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Reconstruction of hydraulic and thermal heterogeneities in shallow fluvioglacial aquifers of Milan (Northern Italy) for heat transport and geo-exchange potential assessment.

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Aquifers beneath big cities are considered a very important resource from an energetic and water supply point of view. Unfortunately, the amount of disposable water and its energetic potential are limited over a long term perspective. In this context, the monitoring of physical-chemical parameters and the assessment of water and energy balances at the city scale is crucial for the evaluation and the preservation of the resources. In order to assess and to optimize the exploitation of the subsurface low-enthalpy geothermal potential of aquifer systems and to predict the evolution of the thermal regime, heat transport processes, both advective and conductive, must be considered. This requires the hydraulic head and the fluid flow velocity field to the be accurately characterized. Numerical modeling has been commonly adopted to estimate homogeneous equivalent hydraulic properties and, trying to calibrate them, to reproduce hydraulic head fluctuations. Nevertheless, if the homogeneous equivalent models can reproduce very well the hydraulic head variations, the fluid flow velocity field is almost always incorrect, and this can generate problems in the heat advection assessment. This is often due to local heterogeneities that are usually not represented but that are crucial for transport simulations. This work aims to describe the spatial variability of the hydraulic and thermal properties of an aquifer starting from borehole log descriptions and grain size distribution analysis and trying to integrate them in a coupled fluid-flow and heat-transfer 3D finite element model. This objective is achieved by converting qualitative borehole log stratigraphic information into hydrogeological and thermal parameters (e.g., hydraulic conductivity, storativity, thermal conductivity) and by interpolating these parameters over the mesh nodes through 3D kriging techniques. This approach is applied to a case study in a decommissioned large industrial district located in Milan (Northern Italy). The local stratigraphic sequence consists of fluvioglacial deposits separated vertically by low permeability layers, resulting in 3 main aquifers showing significant lateral and vertical heterogeneities within the study area. This study shows how the redevelopment of former industrial areas in highly urbanized contexts must be planned carefully to take advantage of the natural resources (i.e. water and energy) and to minimize the impacts of new buildings on the subsurface environment.