

# Overview of US DOE Program Supporting Disposal Research & Development (R&D) for Nuclear Wastes Generated by Commercial Nuclear Power Production

**Presented to:**  
**Republic of Korea Joint Fuel Cycle Studies**  
**Committee Meeting**

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# Presentation Outline

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- **Identification of Nuclear Wastes likely to require disposal**
- **US DOE Used Fuel Disposition Work Activities**
- **Elements of Nuclear Waste Disposal**
  - Research & Development (R&D) activities
  - Experimental and Analysis activities
- **Collaborations and integration**
- **Questions?**

# Used Nuclear Fuel (UNF) and High-Level Waste (HLW) in the United States Today

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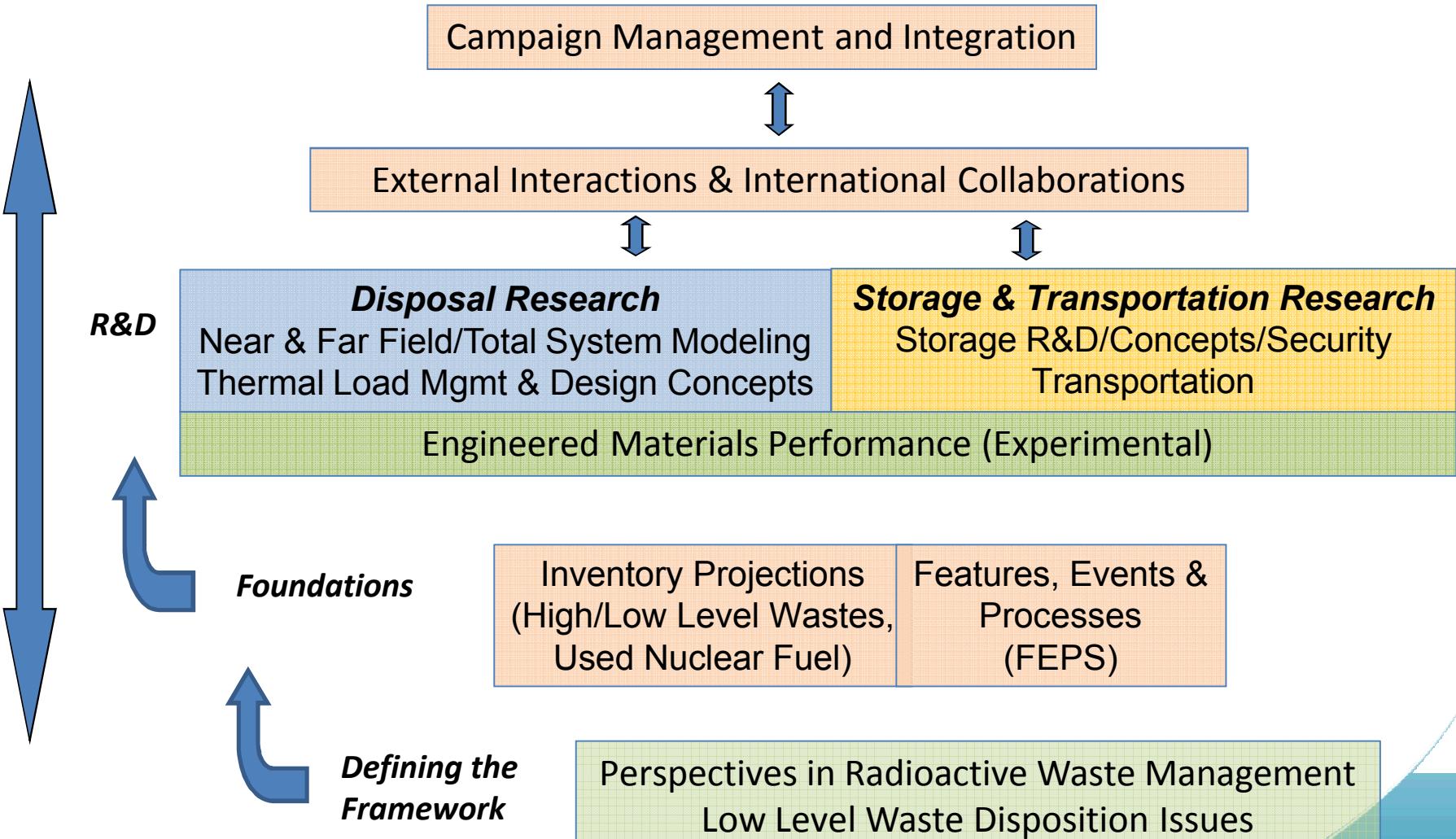
**Commercial Used Nuclear Fuel**

**DOE and Defense-Related  
Used Nuclear Fuel**

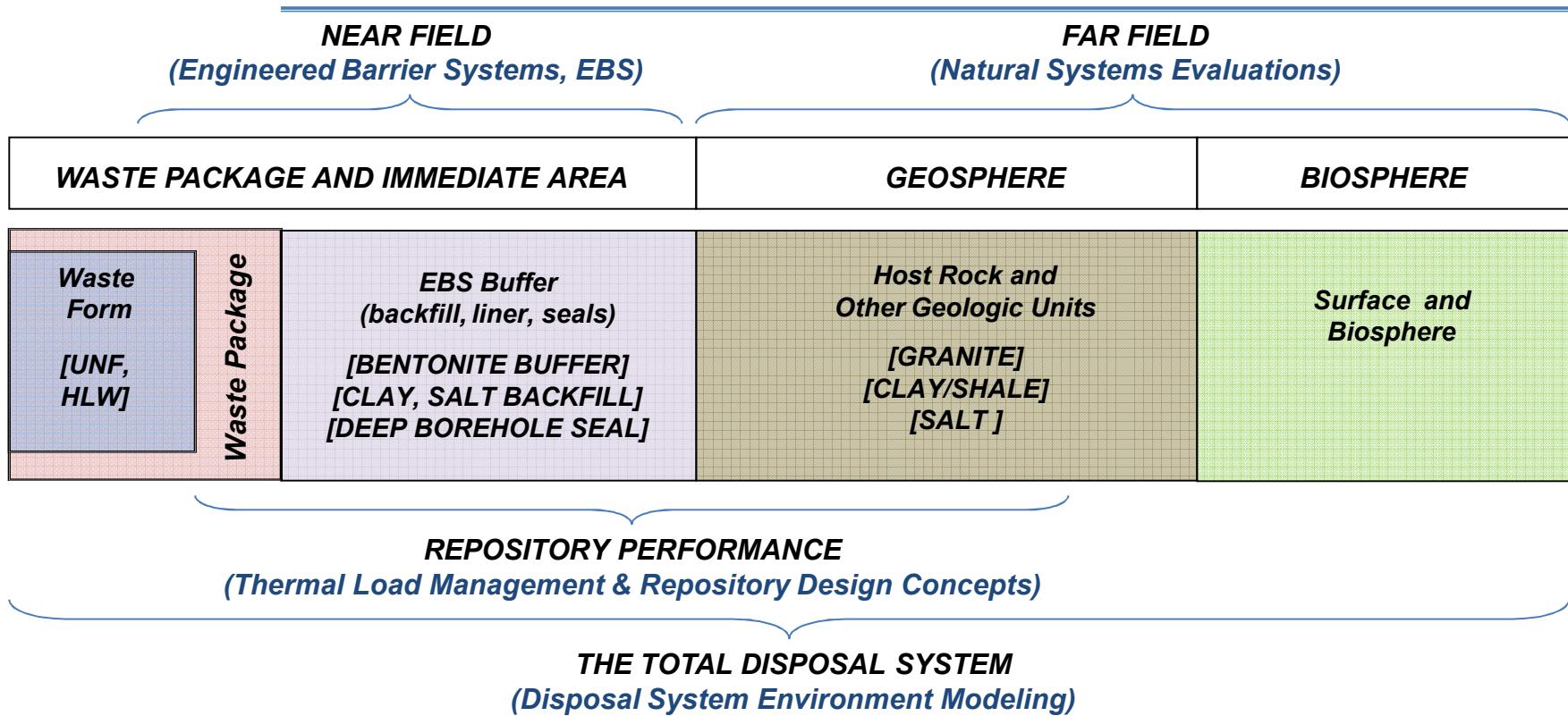


**Defense-Related and Commercial  
High-Level Radioactive Waste**

# US DOE Used Fuel Disposition (UFD) Campaign Work Activities Structure



# Nuclear Waste Disposal Research R&D Elements



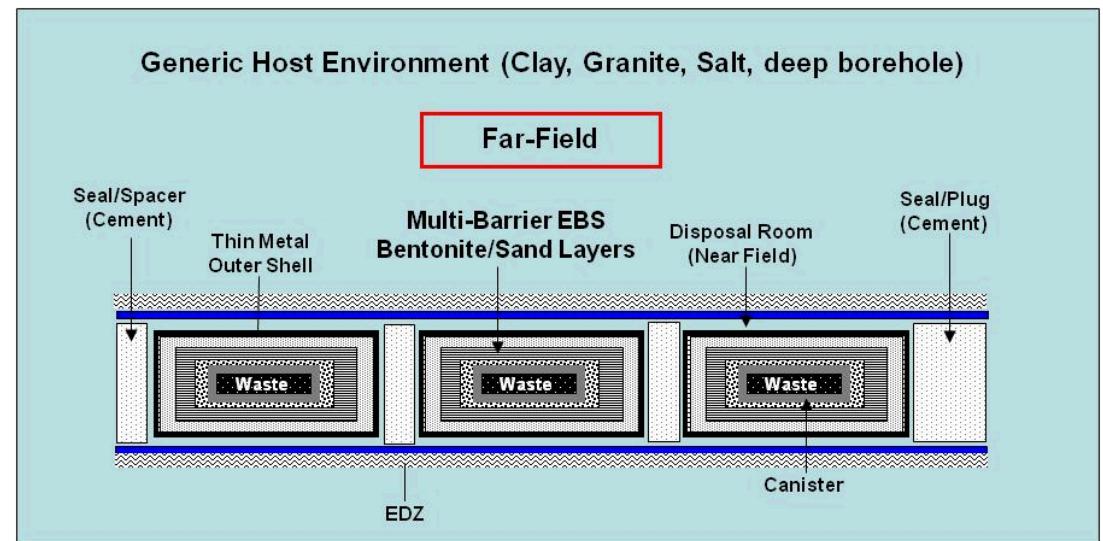
## EXPERIMENTAL , FOUNDATIONAL SUPPORT & ANALYSIS

- Engineered Materials Performance (corrosion studies)
- Nuclear Waste Management Perspectives (regulatory, social issues)
- Features, Events & Processes (how we organize our R&D)
- Low Level Waste Disposition Issues (part of total nuclear waste consideration)
- Inventory Projections (low & high level wastes, used fuel, multiple fuel cycles)
- Salt Disposal Investigations (proposed specific geologic media investigation)

# Engineered Barrier Systems R&D

**EBS and materials evaluation for multiple disposal environments (clay/shale, granite, salt, deep-borehole) including:**

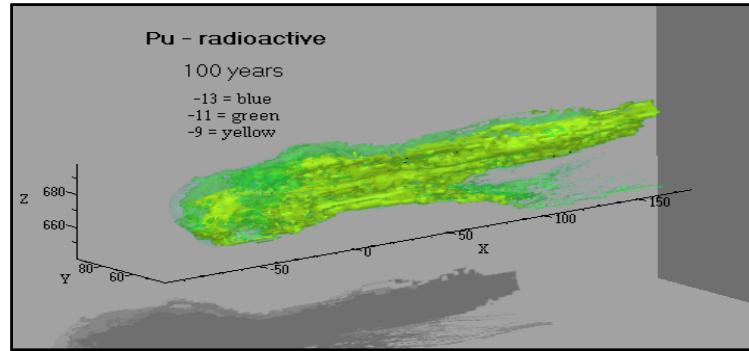
- Barrier phase mineralogy (cement and clay), stability, composition, and structure at high temperatures
- Thermal Hydrological Chemical Mechanical (THCM) coupled process modeling for HLW disposal
- Radionuclide transport experiments in geologic media
- Disposal System Evaluation Framework (DSEF) and knowledge management
- International near-field collaboration (NAGRA, ANDRA, available Underground Research Labs [URL])
- Studies of novel materials for buffer / barrier additives and high performance alloys



# Natural Systems Evaluation R&D

## Evaluation of key natural system attributes of multiple disposal system concepts to evaluate impacts on waste immobilization and isolation:

- Support development of waste disposal strategy.
- Identify pros/cons and technical gaps related to each disposal system concept and develop the R&D path to bridge the identified gaps.
- Evaluate direct disposal of electrochemical refinery waste in salt repository
- Natural system evaluations knowledge management
- Modeling hydrologic flows in representative geologic media
- Modeling radionuclide transport in heterogeneous subsurface environments
- Mechanistic understanding of radionuclide interactions with geologic media in repository performance assessments
- Development of critical field testing and site characterization techniques
- International far-field collaboration (NAGRA, ANDRA, available URLs)



*Simulation: Pu transport in groundwater from an underground nuclear test, Nevada Test Site (Tompson et al., 1990)*

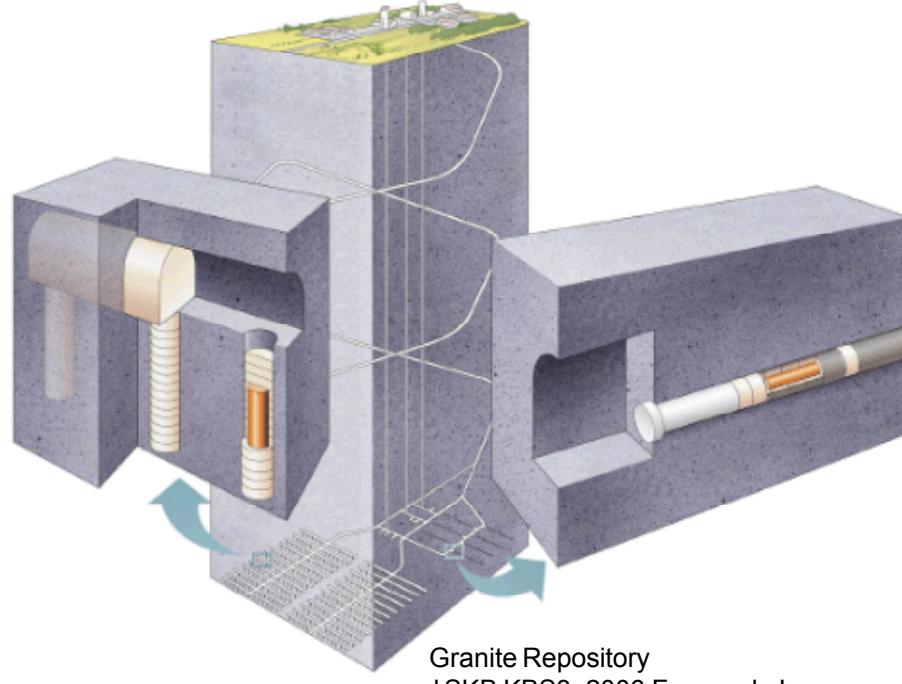


# Thermal Load Management & Design Concepts

## R&D

**Thermal modeling and testing to evaluate thermal loading options for multiple disposal concepts and alternative waste forms:**

- Identify representative repository design concepts and temperature constraints by simulating heat in the near field environment.
- Advanced waste form and decay storage thermal output simulations to evaluate alternative repository concepts.
- Identify alternative repository design concepts from sensitivity studies and international experience
- Analyze the sensitivity of repository systems to thermal limits, including costs, over the range of fuel cycles and design concepts
- Conduct radiolysis investigations



# Disposal System Environment Modeling R&D

Maintain and update models needed to evaluate performance of multiple generic disposal systems. With EBS and Natural Systems R&D, this activity includes

- i. enhancing system models for granite, salt, clay/shale, and deep boreholes;*
- ii. developing models for conceptual engineered barriers; and*
- iii. initiation of models of other disposal as appropriate.*

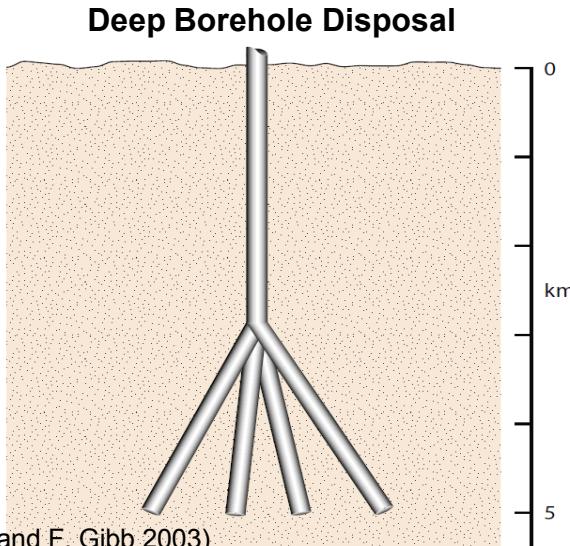


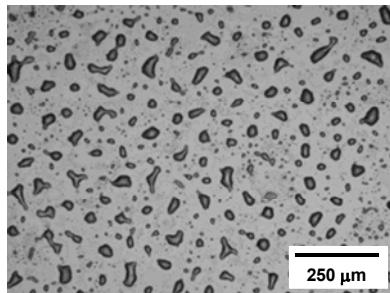
Figure 2. Example of technically advanced deep drilling, a so-called fanned array, with four repository holes fanning out from a common central borehole in the upper region (illustration adapted from Chapman & Gibb 2003, page 32).

- Generic system model refinement: (clay, granite, salt, deep borehole)
- Far Field Flow – architecture and common model implementation
- Develop a generic safety case for the Disposal System Environment Model
- Conduct comparative analyses of options to support the DOE Fuel Cycle Technologies Systems Engineering and System Analysis activities
- Far Field Transport – architecture and common model implementation
- Repository Concept Sensitivity Analysis

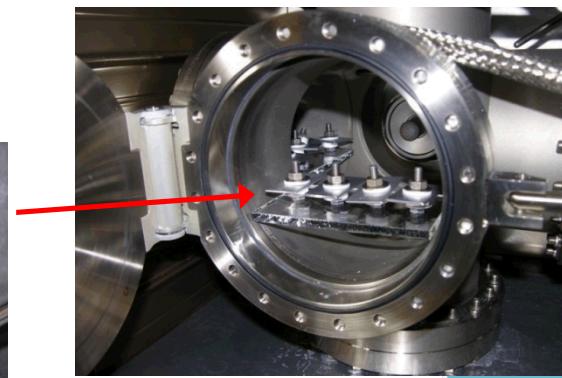
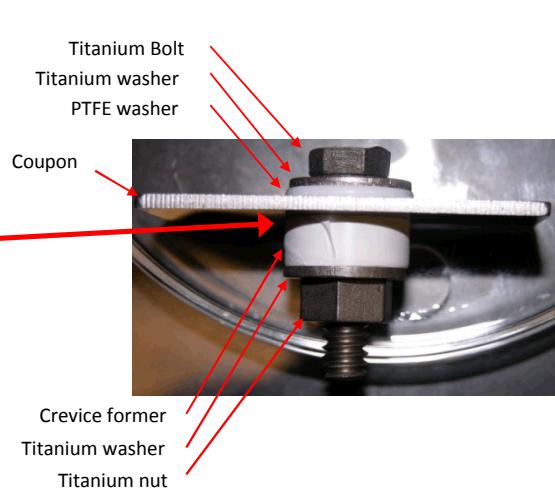
# Engineered Materials Performance R&D

**Experimental work and model development related to the long-term performance of engineered materials (i.e., advanced metal alloys) in repository environments. Provides fundamental data for assessing corrosion of metals over a range of environmental conditions, including high-salinity brines, elevated temperatures, and both reducing and oxidizing water chemistry.**

- Continue ongoing experimental work (Yucca Mountain Project/long-term interim storage),
- Support generic repository concepts and interim storage conditions,
- Characterization of corrosion environments and processes for generic repository/interim storage conditions, and development of geochemical and corrosion models specific to each of the generic repository concepts,



Salt mixture on an Alloy 22 Coupon

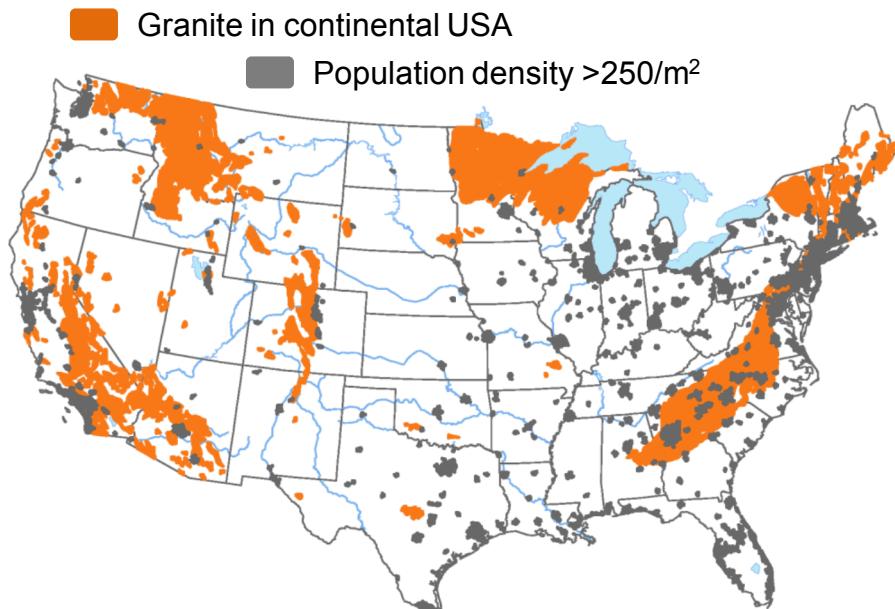


T, RH-Controlled Environmental Chamber

# Nuclear Waste Management Perspectives

Social and political developments have a potential to modify options for nuclear waste management. This activity includes three primary tasks:

- i. *track ongoing developments and evaluate potential impacts on Used Fuel Disposition R&D activities;*
- ii. *review relevant information from social sciences; and*
- iii. *provide analysis and integration of impacts of alternative options on the interfaces among storage, transportation, and disposal operations.*



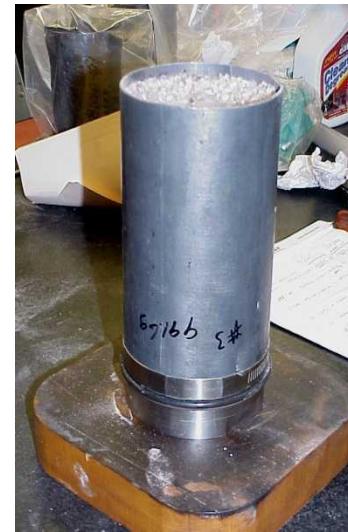
- Waste management integration analyzing the interfaces between long-term storage and permanent disposal for optimization of storage & disposal activities
- Analysis of public and state preferences related to siting, characterization, and operation of radioactive waste management facilities for storage and disposal
- Staged repository development

# Salt Disposal Investigations R&D

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**Proposed multi-year experimental program investigating mechanical, hydrological, and chemical behavior of salt at elevated temperatures consistent with disposal of used nuclear fuel and high-level radioactive waste. Work may include both laboratory and field (i.e., underground) testing.**

- Laboratory Thermal-Mechanical-Hydrological studies
- Coupled process modeling
- Laboratory high-temperature solubility studies
- Field tests



## Crushed Salt Test Assembly

- Used in salt consolidation tests
- Microscopy procedures and petrofabric analyses are proposed

# Integration/Collaboration

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- **Fuel Cycle R&D (FCR&D) Separations/Waste Form Campaign**
  - Science-based approach for waste form development, testing, and qualification with the objective of reducing the environmental impact of a closed fuel cycle
- **FCR&D Systems Analysis Campaign**
  - Evaluating waste management impacts within fuel cycle system analyses
- **DOE offices of Environmental Management**
  - Commonality in issues and modeling capabilities
- **Nuclear Regulatory Commission, Universities, Industry**
  - Experience, knowledge, and expertise is essential in establishing future strategies and approaches
- **International**
  - Ongoing and proposed interactions with Japan, Korea, the European Community, IAEA, and NEA

# Questions?

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**Thank you...**

