

INTEGRATED GEOSCIENCES LABORATORIES, LLC.

(formerly PTS Laboratories, Inc.)

(Environmental * Geotechnical * Core Analysis)

6016 Centralcrest Street, Houston Texas, 77092. Phone: +1 (713) 316 1800

TYPICAL LNAPL MOBILITY ANALYTICAL PROGRAM

Description	Test Method	Sample or Test Frequency
Core Photography: color (white light) plus ultra violet, full-scale strip format, per print (one print/foot)	Proprietary	Per every foot of core recovered. White light (color) photographs are high-detail engineering documents that provide permanent records of the subsurface. Ultra violet photographs record NAPL fluorescence
Core Image Archive: full-scale/continuous strip format (requires full-scale photography color prints) supplied on cross-platform ISO 9660 CD-ROM (analytical data may also be embedded as MS Excel type report)	Proprietary	One per project. Allows posting of data and digital images on corporate server. Initial images delivered via email for additional testing phase sample selection.
Pore Fluid saturation Package: Pore Fluid Saturations (NAPL and water) by Dean Stark extraction; total porosity, air-filled porosity, grain density, dry bulk density, and moisture content	API RP40	One sample every six inches; usually 8 - 12 samples per boring. The samples are taken vertically across the area of NAPL impact.
Grain Size Analysis: Laser or Sieve method; includes tabular data, statistical sorting and graphics in Excel format	ASTM D422 or ASTM D4464	One sample every six inches; usually adjacent to pore fluid saturation samples plus one or two samples per lithology. Laser method for fine-grained sediments and sieve method for coarse-grained sediments.
Drainage Capillary Pressure Data: Centrifugal Method; Air/Water Drainage Capillarity Package; includes initial and residual water saturations, final water production vs. capillary pressure, total porosity, bulk density, air permeability and hydraulic conductivity	ASTM D6836, API RP40, EPA 9100	One or two samples per lithology
Input Parameters for van Genuchten or Brooks-Corey Models from Capillary Pressure Data: Brooks-Corey and van Genuchten parameters obtained by fitting curves to capillary pressure curve data. Relative permeability by Mualem calculations also reported (requires air/water drainage capillarity package)	van Genuchten , Brooks-Corey, Mualem	One or two samples per lithology
Free Product Mobility Package: Applied Centrifugal force demonstrates product mobility; includes residual saturations by Dean Stark, total porosity, grain and bulk density.	Mod. ASTM D425, API RP40	One or two samples per lithology. Usually conducted on sample taken from zone identified by Dean Stark analysis as having highest NAPL saturation.
Fluids Properties Package - LNAPL and Water Pair: Dynamic viscosity and fluid density at three temperatures, surface and interfacial tension for each fluid (three phase pairs; LNAPL/water, LNAPL/air; and water/air)	ASTM D1481, ASTM D445, ASTM D971	One per every fluid (water/NAPL) pair.

Additional Test Methods and Options (LNAPL Mobility)

Description	Test Method	Sample or Test Frequency
Residual Saturation by Water Drive: Sample driven to residual saturation by water/NAPL displacement. Residual saturations by Dean Stark extraction, total porosity, bulk and grain density	Water Drive, API RP40	One or two samples per lithology. Usually conducted on samples taken from zone identified by Dean Stark analysis as having highest LNAPL saturation.
Intrinsic Permeability - Water: Includes specific permeability to water (intrinsic permeability) and hydraulic conductivity	API RP40, EPA 9100, ASTM D5084	One or two samples per lithology and fluid (included in Air/Water Capillarity Package).
Intrinsic Permeability - Water: Includes specific permeability to product (intrinsic permeability) and hydraulic conductivity	API RP40	One or two samples per lithology and fluid.
Atterberg Limits	ASTM D4318	One or two samples per lithology. Necessary to provide an accurate USCS classification. Used in conjunction with grain size analysis data.
Total Organic Carbon: includes fraction organic carbon (foc)	Walkley-Black	One or two samples per lithology
Water/Product Relative Permeability: Water/product unsteady-state method; includes production history, endpoint saturations and relative permeability curve	JBN or J&R	One or two samples per lithology
Drainage Capillary Pressure Data: Centrifugal Method; Air/Water Drainage Capillarity Package; includes initial and residual water saturations, final water production vs. capillary pressure, total porosity, bulk density, air permeability and hydraulic conductivity	API RP40, ASTM D6836M, EPA 9100	One or two samples per lithology
Imbibition Capillary Pressure Data: Centrifugal Method; LNAPL/Water: includes initial and residual fluid saturations, final water production vs. capillary pressure, effective (total) porosity, bulk density, hydraulic conductivity and specific permeability to oil (LNAPL).	API RP40, ASTM D6836M, EPA 9100	One or two samples per lithology
Pore Size Distribution: Mercury Injection Porosimetry; ambient conditions, to 2000-psia injection.	ASTM D4404	One or two samples per lithology