How much LNAPL is present? Tier 3

While the Concawe Toolbox includes the Tier 2 LNAPL Volume and Extent Model (de Blanc and Farhat, 2018) for evaluating how much LNAPL is present, another option is to apply the API LDRM Tool. These two tools can be found here:

- Multi-site LNAPL Tool: Built into Concawe Toolbox Tier 2 under the questions "How much LNAPL is present?" and "Will LNAPL recovery be effective?"
- API LDRM: Download from the API web site here; requires Windows operating system. Note there are two separate manuals: Volume 1 provides background theory and conceptual models. Volume 2 is the actual User Guide with help on parameter selection.

Similarities Between Multi-site Tool and LDRM

- Both calculate specific volume, recoverable volume, and transmissivity at individual well locations using the same relationships.
- Both use the f-factor method to calculate residual LNAPL saturation.

Differences Between Multi-site Tool and LDRM

- LDRM has more choices for relative permeability calculation.
- LDRM allows users to account for smear zones above and below the LNAPL lens, while the Multi-site tool does not.
- LDRM allows users to specify a fixed or variable residual saturation or f-factor, while the Multi-site tool uses only a variable f-factor for residual saturation.
- LDRM simulates LNAPL recovery for several kinds of systems, while the Multi-site tool does not simulate LNAPL recovery.
- LDRM is limited to a 3-layer system, while the Multi-site tool considers up to 10 layers.
- LDRM is limited to a single location, while the Multi-site tool calculates LNAPL properties at unlimited locations simultaneously.
- The Multi-site tool estimates spatial variation of transmissivity and LNAPL volumes, while the LDRM does not.
- The Multi-site tool accesses a customizable soil properties database for different soil types, while the LDRM requires users to enter this information manually for every well.

Overview of LDRM

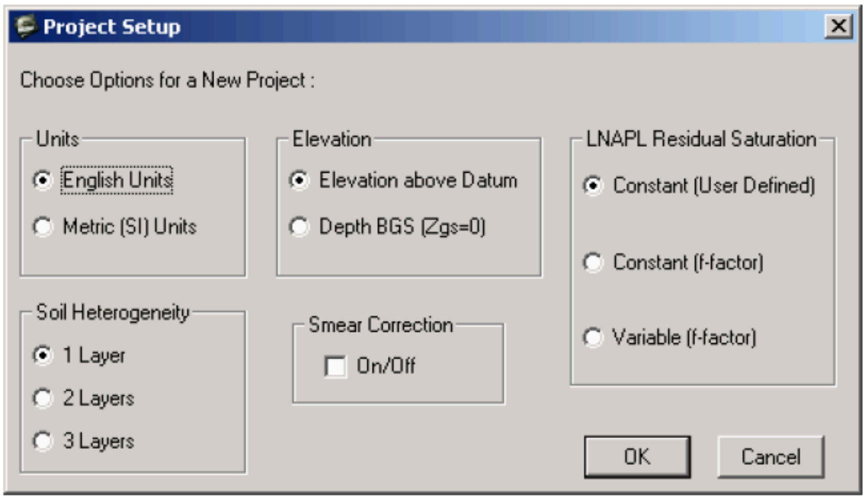
"The API LNAPL Distribution and Recovery Model (LDRM) simulates the performance of proven hydraulic technologies for recovering free-product petroleum liquid releases to groundwater. Model scenarios included in the LDRM are hydrocarbon liquid recovery using: single- and dual-pump well systems, skimmer wells, vacuum-enhanced well systems, and trenches. The LDRM provides information about LNAPL distribution in porous media and allows the user to estimate LNAPL recovery rates, volumes and times." "The Guide has been designed to meet the needs of very busy professionals. As such, the primers and tools can be utilized within 15 to 25 minutes so that information can be gained rapidly. A list of references is also provided to enable more detailed understanding." (API web page).

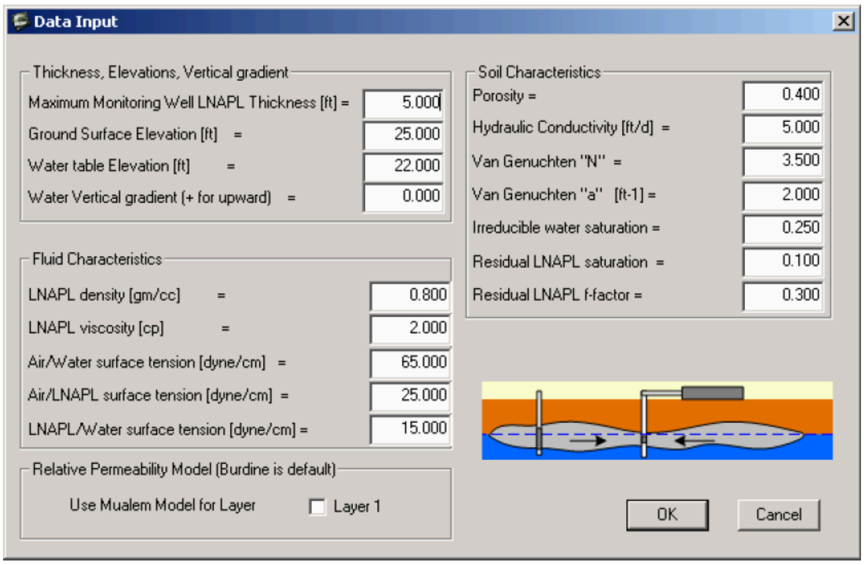
In general, the LDRM is a very powerful tool to simulate multiphase flow behavior that controls LNAPL recovery. To run LDRM, it is helpful to have an understanding of capillary pressure relationships (e.g., van Genuchten relationship; van Genuchten, 1980), LNAPL residual saturation concepts such as the f-factor, and the design of LNAPL recovery systems.

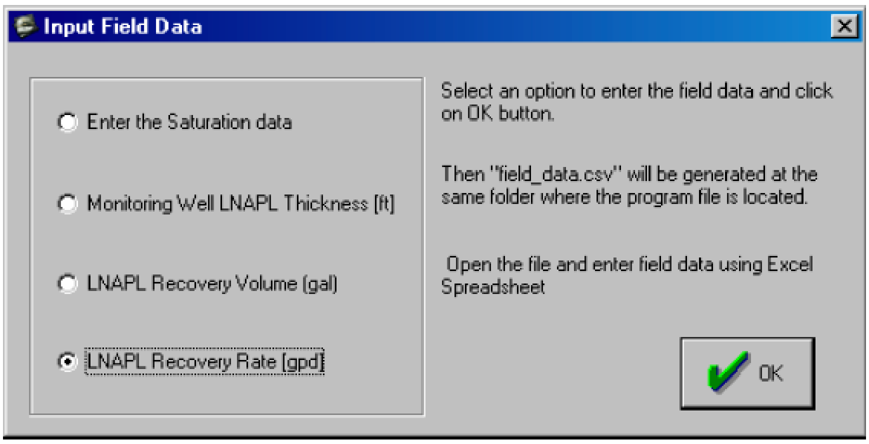
A short video describing LDRM can be viewed here.

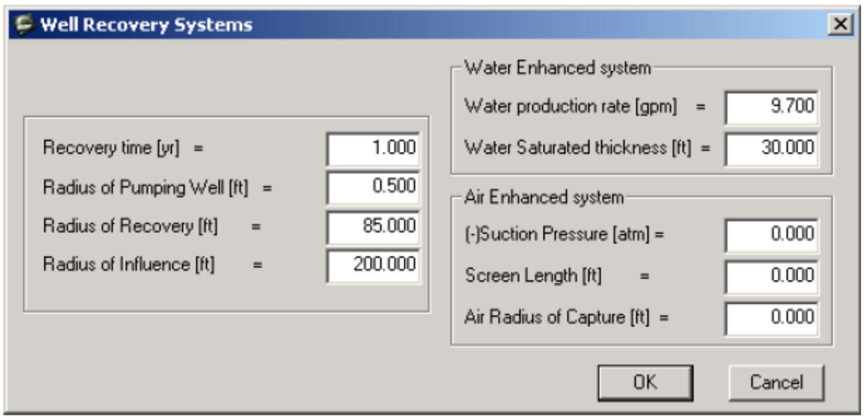
Checklist of Key LDRM Input Data

Images reproduced courtesy of the American Petroleum Institute from "LNAPL Distribution and Recovery Model (LDRM) Volume 2: User and Parameter Selection Guide", API Publication 4760, January 2014





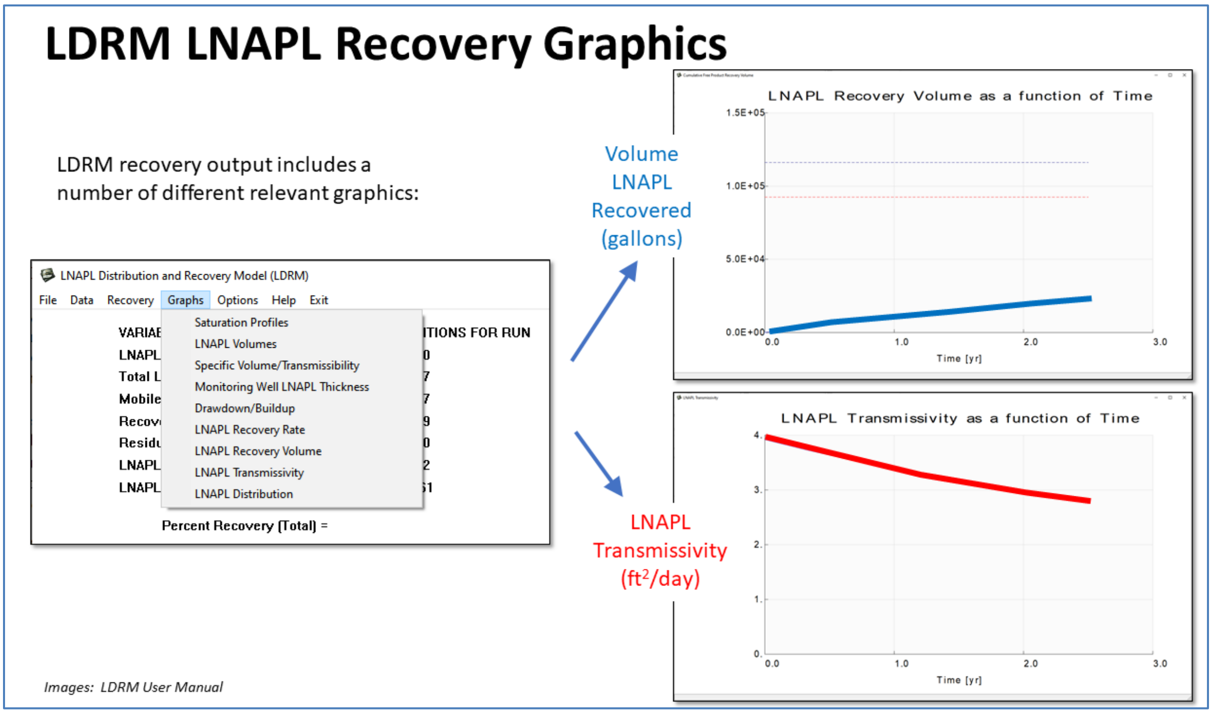




Example LDRM Output

Images reproduced courtesy of the American Petroleum Institute from LNAPL Dissolution and Transport Screening Tool, version 2.0.4, February 2006

Examples of the LNAPL recovery and LNAPL transmissivity graphics are shown below.



General LDRM Flowchart

Determine Type of Problem to be Addressed

- How much LNAPL is present?
- How much LNAPL is recoverable?
- If recoverable, what is best technology to recover LNAPL?

Compile and Enter Input Data

- Setup data
- Soil Properties
- Field Data
- Recovery System Data

If Historic Field Data are Available, Calibrate the Model

- Adjust input parameters to match historical record of LNAPL recovery from pilot tests or interim recovery data.

Generate Output

- Generate output that answers key questions.

LDRM Reference

Charbeneau, R., Beckett, G.D., 2007. LNAPL Distribution and Recovery Model (LDRM) Volume 1: Distribution and Recovery of Petroleum Hydrocarbon Liquids in Porous Media. Volume 2: User and Parameter Selection Guide. American Petroleum Institute.

Other References

van Genuchten, 1980. A closed-form equation for predicting the hydraulic conductivity of unsaturated soil, M.T. van Genuchten, Soil Science society of America Journal, 44:892-898, 1980.