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Impact of Groundwater Flow on Thermal Energy Storage and Borehole Thermal Interference

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Borehole heat exchanger (BHE) systems are drawing increasing attention and popularity due to their potential energy efficiency and environmental sustainability, as well as their worldwide applicability. Consequently the concern for sustainable designs and proper implementation is rising too. Furthermore an improperly planned and executed system can be economically unjustifiable. To address these issues related design software and to some extent regulatory guidelines have been developed. Thermal input load function and interaction with the subsurface significantly affect thermal performance and sustainability of geothermal heat pump (GHP) systems. Of particular interest is the interaction of such systems with groundwater flow and its impacts. However the related guidelines and the design software do not seem to properly address this growing concern. Typically regulations do not distinguish between high and no groundwater flow conditions, nor do they specify a groundwater velocity threshold at which it becomes important. A further limitation is that most BHE design software used by industry assume a closed box approach discounting the heat transport in/out by the groundwater flow. To efficiently model grids of multiple BHEs, FEFLOW® 6 and the integrated BHE solution is used. Single and multiple borehole grids with U-tube heat exchanger are modeled and compared here. All boreholes are assigned equal heat extraction and flow rates; loop temperatures are then calculated over the system lifetime to compare the thermal efficiency and evaluate the thermal interference between boreholes. For the purpose of assessing the effect of groundwater flow on thermal storage as well as interference, multiple heat loads (balanced and unbalanced) are simulated. Groundwater velocity and borehole spacing are also varied to identify possible thresholds for each case. The study confirms the significance of groundwater flow in certain conditions. The results can be applied to improve the regulatory guidelines and design methods in regards with hydrogeological aspect of thermal and economical sustainability.