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Innovative Technology Verification Report

Site Characterization Analysis Penetrometer Systems (SCAPS) Technology Report

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Executive Summary

Recent changes in environmental site characterization have resulted in the application of cone penetrometer (CP) technologies to site characterization. With a variety of in situ physical and chemical sensors, this technology is seeing an increased frequency of use in environmental site characterization. CP technologies employ a wide array of sampling tools and produce limited investigation-derived waste.

The EPA's Monitoring and Measurement Technologies Program (MMTP) at the National Exposure Research Laboratory, Las Vegas, Nevada, selected CP sensors as a technology class to be evaluated under the Superfund Innovative Technology Evaluation (SITE) Program. In August 1994, a demonstration of CP-mounted sensor technologies took place to evaluate how effective they were in analyzing the physical and chemical characteristics of subsurface soil at hazardous waste sites. Prior to this demonstration, two separate predemonstration sampling efforts were conducted to provide the developers with site-specific samples. These samples were intended to provide data for site-specific calibration of the technologies and matrix interferences.

The main objective of this demonstration was to examine technology performance by comparing each technology's results relative to physical and chemical characterization techniques obtained using conventional reference methods. The primary focus of the demonstration was to evaluate the ability of the technologies to detect the relative magnitude of fluorescing subsurface contaminants. This evaluation is described in this report as the qualitative evaluation. A subordinate focus was to evaluate the possible correlations or comparability of the technologies chemical data with reference method data. This evaluation is described in this report as the quantitative evaluation. All of the technologies were designed and marketed to produce only qualitative screening data. The reference methods for evaluating the physical characterization capabilities were stratigraphic logs created by a geologist from soil samples collected by a drill rig equipped with hollow stem augers, and soil samples analyzed by a geotechnical laboratory. The reference methods for evaluating the chemical characterization capabilities were EPA Method 418.1 and SW-846 Methods 8310 and 8020, and University of Iowa Hygienics Laboratory Method OA- 1. In addition, the effect of total organic carbon (TOC) on technology performance was evaluated.

Three technologies were evaluated: the Site Characterization and Analysis Penetrometer System (SCAPS) laser induced fluorescence (LIF) and CP sensors developed by the Tri-Services (Army, Navy, and Air Force), the Rapid Optical Screening Tool (ROST"') developed by Loral Corporation and Dakota Technologies, Inc., and the conductivity sensor developed by Geoprobe" Systems. These technologies were designed to provide real-time, relatively low cost analysis of the physical and chemical characteristics (primarily petroleum fuels and coal tars) of subsurface soil to quickly distinguish contaminated areas from noncontaminated areas. The SCAPS technology is designed and operated to produce screening level data. Results of the demonstration are summarized by technology and by data type (chemical or physical) in individual innovative technology evaluation reports (ITER). In addition to the three technology-specific ITER's, a general ITER that examines cone penetrometry, geoprobes, and hollow stem auger drilling in greater detail has been prepared.

The purpose of this ITER is to chronicle the development of the SCAPS technology, its capabilities, associated equipment, and accessories. The document concludes with an evaluation of how closely the results

obtained using the technology compare to the results obtained using conventional reference methods. One hazardous waste site each was selected in Iowa, Nebraska, and Kansas to demonstrate the technologies. The sites were selected because of their varying concentrations of coal tar waste and petroleum fuels, and because of their ranges in soil textures.

This demonstration found that the SCAPS technology produces screening level data. Specifically, the qualitative assessment showed that the stratigraphic and the chemical cross sections were comparable to the reference methods. The SCAPS sensors did not require sample collection, and thus, avoided the sampling difficulties encountered by the reference methods during this demonstration. The relatively continuous data output from the LIF sensor eliminated the data interpolation required by the reference method. This also increased the apparent resolution of the sensor's data.

The SCAPS LIF operator also qualitatively identified changes in contaminant type by detecting significant changes in peak emission wavelength. The gross soil classifications identified by the technology generally matched the reference method classifications. The chemical cross sections for the LIF sensor showed close agreement to the reference method cross sections in identifying low, medium, and high zones of contamination. Generally, the relative LIF intensity was positively related to the concentration of total petroleum hydrocarbons and total polynuclear aromatic hydrocarbons. In only one case during this demonstration did the SCAPS LIF sensor not identify fluorescence above background for zones sampled that indicated contamination. Reference method sampling indicated contamination in the 100's of the parts per million (ppm) range at Node 5 at the York site. The failure of the SCAPS LIF sensor to identify this zone may have been a result of the horizontal separation between the SCAPS and reference method sampling points, and inherent matrix heterogeneity. The quantitative assessment found that the SCAPS LIF data was most closely correlated to the TPH and volatile petroleum hydrocarbons (VPH) data. Due to matrix heterogeneity up to 50 percent of the original data set used in the quantitative evaluation was eliminated as outliers. This greatly reduced the predictive value of the regression models, however, the remaining data was still used to identify trends. The quantitative data assessment also produced a first approximation of a detection threshold for the SCAPS LIF sensor. For TPH and VPH, based on their regression models, the fluorescence intensity (background corrected) at 0 milligram per kilogram was 157 and 336, respectively. In addition, the lowest concentrations of TPH and VPH detected during the quantitative assessment were 60 and 19 mg/kg, respectively. Both of these low concentrations had fluorescence intensity readings near the thresholds (157 and 336) discussed above.

Based on the continuous data output for both the chemical and physical properties of soil, the SCAPS sensors (physical and chemical) appear to be valuable tools for qualitative site characterization. The lack of better correlation for the quantitative evaluation cannot be solely attributed to the technology. It may also be due to the combined effect of matrix heterogeneity, lack of instrument calibration, uncertainties regarding the exact contaminants being measured, and the age and constituents in the waste. Based on the data from this demonstration, it is not possible to conclude that the technology can or cannot be quantitative in the configuration used during this demonstration. Based on the effects listed above, potential users should not expect the SCAPS LIF sensor to produce data which shows a high degree of correlation when comparisons with conventional data are made on a point-by-point basis. Verification of this technology's performance should be done only on a qualitative level. Even though it cannot quantify actual levels of contamination or identify individual compounds, it can produce relative contaminant distribution data very similar to corresponding data produced by conventional methods, such as drilling and laboratory sample analysis, and it can monitor changes in emission wavelength to identify possible changes in contaminant constituent. The general magnitude of the LIF sensor data directly correlated to the general magnitude of contamination detected by the reference method. The SCAPS performance during this demonstration showed that it could generate this data faster than the reference methods and with little to no waste generation relative to the reference methods. The cost associated with using this technology to produce the qualitative data was approximately $42,000, as compared to the $55,000 used to produce the reference cross sections. In this case, the SCAPS LIF and CP sensors cost less than reference methods, produced almost 1,200 more data points (continuously) than the conventional approach, and provided data in a real-time fashion. It should be noted that the technology's data is screening level, while the reference method approach produced definitive data. The question that this demonstration cannot answer is whether or not it is better to have few data points at the highest data quality level or many more at a lower data quality level. Issues such as matrix heterogeneity may greatly reduce the need for definitive level data in an initial site characterization. Critical samples will always require definitive analysis.