

Direct Sensing Summary Table

Tool	Primary Parameter	Parameter Resolution	Drilling Methods	Typical Productivity per Day	Vertical Parameter Resolution	Limitations	Potential Tool Combinations
<b>Downhole Analytical</b>							
LIF – UVOST® / ROST™	Light PAH NAPL	LNAPL only, can resolve product type	Percussion or static driven DPT	150 – 250'	cm/in	Limited to lithologies that can be pushed, aviation gasoline, chlorinated DNAPL, Heavy PAH NAPL	EC, Injection Flow Logging, CPT
LIF – DyeLIF™	Chlorinated DNAPL	Chlorinated DNAPL	Percussion or static driven DPT	150 – 250'	cm/in	Limited to lithologies that can be pushed, can't specify product type	EC, Injection Flow Logging, CPT
LIF – TarGOST®	Heavy PAH NAPL	Heavy PAH NAPL (Coal Tar, Creosote, crude oil)	Percussion or static driven DPT	150 – 250'	cm/in	Limited to lithologies that can be pushed, not effective on light PAH NAPL, chlorinated DNAPL	EC, Injection Flow Logging, CPT
OIP – UV	Light PAH NAPL	LNAPL only, photos of fluorescence, formation	Percussion or static driven DPT	150 – 250'	cm/in	Limited to lithologies that can be pushed, can't specify product type, Chlorinated DNAPL	EC, Injection Flow Logging, CPT
OIP – Green Laser	Heavy PAH NAPL	Heavy PAH NAPL (Coal Tar, Creosote, crude oil)	Percussion or static driven DPT	150 – 250'	cm/in	Limited to lithologies that can be pushed, not effective on light PAH NAPL, chlorinated DNAPL	EC, Injection Flow Logging, CPT
MIP	VOC distribution	Low ppb to low ppm	Percussion or static driven DPT	100 – 200'	cm/in	Limited to lithologies that can be pushed, NAPL problematic	EC, Injection Flow Logging, CPT
<b>Downhole Physical</b>							
Hydraulic Profiling (Injection Flow Logging)	Flow and pressure, used to estimate hydraulic conductivity	Hydraulic conductivity 0.1 to 75 ft/day	Percussion or static driven DPT	150 – 250'	cm/in	Not effective in high permeability formations	EC, MIP, LIF, OIP, GWS
CPT	Lithologic / hydrogeologic parameters	Soil type, relative density, porewater pressure	Static driven DPT	150 – 300'	cm/in	Limited to lithologies that can be pushed, refusal in bedrock and rocky formations	MIP, LIF, OIP XRF, injection flow logging, electrical conductivity
EC Logging	Formation soil conductivity	Electrical conductivity of formation and/or TDS of groundwater	Percussion or static driven DPT	150 – 250'	cm/in	Log provides non-unique solution that can respond to different subsurface factors	Commonly used as an accessory tool for many direct sensing applications
FLUTe (T-Profiler)	Estimated Transmissivity	Transmissivity range from 0 to 1 cm <sup>2</sup> /sec	Needs open borehole for deployment. Unconsolidated and bedrock applications	Varies	0.5 to 1 ft	Limited to consolidated lithologies, requires pre-planning for borehole diameters and depth	FACT system, blank liner, NAPL FLUTe

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<b>High Resolution Sampling and Profiling</b>							
Screen Point GW Sampler	Aqueous samples	Aqueous samples, parameter based on analytical method used	Percussion or static driven DPT	Varies based on objectives	inches - 1 ft	Low permeability formations	Pneumatic slug testing, mobile lab
Direct-Push Temporary Well Point Systems	Aqueous samples	Aqueous samples, parameter based on analytical method used	Percussion or static driven DPT	Varies based on objectives	1 ft	Limited to lithologies that can be pushed, refusal in bedrock and rocky formations	MIP, LIF, OIP XRF, injection flow logging, electrical conductivity, mobile lab
Soil/ Bedrock Cores	Soil and/or rock samples	Lithologic descriptions, Solid media samples with parameters based on analytical method used	Percussion or static driven DPT, hollow stem auger with sampler, sonic, bedrock coring methods	Varies based on objectives and drilling method	As needed	Limited recovery in some lithologies	Mobile lab, DFN, PID, FID, XRF
HPT - GWS	Estimated hydraulic conductivity, aqueous samples	Aqueous samples, parameter based on analytical method used	Percussion or static driven DPT	Varies based on frequency of sample collection	cm on hydraulic profiling, depth-discrete over 3- to 4-inch interval for groundwater samples	Not effective in lower permeability formations, potential fouling in finer grained formations	Electrical conductivity
Waterloo APS	Estimated hydraulic conductivity, aqueous samples	Aqueous samples, parameter based on analytical method used	Percussion or static driven DPT	Varies based on frequency of sample collection	cm on hydraulic profiling, depth-discrete over 3- to 4-inch interval for groundwater samples	Not effective in lower permeability formations, potential fouling in finer grained formations	Electrical conductivity
FLUTe (FACT)	Vertical profile of VOCs	Limited to analytes that adsorb to carbon. Results reported in mass of VOC per mass of carbon.	Needs open borehole for deployment. Unconsolidated and bedrock applications	deployed in hours, wait time 1-2 weeks	Continuous carbon profile, resolution based on sampling	Not applicable for constituents that do not adsorb to carbon	FLUTe T-Profiler, blank liner, NAPL FLUTe
FLUTe (NAPL)	Presence and depth of NAPL	LNAPL and DNAPL	Needs open borehole for deployment. Unconsolidated and bedrock applications	deployed in hours, wait time 1+ hours	Continuous profile, NAPL detection based on visual inspection of liner	Can't specify NAPL type	FLUTe T-Profiler, blank liner, FACT System
DFN	Distribution of VOCs in bedrock (fractures and matrix)	VOCs, physical rock properties	Bedrock Coring	Varies based on rock type and frequency of sampling	inches to feet, depth-discrete sampling, interval based on objectives and geology	Data representative of mass diffused in the matrix, not a direct measure of dissolved concentrations	Mobile lab
Multi-Level Well Systems	Vertical profile of contaminants	Aqueous samples, parameter based on analytical method used	Any, depends on lithology	Varies	Depth interval determined based on objectives	Depends on system, e.g., FLUTe only in consolidated and direct-push only in unconsolidated or soft consolidated	FLUTe T-Profiler, downhole physical and analytical tools