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

NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: PLANNED *IN SITU* THERMAL TESTS

PRESENTER: WILLIAM J. BOYLE

PRESENTER'S TITLE AND ORGANIZATION: GEOLOGY AND GEOENGINEERING, TEAM LEADER
U.S. DEPARTMENT OF ENERGY
LAS VEGAS, NV

TELEPHONE NUMBER: (702)794-5506

JULY 9, 1996
DENVER, CO

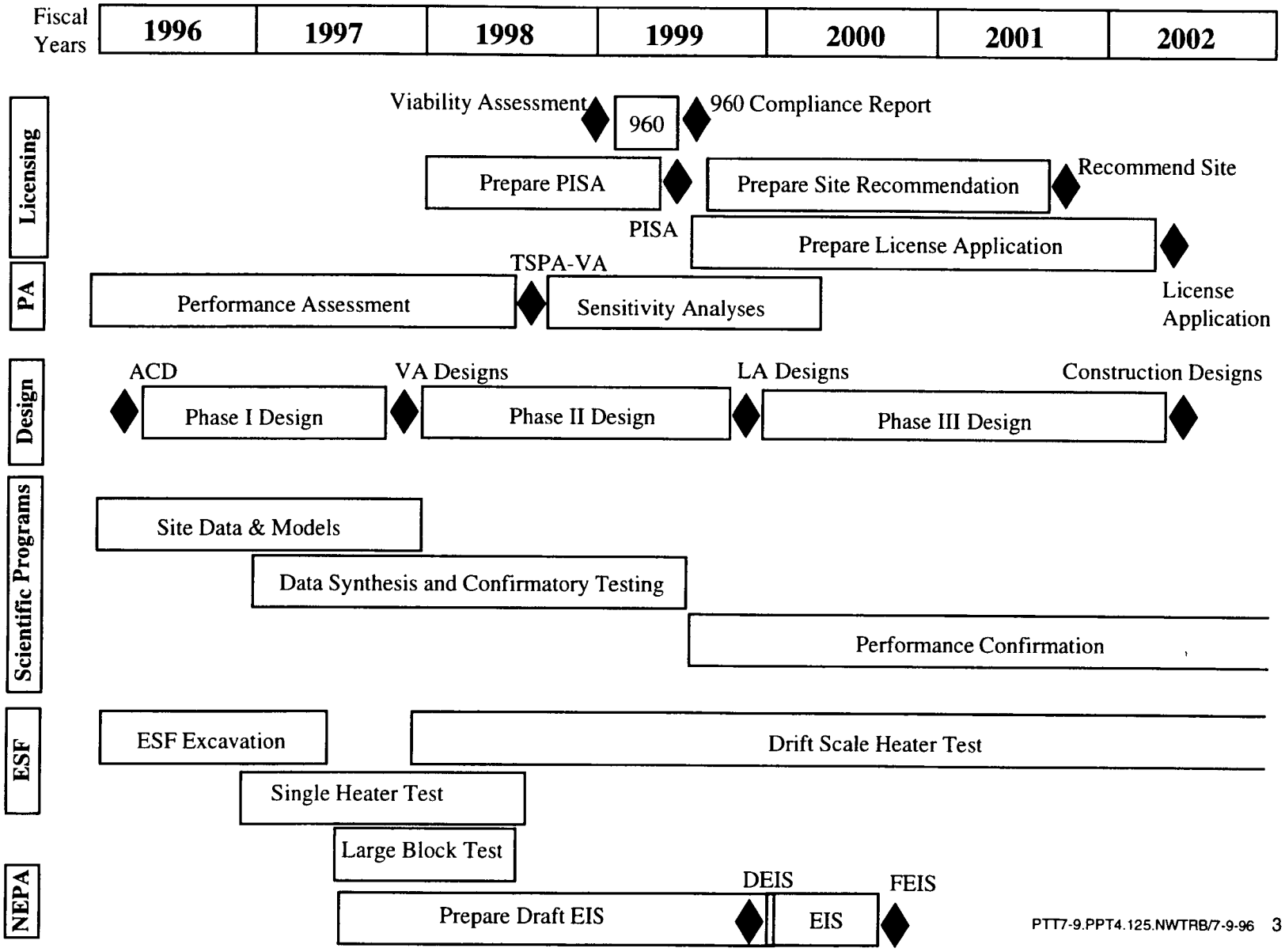
Utility of Thermal Test Data

- For Viability Assessment (VA) Design and VA
- TSPA
- Toward resolving issues identified in the Waste Containment and Isolation Strategy

- Understanding of heat-related processes and parameters

Utility of thermal test data for bullets 1, 2, and 3 is through bullet 4

Summary Schedule



Thermal Test Schedules

- **Large Block Test**
  - Heating starts 2/04/97
  - Cooling starts 8/04/97
  - Final report 4/02/98
- **Single Heater Test**
  - Heating starts 8/26/96
  - Cooling starts 5/28/97
  - Final report 5/19/98
- **Drift-Scale Test**
  - Heating initiated 8/97
  - Cooling initiated 9/99
  - Heating phase report 5/00
  - Status report 9/01

Viability Assessment Design

- **Results from the heating phase of the single-heater test and the large-block test will be available for VA Phase I Design**
  - **Rock mass thermal properties**
  - **Rock mass deformation properties at elevated temperatures**
  - **Rock-bolt anchor performance at elevated temperatures**

Viability Assessment

- **Viability Assessment**
  - **Large-block test complete**
  - **Single-heater test complete**
  - **One year of heating phase of drift-scale test**

All information will be used to enhance the credibility of process models that are the foundation of TSPA

Waste Containment Isolation Strategy (WCIS) Issues

To Be Addressed by Thermal Tests

- Seepage ♣ ♠
- Waste Package Lifetime ♣ ♠
- Release from Package ♣
- Transport ♦
- ~~Dilution~~

♣ Effects of heat explicitly mentioned in WCIS text
♦ Effects of heat implicitly mentioned in WCIS text by reference to effects of heat on fluid flow
♠ Explicitly mentioned in WCIS table on testing related to hypotheses

Heat-Related Processes and Parameters

- Heat Transfer
- Moisture Movement
- Geochemical
- Thermomechanical

Heat Transfer

- Conduction
- Convection
- Radiation
- Heat Pipe

All three thermal tests will provide information about one or more of these processes

Moisture Movement

- Subboiling mobilization in drift ✪
  - from heat
  - from excavation/ventilation
- Subboiling mobilization ✪ ✺ 😐
- Two-phase zone ✪ ✺ 😐
- Condensation zone ✪ ✺ 😐
- Shedding/drainage ✪ ✺
- Imbibition ✪ ✺ 😐
- Dryout zone formation (boiling/subboiling) ✪ ✺ 😐
- Rewetting time ✪ ✺ 😐
- Downspout rewetting ✪

✪ Drift-Scale Test
✺ Single-Heater Test
😐 Large-Block Test

Geochemical

- Return water (to waste package) chemistry ✪ ✺ 😐
- Evolution of nearfield water ✪ ✺ 😐
- Changes to hydrologic pathways ✪ ✺ 😐
- Changes to matrix transport properties ✪ ✺ 😐

✪ Drift-Scale Test
✺ Single-Heater Test
😐 Large-Block Test

Thermomechanical

- Rock mass properties ✪ ✺ 😐
- Drift stability ✪ ✺
- Support-rock interaction ✪ ✺
- Fracture aperture change ✪ ✺
- New fracture formation ✪ ✺ 😐
- Nearfield stress/displacement ✪ ✺

✪ Drift-Scale Test
✺ Single-Heater Test
😐 Large-Block Test

Data and Information Needs Addressed by the Large-Block Test

INFORMATION NEEDS	LARGE BLOCK TEST
Near field T-M-H-C environment	
Changes in rock saturation	Primary
Water chemistry (liquid reflux)	Secondary
Mineralogic changes	Secondary
Propagation of "drying front" (heterogeneity)	Primary
Residual water saturation in "dry zone"	Primary
Drainage/reflux of liquid by fracture flow (heterogeneity, heat pipes, fast paths)	Primary
Rock-mass and fracture permeability changes	Secondary
Conductive/convective heat transfer	Primary
Rock-mass properties over a range of temperature	
Thermal capacity or specific heat	Secondary
Thermal conductivity	Secondary
Thermal expansion	Secondary

Data and Information Needs Addressed by the Single-Heater Test

INFORMATION NEEDS	SINGLE-HEATER TEST
Near field T-M-H-C environment	
Changes in rock saturation	Primary
Water chemistry (liquid reflux)	Secondary
Mineralogic changes	Secondary
Propagation of "drying front" (heterogeneity)	Primary
Residual water saturation in "dry zone"	Primary
Drainage/reflux of liquid by fracture flow (heterogeneity, heat pipes, fast paths)	Secondary
Rock-mass and fracture permeability changes	Primary
Conductive/convective heat transfer	Primary
Rock-mass properties over a range of temperature	
Thermal capacity or specific heat	Primary
Thermal conductivity	Primary
Thermal expansion	Primary
Deformation modulus	Secondary
Ground support and design features interactions at elevated temperature	
Rock-mass ground support interaction	Secondary
Effect of materials on near field water chemistry	Secondary
Effect of near field environment on ground support components	Secondary

Data and Information Needs Addressed by the Drift-Scale Test

INFORMATION NEEDS	DRIFT SCALE TEST
Near field T-M-H-C environment	
Changes in rock saturation	Primary
Drift humidity	Primary
Water chemistry (liquid reflux)	Primary
Mineralogic changes	Primary
Propagation of "drying front" (heterogeneity)	Primary
Residual water saturation in "dry zone"	Primary
Drainage/reflux of liquid by fracture flow (heterogeneity, heat pipes, fast paths)	Primary
Rock-mass and fracture permeability changes	Primary
Conductive/convective heat transfer	Primary
Rock-mass properties	
Thermal capacity or specific heat	Secondary
Thermal conductivity	Secondary
Thermal expansion	Secondary
Strength	Primary
Drift response/stability under thermal conditions	
Ground support and design features interactions at elevated temperature	
Rock-mass ground support interaction	Primary
Effect of materials on near-field water chemistry	Primary
Effect of near field environment on ground support components	Primary
In situ WP material corrosion rates	Primary

Clinoptilolite-Analcime Transition and Volume Change

- Clinoptilolite is not present in the middle non-lithophysal unit of the Topopah Spring unit
- Therefore, volume change phenomena will not be examined *in situ* in any currently planned *in situ* tests
- Would perform more lab tests before pursuing expensive *in situ* tests
- For any *in situ* tests, would consider alternatives (P-tunnel) to Calico Hills at depth