U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: UPDATE ON KEY SCIENTIFIC ACTIVITIES

PRESENTER: RUSSELL L. PATTERSON

PRESENTER'S TITLE AND ORGANIZATION: STAFF, ASSISTANT MANAGER SCIENTIFIC PROGRAMS
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT OFFICE
LAS VEGAS, NEVADA

TELEPHONE NUMBER: (702) 794-5469

JULY 9-10, 1996
DENVER, COLORADO

Key Scientific Activities

- **Unsaturated Zone Flow**
  - Discrete Fracture Model of Tiva Canyon Tuff
  - Flow Modeling
- **Pneumatic Testing**
  - Monitoring
  - Results and Interpretations (SD-7, SD-12, North Ramp Boreholes, Alcove 3)
- **Ghost Dance Fault Investigations**
  - Pneumatic Testing (UZ-7a)
  - Geothermal Borehole in Northern GDF Alcove

Key Scientific Activities

(Continued)

- Saturated Zone Investigations
  - G-2 Aquifer Test
  - Tracer Testing at C-Hole Complex
  - Site-Scale Saturated Zone Flow Model

Unsaturated Zone Flow

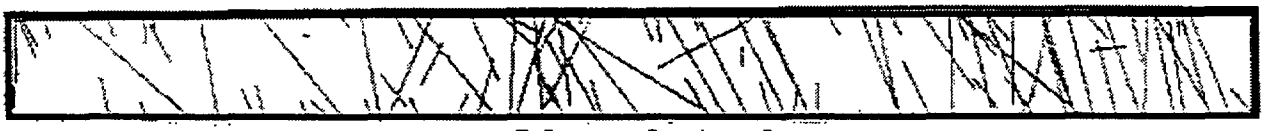
- Discrete Fracture Model of the Tiva Canyon Tuff
  - Model will simulate the interrelationship between the fracture geometry and the flow system
  - Detailed mapping of the Tiva Canyon Tuff in the ESF Starter Tunnel
  - 3-D fracture network was simulated using FracMan model

Unsaturated Zone Flow

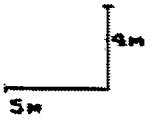
(Continued)

- **Discrete Fracture Model of the Tiva Canyon Tuff**
  (continued)
  - **Model simulated fracture intensities match well with mapped fracture intensities**
  - **Modeling indicates large number of poorly connected fractures within the Tiva unit with few flow paths in a large rock volume.**
  - **Additional application of modeling will be applied to other stratigraphic units**

ESF North Portal - Right Bench Traceplane



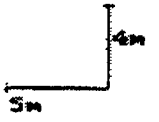
Simulated



Mapped

ESF North Portal - Left Bench Traceplane

Simulated



Mapped

Source: Tiva Canyon fracture model. Mapped area within ESF stations 1+00 and 2+00

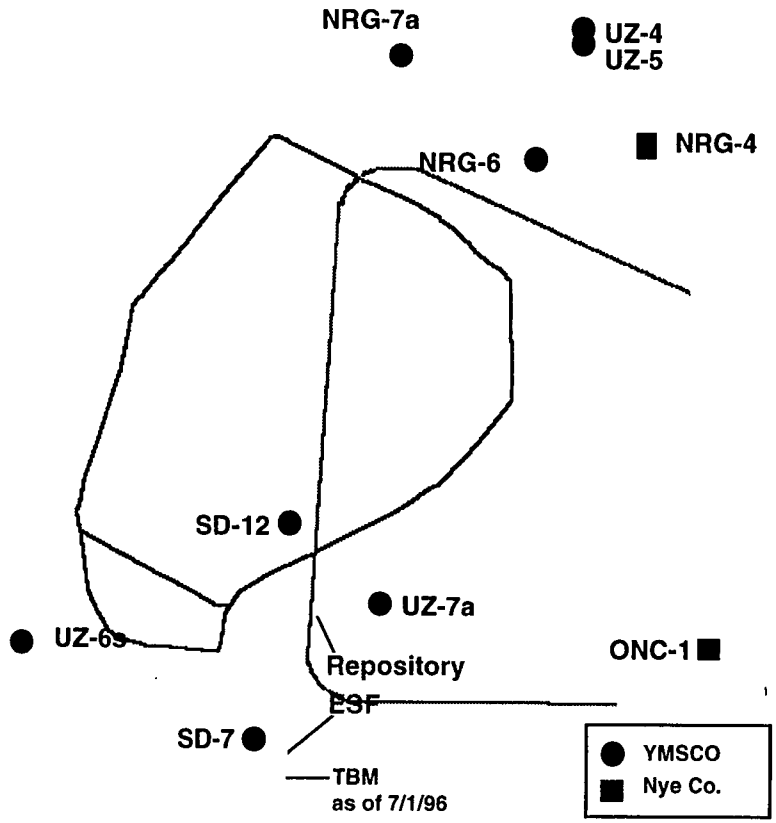
Unsaturated Zone Flow

(Continued)

- Flow Modeling
  - Model calibrations of gas flow, thermal, moisture tension, saturation and perched water are underway
  - Modeling assessment and evaluation of ^{36}Cl and other environmental isotopes has begun
  - Evaluation of percolation flux at the repository horizon for different infiltration maps, numerical formulations and rock properties is underway

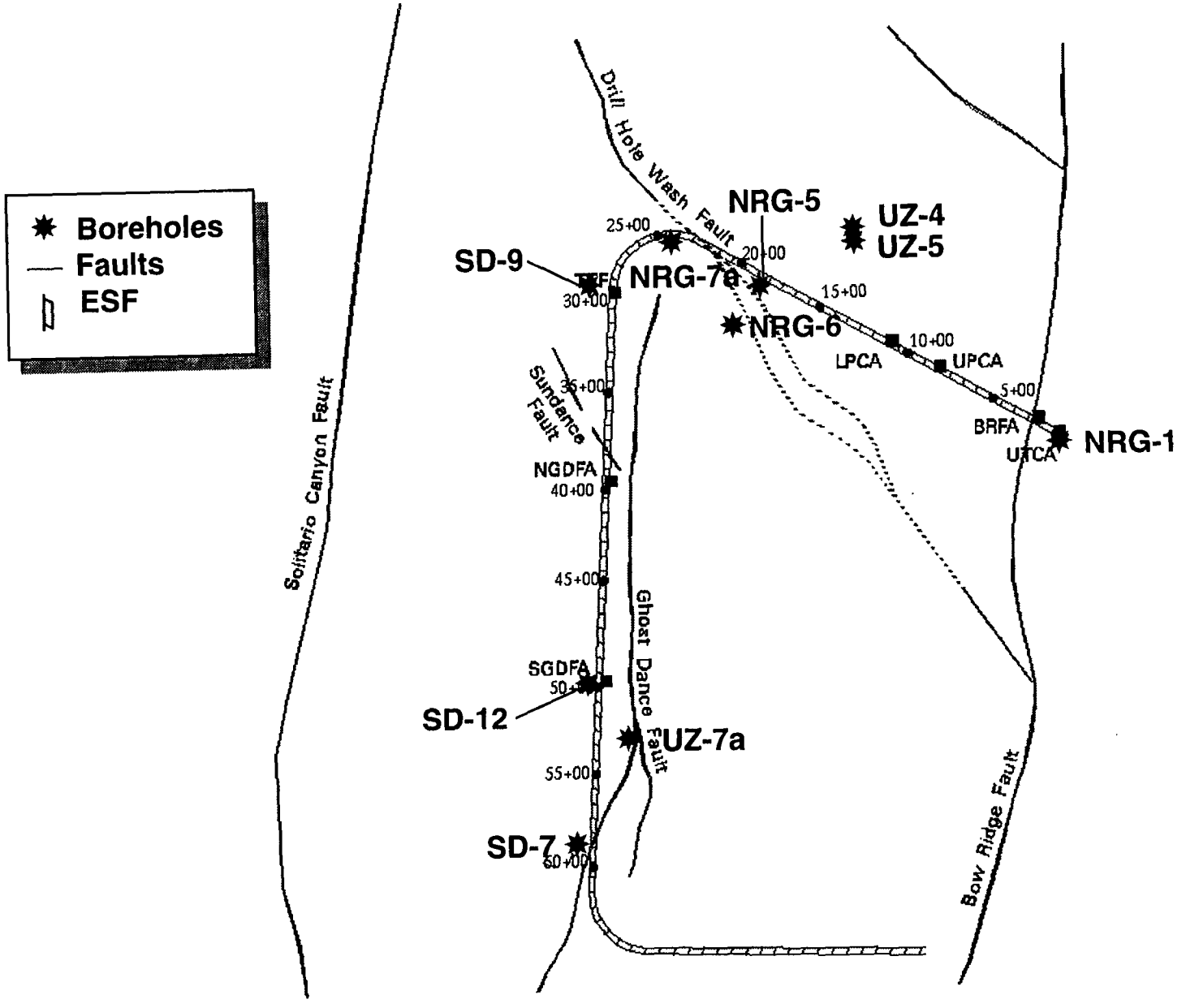
Pneumatic Testing/Monitoring

- DOE currently monitoring eight boreholes
- Nye County monitoring an additional two boreholes
- Response at depth to barometric pressure fluctuations recorded
- Pneumatic response to ESF penetrating PTn recorded
- Pressure response calculations made with UZ gas flow model



Pneumatic Interference Events From ESF Construction

Borehole	Date Event First Observed	Position of TBM (ESF Station)	Horizontal Offset Distance to Affected Borehole in feet (meters)
NRG #1	06/16/95	10 + 68.3	82 (25)
UZ #4	08/12/95	12 + 61.8	1,515 (462)
UZ #5	08/12/95	12 + 61.8	1,390 (424)
NRG #5	09/14/95	16 + 56.3	197 (60)
NRG-6	10/01/95	20 + 02.1	1,631 (497)
NRG-7a	10/21/95	23 + 46.8	157 (48)
SD-9	11/07/95	26 + 54.7	357 (109)


Boreholes
Faults
ESF
Drill Hole Wash Fault
Solitario Canyon Fault
Sundance Fault
Ghost Dance Fault
Bow Ridge Fault
NRG-5
UZ-4
UZ-5
SD-9
NRG-7a
NRG-6
NRG-1
SD-12
UZ-7a
SD-7
25+00
20+00
15+00
10+00
5+00
30+00
35+00
40+00
45+00
50+00
55+00
60+00
LPCA
UPCA
BRFA
UTCA
NGDFA
SGDFA

Pneumatic Testing

(Continued)

- North Ramp Boreholes (UZ-4, UZ-5, NRG-6, NRG-7a)
  - Air K measurements of $\geq$ 10 Darcies have been recorded in the TCw
  - TSw stations showed no amplitude reductions (due to the presence of the PTn) or temporal offsets with increasing depth
  - Air K measurements based on air-injection data indicate horizontal to vertical anisotropy ratios of 10:1 in the TCw and 1:10 in the TSw

Pneumatic Testing

(Continued)

- **North Ramp Boreholes** (continued)
  - This dramatic difference in anisotropy is probably due to sub-horizontal unloading fractures in the TCw, not present at depth in the TSw
  - Important implications for liquid water movement in the repository horizon
    - » Water will have a much stronger tendency to move vertically downward than to spread horizontally
  - Above conclusions being incorporated in evolving UZ site scale flow model

Pneumatic Testing

(Continued)

- Pneumatic response to TBM in main drift boreholes
  - SD-12 record suggests that pneumatic response effects were seen on February 26, 1996, shortly (3 days) after the TBM entered the highly fractured zone (42 + 96, approx. 1,100 feet separation distance)
  - SD-7 record showed effects on June 5, 1996; TBM located at approximately 56 + 11, about 39m south of closest approach by TBM to borehole.

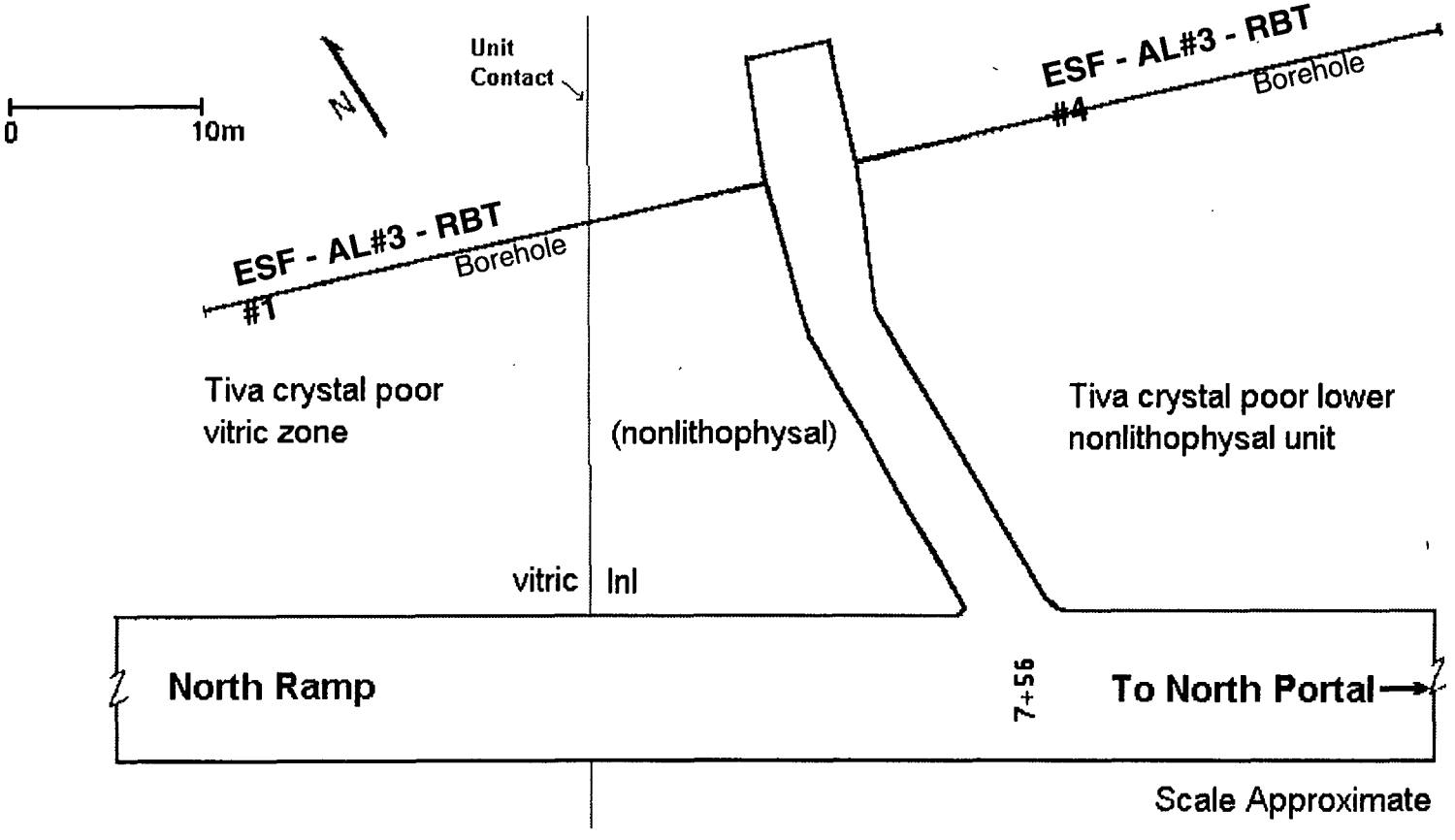
Pneumatic Testing

(Continued)

- **Pneumatic Response at UZ-7a**
  - **Monitoring since November 1995 indicates, unlike NRG boreholes and SD-12, only minor attenuation occurring across the PTn**
  - **In addition, atmospheric pressure changes detected in TSw slightly before or about the same time as in PTn**
  - **Suggests that the pneumatic system is being "short-circuited" by the Ghost Dance Fault**

ESF Alcove 3

Test of lower Tiva hydrostratigraphic unit; two radial boreholes ~ 30 m deep each



Pneumatic Testing

(Continued)

- Alcove 3 (ESF upper PTn contact)
  - Multi-zone packer assemblies installed in boreholes 1 and 4
  - Minimal pressure decreases and time lags observed in the monitored intervals
  - Suggests that the upper nonwelded unit has a large gas permeability
  - Alcove testing results generally support results obtained from surface based testing

Ghost Dance Fault Investigations

- Geothermal Borehole in Northern GDF Alcove 6
  - 30 meter horizontal exploratory borehole through GDF prior to alcove construction across the fault
  - Core samples taken for laboratory measurements, including hydrologic properties, apparent ages of secondary minerals, isotope hydrology, and hydrochemistry

Ghost Dance Fault Investigations

(Continued)

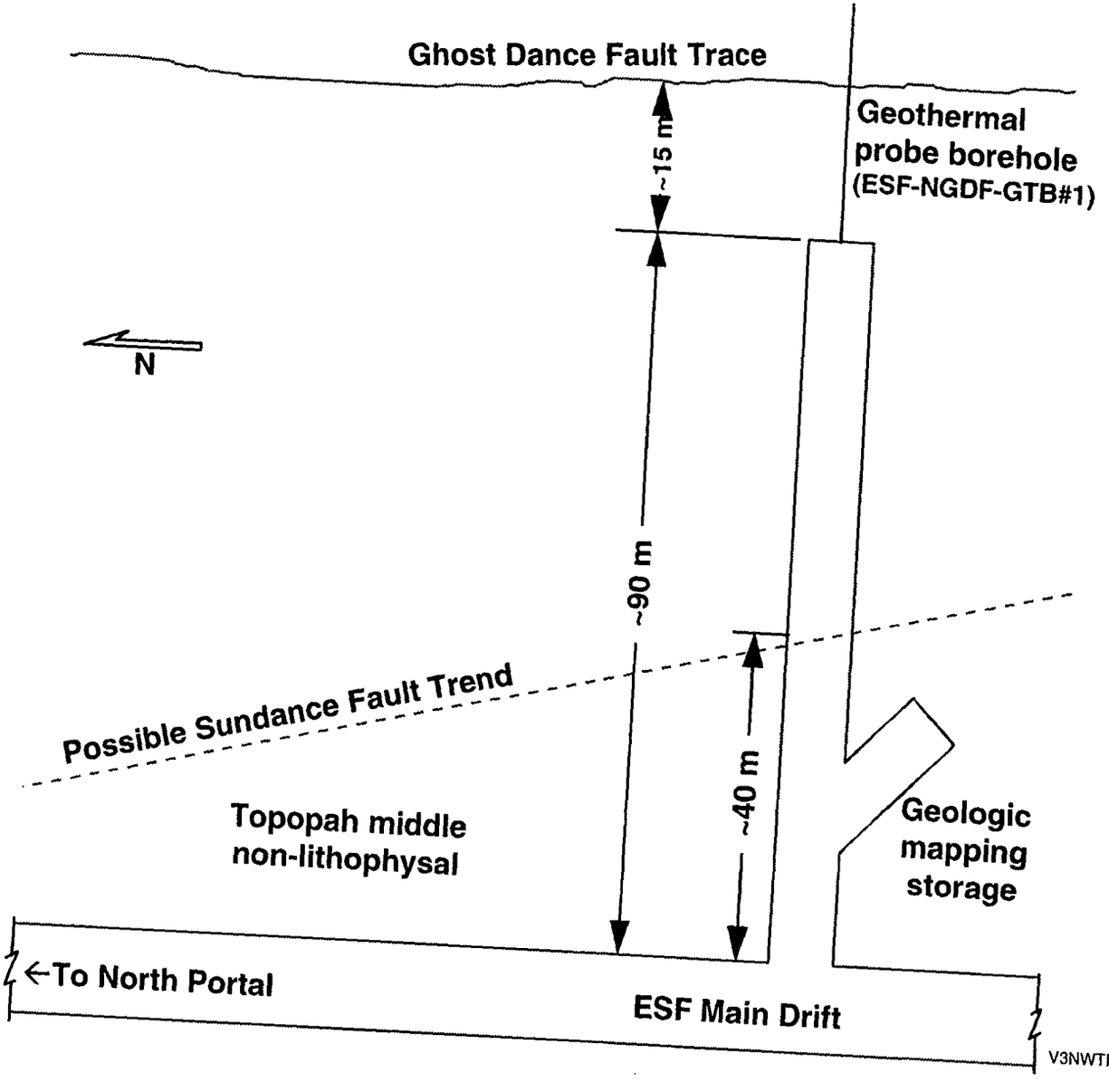
- **Geothermal Borehole in Northern GDF Alcove 6**
  (continued)
  - **Borehole instrumentation and monitoring**
    - » **Temperature logging - profiles across the fault to observe any evidence of moisture or gas movement**
    - » **Geophysical logging - porosity and water content profiles across the fault to help assess the role of the fault as a drain or barrier to water flow**

Ghost Dance Fault Investigations

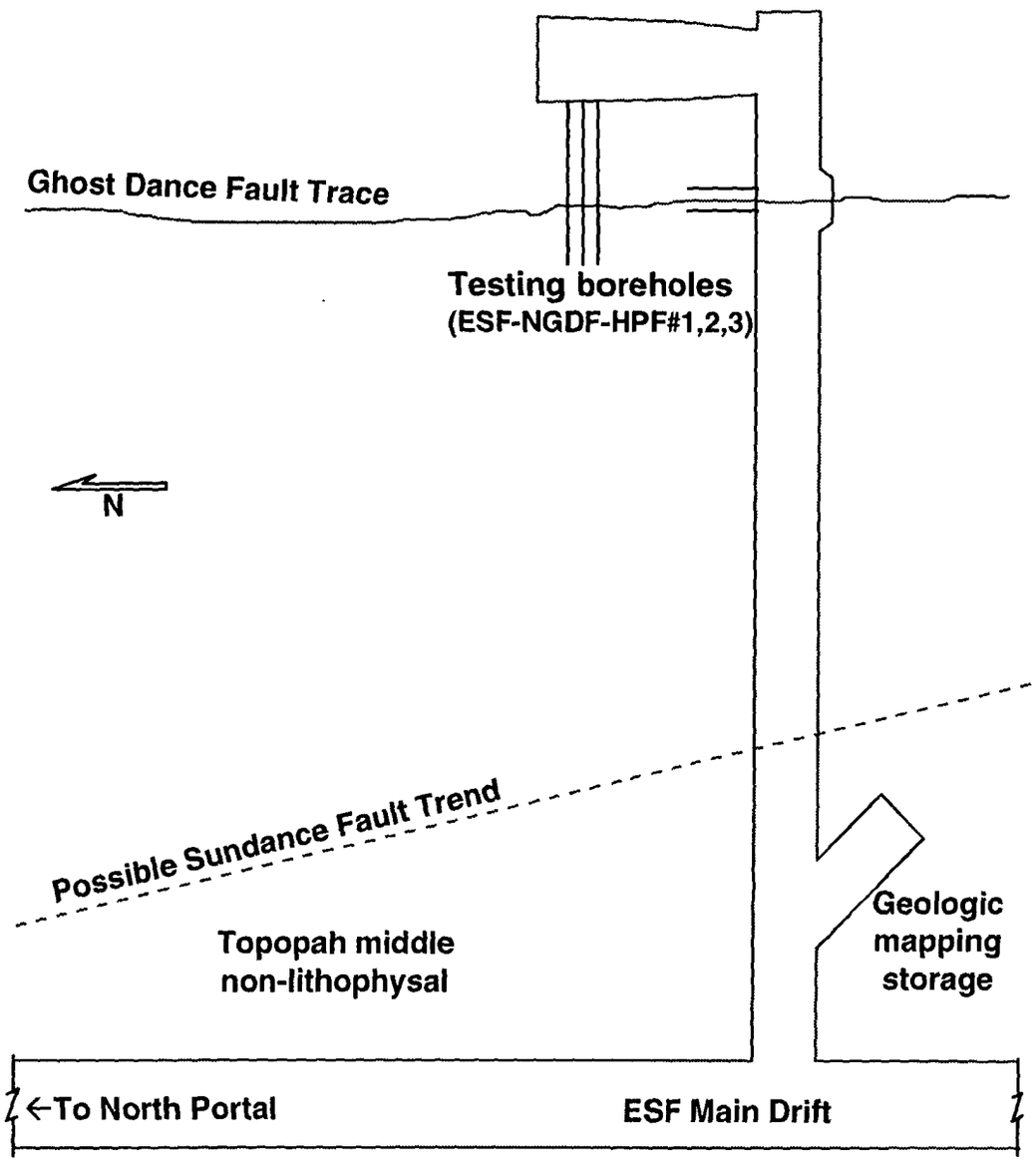
(Continued)

- **Geothermal Borehole in Northern GDF Alcove 6** (continued)
  - **Borehole instrumentation and monitoring** (continued)
    - » **Pressure monitoring - in selected packed-off intervals across the fault to provide a measure of vertical pneumatic diffusivity and connectivity within the fault**
    - » **Gas sampling - in packed-off intervals across the fault for geochemical analysis to provide data on residence times and transport processes**
    - » **Air K testing - single hole testing across the fault to evaluate transmissive properties of the fault and adjacent rock**

ESF Alcove 6: Phase I



ESF Alcove 6: Phase II



Saturated Zone Investigations

- C-Hole Complex Testing
  - Purpose is to conduct hydraulic and tracer tests in the saturated zone to provide flow and transport parameters for site models
  - Have completed two hydraulic tests and two conservative tracer tests during the past year
  - Third conservative tracer test continues
  - Future planned testing activities will be finalized after completion of present testing

Saturated Zone Investigations

- G-2 Aquifer Test
  - Purpose is to assist in investigation of the large hydraulic gradient north of site
  - Continuing to monitor recovery from second pump test
  - Awaiting results of lab analyses and interpretations of field and laboratory data

Saturated Zone Investigations

(Continued)

- **Site-Scale Saturated Zone Flow Model**
  - Model domain and potentiometric surface contours with well control established
  - First iteration of model under development
  - Grid generation and flow modeling in progress

Saturated Zone Investigations

(Continued)

- Regional Saturated Zone Investigations
  - First iteration of model completed
  - Final iteration under development

Conclusions

- Pneumatic data continue to constrain role of PTn and GDF in UZ flow
- Geothermal borehole will provide important data on the role of GDF in UZ flow
- Discrete fracture model of Tiva Canyon Tuff simulates distribution of fractures in ESF Starter Tunnel
- Calibration with observed conditions is in progress

Conclusions

(Continued)

- G-2 and C-hole tests continue to provide constraints on SZ flow and transport
- First iteration of site-scale SZ flow model in progress
- Final iteration of regional-scale SZ flow model in progress