In Situ Permeability Measurements with Direct Push Techniques

Developer: Science & Engineering Associates, Inc.
Contract Number: DE-AC21-96MC33124
Crosscutting Area: CMST

Subsurface Contaminants FOCUS AREA

Problem:

The design of soil remediation techniques such as vapor extraction, air sparging, active venting, and pump-and-treat processes requires knowledge of the flow characteristics of the soil. The most variable of the soil's transport characteristics is its permeability, which can vary by several orders of magnitude in a given geologic and hydrologic setting. Permeability measurements are typically measured in open or screened holes formed by conventional drilling techniques, which are time consuming and expensive operations.

Direct push techniques, such as cone penetrometer and sonic hole formation technologies, have been applied to rapid characterization of geophysical and contaminant distributions in soils. Permeability measurements using conventional models, however, are difficult or impossible to conduct with these techniques because of the potentially significant reduction in soil permeability adjacent to the emplacement rod.

Solution:

It is possible to avoid the impact of localized soil compaction caused by penetrometer emplacement through judicious selection of the measurement geometry. The technique developed in this project entails pressure field measurements at specific distances from the fluid injection source such that a true permeability can be inferred without the complicating effects of the compacted soil layer. The pressure sensors are embedded in the penetrometer rod along its surface to provide a vertical pressure distribution both above and below the fluid injection location. The technique is applicable to both soil gas and saturated water flow conditions.

Benefits:

Conducting permeability measurements with direct push techniques, instead of in drilled boreholes, retains all of the advantages of penetrometer emplacements which have motivated the DOE to advance the direct push capabilities:

- Substantially reduced field costs
- Rapid emplacement
- Minimal secondary waste generation
- Reduced worker exposure to chemical and radiological hazards

The cost savings of the proposed approach, when compared to drilled borehole measurements, are significant. Borehole formation costs range from tens to hundreds of

thousands of dollars for a typical well, depending on the type of drilling operation, nature of contamination, depth of well, and the geologic media. A typical drilling operation for a 100 ft well requires two to five days. By contrast, penetrometer emplacements can be accomplished in one day with a full suite of measurements. For air permeability, the measurement time per station is less than five minutes, so 20 to 40 measurements could be accomplished during one push, in one day. This provides a great deal of spacial resolution in permeability measurements.

Technology:

This project will develop the methodology, validate in the laboratory, and perform prototype field tests of an in-situ permeability measurement system integrated with a direct push emplacement system. The technique uses a spherical, one dimensional steady state porous flow model which is suitable for both soil gas and water (saturated) permeability measurements. A particularly unique feature of the system is that it can be applied in a manner to minimize the effects of soil compaction near the penetrometer surface, and effectively measure the native soil permeability. The development project involves two major efforts: 1) development of a measurement system which will perform in the cone penetrometer operating environment and 2) engineering the measurement package to satisfy the size and operational constraints of penetrometer and other direct push techniques.

Contacts:

Science and Engineering Associates, Inc. (SEA) is a high technology contract R&D organization providing services to the national needs. The Environmental Technologies Division of SEA develops, demonstrates, and provides field services in the areas of environmental characterization, monitoring, and remediation. For information on this project, the contractor contact is:

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