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An experimental study of infiltration processes and groundwater recharge in ephemeral streams

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Accurate estimates of groundwater recharge under losing streams are urgently needed in arid areas, where population and industrial activities predominantly rely on groundwater resources. Conceptually, infiltration tests and measurement of hydraulic conductivity of the streambed and underlying materials are enough to estimate transmission losses, but the variability of streambed hydraulic conductivity makes this method problematic and prone to large error. The objective of this study is to evaluate infiltration rates at increasing surface water levels at the plot scale so as to avoid uncertainties associated with point scale infiltration tests.

A 7-metre length of an ephemeral losing stream in South Australia was instrumented. At a time when the stream was dry, the stream section was dammed upstream and downstream with metal sheets. The stream transect was instrumented with pressure transducers in the surface water, unsaturated zone and groundwater, respectively, and soil moisture and temperature sensors underneath the streambed and in the riverbanks. In order to mimic infiltration in natural conditions, all monitoring equipment was installed without disturbing the streambed, where practical. During a period of 5 days, water was pumped into the isolated section of the stream, and the surface water level was maintained at three constant, increasing, levels. Doing so, the infiltration rate at each water level is equal to the pumping rate required to maintain that water level.

Infiltration rates measured in the field were used to calibrate a 2D model developed within Hydrus®. Hydraulic soil properties were obtained by inverse modelling. The model fairly reproduces measured infiltration rates, and shows that it takes substantially longer for transient infiltration rates to decrease to near steady-state infiltration than previously reported. The model was also used to study the relative contribution of transient and steady state infiltration rates during natural flow events at the field site where the infiltration experiment was performed. Estimates of cumulative infiltration from ephemeral streams, only based on steady-state infiltration rates, is likely to underestimate the total infiltrated volume by more than 60%. We also conclude that infiltration during the 1st hour at the onset of a flow event can account for up to 20% of total transmission losses. The effect of evaporation in arid and semiarid areas was also studied for flow events of different duration and hydraulic head, which results stress the importance of this process in order to differentiate between infiltration and aquifer recharge during a flow event.