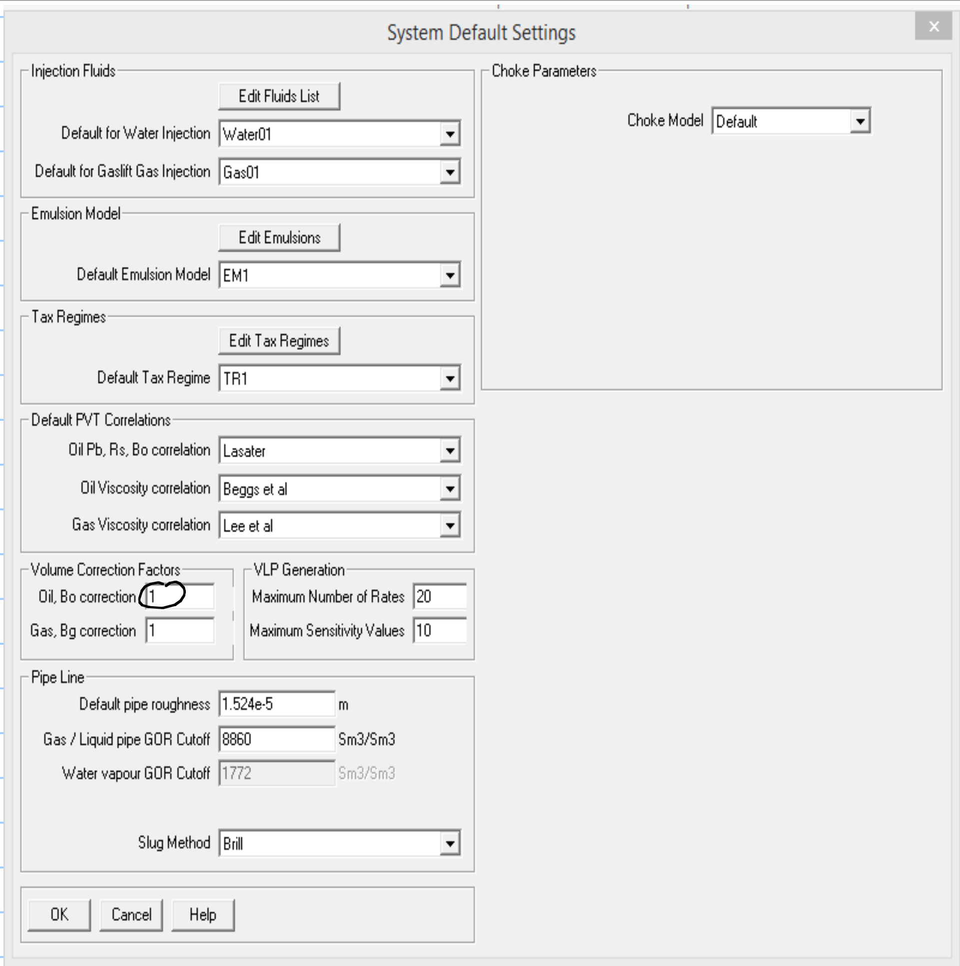
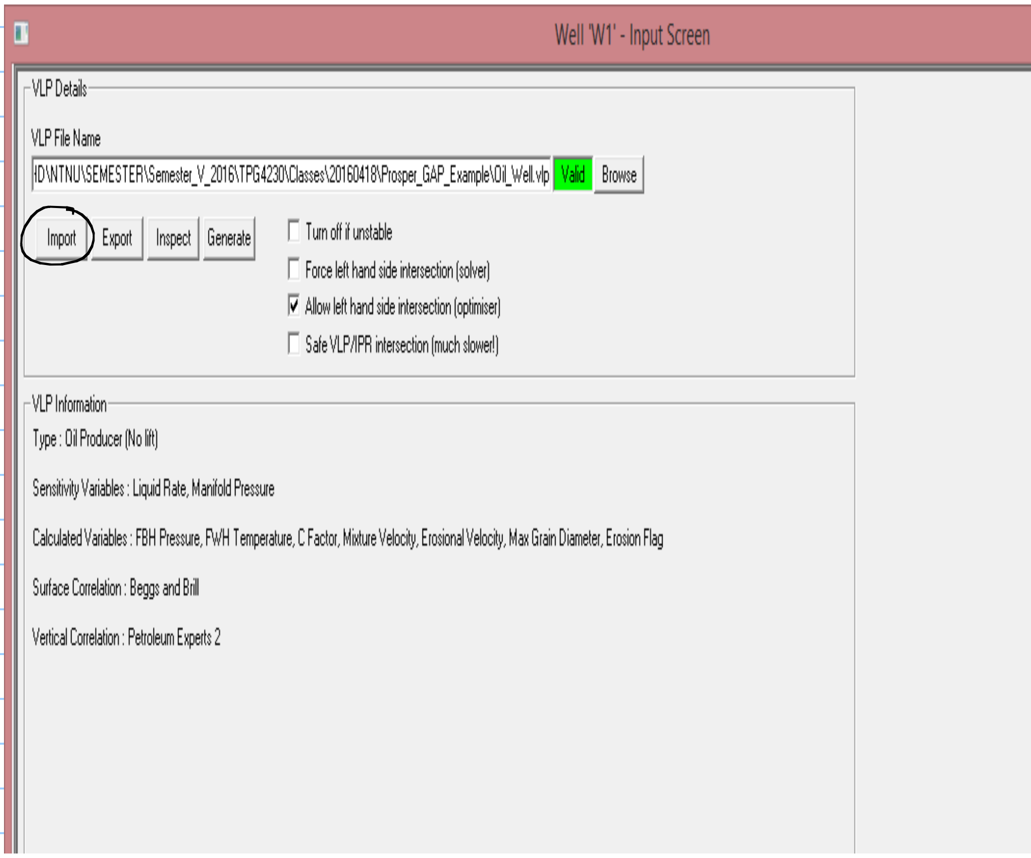
In GAP

BO model settings



• Link prosper file to well in GAP (summary window).

•

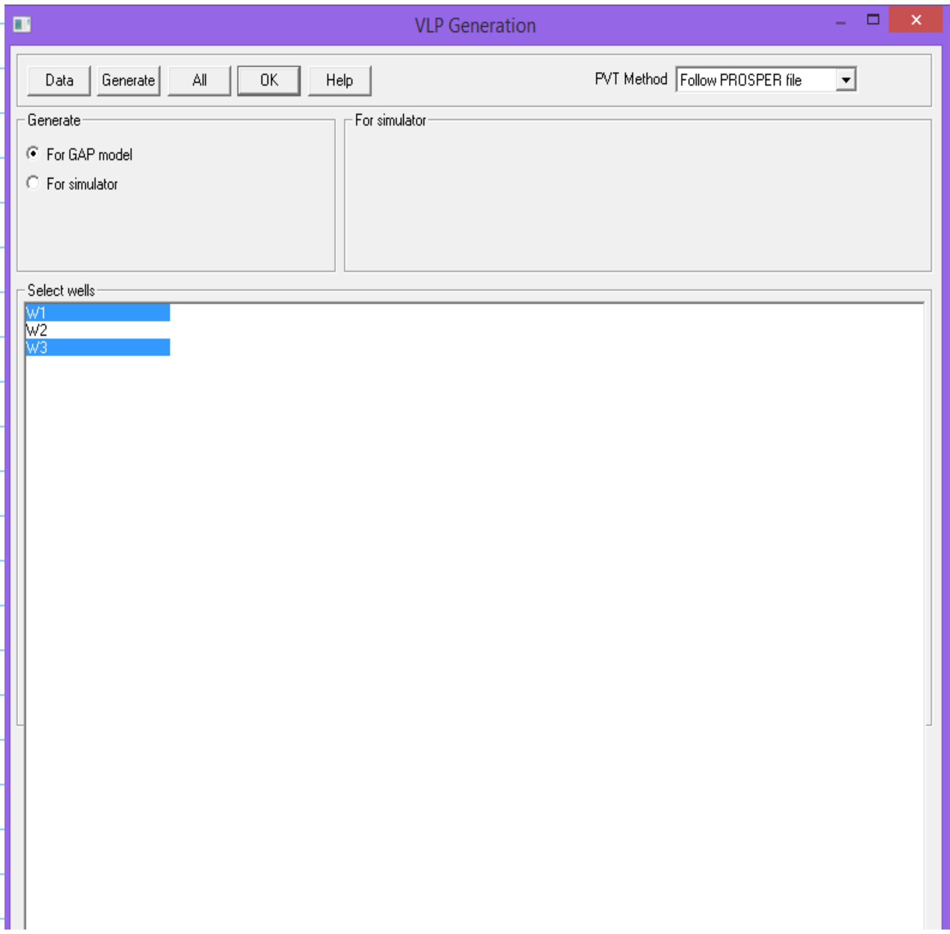


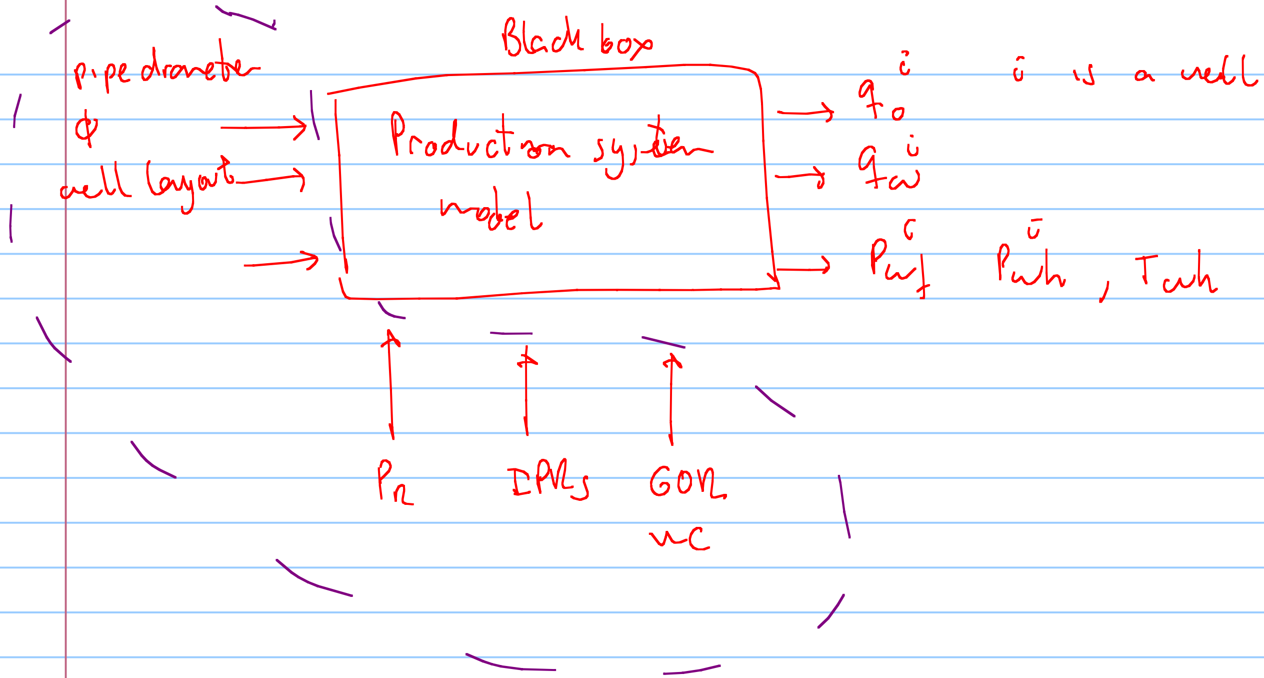
import tpd generated from prosper

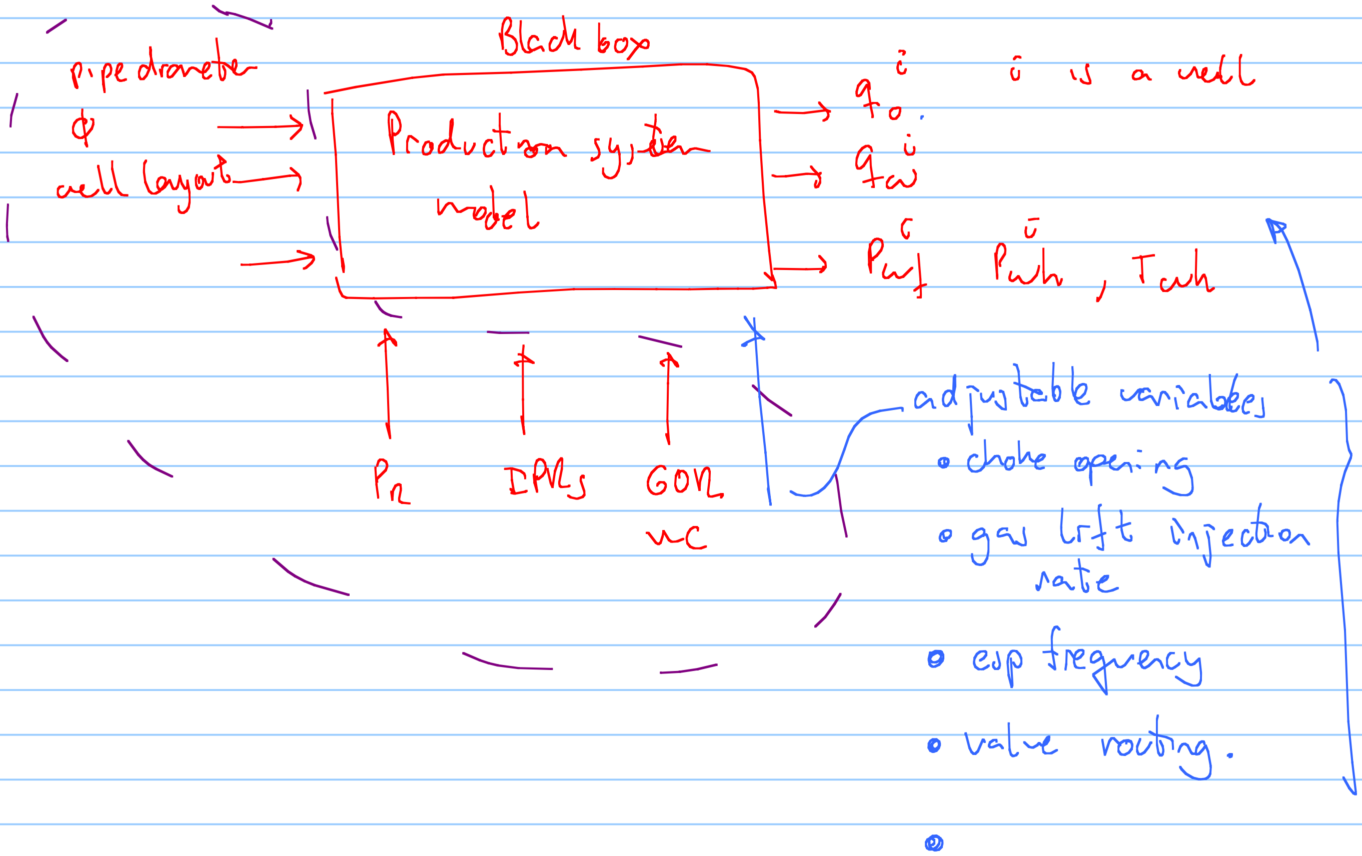
generate automatic .vlp

- Generate well IPR
  - OBS this process might give error "process terminated"
    - typically is because well type in prosper ≠ well type in GAP

Batch generation of VLP curves.







GAP is designed as an optimization software of production systems

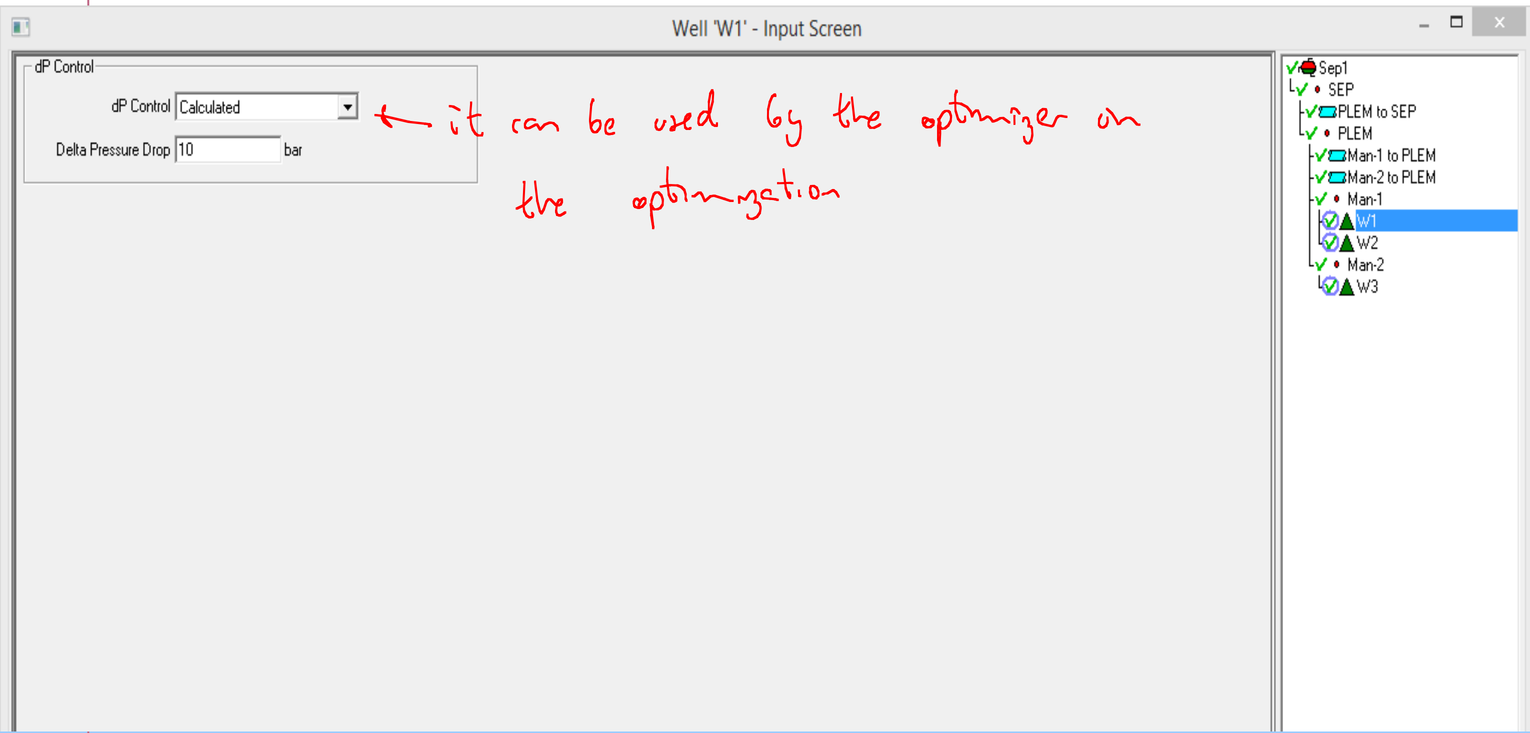
objective: optimize → max oil (if gas

variables → by changing → adjustable element

constraints → by honoring → operational constraints

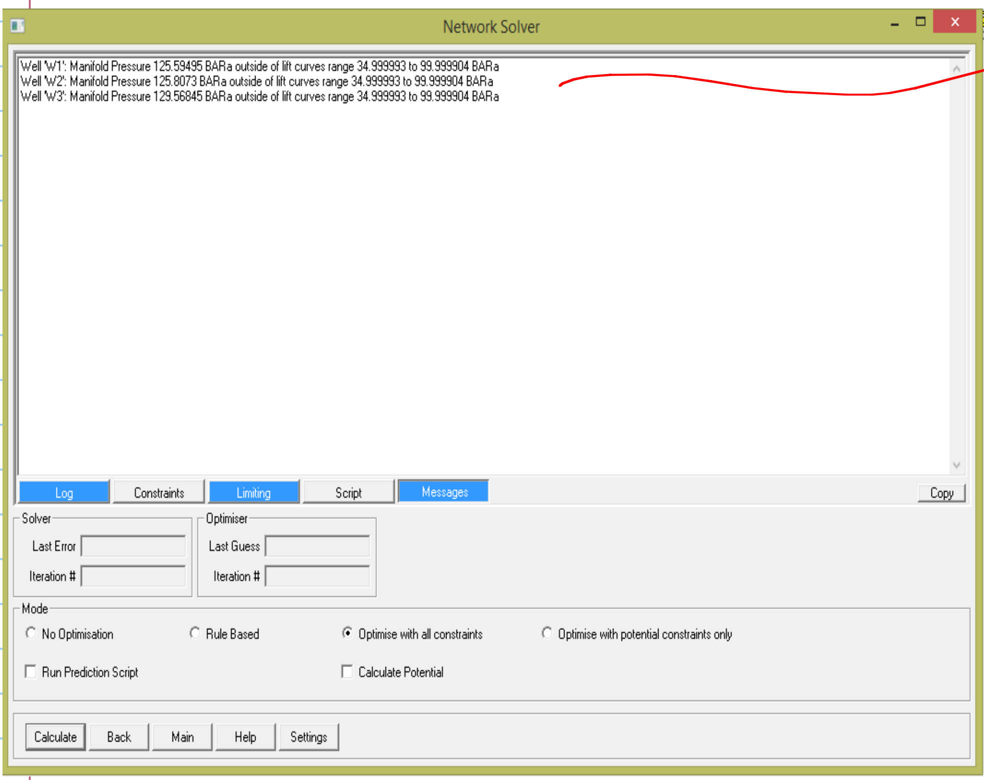
water prod
power capacity

→ GAP cannot make simulations with fixed well rate.

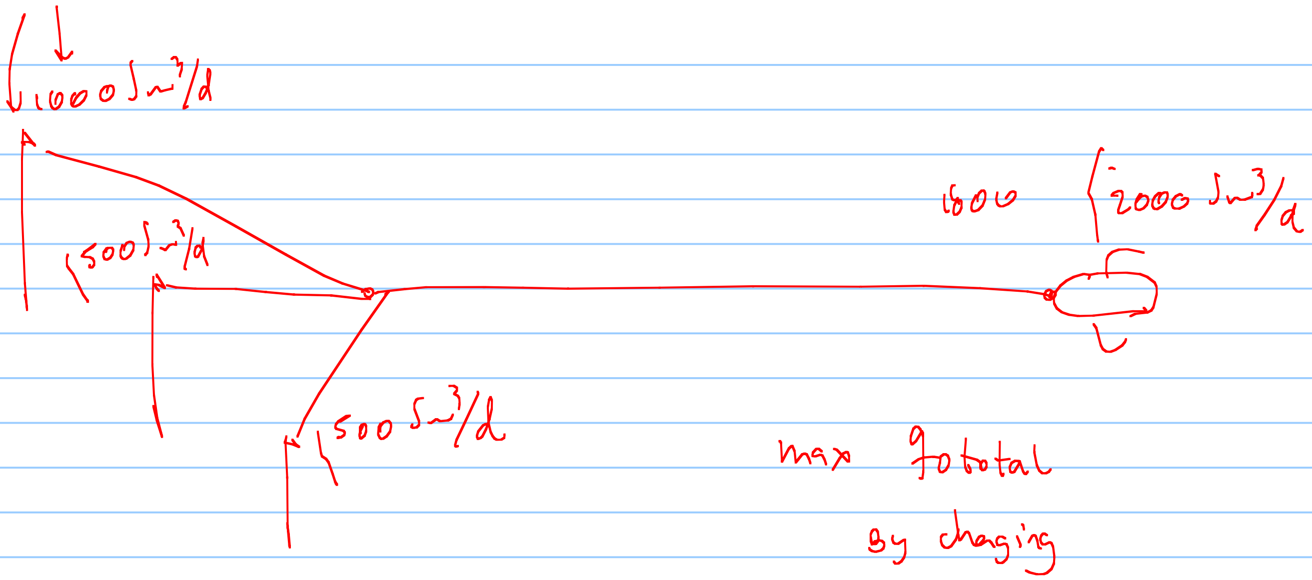


← it can be used by the optimizer on the optimization

optimization to get fixed rate is more expensive computationally than the method used in class



be aware of the warning messages of GAP



max q_{total}

by changing

$$\underbrace{q_1 + q_2 + q_3}\ = \underbrace{2000\ Sm^3/d}$$

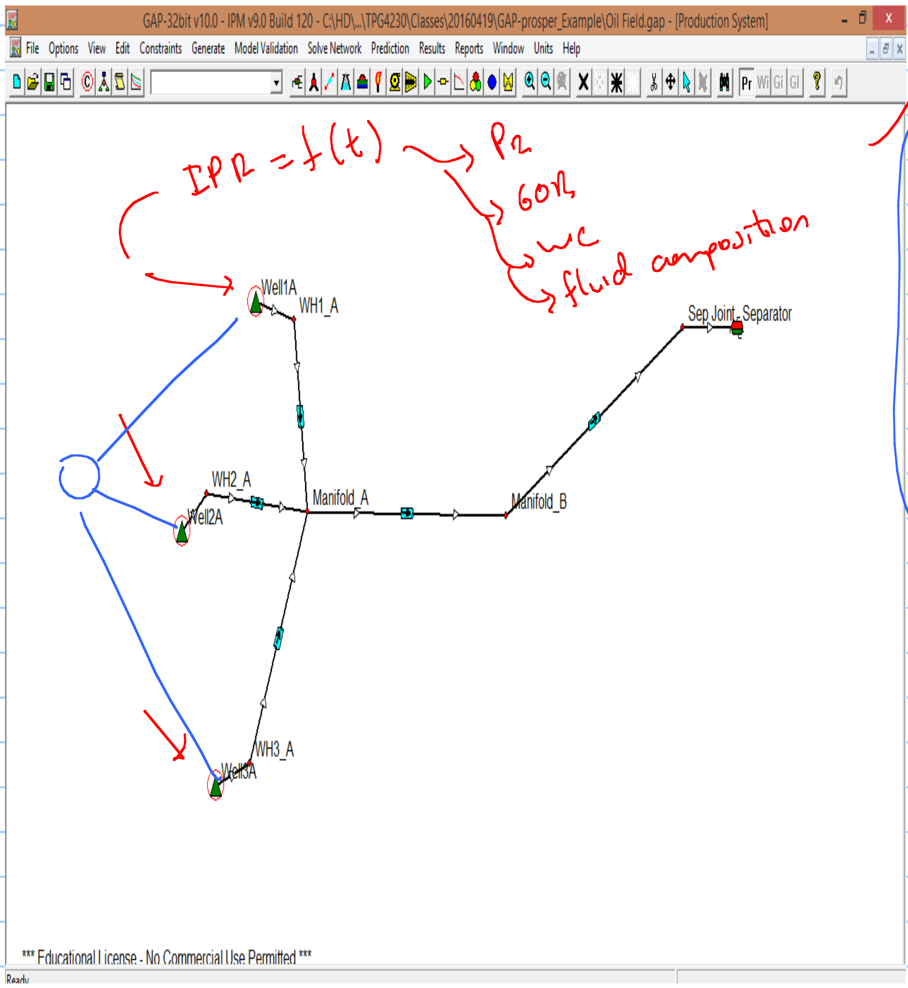
1 eq
3 unknowns } multiple solutions

$q_1 =$ —

$q_2 =$ —

time analysis :

coupling can be done in GAP



→ Petroleum experts

MBAL material balance simulator

↳ Pr vs Np

Reveal ~ reservoir simulator by PETEX.

Eclipse ~ commercial reservoir model

↳ Resolve

Material balance : big volume with average properties

S_o, S_g, S_w, P_R vs (N_p, G_p)

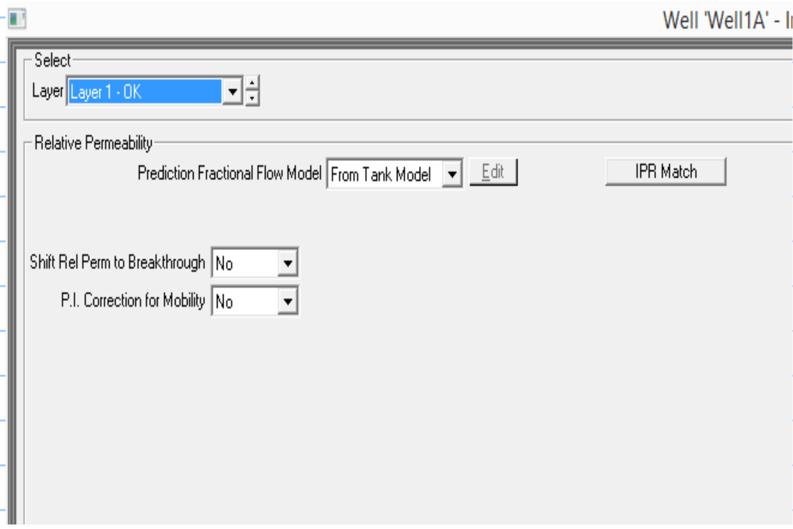
↳ GOR vs N_p, G_p

WC vs N_p, G_p

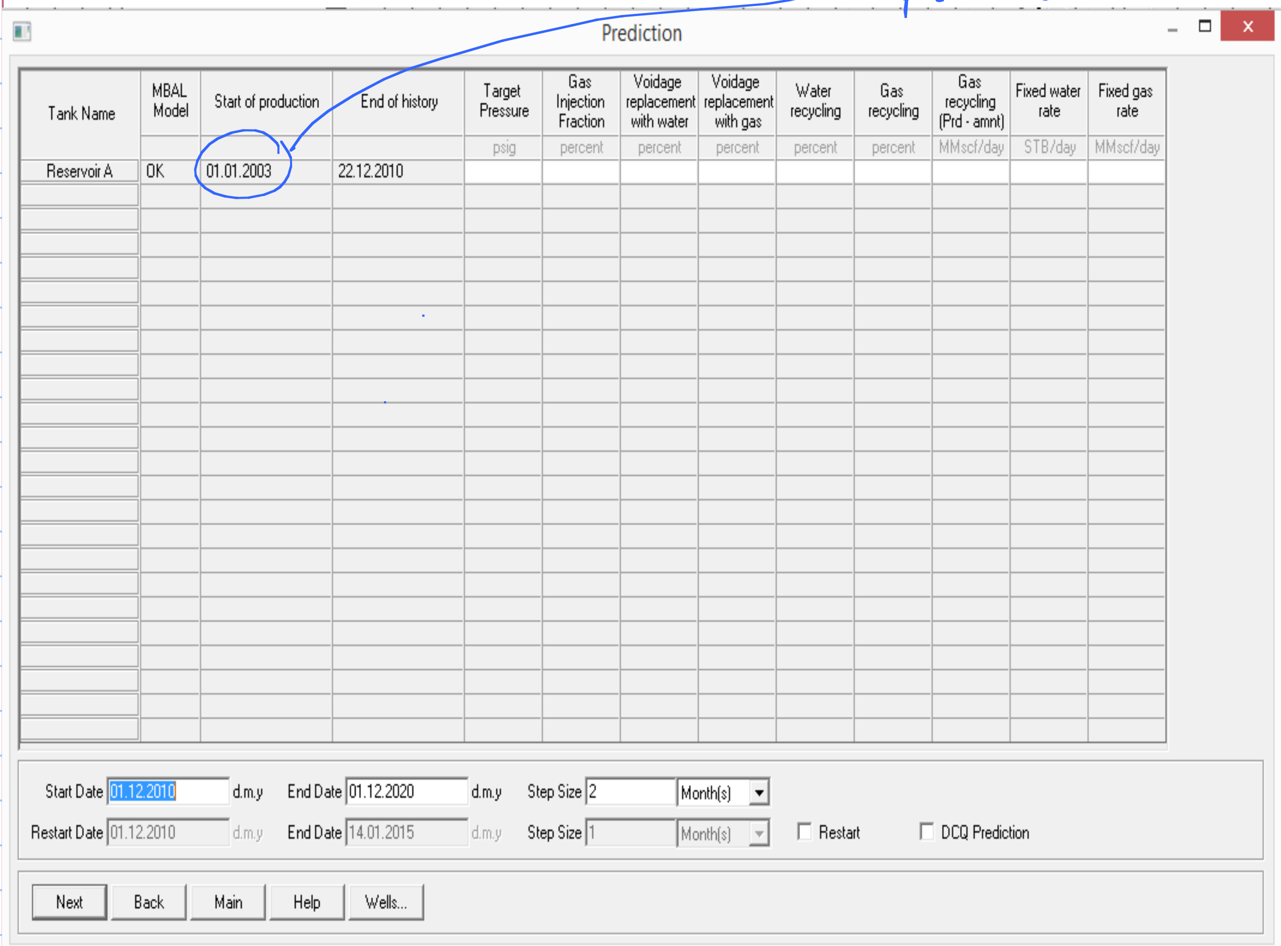
BLACK-OIL PVT FORMULATIONS

from prof. Whitson monograph: "phase behavior"

↳ R_p (GOR) $= f \begin{cases} k_{ro} \\ k_{rg}, \mu_o, R_s, B_o, B_g, \end{cases}$



input in the MBAL.



COMMENTS OBS: !

In exercise 1 of set 5, the pump map changes with μ and ρ !

→ a map has to be generated any time the WC changes. !

→ a template excel file will be provided for problems 2 and 3.

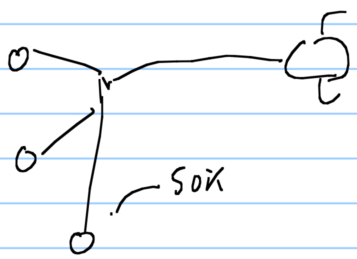
Optimization of production systems

↳ effectivization: make thing better than the way they are now

- maintenance logistics
- predictive maintenance
- trouble shooting { find the cause of an underlying problem.
  e.g. sand production, scale deposition, wrongly sized ESP.
- Data analysis. { visualize, examine, analyze production data to find improvements, better operational conditions, solutions to problems
  room for improvement.

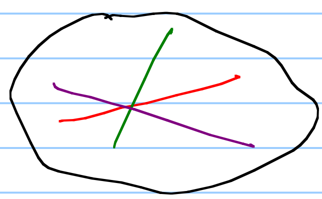
Schlumberger: oil field manager OFM, Spotfire

grouping ↝ cluster
↳ geographical location
↳ same separator.



- Sensitivity analysis with sofware { spider chart, tornado plots

↳ well placement



mathematical optimization

- computerized and automated process to find the best operating conditions
- model ↔ good representation of the production system

advise on the settings that I have to implement to operate under the best conditions

- well placement
- choke opening
- gas lift rate
- diameter of the pipeline
- etc.

Element needed in an optimization

- Search maximum or minimum of an objective function
  - oil production, gas production, condensate prod, plateau length, cost, NPV, Recovery factor
- By changing adjustable parameters, variables in the system
  - well placement, number of wells, choke opening gas lift injection rate, ESP frequency,
- Honor constraints
  - water handling capacity, maximum well length, Power capacity, equipment operational conditions

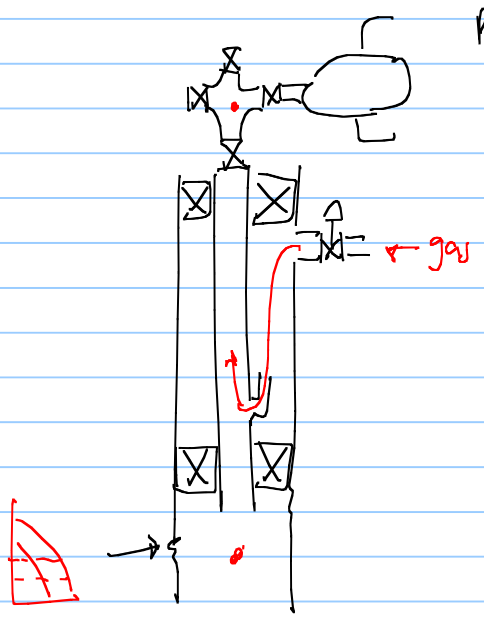
the definition of obj, var, cons. depends on which phase in the life of the asset you are

uncertainty

there are typically two scales → field life scale → evaluation of development, EOR

→ operational time scale {weekly, daily, monthly}

Example: gas lift optimization



$P_{wh} = \text{const}$

$$\Delta p_{tubing} = \underbrace{\Delta p_{hydrostatic}}_{\text{term 1}} + \underbrace{\Delta p_{friction}}_{\text{term 2}}$$

$\Delta p_{hydrostatic} \to \rho_m \cdot g \cdot h$ $\qquad$ $\Delta p_{friction} \to f \, \frac{L}{\phi} \, \frac{v^2}{2g}$

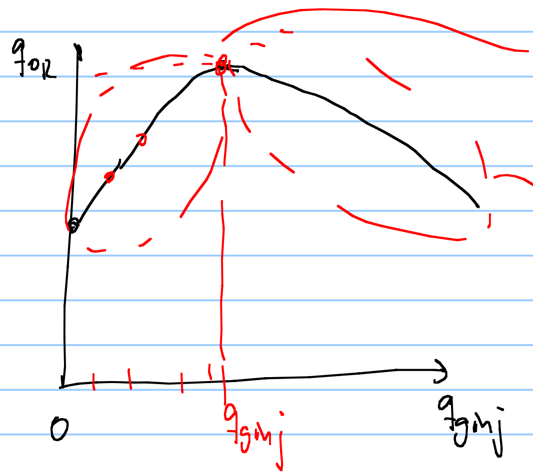
$\uparrow$

$\rho_m \downarrow$ $\qquad$ $v \uparrow$

to generate this curve

we test the well

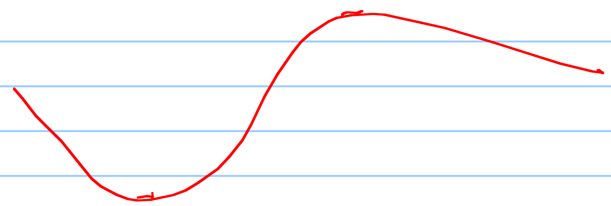
↳ model

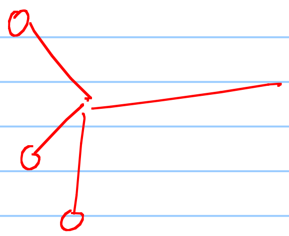


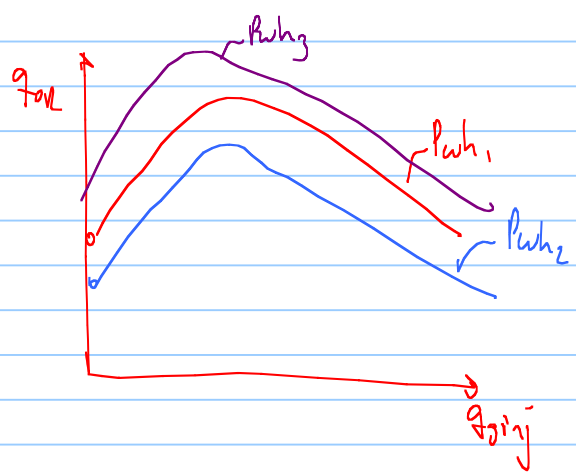
the reduction in term ① is more important than the increase on term ②

the increase in term ② is more important than the reduction in ①

$$\frac{d q_{oR}}{d q_{ginj}} = 0$$



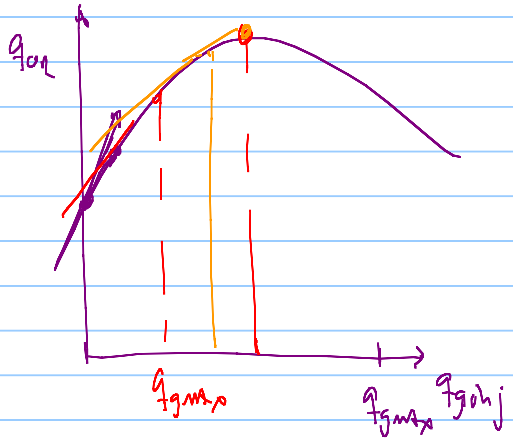




find q_{ginj}^* where q_{on} max $\sim\!\!>$ $\left\{ \begin{array}{l} \dfrac{d\,q_{on}}{d\,q_{ginj}} = 0 \\ \\ \dfrac{d^2 q_{on}}{d\,q_{ginj}^2} < 0 \end{array} \right.$

$q_{on} = f(q_{ginj})$

↓ my model

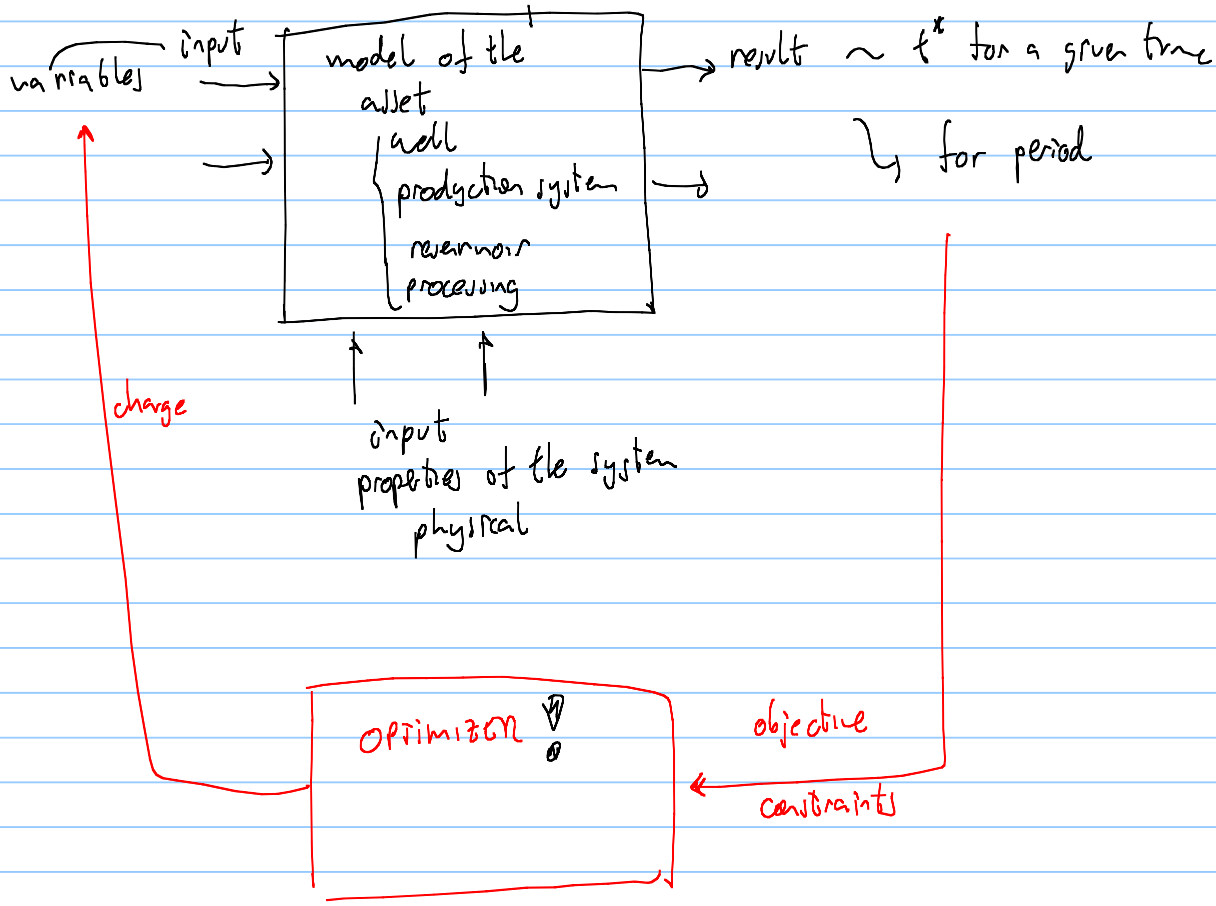


$q_{ginj\,avail} < q_{gmax}$

impact of the constraint

models and optimization

$\bar{y} = \bar{f}(\bar{x})$



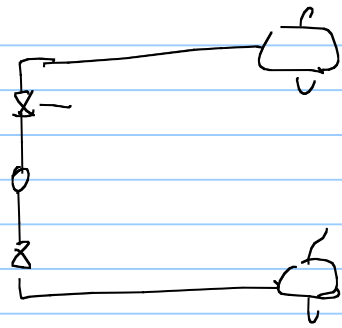
when choosing variables, make sure that they affect the objective and constraints

- Optimization types:

Constrained unconstrained

Continuous or integer 0 - 1
0.06

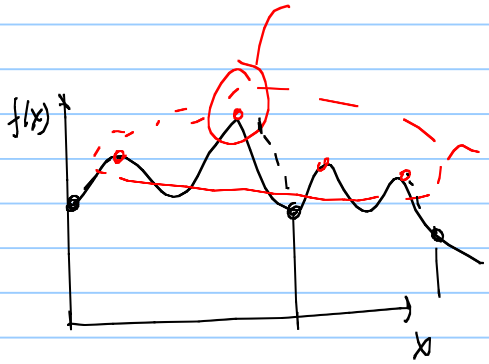
↳ nature of the opt. variable.



- non-linear / linear problems

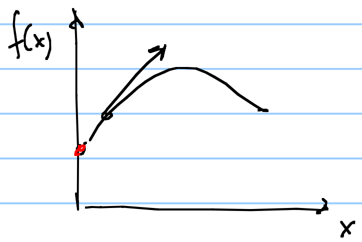
local and global }

↳ method to solve this issue is multi-start



Optimization methods

- Gradient-based ~ determine a search direction using gradients (derivatives)



↳ very efficient for continuous problems

$\frac{\partial f}{\partial x}$ } analytical equation

$\frac{\partial\, fon}{\partial\, fgin j}$ { Black box model?
estimate numerically the derivative.
↳ time consuming for big models and for large number of variables

$x \rightarrow \boxed{B.B} \rightarrow f(x)$

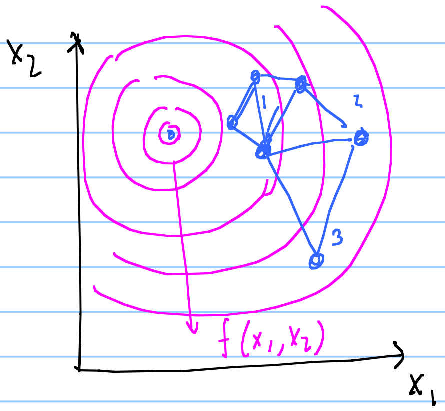
x_1 $f(x_1)$

x_2 $f(x_2)$

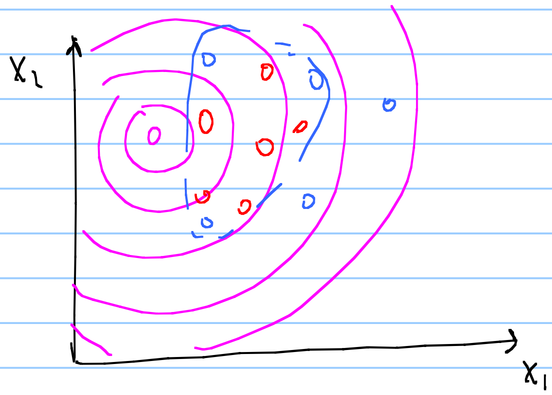
$$\frac{d f(x)}{dx} = \frac{f(x_2) - f(x_1)}{x_2 - x_1}$$

- heuristic methods: start with a collection of points and progress using penalization logic

nelder Mead



- Stochastic methods · random variables, evolutionary algorith, genetic algorith



it 1

it 2

- combinatorial techniques $\rightsquigarrow$ integer problems

Sometimes constraints that are not on the variables are included as part of the objective function

$q_{ginj} < q_{max}$

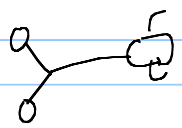
$q_{wat} < q_{max}$

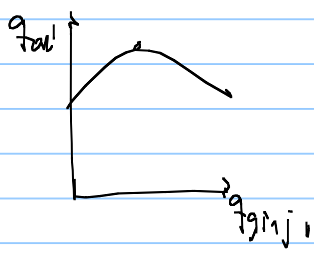
$$\max \left(q_{on} - \underbrace{f \cdot 0.2}_{\text{weight factor}} \, q_{wat} \right) \sim \text{compound objective function}$$

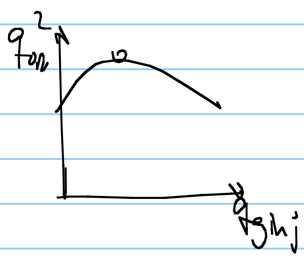
$$\frac{d q_{on}}{d q_g} \qquad \frac{\partial q_{on} - q_w}{d q_g}$$

System of two standalone gas lifted wells

q_{max}







$$q_{on} = \alpha_1 (2 - e^{-\beta_1 q_{ginj}}) - \alpha_2 e^{\beta_2 q_{ginj}}$$

• with the collection of points find the constants in the equation

q_{ginj1}	q_{on1}	q_{ginj2}	q_{on2}	q_{oT}
				$q_{on1}+q_{on2}$
change		change		

$$q_p = \tilde{\alpha}_1(2 - e^{-\tilde{\beta}_1 q_i}) - \tilde{\alpha}_2 e^{\tilde{\beta}_2 q_i}$$

constants tuned with field data