**URS**

May 4, 2004



Mr. Don Hwang
Alameda County Health Care Services
1131 Harbor Bay Parkway, Ste. 250
Alameda, CA 94502-6577

**RE: Fuel Leak Case No. RO0000014, BP Station #11132, 3201 35th Ave., Oakland, CA, Request for Modification of Soil and Groundwater Investigation Work Plan Addendum Field Procedures.**

Dear Mr. Hwang,

On behalf of Atlantic Richfield Company (RM, an affiliate of BP), URS has prepared this letter to the Alameda County Health Care Services (ACHCS) requesting a modification to field procedures proposed in the *Soil and Groundwater Investigation Workplan Addendum,* submitted by URS on May 28, 2003, and a further letter responding to ACHCS technical comments submitted by URS on December 13, 2003. ACHCS approved the proposed scope of work for the soil and groundwater investigation at the former BP service station #11132 at 3201 35th Avenue, Oakland in a letter dated January 13, 2004.

URS performed the onsite portion of the soil and groundwater investigation on April 19 and 20, 2004, advancing six direct push technology (DPT) borings to a maximum depth of 42.5 feet below ground surface (bgs) with a truck-mounted Geoprobe™ rig. Due to unexpectedly high resistance of subsurface soils, the Geoprobe™ DPT rig was not able to penetrate significantly deeper than first encountered groundwater. Vadose zone soil samples and a grab groundwater sample were collected from each boring. It was not possible to collect depth-discrete groundwater samples in the proposed six separate adjacent borings as originally planned, since the DPT depth-discrete water sampling device would not penetrate the high density soils to adequate depths.

Since the Geoprobe™ DPT rig as originally proposed is inadequate for the purpose of collecting depth-discrete groundwater samples in the dense soils encountered in the site vicinity, URS requests a change in scope of work for the proposed offsite borings. URS proposes the use of a cone penetration testing (CPT) rig for logging of the soils and collection of depth-discrete water samples. The CPT rig determines soil characteristics by hydraulically driving a cone penetrometer into subsurface soils. The subsurface stratigraphy is continuously logged using friction ratio and pore water pressure measurement data. When using dual casing, the CPT system is capable of collecting depth-discrete water samples simultaneously with stratigraphic logging within the same borehole. It can collect individual soil samples with some difficulty but not is not capable of continuous coring. Because of the heavier weight of the rig and more powerful hydraulic drive, the CPT rig can penetrate denser soils deeper than the Geoprobe™ DPT rig can. A detailed summary of DPT technology from the EPA *Expedited Site Assessment Guidelines* is attached.

URS proposes advancing only one boring at each offsite location, instead of the originally proposed two, for a total of six offsite borings. The locations will remain the same as originally

URS Corporation
1333 Broadway, Suite 800
Oakland, CA 94612-1924
Tel: 510.893.3600
Fax: 510.874.3268

proposed, three along 35th Avenue and three along Mangels Avenue. URS will collect depth-discrete groundwater samples from relatively high-permeability saturated zones encountered to a maximum depth of approximately 50 feet. Due to the difficulty in soil sampling with the CPT system, URS will collect only one soil sample per boring within the capillary fringe zone. Since the primary purpose of the offsite borings is the downgradient delineation of the dissolved-phase hydrocarbon plume in groundwater, one soil sample per boring should be adequate.

URS does not recommend additional onsite borings with the CPT rig, since the primary purpose of the onsite investigation was soil characterization of the source area, which has been accomplished with the previous Geoprobe™ borings. The existing onsite monitoring wells and grab groundwater samples from the Geoprobe™ borings have provided adequate data for onsite dissolved-phase plume characterization. If necessary, URS can perform the additional CPT borings adjacent to some or all of the previous onsite Geoprobe™ borings.

URS is awaiting approval of City of Oakland encroachment permits to advance the proposed offsite DPT borings located along the 35th Avenue and Mangels Avenue. These permit applications may need to be modified for the revised scope of work, which would be only six borings using a CPT rig. In our January 23, 2004 letter, URS had requested an extension for the subsurface investigation report from the previous due date of March 13, 2004 to 60 days after completion of subsurface investigation field activities, subject to approval of encroachment and boring permits. While URS can currently submit a report for the completed onsite portion of the investigation, we feel it would be more appropriate in addition to being more cost effective to submit the results of the combined onsite and offsite soil and water investigation in a single report within 60 days after completion of the offsite portion of the investigation.

URS would appreciate approval of our proposal to revise the scope of work to six offsite borings using a CPT rig and no additional onsite borings. URS would also appreciate approval to submit the combined onsite and offsite soil and water investigation report within 60 days after completion of the offsite borings, or notification of whether a separate report for the completed onsite borings should be submitted first with the offsite report to be submitted later. Please feel free to contact me at 510.874.1720 with any questions or comments you may have.

Sincerely,

**URS Corporation**

Leonard P. Niles

Leonard P. Niles, R.G. 5774/C.H.G 357
Project Manager

CERTIFIED HYDROGEOLOGIST
LEONARD P. NILES
NO.HG357
EXP. 3/31/06
STATE OF CALIFORNIA

ATTACHMENT

United States Environmental Protection Agency, *Expedited Site Assessment Guidelines*, Chapter V, *In Situ Measurements Using Specialized Direct Push Probes*, pages V-30 – V-38, March 1997.

Cc: Mr. Paul Supple: BP/ARCO, Environmental Resources Management, PO Box 6549, Moraga, CA 94549
Ms. Liz Sewell, ConocoPhillips, 75 Broadway, Sacramento, CA 95818

# *In Situ* Measurements Using Specialized Direct Push Probes

In addition to collecting samples of soil, soil-gas, and groundwater/NAPL samples, specialized DP probes are also available for collecting *in situ* geophysical, geochemical, and geotechnical measurements of subsurface conditions. Because these methods record vertical profiles, they are often called logging instruments. They provide objective information, but the interpretation of measurements may still be subjective, requiring correlation with actual samples. Information that can be collected with these tools includes stratigraphy, depth to groundwater, approximate hydraulic conductivity, and residual and free product location.

Cone penetrometer testing (CPT) is the most common method for collecting *in situ* measurements. In addition, several recent innovations have adapted some logging methods to other DP rigs. The following section discusses CPT and other logging tools currently available with DP rigs. The growth of this technology is very rapid; there are likely to be many new tools in the near future.

## Cone Penetrometer Testing

CPT is a method for characterizing subsurface stratigraphy by testing the response of soil to the force of a penetrating cone. It was developed in the 1920s in Holland by the geotechnical industry and became commercially available in the United States in the early 1970s.

CPT is most commonly performed to depths ranging from 50 to 100 feet; however, depths as great as 300 feet are attainable under ideal conditions (*e.g.*, soft, unconsolidated sediments). Typically, 100 to 300 feet of CPT can be performed per day if the decontamination of probe rods (also referred to as cone rods when used with CPT) and the sealing of holes are necessary; productivity can be doubled when this is not necessary. Production rates can be significantly less if site access is limited or if significant soil, soil-gas, or groundwater sampling is performed.

Traditionally, CPT methods have been used less frequently at sites where investigation depths are less than 40 feet because CPT cones have been pushed with heavy, poorly-maneuverable rigs. Recently, lighter, more maneuverable DP rigs have become available to advance CPT cones. This innovation should make CPT more cost-effective for investigating sites that may have contamination located closer to the surface.

CPT uses sensors mounted in the tip or "cone" of the DP rods to measure the soil's resistance to penetration. The cone, presented in Exhibit V-14, is pushed through the soil at a constant rate by a hydraulic press mounted in a heavy truck or other heavy weight.

Several types of sensors are commonly available with CPT cones. These include piezometric head transducers (piezocones), resistivity sleeves, nuclear logging tools, and pH indicators. Most recently, CPT cones have incorporated sensors to measure the type and location of petroleum hydrocarbons in the subsurface (*e.g.*, laser induced fluorescence, fuel fluorescence detector). The electronic signals from the sensors are transmitted through electrical cables which run inside the cone rods and to an on-board computer at the ground surface, where they are processed. CPT cones can often measure several parameters simultaneously. An example of a CPT log with multiple parameters is presented in Exhibit V- 15.

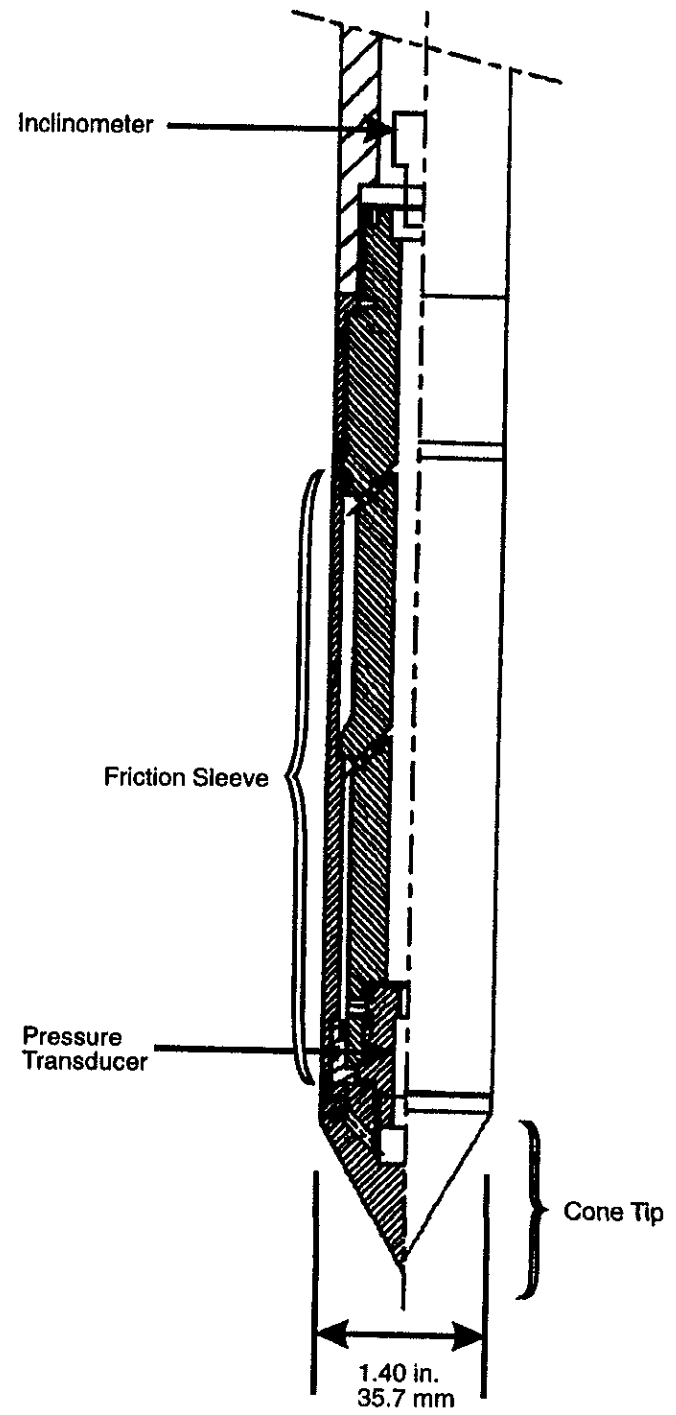
DP rigs that perform CPT can also be used to collect soil, soil-gas, and groundwater samples. In fact, some CPT cones allow the collection of soil-gas or groundwater samples without removing the cone from the hole. Collection of soil samples (and in many cases groundwater samples as well) with CPT, however, currently requires the attachment of DP sampling tools in place of the CPT cone. Because removing cone rods and inserting DP sampling tools is time consuming, most CPT contractors will first advance a CPT hole to define the stratigraphy, then advance another DP hole a few feet away to collect soil or groundwater samples.

The following text describes the cones that are available only with CPT and is followed by a section which describes *in situ* logging tools available for both CPT and other DP systems.

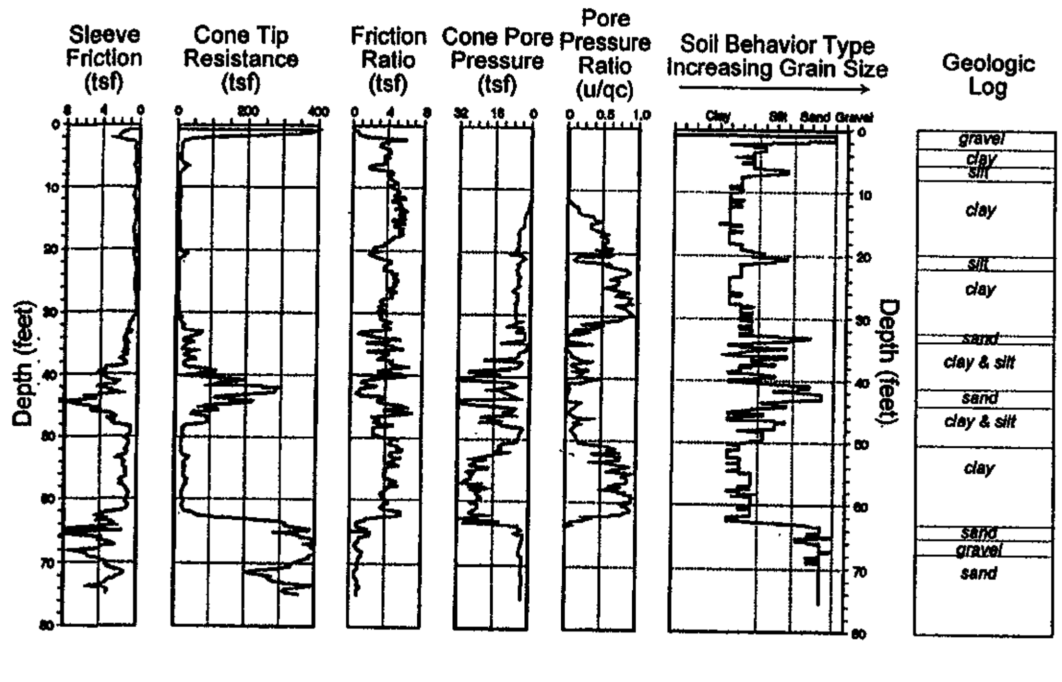
### Three-Channel Cone

The most common type of CPT cone is referred to as a three-channel cone because it simultaneously measures the tip resistance, sleeve resistance, and inclination of the cone. The ratio of sleeve resistance to tip resistance, which is referred to as the friction ratio, is used to interpret the soil types encountered (Chiang *et al.*, 1992). In general, sandy soils have high tip resistance and low friction ratios, whereas clayey soils have low tip resistance and higher friction ratios. As a result, this information can also be used to estimate the hydraulic conductivity of sediments. With the use of the other CPT channels, stratigraphic layers as thin as 4 inches can be identified.

## Exhibit V-14
## Components Of CPT Piezocone

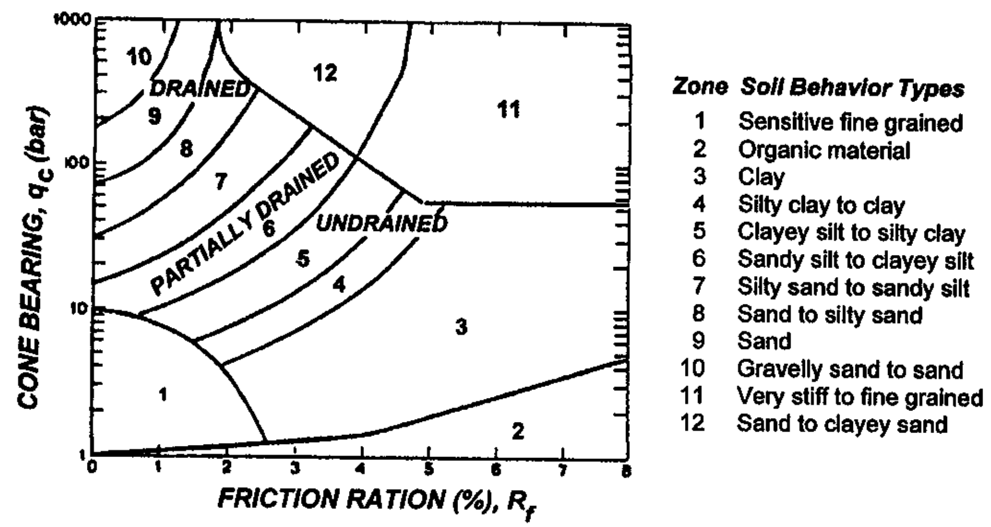


## Exhibit V-15
## Example CPT Data




Source: Berzins, 1993[1]

## Exhibit V-16
## CPT Soil Behavior Types




Source: Berzins, 1993[1]

[1]Reprinted by permission of the National Ground Water Association, Westerville, Ohio. 

Three-channel cones record soil behavior rather than actual soil type because in addition to grain size, the soil's degree of sorting, roundness, and mineralogy can also influence tip resistance. As a result, a boring log may help in the interpretation of CPT data for site-specific conditions. In general, soil behavior type correlates well with soil type. An empirically produced plot of friction ratios and soil behavior types is presented in Exhibit V-16.

The inclinometer mounted in the three-channel cone provides a measurement of the inclination of the cone from vertical. Rapid increases in inclination indicate that the rods are bending, allowing the CPT operator to terminate the sounding (*i.e.*, cone penetrometer test) before the cone and/or rods are damaged.

### Piezocone

The piezocone is similar to the three-channel cone, described above, except that a pressure transducer is also mounted in the cone (previously presented in Exhibit V-14) in order to measure water pressure under dynamic and static conditions. Pore-pressure dissipation tests can be performed by temporarily halting advancement of the tool and letting the pore pressure reach equilibrium. The slope of a plot of pore pressure versus time is proportional to the permeability of the soil and can be used to estimate hydraulic conductivity and define the water table.

## Geophysical And Geochemical Logging Probes

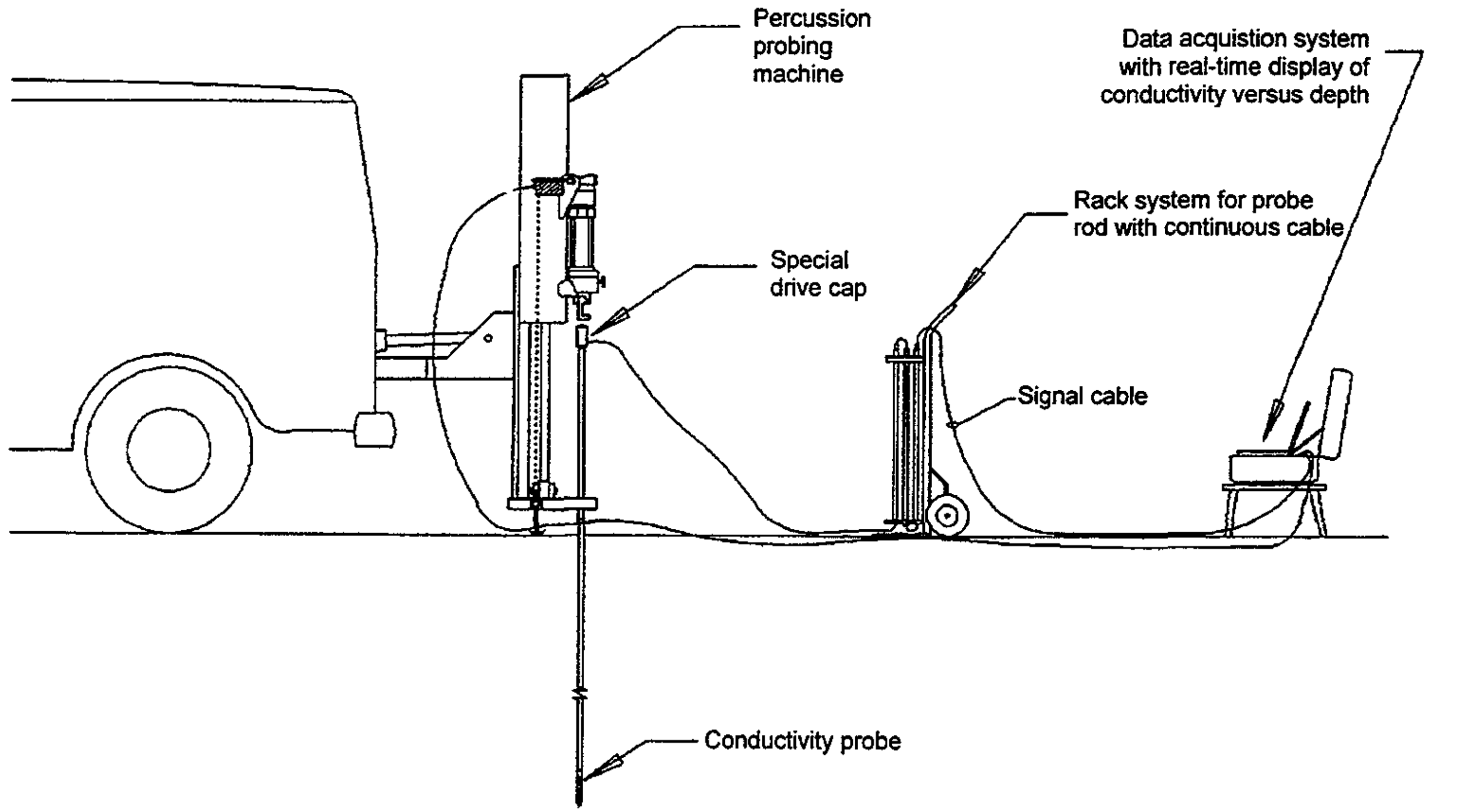
Logging probes are continually being developed for both CPT rigs and other DP probing equipment. The following section describes probes that are available for use with DP technologies in general. Information provided by these probes can be used to interpret site stratigraphy, moisture conditions, and in some cases, contaminant type and distribution.

### Conductivity Probes

Conductivity probes measure the electrical conductivity of the subsurface sediments. Conductivity probes are available with CPT probes and, more recently, with small 1-inch diameter DP systems (Christy, 1994). Components of a small-diameter conductivity probe system are depicted in Exhibit V-17.

Because clay units commonly have a greater number of positively charged ions than sand units, clay layers can typically be defined by high conductivity and

**Exhibit V-17**
**Small-Diameter Direct Push Conductivity Probe**




*Source: Geoprobe® Systems*

sand by low conductivity. These measurements, however, must be correlated with other logging information because conductivity may be the result of other conditions (*e.g.*, moisture content, soil density, mineral content, contaminants). Groundwater tends to increase the electrical conductivity of sediments. Consequently, the zone of saturation may be discernible in logging data if the water table is located in a known resistive layer (*e.g.*, sand) and the contrast is sharp. In a similar way, conductivity measurements may occasionally indicate hydrocarbon contamination if a significant quantity of residual or free product is located in a conductive layer (*e.g.*, clay) because hydrocarbons are resistive (*i.e.*, poorly conductive).

### Nuclear Logging Tools

Nuclear logging tools are geophysical instruments that either detect natural radiation of a formation or emit radiation and measure the response of the formation. They have an advantage over other geophysical methods in being able to record usable data through metal casings. Nuclear logging tools can be advanced with DP probes to define the site stratigraphy, groundwater conditions, and, occasionally, subsurface contaminant distribution. They can be used with CPT cones, some small diameter probe rods, and inside of the outer drive casing of cased DP systems. There are primarily three nuclear methods--natural gamma, gamma-gamma, and neutron.

Natural gamma tools log the amount of natural gamma particles emitted by sediments. Because clays typically have a greater number of ions than sands, clays tend to have more radioactive isotopes that emit gamma radiation. By logging the change in gamma radiation, it is often possible to characterize the site stratigraphy. Gamma-gamma tools emit gamma radiation and measure the response of the formation. Because the response is related to the density of the soil, this method can also provide information about the stratigraphy as well as the porosity of soil. Neutron methods emit neutrons into a sediment and measure a response which is dependent on the moisture content. These methods can, therefore, be used to define the water table. In addition, if the stratigraphy and moisture conditions are defined with other methods, neutron logs can indicate the presence and thickness of free-phase petroleum hydrocarbons. A complete discussion of geophysical logging is presented in Keys (1989).

### Chemical Sensors

Chemical sensors provide screening level analysis of petroleum hydrocarbons at a specific depth, without removing a soil or groundwater sample. When used over an extended area, they can rapidly provide a 3-dimensional characterization of the contaminant source area. There are several *in situ* chemical sensors that have recently been developed for use with DP technologies, and more may be available in the near future. Currently available methods are laser-induced fluorescence (LIF), fuel fluorescence detectors (FFD), and semipermeable membrane sensors. These three methods are discussed in more detail in Chapter VI, Field Methods For The Analysis Of Petroleum Hydrocarbon.

### Discussion And Recommendations

*In situ* logging methods are ideal for heterogeneous sites with complex geology because they can rapidly provide continuous profiles of the subsurface stratigraphy. In addition, unlike boring logs, these logging methods provide an independent, objective measurement of the site stratigraphy. When *in situ* logging methods are used in combination with boring logs, data can be used to extrapolate/interpolate geologic units across a site. If boring log information is not available, several *in situ* logging parameters collected simultaneously will often provide similar information.

Investigators should be aware that *in situ* logging methods should generally be calibrated by pushing a probe next to at least one boring that has been continuously cored. In addition, while geophysical logging methods for defining stratigraphy produce reliable information about the primary lithology of the strata, they provide very little data regarding secondary soil features like desiccation cracks, fractures, and root holes. In silts and clays, these secondary soil features (*i.e.*, macropores) may control the movement of contaminants into the subsurface and may greatly influence the options for active remediation. At interbedded sites where defining macropores is important, continuous soil coring may be a better alternative. Exhibit V-18 presents a summary of *in situ* logging equipment used with DP technologies.

**Exhibit V-18**
**Summary Of *In Situ* Logging Equipment**
**Used With Direct Push Technologies**

| | DP Method | Application |
|---|---|---|
| **Three-Channel Cone** | CPT Only | Measures tip resistance, sleeve resistance, and inclination. It is used to determine soil behavior types which can be correlated with boring logs. |
| **Piezocone** | CPT Only | Measures the rate at which the water pressure returns to static conditions and can be used to estimate hydraulic conductivity and define the water table. |
| **Conductivity Probe** | DP | Measures the conductivity of stratigraphic layers and can be used in conjunction with other methods to determine soil type and, sometimes, contaminant location. |
| **Natural Gamma** | DP | Measures the natural gamma radiation emitted by a formation and can be used to determine stratigraphy |
| **Gamma-Gamma** | DP | Measures the response of a formation to gamma radiation and can be used to determine soil density/porosity. |
| **Neutron Probes** | DP | Measures the response of a formation to neutron bombardment and can be used to determine moisture content of soils. |
| **Chemical Sensors** | DP | Measures the presence of free or residual product and can be used to delineate source areas. |

CPT = Available with cone penetrometer testing equipment only
DP = Available with CPT and other direct push equipment