

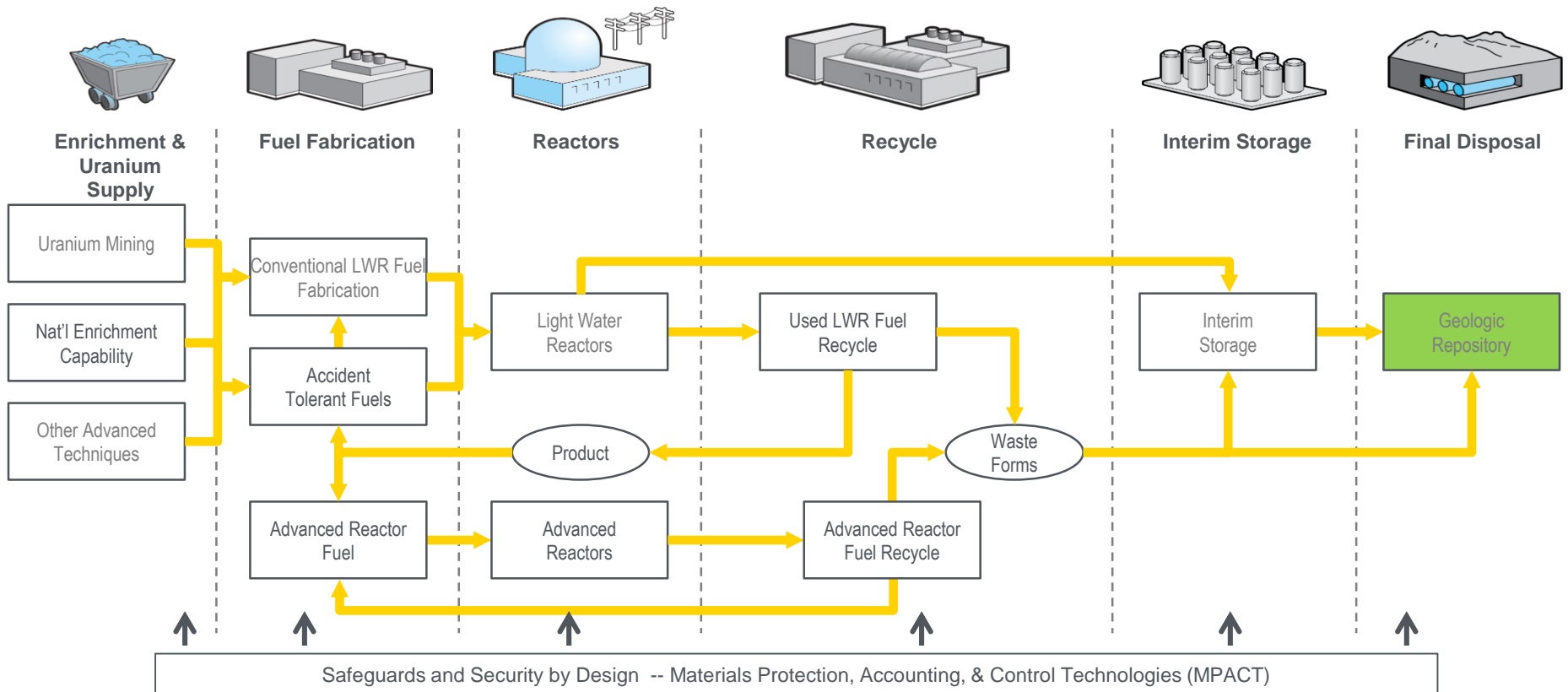


DOE Collaboration and Underground Research Program: Overall Program and Approach

U.S. Nuclear Waste Technical Review Board Workshop
April 24-25, 2019
Burlingame, California

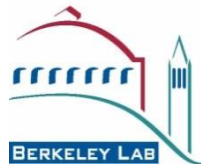
William Boyle, Director
Office of Spent Fuel and Waste Science and Technology
Las Vegas, Nevada

Office of Nuclear Energy (NE) Fuel Cycle Infrastructure



Spent Fuel and Waste Science and Technology Campaign

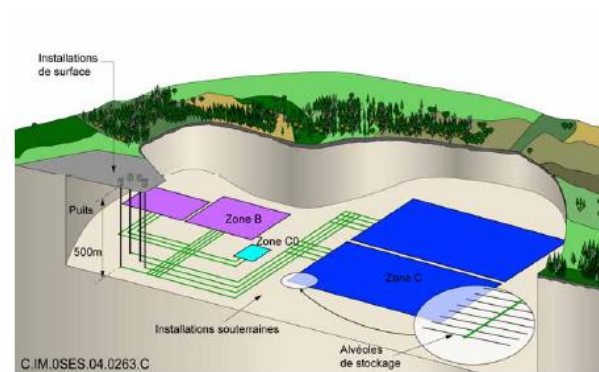
- Managed by the NE Office of Spent Fuel and Waste Science and Technology (SFWST)
- Formerly referred to as the “Used Fuel Disposition” Campaign
- Nine national laboratories support the campaign



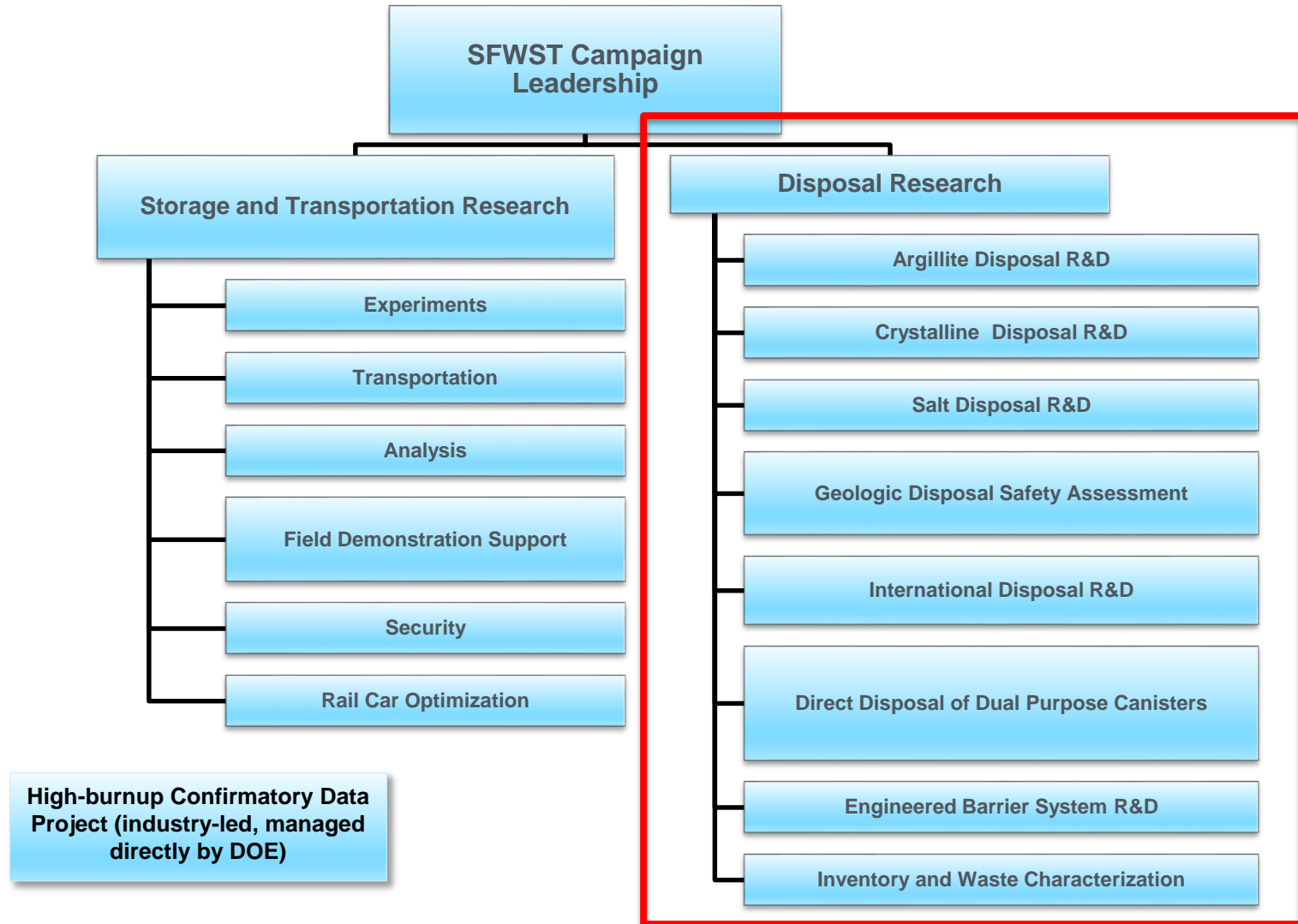
SFWST Campaign Mission



The mission of the Spent Fuel and Waste Science and Technology (formerly 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.



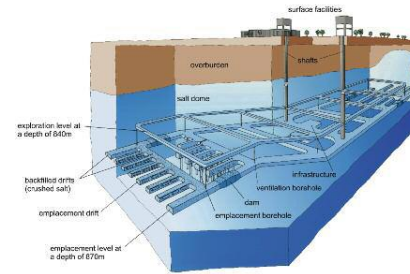
SFWST Campaign Structure



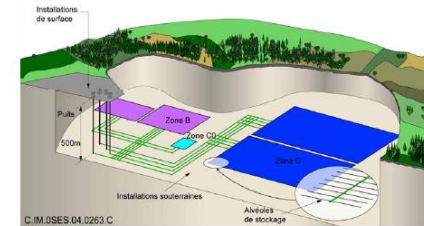
SFWST – Disposal R&D

Current Focus

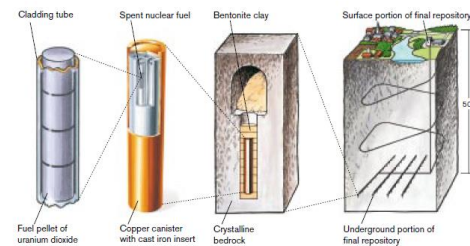
- Provide a sound technical basis for multiple viable disposal options in the US
- Increase confidence in the robustness of generic disposal concepts
- Develop the science and engineering tools needed to support disposal concept implementation
- Conduct R&D on the direct disposal of existing dual purpose (storage and transportation) canisters
- **Leverage international collaboration**



Mined repositories in salt



Mined repositories in clay/shale



Mined repositories in crystalline rock

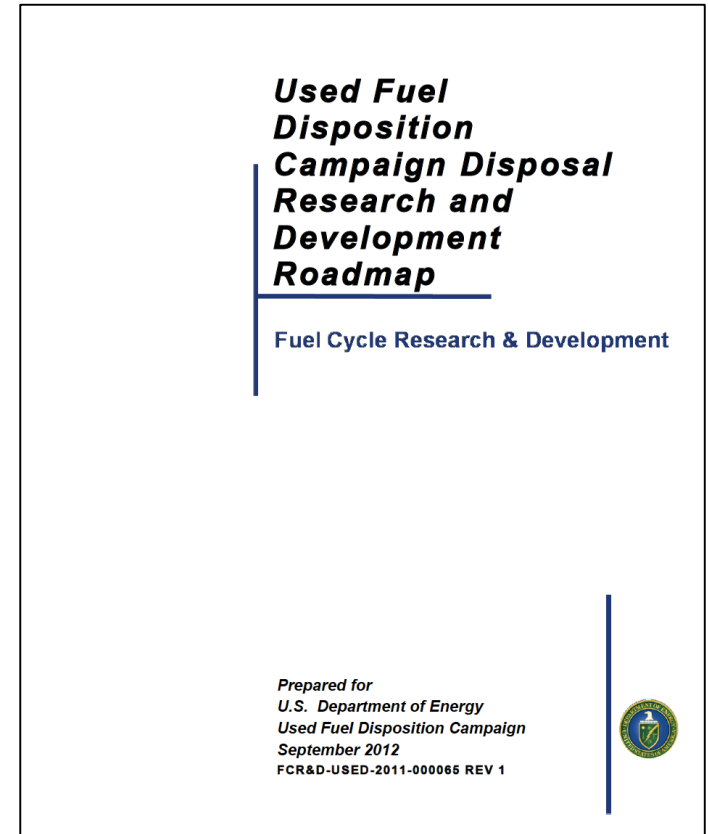
Systematic Process to Identify Research Priorities

Priority Topics in Natural System

- Excavation disturbed zone for shale media
- Flow and transport pathways in crystalline media
- Chemical processes for shale media
- Thermal processes for shale media
- Hydrologic processes for salt media



January 2019 Workshop to Update
Research Priorities



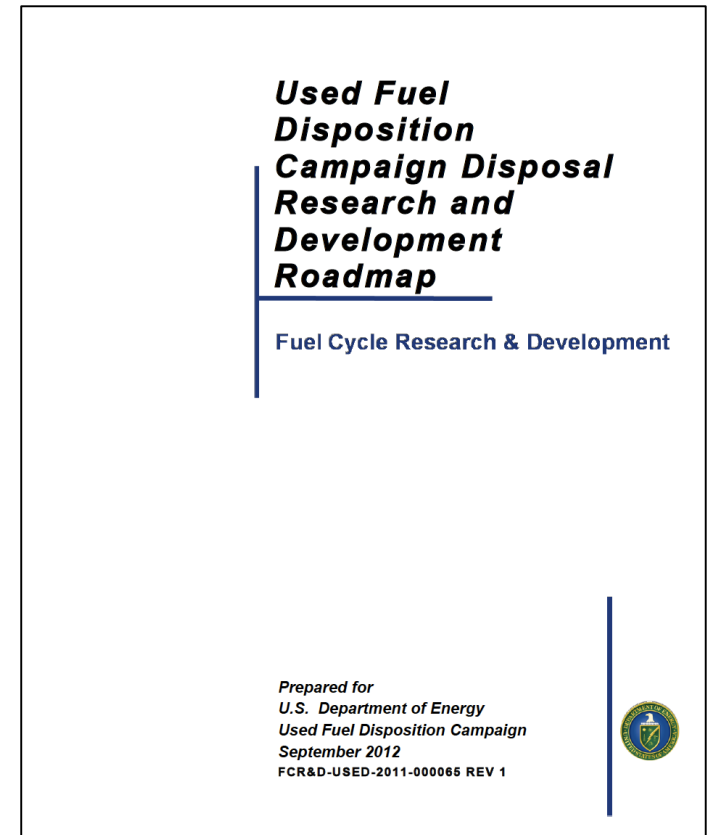
Systematic Process to Identify Research Priorities

Priority Topics in EBS

- Buffer and Backfill Materials: Issues related to chemical, mechanical and thermal processes ranked high
- Overall, chemical processes in the considered EBS components ranked higher than others but are strongly coupled to thermal, hydrological, and mechanical processes within the EBS



January 2019 Workshop to Update Research Priorities



Cross-Cutting Priority R&D Topics

Key Topics	High-Level Research Questions
Near-Field Perturbation	<ul style="list-style-type: none">• How important are thermal, mechanical, and other perturbations?• How effective is healing and sealing of damage zone in the long-term?• How reliable are existing predictive models for the strongly coupled thermal-hydrological-mechanical behavior of clays and salts?
Engineered Barrier Integrity	<ul style="list-style-type: none">• What is the long-term stability and retention capability of buffer materials?• Can bentonite be eroded by contact with water from flowing fractures?• How relevant are interactions between engineered and natural barrier?• Is gas pressure increase and gas migration a concern for barrier integrity?
Flow and Radionuclide Transport	<ul style="list-style-type: none">• What is the effect of high temperature on the diffusion and sorption characteristics of clays?• What is the potential for enhanced transport with colloids?• Can transport in diffusion dominated (clays, bentonites) and advection dominated systems (fractured granites) be predicted with confidence?
Integrated System Behavior	<ul style="list-style-type: none">• Can the early-time behavior of an entire repository system, including all engineered and natural barriers and their interaction, be demonstrated?• Can this integrated behavior be reliably predicted?• Is the planned construction/emplacement method feasible?• Which monitoring methods are suitable for performance confirmation?

Evaluation of International URL Programs

- Initially developed an understanding of ongoing research activities at international disposal research programs and interacting with key researchers in the respective scientific and technical fields
- Identified international program opportunities (URL and non-URL related) for enhancing and complementing SFWST scope both underway and planned
- Ongoing R&D efforts at international URL sites were evaluated to identify opportunities for SFWST campaign research advances (process understanding, modeling and monitoring methods, data)

Considerations for DOE Participation in International Activities

- Benefit to the SFWST campaign and the international partners
- Complementary to US National Laboratory staff capabilities in disposal sciences
- Participate and contribute to disposal research in a cost effective manner
- Gaining research experience and taking advantage of established URLs in a short period of time

DOE's Activities Related to International URLs

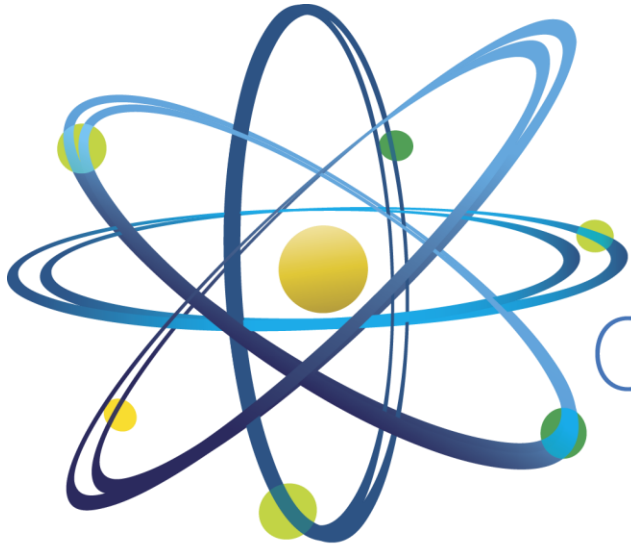
Key Topics	International Experiment	URL	Main R&D Focus
Near-Field Perturbation	Heater Experiment E (HE-E)	Mont Terri, Switzerland	Bentonite/rock interaction to evaluate sealing and clay barrier performance at elevated temperature, micro-tunnel
	Thermal Experiment (TED) Full-scale Emplacement Test (ALC)	Bure, France	Upscaling THM simulations from lab tests to repository scale
	Gas Path Through Host Rock Experiment (HG-A)	Mont Terri, Switzerland	Evaluation of flow paths through the near-field damage zone and specifically along seals
	Thermal Simulation for Drift Emplacement (TSDE)	Asse Mine, Germany	Model benchmarking studies for thermal-hydrological-mechanical behavior salt heater test
	Brine Availability Test in Salt (BATS)	WIPP, USA	Monitoring brine distribution, inflow, and chemistry from heated salt using geophysical methods and direct liquid & gas sampling
Engineered Barrier Integrity	Cement Clay Interaction (CI) Experiment	Mont Terri, Switzerland	Chemical interaction between host rock and engineered barrier materials
	Bentonite-Rock Interaction Experiment (BRIE)	Äspö HRL, Sweden	Understand the impact of flowing fractures in crystalline rock on bentonite saturation, integrity and erosion
	Engineered Barrier System (EBS) Experiment	Horonobe, Japan	Studies of the thermo-hydro-mechanical-chemical (THMC) behavior of the EBS
	Full-Scale Engineered Barrier Experiment - Dismantling Project (FEBEX DP)	Grimsel Test Site, Switzerland	Dismantling and sampling of long-term test evaluating the long-term integrity and performance of heated bentonite
	HotBENT Experiment	Grimsel Test Site, Switzerland	Complex THMC behavior of EBS materials up to 200 degrees C at the canister/bentonite interface.
	Gas Migration in Clay-Based Materials	NA	Laboratory tests and modeling studies to determine complex gas migration processes in bentonite and clays
Flow and Radionuclide Transport	Bedrichov Tunnel Experiment	Bedrichov, Czech Republic	Interpretation of water inflow patterns and tracer transport behavior in fractured granite
	Fault Slip (FS) Experiment	Mont Terri, Switzerland	Evaluation of pressure increase impacts on reactivation of faults
	GREET (Groundwater Recovery Experiment)	Mizunami, Japan	Evaluation of early resaturation behavior in crystalline rock looking at flow behavior and chemical-biological interactions upon resaturation
	Long-Term Sorption Diffusion Experiment (LTDE)	Äspö HRL, Sweden	Monitoring the diffusion behavior in fractured crystalline rock
	DR-A Experiment (Diffusion Retention and Perturbation Test)	Mont Terri, Switzerland	Ion diffusion through compacted clay where electro-chemical charges affect transport behavior
	Colloid-Facilitated Radionuclide Migration Test (CFM)	Grimsel Test Site, Switzerland	Evaluate RN transport of bentonite colloids compared in a shear zone in fractured granite
	Streaming Potential Test	KURT, Korea	Site characterization techniques (in situ borehole characterization)
Integrated System Behavior	Full-scale Emplacement Experiment (FE)	Mont Terri, Switzerland	Full-scale demonstration experiment, one of the largest and longest-duration heater tests

Summary

Presentations to follow will provide further discussion on:

- Active DOE collaboration with international programs, initiatives, and projects benefit the SFWST's disposal research program, and provide access to decades of experience gained in various disposal environments
- Pursuit of avenues for international collaboration and has joined formal collaborative R&D agreements with international partners
- Focus on partnerships that allow for “active” R&D collaboration, often with access to field data and respective interpretation/modeling
- Establishment of a balanced portfolio of international R&D activities in disposal science

Questions?



Clean. **Reliable. Nuclear.**