Appendix A

Equipment information contained in this appendix was provided by Columbia Technologies, LLC of Baltimore, MD.

Equipment Description

The MIP/SC probe is approximately 12-inches (30 cm) in length and 1.5-inches (3.8 cm) in diameter. The probe is driven into the ground at the nominal rate of one foot per minute using a Geoprobe® or similar direct push rig.

Soil conductivity, the inverse of soil resistivity, is measured using a dipole arrangement. In this process, an alternating electrical current is transmitted through the soil from the center, isolated pin of the probe. This current is then passed back to the probe body. The voltage response of the imposed current to the soil is measured across these same two points.

Conductivity is measured in Siemens/meter, and due to the low conductivity of earth materials, the SC probe uses milliSiemens/meter (mS/m). The probe is reasonably accurate in the range of 5 to 400 mS/m. In general, at a given location, lower conductivity values indicate larger particles such as sands, while higher conductivities are representative of finer sized particles such as silts and clays.

The MIP portion of the probe was developed and patented by Geoprobe Systems, Inc. The operating principle is based on heating the soil and/or water around a semi-permeable polymer membrane to 121ºC, which allows volatile organic compounds (VOCs) to partition across this membrane. The MIP can be used in saturated or unsaturated soils, as water does not pass through the membrane. Using nitrogen as a carrier gas, which sweeps across the back of the membrane, the VOCs are carried to the installed detectors. It takes approximately 37 seconds for the nitrogen gas stream to travel through 100 feet of inert tubing and reach the detectors.

COLUMBIA utilizes three detectors: a Photo Ionization Detector (PID), a Flame Ionization Detector (FID) and an Electron Capture Detector (ECD), mounted on a laboratory grade Shimadzu Model 14A gas chromatograph. The output signal from the detectors is captured by a MIP data logging system installed on a MIP Field Computer or laptop computer. Conductivity, speed, detector data and temperature are displayed continuously in real time during each push of the probe. In addition, the data logs can be printed for display and analysis following the data logging run or exported to common spreadsheet software for further analysis using COLUMBIA's SmartData Solutions^{tm} technology.

The PID detector consists of a special UV lamp mounted on a thermostat controlled, low volume, flow-through cell. The temperature is adjustable from ambient temperature to 250ºC. The 10.2 electron volt (eV) UV lamp emits energy at a wavelength of 120 nanometers, which is sufficient to ionize most aromatics (benzene, toluene, xylene, etc.) and many other molecules (H2S, hexane, ethanol) whose ionization potential is below 10.2 eV. The PID also emits a lower response for chlorinated compounds such as TCE and PCE. Methanol and water, which have ionization potentials greater than 10.2 eV, do not respond on the PID. Detection limits for aromatics are in the low picogram range. Since the PID is non-destructive, it is often run first in series with other detectors for multiple analyses from a single injection. Use of the PID is mandated in several EPA methods (8021, TO-14 etc.) because of its sensitivity and selectivity.

The FID responds linearly from its minimum detectable quantity of about 100 picograms. The FID response is very stable from day to day, and is not susceptible to contamination from dirty samples or column bleed. This detector responds to any molecule with a carbon-hydrogen bond, but poorly to compounds such as H2S, CCl4, or NH3. The carrier gas effluent from the GC column is mixed with hydrogen and burned. Hydrogen supports a flame and ionizes the analyte molecules. A collector electrode attracts the negative ions to the electrometer amplifier, producing an analog signal, which is directed to the data system input.

The ECD detector consists of a sealed stainless steel cylinder containing radioactive Nickel-63. The Nickel-63 emits beta particles (electrons), which collide with the carrier gas molecules, ionizing them in the process. This forms a stable cloud of free electrons in the ECD cell. When electro-negative compounds (especially chlorinated, fluorinated or brominated molecules) such as carbon tetrachloride or TCE enter the cell, they immediately combine with the free electrons, temporarily reducing the number remaining in the electron cloud. The detector electronics, which maintain a constant current of about 1 nanoampere through the electron cloud, are forced to pulse at a faster rate to compensate for the decreased number of free electrons. The pulse rate is converted to an analog output, which is transmitted to the data system.

Selective Compound Identification

In addition to the continuous profiling of the basic MIP system, further compound speciation was done by injecting portions of the gas stream directly into the analytical column of a laboratory grade SRUI 8610C Environmental gas chromatograph for analysis. The column was temperature programmed to separate the analytes, which were then detected using PID, FID and DELCD detectors. Compound identifications are based on peak placement with in established retention time windows. Secondary identification of some compounds can be made from the second detector, if the compound responds on both detectors.

Response Test

Prior to logging each MIP location, performance tests with specific compounds are conducted to evaluate the sensitivity of the particular probe, transfer line and detector suite to be used. Using neat benzene to test the PID, and neat TCE to test the ECD, the headspace vapors are introduced to the membrane of the probe for four seconds. To test the FID, butane is released on the membrane for four seconds. These values are compared to predetermined values and recorded.

MIP Log Interpretation

The MIP logs include six graphs. The first graph is conductivity and is measured in mS/M. In general, lower conductivities are indicative of coarser grained particles, such as sands, and higher conductivities indicate finer grained particles, such as silts and clays. The second graph is the rate of penetration (speed of the probe) and is measured in feet/min. This information can be used to determine how hard the subsurface is. The next three graphs are chemical data: PID, FID, and ECD, measured in microvolts (uV). These graphs are a linear scale, and give relative concentrations of contamination. The last graph displays the temperature of the probe as it is advanced in the subsurface. This graph can be useful to determine where the groundwater table is located.