

# Characteristics of local groundwater recharge cycles in South African semi-arid hard rock terrains: Rainfall–groundwater interaction

E van Wyk<sup>1\*</sup>, GJ van Tonder<sup>2</sup> and D Vermeulen<sup>2</sup>

<sup>1</sup>Hydrological Services, Department of Water Affairs, Private Bag X313, Pretoria, South Africa

<sup>2</sup>Institute for Groundwater Studies, University of the Free State, PO Box 339, Bloemfontein, South Africa

## Abstract

The semi-arid and arid regions occupy almost two-thirds of South Africa and fall in the winter and summer rainfall zones of the sub-continent. The annual rainfall patterns can be regarded as intermittent with a significant spatial variability due to the unique winter/summer synoptic systems manifesting over Southern Africa. Summer rainfall events indicate that episodic wet periods, consisting of up to 8 consecutive days, may contain falls that contribute to almost 45% to 60% of the total annual rainfall of an area; associated with relatively higher rain rates ( $1.5$  to  $10 \text{ mm}\cdot\text{h}^{-1}$ ). Hyetograph-hydrograph time-series data sets, however, indicate that episodic rainfall events are responsible for rapid, but sustainable groundwater recharge events. The recurrence rate of these events in the semi-arid and arid regions is still low and aquifer storage-recharge is therefore not an annual event. The recharge flow path through the unsaturated zone reservoir plays an important role in the underdrainage flow pattern, and subsequently the saturated flow regime. It resembles a simple L-shaped flow path driven by direct recharge mounding in the fractured hard rock terrain and indirect recharge to the surrounding sub-reservoirs. The lag-times between rainfall events and water table responses were found to be significantly short; a matter of a few hours to less than a few days. Evidence of multi-modal, time-related infiltration phases during the summer early and peak rainfall intervals, governed by the field capacity status of the unsaturated zone reservoir and the growth status of the local vegetation, were observed. A unique rainfall pattern in semi-arid and arid regions is required before a sustainable aquifer storage-recharge condition develops and such incidences could be a one-in-several-year (5 to 9) event.

**Keywords:** semi-arid and arid regions, unique rainfall patterns, episodic wet periods, hydrogeological profile, fractured hard rock terrain, direct recharge mound, aquifer storage recharge, recharge recurrence rate