

**Recent developments in LNAPL:
If you think you already understand LNAPL – you probably don't**

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In this training session the basic behavior of petroleum hydrocarbon liquids (also known as LNAPL) in soil will be presented. This training provides an overview of the properties of LNAPL and how it behaves in the subsurface in order to technically explain what we have observed in practice. The training is an introduction to understand how LNAPL is distributed in soil and its' conductivity and to make reasonable predictions of the hydraulic recovery of LNAPL.

This training focuses on the underlying principles of capillary pressure and multi-phase flow. Recent LNAPL developments and research will be presented and discussed. We will end the training with applications to real world situations in which heterogeneity and other complicating factors considered and addressed. These real world examples will provide a measure of comfort for applying these basic principles.

The topics to be discussed include how our understanding of NAPL behavior has improved over the last few years. NAPL distribution in the soil will be addressed in light of the effects of various soil properties including pore size distribution, porosity, saturation, capillary pressure and permeability. Fluid properties such as viscosity, density, and interfacial and surface tensions and how these fluid properties affect NAPL distribution and recovery will also be addressed. NAPL distribution in the soil and its saturation determine its conductivity that influences its migration and potential hydraulic recovery. We will also introduce methods of predicting and evaluating recovery of NAPL. We will briefly discuss some assessment techniques and look at core photos taken from within NAPL plumes. We will end with four real world applications of these basic concepts.

What will we learn? LNAPL is not a pancake in the soil resting on the top of the water table. Rather it is distributed with water and air in pore spaces as determined by the capillary pressure. Using well-developed theories and methods, this distribution can be estimated. From this, the volume of LNAPL present in the soil and its conductivity can be estimated. Recovery estimates and performance goals can be set. Not all LNAPL is recoverable as some is trapped by capillary forces, fluctuating water

tables, and relative permeability effects; however, the understanding makes note that certain assumptions in the theory such as homogeneous soils and fluids in vertical equilibrium can raise uncertainty; but armed with our new understanding in addition to good data, we can arrive at a satisfactory understanding of LNAPL behavior in the soil.

This training is based upon the training delivered by the LNAPL cleanup alliance RTDF (www.rtdf.org/public/napl/). The training provided at IPEC will differ in that it will contain some recent developments.

Mark R. Adamski, PG is a regional technology coordinator for Atlantic Richfield Co (ARC a BP affiliated company) where he directs ARC and API research in the occurrence and behavior of LNAPL in the subsurface. He has conducted research on this topic for seven years within ARC and conducted, analyzed, and modeled LNAPL distribution and recovery at BP sites worldwide. As a result of this experience he has presented at conferences, seminars, and workshops internationally for the last five years. He has been involved with the development of landmark regulatory LNAPL guidance documents developed by the State of Texas and the US EPA. His primary areas of current LNAPL study are site characterization techniques, residual saturation, plume migration, and recovery techniques. Mark is currently located in the ARC and BP office at Westlake in Houston.

Vic Kremesec is an Advisor, Remediation Management for BP. He provides technical support on remediation of contaminated service stations to superfund sites for the last 16 yr. In the past few years, he has worked extensively on LNAPL technology development with industry, EPA, and various States and on the evaluation of the vapor intrusion pathway. He is a member of the Advisory Committee for the Soils/Groundwater Technical Task Force of the American Petroleum Institute. He received a Ph D in Chemical Engineering from Northwestern University in 1975 and B.S. in Chemical Engineering from the University of Illinois Champaign in 1969.