Preliminary stages and studies for the development of a 3D aquifer physical model

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Master Thesis:

Preliminary stages and studies for the development of a 3D aquifer physical model

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Abstract

Groundwater issues are among the most important sustainability studies related to topics considered as critical point for the future of planet Earth (Gleeson et al., 2010) in the perspective of a sustainable world. Analyses are focused on two complementary aspects: quantity and quality. Thus, once physical behaviour is analysed, it is coupled with chemical characterisation studies, in order to obtain a better view of an investigated site. The work of this Master thesis begins with a brief overview of the literature which summarizes the challenges of teaching hydrogeology by theoretical lessons coupled with practical activities. The focus is on laboratory experiments implemented on physical models. In fact, to fully understand the process of groundwater flow and solute transport, and to demonstrate the basics fundamental concepts behind, it is important to visualize them in a lab-scale. This thesis is undertaken in the context of the installation of a 3D physical model at the University of Liège as a support to teaching and research works: dimension, set up, construction and support devices used for system optimal functioning are presented. The global aim of the work is to prepare everything needed to set up the sand tank. This is a fundamental step in order to be able to pre-dimension real experiments, to give ideas about the magnitude order of the expected results and to check the reliability of mathematical results and/or low-dimensionality models. Part of the document is centred on the characterization of porous aquifer materials to implement in the physical model, in particular through sand column one-dimensional lab experiments performed on four distinguished types of quartz sands (differentiated by the particles size): in particular a Constant Head Permeability Test and a Salt Tracer Test (KCl). A numerical model of the 3D tank is also developed by the use of GMS-MODFLOW-MT3DS and few experiments are simulated (gradient variation, pumping test at different pumping rates, and tracer test).

Main Figures (numbers correspondent at the ones inserted in the complete manuscript)

FIG 9 : *Dimensions and pictures of the sandbox developed at ULiège*

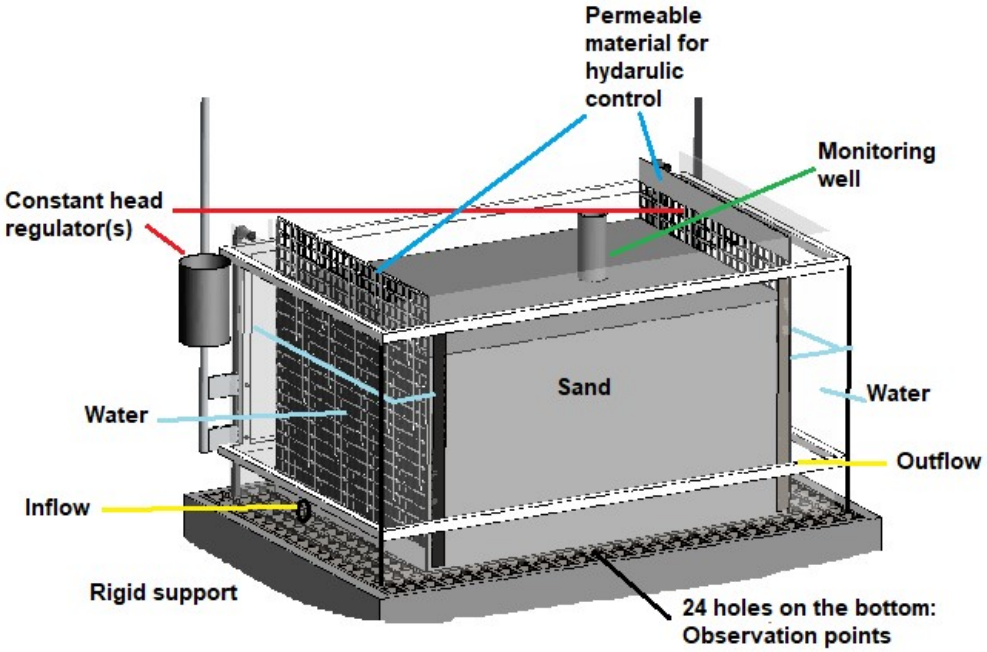

FIG 11: *Components view of the sand tank (modified from iFLUX, 2018)*

FIG 13: *Constant head open overflow devices*

FIG 20: *Funnel use, compaction, saturation and observation of the final columns preparation*

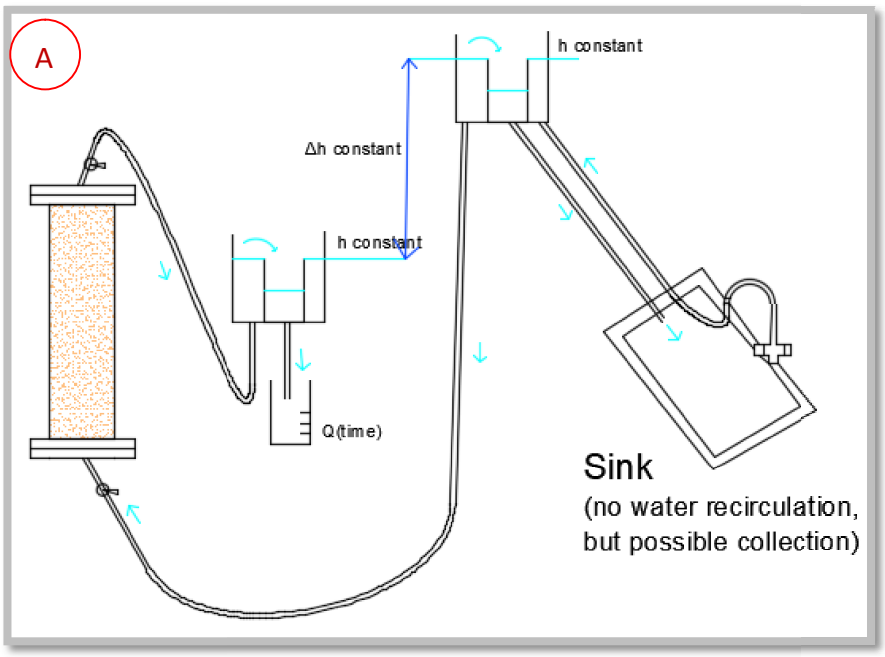

FIG 24: *Final constant head set up : A schema and B real system used*

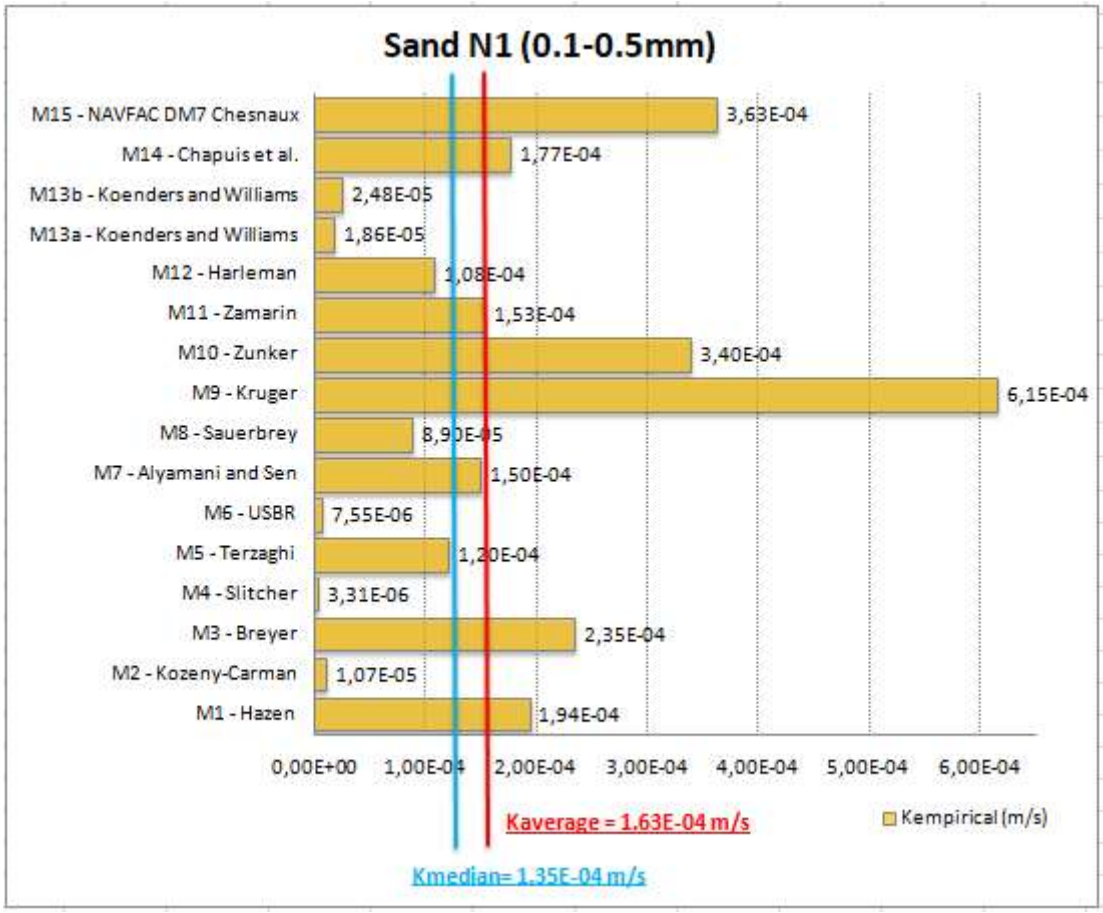

FIG 26 *Statistics on N1 empirical K-values (**all formulas**)*

SAND 1to2 [Cl-]

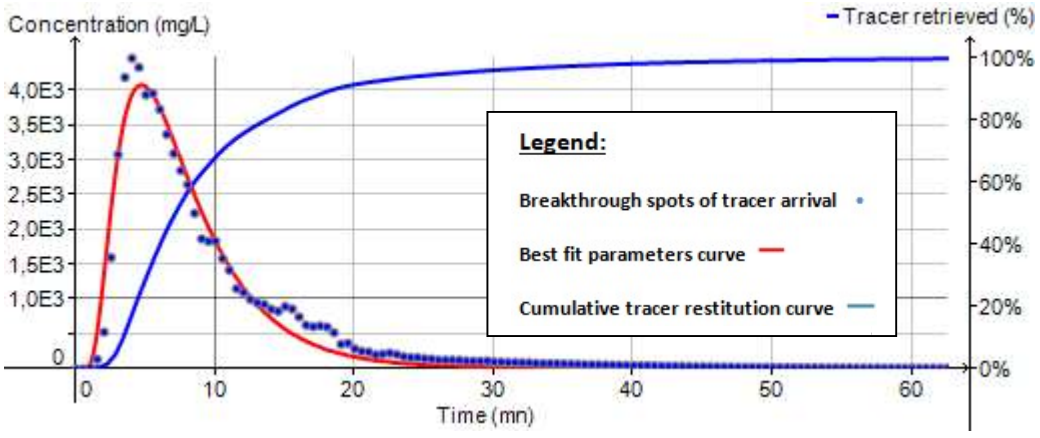

FIG 37 *Interpretation of breakthrough curve of Cl- ions concentration (mg/L) in 1to2 sand*

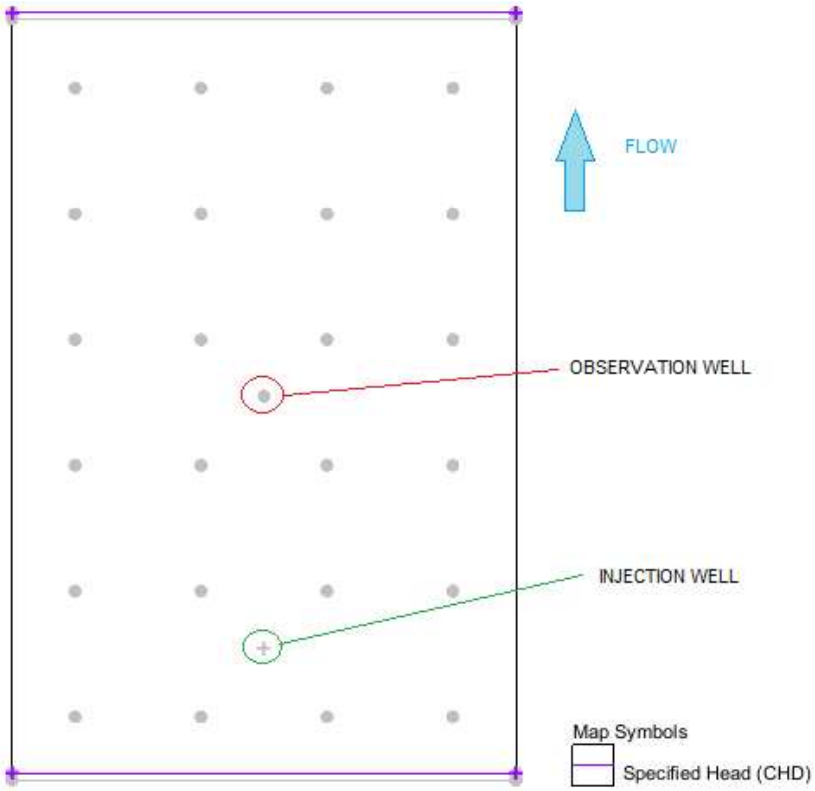

FIG 41: *Tracer injection model coverage visualisation (without grid) in GMS*

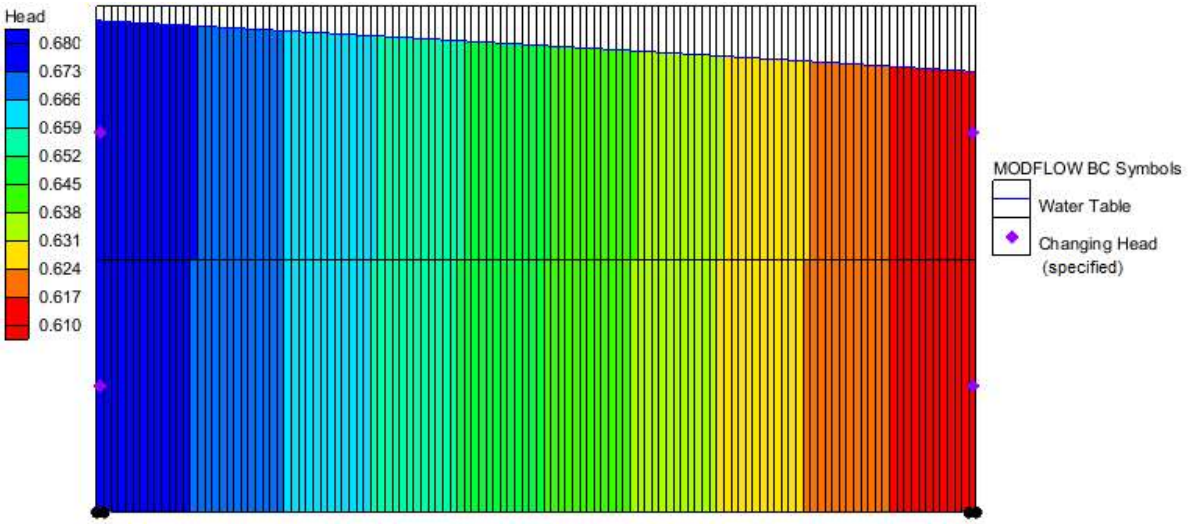

FIG 42 *Steady state flow (Δh = 7 cm): lateral and top view, grid visualization*

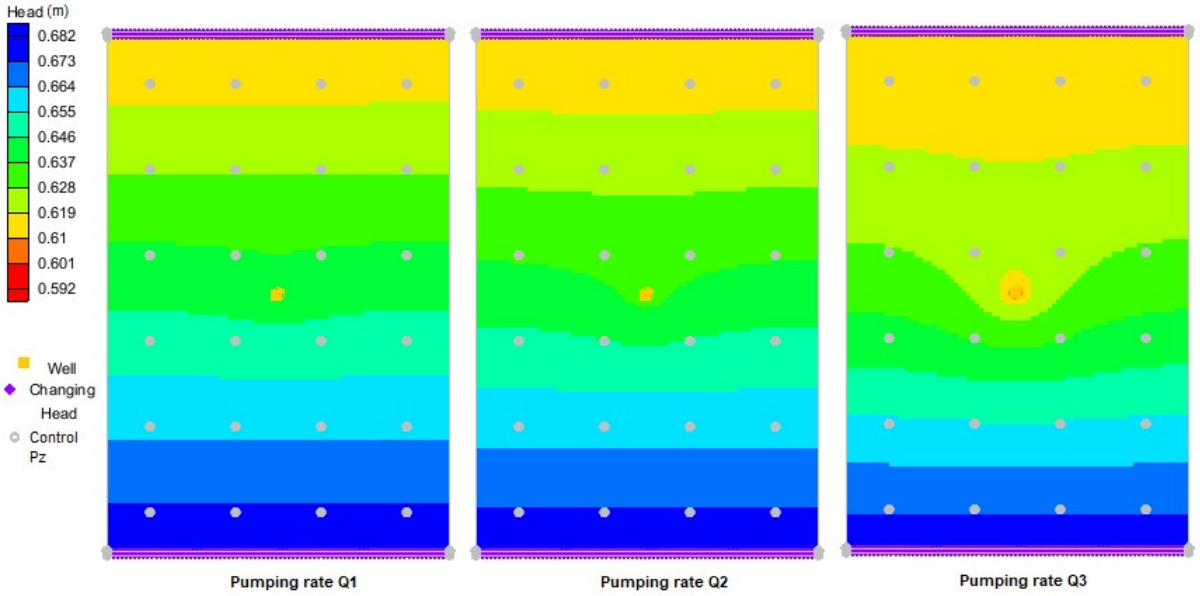

FIG 16 *Step pumping test: heads variation*

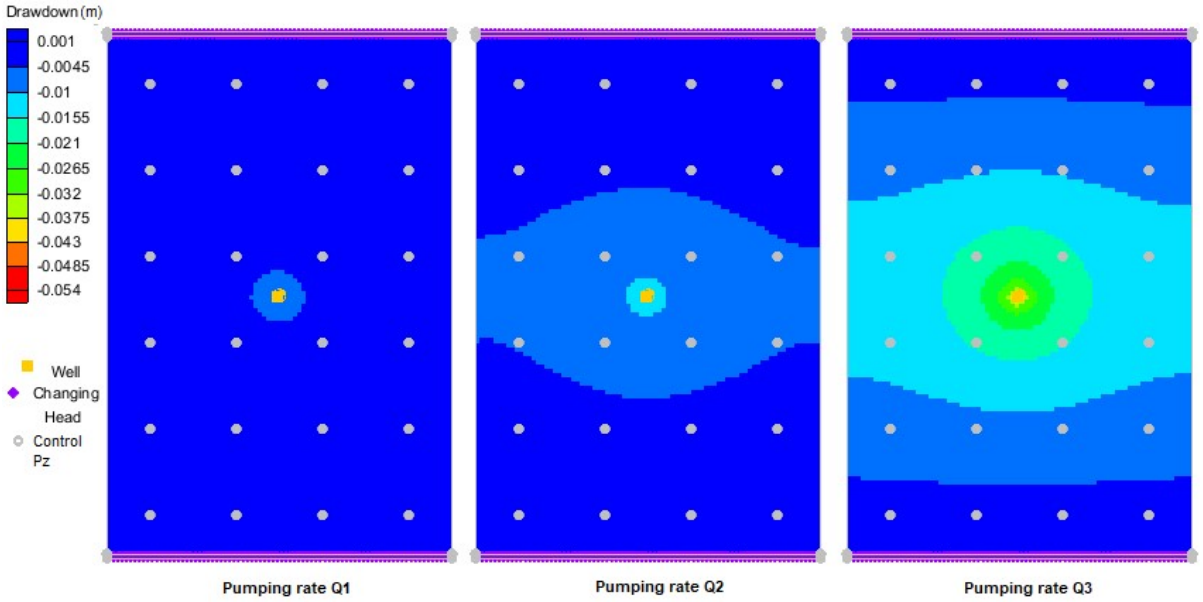

FIG 47 *Step pumping test: Drawdown variations*