

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

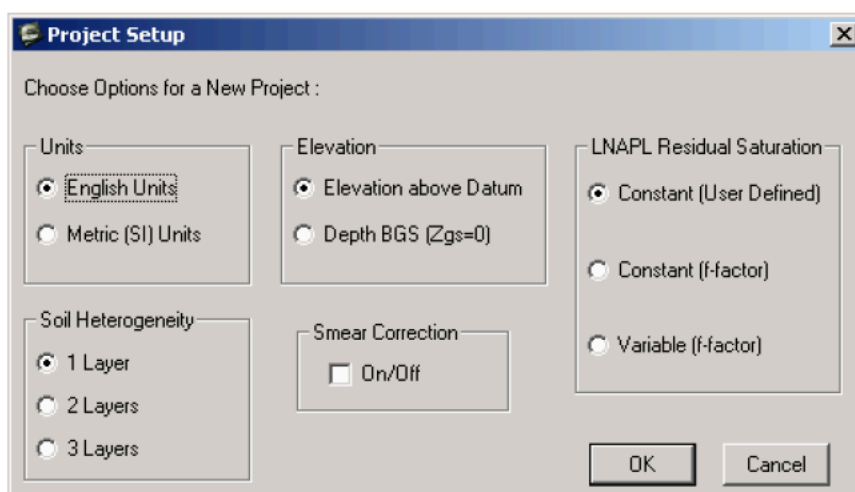
“The API LNAPL Distribution and Recovery Model (LDRM) simulates the performance of proven hydraulic technologies for recovering free-product petroleum liquid releases to groundwater. Model scenarios included in the LDRM are hydrocarbon liquid recovery using: single- and dual-pump well systems, skimmer 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



Project Setup

Choose Options for a New Project :

Units

- ☒ English Units
- ☐ Metric (SI) Units

Elevation

- ☒ Elevation above Datum
- ☐ Depth BGS (Z_{gs}=0)

LNAPL Residual Saturation

- ☒ Constant (User Defined)
- ☐ Constant (f-factor)
- ☐ Variable (f-factor)

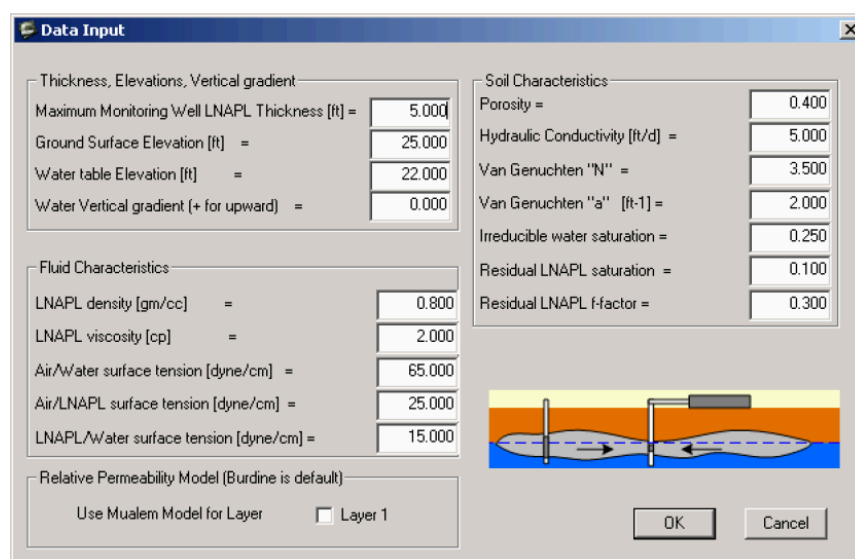
Soil Heterogeneity

- ☒ 1 Layer
- ☐ 2 Layers
- ☐ 3 Layers

Smear Correction

☐ On/Off

OK Cancel



Data Input

Thickness, Elevations, Vertical gradient

Maximum Monitoring Well LNAPL Thickness [ft] = 5.000

Ground Surface Elevation [ft] = 25.000

Water table Elevation [ft] = 22.000

Water Vertical gradient (+ for upward) = 0.000

Fluid Characteristics

LNAPL density [gm/cc] = 0.800

LNAPL viscosity [cp] = 2.000

Air/Water surface tension [dyne/cm] = 65.000

Air/LNAPL surface tension [dyne/cm] = 25.000

LNAPL/Water surface tension [dyne/cm] = 15.000

Soil Characteristics

Porosity = 0.400

Hydraulic Conductivity [ft/d] = 5.000

Van Genuchten "N" = 3.500

Van Genuchten "a" [ft⁻¹] = 2.000

Irreducible water saturation = 0.250

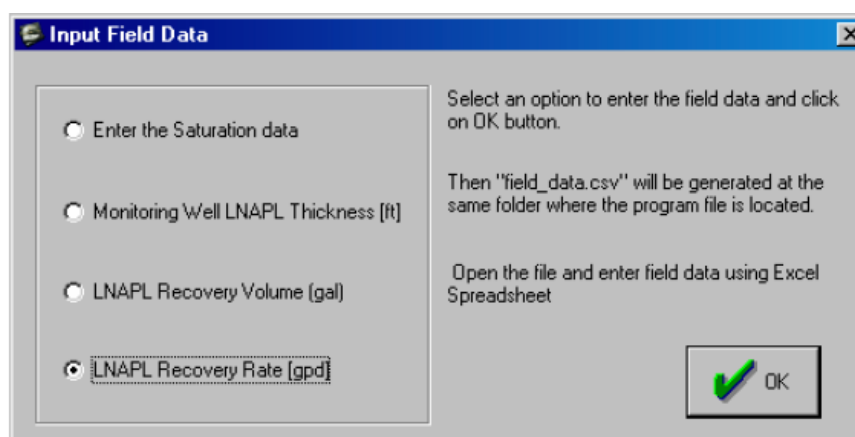
Residual LNAPL saturation = 0.100

Residual LNAPL f-factor = 0.300

Relative Permeability Model (Burdine is default)

Use Mualem Model for Layer ☐ Layer 1

OK Cancel



Input Field Data

Select an option to enter the field data and click on OK button.

Then "field_data.csv" will be generated at the same folder where the program file is located.

Open the file and enter field data using Excel Spreadsheet

☐ Enter the Saturation data

☐ Monitoring Well LNAPL Thickness [ft]

☐ LNAPL Recovery Volume [gal]

☒ LNAPL Recovery Rate [gpd]

OK

Well Recovery Systems

Recovery time [yr] = 1.000

Radius of Pumping Well [ft] = 0.500

Radius of Recovery [ft] = 85.000

Radius of Influence [ft] = 200.000

Water Enhanced system

Water production rate [gpm] = 9.700

Water Saturated thickness [ft] = 30.000

Air Enhanced system

(-)Suction Pressure [atm] = 0.000

Screen Length [ft] = 0.000

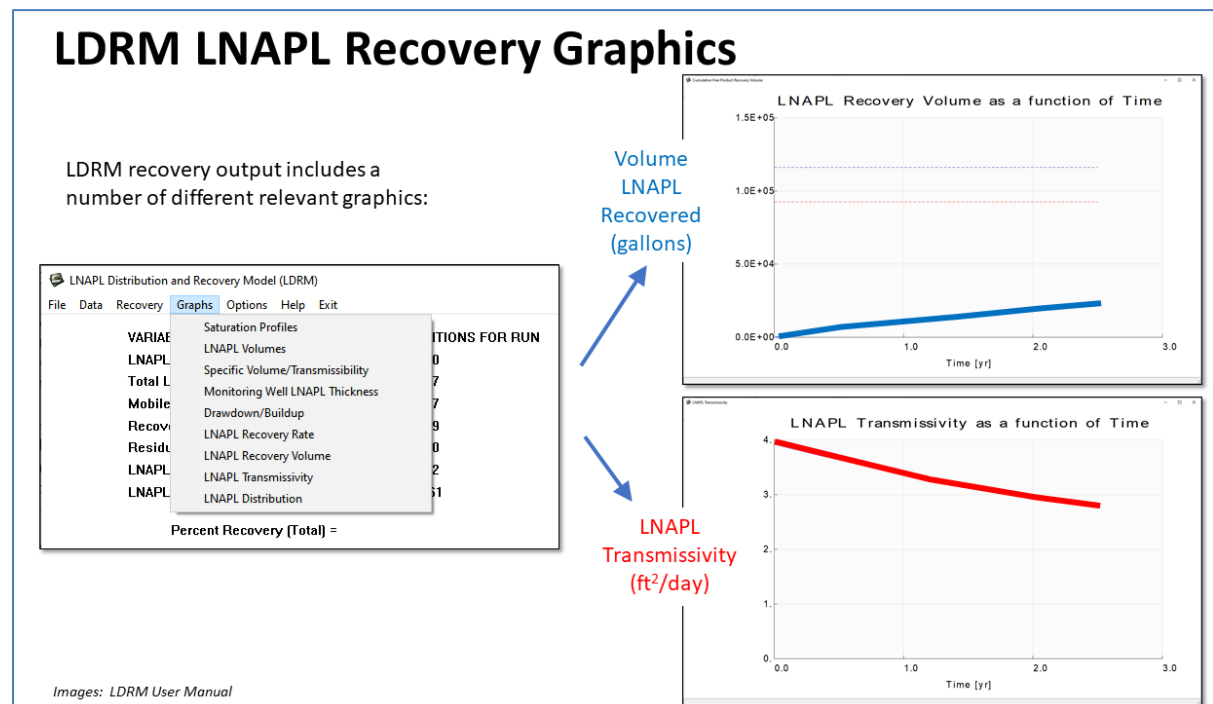
Air Radius of Capture [ft] = 0.000

OK Cancel

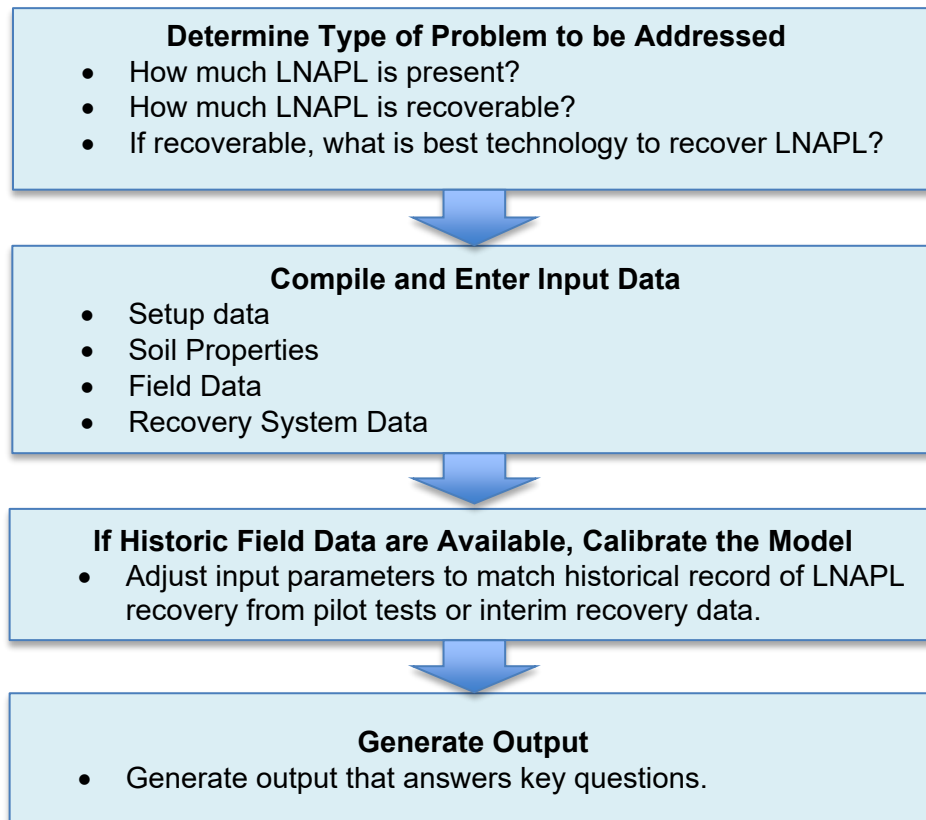
Example LDRM Output

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



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.](#)