DNAPL CHARACTERIZATION TOOLBOX

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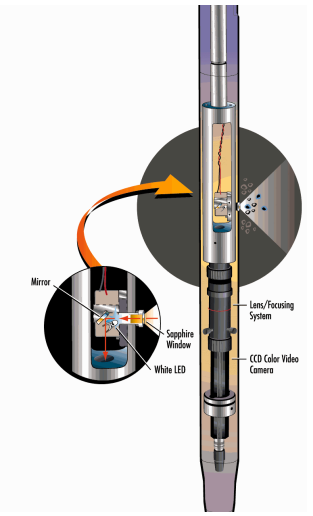
Cone Penetrometer Truck

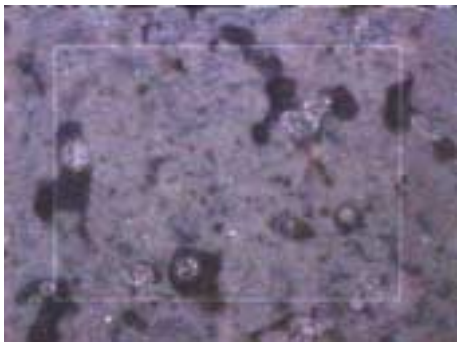
The cone penetrometer is a heavy-weight truck with a hydraulic push system that is used for subsurface site characterization. In the standard configuration, the tip of the cone penetrometer rod is equipped with sensors that measure depth-discrete physical and geologic parameters of the subsurface. Detection instruments and sampling devices for water, gas, and soil have been modified and housed within the cone penetrometer rods to provide detailed contaminant information. CPT technology expedites site characterization and significantly reduces the cost of characterization of contaminated sites and the amount of investigative-derived waste (IDW). Measurements are made in situ which often eliminates the need for sample extraction and significantly reduces the amount of contaminated waste. In situ sampling and analysis also reduces the need for costly laboratory analysis and subsequent risks of sample contamination or alteration. Data is gathered in “real-time”; this capability strengthens and expands decision-making capabilities in the field. Samples can be taken at smaller scale depth intervals with more certainty than with traditional methods such as drilling.

Field Raman Spectrograph

The Raman Spectroscopy probe can be deployed with the cone penetrometer for in situ detection and speciation of compounds. Laser Raman spectroscopy is an inelastic light-scattering technique that identifies specific chemical compounds by their unique spectrum. EIC Laboratories, Inc. has designed a field-hardened Raman spectrograph using fiber optics that can be implemented in a CPT probe. The probe is unique as it allows for in situ determination of a broad range of chemicals, including DNAPL compounds (TCE, PCE, etc). The Raman system is best used for source zone characterization since it is only sensitive to very high concentration or separate phase contaminants. The use of Raman Spectroscopy for in-situ detection of DNAPL was successfully implemented at several SRS locations in 1998.

SPAWAR Geo VIS Probe (Soil Video Imaging System)





The Geo VIS Probe is an in situ video imaging system developed by SPAWAR Systems Center, San Diego. Geo VIS is deployed with the cone penetrometer and used to acquire visual information about the subsurface. The instrument consists of a CCD color camera, lens/focusing system, and a white light-emitting-diode (LED) illumination system. The camera is mounted inside the probe with a sapphire window view-port. In several field applications, the GeoVIS probe has been used successfully to delineate DNAPL and other colored compounds in the subsurface. The Geo VIS has the capability to resolve particles as small as 10µm.

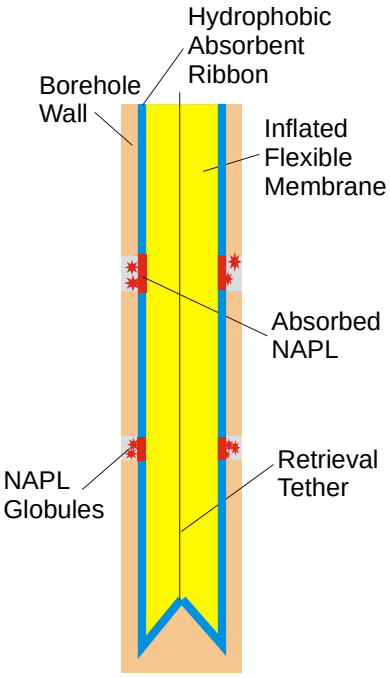
Cone Sipper™

The Cone Sipper is a groundwater and soil vapor sampling device designed to be used with a cone penetrometer truck (CPT). The probe is advanced into the subsurface with the CPT and is used to collect samples at multiple depths in a single borehole while collecting CPT lithology data. Samples are brought to the surface via small-diameter tubes and the device can be purged for reuse *in situ* by injecting distilled water, air, or inert gas. The main advantage of the Cone Sipper over other groundwater samplers is that it eliminates the need for retrieval and decontamination of the sampler between sampling intervals. Its simple construction, using just three pressure-controlled valves, ensures reliable operation. The Cone Sipper has been widely implemented for soil gas and groundwater sampling with the CPT truck.

Science and Engineering Associates (SEA) Cone Permeameter

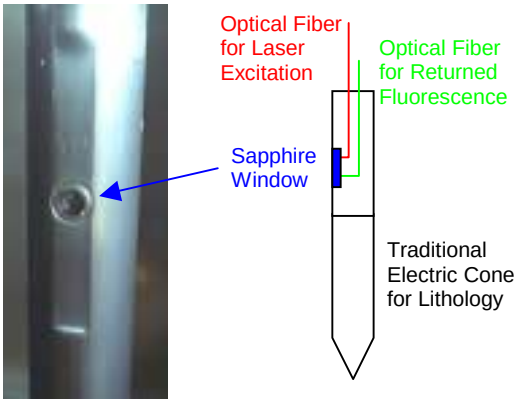
SEA has developed the Cone Permeameter, a probe for in situ, depth-discrete estimation of permeability in the vadose and saturated zones with high spatial resolution. The probe is deployed using a cone penetrometer truck. The Cone Permeameter field measuring system is based on the pressure response of the subsurface to injection of water or air into the subsurface. The flow rate and resulting pressure profiles are collected and the system calculates the permeability for real-time display. The Cone Permeameter provides high resolution, depth discrete measurements of permeability. Due to the small area of influence measured, the system requires injection of very small volumes of air or water. Each sampling interval generally requires only 3-5 minutes, which allows quick acquisition of data. This method may require a regulatory underground injection control (UIC) permit for the saturated zone but exemptions have been awarded in the state of South Carolina.

Ribbon NAPL Sampler



The Ribbon NAPL Sampler (RNS) is a direct sampling device that can provide detailed depth discrete mapping of Non Aqueous Phase Liquids (NAPLs - liquid solvents and/or petroleum products) in a borehole. This NAPL characterization technique uses the Flexible Liner Underground Technologies, Ltd. (FLUTe) membrane to deploy a hydrophobic absorbent ribbon in the subsurface. The system is pressurized against the wall of the borehole and the ribbon absorbs the NAPL that is in contact with it. A dye, sensitive only to NAPL, is impregnated in the ribbon and turns it bright red when the contaminants are contacted. The membrane is retrieved with a tether connected to the bottom of the membrane by turning the liner inside out. At the surface, the liner is everted and the ribbon is removed and examined. The presence and depth discrete location of DNAPL is indicated by brilliant red marks on the ribbon. Sections of ribbon can also be sent for laboratory analysis to identify the specific NAPL compounds that are present. The Ribbon NAPL Sampler can be deployed with direct push methods or traditional drilling methods in both the vadose and saturated zones.

Laser Induced Fluorescence Probe



The Laser Induced Fluorescence (LIF) Probe is a sensor that can be deployed by a cone penetrometer truck for depth discrete delineation of contaminants that fluoresce. At SRS, LIF has been applied to characterization of both dense non-aqueous phase liquids (DNAPL) and light non-aqueous phase liquids (LNAPL). Fluorescence excitation and emission spectra were collected and analyzed for commonly co-disposed constituents to aid in tuning LIF systems. Although DNAPL compounds themselves do not fluoresce at standard excitation wavelengths, organic matter or co-contaminants that do fluoresce can leach preferentially into DNAPL. Thus the fluorescence is used to infer the presence of DNAPL. LIF is deployed using CPT allowing quick screening for DNAPL compounds. The LIF system is best used for source zone characterization since it is only sensitive to very high concentration or separate phase contaminants. The LIF probe is not applicable to DNAPL sites without fluorescing co-constituents.

Membrane Interface Probe

The Membrane Interface Probe (MIP) is a permeable membrane device used to detect volatile contaminants during a CPT push. A thin film membrane is impregnated into a stainless steel screen on the face of the probe. This membrane is heated to 100 - 120 C that leads to quick diffusion of volatile contaminants across the membrane into the carrier gas line. The MIP relies on diffusion of contaminants across the membrane rather than bulk flow of liquid or gas into the CPT rods and up to the surface. The carrier gas transfers the contaminants to an analysis instrument at the surface. Analysis can be done at the screening level using a flame ionization detector (FID) or photo ionization detector (PID) for total VOCs or more quantitatively using a gas chromatograph or mass spectrometer. Typically, the MIP is pushed in conjunction with standard CPT electric cone for lithology determination. Each measurement takes 30-60 seconds with the screening analysis methods and the current lower detection is approximately 200 µg/l (ppb) for trichloroethylene and perchloroethylene. The MIP was developed by Geoprobe Systems and modified for CPT use by the Army Corps of Engineers Waterways Experiment Station.

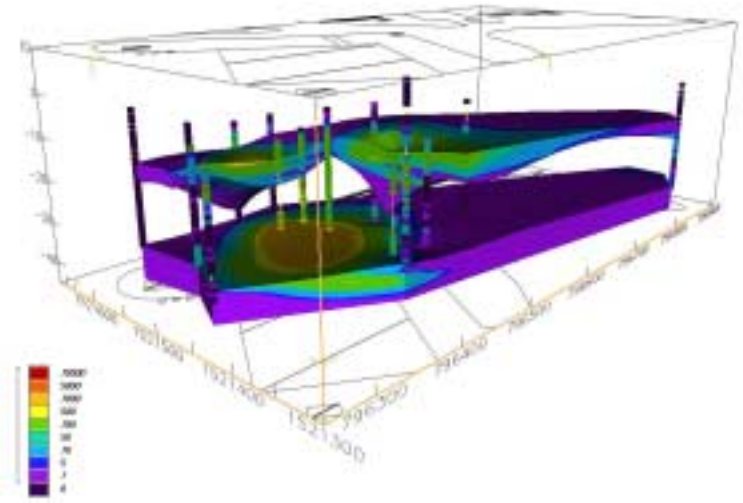
CPT Wireline Vadose Zone Soil Sampler

The wireline vadose zone soil sampling system was developed by Applied Research Associates, Inc. under a grant from the Department of Energy's National Energy Technology Laboratory (NETL) program. Like other direct push soil sampling systems (e.g., MosTap, Vertek, etc.) the wireline tool provides a significant advantage over conventional soil sampling methods when waste minimization is an issue. The small diameter and lack of soil cuttings of the direct push tools eliminates most of the waste associated with subsurface investigations. The wireline offers a further advantage by saving a significant amount of time when several samples are desired since it does not require the retrieval of the push rods for each sample. The wireline soil sampling tool uses a removable core barrel with a locking mechanism that fits inside the push rods. The sampler is deployed and retrieved using a wire tether. Using this method, consecutive one-foot long core samples were consistently collected at SRS at the rate of one every two minutes in pushes to depths of 60 feet.

Sediment Sampling and Analysis

Sediment sampling is used to delineate the geologic framework that controls contaminant migration and define the distribution and mass of contamination through chemical analysis of sediments. The core is described in the field and a geologic log is prepared to provide lithologic information. Sediment samples for chemical analysis are collected at depth intervals of one to two feet depending on field screening results. The field screening is accomplished using a portable photo-ionization detector (PID) which allows continuous screening of the core for a total relative VOC concentration. The technique used to prepare and analyze soil samples for chlorinated volatile organic compound (CVOC) analysis is a modified version of EPA Method 5021.

3-D Visualization of Environmental Data



Synthesis and understandable presentation of environmental data is essential to defensible and cost-effective site characterization and remediation. Commercially available three-dimensional imaging and visualization software programs such as Dynamic Graphics Earth Vision can be used to manipulate and interpret large databases in a coordinated, systematic fashion. The foundation of these methods is the creation of three-dimensional grids that represent the distribution of the modeled parameter in three-dimensional space. These parameters are not limited to contaminant distribution but can include permeability, lithology and other measured parameters. This information can be transformed into visual images. The final product is a powerful scientific and education tool for environmental characterization and remediation.

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