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Abstract

Confirmation of the performance of Yucca Mountain is required by 10 CFR Part 63.131 to indicate, where practicable, that the natural system acts as a barrier, as intended. Hence, performance confirmation monitoring and testing would provide data for continued assessment up to the post-closure period. In general, to carry out testing at a relevant scale is always important, and in the case of performance confirmation, it is particularly important to be able to test at the scale of the repository. We view the large perturbation caused by construction of the repository at Yucca Mountain a unique opportunity to study the large-scale behavior of the natural barrier system. Repository construction would necessarily introduce traced fluids and result in the creation of concrete leachates. A program to monitor traced fluids and concrete leachates permits evaluation of transport through the unsaturated zone and potentially downgradient through the saturated zone. A robust sampling and monitoring network for continuous measurement of important parameters, and for periodic collection of geochemical samples, can be deployed to observe thermohydrogeochemical changes from the repository horizon down to the water table. The sampling and monitoring network can be used to provide data to (1) assess subsurface conditions encountered and changes in those conditions during construction and waste emplacement operations; and (2) for modeling to determine that the natural system is functioning as intended.

Here we present a conceptual design for a monitoring network that serves the dual purpose of observation of changes induced by repository development and the long-term assessment of mountain-scale performance. A network of multifunction borings that permit temperature, pressure, and periodic geochemical sampling serves as the backbone of the monitoring system. Figure 1 shows a schematic of a monitoring boring incorporating an innovative geochemical sampling system, referred to as a U-tube [Freifeld *et al.* 2005], as well as distributed temperature and pressure measurement capabilities. Multilevel monitoring systems can be installed in each boring, and engineered backfill can serve to isolate the measurement intervals. More specialized borings can be used to assess moisture potential, fluid flux, gas permeability, geomechanical conditions and thermal diffusivity. The Performance Confirmation Monitoring Program requires a well completion that can be installed at a reasonable cost, functions reliably for decades, and can be safely and inexpensively abandoned. These design considerations would preclude the inadvertent creation of a vertical conduit through the repository horizon to the water table during the post-closure period.

The Thermal Testing Program at Yucca Mountain provides a conceptual basis for relating monitored parameters to coupled thermal-hydrologic processes. Measurements of pressure, temperature, air-permeability and recovery of liquid and gaseous samples conducted during the Large Block, Single Heater, and Drift Scale Thermal Tests provided

estimates of moisture and heat flux, as well as information on reactive geochemical processes. Unlike the Thermal Tests, the Performance Confirmation Monitoring Program does not have a fixed ending date, except perhaps when the repository enters the post-closure period. Monitoring of traced construction fluids can continue for many decades (or longer if desired). These data are arguably the most unambiguous signal that can be used to validate estimated rates of transport below the repository horizon. Distributed temperature measurements (which reflect bulk averaged moisture and thermal flux), complement traditional transport measurements that mostly reflect smaller-scale localized conditions. Acquiring these complementary data sets will significantly reduce uncertainty in natural system behavior.

Borehole placements and parameters to be measured are guided by the unsaturated zone and saturated zone flow and transport models for the Yucca Mountain. Figure 2 shows a phased approach for developing the Performance Confirmation Monitoring Program. The initial deployment of a monitoring network, shown in Figure 2 as Phase I, should be initiated prior to the excavation of emplacement drifts, so that baseline information can be obtained. Phase II borings will be completed during construction and emplacement of radioactive waste within the repository, and will focus on the region immediately under the repository footprint down to the water table. As the perturbation to the mountain increases in lateral extent, post-emplacement Phase III monitoring outside of the repository footprint will focus on the interface between the unsaturated zone and water table towards the South, following the anticipated trajectory of solutes released from within the repository horizon. It is anticipated that monitoring will be continued up until the post-closure period, when sufficient confidence in the behavior of the natural system will permit cessation of monitoring activities.

In summary, seizing the opportunity of the perturbation at Yucca Mountain provided by the construction of the repository, we present a plan for performance confirmation testing, that is—to deploy a monitoring/sample network of multilevel monitoring stations designed to be installed at a reasonable cost, perform reliably for decades, and be safely abandoned with minimal added cost.

References:

Freifeld, B. M., R. C. Trautz, Y. K. Kharaka, T. J. Phelps, L. R. Myer, S. D. Hovorka, and D. J. Collins (2005), The U-tube: A novel system for acquiring borehole fluid samples from a deep geologic CO2 sequestration experiment, J. Geophys. Res., 110, B10203, doi:10.1029/2005JB003735.

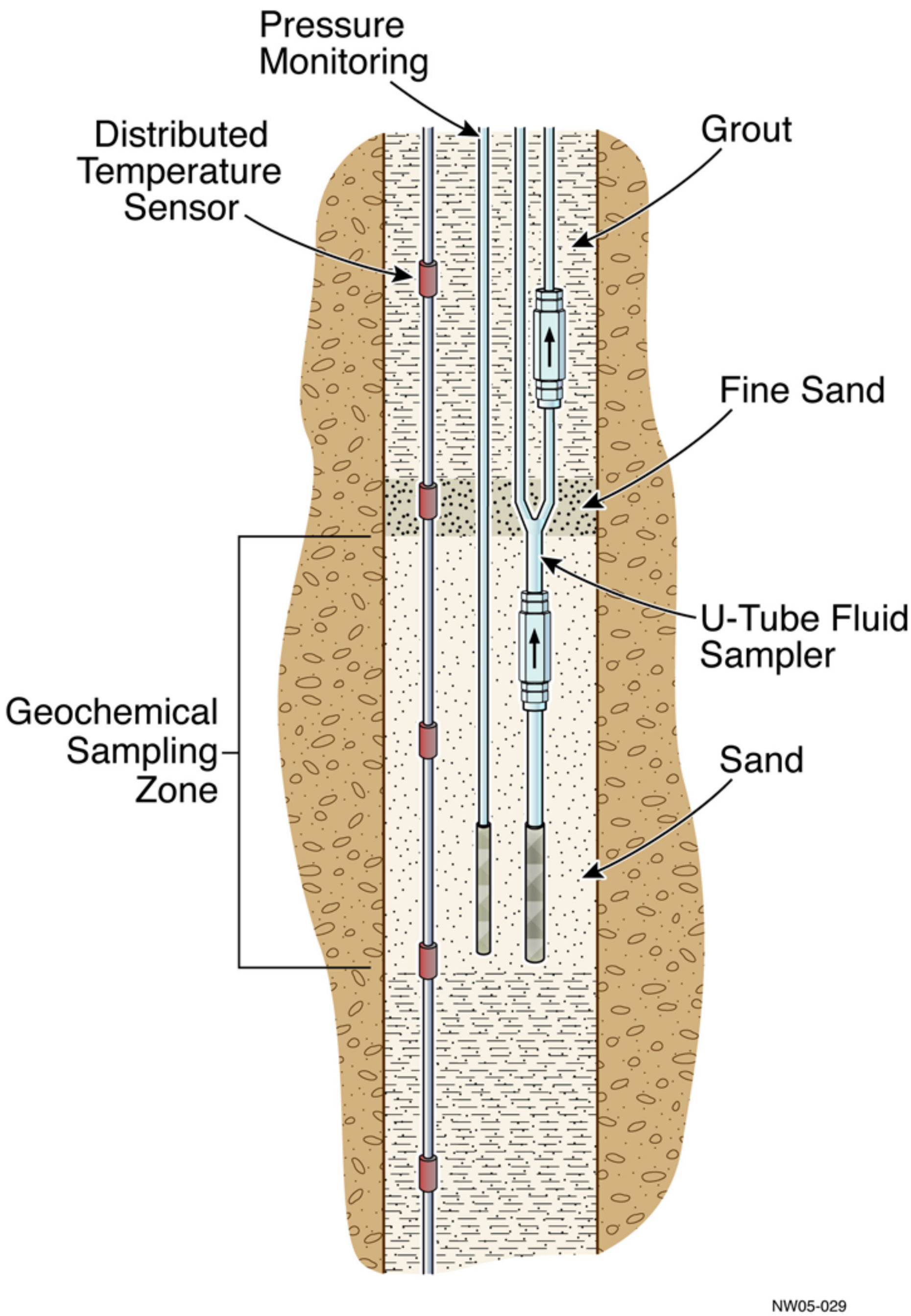

Figure 1. Conceptual layout of an instrumented interval in a Performance Confirmation Monitoring Program borehole. Important measured parameters include temperature and pressure, as well as collection of geochemical samples.

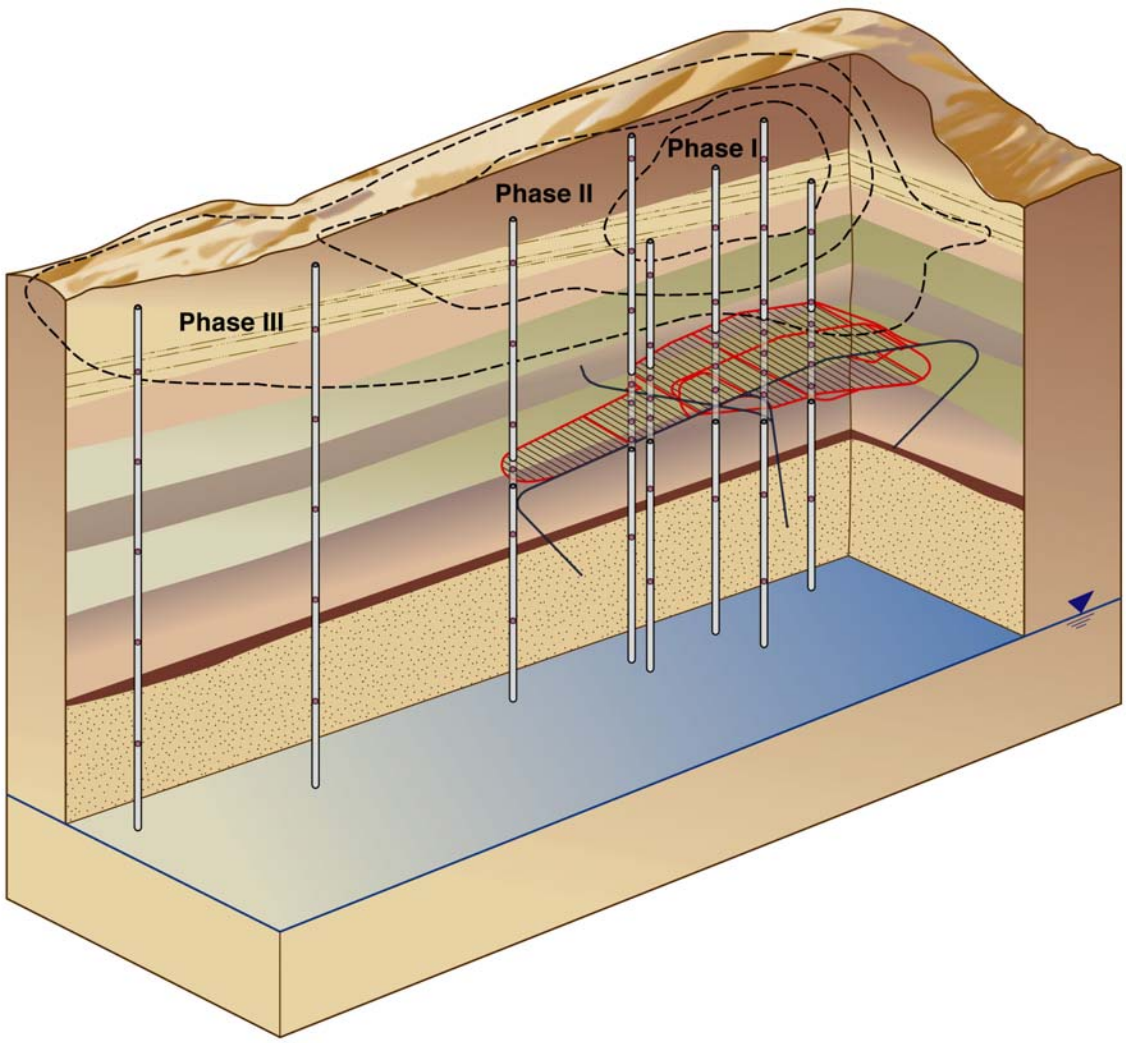

Figure 2. Schematic of a phased approach to the development of a performance confirmation monitoring network. Phase I monitoring boreholes are installed pre-emplacement, during initial repository construction. Phase II borings are installed during emplacement, and Phase III borings are constructed during the post-emplacment to post-closure time period.