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Water Demand Management and Losses in Garankuwa and Mabopane, South Africa

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Abstract
This study attempted to address possible solutions to water demand management for the improvement of efficient use of a given volume of water while increasing water access to new users; application of water demand management tools both at the utility and end-user sides; and managing water losses in the distribution network which is a critical aspect of water demand management. The research was conducted in Garankuwa and Mabopane supplied by ODI Water Services in South Africa. This paper describes water resources in South Africa, water demand management tools in place and water supply to the ODI Water Services. It further presents data for the total purchases of water from Rand water and the final billed water at the utility, and water consumption patterns during the period of July to December 2009. This included attempts made to identify and quantify water losses in Garankuwa and Mabopane during the same period. Suggestions were made on how water losses can be reduced. In Garankuwa and Mabopane it was discovered that human perceptions on water demand management and water wastage through unaccounted-for-water together with the indigenous knowledge systems for the management of natural resources need to be altered as the country is water stressed.

Keywords
Distribution systems; Losses; Tools; Water demand

INTRODUCTION

President Jacob Zuma in his 2010 State of the Nation address stated that South Africa is not a water rich country and that there must be changes in attitudes and behaviour in how water is used at homes, industries and agriculture, (DWA, 2010). There is a consensus that South Africa has enough water to meet the needs of the country in the near future as water resources have been developed ahead of demand, and have normally been able to keep pace with the growing demands of the economy and its increasing water requirements. South Africa cannot afford to rest on this and turn a blind eye to possible and probable future water scenarios as the country is a water-scarce country, with a small river system and many cross-border complexities of sharing the water. The vibrant economy and industrialisation are impacting on these available resources and appropriate and timely corrective measures that need to be taken into account. Failure to manage water resources will result in future water load-shedding if various stakeholders do not address the issue of water resources collectively and individually, (SAEON, 2008).

South Africa is amongst the 30 driest countries in the world and water is a commodity that is finite in nature, (DWA, 2010). 65% of South Africa is semi arid with an average rainfall of 450mm/year that is below the world average rainfall of about 860mm/year. As water resources are categorised in global term as scarce and limited in extent, South Africa is said to be water stressed with an annual fresh water availability of less than $1700m^3$ per capita which is the index for water stress. FAO estimated that the current fresh water availability is 1154 m^3, while the International Water Management Institute (IWMI) estimated that by 2025 the country will be among other countries that will experience a physical scenario of less than $1000m^3$ per capita, the index for water scarcity, (Otieno *et al*., 2004). South Africa's water resources in global terms are limited and scarce as the demand for water is growing as a result of high population growth rate, economy developments, and the urgent need to supply water services to millions of people without water, while the sustainability of our water resources is threatened both in terms of quantity and quality. Future water demand will exceed the existing availability of fresh water resources if the current water usage pattern is not changed. Water demands that have exceeded water availability in a number of areas in the country now have to rely on expensive transfer schemes, (DWAF, 1999). It is often mentioned that South Africa's fresh water resources will be fully utilised within the next twenty to thirty years if the current growth rate in water demand is not altered (DWAF, 2000).

It was the government's obligations to the neglected majority that guided early water policy and implementation efforts and traditional water management thinking that exists today with the construction of the Lesotho Highlands Water Project. South African water managers at local and national levels have been investigating the potential of WC/WDM. These will bring the desire to provide cost effective water services, improve efficiency use of water, and increase municipal revenues through increased tariffs that can run counter to water and wastewater basic needs objectives. South Africa is resolving this by structuring its water philosophy and policies so that a few individuals and industries use less water and that more individuals have access and will be pertinent at a regional level, (Brooks, *et a*l., 2004).

The progressive new South African water law (Water Act 1998) has been expected to bring important changes in the way water is being used and shared among different users in South Africa. The major aim was to ensure a better balance between efficiency, sustainability and equity needs in water allocations. Water must meet the basic human needs of poor people in rural areas who have been disadvantaged for so long and must be a guarantee for all users. Water cannot be allocated just to meet the increasing demand from agriculture, industry and other productive sectors without also satisfying the requirements of aquatic ecosystems and the environmental reserve. The responsibility for decision-making in respect of water allocations must be decentralized to the level of the future Catchment Management Agencies (CMAs). A system of authorizations for water abstractions that must be anticipated with a compulsory licensing when the basin is water stressed, (Levite *et al*., 2002).

Water problems are aggravated by disadvantages in the management of water since sectoral approaches to water demand management have dominated and are still habitual

leading to the fragmented and uncoordinated development and management of the resource. These problems are caused by inefficiencies in water governance and increased competition for the finite resource, (TAC, 2000). Technical standards, methodologies and guidelines are considered to be useful tools when implementing water use and demand management strategies at all levels by municipalities in South Africa (Herbertson *et al*.,. 2001). These tools helps to manage water use and water demand management effectively in South Africa and can be of practical application even in other regions with an approaching water resources crisis. Implementation of water demand management policies is in theory in most developing countries, while a great step towards ensuring that policies can be implemented with the support and co-operation of the people who actually use the water, and can give the opportunity for women to be heard that uses water the most. These problems can be resolved through effective capacity building to encourage willingness for a general change in attitude and awareness of the value of water and through education and awareness campaigns.

This study will bring forth results that will impact the need to apply water demand management tools both at the utility and end-user sides and managing water losses in the distribution network which is a critical aspect of water demand management. It would be easier for any water services provider to promote the concept of demand management for end users, if they can demonstrate that they have reduced the level of losses to an economic level of leakage and water purchased from source will be accountable to the final end of usage. The growth in water demand compared to the supply constraints is leading to an indefensible situation which implies that not only does water conservation have to be applied, but also profound efforts to control water in the distribution systems will have to take place.

WATER DEMAND MANAGEMENT

Water demand management which is the adaptation and implementation of a strategy (policies and initiatives) by a water institution to influence the water demand and usage of water in order to meet economic efficiency, social development, social equity, environmental protection, sustainability of water supply and services, and political acceptability according to (DWAF, 1999), is a pro-active approach to water conservation, which considers water-consumption needs as demands rather than requirements, (Makropoulos, 2002). Water demand management is defined as the development and implementation of strategies, policies, measures and other initiatives aimed at influencing demand, to achieve efficient and sustainable use of the scarce water resources, (Kayaga *et al*., 2007). Water demand management includes two interconnected activities which are the improvement in technical efficiency of water use and the efficient allocation of the available water among competing uses. Improvements in the efficiency of water use are usually undertaken by water providers and water users within the municipality. This is done by meeting the existing needs of individual users and uses with less water, such improvements can free up significant quantities of water. This can be achieved by the use of water saving devices that can accomplish the same purpose while using less water. Any water that have been saved through conservation can be kept in reserve and applied toward the expansion of the same use by the same user or other users or even be reallocated to other sectors, (Dziegielewski, 2003).

Water Demand Management Tools

The following tools which are technical standards, methodologies and guidelines are considered to be useful tools when implementing water use and demand management strategies at all levels by municipalities in South Africa (Herbertson *et al.,*. 2001).

Technical standards. In the SADC region the South African Bureau of Standards (SABS) produces many standards related to the water supply industry that is used in implementing water use and demand management strategies at all levels by municipalities in South Africa

Methodologies. The use of computer controlled management systems is increasing in the municipal sector and the use of water meter management systems helps to combat fraudulent meter bypassing. These systems are expensive and the benefits of operating these systems are also expensive like the systems for leak detection but it should outweigh the costs.

Guidelines. Guidelines relate to the interpretation and communication of policies in a technical area. They express intent, and can be used to steer people in the desired direction in the management of water.

Water Demand Management Strategies

Water demand management should not be regarded as a strategy to meet a number of objectives more than just one objective. The reason why water demand management's full potential is not recognised is that it is often perceived or understood in a limited context and equated to programs such as communications campaigns or tariff increases, while it should be equated to development and implementation of strategies and initiatives associated to managing water usage. The purpose of water demand management strategies is to assist in the establishment and implementation of effective water demand management procedures.

METHODS

The study covers Mabopane and Garankuwa, situated in the North West in South Africa in the City of Tshwane under the Gauteng province the economic centre of South Africa. The City of Tshwane is a major metropolitan area with a population of approximately 2.2 million people. The city has an area of 2350 km^2 that include formal urban areas and informal settlements, which is the result of rapid urbanisation, where substandard or no infrastructure exists. The ODI Water Services supply water to Garankuwa and Mabopane that is purchased from Rand water after purification, then the water is distributed to various areas including these study areas.

The distribution of water resources is characterised by increasing returns to scale as distribution links water generation to its end-use. Standard economic analysis tends to overlook the interaction between these micro-market generation, distribution and end-use, (Chakravorty, *et al*., 2009). A clearly described water balance is the first essential

step in the assessment of volumes of non-revenue water and the management of water losses in potable water distribution system network, (Lambert, 2002). The water balance answers the question of 'how much water is being lost'. (Farley, 2003).

Data was collected during July to December 2009. The patterns of water use were also identified during this period. The aim of the research was to collect data from ODI Water Services in order to identify where the water losses occurred so as to control these losses. To determine water losses a water balance was conducted. It was based on the measurement and estimation of water produced, consumed and lost, and these calculations had to balance. The water balance calculation provided a guide on how much water was lost through leakages from the distribution network, and how much water was lost as apparent losses. Water balances in the various zones was estimated within the reticulation system, simply because some of the meters were damaged due to illegal water consumption.

RESULTS AND DISCUSSIONS

The South African Water Services Act states that all water services institutions are required to develop conditions for the provision of water services that must include measures to promote water conservation and water demand management. The Water Services Act and the Water Act was also set to allow for the development of regulations as well as the principles of the national water conservation strategy which is to be used to identify and develop the regulations that will need to be regularly revised in accordance with the water conservation and water demand management strategies with any technology developments, and their acceptability to consumers and users.

ODI Water Services was set to become the country's first public-public partnership in September 1999, (Baybliss, 2002). The parastal, Rand Water Board was to develop capacity in the local authorities in the municipality of Ga-Rankuwa, Mabopane and other peri-urban areas under the Eastern District Councils, (Baybliss, 2002). In 1999 it was anticipated that ODI would set a standard in water delivery to an impoverished community with a high rate of unemployment where 50% of water delivered was lost. This was on the other hand not a culture of non-payment developed amongst the upper ranks of local government officials but was mixed by about 2 - 4% of peri -urban households who were unable to pay delivery fees. This resulted in skepticism as to whether the public-public partnership was actually a success in South Africa as increased international attention was attracted, (Snowball *et al*., 2002).

After three years, the municipality was to take full responsibility for the systems. There was significant support from unions and promises of financial support from the municipality and the Department of Water Affairs and Forestry (DWAF). However after a year the project was in financial crisis because of continued non payment and failure of the municipality and government to make their promised contributions. The lack of government commitment to the project raised questions of whether the public-public partnership was meant to succeed or it was never really the preferred option, (Baybliss, 2002).

Most of the households in Garankuwa and Mabopane are metered although some of the meters have been tampered with for illegal connections. ODI Water Services has four teams that are maintaining the bulk reticulation system, two teams that are maintaining domestic meters and one team responsible for maintaining the reservoirs and the bulk meters and this brings about a minimum number of pipe breaks. During data collection it was noted that there are consumers that have been restricted the use of water due to non payments. It was discovered that even though the consumers were restricted they continued to consume even more water than the free allocation of up to 6kl per household.

Purchased and sold water in Garankuwa and Mabopane

ODI Water Services is supplied by the Rand Water potable water bulk pipelines and storage reservoirs, which are fed from the Vaal River south of Johannesburg. The ODI Water Services connects to the Rand Water systems through metered bulk connections that feed the water distribution zones via the service reservoirs and some of the distribution zones are also fed directly off the Rand Water system. Water generally gravitates from the service reservoirs, but a number of pumping stations are also required to boost supply in the high-lying areas. Water that is purchased from Rand water cost around R1.2 million a month and is expected to grow due to developments and population growth and as a results of increasing new settlements. Table 1 shows water that was purchased from Rand Water for Garankuwa and Mabopane from the month of July to December 2009.

Table 1 Total water purchased and sold for Garankuwa and Mabopane from July-December 2009.

Month	Area	Purchases	Bulk Zonal	Sales
		SA Rands	SA Rands	SA Rands
July	Garankuwa	429844	433429	331112
	Mabopane	651647	580375	417380
August	Garankuwa	446581	410179	340932
	Mabopane	664549	566622	470594
September	Garankuwa	489449	444503	351278
	Mabopane	751589	619801	504022
October	Garankuwa	471266	483503	321649
	Mabopane	656258	615795	461495
November	Garankuwa	409888	401769	315818
	Mabopane	620039	536966	452294
December	Garankuwa	448167	416964	316945
	Mabopane	787004	722983	460475
Total		6826281	6232889	4743994

ODI Water Services had total purchases of water that indicated a total water purchase of R6 826 281 where a total of R6 232 889 was metered and a sum of R6 145 012 was

finally billed at the end, and this indicates that an amount of R681 269 has been lost in a period of six months through unaccounted for water.

Water consumption patterns in Garankuwa and Mabopane

Water demand management's approaches are designed to achieve effective water sustainability involving changing people's attitudes to water consumption. Future water demand will exceed the existing availability of fresh water resources if the current water usage pattern is not changed. Water demands that have exceeded water availability in a number of areas in the country now have to rely on expensive water transfer schemes. Figure 1 shows the average consumption of water according to the different ranges provided. The range 0kl to 6kl is free and less households consume water at that range as a number of households consume water above 12kl which is too much for a normal household. In the areas it was discovered that in most of the homesteads there was a room or more that were rented out although in most cases they would not exceed five. These tenants also consumed in one meter with the landlord. The areas have a lot of car washing areas that uses a lot of water and small industries.

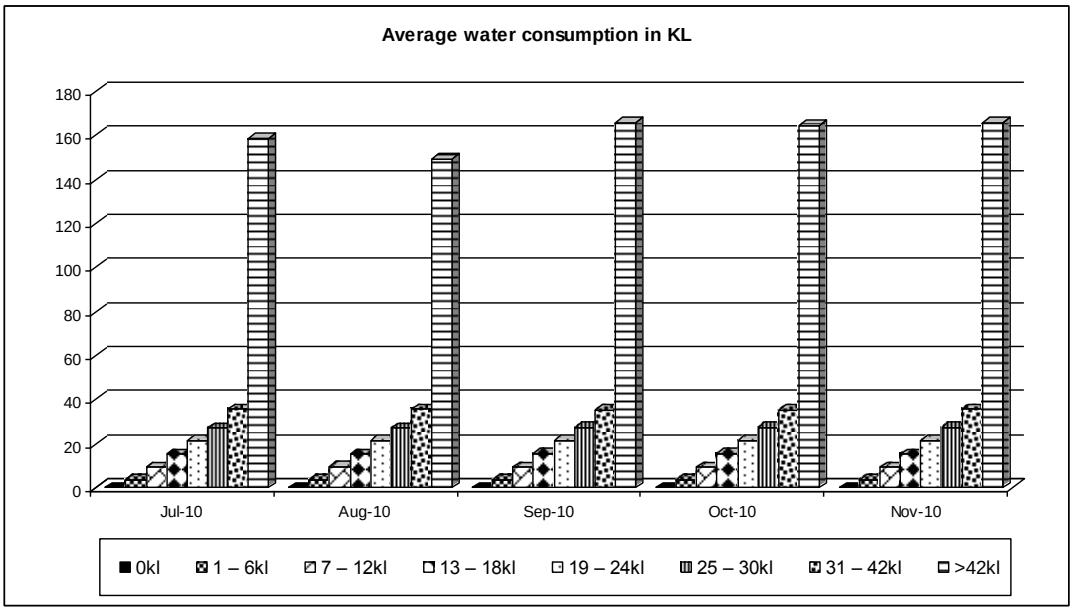

Figure 1 Average water consumption patterns in ODI Water Services

Figure 2 shows the percentage of restricted consumers that continue to benefit from the utility. These consumers had their meters shut down due to non payments and at the end of each month when the meters are read they indicated that water was consumed. The utility is trying to bring these consumers to law although it is a slow process. Figure 2 shows that the percentage of restricted consumers is higher than the percentage of the indigent consumers who are able to pay their monthly bills. Non payment of water has become custom in this areas and it is a wonder why these consumers had to use more water while they are not paying for the services. The answer would be that these communities have not been educated enough about the cost of production of water and the important of water as a finite and scarce resource in South Africa. If there are efforts to reduce water losses, water consumption would be reduced to acceptable levels and

purchases of water would also contribute to costs saving for the water services and thus postponing new supplies of water even further.

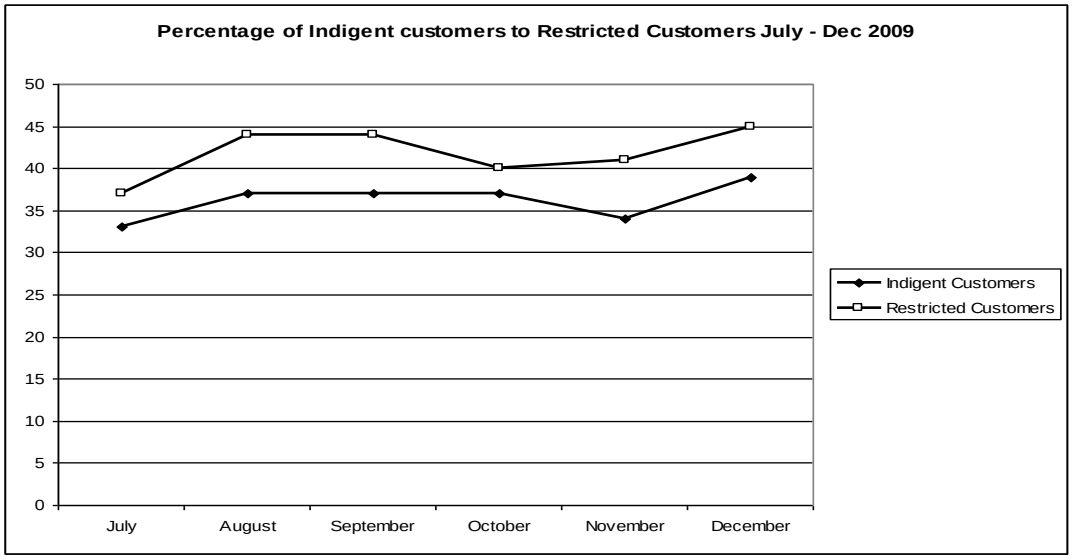

Figure 2 Percentages of Indigent Customers versus Restricted Customers for July – Dec. 2009

Unaccounted-for-water in Garankuwa and Mabopane

Data was collected and unaccounted for water was found to be high in both Garankuwa and Mabopane, with an average unaccounted for water of 30% as shown in figure 3 Tackling this problem would probably be the best way of reducing the two areas water demand in the long run as most of the sources of unaccounted for water were identified and cheap ways to avoid this losses are in place. The percentage of the revenue water losses was found to be the highest as compare to the non-revenue water. This indicates that most of the water losses encountered by ODI Water Services are due to apparent losses.

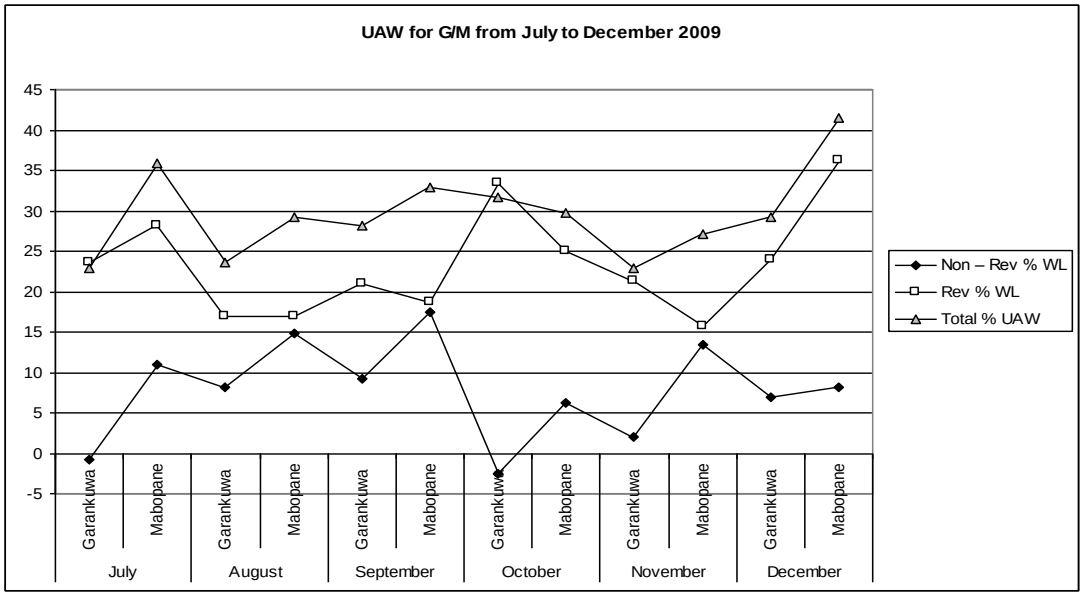

Figure 3 Unaccounted for water in ODI from July to December 2009

CONCLUSION

Water requires sophisticated and expensive engineering infrastructure to harness it since it is fugitive. It is a fundamental, life giving resource of which all kinds of life depends on it for survival. It has obtained an immeasurable value that it is even discussed in political levels. South Africa's water resources in global terms are limited and scarce as the demand for water is growing as a result of high population growth rates, economy developments, and the urgent need to supply water services to millions of people without water services while the sustainability of our water resources is threatened both in terms of quantity and quality. Future water demand will exceed the existing availability of fresh water resources if the current water usage pattern is not changed. Human perceptions on water demand management and water wastage on unaccounted-for-water together with the indigenous knowledge systems for the management of natural resources need to be altered as the country is already water stressed.

Awareness campaigns needs to be enforced to educate the community of Garankuwa and Mabopane about the value of water. As President Jacob Zuma has insisted in his 2010 speech that South Africa is not a water rich country and that there must be changes in attitudes and behaviour in how water is used at homes, industries and agriculture, (DWA, 2010). This calls for more enforcement of water usage and policies to conserve water. In a community where restricted consumers exceed indigent consumers in water consumption stringent water laws should be enforced. There is ongoing work in progress to replace the old meters with new meters that will be hard to by-pass as they will be placed above ground visible enough to notice any tampering. This will be accompanied by random checks that will be enforced by the very strict laws in place as stated by the Assistant Water loss GIS-MIS Manager. The community must also be given an opportunity to participate so as to be part of these campaigns. This will make them feel

part of the new revolution to water conservation and will own it with an understanding that water services have to be paid.

REFERENCES

Baybliss K. (2002) Water privatization in Sub Sahara Africa, problems and policy implications, Presented at the Development Studies Association Annual Conference, University of Greenwich, 9th November 2002

Brooks D. B. and Wolfe S., (2004). Water Demand Management as Governance: Lessons from the Middle East and South Africa

Chakravorty U., Hochman E., Umetsu C., Zilberman D., (2009) Water allocation under distribution losses: Comparing alternative institutions Journal of Economic Dynamics & Control 33 463–476

Department of Water Affairs (DWA), (2010) National Water Week, Together we can do more to save water. (http://www.dwaf.gov.za//) [Accessed 20 January 2010].

Department of Water Affairs and Forestry DWAF, (1999). Water Conservation and Demand Management National Strategy Framework. Department of Water Affairs and Forestry, Republic of South Africa.

Department of Water Affairs and Forestry (DWAF), (2000). Water Conservation and Water Demand Management Strategy for the Water Services Sector www.info.gov.za/view/DownloadFileAction?id=70347 [Accessed 22 June 2009]

Dziegielewski B., (2003). Strategies for Managing Water Demand. Universities Council on Water Resources, Southern Illinois University Carbondale, Water Resources Update, Issue 126, Pages 29-39. November 2003.

Farley M., (2003). Non-Revenue Water. Paper presented to 12th Annual CWWA Water, Wastewater & Solid Waste Conference 28 September - 3 October, 2003 - Atlantis, Paradise Island, Bahamas

Herbertson P.W. and Tate E.L. (2001), Tools for Water Use and Demand Management in South Africa. Technical Reports in Hydrology and Water Resources. Secretariat of the World Meteorological Organization – Geneva – Switzerland. No. 73 WMO/TD – No. 1095

Kayaga S., and Smout, I. (2007), Water Demand Management: A Key Building Block for Integrated Resource Planning for the City of the Future. Water Engineering and Development Centre (WEDC) Loughborough University Leicestershire, LE11 3TU, UK

Lambert A.O., (2002). International Report on Water Loss Management and Techniques. Water Science and Technology: *Water Science and Technology*, Vol 2 No 4 pp1-20, 2002.

Levite H., Sally H. and Cour J., (2002). Water demand management scenarios in a water stressed basin in South Africa. International Water Management Institute (IWMI), 141 Cresswell Street, Private Bag X813, Silverton 0127, Pretoria, South Africa. 3rd WARSFA/ Waternet Symposium; Arusha; October 2002

Makropoulos C. K., (2002). Planning Site Specific Water- Demand Management Strategies. Department of Civil and Environmental Engineering, Imperial College, London, UK. The Journal V18 N1 March *2004* 35

Otieno F.A O., and Ochieng G.M.M., (2004). Water management tools as a means of averting a possible water scarcity in South Africa by the year 2025. Water SA. 30 (5), 120 - 124.

Snowball J.D., Willis K.G. and Jeurissen C., (2002). Willingness to Pay for Water Service Improvements in Middle-Income Urban Households in South Africa: A Stated Choice Analysis. South African Journal of Economics Vol. 76:4 December 2008

South African Environmental Observation Network (SAEON), 2008. The future of water in SA. www.saeon.ac.za/.../no-immediate-threat-but-a-warning-of-emerging-gaps

Technical Advisory Committee (TAC), (2000), No. 4, Integrated Water Resources Management. Global Water Partnership SE -105 25 Stockholm, Sweden