



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

# Scientific Program Overview

Presented to:

**Nuclear Waste Technical Review Board**

Presented by:

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YUCCA  
MOUNTAIN  
PROJECT

# Overview

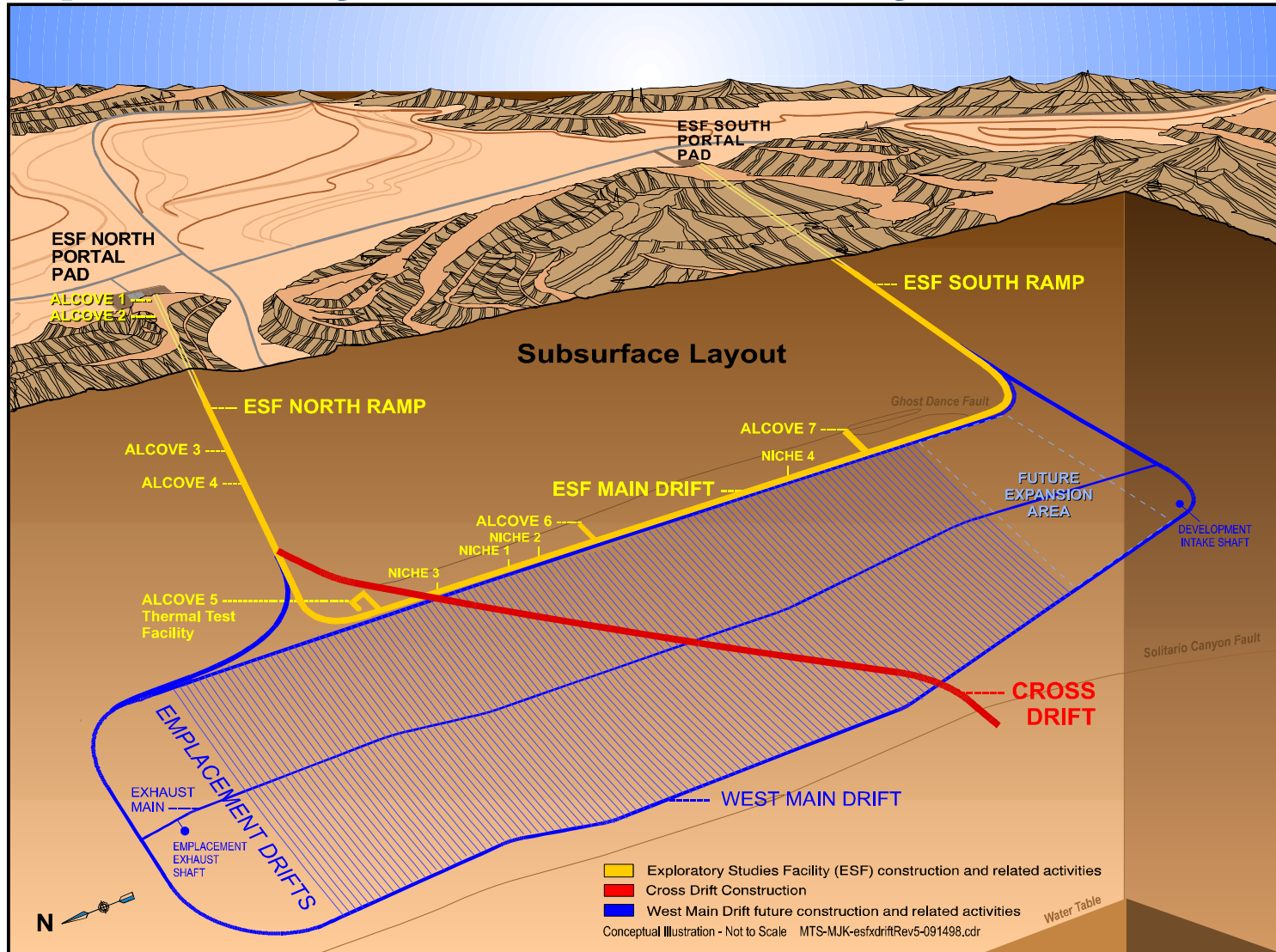
- **Objective is to provide status on natural system testing program, focusing on unsaturated zone (UZ)**
- **Exploratory Studies Facility (ESF) Studies**
  - Alcove 1
  - Alcove 5
- **Cross Drift Studies**
  - Alcove 8 (Crossover Alcove)
  - Niche 5

# Overview

(Continued)

- **Cross Drift Studies (continued)**
  - **Bulkhead Investigations**
    - ◆ **Hydrology**
    - ◆ **Organic Material**
  - **Seepage/Drainage Benches**
  - **Topopah Spring Rock Chemistry**
  - **What Have We Learned in the Cross Drift?**
- **Summary**

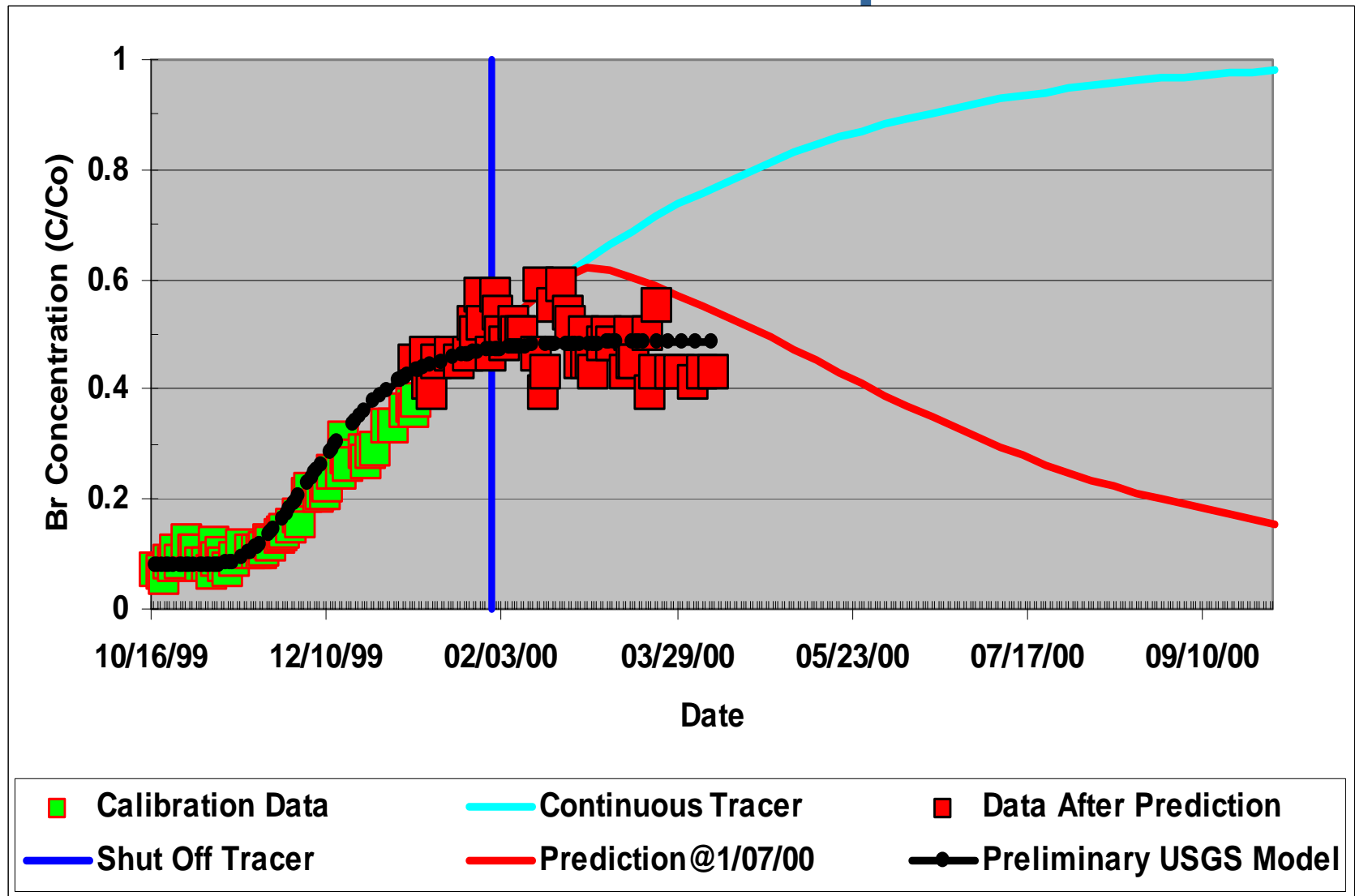
# Exploratory Studies Facility and Alcoves



# Alcove 1

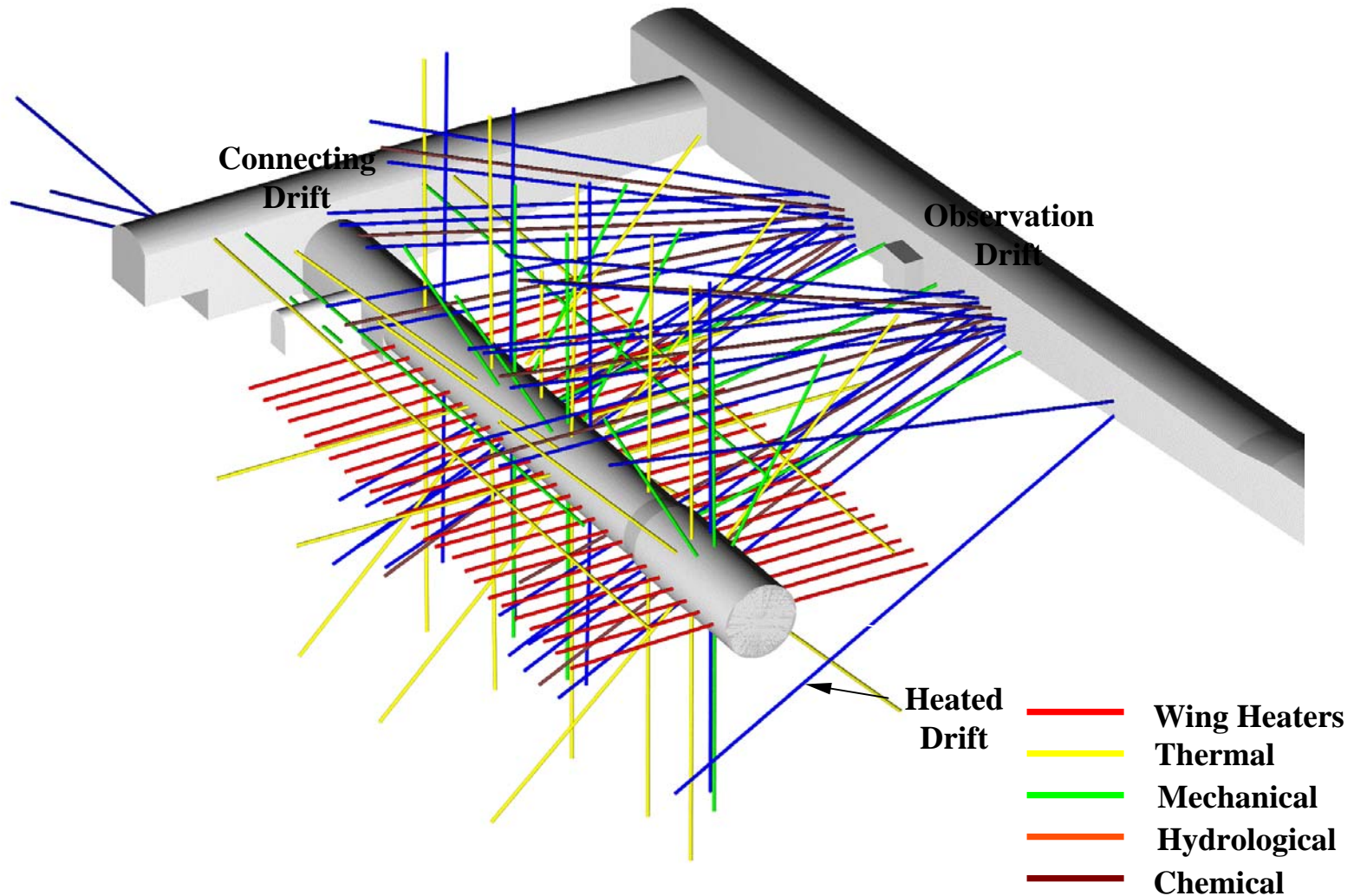
- Evaluate infiltration and percolation through unsaturated welded tuffs and the climatic effects associated with increased precipitation
- Supports UZ Infiltration, Seepage, and Transport models
- Tracer application at the surface ended on January 31, 2000
- Water collection and tracer analysis continue

# Alcove 1 Tracer Experiment

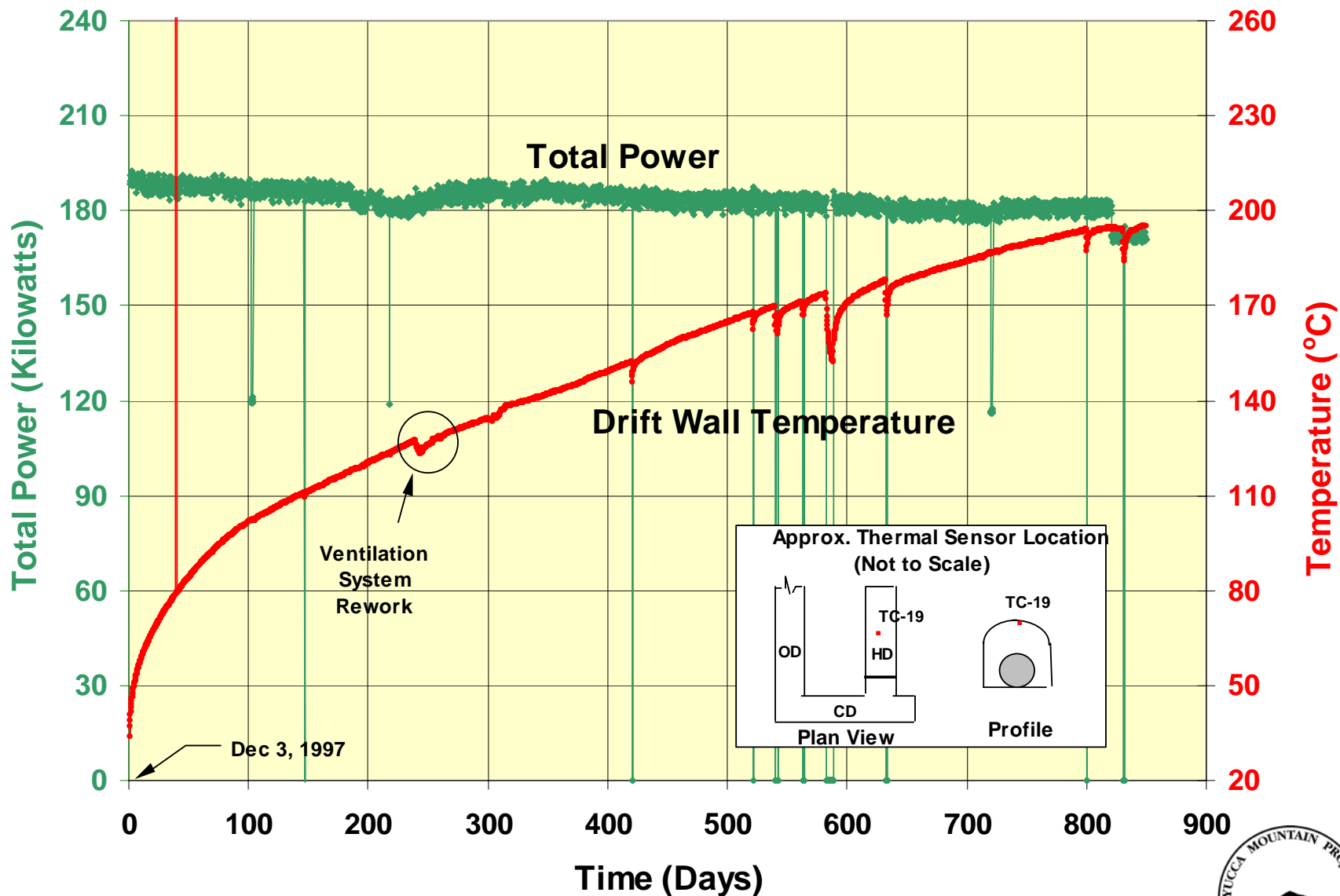


# Drift Scale Test (DST)

Evaluate thermally-coupled processes in potential repository horizon rocks at the field-scale in support of Coupled Process Models, Near-Field Environment Models, and Design



# Drift Scale Test

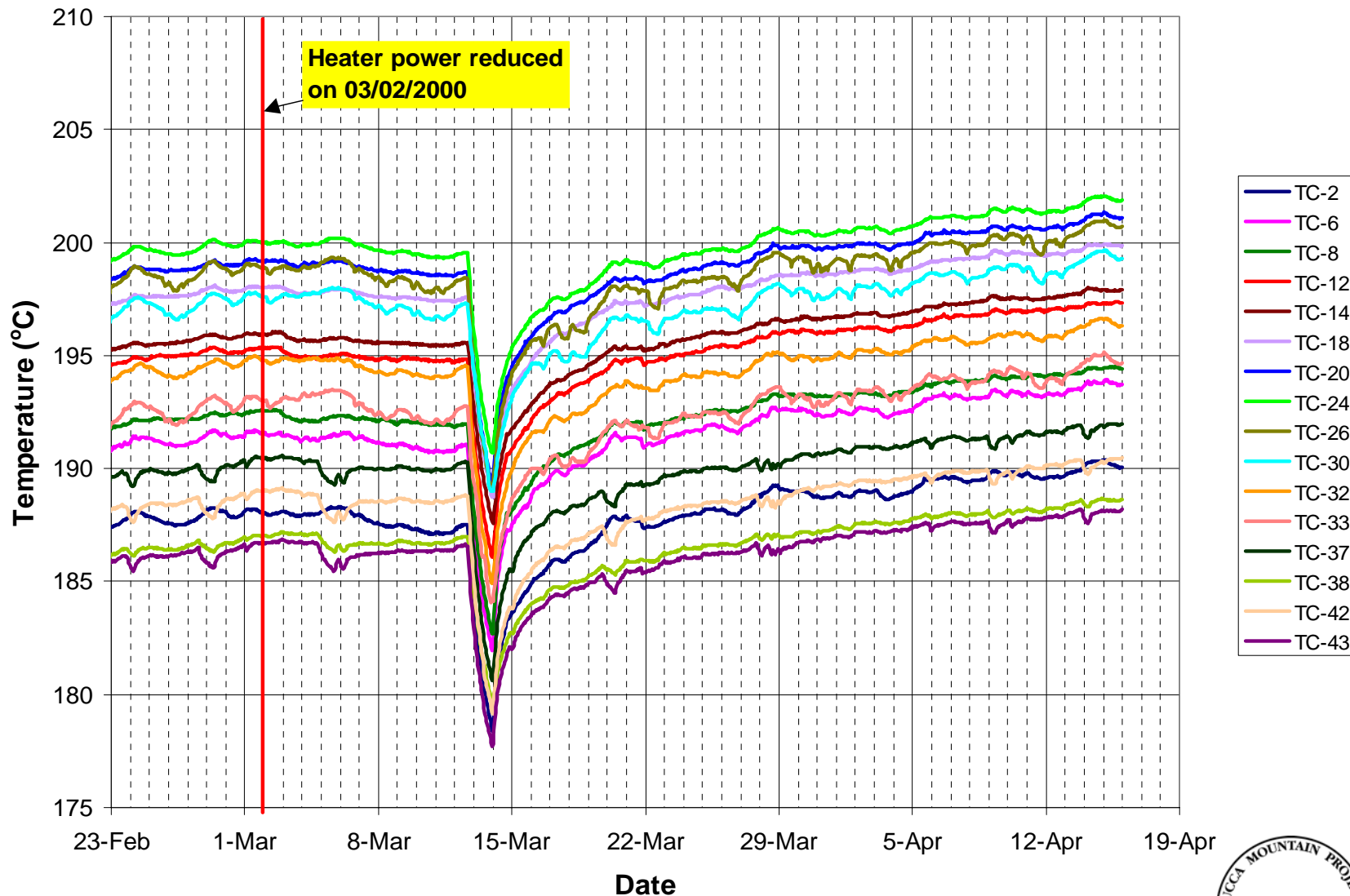




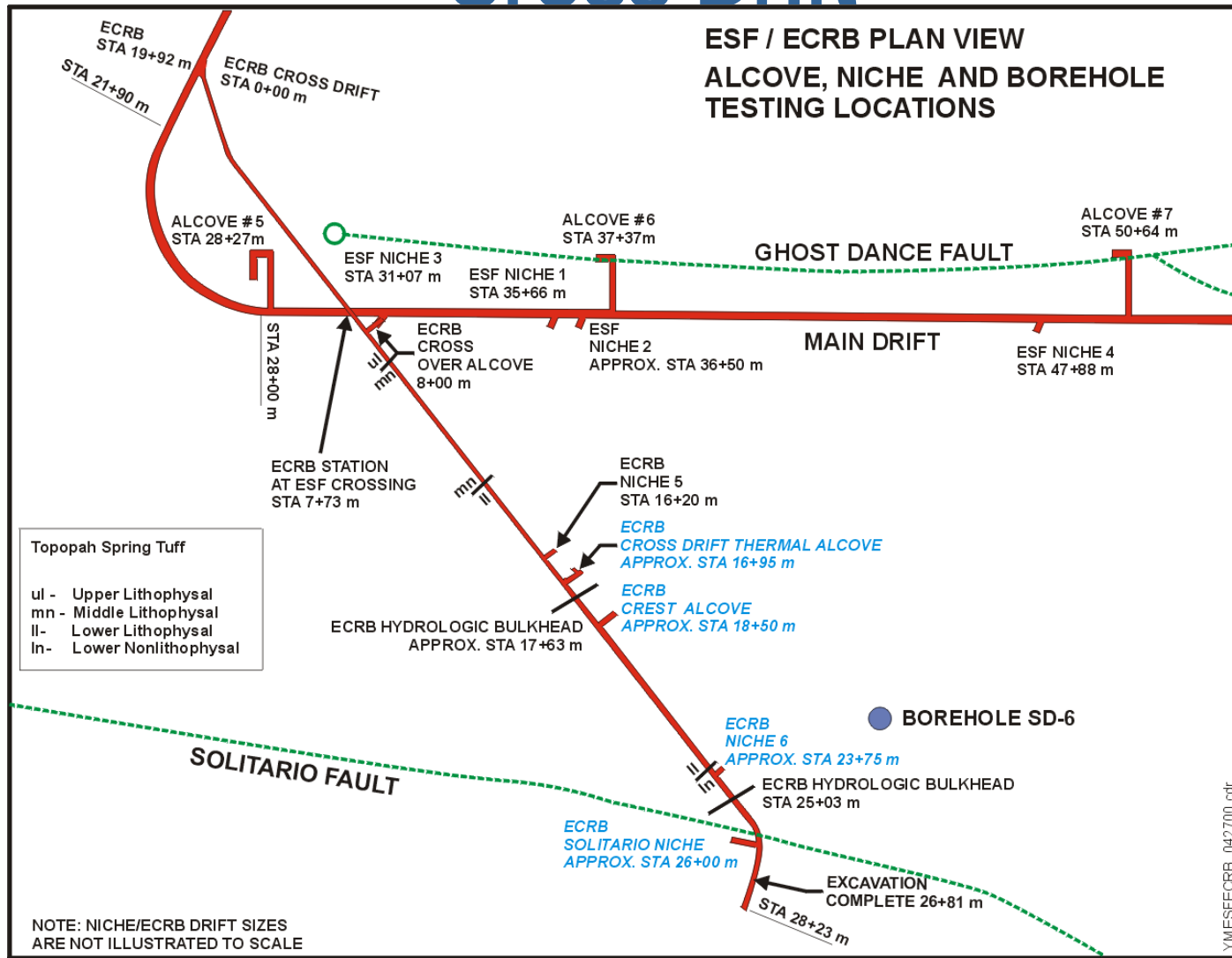
# Maximum Drift Wall Temperature and Heater Power

- One of the goals of the DST is not to exceed 200°C at the drift wall temperature and maintain it for duration of heating phase
- To meet this goal, the power outputs of both the wing heaters and floor heaters were adjusted downward to approximately 95% of output
- The effect of this adjustment on the temperature is being monitored closely

# Drift Wall Temperature: Right Rib



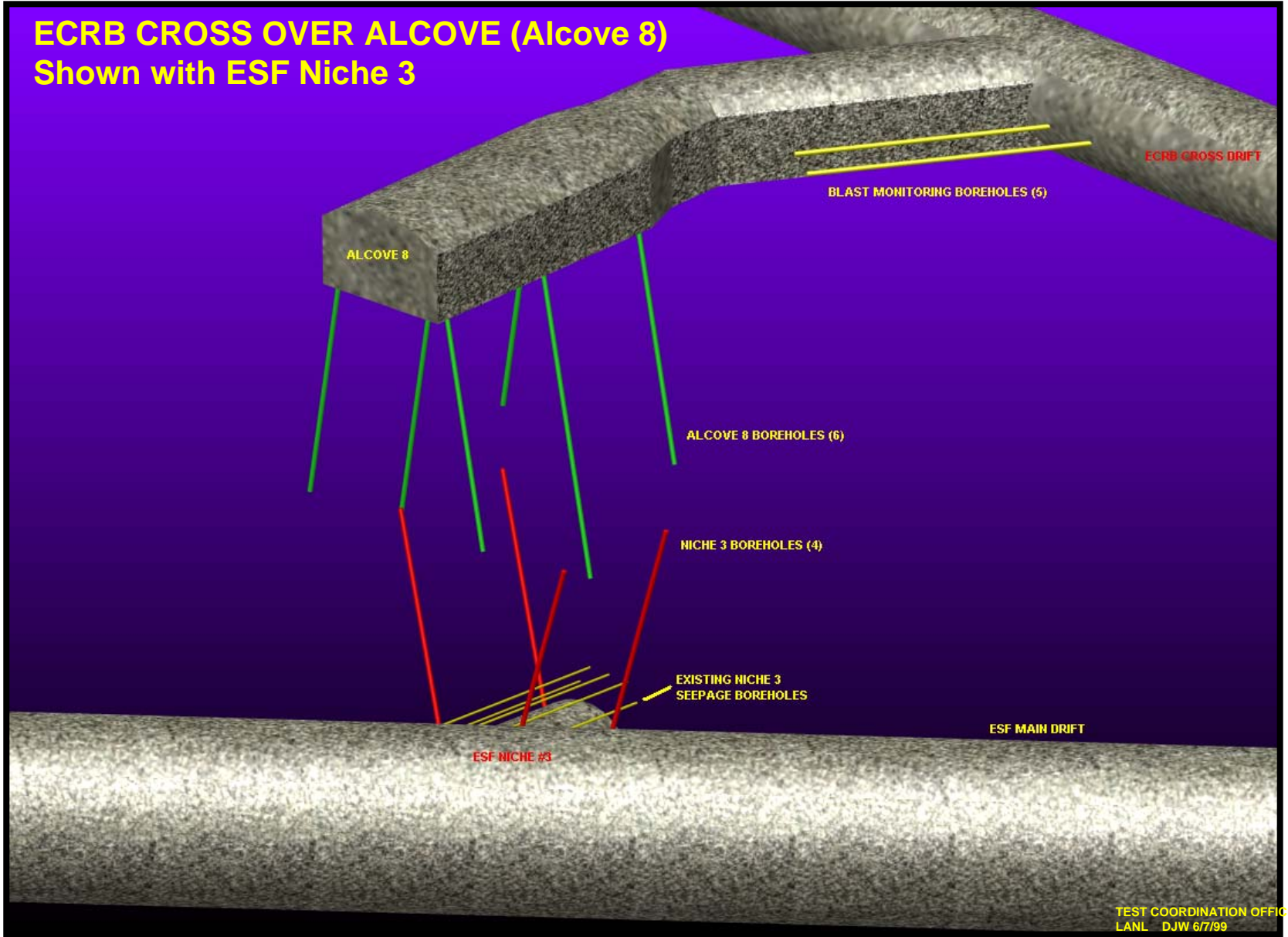
# Exploratory Studies Facility and Cross Drift



# Cross Drift Studies

- **Alcove 8 (Crossover Alcove)(Station 8+00 meters)**
  - Evaluate flow and seepage processes in potential repository horizon rocks at scale of tens of meters
  - Supports UZ Seepage and Transport models
  - Status
    - ◆ Drilling of boreholes up from ESF Niche 3 complete
    - ◆ Excavation by mechanical miner complete
    - ◆ Drilling of boreholes down from Alcove 8 ongoing
    - ◆ Testing planned to begin in May, 2000

# ECRB CROSS OVER ALCOVE (Alcove 8) Shown with ESF Niche 3



TEST COORDINATION OFFICE  
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# Alcove 8/Niche 3

- **Water loss from Alcove 8 was detected in Niche 3**
  - The fracture sets responsible for the flow may have been identified and will be studied as part of the test
  - There is probably little adverse effect on the test from the the water loss during mining
- **A small fault (0.3 m offset) connects Alcove 8 and Niche 3 and will be studied in detail**
- **The scoping test designed to demonstrate water recoverability is set to start within 3 weeks and is located on the small fault**

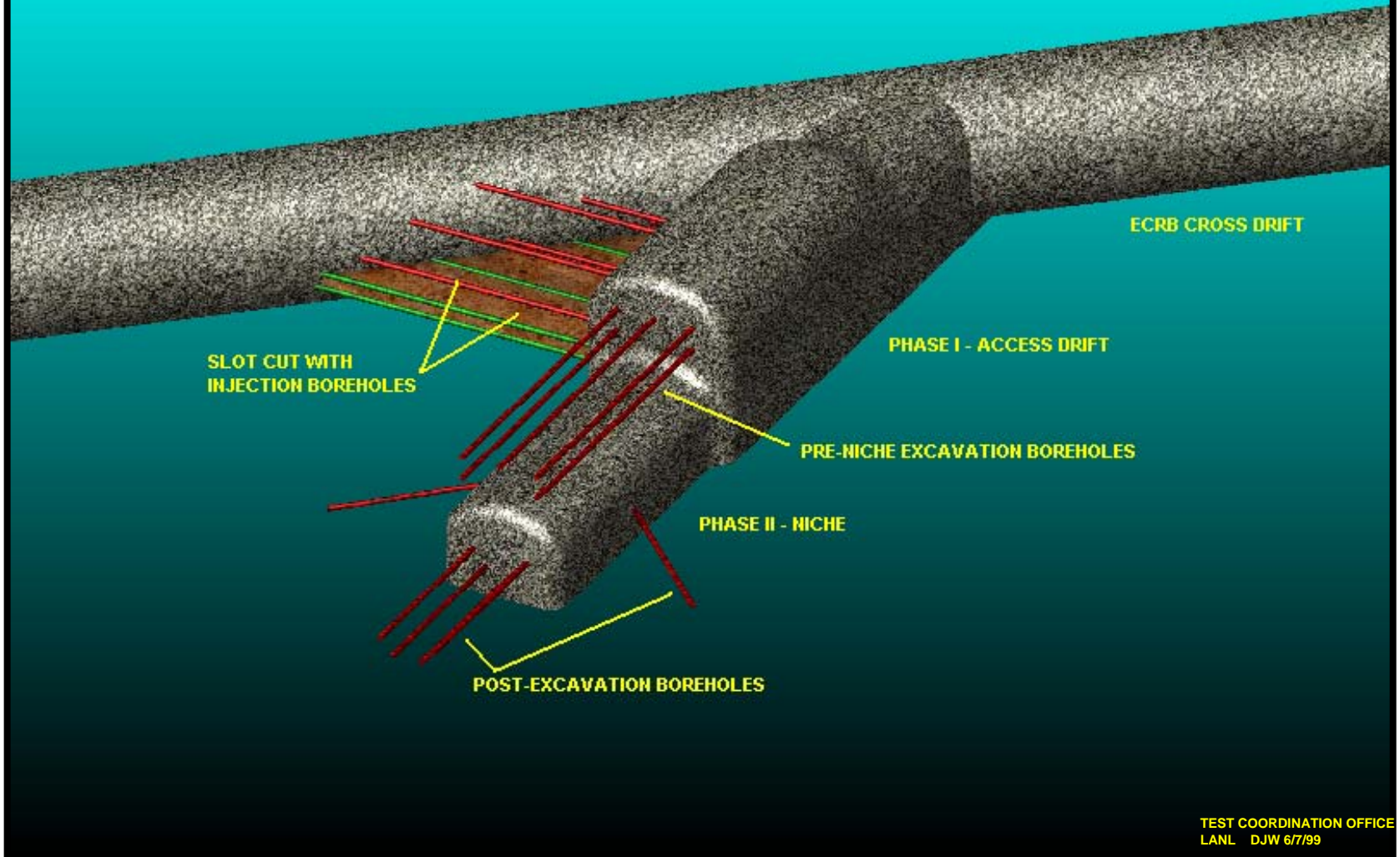
# Cross Drift Studies

(Continued)

- **Niche 5 (Station 16+20 meters)**

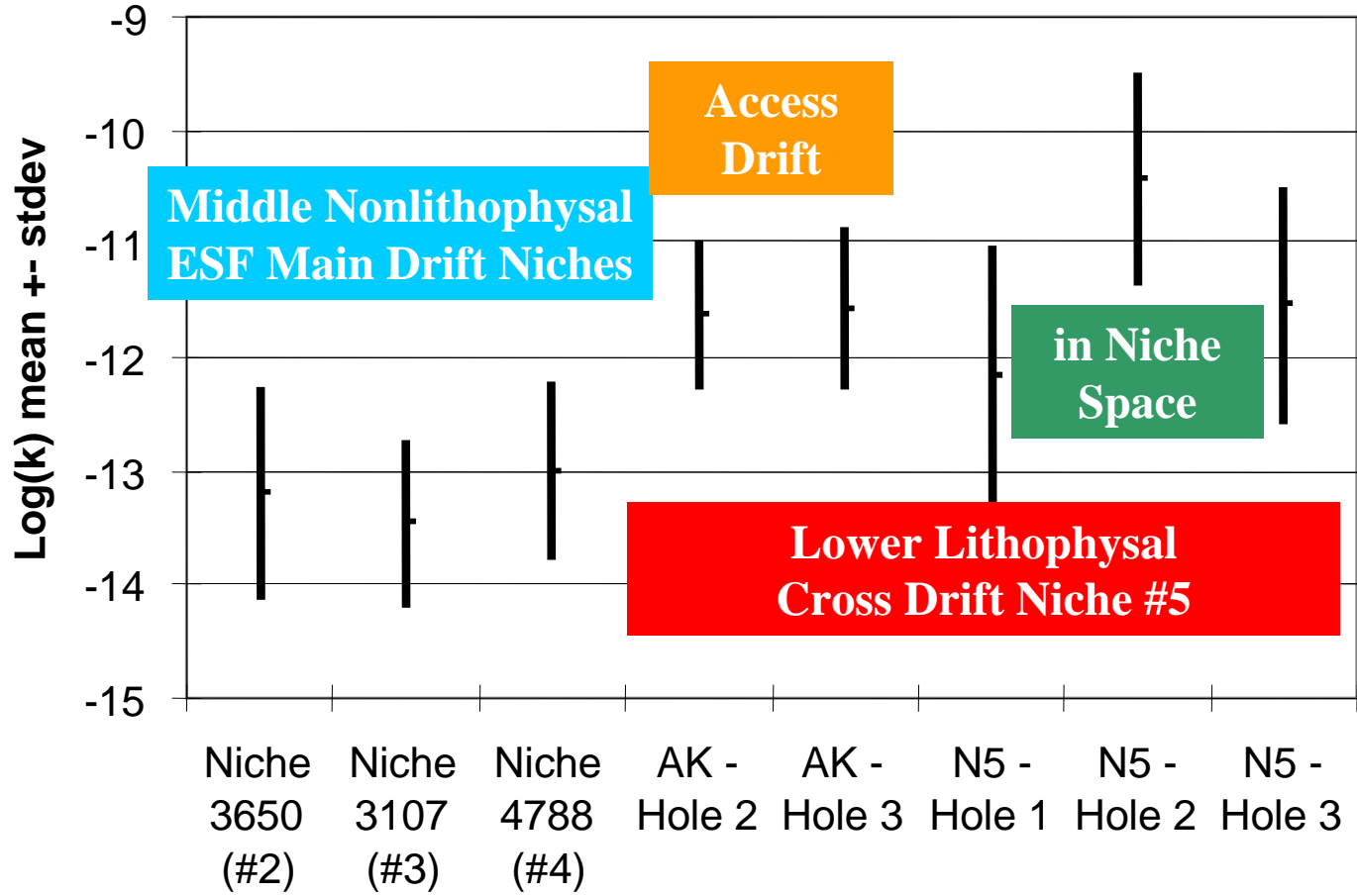
- Evaluate drift-scale seepage processes and seepage threshold in potential repository horizon rocks (Topopah Spring Lower Lithophysal Unit)
- Supports UZ seepage model
- Status
  - ◆ Mechanical excavation of Phase 1 complete
  - ◆ Pre-excavation air permeability borehole testing and Phase 1 air permeability and liquid release testing complete
  - ◆ Mechanical excavation of Phase 2 ongoing
  - ◆ Phase 2 testing planned to begin in June, 2000
  - ◆ Preliminary Results - Lower Lithophysal unit has 1.5 - 2.5 orders of magnitude higher and more heterogeneous permeability distributions than Middle Nonlithophysal unit at ESF Niches

# ECRB NICHE 5





# Lower Lithophysal Pre-Excavation Air-Permeability - Cross Drift Niche #5

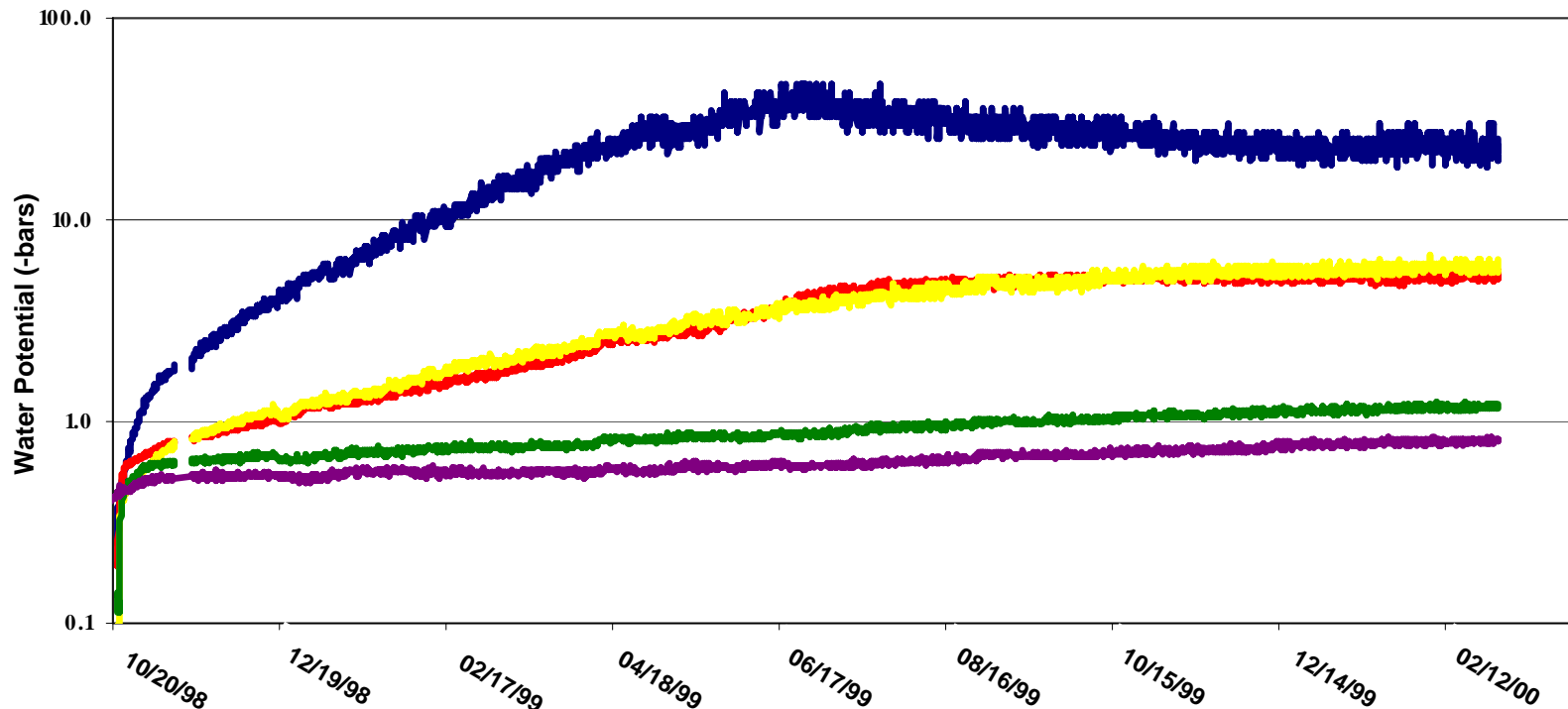


# Cross Drift Bulkhead Investigations

- Evaluate flow and seepage processes in potential repository horizon rocks and Solitario Canyon Fault Zone
- Supports UZ seepage and flow models
- Shallowest depth measured (30 cm) is still wetting up
- Deepest depth measured (2 m) is still drying out (source of water for the 30 cm probe)
- First 1 m of rock may be too dry for seeps to occur
- Condensation seen in the Cross Drift behind the bulkheads has not been detected within the rock
- Third bulkhead and rewiring of lights planned for June, 2000 to minimize test interference to extent practical

# Cross Drift Water Potential Data

XHDP21 - ECRB 23+50



— 23+50 (30 cm) — 23+50 (80 cm) — 23+50 (110 cm) — 23+50 (160 cm) — 23+50 (200 cm)

# Cross Drift Bulkhead Investigations

(Continued)

- **Organic Material**

- **Several species of fungi have been identified in the Cross Drift, particularly near the second bulkhead**
- **Fungi tends to occur on conveyor belt and rail ties**
- **Further characterization of organic material and evaluation of implications for engineered barrier and waste package performance are ongoing**

# Cross Drift Studies

(Continued)

## Seepage/Drainage Benches

- **Characterize fracture properties for evaluation of seepage, seepage threshold flux, and drift drainage**
- **Supports EBS Drift Drainage and UZ Seepage and Flow models**
- **Spatially correlate fracture properties to other measured drift geologic and hydrologic properties (e.g., fracture density, air permeability, and water content) at several locations within Cross Drift**

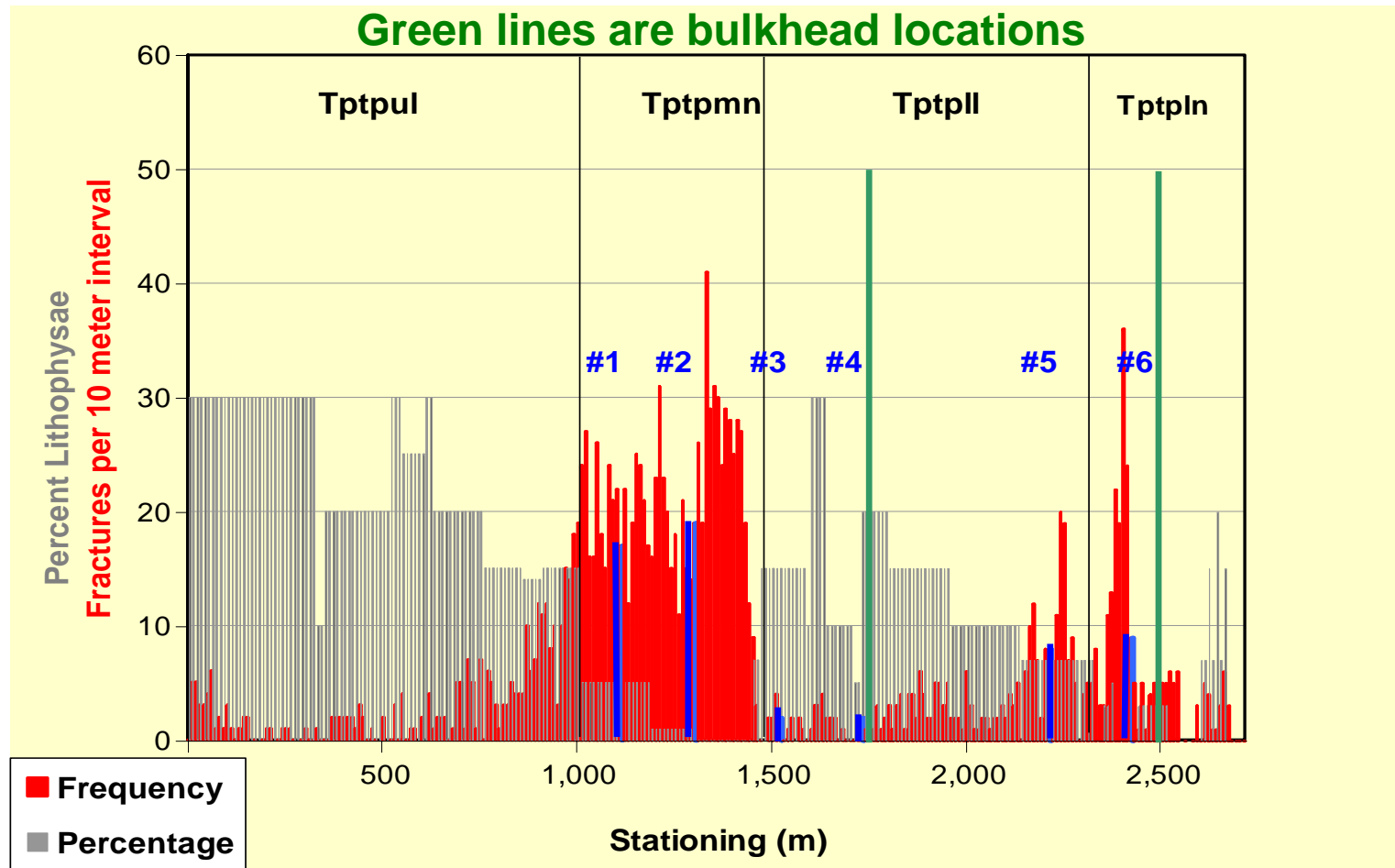
# Seepage / Drainage Benches

(Continued)

## ECRB Fracture Frequency and Lithophysae Percentage

Blue numbers and lines refer to bench locations

Green lines are bulkhead locations



# Seepage/Drainage Benches

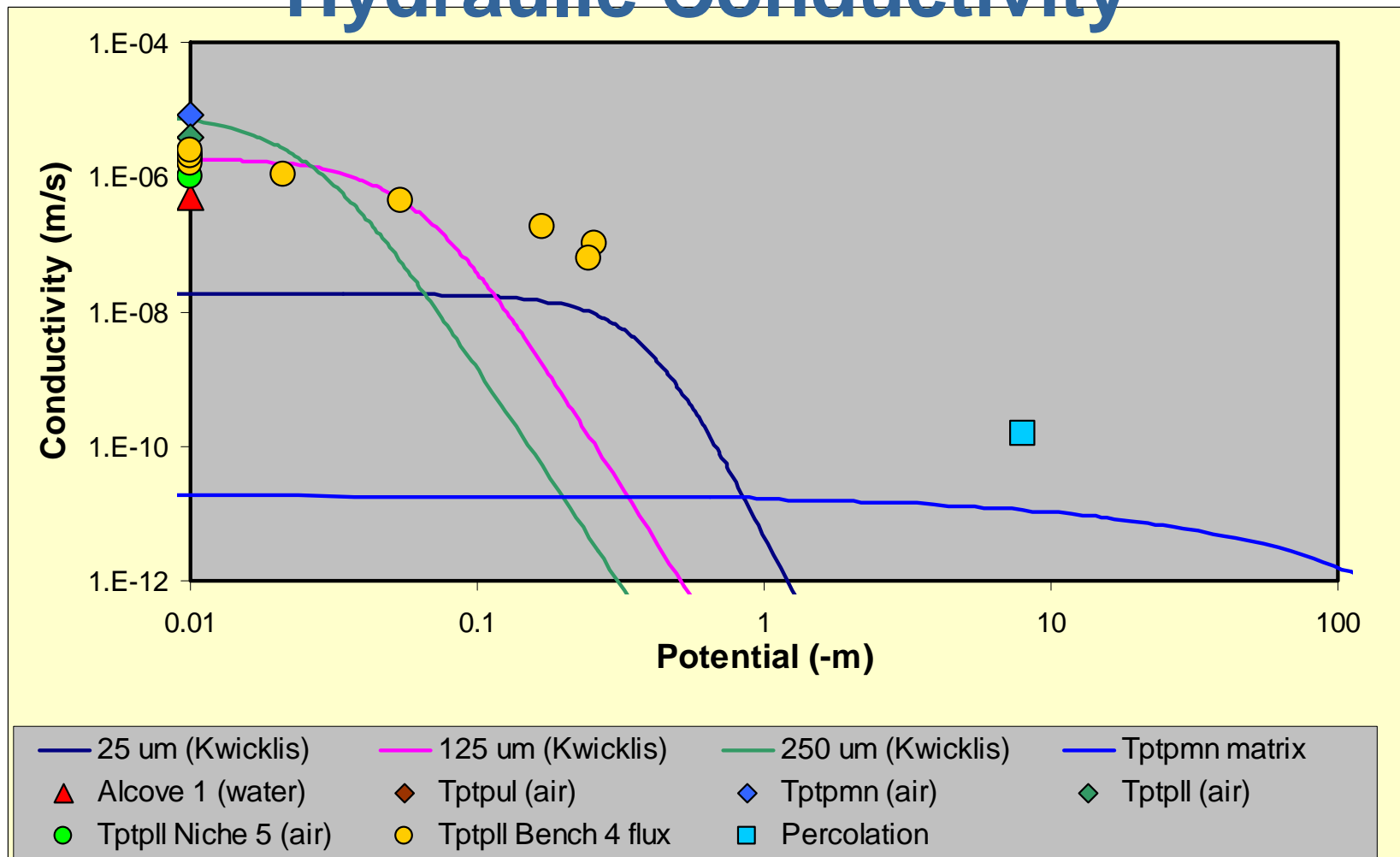
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# Seepage/Drainage Benches

(Continued)

## Hydraulic Conductivity





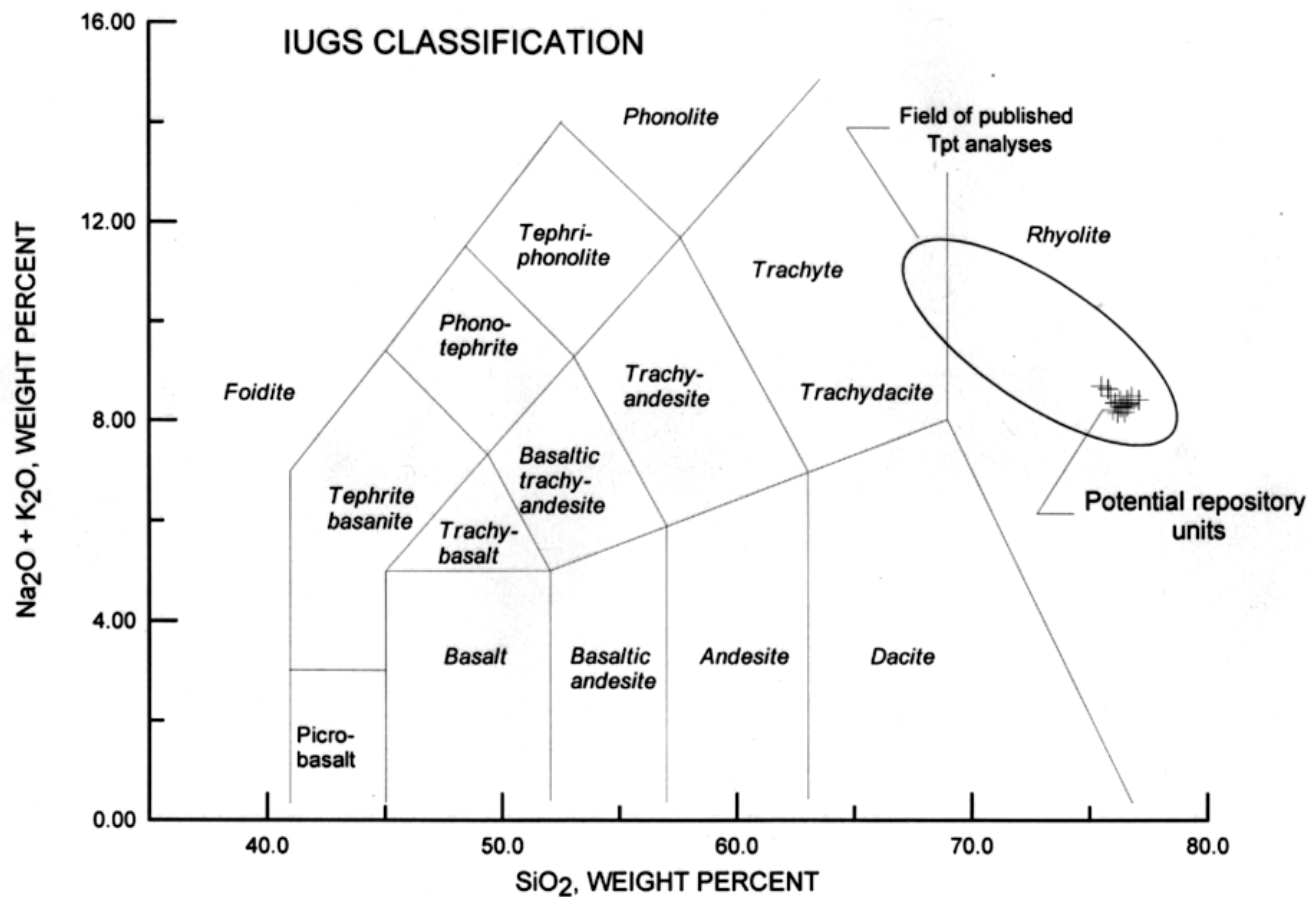
# Cross Drift Studies

(Continued)

## Topopah Spring Rock Chemistry

- **20 core samples from the Cross Drift analyzed by USGS representing Topopah Spring Upper Lithophysal, Middle Nonlithophysal, Lower Lithophysal, and Lower Nonlithophysal Zones (Sta. 10+00 to 25+00)**
- **Input required by Waste Package Design for use in external criticality calculations**
- **Uniform chemistry across subunits**

# Compositionally Uniform High-Silica Rhyolite Constitutes the Potential Repository Horizon



# What Have We Learned in the Cross Drift - Geology?

- **Faults encountered were of the type, size, and offset anticipated by the Predictive Report. A small number of minor faults were encountered (as expected)**
- **The characteristics of predicted faults such as the Sundance and Solitario Canyon faults were nearly identical to what was presented in the Predictive Report**
- **An unanticipated fault with approximately 5 m of normal offset was encountered near station 22+38. The fault may have been obscured by alluvium at the surface**

# What Have We Learned in the Cross Drift - Geology?

(Continued)

- **The Solitario Canyon Fault (SCF) was encountered within a few meters of the predicted location. Orientation of the structure and offset along the fault were essentially identical to predictions**
- **The SCF had only minor physical evidence of water percolation along the fault zone, and no significant secondary mineralization. Some minor iron oxides in the matrix of fault zone breccias were the only alteration observed**
- **Faults across the potential repository block exhibited no significant accumulations of secondary silica or calcite**

# What Have We Learned in the Cross Drift - Geology?

(Continued)

- The footwall of the SCF was more fractured than anticipated from preconstruction investigations. This extended footwall zone was probably due to the presence of a small splay of the SCF intersecting the main splay just north of the Cross Drift alignment
- There is not much deformation within the rock mass between major block-bounding faults

# What Have We Learned in the Cross Drift - Geology?

(Continued)

- **Significant gain in understanding of the nature, abundance, and orientation of small fractures present in the middle nonlithophysal, lower lithophysal, and lower nonlithophysal zones in the potential repository block**
- **Fractures in the lower nonlithophysal zone are not unlike those in the middle nonlithophysal zone**
- **The dip of the lithostratigraphic units has been well constrained between the Ghost Dance fault and the SCF. Preconstruction estimates of the locations and types of contacts were accurate, with the exception of the top of the lower lithophysal zone**

# What Have We Learned in the Cross Drift - Geology?

(Continued)

- **The Cross Drift provided our first good look at the lower lithophysal zone, which makes up the majority of the potential repository (>70%)**
- **To date, the lower lithophysal zone has been treated as homogeneous with respect to fracturing. We now know that fracturing becomes like that of the lower nonlithophysal unit above the lower contact**
- **The intensely fractured zone (IFZ) does not apparently extend to the northwest. The zone was not observed in the Cross Drift or in Solitario Canyon**

# What Have We Learned in the Cross Drift - Hydrology and Geochemistry?

- **Systematic sampling of chloride data is important in constraining infiltration/percolation flux estimates within the potential repository block**
- **The Cross Drift provides access for systematic and feature-based sampling of Cl and  $^{36}\text{Cl}$  and fracture mineral investigations within the potential repository block**
- **To date, no active seeps or drips from the rock have been observed in the Cross Drift excavation**



# What Have We Learned in the Cross Drift - Hydrology and Geochemistry?

(Continued)

- **Water potential data have been collected from boreholes drilled in the Cross Drift. Water potentials are higher than previously believed. These data have an important bearing on UZ flow-modeling efforts**
- **Preliminary air permeability measurements in the lower lithophysal unit show higher values than seen in the middle nonlithophysal unit as exposed in the ESF. These data have an important bearing on seepage and drainage**

# What Will We Learn in the Cross Drift - Hydrology and Geochemistry?

- **The Cross Drift will allow for in situ hydrologic and thermal testing in the lower lithophysal unit**

# Summary

- **Ongoing testing in ESF and Cross Drift continues to address key processes in unsaturated zone**
- **Data and analyses are being utilized in support of process models, performance assessment, and design for Site Recommendation**

# Backup



# Composition of Rocks that Constitute the Potential Repository Horizon

Weight Percent		
	Mean	Stdev
<b>SiO<sub>2</sub></b>	76.29	0.366
<b>Al<sub>2</sub>O<sub>3</sub></b>	12.55	0.147
<b>FeO</b>	0.14	0.050
<b>Fe<sub>2</sub>O<sub>3</sub></b>	0.97	0.076
<b>MgO</b>	0.13	0.021
<b>CaO</b>	0.50	0.027
<b>Na<sub>2</sub>O</b>	3.52	0.109
<b>K<sub>2</sub>O</b>	4.83	0.063
<b>TiO<sub>2</sub></b>	0.11	0.004
<b>P<sub>2</sub>O<sub>5</sub></b>	<.05	---
<b>MnO</b>	0.07	0.008
<b>Cl</b>	0.02	0.004
<b>F</b>	0.04	0.008
<b>S</b>	<.05	---
<b>CO<sub>2</sub></b>	0.01	0.003
<b>H<sub>2</sub>O-</b>	0.24	0.081
<b>H<sub>2</sub>O+</b>	0.40	0.113
<b>SUM</b>	<b>99.79</b>	

Parts Per Million		
	Mean	Stdev
<b>Rb</b>	188	5.3
<b>Sr</b>	25	3.4
<b>Y</b>	32	2.9
<b>Zr</b>	116	3.8
<b>Nb</b>	25	1.1
<b>Ba</b>	55	6.8
<b>La</b>	51	5.5
<b>Ce</b>	84	5.1