

How much LNAPL is present? Tier 3

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

- De Blanc 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 de Blanc 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 de Blanc 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 de Blanc tool does not.
- LDRM allows users to specify a fixed or variable residual saturation or f-factor, while the de Blanc tool uses only a variable f-factor for residual saturation.
- LDRM simulates LNAPL recovery for several kinds of systems, while the de Blanc tool does not simulate LNAPL recovery.
- LDRM is limited to a 3-layer system, while the de Blanc tool considers up to 10 layers.
- LDRM is limited to a single location, while the de Blanc tool calculates LNAPL properties at unlimited locations simultaneously.
- The de Blanc tool estimates spatial variation of transmissivity and LNAPL volumes, while the LDRM does not.
- The de Blanc 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. [link to be added after comments from Concawe]

Checklist of Key LDRM Input Data

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

Relative Permeability Model (Burdine is default)

Use Mualem Model for Layer ☐ Layer 1

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

OK Cancel

Input Field Data

☐ Enter the Saturation data

☐ Monitoring Well LNAPL Thickness [ft]

☐ LNAPL Recovery Volume (gal)

☒ LNAPL Recovery Rate [gpd]

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

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

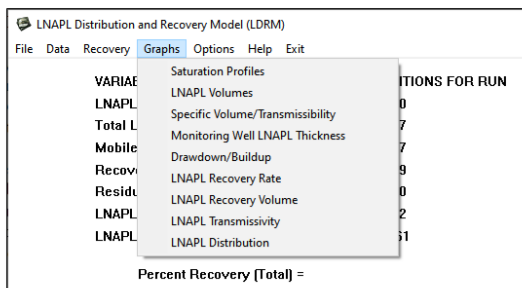
OK Cancel

Example LDRM Output

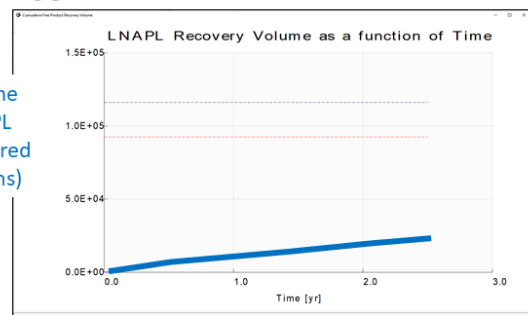
Examples of the LNAPL recovery and LNAPL transmissivity graphics are shown below.

LDRM LNAPL Recovery Graphics

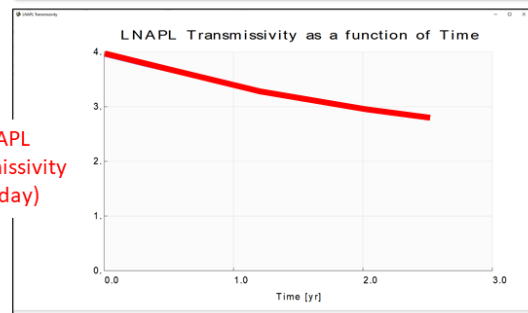
LDRM recovery output includes a number of different relevant graphics:



Volume
LNAPL
Recovered
(gallons)

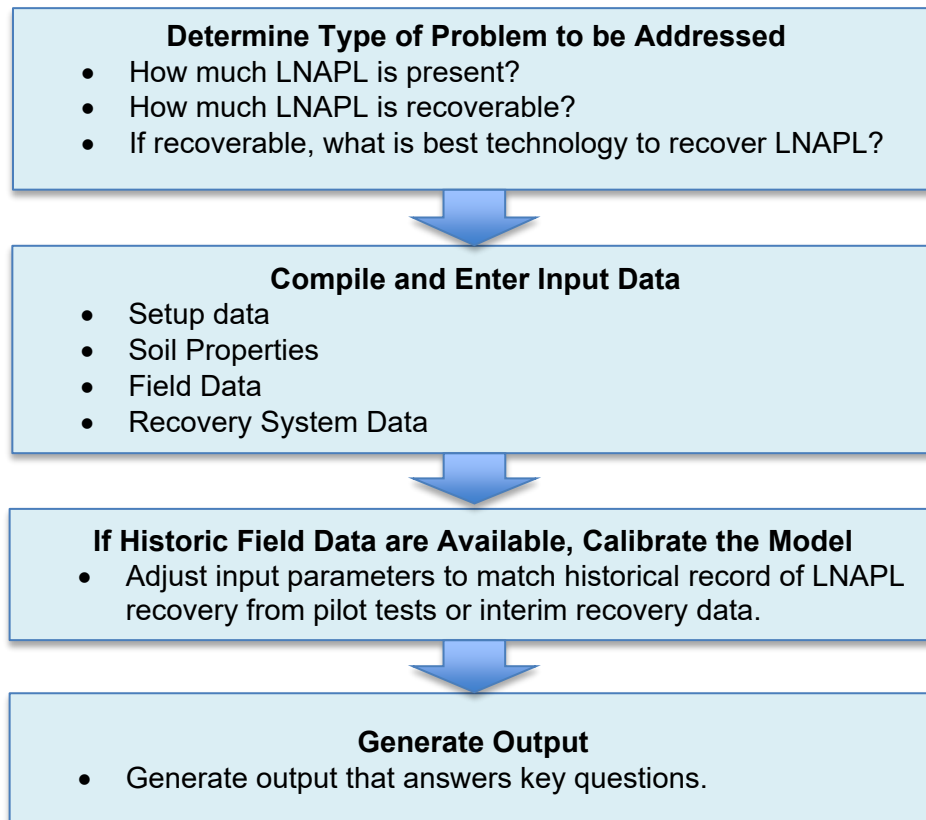


LNAPL
Transmissivity
(ft²/day)



Images: LDRM User Manual

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.](#)