

# Problems of estimating hydrological characteristics for small catchments based on information from the South African national surface water resource database

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## Abstract

Rapid assessments of water resource availability in South Africa have been facilitated by the availability for a number of years of a national data set of naturalised monthly flow time series. However, these data are only available for moderate to large catchments (referred to as quaternary catchments). In the absence of further information it has often been the practice to apply a simple catchment area-based scaling factor to estimate subquaternary scale flow characteristics. This has proved to be problematic in many studies. The paper presents a comparison of quaternary and subquaternary flow data using 41 gauged catchments and develops a simple approach to scaling based on estimates of the mean annual rainfall characteristics for the two areas. The use of the scaling method in a model designed to provide preliminary, low-confidence, estimates of environmental flow requirements suggests that it represents an improvement. However, there is still a need for a method that allows flows of different magnitudes and frequencies of exceedance to be scaled differentially.

**Keywords:** flow regimes, small catchments, scaling, environmental flows

## Introduction

The *Surface Water Resources of South Africa* publications (WR90 – Midgley et al., 1994) have provided a valuable source of baseline regional hydrological and water resource information for many years. Part of its value is that the data were generated using consistent approaches and cover the whole of South Africa, Lesotho and Swaziland based on a spatial subdivision into 1 946 so-called quaternary catchments, varying in size from 50 to 18 000 km<sup>2</sup> (with a median size of 445 km<sup>2</sup>). The database includes 70-year time series (based on a standard period of 1920 to 1989) of naturalised monthly streamflow volume and monthly rainfall depth for each quaternary catchment, as well as naturalised flow data for all the Department of Water Affairs and Forestry (DWAF) streamflow gauging stations that had more than about 5 years of data prior to 1989. The quaternary streamflow data were generated using the WRSM90 version of the Pitman (1973) monthly rainfall-runoff model based on regionalised parameter values.

While there have been some questions about the representativeness of the WR90 flow data in some parts of the country, the database has nevertheless proved to be one of South Africa's major water resource information assets. However, there is one major problem for some water resource assessments and that is the extent to which the data can be used to estimate the natural hydrological characteristics of catchments smaller than the quaternary scale. This issue has been frequently highlighted during recent studies to determine the environmental instream flow requirements of rivers with subquaternary scale catchments. A number of these studies have been undertaken in recent years as part of the process of implementing the new South African National Water Act (No. 36 of 1998). Hughes and Hannart (2003) report on the development of

a model that makes use of time series of natural flow data and a set of regional parameters to provide an initial estimate of the environmental flow requirements for different levels of protection. The basis of the model is that the requirements are expected to vary with the magnitude and variability characteristics of the natural flow regime of the river. The WR90 streamflow database provides the default natural flow data to use with the model (i.e. in the absence of any updated or revised flow data) and the only facility within the model for modifying these data is a simple linear scaling function. Therefore if the model is to be applied at the subquaternary scale it is necessary to be able to estimate the proportion of the total quaternary catchment runoff that is generated above the point of interest.

The relationship between flow volumes from a subcatchment and the total flow volume for the whole catchment will depend upon a wide range of factors, the following being some examples:

- Rainfall variations over the total catchment and particularly the rainfall gradient from the lower parts of the total catchment to the upstream areas. The extent to which these variations are consistent over time will also be of importance.
- Evaporation variations due to elevation and slope differences, as well as differences in vegetation cover.
- The variations in soil, geology and land-cover characteristics and the way in which these all influence runoff generation processes.

These factors will clearly affect the relative total volumes of runoff generated from the subcatchment and total catchment, but they could also affect different components of the flow regimes (high and low flows for example) in different ways. There will therefore be no simple and consistent relationship between the quaternary catchment flow and the subcatchment flow and certainly the commonly used method of scaling the runoff volume on the basis of the ratio of catchment areas is unlikely to be adequate in most

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