EXECUTIVE SUMMARY

Water shortages are a looming threat for agricultural as well as urban users in South Africa. Although the reasons below is by far not the only it has been shown by many authors (e.g. Anderson, 1982, 1983, 1985; Easter *et al*, 1997; Ryan, 1995) that the following reasons is the main cause of water shortages:

- A lack of suitable new dam sites (minimum ecological impact).
- The cost of new water supply infrastructure.
- A lack of political will to implement water demand management strategies.
- The high unaccounted water percentage.
- The pricing of water below its real value.
- Inefficient irrigation systems and leakages.
- The production of low value crops
- Central water allocation instead of transferable water rights (water markets) systems.

The Water Research Commision recognised the need for research to develop a methodology to determine the value of water. A need was also identified to do more research on the contribution that water markets could make to alleviate water shortages through the more efficient use and allocation of water. The Department of Agricultural Economics at the University of the Orange Free State submitted a project proposal to the WRC to address this research need during 1997 and the project commenced in January 1998.

The primary objective with this project was to develop a methodology to determine water values and the impact of a potential water market on efficiency. This included the methodology to analyse water values and water markets as well as the quantification of variables, which will be influenced by the implementation of water markets as an alternative for administrative water allocation in the Berg River basin. Modelling of water markets in South Africa has received very little interest in the past. This is probably because there was an emphasis on supply management through command and control in the old Water Act (1956)

An increasing number of economists believe that market mechanisms should be incorporated in water allocation policies. It is widely recognised that central planning as an economic system has been inefficient. In fact, it is impossible to plan efficiently from the centre, and the bigger and more open the economy is, the more impossible it becomes.

The new National Water Act (1998) makes explicit provision for the transfer of water rights. However, the rules and procedures for introducing water markets have not been stipulated. To date no attempt has been made in South Africa to develop methodologies to simulate water markets. According to the new National Water Act one of the most important tasks of Catchment Management Agencies (CMA's) will be to design water allocation strategies for each of the major catchments in South Africa. This study contributes to enhance the capacity of water authorities to make economically sensible water allocation decisions.

Without a market price, there is little or no incentive to use water efficiently. True pricing will lead to highest-value uses (e.g. drinking water and the production of high value products). Creating incentives for the most-valuable economic use of water will provide certainty; increase supply for more efficient uses, and create an even playing field for all water users including natural systems.

There are legitimate concerns that the market mechanism *per se* will not guarantee equity. Government therefore has an important role to play in ensuring that the rules and procedures exist to deal with externalities. The secret is to achieve a balance that involves interfering in the market mechanism without jeopardising the proper functioning of water markets. The functional organisation for policy-making, water allocation, water management, and monitoring of users plays an important role in the implementation of a sustainable water development system.

The literature abounds with models for analysing alternative water allocation mechanisms. The positive mathematical programming (PMP) technique, which was introduced in this study, to calibrate a regional water market model, is a relatively new approach. The most important finding with regard to modelling is that in similar studies, without the PMP technique, response to policy and other external impacts on farmers' behaviour was probably overstated. The PMP technique causes a regional model, with incomplete information, to respond more smoothly to change in parameters. Traditional calibration approaches require calibration constraints that restrict the range of alternative scenarios; this limits their usefulness in policy analysis. The PMP approach uses the farmers' observed crop allocation in the base year to generate self-calibrating models of agricultural production and recourse use, consistent with microeconomic theory, which accommodate heterogeneous qualities of land and livestock.

The literature review revealed that the spatial equilibrium modelling technique is the best suited for this kind of research. Most of the previous studies used regional linear programming models instead of typical farms to represent the water demand function for agriculture. In this study, typical farms are embedded in the spatial equilibrium model, and are aggregated to represent irrigation regions. This renders it possible to model farmers' behaviour more accurately.

Most other studies used total gross margins to measure farm profitability. In this study whole farm models are incorporated and the net disposable income (NDI) is used as measure of profitability. The NDI is a much more accurate measurement of farm profitability because it also includes overhead expenses, income tax, interest on loans and household expenses. Although depreciation should, according to the definition, also be subtracted form NDI, capital redemption on loans was included to provide for depreciation in an indirect way. Most models used in similar studies concentrated on either the urban or the agricultural sector. In this model both sectors are incorporated in order to simulate the total water demand for the region. Through this integration it is possible to capture the competition between agricultural users and urban users and to run scenarios which impact on both sectors. As will be pointed out in the next section, the opportunity cost of water cannot be captured properly if sectors are modelled separately. The opportunity cost of water is critical in modelling the value of water and the impact of water markets.

Both average and marginal values are used for estimation water values although marginal values are the relevant measure for assessing the efficiency with which water is allocated among alternative uses. Irrigation water values are estimated from both crop-water production functions and farm crop budget studies that use linear programming. In spite of the differences in methodologies used, the primary factors underlying the wide variations in the estimated irrigation water values are the crop grown, the location, and the year of the estimate rather than the methodology employed. This study clearly pointed out that there exist huge inefficiencies in the Berg River catchment. Without a water market the capitilised marginal value[1] of agricultural water ranged between R0 and R20.2 with a median value of R1.6 per m^3. The capitilised marginal value for urban water is estimated to be R10.1 per m^3. When there is relative low water scarcity and a water market is introduced the marginal value of water for all agricultural water users declines to either zero (typical irrigation farms where there is a infrastructure transfer restriction) to 30 cent per m^3 for all other irrigators. The marginal value for agricultural and urban water can be explained through a difference in the transaction cost between agriculture to agriculture and agriculture to urban water transfers. The reduction in the marginal values for water when a water market is introduced indicates a huge increase in efficiency of the allocation system.

Water markets act as buffer when water becomes scarcer. Water can be sold or leased to anyone for any purpose. This provides and incentive to the owners of the water right to conserve water and sell the surplus to those willing to pay a higher price than the value that the present owner attaches to the right, thereby allowing water to be reallocated to higher-valued uses.

When a water market is introduced the market sends price signals to users, informing them about the scarcity situation. The value of water increases and the opportunity cost of inefficient users becomes too high to carry on with their inefficient practices. They react by using water more efficiently. The net disposable income per m^3, which was used as measurement of efficiency, rises in response to the introduction of a water market. This creates "surplus" water, which can be traded to higher-valued uses. When a water market is introduced farmers change to lower-intensity irrigation as water becomes scarcer. When water trade is possible, farmers manage to keep a larger area under optimal irrigation than when it is not possible.

The study clearly indicated that water markets could act as a buffer to keep urban water prices lower when restrictions are imposed. The modelling of urban water prices is over-

[1] See the glossary of terms for a detailed description of the difference between capitalised and rental values.

simplified in this study since block tariffs for urban water have not been introduced. However, the results clearly indicated that in the absence of a water market the price of urban water will increase more rapidly than with a water market. As water scarcity increases, a water market becomes more active. The volume of trade water increases relative to total consumption.

This study has also shown close relationship between the volume of water traded within the agricultural sector and the volume traded between the agricultural and urban sectors. As scarcity increases, the volume of water traded within the agricultural sector decreases and the volume of water right transfers to the urban sector increases.

Transaction costs raise the market price of water and erode the advantages of trade with a subsequent decline in the volume of water transferred. Transaction cost of more than 12 percent of the value of water will cause trade between the agricultural and urban sector of the Western Cape to decline drastically.

To make progress towards the introduction of water markets a new approach to water management is needed; an approach that relies on a well-tuned balance between government regulation and market forces. Such an approach needs to include the following:

- The new Nation Water Act, 1998, will have to be amended or regulations in terms of the Act will have to be introduced, to clearly state the rules and procedures for permanent as well as temporary water transfers. In the present Act water trade is only implicated by referring to the "transfer of water use authorisations".
- Water entitlements need to be clearly defined. The present licensing system provides for a licence that may be granted for a maximum of 40 years, renewable every 5 years with no guarantee that the user will receive the same volume of water. Although this is not necessarily a problem that will impede the functioning of a water market, especially for temporary transfers, the insecurity of tenure may lead to a lower valuation of water. This in return can increase the possibility of inefficiencies in the system because there will be less incentive to buy water.
- Without well-designed institutions, uncertainty about the physical quantity of water available at particular times and locations impedes efficient resource use by

decreasing the expected value of engaging in water-related activities. The process of establishing water-user associations in the Berg River commenced during 2000. Shortly a CMA will be established. The Berg River CMA will have the opportunity to include water market principles in their allocation strategies. Institutions governing water use in general, and water markets in particular, can be structured in such as a way to accommodate externalities. Livingston (1998) pointed out that market failures could be prevented to a considerable extent in order to generate the security and flexibility that provide the foundation for efficient use.

- Livingston (1998) stated that ideally a private water organisation would facilitate efficient markets by:

  1) treating various water interests without bias;
  2) serving as a water broker, thereby lowering transaction costs of water trades;
  3) allowing the price of water to vary according to its changing economic value; and
  4) ensuring that water transfers do not impose uncompensated externalities on other water users.

Water markets themselves tend to evolve over time. Even very simple water markets, if structured well, can be a stimulus for more efficient water use and can spawn continual refinements in the trading system. This concept was clearly indicated in this study. Even if the trade volume is low initially there are immediate gains in efficiency when water trade is permitted. The Berg River CMA can gain experience by instituting a relative simple water market (only internal trade within for example the agricultural sector) and develop over time into a sophisticated market with trade between all user sectors and even trade with other catchments (e.g. the Breed River and possibly the Olifants River).

The research results comply with the main objective as well as sub-objectives that were specified. The reader must take note that the results of the scenarios reported must be interpreted **as relative not absolute changes** from a base analysis. The relative change in this type of analysis is more important than the unit change. Also, the reader should not take nominal values and use it for other purposes since the research results are specific to the Upper-Berg River basin and the Cape Metro region. The values reported in this study are captilised values and should not be compared to rental values that may have been calculated