

# Aquifer parameter identification and interpretation with different analytical methods

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## Abstract

Aquifer tests yield estimations of hydrogeological parameters through suitable analytical models from field data recorded as drawdown variations by time or distance. In practice, most often a single model is adopted with a set of assumptions, and unfortunately, field data deviations from the model type curves are not considered in interpretations. This is a rather mechanistic approach which implies assumptions that the aquifer is geologically homogeneous and isotropic. Such an approach cannot be true because within the aquifer test area there may appear heterogeneities and anisotropies which hinder the application of a single model. It is, therefore, necessary to try several available models for the same aquifer test data, in order to extract possible variabilities in hydrogeological parameters. Such an extensive study can only be done when there is a set of aquifer test data with main and observation wells at different distances and directions.

This paper presents an analysis of an aquifer test in a thick alluvial valley in Pakistan. The aquifer consists of extremely heterogeneous sediments. Different approaches including the Theis, Jacob, Hantush, and Singh analytical models, are used to analyse the drawdown data from several observation wells.

**Keywords:** aquifer parameter, transmissivity, storage coefficient, aquifer tests, analytical methods

## Introduction

Movement and abstraction of groundwater in the geological formations are dependent on the hydrogeological parameters of the aquifers. The purpose of any aquifer test is to determine the hydrogeological parameters. Among the basic parameters are the storativity, transmissivity and leakage coefficients. The hydrogeological parameters are hidden in the field test data and their identification is possible using the available of physically plausible models suitable for the prevailing field circumstances. Evaluation of aquifer parameters, namely, transmissivity  $T$ , and storage coefficient  $S$ , from aquifer test data has been a continual field research. Several conventional and computer-based methods are available for analysing (Kruseman and De Ridder, 1991). Due to a different set of assumptions on each method, the hydrogeological parameter estimates are quite different from each other. Efforts have been made to develop simple calculation methods for aquifer parameters since Cooper and Jacob (1946) proposed their simple and widely used method. The main limitation of this method is that the dimensionless time factor  $u$ , should be less than 0.01. However, according to Singh (2000) it cannot be applied to estimate aquifer parameters when most of the data have  $u > 0.01$ . On the other hand, the curve-matching method proposed by Theis (Lohman, 1972) involves much subjectivity in judging the best match between the observed and theoretical curves, especially when only early drawdowns are considered (Singh, 2000). Furthermore, Sen (1987) proposed a unique storage coefficient determination approach for large diameter wells which experience steady or quasi-steady groundwater flow conditions. The application of the method does not require any complicated mathematical procedure as in the classical-type curve matching procedures. This method becomes

very effective when it is coupled with the Theim (1906) formula. Singh (2000) proposed a simple method for explicit determination of confined aquifer parameters from early drawdown data. This method makes use of a few early drawdown data at an observation well and yields accurate values of confined aquifer parameters with no curve matching requirement. The method converges to the Cooper-Jacob method for late drawdown data. Application of the method on published data sets shows that the estimates of the aquifer parameters using only a few initial drawdowns are as good as those obtained by Theis curve matching when all data, including the late drawdowns ( $u < 0.01$ ), are used. Singh (2001a) has also proposed another robust optimisation method for the calculation of aquifer parameters from shorter duration aquifer test data when there is an impervious boundary. Another simple method that uses the temporal derivative of drawdowns was proposed for the explicit evaluation of confined aquifer parameters utilising the early drawdowns (Singh, 2001b). The method uses an analytical approach to calculate the temporal derivative of drawdowns. The method can analyse the drawdown data on multiple observation wells taken together to obtain averaged aquifer parameters. The method was applied to published data sets and results were compared with the traditional methods already available in the literature. Singh (2002) proposed another simple method for the identification of confined aquifer parameters and effective distance to either an impermeable boundary or a recharge from the drawdowns observed at an observation well due to pumping at a constant rate.

This paper concentrates on a significant issue with regard to the interpretation of aquifer tests, i.e. ensuring meaningful interpretations. This issue commonly arises from the use of computer programs to interpret aquifer test data which generally leads to misinterpretations. The objective of any software is to create the best match of the time-drawdown data regardless of the suitability of the analytical model to the hydrogeological setting. Hence, there are several pitfalls involved in employing commonly used computer programs and mechanistic-type curve fittings without

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