SERDP
Strategic Environmental Research and Development Program
Improving Mission Readiness Through Environmental Research

Cleanup
CU-592

Integrated Characterization Program Combining DOE (PNL) UFA and DoD (NRAD) Sensor Technologies

LEAD AGENCY: Department of Energy (DOE)

LAB: Pacific Northwest Laboratory (PNL)

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PROBLEM STATEMENT: Defining the nature and extent of subsurface chemical contamination is a costly and time-consuming process at sites requiring remediation. Detailed site investigations require installation of many monitoring wells and subsequent analysis of discrete soil and groundwater samples. Effective site characterization is often limited by the ability to select optimal locations for monitoring wells. Furthermore, the ability to resolve horizontal and vertical features in the distribution of chemical contaminants and to determine the transport rates of these contaminants in various stratigraphic layers is a function of limitations imposed by the spacing between wells and the vertical spacing between samples. At present, locations for monitoring wells are usually based on information gleaned from site historical data, ground water hydrology, and/or indirect chemical screening such as soil gas measurements. Because of the limitations of these methods, many wells are not properly positioned and, therefore, yield information of marginal utility. By utilizing cone penetrometer (CPT) mounted sensor technology it is possible to obtain continuous coverage over the investigated depth intervals and more precisely delineate the boundaries of contaminant plumes, thus it is less likely that "clean" material will be unnecessarily removed or subjected to costly remediation procedures.

Although determining the current position of contaminant plumes is important, obtaining the information necessary for predicting future contaminant movement may be of even greater long term importance. Knowledge of the transport characteristics of soils (including hydraulic conductivity) under unsaturated and saturated conditions is required for modeling the transport of contaminants in subsurface materials surrounding hazardous and mixed waste sites. Once the nature and extent of the contamination are determined, it is also necessary to understand the transport properties of the soil to determine the potential risk to public health and environment that will ultimately control the degree and time frame of remediation. If stratigraphic horizons where future contaminant transport will likely occur can be identified, remediation efforts can be more efficiently directed. The hydraulic conductivity of soil depends strongly on the characteristics of the fluid and substrate, and on the volumetric water content of the soil. Traditionally, it has been difficult to obtain transport data on unsaturated and multicomponent systems because of the long experimental durations (weeks to years) necessary for achieving hydraulic steady state. By using the Unsaturated Flow Apparatus (UFA), it is possible to experimentally measure transport characteristics in a very short time frame (hours to days) under the wide range of conditions that exist in the field.This project is an applied research program that couples two relatively new characterization techniques to provide a more powerful characterization procedure. Both techniques stress innovative technologies that allow rapid completion of the installation characterization procedure so that planning future remediation programs may be done in a more cost effective manner. The first technology is the CPT mounted sensors that rapidly delineate contaminant plume boundaries in the subsurface. Developed through a Tri-service DoD collaboration, the Site Characterization and Analysis Penetrometer System has been successfully employed for characterization at several DoD installations. The second technology is the UFA, a system that allows rapid determination of subsurface transport parameters in porous media. It was developed at

DOE"s Pacific Northwest Laboratories (PNL) for use at many DOE sites, including characterization studies at the Hanford Site.

PROJECT DESCRIPTION: This project is structured to develop and demonstrate the synergistic integration of two characterization techniques. The project scope is divided into two phases. This phased approach will allow continual refinement and streamlining of the interactions between the two government laboratories. The initial phase will include a pilot-scale demonstration of the current capabilities of both systems to aid in the planned development of sensor technology that will better evaluate the soil matrix. This development includes work at NRAD on new optical based imaging systems to evaluate grain size distribution that will improve the textural determinations (sand, silt, clay) currently made by CPT point and sleeve resistances. This matrix sensor will optically image the soil matrix at depth, providing a digitized image from which grain size distribution (and pore geometry) can be derived. Additional sensor development will focus on determinations of soil moisture content. The work at PNL will focus on determining the sensitivity of hydraulic conductivities to the variations in soil textural data properties that the CPT with new sensors can detect. This will determine how many representative soil types will be required for UFA measurement to sufficiently characterize the hydraulic properties at a selected field site. The digitized soil matrix images can then be used to develop image analysis programs as input to models for deriving hydraulic transport properties over the full range of soil types observed at a site. The second phase of the project will involve the field scale demonstration of the capabilities of the combined techniques. An installation will be selected based on the type of contaminant (compatibility with developed sensors) and soil textures (initially a limited range in soil texture variations) present at the site. The CPT will be deployed with a combination of sensors and will recover soil samples from representative stratigraphic horizons for UFA studies. Continuous matrix image analysis and moisture content data over the investigated depths will allow continuous determinations of fluid transport properties across the site. As the field demonstration progresses, evaluation of the data will indicate where additional CPT deployments are required to obtain detailed information from specific stratigraphic horizons.

During both phases of the program industrial partners will be working with the laboratories so technology transfer opportunities to promote commercialization will be possible.

EXPECTED PAYOFF: The potential benefit of this project is the development of a superior, rapid characterization program that will allow a more cost effective remediation plan to be developed. The CPT sensor technology is a more rapid, cost effective method to delineate contaminant boundaries than traditional well drilling. The UFA technology is a more rapid, cost effective method to directly determine transport parameters (required for estimating or modeling contaminant movements) than other traditional techniques. Direct determinations are preferable to any estimation techniques because estimations are often overly conservative and lead to extremely expensive remediation programs. By developing the process in conjunction with an industrial partner, commercially available applications could be possible in the near term.

TRANSITION PLAN: PNL will be the lead laboratory for this project. During the initial phase, a contaminated site will be identified for demonstration and participation in the development of the coupling process between these techniques so that the site will be available for later phase field operations. Both laboratories are involved with industrial partners in attempts to transfer these technologies to the private sector.