SAND2013-6888C

Exceptional service in the national interest

Sandia National Laboratories

International Atomic Energy Agency (IAEA) Training in Radioactive Waste Disposal Technologies in URFs Repository Construction and Operation

Peine, Germany

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U.S. DEPARTMENT OF ENERGY | NNSA

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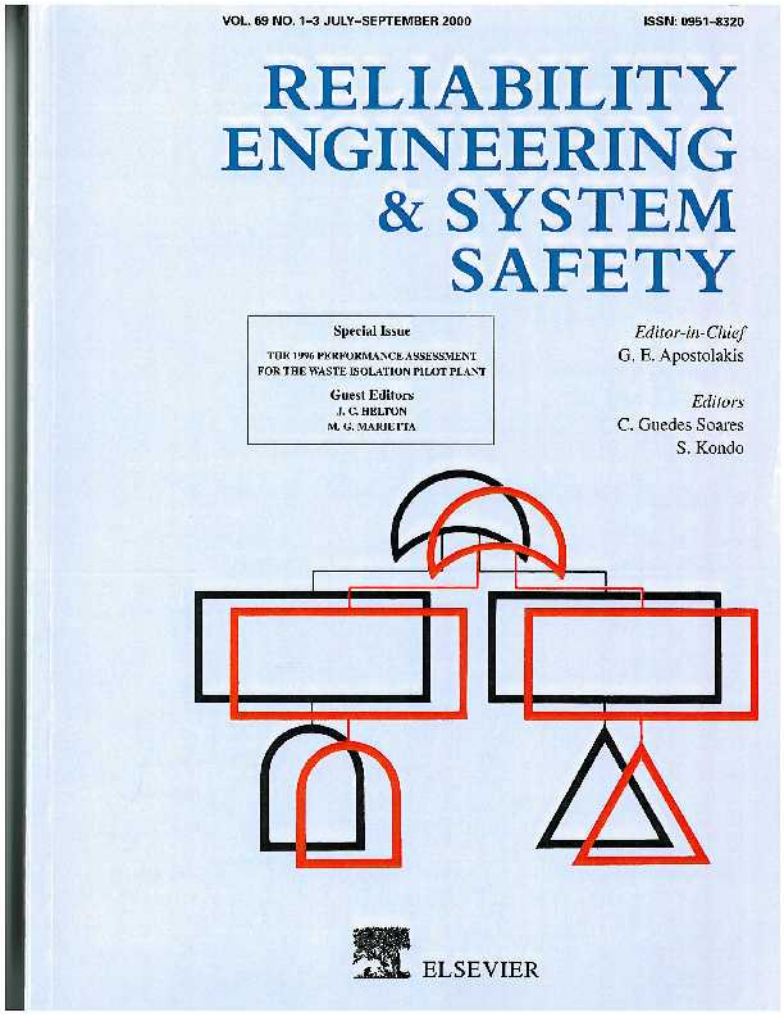
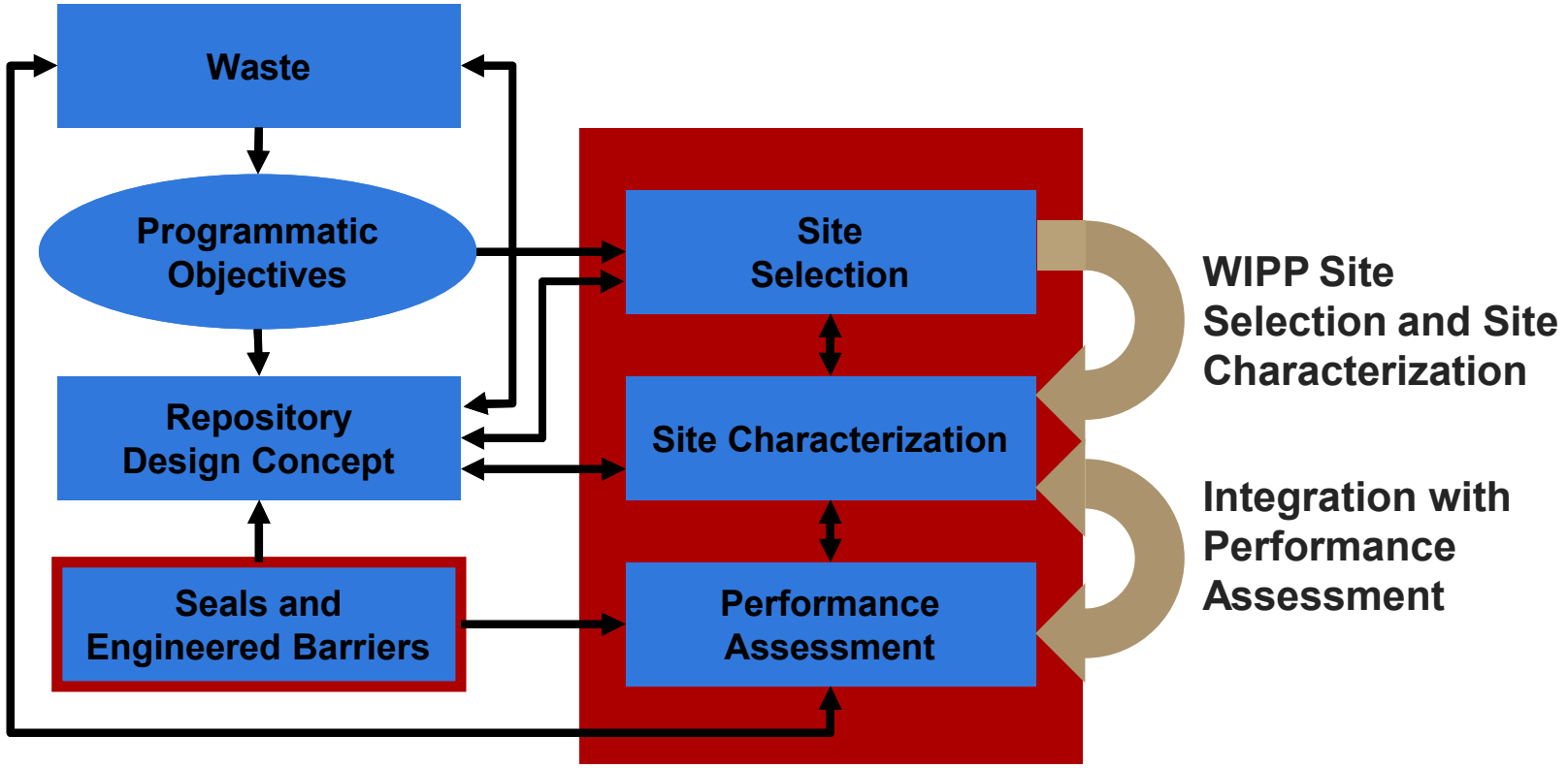
Engineering Solutions for Construction and Maintenance: Bedded Salt Host Rock



Discussion will include

- Engineering and scientific bases for bedded salt disposal
- Discussion of the WIPP success story
- Salt properties verification and validation
- Engineering design based on science.
- Shaft seal system and material specifications
- Examples of performance analysis for the shaft
- Long-term performance of salt disposal

Context for site selection, site characterization, and integration with performance assessment



Bedded Salt was Chosen for the Siting of the US Defense Nuclear Wastes

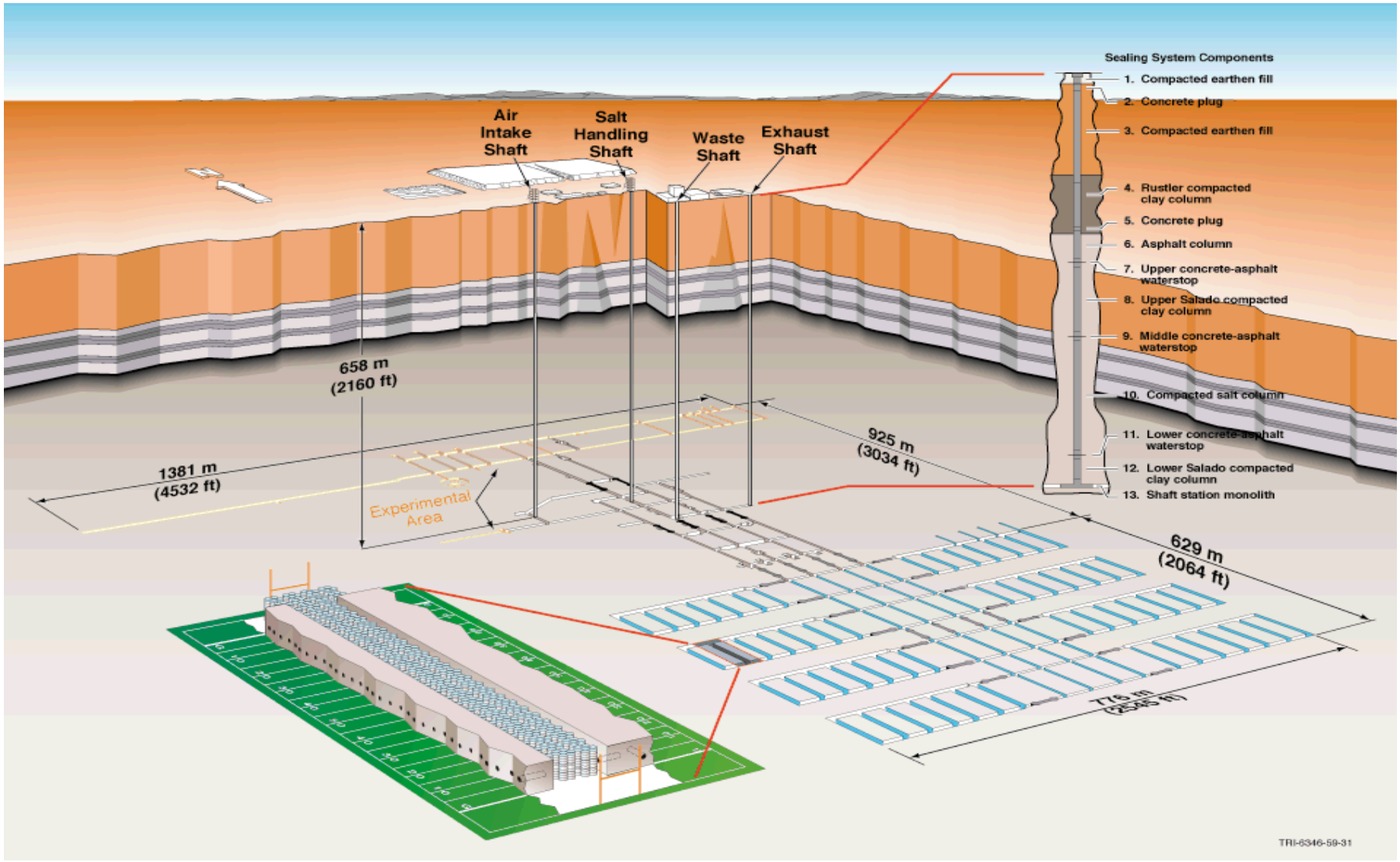
- Salt can be mined easily
- Salt has a relatively high thermal conductivity
- Wide geographic distribution (many potential sites)
- Salt is plastic *
- Salt is essentially impermeable *
- Fractures in salt are self healing *
- Salt has existed underground for millions of years *

* Attributes of Natural Barrier

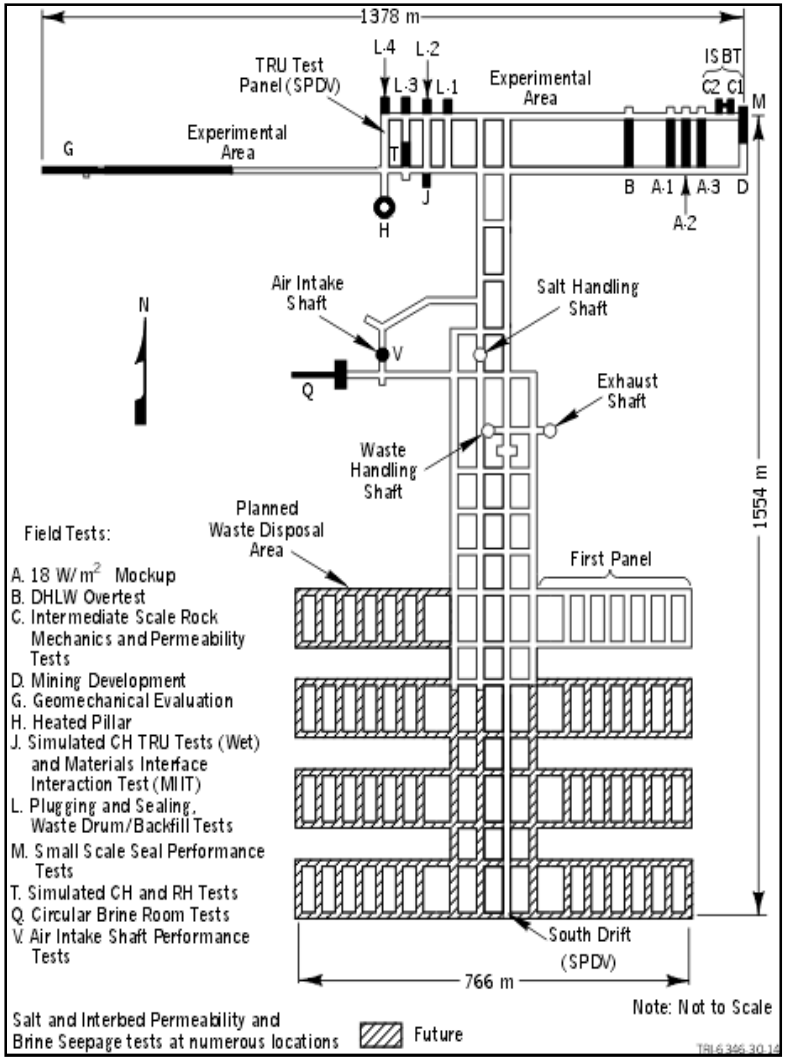
5

Waste Isolation Pilot Plant Chronology 1975-2009

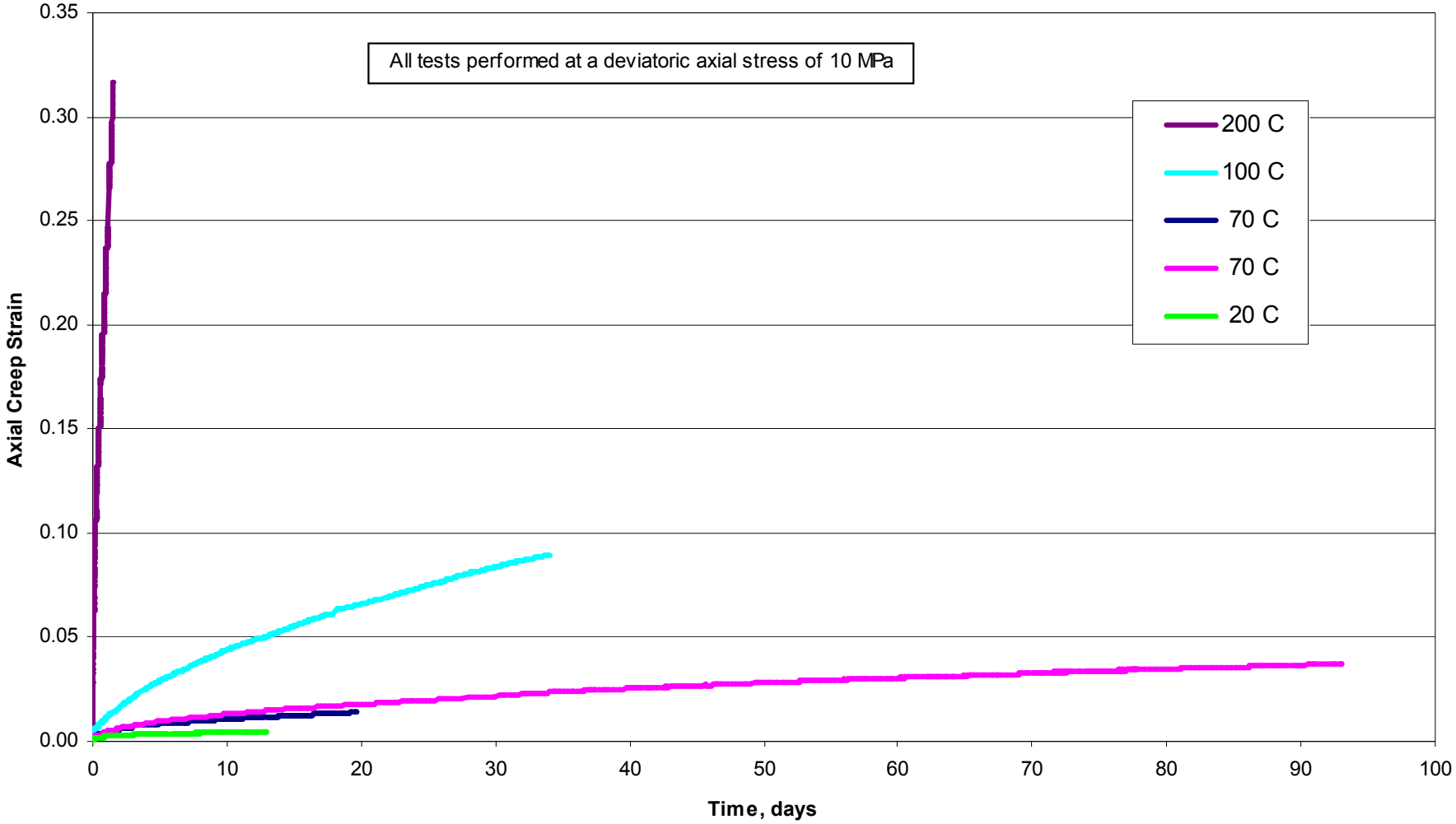
WIPP Facility Layout



Major Tests in the WIPP



Temperature Effect on Salt Deformation

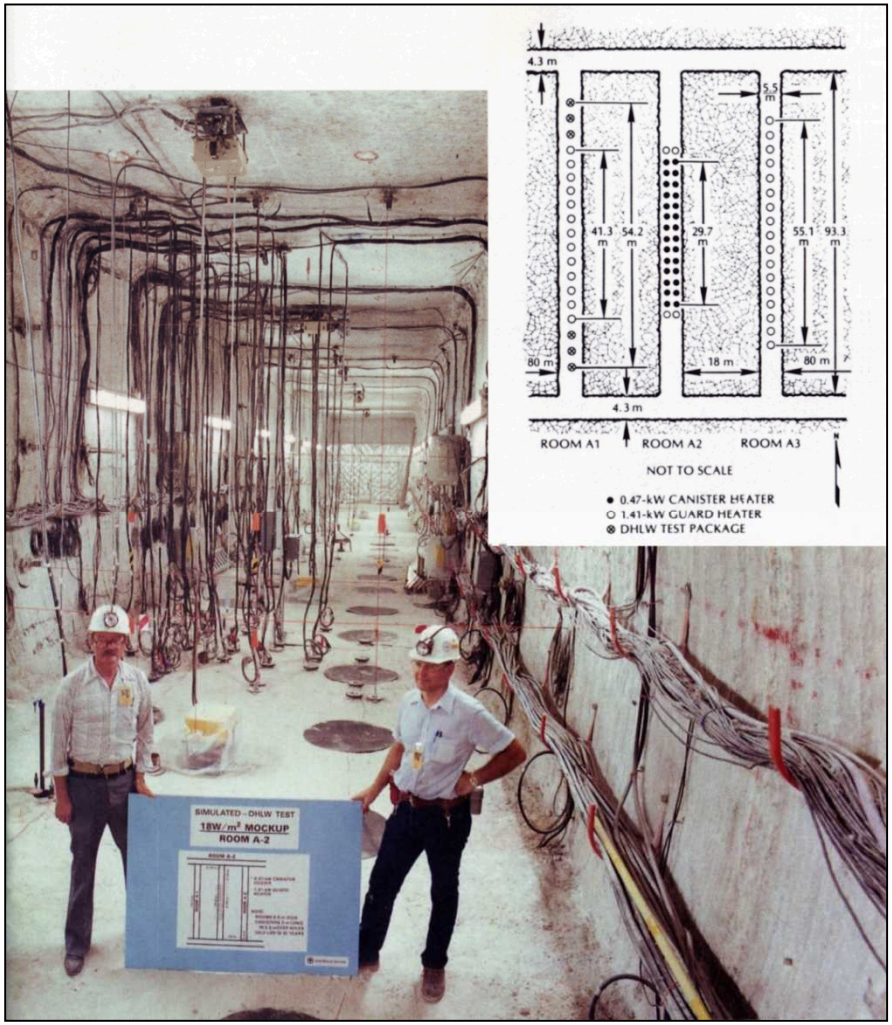


Axisymmetric Test with Insulation

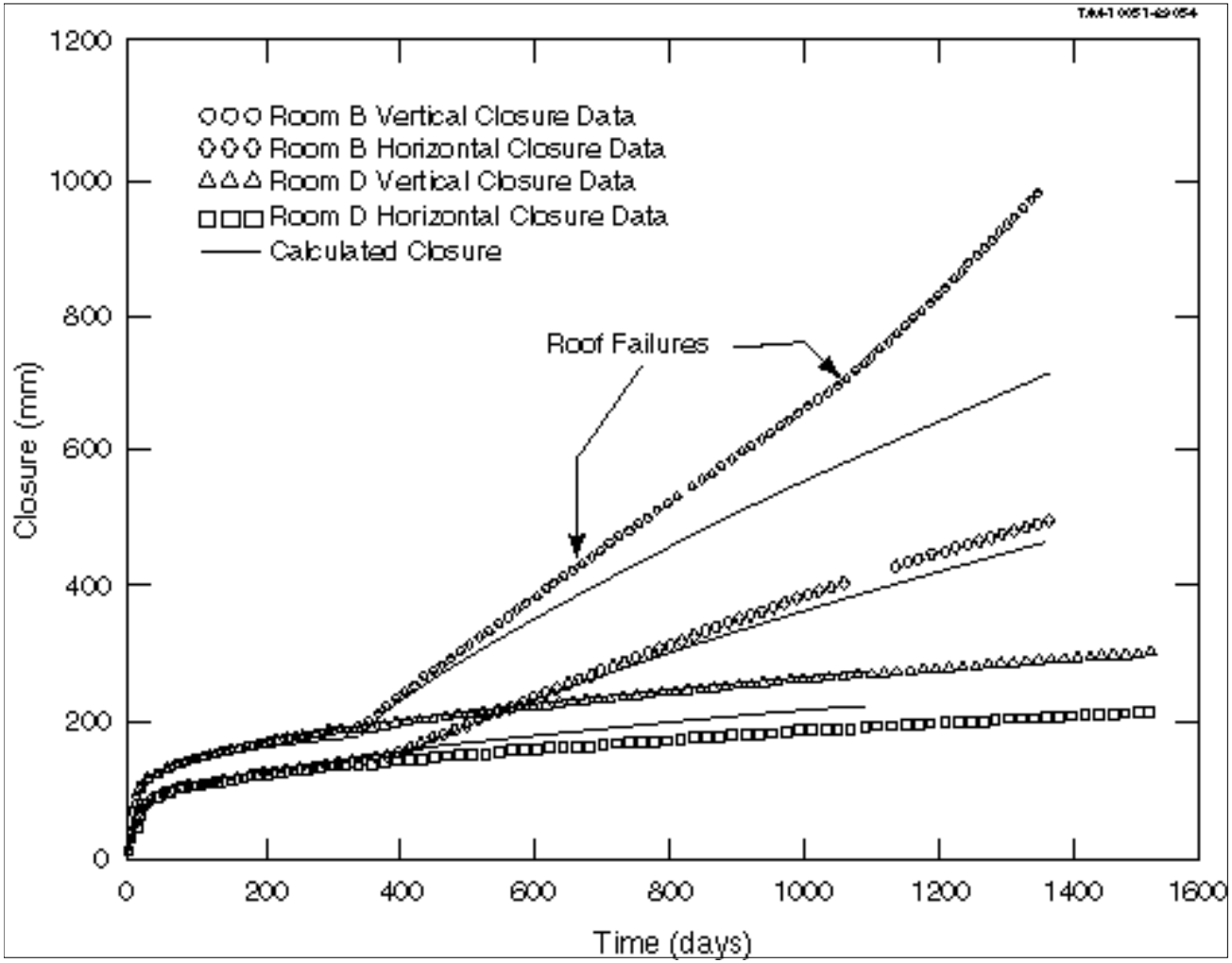
Room H

18 W/m2 Thermomechanical Test

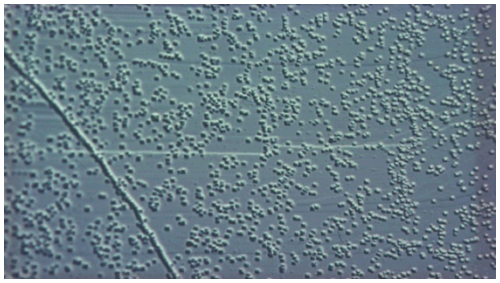
“A” Rooms

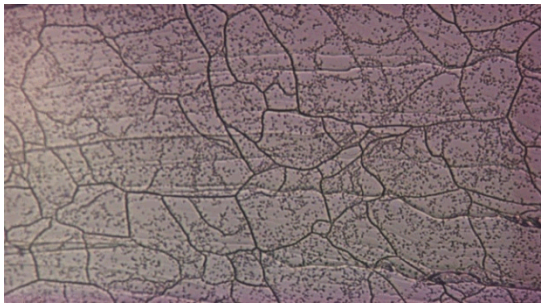


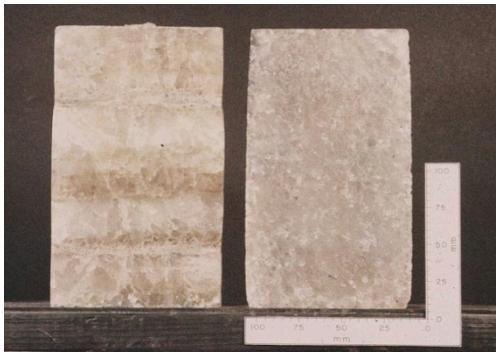
Measured vs. Predicted Room Closure

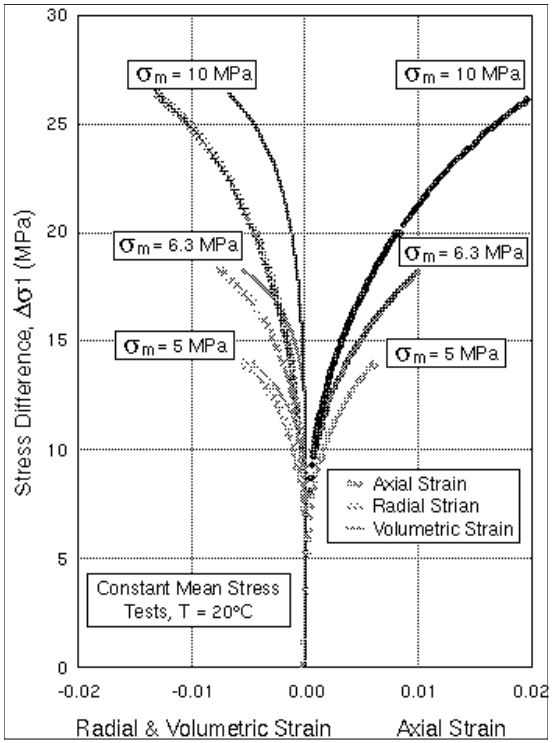


Salt Behavior is Well Understood

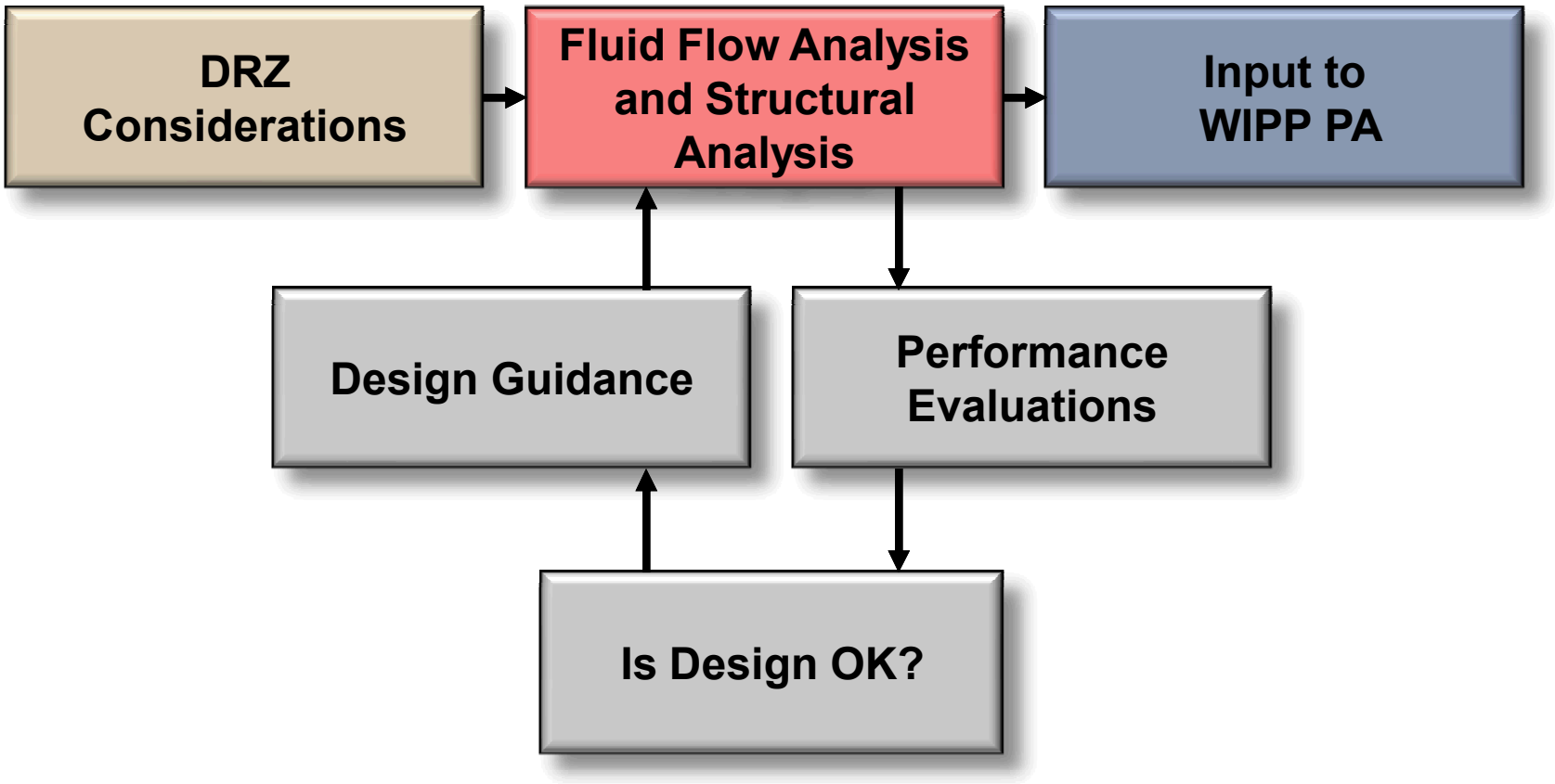








Shaft Seal Systems Analysis Process



Material Specification

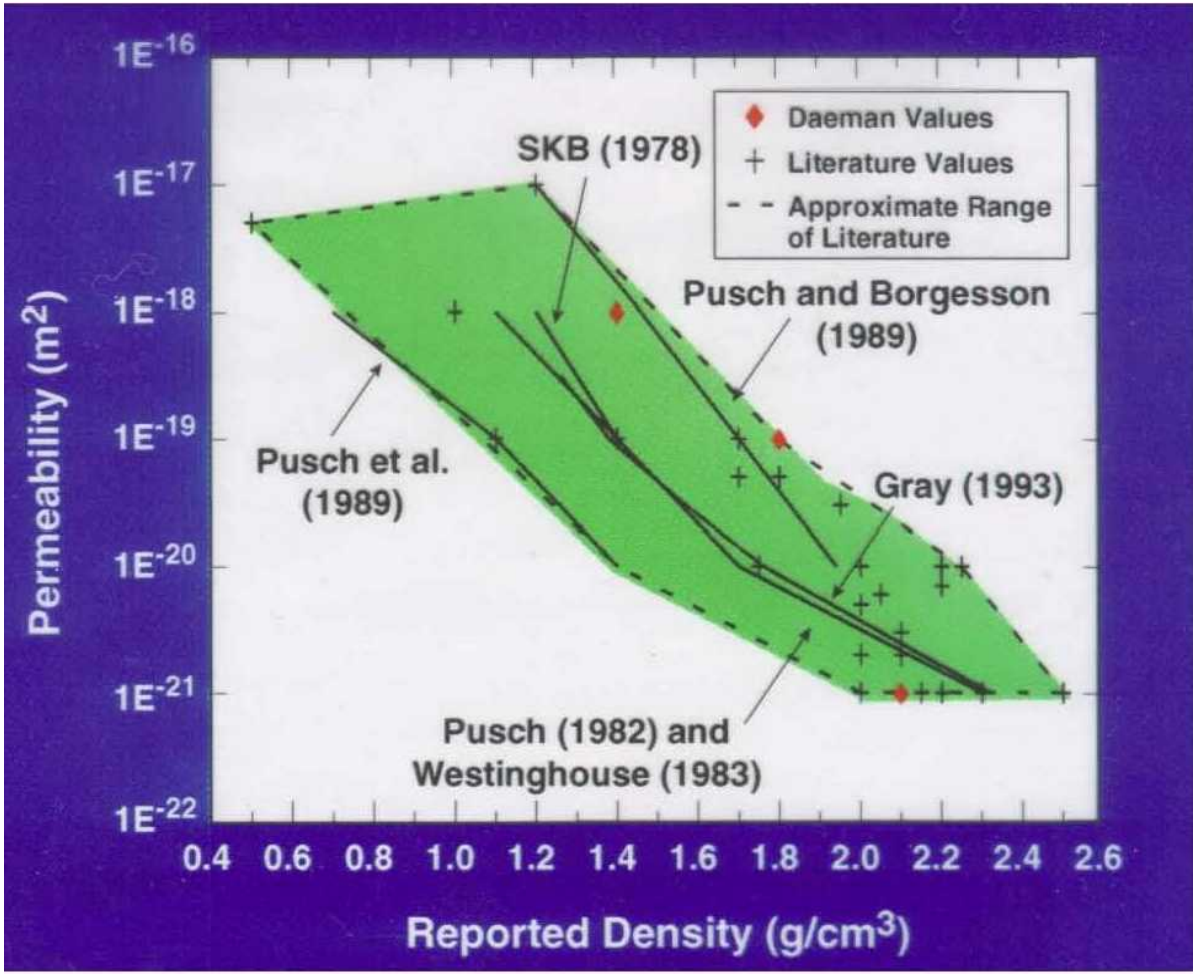
- Functions
- Material Characteristics
- Construction
- Performance Requirements
- Verification methods

Concrete Mixture Proportions

MATERIAL	lb/yd^3
Portland cement	278
Class F fly ash	207
Expansive cement	134
Fine aggregate	1292
Coarse aggregate	1592
Sodium chloride	88
Water	225

Kg/m^3 = (lb/yd^3) * (0.59) Water: Cement ratio is weight of water divided by all cementitious materials

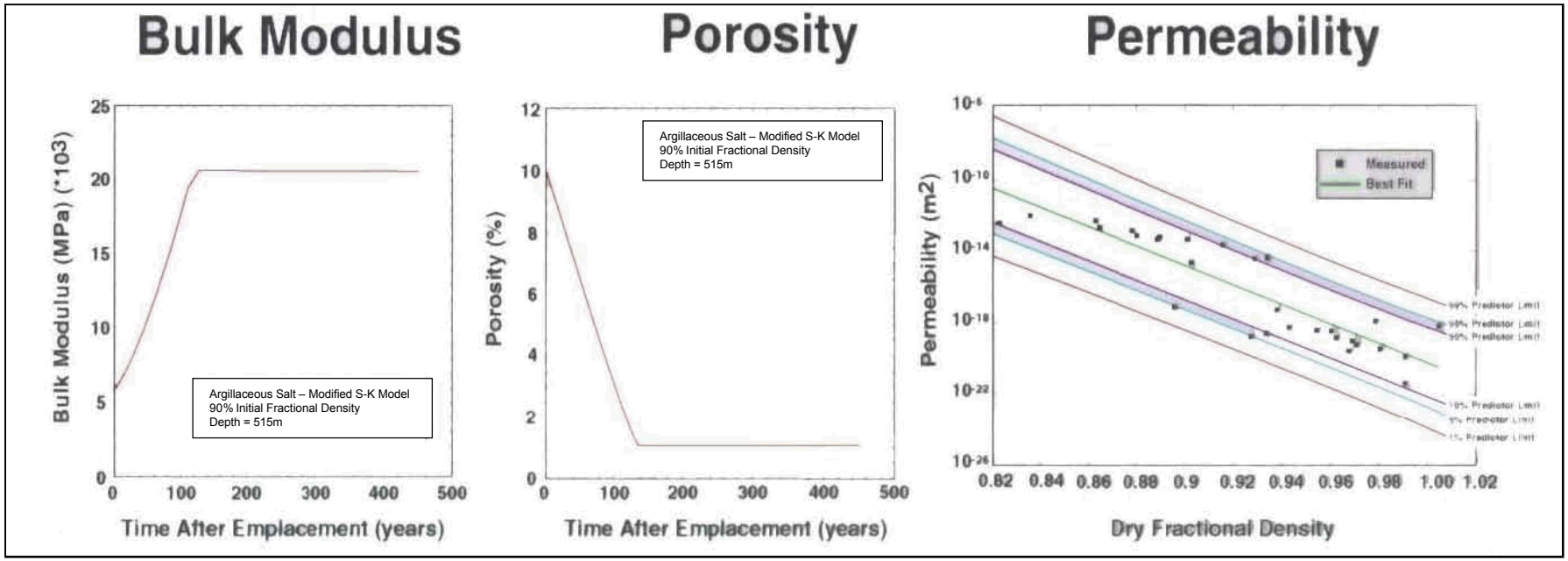
Sodium Bentonite Permeability Versus Density



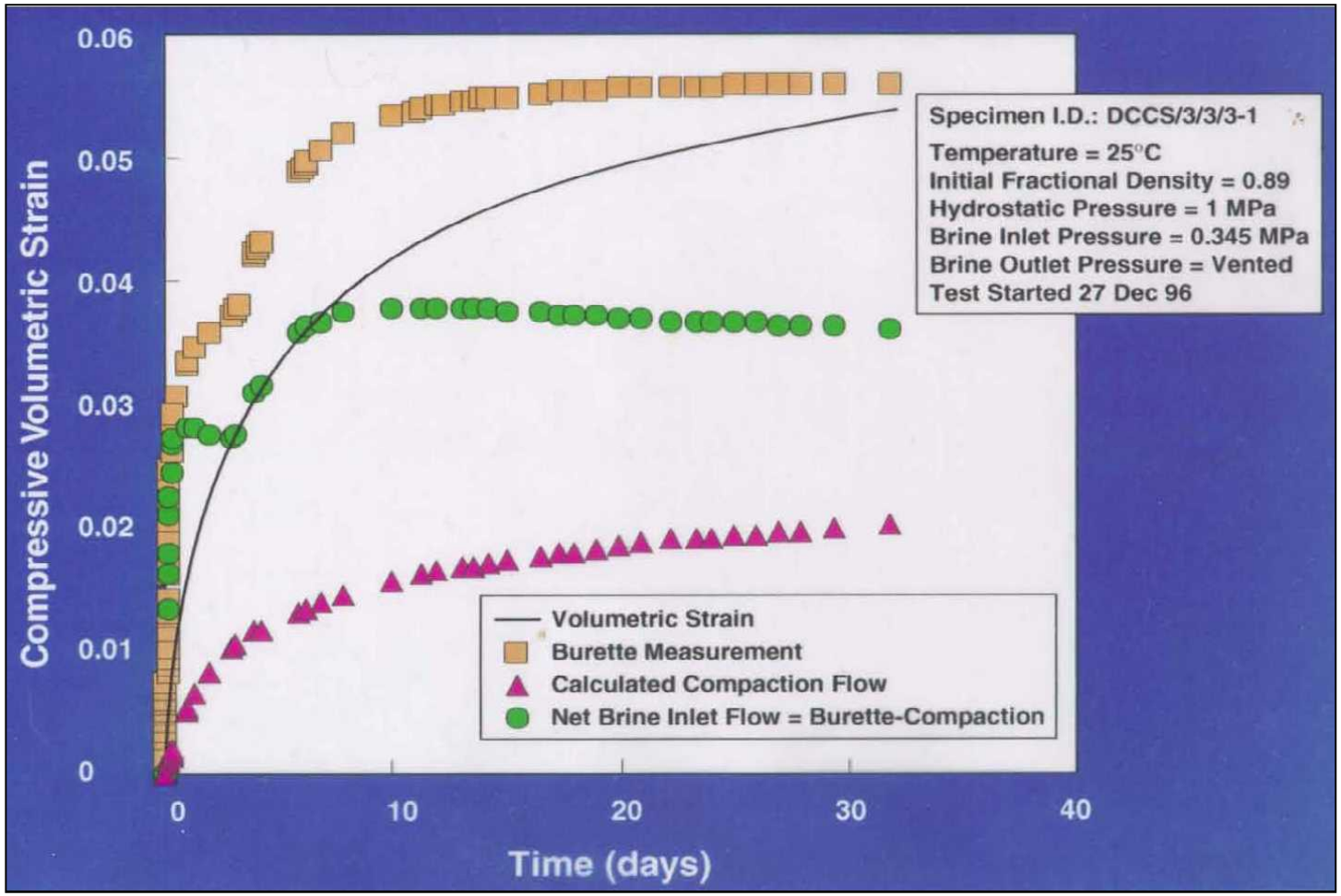
Reconsolidated Salt Properties

Lab Testing

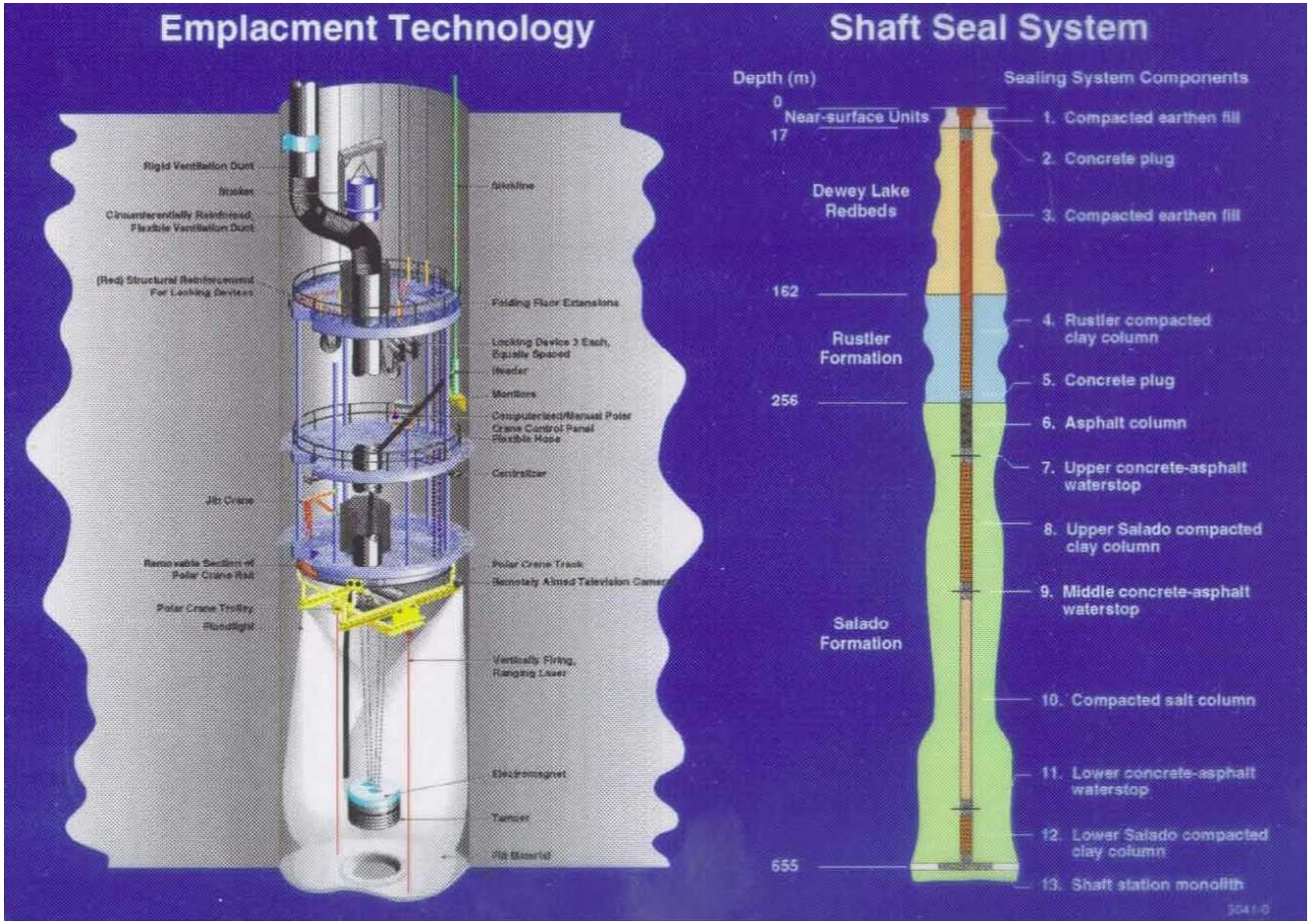
Crushed Salt



Brine Permeability Tests on Specimen



Shaft Seals System Studies Construction



Model 1 – Brine Flow Down

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Objectives

- To predict cumulative brine flow through the seal system down to the salt column and the repository
- To demonstrate the effectiveness of the concrete-asphalt

Assumptions

- Single-phase saturated flow
- 50-year, open-shaft period prior to closure
- Far-field BC is hydrostatic consistent with highest undisturbed Rustler head

Model 2 – Salt Column Performance

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Objectives

- Predict the intrinsic permeability of the salt column component of the seal system
- Demonstrate effectiveness of the salt column as a low permeability seal within 200 years after closure
- Estimate gas migration from the repository horizon

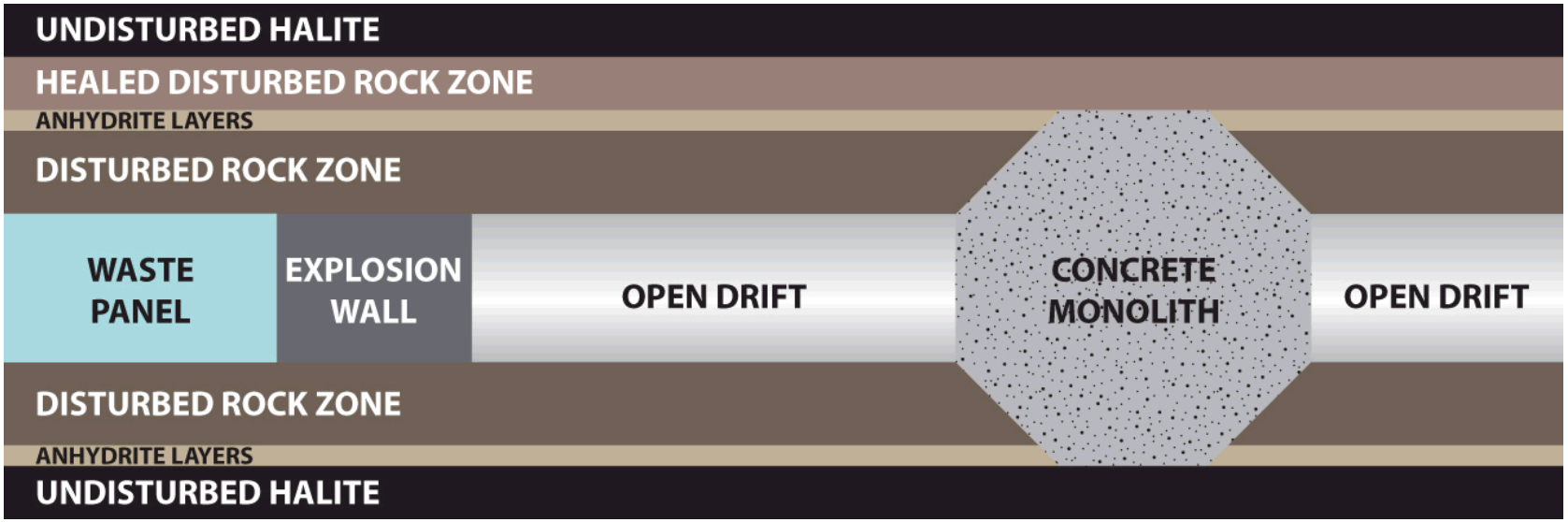
Assumptions

- Two-phase flow (brine and hydrogen)
- 50-year, open-shaft period prior to closure
- Hydrostatic outer boundary condition relative to MB-139

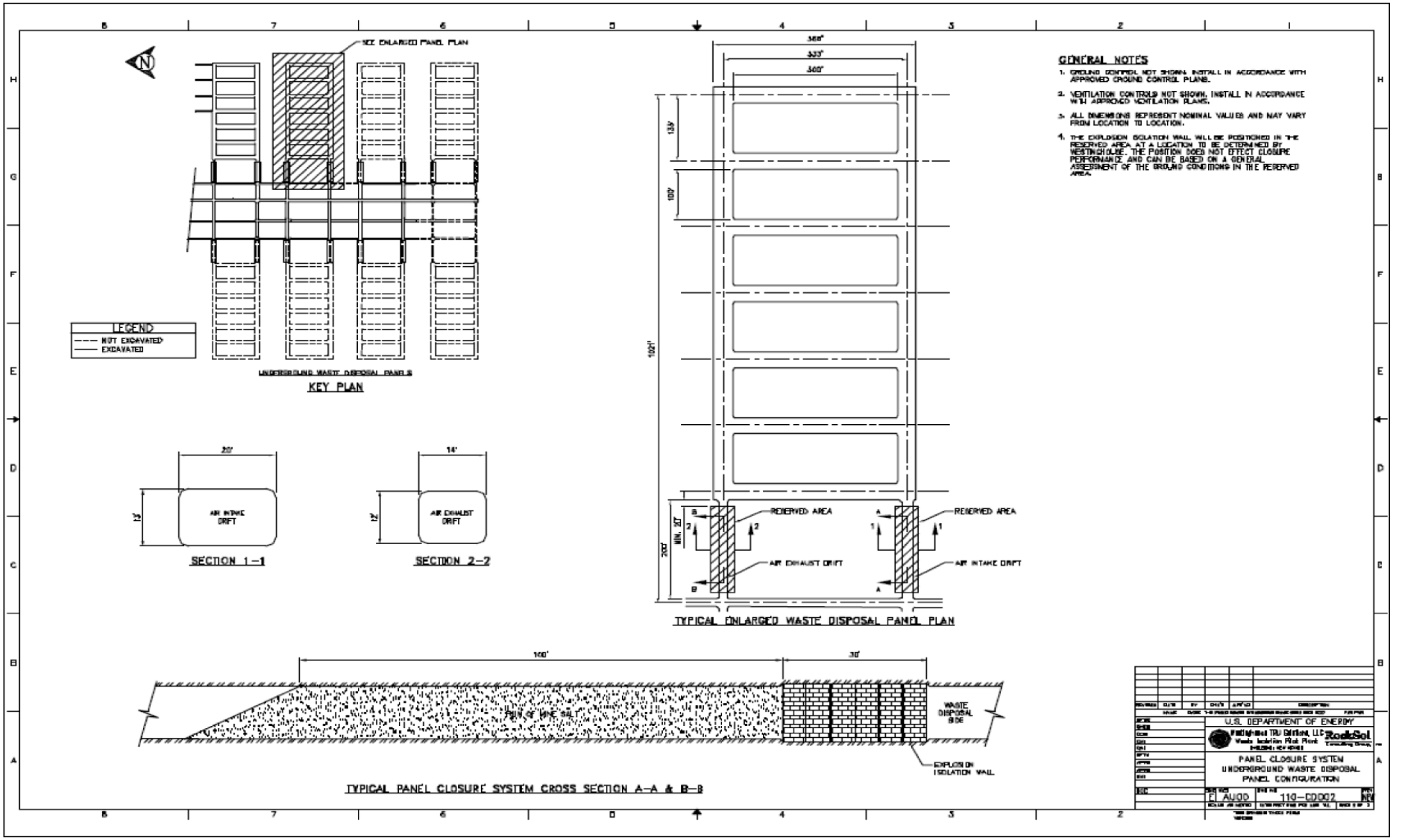
Simulation Code

TOUGH28W is a multi-dimensional, multi-phase coupled fluid and heat simulator for porous and fractured media. This Sandia version of the code was developed from the LBL code TOUGH2.

Option D Panel Closure System



Possible Alternative Panel Closure



Isolation & Containment Strategic Choices for Seals & Backfill

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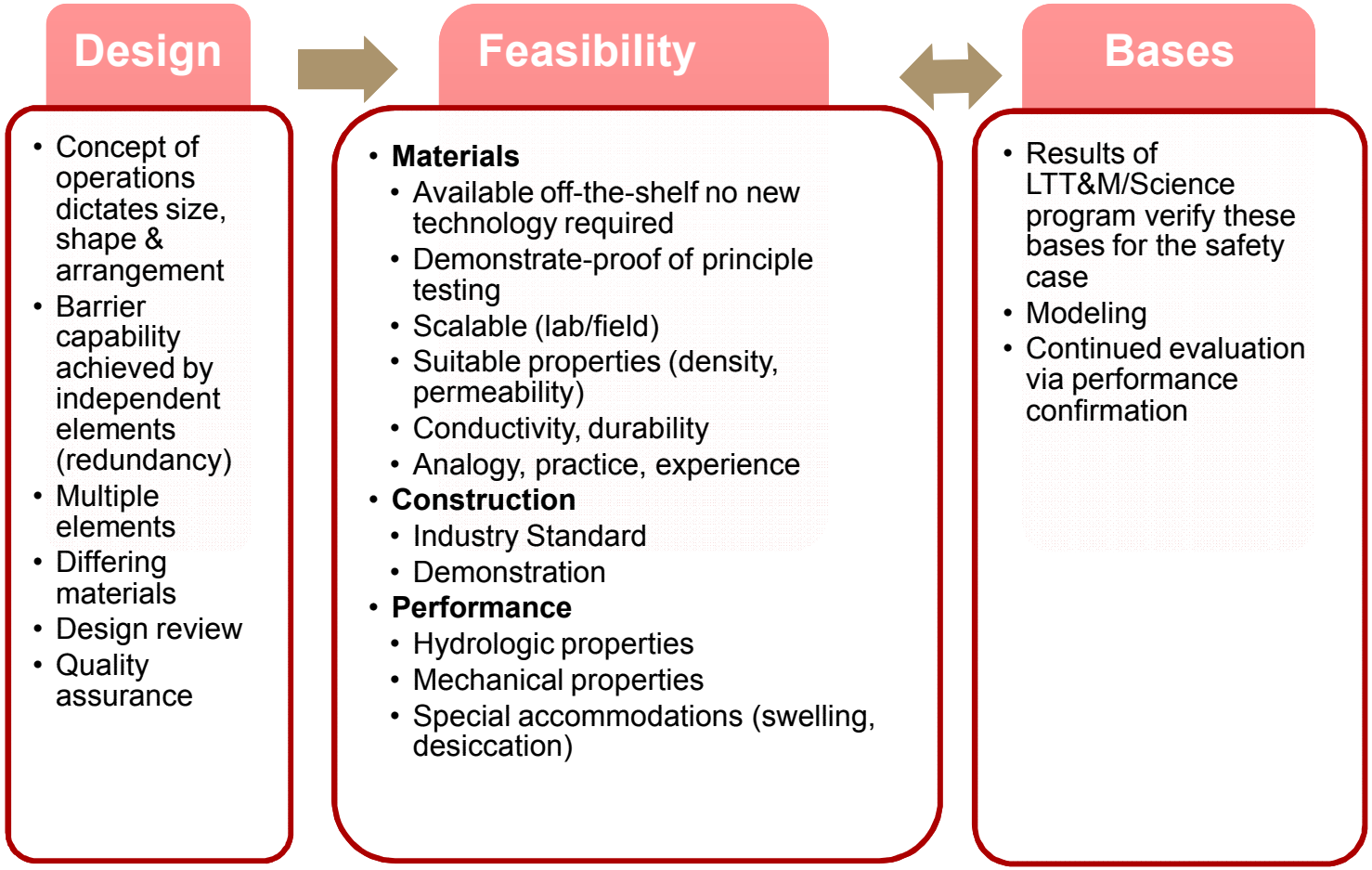


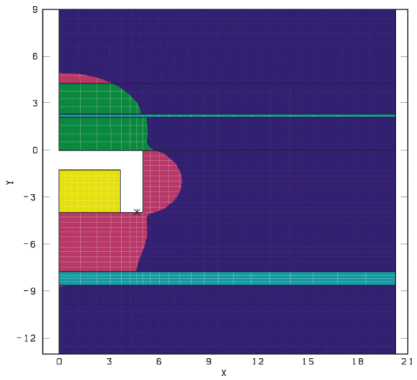
Shaft Seal System Conclusions

- The WIPP shaft seal system effectively limits fluid flow within the seal system
- The salt column becomes an effective barrier to gas and brine migration by 100 years after closure
- Long-term flow rates within the seal system are limited
- Reference to available reports
- SAND97-1287 Shaft Seal System Parameters Document
- SAND96-1326/1 Shaft Seal Design Report

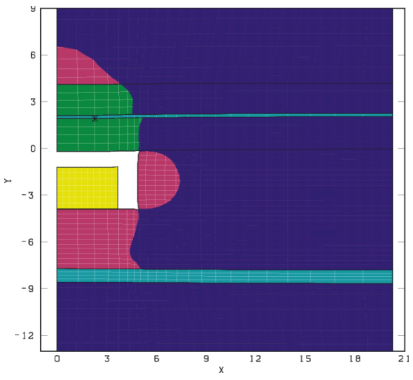
Waste First Received in March 1999

WIPP Disposal Room Evolution

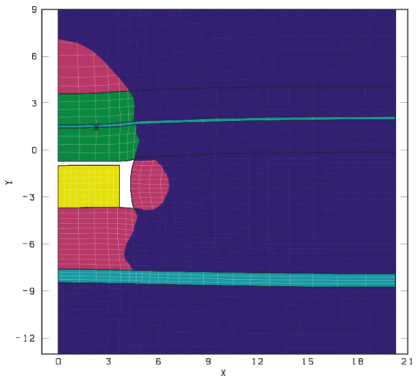
Disturbed Rock Zone around a Disposal Room



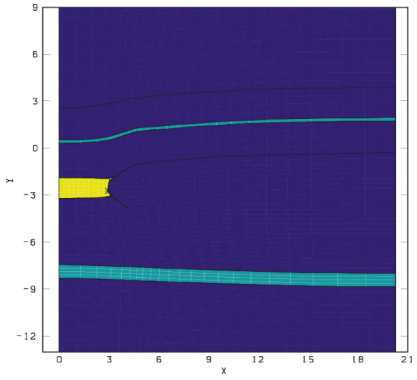
0 year



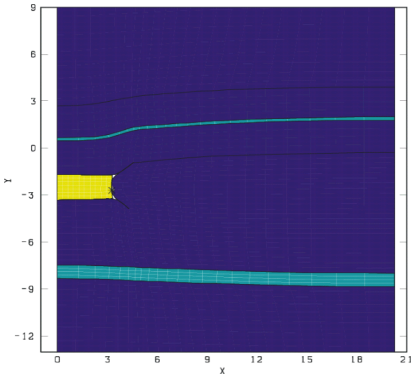
1 year



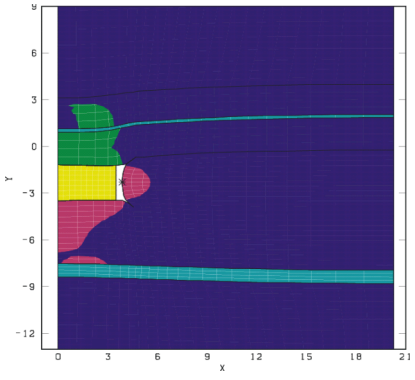
17 years



10,000 years



248 years



50 years

Undisturbed Halite Zone

Argillaceous Halite

Clean Halite

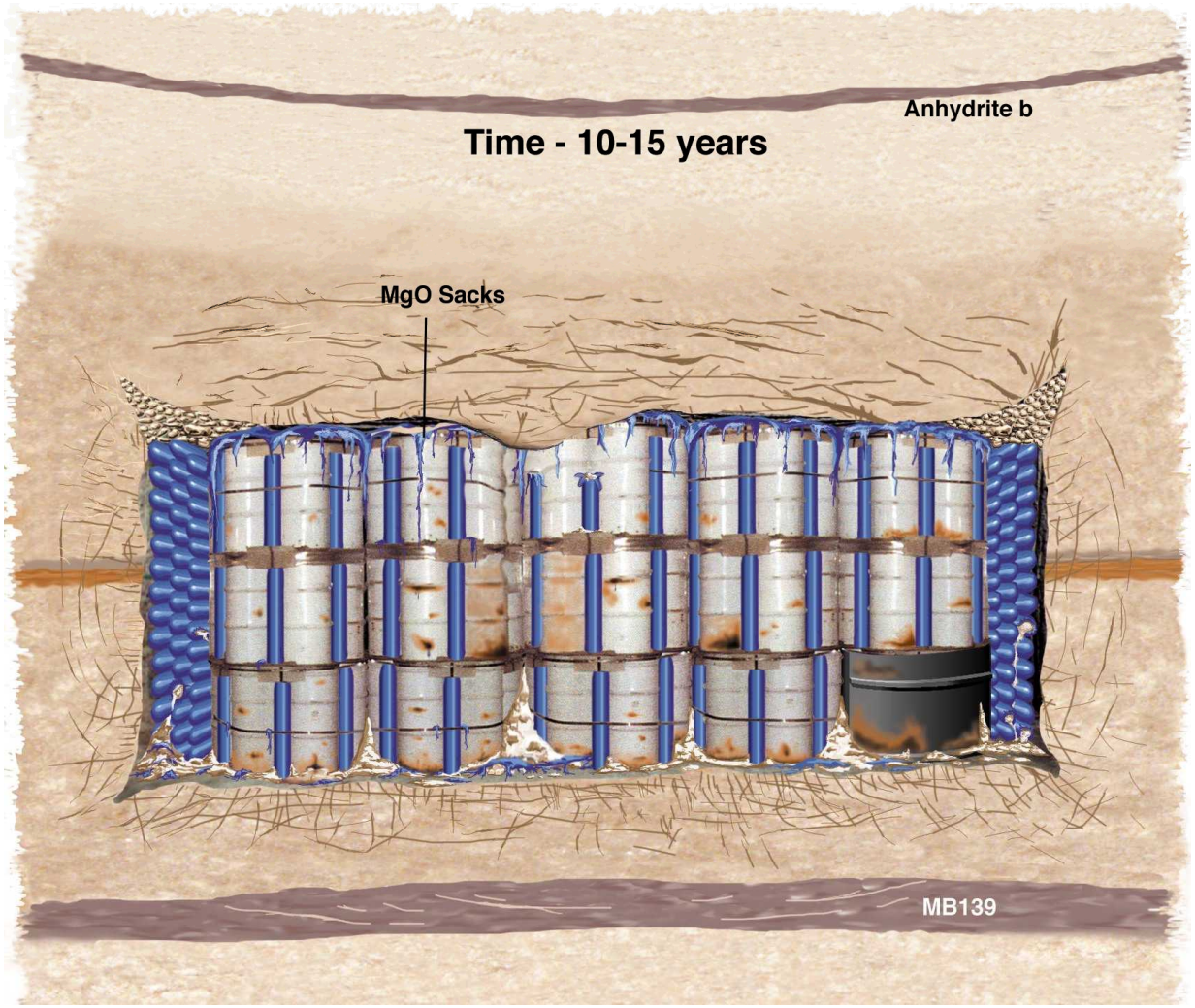
Anhydrite

Waste

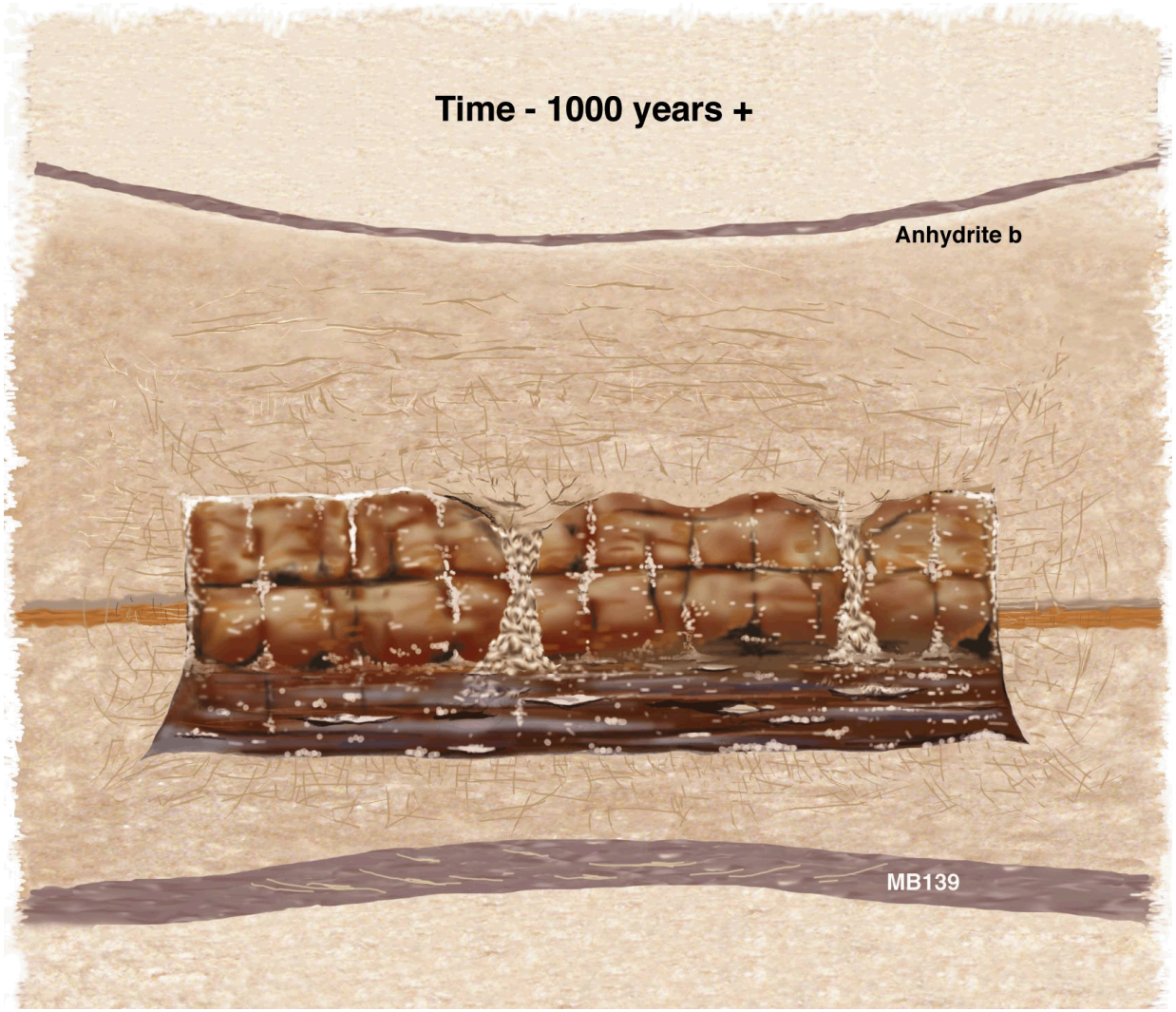
Undisturbed Zone:

$$\sqrt{J_2} \le 0.27 \cdot I_1$$

WIPP Room Evolution at Time=12 years



WIPP Room Evolution at 1000 years



Summary

- Shipments and volume July 6, 2013
  - 11,416 shipments
  - 87,462.88 m3 volume emplaced
- This presentation has discussed US experience in establishing the scientific and engineering basis for bedded salt disposal
- Summarized the WIPP success story
- Salt properties verification and validation
- Engineering design based on science
- Shaft seal system and material specifications
- Examples of performance analysis for the shaft
- Long-term performance of salt disposal