

# Under- versus Overestimation of Aquifer hydraulic Conductivity from Slug Tests

Hongbing Sun<sup>1</sup> and Manfred Koch<sup>2</sup>

<sup>1</sup>*Department of Geological, Environmental, and Marine Sciences, Rider University, US.*

<sup>2</sup>*Department of Geohydraulics and Engineering Hydrology, University of Kassel, Germany*

Extensive examinations of hydraulic conductivities from calculated, simulated, and actual field slug and pumping tests reveal that the well-known Hvorslev- and Bouwer and Rice- slug test methods can underestimate the hydraulic conductivity  $K$  in such a test. This is in contrast to the usual overestimation of  $K$  that the classical theory underlying these slug-test methods - which omits the effects of the aquifer's storativity, and which may, so, be particularly problematic for unconfined aquifers - predicts. Numerical solutions of the exact equations describing a slug test have been carried out which corroborate this overestimation of  $K$  in an unconfined aquifer, but only for low conductivity values ( $K < 1$  m/day), and when the "first straight line segment" of the  $\log(H/H_0)$  vs. *time* plot is used in the Hvorslev- or the Bouwer and Rice analysis. Although, theoretically, overestimation also exists for slug tests conducted in a high-conductivity aquifer, this is partly masked by the absence of early recordings of hydraulic head changes in the observation well as well as a mixture of saturated and unsaturated flow in a slug well after slug injection and so the "inadvertent" utilization of an "inherent" "late straight line segment" in the  $\log H(t)/H_0$  plot often results, in fact, in an underestimation of conductivities in a high conductivity aquifer. Hydraulic conductivity estimation from both our computer simulations and field studies, where the results of slug- and pumping tests are compared, supports this conclusion of the underestimation of the hydraulic conductivity in a slug test for a moderate- to high-conductivity aquifer. Therefore, here it is suggested that for estimating the hydraulic conductivity from a slug test, "a late straight line segment" correction in the  $\log H(t)/H_0$  plot may only be needed in a low-conductivity aquifer, whereas in a moderate- to high-conductivity unconfined aquifer, the early or "first possible straight line segment" in the  $\log H(t)/H_0$  plot of a slug test is recommended, instead of the traditionally used "late straight line segment".

**Keywords:** Slug test, aquifer hydraulic conductivity, Hvorslev- , Bouwer and Rice method