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Aquifer Pumping Test Evaluation

1D classical vs. 2D numerical solutions

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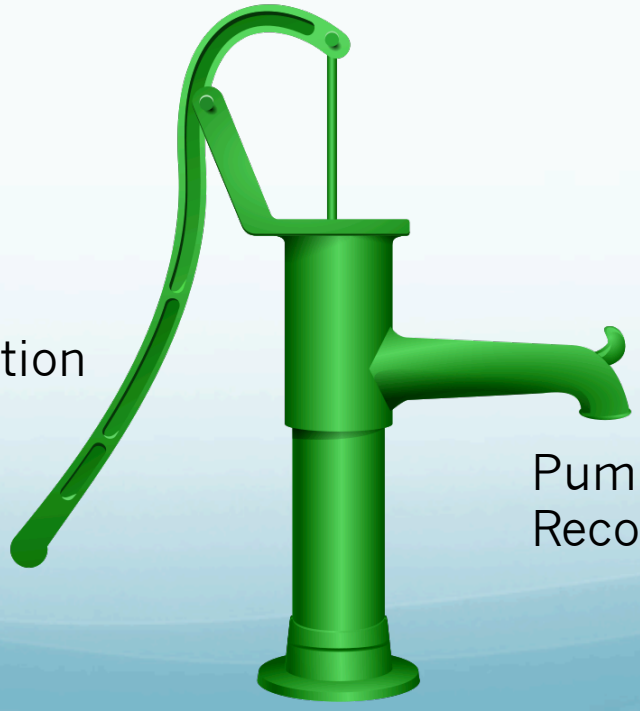
Introduction

In a pumping test the drawdown of the water table in a piezometer is recorded, as response to pumping from a nearby well. Pumping tests belong into the common toolbox of hydro-geologists, used to obtain basic parameters for aquifer characterization.

Required:

Well for pumping
Piezometer for observation



Pump
Recording of drawdown

Pump Test

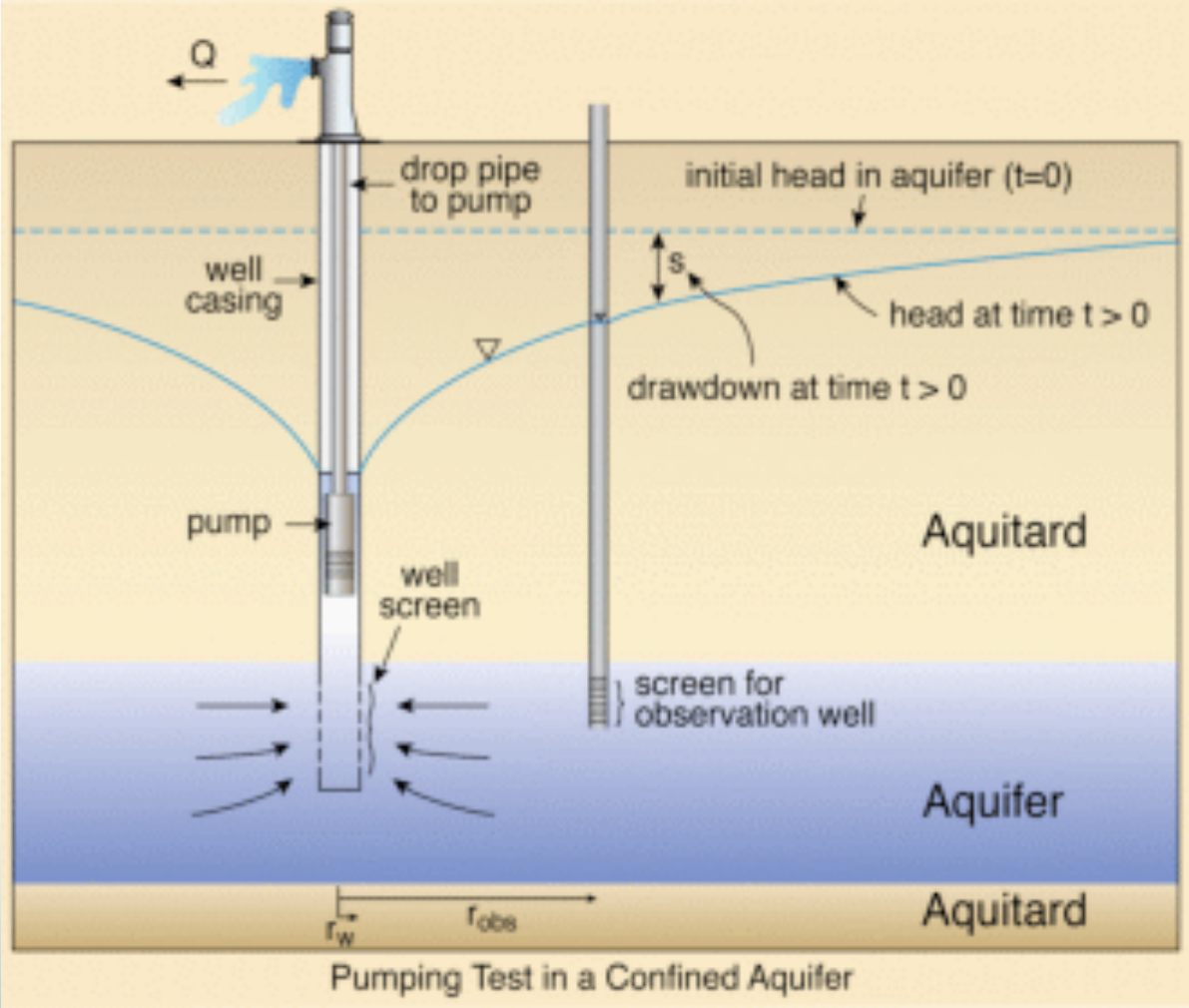
Inverse Modelling Task

Given:

- pumping rate Q
- distance to well r

To estimate:

- transmissivity T
- Storativity S

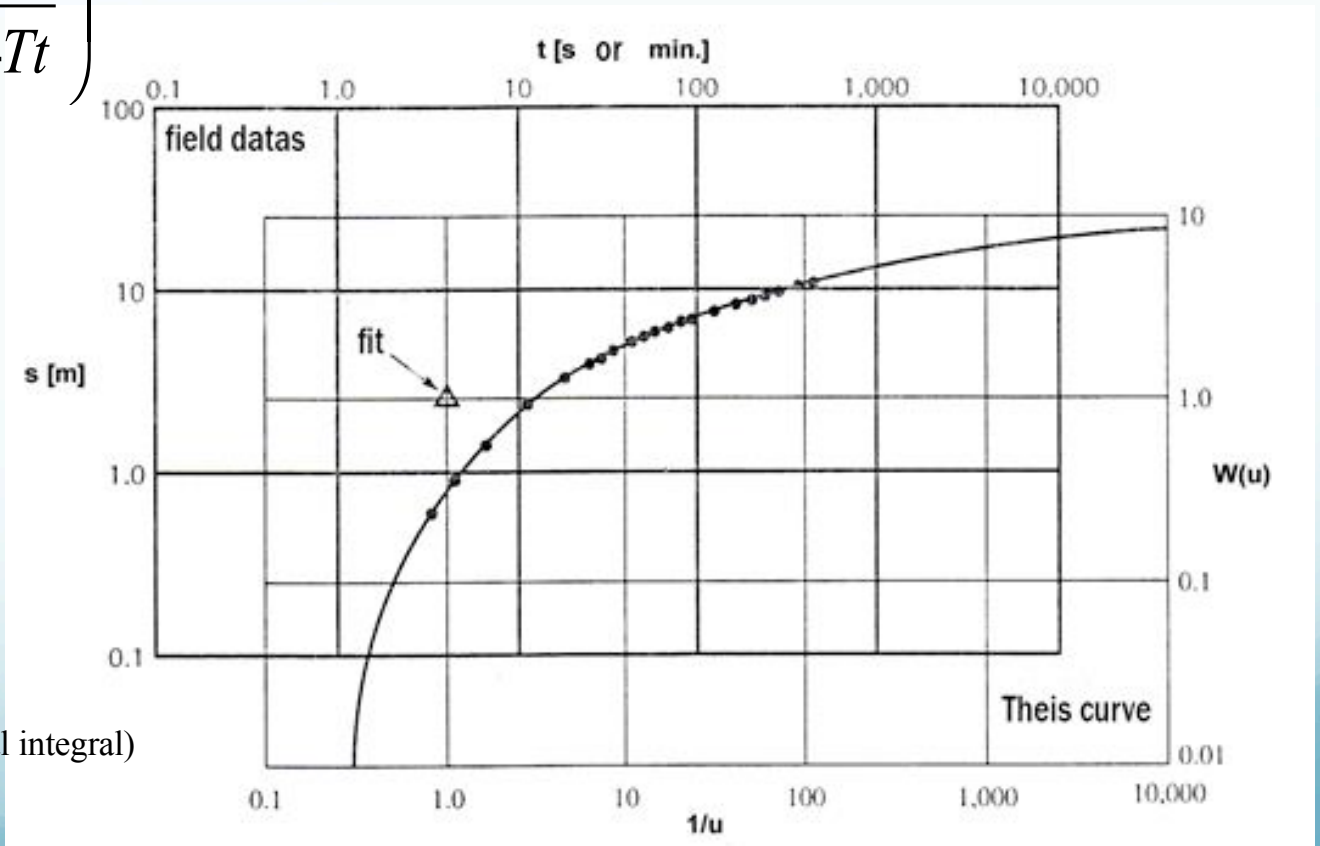


https://midwestgeo.com/webinars/archived/aquiferpumping-01222015.php?item=WArc0104

Evaluation

Classical evaluation in comparison with 1D analytical solutions; here Theis:

$$s(r,t) = \frac{Q}{4\pi T} W\left(\frac{r^2 S}{4Tt}\right)$$



s	drawdown [m]
r	distance from well [m]
t	time [min]
Q	pumping rate [m^3/min]
T	transmissivity [m^2/min]
S	storativity [-]
W	well function (exponential integral)
u	$r^2 S / 4Tt$

https://regi.tankonyvtar.hu/hu/tartalom/tamop412A/2011_0059_SCORM_MFKHT5053-EN/sco_04_05.scorm

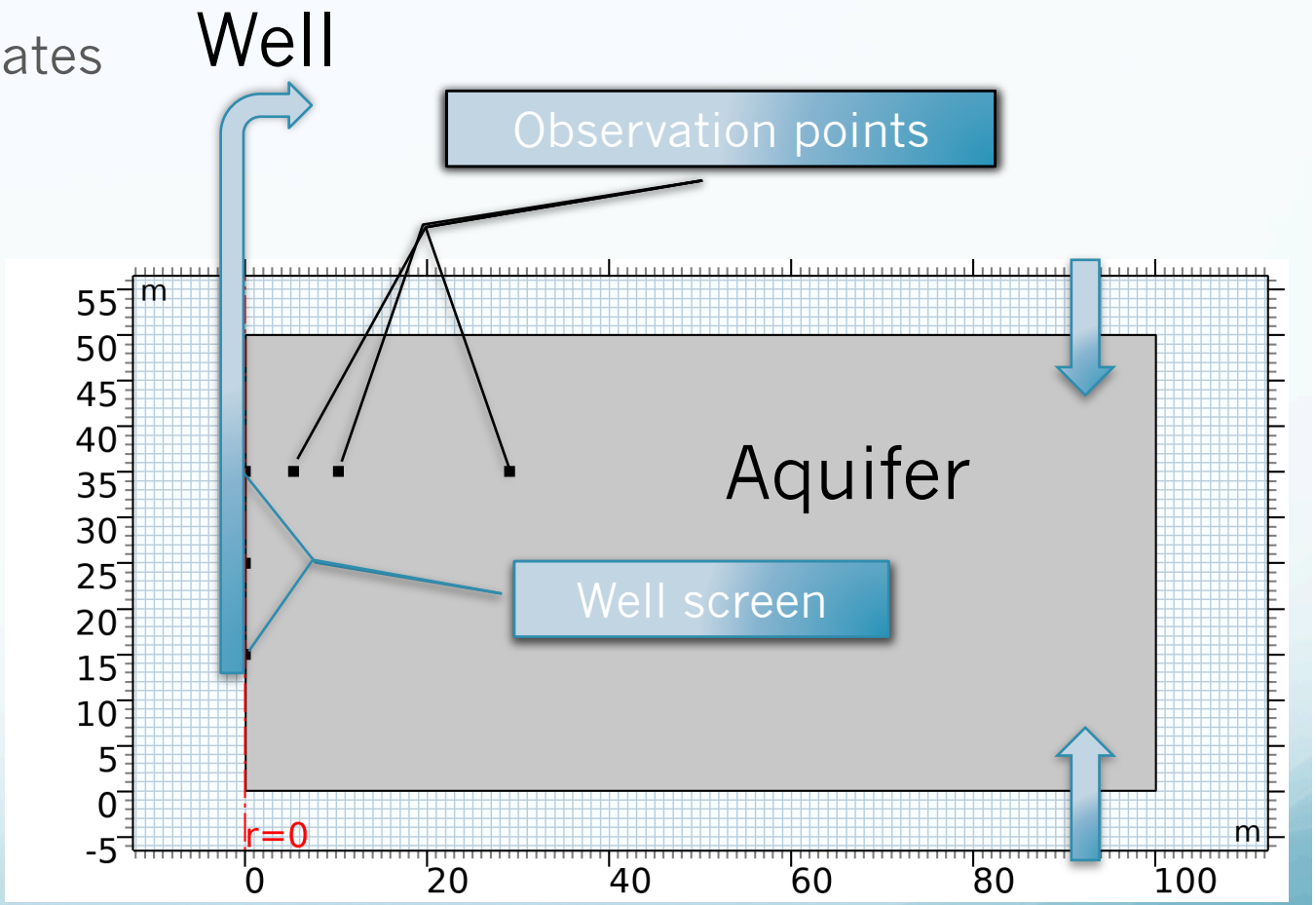
Conditions

for applying the classical method

- Ideal well, ie. penetrating the entire aquifer thickness
- No relevant vertical velocity components
- Piezometer in medium aquifer depth
- Large extend of the aquifer
- No recharge or leakage
- Confined aquifer

2D Model

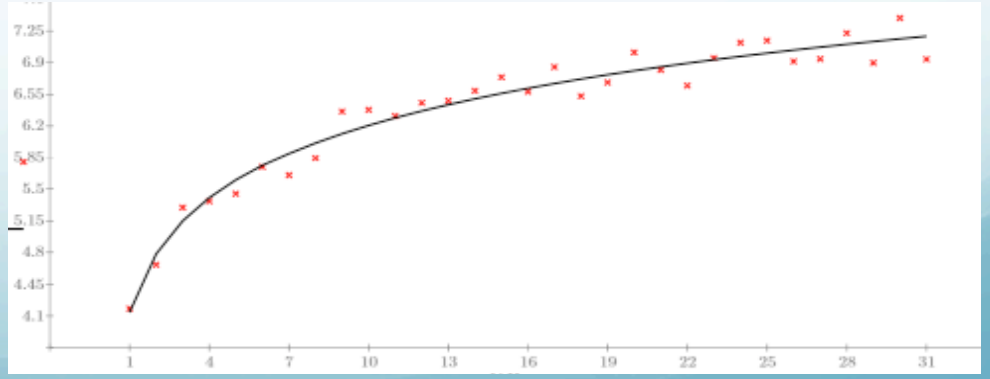
- Cylinder coordinates
- Screen position
- Thickness
- Reach
- Recharge
- Leakage
- Confined and unconfined



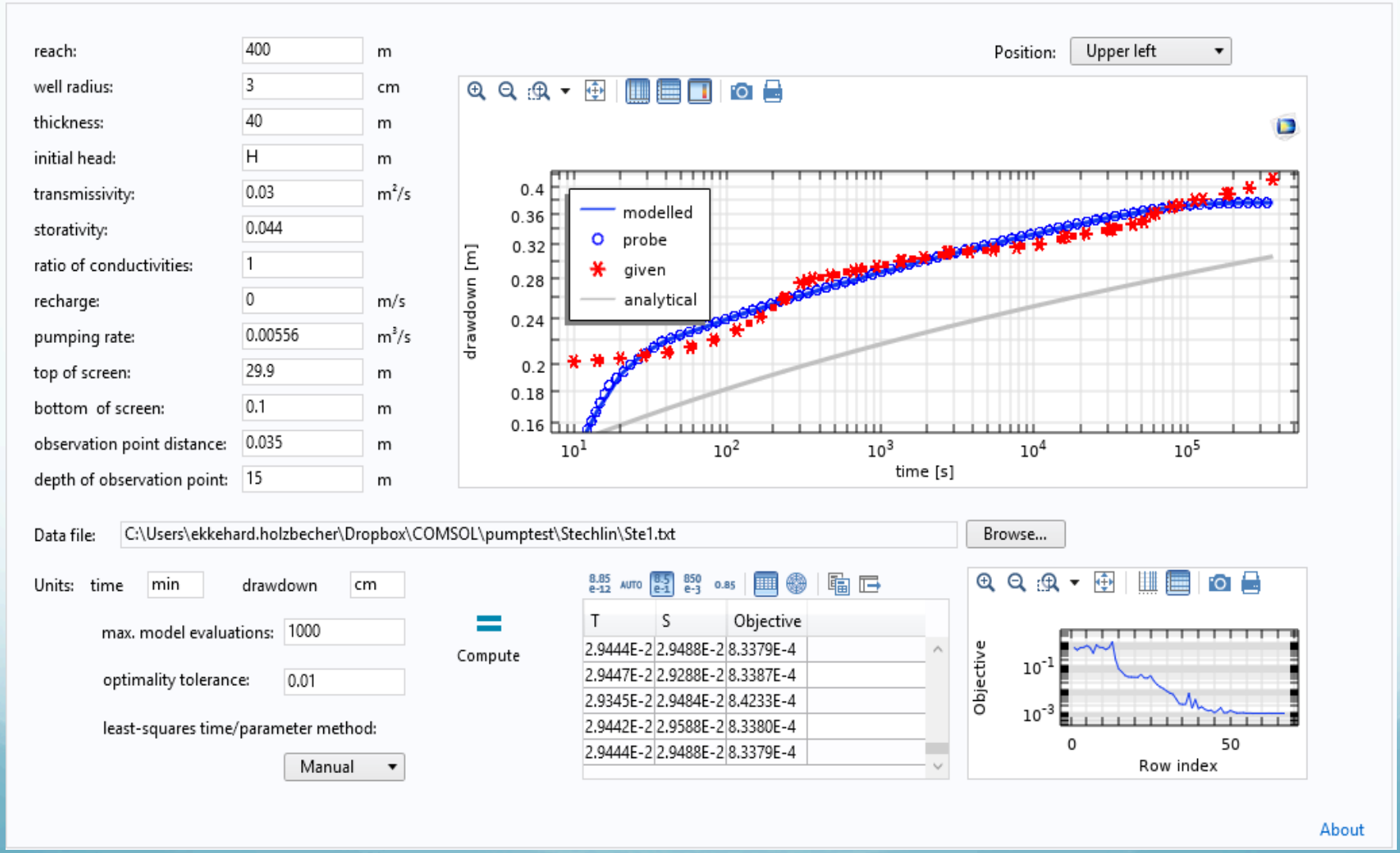
Parameter Estimation

using Optimization Module:

- for parameters: storativity (S), transmissivity (T)
- additional options for:
  - reach, thickness, screen position, leakage, groundwater recharge
- parameter range can be selected
- Least-squares optimization
- Levenberg-Marquard



App


reach: 400 m
well radius: 3 cm
thickness: 40 m
initial head: H m
transmissivity: 0.03 m²/s
storativity: 0.044
ratio of conductivities: 1
recharge: 0 m/s
pumping rate: 0.00556 m³/s
top of screen: 29.9 m
bottom of screen: 0.1 m
observation point distance: 0.035 m
depth of observation point: 15 m
Position: Upper left
modelled
probe
given
analytical
drawdown [m]
time [s]
Data file: C:\Users\ekkehard.holzbecher\Dropbox\COMSOL\pumptest\Stechlin\Ste1.txt
Browse...
Units: time min drawdown cm
max. model evaluations: 1000
optimality tolerance: 0.01
least-squares time/parameter method:
Manual
Compute
T S Objective
2.9444E-2 2.9488E-2 8.3379E-4
2.9447E-2 2.9288E-2 8.3387E-4
2.9345E-2 2.9484E-2 8.4233E-4
2.9442E-2 2.9588E-2 8.3380E-4
2.9444E-2 2.9488E-2 8.3379E-4
Objective
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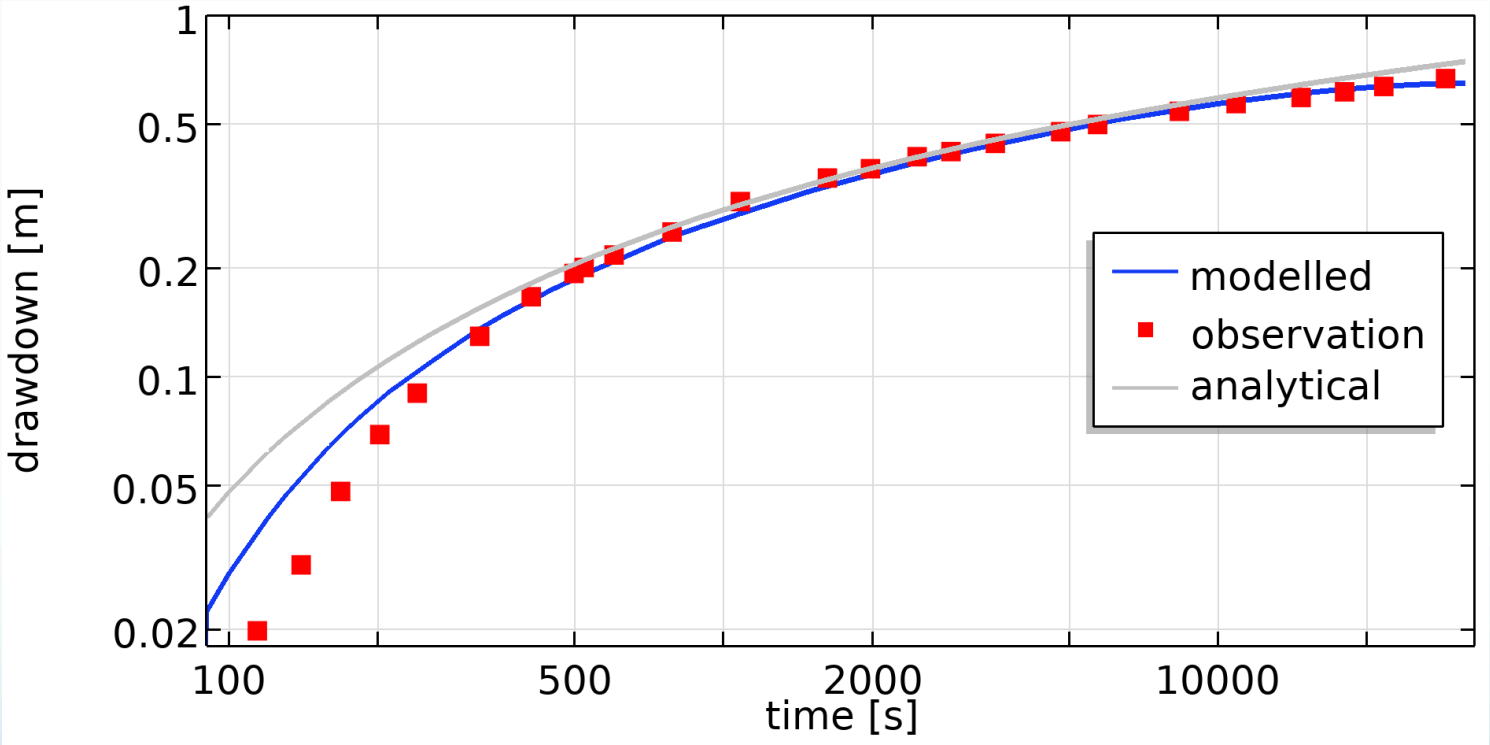
About

Example: Oude Korendijk



Observation well: 90 m distance
Pumping rate: 0.00912 m^3/s

Transmissivity: 0.0054 m^2/s
Storativity: 0.000187

Conclusion

2D numerical methods can be used successfully for the evaluation of pumping tests. They are superior to methods based on 1D analytical solutions, as they are built on less restrictive assumptions. Moreover, one can take advantage of a better site characterization by including known parameters that are not considered in the classical evaluation methods.

THANK YOU!