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

Scientific and Engineering Testing Update

Presented to:
Nuclear Waste Technical Review Board

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YUCCA MOUNTAIN PROJECT

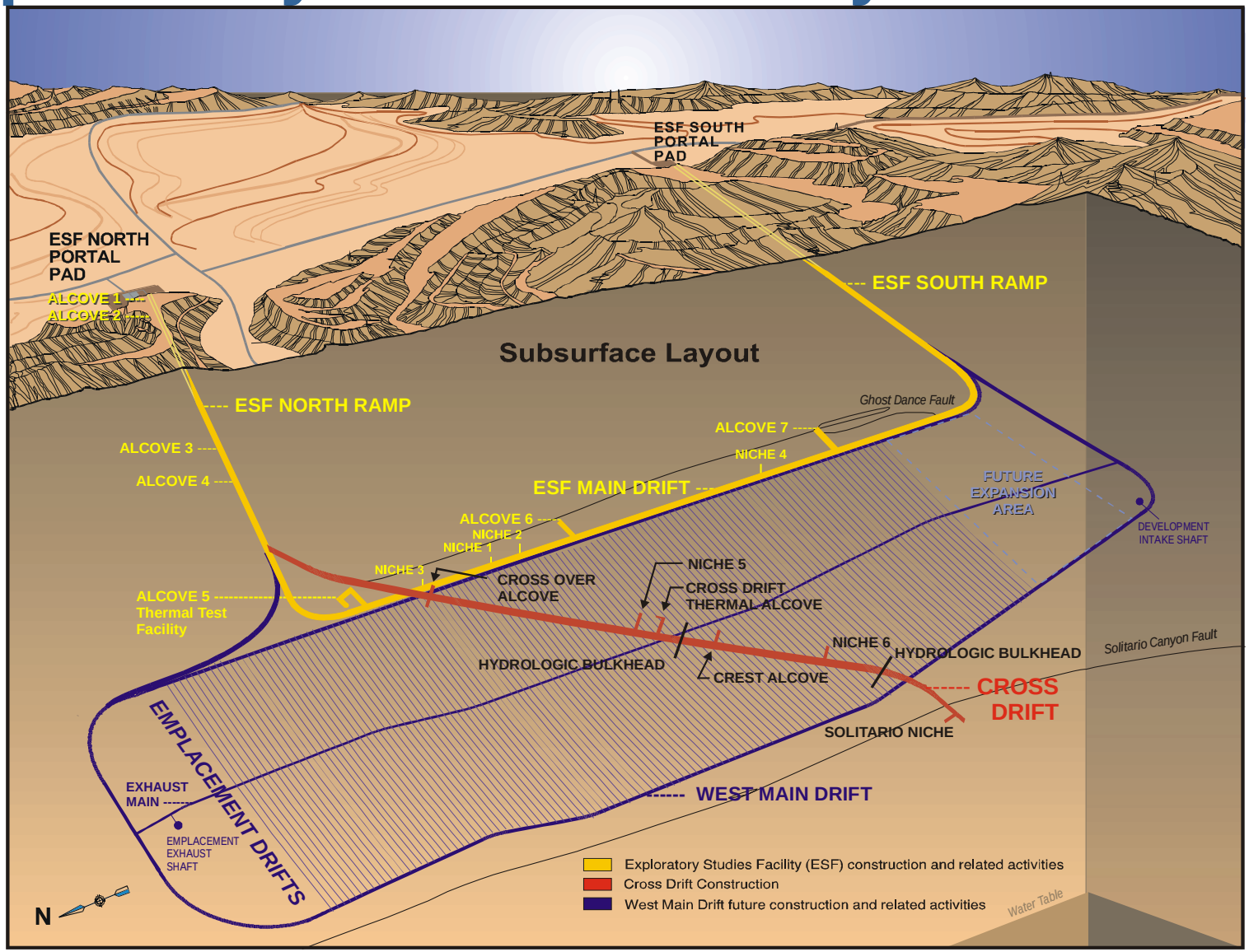
Overview

- **Objective is to provide status on scientific and engineering testing program in support of natural and engineered systems process models and design**
- **Exploratory Studies Facility (ESF) Studies**
  - **Drift Scale Test**
  - **^{36}Cl Validation**
- **Cross Drift Studies**
  - **Niche 5**
  - **Systematic Hydrologic Characterization**
  - **Bulkhead Investigations**

Overview
(Continued)

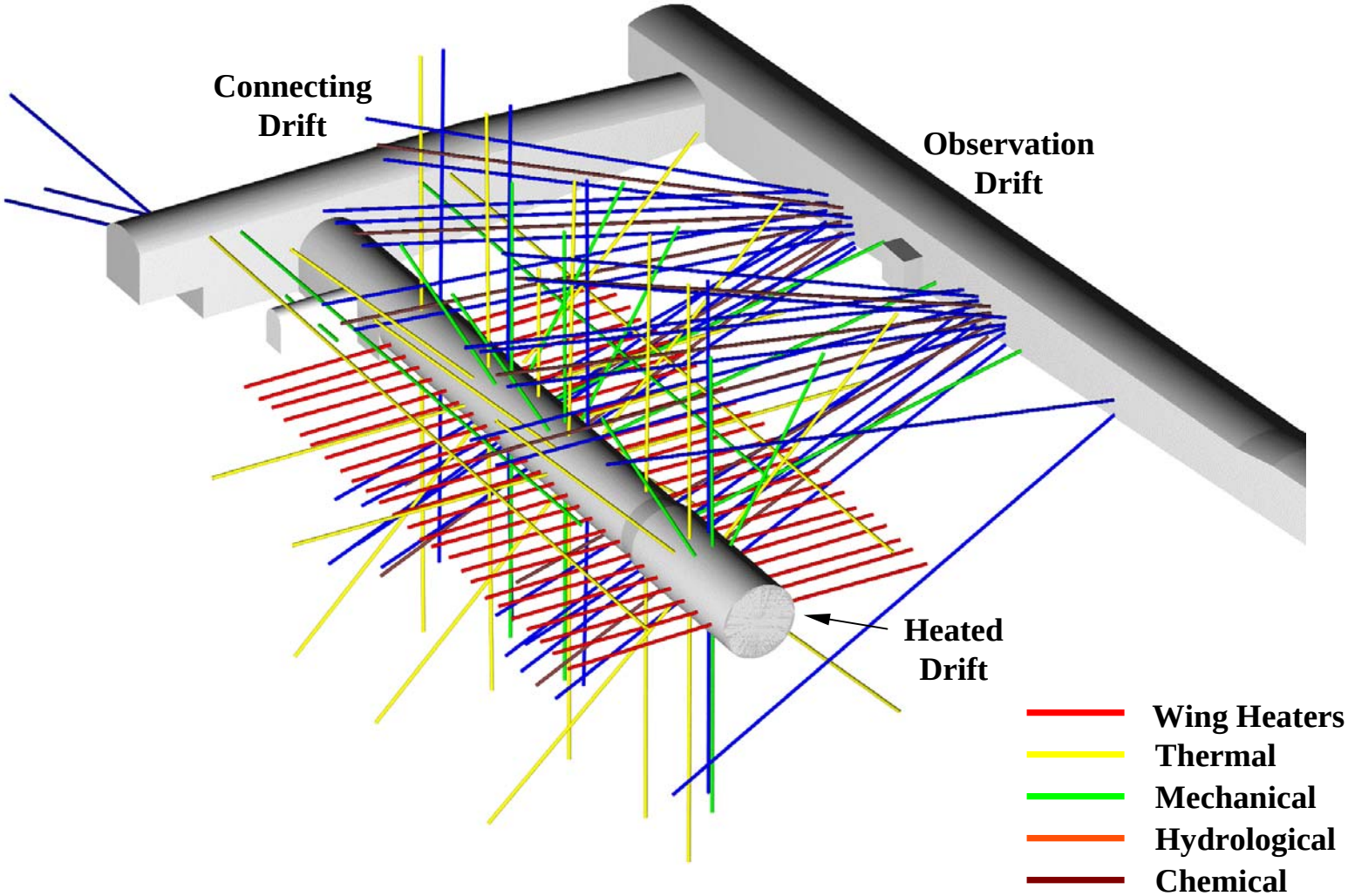
- Busted Butte Unsaturated Zone Transport Test
- Saturated Zone Investigations
  - Alluvial Testing Complex
- Engineered Barrier System Studies
  - Pilot-Scale Testing
  - Ventilation Testing
  - Waste Package Materials Testing
- Summary

Exploratory Studies Facility and Alcoves

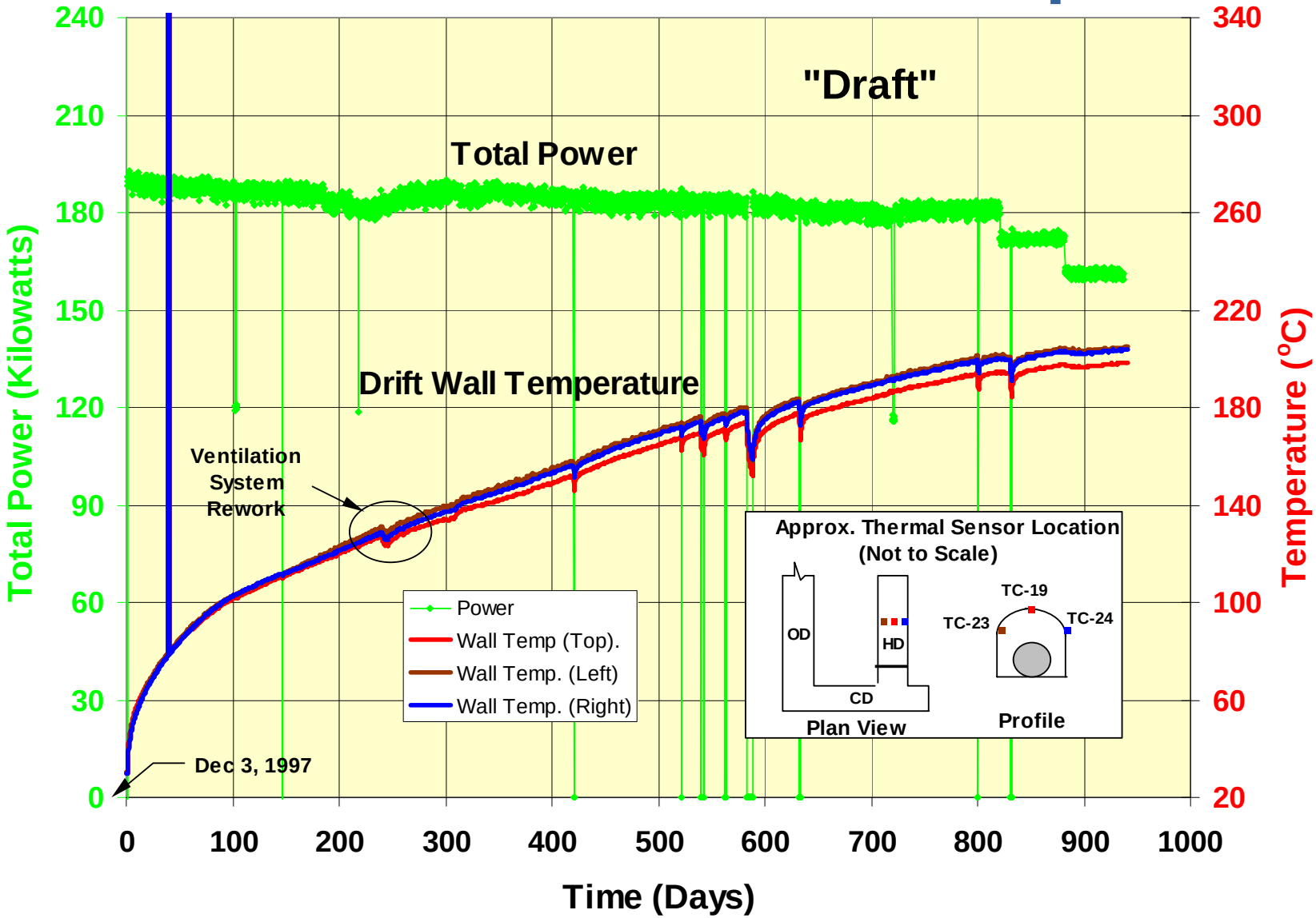


Drift Scale Test (DST)

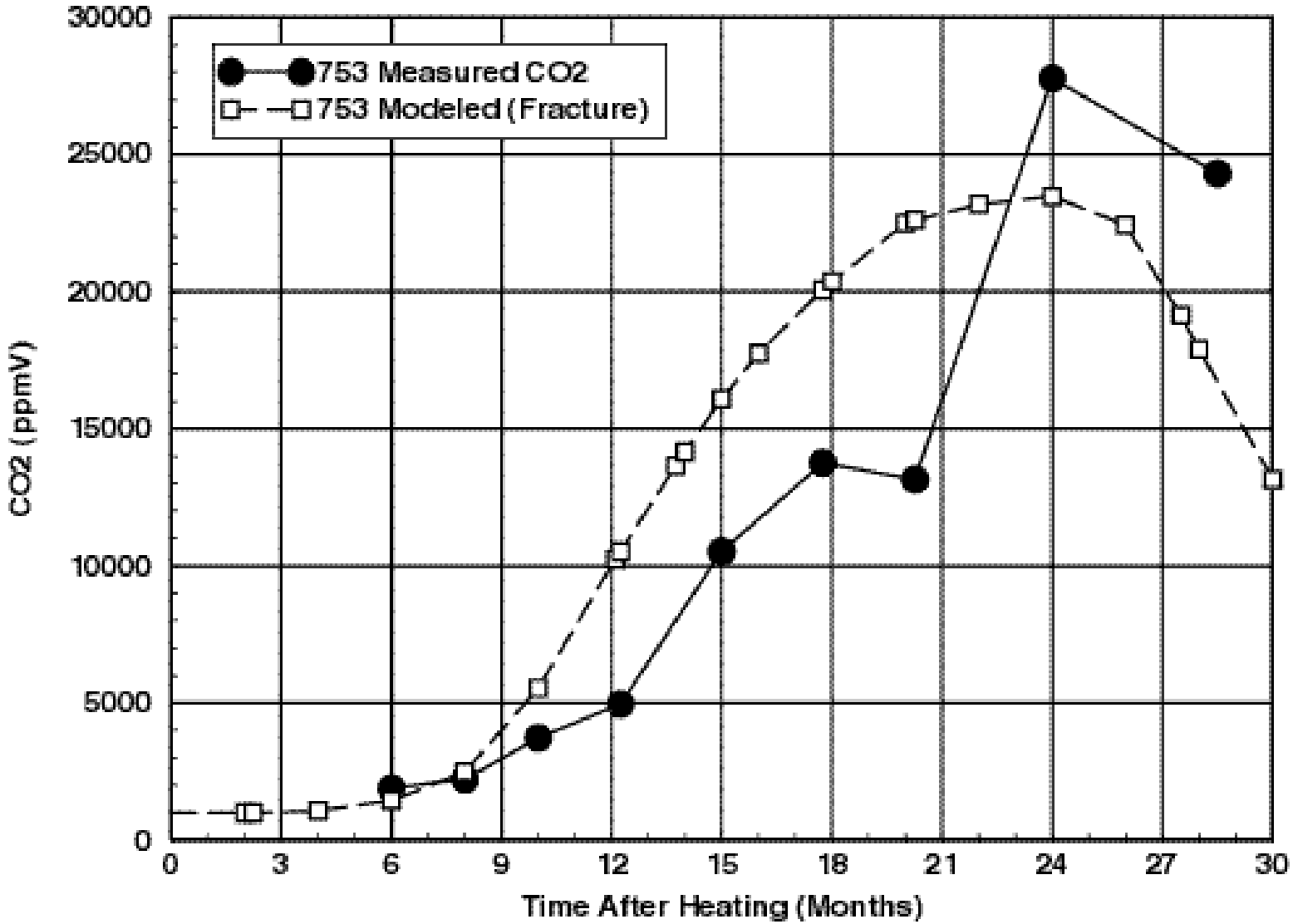
Evaluate thermally-coupled processes in potential repository horizon rocks at the field-scale in support of Coupled Process Models, Near-Field Environment Models, and Design



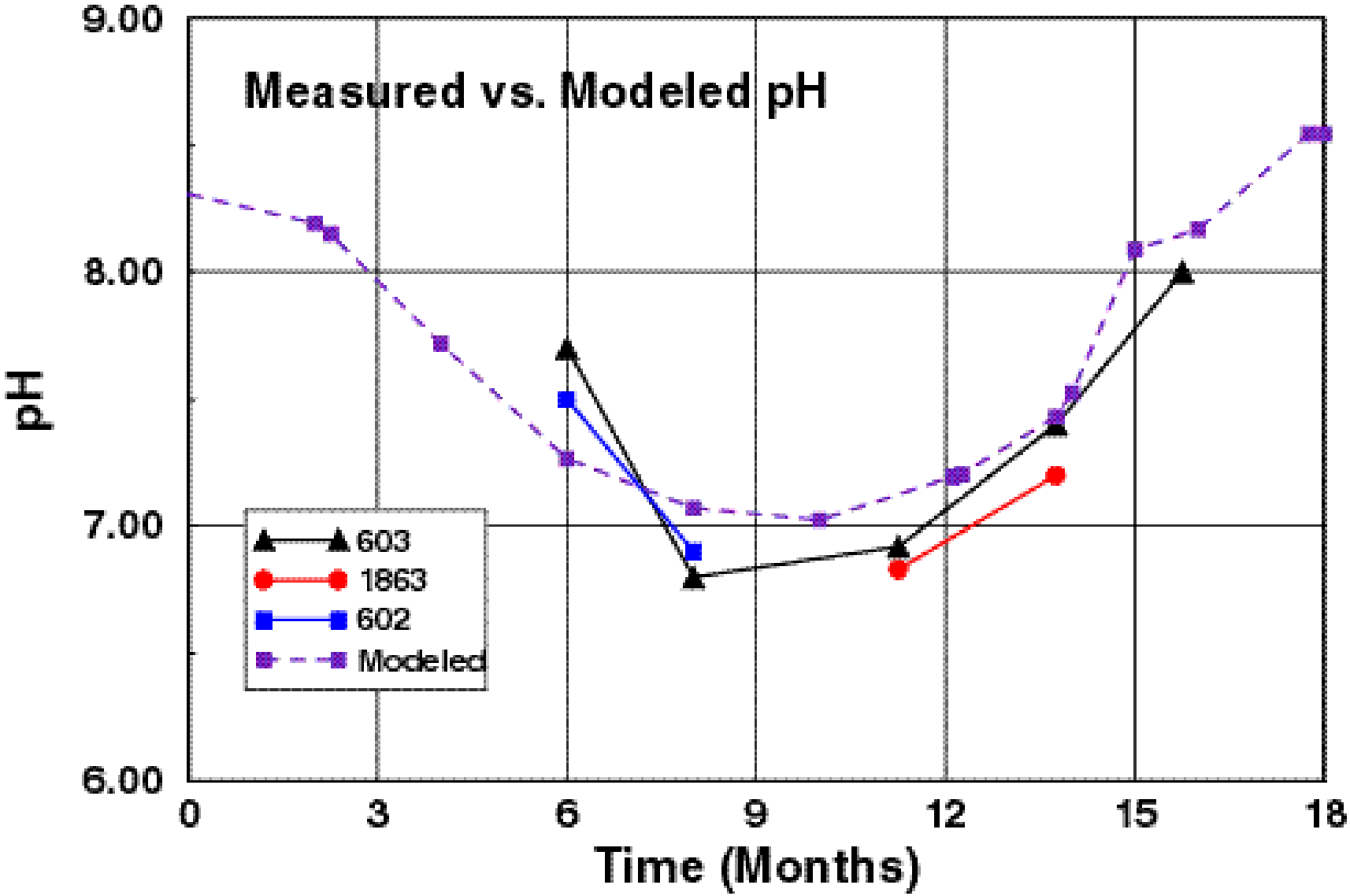
DST Measured Power and Temperature



DST Gas Chemistry Evolution



DST Water Chemistry Evolution



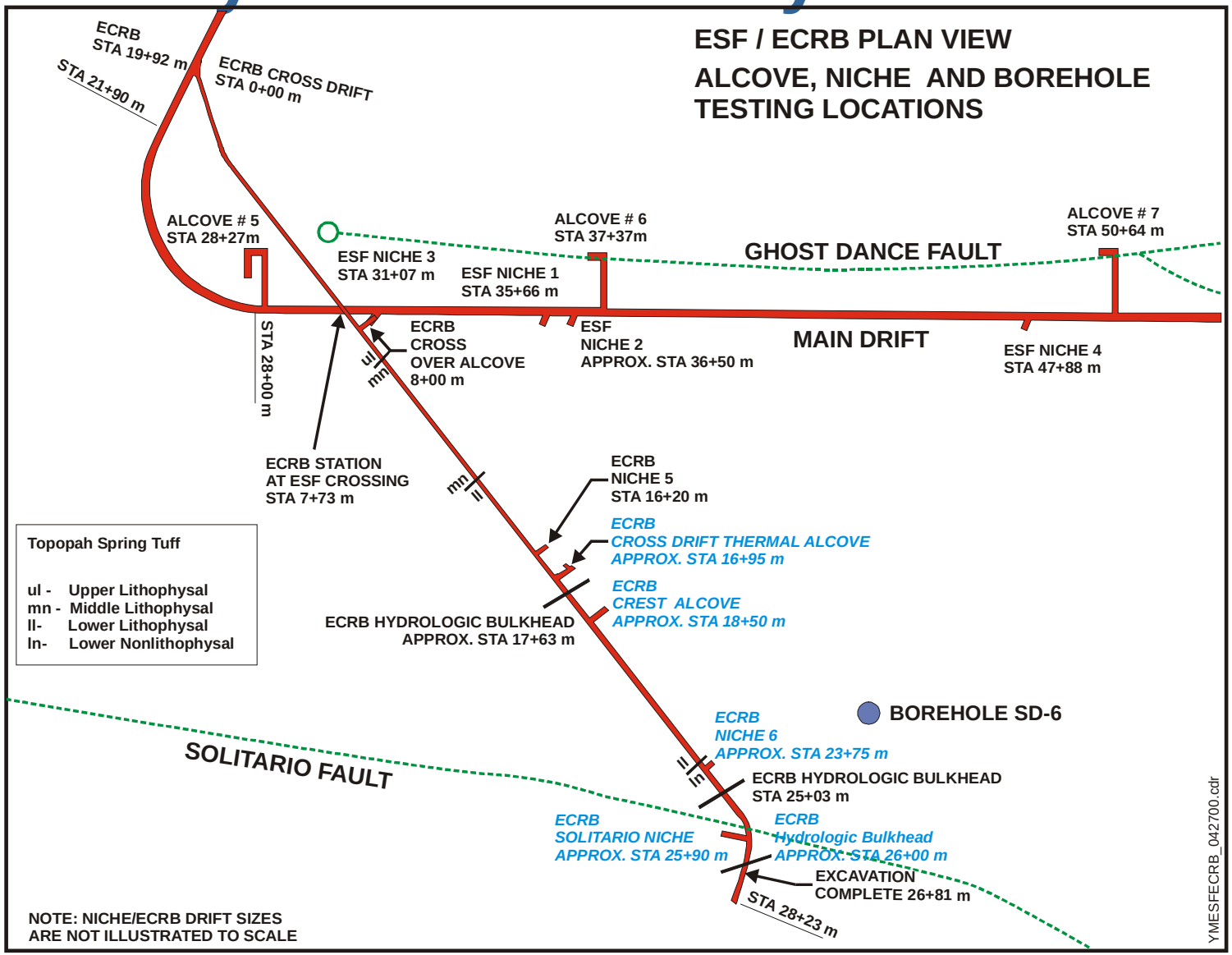
^{36}Cl Validation

- **Validate occurrence of "bomb-pulse" ^{36}Cl at two locations in the ESF (Sundance Fault Zone and Drillhole Wash Fault Zone) in support of UZ Flow Model**
- **Path Forward**
  - **Prepare reference sample for interlaboratory comparisons -- USGS has prepared and distributed aliquots to LLNL and LANL**
  - **LLNL and LANL document how they plan to test for the effect of different leaching procedures on the release of rock Cl (ongoing)**
  - **Laboratory work and comparison of results (ongoing)**

^{36}Cl Validation
(Continued)

- **Path Forward (cont.)**
  - **Team agrees on a standard processing method to apply to the reference sample and validation samples**
  - **USGS conducts tritium analyses of water extracted from validation samples -- to date, 38 analyses have been completed from the Sundance Fault zone and only one analysis exceeds the detection limit**
  - **Team synthesizes results and prepares report**

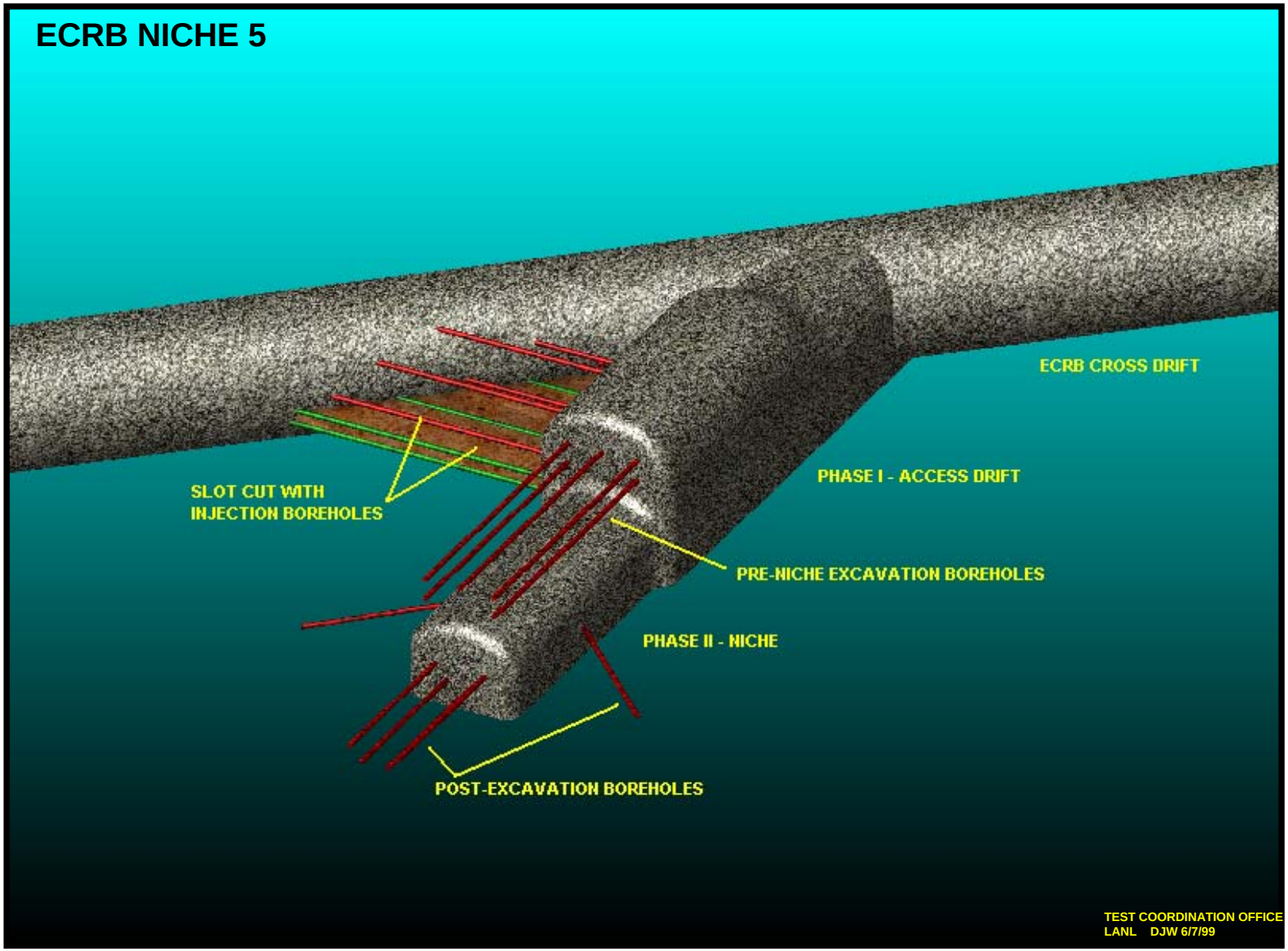
Exploratory Studies Facility and Cross Drift



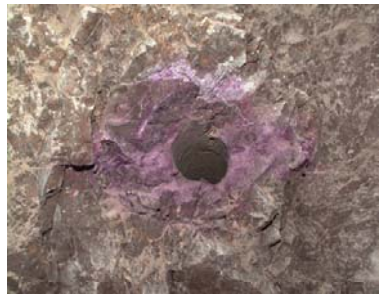
Cross Drift Studies
Niche 5

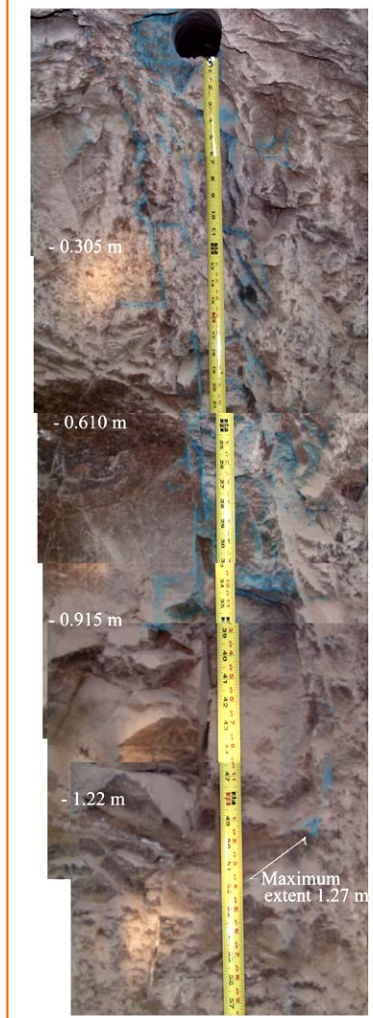
- **Evaluate drift-scale seepage processes and seepage threshold in potential repository horizon rocks (Topopah Spring Lower Lithophysal Unit) in support of UZ Seepage Model**
- **Niche Excavation and Flow Path Characterization Completed**
- **Post-excavation Air Permeability Tests in Progress**
- **Niche Bulkhead Installed for Seepage Threshold Tests under Ambient Humidity Conditions**

ECRB NICHE 5


ECRB CROSS DRIFT
PHASE I - ACCESS DRIFT
SLOT CUT WITH
INJECTION BOREHOLES
PRE-NICHE EXCAVATION BOREHOLES
PHASE II - NICHE
POST-EXCAVATION BOREHOLES
TEST COORDINATION OFFICE
LANL DJW 6/7/99

Comparison of Lower Lithophysal and Middle Nonlithophysal Flow Paths





Lower lithophysal tuff may have:

- **Stronger capillarity**
  (from liquid flow paths observed)

- **Higher permeability**
  (from Niche 5 air injection tests reported on 5/1/00 and from Cross Drift systematic hydrologic characterization results)

Than middle nonlithophysal tuff

⇒ **Potentially Higher Seepage Threshold**

Water Entering a Lithophysal Cavity from Below by Capillary Suction

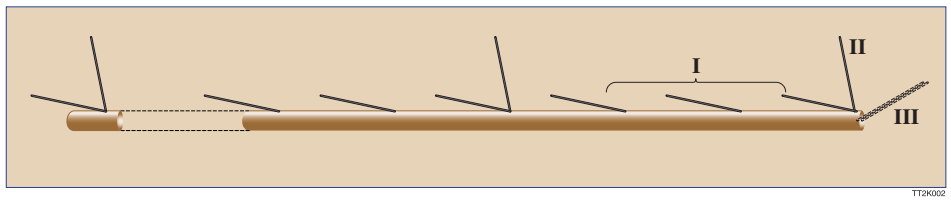
No evidence of dripping into cavities (isolated spots on ceiling and floor) was observed in other lithophysal cavity photos.

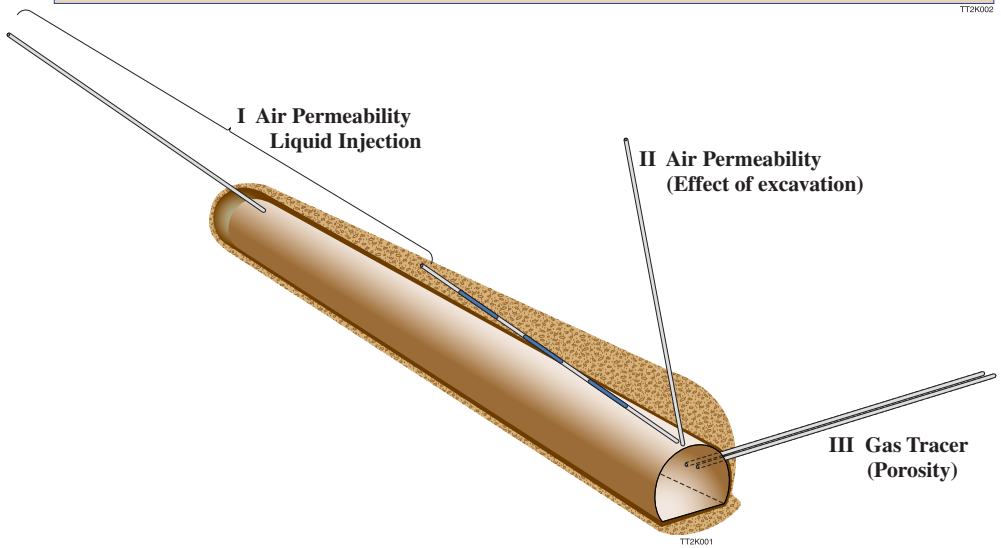
⇒ Possible alternative explanation of calcite observed at the bottom of lithophysal cavities.

Systematic Hydrologic Characterization - Rationale/Approach

- **Provide data on the scales of rock variability and heterogeneity in rock properties (e.g., fracture properties) in support of UZ Seepage Model**

- **Phase I of air permeability and seepage testing conducted systematically along the Cross Drift in Lower Lithophysal unit from CS 14+44 m to the first bulkhead at CS 17+63 m (one slant borehole or borehole cluster per 30 m of drift)**



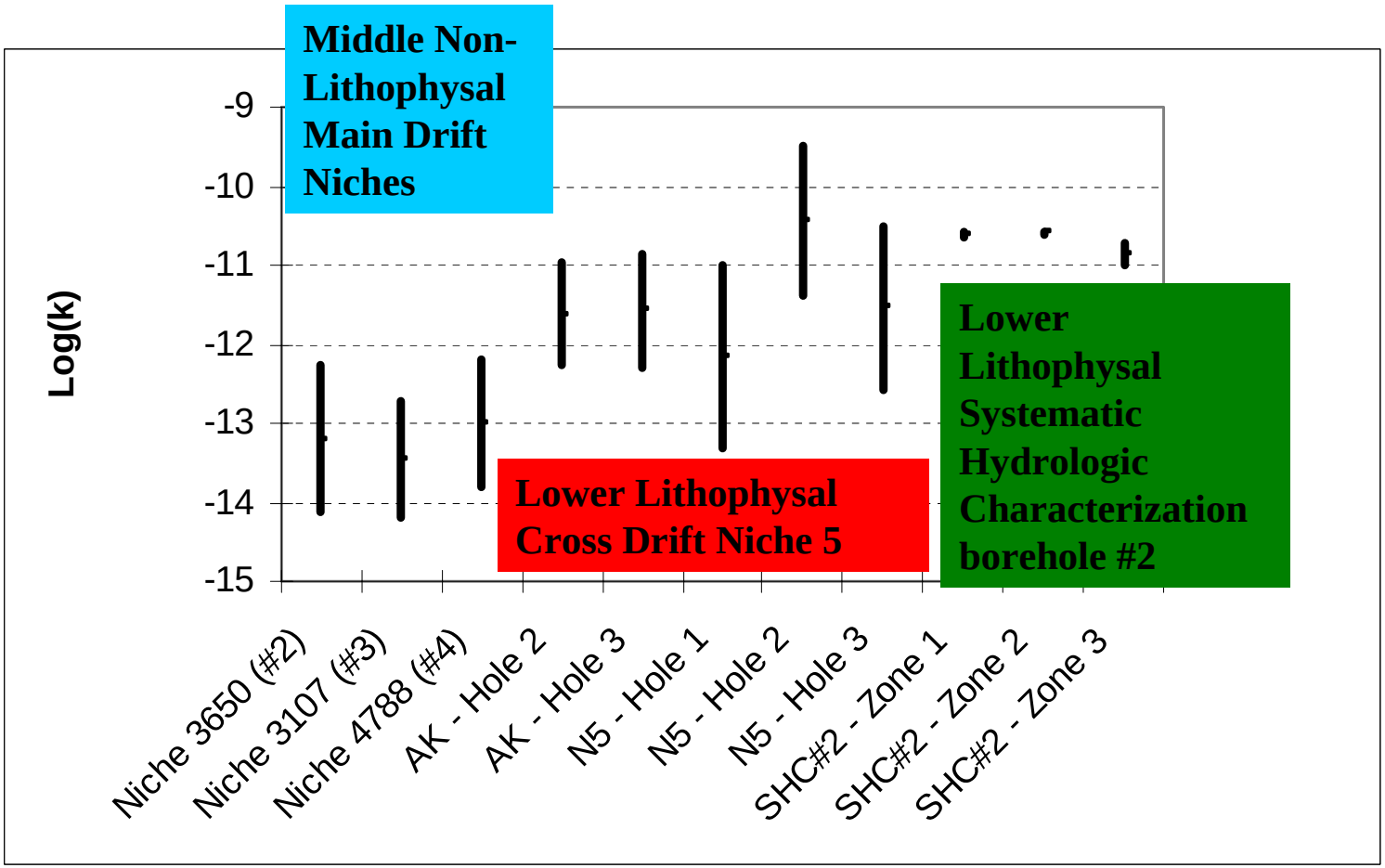


Systematic Hydrologic Characterization - Progress

- **Air permeability and liquid release tests were conducted along borehole ECRB-SYBT-La#2 at Cross Drift CS 17+26 m**
- **Vertical distance of mid-zone to drift crown for zones 1, 2, and 3 are respectively: 1.58, 2.84, and 4.10 m**
- **Seepage tests range from high rate (450 ml/min, point release, < 24 hour) to low rate (30 ml/min, line release, multiple-zone, multiple-week) tests**

Systematic Hydrologic Characterization Testing along Cross Drift

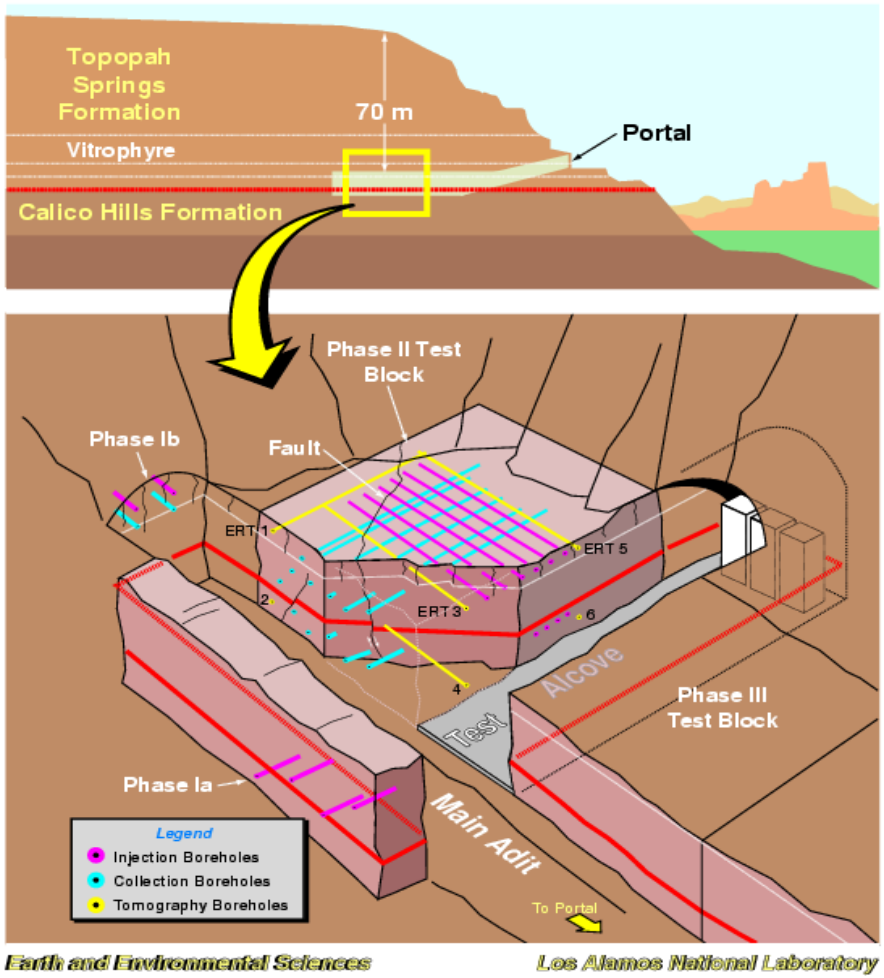
Air Permeability Distributions - Update with New Measurements by Systematic Hydrologic Characterization



Cross Drift Studies
Bulkhead Investigations

- **Evaluate flow and seepage processes in potential repository horizon rocks and Solitario Canyon Fault Zone in support of UZ Flow and Seepage Models**
- **Construction of third bulkhead, rewiring of lights, and installation of additional instrumentation in drift (temperature, wind speed, and drip cloths) ongoing**
- **No apparent evidence of seepage**

Busted Butte Unsaturated Zone Transport Test



- Evaluate influence of heterogeneities on flow and transport
- Evaluate other aspects of site, including fracture/matrix interactions and permeability contrast boundaries
- Consider colloid migration in unsaturated zone (UZ)
- Test use of laboratory sorption data at field scale
- Calibrate and validate site-scale UZ flow and transport model
- Address scaling issues

Busted Butte Tracers for Phase I and Phase II

Phase I:

- Lithium Bromide
- Potassium Iodide
- Fluorescent polystyrene latex microspheres (two sizes) Plutonium Analogs, (colloidal form)
- Sodium Fluorescein
- Pyridone
- 2,4-difluorobenzoic acid
- 2,6-difluorobenzoic acid
- 2,4,5-trifluorobenzoic acid
- 2,3,4,5-tetrafluorobenzoic acid
- Pentafluorobenzoic acid

Phase II (Same as Phase I plus):

- Neptunium Analogs (Np5+):
  - Nickel (II) chloride hexahydrate
  - Cobalt chloride hexahydrate
  - Manganese chloride tetrahydrate
- Plutonium Analog, (Pu3+):
  - Samarium Chloride hexahydrate
- Americium Analogs (Am3+):
  - Cerium (III) chloride hepahydrate
- Rhodamine WT
- Potassium Iodide replaced microspheres on 8/18/99

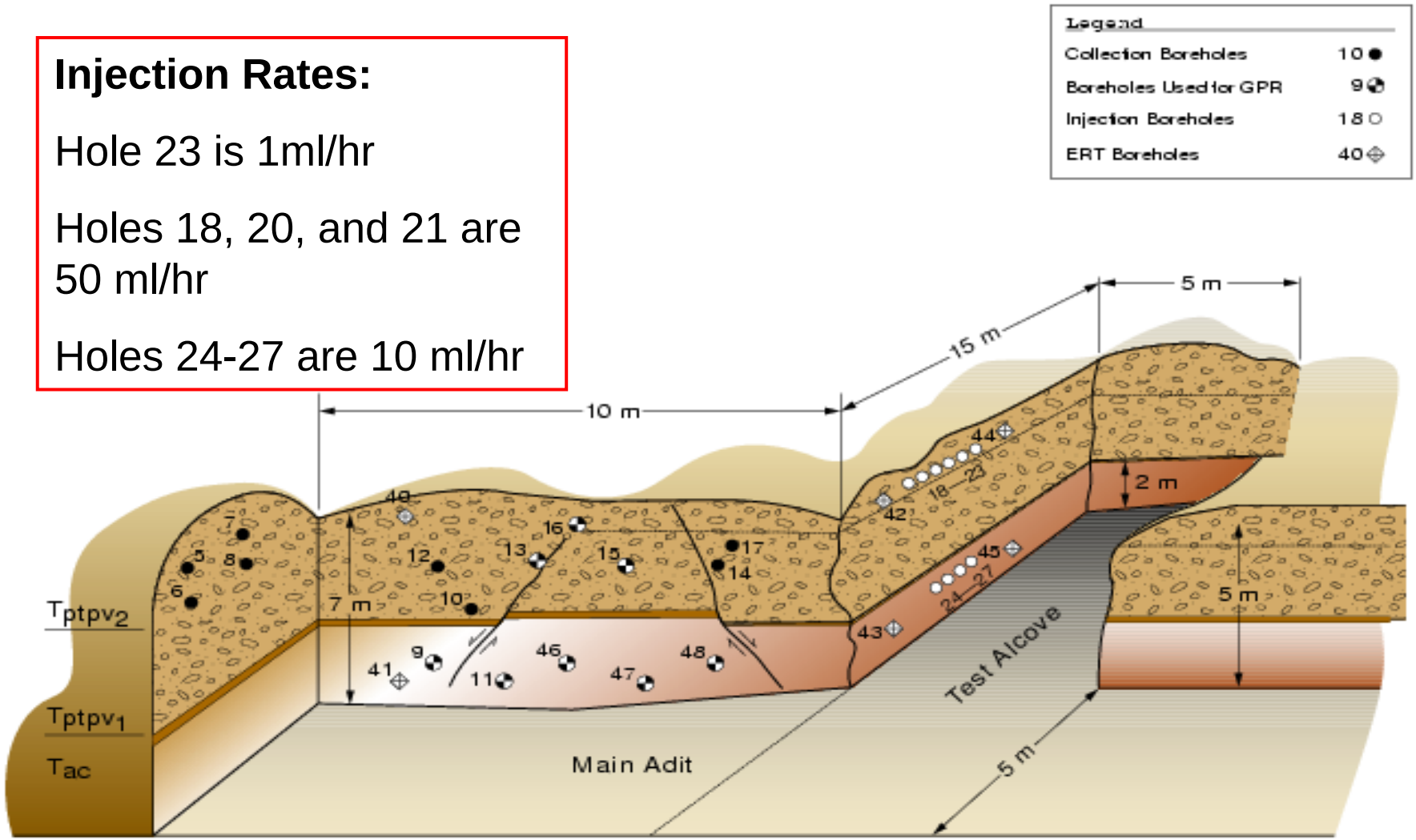
Busted Butte Test Layout: Phase II

Injection Rates:

Hole 23 is 1ml/hr

Holes 18, 20, and 21 are 50 ml/hr

Holes 24-27 are 10 ml/hr



Phase 2 - Status

- **Phase 2 has been running for 22 months**
- **Nearly 15,000 pads collected (as of June 7, 2000)**
  - **3012 pads extracted or underway**
  - **Over 15,000 analyses complete**
- **Multiple geophysical logging runs (ground penetrating radar, electrical resistivity tomography, and neutron logging)**

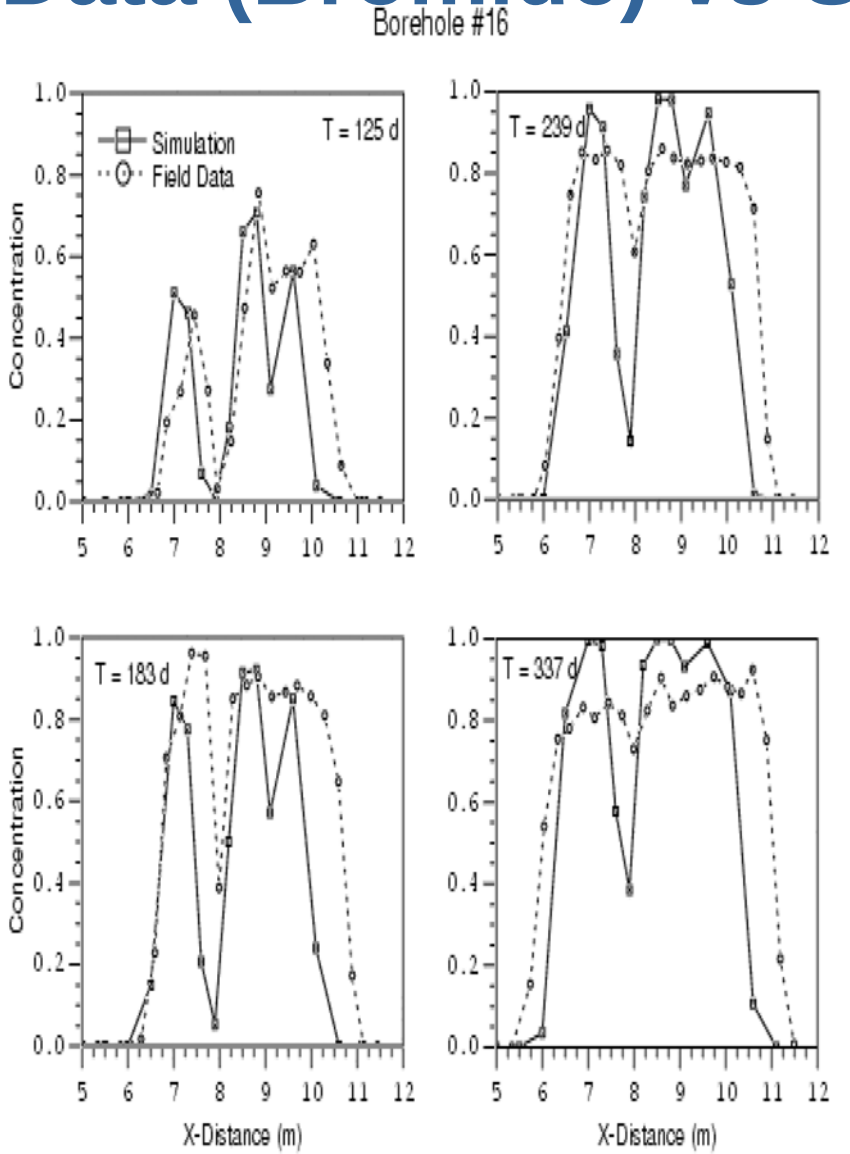
Tracer Observations

- **Breakthrough of non-reactive tracers at all boreholes except 10, 11, and 47**
- **Breakthrough of lithium at boreholes 9, 13, 14, 15(?), 16, 17, 46, and 48**
- **No breakthrough of transition metals**

Modeling: Phase 2

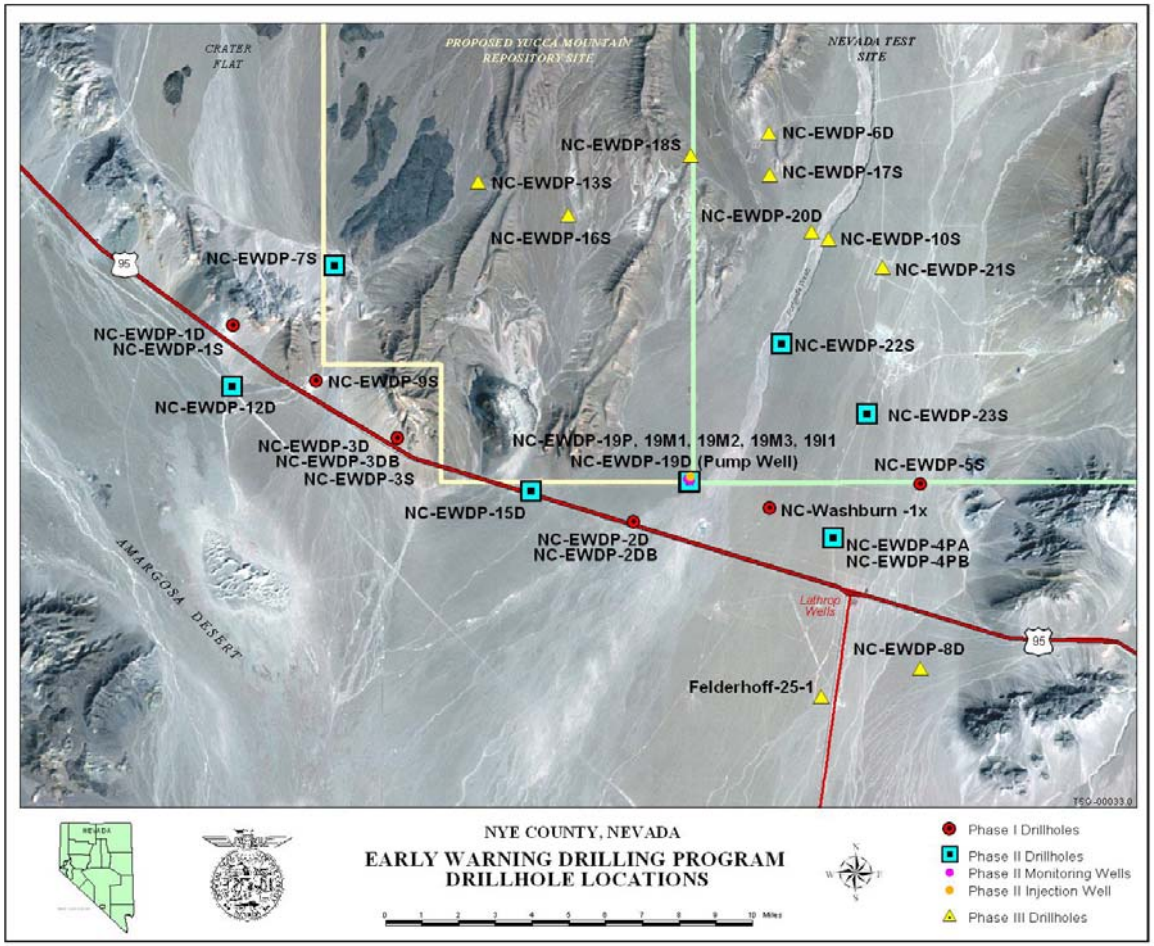
- **Results:**
  - **No faults, three layers**
  - **Looking at Bromide**
  - **Model shows good match of characteristics**
  - **Some boreholes show excellent quantitative match**
- **What factors might be affecting the model results?**
  - **More accurate geology**
  - **Dispersion**
  - **Heterogeneity**

Tracer Data (Bromide) vs Simulation



Unsaturated Zone Transport Test Yucca Mountain Project

Nye County Early Warning Drilling Program



Site-Scale Data Being Collected for the SZ Flow and Transport Model:

(1) Lithologic data into the hydrogeologic framework model
(2) Water-level data for flow field calibration
(3) Hydraulic testing data for flow and transport models
(4) Laboratory sorption measurements (^{237}Np, ^{129}I, and ^{99}Tc) on alluvium for process models and TSPA
(5) Hydrochemistry data for flow field calibrations
(6) Eh/pH data for use in flow and transport models
(7) Hydraulic and transport testing of alluvial aquifer for flow and transport models

Alluvial Testing Complex

- **Drilling of Nye County Well NC-EWDP-19D/D1 complete**
  - **Alluvium from ground surface to 812 feet (static water level at 366 feet); Miocene volcanic tuffs from 812 - 1230 feet; Tertiary sedimentary rocks from 1230 - 1438 feet**
- **Hydraulic testing ongoing**
  - **Nye County conducted flow surveys and 48-hour open-hole hydraulic test of entire section exposed in borehole**
  - **YMP conducted an open-hole hydraulic test (7 day pump/7 day recovery) of the alluvial aquifer to a depth of 812 feet to determine the transmissivity and storativity of the entire alluvial aquifer**
    - **Distant and nearby wells also monitored**
    - **Pumped at 150 gpm with over 100 feet of drawdown (less drawdown than Nye County open-hole hydraulic test)**

Alluvial Testing Complex
(Continued)

- **Isolated-interval hydraulic testing of four intervals in alluvium to take place in late FY00**
- **Isolated-interval tracer testing ("push-pull" with conservative, reactive, and microspheres) to take place in early FY01**

Engineered Barrier System Studies Pilot-Scale Testing

- **Evaluate various engineered barrier configurations and provide data in support of EBS process models**

Pilot-Scale Tests - Canisters 1,2, & 3

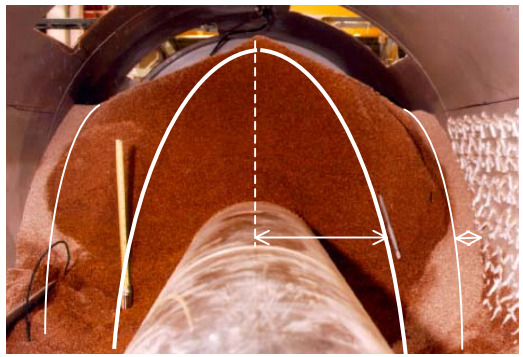
Canister 1

Test Conditions

- Ambient temperature, insulated
- Superpluvial infiltration rate
- Capillary barrier configuration

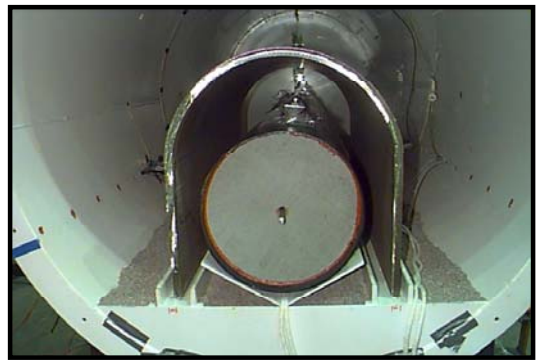
Canister 2

- Ambient temperature, insulated
- Superpluvial infiltration rate
- Plain backfill



Canister 3

- Elevated temperature, insulated
- Superpluvial infiltration rate
- Drip shield - no backfill



Results

- Over 97.5% of the injected water was diverted by the capillary barrier or stored in backfill

- Water moved downward by gravity and spread laterally around simulated waste package

- Drip shield effectively protects mock waste package from drips
- Drip shield creates an environment next to waste package that lowers relative humidity and inhibits condensation

Engineered Barrier Test - Canister 4

Heated plain backfill test with drip shield

Test Conditions

- Temperature-controlled mock waste package and canister (insulated)
- Waste package- 80°C, Test Cell- 60°C
- Superpluvial infiltration rate

Test Configuration

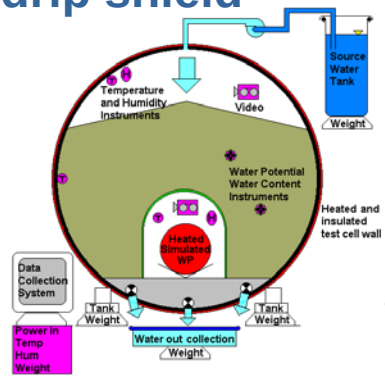
- 4 m long canister, 1.4 m diameter (1/4 scale)
- Overton sand backfill covering drip shield

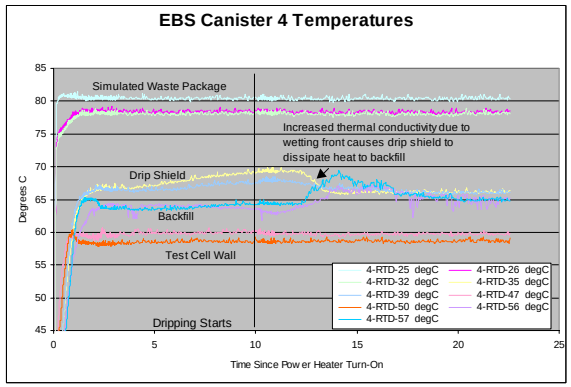
Test Results

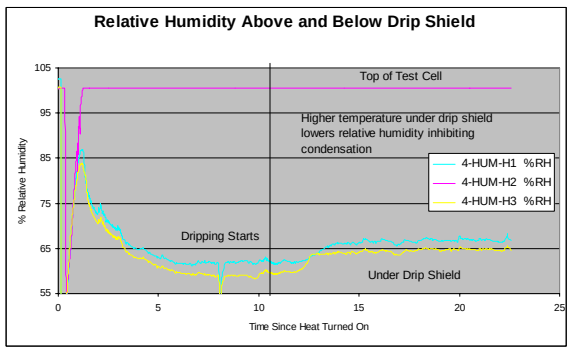
- The drip shield effectively shields the mock waste package from drips
- The drip shield creates an environment around the waste package that is warmer than the drift which lowers relative humidity and inhibits condensation
- Increased moisture in backfill increases thermal conductivity

Status

- Test started Dec. 22, 1999
- Completed May 11, 2000







Engineered Barrier System Studies Ventilation Test

- **Provide data for validation of Preclosure Ventilation Model**
- **Test Design**
  - **Simulated Emplacement Drift 190 feet long - 54 in id Culvert Pipe**
  - **Simulated Waste Package (16 in id steel pipe)**
  - **25 Simulated Waste Packages**
  - **0.35 kW/m of power output**
  - **Expected Simulated Waste Package Surface Temperature 200°C**
  - **Intake air Velocity 60-150 fpm**
  - **Maximum Temperature at Crown 100°C**

Test Status/Schedule

- **Phase I - Heat only with ambient air (August, 2000)**
- **Phase II - Heat only with conditioned air (1st Quarter FY01)**
- **Phase III - Heat-moisture with conditioned air (2nd Quarter FY01)**
- **Phase IV - Blast cooling with ambient air (Last Quarter FY01)**
- **Test Report - Last Quarter FY01**

Engineered Barrier Systems Testing Waste Package Materials

- **Long-term tests have been underway (>2 years) under a range of conditions (immersed, water line, and vapor) to evaluate general and localized corrosion rates**
- **Tests include corrosion-allowance (carbon and alloy steels), intermediate corrosion-resistant (Cu-Ni alloys), and corrosion-resistant (Ni-rich, Ni-base, and Ti alloys) materials with different geometries (weight loss coupons, U-bend specimens, and creviced specimens)**
- **Test conditions range in temperature, ionic strength, and pH**

Engineered Barrier Systems Testing Waste Package Materials

(continued)

- **Specimens removed from long-term tests and evaluated for weight loss and presence of crevice and localized corrosion**
- **Standard Microscopic Techniques and Atomic Force Microscopy are being performed on alloy 22 and standard Ti alloys to follow corrosion processes and to elucidate passive film stability**

Summary

- **Ongoing testing in ESF, Cross Drift, Atlas Facility, and Corrosion Test Facility continues to address key processes in natural and engineered systems**
- **Data collected and analyzed that result from these investigations will be reported in Technical Update Documents and incorporated into the Site Recommendation as appropriate**