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Environmental Field Geophysics

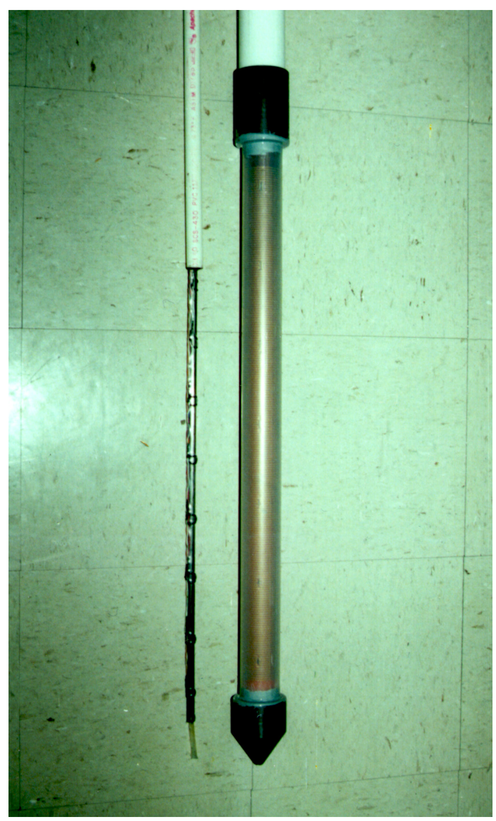
Subsurface Gas Flow Probe

Need

Many techniques for remediating unsaturated sediments involve inducing or controlling air flowing through the material; examples include *in situ* air stripping, air injection to enhance biodegradation, and enhancing the naturally-occurring airflow into and out of the ground due to atmospheric pressure changes. The limited available data indicate that airflow in the unsaturated zone is highly heterogeneous, with air traveling along high-permeability pathways instead of uniformly through the subsurface. Monitoring of the subsurface gas flow during gas-based remediation operations in the vadose zone is thus essential for assessing the effectiveness of the operation.

Description

Sandia National Laboratories has developed an inexpensive, easily deployable probe to monitor subsurface gas flow velocity for air sparging and vapor extraction experiments and operations. This gas flow probe is an extension of another Sandia-developed technology, the in situ permeable flow sensor, which measures the full three-dimensional groundwater flow velocity vector in saturated, permeable sediments. Both instruments are based on the principle that the temperature distribution on the surface of a finite length, heated cylinder buried in a permeable flow field is related to the flow velocity of fluid past the cylinder. In essence, relatively cool temperatures are observed on the upstream side of the probe and relatively warm temperatures on the downstream side. The probes are buried directly in the soil and emplaced using a hollow-stem auger, as boreholes perturb the fluid flow field around the instrument too much for reliable flow measurements.



Photograph of 1-D and 3-D subsurface gas velocity probes

Two versions of the gas flow probe were developed: a 1-dimensional (1D) probe that measures only the vertical component of gas flow, and a full three-dimensional version (3D). The 3D probe is approximately 2” in diameter and 30” long. It contains a cylindrical

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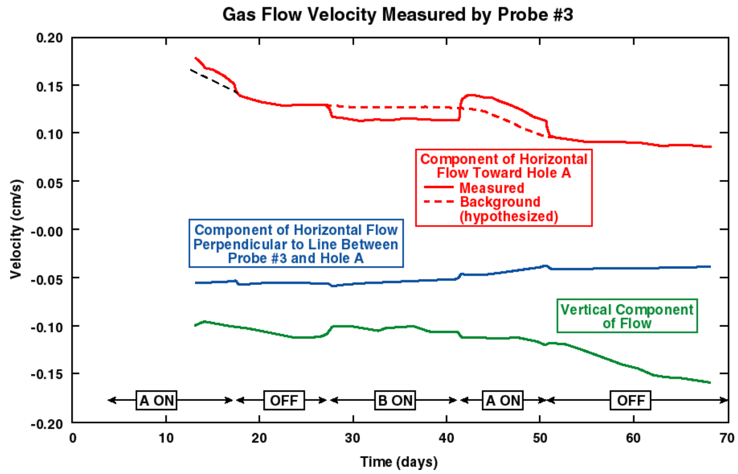
similar to the 3D version, but with a much smaller diameter; it was also designed to be less expensive.



Test results of a field experiment at an air sparging remediation site; 3 components of flow are shown and respond to changes in air flow in the subsurface

The gas flow probes were extensively tested in the laboratory, at a demonstration field site, and at an active remediation project. Results of laboratory testing were highly encouraging. Field testing results indicated that the gas flow probes are sensing changes in the subsurface flow field; it is sensitive enough to detect reasonable changes in vapor extraction rates at distances up to about 20'. The gas flow probe does not appear to be sensitive enough to monitor air flows induced by atmospheric pressure changes. It is also sensitive to longer-term effects unrelated to the air low, including seasonal temperature changes and possible changes in formation water content near the probe (due to probe-induced heating). The gas flow probe is currently at an advanced development stage, with some further testing and modifications needed to make it useable for more routine monitoring.

Reference

Cutler, R. P., S. Ballard, G. Barker, R. Keefe, M. Chavez, H. Stockman, L. Romero., Development of a Subsurface Gas Flow Probe, SAND97-0844, Sandia National Laboratories, Albuquerque, NM, 1997.

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