Update on Scientific and Technical Investigations

Presentation to:
Nuclear Waste Technical Review Board (NWTRB)

Presentation by:
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M&O/LANL

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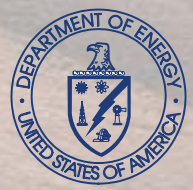


U.S. Department of Energy
Office of Civilian Radioactive Waste Management

Yucca Mountain Project

Overview

- **Climate; Infiltration; UZ Flow Above Repository; Seepage Into Drifts**
  - **Cross Drift Bulkhead Studies**
  - **ESF Moisture Monitoring**
    - » **Alcove 1**
    - » **Alcove 7**
  - **^{36}Cl Validation Study**
  - **Cooperative Work on Fluid Inclusions**

Overview
(Continued)

- **Coupled Processes - Effects on UZ Flow, UZ Transport, and Seepage; Environments on Drip Shield and Waste Package**
  - **Drift Scale Test**
- **UZ Flow and Transport - Advective Pathways and Colloid-Facilitated Transport; Radionuclide Retardation**
  - **Busted Butte**

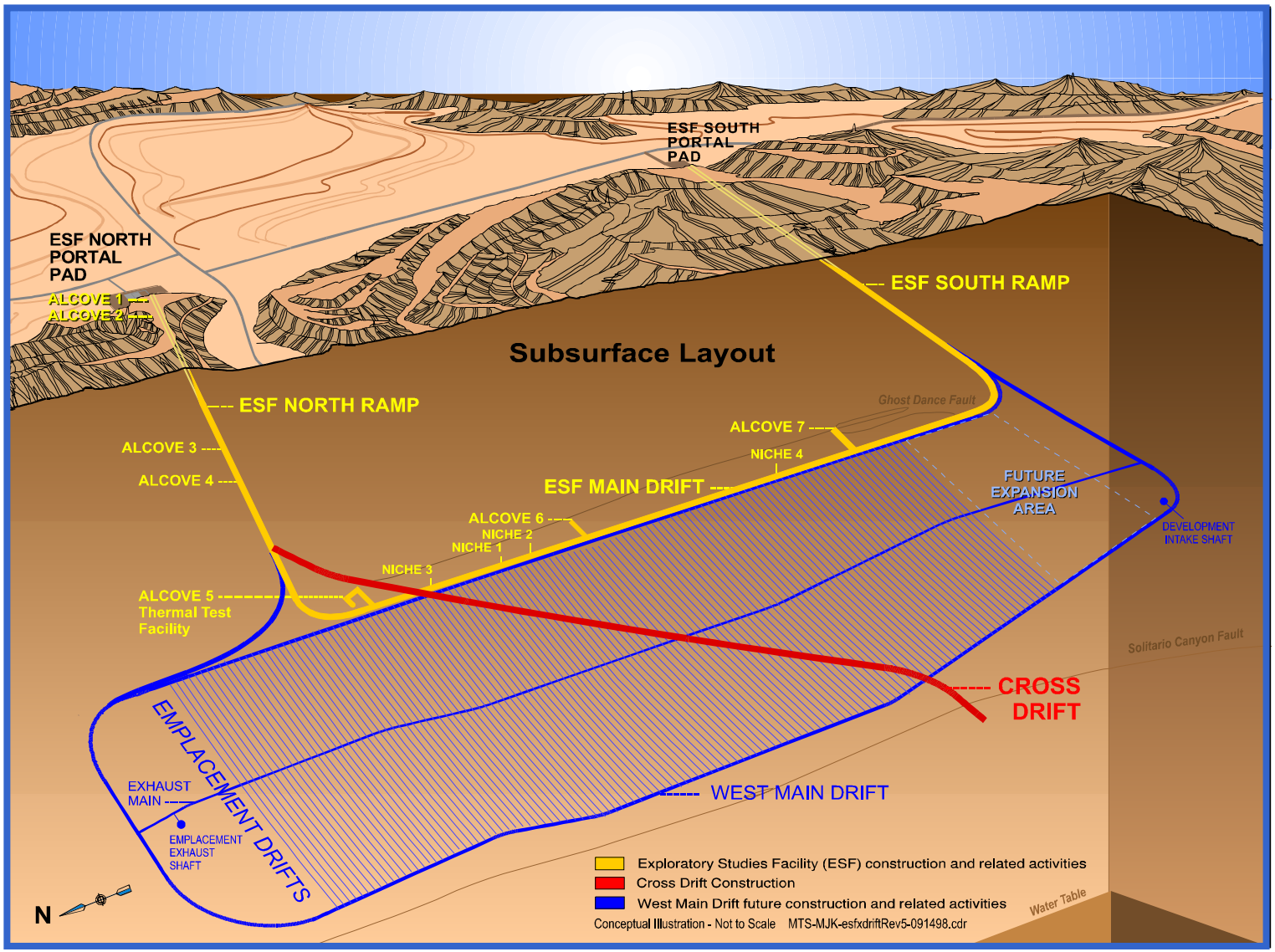
Overview
(Continued)

- **SZ Flow and Transport - Advective Pathways and Colloid-Facilitated Transport; Radionuclide Retardation; Dilution of Radionuclide Concentrations**
  - **Saturated Zone Investigations**
    - » **Integration of Nye County Results**
    - » **SD-6 Aquifer Pump Testing**

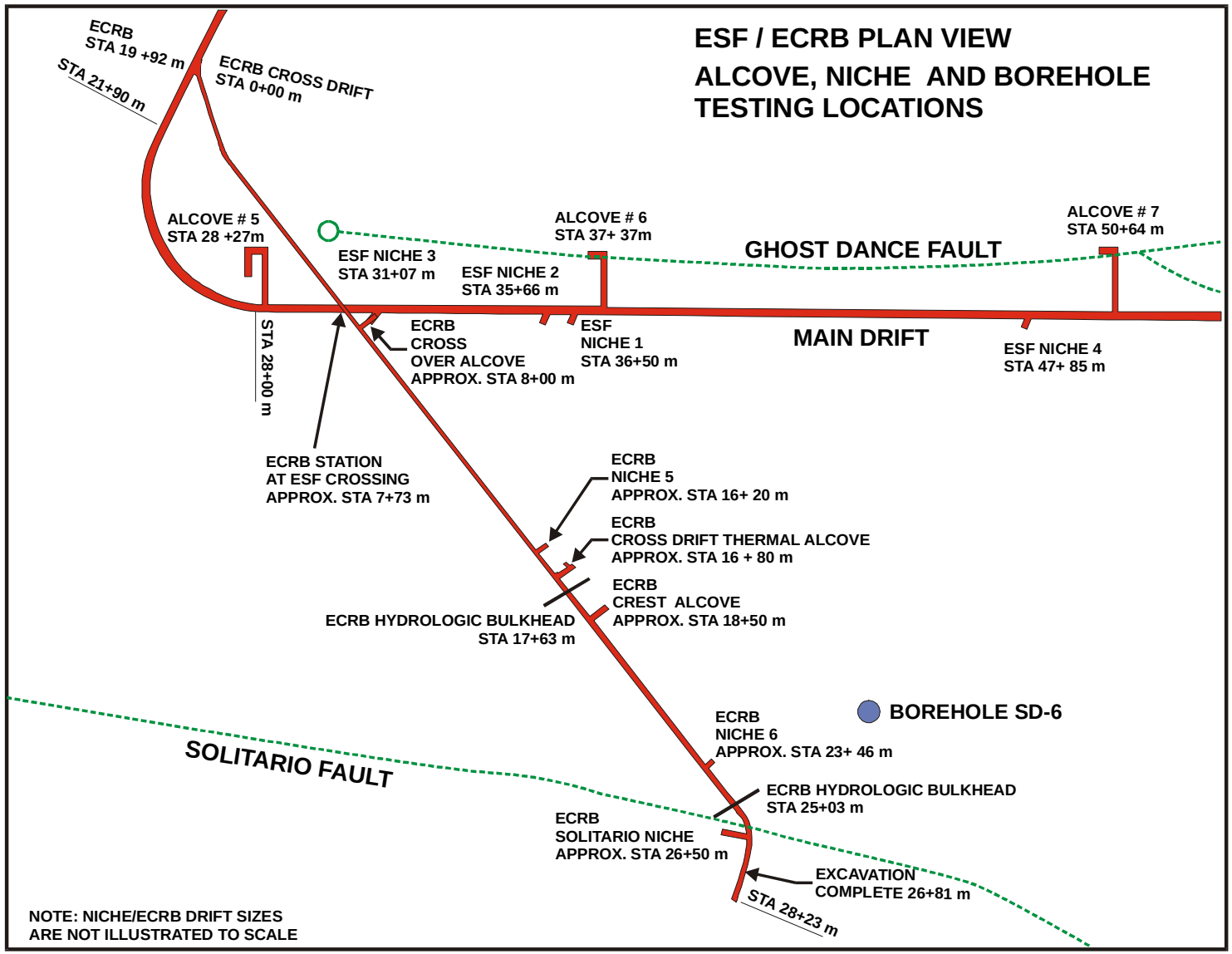
Overview
(Continued)

- **Environments on Drip Shield and Waste Package; Performance of Drip Shield**
  - **EBS Pilot-Scale Testing**
- **Performance of Waste Package Barriers; Performance of Drip Shield; Environments within Waste Package**
  - **Waste Package Materials Testing**

Exploratory Studies Facility and Alcoves



Exploratory Studies Facility and Cross Drift



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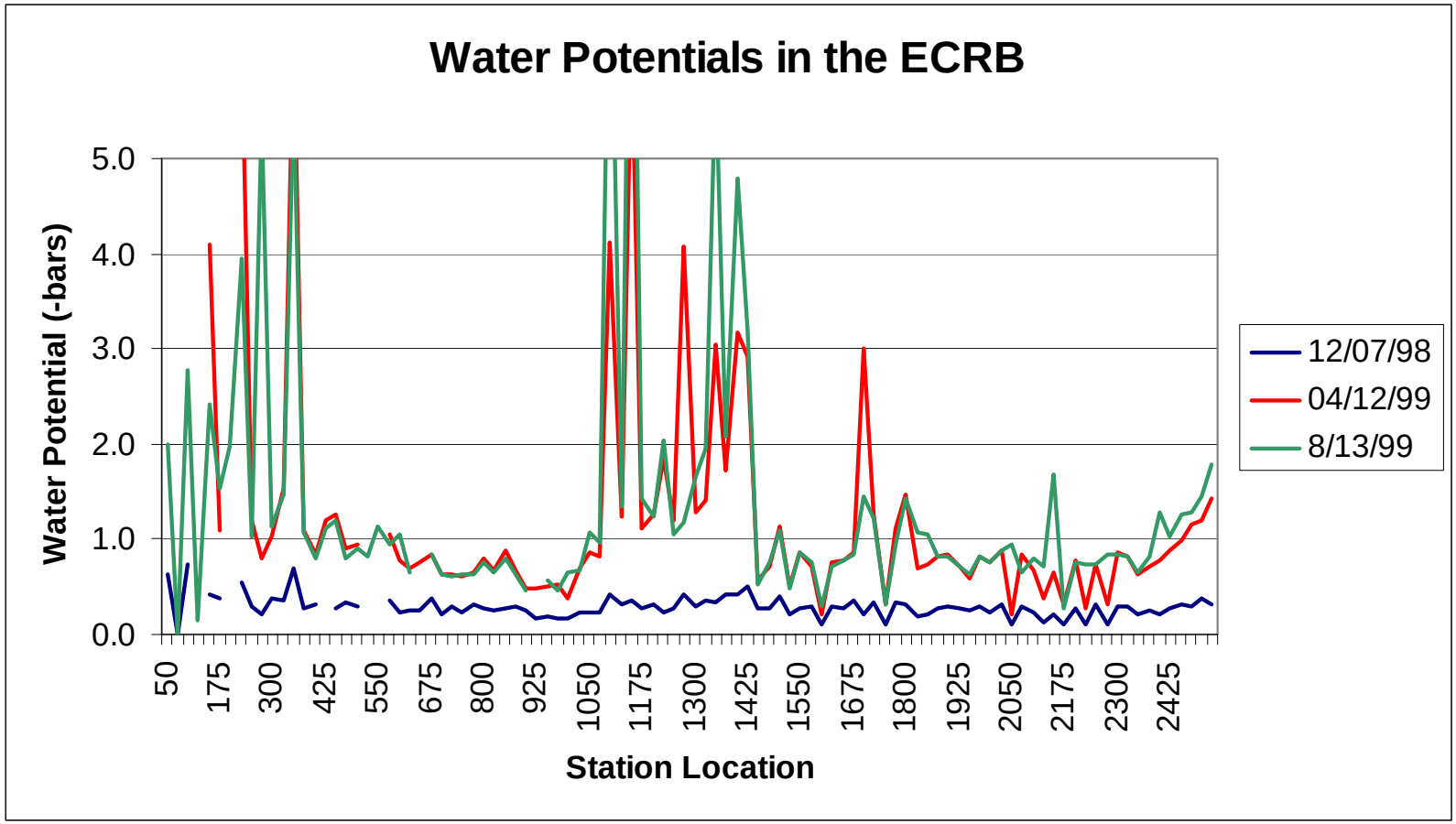
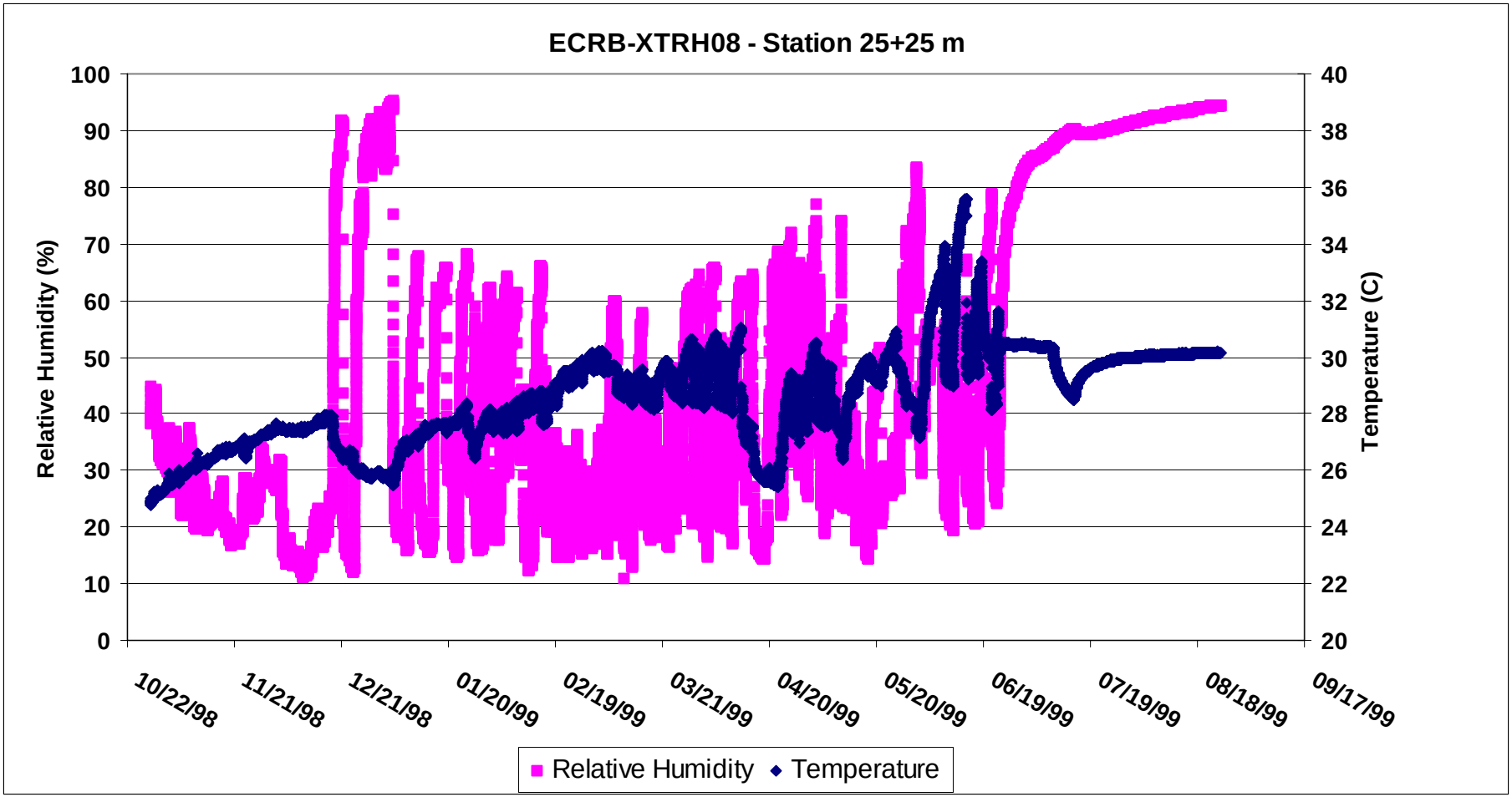
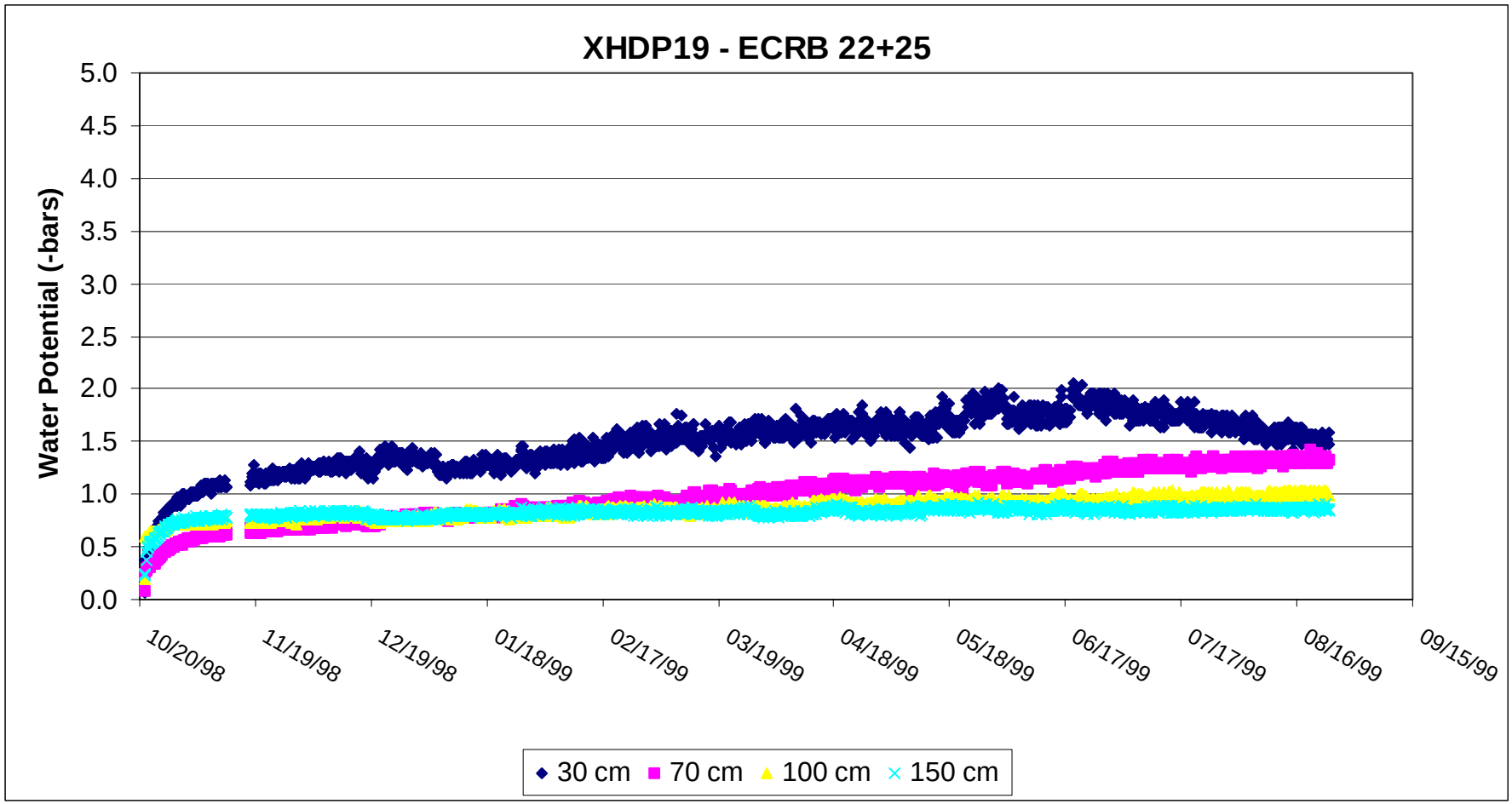
Cross Drift

- **Bulkhead Studies**
  - **Evaluate flow and seepage processes in repository host rocks and Solitario Canyon Fault Zones**
  - **Began in mid June -- bulkheads at Stations 17+63 meters and 25+03 meters**
  - **Systematic hydrologic instrumentation in Topopah Spring Lower Lithophysal and Lower Nonlithophysal Units and Solitario Canyon Fault Zone**
  - **Entry approximately every two months for neutron logging, instrument maintenance, and TBM maintenance -- First entry September 1**

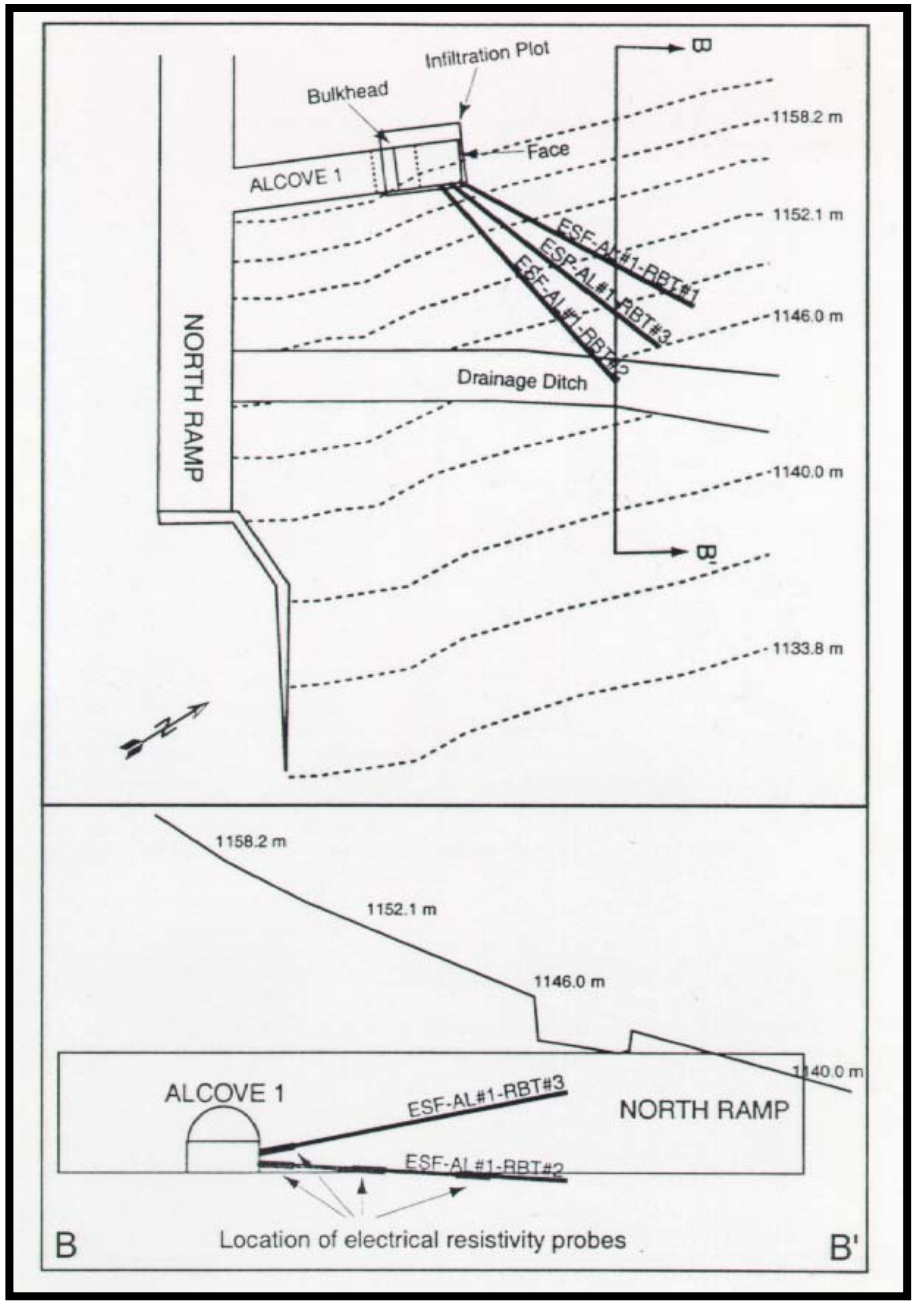

Water Potentials in the ECRB
Water Potential (-bars)
5.0
4.0
3.0
2.0
1.0
0.0
50
175
300
425
550
675
800
925
1050
1175
1300
1425
1550
1675
1800
1925
2050
2175
2300
2425
Station Location
12/07/98
04/12/99
8/13/99

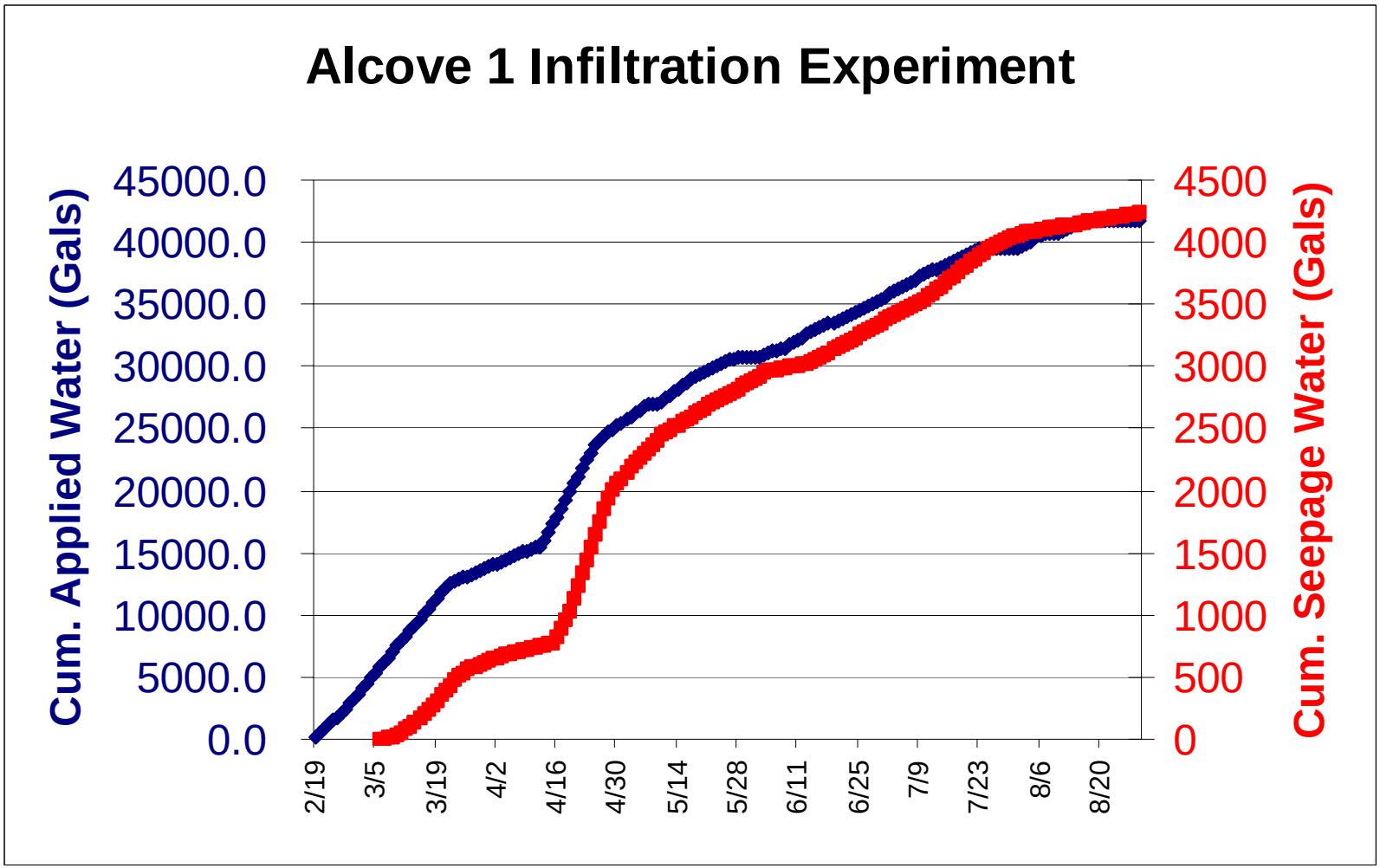

ECRB-XTRH08 - Station 25+25 m
Relative Humidity (%)
Temperature (C)
100
90
80
70
60
50
40
30
20
10
0
40
38
36
34
32
30
28
26
24
22
20
10/22/98
11/21/98
12/21/98
01/20/99
02/19/99
03/21/99
04/20/99
05/20/99
06/19/99
07/19/99
08/18/99
09/17/99
Relative Humidity
Temperature


XHDP19 - ECRB 22+25
Water Potential (-bars)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10/20/98
11/19/98
12/19/98
01/18/99
02/17/99
03/19/99
04/18/99
05/18/99
06/17/99
07/17/99
08/16/99
09/15/99
30 cm
70 cm
100 cm
150 cm

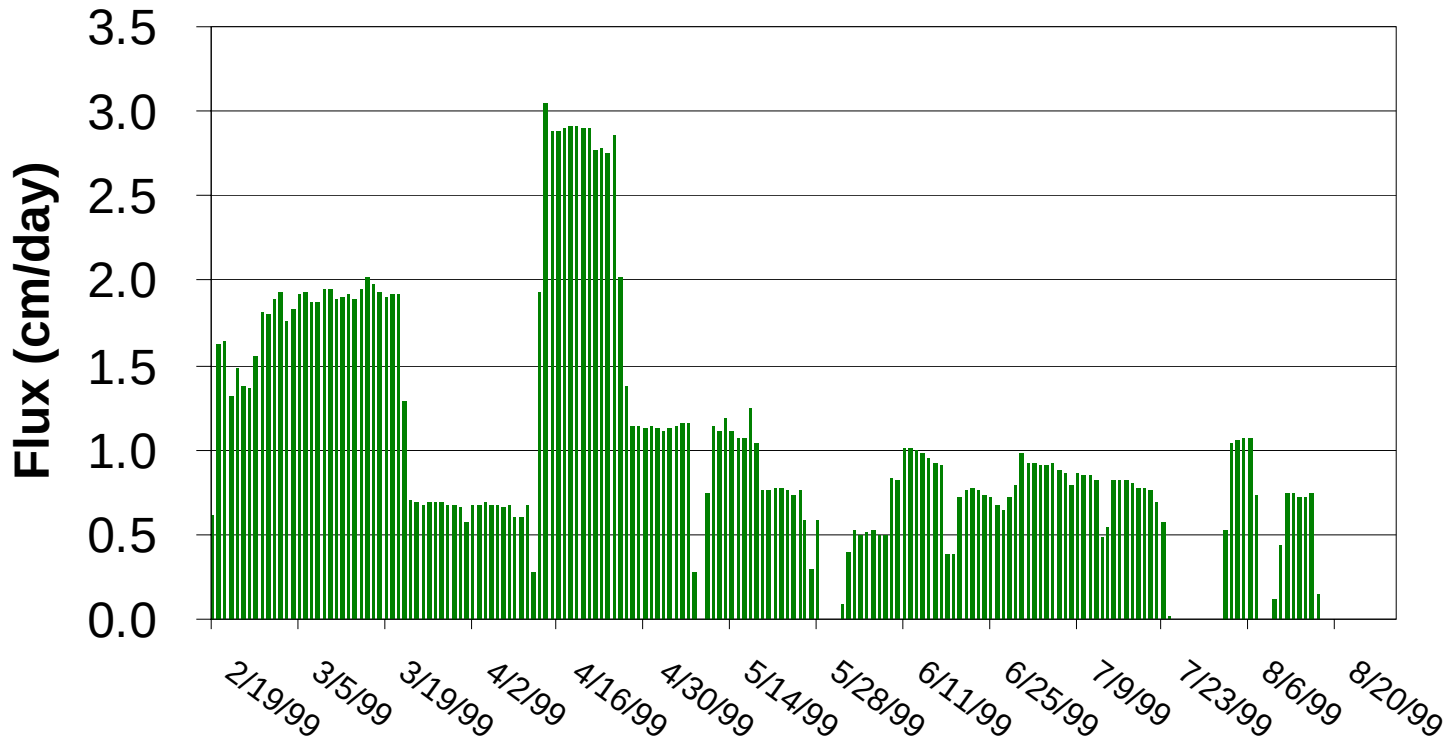
ESF Moisture Monitoring

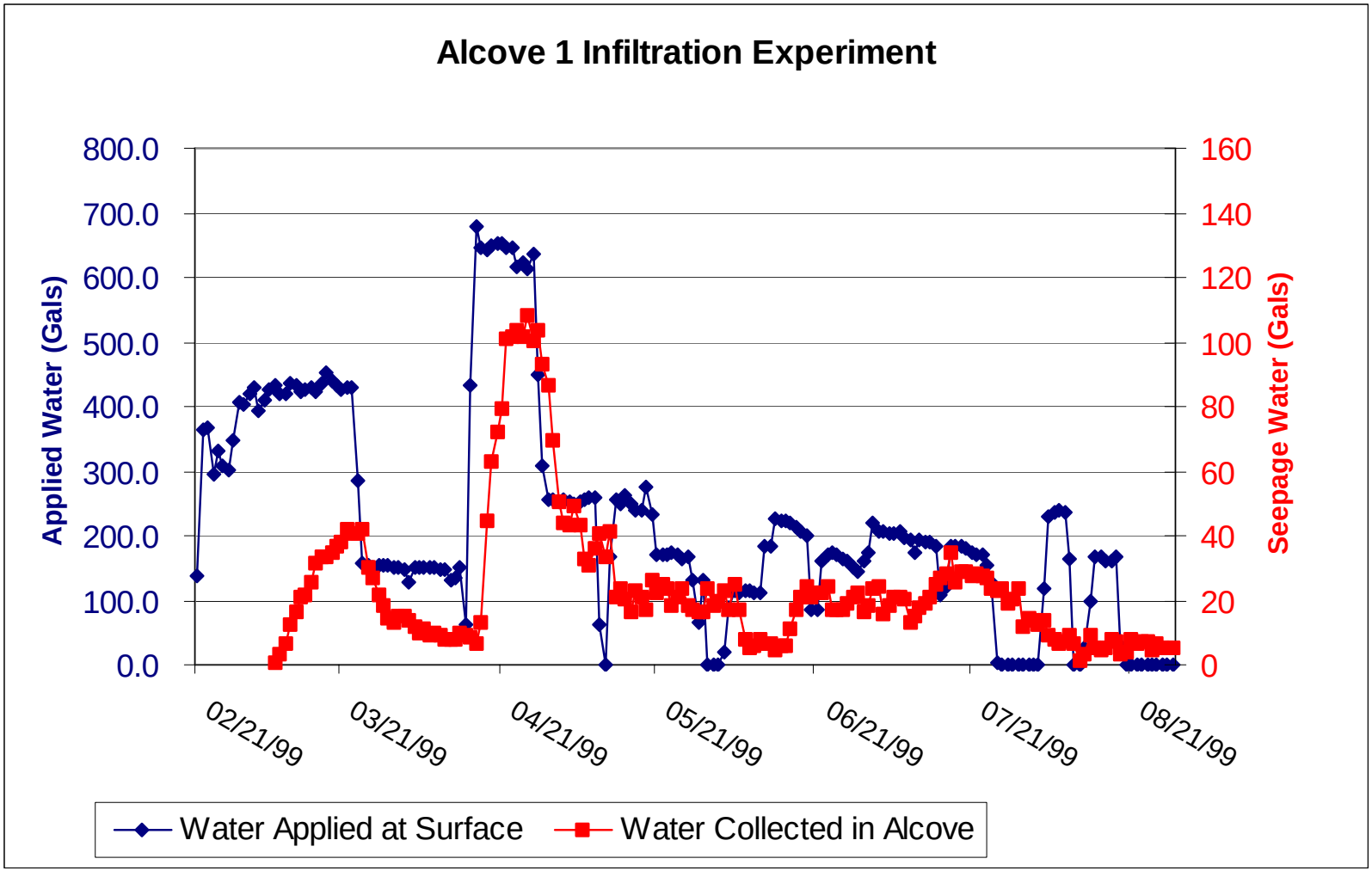
- **Alcove 1 -- Phase 2**
  - **Evaluate infiltration and percolation through unsaturated welded tuffs and the climatic effects associated with increased precipitation**
  - **Water application started on 2/19/99**
  - **As of late August, approximately 41,700 gallons of water applied (varying application rates)**
  - **Water applied equals 7 years of average annual precipitation**
  - **Seepage in Alcove 1 began after approximately 3 weeks**
  - **As of late August, approximately 10% of the applied water was recovered in the alcove collection system**
  - **Varying concentration of aqueous tracer**


Infiltration Plot
Bulkhead
Face
ALCOVE 1
NORTH RAMP
Drainage Ditch
B
B'
1158.2 m
1152.1 m
1146.0 m
1140.0 m
1133.8 m
ESF-AL#1-RBT#1
ESF-AL#1-RBT#3
ESF-AL#1-RBT#5
ALCOVE 1
NORTH RAMP
ESF-AL#1-RBT#3
ESF-AL#1-RBT#2
Location of electrical resistivity probes
B
B'


Alcove 1 Infiltration Experiment
Cum. Applied Water (Gals)
45000.0
40000.0
35000.0
30000.0
25000.0
20000.0
15000.0
10000.0
5000.0
0.0
Cum. Seepage Water (Gals)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
2/19
3/5
3/19
4/2
4/16
4/30
5/14
5/28
6/11
6/25
7/9
7/23
8/6
8/20

Applied Flux of Water (cm/day)

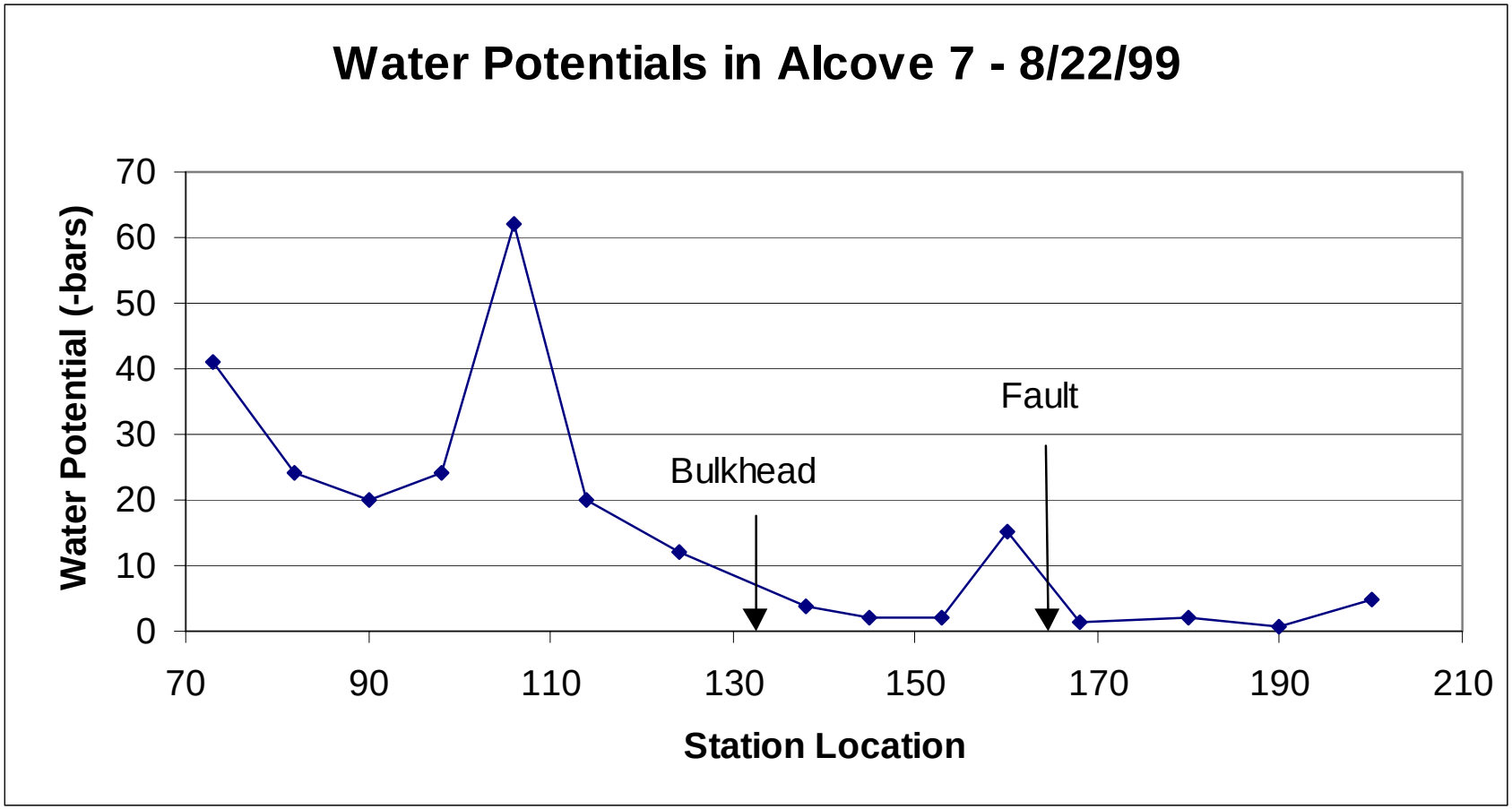



Alcove 1 Infiltration Experiment
Applied Water (Gals)
Seepage Water (Gals)
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
160
140
120
100
80
60
40
20
0
02/21/99
03/21/99
04/21/99
05/21/99
06/21/99
07/21/99
08/21/99
Water Applied at Surface
Water Collected in Alcove

ESF Moisture Monitoring

(Continued)

- **Alcove 7**
  - **Evaluate flow and seepage processes associated with increased precipitation (1998 “El Nino” Event) in Ghost Dance Fault Zone**
  - **Isolated regions in the alcove within fault zone and adjacent areas using bulkheads**
  - **Rock returned to “ambient” conditions (i.e. > 99% relative humidity) relatively quickly**
  - **No dripping water has been detected either visually or using instrumentation**


Water Potentials in Alcove 7 - 8/22/99
Water Potential (-bars)
70
60
50
40
30
20
10
0
70
90
110
130
150
170
190
210
Station Location
Bulkhead
Fault

^{36}Cl Validation Study

- **Validate occurrence of "bomb-pulse" ^{36}Cl at two locations in the ESF -- Sundance Fault zone and Drillhole Wash Fault zone**
- **Collect core from boreholes at Sundance Fault zone and Drillhole Wash Fault zone**
- **Conduct Cl, ^{36}Cl, Tritium, U isotope, and ^{99}Tc analyses -- Study conducted by USGS, LLNL, LANL, AECL, and Purdue University**

^{36}Cl Validation Study

(Continued)

- **Status**
  - **23 boreholes completed -- samples from 13 boreholes examined, split, and distributed; samples from 10 boreholes examined and split**
  - **Procedures at USGS, LLNL, and AECL in place**
  - **LLNL conducted test runs and ready to commence work on core; USGS extracted water from 10 core samples for tritium analyses; AECL has started U-series analyses**

Cooperative Work on Fluid Inclusions

- **Cooperative study involving UNLV, DOE (USGS), and State of Nevada to evaluate paleohydrology of Yucca Mountain**
- **Focus of sampling was in ESF and Cross Drift**
- **Technical Workshops held with all participants**
- **Current focus on selecting samples for more detailed study (petrography, geochemistry, and geochronology)**

Cooperative Work on Fluid Inclusions

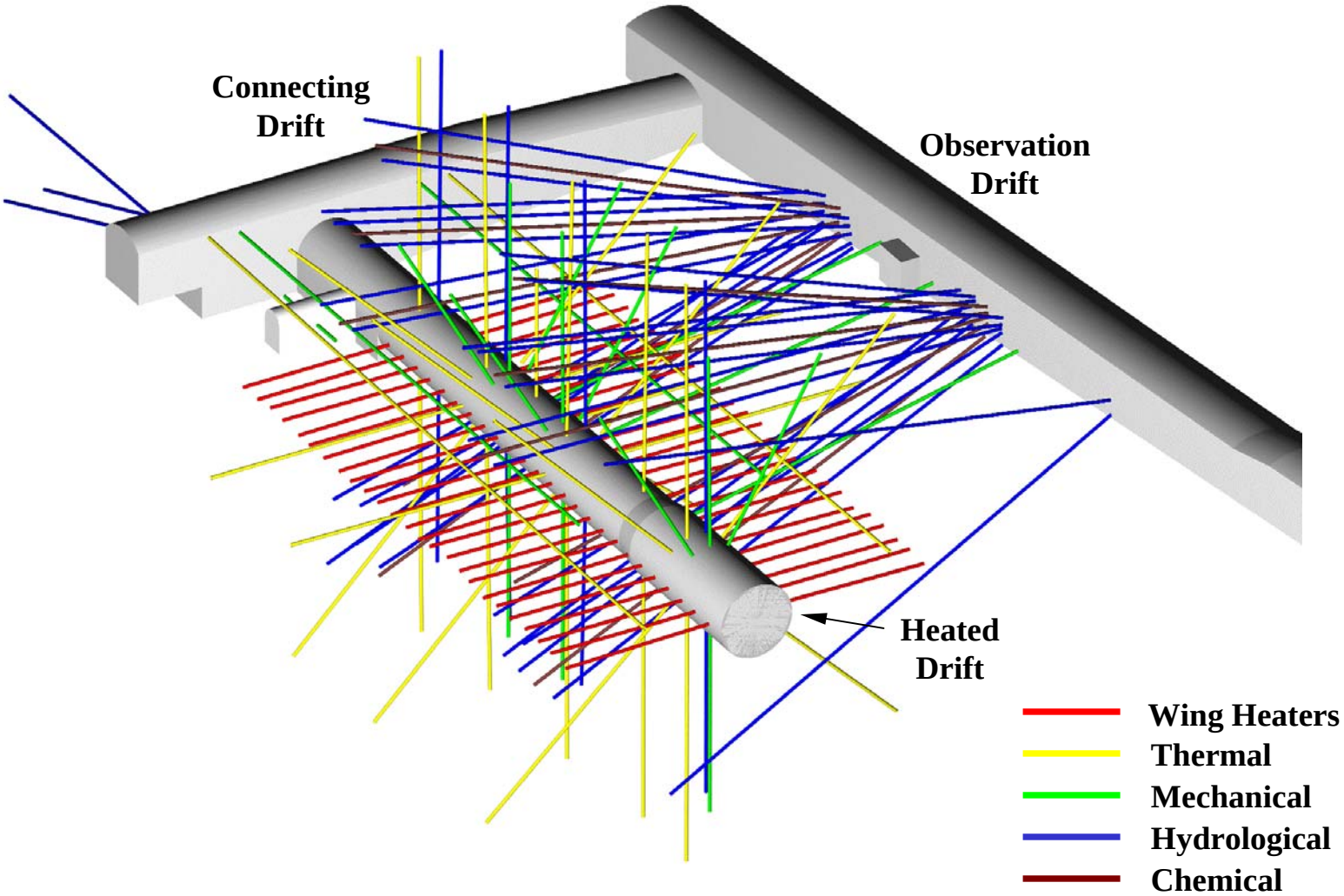
(Continued)

- **Fluid inclusions indicating temperatures of 30-50^{o}C observed in several samples and temperatures up to 80^{o}C in two samples**
- **Microscopic observations by USGS suggest these fluid inclusions are restricted to the earliest (older) parts of the calcite/silica deposits -- probably within a few million years of deposition of the tuff**
- **Geochronologic measurements to be completed in FY00 are key dataset**

Drift Scale Test

- **Evaluate the thermal-hydrologic-mechanical-chemical coupled processes in repository horizon rocks at the field-scale**
  - **Heating phase continues**
    - » **Heat transfer is conduction-dominated with a key role played by moisture through convection**
    - » **Pore water mobilized by heat tending to move below the heated region rather than stay “ponded’ above**
  - **As expected, coupled process phenomena occur at sub-boiling temperatures**

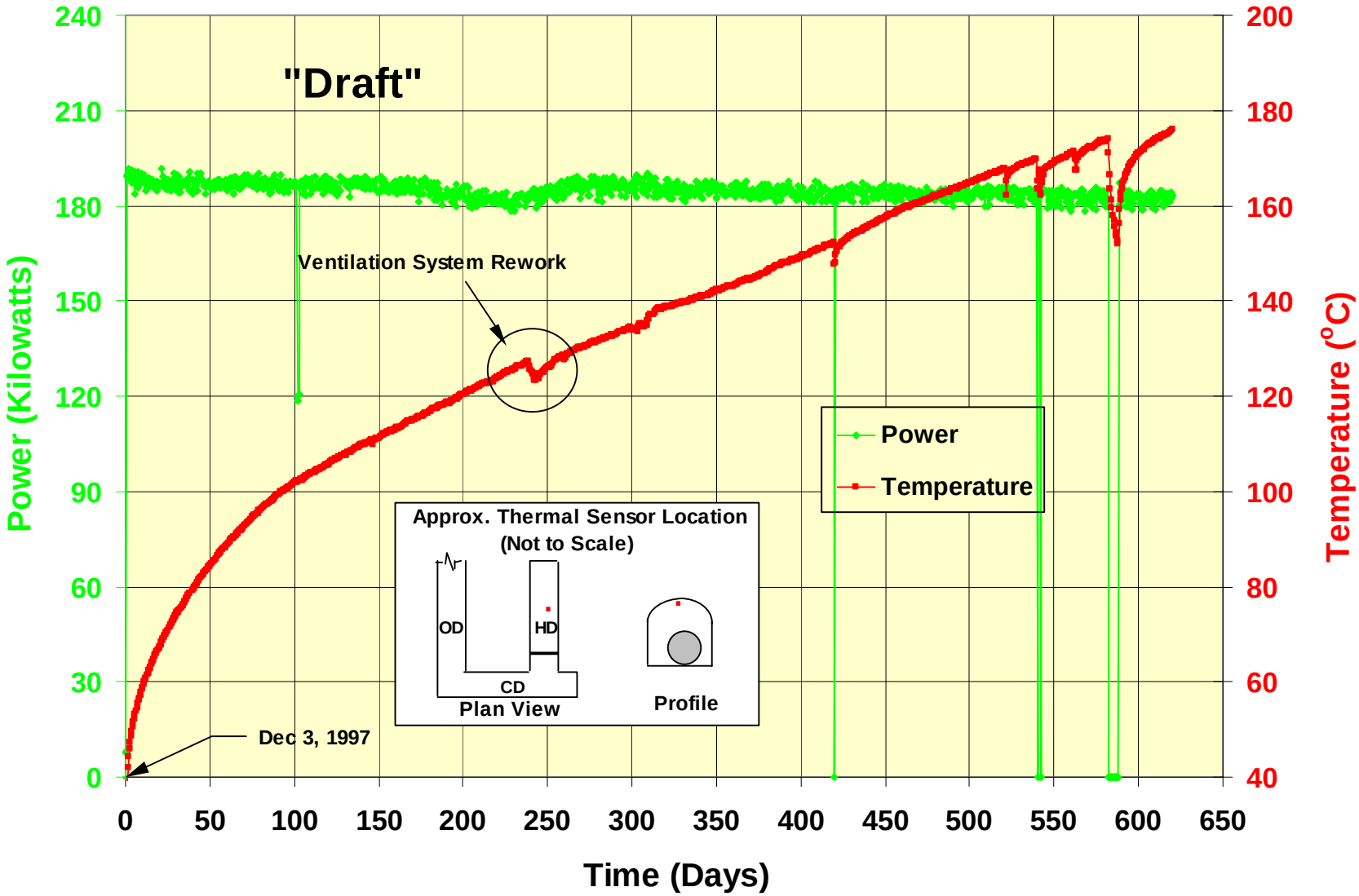
Drift Scale Test:
As-Built Borehole Perspective



Drift Scale Test

(Continued)

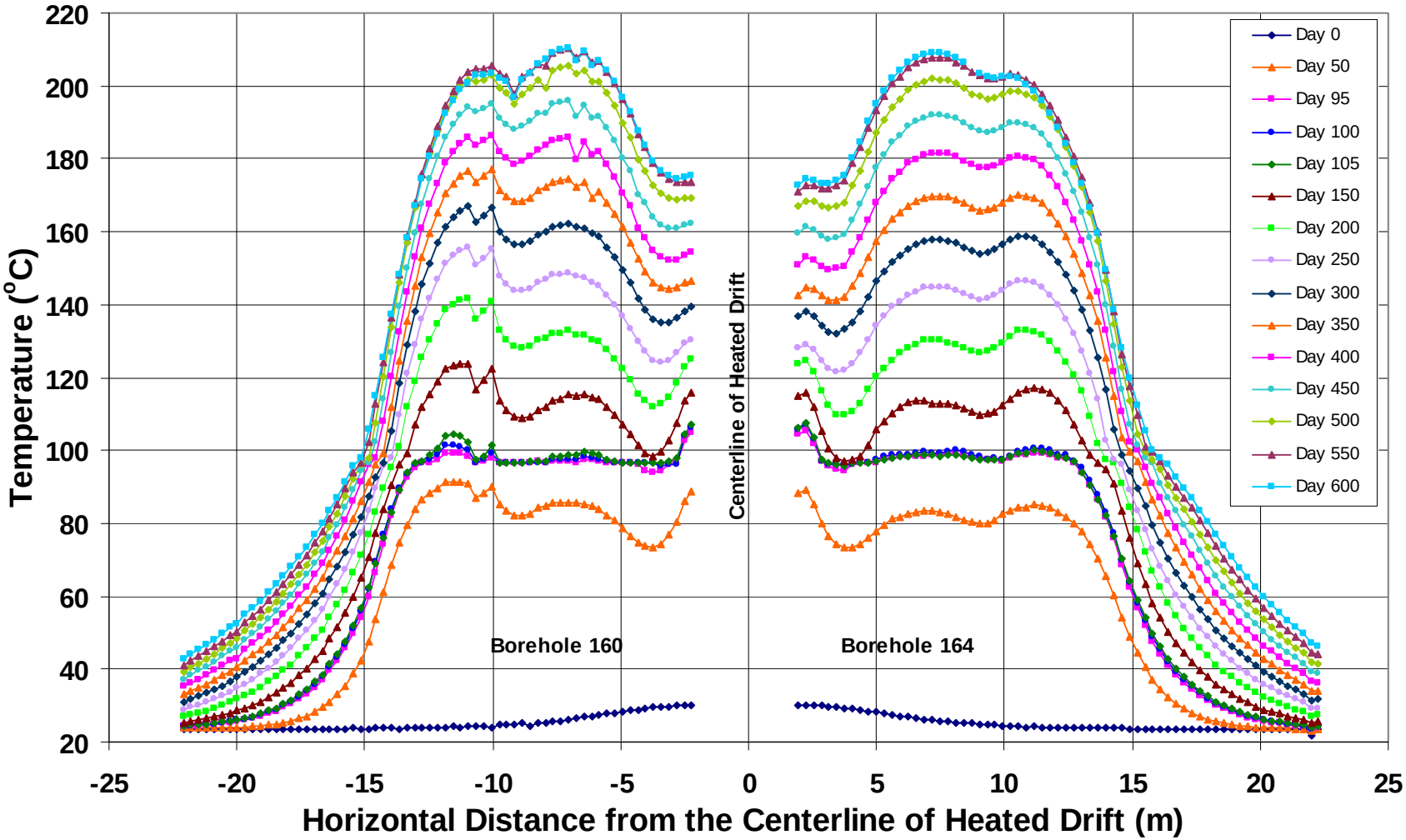
Total Power and Drift-Wall Temperature



Drift Scale Test

(Continued)

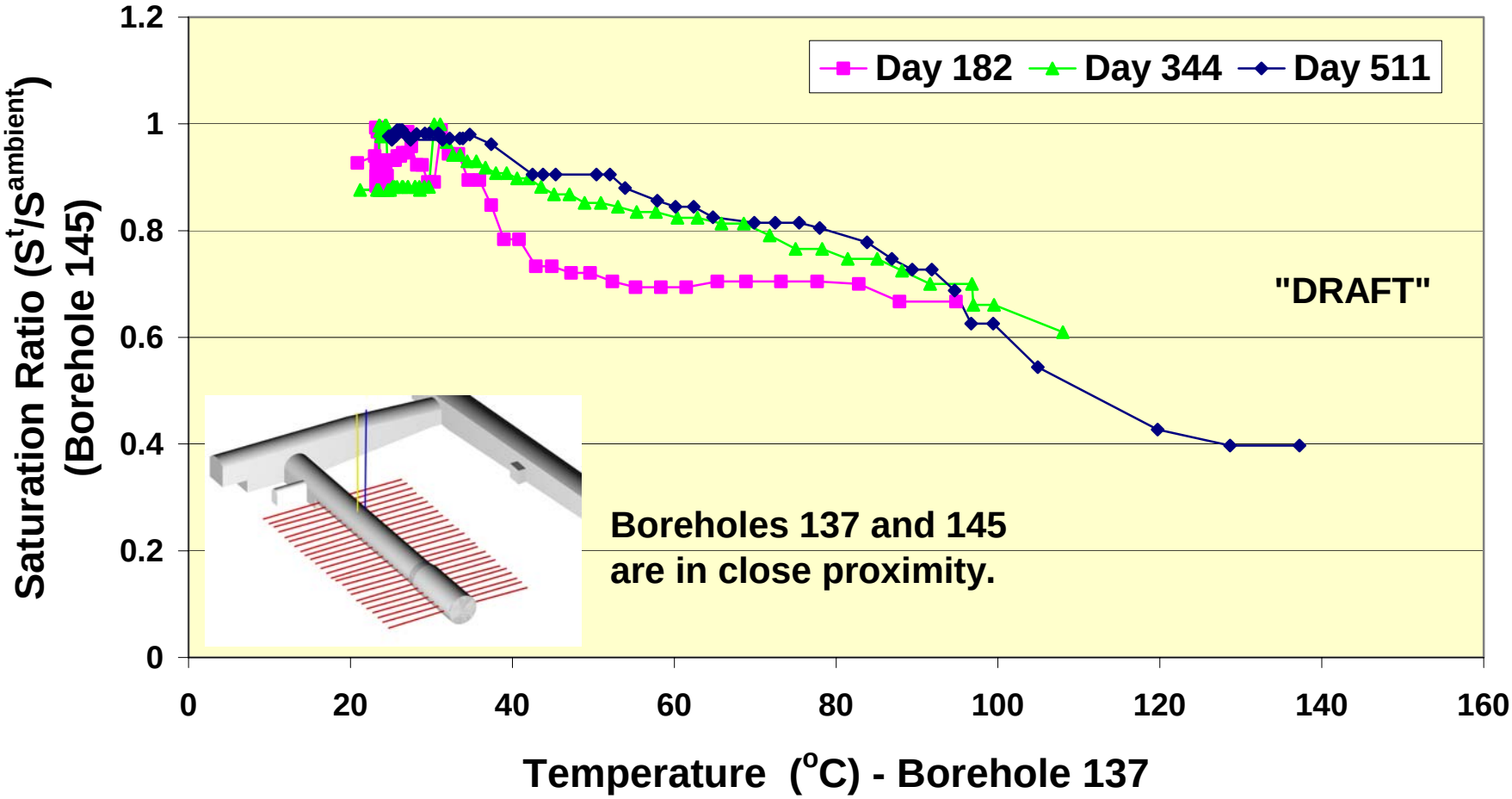
Temperatures Parallel to the Wing Heaters Approximately at Mid-length of the Heated Drift (BH 160 and BH 164)



Drift Scale Test

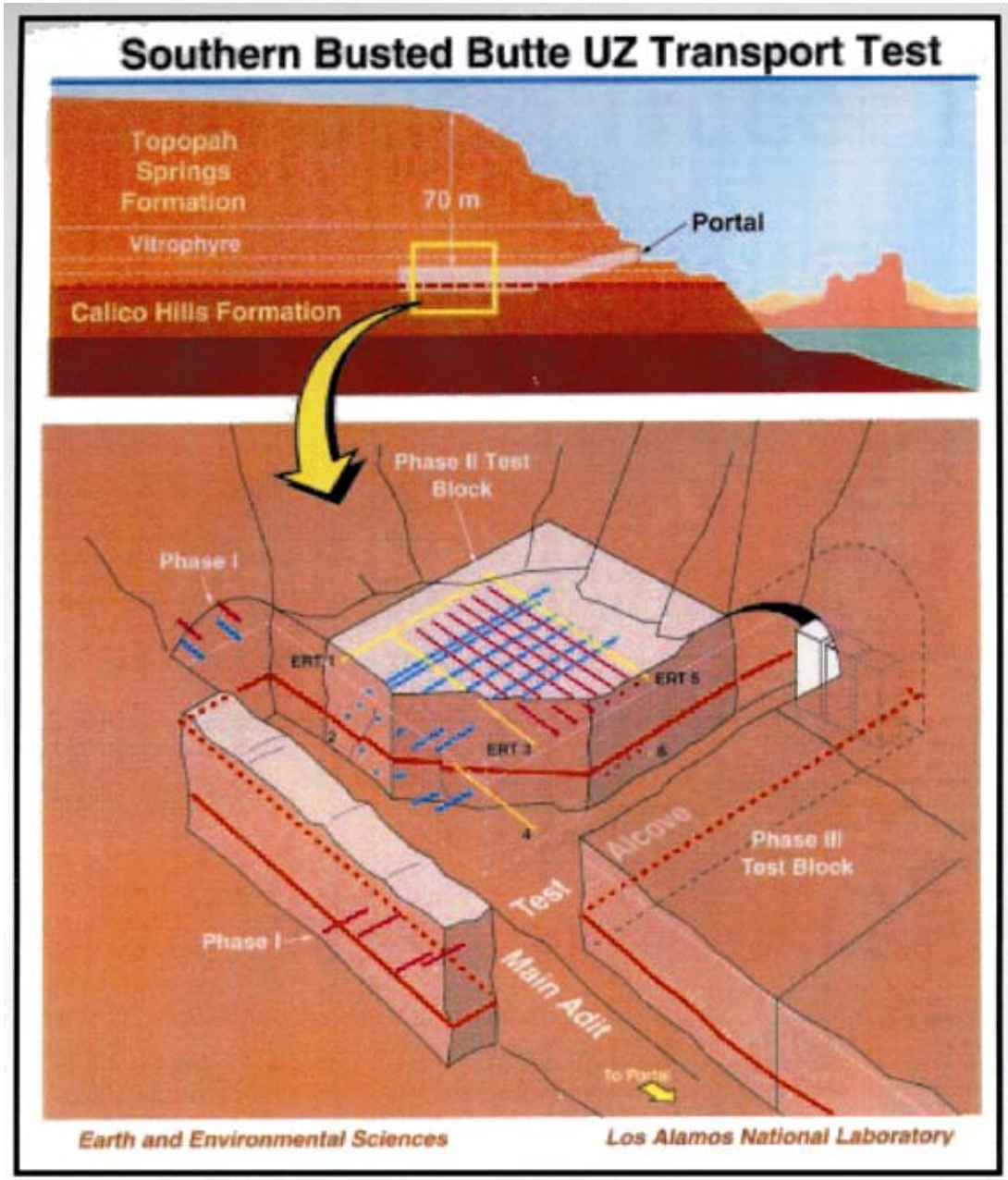
(Continued)

Saturation Ratio Vs.Temperature



Busted Butte

- **Evaluate flow and transport processes and the effect of heterogeneities in unsaturated Calico Hills rocks**
- **Update on Phase 2**
  - **Tracer injection (tracers and microspheres) began June, 1998 and planned to continue into FY00**
  - **Continue to observe breakthrough on collection pads -- quantitative analyses ongoing**
  - **Introduced new tracer, which showed up almost immediately in geophysical logs**
    - » **Difference between ambient and system perturbed by ongoing injection**

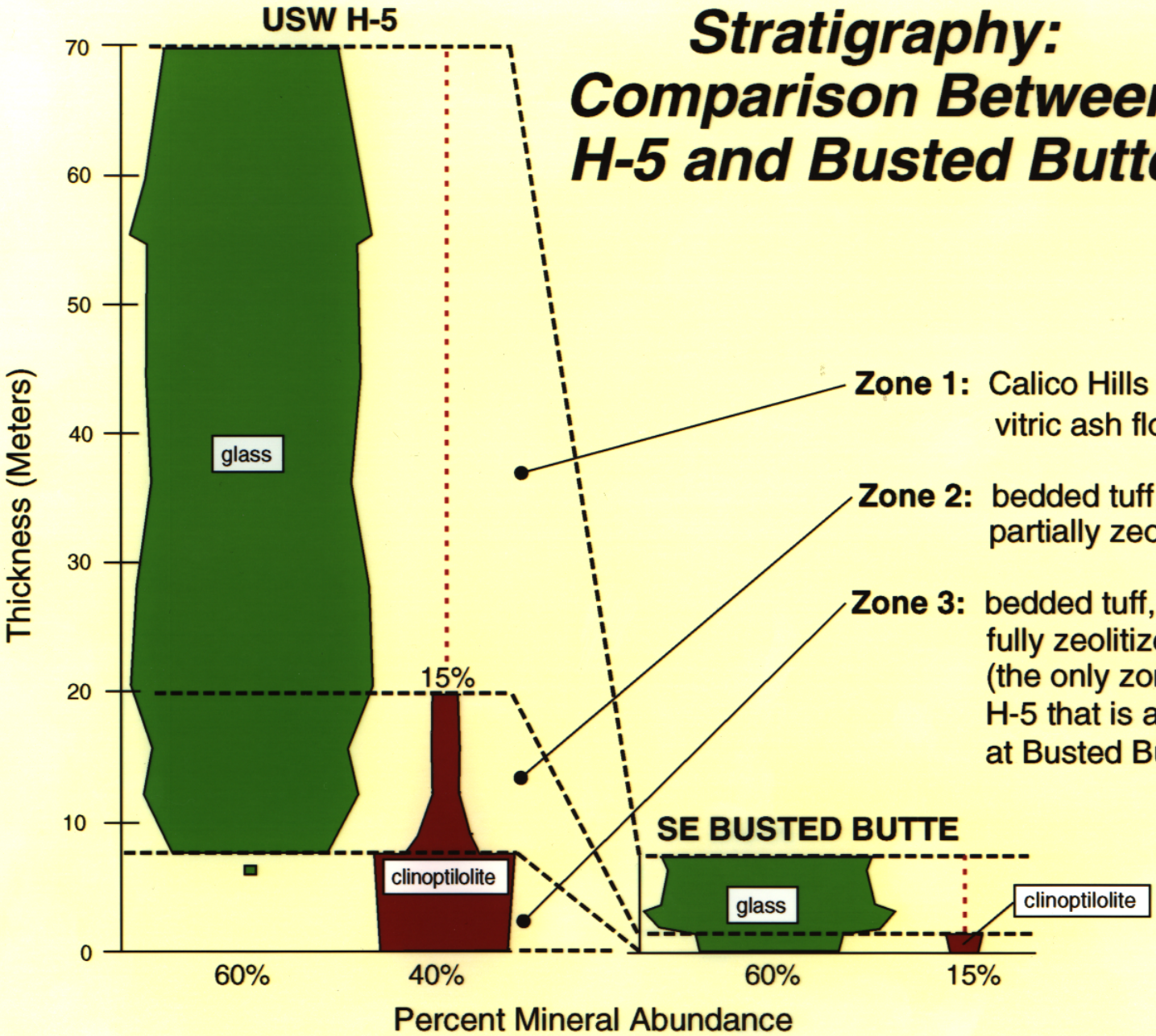

Southern Busted Butte UZ Transport Test
Topopah Springs Formation
70 m
Portal
Vitrophyre
Calico Hills Formation
Phase II Test Block
Phase I
ERT 1
ERT 5
ERT 3
Alcove
Phase III Test Block
Test Main Adit
Phase I
To Portal
Earth and Environmental Sciences
Los Alamos National Laboratory

Busted Butte
(Continued)

- **Applicability to Potential Repository Block**
  - **Busted Butte test bed primarily in a vitric subunit of Calico Hills**
    - » **Evaluating the role of fracture-matrix interaction, matrix diffusion, and matrix-dominated sorption for use in process model and TSPA**
  - **Calico Hills rocks exposed at Busted Butte are a distal extension of the formation located beneath the potential repository horizon - not an analog**
  - **Mineralogic-Petrologic Model provides framework for vitric/zeolitic distribution in Calico Hills rocks beneath potential repository block**

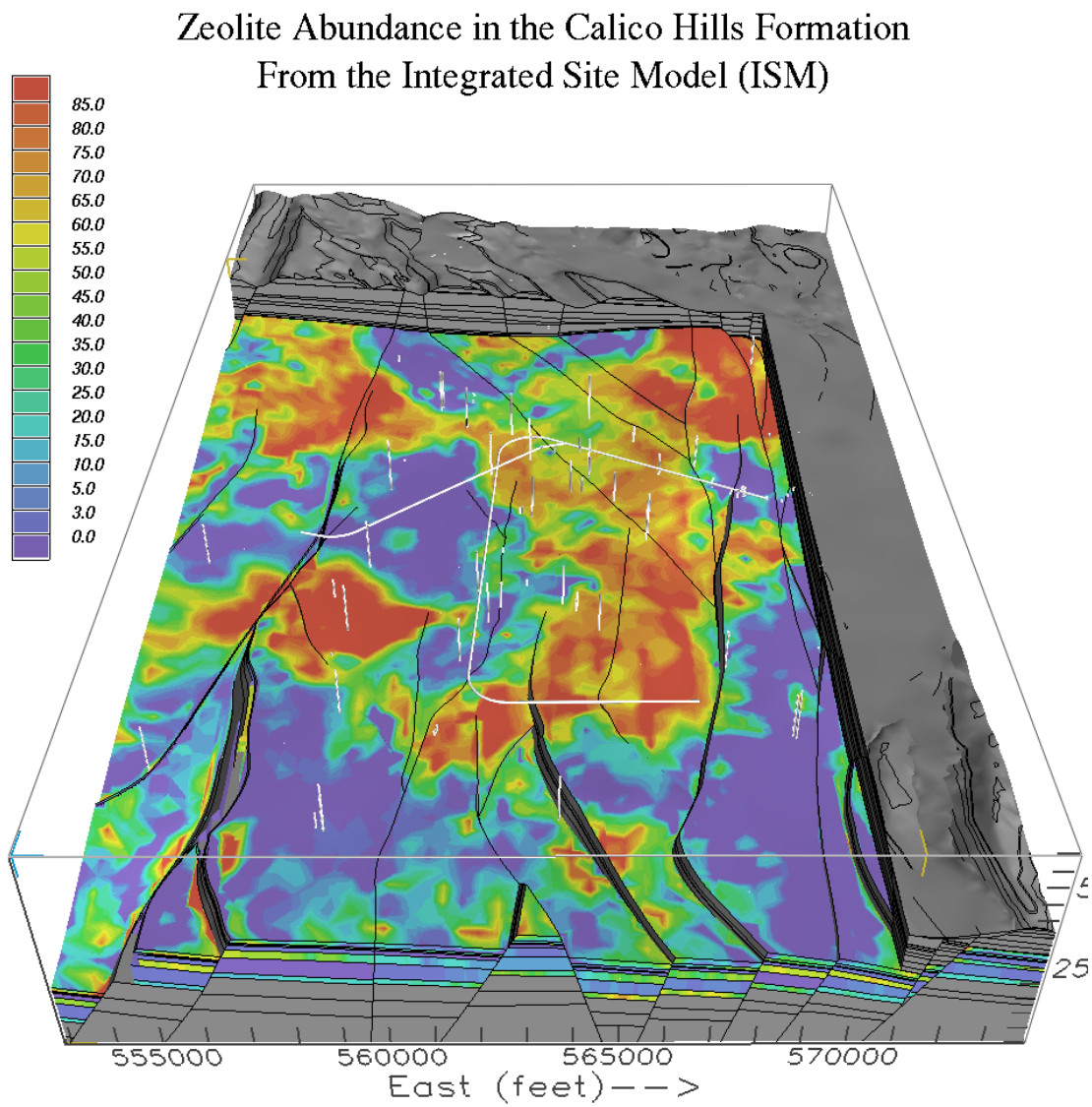
CIC-1/98-1075 (6-98)

Stratigraphy: Comparison Between H-5 and Busted Butte



Busted Butte

(Continued)



Saturated Zone Investigations

- **Integration of Nye County Data**
  - **DOE is incorporating data from the Nye County EWDP into the Site-Scale SZ Flow and Transport Model, including:**
    - **Lithologic data into the hydrogeologic framework model**
    - **Water-level data for flow field calibration**
    - **Hydraulic testing data for flow and transport model**
    - **Laboratory sorption measurements (^{237}Np, ^{129}I, and ^{99}Tc) on alluvium for process model and TSPA**
    - **Hydrochemistry data for flow field calibration**
    - **Eh/pH data for use in flow and transport model**
  - **DOE is establishing processes and interfaces for data transfer and control to allow for timely and quality incorporation of Nye County data**

Saturated Zone Investigations

(Continued)

- **SD-6 Aquifer Pump Testing**
  - **Evaluate SZ characteristics within the potential repository footprint**
  - **Preliminary Results**
    - » **Borehole was pumped for approximately two weeks at an average rate of 15.5 gpm**
    - » **Maximum drawdown was about 163 feet (majority within first day of pumping)**
    - » **No drawdown was observed in nearby boreholes**
    - » **Permeability of the water-bearing fractures is very low -- current hypothesis is secondary fractures were encountered and transmissivity estimates may not be representative of primary fracture system**

EBS Pilot-Scale Testing

- **Evaluate the performance of a Richard's Barrier in support of Design Alternative effort and potential backfill materials**
- **Test Canister #1 initiated in mid-December, 1998**
  - **EBS concept is Richard's Barrier (medium sand over coarse sand) under superpluvial rates**
  - **Richard's Barrier continues to effectively divert water (greater than 98% water diverted)**

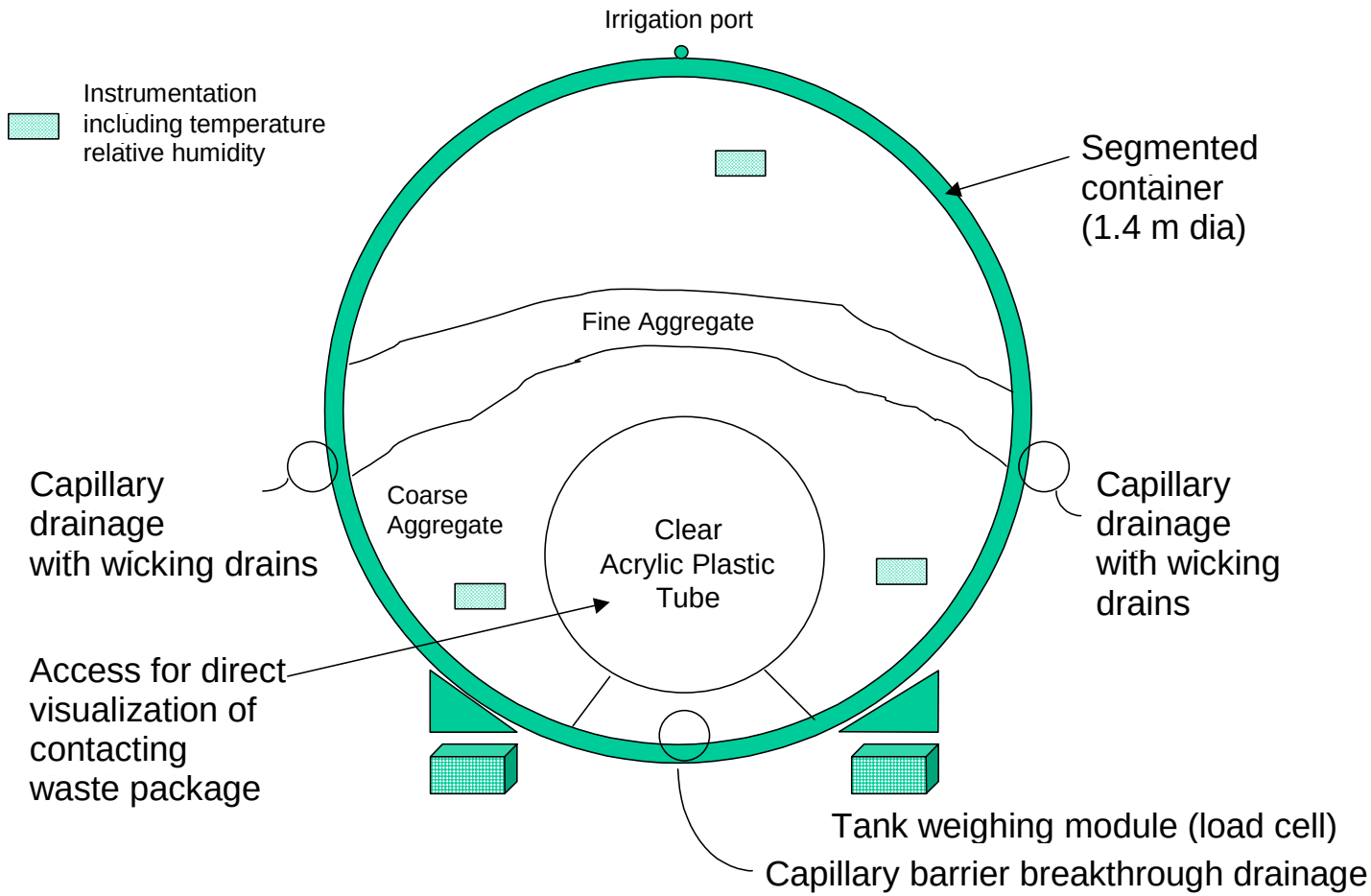


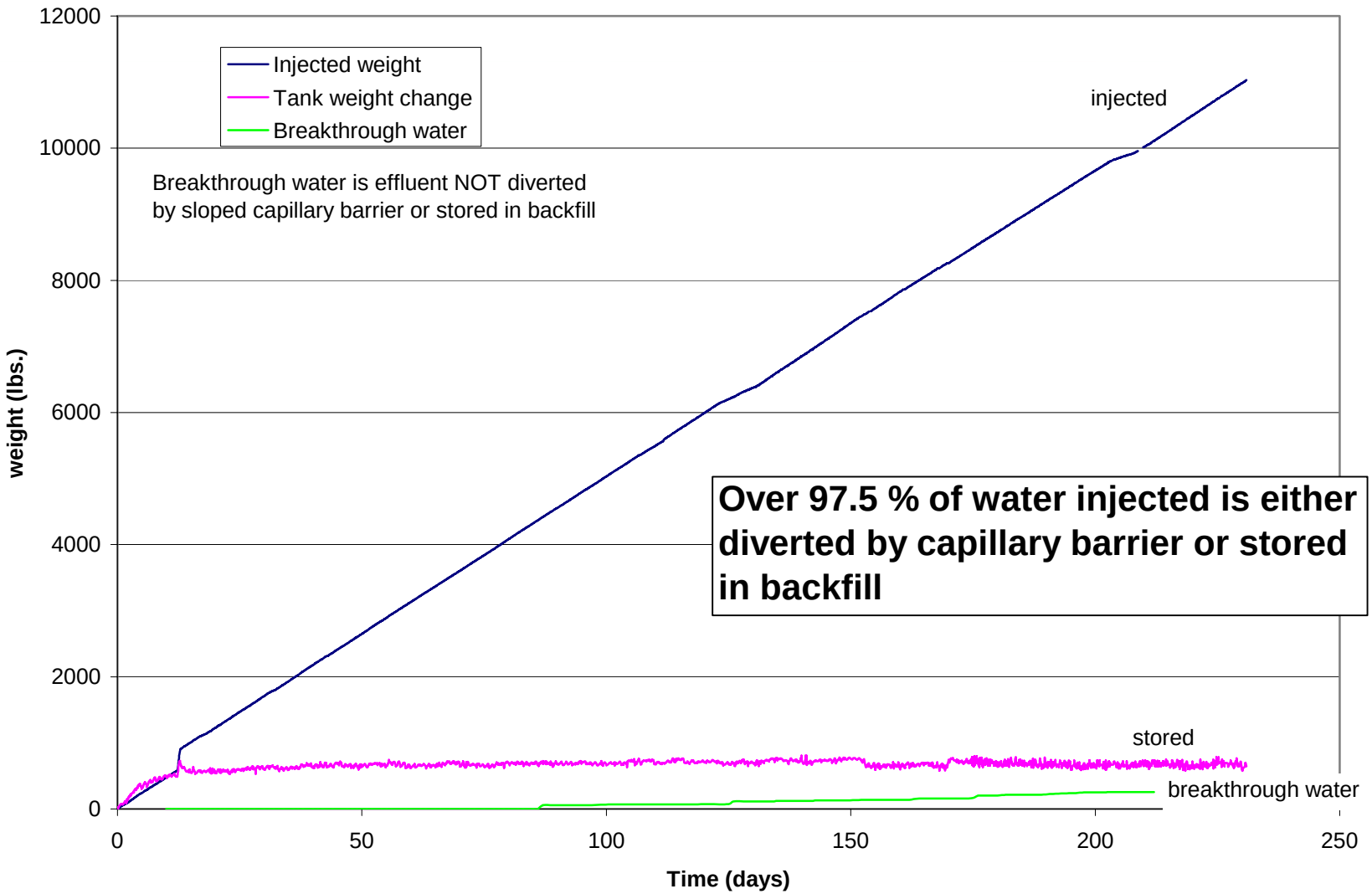
Figure 1-1 cross-section view of ambient capillary barrier 1/4 scale

EBS - PILOT SCALE TESTING

CANISTER #1: RICHARDS BARRIER MATERIALS

A LAYER OF COARSE MATERIAL AND A LAYER OF FINE MATERIAL WAS HAND LOADED INTO CANISTER #1 CREATING A RICHARDS BARRIER FOR TESTING.

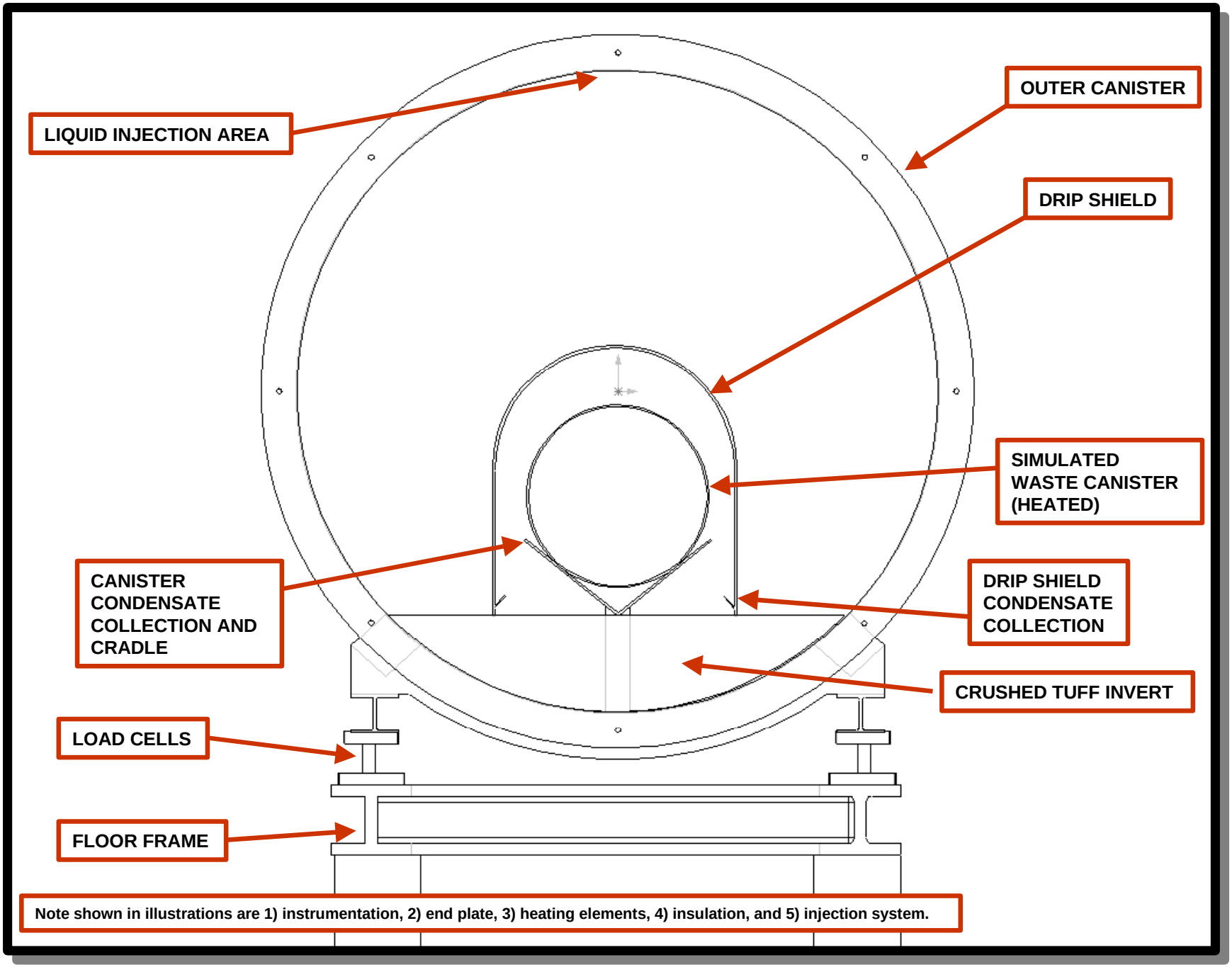
Water Balance

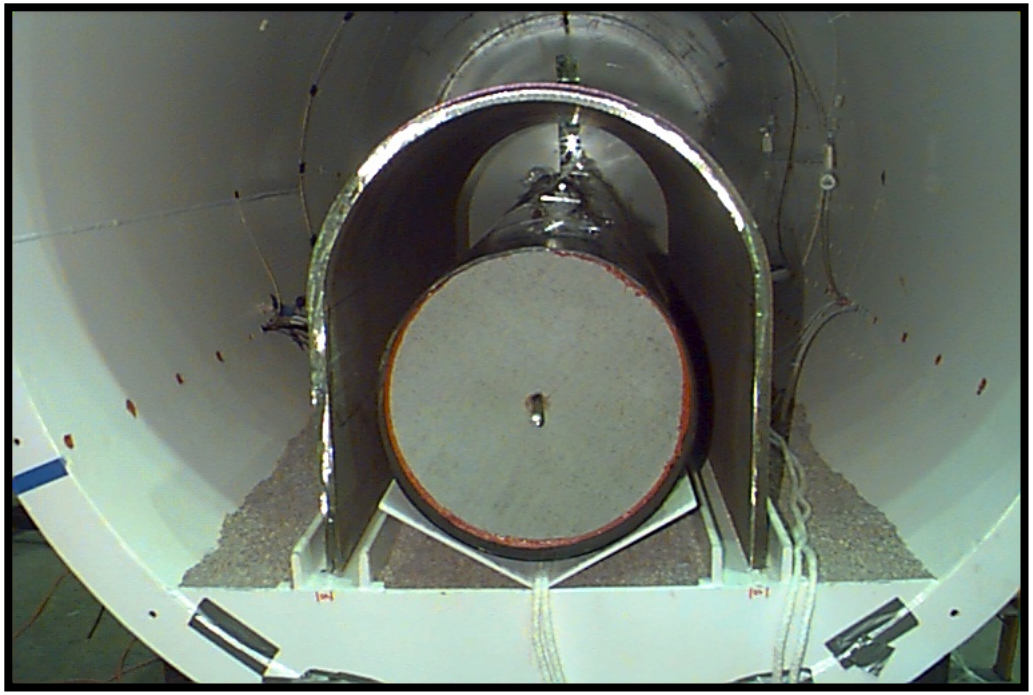


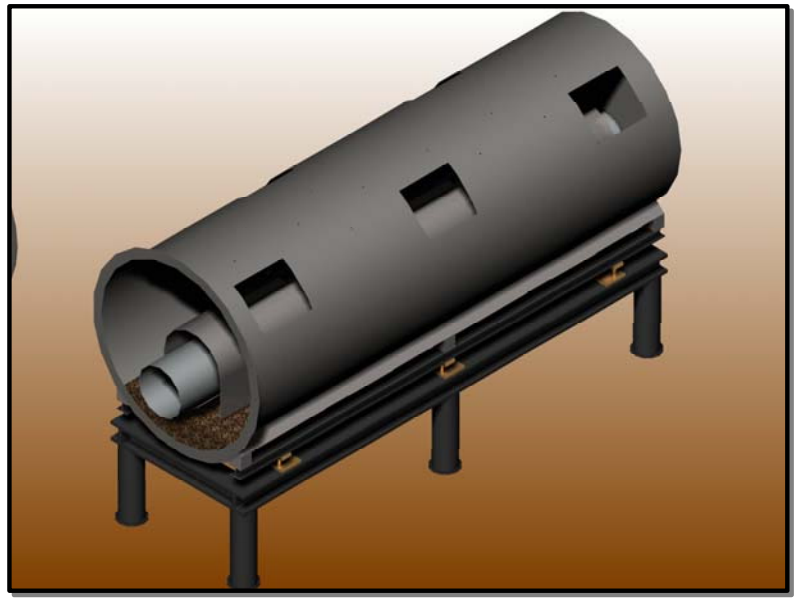
EBS Pilot-Scale Testing

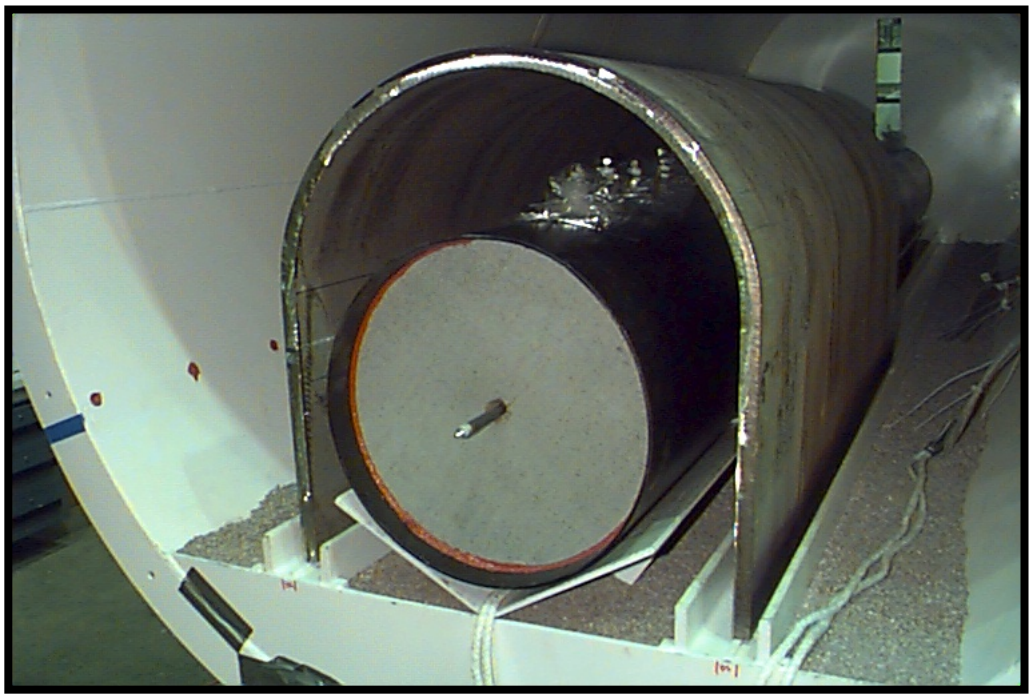
(Continued)

- **Evaluate thermal-hydrologic processes in EBS containing drip shield and waste package**
- **Test Canister #3 initiated in early June, 1999**
  - **EBS concept is Drip Shield (fabricated from 2 cm thick 304 stainless steel) with crushed tuff invert (no backfill) at elevated temperatures**
  - **Phase 1 involves heating with no drip shield**
  - **Phase 2 involves heating with drip shield**
  - **Phase 3 involves heating with drip shield and dripping under superpluvial rates**


LIQUID INJECTION AREA
OUTER CANISTER
DRIP SHIELD
SIMULATED WASTE CANISTER (HEATED)
CANISTER CONDENSATE COLLECTION AND CRADLE
DRIP SHIELD CONDENSATE COLLECTION
CRUSHED TUFF INVERT
LOAD CELLS
FLOOR FRAME
Note shown in illustrations are 1) instrumentation, 2) end plate, 3) heating elements, 4) insulation, and 5) injection system.

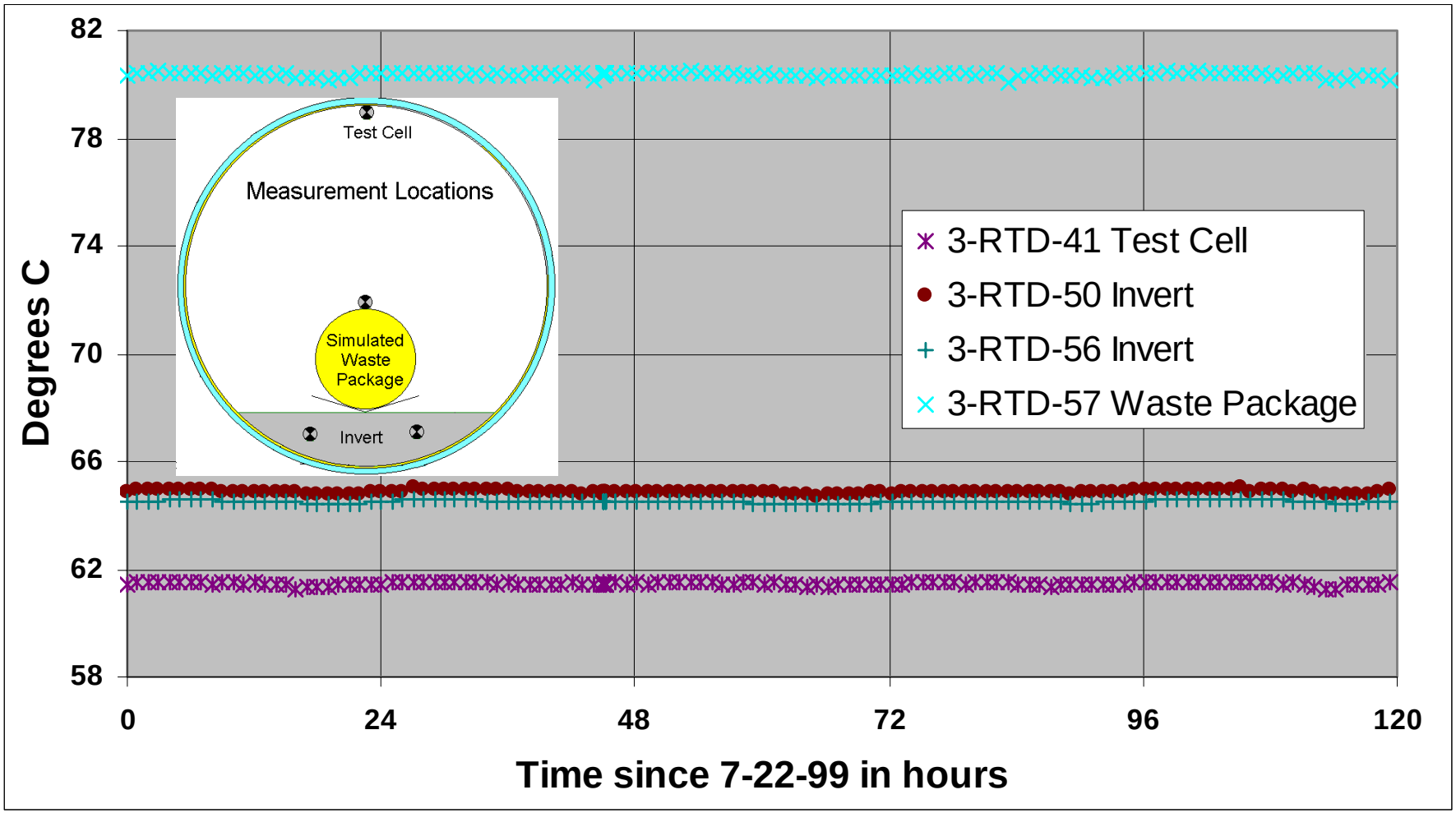






Engineered Barrier System

Canister 3 Temperatures



Waste Package Materials Testing

- **Objective is to confirm corrosion rates and mechanisms of candidate waste package and drip shield materials**
- **Both long-term and short-term testing is underway to address key materials degradation issues**
- **Test environments include range of expected water chemistries including near saturated J-13 solutions from dripping onto hot packages**

Waste Package Materials Testing
(Continued)

- **Localized corrosion testing is emphasizing cyclic polarization, crevice corrosion testing, and hydrogen pickup**
- **Long-term stability of passive films on Alloy 22, titanium Grade 7 and stainless steel is being evaluated utilizing short-term tests and detailed microstructural examination with the Atomic Force Microscope**

Waste Package Materials Testing
(Continued)

- **Stress corrosion cracking of all candidate alloys and hydrogen induced cracking of titanium alloys are being extensively evaluated utilizing a variety of crack initiation and growth tests**
- **Long-term thermal stability of Alloy 22 is being evaluated for the impact of the generation of ordered and precipitated intermetallic phases on long-term corrosion for both welded and aged specimens**