Simulation of a Novel Groundwater Lowering Technique using Arbitrary Lagrangian-Eulerian (*ale*) Method

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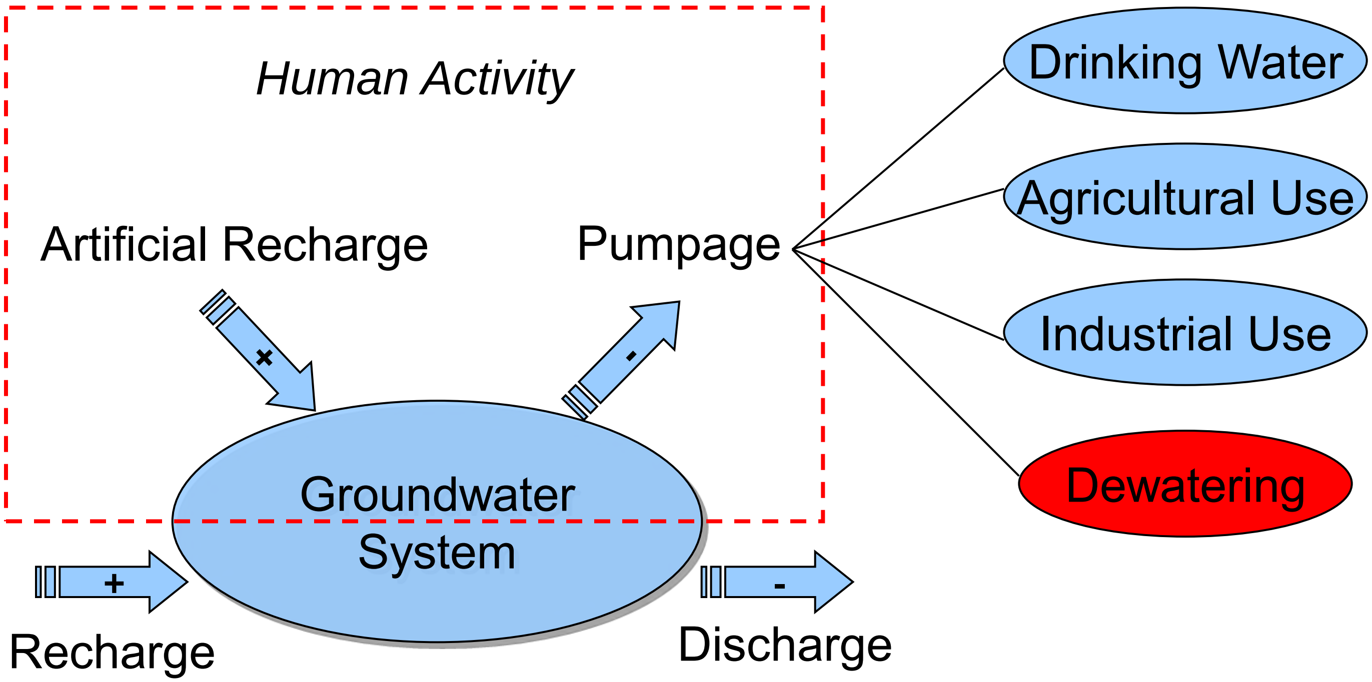
Objectives

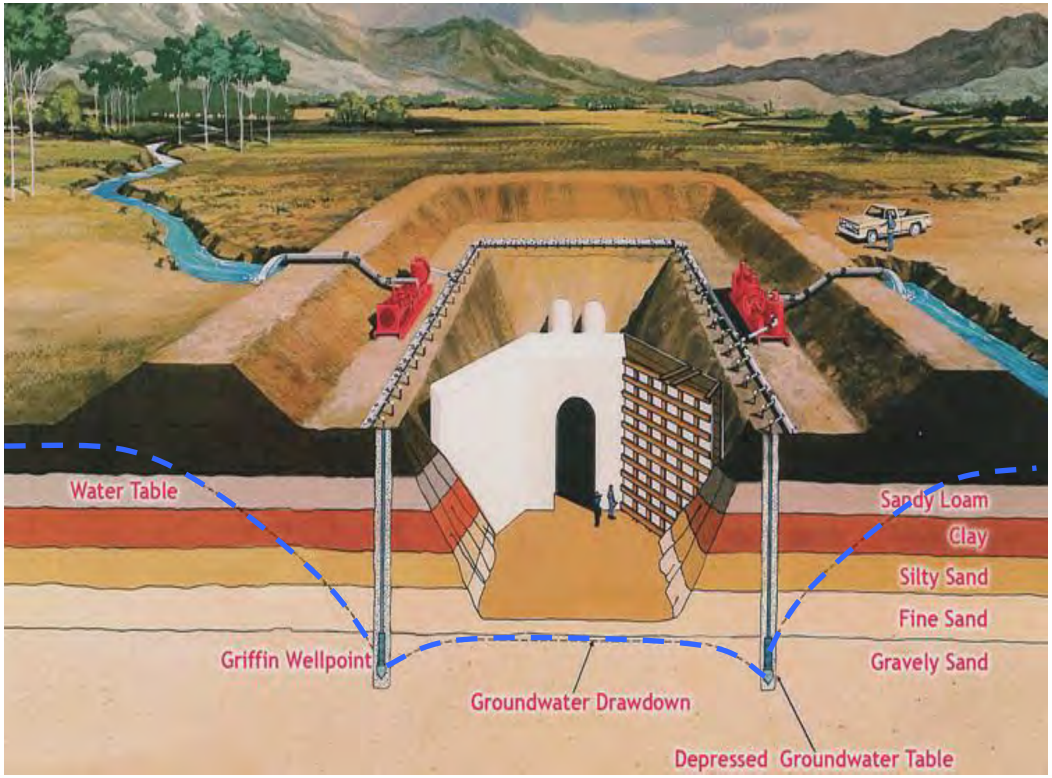
Evaluating an innovative dewatering method

- To avoid the unnecessary groundwater extraction
- To prevent water contaminations
- To lower the cost for dewatering at a site

Groundwater Budget



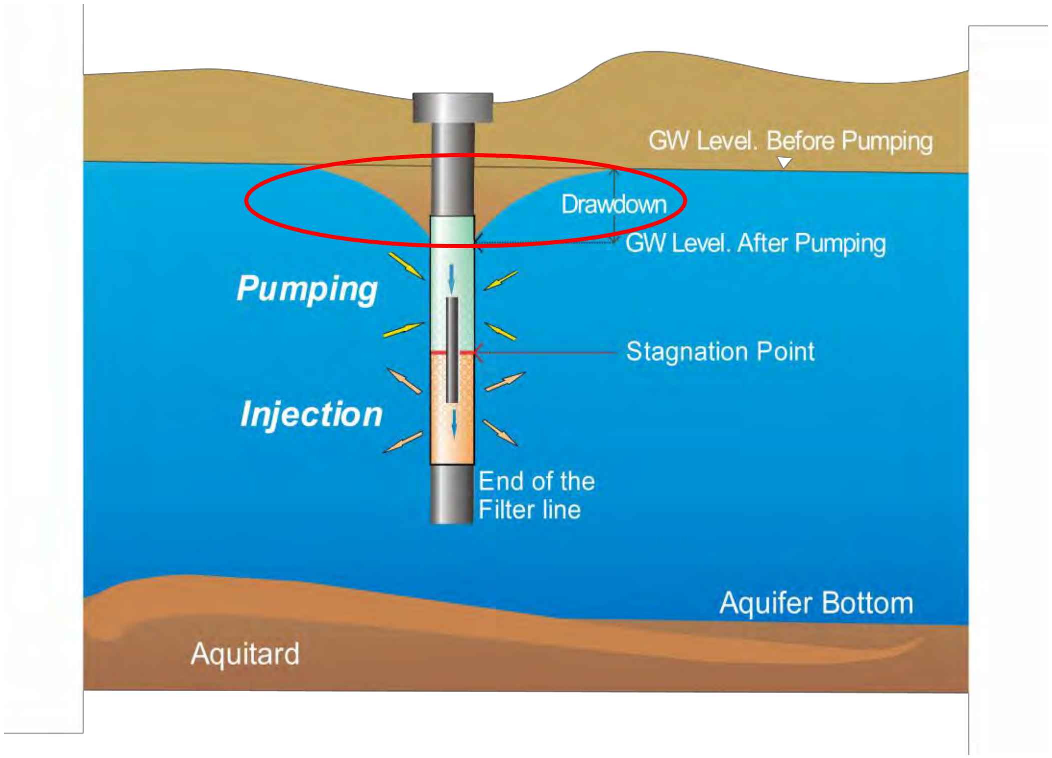
Conventional Dewatering Method



- Wellpoints dewatering.
- Pump water out to the surface.
- Discharge to nearby surface water body or re-inject into ground at distant location.

Griffin, 2011,http://www.griffindewatering.com/dewatering/wellpoint_system.html

Innovative Dewatering Method



- Düsensauginfiltration (DSI)

(W.Wils, 2010, Druckwellen System Düsensauginfiltration)

- Groundwater is pumped at upper part of the borehole.
- Pumped water is injected back into the deeper part of the aquifer.
- Dewatering without water abstraction.

Test Fields

Korschenbroich, Nordrhein-Westfalen

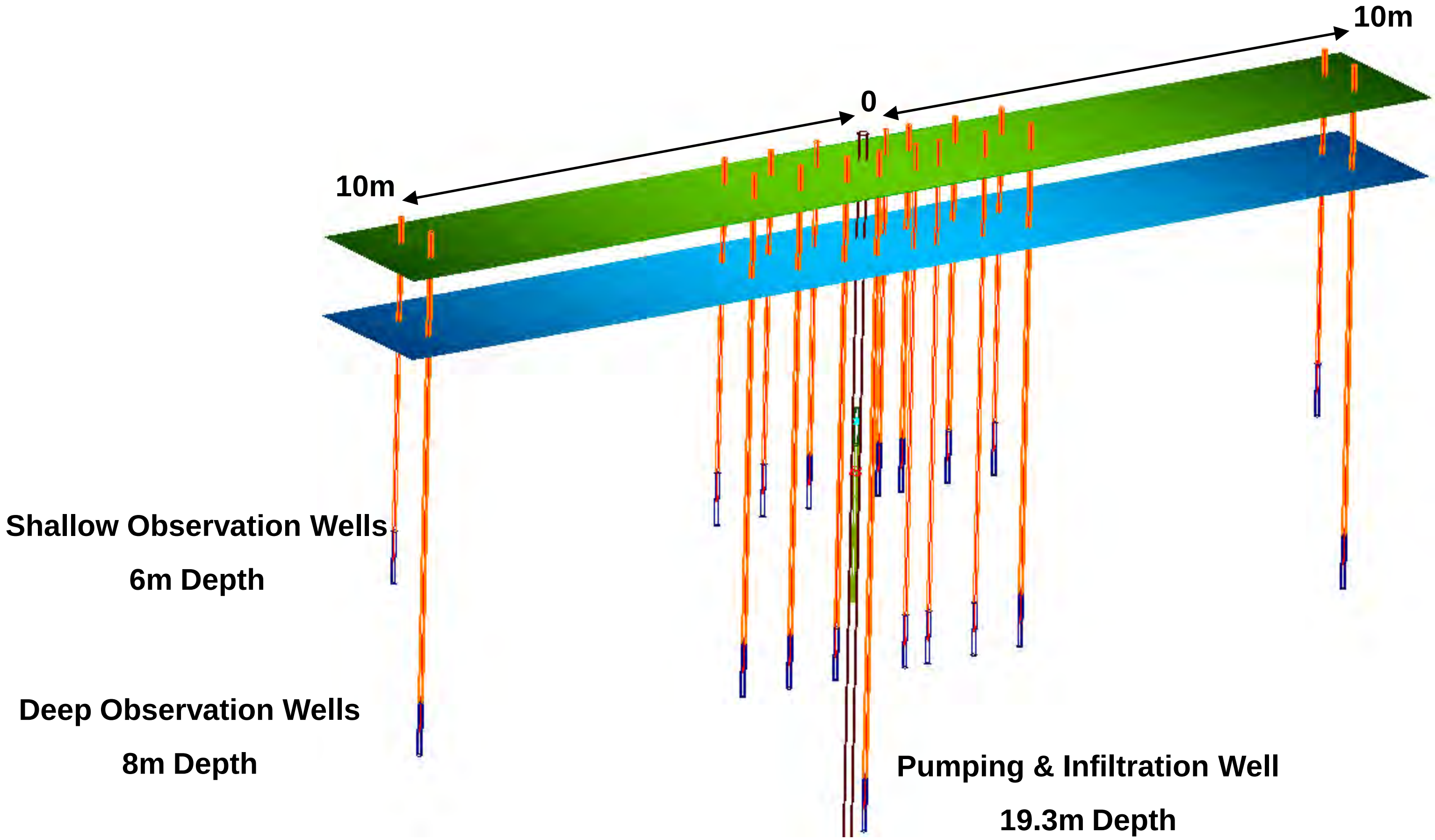
- Multi DSI well
- Unconfined aquifer
- Groundwater level ~3.5m
- Sand, gravels

Plötzin, Brandenburg

- Single DSI well
- Unconfined aquifer
- Groundwater level ~1.5m
- Sand, fine gravels

http://www.hrs-krummhoern.de/Englisch/Germany/germany-map.jpg

Plötzin Field Experiment Set-up



Numerical Modelling

Governing Equations

- Darcy’s Law
- Fluid Mass Conservation

$$\nabla\left(\rho\cdot\mathbf{u}\right)=0 \qquad \mathbf{u}=-\frac{k}{\mu}\nabla p$$

ρ: fluid density (kg/m^3)

u: velocity vector (m/s)

κ : permeability (m^2)

μ: viscosity (Pa·s)

p: pressure (Pa)

Use of COMSOL Multiphysics

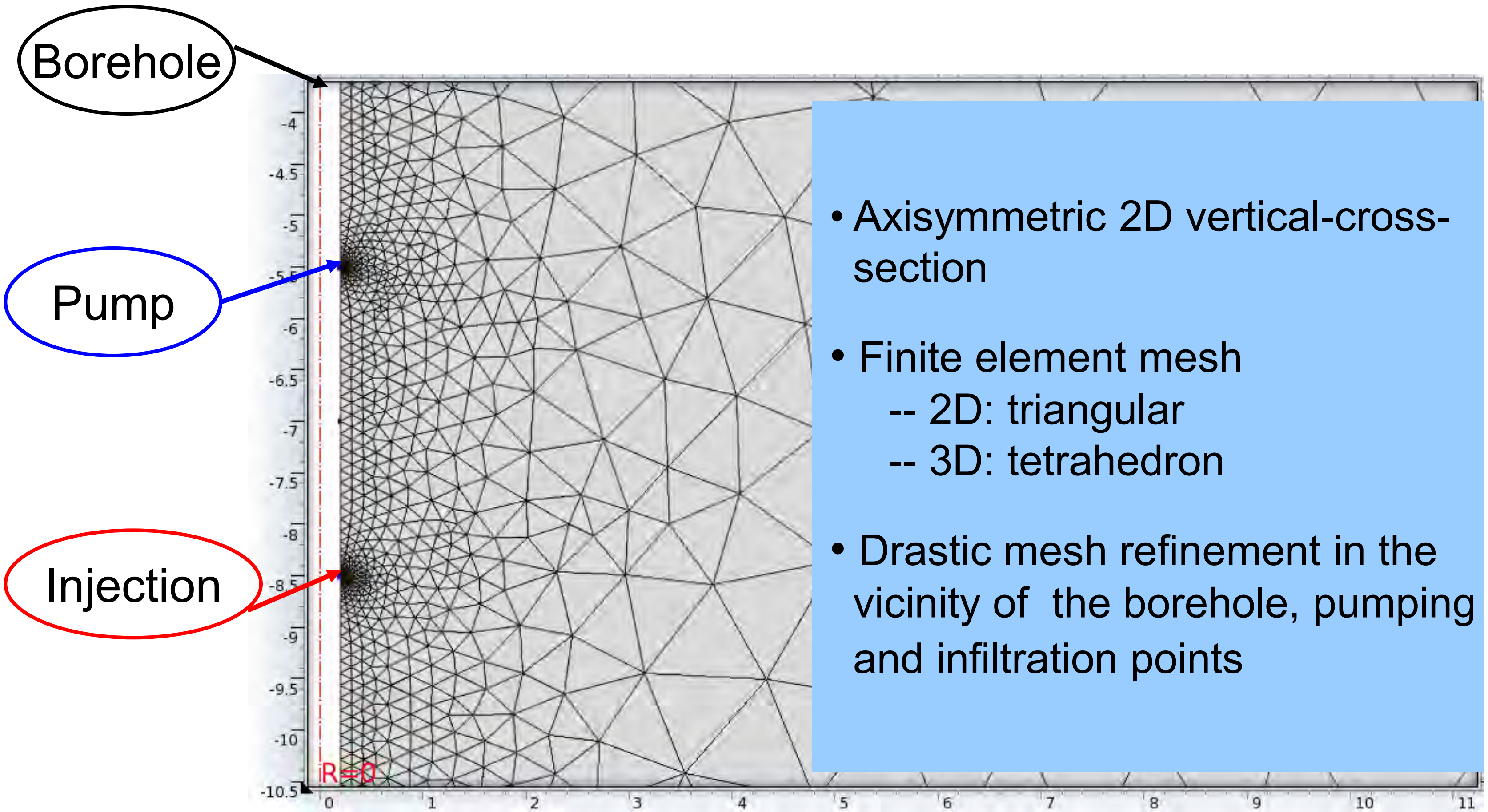
- Darcy’s Law (dl)

  Uses pressure as dependent variable to determine hydraulic head in time and space.

- Moving Mesh (ale)

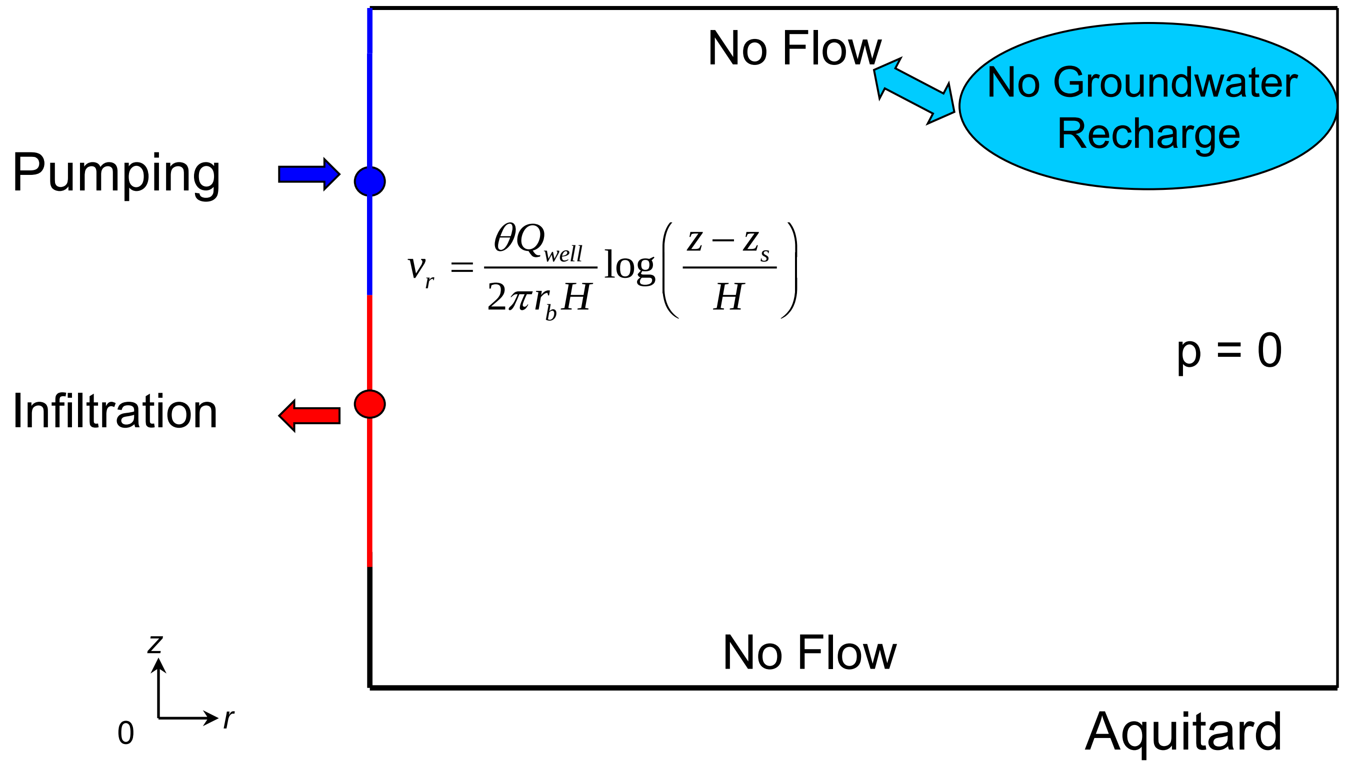
  Computes deformation of unconfined aquifer

Geometry and Meshing



- Axisymmetric 2D vertical-cross-section
- Finite element mesh
  -- 2D: triangular
  -- 3D: tetrahedron
- Drastic mesh refinement in the vicinity of the borehole, pumping and infiltration points

Boundary Conditions (Darcy's Law Mode)



$$v_r = \frac{\theta Q_{well}}{2\pi r_b H} \log\left(\frac{z - z_s}{H}\right)$$

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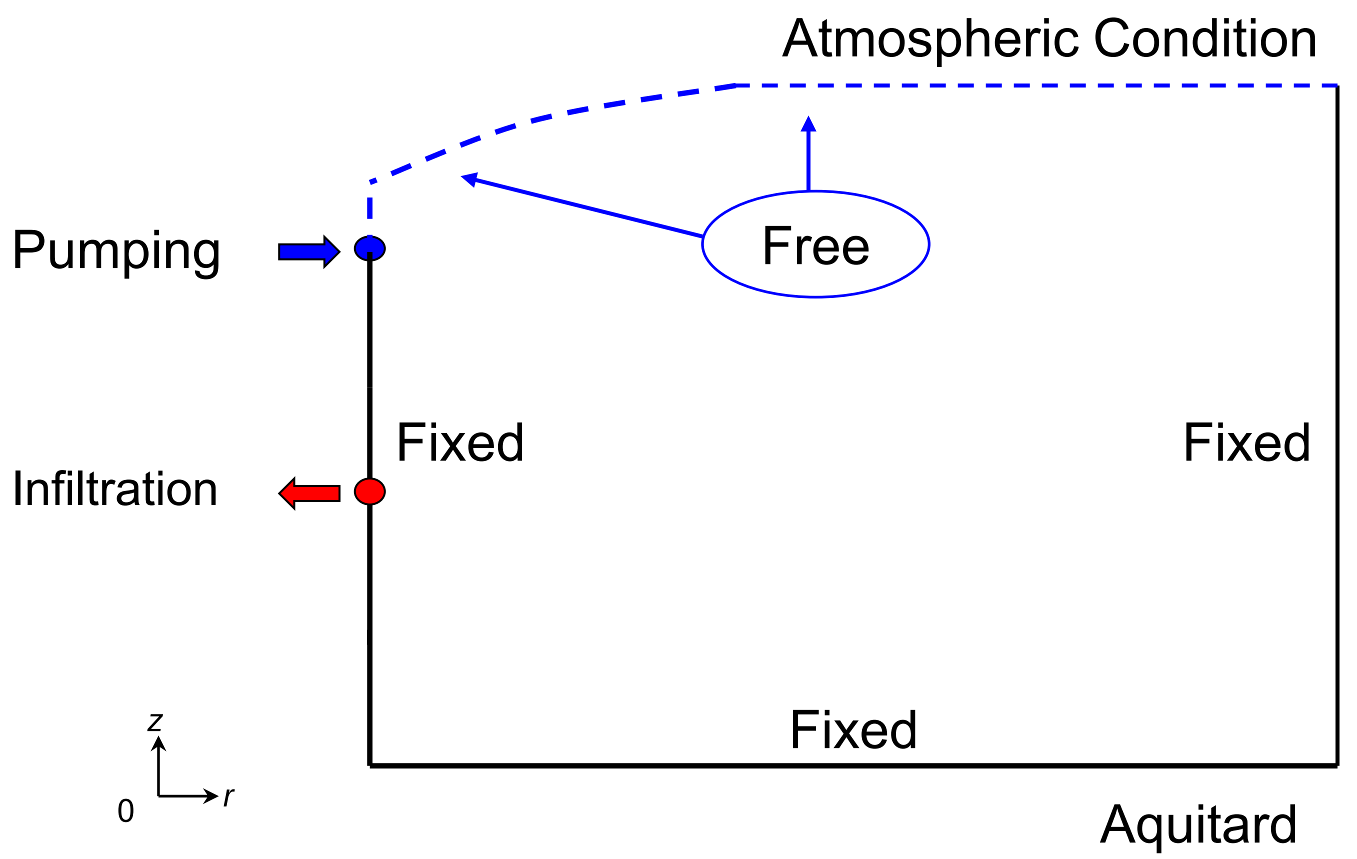
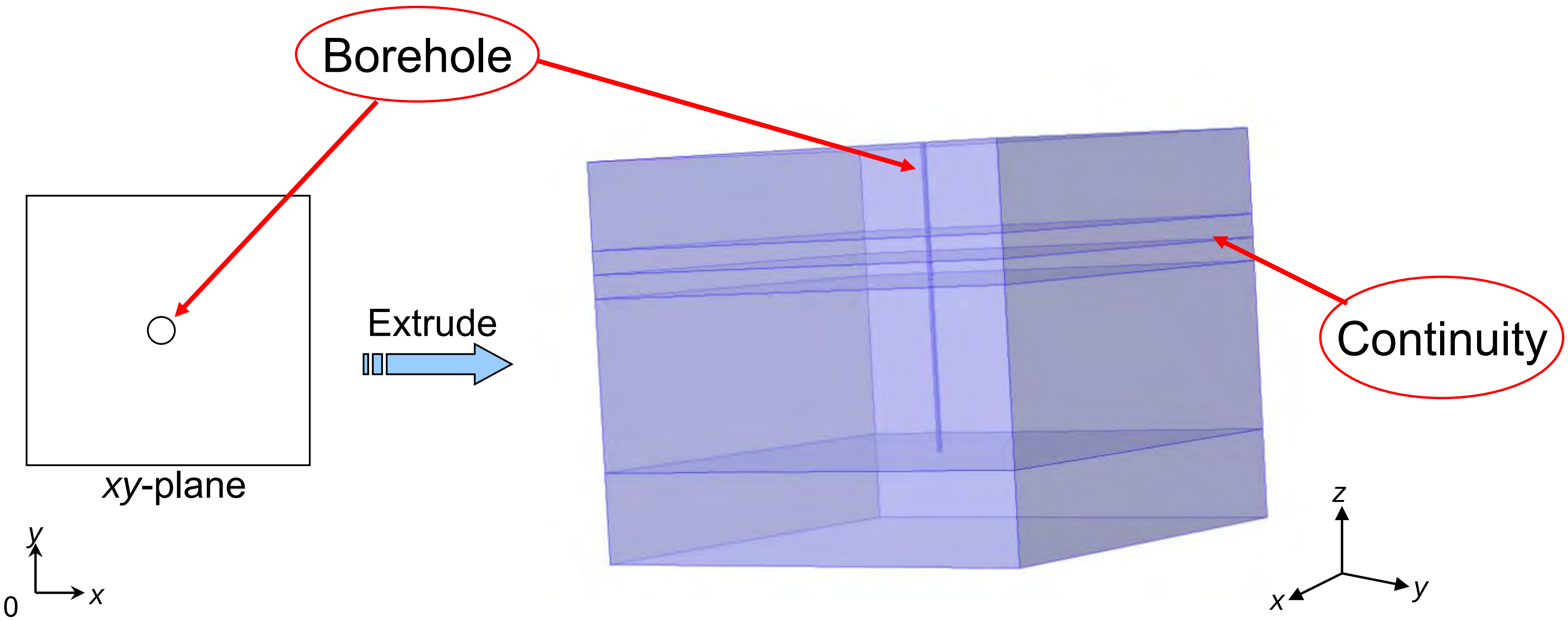
Boundary Conditions (*ale* Mode)



3D Model Set-up

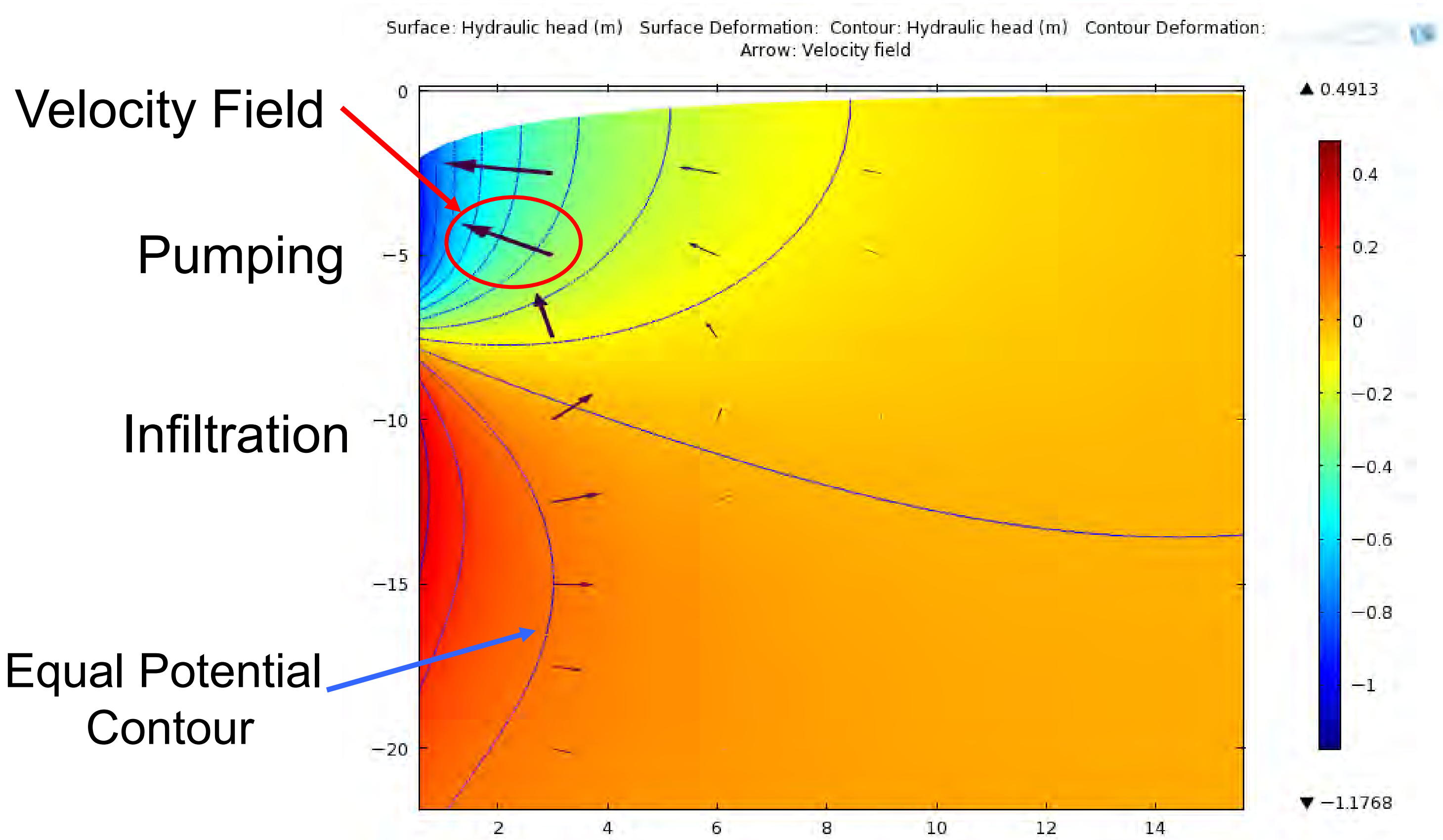


• The same boundary conditions with 2D case are applied respectively.

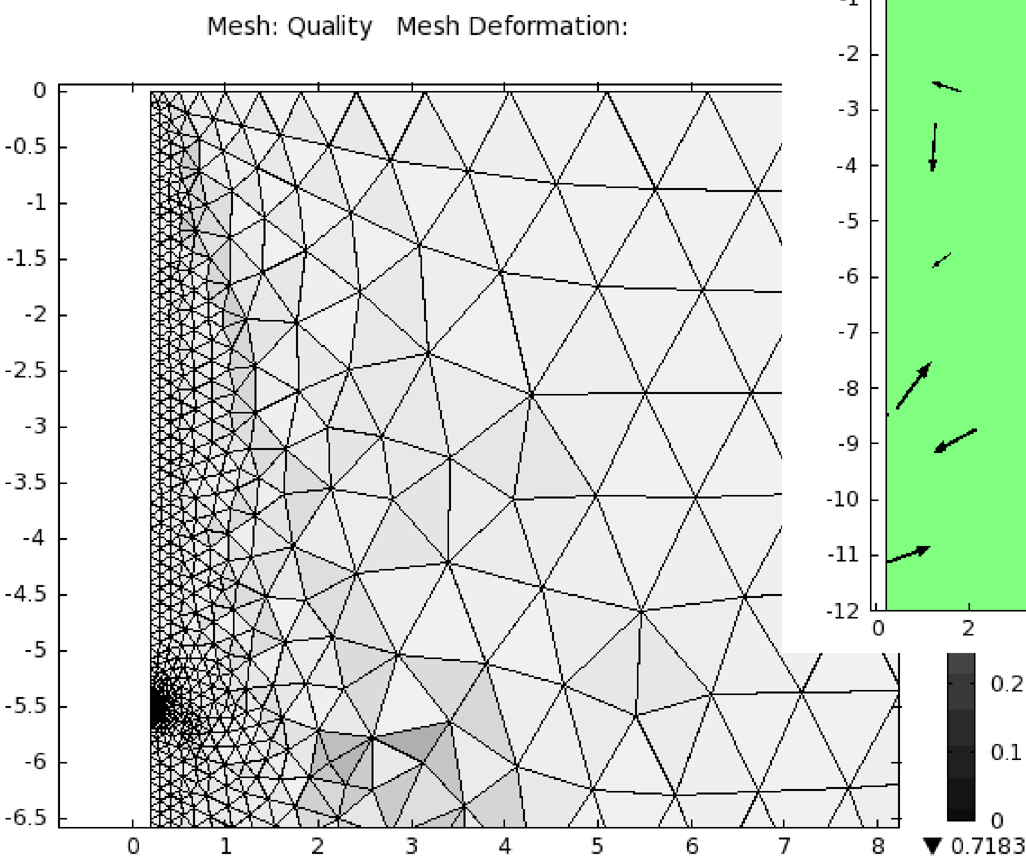
Input Parameters

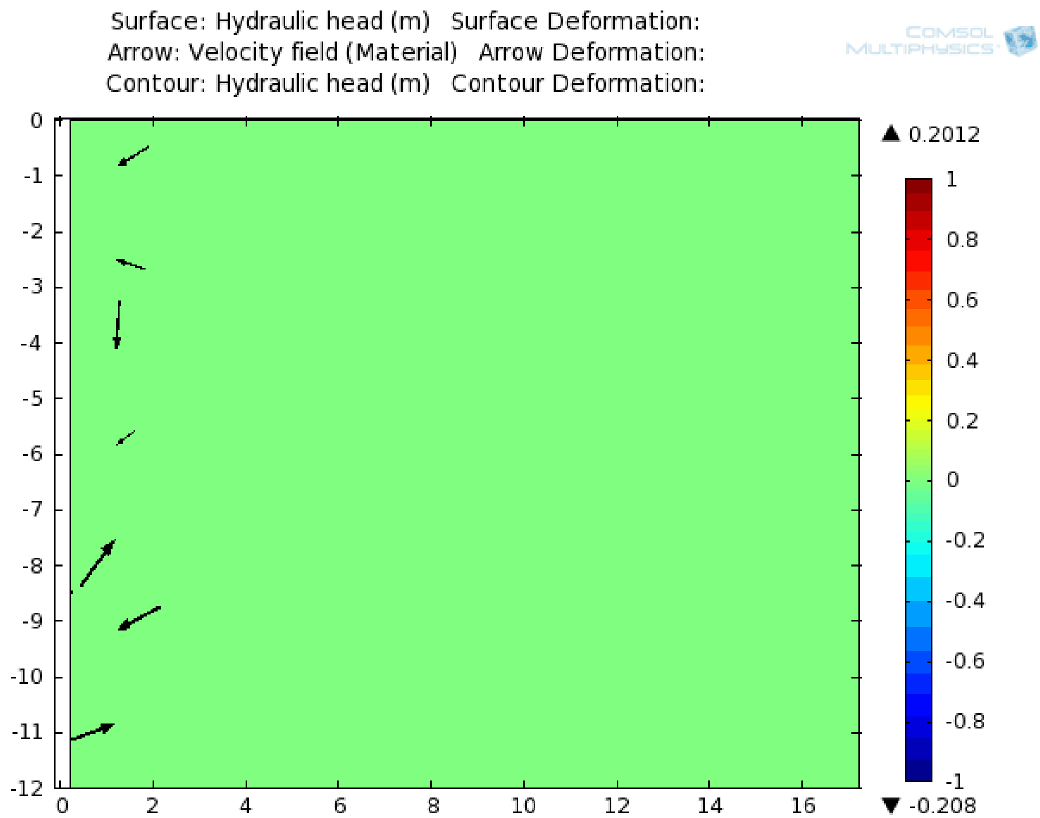
Name	*Value*	*Unit*
Hydraulic Conductivity	$1.5 \cdot 10^{-3}$	m/s
Pumping Rate	22 (0.006)	m^3/h (m^3/s)
Infiltration Rate	22	m^3/h
Porosity	0.2	-

2D Model Result



Moving Mesh





Drawdown Change

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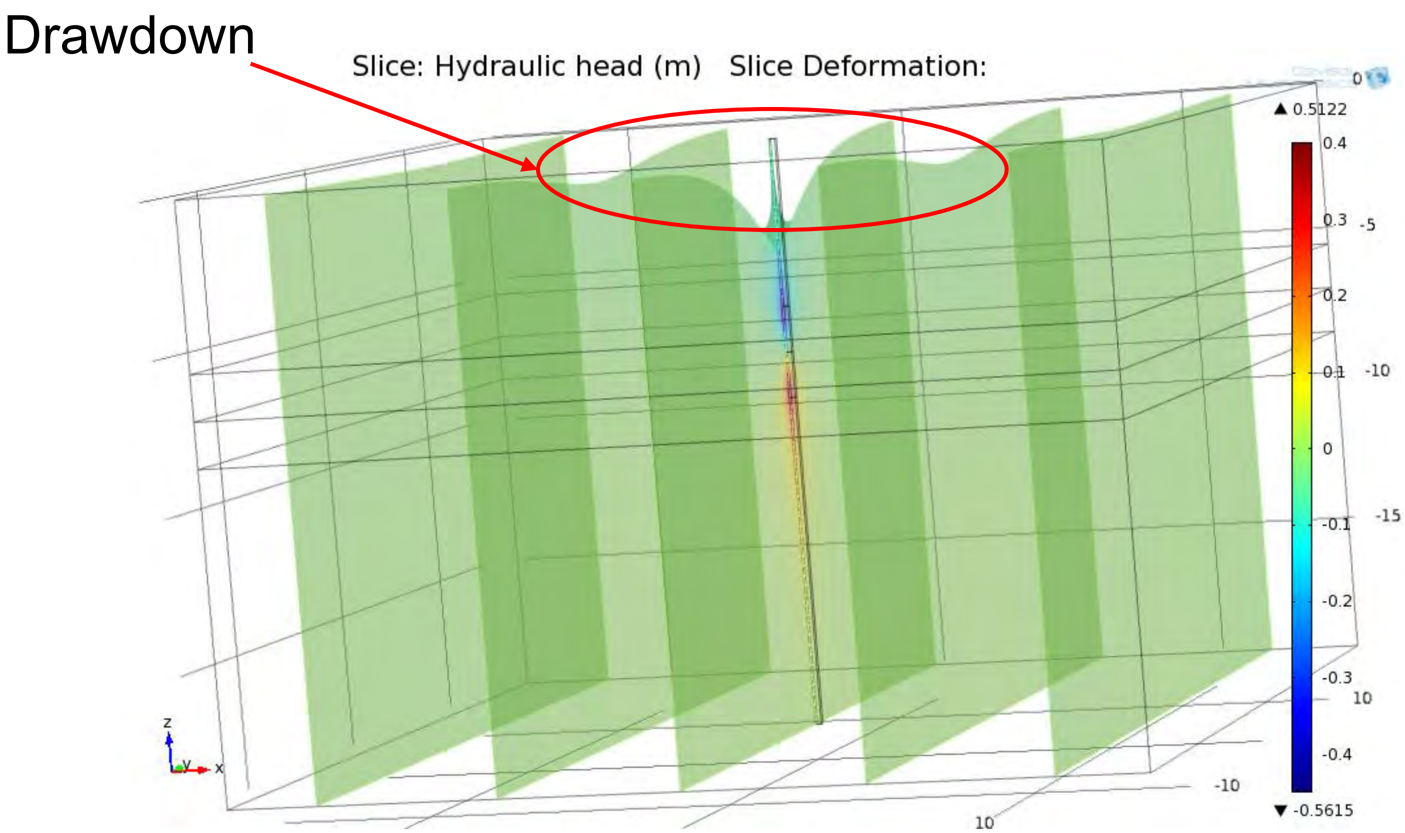
3D Model Result



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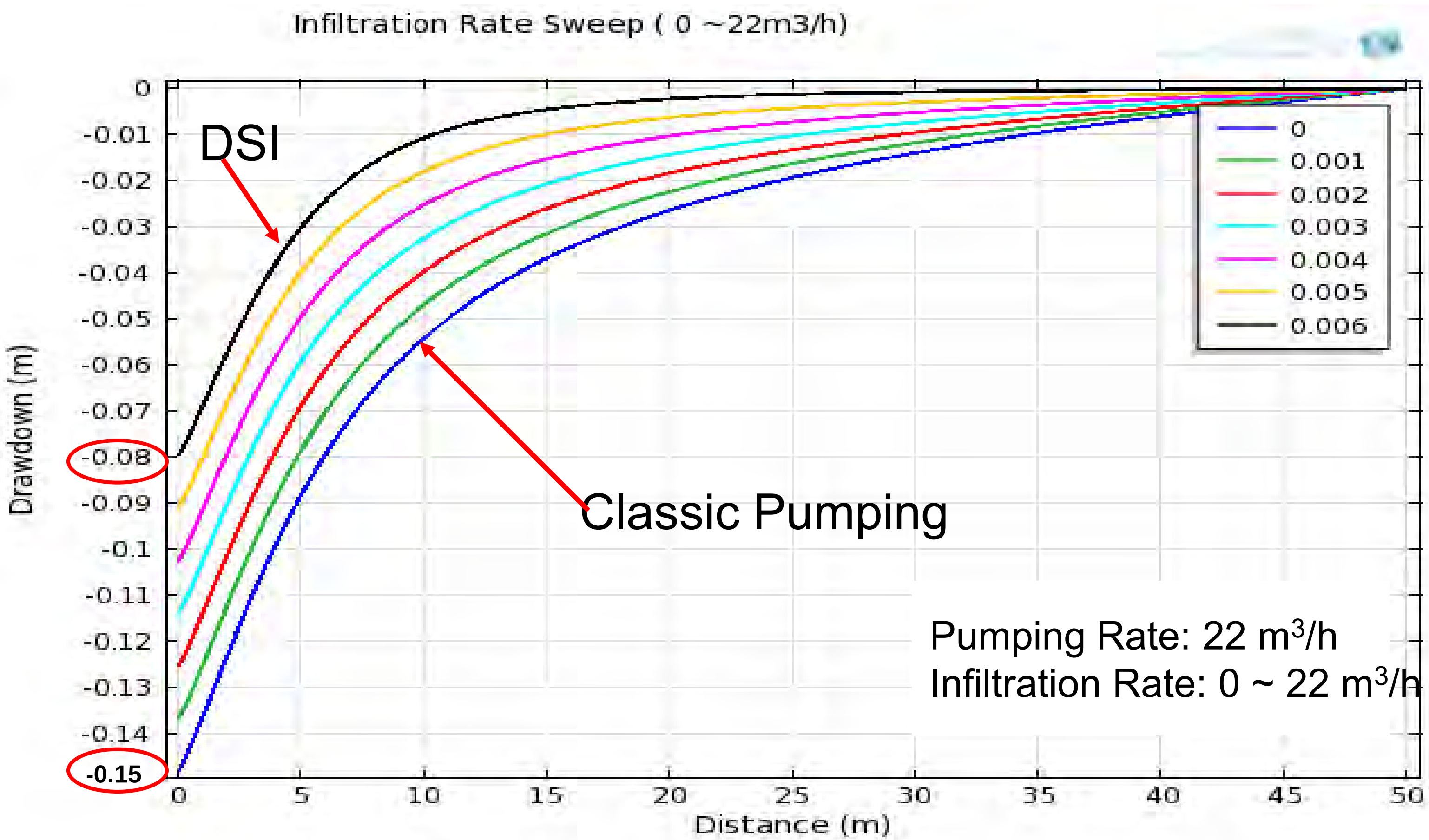
Parameter Variation



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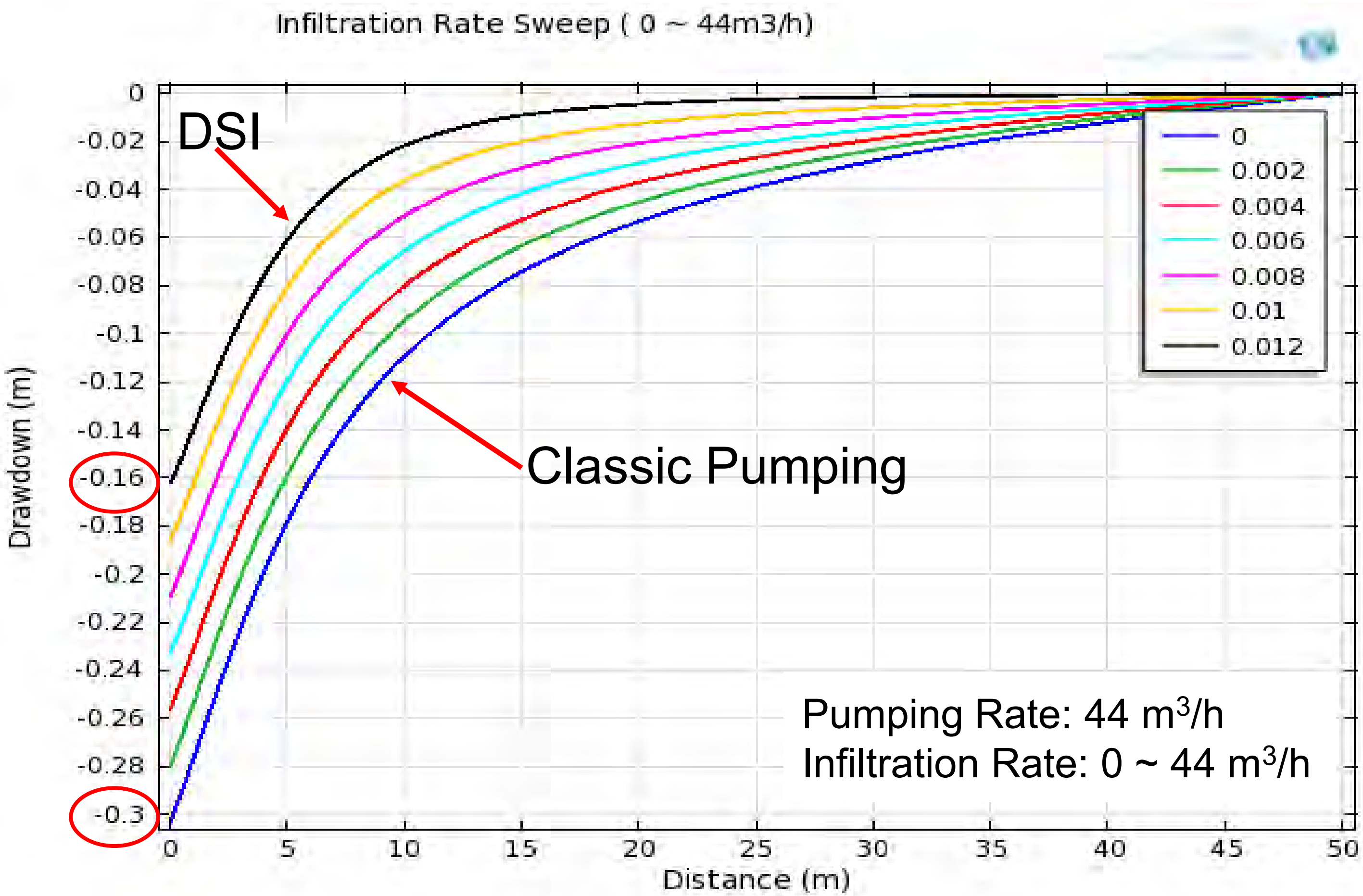

Conclusion

- The results show that the DSI technique is promising.
- Limitations of the DSI method:
  1) Can be only applied for permeable aquifers
  2) High pumping rate might generate a flow shortcut in the direct vicinity of borehole
- More systematic investigation on specific-site conditions will be arranged in the future.
- Influencing parameters will be evaluated in detail via the inter connection of COMSOL and MATLAB

Thank You for Your Attention!

We appreciate the support of

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