



Taking on the challenges of water resource assessment

What promises to be the most accurate assessment of South Africa's water resources to date has just been launched by the Water Research Commission (WRC). Lani van Vuuren investigates the challenges – and the opportunities – offered by the new Water Resources 2012 (WR2012) study.

It is well known that water is South Africa's scarcest resource, and that the country counts among the world's 30 most parched. With an average annual rainfall of only around 465 mm a year (about half the world's average) and a concomitant high evaporation rate, South Africa has a total mean annual runoff of less than 50 000 million m³/a – only 50% of the mean flow of the Zambezi River.

As water will always be in short supply in South Africa, it is extremely important to make sure that the water we do have is developed and managed optimally, not only for the country's citizens and industries, but also for the sake of

its aquatic environment. This makes quantifying exactly how much water we have one of the most important tasks to be undertaken in the local water sector.

A COMPLEX TASK

In addition, South Africa's climate is characterised by extremely complex hydrological features, explains Wandile Nomquphu, WRC Research Manager. "Not only is it highly variable in time and space, it is not unusual to experience extreme climatic conditions in different parts of the country at the same time, for example, drought in one part and floods in the other. Undertaking regular water resource assessments, thus not only allows us to quantify our available water resources, it also helps to augment our understanding of how our natural hydrological cycle behaves."

These assessments fall within the realm of hydrology – a science which, according to Prof Denis Hughes, Director of the Institute of

Water Research at Rhodes University, deals with the occurrence, circulation, and distribution of water on and within the Earth's surface. Basically, he writes in the *South African Geographical Journal*, hydrologists are faced with the (often, daunting) task of using a limited number of quantitative and qualitative observations, together with a conceptual understanding of the operation of processes involved in the movement of water through the hydrological cycle, to estimate the occurrence of water at various locations.

This is usually done with the assistance of hydrological models, which not only have to consider the precipitation and runoff at a certain point, but also other variables such as topography, vegetation cover and rooting characteristics, relative geology and drainage density, to name but a few. To complicate matters, hydrology is a 'living' process, adds Nomquphu. "Raindrops do not fall in exactly the same place every time it rains." This makes long-term monitoring all the more important.

PC POWER

The WR2012 study, which kicked off in April, is the sixth comprehensive national water resource assessment to be undertaken in South Africa since the first was completed in 1952. Financed by the WRC, the study is being undertaken by a consortium of consulting engineering firms, led by SSI. The objective of all of these studies has been to assist decision makers at all levels of government to make informed choices about all policies concerning South Africa's water resources.

According to water resource assessment veteran Dr Bill Pitman, now an independent consultant, each water resource assessment study builds on the technology and knowledge gained from the one before. "A huge factor has been the exponential growth in computing power over recent decades – said to double every two years. This has made it possible to develop better tools using increasingly powerful computing power." So with each consequent study there has been more precision and consequently more accuracy and confidence in the results.

Geographical information systems (GIS) and Google Earth, for example, would not have been possible a few decades ago, Dr Pitman points out. "The WRSM2000 catchment model [now used widely in the South African water resource assessment process] contains a wealth of information over and above what was available from earlier studies." Thanks to the growth in computing power, this catchment model now takes into account the impacts of various forms of land use (e.g. afforestation, alien vegetation, urbanisation, dam construction and water transfers) on water resources, and also models the interaction between surface and groundwater. "Added to all this is the ever-growing user-friendliness of computers and the vast storehouse of the Internet," notes Dr Pitman.

An interesting phenomenon has been that, with each consequent

study it has been found that South Africa actually has less water resources available than previously thought. This is not the result of climate change, says Nomqophu, but actually the result of more precise and accurate assessment. The latest calculation of naturalised mean annual runoff for the country, as determined by the WR2005 study (launched in 2009), has been calculated at 49 210 million m³/year – 4% less than the figure of the 1990 study.

Every study takes three to four years to complete, with at least a decade lapsing between studies. However, with constant change occurring in the South African water sector coupled with increased demands and the looming threat of climate change, the WRC has decided to attempt to shrink this gap. "The current study will be completed around 2016, however, even before the launch of the final results we hope to start the next study," reports Nomqophu.

WR2012 will include updating of all hydrological data up to 2010, further enhancements to WRSM2000, revised groundwater data, and a monthly time series of present day flow, to name but a few. The project will also create a publicly-accessible, Web-based and interactive reporting

system to continually quantify both the surface and groundwater resources of South Africa.

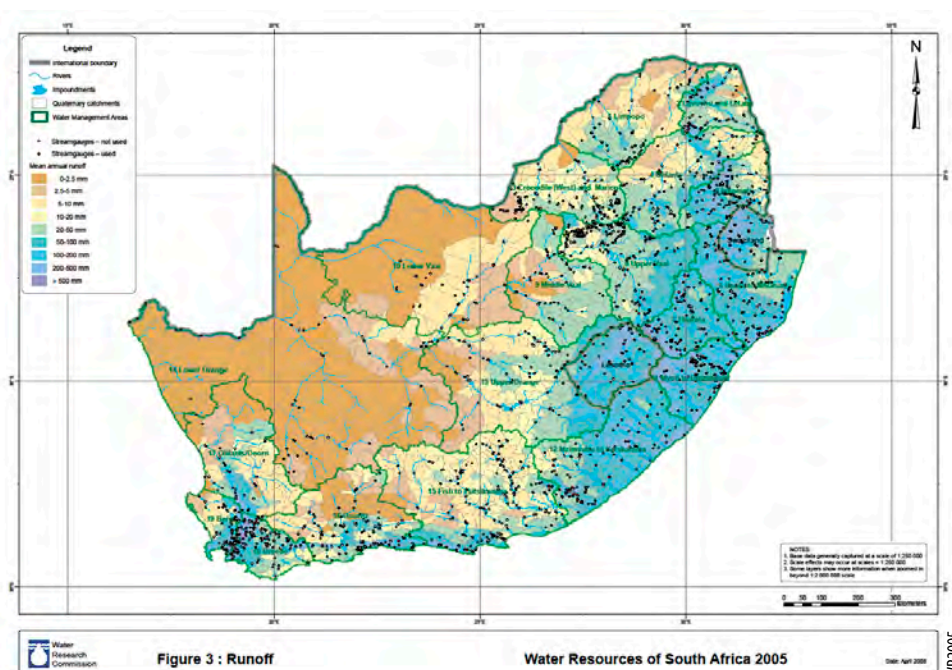
WHERE HAVE ALL THE GAUGES GONE?

All the computing power in the world is useless, however, without the appropriate data to be processed. Spatially representative, long-term consistent records of rainfall and streamflow data are essential for achieving a high level of understanding about water resources.

Dr Pitman explains: "Rainfall is the primary input to hydrological computer models, not only to determine streamflow, but also irrigation requirements and net evaporation from reservoirs (an important factor in the determination of yield). On the other hand, information on streamflow is necessary to calibrate the hydrological models to ensure we get the most accurate determination of our water resources. Thus to undertake water resource assessment without rainfall and streamflow data is a bit like trying to plan for population growth without a proper census."

A gross concern for hydrologists has been the decline of streamflow and rainfall data following the 1990

Mean annual runoff across South Africa.



study. And it is this decline that will by far the greatest challenge to overcome in the WR2012 assessment.

The Department of Water Affairs (DWA) is the responsible body for the collection of streamflow data, part of which is the construction of gauging weirs and the installation of sensitive equipment, which is often the target for vandalism. The main reason for the decline, however, is probably one of insufficient budgets, says Dr Pitman. Nomquphu confirms this.

Another reason is the lack of adequate manpower, which in turn is also budget-related. "Available DWA staff members are dedicated to providing the best service they can, often under very difficult circumstances," notes Dr Pitman. Despite their efforts, however, the number of useful streamflow gauges has decreased from a peak of 450 in the late 1980s to less than 350 in 2004.

The number of useful rain gauges paints a far more serious picture. Most rainfall data is collected by the South African Weather Service (SAWS), who depends largely on private individuals who do the work on a voluntary basis. When the use of time series of flow was first adopted in the 1981 survey, the period prior to 1920 was rejected owing to the relative scarcity of stations open

before that date. "However, we are now in a similar position with the decline in number from a high around 1970 to only about half of that in 2004, which is roughly the same number of stations in 1920," reports Dr Pitman. Some water management areas (WMAs) are worse off, than others. For example, WMAs No. 4 (Olifants) and No. 13 (Upper Orange) now have less than half the number of stations open than was the case in 1920.

Concern over the lack of data points was already highlighted in the WR2005 study and, while several recommendations were made then to responsible authorities, no concrete action has as yet been undertaken to reverse this precarious situation. However, the WRC hopes to stimulate change in the right direction soon. "We have already had informal talks with SAWS and DWA, and workshops are planned for later this year which will involve a wider range of stakeholders to see how we can reverse this downward trend," Nomquphu tells *the Water Wheel*.

In addition, WR2012 team members are working towards recommending the minimum monitoring requirements that the country cannot do without in order to understand and effectively manage its water resources. This information

will be made available within the next two years.

After the WR2012 study is completed South Africa will have a good database covering 90 years, so all is not lost, notes Dr Pitman. "However, if the future is characterised by more severe droughts than we have experienced in the past – either through climate change or other factors – our diminishing network will leave us with ever-increasing gaps in our knowledge of the country's water resources."

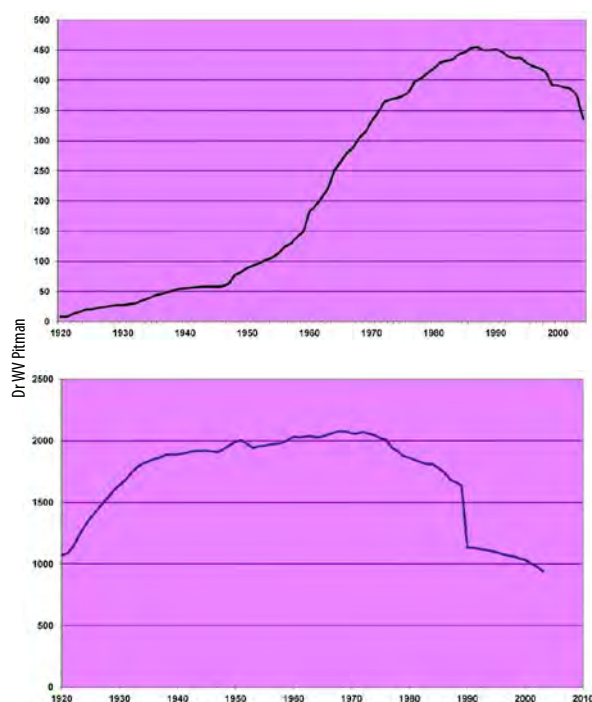
Another challenge to water resource assessment is increased land use and the effect this has on our water resources. The WR2005 study calculated that around 98% of the country's surface water resources were already allocated, which means that many catchments are also over-allocated. Actual monitoring of water use, however, is sorely lacking. "Abstractions and return flows have grown considerably through the decades, but these records are in the hands of individual concerns and local authorities, whose enthusiasm for monitoring usually falls way behind that of DWA," says Dr Pitman.

With surface water resources almost over-allocated, the understanding of the country's groundwater resources is of critical importance, notes Nomquphu. "Efforts are underway to develop a

Land use, such as irrigation, has a huge effect on water resources, yet monitoring of water use on the ground is sorely lacking.



RGBStock



Top: Number of useful flow gauges open in each year.

Above: Number of rainfall stations open in each year.

consistent approach to assess this strategic resource as part of the integrated water resource assessment for the country. However, sustained groundwater monitoring is alarmingly patchy, and this lack of reliable and continuous groundwater records data is a major concern.”

The worsening of water quality is another factor that will be generally addressed in the WR2012 study. After all, water that is too heavily polluted for use is as bad as having no water at all. Nomqophu also bemoans the lack of young hydrologists entering the sector. “Government departments, such as DWA, used to be the premier training ground for young hydrologists and hydrological engineers, however, this fell by the wayside in the mid-1990s. It is extremely important for the sustainable use and management of our water resources that we retain and grow our body of expertise.”

South Africa has come a long way in water resource assessment since that first study by Prof Des Midgley 60 years ago. It will be up to all stakeholders to work together to ensure that this extremely important body of knowledge remains intact for generations to come. □

WATER RESOURCE ASSESSMENT THROUGH THE DECADES

- **1952 study** – The first national water resource assessment study in South Africa was undertaken by Prof Des Midgley, former head of the Witwatersrand Hydrological Research Unit. Back then, Prof Midgley was in the employ of the Department of Irrigation (as it was then known). He collected all the available data and built up consolidated national and regional files, which, up until that time, had been scattered among various authorities in the country. The study was undertaken prior to the advent of the computer age in South Africa, and all calculations were done manually or with the aid of adding machine or slide rule. While Prof Midgley was working on the study he was called to the construction site of the Albasini Dam, in Limpopo. It is said that he took all of his work with him, working late into the night to complete the first comprehensive survey of the surface water resources of South Africa. His efforts earned him his PhD and established him firmly as the leader in water resource hydrology in the country.
- **1969 study** – This study was undertaken by Prof Midgley and Dr Bill Pitman with the benefit of a mainframe computer (single user). The standard means of communication with the computer was via punch card.
- **1981 study** – The study, again led by Prof Midgley and his team at Wits, was undertaken prior to the advent of the personal computer in South Africa. The computing environment was now one of large, mainframe computers linked to a number of remote terminals. This was the first study which made use of the now internationally-recognised Pitman deterministic rainfall-runoff model, which Dr Pitman developed in 1973. Not only could the model be used to extend flow records (as dictated by the availability of suitable rainfall records), but it could also be used to facilitate the process whereby records affected by land use could be ‘naturalised’ by removing the effects of irrigation, afforestation and all water transfers.
- **WR90** – By this time the personal computer had become a useful and versatile analysis tool. In addition, the consulting engineers who undertook this study could take advantage of geographical information systems (GIS) software, which was already being used for a wide range of applications. Prof Midgley also led this team. The study used an updated, PC-based, version of the Pitman model. The new model, known as WRS90, was of modular construction with four types of module – runoff, irrigation, reservoir and channel. This survey produced the most comprehensive set of maps issued yet, containing information such as rainfall, evaporation, runoff, land cover and water use, geology, soils, sediment yield and vegetation, to name but a few.
- **WR2005** – This was the first study to include the interaction between surface and groundwater in the modelling process. It was also the first water resources assessment survey to address water quality issues. WRS90 was upgraded again; this time a Windows version was created (WRS2000), which included, among others, modelling of the surface-groundwater process, improved modelling of the impacts of afforestation, irrigation, alien vegetation and mining areas, as well as improved modelling of wetlands. Water quality was addressed with a new model, called SALMOD. The main innovation of WR2005 was the issue of a DVD with a ‘dashboard’ (menu system) containing all the models, electronic maps, spreadsheets, time-series data files of point rainfall, catchment rainfall and natural flows, reports, WRS2000 networks and associated data files.

Source: WV Pitman, 2011. ‘Overview of water resource assessment in South Africa: Current state and future challenges’ in *Water SA* 37(5), p 659-664