

Laser Induced Fluorescence (UVOST)

Gregg Drilling conducts Laser Induced Fluorescence (LIF) Cone Penetration Tests using a UVOST module that is located behind the standard piezocone, *Figure UVOST*. The laser induced fluorescence cone works on the principle that polycyclic aromatic hydrocarbons (PAH's), mixed with soil and/or groundwater, fluoresce when irradiated by ultra violet light. Therefore, by measuring the intensity of fluorescence, the lateral and vertical extent of hydrocarbon contamination in the ground can be determined.

The UVOST module uses principles of fluorescence spectrometry by irradiating the soil with ultra violet light produced by a laser and transmitted to the cone through fiber optic cables. The light is then passes through a small window in the side of the cone into the soil. Any hydrocarbon molecules present in the soil absorb the light energy during radiation and immediately re-emit the light at a longer wavelength. This re-emission is termed fluorescence. The UVOST system also measures the emission decay with time at four different wavelengths (350nm, 400nm, 450nm, and 500nm). This allows the software to determine a product "signature" at each data point. This process allows determination of the type of contaminant as shown in *Figure Concept*.

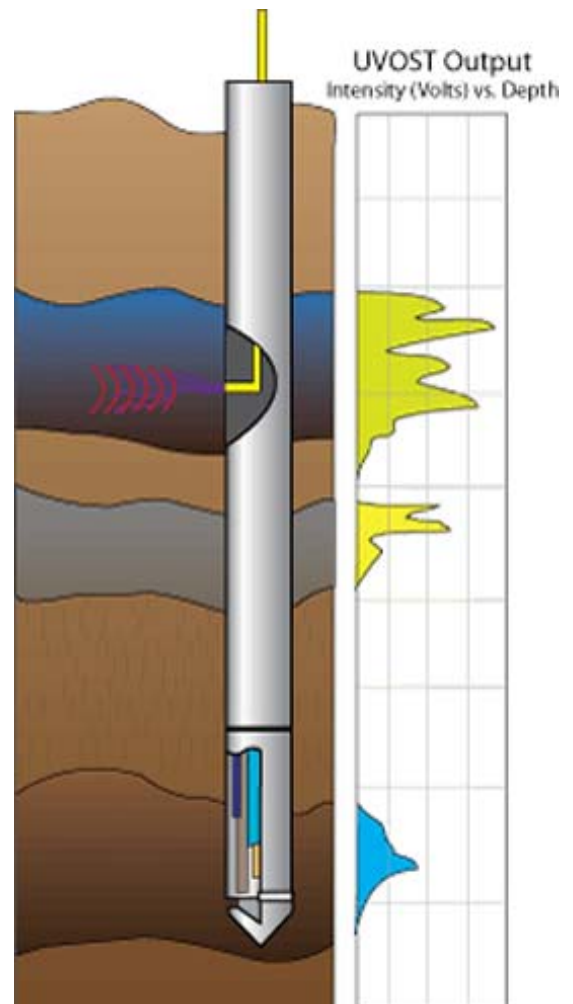
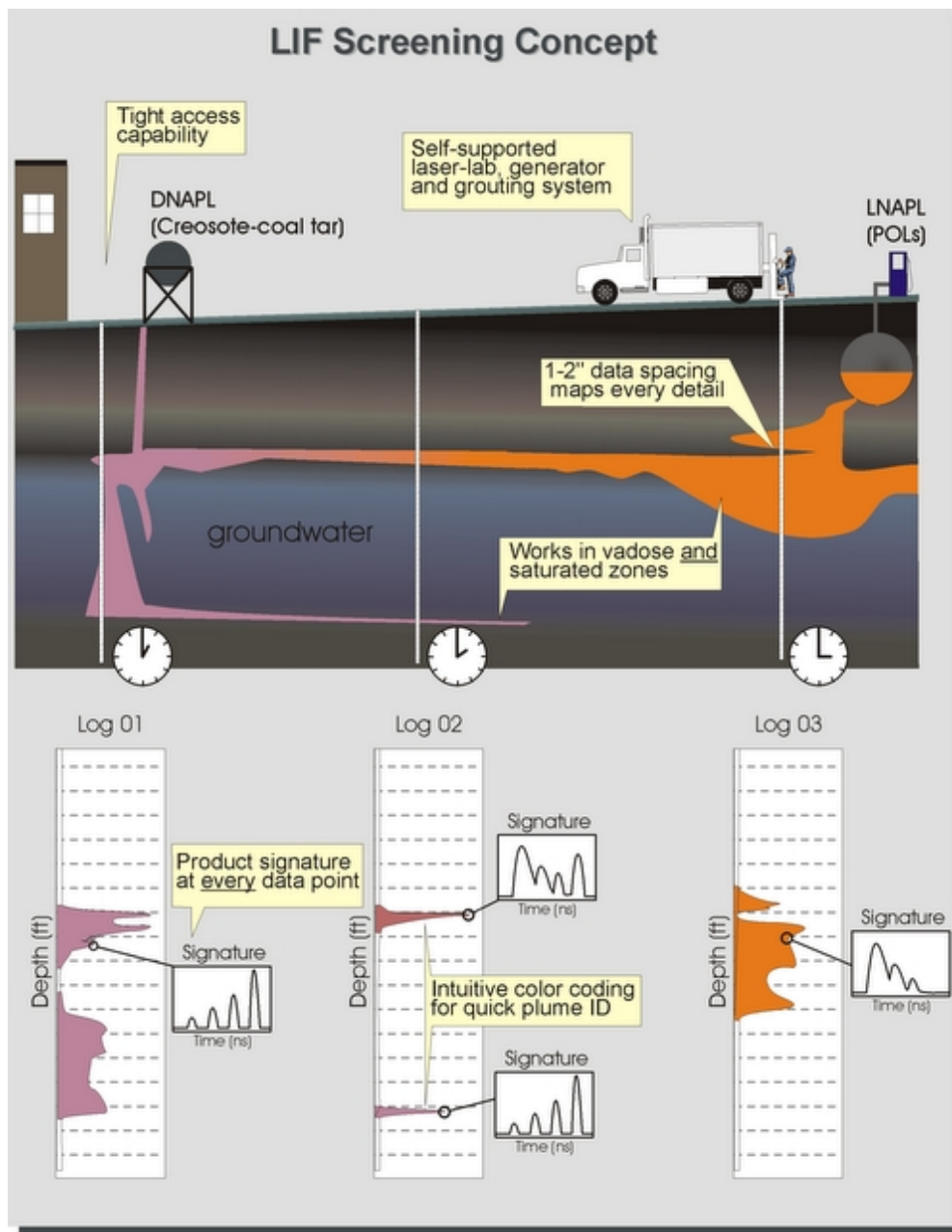


Figure UVOST: UVOST system deployed with the CPT

In general, the typical detection limit for the UVOST system is <100 ppm and it will operate effectively above and below the saturated zone. With the capability to push up to 600 feet per day, laser induced fluorescence offers a fast and efficient means for delineating PAH contaminant plumes. Color coded logs offer qualitative information in a quick glance and can be produced in the field for real-time decision making. Coupled with the data provided by the CPT, a complete site assessment can be completed with no samples or cuttings, saving laboratory costs as well as site and environmental impact.



*Figure Concept (figure provided by
Dakota Technologies)*

Hydrocarbons detected with UVOST	Hydrocarbons rarely detected using UVOST
Gasoline	Extremely weathered gasoline
Diesel	Coal tar
Jet (Kerosene)	Creosote
Motor Oil	Bunker Oil
Cutting fluids	Polychlorinated bi-phenols (PCB's)
Hydraulic fluids	Chlorinated solvent DNAPL
Crude Oil	Dissolved phase (aqueous) PAH's

Potential False Positives (fluorescence observed)	Potential False Negatives (do not fluoresce)
Sea-shells (weak-medium)	Extremely weathered fuels (especially gasoline)
Paper (medium-strong depending on color)	Aviation gasoline (weak)
Peat/meadow mat (weak)	Coal tars (most)
Calcite/calcareous sands (weak)	Creosotes (most)
Tree roots (weak-medium)	"Dry" PAHs such as aqueous phase, lamp black, purifier chips
Sewer lines (medium-strong)	Most chlorinated solvents
	Benzene, toluene, zylenes (relatively pure)



DAKOTA TECHNOLOGIES UVOST LOG REFERENCE

Main Plot :

Signal (total fluorescence) versus depth where signal is relative to the Reference Emitter (RE). The total area of the waveform is divided by the total area of the Reference Emitter yielding the %RE. This %RE scales with the NAPL fluorescence. The fill color is based on relative contribution of each channel's area to the total waveform area (see callout waveform). The channel-to-color relationship and corresponding wavelengths are given in the upper right corner of the main plot.

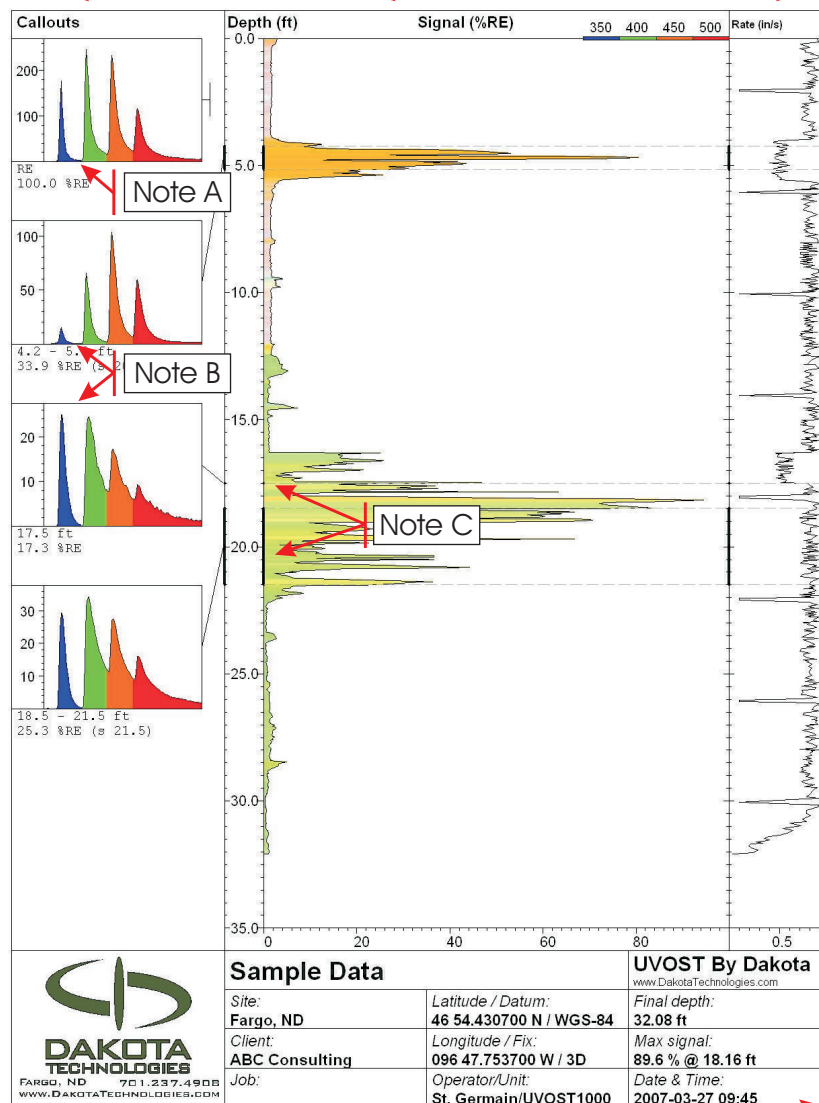
Callouts :

Waveforms from selected depths or depth ranges showing the multi-wavelength waveform for that depth.

The four peaks are due to fluorescence at four wavelengths and referred to as "channels". Each channel is assigned a color.

Various NAPLs will have a unique waveform "fingerprint" due to the relative amplitude of the four channels and/or broadening of one or more channels.

Basic waveform statistics and any operator notes are given below the callout.



Rate Plot :

The rate of probe advancement. ~ 0.8in (2cm) per second is preferred.

A noticeable decrease in the rate of advancement may be indicative of difficult probing conditions (gravel, angular sands, etc.) such as that seen here at ~5 ft.

Notice that this log was not terminated arbitrarily, but due to "refusal", as indicated by the sudden advancement rate drop at final depth.

Note A :

Time is along the x axis. No scale is given, but it is a consistent 320ns wide.

The y axis is in mV and directly corresponds to the amount of light striking the photodetector.

Note B :

These two waveforms show two different products, each with a unique waveform. The first is used motor oil and the second is diesel.

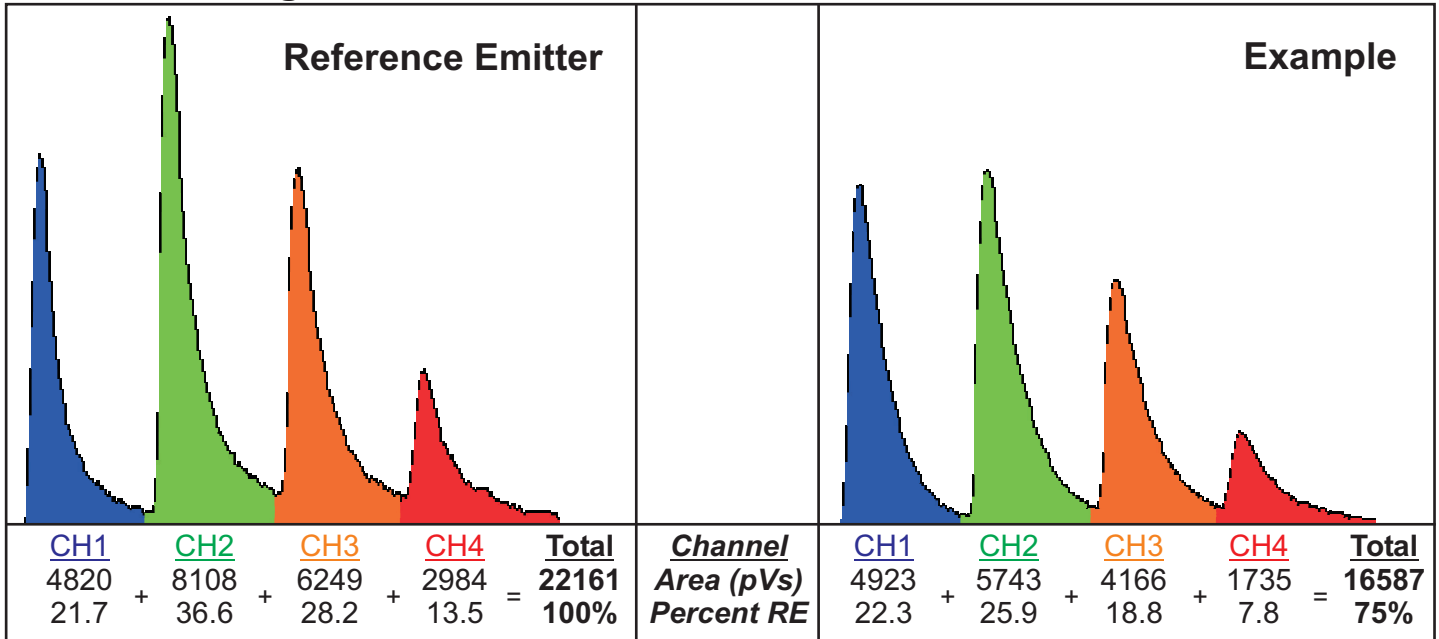
Note C :

Callouts can be a single depth (see 3rd callout) or a range (see 4th callout). The range is noted on the depth axis by a bold line. When the callout is a range, the average and standard deviation in %RE is given below the callout.

Info Box :

Contains pertinent log info including name and location.

Waveform Signal Calculation



Data Files

*.lif.raw.bin	Raw data file. Header is ASCII format and contains information stored when the file was initially written (e.g. date, total depth, max signal, gps, etc., and any information entered by the operator). All raw waveforms are appended to the bottom of the file in a binary format.
*.lif.plt	Stores the plot scheme history (e.g. callout depths) for associated Raw file. Transfer along with the Raw file in order to recall previous plots.
*.lif.jpg	A jpg image of the OST log including the main signal vs. depth plot, callouts, information, etc.
*.lif.dat.txt	Data export of a single Raw file. ASCII tab delimited format. No string header is provided for the columns (to make importing into other programs easier). Each row is a unique depth reading. The columns are: Depth, Total Signal (%RE), Ch1%, Ch2%, Ch3%, Ch4%, Rate, Conductivity Depth, Conductivity Signal. Summing channels 1 to 4 yields the Total Signal.
*.lif.sum.txt	A summary file for a number of Raw files. ASCII tab delimited format. The file contains a string header. The summary includes one row for each Raw file and contains information for each file including: the file name, gps coordinates, max depth, max signal, and depth at which the max signal occurred.
*.lif.log.txt	An activity log generated automatically located in the OST application directory in the 'log' subfolder. Each OST unit the computer operates will generate a separate log file per month. A log file contains much of the header information contained within each separate Raw file, including: date, total depth, max signal, etc.

Common Waveforms (highly dependent on soil, weathering, etc.)

