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ScienceDirect

Procedia Engineering 154 (2016) 340 – 347

Procedia Engineering

www.elsevier.com/locate/procedia

12th International Conference on Hydroinformatics, HIC 2016

3D hydraulic modeling of a complex alluvial aquifer for groundwater resource management

Mingxuan Du[a,*], Elodie Zavattero[a], Qiang Ma[a], Olivier Delestre[b], Philippe Gourbesville[a], Olivier Fouché[c]

[a]*Innovative CiTy lab., Polytech Nice-Sophia/University of Nice-Sophia Antipolis, 1-3 Boulevard Maître Maurice Slama, 06200 Nice, France*
[b]*Laboratory J.A. Dieudonné – UMR 7351, CNRS University of Nice-Sophia Antipolis, 06108 Nice Cedex 2, France*
[c] *Laboratoire Eau, Environnement et Systèmes Urbains, 6-8 avenue Blaise Pascal, Cité Descartes, 77455 Marne-La-Vallée Cedex 2, France*

Abstract

Many cities take nearby alluvial aquifers as their main resource of water supply. Therefore the aquifers, especially shallow aquifers, are always under either the influence of extreme hydrological events, or the threat of pollutants that are generated by the intense urban developments. To ensure an efficient management of water supply regarding both quantity and quality aspect, it requires a good knowledge of the dynamics of the aquifer. Characterizing the exchanges that could exist with free surface flow in associated rivers is one of the key issues. The most efficient way to understand the behaviour of the aquifer is to implement a 3D physically-based hydrodynamic model that can represent all physical processes. However, this approach, in order to become an operational tool, requests a structured methodology for data integration and validation. In this paper, a 3D hydraulic model of the Var lower valley is set up with FEFLOW modeling system. All the important hydrological processes such as precipitation, evapotranspiration, river-aquifer exchanges are considered. Despite a very complex and partially known geological structure, the results for a simulation of 1266 days demonstrate that the model is able to provide an accurate diagnostic on various hydraulic structures that are affecting the aquifer and may induced management difficulties. The proposed approach answers the current management demand and can provide efficient support within the underground resource exploitation.

Peer-review under responsibility of the organizing committee of HIC 2016

Keywords: 3D modeling, complex alluvial aquifer, river-aquifer exchange, FEFLOW, Var River.

* * Corresponding author. Tel.: +33 615650065.
E-mail address: mingxuanism@gmail.com

Peer-review under responsibility of the organizing committee of HIC 2016
doi:10.1016/j.proeng.2016.07.487

1. Introduction

Groundwater is the primary freshwater source for approximately two billion people all over the world in both rural and urban areas [1,2]. The unconfined aquifer is especially vulnerable regarding quantity and quality aspects due to its strong connection to the surface water body such as lakes and rivers. Therefore the groundwater management emphasizes two major aspects [3,4]:

- Controlling the quality of the natural water resource: Groundwater pollution can be caused by different reasons such as accidental events or floodwater. The prevention of seepage into the aquifer and into the associated river and lake is necessary.
- Maintaining the quantity of water supply: Groundwater depletion can be caused by drought or over-extraction. The prevision of reaction plans for such circumstances needs to be considered.

Hence, understanding the groundwater flow dynamics as well as the exchange between the river and its aquifer is a key issue for the long-term water management regarding the two aspects. For this purpose, deterministic hydraulic model is a reliable tool to ensure an efficient groundwater management.

1.1. The Var river valley

Located in the southeast of France (Fig. 1.a), the lower Var river valley is the downstream section of the Var catchment, which has a total area of 2893 km^2. The lower Var river drains water from the mountainous sub-catchments to the Mediterranean sea [5,6]. According to the measurement of discharge at the gauging station at weir n° 1 (Fig. 1.a) from 1973 to 2016, the yearly average discharge of Var river is 50 m^3/s while the highest instantaneous discharge is observed during flood of November 1994, which reached 3750 m^3/s [6,7].

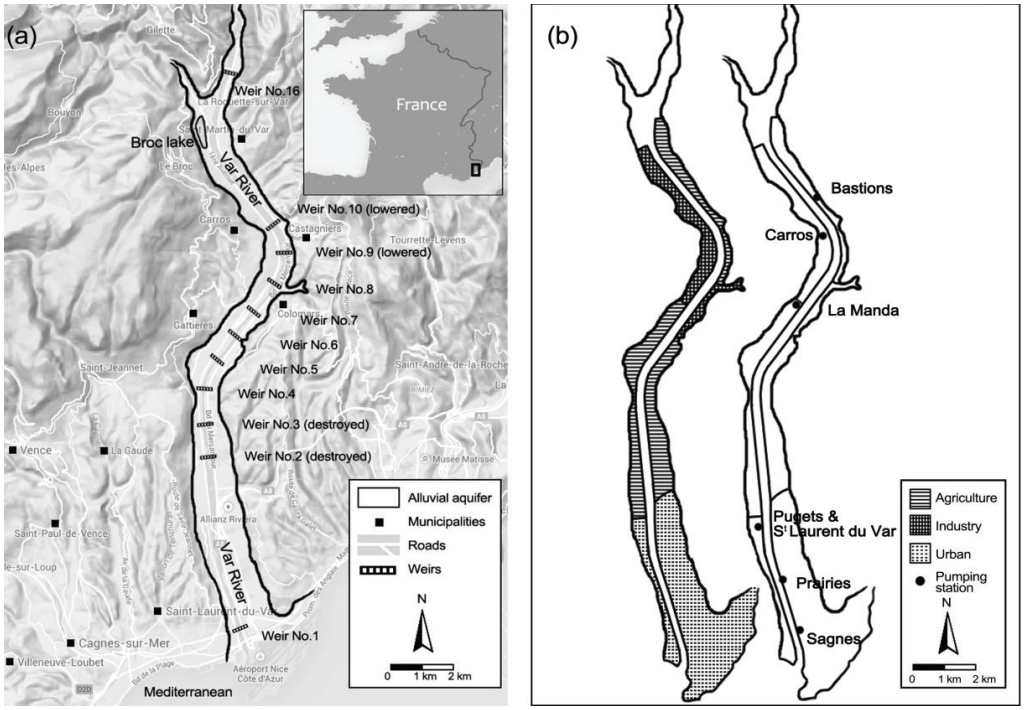

Fig. 1. (a) Study area: the lower Var river valley; (b) Land use map and the pumping stations of lower Var river valley.