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Thermal Impact of Medium Deep Borehole Thermal Energy Storage on the Shallow Subsurface

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Borehole heat exchanger arrays are a well-suited and already widely applied method for exploiting the shallow subsurface as seasonal heat storage. However, in most of the populated regions the shallow subsurface also comprises an important aquifer system used for drinking water production. Thus, the operation of shallow geothermal heat storage systems leads to a significant increase in groundwater temperatures in the proximity of the borehole heat exchanger array. The magnitude of the impact on groundwater quality and microbiology associated with this temperature rise is controversially discussed. Nevertheless, the protection of shallow groundwater resources has priority. Accordingly, water authorities often follow restrictive permission policies for building such storage systems. An alternative approach to avoid this issue is the application of medium deep borehole heat exchanger arrays instead of shallow ones. The thermal impact on shallow aquifers can be significantly reduced as heat is stored at larger depth. Moreover, it can be further diminished by the installation of a thermally insulating materials in the upper section of the borehole heat exchangers.

Based on a numerical simulation study, the advantageous effects of medium deep borehole thermal energy storage are demonstrated and quantified. A finite element software is used to model the heat transport in the subsurface in 3D, while the heat transport in the borehole heat exchangers is solved analytically in 1D. For this purpose, an extended analytical solution is implemented, which also allows for the consideration of a thermally insulating borehole section.