Scientific and Engineering Testing Update

Presented to:
Nuclear Waste Technical Review Board

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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

- Total Power
- Drift Wall Temperature

Ventilation System Rework

Dec 3, 1997

Total Power (Kilowatts)

Temperature (°C)

Time (Days)

- Power
- Wall Temp. (Top)
- Wall Temp. (Left)
- Wall Temp. (Right)

Approx. Thermal Sensor Location (Not to Scale)

TC-19
TC-23
TC-24

Plan View
Profile
DST Gas Chemistry Evolution
DST Water Chemistry Evolution

Measured vs. Modeled pH

pH

Time (Months)

6.00  7.00  8.00  9.00

0  3  6  9  12  15  18

603  1863  602  Modeled
36Cl Validation

- Validate occurrence of “bomb-pulse” 36Cl 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)
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
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
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

- Middle Non-Lithophysal Main Drift Niches
- Lower Lithophysal Cross Drift Niche 5
- Lower Lithophysal Systematic Hydrologic Characterization borehole #2
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 heptahydrate
- 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

Borehole #16

- Simulation
- Field Data

Concentration vs X-Distance (m)

T = 125 d
T = 239 d
T = 183 d
T = 337 d

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

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

Canister 2

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

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

Canister 3

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

Results
- 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.