YUCCA
MOUNTAIN
PROJECT

Scientific Studies Update at Yucca Mountain

Presented to:
Nuclear Waste Technical Review Board

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June 25-26, 1997

U.S. Department of Energy
Office of Civilian Radioactive
Waste Management

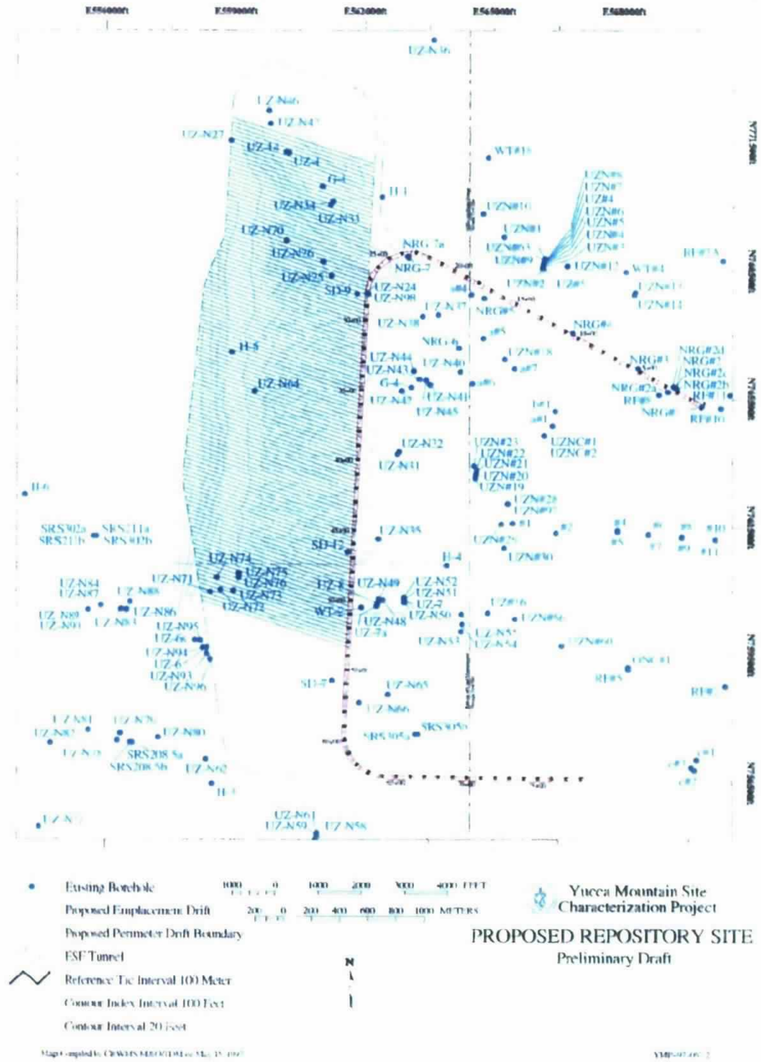
Focus of the Briefing

- Data Collection at Yucca Mountain
- In Situ Thermal Testing
  - Single Heater Test
  - Drift Scale Test
- C-Well Testing
  - Update on Hydrologic Information
  - Update on Transport Information
- ESF Moisture Studies
  - ESF Percolation Study
  - ESF Niche Study

Data Collection at Yucca Mountain

Data Summary

- A 5-mile underground testing facility with 7 major testing alcoves
- About 350 surface-based boreholes (more than 30 miles of drilling)
- About 200 underground boreholes
- More than 75,000 feet of core
- More than 15,000 samples for geohydrologic analyses
- More than 200 pits and trenches
- More than 500 water and rock samples for age dating and geochemical analyses
- Periodic water level monitoring in about 50 boreholes
- Neutron monitoring in about 90 boreholes
- Continuous pneumatic monitoring in 76 hydrogeologic zones
- About 50 seismic monitoring stations



Generalized Rock and Hydrologic Properties, Unsaturated Zone at Yucca Mountain

Unit	Generalized Rock Properties	Generalized Hydrologic Properties	Derived Flux (averaged) mm/yr		Minimum Observed Water Ages* (years)		Method	Data Source
			Fracture	Rock Matrix	Fracture	Rock Matrix		
TCw	Moderately to densely welded Bulk Density 2.23 Porosity 0.1 Thermal Conductivity 1.39 W/mK Fracture Density 35 frac/m^3 About 810 Samples	Saturation about 0.7 Saturated Hydraulic Conductivity about 1 x 10^3 mm/yr About 40 Samples	6	1	Modern	Modern	C-14 Tritium Cl-36	RIB Section 1.12a Geologic/Lithologic Stratigraphy & Hydrologic Properties
PTn	Nonwelded Bulk Density 1.39 Porosity 0.4 Thermal Conductivity 0.57 W/mK Fracture Density 1 frac/m^3 About 690 Samples	Saturation about 0.5 Saturated Hydraulic Conductivity about 7 x 10^4 mm/yr About 65 Samples	0	6	Modern Near Faults	2,000 (SD-12) 3,000 (SD-7)	C-14, Tritium	Recent Project Reports and TDB Submittals Baseline. RIB Section 1.12a Geologic/Lithologic Stratigraphy & Hydro-geologic Properties
TSw	Moderately to densely welded. Bulk Density 2.20 Porosity 0.1 Thermal Conductivity 1.23 W/mK Fracture Density 25 frac/m^3 About 2100 Samples	Saturation about 0.7 Saturated Hydraulic Conductivity about 1 mm/yr About 285 Samples	4	1	Modern Near Faults	Perched water at basal vitrophyre: 2,100-2,700 (NRG7a) 4,000-5,000 (SD-9) 5,700-6,300 (UZ-14)	C-14, Tritium	Recent Project Reports & TDB Submittals Baseline. RIB Section 1.12a Geologic/Lithologic Stratigraphy & Hydro-geologic Properties
CHn	Nonwelded (vitric and zeolitic) Bulk Density 1.74 Porosity 0.3 Thermal Conductivity 1.20 W/mK Fracture Density 1 frac/m^3 About 1300 Samples	Saturation about 0.9 Saturated Hydraulic Conductivity about 1 x 10^3 mm/yr (vitric) and 1 mm/yr (zeolitic) About 220 Samples	0 Vitric 2.5 Zeolitic	3 Vitric 0.5 Zeolitic	Modern Near Faults	500 (UZ-14 & SD-9) 3,000 (SD-12 & SD-7)	C-14, Tritium, Cl-36	Recent Project Reports & TDB Submittals Baseline. RIB Section 1.12a Geologic/Lithologic Stratigraphy & Hydro-geologic Properties

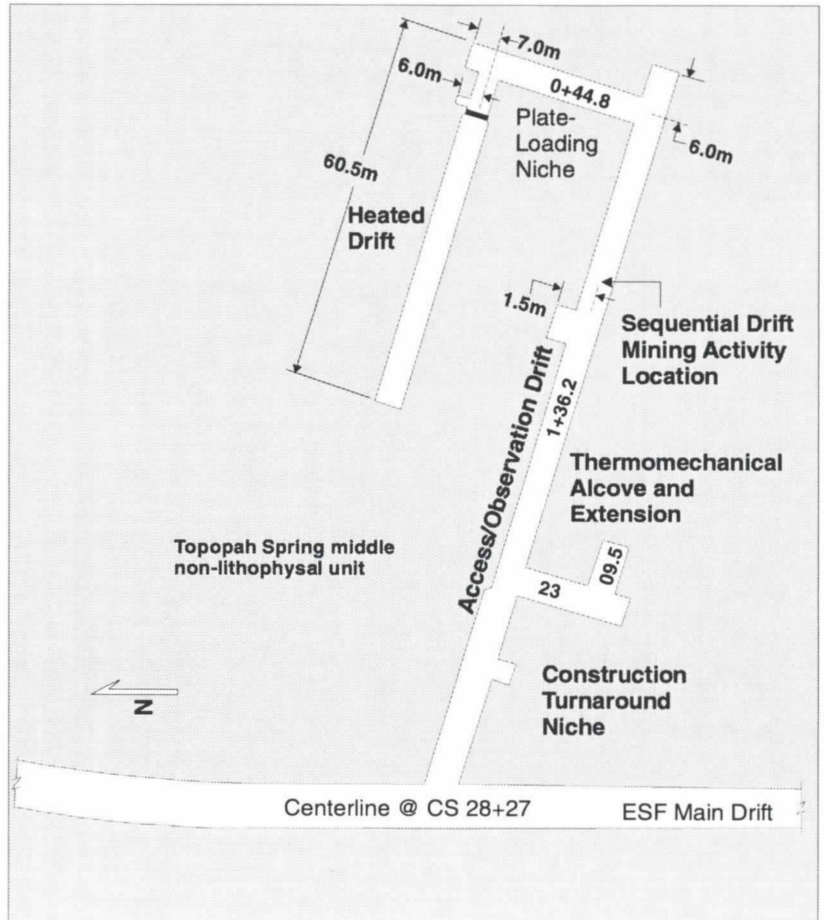
* Maximum inferred ages range from 200,000 to 2 million years

In Situ Thermal Testing

Objectives

- Estimate temperatures, determine effects of heat on moisture, chemistry, corrosion and rock stresses
- Compare predictions with measurements in small-scale (single heater) test
- Extend small-scale model to drift-scale test to calibrate model at large scale

ESF Alcove 5 Thermal Test Facility



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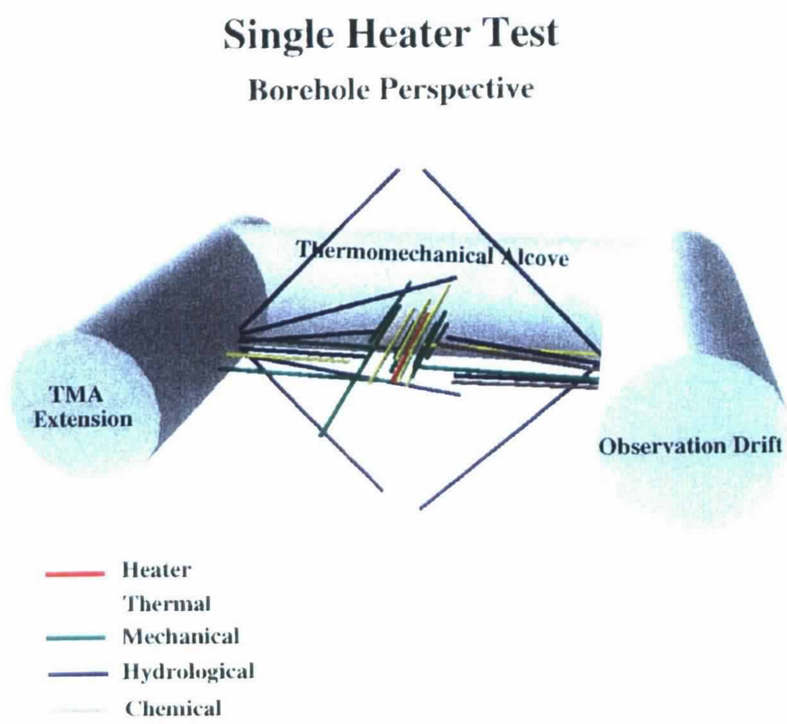
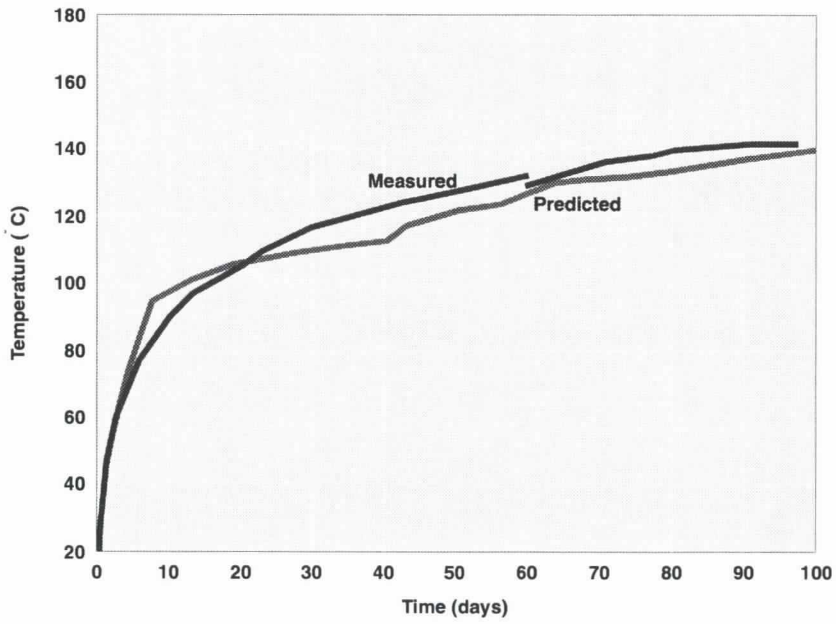
Thermal Testing: Single Heater Test

- One 5 m-long heater, 4 kW
- 530 sensors, 41 holes
- Heated rock volume > 1600 m^3
- Rock heated above 100°C ~ 20 m^3
- Heater started August 26, 1996, and was turned off May 28, 1997, beginning cool-down phase
- Data will be available to support VA

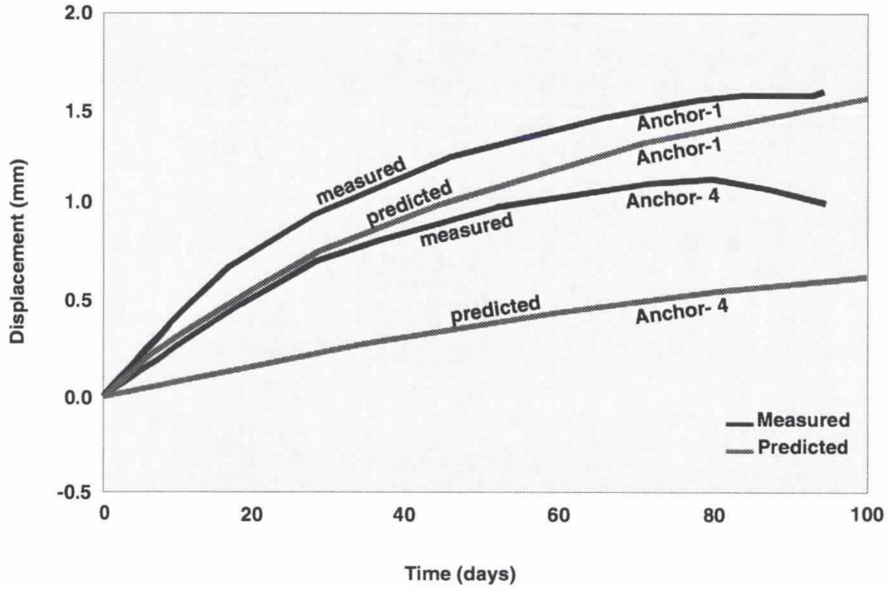


Single Heater Test Key Results

Single Heater Test: Thermal Results



Single Heater Test: Mechanical Results



Single Heater Test: What We Have Learned

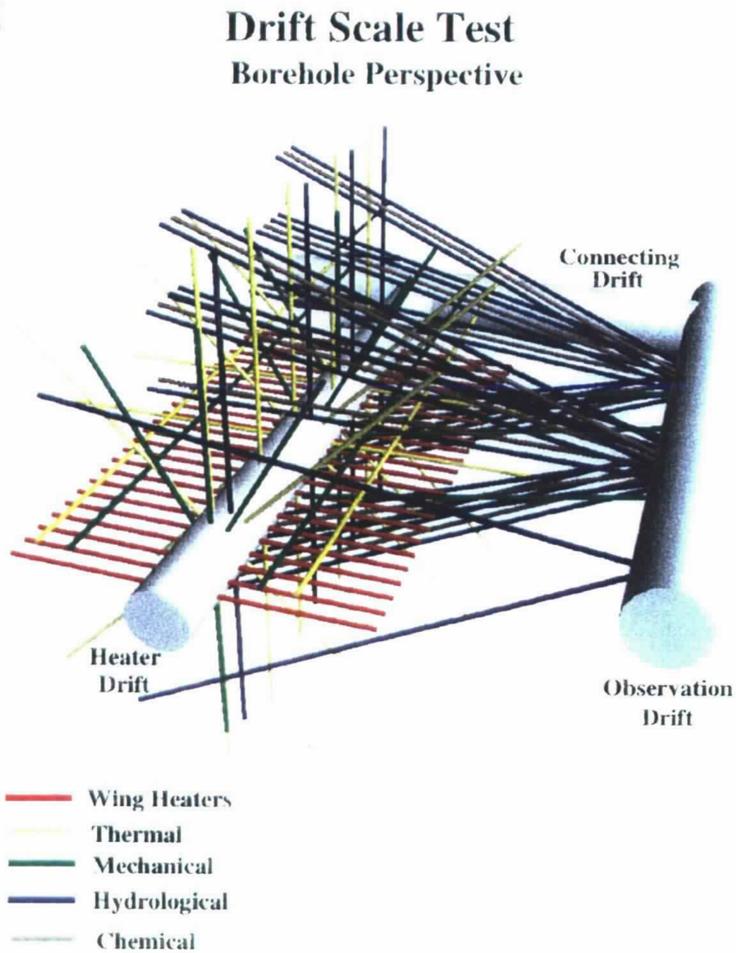
- Temperature predictions are consistent with measured temperatures
- Deviations from the predicted T/M were not unanticipated due to recognized limitations in modeling approach (difficult to account for fracture effects); simple elastic model is insufficient
- Water is mobilized by heat (as expected)--fractures play key role in the mobilization
- Near-field gas chemistry under heated conditions is dominated by water vapor and carbon dioxide
- Water-chemistry results are consistent with modeled predictions of near-field chemical evolution

Thermal Testing: Drift Scale Test

Induce Accelerated Near-Field Processes

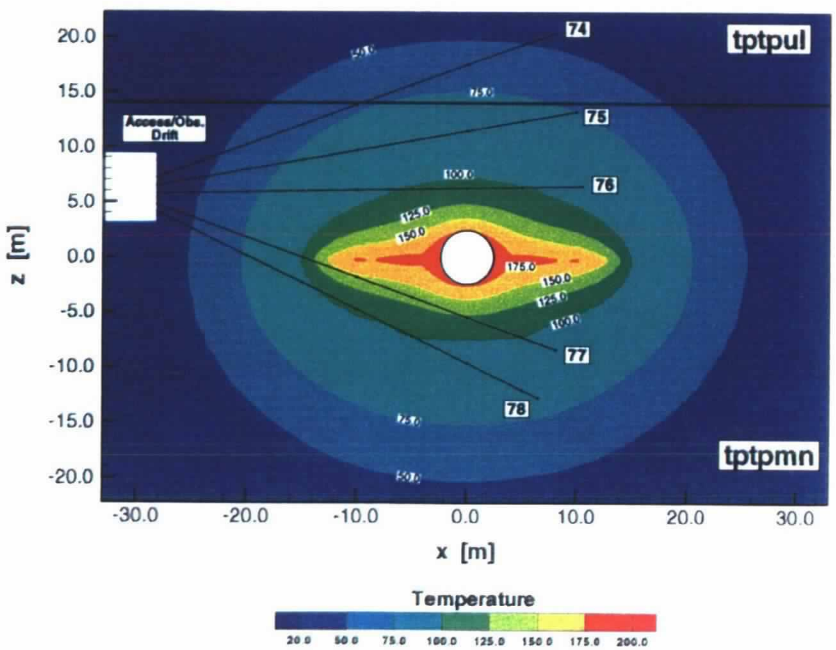
- Heated Drift: 47.5 m long, 5 m diameter
- 147 holes, total length: 3,300 m
- 9 canister heaters: 7.5 kW each
- 50 wing heaters: Inner Segments 1150 watts ea
  Outer Segments 1720 watts ea
- Heating duration: up to 4 yrs
- Rock heated volume: >200,000 m^3
- Rock heated above 100° C:>10,000 m^3
- Total sensors: 3,500
- Data collection system: approx 5,000 channels
- Limited data will be available to support VA, but LA and performance confirmation are the primary customers

	Upper Lith	Middle Non-Lith	Lower Lith
Porosity	0.15	0.11	0.13
Initial Saturation	0.8	0.9	0.8
Thermal Conductivity w(m°k)	1.7(wet) 1.2(dry)	2.0(wet) 1.7(dry)	2.3(wet) 1.6(dry)
Permeability (Darcies)	0.02D	0.01D	0.005D



Thermal Testing: Drift Scale Test Near-Field Performance Predictions

Thermal - Hydrological Situation after 4 Years of Heating
(3.6 mm/yr infiltration, 100%/50% heating schedule, ECM, uniform heat input along drift wall)



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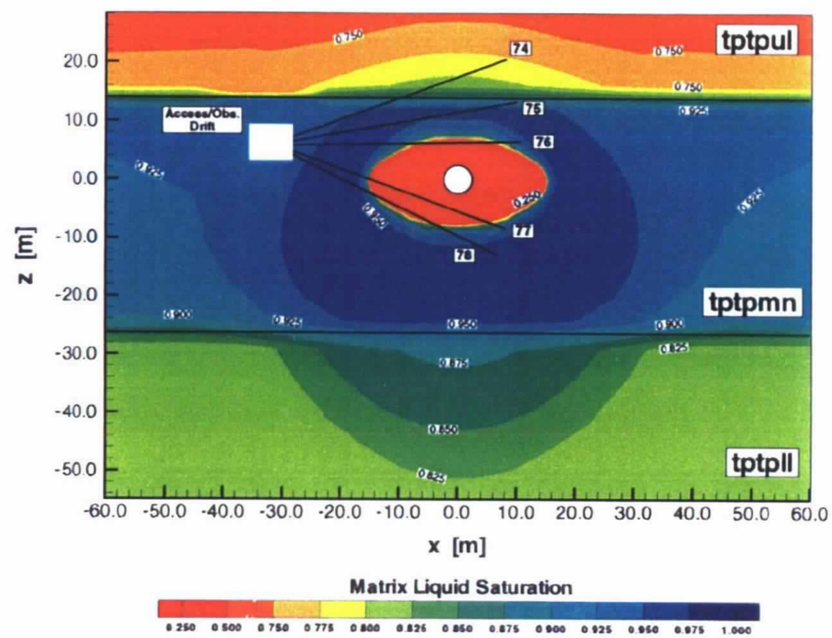
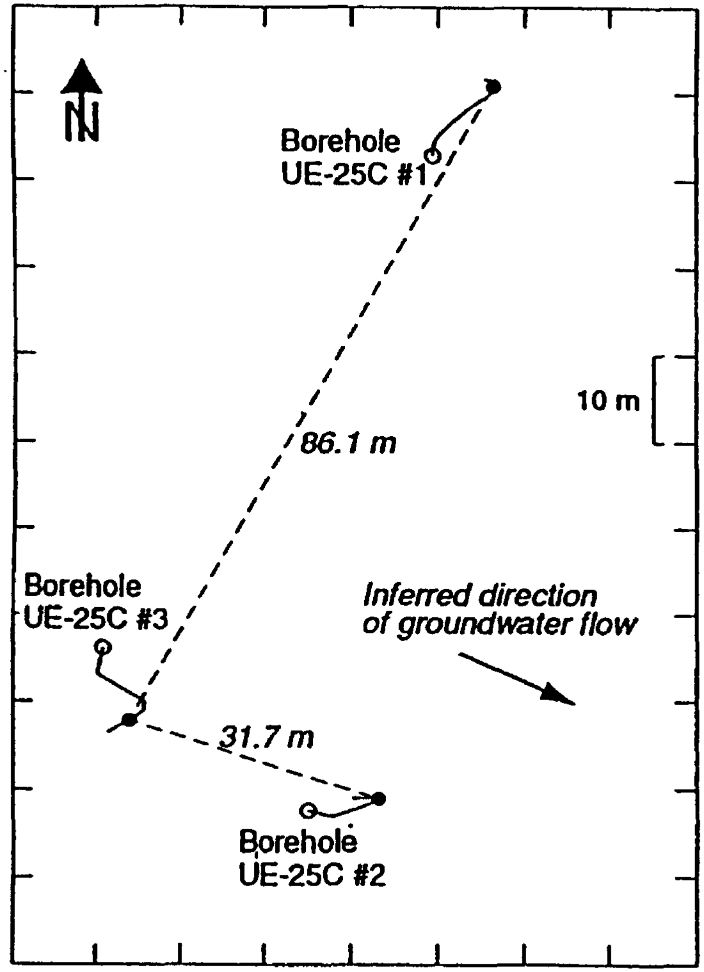


C-Well Testing

Objectives

- Obtain hydraulic properties of the volcanic aquifer through aquifer testing
- Estimate flow and transport parameters from field tests
- Confirm transport parameters measured in the laboratory

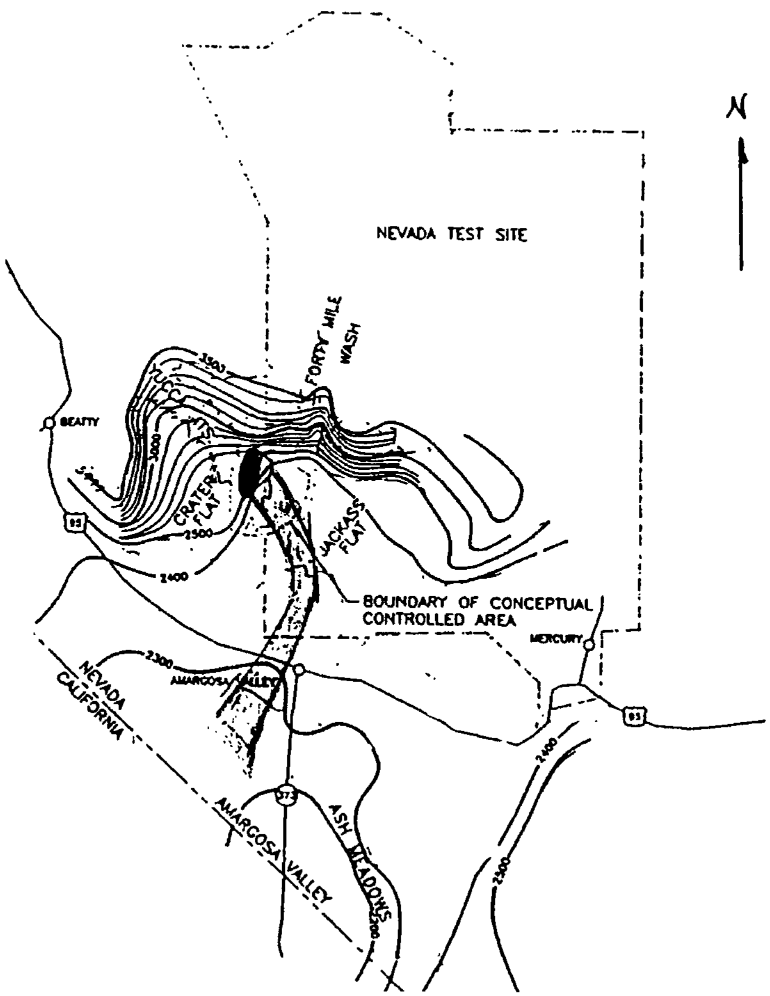


o Borehole location at land surface
• Average borehole location in test interval

C-Well Testing: What We Have Learned

- Range of derived transmissivities is 100 ft^2/day (Calico Hills) to 20,000 ft^2/day (Lower Bullfrog)
- Hydrologic units at this location display anisotropy and lateral heterogeneity
- Measured dispersivity is about 2 m, consistent with measurements at other sites at this scale
- Transport is complex due to heterogeneity; suggests likely important dilution and dispersion effects at larger scale
- Tracers display strong matrix diffusion; suggests radionuclide travel times will be greater than ground-water travel times, and concentrations will be reduced

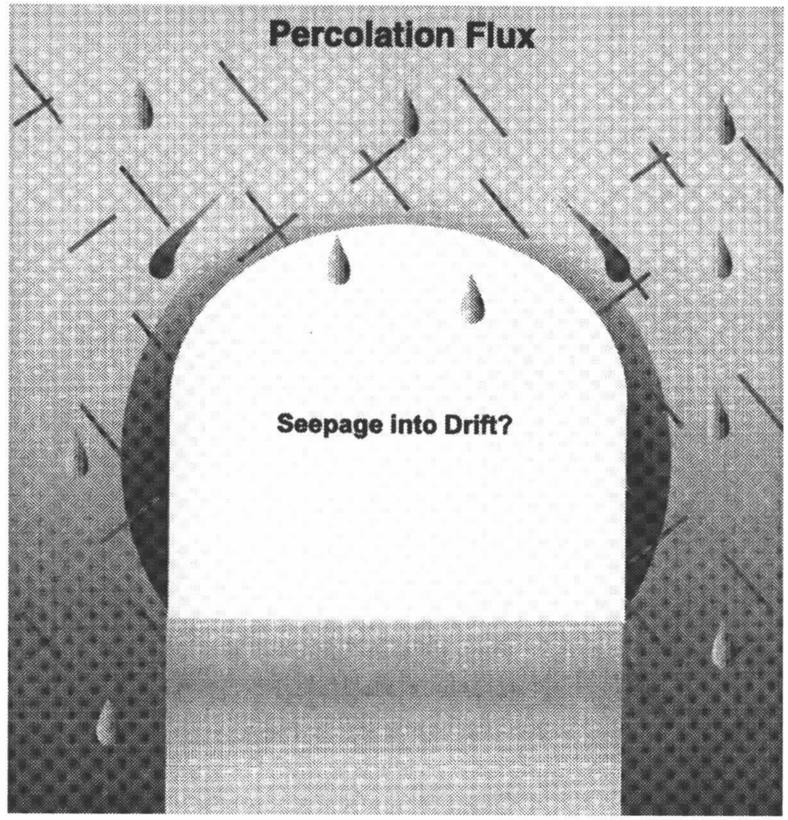
Implications for Radionuclide Transport



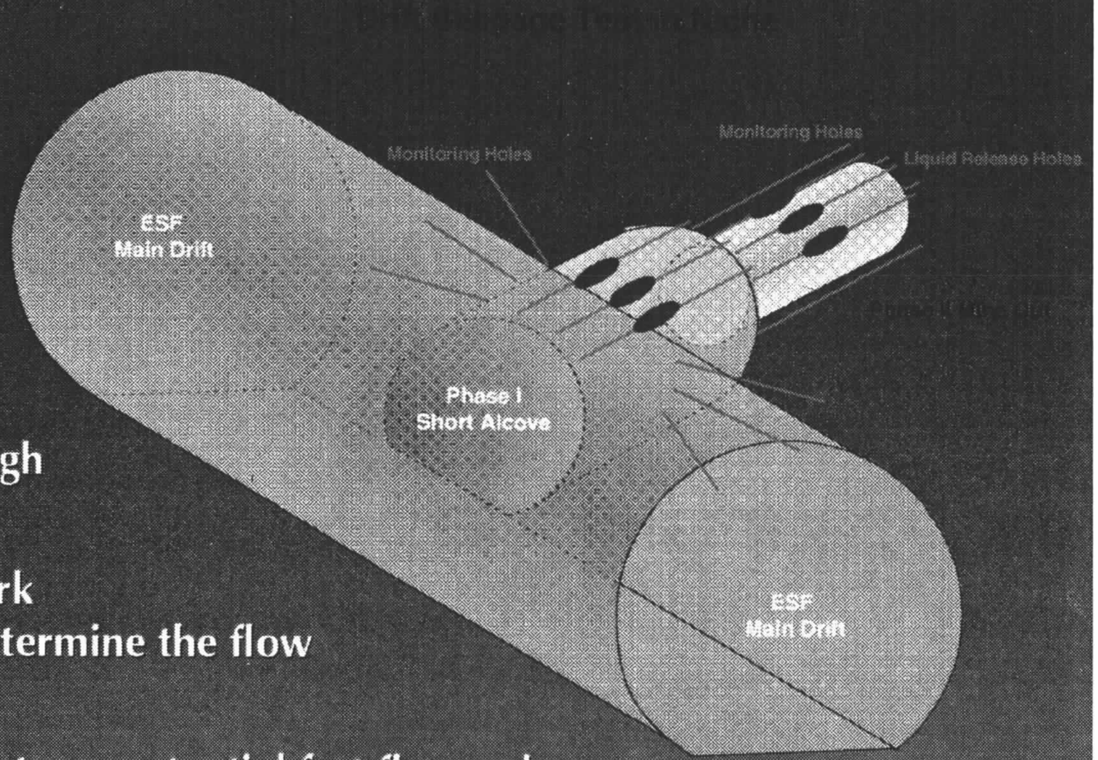
- From lab results confirmed at the c-wells:
  - Mechanical dispersion and matrix diffusion will reduce concentrations at this site
  - Flow and transport data adequate for design and performance assessment
- From the regional flow model:
  - General direction and magnitude of flow known
  - Closed basin; no transport to major population areas

Niche Moisture Studies

- Niche studies focus on seepage into drifts and will
  - Examine fracture/matrix interaction and effective wetted area of fractures
  - Determine threshold flux conditions associated with seepage into drifts
  - Provide data to test models of processes affecting seepage (e.g., capillarity, effects of heterogeneity, dynamic effects)
- Limited data will be available to support VA, with full analyses being available for VA



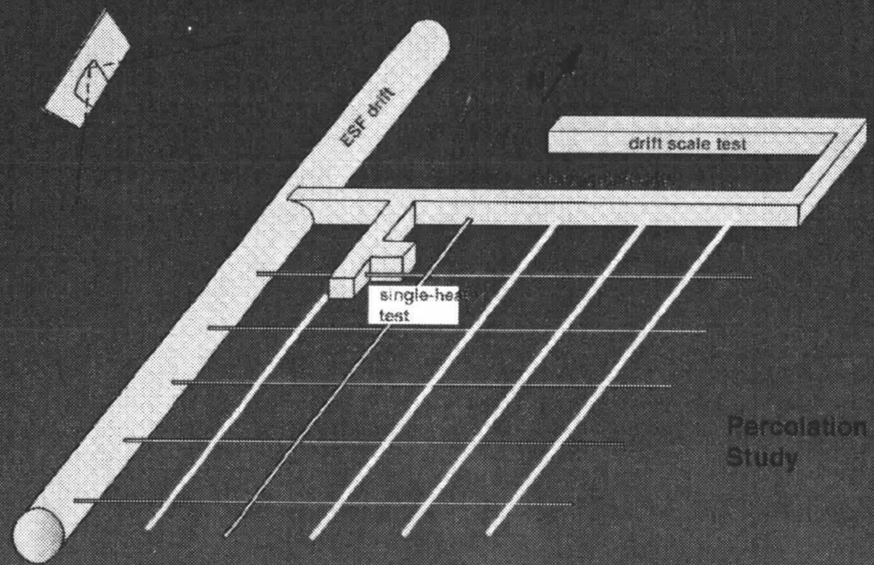
Niche study determines seepage into drifts
(infiltration ≠ percolation ≠ seepage)



- Diversion of liquid release above the crown minimizes drips
- Isolation from main drift provides post-emplacement high humidity conditions
- Local fracture network and heterogeneity determine the flow paths to the drift
- Niche monitoring captures potential fast-flow pulses
- Niche alcove and drift-drift studies lead to better representation of multi-drift repository

Percolation study areally determines available water to feed seepage and contact wastes (infiltration ≠ percolation ≠ seepage)

- Long borehole arrays to have large areal coverage (~100 m^2)
- Test-site selection integrates all UZ knowledge at repository level
- Rock sampling systematically confirms understanding of matrix and fracture properties



- Large-scale measurements of temperature, saturation, moisture potential and fast-flow signals determine percolation flux through UZ model
- Testing and monitoring confirm and improve long-term verification and confirmation of UZ barriers.

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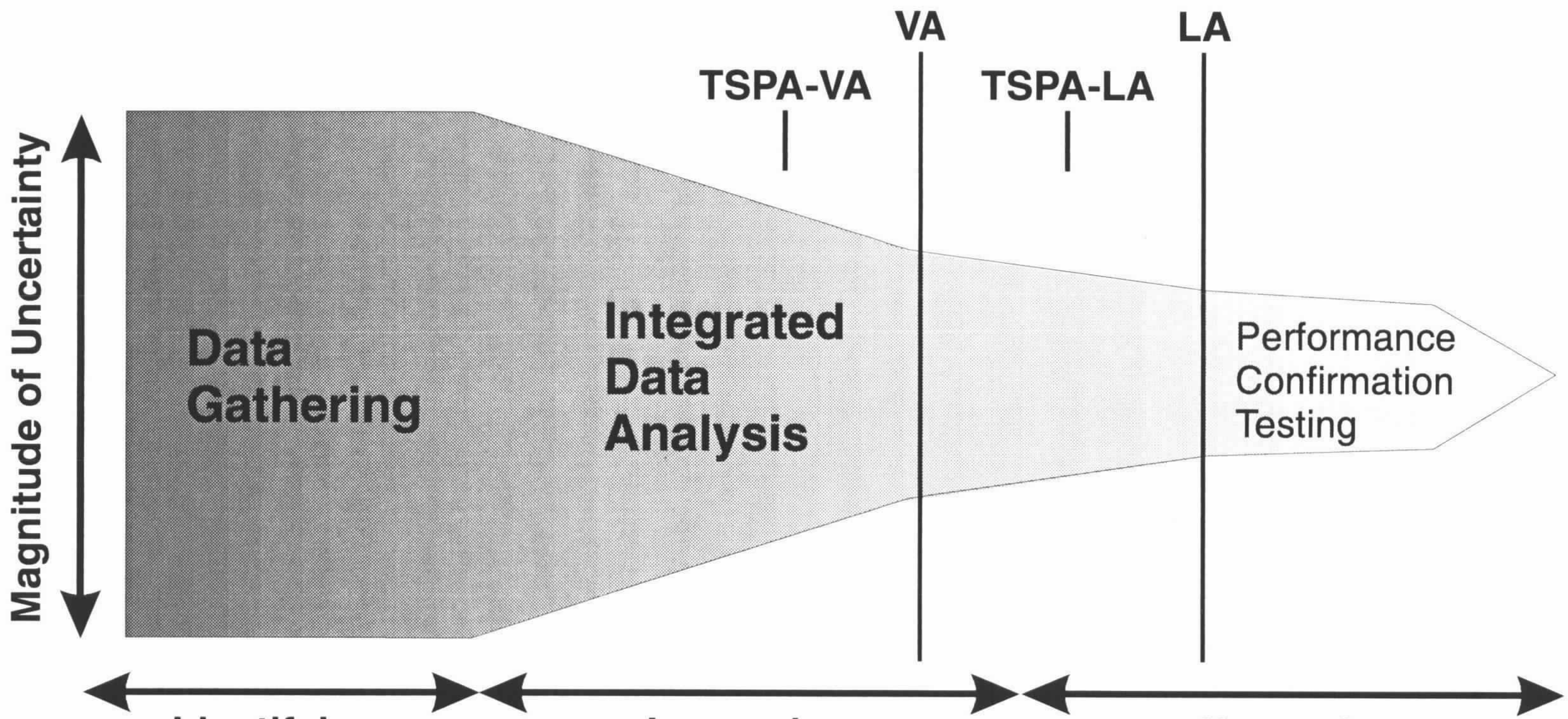
Focusing the Science Program



Identifying Uncertainties:
Geologic Mapping
Borehole Analyses
Rock Properties
Hydrologic Properties
Geochemistry

Increasing Confidence:
Lab & Pilot Testing
ESF/Cross-Drift Testing
Niche Studies
Thermal Testing
Model Confirmation
Percolation Flux Studies
Saturated Zone Testing
Continued Baseline Monitoring

Narrowing Bounds:
Performance Confirmation
Upgrading Analyses
Continued Baseline Monitoring

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