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Repository Technologies at Sandia National Laboratories

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Presented to
Kathy Fredriksen
Principal Deputy Assistant Secretary
Department of Energy Office of Policy and International Affairs

Albuquerque, NM
May 29, 2007

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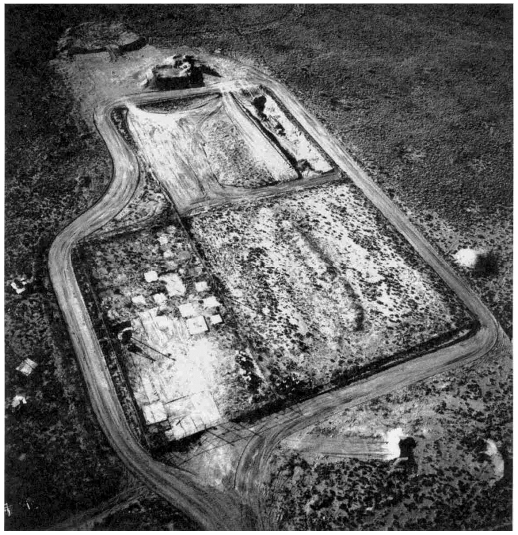
National Nuclear Security Administration

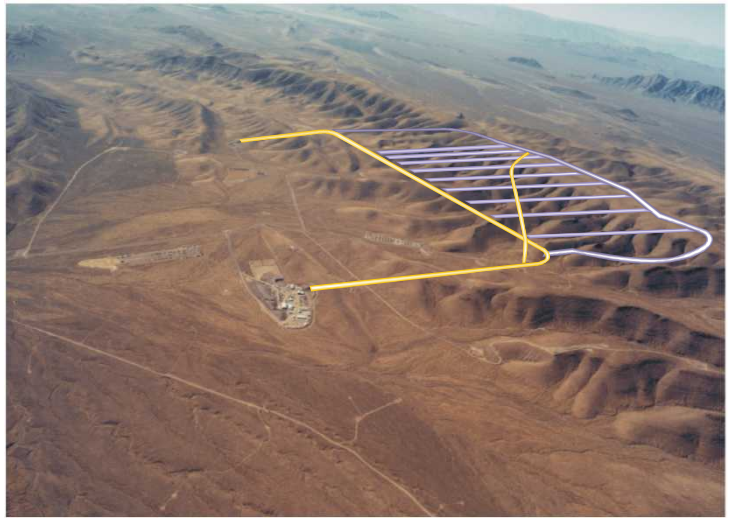
SNL Role in Radioactive Waste Management

Waste Isolation Pilot Plant

Greater Confinement Disposal at Nevada Test Site

SNL Mixed Waste Landfill





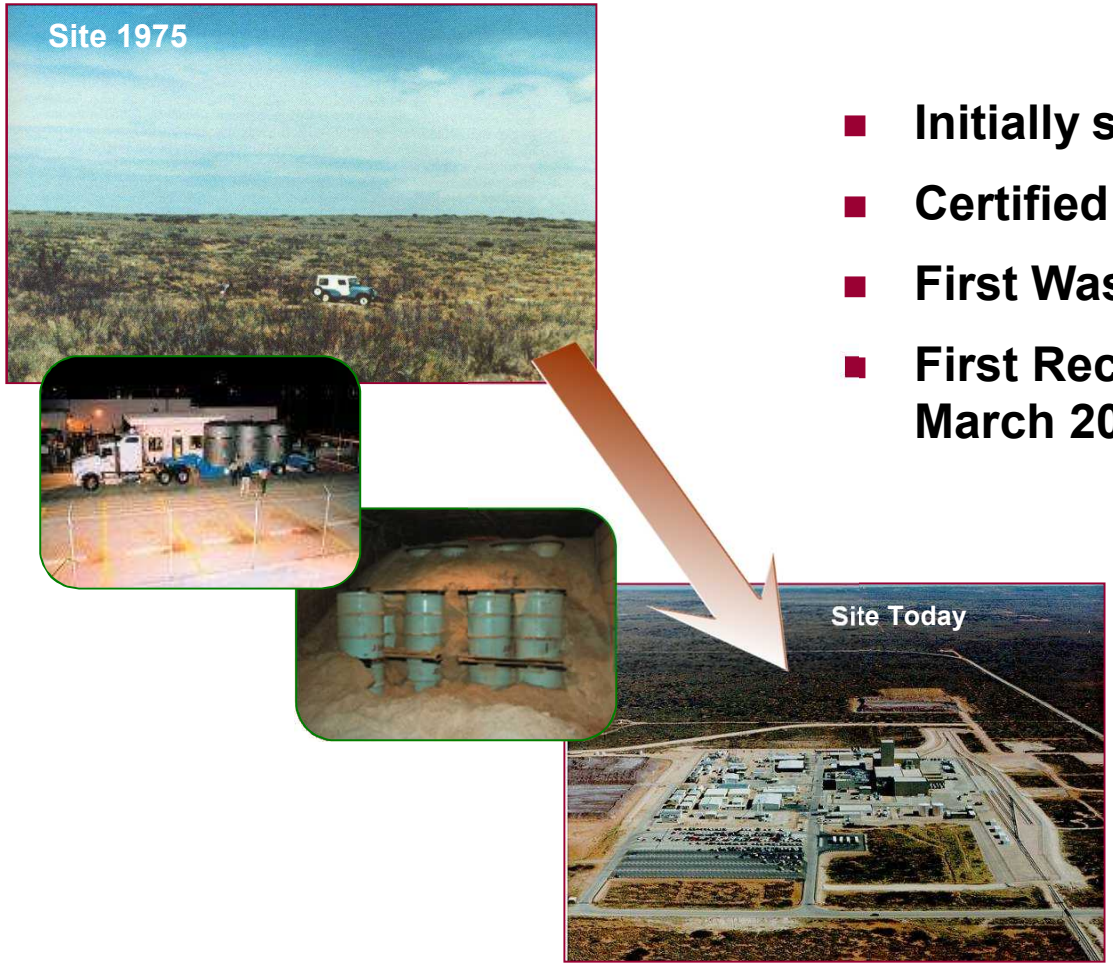
Yucca Mountain

Stages of Repository Science and Technology

- **Site Selection**
- **Site Characterization**
  - **Experimental and field test programs to characterize long-term performance of engineered and natural components of the system**
- **Site Evaluation (Performance Assessment)**
  - **Modeling of future performance under a range of conditions at component and full-system level, with uncertainty**
- **Licensing**
  - **EPA regulations (40 CFR 191 and 40 CFR 194) for WIPP require estimates of repository performance for 10,000 years**
  - **EPA (40 CFR 197) and NRC (10 CFR 63) regulations for Yucca Mountain require estimates of repository performance for 1 million years**
  - ***Final EPA and NRC standards for 1 million years for Yucca Mountain are not yet available***

Waste Isolation Pilot Plant

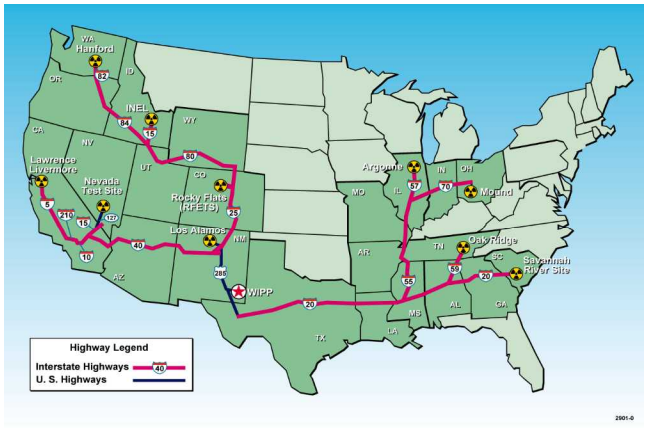
Safe Disposal of Transuranic Waste



- Initially sited – 1975
- Certified by the EPA – 1998
- First Waste Receipt – 1999
- First Recertification Approved – March 2006

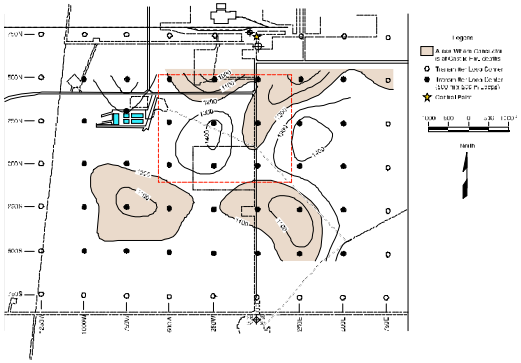
WIPP Transuranic Waste

- **Derived from defense-related activities**
  - **Laboratory and industrial trash contaminated with transuranic radionuclides**
- **175,000 m^3 total volume (~820,000 drums)**
  - **Primarily alpha-emitting radionuclides, relatively little gamma emission**



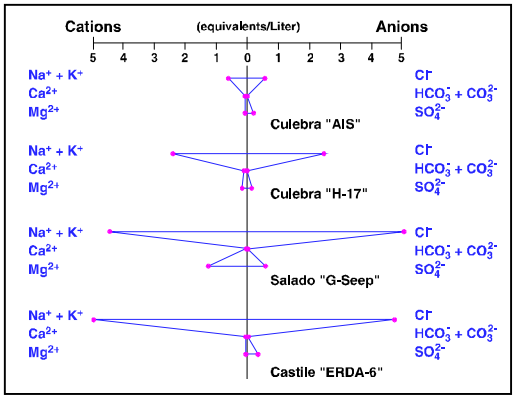
WIPP Site Characterization

Geologic studies



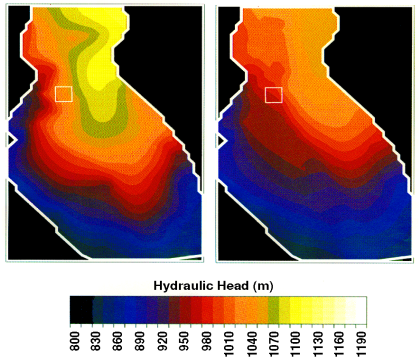
Geophysical surveys

Hydrologic testing



Geochemical sampling and analysis

Geomechanical testing



Numerical modeling

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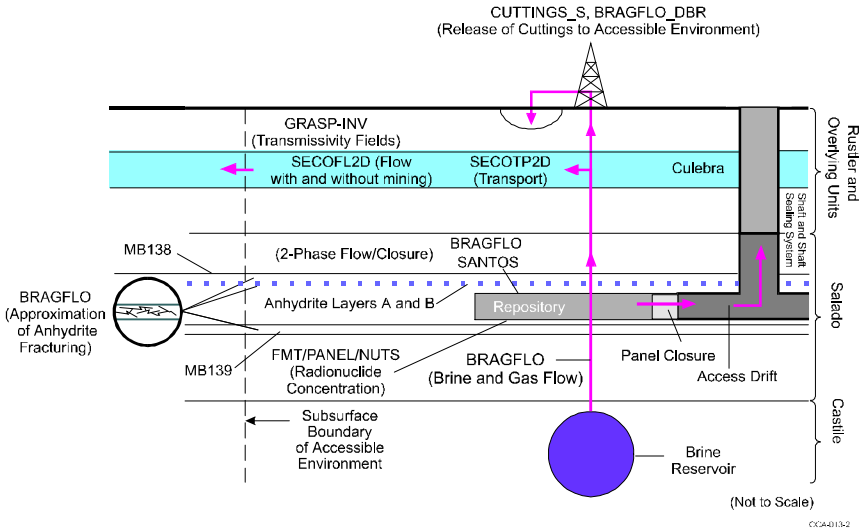
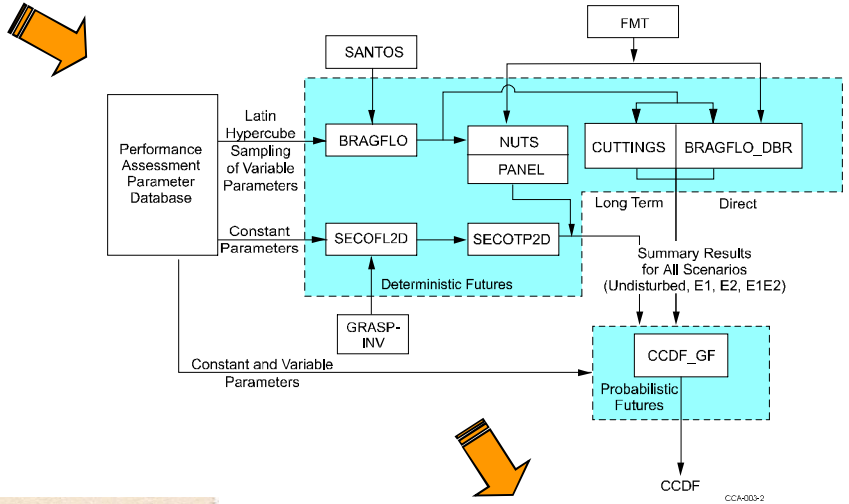
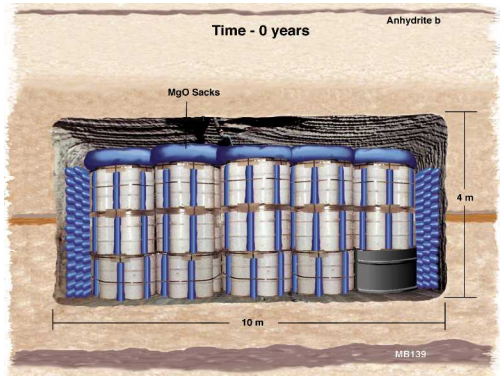
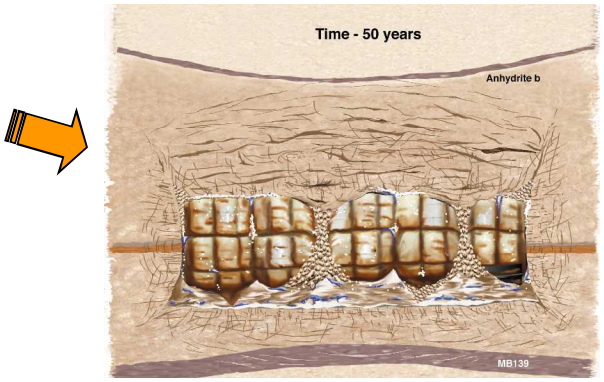
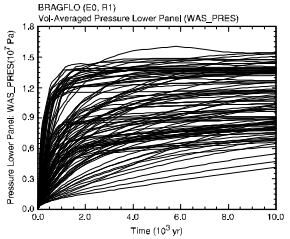
Performance Assessment for WIPP











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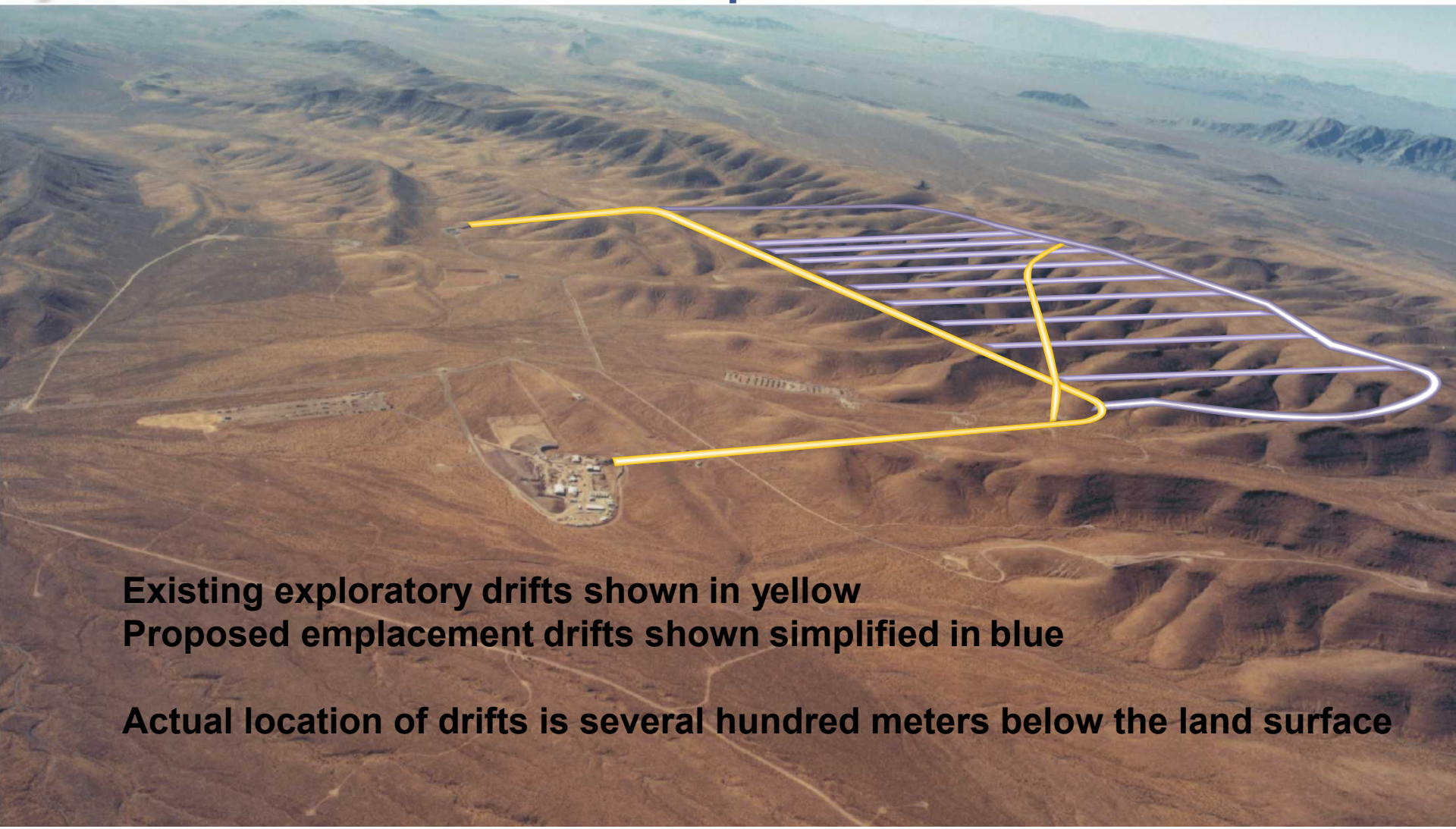
Proposed Repository for High-Level Waste and Spent Fuel at Yucca Mountain



Existing exploratory drifts shown in yellow
Proposed emplacement drifts shown simplified in blue

Actual location of drifts is several hundred meters below the land surface

Waste for Yucca Mountain

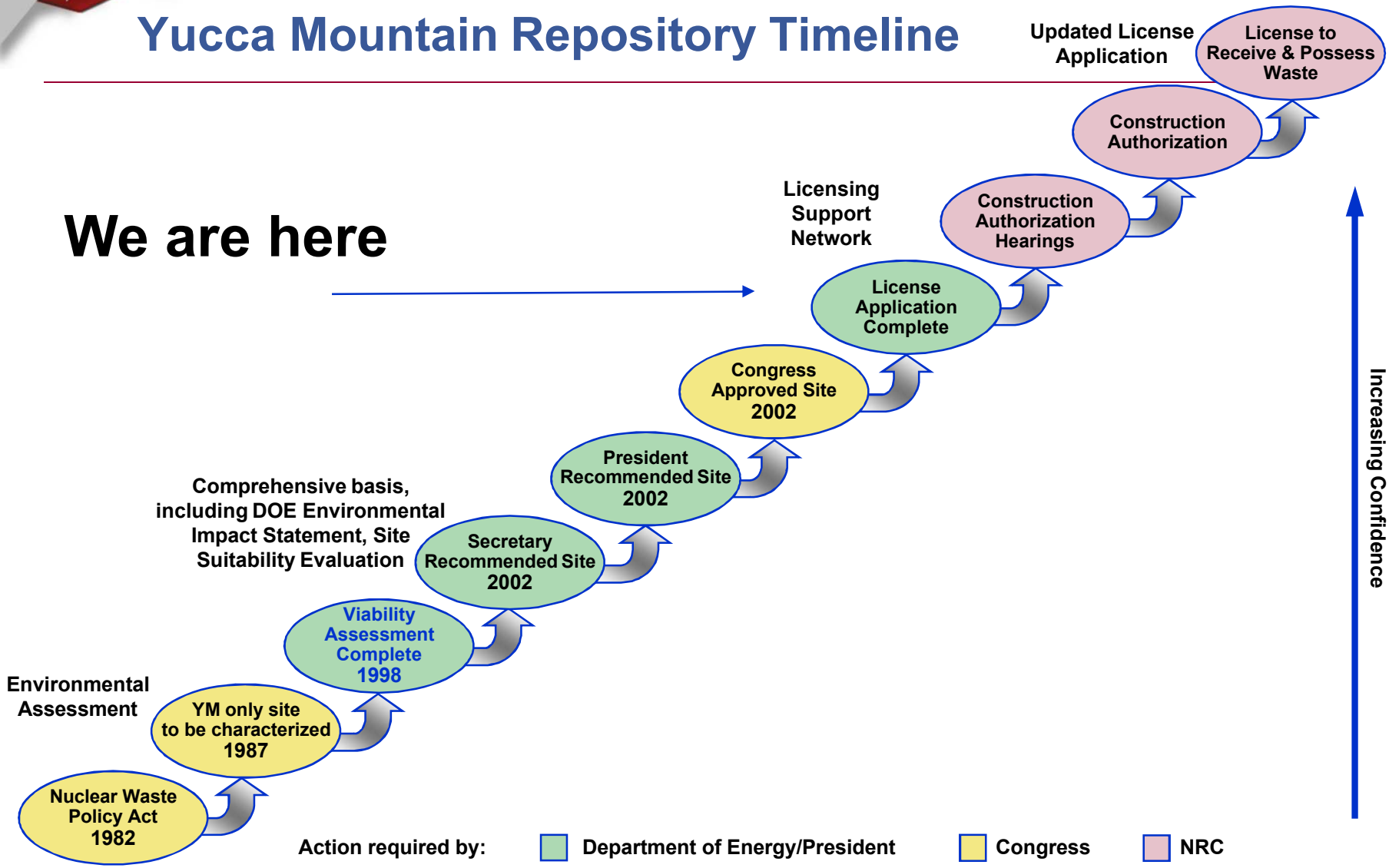
125 Sites in 39 States

Commercial Spent Nuclear Fuel:
63,000 MTHM

DOE & Naval Spent Nuclear Fuel:
2,333 MTHM

DOE & Commercial High-Level Waste:
4,667 MTHM

Yucca Mountain Repository Timeline



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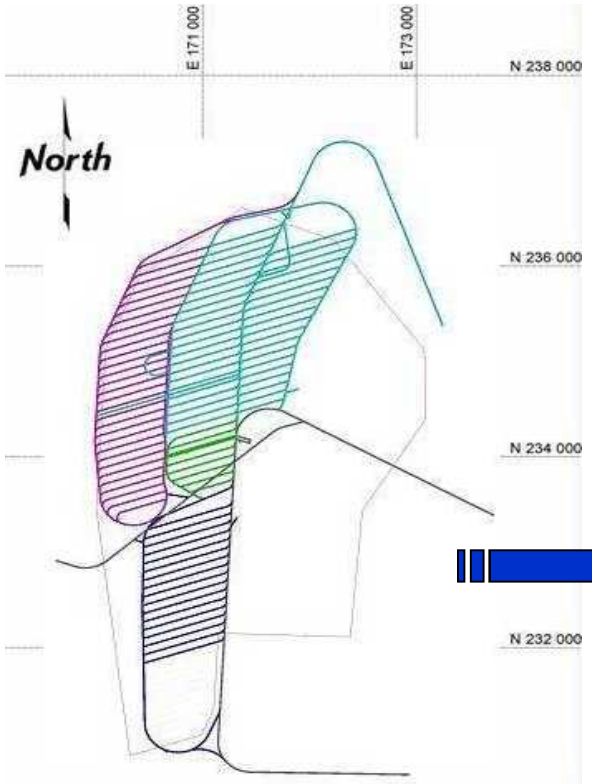
Yucca Mountain Subsurface Design



Emplacement drifts

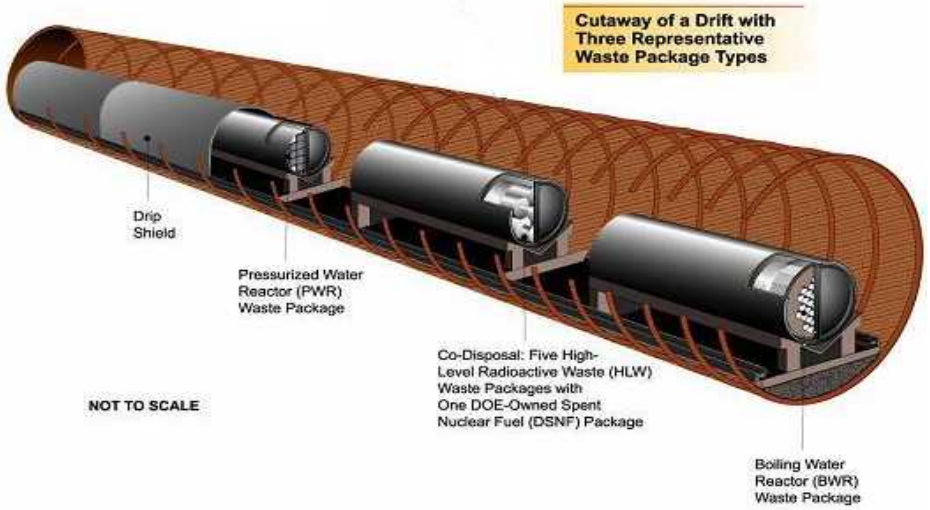
- 5.5 m diameter
- 50-90 drifts, each ~ 1 km long

Waste packages

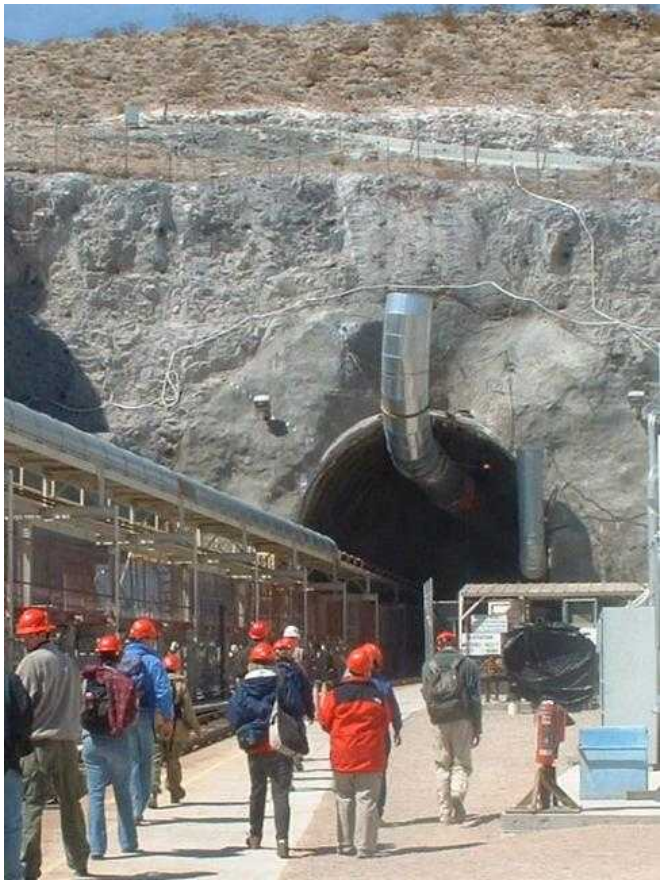
- ~12,000 packages
- ~ 5 m long, 2 m diameter
- outer layer 2 cm Alloy 22 (Ni-Cr-Mo-V)
- inner layer 5 cm stainless steel

Drip shields

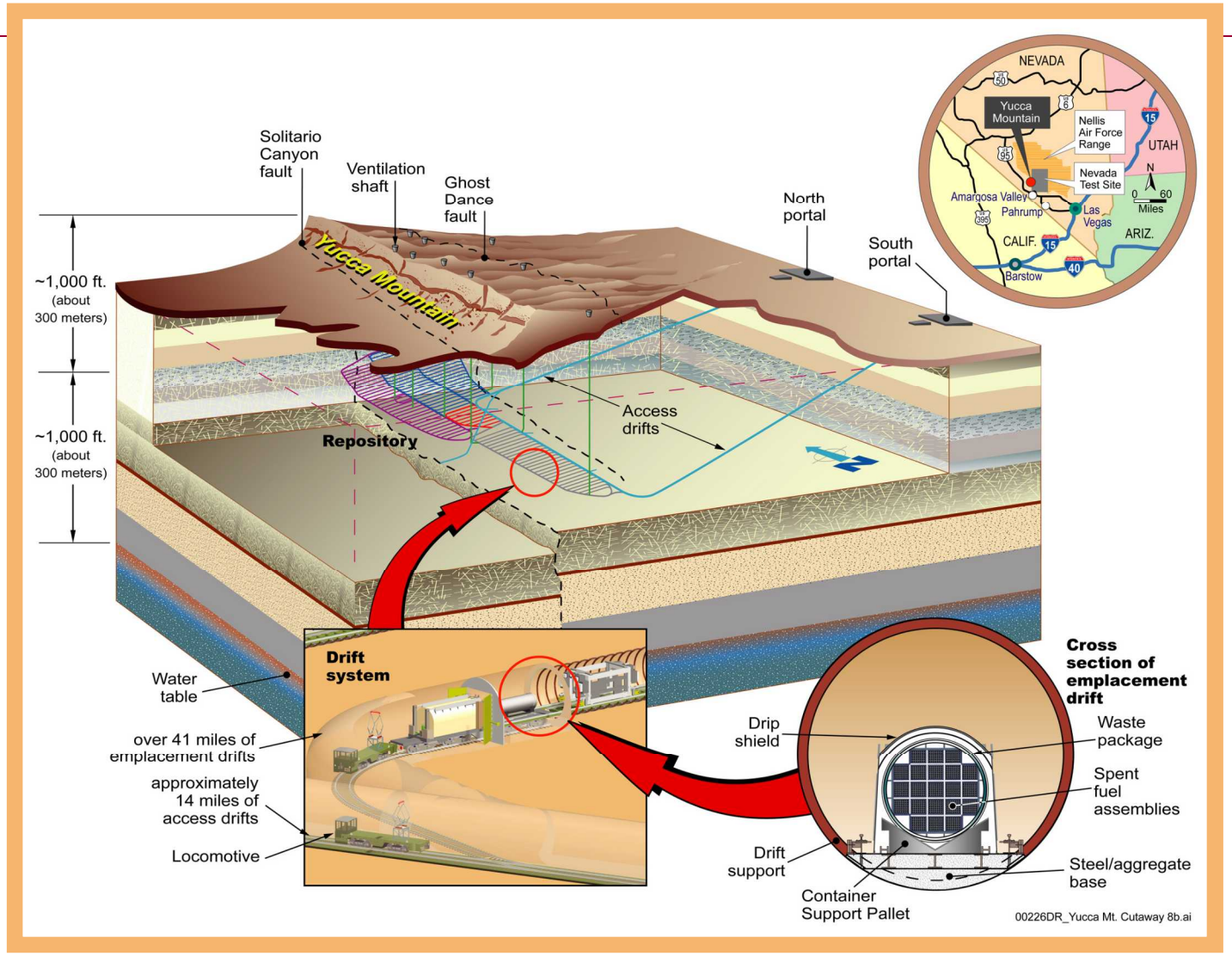
- free-standing 1.5 cm Ti shell



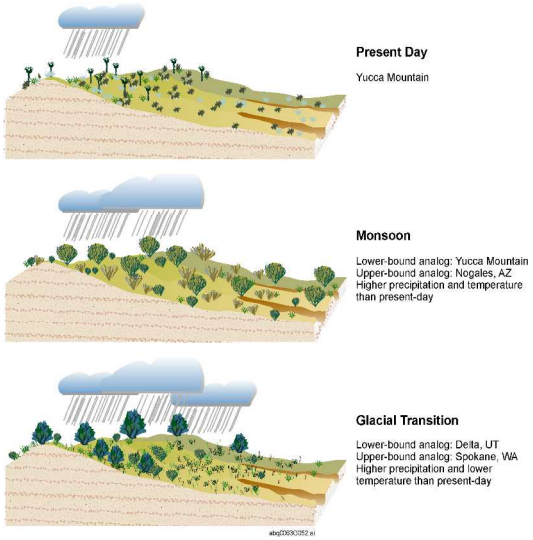
Yucca Mountain Today

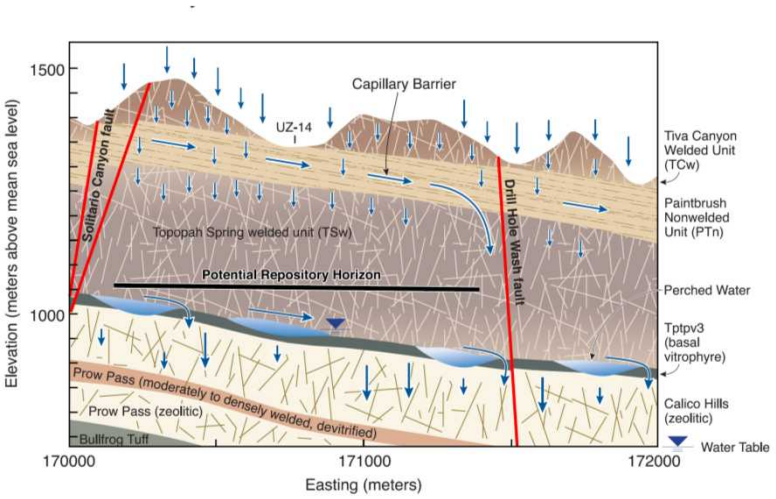


The Natural and Engineered Barrier System

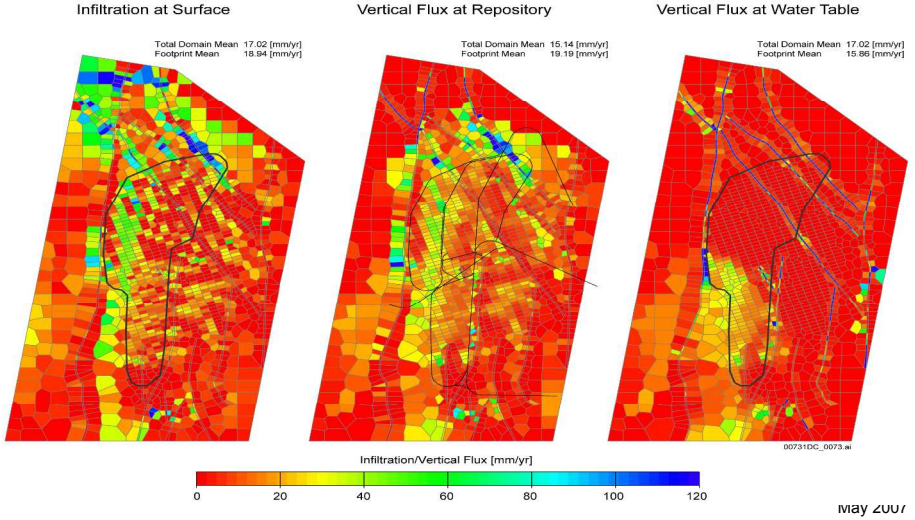


Groundwater Flow at Yucca Mountain

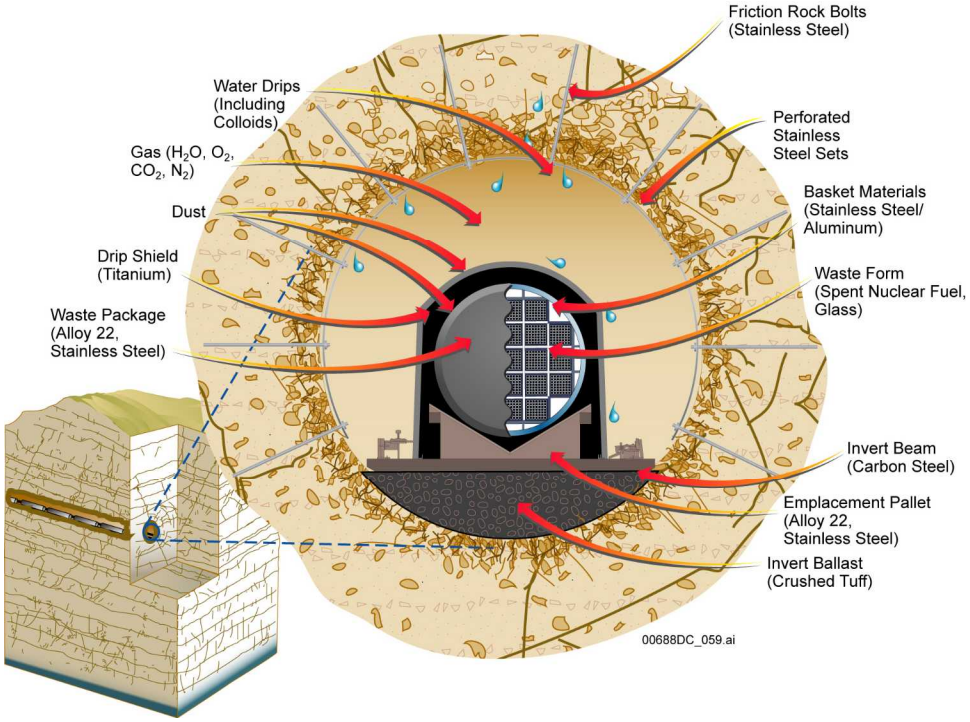


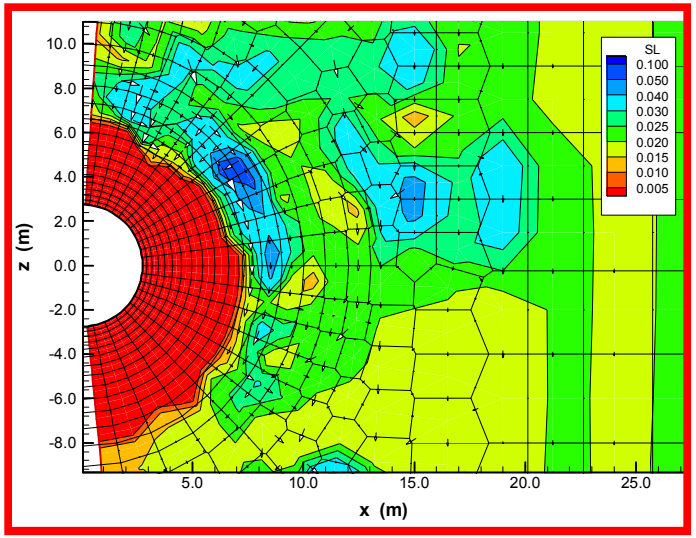


Field tests and models provide basis for understanding infiltration and flow in unsaturated rocks at Yucca Mountain

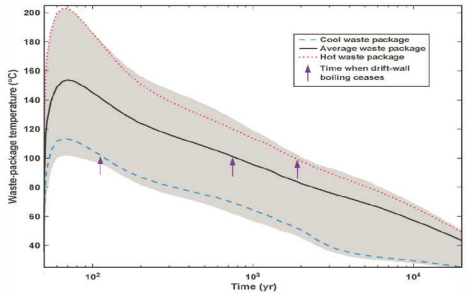


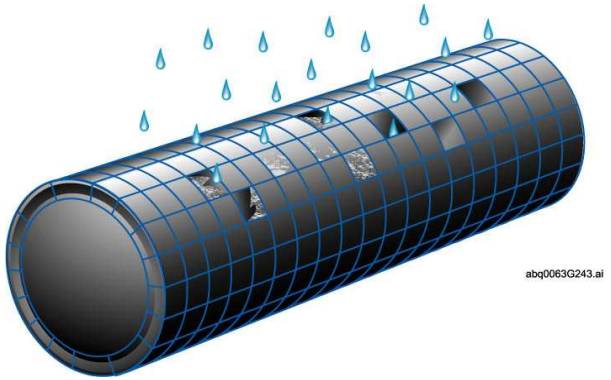
The Emplacement Environment at Yucca Mountain



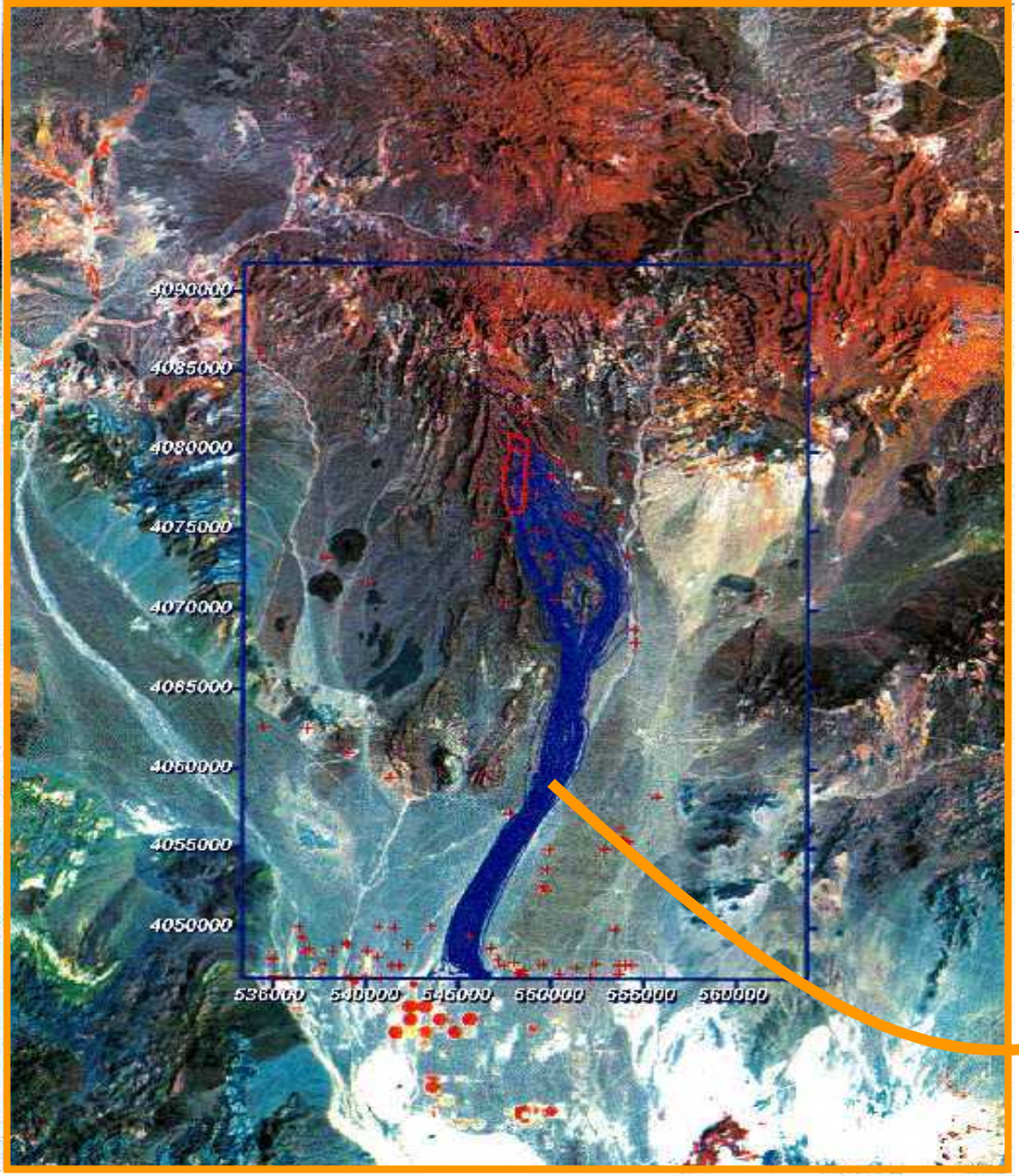


Material testing and models characterize performance of the engineered barriers





Estimating Dose to Hypothetical Future Humans



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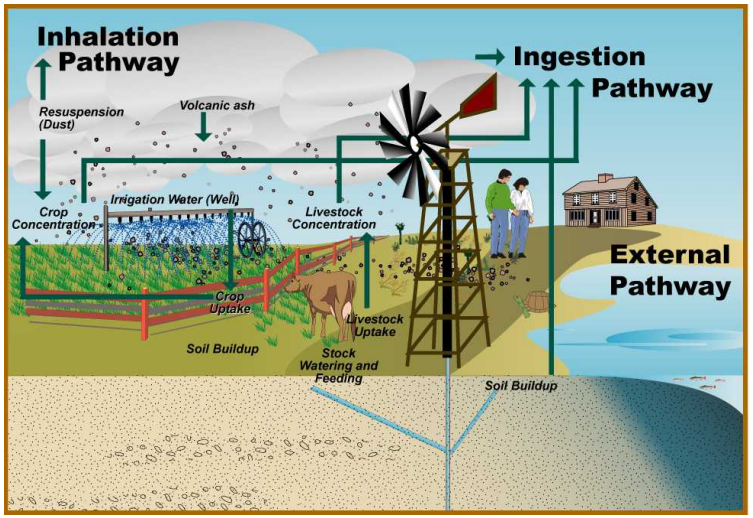
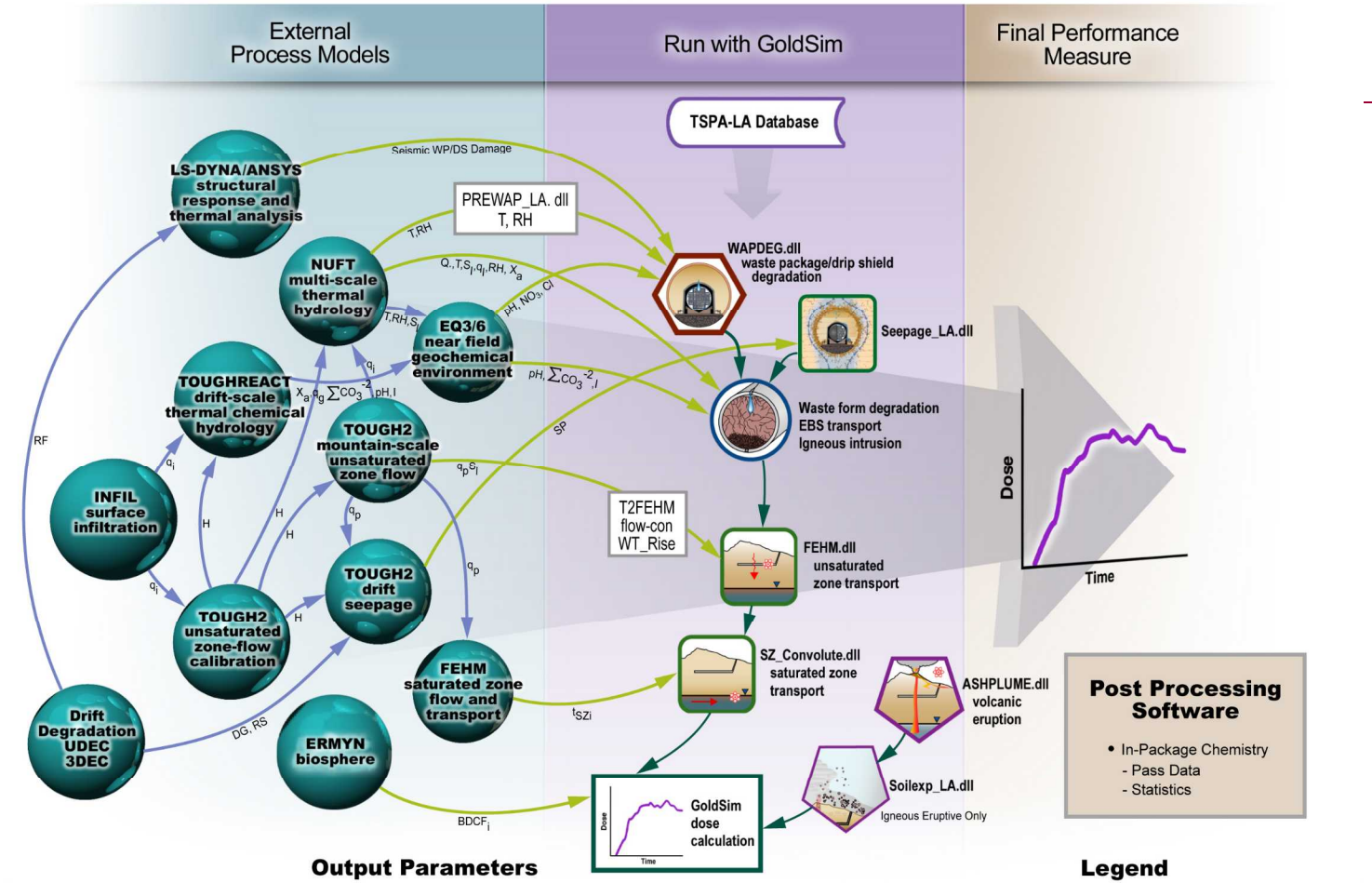


Representative groundwater flow paths modeled for the 2002 Yucca Mountain Site Recommendation

Total System Performance Assessment Architecture



Output Parameters

f_S	Fraction of WPs with Seeps	T	Temperature	I	Ionic Strength
EBS	Engineered Barrier System	RH	Relative Humidity	t_{SZi}	Saturated Zone Transport Time
Q_S	Seep Flow Rate	S_l	Liquid Saturation	$BDCF_i$	Biosphere Dose Conversion Factor
Q.	Evaporation Rate	X_a	Air Mass Fraction	q_g	Gas Flux
pH	pH	q_l	Liquid Flux	H	Hydrologic Properties
ΣCO_3^{-2}	Carbonate Concentration	q_i	Infiltration Flux	SP	Seepage Parameters
q_p	Percolation Flux	DG	Drift Geometry	RS	Rock Strength
NO_3	Nitrate Concentration	Cl	Chloride Concentration	RF	Rock Fall Size and Number

Legend

Response Surface Between Process Models

Response Surface from Process Model to GoldSim

Connection in GoldSim

Preprocessor

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May 2007

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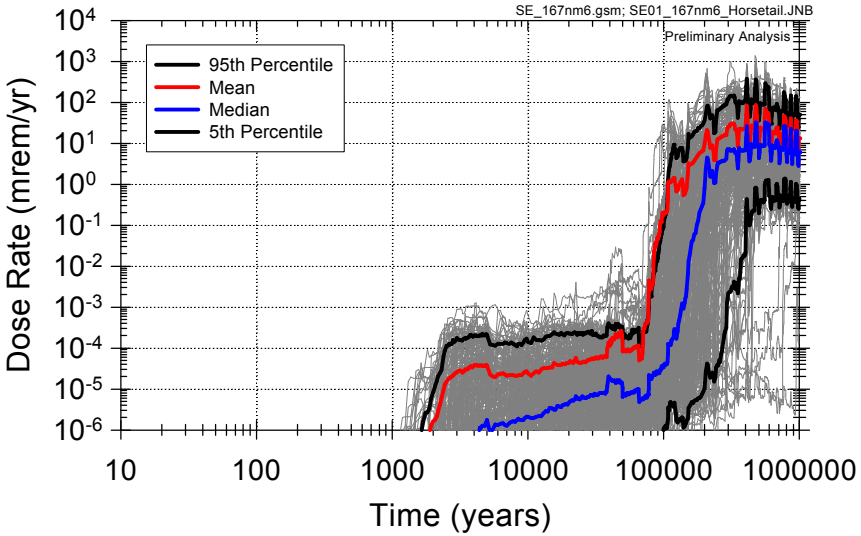
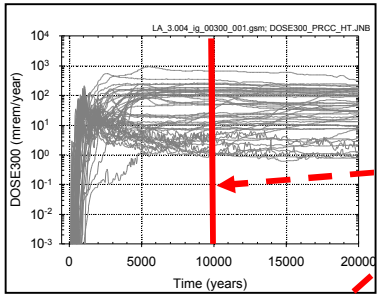
Performance Assessment Results

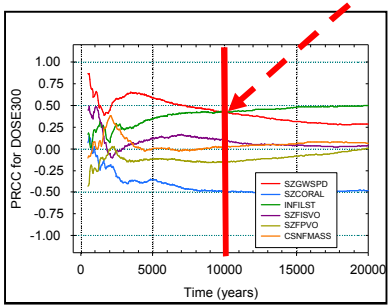
Monte Carlo estimates of overall performance
(Example dose histories from 2002 Yucca Mountain Total System Performance Assessment, nominal scenario only)

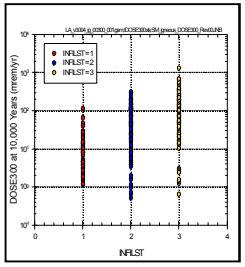


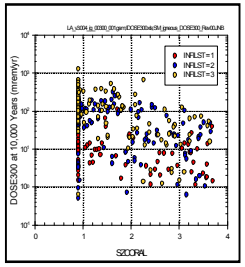


DOSE300: 10,000 yr

Variable	R^2	SRRC
INFILST	0.28	0.53
SZCORAL	0.40	-0.36
SZGWSPD	0.53	0.36
GTCPU239	0.61	0.27
IGPH	0.63	0.15
SZHAVO	0.64	0.09
EP1LOWU	0.65	0.10
EPSLOWPU	0.66	0.09
SZNVF7	0.66	0.08







Sensitivity and Uncertainty Analyses
Identify model inputs important to uncertainty in performance estimates

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Sandia's Experience in Engaging China under the US-China Peaceful Uses of Nuclear Technologies Agreement (PUNT)

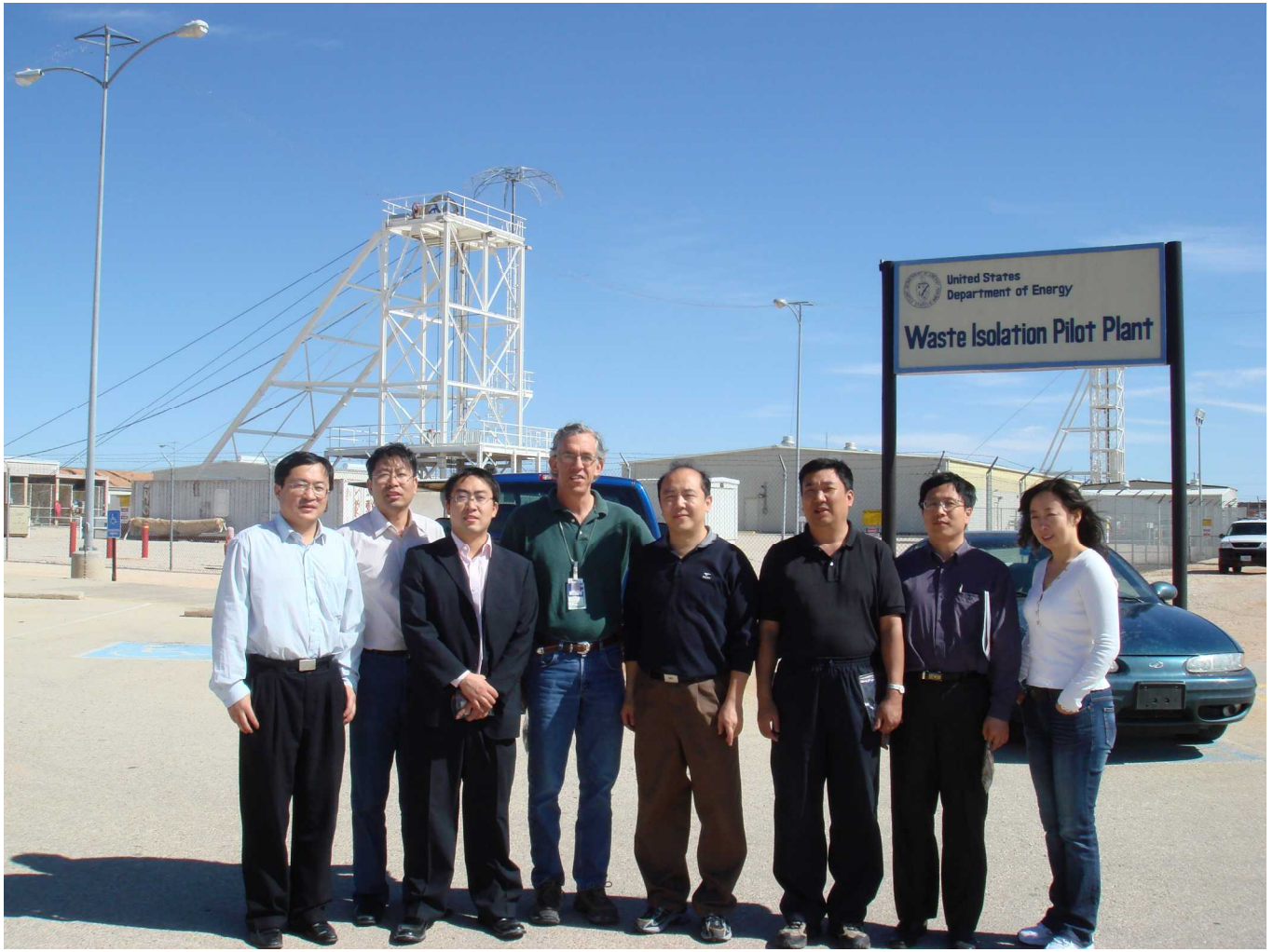
- **Radioactive Waste Management Workshop, February 1999, Beijing**
  - **Focus on WIPP experience**
    - **US participants: DOE's Carlsbad office and Sandia National Laboratories**
    - **China participants: CNNC, CAEA, CIAE, BRIUG, BINE, CIRP, etc.**
- **PUNT Working Group 3 (Radioactive Waste Management)**
  - **1st JCC (Joint Coordinating Committee) meeting in Beijing, China, July 2002**
  - **2nd JCC meeting at Sandia's International Program Building, Albuquerque, NM, February 2004**
  - **3rd JCC meeting in Beijing, China, March 2006**
  - **4th JCC meeting in Washington, D.C., May 2007**

Sandia's Experience in Engaging China under the US-China PUNT Agreement (cont.)

- **PUNT Working Group 3 (Radioactive Waste Management) (cont.)**
  - **June 2005, Beijing, China**
    - **Workshop on Regulations and Standards for Radioactive Waste Management**
    - **US participants: DOE/RW, DOE/EM, NRC, and EPA**
    - **China participants: CAEA, CNNC, SEPA, BINE, BRIUG, CIRP, etc.**
  - **October-November 2006**
    - **Sandia supported DOE/RW in hosting a Chinese delegation (CNNC, CAEA and CIAE) visit to DOE's HQ and waste-management-related R&D and operation facilities: Hanford, Sandia, WIPP, DOE/HQ, Savannah River, and YM site**
  - **May 2007**
    - **Sandia hosted Chinese delegation in Albuquerque following 4th JCC meeting**
- **PUNT Working Group 2 (Nuclear Safety and Security)**
  - **October 2005: Nuclear materials management technology demonstration**
  - **April 2005 and August 2006: Emergency preparedness training for nuclear fuel cycle facilities**

US Delegation and Dr. WANG Ju at the Beishan Repository Site, Gansu, June 2005

China Delegation at Waste Isolation Pilot Plant New Mexico, October 2006



Building on Past Success:
Possible China-SNL Collaboration in Repository Technology

- Site characterization
- Performance of engineered barrier systems
- Radionuclide transport
- Radionuclide source terms (i.e., mobilization from waste forms)
- Alternative waste forms
- Spent fuel management and disposition (e.g., interim storage options, reprocessing techniques)
- Back-end fuel cycle management for advanced reactor technologies
- Advanced modeling of long-term repository performance