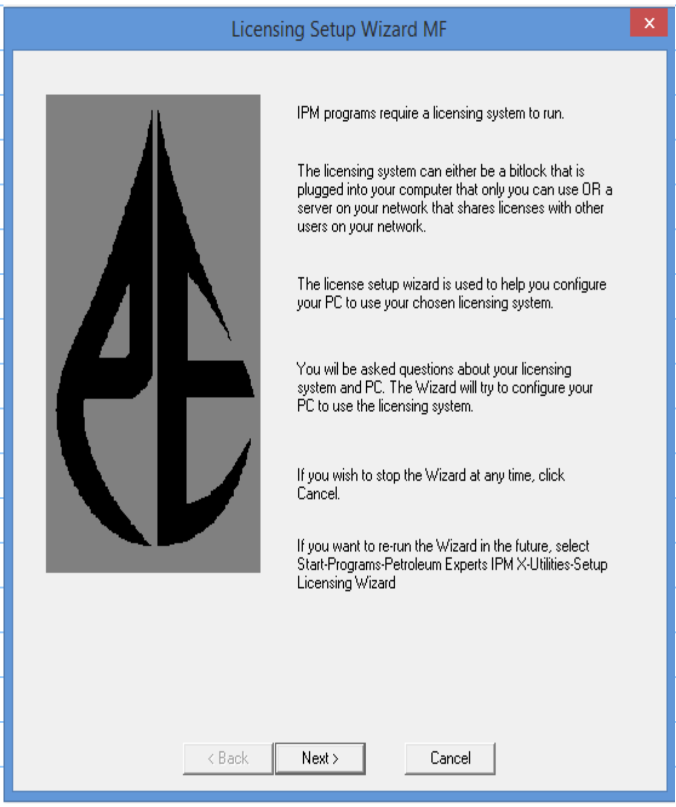
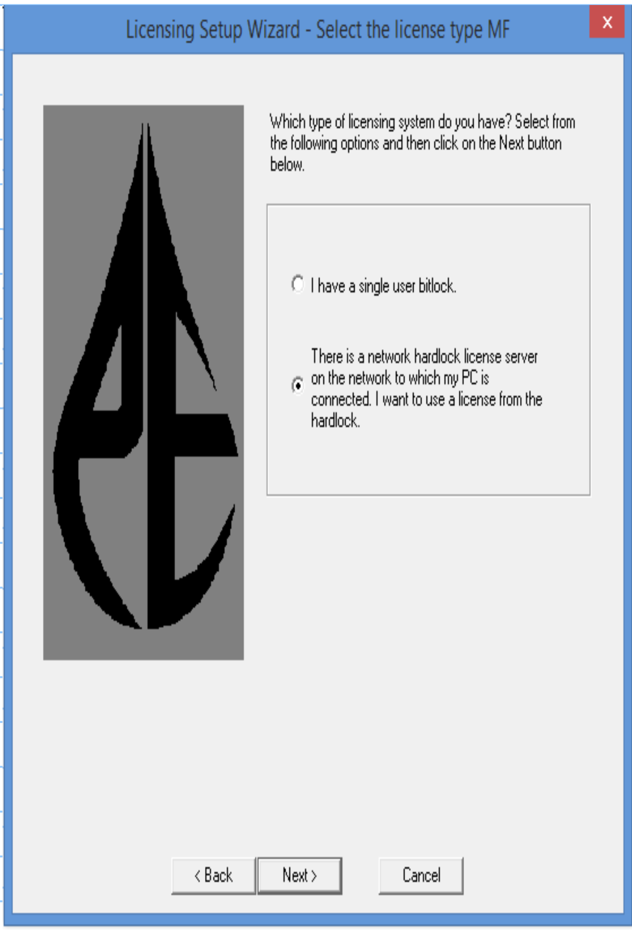
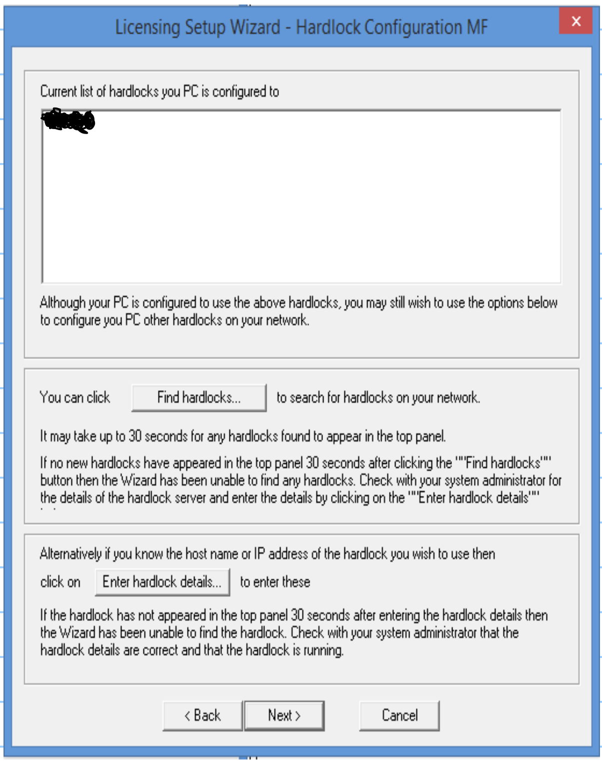
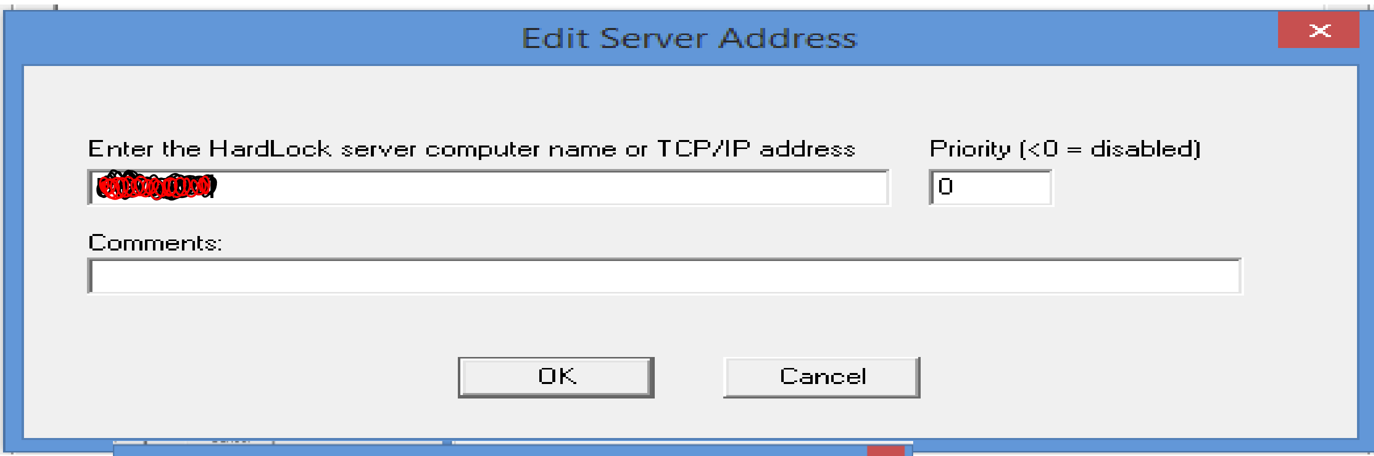
Software suite from Petroleum Experts: UK, Edinburgh

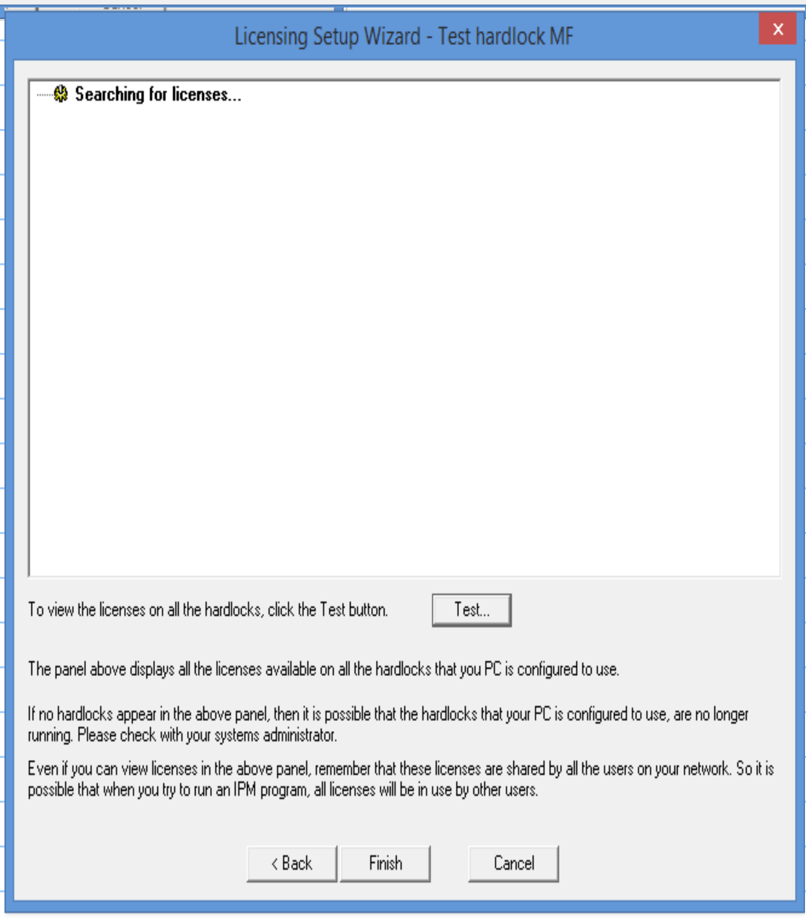
IPM Integrated petroleum management
- MBAL ~ material balance
- Prosper* ~ well modeling
- GAP* ~ networks and production systems (optimization)
- Reveal ~ res. simulator
- PVTP ~ fluid analysis and modeling
- Resolve ~ coupling between reservoir + production system
- IAM integrated asset modeling






Licensing Setup Wizard - Hardlock Configuration MF
Current list of hardlocks you PC is configured to
[redacted]
Although your PC is configured to use the above hardlocks, you may still wish to use the options below to configure you PC other hardlocks on your network.
You can click Find hardlocks... to search for hardlocks on your network.
It may take up to 30 seconds for any hardlocks found to appear in the top panel.
If no new hardlocks have appeared in the top panel 30 seconds after clicking the ""Find hardlocks"" button then the Wizard has been unable to find any hardlocks. Check with your system administrator for the details of the hardlock server and enter the details by clicking on the ""Enter hardlock details""
Alternatively if you know the host name or IP address of the hardlock you wish to use then
click on Enter hardlock details... to enter these
If the hardlock has not appeared in the top panel 30 seconds after entering the hardlock details then the Wizard has been unable to find the hardlock. Check with your system administrator that the hardlock details are correct and that the hardlock is running.
< Back
Next >
Cancel


Edit Server Address
Enter the HardLock server computer name or TCP/IP address
[redacted]
Priority (<0 = disabled)
0
Comments:
OK
Cancel


Licensing Setup Wizard - Test hardlock MF
Searching for licenses...
To view the licenses on all the hardlocks, click the Test button.
Test...
The panel above displays all the licenses available on all the hardlocks that you PC is configured to use.
If no hardlocks appear in the above panel, then it is possible that the hardlocks that your PC is configured to use, are no longer running. Please check with your systems administrator.
Even if you can view licenses in the above panel, remember that these licenses are shared by all the users on your network. So it is possible that when you try to run an IPM program, all licenses will be in use by other users.
< Back
Finish
Cancel

Exercise in Prosper and GAP, TPG4230, Milan Stanko, 20170309.

1. **Subsea oil well modeling in Prosper**

Fluid information:

Use the black oil correlation of Glasø (p_b, R_s, B_o) and Beal (viscosity) to model your PVT behavior.

Solution GOR = 142 Sm^3/Sm3 Producing GOR = 142 Sm^3/Sm^3 Oil gravity = 30 API (876 Kg/m^3) Gas gravity = 0.76 At initial conditions no water.	Formation Water salinity = 23000 ppm No H2S, CO2, N2. Heat capacity of oil = 2.219 KJ/Kg/K Heat capacity of gas = 2.1353 KJ/Kg/K Heat capacity of water = 4.1868 KJ/Kg/K

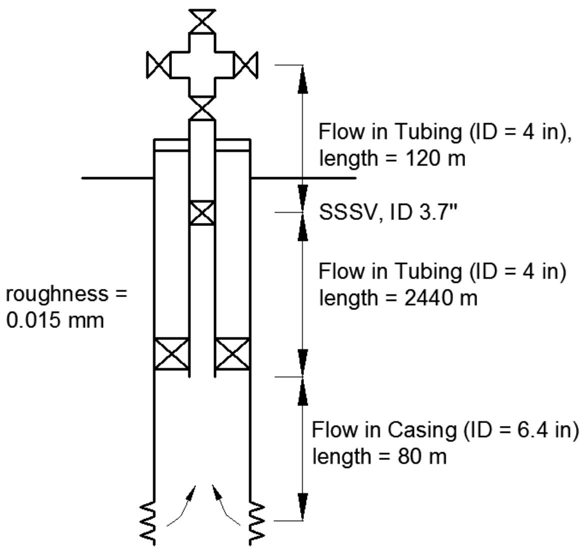
Well layout:

Deviation survey

MD [m]	TVD [m]
0	0
123	122
1059	1036
2164	2103
2640	2560

Geothermal gradient

MD [m]	T [C]
0	4
2640	100



Overall heat transfer coefficient = 45 W/m^2 K

Reservoir info:

Producing from a single layer
Reservoir pressure = 360 bara
Reservoir temperature = 100 C
Water cut = 0%

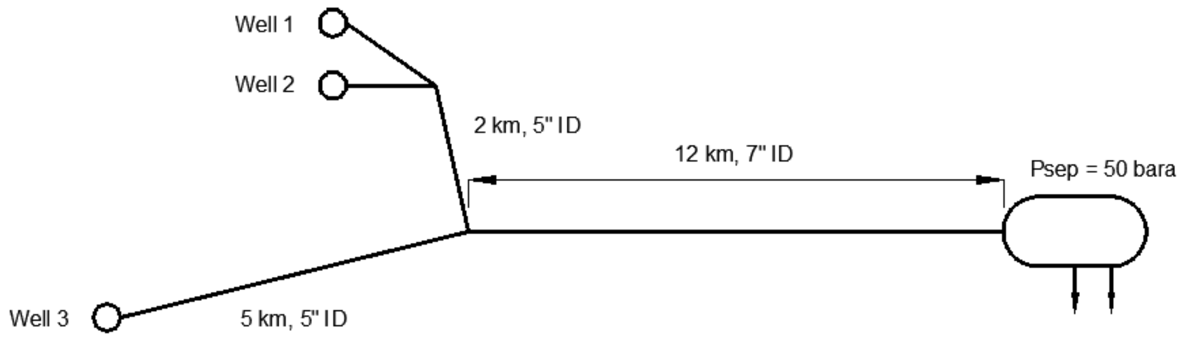
Productivity index = 12 Sm^3/d/bara

Tasks:

- Set up a prosper model of a subsea oil well.
- Report the bubble point pressure at reservoir temperature as predicted by the BO correlation.
- Estimate the producing rate using flow equilibrium assuming that the well is producing against a constant wellhead pressure of 100 bar. Is it correct to assume a linear productivity index?.
- Generate and export lift curves to be used in GAP (in the following exercise). p_{wh} range: 30-150 bara, GOR range: 141 – 500 Sm^3/Sm^3. WC range: 0 – 50 %

2. Modeling of a subsea network with three oil wells in GAP

The layout of the production network layout is shown below. The S riser is not included in the figure. Assume that the water depth is 300 m, and the separator is 30 m above the sea level. The production riser is a lazy "S" riser with a total length of 700 m.



The wells have the same layout as the well created in the previous section, but with different GOR, WC and PI as specified in the table below:

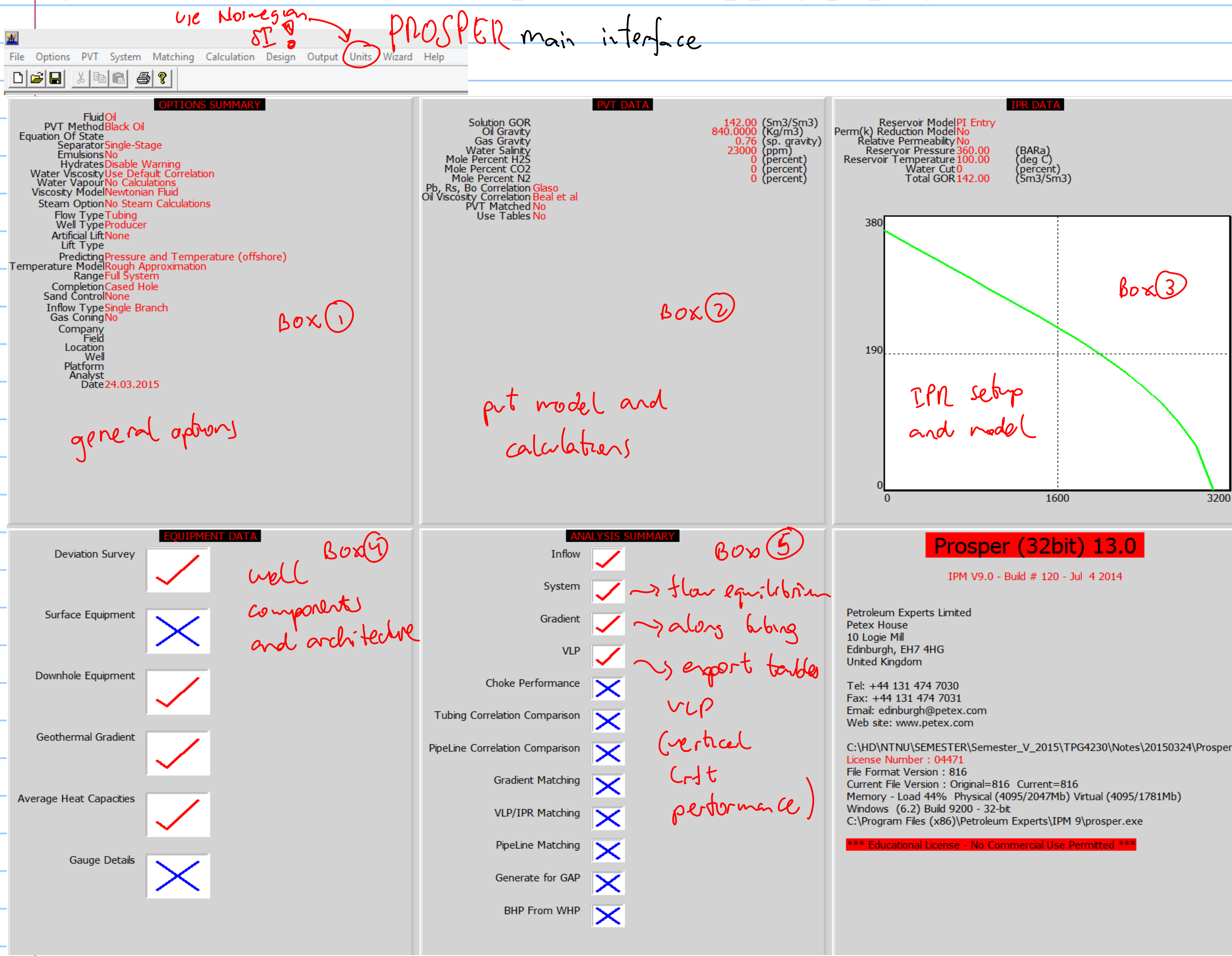
Well	**GOR [Sm^3/Sm^3]**	**WC [%]**	**PI [Sm^3/d/bara]**
Well 1	142	0	12
Well 2	200	40	8
Well 3	250	20	15

Tasks:

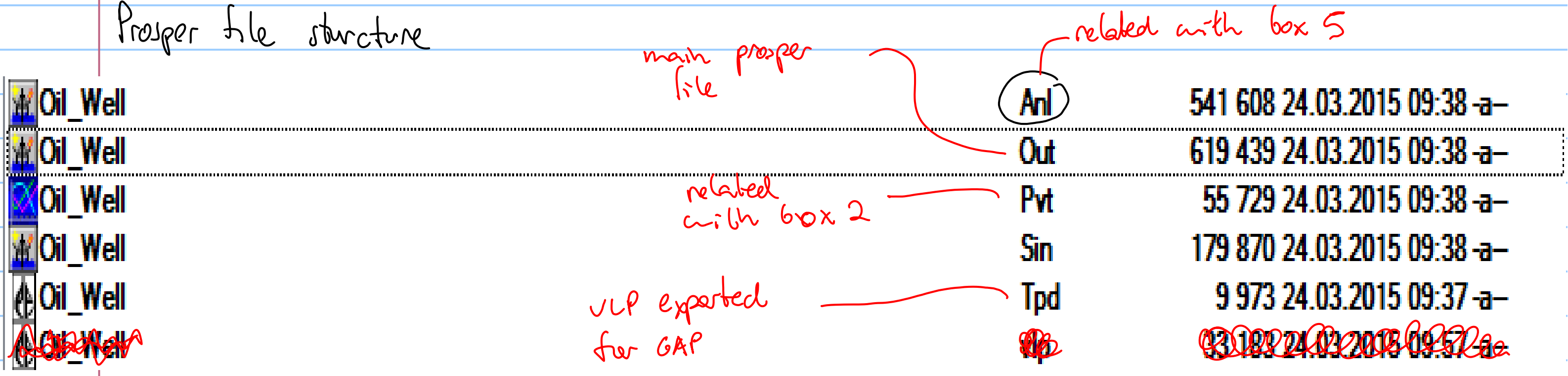
- Build the GAP model of three subsea wells producing to a FPSO.
- Calculate the natural equilibrium flow of the network. Report the flow potential of each well and calculate their split factor.
- Now, assume that the system has to be operated at a constant rate of 2000 Sm^3/d. Try the following methods:
  - Adding a constraint to the separator, add a choke pressure drop (controlled), and run an optimization.
  - Adding a constraint to the wells, and run an optimization

Exercise available here:
http://folk.ntnu.no/stanko/Courses/TPG4230/2017/Class_files/20170309/Exercise_in_Prosper_and_GAP.pdf

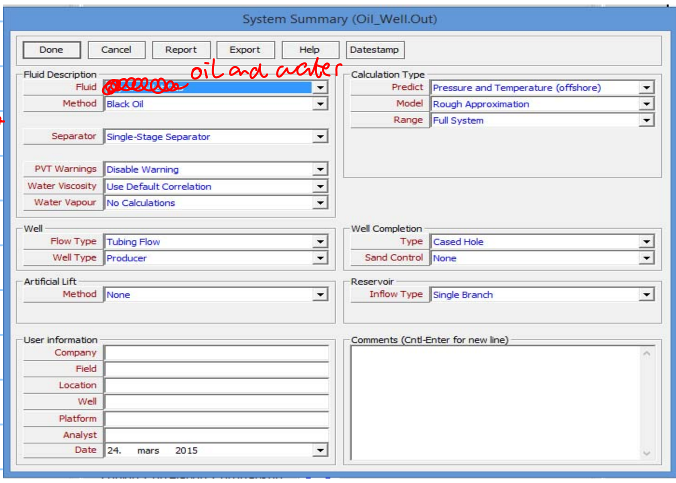
use Norwegian SI ! → PROSPER main interface



Prosper file structure



Double click to access each box:

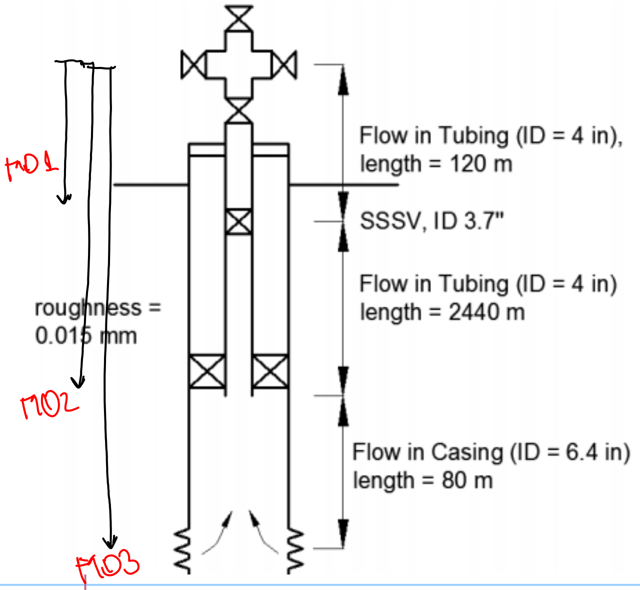


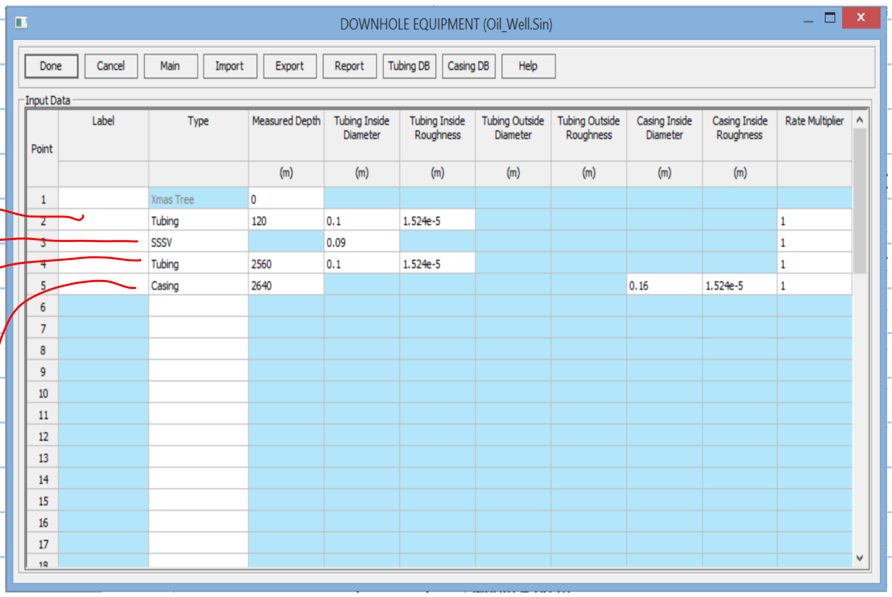
- Remember to save your file.
- the first box has to be completed to input in the other boxes

In prosper the convention to input downhole equipment is:

locate yourself at the well head (x-mas tree) and list, from top down, how many different sections do you observe: flow in tubing, flow in SSSV, flow in tubing and flow in casing.

- Introduce each one on the table. the measured depth is the depth of the end of the section measured from the well head.





DOWNHOLE EQUIPMENT (Oil_Well.Sin)

Done | Cancel | Main | Import | Export | Report | Tubing DB | Casing DB | Help

Input Data

Point	Label	Type	Measured Depth (m)	Tubing Inside Diameter (m)	Tubing Inside Roughness (m)	Tubing Outside Diameter (m)	Tubing Outside Roughness (m)	Casing Inside Diameter (m)	Casing Inside Roughness (m)	Rate Multiplier
1		Xmas Tree	0							
2		Tubing	120	0.1	1.524e-5					1
3		SSSV		0.09						1
4		Tubing	2560	0.1	1.524e-5					1
5		Casing	2640					0.16	1.524e-5	1
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										

MO1

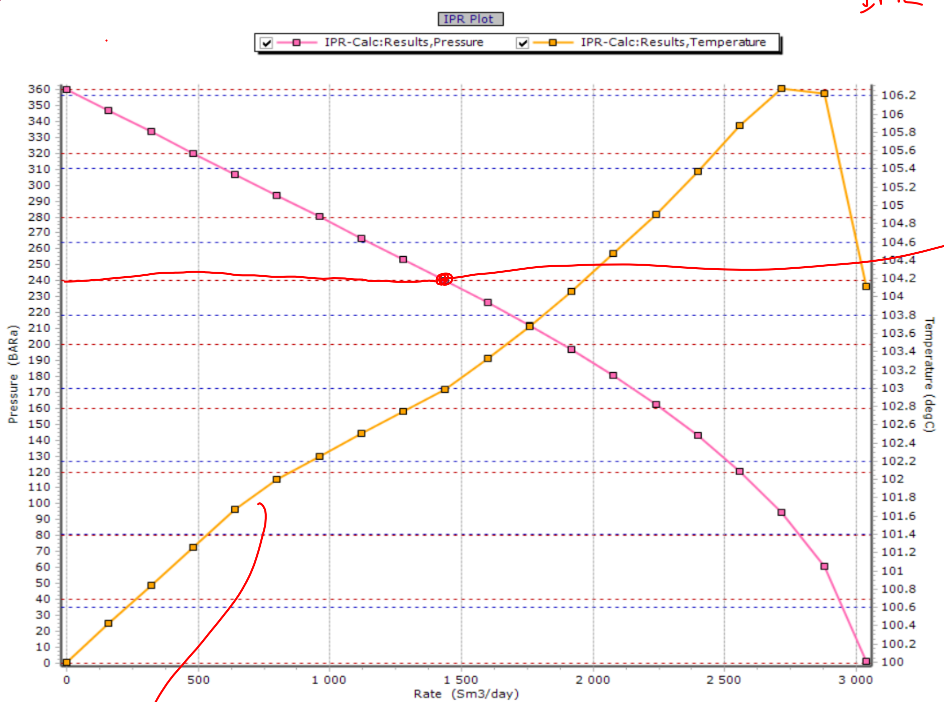
MO1 (we assume that the SSSV has no length)

MO2

MO3

IPR

- Before leaving the IPR module remember to click "calculate". In that way the IPR is available for further calculations

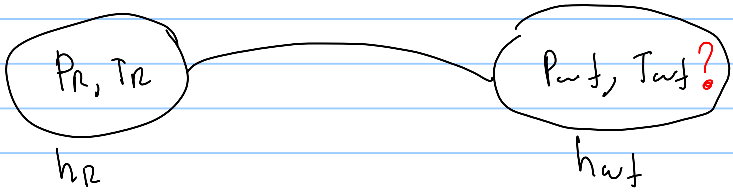


→ Pb (@ Tr)

bellow this Pwf the curve will deviate from the straight line.

here, PROSPER assumes that Tr ≠ Twf. this is because the fluid experiences an expansion process from Pr ⟶ Pwf.

this expansion process is often modeled as isenthalpic, meaning $h_R = h_{wf}$



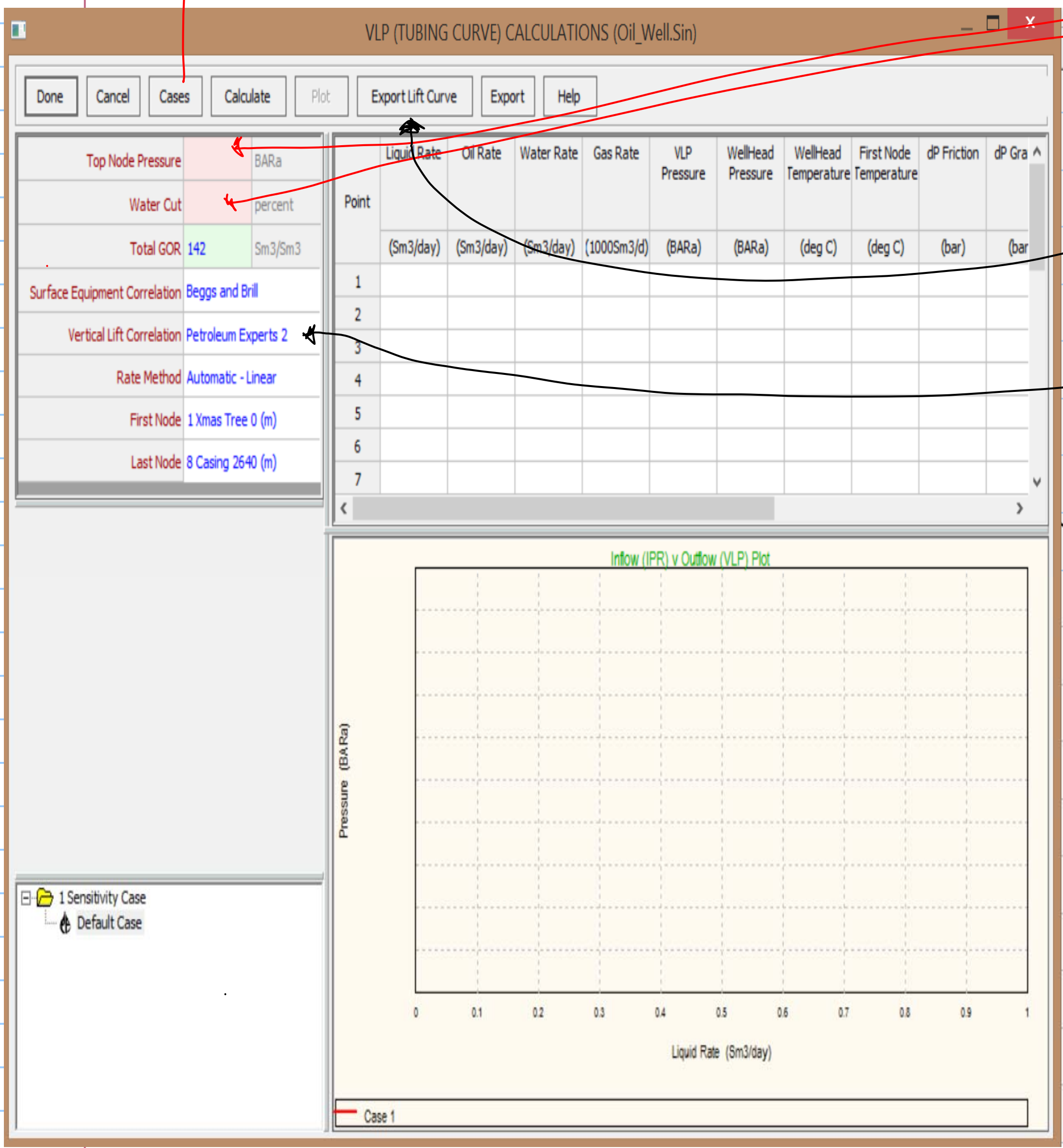
with h_{wf} and P_{wf} it is possible to calculate T_{wf}.

VLP

in "cases", the expected variations of GOR, WC, Pwh are input. To be able to access it, make sure that you filled these two boxes:

to export the curves use

multiphase "expert"



2.8.1.3.1 VLP Correlation Applications

Fancher Brown is a no-slip hold-up correlation that is provided for use as a quality control. It gives the lowest possible value of VLP since it neglects gas/liquid slip it should always predict a pressure, which is less than the measured value. Even if it gives a good match to the measured down hole pressures, Fancher Brown should not be used for quantitative work. Measured data falling to the left of Fancher Brown on the correlation comparison plot indicates a problem with fluid density (i.e. PVT) or field pressure data. **This is thus essentially, a correlation for quality control purposes.**

For oil wells, ***Hagedorn Brown*** performs well for slug flow at moderate to high production rates but well loading is poorly predicted. Hagedorn Brown should not be used for condensates and whenever mist flow is the main flow regime. Hagedorn Brown under predicts VLP at low rates and should not be used for predicting minimum stable rates.

Duns and Ros Modified The Duns and Ros Modified correlation is derived from the Duns and Ros Original correlation. The original correlation was modified by Petroleum Experts to overestimate the pressure drop in oil wells for the slug flow regime. This correlation should not be used for calculating the pressure drop in the wellbore or pipelines and hence should not be used for lift curve generation either. **This correlation should only be used for quality checking of the input well test data.**

Duns and Ros Original The Duns and Ros Original Correlation is derived from the original published method. In **PROSPER** the original Duns and Ros correlation has been enhanced and optimised for use with condensates. This correlation performs well in mist flow cases and may be used in high GOR oil wells and condensate wells.

Petroleum Experts correlation combines the best features of existing correlations. It uses the Gould et al flow map and the Hagedorn Brown correlation in slug flow, and Duns and Ros for mist flow. In the transition regime, a combination of slug and mist results is used.

Petroleum Experts 2 includes the features of the PE correlation plus original work on predicting low-rate VLPs and well stability.

Petroleum Experts 3 includes the features of the PE2 correlation plus original work for viscous, volatile and foamy oils.

Petroleum Experts 4 is an advanced mechanistic model for any angled wells (including downhill flow) suitable for any fluid (including Retrograde Condensate).

Petroleum Experts 5. The PE5 mechanistic model is an advancement on the PE4 mechanistic model. PE4 showed some instabilities (just like other mechanistic models) that limited its use accross the board. PE5 reduces the instabilities through a calculation that does not use flow regime maps as a starting point.
PE5 is capable of modelling any fluid type over any well or pipe trajectory. This correlation accounts for fluid density changes for incline and decline trajectories. The stability of the well can also be verified with the use of PE5 when calculating the gradient traverse, allowing for liquid loading, slug frequency, etc. to be modelled.

Petroleum Experts 6 includes the features of the PE3 correlation plus original work on the affects that water cut can have on a viscous oil.

Orkiszewski correlation often gives a good match to measured data. However, its formulation includes a discontinuity in its calculation method. The discontinuity can cause instability during the pressure matching process; therefore its use is not encouraged.

Beggs and Brill is primarily a pipeline correlation. It generally over-predicts pressure drops in vertical and deviated wells.

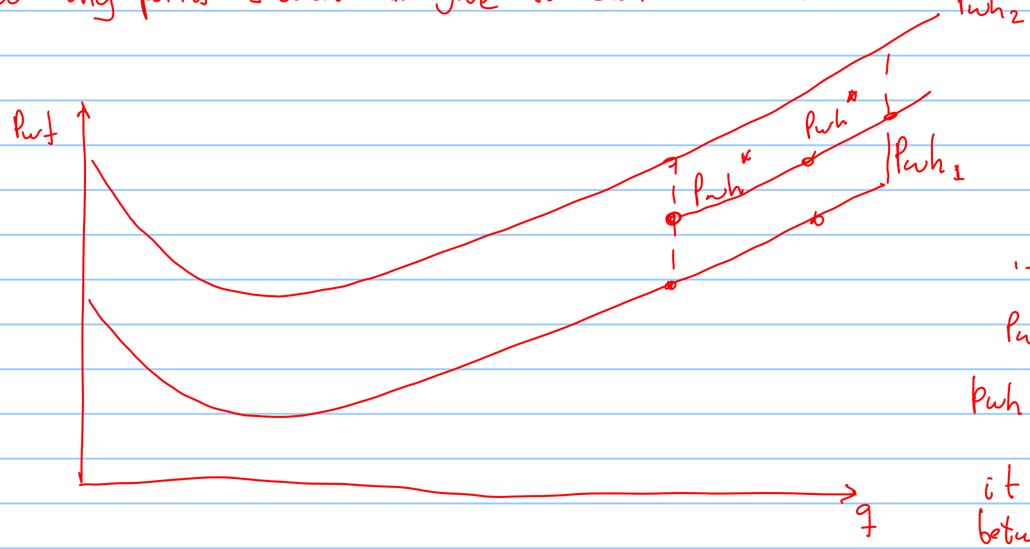
Gray correlation gives good results in gas wells for condensate ratios up to around 50 bbl/MMscf and high produced water ratios. Gray contains its own internal PVT model which over-rides **PROSPER**s normal PVT calculations.

Hydro 3P (internal) is a mechanistic model and considers three phase flow.

➲ There is no universal rule for selecting the best flow correlation for a given application. It is recommended that the Correlation Comparison always be carried out. By inspecting the predicted flow regimes and pressure results, the User can select the correlation that best models the physical situation.

Further details can be found in the **PROSPER** Appendix B | Multiphase Flow Correlations.

how many points should I give for each variable?

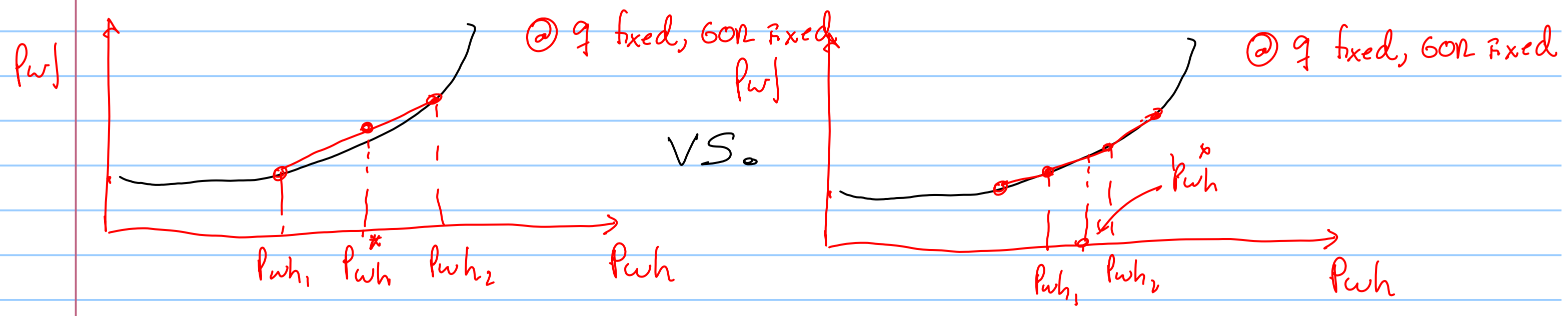


if i need Pwf for Pwh* between

$P_{wh,1} \leq P_{wh}^* \leq P_{wh,2}$

it will interpolate between the two curves above

if $P_{wh,1}$ is relatively close to $P_{wh,2}$ the interpolation error will be small.



Prosper manual available here: → C:\Program Files (x86)\Petroleum Experts\IPM 9\pdf\prosper

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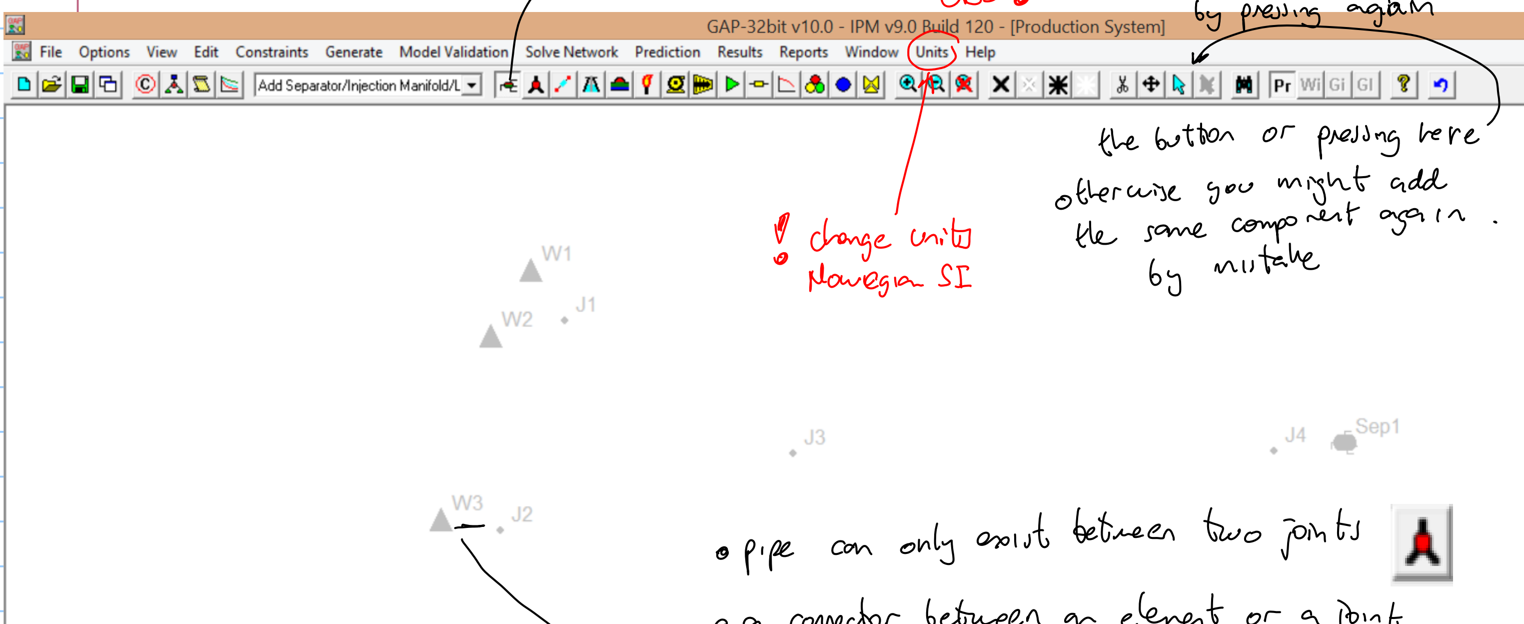
GAP network.

make the network layout

click on the element an click again in the canvas where you want to place it.

OBS! remember to unselect it by pressing again the button or pressing here otherwise you might add the same component again by mistake.

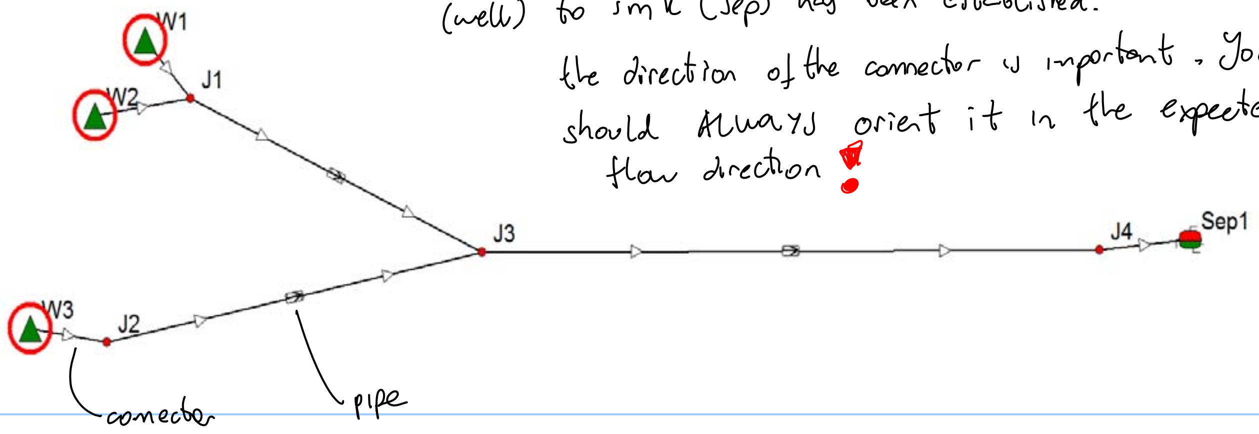


! change units Norwegian SI

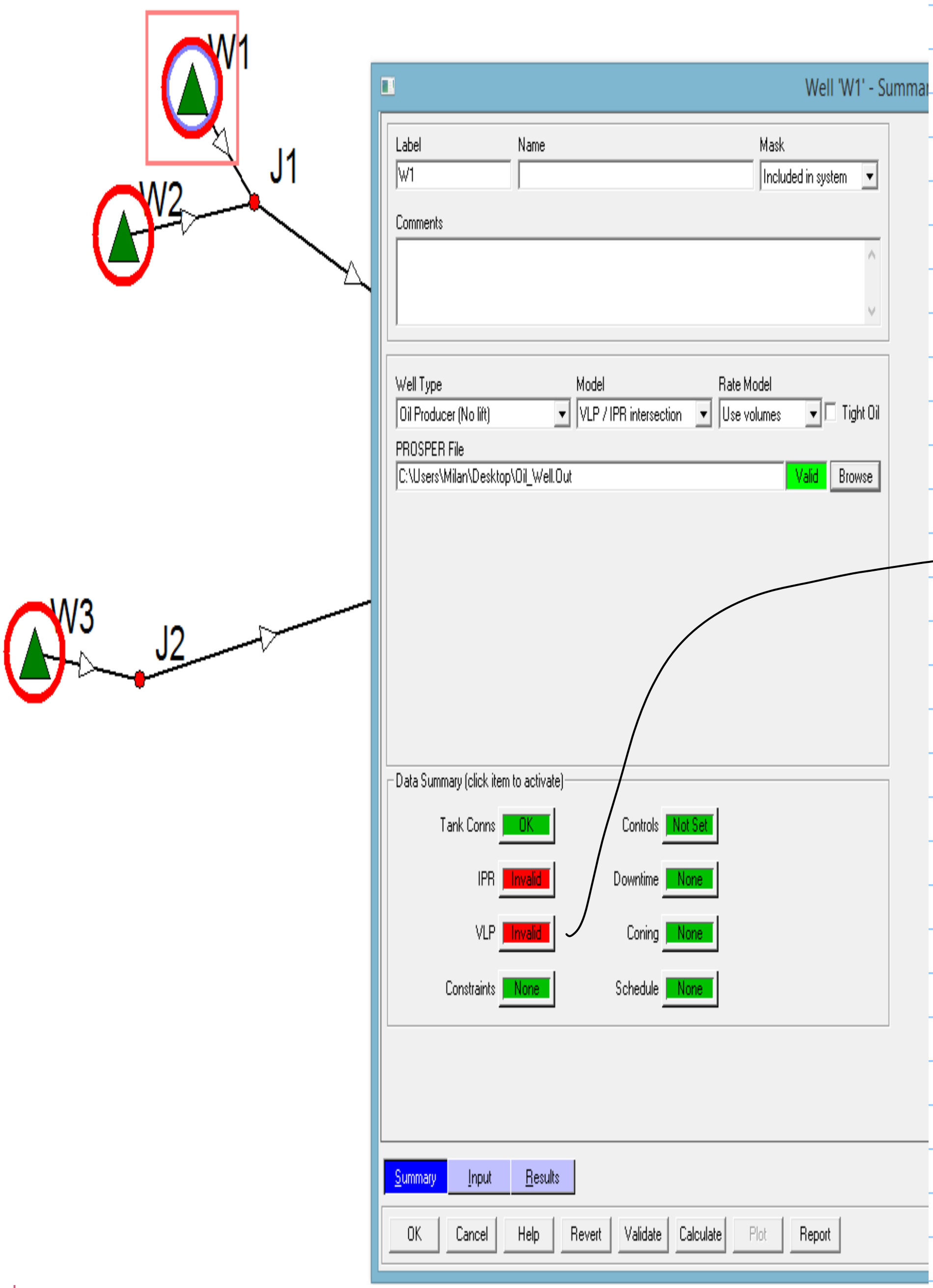
- pipe can only exist between two joints
- a connector between an element or a joint just means that the Pwh of W3 is equal to P_{j2}, have the same rates and conditions

the colors become bright when a full flow path from source (well) to sink (sep) has been established.

the direction of the connector is important. You should ALWAYS orient it in the expected flow direction!

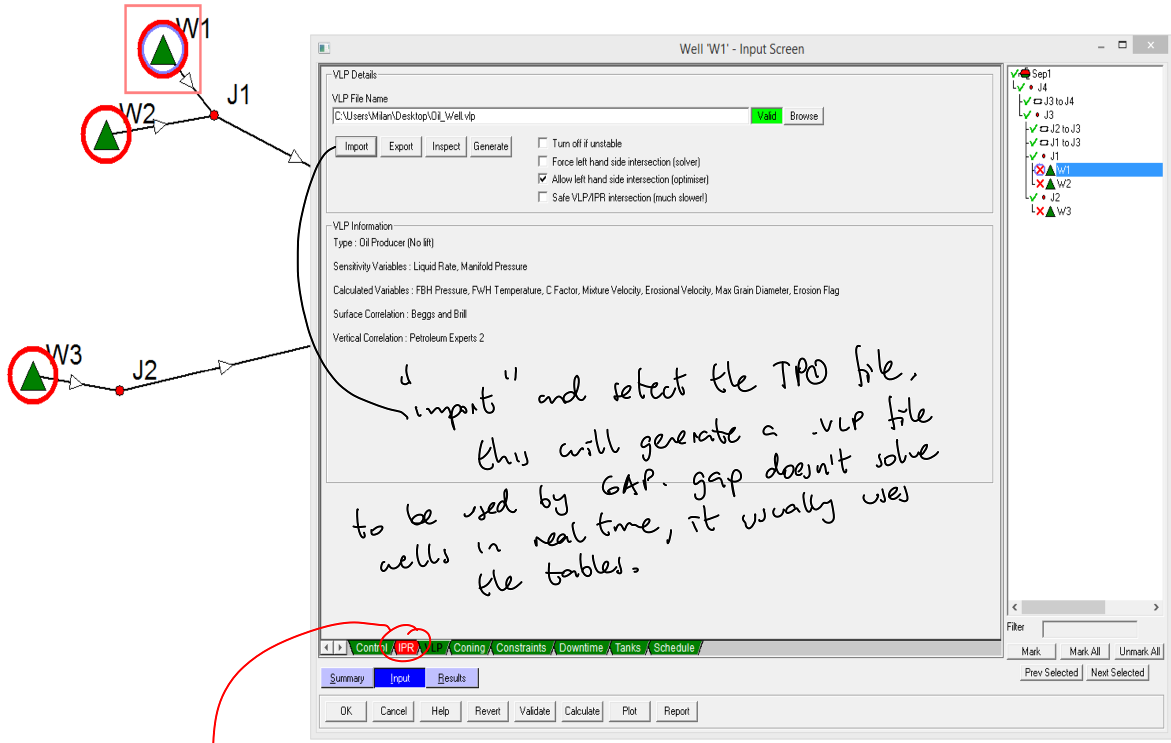


Double click on the wells and link all of them to the proper file we just created



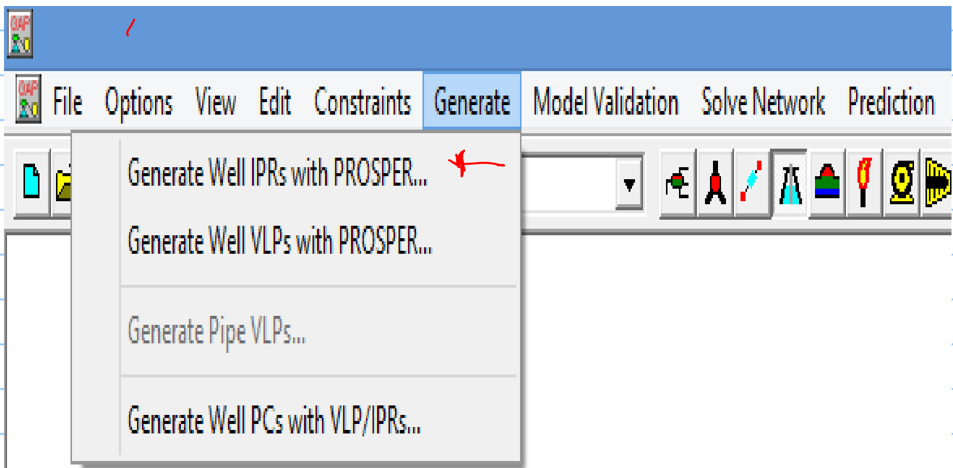
click here to assign the VLP.

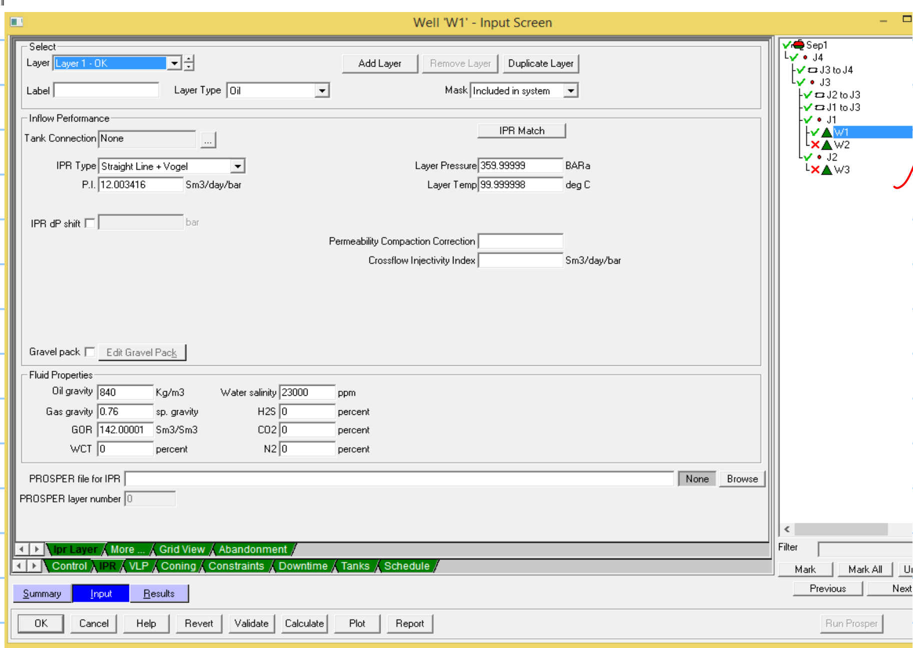
we will assume that all wells have the same layout architecture.



"import" and select the TPO file, this will generate a .VLP file to be used by GAP. gap doesn't solve wells in real time, it usually uses the tables.

IPR hasn't been defined. To transfer it from prosper to GAP go to "Generate IPR"





the IPR is transferred and then can be modified as defined in GAP.