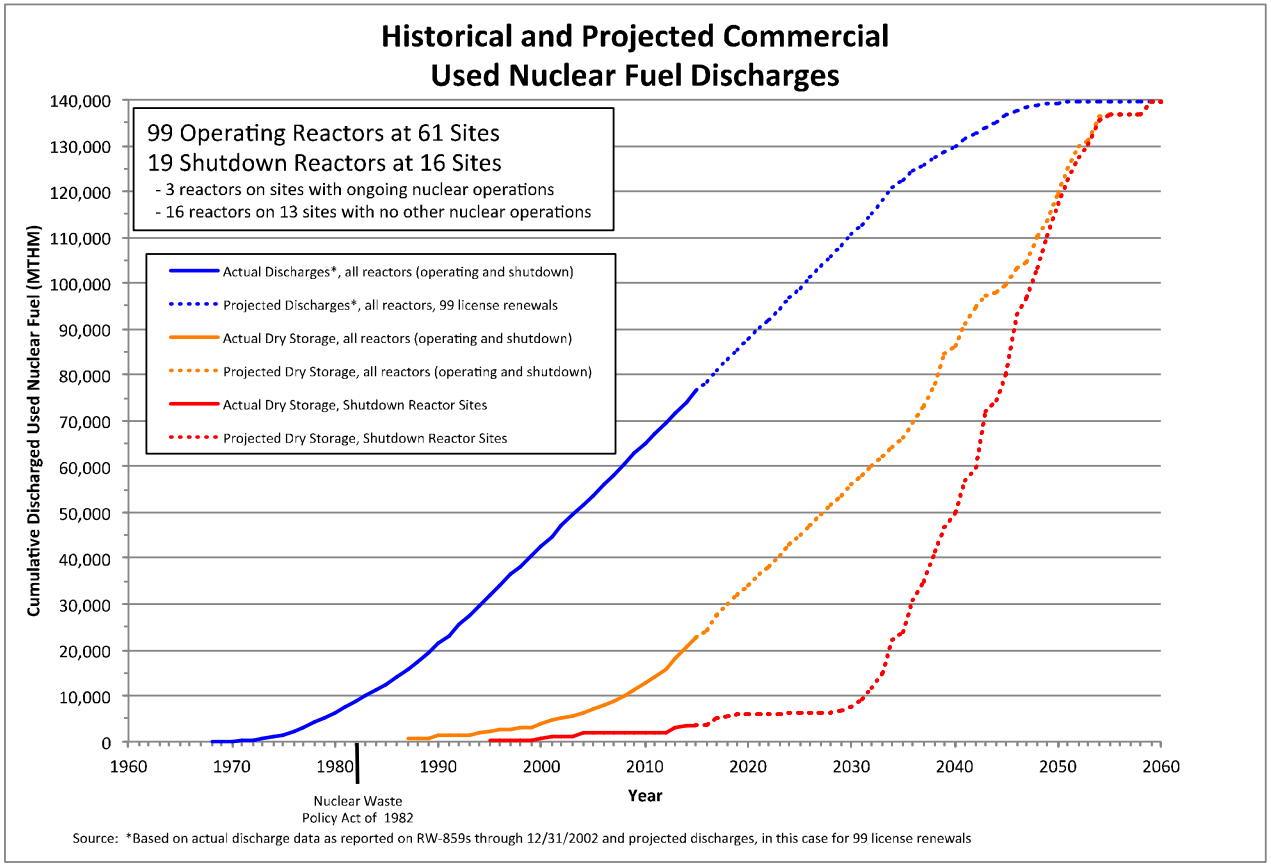
- **Collaboration among Fuel Cycle Technology Campaigns**
  - Full collaboration and shared resources with Nuclear Fuels Storage and Transportation Planning Project (NFST)
  - Support for Fuel Cycle Options Campaign
  - Close interactions with Material Recovery/Waste Form Campaign
    - *Waste form degradation modeling integration*
- **Collaboration with DOE-EM**
  - Canister concepts for deep borehole disposal
- **Industry (Advisory and Assistance Contracts)**
  - E.g., Areva; engineering services task for deep borehole field test
- **DOE/Industry Storage High-Burnup Data Project initiated FY13**
  - Dominion, Areva, Westinghouse
- **EPRI**
  - Extended Storage Collaboration Program (ESCP) (with NRC, utilities, vendors, and international organizations)
- **NEI**
  - Meetings to coordinate prioritization of funded activities

Used Fuel Disposition Campaign External Collaborations (cont.)

- **International Collaborations**
  - Participation in international Underground Research Laboratories in Europe and Korea and in multi-national disposal research activities
  - Bilateral agreements on storage and disposal R&D with Korea, Japan, China
  - MOU for salt disposal R&D with Germany
  - IAEA working groups in storage and transportation
  - Collaboration with Germany and Japan on extended performance of bolts and seals for bolted storage casks and on SS canister stress corrosion cracking
- **DOE NE University Programs**
  - UFD R&D is affiliated with 22 active NEUP research projects (not including FY15 awards)
    - *11 projects in Storage R&D*
    - *2 projects in Transportation R&D*
    - *6 projects in Disposal R&D*
    - *3 Integrated Research Projects in Storage R&D*
- **Other university collaborations (MIT, U. of Oklahoma, University of Sheffield UK)**

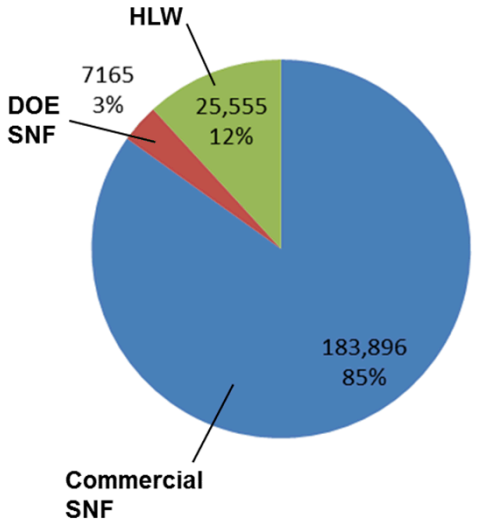
Used Fuel Disposition

Historical and Projected Spent Nuclear Fuel (SNF) and High-Level Radioactive Waste (HLW) in the United States



Historical and Projected Commercial SNF Discharges

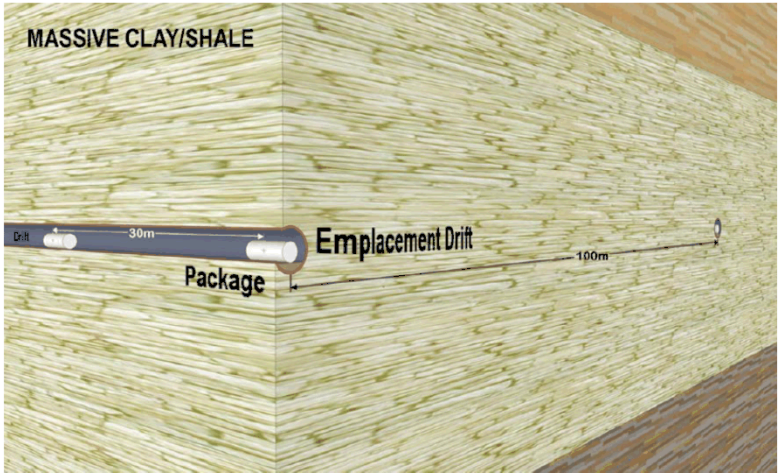
Projected Volumes of SNF and HLW in 2048

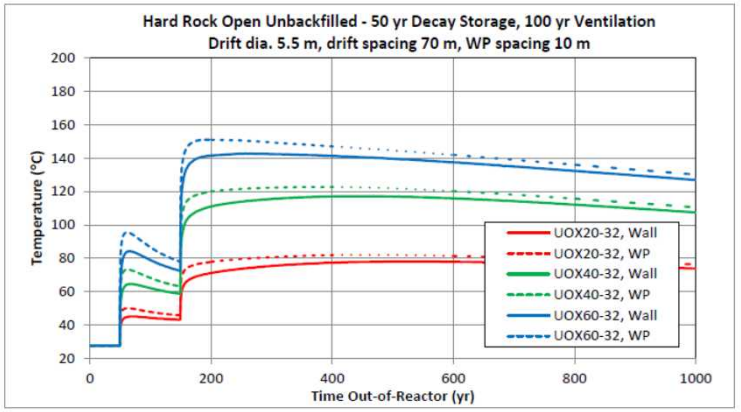


Volumes shown in m^3, assuming constant rate of nuclear power generation and packaging of future commercial SNF in existing designs of dual-purpose canisters

Disposal Research FY15 Highlights

- **Evaluating Technical Feasibility of Direct Disposal of Dual Purpose Canisters (DPCs)**
  - Considerations
    - *Operational challenges (size and mass)*
    - *Thermal management*
    - *Post-closure criticality control*
- **Conclusions:**
  - Direct geologic disposal of some DPCs is feasible in some disposal concepts
    - *Operational challenges can be met*
    - *Thermal management can be achieved through aging, ventilation, and spacing*
    - *Post-closure criticality control may need to be addressed individually for each DPC*
  - *DPC disposal is not an all-or-nothing choice*





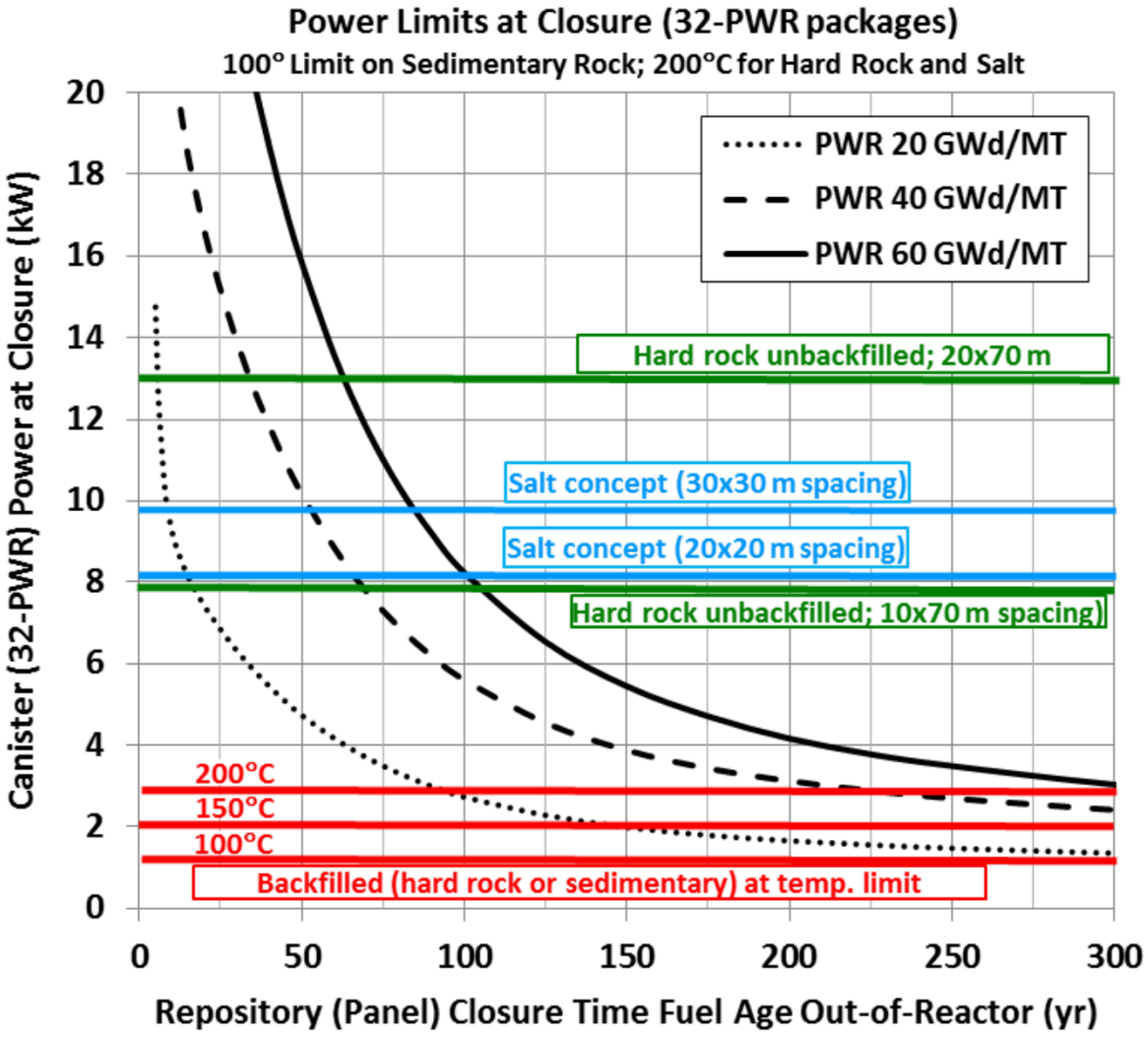
UFD R&D Campaign FY16 Activities

Used Fuel Disposition

Selected UFD R&D 2016 Milestones

- **Selected 2016 Milestones: Storage and Transportation**
  - *Canister Mockup Weld Residual Stress Final Report (SNL, 6/30/2016)*
  - *High Heat Load Thermal Analysis (PNNL, 9/29/2016)*
  - *Sister Pin Test Plan (PNNL, 4/29/2016)*
  - *Documentation of Data Collection of CIRFT Tests on Rod Ends (ORNL, 9/15/2016)*
- **Selected 2016 Milestones: Disposal**
  - *Evaluation of Used Nuclear Fuel Disposition in Clay-bearing Rocks (SNL, 9/15/2016)*
  - *Evaluation of Used Nuclear Fuel Disposition in Crystalline Rocks (SNL, 9/21/2016)*
  - *International Collaboration Activities in Different Geologic Disposal Environments (LBNL, 9/23/2016)*
  - *Deep Borehole Field Test Conceptual Design Report (SNL, 6/30/2016)*
  - *Deep Borehole Field Test Laboratory and Borehole Testing Strategy (SNL, 8/31/2016)*
- **Selected 2016 Milestones: DOE Managed HLW and SNF Research**
  - *Draft Program Plan for the Permanent Disposal of High-Level Radioactive Waste and Spent Nuclear Fuel from Defense and Department of Energy Research and Development Activities (SNL, 07/29/2016)*
  - *Generic Organizational and Procedural Framework for DOE Managed HLW and SNF Licensing (SNL, 9/16/2016)*
- **There are a total of 20 Level 2 Milestones for UFD R&D Campaign in FY16 (one completed at this time)**

Thermal Load Management (cont.)



Source: Hardin et al. 2015, FCRD-UFD-2015-000129 Rev 0 Figure 2-29

Higher burnup fuels require longer preclosure cooling times

Repository designs without backfill or in high-thermal-conductivity salt will need relatively shorter preclosure cooling times to accommodate large packages; underground spacing can have a large impact

Repository designs with thermal constraints on backfill will need long preclosure cooling times to accommodate large packages

Possible Options for an Integrated System

- Introduce a standardized canister to be loaded at reactors in the future
  - Selection of a standardized transportation, aging, and disposal (STAD) canister is repository-design and regulation specific
  - Loading STADs directly from reactor pools (as proposed for Yucca Mountain) is unlikely to happen before perhaps 2030, by which time more than 50,000 MTHM of SNF will be in DPCs
    - Later dates for repository and STAD selection will mean more fuel in DPCs
  - Lack of present incentive for utilities to use standardized canister
- Repackaging of SNF from DPCs to STADs at a consolidated storage facility
  - Cost and schedule of repackaging
  - Management of additional LLW stream (used DPCs)
- Repository design options to handle multiple packaging systems
  - Plan now for disposal of some DPCs, repackaging of others
- Cost considerations–number of handling operations, number of packages, repository design, and complexity of licensing

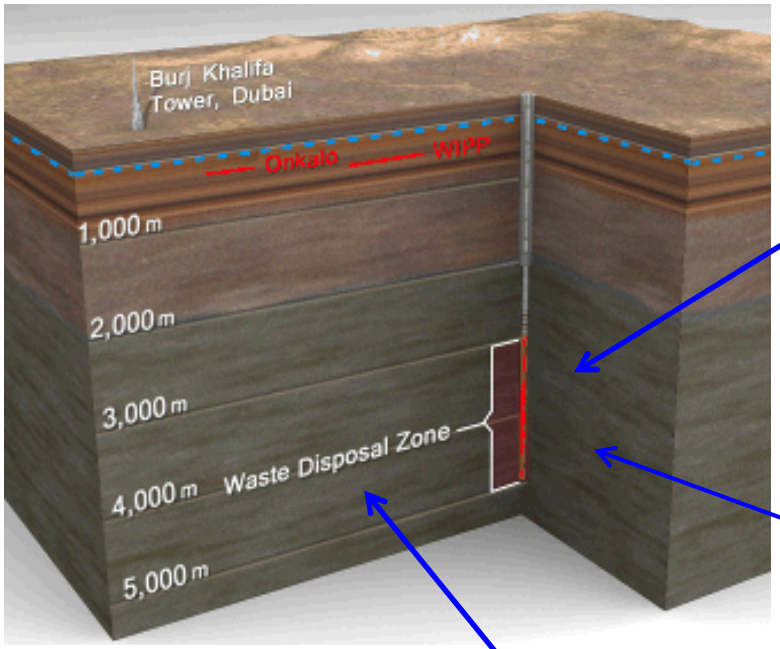
Note: the DOE has relevant work in progress in each of these areas

Deep Borehole Disposal Concept: Why Deep Borehole Disposal?

- **Potential for robust isolation**
- **Gives DOE the flexibility to consider options for disposal of smaller waste forms in deep boreholes**
  - Potentially earlier disposal of some wastes than might be possible in a mined repository
  - Possible reduced costs associated with projected treatments of some wastes
- **Several DOE-managed small waste forms are potential candidates for deep borehole disposal (SNL 2014)**
  - Cesium and strontium capsules. 1,936 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

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 can have very low permeability

- limits flow and transport

Deep groundwater in the crystalline basement:

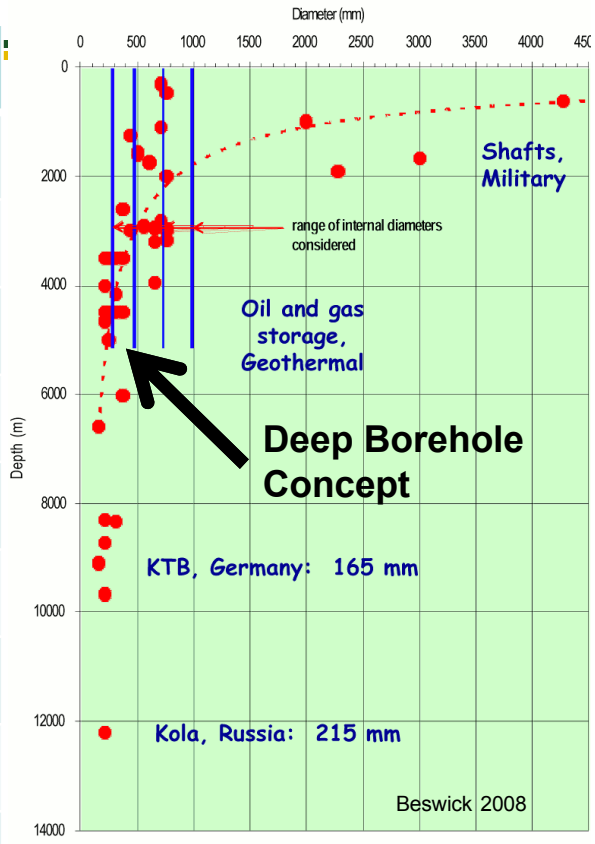
- Can have very long residence times – isolated from shallow groundwater
- Can be highly saline and geochemically reducing – enhances the sorption and limits solubility of many radionuclides
- Can have density stratification (saline groundwater underlying fresh groundwater) – opposes thermally-induced upward groundwater convection

Used Fuel Disposition

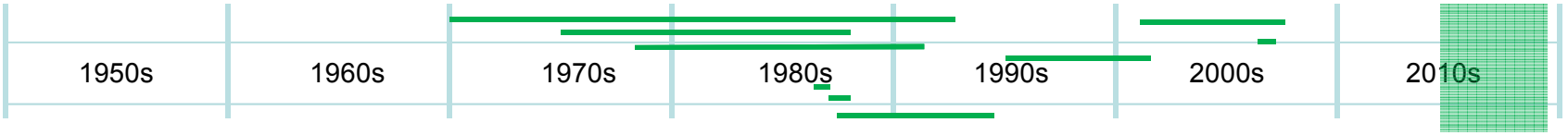
Deep Crystalline Drilling

Site	Bores	Location	Years	Depth [km]	Diam* [in]	Purpose
Kola SG-3	1	NW USSR	1970-1992	12.2	8½	Geologic Exploration + Technology Development
Fenton Hill	3	New Mexico	1975-1987	3, 4.2, 4.6	8¾, 9⅞	Enhanced Geothermal
Urach-3	1	SW Germany	1978-1992	4.4	5½	Enhanced Geothermal
Gravberg	1	Central Sweden	1986-1987	6.6	6½	Gas Wildcat in Siljan Impact Structure
Cajon Pass	1	California	1987-1988	3.5	6¼	San Andreas Fault Exploration
KTB	2	SE Germany	1987-1994	4, 9.1	6, 6½	Geologic Exploration + Technology Development
Soultz-sous-Forêts GPK	3	NE France	1995-2003	5.1, 5.1, 5.3	9⅝	Enhanced Geothermal
SAFOD	2	Central California	2002-2007	2.2, 4	8½, 8¾	San Andreas Fault Exploration
Basel-1	1	Switzerland	2006	5	8½	Enhanced Geothermal

*borehole diameter at total depth



Deep Borehole Field Test DBFT

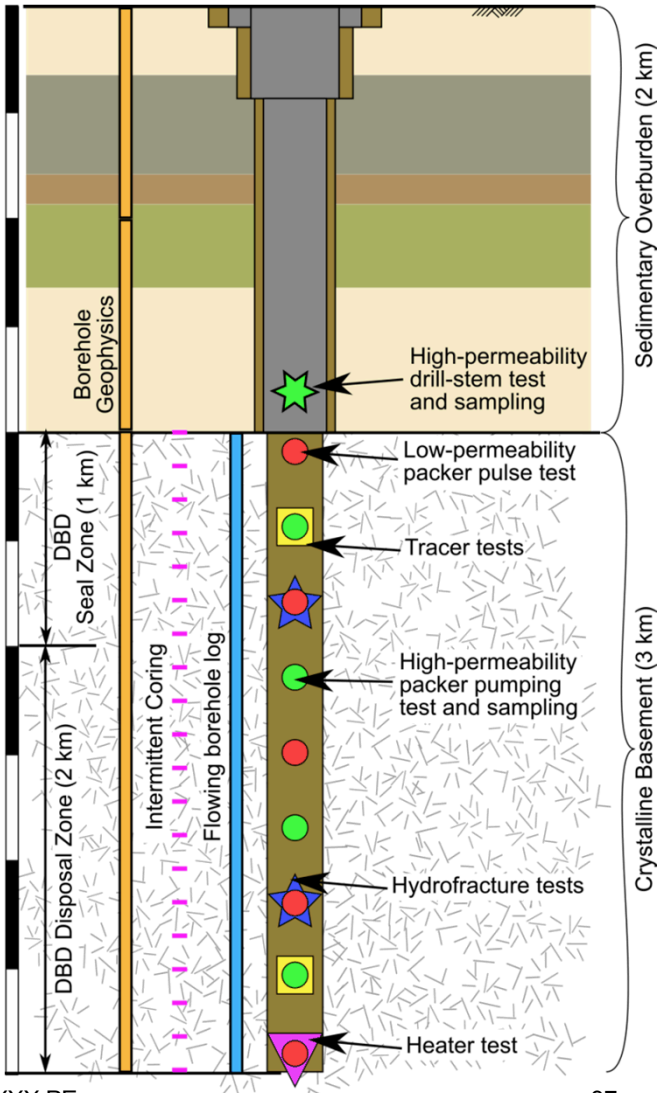


Used Fuel Disposition

Characterization Borehole (CB)

- Not all Char. Methods Included
  - Surface geophysics
  - Testing sedimentary sequence
  - No need to demonstrate in DBFT
- 8.5” diam. ~geothermal experience
- Core 150 m of Bedrock Section
- Testing/Sampling After Completion
  - Packer tool via work-over rig
  - At limits of current technology

Borehole designed to maximize likelihood of good samples

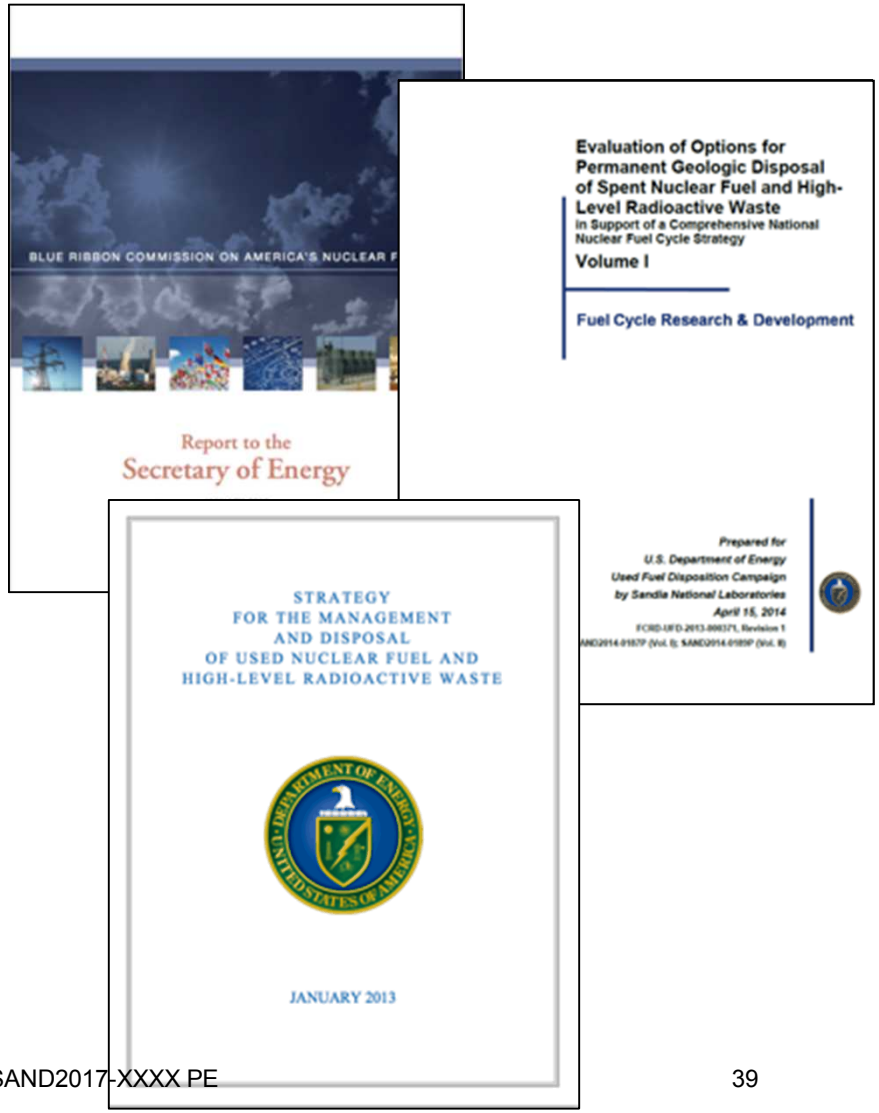


Deep Borehole Field Test
Acquisition of Site and Services

- **Initial Request for Proposal (RFP)/Award**
  - Did not establish a suitable test site
- **US DOE RFP (Solicitation Number DE-SOL-0010181)**
  - Pre-solicitation notice posted on August 5, 2016
  - Final RFP posted on FedBizOps on August 22, 2016
  - Proposals due October 21, 2016
  - Contract award anticipated in early 2017

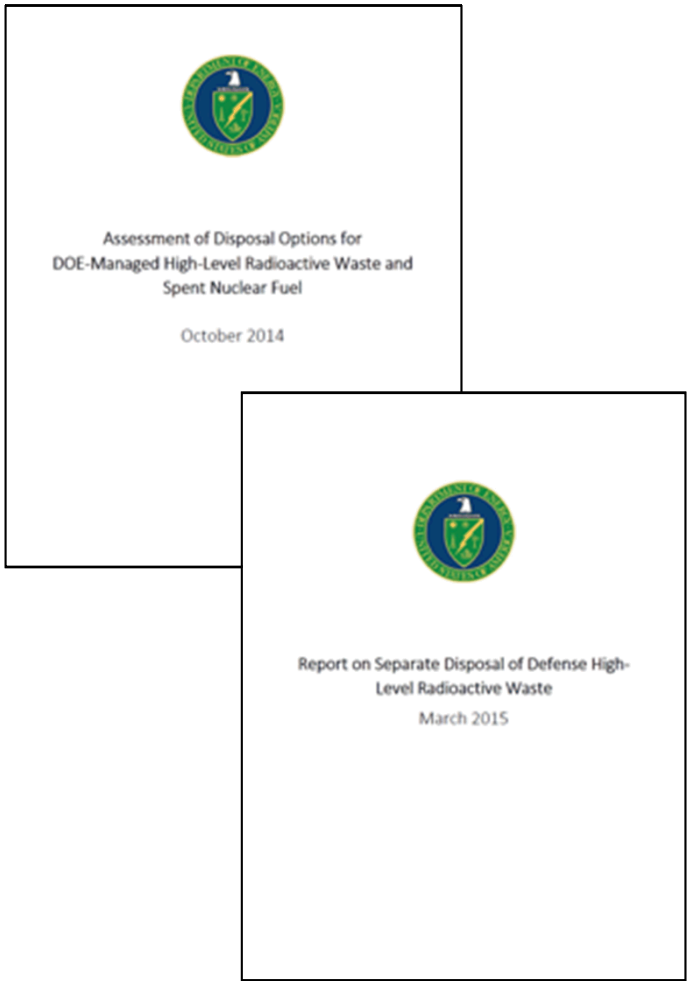
Underlying Documents

- **January 2012 Blue Ribbon Commission (BRC) on America's Nuclear Future report to the Secretary of Energy**
  - Recommends review of "single repository" policy, whereby defense-related and commercial wastes are co-mingled
- **2013 Administration releases "Strategy for the Management and Disposal of Used Nuclear and High-Level Radioactive Waste"**
  - Follows the BRC Report's recommendation to review repository policy
- **April 2014 UFD report "Evaluation of Options for Disposal…"**
  - Concludes that both commingled and separate repositories are technically feasible

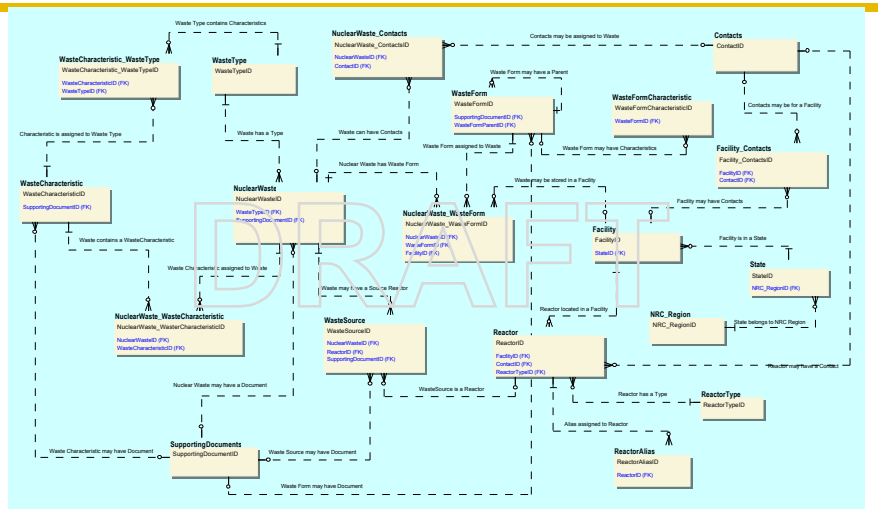


Underlying Documents

- **October 2014 DOE report "Assessment of Disposal Options…"**
  - Recommends that the DOE begin implementation of a phased, adaptive, and consent-based strategy with development of a separate repository for some DOE-managed HLW and SNF
  - Also recommends the DOE retain flexibility to consider deep borehole disposal of some smaller DOE-managed waste forms
- **March 2015 DOE report "…Separate Disposal of Defense High-Level Radioactive Waste"**
  - Presents the basis for a decision in the context of the Nuclear Waste Policy Act



Inventory and Waste Characterization: Complete & Populate Online Waste Library (OWL)

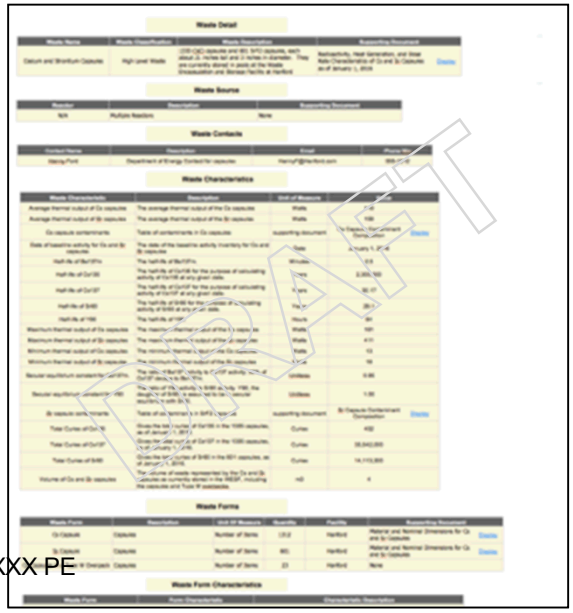


SCOPE:

The on-line waste library (OWL) will be implemented to contain detailed **cross-linked information**, both **technical** and **organizational**, regarding DOE-managed high-level waste (HLW) and spent nuclear fuel (SNF) (D-wastes), and other DOE-managed radioactive wastes that are likely candidates for deep geologic disposal, with **links to the current supporting documents** for the data (where possible).

OBJECTIVES:

- Finalize the initial design of the information system that implements the database
- Implement the database onto a platform with account access available to a prototype group (i.e., DOE and National Laboratory participants)
- Populate the database with at least a portion of the primary technical data for the waste types/forms.



Creating a Design Concept

Inventory
- Dimensions
- Quantity
- Thermal output

Design Concepts
- Packing spacing

From Hardin et al. 2011