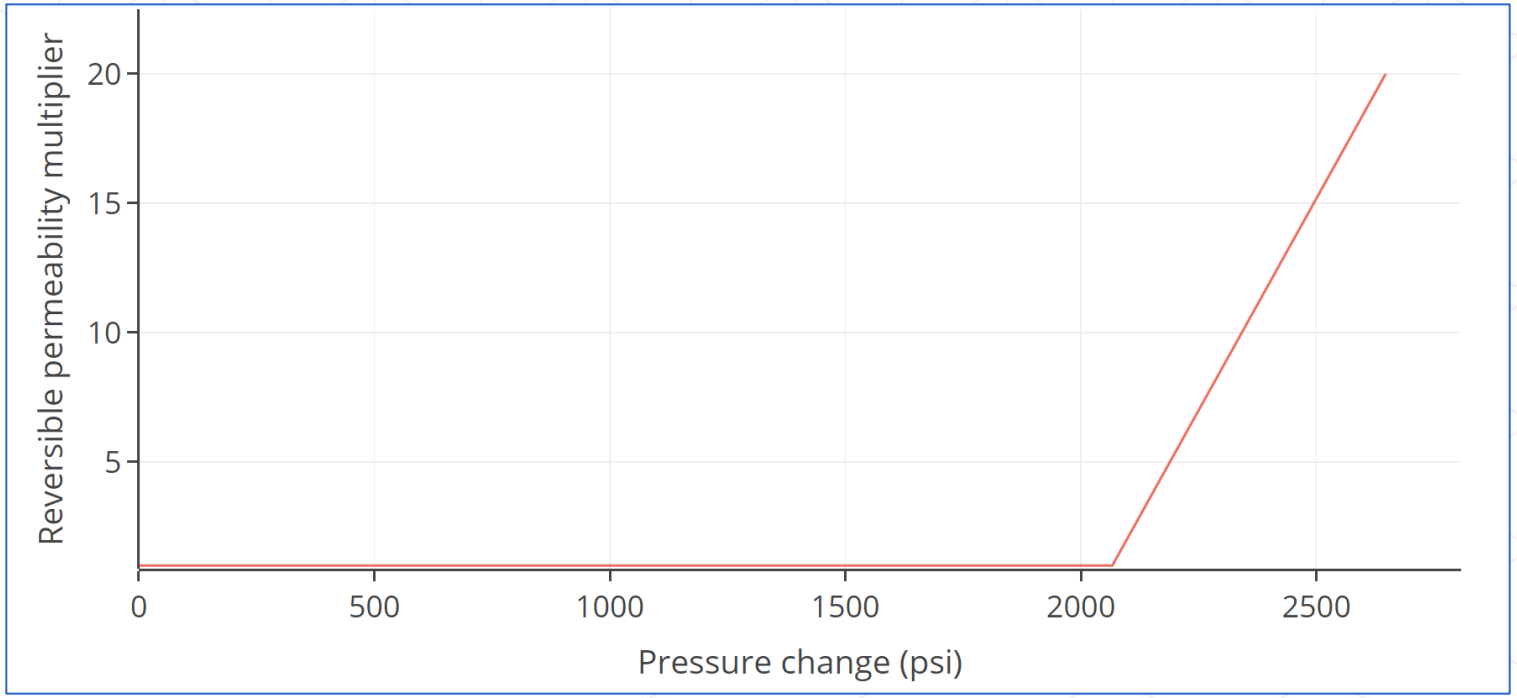
ResFrac



Pressure Dependent Permeability

Pressure Dependent Permeability (PDP)

Pressure dependent permeability makes permeability a function of pressure change. It can be specified for either positive or negative pressure increase. A positive increase would be the result of frac'ing and would increase the permeability to decrease the closure time of the fracture. A negative pressure change would be the result of depletion that results in a decrease in permeability. The changes in permeability can be reversible or irreversible.

For instance, as the frac is progressing the pressure in the matrix is elevated which results in an elevated permeability. As the pressure is dissipated through leakoff or production, if reversible pressure dependent permeability is specified then the permeability returns to its original value. If irreversible permeability is specified, then permeability remains at the highest value.

PDP can be specified on a 'per layer' basis in the curves set tab. Each curve set contains the option to specify PDP for each set of relative permeability curves. In the static model, use the appropriate curve set for the layer in which it is applicable.

Pressure Dependent Permeability – Why?

The PDP tables are used for several purposes. Most often, we use PDP tables to capture accelerated leakoff that may occur during pumping of a full-scale frac job. ***We often find that without substantial PDP, then water flowback at the start of fracturing is greatly overestimated in the simulations.*** This occurs because the fracture does not have time to fully close, and so fluid flows back from the still-open fracture. With PDP, you can accelerate leakoff and get more realistic flowback, such as seen in fiber observations. ***The PDP is mimicking the opening of secondary fractures around the main fractures, which create additional surface area and accelerated leakoff.*** In this context, we generally set the PDP table to nonlinearly increase as the 'deltaP' approaches (Shmin - Pinit), to represent opening of secondary fractures.

You might also use reversible PDP to capture pressure dependent permeability in the matrix or 'system perm'. ***Some shale plays are known to exhibit decreasing permeability as pore pressure depletes.*** Thus, you might choose to have permeability multipliers less than 1.0 for negative 'deltaP' values. Unconsolidated sands are another application where permeability may be substantially pressure dependent.

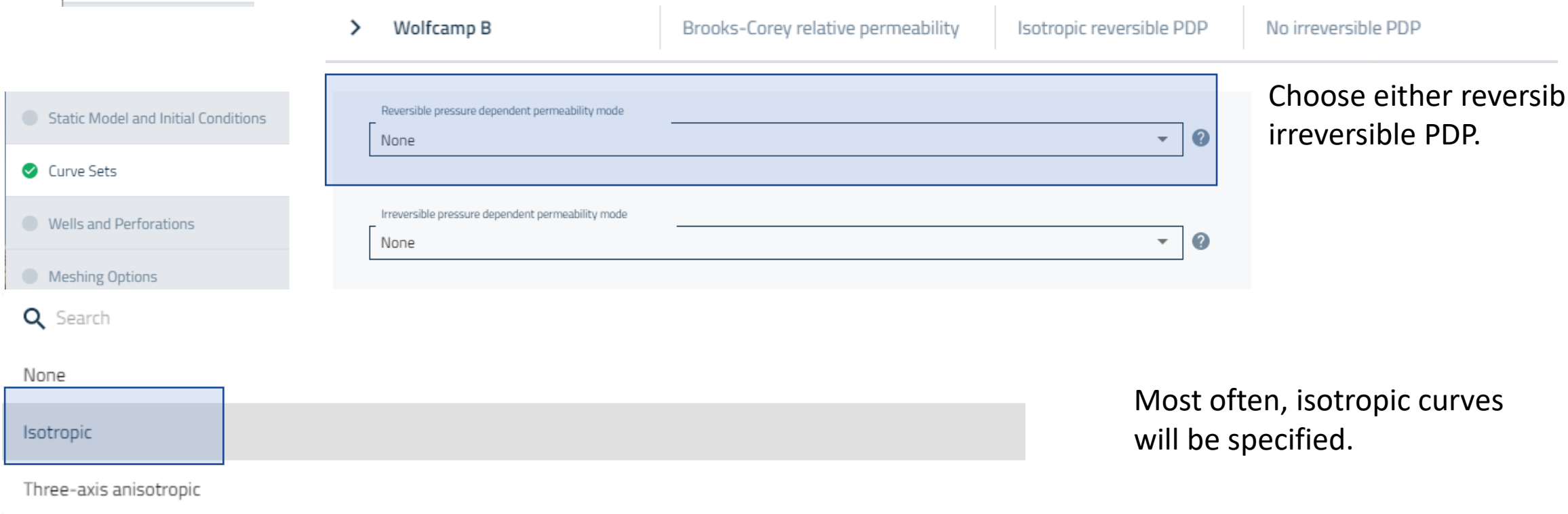
Pressure Dependent Permeability

Three methods to set up curves:

1. Manually
2. PDP Wizard
3. Parameterized

Pressure Dependent Permeability – Manual Setup

In Curve Sets, choose the curve set you plan to set up a PDP table for.



Choose either reversible or irreversible PDP.

Most often, isotropic curves will be specified.

Pressure Dependent Permeability – Manual Setup

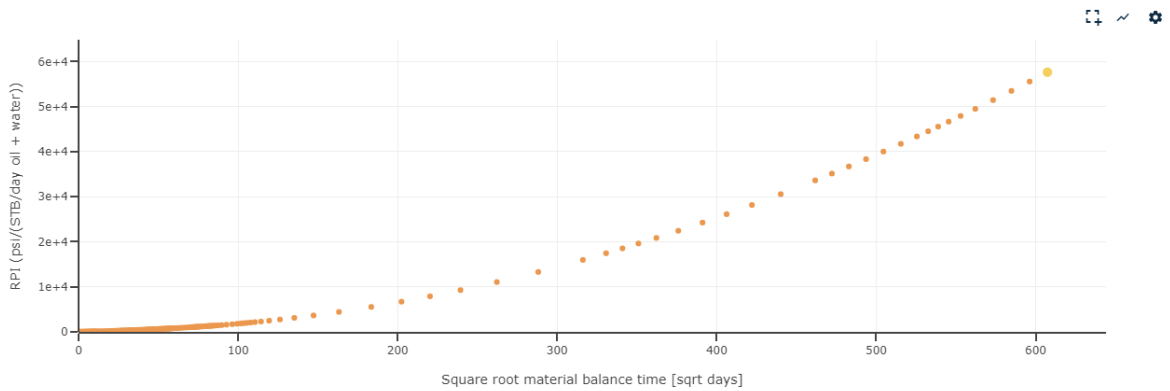
REVERSIBLE PRESSURE DEPENDENT PERMEABILITY TABLE

ISOTROPIC PERMEABILITY FACTOR

ISOTROPIC PERMEABILITY FACTOR

	Delta pressure [psi]	Perm multiplier along Shmin (or x)	
1	1800	250	
2	900	1	
3	0	1	
4	-1000	0.1	
5	-5000	0.01	

New Row Resize Table



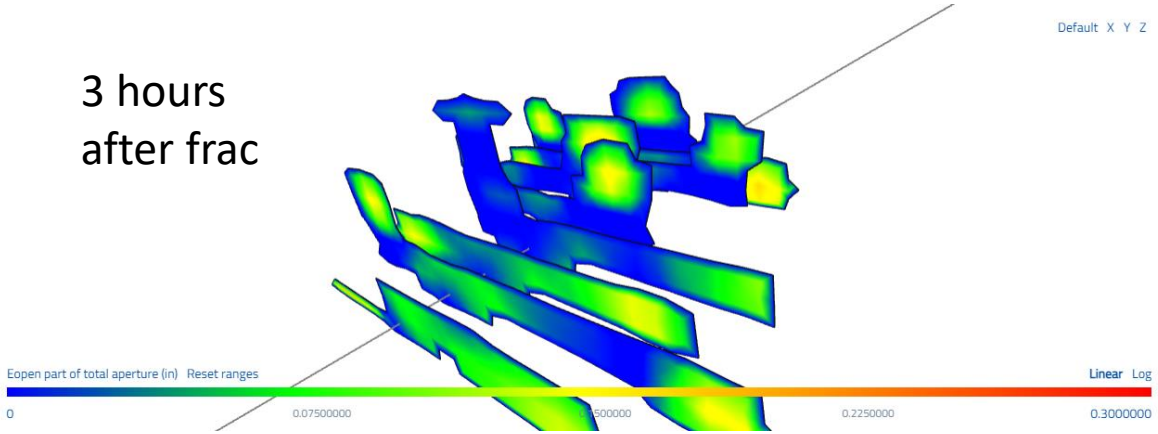
A table appears in the wizard. You will specify a positive delta pressure for increased permeability and a negative delta pressure for decreased permeability (you don't have to do both).

Generally, for frac'ing we find pretty good results when 'initial permeability' times the multiplier comes out to around 10,000 nd. So, for example, if Shmin is around 7000 psi, and initial pore pressure is around 5100 psi, and the permeability 40 nd, then we might set up a PDP table with perm multiplier of 1 at dP of 0 psi, 1 at dP of 600 psi, and 250 at 1200 psi. The key is to look at the open part of the aperture (Eopen in the UI) and ensure that the fractures have closed in a timely manner.

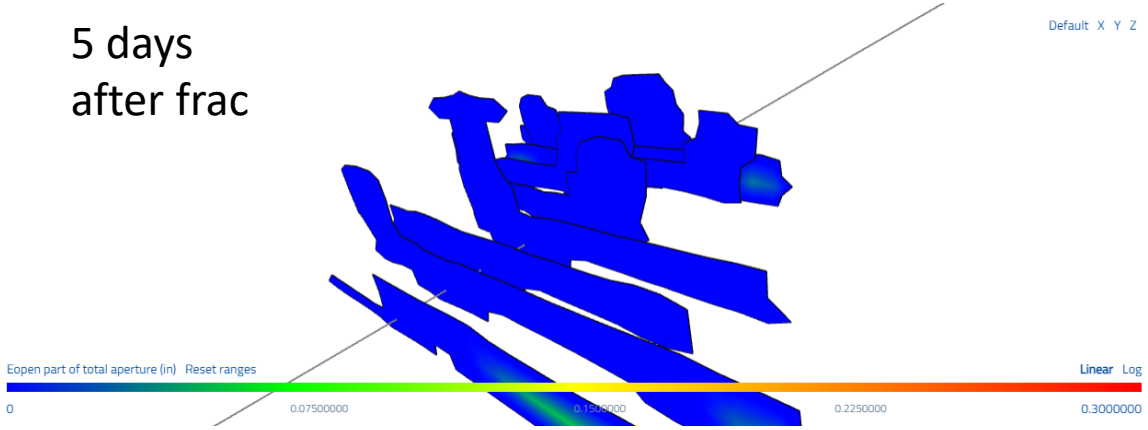
Negative PDP curves are often used to match upward curvature in the RTA trends that would suggest (among other things) that permeability is declining with production. Use the timing of the curvature, change in slope and the pressure to help guide these values.

Pressure Dependent Permeability - Eopen

3 hours
after frac



5 days
after frac



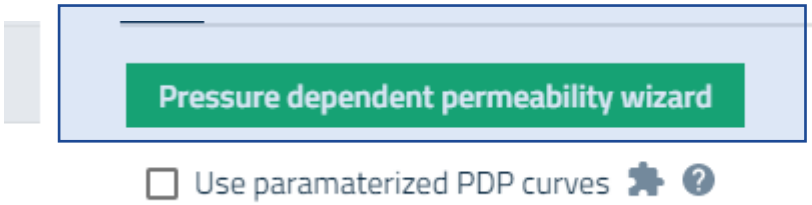
Eopen is the ‘open’ part of the fracture i.e. the parts of the fracture that are not touching proppant or the other fracture wall.

Increasing the PDP multiplier and/or decreasing when the pressure will result in fractures that close faster by increasing the permeability.

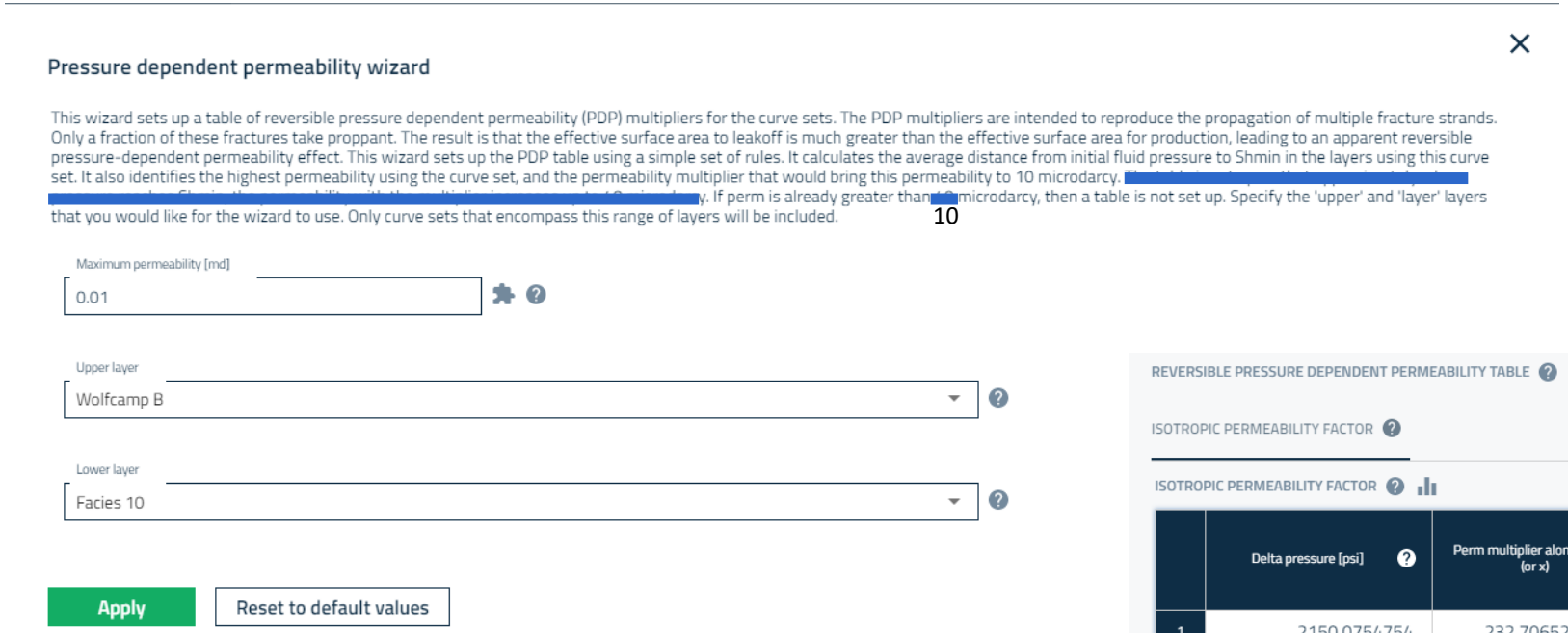
This will reduce the amount of flush water at the beginning of the simulation. The flush water is caused by the fractures still being open when production occurs.

Excessive PDP might hinder frac growth due to increased leak off.

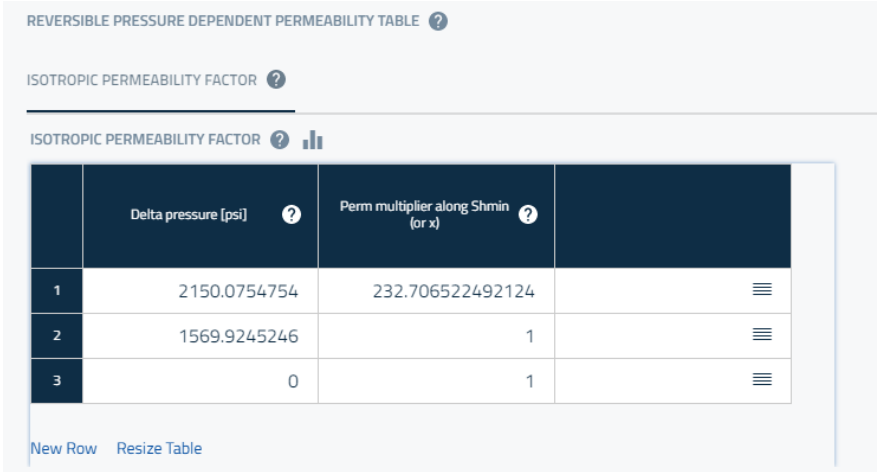
Pressure Dependent Permeability – We have a wizard for that!



The button for the wizard is located at the top of the curves sets tab.



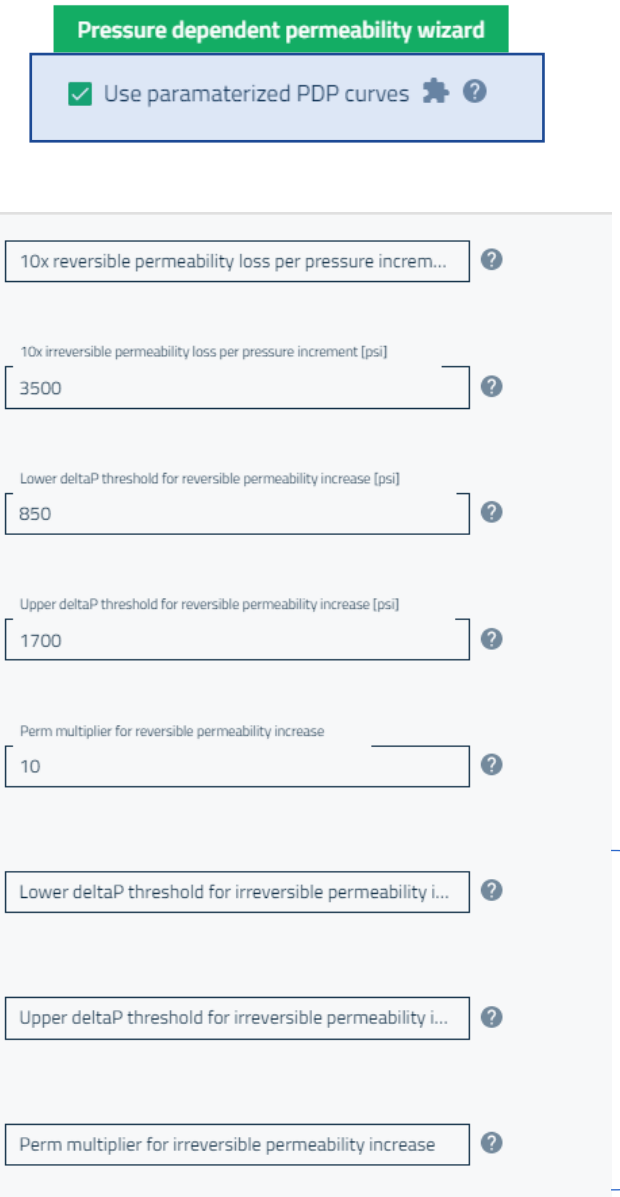
Simply specify the top and bottom of the zone that you want to set up the PDP curves for and that's it! ResFrac will do all the calculations and fill out the table for you.



There is no 'right' answer. Adjust as necessary to achieve the desired results!

ResFrac

Pressure Dependent Permeability – Parametrized Curves



Toggle parametrized PDP curves to open up the following options. The wizard does not work with this option. If any tables have already been completed, they are ignored. Basically, a different way to do the same thing.

Specifies the pressure increment where there is a 10x loss in REVERSIBLE permeability.

Specifies the pressure increment where there is a 10x loss in IRREVERSIBLE permeability.

Specifies the lower pressure limit when REVERSIBLE PDP starts to increase.

Specifies the upper pressure limit where the REVERSIBLE PDP multiplier has maxed out.

Specifies the perm increase for REVERSIBLE PDP that linearly interpolates between the lower and upper pressure limits.

Same concept as REVERSIBLE PDP shown above except for IRREVERSIBLE PDP.

Thank You!

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Last updated Feb 2026