

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

**NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING**

**SUBJECT: EXPLORATORY STUDIES FACILITY
TESTING**

PRESENTERS: DENNIS R. WILLIAMS

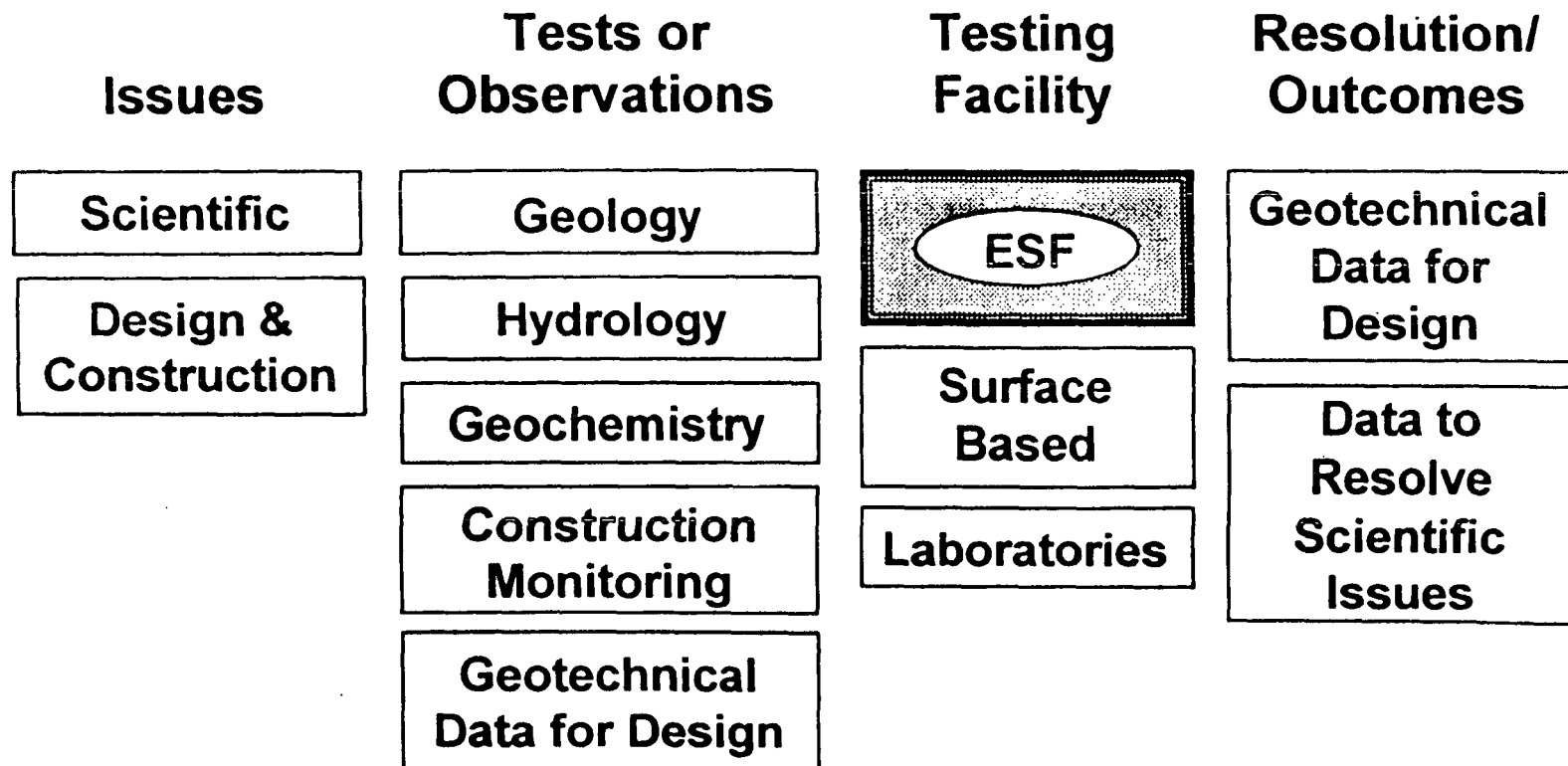
**PRESENTER'S TITLE
AND ORGANIZATION: DEPUTY ASSISTANT MANAGER, SCIENTIFIC PROGRAMS
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
LAS VEGAS, NEVADA**

**PRESENTER'S
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**BEATTY, NEVADA
JANUARY 11, 1995**

Testing Program

Surface Based Testing & Testing Program in the ESF



Objective of Testing

- 1 Satisfy needs of 1998 TSS (Near Term)**
 - field information cut-off is end of 1996.
- 2 Satisfy needs of 2001 LA (Intermediate Term)**
 - field information cut-off is end of 1999.
- 3 Satisfy needs of 2008 License Amendment (Long Term)**
 - field information cut-off is 2006, although confirmation testing continues.

Prioritization of ESF Testing

Basis

- 1 Irretrievable data.
- 2 Satisfy needs of TSS and LA through reducing key uncertainties in waste isolation strategy and by gathering adequate data to docket LA.
- 3 Long duration tests.

Irretrievable Data

- 1 Perched water.**
- 2 Geologic mapping.**
- 3 Construction monitoring.**
- 4 Testing for pneumatic response/properties.**

Address Specific Board Question

- **Test alcoves are planned at the upper and lower contacts of the Paint Brush vitric nonwelded tuff unit (PTn), in which geomechanical, hydrogeologic and geochemical tests are to be performed.**
 - ***What specific data is to be collected in these test alcoves, and how will this data support the site suitability determination?***
 - ***What rationale led to the decision to make this testing of higher priority than all other exploration and testing activities?***
 - ***Does this high priority result from linkage to the waste isolation strategy?***

Tests in Alcoves 3 and 4 (in Upper and Lower Contacts of PTn)

- 1 Tests driven by waste isolation strategy.**
- 2 Address key uncertainty regarding percolation distribution.**
- 3 Data to be collected are bulk permeability, composition of fluids, test results on fluid movement. (Hydrochemistry & radial borehole tests).**
- 4 Confirm contrast in hydrologic and pneumatic properties between PTn and adjoining strata.**

Reducing Key Uncertainties

Key Uncertainty	ESF Activity/Test
1. Extent of perched water and seeps	1. Monitor seeps during: 1) construction monitoring, 2) geologic mapping, & 3) consolidated sampling
2. Time for water to reach repository and water chemistry	2. Heater tests: 1) water chemistry samples, and 2) observe distribution and precipitation of minerals
3. Focusing/channeling of infiltration flux	3. Observe and sample seeps
4. Potential extent of pitting and microbiologically induced corrosion	4. *Monitor microbe population *Material coupons placed in EBS field test
5. *Fraction of waste package surface degraded *Potential for liquid film *Diffusion rate in backfill material *Advective flow in EBS	5. EBS field test- *Mode of contact *Quantify of water, water chemistry *Sampling for rock-water interaction testing
6. Travel time in unsaturated zone	6. *Radial borehole testing *Diffusion testing *Fracture mapping *Major fault test *Monitoring seeps

Reducing Key Uncertainties (continued)

Key Uncertainty	ESF Activity/Test
7. Conceptual model for fracture-matrix coupling in partially saturated media	7. Same as in #6 above
8. Dispersion caused by small-scale heterogeneity	8. In-situ transport experiments in Calico Hills and/or P-Tunnel
9. Effect of heat on near-field processes and waste package environment	9. Heater tests in the ESF to study coupled thermal-mechanical-hydrologic-chemical processes
10. Potential effect of faulting and ground motion on engineered barriers Potential development of or renewal of flow paths along faults Potential for water table rise	10. Underground mapping -- drifts, fault location and characteristics
11. Potential volcanic effects -repository -water table -waste packages -faulting/fractures	11. Underground mapping -- all drifts
12. Direct intrusion, introduction of fluids	12. Evaluate samples for metallic resources

Critical Data from the ESF for TSS and License Application

- **Geology**

- **Geologic mapping will augment the database for the site stratigraphic and structural model, laboratory testing of samples collected from the ESF will help understand the spatial distribution of rock properties in the block.**

- **Hydrology**

- **Tests in alcoves and monitoring and testing of possible perched water will provide data to investigate the flow of fluids in the unsaturated zone, barriers to flow, potential fast pathways and bulk permeability.**

- **Geochemistry**

- **Samples collected from the ESF will be used to study bulk and fracture mineralogy, to perform microbiological assay of ambient microbe population and to study the effect of man-made materials on waste package environment.**

Critical Data from the ESF for TSS and License Application (continued)

- **Heater Tests in ESF**
 - **Thermal tests in the ESF will provide data to understand the effect of heat on the coupled thermal-mechanical-hydrological-chemical processes in the near-field.**
- **Construction Monitoring**
 - **These are measurement of irretrievable data of the rock mass response to excavation.**

ESF TEST PROGRAM LOCATIONS

TBM TESTING

- HYDROCHEMISTRY TESTS IN THE ESF
- CONSOLIDATED SAMPLING
- UNDERGROUND GEOLOGICAL MAPPING
- PERCHED-WATER TESTING IN THE ESF (CONTINGENCY)
- CONSTRUCTION MONITORING

NORTH PORTAL

ALCOVE #1 (Completed January, 1994)

- HYDROCHEMISTRY TESTS
- RADIAL BOREHOLE TESTS (ANISOTROPIC)

ALCOVE #2 (March, 1995)

- HYDROCHEMISTRY TESTS
- HYDROLOGIC PROPERTIES OF MAJOR FAULTS (BOV RIDGE)

9 DEFERRED ALCOVES
IN THE NORTH RAMP

NORTH RAMP

ALCOVE #3 (September, 1995)

- HYDROCHEMISTRY TESTS
- RADIAL BOREHOLE TESTS (TIVA CANYON/PTn CONTACT)

ALCOVE #4 (October, 1995)

- HYDROCHEMISTRY TESTS
- RADIAL BOREHOLE TESTS (PTn/TSw CONTACT)

ALCOVE #5 (March 1996)

- HYDROCHEMISTRY TESTS
- HYDROLOGIC PROPERTIES OF MAJOR FAULTS (DRILL HOLE WASH)

SOUTH PORTAL

**CORE TEST AREA
OR
NORTH RAMP EXTENSION**

- THERMAL/MECHANICAL PROPERTIES
- NEAR-FIELD HYDROLOGIC/GEOMECHANICAL PROPERTIES
- DIFFUSION TESTS IN THE ESF
- PERCOLATION TESTS IN THE ESF
- CONSOLIDATED SAMPLING
- UNDERGROUND GEOLOGICAL MAPPING
- RADIAL BOREHOLE TESTS IN THE ESF
- HYDROCHEMISTRY TESTS IN THE ESF
- CONSTRUCTION MONITORING

ALCOVE #6 (July, 1996)

- HYDROCHEMISTRY TESTS
- HYDROLOGIC PROPERTIES OF MAJOR FAULTS (SUNDANCE/GHOST DANCE)

MAIN DRIFT

ALCOVE #7 (November, 1996)

- HYDROCHEMISTRY TESTS
- HYDROLOGIC PROPERTIES OF MAJOR FAULTS (GHOST DANCE)

SOUTH RAMP

4 DEFERRED ALCOVES
IN THE MAIN DRIFT

13 DEFERRED ALCOVES
IN THE SOUTH RAMP

NOTES:

FINAL DECISIONS ON DEFERRAL:
TEST/EXCAVATION AND TESTING IN DEFERRED ALCOVES IS DEPENDENT ON OBSERVATIONS DURING OPERATION AND EVALUATION OF EARLY TEST RESULTS, AND PROGRAM PRIORITIES.

Location of Test Alcoves

Alcove	Location	Test
Alcove #1	In Starter Tunnel	Radial Borehole Test, Hydrochemistry Test in Tiva Canyon
Alcove #2	Next to Bow Ridge Fault	Hydrologic Properties of Major Fault, Hydrochemistry Test
Alcove #3	Tiva Canyon/PTn contact	Radial Borehole Test, Hydrochemistry Test
Alcove #4	PTn/TSw1 contact	Radial Borehole Test, Hydrochemistry Test
Alcove #5	Next to Drill Hole Wash	Hydrologic Properties of Major Faults, Hydrochemistry Test
Alcove #6	To Ghost Dance Fault (Ghost Dance/Sundance Contact)	Hydrologic Properties of Major Faults, Hydrochemistry Test
Alcove #7	To Ghost Dance Fault	Hydrologic Properties of Major Faults, Hydrochemistry Test

SUMMARY TABLE OF PLANNED ESF TESTS
GROUPED BY CONSOLIDATED PROGRAM
(SOURCE: ESF TPP 91-5)

SCP TEST ACTIVITY	SCPB REFERENCE NUMBER	SCP PROGRAM NAME
<i>Consolidated Sampling*</i>		
• Chloride & Chlorine-36 Measurements of Percolation at YM	8.3.1.2.2.2.1	Geochemistry
• Matrix Hydrologic Properties Testing	8.3.1.2.2.3.1	Geohydrology
• Petrologic Stratigraphy of the Topopah Spring Member	8.3.1.3.2.1.1	Geohydrology
• Mineral Distribution Between Host Rock and Accessible Environment	8.3.1.3.2.1.2	Geohydrology
• Fracture Mineralogy Studies of the ESF	8.3.1.3.2.1.3	Geohydrology
• History of Mineralogic and Geochemical Alteration of YM	8.3.1.3.2.2.1	Geohydrology
• Biological Sorption and Transport	8.3.1.3.4.2	Geohydrology
• Laboratory Tests (Thermal & Mechanical) Using Samples	See Note 1	Thermal & Mech. Rock Prop.
• Repository Horizon Rock-Water Interaction	8.3.4.2.4.4.2	Waste Package Characteristics
<i>Intact-Fracture Test</i>	8.3.1.2.2.4.1	Geohydrology
<i>Percolation Tests in the ESF</i>	8.3.1.2.2.4.2	Geohydrology
<i>Radial Borehole Tests in the ESF</i>	8.3.1.2.2.4.4	Geohydrology
<i>Bulk Permeability Test in the ESF</i>	8.3.1.2.2.4.3	Geohydrology
<i>Excavation Effects Test</i>	8.3.1.2.2.4.5	Geohydrology
<i>Perched-Water Testing in the ESF</i>	8.3.1.2.2.4.7	Geohydrology
<i>Hydrochemistry Tests in the ESF</i>	8.3.1.2.2.4.8	Geohydrology
<i>Hydrologic Properties of Major Faults Encountered in the ESF</i>	8.3.1.2.2.4.10	Geohydrology
<i>Diffusion Test in the ESF</i>	8.3.1.2.2.5.1	Geohydrology
<i>Field Scale Experiments to Study Radionuclide Transport at YM</i>	8.3.1.3.7.2.2	Geochemistry
<i>Underground Geological Mapping</i>	8.3.1.4.2.2.4	Rock Characteristics
<i>Seismic Tomography/Vertical Seismic Profiling at the ESF</i>	8.3.1.4.2.2.5	Rock Characteristics
<i>Construction Monitoring*</i>		
• Access Convergence Test at the ESF	8.3.1.15.1.5.1	Thermal & Mech. Rock Prop.
• Evaluation of Mining Methods	8.3.1.15.1.8.1	Thermal & Mech. Rock Prop.
• Monitoring of Ground Support Systems	8.3.1.15.1.8.2	Thermal & Mech. Rock Prop.
• Monitoring Drift Stability	8.3.1.15.1.8.3	Thermal & Mech. Rock Prop.
<i>Thermal/Mechanical Properties*</i>		
• Heater Experiment in TSw1	8.3.1.15.1.6.1	Thermal & Mech. Rock Prop.
• Canister-Scale Heater Experiment	8.3.1.15.1.6.2	Thermal & Mech. Rock Prop.
• Yucca Mountain Heated Block	8.3.1.15.1.6.3	Thermal & Mech. Rock Prop.
• Thermal Stress Measurements	8.3.1.15.1.6.4	Thermal & Mech. Rock Prop.
• Sequential Drift Mining	8.3.1.15.1.5.3	Thermal & Mech. Rock Prop.
• Heated Room Experiment	8.3.1.15.1.6.5	Thermal & Mech. Rock Prop.
• Plate Loading Tested Block	8.3.1.15.1.7.1	Thermal & Mech. Rock Prop.
• Rock-Mass Strength Experiment	8.3.1.15.1.7.2	Thermal & Mech. Rock Prop.
• Overcore Stress Experiment in the ESF	8.3.1.15.2.1.2	Thermal & Mech. Rock Prop.
<i>Air Quality and Ventilation Experiment</i>	8.3.1.15.1.8.4	Thermal & Mech. Rock Prop.
<i>In Situ Testing of Seal Components</i>	8.3.3.2.2.3	Seal Characteristics
<i>Near-Field Hydrologic/Geomechanical Properties*</i>		
• Mechanical Attributes of the Waste Package Environment	8.3.4.2.4.3	Waste Package Characteristics
• Repository Horizon Near-Field Hydrologic Properties	8.3.4.2.4.4.1	Waste Package Characteristics

NOTE: 1) 8.3.1.15.1.1.1; 8.3.1.15.1.1.2; 8.3.1.15.1.1.3; 8.3.1.15.1.2.1; 8.3.1.15.1.3.1; 8.3.1.15.1.3.2; 8.3.1.15.1.4.1; 8.3.1.15.1.4.2
2) ESF locator test names (Calico Hills Test, Demonstration Breakout Room) are not separately listed.
3) *Multi-Purpose Borehole Test* (Optional =SF Shaft Test) is not listed.
4) *Development and Demonstration of Required Equipment Test* is not currently planned.
Consolidated Test Program Name

CONSOLIDATED ESF TEST PROGRAMS
CATEGORIZED BY LICENSE APPLICATION AND MAJOR SITE SUITABILITY REPORTS
SUPPORTED*
(SOURCE: OMB 5-YEAR PLAN)

ESF TEST/PROGRAM	TECHNICAL BASIS REPORTS SUPPORTING HIGHER LEVEL FINDINGS
<i>Consolidated Sampling</i>	<ul style="list-style-type: none"> • Geochemistry/Post Closure Rock Characteristics • Geohydrology/Transport • Preclosure Rock Characteristics
<i>Intact-Fracture Test</i>	<ul style="list-style-type: none"> • Geohydrology/Transport
<i>Percolation Tests in the ESF</i>	<ul style="list-style-type: none"> • Geohydrology/Transport
<i>Radial Borehole Tests in the ESF/ Bulk Permeability Test in the ESF</i>	<ul style="list-style-type: none"> • Geohydrology/Transport
<i>Excavation Effects Test</i>	<ul style="list-style-type: none"> • Geohydrology/Transport
<i>Perched-Water Testing in the ESF</i>	<ul style="list-style-type: none"> • Geohydrology/Transport
<i>Hydrochemistry Tests in the ESF</i>	<ul style="list-style-type: none"> • Geohydrology/Transport
<i>Hydrologic Properties of Major Faults Encountered in the ESF</i>	<ul style="list-style-type: none"> • Geohydrology/Transport
<i>Diffusion Test in the ESF</i>	<ul style="list-style-type: none"> • Geohydrology/Transport
<i>Field Scale Experiments to Study Radionuclide Transport at YM</i>	<ul style="list-style-type: none"> • Geohydrology/Transport
<i>Underground Geological Mapping</i>	<ul style="list-style-type: none"> • Preclosure Rock Characteristics • Geochemistry/Postclosure Rock Characteristics
<i>Seismic Tomography/Vertical Seismic Profiling at the ESF</i>	<ul style="list-style-type: none"> • Geochemistry/Preclosure Rock Characteristics
<i>Construction Monitoring</i>	<ul style="list-style-type: none"> • Preclosure Rock Characteristics • Reasonably Available Technology
<i>Thermal/Mechanical Properties</i>	<ul style="list-style-type: none"> • Geochemistry/Postclosure Rock Characteristics
<i>Air Quality and Ventilation Experiment</i>	
<i>In Situ Testing of Seal Components</i>	<ul style="list-style-type: none"> • Reasonably Available Technology
<i>Near-Field Hydrologic/Geomechanical Properties</i>	<ul style="list-style-type: none"> • License Application

* All tests and Consolidated Test Programs identified in the left column support elements of Total System Performance Assessment, Final Site Recommendation Report, and License Application, as well as the Technical Basis Reports identified in the right column

**IN SITU TEST LOCATIONS AND IMPLEMENTATION
LOGISTICS FOR ESF TESTS/PROGRAMS**
(SOURCES: SITE PROGRAM ANNUAL PLAN 1994 & 1996, OMB 5-YEAR PLAN)

YEARS IN PARENTHESIS INDICATE INITIAL START (PLANNED OR ACTUAL) OF TEST OR FIRST PROGRAM COMPONENT

- I. CONSTRUCTION PHASE (NON-DEFERRABLE) TESTS CONDUCTED IN TBM ENVELOPE
- Consolidated Sampling (1993)
 - Perched Water Testing in the ESF (Contingency) (1993)
 - Hydrochemistry Tests in the ESF (1995)
 - Underground Geological Mapping (1993)
 - Construction Monitoring (1993)
- II. CONSTRUCTION PHASE (NON-DEFERRABLE) TESTS IN ALCOVES
- Perched-Water Testing in the ESF (1994)
 - Consolidated Sampling (1994)
 - Radial Borehole Tests in the ESF (1994)
 - Hydrochemistry Tests in the ESF (1994)
 - Hydrologic Properties of Major Faults Encountered in the ESF (1995)
 - Underground Geological Mapping (1994)
 - Construction Monitoring (1994)
- III. DEFERRED (POST "INITIAL LOOP") TESTS IN THE ESF RAMPS/MAIN DRIFT
- Consolidated Sampling (1997)
 - Excavation Effects Test (1997)
 - Intact-Fracture Test in the ESF (1997)
 - Seismic Tomography/Vertical Seismic Profiling at the ESF (1997)
 - Construction Monitoring (1997)
 - Air Quality and Ventilation Experiment (1996)
 - In Situ Testing of Seal Components (1998)
- IV. IN SITU ALCOVE TESTS IN THE CORE TEST AREA/RAMP EXTENSIONS (TSw2)
(Including Deferred Ramp Alcoves)
- Consolidated Sampling (1994)
 - Radial Borehole Tests in the ESF (1994)
 - Hydrochemistry Tests in the ESF (1994)
 - Hydrologic Properties of Major Faults Encountered in the ESF (1995)
 - Underground Geological Mapping (1994)
 - Construction Monitoring (1994)
 - Percolation Tests in the ESF (1996)
 - Diffusion Test in the ESF (1996)
 - Thermal/Mechanical Properties (1996)
 - Near-Field Hydrologic/Geomechanical Properties (1997)
- V. PLANNED TESTS IN CALICO HILLS NONWELDED UNIT (All Tests TBD)
- Underground Geological Mapping
 - Consolidated Sampling
 - Field Scale Experiments to Study Radionuclide Transport at YM *
 - Intact-Fracture Test
 - Percolation Tests in the ESF
 - Radial Borehole Tests in the ESF/Bulk Permeability Tests in the ESF
 - Hydrochemistry Tests in the ESF
 - Diffusion Test in the ESF
 - In Situ Testing of Seal Components

Long Duration Tests

- 1 Drift scale heater test to study thermal mechanical-hydrologic-chemical coupled processes involve heating and cooling large volume of rock and hence require six to seven years to complete.**
- 2 For results of this test to be analyzed for selecting thermal load options prior to the application in 2008 to receive and possess waste this test will have to be started in 1998-99 time frame.**

Address Specific Board Question

- A thermal test alcove is to be located in the high lithophysae welded devitrified tuff (TSw1).
 - *What data is to be obtained and is the data to support the site suitability determination, licensing, or both?*
 - *What impact will the non-representative (i.e., to repository construction) drill and blast excavation and the introduction of water into the host rock during excavation affect thermal testing data?*
 - *What is the linkage between this testing and the reference repository thermal management strategy? The waste isolation strategy?*

Use of Results from Thermal Test in ESF

- 1 Primary use is for License Application.**
- 2 Observations during early phase of test may provide information supporting site suitability.**

Representativeness

- 1 Location of first ESF thermal test is not chosen yet.**
- 2 If TSw1 is chosen as location for the first ESF thermal test it will be so to start test early and it will be in that part (lower third of upper part) of TSw1 which is similar (non-lithophysal) to TSw2.**
- 3 Difference in the effect of excavation between mechanized method and controlled drill and blast is small and is outweighed by the ease and cost of construction of involved test configuration by controlled drill and blast.**
- 4 Major part of the water used in drill and blast is recoverable. Effect of water introduced during drilling on test results is considered small.**

Thermal Tests in ESF

- 1 Test driven by need for early understanding of coupled thermal-mechanical-hydrologic-chemical processes in the near-field.**
- 2 Test results will help decide thermal management strategy. Aspects of thermal testing are independent of thermal management strategy.**
- 3 Tests simulating high thermal load will also provide understanding of processes under low thermal load.**