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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Water use allocation

Investigating stream flow reduction activities

A WRC study investigated methods and guidelines for the licensing of streamflow reduction activities, with particular reference to low flows.

Stream flow reduction and low flows

Approaches to the licensing of stream flow reduction activities (SFRAs) and the allocation of water to the environment (the Reserve) have highlighted the importance of low flows in water resources assessments. There have been inconsistencies and inadequacies in answering the question as to how much the low flow of a river can be reduced, or how much of this low flow can be allocated, without impacting on the economic viability of downstream water users and the ability of the resource to meet the Reserve.

The complexity of this question has proved a stumbling block to interpreting and implementing the National Water Act (NWA) of 1998. Difficulties have ranged from different definitions and derivations of the term 'low flow', to a lack of understanding of the hydrological processes that generate low flows and the inadequacies of hydrological models used to represent them.

It has consequently been necessary to address such issues in an effort to render management tools (e.g. tools used for the assessment of forestry water use, for environmental water requirements and now also for the licensing of SFRAs) which have often been developed independently of each other, more compatible and usable.

In developing methods and guidelines for the licensing of SFRAs, two of the key thrusts have therefore been:

- To improve the low flow and SFRA-related routines in hydrological modelling systems to better serve the needs of water resource managers, and
- To integrate model output into decision-making processes concerning water allocation and licensing, with particular emphasis on SFRAs and low flows.

Land use and low flows

The role of land use in a catchment is of critical importance. It governs partition of rainfall between water vapour flows to the atmosphere as evaporation and transpiration, and flow of water to rivers and groundwater. In arid and semi-arid regions, where atmospheric demand is high and recharge to groundwater and rivers is relatively small, a small change in the land use can have a profound effect on recharge to groundwater and streamflow, especially in periods of low rainfall, and thus on the generation of low flows. Land use changes may take place gradually (e.g. gradual invasion of exotic species) or be sudden and drastic (e.g. the large-scale conversion of grasslands to forest plantations or croplands).

There are many definitions of low flows. Typically these reflect some point on a flow duration curve. However, in this investigation, low flows were considered, less arbitrarily, to be those flows which are generated from the movement of water, in unsaturated form, down the hillslopes of the catchment to the river.

This is water derived from localised shallow water tables and from the 'regional groundwater' table. The focus was thus not so much on interpretation of time series of recorded flows, as on the hydrological processes through which low flows are generated and impacted on by vegetation.

Conceptualisation of improved modelling routines for flow generation

In seeking to improve the routines that simulate the generation of low flows, two approaches were followed. The first was to better conceptualise the hydrological processes which give rise to low flows. In doing so, specific attention was given to the improved representation of soil water movement in the sub-surface and to better conceptualisation of evaporation and transpiration and how these processes relate to the uptake of water from soil by plant roots.

The second approach was to search for information on different flow components (*quickflow, interflow, baseflow and groundwater discharge*) and to determine how these are affected by

afforestation under varying climatic conditions and in different catchments. This was done through various forms of analysis of historical time series from South African paired catchment experiments.

Various hydrograph separation methods were applied and both statistical and graphical analyses were undertaken to generate, among other things, a suite of statistical models to describe the impact of afforestation in these catchments that could supplement earlier statistical models. Detailed analyses of data from Cathedral Peak and Jonkershoek, in particular, but also from other catchments, highlighted the relative importance, in a flow regime, of quickflow and delayed flows, as well as the role of the soil as a buffer in delaying catchment response.

Improved low flow simulation by ACRU

The improved conceptualisation of hydrological processes and the intensive analyses of observed flows in different catchments have enabled improvements to be made to the simulation of low flows in the ACRU agro-hydrological modelling system. These include the development and incorporation of improved routines to simulate soil water movement and evaporation and transpiration from forests.

The importance of providing for different vegetation types in addition to forests has been accommodated by modifying the Penman-Monteith equation in ACRU through the introduction of the Granier-Lohammer approach, which considers vegetation canopy resistance, and by suggesting relevant values for the model parameters.

Improved modelling routines have been tested at two of the country's active research catchments (Weatherley and Two Streams). These tests have highlighted the importance of sound field-based research in providing hydrological understanding on which the conceptualisation of the new ACRU routines was based. The use of a large aperture scintillometer (LAS) to directly estimate water use of dryland sugarcane is proving to be valuable component of such field-based research.

Promotion of synergy among researchers and managers

The need to pursue technical and management objectives in parallel in order to ensure optimal applicability and usability of the products of SFRA-related research was recognised at the outset. Consequently, close links were forged and maintained between the research team, the Department of Water Affairs, the sugar and forestry industries and other workers involved in hydrological process-based research that focuses on the effects of land use change on low flows.

Through these interactions, the concerns and requirements of all stakeholders have been considered and the tools and recommendations arising from the research shaped accordingly.

Development of SFRA assessment tools and training in the application of these tools has been undertaken in collaboration with the organisation Water for Africa.

Guidelines for declaration of additional SFRAs: the concept of 'green water'

A product of the investigation has been a set of guidelines for considering the stream flow-reduction status of land uses which may eventually be declared SFRAs. In essence, the guidelines recommend adopting a 'green water' approach for the identification and declaration of additional SFRAs and a 'blue water' approach to their regulation.

Green water is represented by water vapour and refers to the flow of water to the atmosphere as evaporation from soil, lakes, and canopy-intercepted water, plus the transpiration by vegetation. Broad-scale tools, such as the remote sensing-based SEBAL or soil water budget-based evaporation estimation models, are recommended for identification and declaration of SFRAs, while land-use sensitive distributed hydrological models are recommended for the regulation of SFRAs at appropriate management scales.

Compatibility of Reserve and SFRA determinations

The SFRA Assessment Utility is a user-friendly software tool that has been developed and is designed to integrate with existing Reserve planning tools (e.g., SPATSIM) and uses a compatible database for storage of SFRA information. A methodology for the consideration of the Reserve when assessing SFRA license applications has also been produced. Training material in this regard has been developed through collaboration with the Institute for Water Research, Rhodes University and Water for Africa.

SFRAs and alternative land uses

Ideally, model-based consideration of changes from a SFRA land use to an alternative land use (such as sugarcane) and the economic implications thereof should be complemented by process-based field research into the water use of the alternatives. In this regard, the large aperture scintillometer (LAS) is proving to be a useful and reliable tool. Another option is a remote-sensing technology-based tool such as SEBAL, which is currently being tested with promising results.

Further reading:
To obtain the report, *Methods and Guidelines for the Licensing of SFRAs with Particular Reference to Low Flows* (**Report No: 1428/1/09**), contact Publications at Tel: (012) 330-0340; Fax: (012) 331-2565; E-mail: orders@wrc.org.za; or Visit: www.wrc.org.za to download a free copy.