Wm-0011

ALCOVE 8-NICHE 3 CROSS-OVER TEST PLAN

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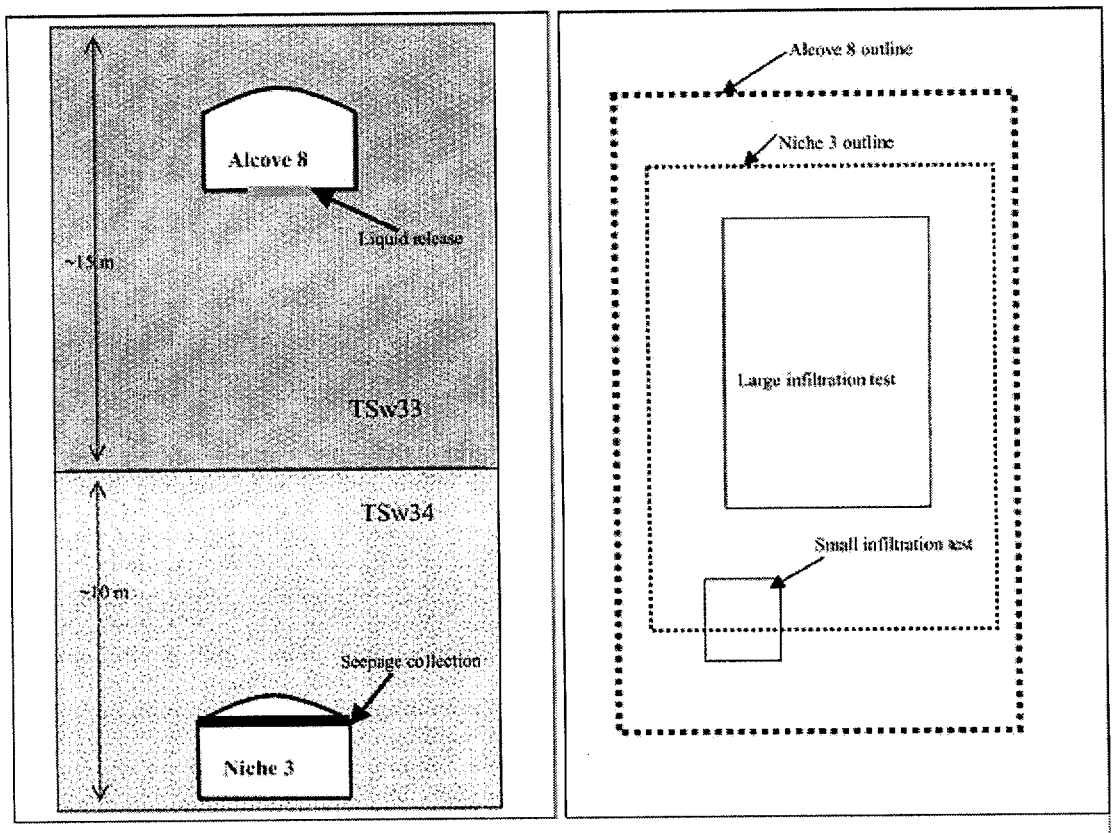
Objectives:

The cross-over test is located at the unique location where Alcove 8 in the ECRB Cross Drift is directly above the Niche 3 in the ESF Main Drift, as illustrated in Figure 1. The test objectives are:

- Quantify large-scale infiltration and seepage processes in the potential repository horizon.
- Evaluate matrix diffusion mechanism in long-term tests across an lithophysal-nonlithophysal interface.
- Measure fault and fracture properties and estimate fracture-matrix interface area by analysis and modeling of tracer test results.

Figure 1. Layout of Alcove 8 - Niche 3 Cross-over test bed.



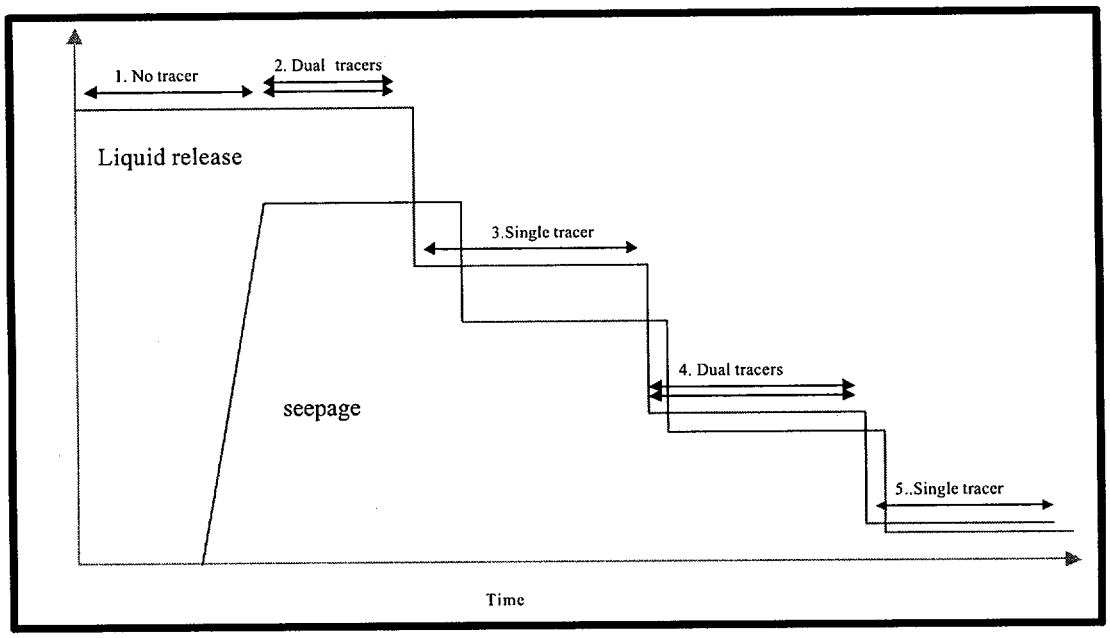
A. Vertical section

A. Plan view

Approaches:

Both active testing and passive monitoring programs are used to measure induced seepage at Niche 3 from controlled infiltration at Alcove 8.

- Water releases are in Alcove 8, first from a 1 m x 1 m area, and later from a 3 m x 4 m plot, as illustrated in Figure 2.
- Geophysical measurements (neutron logging and ground penetrating radar) and cross-hole air-injection tests are conducted in vertically slanted boreholes, as illustrated in Figure 3.
- Niche 3 is instrumented with wetting front sensors in boreholes (Figure 4) and seepage collectors (Figure 5). Evaporation rate and relative humidity conditions behind bulkhead will be monitored to estimate the correction factor for seepage rate.
- Multiple tracers with different diffusivity values are used in series of liquid tests, broadly outlined in the following sequence.



Proposed sequence of tests in Alcove 8-Niche 3 Cross-over Test.

Figure 2. Alcove 8 Infiltration.

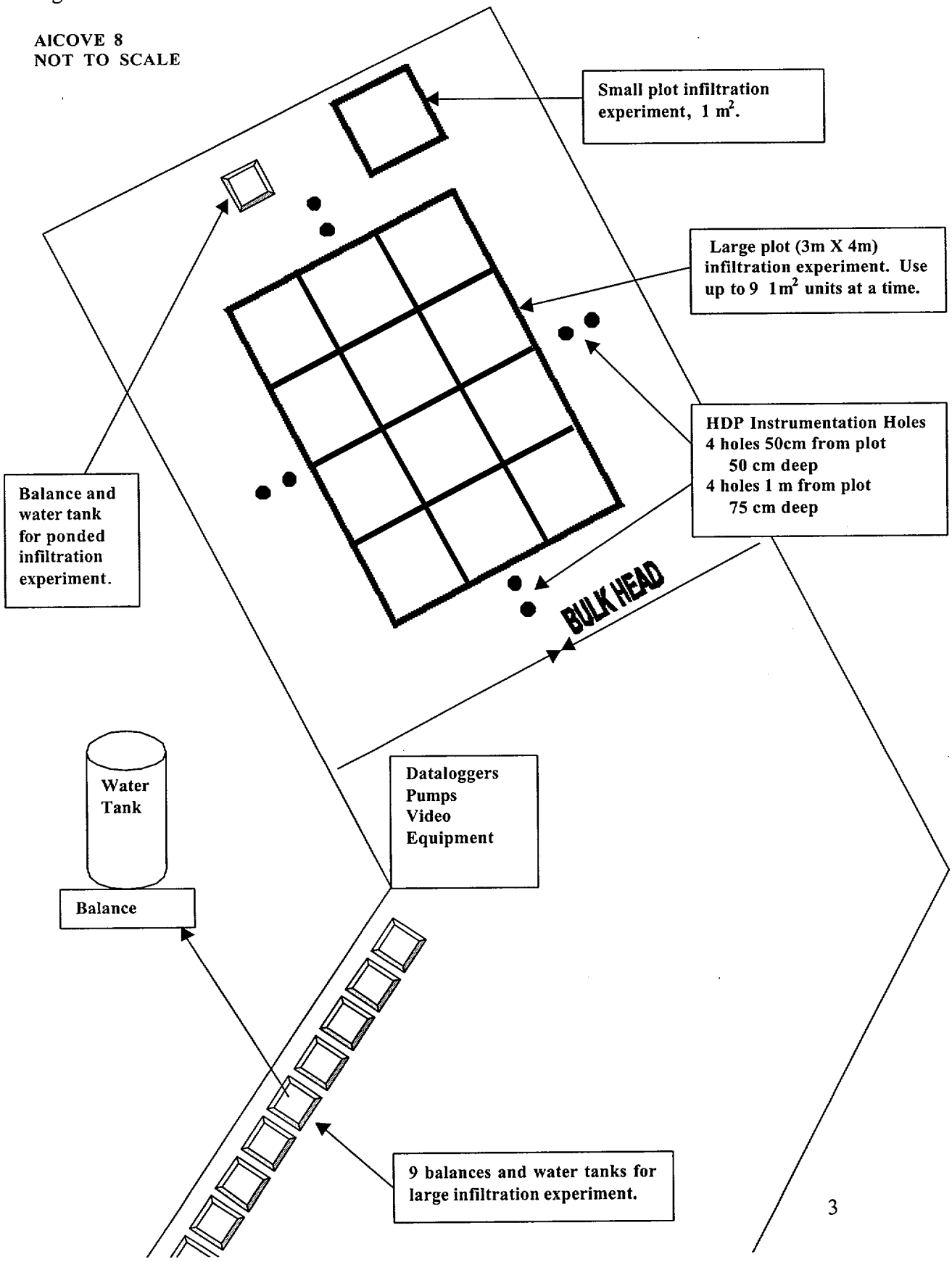


Figure 3. Boreholes between Alcove 8 and Niche 3.

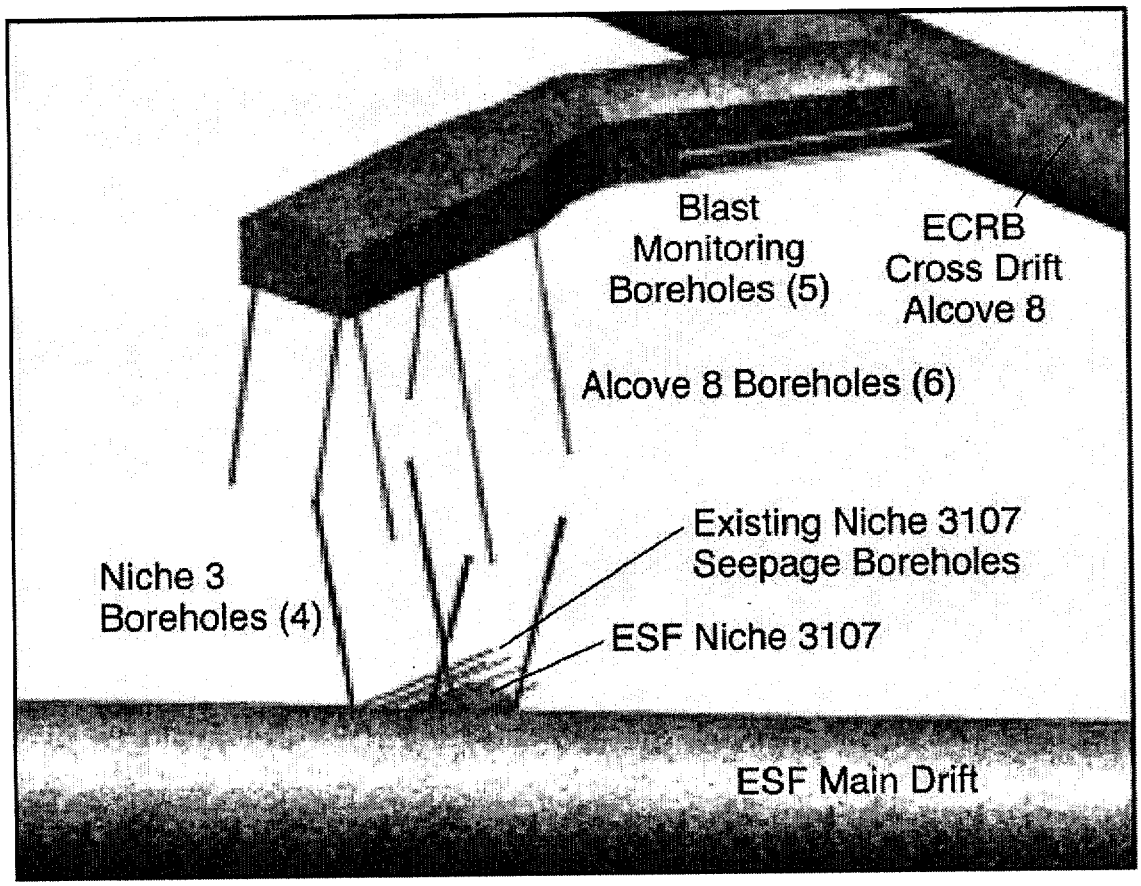


Figure 4. Boreholes with wetting front detectors in Niche 3.

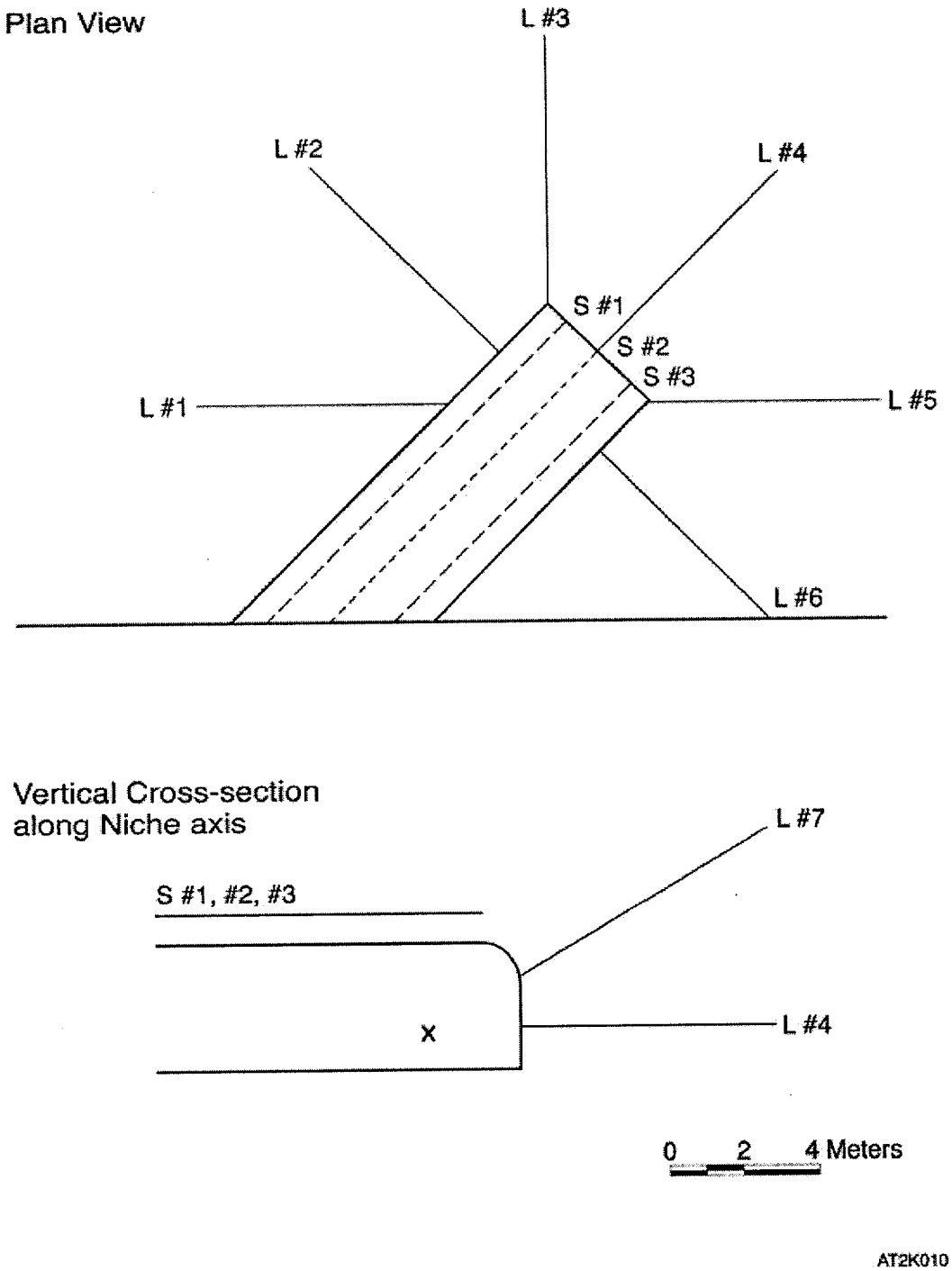
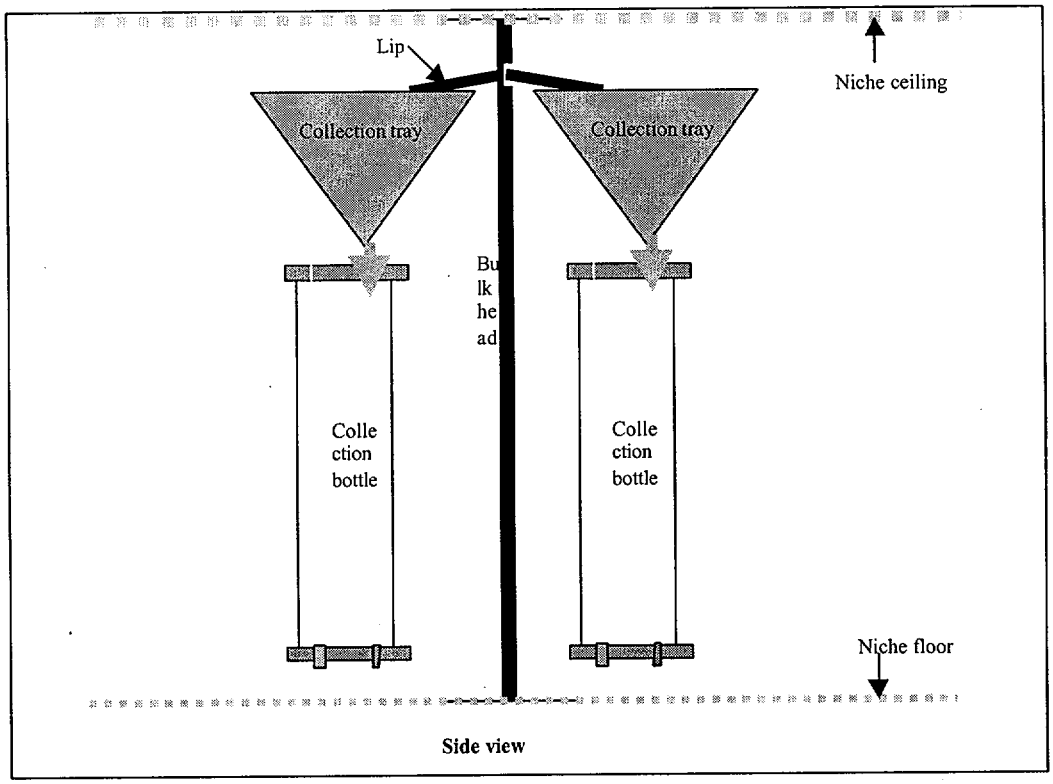
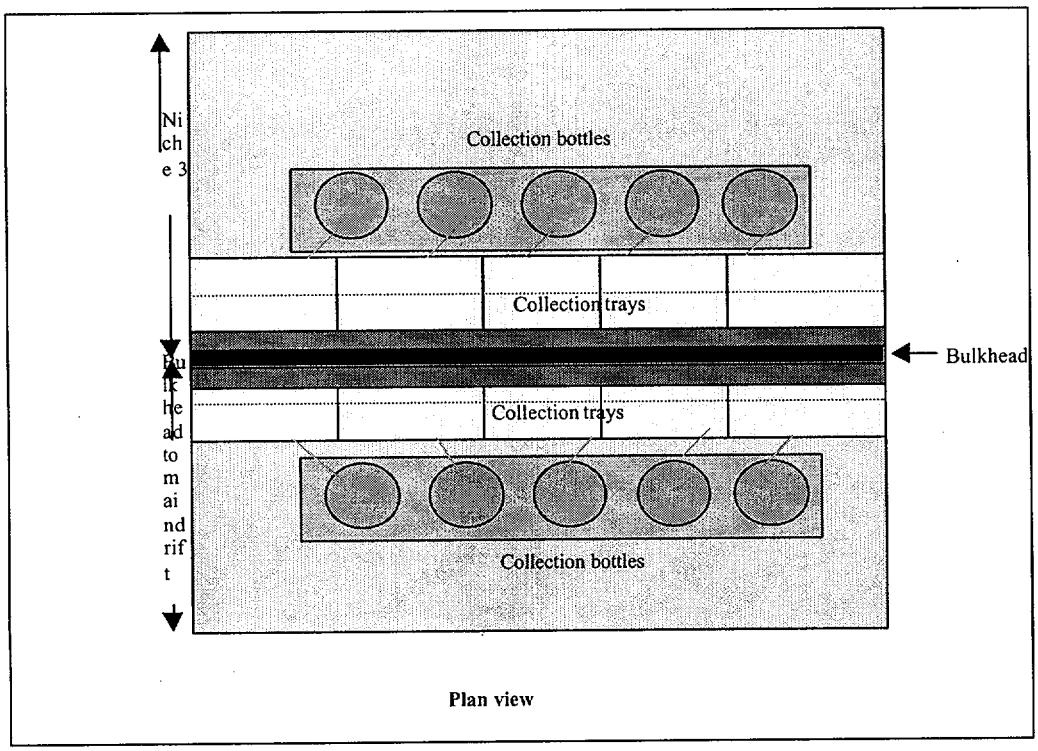


Figure 5. Seepage collection system installed near the bulkhead in Niche 3 for the fault test.





Phase I. Saturated flow and transport

1. Start the test with constant head (~ 2 cm water) until steady seepage is observed in Niche 3.
2. Introduce two tracers with different molecular diffusion coefficients (Br and PFBA) into the release water with same boundary condition (constant water head).

Phase I test will provide information on:

a. *Importance of matrix diffusion by comparing the breakthrough curves for two tracers.*
b. *Saturated hydraulic conductivity for fractures based on observed infiltration fluxes at Alcove 8.*
c. *Fracture porosity by analyzing tracer test results for PFBA which has a smaller molecular diffusion coefficient.*
d. *F/ M interface area under saturated conditions by matching the tracer test results (if matrix diffusion is important)*

Phase II. Unsaturated flow and transport

3. Reduce the flux at upper boundary. Add a new single tracer after steady seepage rate observed in Niche 3.
4. Repeat the above step for a few tests with lower fluxes. Two tracers will be used for at least one test in Phase II.

Phase II test will provide information on:

e. *F/M interface area as a function of flux by analyzing tracer test results for different infiltration fluxes.*
f. *Calibrated flow and transport properties using ITOUGH2.*
g. *Fracture relative permeability as a function of flux.*

Time Frame

Once seepage has occurred in the Niche a series of flux rates will be tested. Each infiltration test will last approximately 3 weeks. Approximately a total of 8 different fluxes rates will be tested. Following these flow tests a series of tracer tests will be performed. Each of these tests should last approximately 3 weeks. A total of 10 tests may be conducted.

The test duration depends on the hydrological properties which are spatially variable. During and after the tests, numerical modeling will be performed to analyze and interpret observations and predict the test conditions. Data analysis and model interpretation can be used to determine if test duration is sufficient and flow rate and tracers can be changed.

Tracers and Analysis

Below is a list of tracers that we are proposing for the test. Note that we have listed more tracers than those that can be used for the five tests to indicate that tracers are available in case that more than 5 tests will be conducted.

TABLE 1. Tracer application design at Alcove 8 / Niche 3

Tracer phase	Tracer chemical	Aqueous diffusion coefficient ($m^2/s \times 10^{-10}$)
Release 2	LiBr + PFBA	Br^-: 20.8; PFBA: 7.6
Release 3	2,4-DFBA	8.1
Release 4	Iodide + 2,6-DFBA	I^-: 20.5; 2,6-DFBA: 8.1
Release 5	2,3,4,5-TeFBA	7.8
	2,5-DFBA	8.1
	3,4,5-TFBA	7.9
	2,4,5-TFBA	7.9
	2,4,6-TFBA	7.9

Abbreviation:

PFBA: pentafluorobenzoic acid
TEFBA: tetra-fluorobenzoic acid
TFBA: tri- fluorobenzoic acid
DFBA: di-fluorobenzoic acid

The use of fluorinated benzoic acids (FBAs) as water tracers has received considerable attention, because FBAs are generally nonreactive, resistant to degradation, and relatively easy to be analyzed. The choice of 16 derivatives of FBA tracers is especially useful for studies that require multiple nonreactive tracers. Furthermore, The FBA tracers have larger molecular sizes than the halide tracers, which could be exploited to investigate the contribution of diffusive mass transfer (e.g., matrix diffusion) to solute transport. The application of FBAs is pending on the use permit under review.

Test Participation:

USGS is responsible for infiltration and heat dissipitation probe (and other potential instrumentation) installation in Alcove 8, and neutron logging in boreholes.

LBNL is responsible for the seepage sample collection and wetting front detection in Niche 3, tracer analysis, cross-hole air injections, ground penetrating radar tomography studies from boreholes, data analyses and model calibration with UZ flow and transport model and seepage models.