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Estimating Groundwater Availability at Catchment Scale using Streamflow Recession and Instream Flow Requirements of Rivers in South Africa

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Groundwater is an important resource for multiple uses in South Africa. Hence, setting limits to its sustainable abstraction while assuring basic human needs is required. Due to prevalent data scarcity related to groundwater replenishment, which is the traditional basis for estimating groundwater availability, the present article presents a novel method for determining allocatable groundwater in quaternary catchments through information on streamflow. Using established methodologies for assessing baseflow, recession flow, and instream ecological flow requirement, the methodology develops a combined stepwise methodology to determine annual groundwater storage volume using linear reservoir theory, essentially linking low flows proportionally to upstream groundwater storages. The approach was trialled for twenty-one perennial and relatively undisturbed quaternary catchments with long-term and reliable streamflow records. Using the Desktop Reserve Model, instream flow requirements necessary to meet the present ecological state of the streams were determined, and baseflows in excess of these flows were converted into allocatable groundwater storages on an annual basis. Results show that groundwater development potential exists in fourteen of the catchments, with upper limits to allocatable groundwater volumes (including present uses) ranging from 0.02 to 2.57 x 10⁶ m³ a⁻¹ per catchment. With a secured availability of these volume for 75% of the years, variability between years is assumed to be manageable. A significant ($R^2 = 0.86$) correlation between baseflow index and the drainage time scale for the catchments underscores the physical basis of the methodology and also enables the reduction of the procedure by one step, omitting recession flow analysis. The method serves as an important complementary tool for the assessment of the groundwater part of the Reserve and the Groundwater Resource Directed Measures in South Africa and could be adapted and applied elsewhere.

