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**Optimisation of Water Demand Management Opportunities in  
Non-residential Facilities within the Cape Metropolitan Area  
Based on Economic Efficiency**

**Joseph Roman Kombe**

University of Cape Town

**A thesis submitted to the Faculty of Science, Department of Environmental & Geographical  
Science, University of Cape Town, in partial fulfilment of the requirements for the  
Masters of Philosophy Degree in Environmental Science**



**University of Cape Town  
September 2000**

# **Optimisation of Water Demand Management Opportunities in Non-residential Facilities within the Cape Metropolitan Area Based on Economic Efficiency**

**by  
Joseph Roman Kombe**

I would like to gratefully acknowledge the financial assistance rendered by the Swedish Agency for Research Co-operation with Developing Countries (SAREC) through its Regional Marine Science Programme (East Africa).

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Masters of Philosophy Degree in Environmental Science**



**University of Cape Town  
September 2000**

## Declaration

I declare that this dissertation is my own unaided work. It is submitted as the final fulfilment of the requirements of a degree of Master of Philosophy in Environmental Science in the University of Cape Town. It has not been submitted before for any other degree or examination in any other university.

Signed by candidate

Joseph Roman Kombe

*J. Kombe* day of *April* 2000

# Abstract

**This dissertation is a result of a research conducted between January – July 2000, on Water Demand Management (WDM) strategy, measures, methodology and procedures; practical water auditing in seventeen non-residential facilities within the Cape Metropolitan Area (CMA) in South Africa; and some findings of a questionnaire survey conducted in the CMA.**

**The principal aims of this dissertation were:**

**Firstly, to identify opportunities for reducing and saving water in these facilities by using WDM strategies and measures based on economic efficiency.**

**Secondly, to attempt to present practical methodology and systematic procedure for identification, planning and designing effective WDM programmes suitable to non-residential facilities in the CMA.**

**Thirdly, to give practicable recommendations for choosing and implementing best alternative WDM strategies and measures within the CMA.**

**Key findings:**

**Firstly, the CMA faces numerous challenges and opportunities as regards to provision of potable water during this new era of political dispensation. One such challenge is how to provide potable water for all its 3.2 million people and for the productive sectors, all together consuming about 900 million litres of potable water a day.**

**Secondly, there is a persistent water shortage in the area as a result of increased water demand and wastage. Increased demand for water as a result of objective reasons is inevitable and not necessarily a problem. The major problem is how to reduce water wastage, which increased by 92% between 1998 and 1999. Unaccounted for water (UAW) in 1999 amounted to about 171 million litres a day, that is 19% of the produced potable water as compared to 87 million litres a day and 11% respectively in 1998.**

**Conservative estimates showed that successful implementation of WDM could in the long run reduce water consumption in the CMA by 30 - 50% and UAW by 40 - 50%. Another problem is how to optimise WDM opportunities in industrial facilities and organisations by using economic efficiency as a basic criterion so as to guarantee that water demand meets supply and not vice versa.**

**Thirdly, the existing water resource infrastructure in the area is already over-stretched. The historical predominant supply-side management approach, which concentrated on the building of more dams and other supply augmentation schemes have proved to be inadequate and are costly - when social and environmental negative impacts ("externalities") are taken into account.**

**The presented facts from local and international experience demonstrated that supply - side water management in its own is not a panacea for THE water shortage problem. Therefore, this thesis presented 'optimisation of WDM based on economic efficiency' as an alternative approach that could be used to solve the**

water crisis in the area. WDM is defined as those management measures that tackle water resource from the consumption side.

Fourthly, it found out that it is possible to follow a clear methodology and procedure to identify, plan, design and use multi-criteria, economic tools and techniques to test alternative water reduction and saving strategies and measures in any facility in the area before they are adopted for implementation.

Consequently, it was shown that economic efficiency as a concept embodies efficacy, financial sustainability, exchange and technical efficiency, and does not necessarily exclude the possibility of integrating into it other criteria, such as equity and environmental sustainability. And that optimisation of WDM opportunities entails maintaining existing water resources using best management practice and equipment, devices or systems in good working order so that they do not use excess amounts of water unnecessarily. This can be achieved by using WDM strategies and measures - technological, economic, managerial, sociological-educational measures and other creative possibilities for attaining water reduction and saving in a facility or an area, without interfering with the quantity or quality of production or the welfare of water consumers.

In a bid to solve the basic problem tackled by this dissertation three major objectives were pursued:

- Analysis of Water Conservation (WC) and WDM options and relating them to pertinent economic theories, principles, and measures relevant to efficient water management in the study area.
- Exploration of possibilities for applying economic efficiency criteria in order to maximise WDM opportunities in the study area without compromising important criteria such as social equity, welfare standards, environmental quality and optimum production, and
- Detailed presentation of 'ingredients', practical methodology and systematic procedure for planning and designing effective WDM programmes suitable to non-residential facilities within the CMA.

In sum, as regards to methodology and procedure to engage WDM strategy and measures in the CMA, it was found that it is possible and necessary to take the following seven steps:

1. Value water as a scarce economic resource by taking into account its direct and indirect functions and costs of production,
2. Conduct water auditing and leak detection surveys,
3. Identify appropriate WDM strategies, measures, techniques and opportunities by considering possible options and alternatives for optimising WDM opportunities indoors and outdoors,
4. Assess and evaluate WDM measures by a using a holistic approach,
5. Identify the right water-efficient equipment, devices and fixtures and use technical expertise to determine their performance prior to their installation or retrofitting,
6. Formulate plans and design efficient WDM programmes for specific facilities and areas, and
7. Start implementation of WDM programme, monitor progress, assess/re-visit options, update programme to fit the actual situation.

**Based on these key findings four key conclusions have been made:**

**Firstly, WDM in contrast to supply-side water management through augmentation schemes is a viable and promising water management approach suitable for the CMA. Optimisation of WDM opportunities can save water, lower potable water production and distribution costs, and thus increase the propensity to make profit in a commercial or an industrial facility.**

**Secondly, application of economic principles, methods of analysis and financial accounting on alternative WDM strategies, measures, plans and programmes is very essential for achieving water use efficiency. The later can be achieved only after passing economic efficiency tests, which are based mostly, but not limited to Cost-Benefit Analysis (CBA), Opportunity Payback Analysis (OPA).**

**Thirdly, retrofitting existing conventional water wasting devices/fixtures is a viable option in situations where small parts of existing devices can be replaced to improve or restore efficiency. Water efficient devices/fixtures such as gravity flush toilets, flushometers, cyclic flush urinals, infrared and ultra sonic operated systems or microwave sensors are viable options. Other options include - automatic shut-off faucets, or showerheads with pressure reducing valves, "electric eye" sensors and other modern devices.**

**Fourthly, in watering outdoors "Xeriscape" landscaping methods are the most efficient method that can be used to reduce water wastage. This can be achieved through the application of seven principles of 'xeriscaping', which are based on optimisation of watering process, improvement of soil texture and employment of modern gardening methods.**

**Based on the findings of this research this dissertation presented three key recommendations:**

**1. In order to initiate and implement a comprehensive WDM strategy in the CMA there should be a proper policy and legal framework, economic and financial means, administrative, infrastructure and technological capacity. However, the CMA and the associate Metropolitan Local Councils should not wait for the establishment of adequate institutional structures in order to start implementing WDM strategy and measures in the area.**

**2. Implementation of the initial steps for engaging WDM strategy, i.e. stage-by-stage facility and area-wide inventory of water systems through water auditing and leak detection survey should start with immediate effect. This can help to know the ' water situation ' and can start the momentum for proper functioning of the utilities, thus creating the necessary enabling environment for future institutional structuring and internal capacity building.**

**3. All industrial, commercial, and institutions in the CMA should explore opportunities for reducing and saving water by using WDM strategies and measure in their respective facilities and organisations.**

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## **LIST OF ABBREVIATIONS & ACRONYMS**

**AWDO** - Alternative Water Demand Options (for the CMA)

**AWWA** - American Water Works Association

**BA T** - Best Available Technology

**BMP** - Best Management Practice

**CBA** - Cost-Benefit Analysis

**CMA** - Cape Metropolitan Area

**CMC** - Cape Metropolitan Council

**CMR** - Cape Metropolitan Region

**CTWU** - Cape Town Water Undertaking

**DFA** - Dual Flush Adapter (for toilets)

**DWAF** - Department of Water Affairs and Forestry

**EEU** - Environmental Evaluation Unit

**EPA** - Environmental Protection Agency (USA)

**GDP** - Gross Domestic Product

**IBWT** - Inter-basin Water Transfers

**IEMP** - Industrial Energy Management Project

**IRP** - Integrated Resource Planning

**IUS** - Infrared & Ultrasonic Sensors

**MLCs** - Municipal Local Councils

**MWRA** - Massachusetts Water Resources Authority (USA)

**MVD** - Money Value Discounting

**NBI** - National Botanical Institute

**NCDENR** - North Carolina Department of Environmental Natural Resources  
(USA)

**NMOSE** - New Mexico Office of the State Engineer (USA)

**OPA** - Opportunity Payback Analysis

**OECD** - Organisation of Economic

**SA** - Republic of South Africa

**SABS** - South African Bureau of Standards

**SADC** - Southern Africa Development Co-operation

**SoE** - State of the Environment (CMA 1998)

**TEVW** - Total Economic Value of Water

**TOR** - Terms for the Reference

**UAW** - Unaccounted for Water

**UCT** - University of Cape Town

**ULF** - Ultra Low flush (toilets flushing 6 litres of water / flush or lower)

**UN** - United Nations

**USA** - United States of America

**WC** - Water Conservation

**WDM** - Water Demand Management

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## FOREWORD

In 1998, after spending ten years in government business, as an economist in Tanzania, four of which in departments/ministries dealing with environmental and natural resources management in the country, I made a decision to study Environmental Science. This was triggered by the fact that I noticed there is a dearth of Environmental and Resource Economists in my county. I realised that most politicians and technocrats were paying lip service to environmental problems, and could not link environmental management issues with economic development policies and strategy.

In many cases economic development and environmental protection were considered as separate entities with conflicting agenda. More so, the connection between economics, development, poverty alleviation and environmental protection was not obvious to many policy makers. After studying the 1986 Brundtland Report – “Our Common Future”, “Going Green” (Cock & Koch, 1991), “Small is Beautiful” (Schumacher, 1973) and other related literature, I realised that we can make the world a better place to live. Apparently I discovered that economics can and should play a greater role in poverty alleviation and in environmental management and protection.

Furthermore, I realised that there was no way sustainable development can be achieved by pursuing economic growth at any cost without taking into account social and environmental implications. Like wise, environmental management and protection can not be attained without financial and economic considerations.

Finally, I realised that economists can play a crucial role in the quest to attain sustainable development in a given country, if they know the nature and the basics of environmental science. This was, amongst others, an important deciding factor in joining the UCT Master of Philosophy programme in Environmental Science in the Department of ENGEO.

This dissertation is the initial fulfilment of my dream to breach the gap between economics and environmental management by applying economic principles and theories in solving environmental problems. One such problem is how to manage scarce water resources in a sustainable way in an area like the CMA by using Water Demand Management strategies and techniques.

This dissertation is, furthermore, an attempt to break away from the tradition to produce ‘standard’ impractical dissertations. I have made an attempt to meet both the academic requirements for a dissertation, as well as those to present a concise practicable methodology and procedure for leak detection survey and for planning and designing effective WDM programmes.

I have paid special attention to the financial and economics side of water management, but without recourse to ‘economism’ or over simplification of what needs to be done by non-economists - the workers and water consumers, who are actually the target of this work.

I deliberately included some cartoons and ‘eye catching’ plates, which conveys important message(s) as I believe that they convey a message better and are easy to remember. After all, environmental/educational campaigns should use all possible means of communication, especially those ones which attract people to pay attention so as to see, read or listen.

I have deliberately excluded complex theories, equations, matrices, working sample forms in the text, but included some of the relevant ones as attachments in the appendices. Although this format may not be so much acceptable in some academic circles, the nature and goals of this particular work warranted this format. After all, in my opinion the major intention of a practicable course, like the MPhil is to equip students with practicable tools to solve environmental problems in society, through investigation and correct application of knowledge. Complete exclusion of these attachments would have defeated the purpose of this work. It is for this reason that I chose to move from ‘theory to practice’ by showing how economic theories, especially Economic Efficiency and Cost–Benefit Analysis, Opportunity Payback Analysis and Integrated Least Cost Planning, and others, can be applied in the Cape Metropolitan Area to solve the water problem.

Joe R. Kombe. Cape Town, September 2000.

# ACKNOWLEDGEMENTS

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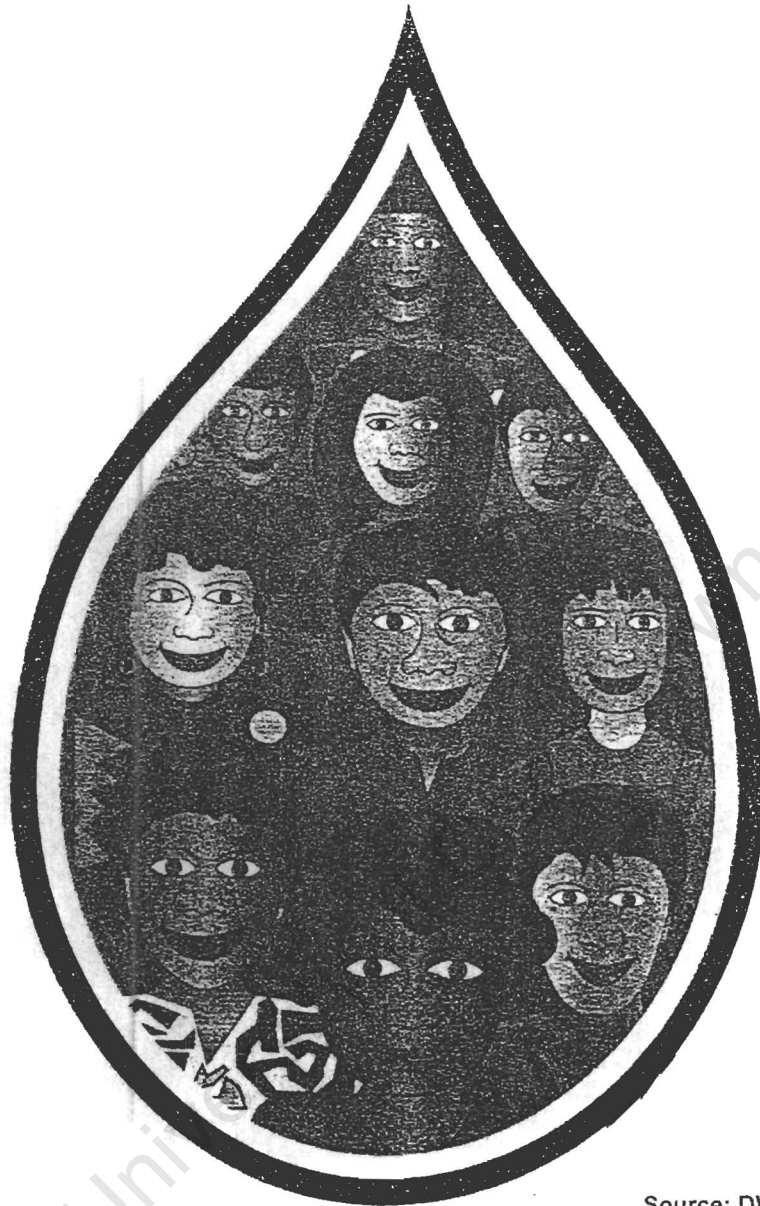
Special thanks and appreciation as well goes to Dr. Magnus Ngoile, the Director General of NEMC - Tanzania, Co-ordinator, SAREC Regional Marine Science Programme, and Dr. Anders Granlund, SAREC Officer in charge of the Marine Science Sector for their support.

I am especially indebted and wish to give thanks to Assoc. Professor Susan Parnell of the Department of Environmental and Geographical Science, and Mr. Antony Leiman, Senior Lecturer, School of Economics, University of Cape Town, who kindly supervised this dissertation.

I thank all the staff at the Department of Environmental and Geographical Science, and tributes to Professor Richard Fuggle, Head of Department, Mr. Richard Hill and Mr. Kevin Winter the MPhil programme Co-ordinators for their tireless efforts throughout the course.

I owe most to my family, my dear partner Maureen, my children Diana, Elizabeth and Albert, who sacrificed for me and were a constant source of love and support. Thank you.

Lastly, but not least I give a special tribute to my late brother, Ben, who to the very last minute of his short life, gave me indefinite moral and physical support during the studies and research leading to this dissertation. Since he could not live to witness the results, as he passed away in May 2000. I dedicate this work to him. May his soul rest in peace. Amen.



Source: DWAF Annual Report, 1999

" Changes in the South African society in general and specifically within the CMA, fast growing population, economic growth, wastage of water, and the imperatives for equity of access to water, have placed new demand on what is, although renewable, a limited resource " [DWAF, 1999; JRK, 2000] .

However, there should be "some for all for ever" [Hon. Kader Asmal, 1997]

## CHAPTER I

### • Introduction

# 1. INTRODUCTION

**"Ours is a drought-prone country, and our vulnerability in terms of water shortage is steadily increasing. For too long we have treated water with an almost reckless abandon. Now, as we recognise the need for democratic access to this scarce resource, steps have had to be taken to 'make every drop count'... and our goal for water [should be] some for all, forever, ... for a new era of water management has dawned for South Africa..."**

Hon. Prof. Kader Asmal, MP

Then Minister of Water Affairs and Forestry.

Source: DWAF, April 1999. *A to Z of Water Saving Devices* p.1.

## 1.1 Background

This first chapter gives a synopsis of the fresh water situation in the world and in South Africa in general; and more specifically highlights a water problem facing the Cape Metropolitan Area, located in the Western Cape Province in South Africa. Apart from the background to the problem, this chapter presents the aims, objectives, hypotheses, methodology, literature review and structure of this dissertation.

The central theme of this dissertation is that fresh water as a natural resource is scarce, hence it needs to be properly valued, diligently utilised, and not wasted. Water is an essential natural resource, without it life would be impossible. It is a natural resource that can be renewed or depleted, depending on the source and on use. Its source can be either from the surface (surface waters) or from the ground (ground water).

Surface waters are provided by the earth's hydrological cycle, and are considered to be renewable. Ground water as a long time (hundreds of thousands of years) accumulation of water in underground aquifers is considered to be a depletable resource stock, since only a small proportion (less than 5%) can be withdrawn each year and replenished by seepage of water from rainfall or snow melting.

Although, the total global water supply is about  $1350 \times 10^6 \text{ km}^3$ , only 0.1% is surface and atmospheric water of which, about only 1% is fresh water that can be productively utilised. As well, the regional water balance i.e. land precipitation, hydrological systems, and evaporation on land areas are not the same or equally distributed in all areas of the earth's surface (Gois, 1972; Moore, 1988; Baseline Report, 2000).

World-wide run off, a measure of water supply is relatively high, amounting to about  $42,500 \text{ km}^3$  annually, as compared to global demand of  $2800 \text{ km}^3$ , (Moore, 1988). This creates a false picture, again because of the imbalances in distribution pattern, reliability in supply, and availability and accessibility. The reality is that fresh water in general is fast becoming critically scarce in many parts of the world (OECD, 1989; Davies & Day, 1998).

There are many factors that contribute to this shortage, including climate change/drought, human population growth, economic development, and natural inequitable distribution of water in different parts of the world. The tasks of solving this water shortage problem so as to guarantee a continuous supply of water and the safe disposal of wastewater are straining many governments and municipal authorities in the world to the limit (Ashton, 1996).

Obviously, the magnitude, type and degree of intensity of this water problem varies from one part of the world to the other, from region to region, country to country and from area to area. The major challenge to scholars/ researchers, development economists, water resource planners, and policy makers is how to adequately meet the ever-increasing demand for water, and provide solutions that tackle the potential water shortage in some areas such as the CMA.

The traditional approach to solve water shortages has been to concentrate on supply augmentation schemes by constructing more dams, reservoirs and treatment facilities. (Ninham Shand et al, 1993; The Water Program, 1994; Clayton, 1995; Winpenny, 1996; Davies & Day, 1998; DWAF, 1999a; Baseline Report, 2000).

In a bid to supply more water enormous, expensive water projects were conceived and constructed in many parts of the world at a tremendous financial, social, and ecological cost (Davies & Day, 1998; World Bank, 1993). These large water projects have often led to increased energy use, increased industrial production, and created employment opportunities to the lucky few; but more than often caused environmental degradation, added to national debt and caused relocation of people. Furthermore, in many cases it caused social and economic havoc, including poverty, diseases, increased social inequality and 'consumerism' by the affluent sections of society. No wonder in this regard in *Vanishing Waters* Davies and Day conclude that: "...almost every target water-supply scheme creates new problems as it solves old ones" (Davies & Day, 1998 p.10).

In order to get the bigger picture it is useful to examine albeit briefly the water profile of South Africa in general, and Cape Metropolitan Area (CMA) in particular. Figure 1.1 shows the location of the study area - the Cape Metropolitan Area (CMA) in relation to the African Continent, the Republic of South Africa (SA) and the Western Cape Province.

## 1.2 The Water problem in South Africa

South Africa is a dry, water scarce and water stressed country. (DWAF, 1999 ; Baseline Report, 2000). The average annual rainfall is only 497 mm compared with a world average of 860 mm. As depicted in Figure 1.2 the average rainfall varies from more than 800mm to less than 200 mm per year. The reality is that rainfall varies in amount from as little as 50 mm a year in parts of Kalahari to over 3 000 mm a year in mountainous parts of the country. Added to this, there is a considerable variation in the rainfall from year to year.

The recent *El Niño* and *La Nina* weather phenomena has exacerbated the situation by increasing variability, and intensity of rainfall and drought. Davies and Day (1998) report severe existence of a drought in SA in 1985 "**resulting in serious water shortages in living memory**" (op.cit. p.2). This fact is well documented in the relevant literature.

The severe floods that occurred in the Northern Province and Mpumalanga in SA from February to March 2000 paradoxically caused a severe shortage of safe drinking water in the region because it disrupted and ruptured water pipes. Taking into account all these factors it is evident that SA is a semiarid climate country with unpredictable and erratic rainfall (Rand Water: Water-Wise, 1999). As well, according to UN statistical classifications, SA is a water-stressed country because there are less than 1700 kiloliters of water for each person each year (Chenje, 1996).

There are a number of other factors that contribute to the water supply problem:

- ◆ Fast increase in both industrial and agricultural production,
- ◆ Increased water demand as a result of improved welfare and affluence - created demand for luxurious items such as private swimming pools, sauna, jacuzzi, washing cars, watering lawns et cetera, and
- ◆ A fast population growth in the average at 3.8 % in SA, and 3.7% per annum in the CMA. The present population size, which stands at about 40 million people in SA and about 3.2 million in the CMA, will reach, about 55 million, and 4.3 million respectively by the year 2020 (Bekker et al. 1998; Baseline Report, 2000). All these people will need safe, clean potable water for drinking, cooking, cleaning, swimming, mining, manufacturing, watering and cooling et cetera. More water will be needed as well for irrigation and industrial

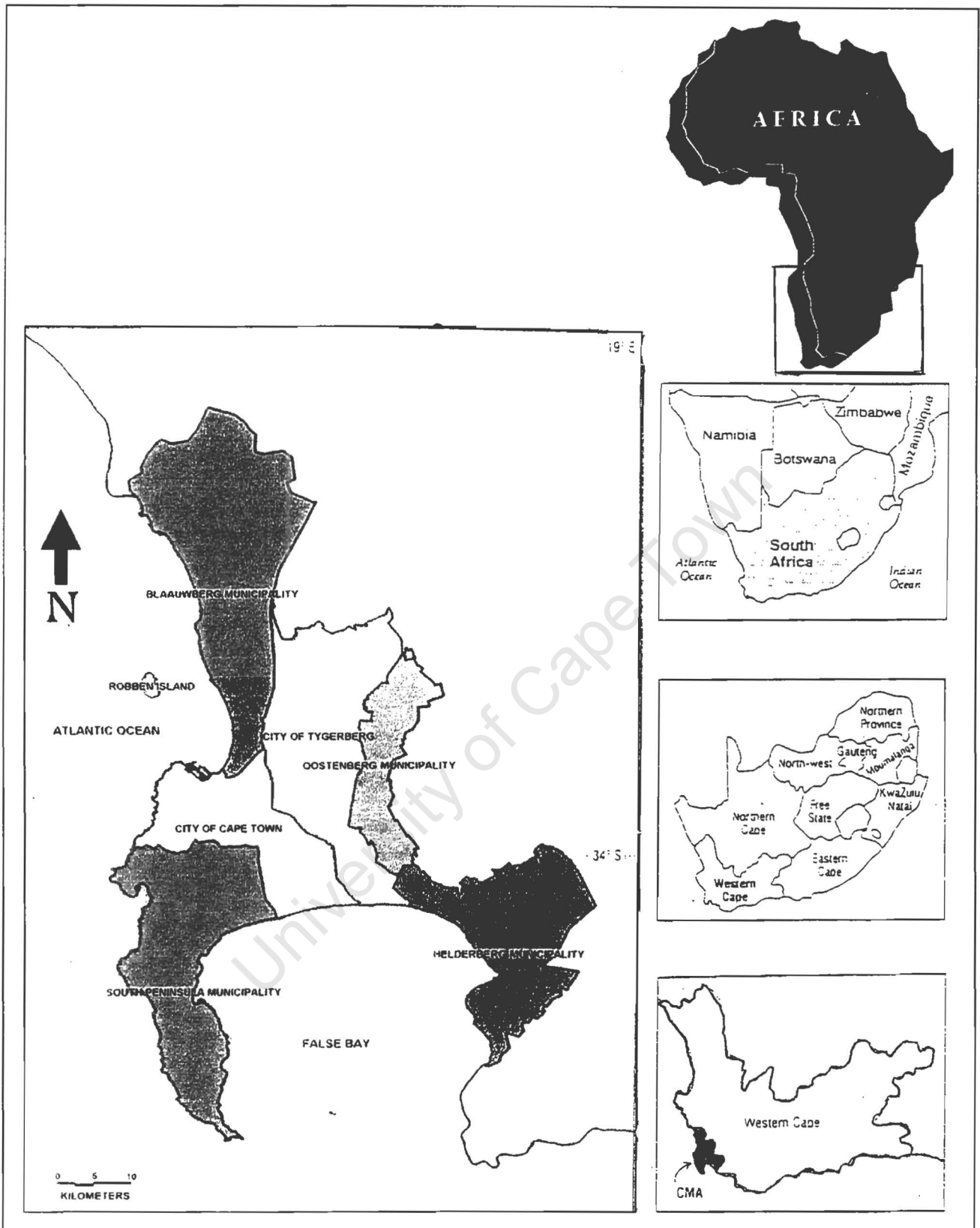


Figure 1.1: Map of the Cape Metropolitan Area, showing its position in relation to the African Continent, the Southern African Region, and the Western Cape Province. Source: DWAF, 1999; CMC, 2000; Baseline Report, 2000).

production. But, unfortunately South Africa's natural water supplies are limited. Only between 8.5% and 9.0% of rainfall in the area is successfully converted into usable water sources, such as rivers and lakes. (Asmal, 1996; Rand Water, 1999). Figure 1.3 depicts an estimate of South Africa's potential evaporation. The CMA is located in an area of Mediterranean type of climate with winter rainfall and low/moderate evaporation (Preston-White et al., 1983).

### Then what will SA do next?

As stated above traditional responses to increasing water demand have been to increase supplies, by constructing dams and reservoirs. SA has gone even a step further by executing inter-basin transfer schemes. Today there are 550 government dams with total capacity of 37, 000 cubic km., and many inter-basin water transfers or "impoundments". As shown in Figure 3.3 (p.42) if the rate of water use and wastage continues at the present rate by the year 2030 more inter-basin water transfers will be required. Six of these inter-basin transfers will have capacities of supplying greater than 100 million cubic metres per annum SA (Davies and Day, 1998; Enviro-Feature, 1999). What is frightening/interesting is the fact that some of these transfers are from outside SA.

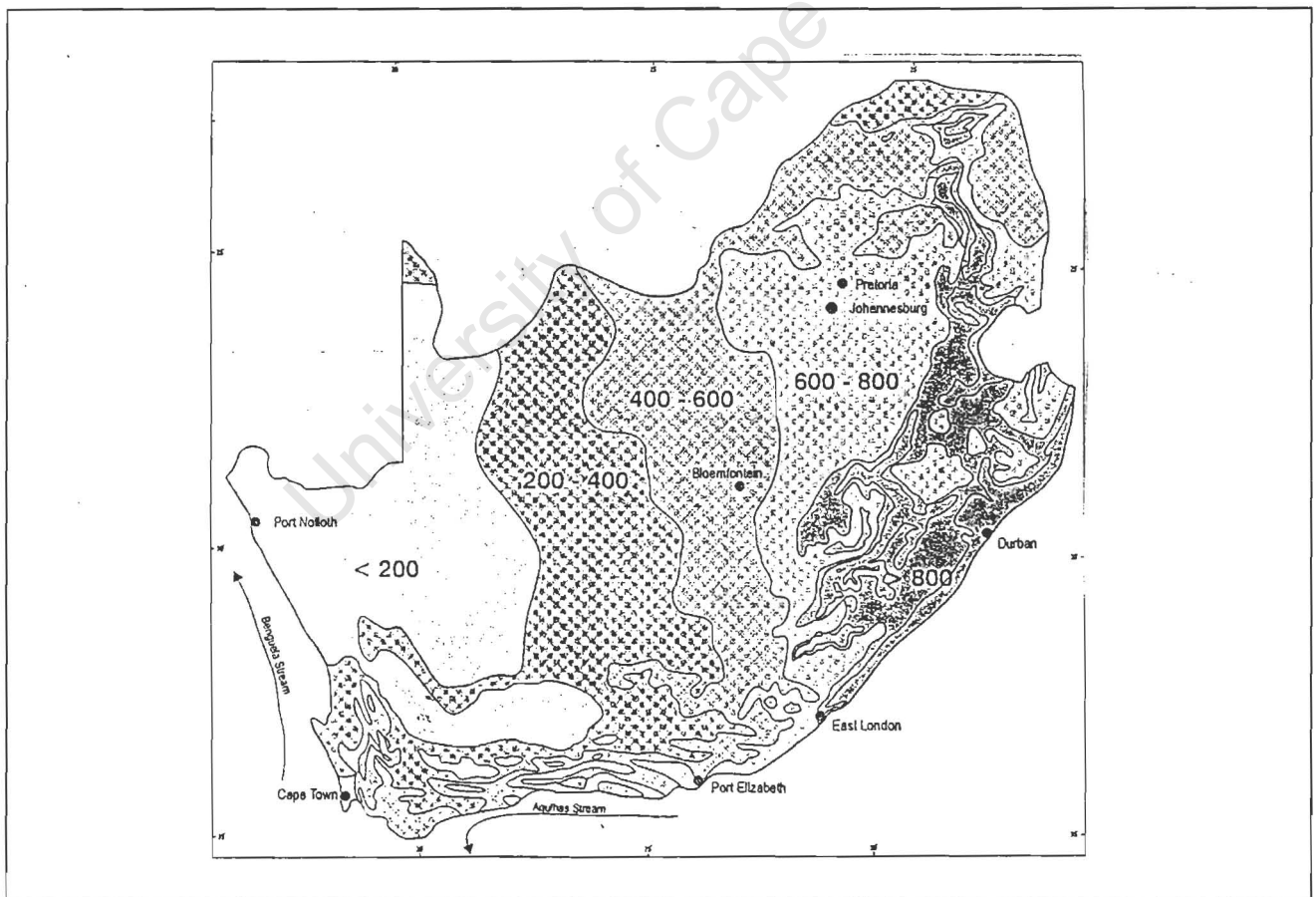


Figure 1.2: Annual Rainfall in South Africa. Source: DWAF, 1987.

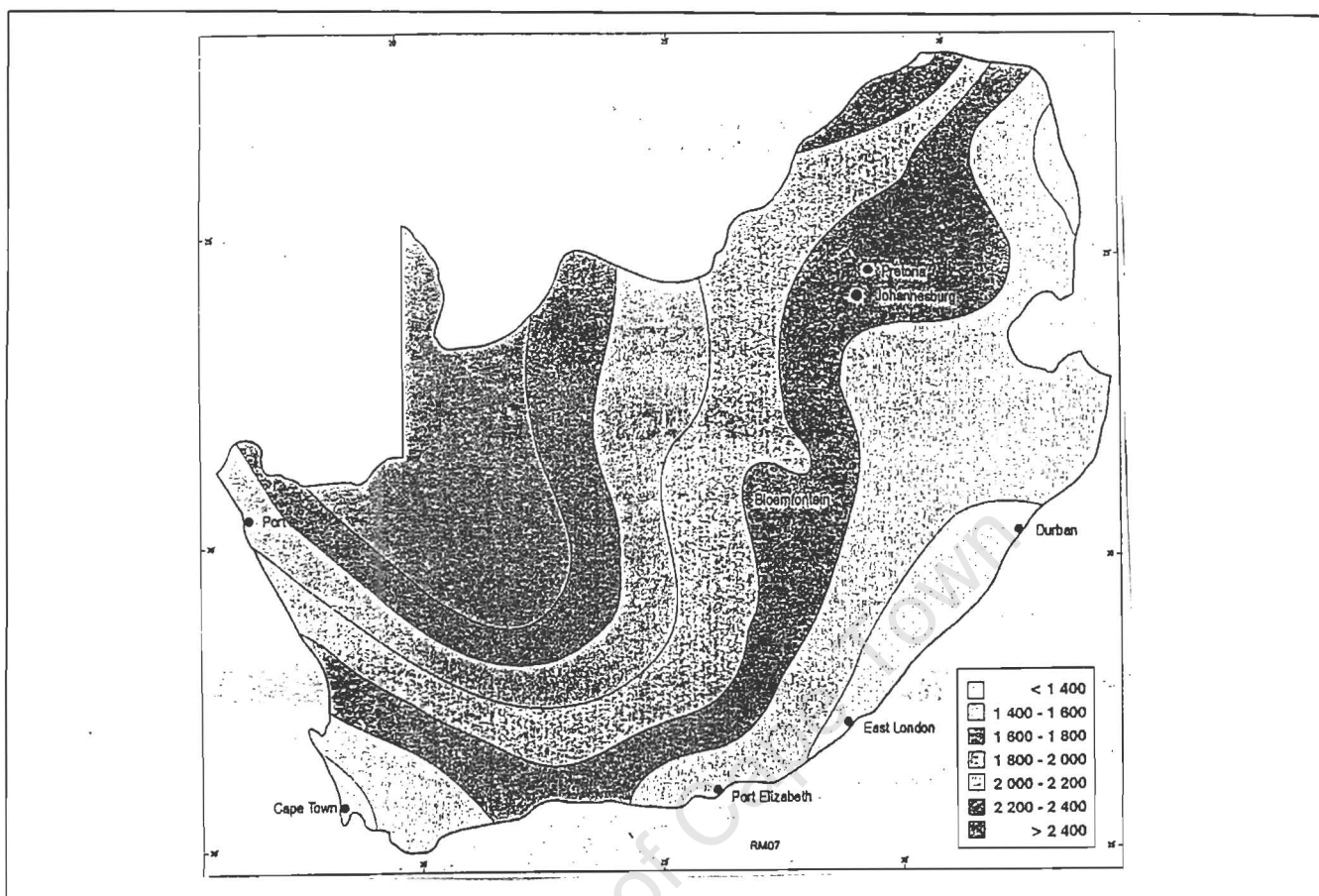


Figure 1.3: Potential Evaporation throughout South Africa. Source: DWAF, 1887.

Phase 1A of Lesotho Highlands Water Project, which was the first international water importation scheme in SA was commissioned as early as 1987. This is a clear manifestation of the fact that easily accessible water resources in SA have already been tapped. And the reality is that supplies are approaching their physical limits, and new supplies can be available only at increasing costs (DWAF, 1996; Davies and Day, 1998).

Research from other parts of the world have established that the cost of producing a unit of water from the 'next project' is often two to three times that of the current one. 1991). All these problems and limitations of supply side of water management made it necessary for South Africa's Department of Water Affairs and Forestry (DWAF) to make significant advances in exploration of alternative water use efficiency options. They include a countrywide water conservation campaign each year and demand side management interventions, such as water audit campaign in schools, commonly known as the "2020 Vision for Water Project".

Other bold initiatives include the "Working for Water Programme" launched by the then Minister for Water for Water Affairs and Forestry Professor Kadar Asmal in 1995 and the 1999 Draft Water Conservation and Demand Management National Strategy Framework document. All these efforts subscribe to the fact that water is a scarce resource in South

Africa and should be conserved and utilised diligently by using demand side options. The starting point is to realise that fresh water as a resource is scarce and it has to be treated as such.

### 1.3 Ignorance and illusion about water scarcity in the CMA

There is evidence to conclude that water in the CMA is treated as though it is available in unlimited quantities, and supplied at zero or low cost to consumers. Research by Ninham Shand (1994); Guy Preston (1995); Davies and Day (1998); attests to this conclusion. The extent of this illusion and ignorance about the realities of water scarcity in the CMA has yet to be fully established and dealt with.

This is exactly what the Cape Metropolitan Council (CMC) is grappling with at the moment. It has commissioned a number of consulting firms and researchers to carry out the job. Under the auspices of Arcus GIBB, a consulting company a group of four Masters Students from the Department of Environmental and Geographical Science at the University of Cape Town conducted research in June-July, 2000 to establish the attitude and perceptions of large water users in the CMA.

As part of the study the Masters students carried out water audits in seventeen (17) non-residential facilities in the CMA in order to establish the water use situation, type of devices used and their condition, and above all to explore the opportunities for retrofitting in order to reduce and save water. The product of that research is a document titled: "**An Assessment of Water Demand Management and the attitudes, perceptions, and practices of large water consumers within the CMA**", thereafter referred to as the UCT-CMA Water Study (2000), and cited as "Baseline Report 2000" in this thesis.

According to preliminary results of the questionnaire survey results included in the Baseline Report (2000) 53% of large water users in the CMA know the source of the water they are using is outside of the CMA, while 4% are uncertain, and only 4.3% are uncertain about the status of future water supply and demand. However, it is encouraging to know that 67% of the respondents are aware that water is scarce in the CMA ( See Appendix B and the Baseline Report, 2000 section 3).

These results show that large water users in the CMA are well informed about the water situation in the area and that is a good starting point for introducing water conservation (WC) and water demand management (WDM) measures. But, before that a lot of ground work in the form of research to determine the appropriate measures, technical and administrative capabilities, availability and affordability of water saving devices is necessary.

This dissertation is linked to the UCT-CMA Water Study (2000) and is in fact a by product of it in the sense that it shares the same data base, covers the same study area, and it is about water. However, it is independent not only because it is researched and presented by one member of the Masters group, but as well/more so because its methodology, approach and subject matter is different as will be shown below.

### 1.4 About this thesis

This thesis is a product of a six months of research conducted between January - June, 2000, actual water audit exercise, and a questionnaire survey conducted between June and July, 2000 in the Cape Metropolitan Area (CMA), situated in the Western Cape Province of South Africa. Figure 1.1 shows the geographical location of the CMA, the study area covered by this thesis.

The UCT-CMA Water Study (2000) investigated the potable water use situation, attitudes and perceptions of large water users, and audited 17 industrial, commercial and institutions in the CMA.

#### **1.4.1 The aims, tasks and challenges of this thesis**

The principal aim of the water use audit was to collect data which could give a picture of the water use situation in non-residential premises by physically checking the type and condition of the water devices - faucets, showerheads, cisterns, cooling towers, boilers, irrigation systems etc. The aims and objectives of the UCT-CMA Water Study were successfully fulfilled as per its Terms of Reference, BUT what next?

The next stage is to try to implement some of its major recommendations - the need for the CMA water users, and the Water Authority (CMC) to optimise WC and WDM opportunities. The challenge is how to implement these recommendations by solving three serious problems:

- **How to identify the appropriate and effective WC/ WDM opportunities;**
- **How to identify the right water efficient devices/fixtures and equipment, and**
- **How to formulate and present a viable methodology and procedure for planning and designing efficient WC/WDM programmes for specific facilities within the CMA and for the CMA itself in general.**

Solving these three problems constitute the major task and challenge of this dissertation.

The underlying intention is to find out to what extent modern water saving devices are used to save water wastage; and whether WC options, especially WDM measures and strategies could be applied in the CMA in order to achieve water use efficiency.

#### **1.4.2 Objectives of the thesis**

This dissertation will pursue three major objectives:

- To critically analyse WC/WDM options and discuss pertinent economic theories, principles, and measures relevant to efficient water management in the CMA.
- To explore possibilities of applying economic efficiency criteria to maximise WDM opportunities in the CMA without compromising important criteria such as social equity, welfare standards, environmental quality and optimum production, and
- To attempt to analyse and present the major 'ingredients', practical methodology and procedures for designing water efficient programmes suitable to non-residential facilities in the CMA and for the CMA itself.

#### **1.4.3 Statement of the problem**

The existence of a potential water problem in the CMA is not disputable from a scientific (empirical) point of view. The fact is that under the current rate of water use of 900 million litres per day, and water consumption at rates and losses shown in Figure 3.4 (p.46) and a high population growth rate of 3.7% per year, water demand will inevitably outstrip supply for it between 2020 and 2030 (Ninham Shand et.al.,1994; Ashton,1996; Davies & Day, 1998; Water Workshop, 2000; Baseline Report, 2000).

The notion that this potential water shortage in the CMA can be abated, by exploiting WC potential, including WDM strategies is NOT a new one either. It has been a subject of discussion for more than a decade. The issue is how to translate this notion into practical action. Therefore, the **basic problem is that of how to abate the potential water shortage**

**in the CMA by designing effective WC/WDM programmes by building in them economic efficiency as a basic criterion.**

This necessitates the application of economic theory, principles and instruments in the attempt to critically evaluate water conservation and water demand management measures in the CMA. Consequently, it necessitates a quest for answers to the following three interrelated questions:

- 1) Is water in the CMA regarded and treated as a scarce economic resource?
- 2) Can economic theory, principles and instruments be successfully applied to assist water demand management strategies and measures in order to optimise water conservation efforts in the CMA?
- 3) How can CMA 's long-term needs for water conservation be optimised from the demand management perspective?

This thesis will strive to give answers to these questions while testing a number of hypotheses as stated below:

#### **1.4.4 Hypotheses**

The basic hypothesis is that **the existing water supply in CMA is enough to meet water demand if wastage of water is checked/stamped out by optimising WDM opportunities by employing water efficiency techniques and water reducing devices.**

The central presupposition is that **in many cases the failure to treat water as a scarce economic resource, and consequently, the failure to apply relevant economic theories, principles and measures in water WC/WDM is the basic factor that perpetuates the water problem in the CMA.**

Consequently, this research will attempt to meet the above-mentioned objectives by answering the three questions posed above, while testing the following two hypotheses:

- 1) Application of economic efficiency criterion to WDM programmes is the key to realising the maximum potential for water conservation efforts in the CMA.
- 2) If water auditing and leak detection survey is carried out in industries, commercial and institutional organisations within the CMA, and the opportunities for WDM therein are optimised, a considerable amount of water can be reduced and saved and thus abate water shortage in the area.

#### **1.4.5 Study Area**

The CMA area covered by this dissertation is depicted in Figure 1.1 and includes six municipalities: Cities of Cape Town, Tygerberg ;municipalities of Blaauwburg, Oossterberg, and Helderberg and South Peninsula. The local government leadership in this area provided by the Cape Metropolitan Council (CMC) in partnership with the six Metropolitan Local Councils (MLCs) (City of Cape Town Municipality, GIS Dept., 2000; Baseline Report, 2000).

#### **1.4.6 Motivation and Inspiration of the research**

As stated above one of the major presuppositions of this dissertation is that since the CMA is a water scarce area, we should be able to apply economic theories, principles and measures to tackle this problem from the demand management side.

Such an approach has been used in other countries with more or less similar climatic conditions, and water scarcity problem. Examples from case studies conducted in the U.S.A. (California, Austin, New Mexico, and In the North Marine Water District); in Canada; in Australia (Perth, Kalgoorlie Boulder); in Great Britain (Foxhayes and Exwich Schools); in Israel; in Egypt (Cairo); in Thailand (Bangkok) and in some of the SADC counties such as

Namibia (Windhoek), Zimbabwe and Botswana (Macy et al.; 1998; Baseline Report, 2000; Goldblatt et al, 2000).

This does not in any way imply that there is no research carried on the water situation or WC and WDM in the CMA by researchers in South African. A lot of research at country and provincial level, including, Chapman's " The Need and Implementation of a Water Loss Control Programme for Local Authorities (1990)" a "Systems Analysis of Western Cape Long-term Water Demand in Western Cape" was carried as early as 1991(Ninham Shand et al, 1994).

These researches demonstrated that water supply augmentation is not sustainable, and that the way forward is for the CMA to adopt the concept of WC as an objective and WDM as its strategy for implementation (DWAF, 1995; Preston, 1995; Niekerk & Little, 1995; Davies and Day, 1998). But up to 1998 the CMC and MLC did nothing substantial to implement the recommendations. However, the situation changed in 1999 as a result of a number of the objective factors:

- High and growing demand for potable water,
- High and rising water development costs,
- Pressing externalities such as water pollution,
- Intensive competition between all users of water in the area, and
- The need to supply water to all, for as Kader Asmal the then Minister for Water Affairs and Forestry promulgated in 1994 - there should be "**some water for all, for ever**" (Asmal, 1994;Schur, 1996; DWAF, 1999).
- Pressure from the Department of Water Affairs and Forestry (DWAF), which required all SA municipalities to present and implement WC and WDM initiatives before they embark in constructing new dams. As regards to the CMA the Water Affairs and Forestry Minister Ronnie Kasrils recently said:

**" I am not going to put in another dam [Skuifraam dam] while consumption is being driven up by those wasting water. I have got to see proper water management. People are wasting water and I wont allow that. Cape Town will have to wake up to that"**

(Reported in the Cape Times of August 23, 2000 p.1, by Melanie Gosling: See **Appendix A**).

Under this pressure the CMC decided in 1999 to initiate a thorough study into the water situation in the Cape Metropolitan Region known as: "**Alternative Options to Meet the Water Demand for Water in the Cape Metropolitan Region**" referred to as (the CMC-Alternative Water Demand Options, 1999), and cited as (CMC - AWDO, 2000) in this thesis.

Apart from the efforts made in the Baseline Study (2000) this thesis intends to subscribe further to this noble endeavour by making some inroads into the economics methodology for meeting WC objectives in the CMA by using some WDM measures. This could be done by optimising inherent WDM opportunities in the area; hence the thesis among other things intends to present a procedure for designing efficient water programmes for the CMA.

#### **1.4.7 The scope of the thesis**

This thesis will therefore concentrate on critiquing the application of the economic efficiency criteria in planning long-term WC options and using WDM strategies and water saving opportunities in the CMA. It will assess the current situation, explore the theoretical missing links, employ costing and forecasting principals to calculate water saving and analytical methods to compare and contrast the various efforts. It will illuminate the procedure to

conduct cost-benefit analysis of water conservation programmes and opportunity pay back calculations for WC/WDM programmes.

#### **1.4.8 Delimitation and Limitations**

This dissertation does not cover the financial-economic mechanisms for water billing and tariff structures, price elasticity, water demand forecasting, or actual implementation of WC and WDM programmes - policies, legislation and administrative aspects of these programmes.

Actual water pricing mechanism and tariff setting exercise for example falls within the ambit of the topic covered by this thesis but has been considerably dealt with in South African literature. There are a number of credible studies going on at present and there is a national debate based on **DWAF 's Water Tariff draft document** prepared by the Palmer Development Group in 1998. Other relevant initiatives include the Water Research Commission's **"Management Guidelines for Water Service Institutions (urban): Introduction to Water Services Management in South Africa's Urban Area"** prepared by the Palmer Development Group in 1998. Other accomplished works related to water pricing include UCT's **"The User-pays Project conducted in the Kruger National Park (Tendele)"** in 1998 under the leadership of Dr. Guy Preston; and the **"Price Elasticity and Water Demand Management Study "** being conducted by the Palmer Development Group as part of the CMC-AWDO. Further more, the UCT-CMA Water Study Baseline Report (2000) Section 2, sub-section 2.2.2 shed sufficient light on water pricing and water tariff system in the CMA.

This thesis is an extension of the research conducted for the Baseline Report (2000) hence some how it is constrained by the Terms of Reference of the former. For instance most appointments to meet and interview the CMC and MLC officials were hindered or delayed by bureaucratic procedures, and the confidentiality clause binding the questionnaire survey results. Names of the water users and those of audited facilities can not be disclosed by the researchers (See **Appendix B**. Time constraint was another problem. The preparations of the Baseline Report (2000) and this dissertation were more or less running concurrently. Despite these limitations strenuous efforts were made to make sure that these limitations were overcome.

#### **1.4.9 Literature Review**

##### **1.4.9.1 Water as a scarce economic resource**

So far it has been shown that given current water consumption trends future supply of fresh potable water in South Africa in general, and the CMA in particular will not be sufficient. Supply for water cannot adequately meet demand, and supply augmentation has proved to be costly, and unable to meet long term demand for water.

To aggravate the situation there are occasional droughts, floods, and a historical inequitable regional and locality distribution of water in the country. As it was mentioned earlier and as it will be shown below, SA is a water scarce country and the CMA is no exception. But, unfortunately, the need to conserve water and allocate it to socially and economically valuable uses has not always been so evident neither in SA nor in the CMA (Koekemoer, 1999).

In the literature there is a dearth of information about the evaluation of water management in the CMA using economic criteria. **The economics of water conservation and demand**

**management in general, and water as a commodity in particular, are either completely ignored or are not given due weight and consideration.**

Policy makers in water sector in many parts of the developing world, including South Africa, have been reluctant to treat water solely as a commodity subject to free market forces and prices. After all, other criteria such as *equity*, *strategic* and *environmental* considerations have to be taken into account in the provision of water services.

#### **1.4.9.2 Economic scarcity and efficiency**

There is consensus by key stakeholders in the water sector in the CMA of the need to increase efficiency of water supply. Furthermore, it is acknowledged by the CMC policy-makers, researchers and some large water users that water is NOT used efficiently in the CMA. But, there is no consensus on how water consumption in excess of the 'basic needs' requirement should be dealt with. The question is should market forces be employed to determine **economic efficiency** and thus direct the allocation of water resources? (CMC-AWDO, 1999; Ninhan Shand, 1999; Baseline Report, 2000).

In other words, should water be treated as a scarce resource in CMA, with the future tariff system and price reflecting its economic scarcity value? Can water in the CMA be treated as a commodity subject to market forces and pricing? What about the issue of 'affordability' especially by the very poor and vulnerable? Are there any 'safety nets'? What about other important criteria such as sustainability of fresh water as a resource, and of water supply programmes, and environmental/ ecological considerations?

These are some of the pertinent questions the answers of which could do justice to 'water valuation' and 'water pricing' as a topic. But because of the delimitation reasons mentioned above this work will not deal with the details tariff systems and of water pricing.

#### **1.4.9.3 Level of awareness and attitude towards water**

Attitudes and perceptions towards any natural resource are shaped by the amount of knowledge or information possessed by individual(s), group(s), or society. Ignorance contributes heavily to perceptions, attitudes, illusions and myopic beliefs. Therefore awareness campaigns to educate water users about a potential water shortage, and the need to avoid water wastage by changing habits is necessary.

For example, a 1994 research conducted in SA by Simon Foster (on behalf of the South African Water Research Commission (WRC) to determine the value people place on water, concluded, and: **"...more than 70% of female and over 30% of male respondents did not know the origin of their towns' water"** (*Water Sewage and Effluent*: 14: 4, 1994 p.15). This ignorance is reflected in the negative attitude to water-use restrictions and reduction measures, and water conservation programmes in general.

The reality is that water is taken for granted and undervalued by many South Africans, **"particularly those living in the middle to upper class suburbs"** (Foster, 1994 p.15). Of course, water is not treated as a scarce resource as long as it remains readily available from the taps, and its price remains at what Davies and Day calls **"a ridiculously, laughably low average (1991) price of 0.1 cents a litre ... "** (Davies and Day, 1998 p. 9).

Historically, the actual price paid by water customers does not cover the real provision costs of water in SA, the government covers the difference with budgetary subventions in the form of subsidies by using tax- payers' money (WRC Report No.TT 98/98, 1998).

As it will be shown later, subsidisation is not economical as it promotes water use inefficiency and wastage. As a matter of principle, the User Pays Principle should apply. Temporary

subsidies should be encouraged only to water used to meet 'basic needs', and water used over and above that amount should be charged at progressive rates based on the marginal cost of water provision. This will compel water users to pay higher rates for increased quantities of water used.

Experience from poor rural sections of the community in SA shows that a walk of several kilometers to obtain water from a polluted river, or bore hole is not unusual. Poor people living on the city periphery or shacks are paying a larger percentage of their meagre income for access to clean and adequate water than those earning more and living in affluent areas (*Water Sewage and Effluent*, 14: 4, p.15).

The fact that water is available to some people so cheaply is one of the reasons why they do not value this scarce resource and can afford to use more than is necessary.

Normally, scarcity of a products is reflected in its price. This is not usually the case for water in SA. As it will be elaborated further in the next chapters, there are various underlying causes of this problem of under-valuation of water as a natural resource. Some of these causes include the following:

- the fact that water is considered to be a public good,
- the existence of uncompensated 'externalities' in its use, and
- the false notion that water supply is unlimited relative to its demand.

However, recent changes in South African society triggered by the new political dispensation and the imperatives for equality of access to water as enshrined in the Constitution of SA; and the 1998 Water Act have placed new demands on what is, although renewable, a limited resource. Indeed, as an essential life supporting resource, water should be shared 'equally', according to the spirit of "**some for all for ever**" (The Constitution of SA, 1996; Hartwick & Olewiler, 1998; DWAF, 1998, 1999). This theme will be elaborated further in the next chapters. As for now the methodology that will be used in this thesis will be outlined.

#### **1.4.10 Methodology**

This dissertation is a continuation of the Masters students' group effort (- which culminated to the UCT-CMA Water Study (2000)) on an individual basis. Thus, inevitably and understandably, it shares the basic data and some methods. However, its research methodology - including its conceptual framework, approach, procedure, instrumentation, apparatus and some methods will be different.

The research undertaken for this work is based on literature review of local and international treatises, qualitative and quantitative analysis of empirical data collected from fieldwork. The field work was preceded by a short practical course on how to do water auditing conducted by Mr. Roy Donovan, a water audit expert consultant, director of Tweeddale Consulting Services CC. Actual water auditing of 17 industrial, commercial, or institutional facilities in the CMA were conducted between June - July, 2000. Some results of the Baseline Report (2000) questionnaire, personal direct communication and indirect interviews by using facsimile and e-mail are used. Some of the specific methods of approach are briefly outlined below:

##### **Literature survey**

This research will use information from literature review of empirical treatises. This was done to create and improve a theoretical basis on which to compare WC/WDM options and opportunities in the CMA. The following methods were used to collect relevant literature:

- Direct collection from the University of Cape Town, University of Stellenbosch, CMA, DWAF and private libraries.

- Indirect collection by requesting information from relevant sources, such as the MLCs, and the WRC of SA, and
- Internet search

This was a continuous exercise throughout the research and compilation period.

The intention was to be conversant with water management issues as locally and internationally practiced. This provided a basis for reviewing and critiquing available literature, case studies, and presenting a methodology and procedure for designing WC/WDM programmes for the CMA.

### **Data collection**

Relevant data was obtained from various sources:

- Published data from books, scientific journals; and unpublished researches, dissertations and reports - including the UCT-CMA Water Study Baseline Report (2000).
- Results of the questionnaire survey conducted in the CMA in June - July 2000 for the Baseline Report (2000).
- Extractions from CMA's and MLCs' water bills, water statistics, and
- Personal collection from the water audit field exercise conducted on premises of the 17 different facilities in the CMA.

### **Data analysis**

Collected data on relevant variables, including water supply and demand, population size, growth rate, production, and others was subjected to rigorous quantitative analysis by using a statistical approach.

### **Methods**

Both descriptive and inferential statistic methods of analysis, graphs, tables and schematic diagrammes were used when and where deemed necessary in order to illustrate some points and arguments. Other particular methods are as follows:

- In order to strike a balance between economic methods and other social science methods too much abstraction, assumptions, and 'mathematisation' is avoided and complex theories and equations will be included when necessary, and only as an Appendix.
- An attempt will be made to use a holistic, and pragmatic approach without sacrificing economic rationale.
- The historical methods will play an important role especially when it comes to analysing historical records pertaining to water consumption records.
- Other scientific methods will include comparative analysis, systems analysis, cost-benefit analysis, opportunity-payback analysis and sensitivity analysis, as the case may be.

#### **1.4.11 Definition of the key words and terms**

This thesis examines a relatively new concept of water management and uses economics, management, and some technical terms that are not commonly used by most people, especially the ordinary water consumers who are actually the target of this work. It is therefore pertinent to give a clear definition of the key terms right from the outset. The key words/ terms that will be frequently used in this work are the following: **Water Conservation, Water Demand Management, Economics, Economic Efficiency, Water Efficiency, Scarce water resources, Optimisation, Water Demand Management Opportunities and Water Demand Management Measures.** Although a comprehensive glossary is included at the end of the thesis for easy reference by some readers, all the readers are invited to read

and to familiarise with the specific meaning of these few terms/words as they are used in this thesis before proceeding.

- **Water conservation** is defined as the efficient use of water so that wasteful uses are eliminated. In essence it is the saving of water by any means including water efficiency. (Bouman et al, 1980;NMOSE, 1999; DWAF,1999b).

It is considered as an objective as well as a strategy in water resource management. 'Conserving Water' traditionally meant 'water preservation' and to many consumers it often meant curtailment: not to be able to flush the toilet/ urinary or to wash the car as often, and many other inconveniences. However, today it is widely acceptable that "conserving water" does not necessarily lead to depreciation of the quality of life styles as a result of 'consuming' or 'wasting' less water.

As it was depicted in the Baseline Report (2000), and will be further elaborated in this thesis, conserving water in essence calls for the employment of improved water saving technologies and devices, retrofitting the toilets, faucets, showerheads, changing irrigation equipment etc, as well as application of innovative management strategies. It involves as well the change of attitude towards water as a finite resource.

- **Water Demand Management** can be defined as those management measures which tackle water resource from the consumption side. It entails taking into account the value of water in relation to its costs of provision, and introducing measures which require water-users to relate their usage closely to those costs (Kreutzwiser et al, 1989; Winpenny,1994;Goldblatt,2000;Gillman,et al, 2000; [www.up.ac.za/academic/libarts/polsci/awiru/op5.html](http://www.up.ac.za/academic/libarts/polsci/awiru/op5.html)).

- In essence it implies treating water more like an economic resource as opposed to an abundant value-less resource, provision of which is free as an automatic public service. WDM is therefore, essentially a WC strategy and not an objective in itself.

- **Economics** - is defined and used in its broadest meaning as those theories, principals and measures concerned primarily with the efficient, least-cost allocation of scarce productive resources. As a discipline economics studies the relationship between limited means and unlimited wants. In the water context, the basic economic problem as depicted and dealt with in this work, is that of limited supply of water as compared to the ever increasing need (demand) for water for consumption. It is now commonly agreed that water is a scarce resource, in the sense that availability of required fresh potable water is a problem in many parts of the world. Even where it is available, there is a cost attached to it, a factor that some times makes it expensive and unaffordable to some sections of the population.

In this work, in the next chapters a development economics perspective will be used in order to accommodate structural and institutional transformations taking place in the water sector, in the CMA. This augurs well with the new tasks of transforming the entire South African society in a manner that the fruits of economic prosperity will/can benefit the broadest segments of the population (Torado, 1987;The SA Constitution, 1995; Water Services Act of 1997; National Water Act No 108, 1998).

- **Economic Efficiency** - There are two concepts of efficiency: economic efficiency and technological efficiency. Economic efficiency occurs when cost of producing and exchange of a given output (goods and services) is as low as possible. Technological efficiency is an engineering matter and occurs when it is not possible to increase output without increasing inputs. Given what is technologically feasible, some thing can or cannot be done. Economic efficiency depends on the prices of the factors of production and specialisation in production and exchange based on the comparative advantage,

least cost planning and market forces. Something that is technologically efficient may not be economically efficient, but something that is economically efficient is always technologically efficient (Parking et al., 2000). Furthermore, it will be demonstrated in this thesis that economic efficiency can be compatible with other societal water allocation criteria such as equity and sustainability as long as proper planning and application of a proper mix of economic instruments is effected.

- **Water efficiency** - is the employment of devices and practice which result in less water being used for the same task or function. An efficient practice would be recycling water for a second use. Utility-based efficiency measures include metering, leak detection and repair programs, improved tariff structures, and pressure-reduction programs (The Water Program, 1994; SADC -IEMP, 2000).
- **Scarce (water) resources** - means that there is a limited supply of potable water relative to demand. It implies that the existing water resource is not enough to meet all the customers' requirements at that particular point in time.
- **Optimisation** - means achieving best or most favourable level among options. Optimisation of water systems means maintaining existing water using equipment or systems in good working order so that they do not use excess amounts of water.
- **WDM Opportunities** - These are the existing technological, economic and other possibilities for attaining water reduction and saving in a facility or an area without interfering with the quantity or quality of production or the welfare of water consumers.
- **WDM Measures** - These are the tools or means through which WDM is effected. A xxxxxx comprehensive list of WDM measures is summarised in Table 4.1 on page 58. It includes economic, managerial, technological and sociological/educational measures. This thesis focuses on the highlighted measures in Table 4.1.

#### 1.4.12 Structure of the thesis

The foundation of this thesis will be built around the concepts of economic efficiency as the basis of achieving optimum allocation of water resources, reducing and stopping water wastage in non-residential facilities in the CMA. This thesis has ten inter-linked chapters.

**Chapter I** briefly presents the water problem as it is in the world, SA and the CMA. This chapter identifies the existence of a potential water crisis in the CMA and emphasises that water resources in the CMA are limited and, in global terms scarce. The demand for water however is growing due to a high population growth rate, a fast developing economy and due to the necessity to address the historical inequalities by extending water services to all the people living in the area. It pointed out that there are many signals which suggests that sustainability of water resources is threatened both in terms of quality and quantity and apparently unless the current water usage patterns are changed, availability of fresh water resources will fall short of demand within the next twenty years. Already CMA relies on construction of expensive dams and transfer schemes because demand of water resources exceeds availability within the area.

**Chapter II** will be the starting point of tackling this potential problem. It will present the theoretical and conceptual framework for water valuation and argue that water is undervalued in many parts of the world, the CMA included.

**Chapter III** will seek to prove by using examples whether the contentions and theories discussed in Chapter II are true or not by presenting the actual water supply and demand situation in the CMA. It will attempt to show that water supply augmentation schemes are costly in all aspects - socially, environmentally, ecologically and economical; and that a new approach to water management is needed, at least to defer the construction of new dams in the area or nearby areas, until contingency measures for mitigating possible negative externalities are made.

**Chapter IV** will seek to demonstrate that a 'new water management approach' could be WDM based on water use efficiency, and effectiveness in optimising water conservation opportunities.

This chapter will therefore lay the foundation of further discussion about WC and WDM measures to be dealt with in Chapter VI. **Chapter V** however is a necessary interdiction in that it will presents Water Auditing and Leak Detection Survey as the very necessary initial steps or precursor for planning and for implementing any WC or WDM strategy. This is because Water Auditing and Leak Detection Survey takes an inventory of the water situation and identifies appropriate WDM measures in a given facility or area and explores the possibilities of optimising them by using the best available measures.

**Chapter VI** will build upon the theoretical aspects presented in Chapter IV and the findings obtained by the Water Auditing and Leak survey presented in Chapter V. This chapter will start by expounding the concept of water efficiency based on cost reduction, and move on to explore the opportunities of WDM in industrial, commercial and institutions in the CMA. It will culminate in presenting a methodology and systematic procedure for optimising WDM opportunities in industrial, commercial and institutions in the CMA.

Special attention will be paid to the methodology and procedure for calculating the amount of water saving, and the best technological practice by using modern water efficient fixtures/devices and equipment currently available in the market.

**Chapter VII** is a logical follow-up of the previous chapter, and will present the nexus between advances in economic analysis and implementation of WDM measures by presenting a methodology and procedure for assessing and evaluating impacts of alternative WDM measures and strategies. Only after accomplishing this task can alternative WDM strategies and measures be presented to the Authorities, so that they could make a choice of the best measure(s) or strategy.

**Chapter VIII** will accomplish the final task of presenting a methodology and procedure for designing a water efficient WDM programme by using multi-criteria and holistic approach based on economic and technological efficiency as discussed in the previous chapter.

**Chapter IX** will provide a synthesis of the major aspects of WDM discussed in the previous chapter without repetition, by adding new dimensions and perspectives. Special attention will be paid to integrating of WDM strategies and measures into water resource and water services planning process in the CMA.

**Chapter X** will give a general conclusion and some pertinent recommendations.

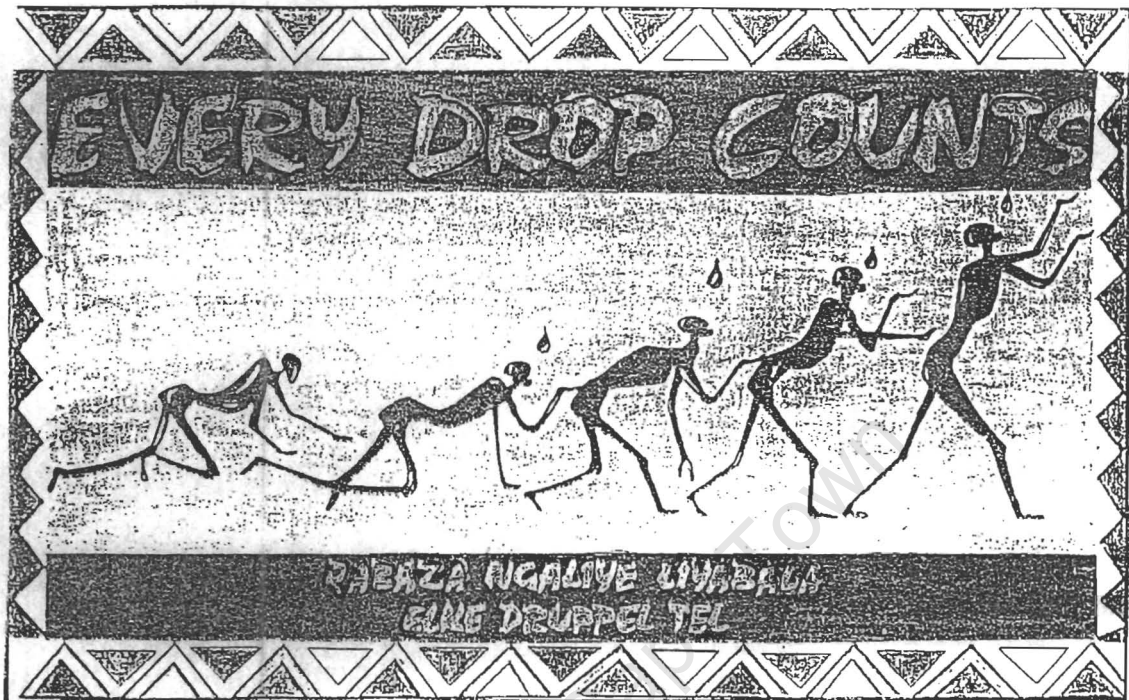
Apart from a list of cited references, a comprehensive glossary, a list of contacted people, and an appendix is attached as part and parcel of the discussion and methodologies and procedures presented in the preceding ten chapters.

When ever possible some relevant cartoons, plates and quotations are used at the beginning or the end of chapters or sections to convey important messages relevant to the topic under discussion.

Apart from for headings and subheadings, **bold** is used for quotations, and new words or new terminology, which are defined in the glossary.

The point of departure in the next chapter is to discover the real total value of water and to solve the 'paradox of value' involving water and diamonds, so as to know why water as a resource is undervalued; and what the consequences of this under-valuation are.

University of Cape Town



Source: CMC, 1997

" We never know the worth of water until the taps dry up " [JRK, 2000]

## CHAPTER II

- Valuation of water as a scarce resource

## 2. VALUATION OF WATER AS A SCARCE RESOURCE

"South Africans undervalue water. Many South Africans particularly those living in the middle and upper class suburbs, are unaware of just how scarce a resource water is in this country. And they will proudly remain unaware unless their supplies suddenly dry up or become extremely expensive." Simon Forster of Economic Project Evaluation Consultants, 1994.

"Cape Town is wasting water and could soon have a system of "stepped " water tariffs... We haven't been charging enough." Water Affairs Minister Ronnie Kasrils reported in the *Cape Times*, August 23, 2000.

### 2.1 Introduction

In the previous chapter it was established that SA and CMA are dry and water stressed areas, which under normal circumstances should treat the existing water as a highly valuable scarce resource. As well it was shown that if the current rate of water demand growth rate persist, this part of the world could face water supply shortages by 2020. Yet it was shown that water is wasted and not treated as a scarce economic resource in many parts of the world, including the CMA. The basic question posed in this regard was whether or not market forces should be employed to allocate this vital resource by fixing its price in the market and thus enhancing economic efficiency. Other pertinent questions posed included: Can water resources in the CMA be treated solemnly as a commodity and subjected to market forces and principles? How is water given value?

This chapter attempts to answer these questions by building upon the preliminary theoretical assertions, facts and prepositions presented in the last chapter. It will briefly explain the so called '**paradox of value**', discuss how water is undervalued in the 'free market' system, present the real cost of water, and the framework for water valuation from an environmental economics perspective. In order to achieve these goals this chapter will tackle these questions and other related aspects under the following seven sub-sections: Theory behind water valuation; Total Economic Value of Water; Varieties of costs of water; Cost of water in different countries. And finally attempt to present a comprehensive procedure and framework for water valuation.

### 2.2 Theory behind the value of water

Economic valuation of environmental resources such as water is based on a number of basic premises or conditions relating to the 'free market' economy as per neo-classical economic thought:

- The resource has to be well-defined, secure and exclusive,
- There exists property right(s) to ownership of that resource,
- The ownership of the resource should be transferable,
- There should be a full information available concerning the quality and quantity of this resource, and
- All markets for this resource should be perfectly competitive.

(Ortolano, 1997; Kombe, 1999)

Any firm that owns a good or service which meets these basic criteria is a "price taker" in the sense that it can buy or sell its goods or services at the going market price (Seneca & Taussig, 1984). Many environmental goods, such as water, air, access to the beautiful beaches etc. do not meet these criteria hence they do not qualify due to the fact that they do not have a clearly defined ownership rights because of their status as 'common shared resources'. As compared to other natural resources such as oil, gas, and coal; water and air

have extremely large, perhaps prohibitive 'market costs', that is the cost of establishing their ownership or establishing a working price systems for them is high (Hyalte et al., 1985). Consequently, the latter are treated as '*res nullius*', that is, "free goods" and are misused as they are not afforded the protection offered by private ownership.

One reason may be that although some kind of property rights can be established on certain common resources, water in this case, the cost associated with enforcing these property rights, otherwise known as **transaction costs**, outweigh the benefits by the owner (Steiner, 1969).

Theoretically, the higher the transaction costs, the lower the net benefits gained from these property rights. Thus, due to high transaction costs the market price for water is likely to underestimate its economic value to society (Dohan, 1977).

At this juncture the so called "**paradox of value**" involving water and diamonds should be explained: This paradox or puzzle was raised by Adam Smith, the 'father of economics' more than 230 years ago and raises the following fundamental question:

**Why water, which is essential for life itself so inexpensive, but diamonds, which are useless compared with water, and are non-essential items to most people, are so expensive?**

This 'paradox' can be solved by differentiating between **total utility** and **marginal utility**. The total utility, that is the 'complete satisfaction' that we get from water is enormous but the more we consume water the lower its incremental value or marginal utility (Parkin et al., 2000). When we are thirsty for example, the first glass of water we drink has a higher utility to us than the following one, and as we quench our thirst, the benefit we get from one more glass of water diminishes to a tiny value. As for diamonds on the other hand, they have a small total utility relative to water, but because we buy few diamonds, they have a high marginal utility. The notion that generally there is an abundance of water supply out there relative to the demand for it lowers its price. The outlook and "free gift of nature" attitude towards water as a resource has throughout history led to general institutional, policy and market failures on a universal scale (Winpenny, 1994).

**What then is the real value and cost of water?** The next sub-section will highlight the framework for determining total economic value of water (TEVW), and the framework for placing the 'right' value on water.

## **2.3 Total Economic Value of Water**

Historically, the value of water has had many social, political, religious, diplomatic overtones, not necessarily reflecting economic rationale. It was previously argued in the introduction that the most basic reason why there is a potential water shortage in the CMA, for instance, is the failure of CMC (supplier) and the water consumers in the CMA to treat water as a scarce economic resource of considerable economic value.

There is a general consensus in the literature that water is 'scarce' in the CMA. Indeed, nowhere in the literature it is denied that CMA has a potential water shortage. Conservative estimates show that demand for water will outstrip its supply by the year 2020 (DWAFA-SA, 1991, 1992; Davies et al., 1998; Baseline Report, 2000).

The contention that water is generally under-valued in most parts of the world requires a theoretical elucidation and a practical substantiation. To do this there is a necessary to grasp

the concept of **Total Economic Value of Water (TEVW)**. The various components of TEVW are schematically presented in Figure 2.1.

TEVW incorporates a number of direct and indirect values to human society, including the following: Direct utility to living things; Indirect functional benefits such as transport, cooling the earth, rainfall formation, supplier of carbon dioxide, and acts as a "sink" for wastes. Other values are: Optional use value for future use and to ensure sustainability; Bequest value—especially for future generations and Existence or Intrinsic value derived from the knowledge of water's continued existence (Dixon, 1986).

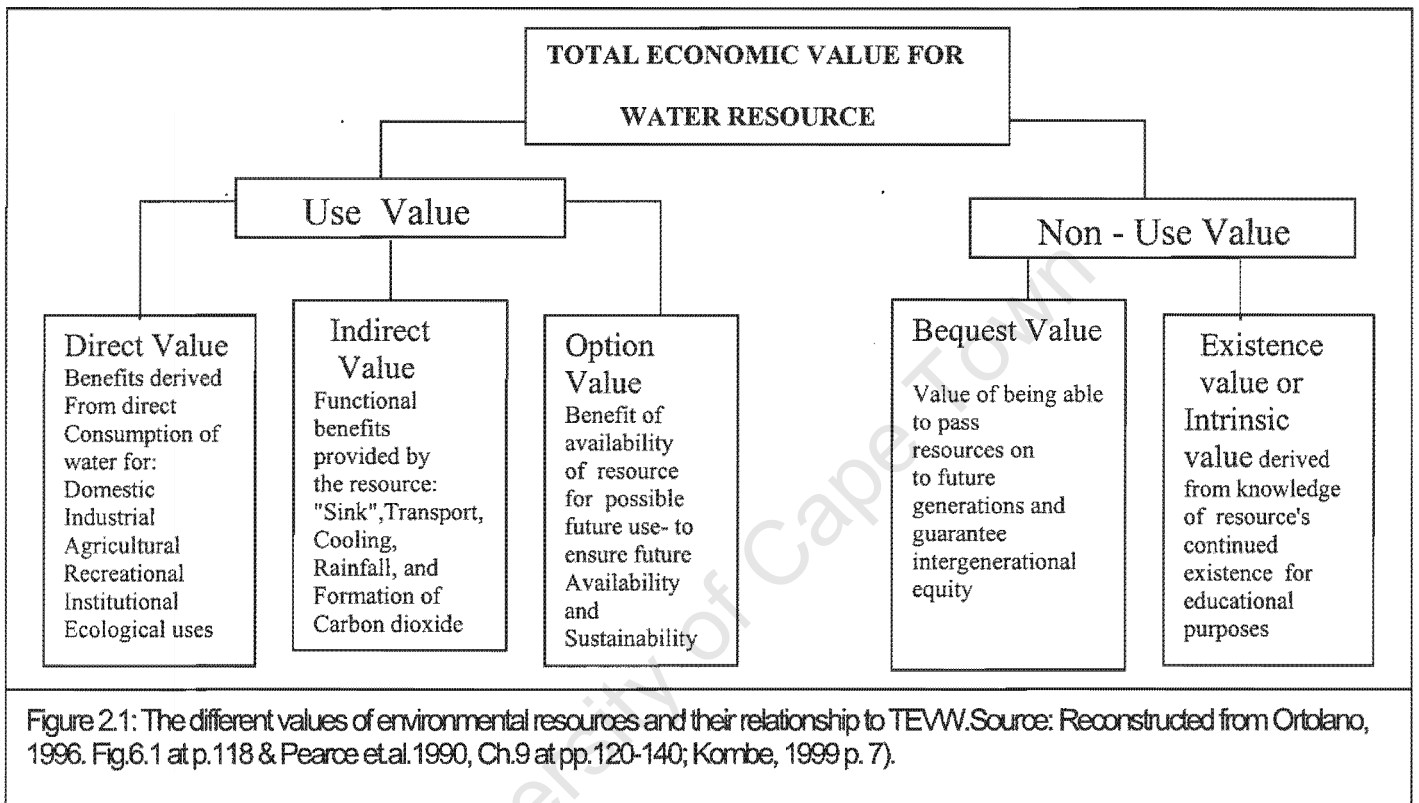


Figure 2.1 summarises the typical salient values and function for water. In order to appreciate fully the value of water as an environmental/natural resource, one has to take into account the various components of the TEVW as depicted in Figure 2.1. Economic importance of water in the CMA is reflected by the extent of water consumption in the area as shown in the structure of water demand in Figure 3.4.

## 2.4 The Cost of Water

What consumers pay for water is only part the its overall value (Moore, 1989). The cost of water to the consumer substantially varies from one place to the other and from one country to another. This depends on a number of factors, including the extent of variable and fixed costs, environmental costs, and opportunity costs as discussed below.

Availability of water to users in some situations can be achieved at little or no cost, for instance, water sourced from a natural spring, from a fully recharging aquifer, or use of

season rainwater for raising crops. Rainwater harvesting from rooftops needs a small investment for equipment-tanks, collectors and installation charges.

Once these small costs are paid, the rainwater is also free for all practical purposes. The marginal cost, that is, the cost of obtaining the next unit of water is very low, more so where the investment in supply capacity is still under utilised. However, normally water has a significant real cost of supply.

## **2.4.1 The Varieties of Costs of Water**

### **2.4.1.1 Costs of provision**

Costs of provision are costs incurred for capital procuring fixed assets and recurrent outlays in water supply, treatment and distribution, drainage, sewage collection and treatment (Winpenny, 1994). Costs of provision constitute a major factor in determining the price of water. There is a consensus, at least among economists, that water tariffs should be based on the marginal cost of supply, that is the cost of adjusting long-term capacity caused by a given change in demand (Winpenny, 1994). This pricing rule assumes/presupposes that water consumption is optimised, in the economic sense, at the point where the net benefit from marginal (last) unit of supply equals the cost of providing that increment. If the benefits were greater, there would be net gains from expanding supply. Society would gain more by reducing supply to the point of equilibrium if the benefits were less.

### **2.4.1.2 Environmental costs**

These are the costs incurred by the environment when water is abstracted or used (e.g. damming rivers, destroying wetlands, depleting aquifers), as a 'sink' for disposal of waste water (sewage, effluent, run-off). At present it is not possible to measure in exact economics or financial terms environmental and ecological damage (cost of externalities) caused by human activities. However, it is possible to use environmental economics or natural resource valuation methods, such as contingency valuation and cost benefit analysis to get rough figures.

### **2.4.1.3 Opportunity costs**

At any given time and place water as a finite resource has different uses and users competing for it. Therefore water costs have to be allocated between the various users. In a municipality such as the CMA, water is used in different sectors of the economy and for domestic purposes. If water was to be treated as other goods, and were traded like them according to the market forces of demand and supply, these alternative values would be reflected in its price. Unfortunately, in many parts of the world well functioning water markets are non-existent, hence the opportunity cost is seldom signaled to the consumer or polluter. However, the existence of competing alternative consumers warrants charging at least the economic price, that is the price that covers the provision costs discussed above. Examining the cost of water in other areas/countries, it will give a picture or indication of the value of water.

## **2.4.2 Cost of Water in Different Countries**

Water costs vary substantially from place to place depending on the interplay of many factors including, the availability of water, location of water supply source, cost of equipment, installation costs, technology used, taxation and tariffs. Water costs, for instance, among industrialised users vary substantially (Moore, 1989) depending on the production costs and

the extent of respective government subsidy on water. Variability in the amount the consumers pay depends on whether the rates reflect the full costs, or are subsidised or not. Water is in practice widely undervalued, and this leads to its inefficient use and abuse by consumers since they do not feel any financial pinch inflicted by the low water bill. The value of water is usually equated to the cost of producing it; costs of equipment, installation, plumbing, treatment and distribution. Presumably, this does not cover the whole total value for water, as it leaves out the cost of non-use values including, existence value, bequest value, and partially, if at all, places full value to option value aspects, such as sustainability.

The real economic value of water, in economics terms is the marginal cost of provision plus marginal external cost as graphically depicted in Figure 2.2.

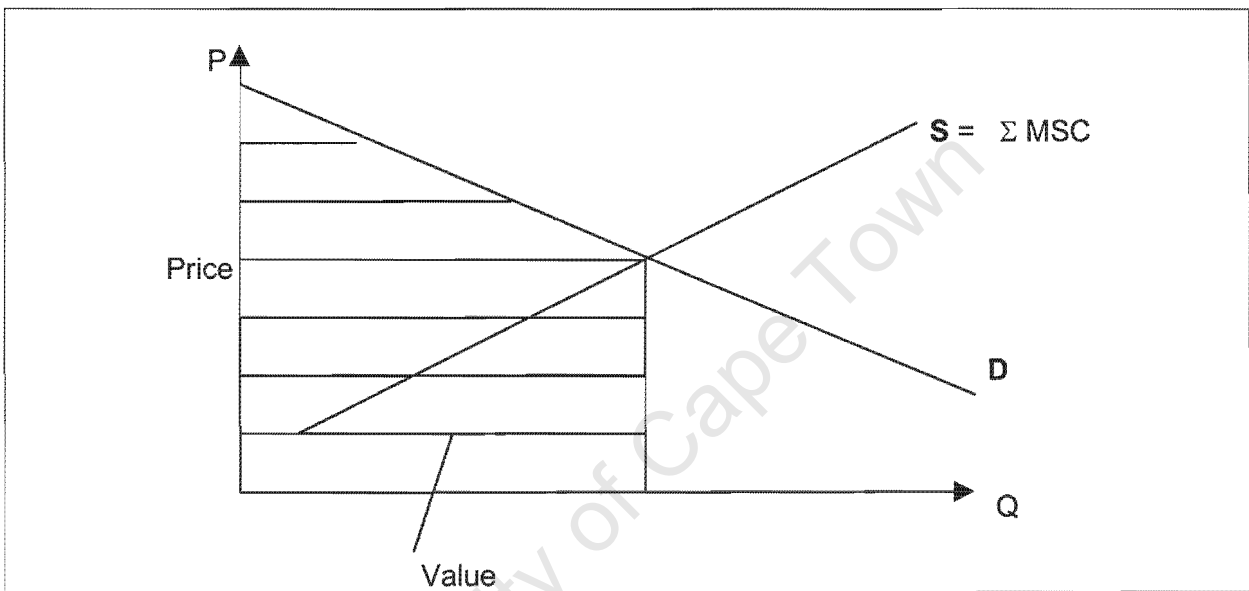


Figure 2.2: Value of water from economics point of view  
Source: Author's construction.

In Figure 2.3 it is assumed that in an optimal 'free market' world, where water markets exist, and are perfect, supply of water is equal to the sum of marginal social cost ( $S = \Sigma MSC$ ) and thus equal to the marginal cost of provision plus marginal external cost. The shaded part in the graph depicts the total value of water. Today's realities, including, occurrence of intermittent droughts and floods, actual and potential water shortages in many parts of the world have called for a serious consideration of some alternative methods/approaches to evaluation of water as outlined below.

## 2.5 Procedure and framework for water valuation

### 2.5.1 "Next Best Alternative"

This approach establishes the value of water by determining the cost of the best alternative (Mitchell, 1884; Moore, 1989). It reflects the cost of obtaining and delivering alternative supplies.

Today, in many parts of the world, the next best thing alternative to supply augmentation is demand management. These 'cost savings' could be considered as the value of water at that place in time. To these cost savings the value of social and ecological costs forfeited should be included to come close to the TEVW (Moore, 1989; Ortolano, 1997).

### **2.5.2 Value Added**

The value of water can be established by determining the value added to a product or process by the input of water.

This procedure is more suitable when applied to recreational or value of agricultural output. In the case of agriculture the value added to farm yield as a result of irrigation can be attributed to water.

This concept can also be applied when evaluating the costs of a dam in terms of a loss incurred to "downstream" water users, whose water is impounded, degraded or flooded. That is why an economic analysis of the impact of upstream action on communities and activities downstream is important for calculating appropriate compensation (Mitchell, 1988).

### **2.5.3 Existence Value**

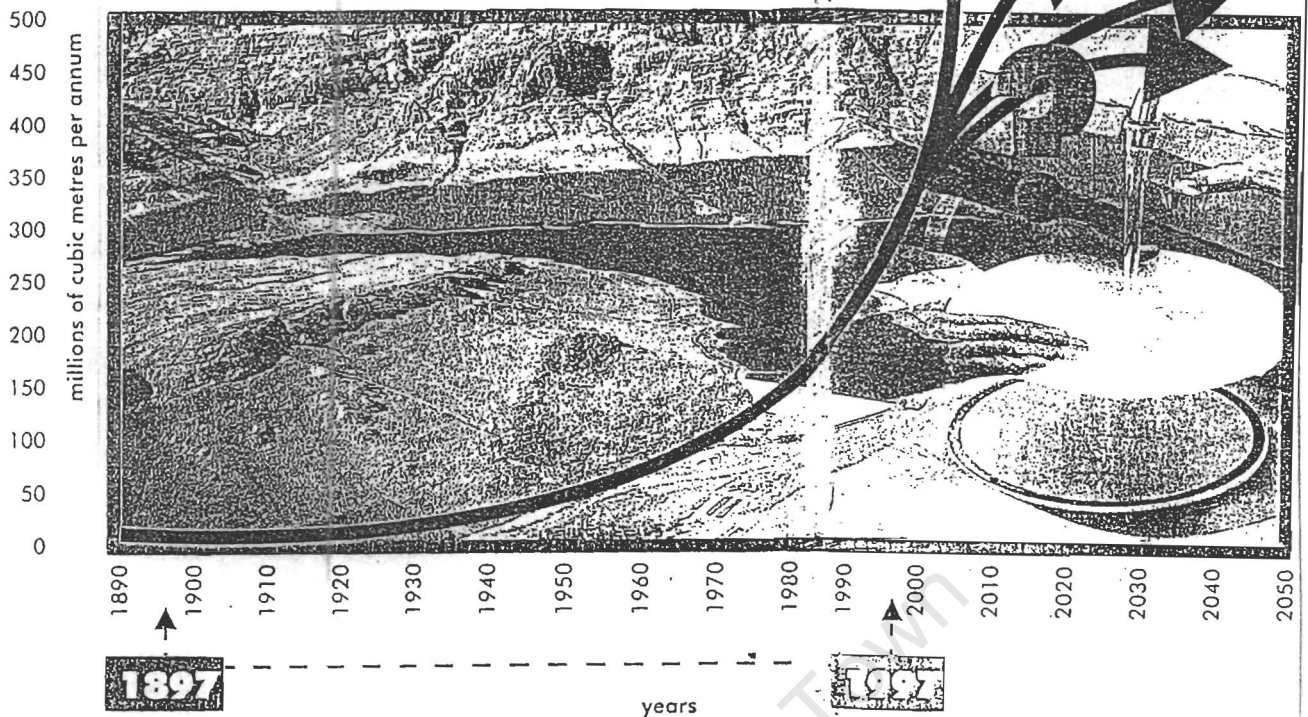
An existence value, otherwise referred to as intrinsic value, could be assigned to water before it is developed. The explicit value is determined by bargaining between or among interested and affected parties. This existence value is added to the costs of supply, treatment and distribution to get to the full cost to the user (Mitchell, 1988; Moore, 1989).

In summary, the real value of water can be established by using the three methods discussed above. However, it has to be borne in mind that these three approaches for estimating the value of water are rarely applied in isolation. In other words, the valuation of water as a resource employs a combination of these approaches. They emphasise that the total economic value of water can be obtained only when attention is paid to environmental recreation and non-participatory values which might be polluted or destroyed by a water supply augmentation scheme (Muller, 1985; Brooks and Peters 1989; Moore, 1989).

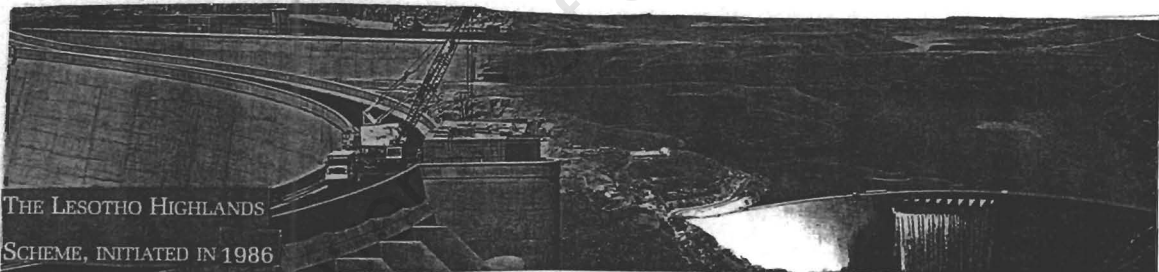
## **2.6 Conclusion**

This chapter has proved right the hypothesis that water as a resource is generally undervalued despite its vital functions including the direct support of life on earth. This undervaluation is based on economic valuation theories, premises and methods operating in the so called perfectly 'free markets' which in practice do not exist. Today environmental economics has made a breakthrough by providing a methodology for establishing full value of natural resources such as water.

Total economic value of water can be established by taking into account all the costs involved from the society point of view: costs of provision, environmental/ecological costs, and opportunity costs. In an optimal world supply of water would have been equal to marginal social cost, that is, equal to the marginal cost of provision plus marginal external cost. However, since, the 'optimal world' seldom exists, the supply of water is influenced not only by 'economic rationale' but as well by political, social and strategic factors as will be elaborated in the next chapter.



" When the Woodhead dam was built it was expected to solve all of Cape Town's water problems. Instead, the demand increased so rapidly that no sooner was the Woodhead finished, than a start had to be on the Hey-Hutchison". Source: CMC, (1997) - Woodhead Dam Centenary:



THE LESOTHO HIGHLANDS  
SCHEME, INITIATED IN 1986

" Water supply the CMA is becoming scarce due to a number of factors: increased population growth rates, improved life styles, and dwindling supplies, both in quantity and quality. The resultant is an increased demand for water, high and rising water development costs, intensive competition amongst all users of water " [JRK, 2000]

## CHAPTER III

- Supply & demand for water in the Cape Metropolitan Area

### 3. SUPPLY AND DEMAND FOR WATER IN THE CMA

"The forces to be dealt with are so numerous that, it is best to take a few at a time...Thus we begin by isolating the primary relations of supply and demand..." Alfred Marshall (1842-1924) - The Father of modern day theory of Demand and Supply - in the *Principals of Economics*. (Parkin et al., 2000 p. 94).

#### 3.1 Introduction

One of the consequences of under-valuation of water as a resource is that its supply and demand creates a vicious circle situation, whereby water supply endlessly chases demand for it. This is the normal simplistic way of understanding the forces of supply and demand for water. In economics the heading of this chapter is incorrect in the sense that it does not follow logical economic sequence of events. Its like putting the cart in front of a horse, because supply of a good or service is a response to its demand and not vice versa. To 'demand' some thing in economics imply that one is has the desire (a want) for it, and has the willingness and ability to pay a certain price in order to possess it. In other words it is not just the need for it, it is as well the plan and ability to afford it. In life it is how much of a good or a service people in the market will buy at a given price over a certain period of time.

Supply in economics refers to how much a good or a service will be offered for sale at a given price over a given period of time. The quantity supplied of a good or service is the amount producers and service providers plan to sell during a given time (Harvey, 1993; Parkin et. al., 2000). But, unfortunately provision of water, as an essential natural good does not comply with these economic principles and logic.

This chapter first presents the conceptual framework for understanding supply and demand for water; secondly, presents the current water sources and future supply options of water resources in the CMA; and thirdly, it evaluates past demand trends and presents current and future demand forecasts.

#### 3.2 Conceptualisation of supply and demand

To non-economists supply of water simply means the quantity of water available in a reticulation system (potable water) which is ready for utilisation by people regardless of the distribution system. Demand for water simply means the amount of water used at a given time in a particular place regardless of whether the users can afford to pay for it or not.

Therefore, 'supply' of water to meet future water demand is planned well in advance and supply augmentation schemes and infrastructure are built before hand so as to meet future 'demand'. In the short run when a new dam is built demand for water can be met temporarily and a surplus supply created. This temporary excess supply means that the CMC has an incentive to sell as much as it can in order to get revenue in. Depending on the elasticity of demand, (that is the degree of responsiveness of demand to price changes), this may mean raising prices and selling less water (if elasticity  $< 1$ ) or lowering prices and selling more water (if elasticity of demand is  $> 1$ ).

However, experience from the CMA itself shows that the 'meeting' of water supply to water demand is short lived, given the reality that over time an increase in industrial production and population growth will consume any excess supply. Furthermore, if supply and demand forces were allowed to operate freely, the more the water available and supplied, the less valuable it would have become, that is, the lower the price for it and consequently the more

likely the amount of wastage. In most parts of the developing world, supply of water still chase demand for it, and the CMA is no exception.

It was noted above that in economics, demand for a good or service precedes supply and that the later normally responds to demand. Supply for a commodity to the market is triggered by demand for it, unless the producers/suppliers want to risk (not selling at all) resources by anticipating demand or creating demand- is not the normal way of things in the 'free market'. Let us move the discussion further by examining how the forces of demand and supply for water operate in a 'free market'.

Demand and supply are the dominant forces in the free market arena, and can be considered as two sides of the same coin. The fact is there can be no supply without demand and vice versa. The impact of these two forces on fixation of price is enormous, especially when they are not disturbed/influenced by outside forces, i.e. operate in a perfectly free market. In such a market it is assumed that the forces of demand and supply operate, pulling in opposite directions acting according to the laws of demand and supply.

The law of demand states that:

**Other things remaining the same, the higher the price of a good or service the smaller the quantity demand and vice versa.**

The law of supply states that:

**Other things being equal, the higher the price of a good or service, the greater the quantity supplied and vice versa.**

However as discussed above water has unique properties and do not comply with the laws governing the function of market forces, unless it can be privately owned and traded as a commodity. At present in many parts of the world water is still regarded and treated as a public property that should be controlled by governments at different levels, or collectively by communities. It is assumed that it should be consumed more or less equally by all the people, especially to meet the 'basic needs' regardless of their ability to pay for its full costs.

For the purpose of this thesis the reality that the CMC is the water authority, the supplier of most of the water in the CMA. It is necessary therefore, to consider supply and demand for water in the area as mutually inclusive forces regulated by the CMC/local government by fixing tariff rates/prices for it based on a number of criteria to be discussed later in Section 7.2.

Further discussion will be based on Figure 3.1, which shows that there are a number of factors that can influence demand and supply of water. Most of these factors will be discussed in the next sections, especially in the context of WDM in the CMA. Suffices here to lay the foundation of the next discussions by highlighting the major principles, variables of demand and supply of water and their operating mechanisms as presented in Figure 3.1:

- Fresh potable water as a resource is limited in supply at a particular place in time even if the factors (- summarised in the upper box to the left) influencing its increase in the are in full operation. After all, there are some factors that act as 'contra', by fuelling a decrease in water supply (- summarised in upper the box to right) such as evaporation and pollution. The interplay of these opposing factors (+) and (-) s to supply creates a limit of yield of water resource in a given area in time.

On the contrary, the demand for water as a resource is unlimited in the sense that it keeps on growing as a result of both objective and subjective factors e.g. population growth and lack of water saving awareness, respectively (as summed up in the lower box to the left).

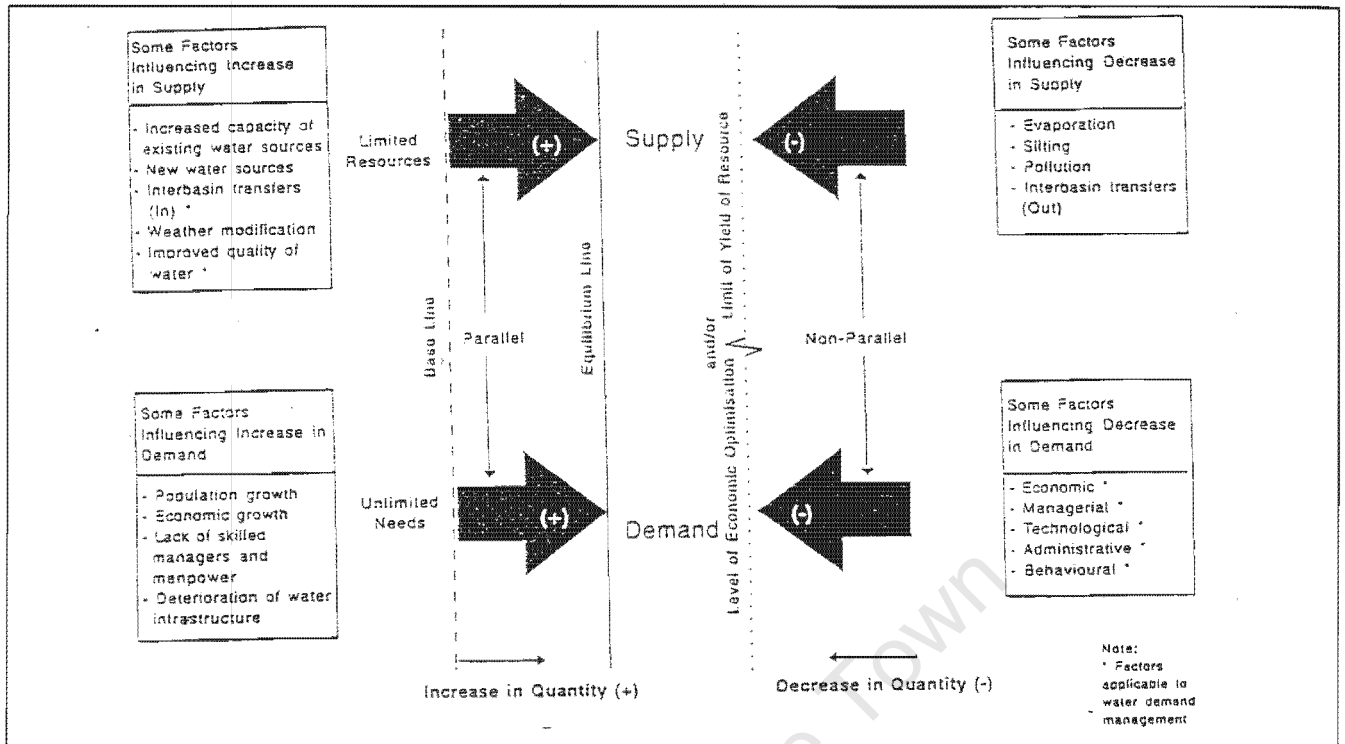


Figure 3.1: Schematic conceptualisation of water supply and demand forces

Source: Modified from Seneca et al, 1984; Vickers, 1991; Parking et al , 2000.

- This constant increase in quantity of water demanded (+) can be encountered by a number of factors that can check it, that is halt its increase or even decrease it. These factors are marked a negative sign (-) and are referred to as the WDM measures in this thesis (summed up in the lower box to the right) or WDM tools in the literature.
- Demand and supply can reach 'equilibrium line' when their quantities are equal (supply (+) = Demand (+)). But, this ideal situation/ encounter rarely happens in the developing world because of rapid industrial and population growth, financial constraints and inability to control the factors influencing supply and demand.
- Wastage of water can be reduced by using WDM strategies that include: economic, managerial, technological, administrative and educational measures as will be shown in the next sections. Optimisation of these WDM measures and opportunities therein can lead to reduction in water use and water saving without affecting the level of production or living standards.

Bearing in mind these important conceptual/theoretical frameworks pertaining to water supply and demand we can proceed to analyse water supply and demand in the CMA.

### 3.3 Sources of Present Water Supply to the CMA

Water supply to urban areas refers to the quantity of existing potable water available for consumption or utilisation. The water supply network of the CMA is "complex and extensive" (Baseline Report, 2000). The present raw water supply in the CMA has a combined firm yield of about 279 million cubic meters per year ( $279 \times 10^6 \times \text{m}^3/\text{a}$ ). Table 3.1 summarises the present sources of supply of water to the CMA.

**Table 3.1: Sources of Water Supply to the CMA in 2000**

	Source	Owner	Yield (million m <sup>3</sup> /a)
1.	5 dams and springs on Table Mountain Sivermine dam on Constantia berg	CMC	5.1
2.	Kleinplaas and Lewis Gay Dam	CMC	1.8
3.	Wemmershoek Dam	CMC	56.4
4.	Steenbras Dam	CMC	38.0
5.	Voelvllei Dam	DWAF	66.4
6.	Wellington Dams	Municipality of Wellington	0.7
7.	Paarl Dams	Municipality of Paarl	1.3
8.	Eerste River Valley Dams	Municipality of Stellenbosch	5.7
9.	Strand and Somerset West Schemes	Municipality of Somerset West	3.5
10.	Theewaterskloof and Kleinplaas Dam	DWAF	93.0
11.	Atlantis & Mamre (36) boreholes	CMC	4.4
12.	Somerset West (there are 4 boreholes)	CMC	0.6
13.	Palmiet River Phase I	DWAF	33.0
	Total		278.9

Source: **Modified from DWAF, 1992; Baseline Report, 2000.**

The bulk of this supply originates from five large dams - Steenbras Upper and Lower; and Wemmershoek owned by the CMC and neighbouring municipalities; and the Voelvllei and Theewaterskloof owned by the DWAF (DWAF-SA, 1992; Baseline Report, 2000).

This supply from the large dams is supplemented with about 15 small dams of not more than 3 million m<sup>3</sup>/a each.

## 3.4 Future water supply options for the CMA

### 3.4.1 Introduction

In order to ensure the CMA gets a constant supply of water in the future, way back in 1994 the Cape Town Water Undertaking (CTWU) commissioned a study - the "Western Cape Systems Analysis". This study among other options to explored the possibility of building a number of water augmentation schemes to supplement those already under the CTWU (DWAF, 1994-a; Ninham Shand et al., 1994; Baseline Report, 2000).

The study recommended many options - ranging from gigantic surface supply from new dams and reservoirs, ground water schemes, to radical, expensive but feasible options including re-use of sewage effluents, desalination of seawater, maintenance of catchment areas. As well as unconventional water supply options such as towing icebergs from Antarctica, and importation by tankers from Zaire River. Details of these options are summarised and attached in **Appendix C**.

However, the map in Figure 3.2 shows the position of the proposed new dams and pipe lines vis a viz the existing ones. Of interest to note on Figure 3.2 is that four major tunnels - the Steenbras, Theewaterskloof, Wemmershoek and Voelvleit dams crossing mountains and valleys to supply water to the CMA.

South Africa is one of the world leaders as far as removal of water from one part of a catchment to another (Davies and Day, 1998). This is what is called 'inter basin water transfers' (IBWTs) as shown in Figure 3.3. As for the CMA the most important IBWTs are the Riviersonderend-Berg-Eerste and the Palmiet schemes.

Taking into account the stance and stand of the DWAF on the construction of new dams as vividly expressed by the Minister of Water Affairs and Forestry - that as Minister he is "**not going to put in another dam while consumption is being driven up by those wasting water**" in the CMA. (For details see **Appendix A**). Therefore, various surface supply options, especially new dams will not be constructed, at least in the near future unless WC and WDM options are fully exploited in the CMA.

Consequently, it is pertinent to discuss the other alternative options for supplying water to the CMA including the following measures: Recycling and re-use of sewage effluent; Desalination of seawater; Maintenance of catchment areas; and the unconventional sources of water.

### 3.4.2 Recycling & Re-use of Sewage Effluent Option

Both local and international experience shows that sewage effluent can be recycled and re-used as fresh water. The CMA has up to now a number of treatment works, including: the Mitchells Plain, the Macassar, the Zandvliet, and the Cape Flats works.

Combined these treatment works yield about  $20 \times 10^6 \text{ m}^3$  annually, with a **unit reference value** calculated at R 0.87 per  $\text{m}^3$ . This water can safely be used for irrigation purposes, but needs further treatment (tertiary) before it can be blended with fresh water to become potable, and hence normal and safe (free of pathogens and toxins) for human consumption. This tertiary treatment is costly, and increases the unit reference to R 1.51 per  $\text{m}^3$  (Baseline Report, 2000). Apparently, this option is viable as long as its unit reference value is among the lowest, hence if implemented could to some extent alleviate pressure of constructing new dams.

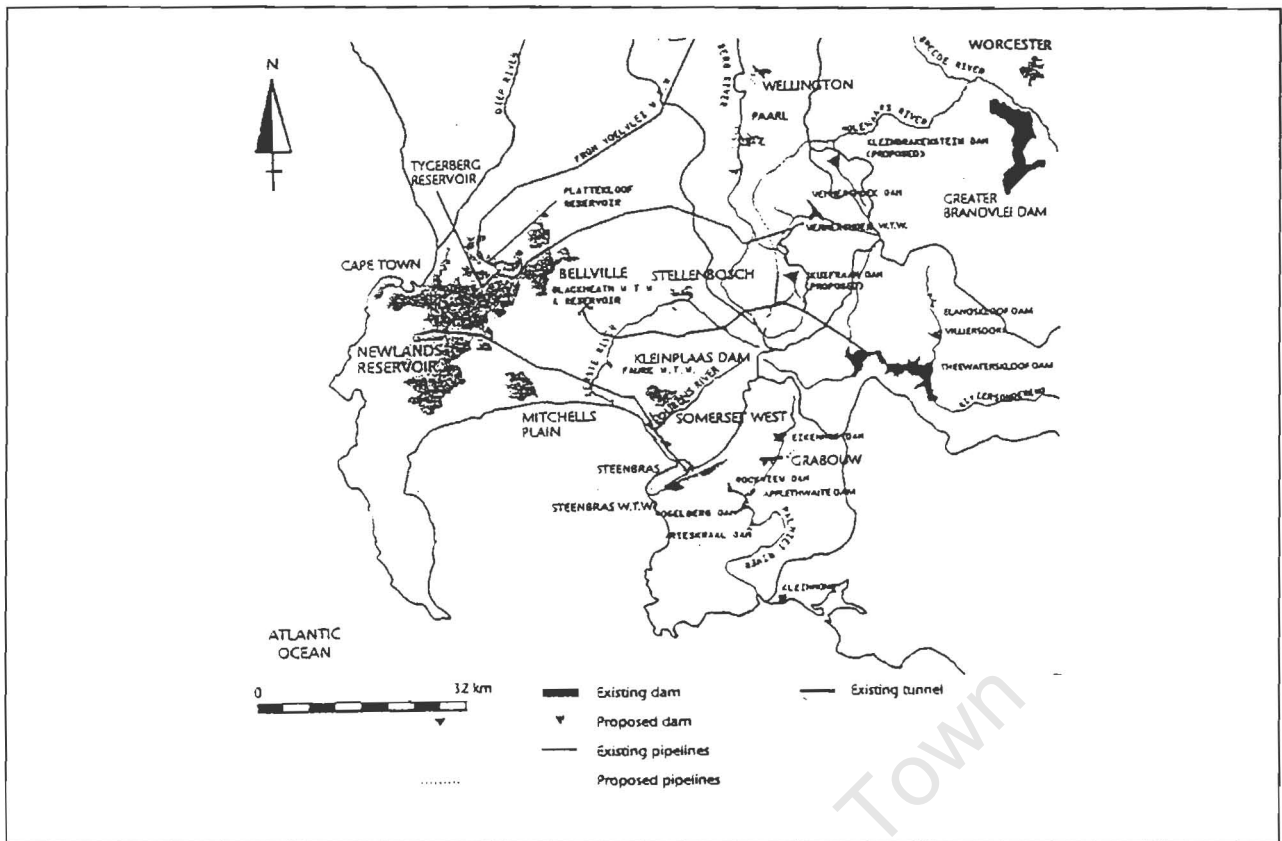


Figure 3.2: Water sources of the CMA as ascertained during the Western Cape Systems Analysis. Source: Davis & Day, 1998 reproduced from WCSA Ninham Shand.

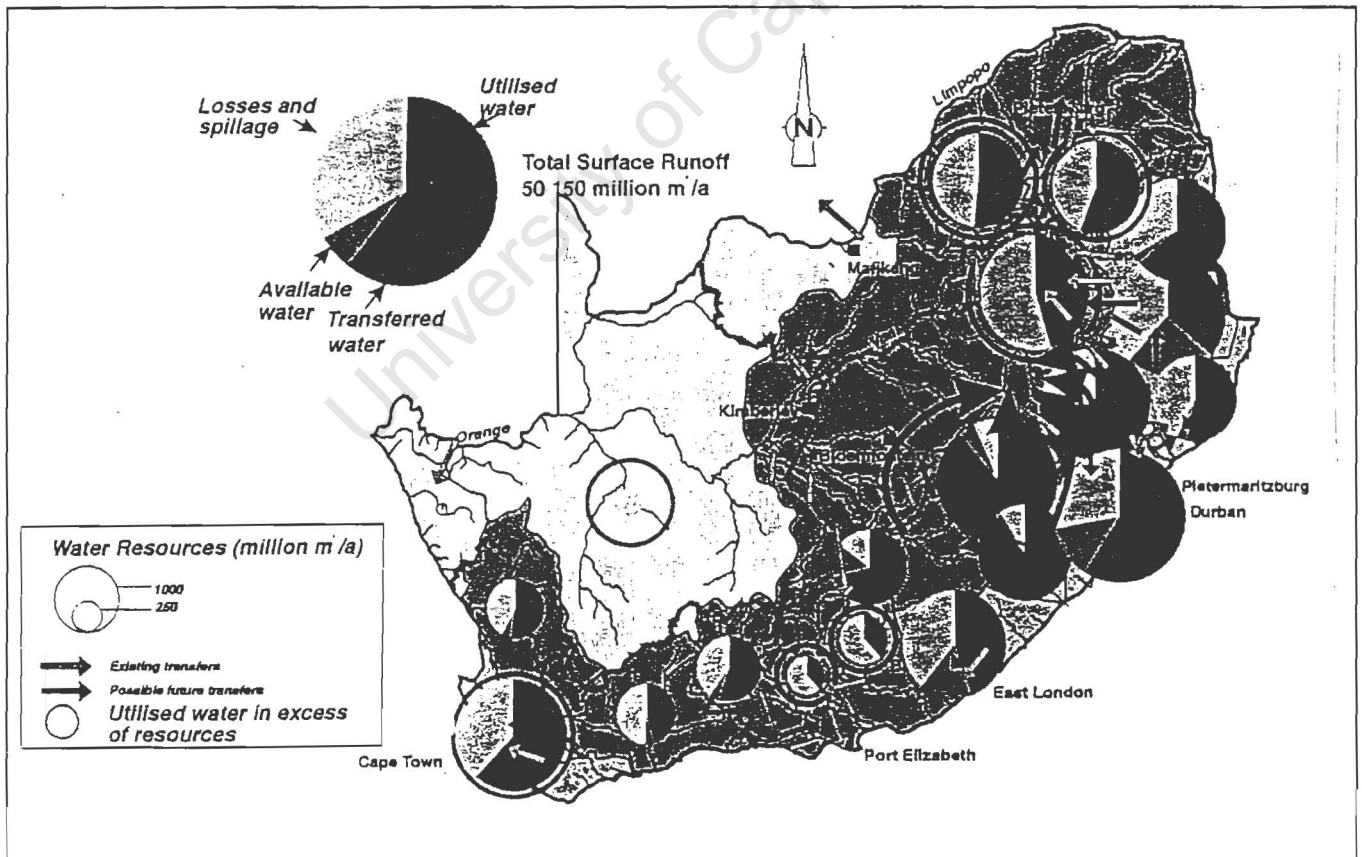


Figure 3.3: 2030 Water Utilisation in SA showing Inter-basin Transfers assuming that no implementation of WC& WDM measures. Source: WRSA Figure 22, DWAf, 2000.

### 3.4.3 Desalination of Sea Water

Seawater (saline) can be desalinated to provide unlimited fresh water supply for CMA, but the costs for it are very high. For example, despite the advantage of warm water (10 °C warmer than sea water) of already existing electrical reticulation facilities at Koeberg nuclear station, a desalination facility on the area can yield 100 x 10<sup>6</sup> m<sup>3</sup> p/a with a unit reference value of R 3.20 per m<sup>3</sup>. This implies that the venture at the moment is too expensive as compared to other options.

### 3.4.4 Maintenance of Catchment Areas

There is evidence in the literature that conclusively suggests that alien species are 'water thirsty' hence they reduce stream flow of infested areas (Preston and Davies, 1995; DWAF - The Working for Water Programme, 1999 ; Baseline Report, 2000). This is a necessary strategy for water conservation in the CMA and with an average unit reference value of between R 0.15 - R 0.30 per m<sup>3</sup> it is not so costly.

### 3.4.5 Unconventional Sources of water

- Importation by tanker e.g. from Zaire River: With a unit reference value of R 7.00 per m<sup>3</sup> this option is too expensive and economically not viable at least for now.
- Rainwater harvesting: This can be an important source of fresh water, and with a unit reference value of R 3.00 per m<sup>3</sup> is expensive, but a feasible option.
- Towing icebergs from Antarctica: So far, this option is not yet fully studied, but apparently it is unrealistic as the venture would be expensive.

### 3.4.6 Conclusion

To the CMC supply of enough potable water to the CMA is a high priority in order to support human life and for production purposes. So as to meet the ever-increasing demand for water the CTWU and later the CMC and previous governments struggle to build massive supply dams and reservoirs in the past 150 years or so, but the problem could not be solved once and for all.

Future water supply to the CMA is hinged on a few viable options: Building more dams and reservoirs, especially outside the CMA; Effecting interbasin transfers by using pipes and tunnels; Further exploitation of underground aquifers; Recycling and re-use of sewage water; and maintenance of catchment areas.

Today new supply augmentation schemes such as the planned Skuifraan dam (with a potential yield of 101 million m<sup>3</sup> - see Appendix C) and Palmiet Phase II (186 million m<sup>3</sup>); and interbasin water schemes such as the Brandvlei - Theewaterskloof and Michell's Pass - Voelvlei schemes are still on the top of the agenda. Unfortunately, there is a sense of urgency to supply more water to the area under any costs in order to meet the ever-increasing demand for it. This can create a serious threat to the environment; distort natural ecological balance; deprive other regions of water; and can cost a lot of money to the CMC and thus can limit its ability to embark on some other development programmes in the area.

That is why initially the DWAF was adamant to the government decision not to approve construction of any new dam unless, as Minister Ronnie Kasrils said - "proper management" of the existing water resources is effected and wastage is curbed " (Gosling in the *Cape*

*Times* of August 23, 2000 p.1). This 'proper management ' as will be discussed in the next sections refers to WDM strategies and measures. As for now it is appropriate to explore the 'other side of the same coin' i.e. - water demand.

**What are the factors fuelling water demand in the CMA? What is the actual demand for water in the CMA?** These questions and related pertinent aspects will be discussed in the next sub-section.

## 3.5 Water demand in the CMA

### 3.5.1 Definition of water demand

As it was discussed in the introduction to this section, the term 'demand' refers on different occasions to needs, wants, desires by people ready to buy, employ goods or services respectively. In economics 'demand' means **the amount of goods or services that consumers are willing and are able to purchase in a particular time in a specific space at a particular price**. It was shown schematically in Figure 3.1 that demand and supply are two sides of the same coin, and are the major forces that operate in the market acting parallel to each other.

Water demand as used here is the amount of water called for or needed in a certain time or in a certain circumstance in the CMA. It is 'value loaded' in the sense that its estimation is based not only on objective factors such as population and industrial growth rate; but as well on subjective values such as '**the basic needs**', equal distribution, 'affordable prices' *et cetera*.

Outlined and discussed in this sub-section are four essential topics, which are necessary to understand the situation and extent of water demand in the CMA. These topics are the following: Factors affecting water demand; Classification of water consumption; Current level of water demand in the CMA; and Reconciliation of demand for water to the existing supply in the CMA.

### 3.5.2 Factors Affecting Water Demand Growth

The major underlying factors influencing water demand growth are population growth and economic development (van Niekerk et al, 1995). An increase in the number of people increases the need (demand) for more water and the later increases as peoples' wealth grows. As communities prosper they increase their needs for water, move beyond the "basic needs " requirements (for drinking, cooking, single-tap / basin-washing and subsistence farming) to affluent uses such as two or more bath and taps in the house, swimming pools, saunas and overhead irrigation.

There are a number of other factors besides population and economic growth that also influence water demand growth. These other factors include:

- Physical conditions of a place - climate and relief,
- Cost and water tariff structure,
- Living standards,
- Level of technology,
- Water conservation and WDM strategies, and
- Where it is used and for what purpose/process.

The focus of this thesis is on the last three areas, namely, how water can be used more efficiently in commercial, industrial and institutional facilities by applying WC and WDM measures and the best available technology.

### Water usage depends on what?

In industries the amount of water used for a specific task depends on a number of factors, such as: The task to be carried out (e.g. water for drinking, washing, flushing, cooling, irrigation purposes); the size of the task (e.g. tons of product produced, square meters of the building floor)., It depends as well on the size of the population served; and the level of water efficiency of the performed tasks (Brooks and Peters, 1989). The same basis can be used in other areas after taking into account the particular characteristics of each area.

### 3.5.3 Classification of water consumption

Usually the demand of water is classified by sector, indicating whether it is used for Industrial, Agricultural, Commercial purposes or other demands as shown in Figure 3.4 below. However, it is common as in the case of CMA to be classified according to where water is used, viz., **Residential** (Domestic/Household) and **Non-residential** including (Industries, public and private organisations/institutions or installations)(Ploeser at al., 1992). A mixture of the two sectors, that is sectoral-functional and positional is used in the CMA, South Africa and in the SADC Region (Ninham Shand, 1994; Macy, 1999; Baseline Report, 2000).

### 3.5.4 Current(1999) level of Water Demand in the CMA

Generally, water demand can be obtained by analysing historical water use, and normalising the data to take out the effects of weather.

The CMA water demand is a combination of demand from individual sectors served by the municipal water and sewer system plus allowance for leakage and infiltration, otherwise collectively referred to as **unaccounted for water loss** (Brooks and Peters, 1989; Malan, 1994).

The most current water demand profile of the CMA is shown in Figure 3.4. This was obtained by updating previous WDM estimations by Ninham Shand in 1991, 1994, & 1999; and the figures are substantiated by both the Water Demand Workshop (3 March, 2000) and the UCT - CMA Water Study (2000).

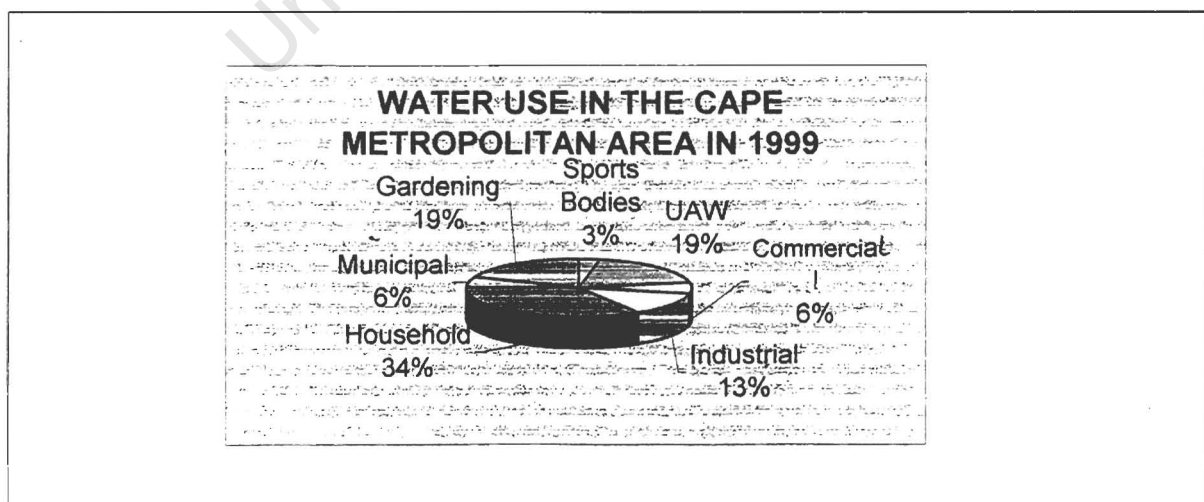


Figure 3.4: Water use by sector in the CMA in 1999.

Source: DWAF: Water Demand Workshop: 3 March 2000

Figure 3.4 shows that most water in the CMA (34% - 306 MI/d) is used in households, about 19 % i.e. 171 MI/d is used for gardening, while 13 % i.e. 117 MI/d and 6 % i.e. 54 MI/d for industry and commerce respectively. The amount of unaccounted for water (UAW) increased from 11 % i.e. 87MI/d in 1998 to 19 % i.e.171MI/d in 1999. This is serious because it indicates a dramatic increase by 96.5% in water wastage and water stealing in the area. The excessive wasteful use of water for gardening lawns (19% i.e. 27MI/d) could be reduced. As would be shown in Section 6 and as the South Peninsula Municipality directed (see **Appendix T**), this reduction can be achieved by using water efficient techniques and "xeriscaping" methods.

### 3.5.5 Factors affecting water demand in the CMA

Water demand is a function of many variables but the salient ones include population growth, increase in production, change in welfare status (affluence) and weather variability. The actual methodology for calculating water demand is outside the scope of this thesis. Suffices, here to state that water demand, and water use sector-wise is constantly changing in the CMA reflecting the changes in the major variables presented above. Table 3.2 shows projections in percentage changes of population and water demand in the CMA.

Table 3.2: **Population Growth & Water Demand in the CMA 1980-2010**

Year	Population ('000)	Water Demand (million m <sup>3</sup> /a)			
		Domestic	Industrial	Other*	Total
1980	1760	102	25	43	170
1985	1980	125	33	53	211
1990	2220	152	41	63	256
2000	3200	216	61	90	367
2010	3800	275	80	114	469

\*Mainly for municipal use, particularly for businesses and for watering of public grounds.

Source: **Projections by Spies & Barriage, 1991; Central Statistics Service, 1997; Bekker and van Zyle, 1998; Baseline Report, 2000.**

Table 3.2 shows that population in the CMA almost doubled in the last 20 years. In the next 10 years it will increase by 19% implying that there will be a more than proportionate increase demand for water by 2010. The conventional supply of water is about 279 million cubic metres per year (see tables 3.1 & 3.2), hence there is a deficit of about 88 million cubic meters (367-279). If the current rate of 4% increase of demand is maintained then demand for water in 2010 will reach about 514 million cubic meters ( $[367 \times 4\% \times 10 \text{ years}] + 367$ ).

This shows a deficit of about 45 million cubic meters of water (514-469). In short the demand for water in the CMA is increasing at a higher rate than its supply. Even if a new dam, the Skuifraam is built, the generated water surplus cannot last forever. Hence, water supply augmentation alone is not a permanent solution to the water problem in the area.

### 3.5.6 Evaluation of present water use in the CMA

A comparison between the (1999) water use in the CMA (which was around 900 million liters per day) to the amount of 1998 (which was about 794 million liters per day) shows that there was an increase of 13.4% over one year (Ninham Shand et al., 1999; The Water Demand Workshop, 3 March 2000; Baseline Report, 2000). This trend is likely to increase as a result of both rapid population growth rate (3.7%) and an increase in industrial production. The CMA is the economic power engine of the Western Cape Province. The latter currently

has the fastest growing economy in SA, and commands a solid 14% of the total production in SA.

Its economic growth outstrips the national average by 2%, and with a Gross Domestic Product of about R 656 million per annum ranks only second to Gauteng (Nortje, 1998; CMC, 1998; UCT- SoE, 1999). Natural reproduction, influx of people to Cape Town from other areas, increase in water use for productive purposes and change of consumption patterns fuels the demand growth to an average rate of 4% increase per annum (Carlipp, 1998).

The average amount of water used daily in the CMA is about 250 liters per person, but the range of quantity of water consumption is considerable, between 15L/p/d in informal settlements and 1750L/p/d in affluent Upper Constantia (Preston, 1995; CMC, 1997). As indicated earlier if this current rate of consumption continues the demand of surface water in the CMA will outstrip supply by the year 2020. Inevitably, the people of CMA in general, and the CMC in particular, have an obligation to come up with reliable options and solutions to solve this potential water crisis.

### 3.5.7 Reconciling water demand to supply

Most of the supply augmentation schemes discussed above are extremely expensive, as the financial, ecological and social costs are very high. The opportunity costs of the various schemes as Preston & Davies (1995) demonstrated in the case of Palmiet Scheme Phase 1 are enormous - R81 million per year savings from treatment and distribution, let alone environmental and ecological costs related to the dams.

Apparently, the only feasible solution, at least in the next 5-15 years is to adopt WDM measures, which according to a number of scientific, but conservative estimations can save up to 10% of the total water use in the CMA (Ninham Shand, 1994; Preston, 1995; van Niekerk, 1995).

In the Kruger National Park WDM measures reduced tourists' water consumption by 81% within a short time (Preston, 1994). Furthermore, Section 2 of the UCT-CMA Water Study Baseline Report (2000) demonstrated that WDM and WC measures are indeed effective in reducing and saving water at both international and local level (Baseline Report, 2000).

As it will be shown in Section 8 this water saving can only be achieved at a cost to the Water Authorities (CMC & MLCs) in the form of revenue loss. But this revenue is inevitable and is negligible when compared to the capital outlay for constructing new water supply facilities and importation of water. As well the loss of revenue that can be incurred in the form of unpaid taxes if for instance industries shut down as a result of lack of water. All in all water reduction and saving is beneficial to society as a whole, hence should be pursued with full force regardless of short-term loss of revenue to water supply agents. In this regard it has become clear in South Africa in general, and CMA in particular, that ways of conserving water by using WDM strategies have to be implemented without hesitation as there is no other immediate better option (Chapman, 1997; DWAF, 1998; 1999; 2000).

Apparently, there are many signals that indicate that the CMC understands this necessity and is ready to meet this challenge. For this reason it established a WDM Section in its Departments whose aim is to achieve a 10% saving on projected bulk water demand in the CMA by the year 2010 (CMC, 1999). Furthermore, it was for the same reasons that the CMC commissioned the " **Alternative Options to Meet the Demand for Water in the CMA**" Study in 1999.

### 3.5.8 Conclusion

This section presented and discussed the past, present and future situation of water supply and demand in the CMA. To start with it was argued that the term 'supply' and 'demand' as used in the CMA and in this thesis do not strictly comply with their 'economics' meaning. This is explained by the fact that as a resource, water is not yet considered as a commodity, and water markets in the CMA are not yet fully developed. Price for water is fixed by the CMC, which holds a monopoly of bulk potable water production and distribution in the area.

Thus to non-economists supply of water to urban areas simply means the quantity of potable water available in a reticulation system which is ready for utilisation by people regardless of the distribution system. For the same reasons and same line of thinking 'demand for water' simply means the amount of water used at a given time in a particular place regardless of whether the users can afford to pay for it or not. These simplistic connotations does not convey the strict 'economics' meaning of these terms but are the ones mostly used by Water Authorities (DWAF and the CMC) and the customers in the area. It is for the same reasons that the Water Authorities in the CMA (previously the CTWU and now the CMC) considers its major role as that of 'supplying' more water to the area in order to meet 'demand'.

Historically, the quest to implement this task led to the construction of expensive water schemes - dams and inter-basin water transfers. But with time these supply augmentation schemes proved to be insufficient to cover the ever-increasing demand for water. This created what is referred to in this thesis as a "**vicious cycle of water supply and demand**". Implying that supply can never permanently meet demand not only because the later keeps on growing, but as well because more supply at low rates, fuels water consumption and encourages more wastage. Therefore the long term solution to avoid this situation is to reconcile water demand with supply by using WC and WDM strategies and measures such as increasing water use efficiency, maintenance of water catchment areas, recycling and re-use of sewage water and other WDM measures.

Furthermore, it was argued that demand and supply can be considered as two sides of the same coin, which act parallel to each other and yet have got positive and negative factors that influence their levels. In a 'free market' situation demand and supply is capable of adjusting itself and can reach an optimum point whereby supply = demand. At this point water resources will be optimally distributed to the customers and maximum benefits will be derived by the society as a whole. As for now in the absence of 'free markets' for water, and the fact that there is a lot of wastage around despite an existence of a potential water shortage in the area by 2020, one of the viable options is to adopt WDM strategies. The way forward as will be presented in Section 6 is to increase water-use efficiency and to optimise WDM opportunities by applying WDM measures.

**What then is the essence of WDM?**

**What are the principles and measures of WDM?**

**Is there a connection between WC and WDM?**

The next chapter will give answers to these questions by critiquing WC/WDM objectives, strategies and measures.

"If this is the stream of life we should not waste it !." [JRK, 2000]



" Water Conservation can be regarded be both an objective as well as a strategy for efficient water resource management. WDM should not be regarded as an objective, but rather a strategy to meet the various objectives listed in this chapter. WDM is a little more than efficient use of limited water resources. To realise its full potential it requires the integration of water conservation concepts into all water resource planning and management, both in private and public sectors in the CMA. This integration will help the CMC to move to the least-cost planning approach, which is based on economic efficiency ". [JRK, 2000].

## CHAPTER IV

- **Water conservation & demand management**

## 4. WATER CONSERVATION AND DEMAND MANAGEMENT

"The implementation of WC/WDM principles is essential in meeting the national goals of basic water supply for all South Africans and the sustainable use of water resources... A paradigm shift to the principles of WC/WDM is required in the water supply industry and this can be achieved through understanding and comprehensive strategies ". DWAF: Draft WC and WDM National Strategy Framework, 1999 pp. 6 & 8.

### 4.1 Introduction

This chapter defines Water Conservation and Water Demand Management, elaborates their interrelation and highlights their role as an objective and strategy respectively for achieving water efficiency.

WC and WDM are often used as synonymous terms although the meaning and implications of these terms is very similar, it is important to recognise the difference. A definition of both terms and brief explanation is presented below, thereafter an elucidation of their salient roles and functions is presented together with type of costs and principles involved in their application.

#### 4.1.1 Water Conservation Defined

There is a variance in definitions of WC presented in different dictionaries but they all generally allude to, "preservation care ", "protecting from loss or waste" and "protection of natural resources" and "efficient and effective use of water resources". Historically, both in South Africa and internationally the connotation and implementation of water conservation has varied. From time immemorial, water conservation meant dams to capture, store, and distribute water as needed. The Romans built the aqueducts, the ancient Egyptians under the Pharaohs built water storage facilities fed by irrigation canals collecting water from the Nile River. In the CMA the first dam was built as early as in 1852 - this is the De Waal Park Reservoir, followed by the Monteno Reservoir in 1896 (DWAF, 1992).

These reservoir systems were designed to conserve water by preventing the wastage of water to the ocean. The major objective was to capture water, preserve it, and use it anyhow, anywhere needed, as long as new supply augmentation schemes could be developed.

But, the limits of supply side management became obvious as noted by Chapman (1997) and others; hence, over the last two decades the meaning of WC became restricted to " use less water" and "protect the environment" human life included (Draft WC & DM National Strategy Framework DWAF, 1999 p.12).

WC can conveniently be defined as "**the minimisation of loss or waste, the preservation, care and protection of water resources and the efficient use of water**" (op. cit. p.12). For this reason the term demand management was often preferred and became more widely used throughout the world. Demand management however is limited and does not include all the connotations of protecting and caring the natural water resources as is mostly limited to people's water consumption needs.

In order to overcome the dilemma and shortcomings of the current connotations of water conservation, the Bureau of reclamation of the United States Department of Interior defines water conservation as follows:

**" Improved water management through the implementation of best management practices"**. This definition marked a paradigm shift from the old un-progressive meaning to

the modern connotation which implies that water use can be reduced if managed properly by using water efficient practices and devices; by changing our illusions and attitudes towards water; and stopping water wasting habits.

#### **4.1.2 Demand Management Defined**

For many years demand analysis consisted of projecting growth curves of consumption forward in time as a function of some independent variable such as population (refer to the water demand scenarios in the Baseline Report (2000) in Section 1).

The connotation of demand management has changed substantially over the years but a definition adopted by the South African DWAF Draft Water Conservation and Demand Management National Strategy Framework (1999) captures the salient aspects and runs as follows:

**"Water demand management is the adaptation and implementation of a strategy (policies and initiatives) by a water institution to influence the water demand and usage operation in order to meet any of the following objectives: economic efficiency, social development, social equity, environmental protection, sustainability and water supply and services, and political acceptability"** (op. cit. p.12)

This is a 'blanket definition' which stipulates the aim and objectives of WDM as a strategy for influencing water-use efficiency from the consumption side. The salient aspects of this definition will be explored further in the next sub-section and in Sections 6 and 7.

### **4.2 The Role of Water Conservation & Water Demand Management**

The potential role of water conservation and demand management in the CMA is significant and is reviewed briefly herein under the various categories of water sectors and objectives, viz., Security of supply; Protect existing water resources and Economic efficiency.

#### **4.2.1 Security of supply**

The goal is to be able to reconcile future demand and supply. As pointed out in the introduction with the current growth of demands it is estimated that the CMA will have utilised all natural water resources in about 20 years unless WC and WDM measures are implemented. The major reasons attributing to the problem of ensuring availability of water resources for the future in the CMA were discussed above in Section 2, and will only be summarised herein as follows:

- Population growth rate is at 3.7% per annum,
- Rapid economic growth in the area.  
The CMA increased its share in the country's total production from 10% in 1980 to 14% in 1999 (Nortje, 1998; CMC-Economic Department, 1999: Baseline Report, 2000),
- Most of the storm water in the CMA is wasted as runoff to the oceans.
- There is large backlog of infrastructure in the area: Housing (19% of CMA's inhabitants live in informal dwellings) and piped water service delivery covers only 79% of the CMA's inhabitants (CMC, 1997).
- Expensive alternative water resources such as desalination of sea water and towering icebergs from Antarctica or importation from the Zaire River appears to be in the horizon but at the moment they are unrealistic considering their social, economic and political repercussions.

#### **4.2.2 Protect existing water resources**

Water conservation can play an important role in protecting the existing water resources. Examples of water conservation measures to protect water resources are as follows:

- The removal of alien invading plants, which reduces surface runoff and the yield of existing resources by an estimated 10% in such catchment areas,
- The protection of groundwater resources by not allowing extraction to exceed the rate that it can be replenished.
- The maintenance of wetlands as they act as natural water reservoirs.

#### **4.2.3 Protection of the Environment**

Reducing water demand reduces the impact of water withdrawals on the environment and often results in increased stream flows or decreased demand on groundwater sources.

The environment and its eco-systems are under threat and need to be protected from over utilisation of water resources and the continuing development of new dams (Dohan, 1997). Current land and water utilisation is having a damaging effect on the ecology of rivers, lakes, wetlands and estuaries (Davies & Day, 1998).

#### **4.2.4 Economic efficiency**

Government and public utilities have a responsibility to society to ensure not only the efficient usage of water resources but also the efficient usage of public funds. One of the main objectives of demand management is economic efficiency and in the potable water services sector, economic efficiency may often be a more important objective than water resource considerations.

In calculating the economic efficiency of any water conservation and demand management activity, it is important not only to look at costs of implementing those initiatives, but also to look at sustainability of the measures to reduce consumption. The economic efficiency that can be achieved through water conservation and demand management is to evaluate the net present value of the difference between the cost of demand management initiatives and the economic benefits derived.

The economic value of demand management initiatives can be classified into two categories: direct cost savings and indirect cost savings (Mirrilees et al., 1995).

##### **Direct cost savings**

Direct cost savings are easily appreciated and relate to the savings achieved by the water utility by managing the distribution system efficiently. In the water services sector it involves reducing unaccounted for water, which include reducing distribution leaks, illegal connections and faulty metering and billing. In the irrigation sector this include losses such as seepage from canals, distribution leaks and unauthorised abstraction of water (Weimer, 1992).

A less conventional directional cost saving is reducing domestic water leaks and consumption in areas with low payment levels for services. Although repairing and retrofitting domestic house installations are classified as customer demand initiatives rather than distribution management initiatives, water services institutions cannot ignore the potential cost savings by implementing such initiatives at their own cost. Finding and repairing domestic leaks has the added advantage of making water more affordable to consumers and thus increasing the level of payment.

### **Indirect cost savings**

Indirect cost savings are less appreciated and relate to concepts such as avoided costs. The indirect cost savings can be divided into three categories, operation savings, capital cost savings, and environmental savings. A possible fourth category is political cost savings, but this is abstract and can be ignored. Savings should also be looked through the entire water cycle at each of the following four categories of water resource management, distribution management, customer demand management, and return flow management. For example the operating costs of water used to flush a toilet is the sum of:- electricity costs for pumping water through a water transfer scheme, the payment of royalties if they exist, the chemical cost for purifying the water, the electricity cost for bulk water supply pumping, the operating costs for distribution, and the chemical and electricity costs for the collection and treatment of effluent (Preston & Davies, 1995:

<http://www.epa.gov> "Saving water and money at work".

Reducing the growth in demand will postpone large infrastructure requirements that will result in significant financial savings. The real long-term interest rate in South Africa is estimated to be between 6% to 8%. For example, in Gauteng alone it is estimated that R 10 billion will have to be spent on new wastewater treatment plants over the next 20 years, and new water augmentation schemes at a cost of another R 17 billion if the growth in demand is not altered. The net present value of postponing all bulk water supply infrastructures by one year alone exceeds R 2 billion. (African Water Page, 2000).

#### **4.2.4 Social development and equity, customer focus**

There are approximately 16 million people in South Africa who have no operating water supply with their source of water an average of 1 km away - among them 12 million people are without access to potable water. (The African Water Page, 2000). If the basic water needs of 25 litres per day per person (which is below the United Nations 50L/p/d requirement) are provided, the total water requirement is only 300 MI/d (United Nations – 600 MI/day).

Once the infrastructure is provided a major challenge is how to maintain, manage and prevent the abuse of such systems once constructed. Through the implementation of the principles of demand management and customer focus, solutions can be found to ensure that customers do not use more water that they can afford and therefore ensure the sustainability of the services.

Other positive arguments in favour of WC and WDM are the following:

- ◆ By minimising domestic water losses, installing water efficient plumbing fittings and educating existing consumers, the cost of potable water services particularly to the poor can be reduced to affordable levels (Khosa, 1999).
- ◆ By reducing distribution water losses and inefficient consumption, existing resources and bulk infrastructure can be used to provide new services to people without having to develop new sources (Maddaus, 1987).
- ◆ Water conservation and demand management initiatives generally offer more job opportunities to the community than supply side management initiatives (Johnson, 1995).

### **4.3 The scope of WC & WDM measures in the CMA.**

WC and WDM initiatives from a Water Utility's perspective will include any measure that can reduce total amount of water abstracted from the water source. This will include a number of measures which aim at reducing losses in the purification process, the bulk distribution

system, distribution system of the CMA Water Undertaker, and the consumption by the end user (DWAF-: Draft WC & WDM National Strategy Framework, 1999).

In the literature most researchers/authors, include the entire water supply chain – from point of abstraction to the point of usage, that is, including all levels of distribution management and customer demand management.

This section took the same line, as it avoids confusion. The conservation measures related to management of water resource in general, such as clearing of alien species in and around water sources and catchment areas, and return flow are not considered in this work.

## 4.4 Conclusion

This section has shown that WC & WDM have a special role to play in the CMA to reduce and save water. The two can be regarded as the objectives and strategies for implementing water efficiency programmes respectively. Their roles aim at achieving three major objectives, namely: Achieving security of future water supply; Protection of the environment; And protection of the existing water resources, while guaranteeing economic development and social equity and accountability while ensuring economic efficiency. Although there are a number of interesting definitions of WC & WDM, together they reveal a number of facts as summarised below:

- WC can be regarded as the domain in which WDM is a large subset,
- WC can be both an objective as well as a strategy for efficient water resource management,
- WDM should not be regarded as an objective, but rather a strategy to meet the various objectives listed in its definition given above (dealt with in section as criteria for water efficiency) WC as a strategy should be considered in its widest current meaning,
- The essence of WC and WDM is to develop and implement strategies and initiatives that could manage water resources in an efficient manner, and
- WDM should be perceived in unlimited context, as a multifaceted, creative and adequate option, and not limited or equated only to communication programs or tariff increases.

As it will be shown later WDM is a strategy and locomotive for achieving economic efficiency of water as a resource, social development, and social equity. If correctly and deliberately employed they can achieve these ends without compromising affordability and sustainability (Winpenney, 1984; Sokutu, 1996; The Draft WC & WDM National Strategy Framework, 1999; Baseline Report, 2000).

The principles of WDM require that water institutions are accountable to the public, and this in turn requires that institutions understand the consumers and their needs and provides the best solutions to meet them. In real life what water consumers need is a steady supply of portable water of the right quality and quantity at an 'affordable' price. Any solution that can achieve this end without compromising the welfare of consumers is considered positive and acceptable. The best solution to achieve this end is supposed to be provided by the Water Authority through a number of WC&WDM "measures" or "tools". Presented in Table 4.1 is a summary of typical long-term urban WC/WDM measures. The next sections will discuss these measures in details as they crop up in different relevant topics.

The measures in Table 4.1 that will be discussed in detail are highlighted, and will be dealt with in Sections 5 & 6. The starting point for implementing any WC/WDM strategy is to

conduct a water audit and leak detection survey in order to establish the actual water situation in the facility or an area. This initial process can be regarded as fact-finding process otherwise referred to in the literature as water inventory, and is followed by a prescription stage in which the necessary measures are recommended.

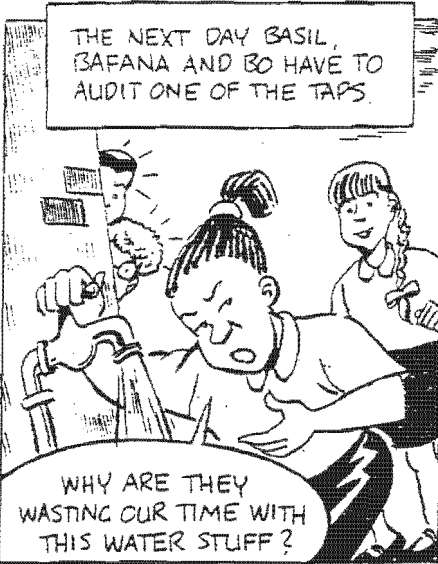
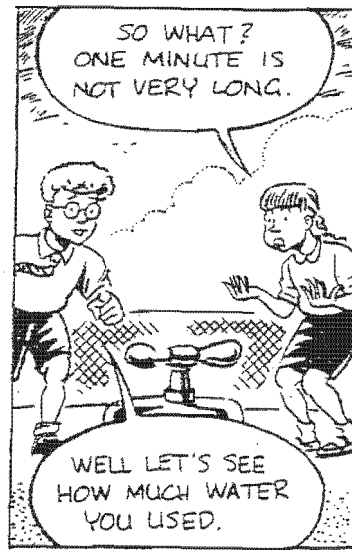
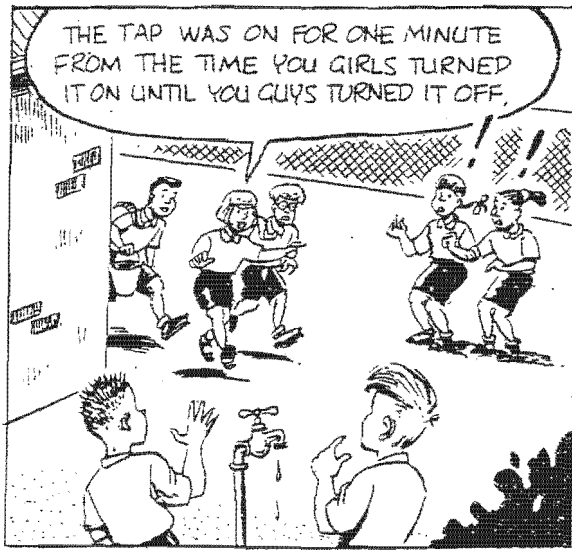
The next two chapters will follow the fore-mentioned logical sequence. Water Audit and Leak detection and repair will be covered in Section 5. Water saving devices, and the water efficient practices, such as water recycling in industries and "xeriscape" landscaping, and others would be dealt with in Section 6.2.

University of Cape Town

Table 4.1: Summary of typical long-term urban water conservation and demand management measures

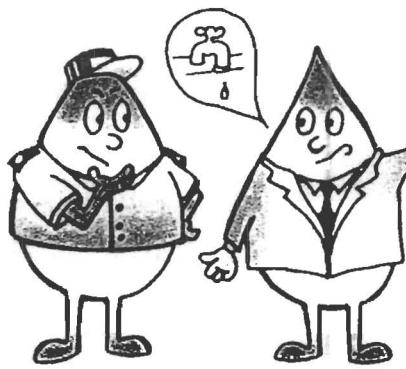
TYPE OF STRATEGY	AREA OF APPLICATION	MEASURES
Economic	Country/ Regional/Municipal/ Local Municipalities	Sliding scale tariff structure Excess use surcharge Sewer surcharge Summer surcharge Pre-payment meters
Managerial	Regional/Municipal/ Local municipalities	Universal metering Meter repair programme Limiting distribution pressure System rehabilitation Water Audit & Leak detection and repair programme
Technological (Consumer-oriented)	Indoor residential & Non-residential buildings	Toilet tank displacement Dual flush toilets Lower flow toilets flushes Lower flow shower heads Shower flow restrictors Tap aerators Insulate hot water pipes Water efficient appliances
	Landscape irrigation	"Xeriscape" Landscaping - Efficient landscape design - Low water use vegetation - Scheduled irrigation - Efficient irrigation systems - Tensiometers
	New construction	Low-flush/dual flush toilets Low water use vegetation Tap aerators Water efficient appliances
	Industrial	Recirculation of cooling water Re-use of process water Re-use of treated waste water Process modification Low water-using fixtures
Sociological/ Behavioural/ Educational	General public	Public Information -water bill pamphlets -water care facility tours -meetings/seminars -media information -in-school -education/competitions

Source: Adapted and modified from: Clayton, 1995; WCSA, 1993; NMOSE, 1999.  
**NB:** The measures dealt with in this thesis are highlighted.



Source; DWAF, (1997) Water Audit: How can your school be water-wise. p. 19. |

" Illusions about water wastage...it's never too late to learn. We cannot control if we cannot measure.... Water auditing is the starting point..." [JRK, 2000]



# LEAKS

## FIND THEM AND STOP THEM

Check all the immediately obvious places for leaks such as dripping taps, Encourage all staff to be on the look out for leaks

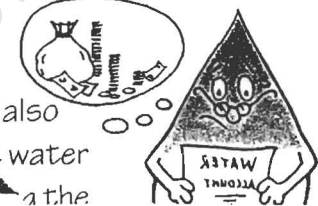


The first step to water conservation in the home is to check for leaks. Studies Factory managers - carry out a water audit to identify wasteful practices, leaking pipes (especially underground pipes), machines etc.

Try pressing a piece of toilet paper against the inside back surface of the bowl.

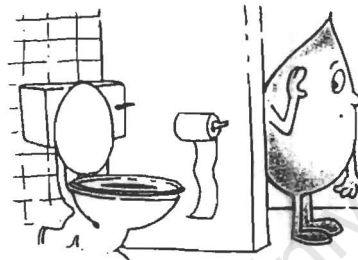


that is leaking. (T) leaking hot water to be heated.



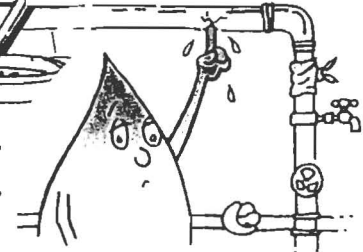
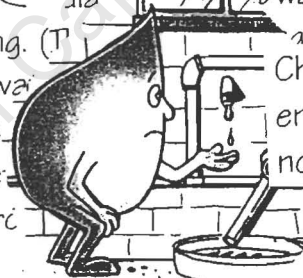
asteful but also at water

Check overflow pipes to ensure that water is not draining out.



toilet, it's leaking. Some toilet detect because the trickle in

The toilet biggest source



Source: Camps, S. (date unknown) . A Guide to Water Saving in SA.

## CHAPTER V

### • Water Auditing & Leak Detection Survey

## 5.WATER AUDITING & LEAK DETECTION SURVEY

" We have to know what we are doing with our water before we can do something about it ". Prof. Kader Asmal in DWAF, 1997: *Water Audit - How your School can be water-wise* p. 2.

"An effective way to conserve water - and save money - is to detect and repair leaks in municipal system ". (American Water Works Association: *Water Audits & Leak Detection Manual M 36*, 1990. p. iv.

### 5.1 Introduction

In the previous chapter it was established that WC and WDM could play a special role in achieving water efficiency in the CMA. It was concluded that WC/WDM as an objective and strategy respectively for achieving long term water efficiency, that is water reduction and saving can be effected by using four measures or tools. These measures and their major components were summarised in Table 4.1, and include Economic, Managerial, Physical-technologic, and Sociological/Behavioural/Educational measures.

The next two sections (6 & 7) will concentrate on the second and the third type of measures i.e. managerial and physical- technologic measures respectively.

This section presents water audit and leak detection survey and repair programme as one of the most important measures to save water wastage not only in the CMA, but as well for any other part of the world. Leak detection survey is a necessary companion of a water audit/survey.

But the question is whether this is the appropriate place for this topic. Certainly, the answer is YES because it is necessary to know the state of the water reticulation system and water using equipment and devices in a given area or facility before any recommendations to make changes such as retrofitting with water saving devices could be effected.

In the literature there is a general consensus that water audit and leak detection survey are the crucial initial steps and key activities of any water efficiency programme (Sugawara, 1985 ;Shore, 1988; AWWA-M36, 1990;The Water Program, 1994; MWRA,1995; NCDENR,1998;).

The American Water Works Association unequivocally states that **"water audit, followed by a leak detection programme, can help water utilities reduce water and revenue losses and make better use of water resources"** (AWWA-M36, 1990 p.1).

This thesis takes the same position, initially by hypothesising it in the introduction, and posing a research question, which sought to explore and decipher the extent to which water auditing and leak detection and repair can contribute towards water efficiency in the CMA.

Furthermore, the Baseline Report (2000) which actually is the precursor to this work, dealt in *extensor* with water auditing as an essential tool for efficient water management (Baseline Report, 2000). Leak detection and repair were not given due weight but were briefly mentioned in Section 2, obviously because it was not included in the TOR of that study. For this reason this chapter will not only complement that work by covering the 'leak detection and repair part' of the topic, but will as well lay the base for the next two chapters. In this regard it is advisable to bear in mind the 'audit part' as it **"is the key activity of any water efficiency program"** (NCDENR, 1998, p.100).

How ever, because the two surveys are inter linked it is necessary and useful to recapitulate the definitions and some salient common issues regarding water audit and leak detection before we concentrate our attention exclusively to the later.

### **What is a water audit?**

A water audit identifies how much water is lost and what that loss costs a facility or a utility. Meters and other system-control equipment and records are thoroughly checked for accuracy. The overall goal of a water audit is to help the water utility and/or water consumer to select and implement programs to reduce the distribution-system losses and water devices (faucets, toilets etc.) respectively.

### **What is leak detection?**

Leak detection is a survey of a water distribution system and water devices to identify leak sounds, or actual water dripping and pinpoint the exact locations of hidden underground or under wall leaks (AWWA-M36, 1990; Makar et al., 1999; <http://twri.tamu.edu/twripubs/WrtResrc/v13n3/text-3.html>

### **Cost of Leak Detection**

The cost of leak detection includes the costs of equipment and personnel. A crew is needed to survey the system, and personnel are also needed to pinpoint leaks, estimate water losses, and provide documentation. The cost of a leak detection crew depends on whether the utility uses its own staff, a consultant, or both.

Leak repair costs are not considered a direct cost of a leak detection program. Since leaks are continually discovered and repaired in the normal course of the utility's operations, the leaks found by the leak detection program would eventually be repaired at some time in the future, sometimes under emergency conditions.

### **What are the benefits of water audits and leak detection?**

Water audits and leak detection programmes can achieve substantial benefits, including the following:

- Reduced water losses: Water audits and leak detection are necessary first steps in a leak-repair programme. Repairing the leaks will save money for the utility, including reduced power costs to deliver water and reduced chemical costs to treat water.
- Financial improvements:
  - To the Water Authority a water audit and leak detection and repair programme can increase revenues from customers who have been undercharged, lower the total cost of wholesale supplies, and reduce treatment and pumping costs.
  - To the customer leak repair directly reduces the quantity of water recorded by the meter, and thus reduces the water bill. This however is not the case for customers charged flat water rates.
- Increased knowledge of the distribution system: During a water audit, distribution personnel become familiar with the distribution system, including the location of mains and valves. This familiarity helps the utility to respond quickly to emergencies, such as main breaks.
- More efficient use of existing supplies: Reducing water losses helps stretch existing supplies to meet increased needs. This could help defer the construction of new water facilities, such as new well, reservoir, or treatment plant.

- Safeguarding public health and property: Improved maintenance of water distribution system helps to reduce the likelihood of property damage and safeguards of public health and safety.
- Improved public relations: The public appreciates maintenance of the water system. Field teams doing the water audit and leak detection or repair and maintenance work provide visual assurance that the system is being maintained.
- Reduced legal liability: By protecting public property and health and providing detailed information about the distribution system, water audits and leak detection help protect the utility from expensive lawsuits from leakages of potable water..

After the above clarifications we now move on to examine the techniques for conducting leak detection surveys for piped, pressurised, potable water in a distribution system - out doors and in doors.

This section will briefly outline and discuss 10 topics related to leak detection and repair:

- 1) Location of leaks,
- 2) Types of leak detection and costs involved,
- 3) Leak detection methods,
- 4) Preparations for conducting a leak detection survey,
- 5) Procedure for leak detection,
- 6) Methods of pinpointing leaks,
- 7) Uncovering leaks,
- 8) Measuring and calculating water loss by leaks, and
- 9) Evaluation of leak detection and repair effectiveness,

## 5.2 Location of leaks

Generally speaking, leaks can be divided by type into six categories based on where they occur. Leaks may be located on the main, the service line, a residential meter box, in valves and in residential devices and equipment. Of course, "miscellaneous" leaks also occur elsewhere in the system. Causes of leaks include improper installation, settlement, overloading, corrosion, physical damage, or old age.

### Main Leaks

According to the American Water Works Association Manual (1990) main leaks range from a low 2 L/m to over 2000L/m. Leaks due to corrosion usually start out small but can grow to very large leaks. Splits can occur due to excessive pressure, improper installation, settlement, and overloading. Joint leaks can occur due to corrosion, improper installation, improper materials, or overloading.

### Service-Line Leaks

Service-line leaks range from a low of 1 L/m to over 30 L/m. Service-line leaks are caused by the same factors as main leaks.

### Indoor Leaks

All facilities whether residential or non-residential will face some leak (NCDENC, 1998). These leaks may be caused by holes or breaks in customer service lines, inefficient hose-bib or shutoff valves, holes or breaks in interior plumbing lines, or leakage inside plumbing fixtures (leaks in toilet-fixtures and taps are common in the CMA). Leaks are commonly found in piping joints, pump seals, hose nozzles/shut off valves, drinking fountains, toilet cisterns, processing equipment, urinals, and other locations. Elimination of leaks depends on their type and size, but more than often it typically includes tightening or replacing fitting.

### **Valve Leaks**

Broken valves and loose packaging are common causes of this kind of leak. Valve leaks may start in system controls, such as pressure-sustaining valves, pressure-reducing valves, pressure-relieve valves, blow-off , altitude-control valves, air-release valves, and others.

### **Miscellaneous Leaks**

Breaks in water mains can be caused by excessive pressure, overloading, improper installation, improper materials and improper operations.

## **5.3 Types of out door leak detection and their costs**

### Leak Detection Overview

There are two basic types of out door leaks: visible and non-visible. Visible leaks can be seen emerging from the ground or pavement. The source of the leak may be a considerable distance away from the area where it is observed. Non visible leaks may percolate into the surrounding ground or may enter storm drains, sewer, stream channels, or old abandoned pipes.

### Costs of Underground Leaks

Water takes the path of least resistance; it may surface. Most leaks start small and grow larger over time. Most non-visible underground leaks have an average life of two years. As water leaks, it creates an underground cavity. This increases the potential for damage to overlying property. There are many examples of leaks that never surface.

### Value of Recoverable Leakage

Usually, when we think of leak detection, we think of the distribution worker wearing listening equipment. This is the direct form of the detection - listening for the leak itself. But there are other methods of leak detection, including zone-flow measurement and the water audit. Rather than pinpoint leaks, these methods indicate whether water is leaking and give a general idea of where the leak might be. A fourth means of leak detection is not really a method, but happenstance: the accidental discovery of leaks during the normal course of distribution-system maintenance ( Bessey et al., 1993).

## **5.4 Overview of leak detection methods**

### Water Audit

Conducting a water audit is an efficient way to determine the total volume of water that is leaking from distribution system. The final part of the water audit is the preparation of a leak detection and repair plan, which outlines the equipment, type of crew, method of surveying and pinpointing leak detection and repair plan in detail. Detailed presentation of procedures for conducting Water Audits and Leak Detection Surveys are attached in **Appendices D** and **E** respectively. Sample forms for filling in during the actual leak detection survey are attached in **Appendix F**.

### Audible Leak detection

Audible leak detection uses electronic listening equipment to detect the sound of the leakage. Pressurised water that is forced out through a leak loses energy to the pipe wall and to the surrounding soil area. This energy creates audible sound waves that can be sensed and amplified by electronic transducers or, in some cases, by simple mechanical devices. The sound waves are evaluated to determine the exact location of the leak. A trained operator conducts an initial listening survey of the entire distribution system and records all

suspect sounds. Later, the areas with sounds are rechecked. If the sounds can still be heard, leaks are pinpointed.

#### Zone Flow Measurements

This method can be used as an extension of the water audit or, in some cases, as a leak detection method. Its purpose is to determine whether a sector or zone of a water system suffers major leakage.

To effectively conduct a zone flow measurement, a utility must maintain good maps, have valves located at zone-control points, and provide a tap in the main for a recording pitometer (AWWA M – 36, 1990)

#### Normal Course of Operation

Utilities discover leaks accidentally in the normal course of operations and maintenance. For example, in a valve fixing – exercising leaks may be discovered. Meter readers have the opportunity to check for visible meter-box leaks when reading meters.

### **5.5 Calculating the quantity of water loss of discovered leaks**

Leaks are measured to determine the rate of loss, the total volume of water lost during the leak's span life and the cost savings by repairing the leak. This can be done in three ways:

- By using a bucket of known volume and stopwatch,
- By using a hose and a meter, or
- By indirect calculations by using modified-orifice and friction-loss formulas (Coetzee, 1993). Lets briefly examine each of these methods.

#### Bucket-and Stopwatch Method

The bucket-and-stopwatch method is the simplest and practical method for to determine leak loss. It involves holding a container against a discovered leak for a predetermined time period of time by using a stopwatch. The captured water is then measured by using a calibrated cup, beaker or other container of known volume. Then the calculations are done by converting time and volume to litres per minute or by comparing the data against pre-prepared mathematical conversion tables and water leak equations presented in **Appendix G1 , G2 & G3**.

#### Hose and Meter Method

This is the most direct method of measuring leaks, but it requires some mechanical effort. It can be done by connecting a hose to the leak and direct the flow through a meter.

#### Calculation Method

This is the simplest method to perform in the field, but it requires calculations. This method is often helpful for large leaks where the flow is too great to measure and the main must be valved off. It requires that the size and shape of the hole be measured and that the line pressure be determined. A pressure gauge or a hand-held blade **pitometer** could be used to determine the pressure of the water coming from the leak or a nearby fire hydrant. This method also uses some assumptions regarding the shape of the hole, which may introduce error.

For losses from such items as pipes or broken taps, assume an orifice coefficient of 0.8 and calculate flow in litres per minute from the formulae presented in **Appendix G1**.

## 5.6 Determining the effectiveness of leak detection and repair

After repairing leaks, record all information regarding excavation, flow rates, and repair on the leak repair report. This will help with future repair projects and provide information to be used in evaluating the benefits of the leak detection project.

An important and often neglected post-survey step is determining whether the project was a cost-effective water conservation measure or not. To determine whether leak detection and repair was cost-effective, the municipality or facility must evaluate the completed leak detection project by using the cost-benefit and opportunity payback analyses methods presented in Section 7 and in **Appendix H**.

## 5.7 Concluding remarks

In this section I have attempted to emphasise the importance of leak detection and repair in order to save water. Leaks can waste between 5% to 35% of potable water in a distribution system (White, 1994). Steve Camp (date unknown) of the SA Water Conservation Campaign reports that a leaking toilet, for example can waste up to 100,000 litres in one year! That amount is enough to take three full baths every day for a year. Obviously the need for leak detection and repair can not be overemphasised.

All water reticulation systems and water facilities will experience some leak some time due to old age, increased water pressure, corrosion, wear and tear, accident or caused by other factors. Therefore a constant surveillance is necessary. Passive leakage control, that is repair of those leaks that are seen and reported is not enough and not scientific. In Pittsburgh, USA a 20 - year 4 million liter-a-day leak was discovered to be the source of a "natural spring"! (AWWA Mainstream, 1986). The point is, some leaks appear so natural that they can be easily dismissed as normal.

Leakage control depends to some extent on knowing where to look for leaks, otherwise it can be time consuming and thus costly to search for leaks every where. On the part of Water Authority it is possible to attain significant reductions in the capital costs of supply works by reticulation leakage control. To water consumers leakage of metered water means paying for water not consumed hence it is wastage of money (Shore, 1988).

Now that the importance of water audit and leak detection survey, methodology and procedure for conducting them have been established we can move forward to discuss other WDM measures and how they can be mobilised and optimised in order to maximise water reduction and saving by increasing water efficiency.

" Technological efficiency is an engineering matter and occurs when it is not possible to increase output without increasing inputs. Given what is technologically feasible, some thing can or cannot be done. Economic efficiency depends on the prices of the factors of production. Something that is technologically efficient may not be economically efficient, but something that is economically efficient is always technologically efficient. As regards to water sector, water efficiency can be defined as the employment of devices and practice which result in less water being used for the same task or function. An efficient practice would be recycling water for a second use. Utility-based efficiency measures include metering, leak detection and repair programmes, improved tariff structures, and pressure-reduction programmes. Optimisation of WDM opportunities in industrial, institutional or commercial facilities in the CMA should be examined in three areas: indoors heating & cooling for industrial purposes; indoors sanitary & other service purposes; Outdoor watering. These are the major areas where there exist many opportunities for more efficient water use ". [JRK, 2000].

## **CHAPTER VI**

- **Optimisation of WDM opportunities in the CMA based on water efficiency**
- **Water efficiency**
- **Optimisation of WDM opportunities in the CMA**

## **6. OPTIMISATION OF WATER DEMAND MANAGEMENT OPPORTUNITIES IN THE CMA BASED ON WATER EFFICIENCY**

### **6.1 Introduction**

Once water audits and leak detection surveys are done the next logical action is to seek ways to address the weaknesses/problems which hinder water efficiency in the facility or area. In other words, the next steps/actions are to try to optimise existing water saving opportunities or create new ones by using the best technology with least costs, retrofit or tune-up existing devices and equipment, repair leaks, and to conduct an educational campaign to change water-wasting practices.

The starting point however, is to know exactly the essence of 'water efficiency', how to determine water efficient appliances/devices; and to identify and appraise the costs of the an existing options and alternatives.

This chapter analyses and discusses two major topics which together form the central pillar of this thesis:

- ◆ Essence and techniques of water efficiency, and
- ◆ Optimisation of WDM opportunities in the CMA by using water efficiency techniques, technology and best practices.

### **6.2 Essence and techniques for water use efficiency**

There are two concepts of efficiency: economic efficiency and technological efficiency. Economic efficiency occurs when cost of producing a given output is as low as possible. Technological efficiency is an engineering matter and occurs when it is not possible to increase output without increasing inputs. Given what is technologically feasible, some thing can or cannot be done.

Economic efficiency depends on the prices of the factors of production. Something that is technologically efficient may not be economically efficient, but something that is economically efficient is always technologically efficient (Parking et al., 2000). As regards to water sector, water efficiency can be defined as the employment of devices and practice which result in less water being used for the same task or function. An efficient practice would be recycling water for a second use. Utility-based efficiency measures include metering, leak detection and repair programs, improved tariff structures, and pressure-reduction programs (The Water Program, 1994; SADC Water Efficiency Guide Book, 2000)

Water efficiency and WC are interchangeably used although these terms have different meanings, as defined in the introduction.

To recapitulate, WC is the saving water-use by any means including water efficiency, while the later entails the use of devices and practices which result in less water being used for the same task or function. This sub section lays the practical basis for determining water efficient devices/fixtures and cost reduction as the basis for achieving water efficiency.

### 6.2.1 Water- efficient fixtures

Water-efficient appliances, fixtures, and equipment as presented in the next sub-section can be used to reduce water use, thanks to their design. These water-use fixtures use technology to determine the amount of water used, and not the attitude of the users.

The efficiency of water-using fixtures can be presented as follows:

$$\text{Efficiency} = \frac{\text{Minimum amount of Water required to perform a service}}{\text{Water actually used by the equipment}}$$

For each model of product, water use per capital, per cycle, or per day can be calculated so as to come up with water-use coefficients among different models. This provides an indication of relative water efficiency, and is the basis for calculating the savings that could be achieved by installing that model.

<http://www.mwra.state.ma.us/water/html.bullet4.htm>

In cases where there are several generations of a model, each with a different water-use coefficient, it is possible to compare generational cost-effectiveness by using weighted average coefficient (Brooks & Peters, 1989).

$$\text{Weighted average water-use coefficient} = \frac{\text{Sum of (market shares x water coefficients for each generation)}}{\text{Sum of market shares}}$$

Thus, actual water savings as it will be shown in the case of CMA in Section 9 can be estimated by using water coefficients based on typical use for both conventional water-efficient technologies, and weighted average coefficients.

### 6.2.2 Cost Reduction as the basis for Water Efficiency

Both international and local case studies cited in the CMA Water Study Report have shown that adoption of water efficient technology and devices reduce water consumption and save water and energy costs (Baseline Report, 2000 - Section 2).

Efficient use water resources needs employment of efficient technologies, appropriate rate structure, educational and incentive programmes (<http://www.mwra.state.ma.us/water/html.bullet2.htm>).

Calculations of the costs of water savings of retrofitting programmes such as the installation of water-efficient toilets, faucets, aerators, and water saving showerheads is not a difficult task (Donovan, 2000).

But costs of water savings from tariff structure changes, and educational programmes can be difficult to calculate as they involve prediction of behavior changes that can influence water savings attitudes (Eberhard, 1995).

Despite of these difficulties, experience from Western Cape, especially the Hermanus example and the '2020 School Water Audit Project', has shown that these calculations can

be done and are being done in South Africa. Water savings could relatively easily be calculated in other programmes such as recycling (reclamation and re-use), industrial and commercial water efficiency programmes and 'xeriscape' landscaping.

In summary water efficiency can be influenced by a number of factors: Water-saving technology- devices and equipment, and deliberate efforts by water users to change negative attitudes towards water. The amount and cost of water saved by implementation of water efficient equipment or devices can be quantified in financial terms. Cost reduction is therefore the basis for achieving water efficiency and thus achieving economic efficiency in any organisation, be in industrial, commercial, public or private institution as will be shown in details in the next section.

### **6.3 Optimisation of Water Demand Opportunities in Non-residential Facilities in the CMA**

Experience from both developed and developing areas show that industrial, commercial, and institutional facilities are unique in the many ways they use water.

However, over the last 20 years there are many industry standard approaches to water efficiency that have been developed and are applicable to a wide range of applications. None the less, manufacturing or industry sectors that are similar can learn from the water efficiency experiences of companies in other parts of the world that have faced severe water shortages and have already examined and implemented a great many water conservation and demand reduction opportunities. (<http://www.mwra.state.ma.us/water/html/bullet2-6.htm>) - Water efficiency and management in **hospitals, restaurants, commercial buildings, schools & athletic facilities** and some **case studies** respectively.

Water can be used in three categories of functions - for processes; for domestic use; and for outdoor watering.

This sub-section analyses water efficiency opportunities in the following three categories of water-use operations in industrial, institutional, or a commercial facility, since they are the major areas where water is mostly used in non-residential areas. These water-use operations can be grouped as follows:

- Process water use in industries,
- In door water use in cooling and heating, and
- Out door water use.

#### **6.3.1 Process water use in industries**

Process water use in industries will be discussed under the following inter-linked four major headings: Management Opportunities in process water use; Categories of water use operations; Evaluation approach for water management opportunities; and Process water use reduction opportunities.

##### **6.3.1.1 Management Opportunities in process water use**

In most industrial, institutional or commercial facilities there exist many opportunities for more efficient water use. Once identified and implemented, these opportunities can lower the demand on water supply required to operate. A combination of demand management and

supply side management opportunities can significantly reduce the volume of water that industry normally use.

Examples from the Baseline Report (2000) Section 2 (including, Canada, USA, Australia, Egypt, Namibia and SA - Hermanius and UCT) shows that implementing WDM measures can save large quantities of water, labour and time. These savings could mean huge financial savings (Baseline Report, 2000).

Although each industrial, commercial and institutional facility is fairly unique in their use of water, it is possible to discuss water efficiency opportunities and approach that should be taken to identify those opportunities in such a way that they can be applied to any facility.

This work will define and pinpoint demand management opportunities that may be applicable to water efficiency programmes that authorities may wish to plan and to implement in their facilities.

Using water wisely is a seemingly simple, but important, aspect of any water efficient program. An examination of water use operations or practices in a facility can often lead to a number of opportunities to reduce water use and thus lower water demand. Evidence from many examples examined in the Baseline Report (2000) attests that there are very few industrial, institutional or commercial sites that cannot benefit from a review of their water use operations and practices.

#### **6.3.1.2 Categories of Water Use Operations**

Within a facility, the first step is to identify demand reduction opportunities by dividing the use of water at that facility into separate categories. This division can assist in making the task of finding demand reduction opportunities much easier. The division of water use into three separate categories as mentioned above, including process water use, indoor water use, and outdoor water use will also simplify estimates of reduction potential and cost benefit analysis.

#### **6.3.1.3 Evaluation Approach for Water Management Opportunities**

Most water management manuals agree that water management opportunities can be evaluated by using five general approaches (AWWA M 36 ,1990;The Water Program, 1994 SADC- IEMP Water Efficiency Guidebook, 2000). These five approaches are the following:

- **System optimisation**

This entails maintaining existing water using devices/fixtures and equipment or systems in good working order and making sure that at any given time they are not using excess amounts of water unnecessarily.

- **System Replacement**

Replacing existing equipment or retrofitting equipment or devices/fixtures with more water efficient types/models.

- **Reuse/Recycle**

Replacing the use of fresh water in existing equipment with water that has already been used in the facility at least once.

- **Process/Operational Changes**

Perform the same task, with less water or altering any existing process in the facility that uses less water.

- **Discretionary Use Changes**

Some jobs can be performed with less water but this may depend on the discretion of the operator or user. Changing the way in which workers carry out their tasks is very important.

Each of these options will be discussed in more details below and in Chapter IX.

#### **6.3.1.4 Process Water Use Reduction Opportunities System Optimisation**

Maintenance programmes should be carried out at most facilities on a regular basis in order to optimise process operations. Water using devices and fixtures or equipment should be regularly maintained and repaired to optimise performance.

Routine maintenance schedule and inspection programmes should be maintained in order to ensure economy of water use.

According to the AWWA M 36 (1990) and the Water program (1994) and the SADC- IEMP Water Efficiency Guidebook (2000) the following regular routine can be followed in order to take advantage of water use optimisation opportunities in a facility:

- Inspect water using equipment for leaks and conduct necessary leak repairs as discussed in Section V,
- Maintain control valves and water pressures at optimum settings for efficient water use,
- Monitor water use rates to identify problem areas and gauge water reduction success,
- Carry out routine maintenance on water using equipment to replace seals, washers and other required plumbing components,
- Calibrate water use settings or cycles on equipment to match requirements at varying production or operating rates,
- Educate all workers and water users on the goals of that water efficiency programme, and
- Educate all employees and water users on the goals of water using devices/equipment they are required to operate (The Water Program, 1994; White, 1994; SADC-IEWP, 2000; Baseline Report, 2000)

#### **System replacement**

Normally replacement of equipment/devices can be carried out at the end of the equipment's or device's life span when it becomes obsolete or causes maintenance problems. At this juncture, replacement must be effected by using a water efficient equipment.

Today, in order to cope with stiff competition most manufacturers develop and update new equipment to incorporate water efficiency into their designs. Thus a proper selection of the right equipment or device can dramatically impact on the cost effectiveness and profitability of a given facility. As demonstrated in the Baseline Report (2000) Section 2 in the case of water taps, cisterns, showerheads etc., new equipment, which substantially reduces the volumes of water used when compared to existing equipment may have an attractive payback period. It may be possible in some instances to replace equipment cost effectively prior to the equipment becoming otherwise, outdated.

It is also important to examine the equipment in use to determine if an alternate method or process that uses less water or may be even using no water at all, as in the case of air-cooling instead of water-cooling equipment, can accomplish the same tasks. This option is discussed further in Chapter IX.

In an industrial facility for example, number of new designs or alternative methods substantially impact the general equipment areas especially in, but are not limited to:

- Cooling and heating water systems
- Air conditioning systems
- Water treatment systems
- Washing machines
- Compressor systems
- Sterilises
- Food washers, *et cetera*. (SABC-IEMP, 2000).

### **System retrofitting**

This involves replacing only parts of a device/fixture or equipment in order to enhance water efficiency as an alternative to complete replacement. Experience from else where, and even from the CMA itself (See Baseline Report Section 2) shows that system retrofitting is normally a cost-effective water demand reduction opportunity. In an industrial, commercial or institutional facility there are potentially a number of operations or processes that can be altered to use considerably less water by installing:

- On/off timing devices;
- Pressure control devices
- Flow restrictors
- Efficient heat exchangers
- Water outflow diffusers
- Insulation on hot water pipes, and
- Insulating cold water pipes in cooling operations (Environmental Canada, 1997;SABC-IEMP, 2000).

### **Reduce - Reuse - Recycle (the 3Rs)**

A closed loop cooling tower system in a number of industrial, commercial and institutional facilities is the most significant opportunity, in terms of water use demand reduction. Such a system can eliminate or substantially reduce the volumes of once through cooling water that is used in compressors, coolers, air conditioners or a variety of manufacturing equipment. According to the SADC Water Efficiency Guidebook (2000) there are a number of necessary steps that should be followed before executing the 3Rs:

- Determine the minimum acceptable water quality required for use in the equipment/device,
- Identify potential sources of wastewater in the facility of an acceptable quality for use in the equipment/device,
- Explore the possibility of providing that wastewater for reuse in the equipment/device,
- Test the wastewater from the piece of equipment to determine if it is of an acceptable quality for recycling back to the same equipment/device.

Experience shows that reuse/recycle opportunities can be greatly enhanced by considering some simple level of wastewater treatment such as filtering or filtering instead of carrying out advanced filtering. However, advanced treatment not only provides a water source but may also significantly impact the cost of wastewater discharges (White, 1994). A good example is shown by Mondi Kraft mill in Piet Retief where water consumption was reduced by 40% (see article in **Appendix L**) after installing a R25-million water treatment plant.

## **Operational /Process Changes**

Operational or process changes are normally designed to carry out specific operational or manufacturing tasks. In this case specific processes at any facility that require the use of water can be assessed in terms of how the process uses water and for what purpose. The value of water use to the process can be evaluated and alternative methods of achieving the same results without as much water or with no water at all can be explored.

### **Discretionary uses**

In some instances the quantity of water used in some operational areas of a facility are within the prerogative of the operator. Specific examples may include quantity of water used in equipment cleaning; water used for food cleaning or rinsing; water used for food thawing; water used in floor cleaning *et cetera*. Thus, an appropriate educational programme and employee involvement programme can promote the more efficient use of water and change employee perception and attitude in regard to the wise use of water.

Let us now turn to specific water efficiency options as applied to the three specific water use areas in industrial, commercial, and institutional organisations. These options will be discussed under three headings, namely; Process Water Use for Cooling and Heating; Residential Indoor Water use for direct and indirect consumption; and Residential Outdoor for watering gardens (lawns/turf, flower beds and sports fields).

## **6.4 Water Efficiency Options for Cooling & Heating**

Cooling and heating is essential for homes, industrial plants, office buildings, hospitals, commercial and other institutions. Therefore understanding how various water using cooling and heating equipment operate in these areas is essential for designing and implementing a water efficiency plan.

This sub-section will present and discuss in detail ways for optimising water efficiency in cooling and heating processes in non-residential premises/facilities. The discussion will following sequence of topics: Types of water cooling processes; Water efficiency opportunities in cooling towers; Optimisation of water saving opportunities in a cooling tower; Saving water in boiler & steam generator systems and a summary of the section.

### **6.4.1 Types of water cooling processes**

There are two ways how water is used for cooling purposes: Once-through cooling and Re-circulating cooling water loop. The practice of running water continuously through an item/device requiring cooling, with the water going directly to the drain for disposal is referred to as 'Once-through Cooling' (MWRA, 1995).

Once-through Cooling often is found in seven possible locations or equipment:

- Air conditioners
- Refrigeration systems
- Ice Machines
- Process/Lab Equipment
- Process Tanks/Baths
- Air compressors

But, because once-through cooling wastes a lot of water, items using such a system have for a long time been discouraged by some municipal sewage regulations (e.g. in Massachusetts, USA) and cost factors.

Today, there are several actions that can be taken to eliminate once-through cooling.

- Replacing once-through cooling equipment with air-cooled models. For example, air cooled air conditionals/compressors can be installed instead of using once-through cooling.
- Connecting the equipment to a re-circulating cooling water loop instead of using once-through cooling.

Most of the cooling today is done by using re-circulating cooling water loop systems. The most common of such cooling systems are cooling towers. In order to get a clear picture of these two types of water-cooling **Appendix I** schematically presents once - through cooling - Figure I(1) and cooling loop system - Figure I(2).

#### 6.4.2 Water efficiency opportunities in Cooling Towers

What are the functions of cooling towers?

Cooling towers represent the largest user and re-user of water in industrial and commercial applications. They use large volumes of water because they are designed to remove heat by evaporation, “ **just as human bodies cool off when sweat evaporates in breeze**” (NMOSE, 1999 p.60). The rate of evaporation from a typical cooling tower is about 1% of the rate of water flow through the tower for every 5°C decrease in the water temperature achieved by the tower.

A cooling tower cools a circulating stream of water through internal large materials called wet decking. The droplets on the wet decking are exposed to an air-flow to cause some evaporation. This evaporation causes cooling by the mechanisms of evaporative cooling and exchange of sensible heat. The rest of the cooled water then flows to an air conditioning unit or the equipment and heat exchange occurs, cooling the equipment and the circulating water is heated. This warmed water then returns to the cooling tower to be exposed to airflow, cooled, and the whole process begins anew. In short this process can be depicted schematically as shown in **Appendix I** Figure I(3).

#### 6.4.3 Optimisation of water saving opportunities in a cooling tower

Optimisation of water efficiency in a cooling tower can be achieved in a number of ways: Blowdown optimisation, reduction of scale, prevention of corrosion and bio-fouling, reducing drift and bleedoff loses, and re-cycling and re-using water. These different methods will be elaborated below.

##### **Blow down optimisation.**

'Blowdown water' that is, water that is removed from the re-circulation cooling water to reduce contaminant build up in the tower water should be properly controlled in order to maintain thermal efficiency, proper operation and life span of a cooling tower.

Optimisation of blow down, in conjunction with proper water treatment (to reduce high levels of dissolved solids – calcium carbonate, silica, iron oxides etc) represents the greatest opportunity for water efficiency improvement.

Blowdown is minimised when the concentration ratio increases. According to the North California Water Efficiency Manual (1998) “ **typical concentration ratios are 2 to 3, and generally can be increased up to six or more** ” (NCDENR, 1998 p.44).

But, technically significant reductions in water consumption can be made by increasing the concentration ratio only if the cooling tower has been operating at concentration ratios of six or less. In essence, the higher the concentration the less additional water can be conserved because at such high levels of concentration losses to evaporation reach 90% or more, and cannot be returned.

### **Reduction of Scale**

**Scale** on cooling towers refers to amount of minerals deposited on its surface. These acts as an insulator hence reduces cooling capacity of the tower, can obstruct the flow of water, resulting in high-energy costs. Chemical treatment and regular bleed-off can reduce mineral concentration and prevent the formation of scale.

### **Prevent Corrosion and Biofouling**

Corrosion of the metal surface of cooling tower can be caused by increased mineral concentration, scale, and dirt and acidity below (i.e. pH).

**Biofouling** is caused by bacteria, algae, slime, and fungi, which flow around the wet deckings and tubes in cooling towers, because of the warm, moist environment. As a result of this invasion by these organisms water flow is impinged or clogged, promoting scaling and corrosion, which in turn decreases the transfer efficiency of the system.

Corrosion and bio-fouling can be controlled by the use of corrosion inhibitors and biocides, respectively (NWRA, 1995; NMOSE, 1999).

### **Reduce drift and bleed-off losses**

The loss of water from a cooling tower in the form of mist is called a drift. Drift to account for 0.05 to 0.2% of the total water circulation rate. Elimination of drift through baffles or drift eliminator will improve operating efficiency, retain water treatment chemicals in the system, and therefore reduce running costs and conserve water. 'Bleed-off' or 'blowdown' losses can be minimised by increasing the chemical "holding" capacity of the cooling towers' circulating water. This can be achieved by applying inhibitors such as **organophosphates** (anti scale inhibitors), and **polyphosphates** (corrosion inhibitors).

The combined effect of these inhibitors is to increase the towers' holding capacity of total dissolved solids. This factor has two positive effects: minimising bleed-off and therefore the scaling in cost of chemicals, and water. Therefore, it is advisable to monitor the cooling tower's circulating water closely, install conductivity and flow meters on make-up and bleed-off lines. And take preventive measures, add some inhibitors, adjust **pH** by adding sulphuric acid, add oxidising agents such as ozone, and install side stream filtration to prevent pollution by air-borne dust.

### **Recycling and reuse**

'Bleed-off' water can be recycled and reused in the zone cooling towers as 'make-up' water that is, water added to the cooling towers to replace evaporation bleed-off and drift losses.

## **6.4.4 Saving Water in Boiler & Steam Generator Systems**

Boilers and steam generators are commonly used in large heating systems at facilities where process heating is used, or in kitchens for washing and cooking (NMOSE, 1999).

There are a number of factors that influence water and energy conservation options in boilers and steam generators:

- The size of the system,
- The amount of system used,
- The amount of condensate return, and
- The technical design of the boiler/steam generator (MWRA, 1995).

Just like in cooling towers, boilers or steam generator systems need "make-up" water to compensate for water lost when they are "blown down" or "bled-up" to expel any solids or scales that may have built up. Likewise, the water in boilers/stream generator systems is periodically treated with various solids or scales that may have built up chemicals to prevent scale formation and corrosion in the steam distribution system. This can be considered a water saving measure in boiler and steam systems because it reduces water, energy, and chemical purchase costs. How can water be saved? A number of measures can be used to conserve/save water used by boilers/steam generator systems:

- Limit the amount of bleed-ups to match water quality requirements,
- Install an automatic blowdown control for boilers to better manage the treatment of boiler make-up water,
- Steam traps are an important component of steam system's efficiency, hence constantly check these traps and lines for leaks and repair them as soon as they are detected, and
- Recover **steam condensate** and return it for use as system make-up water, while warm so as to save energy and water costs (Baseline Report, 2000).

If return-steam condensate to the boiler is not in place, there is good reason to install one. Recovering and re-using condensate return steam may cut operating costs for a steam system by 50 - 70% (NMOSE, 1999 p. 68).

- Use an automatic control system to turn off the unit when it is not in use during the night or weekends, and
- Recover and re-use recycled blowdown water.

#### **6.4.5 The key variables and equations for a cooling tower & boiler systems**

**How much water can be saved from a cooling tower or a boiler?**

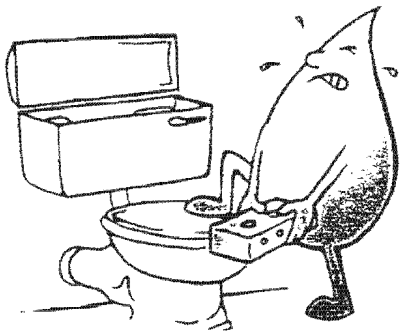
**How much evaporation takes place in a cooling tower or a boiler?**

**What is a water balance for a cooling tower? How is it calculated?**

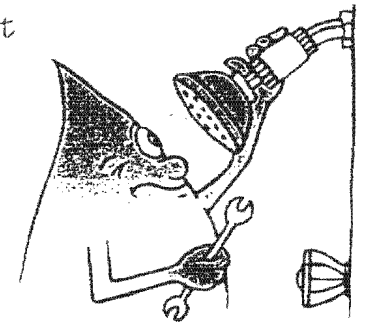
The answers to these pertinent questions are of technical and procedural nature and involve a number of equations as shown in **Appendix J & Q**.

In sum, this there is considerable scope for optimising WDM opportunities in industrial, commercial and institutions. These opportunities can be optimised not necessarily by using expensive technology, but simply by improving operational efficiency by employing the right techniques and best practice. The actual amount of water and energy saving by particular heating or cooling equipment can be calculated by using scientific formulae and equations. As well it is important to conduct frequent auditing and leak detection survey so as to detect absolute and leaking equipment and replace or seal as the case may be. Apart from cooling and heating indoor water consumption can be used for sanitary, cooking, and washing purposes. The next sub-section will discuss ways and means to optimise WDM opportunities in these areas.

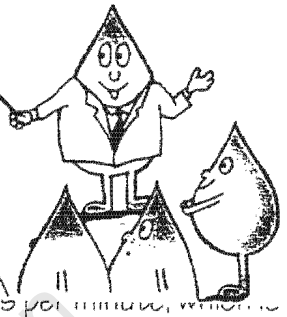
# USING WATER MORE EFFICIENTLY... AT WORK INDOORS



Installing a new water-efficient showerhead is another excellent way to conserve water in the bathroom. It's cheap and easy - and should pay for itself in a fairly short space of time.



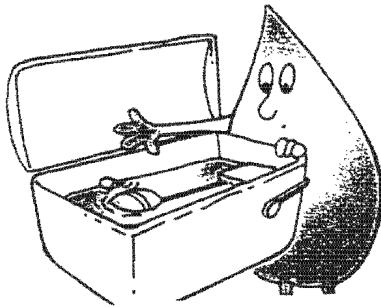
Many people use a brick instead of a plastic bottle in the cistern. This is not advisable as it might disintegrate. If, however, you find a brick more suitable, it would be best to wrap it in strong plastic.



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... more than enough for a good shower.

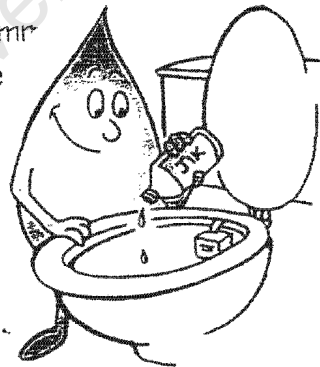
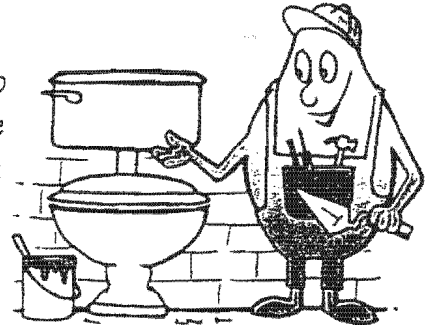
Your present showerhead may have to be replaced by a modern efficient showerhead to achieve best results at the lower flow rate.



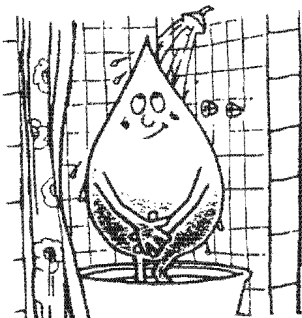
To be sure that the water in the cistern flushes effectively, you must check that the float valve maintains the water level at about 20mm below the overflow pipe to optimise the energy available for the flush.

## Ultra low-volume toilets

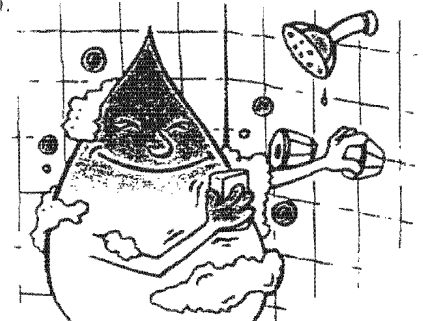
These are an excellent way to improve water efficiency in the bathroom. They are becoming more easily available in South Africa, and if you are building



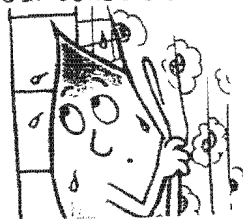
A few drops of bleach in the toilet bowl, or a dispenser of coloured antiseptic in the cistern will postpone the need to continuously flush after urination.



You can also shower standing in a plastic tub or basin. This will allow you to collect the water for some other purpose such as for use in your toilet cistern.



Reduce the shower flow to a minimum necessary for a comfortable shower. Reduce your shower time to a maximum of five minutes.



A further saving can be achieved by turning off the shower taps while you soap up, only opening them again to rinse off.

## **6.5 Reduction of indoor - water use**

In industries, commercial and institutional organisations water is used indoors, that is within facilities or premises not only for cooling and heating purposes as discussed above, but as well for sanitary purposes. Indoors sanitary system includes toilets, urinals, taps, showers, baths, washing machines and other faucets and devices.

This sub-section presents a systematic analysis of water reduction and saving of this indoor sanitation system and the respective possibilities for maximising WDM opportunities therein. Technical aspects of each device, faucet or equipment will be analysed in order to find out whether it is possible to improve water use efficiency by adjusting, fixing or replacing with modern water efficient models.

This task will be accomplished by discussing indoor system optimisation prospects, followed by an analysis of water efficient equipment/devices within facilities.

### **6.5.1 System optimisation prospects**

Indoor water demand in industries, commercial and institutions can be reduced and saved by maintaining the plumbing fixtures so as to reduce or stop leakage in the washrooms (toilets, urinals and showers), and kitchen.

System optimisation can include:

- Fixing dripping showerheads and sinks,
- Fixing leaky toilets that constantly run,
- Initiating and implementing regular maintenance plan
- Maintaining correct hot water tank (geyser) temperature to avoid damage or tank burst.
- Insulating all hot water pipes to minimise faucet run time.

Experience from various parts of the world show that greatest long-term reliable savings from indoor water use comes from installing water-efficient fixtures in new buildings and replacing conventional fixtures in existing buildings. This is referred to as system replacement, and has to take into account the requirements of different user groups, including - Public and employee use, Children, Women and Men; and patients, old and disabled people.

The reason for this is that, opportunities for reducing the use of water may be different for each group, even in cases where the facilities are the same.

Reducing indoor water use yields both peak savings and operational benefits of both commercial and residential, is a good initial measure in an efficiency water program because indoor water is costly. As a matter of necessity it must be treated to potable quality, must be reliable, usually boiled, pumped and later treated again at a cost, as wastewater. It is for these reasons that a water efficiency program has to be cost effective. This can be achieved by utilising water-efficient equipment, which as well has to be cost-effective for both customers and utilities.

Today, indoor water-efficient equipment and devices are readily available in the local and international markets; if properly chosen, and installed, are well accepted by users.

### **6.5.2 Water- efficient Equipment**

There exist water efficient equipment/devices of different types and value, each with different potential for water savings. A survey of most common indoor equipment, toilets, urinal

showerheads, faucet aerators, washing machines, and dishwasher is necessary before making a decision on the type of WDM measures to be employed.

## TOILETS

There are many different types of water-efficient toilets in the market. But, the three major types include gravity flush, flush valve, and pressurised tank type. These types of toilets are in turn called traditional, low-flush, or ultra-low-value (ULV) or ultra-low-flush (ULF) depending on the amount/volume of water they use per flush. Conventional/traditional toilets use 15 to 20 litres of water per flush, but low-flush toilets use only 6 litres of water or less (4\_5.htm p.3). ULF and ULV use only six litres per flush. Obviously, the less water a toilet uses, the higher the volume of water that can be saved.

### Gravity Flush Toilets

These are the most common in most parts of the world. Water efficiency options for gravity flush toilets include improved maintenance, retrofit, and replacement options (NCDENR, 1998).

Retrofitting or replacing a traditional gravity flush toilet with a 6 L. per-flush-unit can in the average save about 25 to 85 litres of water per day. However, it should be noted that experience from California has shown that retrofit options of gravity flush systems have limits. Toilets that consume more than 6L. per flush are most effective, the contrary is true for those toilets that consume 6L. or less water per flush because in some cases a single flush can fail to clear 'solids'.

Simple displacement devices such as hippo bags, bottles, bricks can be inserted into the toilet tanks in order to reduce the water per each flush cycle. Of importance to note is that, while these devices are inexpensive or easy to install, they do require regular maintenance. Bricks or other objects should not be used because of the possibility of generating granular contaminants, which can prevent proper closure of the flapper and damage flow valves.

A plumber can do adjustments to the flush valves in the toilet cistern by replacing the existing flush valve in the tank with a flapper valve in order to reduce the amount of water flow per each flush cycle.

Dual flush adapters (DFA) can be fitted into the existing flush valves in order to allow users to use a standard flush for solids removal or a modified smaller flush for liquid and toilet paper. Experience from the United Kingdom shows that DFA can save between (3 to 6 litres per flush). But, user instructions about the proper use of these DFA systems are necessary.

ULF & ULV toilets usually use between 4l and 6l of water per flush. Thus, water consumption can be reduced from 10 – 14 litres by replacing the traditional toilets. There are many types of models in the market some operate by using a combination of air pressure and gravity or gravity alone.

### Pressurised tanks system toilets

Apparently, the pressurised tank toilet is the most modern and efficiently designed toilet today in the market. Water line pressure is used to compress air in the sealed tank in the toilet. This compressed air greatly increases the flush water force when flushed.

A good example of these toilets is those used in aeroplanes. They are highly effective in removing waste, but are more costly.

### Flushometer (Flush Valve) Toilets

Flushometers are flush valve toilets which use water line pressure to flush solids, liquids and paper into the sanitary sewer system.

Flushometers have a high potential for water saving because it is possible to insert a valve, which can reduce flush volumes by (3 to 6 litres per flush). Inefficient units can be replaced with ultra low flush valve mechanism so as to maximise water savings.

### URINALS

Urinals can be operated in a variety of ways, from traditional pull chain/cord or cyclic flush, to button operation, to the 'demand responsive' type, which uses remote sensors to detect and flush whenever the facility is used.

Cyclic flush urinals are supplied by two 6 - 12 litre cisterns and operate 24 hours a day, using a lot of water (some experts in Australia estimated that about 12 million litres per annum are used by these 24-hour-operating cyclic flush urinals)(White, 1994). This massive wastage of water makes this type of urinal very undesirable in modern times. In many countries such as New Zealand, Australia and USA, Water Authorities have stopped using these types of urinals in public places. In the CMA as observed during the water audit cyclic flush urinals are still found in a number of premises.

Pressure operated urinals have a controller which detects a drop in the supply pressure resulting from a nearby cistern or tap and activates a pre-set amount of water into the cistern. The advantage of this type of urinal is that it can be adjusted to flush after a certain number of flushes after a certain number of 'operations'. This enables the unit to provide a flushing operation roughly proportional to the activity in the toilet and shuts down at times of zero using. Furthermore it not expensive (about R 1400), and it does not use energy. However, it has some minor disadvantages in that it can not distinguish between people who enter the wash-room to use the hand basin or pans rather than the urinal. As well if the last person to leave at night does not trigger it to flush there will be no flush until next day. This causes the wash-room to smell.

The traditional pull chain/cord operated cisterns are water efficient if the size of the cistern is between 6-11L. Otherwise, the large, 13-15 L. cisterns waste more water per flush.

Sensor-operated systems use infra-red or microwave sensors to determine whether the urinal is being in use or not. There exist different types of systems, some of the latest types super sensitive as they can detect the salt content of the urine in the bowl, while others can detect the number of users and allow an appropriate rate of flush just enough to keep the place clean (White, 1994)

### FAUCETS

Traditional faucet flow rates range from 3 to 5 litres per minute. Research by John Woodwell of the Rocky Mountain Institute proved that modifications of faucets by adjusting flow valves to the faucet, and retrofitting aerators in order to control water flow can save about 3 – 5 % of total indoor residential water use (Woodwell, 1990). Some faucet aerators can reduce flow to 1.5 litres per minute (SADC – IEMP, 2000).

Aerators can be screwed onto the faucet heads and add air to the water flow while reducing water flow. There exist different types of aerators in the market ranging from low flow ones (3L/m to 11L/m) and ideal for hand washing and kitchen washing purposes respectively. There are many types of water faucet and control systems in the market:

- Metered self shut off – once new lever is depressed, the faucet delivers a water flow for a pre-set time period, (5 – 20 seconds) and automatically shuts off. They are reported to reduce water in public washrooms by 50% when properly working and not leaking.
- Automatic shut- off - once handle is released, a valve shuts off and stops the water flow (UCDENR et al, 1998).
- Aerators cost between R40 to R70 installed and typically yield a payback within a few months – through reduced water and energy bills, as a result of reduced water quantity of water and hot water use respectively (Vickers, 1990).

## WASHING MACHINES

Different washing machines use different volumes of water per load. Most top-loading machines use more water as they are designed to operate by submerging clothes in a tub full of water and agitating them on a vertical axis. Front-loading washing machines typically use 40% less water than top-loading washers (Woodwell, 1990).

Today in the market there are some efficient washing machines, which combine the convenience of top-loaders with the efficiency of horizontal axis machines in the top-loading horizontal axis machines. Efficient washing machines of this type reduces water use to 160 – 180 litres per load as compared to 210 L/load for conventional models. It is almost impossible to retrofit washing machines therefore, the best measure is to replace them as they become obsolete or break down.

## SHOWERHEADS

Water efficiency can be achieved by replacing conventional showerheads.

Most conventional showerheads typically use 14-32 Litres per minute (L/m) showerheads at 60 psi water pressure.

In most water conscious countries, high-flow showerheads have been replaced with low flow (11 L/m) and ultra-low flow (6 L/m) ones (NCDENR et al, 1998; The Water Program, 1991; SADC-IEMP, 2000). There are many different models of new water efficient showerhead models in the market. As Colin Laird (1991) concludes - showerheads vary widely in "feel" from misty to needle-like to pulsating to a vigorously pounding flow.

Experience (from the USA - Phoenix Arizona, Texas, and Boston Metropolitan Area) has shown that replacing a conventional showerhead with water use by an 11 L/m fixtures could save households water use by 19 L/cap/day\_(Vickers, 1990)

Savings from installing water efficient showerheads should be considered as well in terms of reduction of energy consumption for hot water generation.

## PRESSURE REDUCING VALVES

High pressure normally above 50 psi increases the water flow from spigots, hoses, faucet or showerhead, and thus increases a wastage of water. Technically it is simple to lower excessively high-line pressure in order to reduce water flow and the formation of leaks.

Experience from North Carolina in the USA shows that a pressure reduction of 15 psi from 80 to 65 psi can reduce water flow by about 10% without sacrificing water service (NCDENR et al, 1998).

## INFRARED & ULTRASONIC SENSORS

Infrared and ultrasonic sensors (IUS) are sometimes called “electric eye” sensors because they deliver a metered flow only when a fixture is in use. IUSs can be fitted in lavatory faucets, urinals, and toilets.

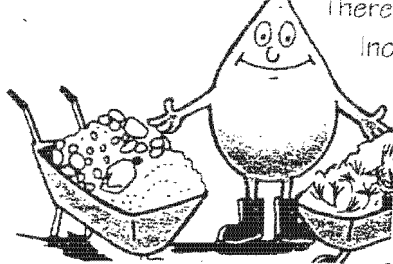
IUSs have a number of advantages over other devices:

- For faucets both the flow rate and activation time can be adjusted
- The self-activation (“no-touch”) is helpful as it can prevent the spread of disease, and is useful for users with disabilities. Although IUSs are a bit expensive, (about R1500 a device) they are a good value for money as the scope for water savings are high.

### 6.5.3 Conclusion

All the examples and devices discussed above demonstrate that water efficient fixtures, including ultra-low-volume per flush toilets and urinals; water efficient showerheads, washing machines, and faucets aerators can reduce indoor non-residential (and residential) water consumption. In the USA this reduction is estimated at 35% or more (The Water Program, 1994). Under normal conditions there is no concrete reason to why the CMA cannot more or less reduce the same amount. Conventional water fixtures are the most water wasting devices, hence they should be replaced as soon as they are obsolete, or financially feasible to do so. This is justifiable because the scope for saving water and energy is high, and thus the stakes for opportunity payback are as well high.

In the next section water reduction opportunities out doors in non-residential premises are discussed with particular reference to the CMA.

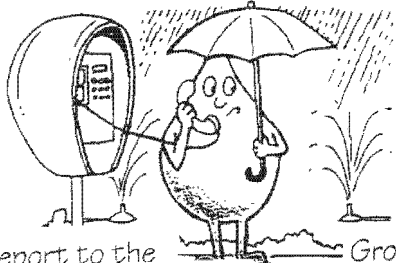


There are two types of mulches:  
Inorganic - gravel and pebbles,  
and Organic - bark chips,  
sawdust, pine needles

There are many benefits  
to mulching:

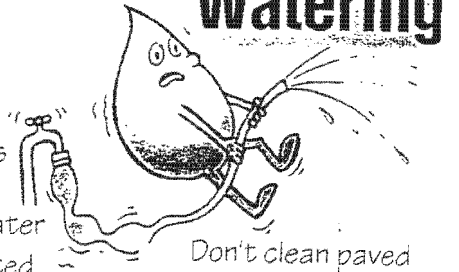
It reduces water  
evaporation and  
run-off.

## USING WATER MORE EFFICIENTLY... OUTSIDE Watering

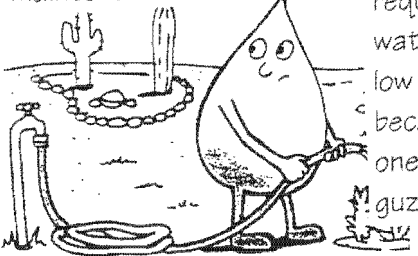


Report to the maintenance staff if

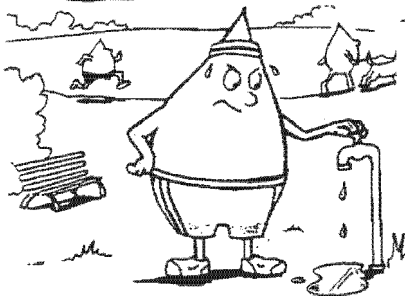
You don't have to try hard to waste water outside. Some hoses gush out about 30 litres per minute.



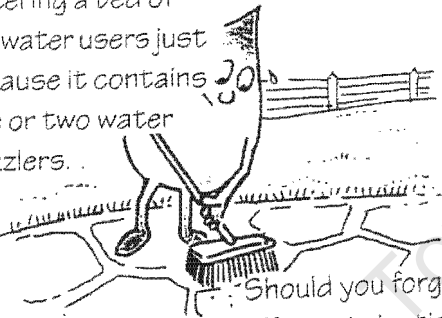
Don't clean paved areas with a hose-pipe - rather brush it down with a good garden broom.



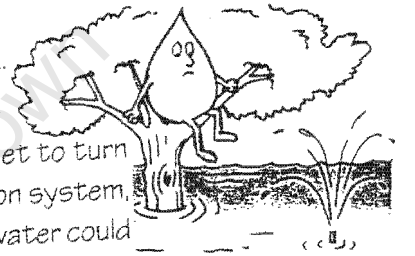
Group plants according to their water requirements. Much water is wasted watering a bed of low water users just because it contains one or two water guzzlers.



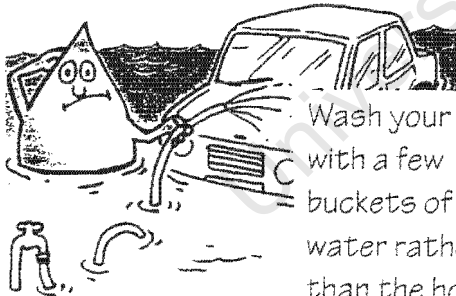
Turn off all taps left running in public places.



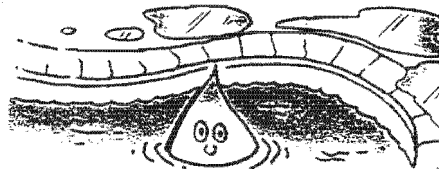
Should you forget to turn off your irrigation system, 1000 litres of water could be wasted every hour.



Place a cover over your pool to prevent huge losses through evaporation.

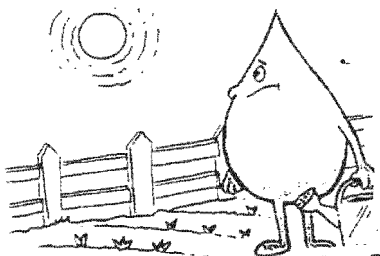


Wash your car with a few buckets of water rather than the hose.

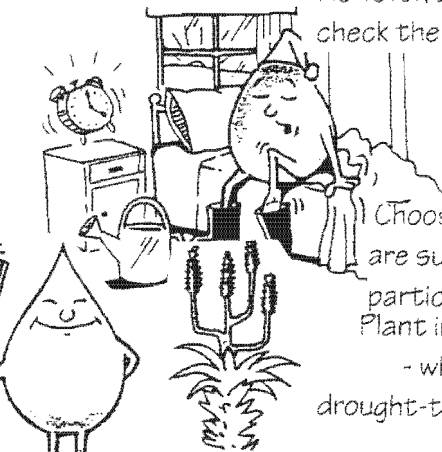


Keep water levels in your pool to a minimum to prevent water wastage through splashing.

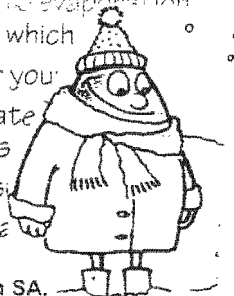
Install a timer and the mistake will never be made. However, do remember to check the timer regularly.



In spring and summer, avoid watering in the middle of the day, considering the high rate of evaporation.



Water early in the day and less on windy days to reduce loss due to evaporation. Choose plants which are suitable for your particular climate. Plant indigenous - where possible - drought-tolerant plants.



## 6.6 Opportunities for achieving Water Efficiency in Outdoor Watering

" Millions of litres of water are wasted every year by incorrect watering practices. How often to water and for how long depends on your soil type. The most efficient method of watering is to group plants with similar water needs and to plan an irrigation system accordingly "

NBI & DWAF, 1998: *Water- wise Gardening for winter-rainfall regions*. p.12.

### 6.6.1 Introduction

Outdoor watering is another important aspect of non- residential water use, which is sometimes overlooked. Outdoor non-residential water use refers to water used to irrigating flower beds & orchards, lawns, keeping sports grounds green, and maintaining public landscapes.

Outdoor watering may appear to be a small component of total annual water use, that is, between 15 % and 20 % in the case of CMA for the last five years. But it takes place in the middle of summer when water is needed most and may constitute about 40% to 80% of a utility's peak summer use (van Niekerk, 1995).

Use of water at a peak season drives the need for additional water-treatment capacity, and thus it is a prime target for a load-management programme.

Although it is difficult from the literature point of view to pin down exact percentages of water savings - in fact, because none exists as there are so many variables, vagaries of nature included, it is generally agreed that there is a considerable scope for outdoor watering efficiency (NCDENR, 1998).

Evidence from the USA (North Marin Water District in California, Gary and Salisbury Municipalities in North Carolina and New Mexico) shows that about 10 – 30% of water supply can be saved by using efficient outdoor watering methods and reducing the size of lawn (Nelson, 1992; NCDENR, 1998; NMOSE, 2000).

Today local and international experience provide a number of efficient watering methods, including the relatively new approach referred to in the literature as "Xeriscaping".

The next section presents and discusses this "Xeriscaping" as a method of landscaping for enhancing water saving and increasing efficient watering in both no-residential and residential areas in general.

### 6.6.2 Definition, goals and scope of Xeriscaping

The term "Xeriscape" is derived from the Greek word "Xeros", which means "dryness" (NMOSE, 2000 p.48). Xeriscaping can be defined as an approach that ensures water-efficient landscaping appropriate to the natural environment. This approach "... **combines selecting, placing, and maintaining plants for optimum water management**" (NCDENR Water Efficiency Manual, 1998 p.50).

The goal of a Xeriscape is to lessen the amount of water used on landscape plants, while maintaining the aesthetic and functional qualities of a site. This goal can be achieved in many ways, including the use of drought-resistant plants, reduction of turf size, and other commonly known water-efficient landscaping methods.

Documented international experiences show a high prospect of saving water by using Xeriscape methods. For example, a study carried out in Sacramento, California (USA) in 1990 examined townhouse and condominium landscapes maintained by professional landscape contractors found that:

- Reducing the amount of turf in water conserving landscapes by half as much as used in the traditional yards of the same size reduced water requirements by 54%; 25 less labour; 22% less herbicides, and 44% less fuel to maintain (Water Conservation News, 1990 p.14).

Examples from else where - Kalgoorlie-Boulder, Australia, and State of North Carolina, USA supports the conclusion that Xeriscape is a promising innovative approach for an efficient landscaping method, which can reduce water demand by as much as 50% (The Water Program, 1994;NCDENR, 1998;SADC-IEMP, 2000).

### 6.6.3 Principles of Xeriscaping

There are seven basic principles of Xeriscaping commonly presented in the literature as outlined below:

#### A. Planning and Design

Proper planning and good designing are two essential first steps to water-efficient landscape. It is essential to consider the site conditions and the "micro-climate" thereof (drainage, soil type, sun exposure/shade, shape/grade, type of flora and fauna, aesthetic preferences, and water availability).

Landscape planning based on xeriscape zones is essential. This entails decision of an area into at least three zones: "Aerial", "Transition", and "Oasis" (Moderate water) (NCDENR, 1998 p.51; NMOSE, 1999 P.49).

Of importance to note are the following points/issues:

- Plants of similar water needs are grouped into specific zones.
- Those plants with higher drought resistance qualities are placed to the outer zones, while those with the lowest draught resistance qualities (i.e. highest water users) are placed in the "Oasis zone" near to the buildings, and includes the lawn area as shown in **Appendix K**.

#### B. Soil Analysis and Improvement

Soil analysis is essential in order to establish soil qualities and absorptive capacity. Its results enable one to take ameliorative measures, such as addition of organic matter (e.g. compost, mulch or manure), fertilisers or changing its pH before appropriate plants are planted.

#### C. Appropriate tuft size and practical turf area

Mowing turf at alternating heights can save up to 30% in water requirements.

Turf grasses such as "kikuyu" are known to have the largest water consumption patterns of any plant group. Therefore, the area under these types of grasses can be reduced in order to reduce water requirements.

#### D. Plant Low-Water-Use Plants

Explore the possibility of using native and low-water-use plants like fynbos and other water-wise plants (see Appendix M). Whenever possible it is advisable to plant alternative ground covers that are water-wise, or use patios and decks in order to further reduce water consumption.

## **E. Use Mulches**

Mulches are any organic materials such as compost mixtures, grass, pine straw, dry leaves etc. They are placed around the root zone of a plant for a number of reasons:

- to cover and cool the soil,
- to retain soil moisture and thus minimising water demand.

## **F. Efficient Irrigation**

Efficient irrigation can be accomplished by using a combination of factors: proper design, installation, and maintenance of both the irrigation scheme and the landscape. Effective irrigation "incorporates watering plants deeply, infrequently, and slowly" (NCDENR, 1998 p.52).

There are a number of common practical experiences from local and international arena that can be learned and taken into account during outdoor watering:

- Automatic systems, such as drip emitter pipes and spray emitters that target the root zone of each plant save water and are cost-effective.
- Uniformity of the water being applied by the irrigation system is a determinant factor in irrigation efficacy. Adjustments to the sprinkler operating pressure, type of nozzle used, and sprinkler spacing are important factors to consider in order to achieve sprinkler uniformity.
- Overhead sprays and mid-day irrigation is less effective and increases water loss by evaporation.

## **G. Appropriate Maintenance**

Proper and regular maintenance of irrigation equipment and devices; attention to landscape (mowing grass, weeding, regular aeration of clay soils and keeping nutrient levels balanced) are crucial elements in sustaining water efficiency.

A combined application of these principles can lead to reduction of water wastage and efficient watering not only in new landscapes but as well in existing ones. The challenge is how to transform existing landscapes to fit xeriscape requirements. This will be discussed below.

### **6.6.4 Water Efficient Options for Existing Landscapes**

**The key question is how can the existing landscape be improved so as to achieve water efficiency?**

There is ample evidence from many parts of the world, which shows that existing landscapes can be improved so as to increase water efficiency. Performance improvement can be achieved by applying the principles of xeriscaping reviewed previously herein. However, additional assistance can be obtained from specialists – certified landscape irrigation designers, and gardeners.

Furthermore, there is a wide variety of simple to install and operate water efficient technologies and devices in the market as presented below.

### 6.6.5 Water Efficient Technologies for Xeriscape

To commercial, industrial and institutional facilities it is economical (time and financial-wise) to install automatic timer/controller on existing landscape manual irrigation systems (NCDENR, 1998). The automatic timer or controller operates the sprinklers on a pre-determined day of the week for the correct amount of run time.

Installation of soil moisture sensors can assist to stop the sprinklers from operating when the plants' water needs have been met by natural precipitation. It is interesting to note that modern technology and science have made it possible to use centralised PC-based irrigation systems to manage many irrigation controllers wide-spread in different sites.

Experience from California in the USA (Programs developed by the Centre for irrigation Technology of California State University, Fresno) shows that it is possible to use PC programmes such as the "Hyper-SPACE" to monitor and generate graphic representation of sprinkler efficiencies. The so-called "SPACE Irrigation Survey" can be used to analyse the costs versus the benefits of improving irrigation efficiency (NMOSE Water Conservation Guide, 1999).

### 6.6.6 Conclusion

Adding it all up, there are a number of ways that existing landscapes can be made water-efficient:

#### 1) Knowing when and how to water

- Water the landscapes early morning or late evening (before 9:00 am) to minimise evaporation and maximise absorption.
- Refrain from watering when it is raining or windy (i.e. when wind is less than 17km per hour).
- Water deeply and less frequently (once or twice a week) instead of lightly everyday. Deep watering allows plant roots to grow deeper, and thus, allows them to be more drought tolerant since they become more capable of drawing moisture from a larger volume of soil.
- Eliminate over watering in order to avoid water logging. This can be achieved by using 'evatransportant' (ET) data to help determine a plant's water needs; or to water only when plant groups show signs of water stress (NCDENR, 1998; NMOSE, 1999).

#### 2) What to do? (Adjustments, Attachments, modifications)

1. Adjust sprinklers and other water efficiency devices to concentrate watering on the root area of plants not the leaves or trunks.
2. Attach a nozzle or spray head with an automatic shut off option to save water when so desired.
3. Adjust sprinklers to water desired landscape plants/grass, not pavements, streets, sidewalks, walls, or parking lots etc. Apply water only when and where it is needed.
4. Improvement the maintenance system, program or plan; check for leaking valves, broken sprinklers, worn spray nozzles and repair or replace them as the case may be.
5. Adjust the runtimes (operating time) of sprinklers to match the monthly or seasonal requirements.
6. Incorporate alternative water sources such as rainwater, wells, grey-water as opposed to potable municipal water.

7. Maximise water conservation by replacing old type sprinkler systems/heads with newer, water efficient models and use them in the right place. The following sprinkler types are recommended (See **Appendix K**).
- Pop-up sprinkler models. They retract when not in use, hence they cannot easily be damaged by foot traffic or lawn mowers.
  - Fixed-spray sprinklers  
They produce a tight, constant fan of water that is ideal for small landscape designs and lawns.
  - Impact rotor sprinklers  
They feature multiple rotating streams that are designed for medium-sized turf area.
  - Drip irrigation systems and subsurface trickle irrigation  
Drip irrigation and subsurface trickle irrigation are used to water shrubs, perennials and trees. This type of irrigation is considered to be more efficient than sprinklers because they deliver slow, steady amounts of water directly to plant root zones, and thus reduce water loss to evaporation, over-spray and run off.

#### 8. Use Water Efficient Plants

Selection of appropriate plants is a major factor in the preparation of water efficient landscape. Plants' need for water differ according to species and the type of macro & microclimate. In a xeriscape, plants' watering needs are divided by hydrozones (refer to principles of xeriscaping in 6.5.2.2 A above). Drought tolerant and native plants (in contrast to exotic, water hungry alien plants) should be planted because they are more resilient and adaptable to the local rainfall patterns. As for the CMA a list of water-wise species of plants is attached in **Appendix M**. It is advisable to consult this list before introducing any plants in your landscape.

All in all, there is a considerable scope for increasing water efficiency by a number of viable options for the existing landscapes. By simply knowing **'when and how to water'** and following the **'what to do'** advice given above water efficient landscaping can be easily achieved.

## 6.7 Conclusion

Based on the presentation and findings of the six sections of this chapter, one can conclude that optimisation of WDM opportunities is a technologically and economically viable option for facilities in the CMA. To start with, it was shown that there are some substantial water reduction and costs saving benefits, hence some considerable financial gains in embarking in WDM strategies and measures. This inevitably can act as an incentive to water customers to embark on WDM initiatives. The technology involved in WDM need not to be very expensive, as it can involve simple retrofitting of the existing equipment, tuning up existing devices and fixtures or making some adjustments or minor changes in the attitude and practice of water consumers and workers.

The section also shed some light on the relationship between the use of modern technology and economic efficiency. It is now obvious that given what is technologically feasible, some thing can or cannot be done due to inhibitive high costs. However, something that is technologically efficient may not be economically efficient, but something that is economically efficient is always technologically efficient because economic efficiency depends on the prices of the factors of production. As regards to water sector, water efficiency can be defined as the employment of devices and practice which result in less water being used for

the same task or function, and is based on cost reduction. In that sense achieving water efficiency is compatible with economic efficiency.

The amount and cost of water saved water through implementation of water efficient equipment or devices can be quantified in financial terms. Cost reduction is therefore the basis for achieving water efficiency and thus achieving economic efficiency in any organisation, be in industrial, commercial, public or private institution.

In all categories of water use, water efficiency can be influenced by a number of factors: water-saving technology - devices and equipment, and deliberate efforts by water users to change negative attitudes towards water. Generally, water saving can be achieved by employing either of the following measures: System optimisation, system replacement, reducing - re-using - recycling, operational or production changes or by using discretionary alternative uses such as dry sweeping, or shutting off taps between rinsing steps, i.e. when not directly used. Specifically, vast opportunities for saving water exist especially in washing machines, cooling towers and boiler systems as they use large amounts of water at a given time. As for cooling towers and boilers large quantities of water saving can be achieved by optimising blow down processes, reducing scale, drift and bleed-off losses, and recycling of water.

As regards to indoor water use, there is a considerable scope of water reduction and saving by optimising systems - fixing drippings in showerheads, taps and sinks, fixing leaky toilets that constantly run. As well by initiating and implementing a regular maintenance plan, maintaining correct hot water tank (geyser) temperature to avoid damage or tank burst and insulating all hot water pipes to minimise tap run time. Retrofitting existing water wasting devices/fixtures is another viable option. Water efficient devices/fixtures such as gravity flush toilets, flushometers, cyclic flush urinals, infra-red sensor operated systems or microwave sensors, aerators, automatic shut-off faucets, or showerheads with pressure release valves or electric eye sensors and other modern devices.

The opportunities for reducing and saving water in outside watering are as well vast, especially by using the modern methods known as "Xeriscape" landscaping, whereby seven principles of optimising watering process, soil, and gardening methods are utilised. These seven principles of "xeriscaping" include: planning design which considers micro climate-shade, drainage, type of soil, grade, zones, flora and fauna of that particular place; soil analysis; maintenance of lawn size; selection of appropriate plants to fit hydrozones; use of best gardening practice- use of mulching, use of automatic shut -down drip irrigation systems and sprinklers and other water saving methods and equipment and appropriate maintenance of irrigation equipment.

Based on these findings, it is recommended that all industrial, commercial, and institutions in the CMA should explore and utilise WDM opportunities in their respective facilities of organisations in order to reduce water wastage. Indeed, optimisation of WDM opportunities can save water, lower potable water production and distribution costs, and thus increase the propensity to make profit in a commercial or industrial facility.

Now that we have examined how water can be reduced and saved in doors and outdoors in non-residential facilities by using water efficiency techniques, technology and best available practices we can move on to the next chapter, which will discuss methodologies, procedures and techniques for assessing and evaluating WDM measures. The starting point is to know the present criteria for water resource allocation in the CMA, since they are the yardsticks or benchmarks for assessing any WDM measure.

" Evaluation of effectiveness of WDM measures is essential in order to establish beforehand the outcomes and achievements of alternative measures so as to facilitates the process of choosing the best alternative measure for a facility or an area by decision-makers. Any assessment or evaluation is normally based on a set of benchmarks or criteria. Therefore the starting point is to establish criteria for water allocation in the CMA; and then to use these criteria to evaluate/assess prospects for the different alternative measures pertinent to a facility or an area. Economic criterion is not the sole one pertinent to planning and managing water services in the CMA. The whole list includes: Economic viability criteria (Efficacy, Economic efficiency, Equality, Fiscal effects, Sustainability, Administrative Feasibility), Environmental impact, Political & public acceptability, and Strategic considerations". [JRK, 2000]

## CHAPTER VII

- **Assessment & Evaluation of Water Demand Management Measures**
- **Criteria for efficient water resource allocation**
- **Economic evaluation of WDM measures**

## **7. ASSESSMENT AND EVALUATION OF WATER DEMAND MANAGEMENT MEASURES**

### **7.1 Introduction**

The previous chapter examined the theoretical and practical aspects of water efficiency, water efficient practices and ways how to optimise and maximise WDM opportunities in the CMA. This chapter moves a step forward by focusing on how to assess and evaluate effectiveness of these WDM measures in saving water at facility (project) and area (programme) levels.

The evaluation of effectiveness of WDM measures is essential in order to establish beforehand the outcomes and achievements of alternative measures. This is important because it facilitates the process of choosing the best alternative measure for a facility or an area by decision-makers.

Any assessment or evaluation is normally based on a set of benchmarks or criteria. Therefore the starting point is to establish criteria for water allocation in the CMA; and then to use these criteria to evaluate/assess prospects for the different alternative measures pertinent to the facility of area.

Thus, this chapter aims at accomplishing two major tasks in two sections: Section 7.2 critically discusses the criteria for efficient water allocation in the CMA. Section 7.3 presents Cost-Benefit and Opportunity Payback Analyses as the appropriate economic evaluation methodologies of establishing the effectiveness of WDM measures prior to their application in water conservation projects or programmes in the CMA.

### **7.2 Criteria for efficient water resource allocation**

#### **7.2.1 Introduction**

This section presents and discusses the criteria which water resource planners and project analysts in the CMA can apply to the new pro-water (demand management) saving projects and programmes. It was noted earlier that the rationale for adopting WC and WDM strategies hinge on the reality that water supply the CMA is becoming scarce due to a number of factors: increased population growth rates, improved life styles, and dwindling supplies, both in quantity and quality. The resultant is an increased demand for water, high and rising water development costs, intensive competition amongst all users of water.

It is thus increasingly important and logical that the existing scarce water resources should be allocated efficiently. Again by efficient we simply mean that the price of water should reflect its economic scarcity value. This necessitates CMC to make economic decisions on water-use.

But, inevitably these 'economic decisions' have to take into account other legitimate factors, including social, political, environmental/ecological and strategic objectives.

In other words, the economic criterion is not the sole one pertinent to planning and managing water services in the CMA.

A comprehensive list of criteria would include the following:

### 1) Economic viability criteria

- Efficacy
- Economic efficiency
- Equality
- Fiscal effects
- Sustainability
- Administrative Feasibility

### 2) Environmental impact

### 3) Political & public acceptability, and

### 4) Strategic considerations.

We can now proceed to briefly discuss these criteria as applied or could be applied in the CMA.

#### 7.2.2 Efficacy

The degree of achievement of declared water policy objectives is referred to as efficacy of policies. The response to a given policy 'effort' or the 'elasticity' of the response to different policies is vital to policy makers (Winpenny, 1994).

As regards to water allocation it is necessary to know how people of different income groups respond to changes in the price of water. This is called the elasticity of water demand, and is the clearest measure of response or reaction in a given water supply area.

In the case of CMA a thorough research on price elasticity of water is still pending, but there are indications in the CMC Alternative Options Study Terms of Reference (TOR) that mentions that it is the responsibility of the Palmer Development Group to conduct this research (CMC – AWDO Final Draft dated 01/02/2000, p. 21).

The TOR of the CMC-AWDO stipulates that determining price elasticity of water in the CMA is necessary. The CMC -AWDO stated that this study of price elasticity and water tariff patterns within the CMA would be based on the water tariff model developed by the Palmer Development Group on behalf of the South African Water Research Commission (WRC) (Op.cit.p.21).

The results of question No 9 a & b of the Baseline Report (2000) questionnaire shows that 50 % of non-residential water users in the CMA will reduce water consumption if the price is increased (See **Appendix B** and Baseline Report, 2000 Section 3). Judged on this information and that obtained from personal communications during the data collection and field-work period, there are all indications that future water demand will not be reduced as a result of slight price changes.

In other words, by simply increasing the price of water the desired effect of reducing water demand can not be achieved. To use economics jargon, because the current water prices are very low, and because water as a commodity has no perfect substitute, slight increases in price will not trigger massive changes in the amount demanded. Unless the prices are very high, the elasticity of water demand will remain less than 1.

Further investigation/research of the effects of tariff increase on water consumption in the City of Cape Town can give a clue to what the response might be for CMA in general.

Certainly, it will give a clue to a general picture, but not the real picture because experience from elsewhere shows that the degree of responsiveness to price changes, that is price elasticity of water varies substantially from area to area, and from one income group to another. It to a large extent depends on whether the amount consumed is to fulfil the basic

needs, is an essential input for production, or is for satisfying affluent extra needs such as irrigating lawns (Whittington et al., 1991; Winpenny, 1994).

Thus, efficacy is related to the criterion of acceptability, discussed below. To what extent it should be applied in planning water policy objectives depends on many often factors including the impact of the other criteria discussed below.

### 7.2.3 Economic efficiency

#### 7.2.3.1 Introduction

Water allocation to different sectors can be viewed from a purely economic point of view as "a portfolio of investment projects" (Dinar et al., 1997 p.4).

Water can be considered as a scarce economic resource, a "natural capital" to use the terminology of Schumacher (1973) in '*Small is Beautiful*'; and the Productive/Economic Sectors use this natural capital to produce returns. In order to maximise social welfare there should be an economically efficient resource allocation, whereby the marginal benefit from the use of the water resource is equal across sectors. In other words, the benefit derived from using one additional unit (the marginal unit) of the water resource in one sector should be the same as it is in any other sector. If not, society would benefit by allocating more water to where the benefits, or returns, will be highest (Dasgupta & Heal 1979; Conrad & Clark, 1987; Schur, 1996; Dinar et al., 1997)

#### 7.2.3.2 Theory and Model for Economic Efficiency of Water

Theoretically the interplay of the forces of demand and supply in a water market determines the optimum price for water and ensures an efficient distribution of water in all sectors. Furthermore, the efficiency criterion requires that the economic benefits of policies exceed their costs.

The supply and demand curves can be used to illustrate how the economic efficiency criterion can be applied to water conservation in the CMA.

A simple economic model set out in Figure 7.1 is necessary to illustrate the salient points. The demand curve shows the consumers' willingness to pay for the amount of water consumed. It is normally a downward-sloping curve from left to right, reflecting the diminishing marginal valuation of successive increments of water.

The fact is that in real life people are willing to pay more for the initial units of water, for instance the first glass of water to a thirsty man, then the next glasses of water are less desired, hence less demanded. The supply curve slopes upward from left to right relating to the fact that prices are fixed at the point or above the point, where demand and supply curves intersect.

In Figure 7.1 net benefits are maximised at point **Z** when **OC** units of water are produced with a price of **OP**. Point **Z** is the optimum point, otherwise economists call it the *Pareto optimality*. Net benefits, the excess of the area under the demand curve over that under the supply curve, are represented by the area **DSZ**.

If consumption is higher than this, say **OE**, the costs **CZUE** of supplying the increment **CE** exceed benefits **ECZX** by **ZUX**.

Conversely, if consumption is restricted to **OL** the loss of consumer benefits **CLNZ** exceeds the supply cost savings **CLJZ** by **JNZ** and this solution is also sub-optimal.

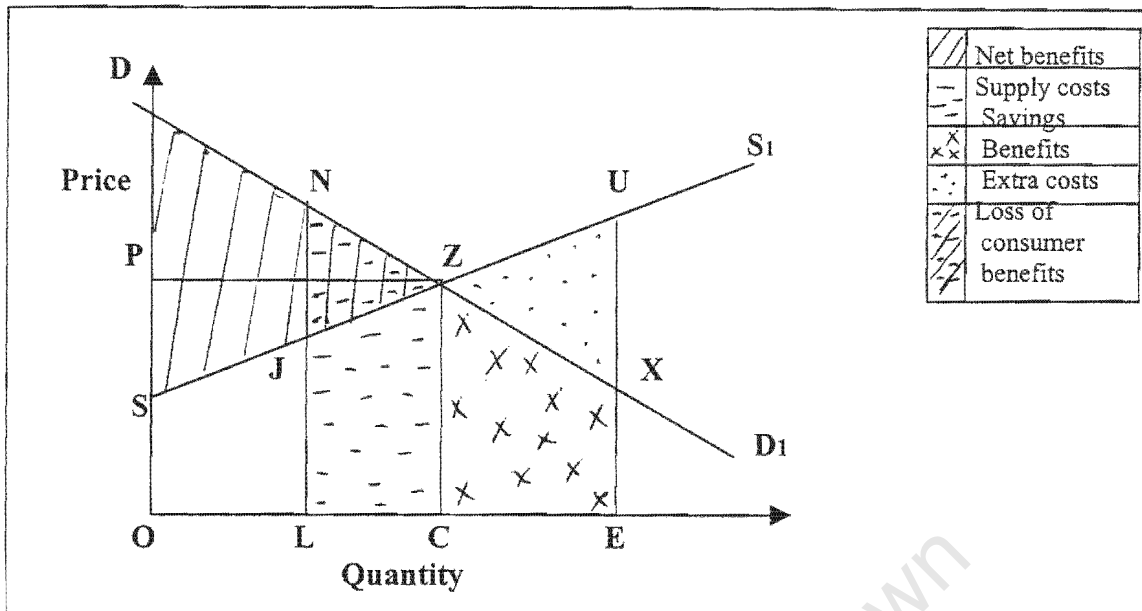


Figure 7.1 Theoretical graph model to illustrate economic efficiency of water  
Source: Author's adaptation

### 7.2.3.3 Equity

Equity and access to water supply services have a place in water resource allocation (Winpenny, 1994; Dinar et al. 1997; DWAF, 1998).

The objective of equity is to impose fairness of allocation of water resources across economically disadvantaged groups. This may or may not be consistent with efficiency objectives. In the case of residential (household) water use, for example, an equitable allocation of water resources implies that all households have a basic right to have access to water services regardless of their ability to pay for it. Meeting this objective may require the government/municipalities to provide subsidies, or offer free water services, or adopting a differential pricing structure based on the level of income. Experiences from elsewhere, for instance, from Egypt (Cairo) and Thailand (Bangkok) demonstrate there are some difficulties in implementing such policies, especially with regards to how to determine which group of people qualify to get 'free water', at what level (percentage) should water subsidies be fixed and for how long (Maddaus et al., 1996; Weber & Parsons, 1997).

In the case of the CMA the challenge in one hand is not to break away from the apartheid biased approach to water resource management "**whereby allocation of water was never merely an economic matter, but a socio-political one**" (DWAF, 1998 1B-6 p. 4). On the other hand (or rather simultaneously) the challenge is how to comply with the new realities of political freedom and domestic rights enshrined in the New South African Constitution (1995); and the subsequent new National Water Act (1998), Policies and Laws (The Constitution of SA, 1995; The New Water Act, 1998; WRC, 1998).

The DWAF Water Pricing Policy gives guidelines on how to address social objectives by taking into account social equity needs. The latter has to be understood from two points of view, viz.,

- Adequate access to water supply services; and
- Direct access to bulk government water (1<sup>st</sup> tier water).

Accessibility of water supply services is a Constitutional right, prominently addressed in the New Water Act of 1998 in terms of the basic human needs reserve. The Water Act requires water services to be extended to individuals in order to cater for basic needs, that is, water for drinking, food preparation and personal sanitation. This could be achieved either by CMC providing water **free of charge** to the low-income, unemployed, poor sections of the CMA. Or by having **lifeline tariffs**, which are subsidised to the extent that ultimately token prices do not hinder accessibility to water for basic needs.

A serious problem to be resolved by the CMC is that of how and at which level to fix the subsidies. This can be done either by providing subsidies direct to the individual consumer via the budgetary allocations or by indirectly subsidising the resource cost of water.

In weighing up the alternatives, it has to be recognised that the latter option is administratively easier, and economically viable as compared to the former option.

Provision of free water-saving devices and retrofitting service could be used as a strategy to save water and reduce future water supply costs. Direct subsidies almost always have negative impacts such as resource overuse, wastage, and above all are not economically sustainable (Panayotou, 1987; OECD, 1997; Kombe, 1999).

Direct access to government/Municipal bulk water supply on concessionary basis could be used by CMC in order to support development efforts by disadvantaged individuals and communities within the CMA (DWAf and Water Institute of SA, 1998).

### 7.2.3.3 Ecological & Environmental Impact

Economic methods of ecological and environmental valuation can be used in order to quantify the net effects of WC and WDM initiatives - programmes and projects on the environment. The net effects should be incorporated into economic appraisal, either as credits or costs, using recognised techniques such as the cost benefit analysis (CBA), or Cost efficiency analysis (CEA) as discussed in section 7.2. and elucidated further in **Appendix H**.

There is no doubt that the CMC and the MLCs in the CMA are in favour of development that is ecologically and environmentally sustainable. Economic use and wise use of its scarce water resources while pursuing economic growth goals without compromising the present and future quality of water resource is their motive (CMC - AWDO, 2000; Pers. Comm. CMC Water Engineer and WC National Strategy Coordinator, March 2000).

The CMC needs to ensure that water supply, WC and water demand management options pursued in the CMA do not become unacceptable/unpalatable by causing irreversible negative impacts on population or ecosystem. Water efficiency in this regard can be achieved by protecting the ecological reserves and water sources by cleaning up alien species, diffusing sources of pollution, and enforcing the '**polluter pays principle**'.

### 7.2.3.5 Financial effects

Financial considerations have considerable impact on the distribution of water in a country, region or an area. The snag is that many areas with serious water problems also have a weak financial base. This is a typical condition in most developing countries.

In other words, there is a correlation between weak public finances and public infrastructure, such as those of a reliable, modern supply system (Khosa, 2000). Provision of water services in a municipality depends on the availability of funds, usually from taxes. A weak or narrow tax base inevitably leads to a weak financial base (small budget) and a subsequent inadequate funding of water and sanitation programmes.

A primary criterion is the net effect of a policy on the finances of a municipality, while a secondary criterion is the effect on the finances of water utilities and irrigation agencies (Winpenny, 1994). The net effects of water pricing policy, for instance, can be positive, that is increasing the coffers of a water utility/municipality, or negative, depending on the amount and extent of subsidies and operating costs.

In the case of CMA, there is a need for a new financial framework that will take into account the water sector's new challenges. The CMA and the MLCs should aim to:

- increase efficiency by adopting WC and WDM measures,
- become financially autonomous – this will enhance financial sustainability by increasing financial accountability, reducing dependency on government subsidies, and encourage creativity and interest in income generation,
- increase private sector involvement - this will inject new capital, technical know-how, enhance transparency in administrative and decision making processes in the water sector,
- enhance financial accountability and
- ensure that water is affordable.

Economic efficiency requires that the full financial cost of supplying water should be recovered from water users. But, as we have seen above, full financial cost recovery cannot be understood or realised devoid of meeting social and equity objectives. Therefore, the cost recovery as it was noted in Section 11, must be based on the **principle that those who drive the marginal cost by using more water than that required to meet the 'basic needs' must pay the marginal price**. In practice it means that water used in excess of the basic needs must be paid for in a higher rate. This is called a **'two-part' tariff** or an **'increasing block'** tariff structure, and is part of the pricing mechanism.

### 7.2.3.6 Other Criteria for Water Allocation

Optimal allocation of water resource requires an appropriate combination of resource allocation mechanism and principles. There are other several criteria used to compare forms of water allocation, which could be taken into account in the CMA (Howe et al., 1986; Dinar et al., 1997-a & b):

- **Sustainability of water policies.**

Short- term water policies should only be adopted and implemented during a time of crisis, such as drought. Long-term planning supported by policies which make a long-term impact on water use, technological adaptations such as WDM strategies and tools, and those which change consumer habits are more sustainable.

- **Flexibility in the allocation of water supplies.**

This could be achieved if CMC and the MLCs have a thorough knowledge of water consumers' requirements, modern equipment and well-trained personnel. This will enable the

water authorities and technical staff to react quickly and effectively to demand shifts, repair of leaks, plumbing of new areas. This will make it possible to satisfy demand for water, and increase the possibility of minimising the costs of supplying water to the CMA.

- **Predictability of the outcome of the allocation process.**

Good planning should be able to predict the outcomes of water allocation so as to minimise uncertainty.

- **Security of tenure of established users.**

Generally, secure customers (tenant and homeowners) tend to use water efficiently because of the 'sense/feeling' of belonging to the area or ownership of the premises. On the contrary squatters do not have a security of tenure and hence can not establish themselves as reliable customers. Security that does not compromise flexibility is necessary and possible to guarantee as long as the reserve of water resource is available to meet emergency demand.

- **Political and public acceptability.**

The public should be involved or informed so that resistance in allocation and implementation of policies is reduced to the minimum or overcome completely. Persuasion, education, political sacrifice and negotiation should be used to cultivate good will, in order to minimise or neutralise public resistance and possible antagonism to water demand measures.

- **Administrative feasibility**

Implementation of an allocation mechanism or policy needs administrative capacity of the Municipal Water Department. This is necessary so as to be able to enforce, supervise, monitor and evaluate implementation.

- **Payment of real opportunity costs**

Real opportunity costs of providing water resources are paid by the consumer(s), so that other demand or externality effects are internalised. This has two advantages: First, it allows allocation of water resource to take into account environmental uses with no direct market value and secondly, it directs the employment of water resources to those activities with highest value (Dinar et al., 1997a & b).

### **7.2.3.7 Conclusion**

Water resource allocation is a complex exercise, which requires a holistic approach and application of multi-criteria to execute. Although application of economic efficiency criterion is paramount in determining financial sustainability, other criteria such as equity, environmental and ecological considerations must be taken into account when designing and implementing WDM programmes.

The next section presents a methodology and procedure for assessing and evaluating effectiveness of WDM measures prior to their application in water conservation projects and programmes using a holistic approach, by taking into consideration the various criteria discussed above.

## **7.3 Economic evaluation of effectiveness of water demand management measures**

### **7.3.1 Introduction**

In this section methods and techniques used for economic appraisal and evaluation of water demand management options/measures for achieving water efficiency are discussed. There are a number of economic evaluation measures, but for determining the extent of water efficiency and the amount of saving, two of them are the most important, namely, Cost - Benefit Analysis and Opportunity Pay back Analysis. These two analyses are outlined and discussed below.

### **7.3.2 Cost-Benefit Analysis of WDM Measures & Programmes.**

So far it has been established that a carefully planned and executed WDM programme can reduce water consumption in a facility or an area. In the literature the figures for the amount of water reduction are between 10-30 % reduction (White, 1994; SADC-IEMP, 2000).

While there are many non-financial benefits (environmental, ecological, social) of implementing WDM options, the major financial benefit for a water authority is their potential to reduce expenditure related to the supply of water (Macy et al, 1989; White, 1994). The latter are the avoided costs of water supply business, and mostly include capital costs (through postponing construction of capital facilities) and avoided operating costs, which accrue as a result of reduction in the pumping and water treatment (Pearce, 1983).

#### **Why is a cost-benefit analysis necessary/important?**

##### **7.3.2.1 The Need for a cost-benefit analysis**

A complete cost-benefit analysis is an effective way to evaluate alternative water conservation programmes. Since it involves a complete analysis of all potential water savings and their net costs, such an analysis yields an understanding of total programme costs and associated benefits. This information is vital to both the Water Utility (in this case CMC) and the water customers wishing to implement a WDM programme.

##### **7.3.2.2 Different-perspective for a Cost-Benefit Analysis**

The cost-benefit analysis of a demand management measure should be carried out from a number of perspectives.

The different stakeholders have to be taken into account - the water authority/(municipal council); the customers who participates in the demand management measure, and the customers who does not participate in the particular measure and does not receive the benefit directly (White, 1994).

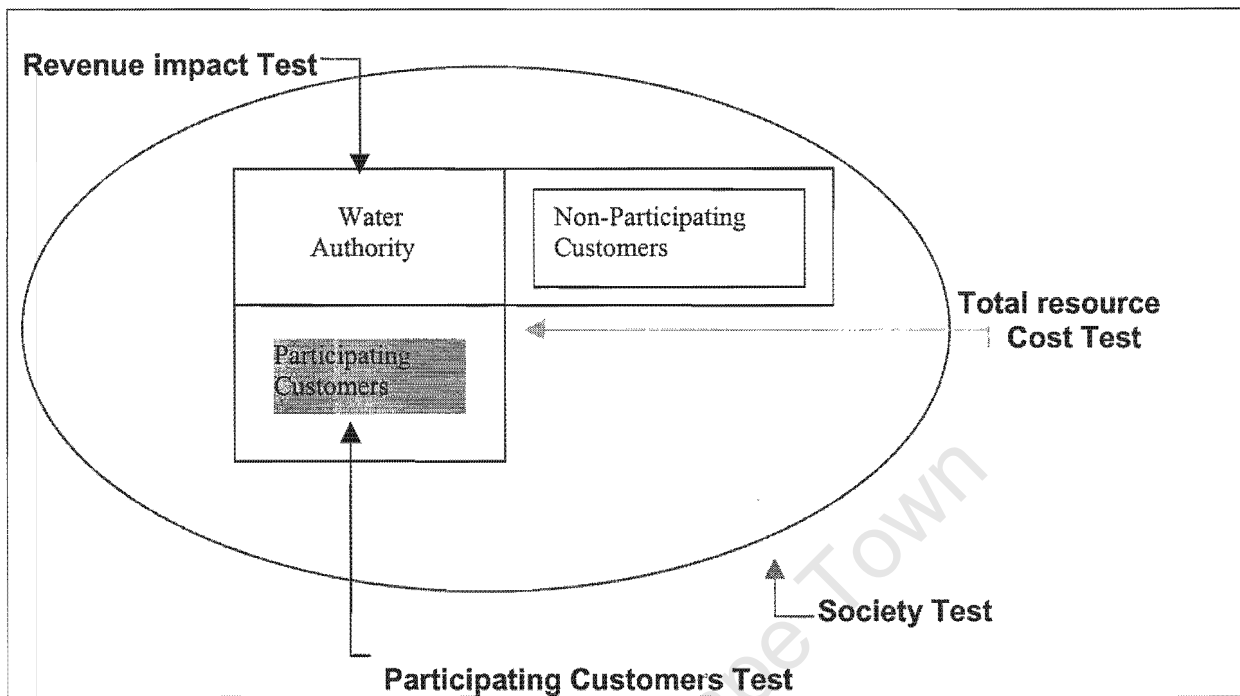


Figure 7.2: **Various Tests for Economic Evaluation of a Water Demand Management Measure:** (Source: Author's modification from: White, 1994: *WiseWater Management* p.13).

Various tests as shown schematically in Figure 7.2 should be as well taken into account. The various tests involved are the following:

- ◆ **Revenue impact measure test** - what are the revenue, losses and gains to the various parties?
- ◆ **The societal test** - what are the net benefits and losses to society/community?
- ◆ **Are there environmental/ecological costs/benefits?**
- ◆ **The total resource cost test** - what are the overall costs and benefits to all the stakeholders?

The total resource cost test as clearly and correctly stated by, Stuart White of the WRAA " is the primarily economic evaluation tests for measuring the merit of a demand management measure as a resource options" (White, 1994 p.13). It takes into the costs of the costs and benefits of the participating and non-participating customers as well as those of the water authority. Further discussion of these economic tests for economic evaluation of demand management options are presented in Chapter IX.

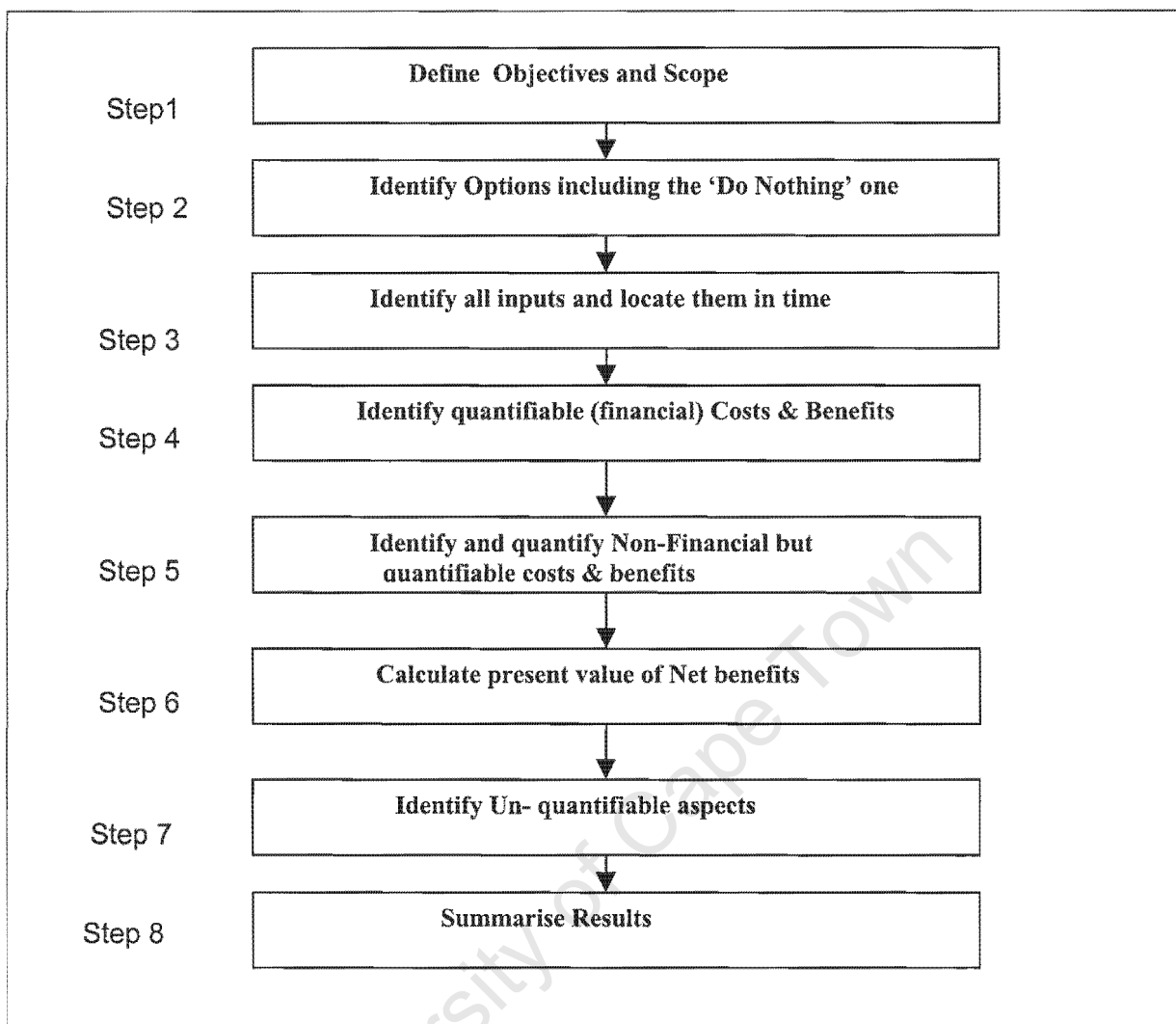


Figure 7.3: **Cost-Benefit Analysis Procedure for WDM Programmes**

Source: Author's modification after Macy & Madaus, 1989; ADB, date unknown.

### 7.3.2.3 Procedure to calculate Costs and Benefits of a WDM measures

The evaluation or appraisal of WC/WDM measures or programmes requires extensive calculations of the quantity of water savings, costs involved and obtained benefits.

There are a number of steps commonly agreed to in the literature for an economic appraisal of any conservation capital investment. A detailed explanation of these steps is presented in **Appendix H**. Figure 7.3, however, summarised these steps. Of great importance to note is the fact that the value of money changes with time. Therefore it is necessary to discount and calculate interest rate relationships by using the formulae in **Appendix N**.

## 7.4 Opportunity Payback Analysis

This sub-section presents the essence of opportunity payback, the procedure to carry it by using sample examples for illustration. It will accomplish this task under the following interrelated sub-topics: Essence of opportunity payback analysis; Procedure for calculating it; Sample calculation of payback; and Conclusion.

### 7.4.1 Essence of opportunity payback analysis

#### What is an Opportunity Payback Analysis?

The purpose of this analysis is to tell whether the WC/WDM measures being considered are economically viable. It determines how long it takes to pay back the investment. Thus it is a logical follow up of the analysis of costs and benefits discussed above. Costs are those associated with the water efficiency measures. These include equipment purchase, installation, training, process modification and maintenance. Benefits are mainly decreased costs of water purchase and sewer charges. When water is heated, cooled, or chemically treated when used, then additional benefits (cost savings) will accrue. Obviously, if water consumption is not metered or charged as a flat rate (example R100/month) regardless of use there is no economic incentive to conserve (SADC-IEMP, 2000)

The payback period is cost divided by annual benefit. For example, if a new system is put in place which recycles the final rinse in a commercial washer and utilises it in the initial wash, while the other costs are known: the cost of the equipment is R10000, the savings in water consumption is R5000 per year. The payback period is  $R\ 10000/5000 = 2$  years.

The question we have to ask is whether the investment is worthwhile or not. The answer is, we can not know the answer at the outset unless the payback period is very short, 1 – 3 years for small scale projects or very long, say 10 - 15 years or more for large scale programmes. The point is pay back period -short or long period in itself does not provide an unqualified "yes" or "no" to the investment. A step further must be taken to calculate the payback period per unit of water made available. After this a more rigorous cost-benefit analysis as discussed above and economic analysis as presented in **Appendix O** is required.

### 7.4.2 Procedure for calculating opportunity payback analysis

In order to accomplish opportunity payback analysis two steps should be followed: Firstly, identify options for saving; and secondly, estimate the amount of water savings of the identified option(s) or measure(s) as elaborated below.

Evaluate each option/measure and determine which are the most attractive financially. The steps involved in this analysis are relatively simple. For each option identified calculate the costs, savings, and benefits on annual basis by using the following steps:

- Estimate volume of water saved.
- Estimate any water heating/chilling/treatment savings.
- Estimate water/sewer surcharges savings.
- Estimate any additional operating costs (or savings) associated with the option.
- Add the heating, treatment, water and sewer savings and subtract any additional annual operating cost. The resultant is called the Net Annual Savings (Rands per year).

- Estimate Capital Cost of the option. This will include purchase price, installation of the new equipment, and disposal/salvage of the equipment.

This information can then be used to calculate the payback period. As indicated above this is useful for low cost options, or options which provide large savings immediately. Certainly, it does not take into account the time value of money; but it is the simplest and hence the most commonly used measure (Hall, 1996)

### 7.4.3 Payback Calculation

Simple Payback is then calculated as follows:

$$\text{Payback (years)} = \frac{\text{Capital Cost (R)}}{\text{Net Annual Savings (R/year)}}$$

In practise, often projects with short payback periods of up to 3 years are usually considered as optimum and recommended for implementation. Options with longer payback periods may require further analysis, taking into account the impact of economic phenomena such as inflation rate and interest on loans prior to recommendation.

A calculation for a simple washroom upgrade can be seen in the example below in Table 7.1

Table 7.1 : **Sample Calculations for Washroom Upgrade in the 'City Leisure Complex', Cape Town as at July 10, 2000**

Measure	Replacement of Urinals with Waterless Model
<b>CONSUMPTION</b>	
Current Consumption	1020 L/day x 250 day/year = 255,000 L/year = 255 m <sup>3</sup> /year
Projected Savings	None, waterless equipment 255 m <sup>3</sup> /year
<b>SAVINGS</b>	
WaterplusSewer Surcharge Rate	R12.50/m <sup>3</sup>
Water Heating	R0/m <sup>3</sup>
Water Treatment	R0/m <sup>3</sup>
<b>TOTAL SAVINGS</b>	R12.50/m <sup>3</sup> x 255 m <sup>3</sup> /year = R3,187.50/year
Additional Operating Cost	R0.020/use x 85 users x 2 uses/day x 250days/year =R850.00/year
<b>NET SAVINGS</b>	R3,187.50/year – R850.00 = R2,337.50/year
<b>CAPITAL COSTS</b>	
Purchase	R 3,000.
Installation	R 1,000.
Modifications	R 700. (repair wall)
Disposal Cost/ Salvage Value	R 300.
<b>TOTAL</b>	R 5,000 X 3 fixtures = R 15, 000.
<b>SIMPLE PAYBACK</b>	R 15, 000 ÷ (R2,337.50/year) = 2.1 years

Source: Author's construction.

The figures are imaginary and are used for illustration purposes only. For this work there is a need to explain each step and the calculations involved as presented below:  
In this example three urinal fixtures are replaced with waterless models for 255 days per year

In Table 7.1 the respective facts and calculations are as follows:

1. Prior replacement water consumption was 255m<sup>3</sup>/year. This can be considered as the projected water saving.
2. Saving from (sewer surcharge, heating and water treatment). There will be no heating or water treatment but only sewer charges of R 12.50/m<sup>3</sup>.
3. Total savings:(no. 1x2)= R 3187.50/y +Additional operational costs R850.00/year.
4. Net savings = Total savings- Additional costs = R 2337.50/year.
5. Total Capital Costs = [Capital costs (R3000) + Installation costs (1000) +Modification Costs (700) + Salvage value (300)] x 3 fixtures = R 15000.00
6. Simple Pay back =R 15000 / R 2337.50/year = 2.1 years

In sum, what was explained above should be presented in a table form as shown in Table 7.1. Such a summary table is desirable as it easily depicts all the salient elements and the respective calculations involved in opportunity payback analysis. Table 7.1 shows that 255,000 litres can be saved, and this amounts to 535.500 litres for the first 2.1 years when the total capital outlay-costs of the new installation are recouped.

This section has shown that Cost-Benefit and Opportunity Payback Analyses are essential tools of analyses of any WDM measure in order to establish its economic viability taking into account social and environmental costs. Only after their completion a clear picture of the impact, costs, benefits, and time needed to recover capital expenditure on alternative WDM measures can be established. After this process the best alternatives can be presented/ recommended to decision makers in order to choose measure(s) to be implement in the facility's/area's water programme.

## 7.5 Conclusion

This chapter has established a number of interesting facts in its three sections:

- ◆ That a holistic approach to water resource allocation is essential in order to take into account all the pertinent criteria,
- ◆ That economic viability is the central pillar/ basis of any WDM strategy and includes a number of criteria such as economic efficiency, efficacy, fiscal effects, administrative feasibility, equity and sustainability,
- ◆ That other criteria including environmental/ecological impacts, political and public acceptability should be taken into account,
- ◆ That Cost-benefit analysis of alternative WDM measures is essential so that the salient characteristics of alternative options are made clear to decision makers so as to assist in making the right choice,
- ◆ That a Cost-benefit of a WDM measure should take into account the impact of implementing such a measure to the different stakeholders, including, the Water Authority, the participating and non-participating water customers, and

- ◆ Opportunity payback analysis is essential in order to establish the net water saving, and the period taken to recover/recoup the capital outlay for retrofitting water saving device(s) or for making adjustment to water fixtures so as to optimise water use efficiency.

Now that all the necessary methodological and procedural elements for calculating, planning and assessing WDM measure(s) are known it is possible to move to the next stage - that of actual planning and designing a WDM project or programme for either a facility or an area such as the CMA. This task will be accomplished in the next chapter.

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" There is a need to use "Integrated Least Cost Planning" or "Integrated Resource Planning" to foster the course of water conservation goals by using WDM strategies and measures.

A water efficient programme should be designed to incorporate water reduction measures that best achieve the goals set out for the activities at that particular facility. Steps leading to such a programme should include: Establishment of the goals of water reduction programme; Identification of all reasonable reduction measures; Identification of positive and negative impacts of the reduction measures; Preliminary evaluation to screen out undesirable measures; Cost-benefit analysis; Opportunity pay back analysis; Preparation of a plan of implementation; and Development of the recommended water reduction programme" [JRK, 2000].

## **CHAPTER VIII** The way forward:

- **Planning & Designing a water efficient conservation programme**

## **8. DESIGNING A WATER EFFICIENT CONSERVATION PROGRAMME FOR THE CMA**

### **8.1 Introduction**

The results of the pilot water audits conducted in the CMA, and discussed in Section 3 of the Baseline Report (2000) will aid the consumers - the commercial, industrial and institutions and the CMC - the Water Authority to plan and implement WDM measures in their facilities and the CMA respectively. The objectives and methodology for implementing this task basically differ for the two areas as they represent different levels of action and responsibility. The programme for the Water Authority is of a macro level in nature, that is, it covers the whole of the CMA and may cover all or some section of (non-residential or residential) water users. That of a facility i.e. institution or organisation is of a micro level in nature, in the sense that it is meant for that particular consumer or group of facilities only.

This chapter outlines in detail the salient tasks and stages of designing efficient WDM programmes for facilities and areas such as the CMA. Section one outlines steps for designing a water efficient programme for any non-residential water consuming facility in the CMA, and section two outlines the procedure for designing a WDM programme for the CMA. This is a final methodology chapter and aims at bringing together the various methodologies and procedures for planning, assessing, and evaluating WDM measures to form a comprehensive methodology for designing a facility-wide and area-wide water reduction and saving programme for the CMA.

In order to accomplish this task this chapter first presents Figure 8.1- a schema/chart that shows the sequence of events and stages necessary for designing this WDM programme for both areas. Section one deals with how to design a WDM programme for non-residential facilities in the CMA and then Section two moves further to accomplish the same task for the CMA in general.

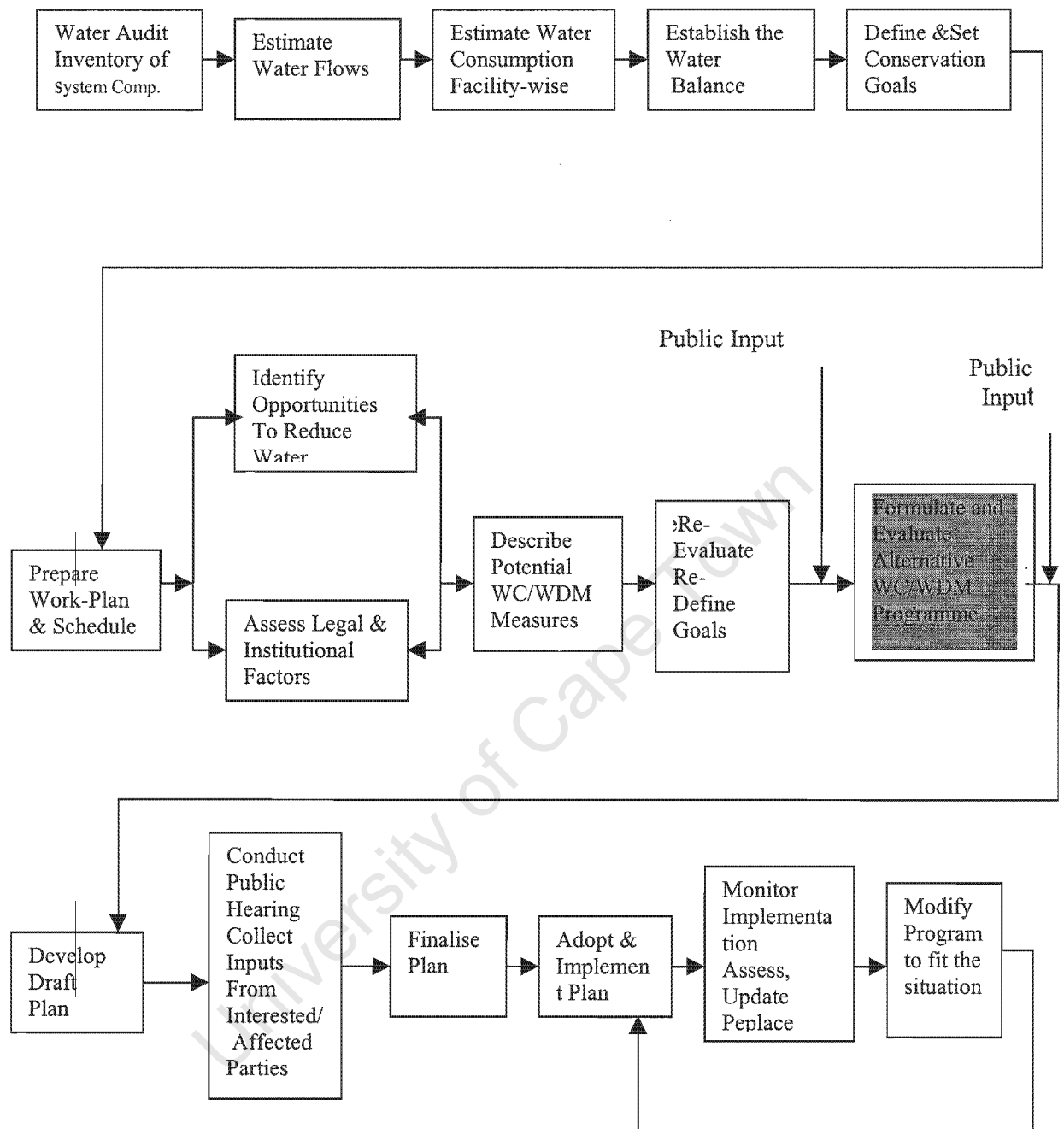


Figure 8.1: **Steps for Developing a Water Conservation/ Water Demand Management Programme**

Source: Author's Modification from: Maddaus, 1986; Macy & Maddaus, 1989 Hall, 1996

## 8.2 Designing a Water Efficient Programme for Non -Residential Facilities in the CMA

### 8.2.1 Introduction

Non-residential water consumers are industrial, commercial, public and private institutions. Their size, activities and operations differ considerably, hence there can not be a single water efficiency program. Therefore it is logical and practicable that each facility should design its own water efficiency program taking into account best practice from both local and international experiences.

This section outlines the 'A to Z' steps which are necessary for designing a water efficient programme for a facility. To achieve this task this section is divided into four major sub-sections that form a logical sequence:

- 1) Inventory of Systems Components - (water use operations, estimations of water flows, water consumption, and water balance;
- 2) Steps for designing an efficient water programme;
- 3) Plan and Sample Plan; and
- 4) Monitoring and assessment of the programme.

These steps are a combination of the steps schematically depicted in Figure 8.1.

### 8.2.2 Inventory of Water System Components

The objectives of this initial step are the following:

- To identify each facet of the water distribution system and define the system as a whole,
- To obtain a complete list of all water consumption (litres per use, or litres per minute) for each type of device,
- To determine which devices are inefficient and represent opportunities of saving.
- To get information on each point or category of consumption in order to be able to estimate water consumption by category.

Facility's water distribution system that are considered necessary for the system definition include the following:

- flow meters, their type and ratings
- distribution (hot and cold water pipes)
- storage (reservoirs, holding tanks)
- specification (toilets, faucets, showers, cooling water lines - including brand names, model numbers and flow rate).

This information should be obtained from different sources, including, the plumbing plans, actual visual inspection of the facility, discussion with relevant personnel, or from previous audit reports or publications (<http://www.ec.gc.ca/water/en/info/pubs/manual>).

Typical inventory of consumption in a premise should take into account all the components of indoor and outdoor water-use areas, that is, processing, maintenance, temperature control, wash rooms, laundry, kitchens, and outside grounds - as discussed in Section 6 above. This inventory of water consumption in a premise commonly referred to as a water audit or water survey (UCT Water Survey, 1997; SABS, 1996).

The basic procedure for implementing an audit/survey of water use operations is presented in Section 2.3 of the Baseline Report (2000) and is attached herein in **Appendix D** for easy reference and is part and parcel of Section 5 of this work.

Suffice to say that the results of the audits/surveys can be summarised in computer-generated spreadsheets for effortless retrieval and review. These results can provide valuable information for calculating water flows and quantity of water consumption in a facility.

### **8.2.3 Estimation of Water Flows**

A standard procedure for estimating water flows is presented herein in **Appendix P**.

### **8.2.4 Estimation of Water Consumption**

A summary of estimations of water usage by different devices and equipment is presented in **Appendix Q**. The information and formulae for calculation are provided for easy reference. All these estimations discussed above provide a basis for calculating a **water balance** of a facility or an area/municipality such as the CMA as presented below.

### **8.2.5 Estimation of Water Balance**

The ultimate goal for performing all the estimations and calculations presented above are to get adequate information for calculating water balance for a facility or an area.

The purpose of water balance calculation is to ensure that all water uses in a facility are identified and accounted for (Environment Canada, 1997; SADC-IEMP, 2000). This is done by comparing the total water consumption figure obtained during the facility water audit and the known quantity of water consumption.

Normally, the estimated figure for water balance should be as close as possible to the **water meter** readings. If the results show that the sum of water consumed in all operations is more than the total water supplied, it is assumed that the calculations are wrong, due to double counting, arithmetic error or both.

Conversely, if the results of the inventory are less than the meter readings, then it is assumed that there is an omission of water uses or there is inaccuracy in the main meter in either case. The meter balance should be re-examined in all operations so as to refine the flow estimates and/or detect water losses through leak detection as outlined in Section 5. Thereafter, we should be able to identify and quantify the various types of water balances as presented below.

#### **Types of Water Balances**

There are three types of water balances, namely: Facility wide Water Balance, Main Meter Balance, and Sub-area Water Balance. Their main objectives and characteristics are briefly outlined below.

##### **1) Facility wide Water Balance**

This is a water balance for the whole facility or premise. Its objective is to sum up all of the individual water use volumes and to equate it with the quantity of water supplied to the facility as per the main meter record.

## 2) Main Meter Water Balance

The main meter water balance takes into account the total water supplied to the facility and the total water volume supplied to each sub-area only (Environmental Canada, 1997).

It has a dual purpose - first, to identify sub-area of major water consumption and secondly, to pinpoint major discrepancies between the main water volume supplied to the facility, and the sum of water volumes supplied to each sub-area.

## 3) Sub-area Water Balance

This is a "location-by-location inventory", and is used to obtain a usage estimate for each area and sub-area as illustrated in Table 8.1. The major objective of sub-area water balance is to identify the volumes of water used by each operation in the area. These estimates can be summed up to get a total volume of water used in the area as shown in Table 8.1.

The total water volume in an area is then combined to get the facility wide water balance, which normally should be more or less equal to the average water billing history/known average metered water volume of total that facility.

Of importance to note is that there is no perfect balance between consumption and billing, hence a variation of few percentage points (1-10%) is acceptable and considered as adequate considering the uncertainties in the estimates and the extent of work involved (SADC-IEMP, 2000 ; <http://www.ec.gc.ca/water/en/info/pubs/manual/e>).

**Table 8.1: Water Consumption by Location**  
Location: Ground Floor, City Leisure Hall, Men's Washroom

Type of Device	Make and Model	Number of Devices	Usage Estimator	Unit Flow	Daily Consumption Estimate
Urinal, Manual	Walcro, Wastrel	4	85 males, One 8-hour shift	6L/flush	4 x 85 x 6 = 2040 L
Toilet, Tank-type	Syphonic -11l High level - close coupled	6	85 males, One 8-hour shift	11L/flush	6 x 85 x 11= 5610 L
Sink, hand Wash two-valve faucet, aerated	Delta Niagara	4	85 males, One 8-hour shift	2.5 L/min	4 x 85 x 2.5 = 850 L
Shower, two-valve	Water-Pik Prodigal 1000	2	2x10 min./day	15 L/min	2x 2 x 10x15= 600 L
Washing Machine Top loading type	Kenmore Service-master	1	2 Loads/day	140 L/load	1x 2 x 140 = 280 L
<b>Total Daily Usage</b>					<b>9380 L</b>

Source: Author's modification from SADC- IEMP, 2000.

## 8.2.6 Steps for Designing a Water Efficient Programme

A water efficient programme should be designed to incorporate water reduction measures that best achieve the goals set out for the activities at the facility. Steps leading to such a programme should include:

- Establishment of the goals of water reduction programme
- Identification of all reasonable reduction measures
- Identification of positive and negative impacts of the reduction measures
- Preliminary evaluation to screen out undesirable measures
- Cost-benefit analysis
- Opportunity pay back analysis
- Preparation of a plan of implementation
- Development of the recommended water reduction programme.

Further elaboration of these steps is necessary in order to be very clear of the tasks to be accomplished ahead.

### Goals

The key questions to ask here are:

**What are the goals, benchmarks or targets for water use reduction and saving in that particular facility?**

Water efficiency through WDM can achieve several goals as presented in Section 4&6 above, but the prime goal is to achieve water and/or cost savings to the facility.

The management of the facility will likely play a major role in establishing goals for the programme.

### Alternative reduction measures

**Are there any alternative measures?**

A water efficiency programme should be designed to incorporate alternatives that best achieve the goals set out for the activities at facility. While considering alternatives there are a number of factors that should be kept in mind:

- Capital and operating costs
- Water, sewer and energy cost savings
- Environmental/ecological and social impacts
- Acceptability to the interested and affected parties (i.e. to staff, customers, community and authorities)
- Period of effectiveness
- Training needs
- Period of effectiveness
- Disruption
- Space requirements
- Ethics and aesthetics (Environmental Canada, 1997;SADC-IEMP, 2000).

Water reduction measures and practices specific to the facility for each water use area or category can be identified. When the list of available measures has been completed, then the intangible impacts, as well as financial and water savings impacts of each measure, must be evaluated against the goals set by water efficiency programme of the facility.

## **Impacts of water reduction measures**

A holistic approach to assessment of the possible impacts should be used in order to capture all the aspects of the programme. The following impact categories need to be considered: economic, social, political, environmental and ecological and technical impacts. Specific impacts that should be determined for measures include: political acceptance, environmental impacts, reliability, short – or long-term effectiveness, and other impacts specific to the goals of the programme. The impact of water reduction measures on the facility must be determined by using cost-benefit analysis and opportunity payback calculations as discussed in Section 7 and will be further elaborated below.

## **Cost-Benefit and Opportunity Pay back Analyses**

A cost-benefit calculation will determine the net savings that would be made by the most cost-effective water reduction measure. To obtain the information needed to derive the costs and savings, a detailed examination of the potential water reduction measure must be undertaken.

The general approach to calculating the net benefits of a WDM measure is ached in **Appendix H** and opportunity pay back estimates was discussed in Section 7. These procedures should suffice to accomplish this task.

## **8.2.7 Preparation of an implementation action plan**

The results of the impact assessment established by the cost-benefit and opportunity payback analyses should be used to develop a plan to meet the goals of the facility's water efficiency programme. The resulting programme should consist of a number of compatible water reduction measures and should show the net benefit and net water volume savings, as well as a number of non-quantifiable benefits. The implementation action plan should contain a number of elements: Implementation schedule; User education plan and arrangements to promote the plan.

### **Implementation schedule / Time Lines**

A plan schedule for implementation of a programme should be developed by the water efficiency programme management team in co-operation with the facility's technical staff.

This may include all components of the water efficiency programme, including education programme, retrofits/installation, and follow-up activities, based on: the goals for water savings, the available and projected budget for the current and future years and the staffing available for education and assessment activities.

Basically the plan schedule for implementation should include:

- A budget showing costs and sources of funding by fiscal period.
- Plan for process change or equipment installation including estimated length of shutdown or disruption.
- Staff involvement - who, when, for what length of time.

When developing the implementation plan a number of factors must be taken into account:

- The available capital for investment in water efficiency.
- The best order of implementation of water efficiency measures is to start with the low cost, fast payback options.

- The existing workload for those individuals who will be responsible for implementation (some opportunities may require modest time commitments, others may take a lot of staff time to implement),
- The institution's ability to absorb changes, particularly if many changes are going to take place in a single area.
- Convenient time from the perspective of customers and workers (SADC - IEMP, 2000).

### **User education plan**

It is vital to any long-term water efficiency programme that the water users know why it is important that they use their water wisely. This water-user education has two primary purposes:

- To encourage the users to follow reduction programme procedures, and
- To facilitate the users' acceptance of water reduction measures implemented by management

### **What are the key elements for water-user education programme?**

Key elements of an effective education programme may include:

- A theme, representing the water efficiency programme,
- An education co-ordinator to co-ordinate the distribution of educational materials and educational programmes,
- Educational materials, such as in-house newsletters, water reduction guides, posters, to communicate the goals and encourage user participation,
- An education plan, including communication methods and a schedule of implementation and follow-up,
- Follow-up of the educational program, especially if user habit or attitude changes are required as part of the water efficiency plan of the facility. The follow-up will either encourage user participation or inform the educator whether the education program is inadequate or too infrequent, and
- Modification of the water efficiency programme where the education programme has not accomplished the expected user involvement.

### **Arrangements to promote the plan**

For large organisations, communication and promotion should be included in the plan. Regardless of the size of the organisation, there are a few key points to keep in mind:

- Identify the people who will be affected by a proposed change(s).
- Explain why the change(s) is/are being made and what the benefits are.
- Explain how the change will affect people during the implementation and afterward.
- Suggest how those in the affected area can help during implementation or afterward.
- Ask if there is anything happening in the affected area that would affect/alter the implementation plan.
- People in the affected area should be notified well in advance and reminded a short while before the implementation starts.

### **8.2.8 Close monitoring arrangements**

In order to ensure that the measures taken have been correctly implemented there is a need to periodically check a number of items:

- Water bills over the twelve months following the installation or process change and where possible actual flow rates against those predicted,
- Reports and records which had been an agreed part of the implementation, and
- Financial reports indicating actual costs of purchase, installation and maintenance.

This stage should also include the production of reports that indicate the meeting of targets and any remedial measures necessary.

Water efficiency is a dynamic process hence provision for future measures for further improvement in the existing systems and to build in efficiency in new equipment and processes should be made.

### **8.2.9 Programme assessment**

Routine progress assessment of water savings may reveal the areas where measures are successful or ineffective. It would also indicate where modifications to the programme might be required. Modifications may be carried out and evaluated by the programme management and staff of the facility based on the following factors:

- Examination of the main meter records as well as the various internal meter records to determine overall water savings and water savings in individual sub-areas
- Surveys of user participation and attitude
- Acceptance by facility management
- Reports from the education co-ordinator.

It is recommended that WDM programme effectiveness reports should be submitted routinely to the facility management and in turn to the users to encourage further participation.

The WDM programme should be regarded as a dynamic process that needs constant monitoring and adjustments-especially upgrading it according to the latest developments/achievements/failures or occurrence of new technology.

### **8.2.10 Update of programme elements**

The routine assessment of the WDM programme will help to identify which measures are not effective hence could be modified or replaced. Replacement measures should be thoroughly evaluated by conducting both an impact analysis and a cost-benefit analysis prior to implementation.

Now that the methodology and procedure for designing a WDM programme for a facility is known, the same methodology and procedure for calculations; tactics and stages can be applied to an area like the CMA. But this time one has to take into account the differences in the magnitude of the variables and subjects involved. This is delineated in the next sub-section.

## 8.3 Designing a water demand management programme for the CMA

### 8.3.1 Introduction

The preceding section presented a methodology and procedure for designing and implementing water efficient programme in institutions, industrial, and commercial facilities in the CMA. That was an important initial step (phase one) towards the second phase, which is to formulate an effective WDM programme for an area such as the CMA. In practice the two phases should follow each other, for programmes in phase one are part and parcel of the wider programme in phase two.

An effective WC/WDM for the CMA must have clearly defined goals, a written plan that sets forth the policies, facts, figures, budget, incentives, time schedule and sibilities for completion of plan elements and expected results.

Public participation in the programme is likely to be the key to its success and active public involvement in drawing up the plan is therefore essential. Public hearings - (what is commonly known as 'indaba' in SA) are essential in order to exchange views, educate the public, and increase transparency.

Some elements of WDM such as metering and leak control programmes may involve a lower level of public involvement, but nevertheless may cause inconvenience to the users therefore maintaining a good flow of information and good communication is important.

Having spelt out the ingredients of an effective WDM for the CMA the next step is to focus on the specific components of such a programme and to outline each of them.

The major task of this section is therefore, to outline and discuss how to design an effective WC programme WDM measures which will reduce and save water in the CMA without compromising the welfare of water consumers in the area. In order to achieve this vital goal the programme must meet a number of criteria:

- Must be effective,
- Cost effective, and
- Attractive and practicable to the water consumers so as to ensure full participation.

The WC/WDM programme should also be in accordance with the general criteria and principles of affordability, fairness, sustainability, efficient resource allocation, economic development, transparent subsidies, accountability, price stability, simplicity and political and public acceptability as discussed in Sections 1 & 7 in this work. In order to avoid repetition, this section will concentrate only on the new aspects typical to formulation of a municipal WDM programme. Those relevant aspects already dealt with in phase one (facility level in Section 8.2) will only be referred to and elaborated further whenever possible and necessary so as to enhance clarity.

An effective WDM programme for an area such as the CMA requires a plan that sets forth the policies, facts, figures, expected results, and recommendations implementation. Figure 8.2 presents the necessary steps to be followed in developing such a programme.

This section focuses on the tenth stage, shaded in Figure 8.1 which schematically shows the various stages and tasks involved in formulating and evaluating a WDM programme for an area such as the CMA.

The starting point is to examine the steps involved in formulating and evaluating a water conservation programme for an area/ municipality. There are six distinct but linked tasks as shown in Figure 8.2, namely:

- 1) Developing and compiling a list of WC/WDM measures
- 2) Application of criteria to streamline the list
- 3) Developing a locale-specific database on water use and demographics etc.
- 4) Performing a cost-benefit and opportunity payback calculations and analyses for each measure,
- 5) Holistic analyses of cost –benefit and opportunity payback analyses and prioritisation according to merits, and
- 6) Selecting measures for the total WC/WDM programme  
(Environmental Canada, 1997; Macy et al., 1989; SADC-IMEP, 2000).

Some of these tasks were analysed in the previous sections, especially in Chapter 4-6, and in section 8.2 of this chapter. Suffices then to elaborate further only some of these tasks as presented below:

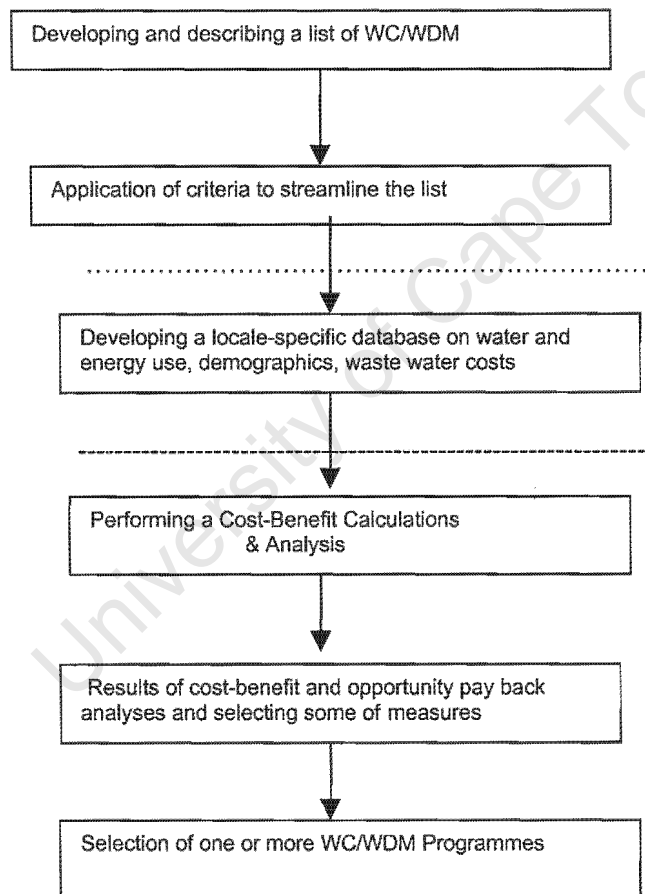


Figure 8.2: **Sequence of Tasks for formulating and evaluating Water Conservation/Water Demand Management Programme.**

Source: Compiled from OECD, 1989; Macy & Maddaus, 1989; World Bank, 1995 and Hall, 1999.

TABLE 8.2 Criteria Matrix

Conservation Measure	No Significant Attitude change Required	Political Acceptability	Expected Unit Water Savings	Feasibility	Reliability
Retrofit devices	Favourable	Favourable	Favourable	Favourable	Favourable
New Plumbing code	Unfavourable	Unfavourable	Favourable	Unfavourable	Favourable
Water Audit	Favourable	Favourable	Favourable	Favourable	Favourable

**NB.** This sample criteria matrix shows that retrofit devices and water audits are favourable in all four counts/criteria, where as the plumbing code has problems – It is considered ‘unfavourable’ in two measures, hence it should be re-examined and revised so as to take into account customers’ inputs, political, and feasibility aspects.

### 8.3.2 Developing and compiling WC/WDM measures

The WC/WDM tools/measures and devices are outlined in Section 8.2 of this thesis should be considered in conjunction with the results of water audits conducted in the CMA and the respective recommendations presented in Section 2.3 of the Baseline Report (2000). Thereafter a criteria matrix that takes into account all those factors noted above could be drawn as shown in Table 8.2 in which scores are made to such criteria as acceptability, feasibility and reliability. Results of the cost-benefit analysis (see section 7 and **Appendix H**) should be presented for selection of "ear-marked" WDM measures.

### 8.3.3 Developing a locale-specific data base

Developing a locale-specific database should include figures of annual water-use, demographics, water, energy and wastewater costs for the CMA as elaborated below.

#### Water use

The procedure is to categorise water use according to place, that is, residential and non-residential as discussed in Section 6. While the residential water-use categories are single and multifamily, the non-residential categories are commercial, industrial, public & private institutions.

This data can be presented in the form of a total yearly water use by customer class or by category.

#### Demographic data

These data are required for the calculation of total water savings. For the CMA this data can be obtained from its Economic and Social Development Directorate database, the Statistics South Africa, and from relevant various studies carried within the CMA such as the Western Cape System Analysis carried by Ninham Shand and BKS Inc., (1994). Other sources are Metropolitan Development Consortium (1998); UCT-EEU State of the Environment Report for the CMA for 1998 (1999) and the on going CMA-AWDO (2000) and other sources.

If this data is not enough CMC can initiate a specific study to get specific data. But, before this is done it is necessary to explore the possibility of getting /extracting and extrapolating

the available information indirectly from other composite sources such as the 1996 census data.

#### Water and Wastewater costs

Both the variable and capital costs discussed in Sections 2 and 7 should be included in the database. As discussed and concluded in Section 7 any water reduction through WC/WDM reduces the Water Authority's costs, hence they are considered as savings. Overhead or fixed costs should be included because as water management experts - Macy and Maddaus contend " **they will be incurred whether or not water is saved**" (Macy et al, 1989 p.44).

#### Developing a measures data base

After establishing a representative database consisting of water use, demographics, and water and wastewater costs it is necessary to define the characteristics and assumed effectiveness of conservation measure. This measures database should include some information which elaborates such measures as regards to the following aspects:

- Type of measure (descriptive) and implementation schedule,
- Potential **market penetration**, i.e. where, and how much. In this case the market area is the CMA and the extent of penetration will be determined by the CMC, but it should be borne in mind that all the customers in the CMA will not install/retrofit and use a particular conservation measure. This has a number of explanations, including:
  - lack of enough knowledge and belief on the need to conserve water,
  - lack of interest in the particular measure lack of motivation to implement a particular measure,
  - the measure may not be cost effective, and
  - the measure may not be applicable to certain customers, and/or problems with enforcement mechanism.

It is of particular importance to learn from past own experiences and from other countries.

- Program framework period, i.e. year of implementation and expected year of completion,
- Amount of water saved by a device per minute, per person or other suitable basis.
- Amount of energy saved, and
- Customer and municipal costs to implement the measures.

### **8.3.4 Conducting Cost-Benefit Calculations**

The general procedure for conducting a cost-benefit analysis is presented in **Appendix H**, while a sample for elements of actual cost-benefit calculations are presented in Table 8.1 & 8.2. After making these vital calculations the results provide a useful input towards selecting a conservation programme.

Selecting a WC/WDM programme should be based not only on water reduction and financial savings, but as well on the other criteria and aspects discussed throughout the thesis, but more especially in Sections 2-7, that is, environmental, ecological, social-political, and sustainability aspects of such a programme.

Individual relevant water efficient devices and measures should be included in the initial stage of evaluation , and in the final stage only appropriate measures for a specific WC/WDM should be selected for implementation.

### 8.3.5 Developing the Programmes

#### How many programmes should be developed?

In order to enhance possibilities for choosing the right programme for an area a minimum of three different programmes should be prepared and presented so as to provide alternative options to choose from. Most water management experts prefer to group the various WC/WDM measures into three programmes of varying intensity (Macy et al, 1989; Environmental Canada, 1997).

These three programmes can have the following characteristics:

**Programme 1:** A minimum programme with low water savings (typically about 5%) but high cost-benefit ratios.

**Programme 2:** A moderate programme, with average water savings (typically 10%) and a cost-benefit ratio near 1.

**Programme 3:** A maximum programme with above-average water savings (typically 15% or more) and possibly a cost-benefit ratio less than 1.

It should be noted that level savings do vary according to the type and number of conservation measures in each programme. The intention of developing three programmes is to enable interested and affected parties/public, and the CMC decision makers to give their opinions before choosing 'the right programme' taking into account the financial, social, economic and political obligations.

After taking into account these factors the selected three programmes are then further elaborated, and improved by recalculating the net savings, benefits and costs in a bid to improve them. This iterative process continues until a compromise/desired programme is achieved and accepted. The next steps as shown in Figure 8.1 are to develop a draft plan, conduct public hearing, improve and finalise the plan taking into account public inputs.

The next stage is that of implementing the chosen water efficiency programme as indicated in Figure 8.1. Major elements that may be considered in the implementation plan are the same as those for a facility as discussed above in Section 8.2. The later includes - Selection of the right staff; development of a user education programme; implementation of programme; assessment of programme effectiveness; monitoring and update of programme elements by taking into account actual developments on the ground.

### 8.3.6 Conclusion

Designing a water efficient conservation programme is one of the two prime tasks to be accomplished by a facility administration or a Water Authority. The other task (which is outside the scope of this thesis) is to supervise implementation of the programme in order to ensure its success. Designing a water efficient programme has many steps and stages which require specialist input as well as input of interested and affected parties, including: workers, professionals, the public, and respective water authorities. Timely inputs from the interested and affected parties are very important and necessary not only for creating a sense of ownership of the plan, but as well to tap the rich local experience of the actual water users. And above all, to ensure a full support of the programme in order to be able to implement it successfully.

Essentially, water efficient programmes for facilities should be part and parcel of an area's/municipality's water conservation programme.

In other words, water efficient programmes for facilities in the CMA are supposed to be components of a general CMA water conservation programme. While the former is of micro nature, in that it focuses on individual facilities, the latter is of a macro nature, for it covers a wider scope - the whole of the CMA. That is why the methodology and tools involved are essentially the same, but vary only in magnitude and in size.

WC/WDM programmes should meet the criteria for water efficiency discussed and emphasised in all the Sections of this work, viz., should be economically efficient, cost effective, equitable, sustainable, transparent, participatory in nature, and environmentally sensitive.

An effective WC/WDM programme must have clearly defined goals, a well formulated plan that puts forward the policies, facts, figures, budget, time schedule, responsibilities, completion framework/schedule of plan elements and anticipated results.

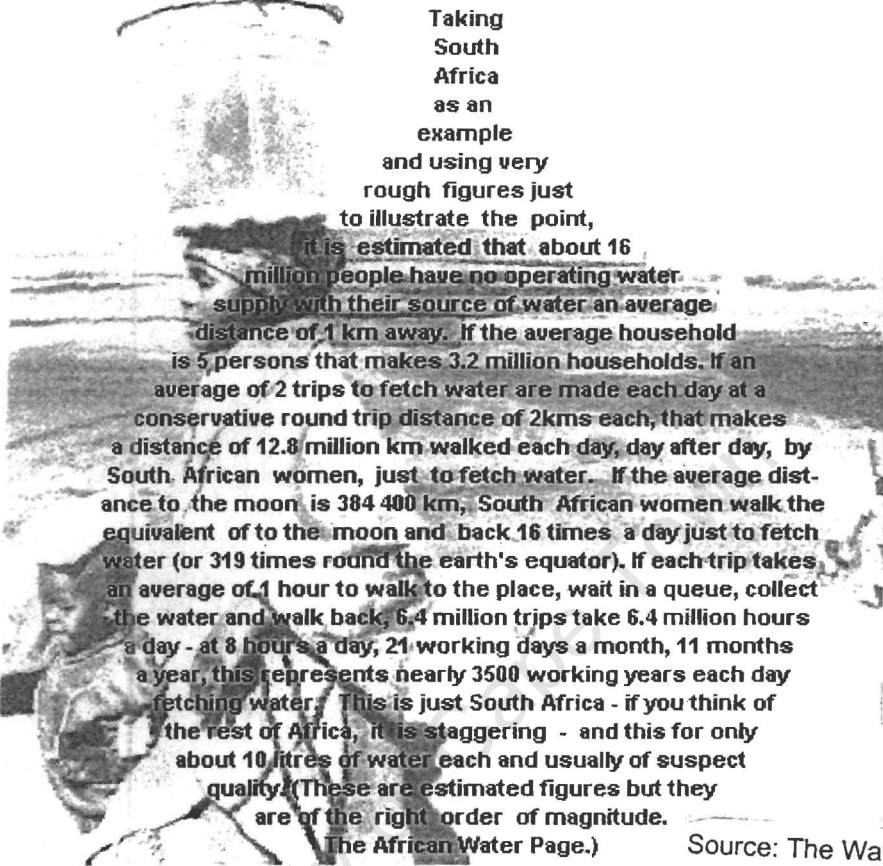
### **What follows next?**

The next stage is to start implementation of the chosen programme. Implementation of a WDM programme should be flexible enough to accommodate changes emanating from technical necessities, public response, current best alternative measures based on best available technology. The use of public inputs, computer software and experience from elsewhere are indispensable advantages that should be fully utilised to prepare a viable water conservation programme based on water demand management strategies and measures.

The management authorities in industrial, commercial, and institutions in the CMA and the CMC and MLCs should take advantage of regular communications mechanisms in the area: including radio, television, public meetings, newspapers, bulletin boards, newsletters and internet sites. Communications will be important throughout the entire water efficiency project and not only designated periods such as the 'Water conservation week'. Authorities need in advance to explain what is happening, where and why.

During the designing and implementation period workers and customers have to be regularly informed of changes so that they can adjust smoothly and capitalise on water-saving strategies. After implementation, Authorities need to make sure the programme's successes are known and recognised. This can help to secure further support for additional efforts and encourage new ideas and suggestions for further savings.

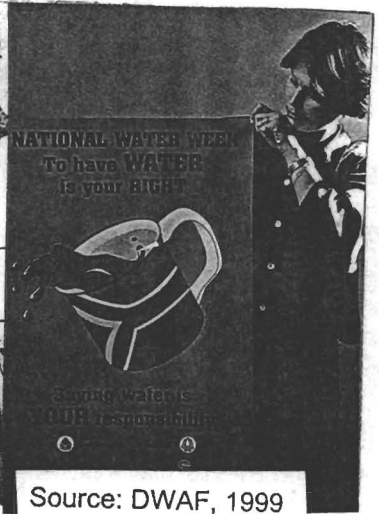
## EVERY DAY



Taking South Africa as an example and using very rough figures just to illustrate the point, it is estimated that about 16 million people have no operating water supply with their source of water an average distance of 1 km away. If the average household is 5 persons that makes 3.2 million households. If an average of 2 trips to fetch water are made each day at a conservative round trip distance of 2kms each, that makes a distance of 12.8 million km walked each day, day after day, by South African women, just to fetch water. If the average distance to the moon is 384 400 km, South African women walk the equivalent of to the moon and back 16 times a day just to fetch water (or 319 times round the earth's equator). If each trip takes an average of 1 hour to walk to the place, wait in a queue, collect the water and walk back, 6.4 million trips take 6.4 million hours a day - at 8 hours a day, 21 working days a month, 11 months a year, this represents nearly 3500 working years each day fetching water. This is just South Africa - if you think of the rest of Africa, it is staggering - and this for only about 10 litres of water each and usually of suspect quality. (These are estimated figures but they are of the right order of magnitude.

The African Water Page.)

Source: The Water African Page, 2000



Source: DWAF, 1999

## CHAPTER IX

# • Synthesis: Concluding discussion

## 9. CONCLUDING DISCUSSION

### 9.1 Introduction

This concluding final discussion chapter acts as a synthesis of the salient arguments and findings discussed the previous chapters. It intends to widen and deepen the scope of WDM strategies so as to fit into the water resource and water services planning gamut. As such WDM strategies and measures are planned and effected by people for people. Therefore there is no way that they can operate without proper infrastructure or in abstraction, without taking into account the various societal and individual water consumers' interests. Therefore, during the planning, designing and implementing WDM programmes a holistic approach is needed in order to capture all relevant aspects and various perspectives, including gender and vulnerability aspects.

Thus, this chapter will critically examine these issues/aspects albeit briefly under the following headings: Water resource and water services planning; Perspectives on WDM; Measures for water demand management; Need for sound infrastructure and institutional capacity; Perspectives on WDM; Gender aspects of WDM; and Future actions and research areas.

### 9.2 Water resource and water services planning

There are a number of challenges and problems encountered during water services planning for an area like the CMA. The biggest challenge with regard to WC/WDM strategies is how to equate demand management initiatives to supply side management initiatives and consider them as part of the water resource planning process. Often WC/WDM initiatives are considered as strategies associated only with environmental or communication strategies instead of being part of the water resource or water services planning. This often limits the scope of WC and WDM considerably, which can lead to inefficient water supply planning.

There is as well a problem of balancing economic efficiency with social and political realities such as poverty/inability of some sections of the population to pay for water and the issues of humanity and correcting the inequalities of the past (See **Appendix U**; Kxosa, 2000).

Another constraint is that water conservation campaigns in many parts of the world are often only considered during a period of drought or water shortage or as a once a year campaign, so that once the shortage ends, the campaigns are suspended. Although at present this is not the case in the CMA, deliberate efforts could be done to make sure that this precious resource is not undervalued. Together with this, negative attitudes of water users can be induced to change and abandon their water wasting habits as reported in the media (Water Sewage and Effluent Vol.14 No.4, 1994 p. 15; Koekemoer in the Cape Argus, 21-12-1999;) - attached in **Appendices S & T** respectively.

Another problematic area is associated with inadequate, segregated/disintegrated planning, designing and implementing WC/WDM programmes. There is a need to use "**Integrated Least Cost Planning**" (ILCP) or "**Integrated Resource Planning**", (IRP) to foster the course of WC goals by using WDM strategies and measures.

**What is meant by "Integrated least cost planning"?**

ILCP and IPR which emerged in the context of regulation from electricity utilities in the USA, emphasises WC and WDM as potential alternatives to increasingly expensive supply side management options (AWWA, 1990; The Water Program, 1994).

IRP is a process of determining the appropriate mix of demand-side and supply-side resources that are expected to provide long-term, reliable service to water users at the lowest reasonable cost and which maximises benefits to society and minimises the impact to the environment. IRP for water utilities is an evolving idea and certain new concepts such as avoided costs and cost benefit tests have to be appreciated. The National Association of Regulatory Utility Commissioners in the USA defined least-cost planning as follows:

**“... [It is] a way of analysing the growth and generation in utilities that considers a wide variety of both supply and demand factors so the optimal way of providing services to the public can be determined. A path is chosen that will ensure reliable service for the customers, economic stability and a reasonable return on investment for the utility, environmental protection, equity among ratepayers, and the lowest costs to the utility and the consumer.”**

This definition includes all the criteria for water resource allocation discussed in Section 7 and puts an emphasis on the main functions of ILCP approach and demand management paradigm, including the following:

- To integrate initial capital costs to operating costs in the planning process,
- To introduce social, environmental and economic issues as important considerations in the planning process,
- To focus on the end consumers and users, and
- To integrate the planning of the various institutions in the water supply chain.

The opportunities for demand management discussed in Section 6 exist due to the high levels of wastage and because most of the time water is used for the service that is derived from it and not for the water itself. Some examples to illustrate this are as follows:

- Flushing a toilet. The objective is to clean the pan and if through technologies the water required to flush a toilet is reduced to 6 litres rather than 16 or 11 litres, the consumer's lifestyle is not altered but water consumption is reduced significantly.
- Watering of lawns. The objective is to maintain 'healthy'- green lawns. Through better water efficient practices, and xeriscaping practices, water wastage/consumption can be reduced significantly without reducing the aesthetic of the area.

The IRP process can be used to determine how feasible and at what rate these inefficiencies can be explored as alternative resources.

One of the obstacles to the IRP process is whose costs are supposed to be the “least”: the utilities, the existing water customers, the future customers, secondary consumers (consumers that use water downstream of the return flow of the initial consumers) or society at large. This becomes even more complicated when one considers that by implementing a WDM initiative there are participating consumers and non-participating consumers as discussed in Chapter VIII

. It is possible that the implementation of a WDM initiative may be of financial benefit to consumer or community “X” who was involved directly by that initiative, but of a financial burden to consumer or community “Y” who was not participating or involved. One can argue however that IRP process should aim to achieve the least-cost to society at large.

It is important particularly considering the CMA's socio-political background that the impact of any WDM initiative is looked at from various perspectives. The CMC and the MLCs (or appointed Water Utility in the area) need to be transparent to their consumers and involve public participation in any planning process.

There are various economic tests that should be considered before deciding on any demand management initiative and these should also include environmental and even political costs if possible. A very important aspect of the principles of IRP is the need to look at the water supply chain holistically for every water use category (Hall, 1996). This requires co-ordination and co-operation by all utilities and organisations in the supply chain. Thus as regards to water IRP can only be achieved through the ethos of partnerships and customer focus, taking into account the various perspectives of WDM.

### **9.3 Perspectives on Water Demand Management**

There are three conceptual levels of WDM, namely, level of the individual facility/firm - industry, institution or household; society level, and the truly radical level of questioning common notions of water need and consumption (Brooks et al., 1989). A holistic approach to WDM requires that all these three levels should be examined, and this is what the preceding chapters attempted to accomplish.

The CMC as the proprietor of the Water Utility, industrial and other institutions, or households can be treated as individual economic units. For any of them optimisation of WDM measures and opportunities is a matter of cost-effectiveness. One of the key questions asked is whether investment into water reduction measure/ tools; fixtures or devices pay off in what over terms relevant to that particular economic unit or not.

In Chapter VII it was shown that investing in water reduction measures could save water and energy, which in terms translates into financial savings – time, money or efforts. But, there is a lot of balance to be made as regards to water pricing, and economic incentives - which were not the centre of focus in this work. However it was mentioned in Chapters I & II that when water prices are too low, the value of water is not fully reflected and this does not appeal to anybody to save water. As well, misplaced incentives such as rebates for water reduction and subsidies for using water can act as a hindrance to water-use efficiency and acts as contra force against WDM objectives.

When water demand is viewed at a Society level it is in a much wider perspective where a wider set of variables comes into play.

As explained in Chapters I & II water is a life supporting resource, which is partially renewable and partially non-renewable; moves around, crosses country boundaries and has enormous absorptive capacity. All these aspects attribute to the uniqueness of water as a scarce resource and calls for special social rules to depict who can use water, how much, and when. The water allocation criteria discussed in section 7 are essential, especially to ensure that everyone can get some water to meet the basic needs for drinking and sanitation.

But, the greatest challenge to the CMA society is how to maximise water allocation effectiveness by using all the discussed criteria, and by using a balance between market forces of demand and supply and government/municipal policies, laws and by-laws. Furthermore, as it was demonstrated in Section 7 & 8 calculations of the costs and benefits of WDM measures at society level are complex and less definitive than the calculations involving individual economic units.

Finally, application of WDM strategy in an area such as the CMA has to take into account other aspects including availability and affordability of the water efficient devices/fixtures; possible "externalities" and common property/ public good aspect of water resources. As regards to 'affordability' it is unfortunate that the CMC "**will not follow Durban's lead and provide a free six kilolitre water lifeline for the poor as part of a multi-step tariff - at least not until after the unicity becomes a reality**" (West et al., reporting in the *Cape Times* of 29-02-2000 - see **Appendix S**).

## **9.4 Measures for water demand management**

In Section 4 the tools or measures for WDM were presented, and summed up in Table 4.1. These tools/measures and techniques to promote WDM can be classified in many ways. One way of classifying them is by using their functions as is presented in Table 4.1, viz.: economic, managerial, technological, and educational/sociological/behavioural measures. Another way of classifying these measures is by grouping them in four categories: Market based measures; Radical perspectives; Non-water based measures (Brooks et al., 1997).

### **MARKET BASED MEASURES:**

Historically, in most parts of the world including the CMA, water distribution was and is still based on administrative measures (with political motivation) and / or according to natural social needs. The later was done without a lot of restrictions, more or less depending on the Water Authorities' or in many cases on the customers' financial capacity to shoulder the reticulation costs (Mirrilees et al., 1994; Pers. comm. Donovan, 2000).

But, today as a result of water scarcity, and efficiency of the market mechanisms, in many parts of the developed world water is traded as any other commodity. In the CMA the era for market based measure has come and is here to stay. Therefore, economic measures and incentives, including water prices and tariffs (taking into account the nine principles in **Appendix R**); and water subsidies have to play a greater role in water allocation in the CMA today and in the future. Already the CMC have commissioned a number of studies towards this end, including the current Study on "Alternative Options to Meet the Water Demand for the CMA". And the Palmer Development Group was assigned to study water tariffs, and the water price structure (CMC-AWDO, 1999; Baseline Report, 2000).

Economic and financial instruments (taxes, surcharges, subsidies, rebates and others) can be attractive tools to reduce the pressure on water resources if properly applied. Since optimisation of WDM opportunities as discussed in Section 6 is mostly based on financial and economic benefits derived from the water savings, it is imperative that financial and economic policies make water customers and decision-makers / water authorities more aware of the value of water. Consequently, the activation and application of these market-based tools should be subjected to the same rigorous appraisal and testing to make sure that they meet the various criteria and tests presented in Sections 7 & 8 respectively.

### **RADICAL PERSPECTIVES:**

Finally, instead of using WDM measures to reduce and save water one could go to the extreme by questioning the purpose of water use in some areas/devices and operations. These radical options are what David Brooks (1997) dubbed "Soft water paths". There are quite a number of radical alternative perspectives / options to substitute water as a productive resource. Some of these options were discussed in Sections 8 and are listed below.

**1) Using air for cooling purposes instead of water.**

This involves system replacement in order to install equipment, which uses air for cooling instead of water in performing its operations.

**2) Using pressurized tank system toilets and flushometers**

They use (pressure) compressed air to clean the toilet solids.

**3) Using non-water based sanitation**

For example, pit-toilets in isolated areas instead of trying to link them with the city water reticulation and sewage system.

**4) Use treated effluent water for watering instead of fresh potable water.**

**5) Use local sources of water supply such as water harvesting as part of demand management.**

**6) Use xeriscaping methods and replacing alien water thirsty plants with indigenous drought resistant plants (see a list of suitable plants for the CMA in Appendix M.)**

All these radical options can shift the pressure of applying WDM measures on the existing fresh potable water; save water and reduce water supply costs.

Although economic efficiency based on market pricing is currently widely advocated in the literature, careful analysts see it as a necessary but insufficient incentive for achieving efficiency, sustainability and equity. In other words as amply argued in Section 7 economic efficiency based on market measures, especially pricing mechanisms is not the only criterion, which should be used to maximise water allocation benefits to the CMA customers. The author argues that water subsidies should be explicitly justified and should not be permanent. Furthermore, water tariffs could be designed to encourage water saving not just to recover costs, and that safety nets and lifeline pricing should be created and adopted in the to make water affordable to the poor especially to meet the basic needs for life.

**NON-FINANCIAL BASED MEASURES:**

Together with the market based WDM measures discussed above, there are a number of non-financial measures that can be applied to promote WDM (Brooks, 1997; SADC – IEMP, 2000). The most prominent are the following:

• **Educational/Behavioural measures.**

Advocacy by using Public awareness campaigns, education in schools, seminars and workshops. The awareness and lobbying campaigns are important components of implementing any WDM programme. As was discussed in Section 8 they are considered as essential strategies to implement successfully any WDM in a facility or an area.

• **Legislation and Regulation:**

Market and non-market based measures for operationalising WDM measures should go hand in hand with pertinent legislation and regulation for water use and water

management. The function of appropriate legislation - laws and by-laws is to establish a legal basis to enforce policies and decisions made by the Government / Local Government and Municipal Councils (CMC & MLC). The aim is to regulate rather than to use coercive means (exhortation) to force people to comply with WDM policies and rules (laws / by-laws). A good example of such by laws is for example Section 184 of the Municipal Ordinance No 20 of 1974 which empowers Municipals' Chief Executive Officers to restrict water use whenever they deem it necessary. An example of how these laws could be used to reduce water wastage was demonstrated by the South Peninsula Municipality in 1999, as seen in **Appendix T**.

The Draft Water Conservation and Demand Management National Strategy Framework (DWAF, 1999) clearly articulates the objectives, goals, mechanisms and strategy framework for implementing WDM measures to South Africa's society at large. CMC could adapt this WC/WDM Strategy Framework, and use it as a basis for its own WDM regulations and by-laws.

In sum, although regulations have a bad name, they are often more effective, appropriate and efficient for managing water demand. The range of non-market measures is wide enough to preclude generalisation, but one can say that in the case of CMA, they should be chosen to augment and if possible to reinforce, the effects of market-based measures discussed above.

#### DIRECT INTERVENTION

Direct intervention by the CMC/Water Authority in providing services, retrofitting water reduction equipment, fixing leaks, adjusting pressure or imposing direct temporary restrictions is necessary, but this can be done, is being done in public places. This can not be done in private property – industries, commercial institutions, and households. The correct move is to co-ordinate direct and indirect intervention moves and involving public and private initiatives in order to fully optimise WDM opportunities. Other essential elements for implementing WDM as noted by Khosa (2000), are a presence of a sound infrastructure and institutional capacity.

### **9.5 Need for sound infrastructure and institutional capacity**

WDM measures, can only be successfully implemented if water consumption is metered and water audits and leak detection and repair is done. Although water metering and water audits were only mentioned by way of passing (i.e. not covered by this thesis as they are adequately covered by the Baseline Report (2000) they are indeed the first steps towards implementation of any other WDM measure. For instance, it is impossible to know where the leaks are located without doing a water audit/leak survey.

Likewise water audits are necessary in order to know the type of devices/equipment in place in any facility; and to know exactly their technical conditions, and to determine the possibilities for retrofitting with water efficient equipment. Water billing can not be effected without having water meters in place, therefore the later is a pre-requisite for any water billing and any water pricing exercise.

One of the good issues learnt from the water auditing exercise conducted by the author and fellow Masters students was that the CMA has an elaborate water reticulation system but the maintenance is not up to date. Apparently, a lot of leak repair work is needed since the amount of unaccounted-for-water loss is between 15-20% of the water production.

This amount of water loss is high, especially for a water scarce area. It could be reduced by employing the leak detection methods discussed in Section 5 and solved by replacing old pipes, mending leaks and by identifying illegal connections by using listening equipment and by metering all customers ([http:// www.oas.org.sop/prog.chap4-5.htm](http://www.oas.org.sop/prog.chap4-5.htm)).

Experience from the USA shows that unaccounted-for-water losses can drop by up to 36% after successfully introducing metering and leak detection and repair programme (AWWA-M36, 1990). Apparently, there is no clear reason why the CMA can not reduce water losses by the same amount as in the USA.

Apart from administrative and technical aspects, institutional support also includes the support of water users and gender perspective, especially women since they are key water users in any society.

## 9.6 Gender and water demand management

WDM can not take place in abstraction without taking into account society and people's habits, perceptions, attitudes and gender perspectives. Gender refers to the social differences between women and men and how they interact with each other and their environment. Management and planning of water resources and implementation of WDM measures are sensitive issues, which should involve all the members of a given society. But, women should be involved fully as they have an important role to play in sustainable water management as they are so directly connected and concerned with the needs and quality of life in the work place and their families.

All in all, women are key water users hence any WDM programme should take into account their needs and opinions. So as to be effective WDM strategies in the CMA will need to be tailored to take into account priorities based on gender in the different sectors hand in hand with the various water criteria discussed earlier and pass the five economic tests referred to in Section 8.

## 9.7 Economic Tests for Water Demand Management

As mentioned in Section 8 and depicted in Figure 8.1 there are three major stakeholders /agents or players involved in WDM in the CMA. To recapitulate, these stakeholders are the following: Bulk water supplier (Government/Municipal Authorities); Urban water supplier/distributor(s) (The Water Authority/ Distribution Agency); and water consumers – both participating and non-participating in particular WDM measures.

WDM measures and policies affect each stakeholder or agent differently hence the net economic affect to each should be carefully appraised by using cost-benefit analysis. The bottom line is that WDM measures must pass the tests by taking into account the requirements of each stakeholder as outlined below:

### ◆ The Participating (customers) test

It measures the costs and benefits to the participating customer(s) by using the net present value (NPV), the benefit cost ratio (BCR) and the internal rate of return (IRR) against the discount rate (DR)

$$\text{NET BENEFITS} = \text{REDUCED BILLS} - \text{CUSTOMER COSTS}$$

#### ◆ Water Authority Test

This test measures the direct costs and benefits of WDM measures of the Water Authority. The financial benefits to the Authority results from the avoided operating costs and the avoided capital requirements from deferred works.

$$\text{NET BENEFITS TO WATER AUTHORITY} = \text{REDUCED OPERATING COSTS} + \text{SAVINGS FROM DEFERRED CAPITAL EXPENSES} - \text{PROGRAMME COSTS}$$

#### ◆ Total Water Resource Costs

This test measures all the costs and benefits to both the participating customers and the water authority. It involves the indirect costs to the Water Authority that arise from loss of revenue from reduced water sales.

#### ◆ The Revenue Impact Measure Test

This measures the impact of the WDM measure on the Water Authority and includes the effects of foregone revenue.

$$\text{REVENUE IMPACT} = \text{REDUCTION IN OPERATING COSTS} + \text{REDUCTION IN CAPITAL COSTS} - \text{PROGRAMME COSTS} - \text{REDUCED REVENUE}$$

#### ◆ Societal test

This test takes into account all the costs and benefits to all the participating customers or agents as well as quantifiable environmental and ecological impacts.

In sum, WDM programmes must pass all these tests before it is passed for implementation. If the results of any of these tests are negative, the programme should be re-designed in order to re-distribute the potential costs and benefits. Consideration of the results of these economic tests is essential for making decision on alternative measures and programmes.

The decision-makers in the CMC and the MLC's should concentrate on scrutinising the overall results of these tests before making any decision to go ahead with the promotion and investment in WDM strategies in the CMA. If the Water Authority prospects or the overall societal benefits are high, and the individual customers (households or industrial consumers) are lower; the authorities (CMC/MLC's) can intervene by using a portion of their net savings to subsidise water saving technologies so that they can be affordable for more customers in the near future.

## 9.8 Charting the future

Throughout this thesis it has been demonstrated that because water is scarce in the CMA, and there is a lingering water shortage in the future, there is a need to use WC and WDM strategies and measures in order to abate this problem. In the preceding chapters it was

shown that it is possible to defer further construction of expensive water augmentation schemes in the CMA by exploiting existing WC and WDM opportunities.

This can be done by optimising existing WDM opportunities and by using the various economic, managerial, technological and educational measures discussed in this work.

Finally, the way forward was charted by showing the methodology and procedure for designing water-efficient programmes at facility - industrial, commercial, institutional, and municipal levels.

The CMC as a driving force behind this quest for solving the water problem in the CMA should pursue this endeavor to its logical conclusion. Most of the necessary components for implementing WDM in the CMA are present. The technical know-how (expertise); water- saving technology - devices or fixtures and equipment are available in the CMA and in SA. Most large water users (67% and 72%) are aware of the fact that water is scarce in the CMA and in the Western Province respectively and are ready to adopt WC/WDM measures. (See the Baseline Report, 2000 Section 3).

The way forward is to start planning and implementing a range of WDM strategies and measures and continue to solve unforeseen problems as they crop up by using both local and international experience.

Lastly but not least, it is obvious from the proceedings of this thesis that there is a need to continue research on a number of grey areas related to WC and WDM in the CMA. The following are some aspects that would require research and understanding:

- ◆ Correlating water saving measures with energy saving ones. From the examples and arguments presented in this thesis it is obvious that water could be saved by adopting WDM strategies and measures; but water use indoors is inseparable with energy-use for heating water. It is thus correct to study and establish the correlation between the costs and savings of resources so as to get a holistic picture of the actual financial implications of adopting WDM measures.
- ◆ To establish a correlation between adopted WDM measures and efficiency in production. Saving water is useless if it negatively affects production or business in a respective industry or a commercial organisation. Preliminary studies should therefore be conducted beforehand to establish the possible repercussions of adopting WDM measures in the level and quality of production on a particular area or facility.
- ◆ To undertake research on attitudes, patterns and possible reactions of water consumers to WDM measures at different stages of their implementation. An initial questionnaire survey such as that one conducted by the Masters Group in the Baseline Report (2000) should be only the beginning of the process. Occasional surveys are necessary in order to know exactly what the water customers want and are ready to do in order to save water.

"Water Demand Management based on economic efficiency is the best new approach to use scarce water resources in the CMA. WDM is as much about efficient use of scarce water resources as about efficient use of scarce financial resources. However, it is equally important to note that water conservation & demand management alone will not replace supply-side developments. WDM and water supply augmentation should supplement each other - the former can postpone the later so that money is saved and contingency measures for avoiding & reducing potential negative environmental impacts are made. WDM has to focus on the way in which water is used - wisely, efficiently, cost effectively, equitably and sustainably. WDM is not a novel thing, novel is the implementation of its full potential through optimisation of water reduction and saving opportunities. Industrial, commercial and institutional organisations within the CMA have vast water reduction and saving opportunities. The methodologies and procedures presented in this work should be used by facilities in the CMA". [JRK, 2000

## CHAPTER X

### • Conclusion & Recommendations

# 10. CONCLUSIONS & RECOMMENDATIONS

## 10.1 Conclusions

Based on the findings and the tasks accomplished in this thesis, the following conclusion may be drawn: That there is a considerable scope to reduce and save water in non-residential facilities within the CMA if bold measures are taken to optimise the existing WDM opportunities. And that water demand management is the new, promising, sustainable water management approach suitable for the CMA.

It was shown that historically, the predominant approach to water resources development in the CMA focused on developing new supplies - dams and reservoirs and structures - purification facilities, pipelines and tunnels to manipulate available supplies to meet perceived ever-increasing water demand. Hallmarks of this paradigm include large dams such as the Wemmershoek, Steenbras, Voelvlei, Theewaterskloof and the Palmiet dams; and water diversions or inter basin transfers, and international importation of water from other countries such as Lesotho. Because this water supply management approach considered water needs as requirements that must be met at any cost, and not as demands that are variable and changeable, it has led to overuse of the resource, over-capitalisation, resource wastage, pollution, and other social, environmental and ecological problems of varying severity. Water supply and demand created a vicious cycle scenario whereby supply is endlessly chasing demand for water. This thesis showed that this prevailing type of water supply management paradigm can not give a permanent, cost-effective solution to the water problem or the potential water crisis.

This thesis addressed the central research question posed in the introduction - that of how to abate the potential water shortage/crisis in the CMA by designing effective WDM programmes based on economic efficiency as a basic criterion. This was done while pursuing a three-prong strategy: Exploring the underlining economic theory, and correlating it with practice. Moving from 'global to local', by taking into account international, and national (SA) experience and the actual local situation in the CMA. And by adopting a holistic approach in evaluating and presenting WDM strategy as part and parcel of an Integrated Resource Planning process and the political, social and economic gamut in the CMA. Furthermore, it was shown that there are a number of WDM measures and perspectives, including market based - financial-economic and managerial measures such as water auditing and leaks detection surveys, non-market based measures such as educational programmes, and popular participation which are indispensable.

In all the preceding nine chapters it was shown that unless WDM as a new alternative approach to water resource management in the area is adapted, coupled with courageous policy making and rigid implementation strategies based on economic efficiency is adopted, the water shortage problem can not be solved.

This relatively new alternative approach to the CMA places water demands themselves, not structural solutions, at the centre of concern, and develops large capital-intensive structures only after water conservation strategies and measures based on optimisation of WDM opportunities have been fully explored. The intention is to make sure that future water supply augmentation schemes, such as the Skuifraam dam, are deferred as much as possible in order to get enough time to study alternative options. Furthermore time is needed to put up concrete contingency plans for lowering or mitigating potential negative impacts of the proposed projects in a more socially beneficial and environmentally friendly manner.

Certainly, we have to know what we are doing with our water before we can do something about it. Therefore the starting point for engaging WDM strategy is to carry out an inventory of the water system in a facility or an area by conducting water auditing and leak detection survey. The point is water audit followed by a leak detection programme is one of the most powerful tools for WDM and can directly help water utilities reduce water wastage and revenue losses and make better use of water resources. Only after establishing the actual water situation and the state of water using equipment/ devices and fixtures can we proceed to prescribe remedial or improvement measures – be they simple tuning, adjustment, retrofitting or complete replacement. The information collected during the auditing exercise can provide a reliable source of data for planning and designing an optimum WDM programme for that particular facility or area.

Optimisation of WDM opportunities is a viable option to achieve water reduction and savings in industrial, commercial and institutions - indoors for cooling, heating, and for sanitary systems; outdoors for watering landscapes. It can as well be instrumental in encouraging energy and raw material savings, and potential reuse of wastewater. Generally, water saving in the CMA can be achieved by employing the following measures: System optimisation, system replacement, reducing-re-using-recycling strategy, making operational or production changes, or by using discretionary alternative uses such as dry sweeping, or shutting off taps between rinsing steps. Radical options such as using air for cooling purposes instead of water, using non -water based sanitation, use of treated effluent water for watering, and "xeriscaping" methods are viable options that can be seriously considered for application in specific locations in a facility or an area.

As regards to indoor water use in the CMA, there is a considerable scope for water reduction and saving by optimising systems - fixing drippings in showerheads, taps and sinks, fixing leaky toilets that constantly run. And by initiating and implementing a regular maintenance plan, maintaining correct hot water tank (geyser) temperature to avoid damage or tank burst and insulating all hot water pipes to minimise faucet run time.

Retrofitting existing water wasting devices/fixtures is another viable option. Water efficient devices/fixtures such as gravity flush toilets, flushometers, cyclic flush urinals, infrared sensor operated systems or microwave sensors, aerators, automatic shut-off faucets, or showerheads with pressure release valves or electric eye sensors and other modern devices can be used.

In watering outdoors "Xeriscape" landscaping methods are the most efficient method that can be used to reduce water wastage through the application of seven principles of optimising watering process, soil, and gardening methods. These seven principles of "xeriscaping" include: planning design, which considers micro climate of the area - shade, drainage, type of soil, grade, zones, flora and fauna of that particular place. Other principles include: soil analysis; reduction of lawn size; selection of appropriate plants to fit hydrozones; use of best gardening practice - use of mulching, automatic shut-down drip irrigation systems and sprinklers and other water saving methods and equipment and appropriate maintenance of irrigation equipment.

Finally, in contrast to conventional approaches WDM is much more aggressive in the use of economics to influence the origin of water demands in the first place, to provide incentives for achieving water savings in the cheapest possible manner. Water Demand Management also depends critically on raising public awareness, and on adaptation of a series of economic techniques, awareness campaigns, and structural and operational

measures. All these aspects can be built early into all stages of WDM programme planning, designing, and implementation.

Conducting public educational awareness campaign programmes is necessary to support WDM programmes in the CMA even in non crisis times so as to put across the importance of water saving to society, to environmental quality, and to achieve reliability and sustainability of this vital service.

International experience cited in the thesis shows that there is scope to save water through leak repair by between 15-20% in the industrial sectors and by 20-25% in the domestic and commercial sectors. In the CMA where between 15 - 25% is unaccounted for water (UAW) if WDM measures are successfully implemented a number of attainments can be achieved in the long run. Preliminary estimates show that a reduction of water consumption by 30% - 50% and saving of UAW by between 40 - 50% can be achieved with no deterioration in welfare/life style. If this saving is achieved it can significantly reduce capital costs for expansion of water supply, treatment costs and costs for infrastructure.

Although in the short run implementation of WDM measure implies that the CMC and the MLCs will be denied revenue from a certain amount of immediate water sales, the long term proceeds from the 'avoided' water supply costs can be enormous.

Reverting to the original basic problem and hypotheses; and taking into account the arguments, evidence, methodologies and procedures presented in the nine sections of this work; together with the preceding conclusions three final general conclusions can be made:

**Firstly**, WDM is indeed, a viable and promising option that can be used to abate the potential water problem/crisis in the CMA.

**Secondly**, relevant economic theories, concepts of allocation of scarce resources (including water pricing and demand forecasting which were not covered by this thesis), optimisation and maximisation of net gains, CBA and OPA, market forces of demand and supply, IRP and LCP can be and should be applied to WDM programmes in order to ensure their long term sustainability.

**Thirdly**, optimisation of WDM opportunities in non-residential facilities in the CMA can be achieved through the application of a combination of criteria, but the economic viability criterion, which inevitably incorporates, economic, exchange and technological efficiency, is a necessary condition for a successful future water resource management in the area.

## 10.2 Recommendations

As a result of the findings and conclusions of this thesis, the following recommendations can be made:

- In order to initiate and implement a comprehensive WDM strategy in the CMA there should be a proper policy and legal framework, economic and financial means, administrative, infrastructure and technological capacity. However, the CMC and the MLCs should not wait for the establishment of adequate institutional structures in order to start implementing WDM strategy and measures in the area.

- All industrial, commercial, and institutions in the CMA should explore and utilise WDM opportunities in their respective facilities of organisations in order to reduce water wastage.
- Implementation of stage – by - stage facility and area-wide WDM strategy should be adopted with immediate effect. This can help to start the momentum for proper functioning of the utilities, thus creating the necessary enabling environment for future institutional structuring and internal capacity building.
- The CMC should enact a by-law that would compel all industrial, commercial, and institutions in the CMA to design and start implementing WDM measures in their respective facilities or organisations.
- The CMC should expedite the completion of the CMC-AWDO study and start implementation of at least some the pertinent recommendations, including the ones presented by the UCT - CMA Water Study (2000) and the ones presented in this thesis.
- Although the Government has just approved the R 850m Skuifraam dam (as reported in the *Cape Argus* of September 23, 2000:- see **Appendix V**) the CMC, MLCs, and the CMA water consumers should not consider the construction of this dam as the panacea of the water problems in the area. Hence, to take it as a pretext for not implementing WDM measures. Past experience attests to the contrary. Under the current rate of population and production growth, and the level of water consumption and wastage, the **vicious circle of water supply and demand** cannot be permanently broken unless water supply augmentation efforts are supplemented by demand side management efforts.

The ball is now in the court of the Provincial Government, the CMC and industrial, commercial and institutions within the CMA. Are they ready to embark on water conservation efforts by using Water Demand Management? Are they ready to increase water efficiency by optimising the existing WDM opportunities within their facilities? Time will tell.

At this juncture the words of the great German poet Johann Wolfgang von Goethe are pertinent and directly applicable to proper management of scarce water resources in the CMA based on economic efficiency:

**" Knowing something is not enough, you have to apply it:  
Wanting something is not enough, you have to do it ".**

German poet Johann Wolfgang von Goethe.

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**A COMPREHENSIVE GLOSSARY**

## COMPREHENSIVE GLOSSARY

**Aquifer** - A geological formation or group of formations capable of receiving, storing and transmitting significant quantities of water.

**Avoided costs** - The savings associated with undertaking a given activity (such as demand management) instead of an alternative means of achieving the same results (such as adding supply); can be used to establish the least-cost means of achieving a specified goal.

**Basic needs** - A relative term that refers to the minimum requirements in shelter, food and water for human survival etc.

**Best management practice** - A measure or activity that is beneficial, empirically proven, cost-effective, and widely accepted in the professional community.

**Blow-down (water)** - (also known as bleed-off water) Is the removal of water from the re-circulation in a cooling tower in order to reduce contaminants built-up in the tower water.

**Cost - Benefit analysis.** A comparison of total benefits to total costs, usually expressed in monetary terms, used to measure efficiency and evaluate alternatives.

**Dam** - A structure constructed across a river valley to store stream flow and allow it to be diverted for water supply use or released in a controlled manner for downstream.

**Drift** - Loss of water from a cooling tower in the form of mist.

**Desalination** - The process of removing salts to produce fresh water.

**Capital facilities** - Physical facilities used in the production, transmission, and distribution of water.

**Conservation pricing** - Water rate structures that help achieve beneficial reductions in water usage.

**Cost-effectiveness** - A comparison of costs required for achieving the same benefit by different means. Costs can be expressed in any monetary denomination, but benefits can be expressed in another unit (such as a quantity of water saved).

**Customer class.** A group of customers (residential, commercial, industrial, wholesale, and so on) defined by similar costs of service or patterns of water usage.

**Demand forecast** - A projection of future demand that can be made on a system-wide or customer-class basis.

**Discount rate** - A percentage that is used to adjust a forecast of expenditures to account for the time value of money or opportunity costs; it can be based on the utility's cost of capital.

**Demography** - Population and socio-economic dynamics ( migration, immigration, mobility, mortality etc.) at a specific place in time

**Devises/equipment** - Fixtures, appliances, and activities that use water.

**Drought** - A sustained period of inadequate or subnormal precipitation that can lead to water supply shortages, as well as increased water usage.

**Ecosystem** - The combination of all factors, biotic and abiotic, that make up a particular environment and its organisms: the primary ecological unit, which may vary in size.

**End user** - Residential, commercial, industrial, governmental, or institutional water consumer.

**Evapotranspiration** - Water losses from the surface of soils and plants.

**Fixed costs** - Costs associated with water services that do not vary with the amount of water produced or sold.

**Greywater** - Treated wastewater used for non-potable purposes, such as irrigation.

**Hydrozones** - Areas classified according to water content or requirements. In xeriscape landscaping three such zones are distinguished - "arid" (least water), "transition" (moderate water) and "oasis" (more water requirements).

**Integrated Resource Planning.** - An open and participatory planning process emphasising least-cost principles and a balanced consideration of supply and demand management options for meeting water needs.

**Irrigation scheduling** - An automated method for optimising outdoor water use by matching the watering schedule to plant needs.

**Large water consumer/user** - A water customer, in this case industries, commercial or institutional organisations within the CMA that use more than 100 kilolitres of water a day, hence their usage is substantial relative to other users.

**Leak detection** - Methods for identifying water leakage in pipes and fittings.

**Low water-use landscaping** - Use of plant materials that are appropriate to an area's climate and growing conditions (usually native and adaptive plants).

**Marginal-cost pricing** - A method of rate design where prices reflect the costs associated with producing the next increment of supply.

**Marginal utility** - Satisfaction derived from consuming one more unit of a given good or service

**Market penetration** - The extent to which an activity or measure is actually implemented compared to all potential uses or markets.

**Meter** - An instrument for measuring and recording water volume.

**Microclimate** - Atmospheric conditions typical to a locality as a result of its uniqueness.

**Natural Capital** - Resources extracted from the environment and used for production (e.g. Coal, oil, gas etc.)

**Net benefits** - The numerical difference between total benefits and total costs, both of which must be expressed in the same unit (in this thesis the unit used is the Rand).

**Net present value** - The present value of benefits less the present value of costs.

**Non-residential customer/water user** - A commercial, industrial or institutional utility customer.

**Opportunity cost** - The value of a foregone opportunity that cannot be pursued because resources are taken up by a chosen activity.

**Peak demand** - The highest point of total water usage experienced by a system, measured on an hourly and on a daily basis.

**pH** - Refers to the acidity or alkalinity of water.

**Pitometer** - A gauge for measuring pressure of water from a pipe/leak

**Potable water** - Water generally considered suitable for human consumption.

**Precipitation rate (sprinkling)** - The surface application rate for landscape watering, usually expressed in centimeters per hour.

**Present value** - Future expenditures expressed in current currency unit (\$, R, etc.) by adjusting for a discount rate that accounts for financing costs.

**Pressure regulator** - A post-meter device used to limit water pressure.

**Price elasticity of demand** - A measure of the responsiveness of water usage to changes in price; measured by the percentage change in usage divided by the percentage change in price.

**Rationing** - Mandatory water-use restrictions sometime used under drought or other emergency conditions.

**Retrofit** - Replacement of parts in an existing plumbing fixture or water-using appliance in order to improve its operational efficiency.

**Recycling** - Refers to multiple uses of water after some form of operation

**Sensitivity analysis** - An analysis of alternative results based on variations in assumptions; a "what if" analysis.

**Scale** - Scale on cooling towers refer to amount of minerals deposited on the surface, and thus reduces cooling capacity and the tower.

**Toilet tank displacement device** - A plastic bag or dam installed in a toilet tank to reduce flush volume. Considered effective only for fixtures using more than 11 litres per flush.

**Toilet flapper** - Valve in the toilet tank that controls flushing.

**Transaction costs** - Costs associated with enforcing property/ ownership rights of a or property.

**Treated water**. Water treated to meet drinking water standards.

**Ultra-low-flush toilet** - A toilet that uses not more than 6 litres per flush.

**Unaccounted-for water** - The amount of non-account water less known or estimated losses and leaks.

**Unit reference value** - These are estimated costs per cubic metre of water for the associated scheme. Should be considered incomplete if costs of environmental impacts are not taken into account.

**Variable cost** - Costs associated with water service that vary with the amount of water produced or sold.

**Water Audit (end-use)** - A systematic accounting of water uses by end users (residential, commercial, or industrial), often used to identify potential areas for water reduction, conservation, or efficiency improvement.

**Water Audit (system)** - A systematic accounting of water throughout the production, transmission, and distribution facilities of the system.

**Water Conservation** - Any beneficial reduction in water losses, waste, or use.

**Water distribution facilities** - Pipes, treatment, storage and other facilities used to distribute drinking water to end users.

**Water losses** - Metered source water less revenue-producing water and authorised unmetered water uses.

**Water-use budget** - An accounting of total water use or projected water use for a given location or activity.

**Water reuse** - Beneficial use of treated wastewater.

**Water tariff** - The schedule of a utility's water rates and charges.

**Water supply management** - Measures deployed by the utility that improve the efficiency of water production, transmission, and distribution facilities.

**Xeriscape** - Landscaping that involves seven principles: proper planning and design; soil analysis and improvement; practical turf/lawn areas; appropriate plant selection; efficient irrigation; mulching; and appropriate

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# APPENDICES

## • A - V

## APPENDIX A

The capital city of the CMA in the Western Province is wasting water... it may face water curbs... no more approval of new dams by the government... at least for the time being... "I'm not going to put in another dam." - Hon. Ronnie Kasrils - Water Affairs Minister (Reports the *Cape Times*: 23-08-2000)

# Wasteful city facing water curbs

*Cape Times: Wednesday Aug. 23, 2000*

**MELANIE GOSLING**  
ENVIRONMENT WRITER

CAPE TOWN is wasting water and could soon have a system of "stepped" water tariffs, under which consumers who use large volumes will be charged at much higher rates, as is already being done in Hermanus.

Water Affairs Minister Ronnie Kasrils said at a media briefing yesterday that the city needed to wake up to the fact that it was wasting water and realise that the Skuifraam dam would not be built to increase local water supplies until the city could prove it was curbing wastage.

The best way to do this was to penalise consumers for wastage through a stepped tariff system. "We haven't been charging enough. We're in discussions with the provincial and local governments about this," Kasrils said.

He said the Western Cape was one of the provinces which faced the biggest challenges concerning water supply, and he would be unveiling a water conservation strategy for the province "in the near future".

The stepped tariff system, applied in Hermanus, means wealthier consumers are hardest hit as they generally consume more water for swimming pools, more than one bath or shower and larger gardens.

Kasrils said all the statistics pointed to Cape



**WAKE-UP CALL:** Water Affairs Minister Ronnie Kasrils says city must wake up to its wastage.

Town needing another dam. "But I'm not going to put in another dam while consumption is being driven up by those wasting water. I've got to see proper water management. People are wasting water and I won't allow that. Cape Town will have to wake up to that."

At the briefing, Kasrils released the annual report for his department's Working for Water

programme designed to increase water supply with a country-wide system of hacking out thirsty alien vegetation.

Last year, the programme cleared close to 240 000ha of aliens — an area larger than the Richtersveld National Park and nearly 10 times the size of the Cape Peninsula National Park.

However, the project was still not clearing aliens as fast as they were spreading throughout South Africa — at a rate of 5% a year.

The programme already had to clear 10 million hectares of aliens, an area larger than KwaZulu-Natal. To stop the spread it would have to clear around 500 000ha a year.

The Western Cape had the worst alien infestation in the country, largely because species like wattle and rooikrans were brought into the area in colonial times to stabilise sand dunes.

Kasrils said the new regulations in terms of the Conservation of Agricultural Resources Act would be promulgated next month.

These will stipulate the circumstances under which invasive aliens may be grown and will allow the authorities to enter private land without the landowner's permission to clear weeds and invader plants.

The regulations will also compel landowners to clear their land of invasive aliens before they can sell, transfer, rezone or sub-divide their land.

# APPENDIX B

Questionnaire survey forms used by the UCT – CMA Water Study:



DEPARTMENT OF  
WATER AFFAIRS  
AND FORESTRY



## INTEGRATED WATER RESOURCE PLANNING STUDY REGISTRATION FORM AND QUESTIONNAIRE JULY 2000

Thank you for agreeing to participate in the Cape Metropolitan Council's '**Integrated water resource planning study**'. Please complete this registration form and the attached questionnaire, and **FAX** it back to **(021) 650 3791** by the **24<sup>th</sup> July 2000**. The FAX can be marked for the attention of the '*UCT Water Demand Management Group*'. Should you have any problems in this regard, please do not hesitate to call our group at **(021) 650 2957** and we can make an alternative arrangement.

*NB. The information provided will in no way be directly linked to the respondent or his/her organisation and will not be utilised, other than for the purposes of the study.*

### **Organisation Registration Form:**

NAME OF ORGANISATION:.....

TYPE OF ORGANISATION (the dominant activity the organisation is involved in):

.....

ADDRESS: .....

.....

TELEPHONE: ..... FAX: .....

### **Optional: Representative's details**

TITLE: ..... INITIALS: ..... SURNAME: .....

FIRST NAME: .....

POSITION: .....



**NINHAM SHAND**  
CONSULTING ENGINEERS



**LAWGIBB**  
**GROUP**  
CONSULTING • DESIGN • MANAGEMENT  
**ARCUS GIBB**

# QUESTIONNAIRE ON WATER CONSUMPTION IN THE CAPE METROPOLITAN REGION

## Respondents Notes:

- As well as being representative of the organisation, the person answering this questionnaire should have knowledge of water consumption within the organisation.
- The questionnaire should take approximately 15 minutes to complete.
- The sections within the questionnaire should be approached as follows:

### **Section 1. National and Regional Level Issues**

This section is included to get an idea of your attitudes and perceptions of water related issues at a national and regional level.

### **Section 2. Organisation Level Issues**

This section is included to get an idea of actual water consumption at the organisation level.

## **1. National and Regional Issues**

- 1a) In your view, natural fresh water resources (rivers, dams, rainfall and groundwater) in **South Africa** are... *(Please ✓ choice)*

Extremely plentiful	Plentiful	Adequate	Scarce	Extremely scarce	Uncertain
---------------------	-----------	----------	--------	------------------	-----------

- 1b) In your view, natural fresh water resources in the **Western Cape Province** are... *(Please ✓ choice)*

Extremely plentiful	Plentiful	Adequate	Scarce	Extremely scarce	Uncertain
---------------------	-----------	----------	--------	------------------	-----------

- 1c) In your view, natural fresh water resources in the **Cape Metropolitan Area (CMA)** are... *(Please ✓ choice)*

Extremely plentiful	Plentiful	Adequate	Scarce	Extremely scarce	Uncertain
---------------------	-----------	----------	--------	------------------	-----------

- 2) If you were challenged with solving a water shortage problem in the CMA, what do you think would be the most suitable alternative to solve the problem? Suitability should cover feasibility, effectiveness and environmental sensitivity. **Of the options provided below, please rank your best alternative 1, your second best alternative 2 and your third best alternative 3, etc.**

- [ ] Construct more dams in the catchment areas  
 [ ] Pump water from other areas

- ] Desalinate sea-water
- ] Water loss management and control (leakage detection and repair programme)
- ] Implement escalating block-rate tariff (the greater the amount of water used, the greater the charge for each additional unit.)
- ] Recycle more water
- ] Implement water restrictions
- ] Promotion of the use of water saving fixtures and fittings (retrofitting).
- ] Use groundwater resources (e.g. aquifers)
- ] Tow icebergs from the Antarctic
- ] Clear more invasive trees from the catchment areas
- ] Other

If other, please elaborate further:

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- 3) The total water demand for the CMA is estimated at 900 MI/day based on the water use for the year 1999. The categories of sectoral water use, and their estimated percentages of the total demand are listed below (City of Cape Town, City Engineer's Annual Report dated 1995/96):

Household	34%
Gardening and Sports Bodies	22%
Industrial	13%
Commercial	6%
Municipal	6%
Unaccounted for water (UAW) <sup>1</sup>	19%

In your opinion, prioritise which sector has the potential to save the most water (**Rank sector with greatest potential to save water as 1 followed by the sector with next greatest potential saving ranked as 2 etc.**).

- ] Household
- ] Gardening and Sports Bodies
- ] Industrial
- ] Commercial
- ] Municipal
- ] Unaccounted for water

- 4) Below is a map of the CMA, showing the six Metropolitan Local Councils (MLC) boundaries. In your opinion, where is most of your organisation's water sourced from? (**Please ✓ one choice**)

<input type="checkbox"/>	Within your organisation's municipal boundary
<input type="checkbox"/>	From a number of municipal areas, but within the CMA
<input type="checkbox"/>	From outside the CMA
<input type="checkbox"/>	Uncertain

<sup>1</sup> **Unaccounted for Water (UAW):** This is water that is lost from the reticulation system either through leaks, unmetered consumption and/or theft (Davies and Day, 1998).

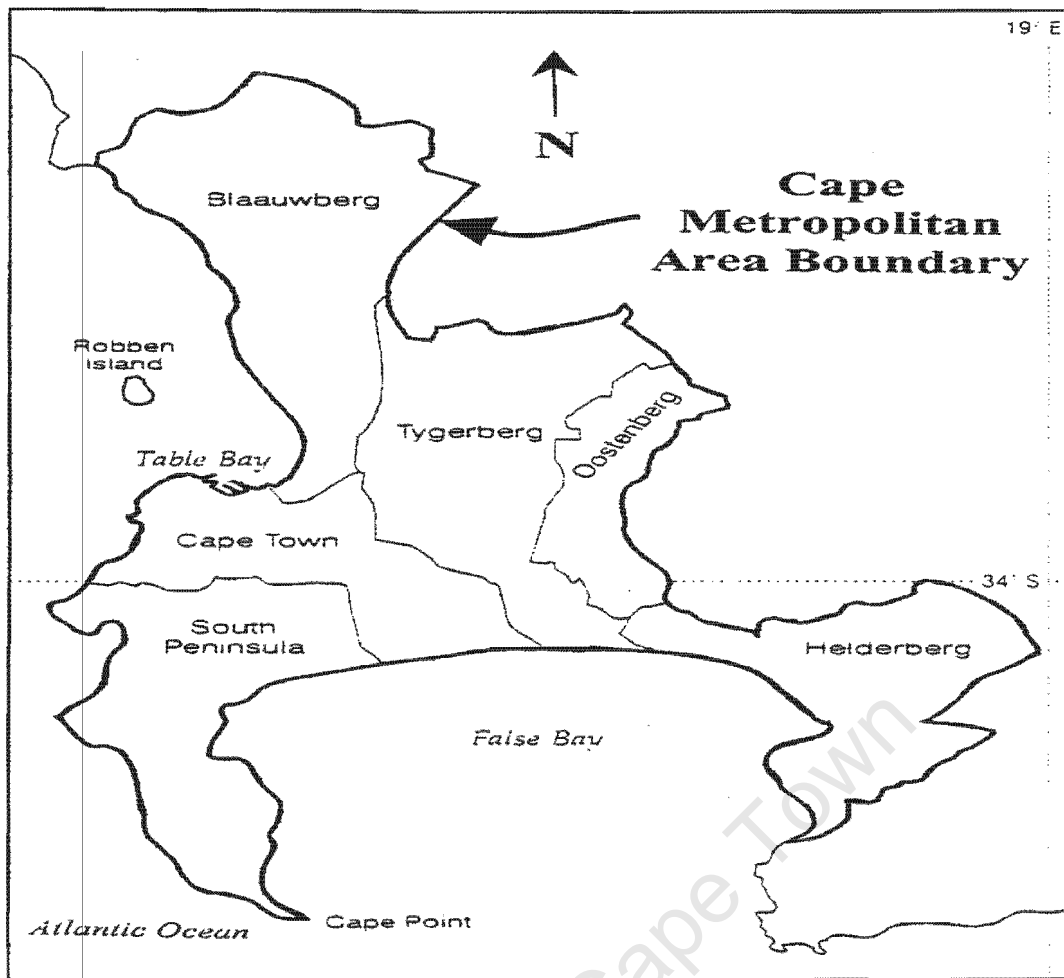


Figure taken from State of the Environment Report for the CMA, Year One-1998

5) In your view, when do you estimate that the demand for potable water will exceed the existing supply within the CMA?

<input type="checkbox"/>	Less than <b>one year</b>
<input type="checkbox"/>	Between <b>one</b> and <b>five</b> years
<input type="checkbox"/>	Between <b>five</b> and <b>twenty</b> years
<input type="checkbox"/>	Between <b>twenty</b> and <b>fifty</b> years
<input type="checkbox"/>	<b>Longer than 50 years</b>
<input type="checkbox"/>	<b>Uncertain</b>

6) What are your feelings about the following statement?

*Water use (including water resource development) in the CMA has little effect on the environment of the Western Cape.*

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Strongly agree	Agree	Indifferent	Disagree	Strongly disagree

Please explain your choice:

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## 2. Organisation Issues

7a) Does your organisation have an Environmental Policy?

YES	NO
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7b) Does your organisation have a Water Conservation Strategy? (e.g. strategy to retrofit e.g. automatic flushing urinals, upgrade water fittings, fix leaks, utilise more water efficient devices/equipment or optimise irrigation and/or garden watering)

YES	NO
-----	----

7c) Does your organisation publish an environmental report?

YES	NO
-----	----

7d) If yes, does this environmental report include information on water use?

YES	NO
-----	----

7e) Would your organisation be prepared to make any of this information available?

YES	NO
-----	----

7f) Does your organisation have an environmental management system? (e.g. based on ISO 14001)

YES	NO
-----	----

8a) How much potable and non-potable water (in kilolitres) does your organisation use per month? **(Please provide the quantity of water in the block, or if uncertain ✓ unknown)**

Water Type	i) Potable	ii) Non-Potable
Water volume (Kl/month)		
Unknown		

8b) Please tick (✓) the sectors of your organisation's water use in which the quantities used are known and monitored. Also, please cross (X) those you don't know.

- Cooling and heating
- Domestic uses (e.g. toilets and showers)
- Process rinsing
- Cleaning activities

- Kitchens and laundries
- Landscaping
- Evaporation
- Leaks
- Other. Please specify \_\_\_\_\_

9a) Of your organisation's total monthly operating costs, what percentage does your average monthly water bill constitute? **(Mark with a X on the most likely %)**



	Uncertain
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9b) Some areas in the CMA are subject to a 5-step or block tariff structure for domestic water use. This pricing strategy is based on the principle whereby the more water you use, the more you pay per extra unit. Do you think that this system should be imposed on all organisations using large amounts of water in the CMA?

YES	NO
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Comments:

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10a) Has an **environmental audit** ever been conducted on your site/premises?

YES	NO
-----	----

10b) Has a **water audit** ever been conducted of your site/premises?

YES	NO
-----	----

10c) Would your organisation be willing to have its water consumption assessed/monitored as part of a water audit?

YES	NO
-----	----

Comments:

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10d) If you answered "YES" in the previous question, would your organisation allow the information, gathered during the water audit, to be published?

YES	NO
-----	----

10e) In your opinion, how would a water audit benefit your organisation?

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10f) If it is clear from the results of a water audit that there is a potential for water demand management<sup>2</sup> and/or savings within your organisation, what would encourage your organisation to implement the necessary changes?

Comments:

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11a) Does your organisation re-use any of its own water? (i.e. re-use of any water excluding sewage by recycling and/or treating water which has already been utilised on your organisation's premises)

YES	NO	UNSURE
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11b) If **yes**, what quantity of this water does your organisation re-use?

kl /month
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11c) If your organisation does re-use water, what percentage of your total water use does this re-use constitute? (**Mark with a X on the most likely %**)



Unsure
--------

<sup>2</sup> **Water Demand Management:** The adaptation and implementation of a strategy by a water institution to influence the water demand and usage of water. Strategies can include leak detection/repair programmes, promotion of water efficient fittings, promotion of private boreholes, water audits and price elasticity of water.

11d) If your organisation does **not** presently re-use water (excluding sewage by recycling), do you think that there is a possibility that your organisation may be able to re-use part of this source in the future?

YES	NO	UNSURE
-----	----	--------

11e) What percentage of your total water use could **potentially** be re-used by your organisation? (assuming latest technology and investment in infrastructure)



	Unsure
--	--------

12a) Does your organisation use any of the following in its operations?

	Treated municipal wastewater effluent
	Sea-water
	None of above

If **yes**, for what purpose?

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12b) If your organisation does not utilise any of the types/sources listed in question 12a, is there a possibility that you may be able to use these types/sources in the future?

YES	NO	UNSURE	Treated municipal wastewater effluent <sup>†</sup>
YES	NO	UNSURE	Sea-water

13) Has your organisation considered any of the following as potential water conservation measures? (*Please ✓ suitable choice*).

- Education
- Retrofitting
- New technological advances
- Leak detection
- Improved water metering
- Advances that save water and encourage water recycling

Comments:

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14a) Proponents of water conservation consider the price of water to be insignificant and hence one of the factors encouraging inefficient use. If the water price was to increase, would your organisation's attitude towards water use and conservation change in any way?

YES	NO
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Comments:

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14) If **yes**, by what quantity might your organisation's water use change?

kl /month
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Unsure
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Comments:

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15) What do you see as effective ways of changing your organisation's water consumption?

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16) Please indicate any further comments below:

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***Thank you for your participation***

## APPENDIX B-2

### Presentation & discussion of some relevant questionnaire responses as reported in the UCT – CMA Water Study (2000).

The aim of this section is to provide a general analysis and discussion of the results from the 46 returned questionnaires. Each question appears in blue text as it does in the questionnaire. The question is followed by a graphical representation of the responses and a brief discussion. Not all the questions are represented graphically as for some it was deemed unsuitable.

The largest concentration of water users were found in the City of Cape Town, followed by City of Tygerberg, Blaauwberg Municipality, South Peninsula, Helderberg Municipality and Oostenberg Municipality. In total 46 questionnaires were returned to the UCT Study Group by the cut-off date of 24<sup>th</sup> July 2000. Due to various time-related constraints, the UCT Masters Group received a 23% response rate to the questionnaire, which can be considered reasonably successful.

Table 3.2: Summary of sent and received questionnaires

Municipality	Questionnaires Sent	Questionnaires Received Back	% Success
Blaauwberg Municipality	28	5	18
City of Cape Town	68	12	18
City of Tygerberg	46	18	39
Helderberg Municipality	14	2	14
Oostenberg Municipality	15	2	13
South Peninsula	28	7	25
<b>Total</b>	<b>199</b>	<b>46</b>	<b>23</b>

Question 1a) In your view, natural fresh water resources (rivers, dams, rainfall and groundwater) in South Africa are... (Please ✓ choice)

Extremely plentiful	Plentiful	Adequate	Scarce	Extremely scarce	Uncertain
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Respondents: 46

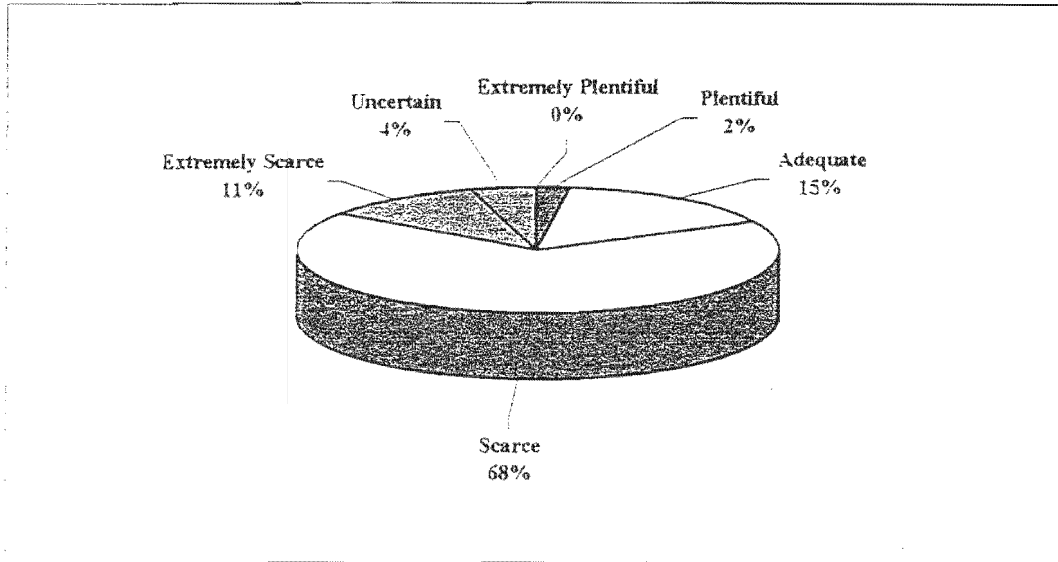


Figure 3.2 Respondents' perception of freshwater resources in South Africa

Question 1b) In your view, natural fresh water resources in the Western Cape Province are...  
 (Please ✓ choice)

Extremely plentiful	Plentiful	Adequate	Scarcely	Extremely scarce	Uncertain
---------------------	-----------	----------	----------	------------------	-----------

Respondents: 46

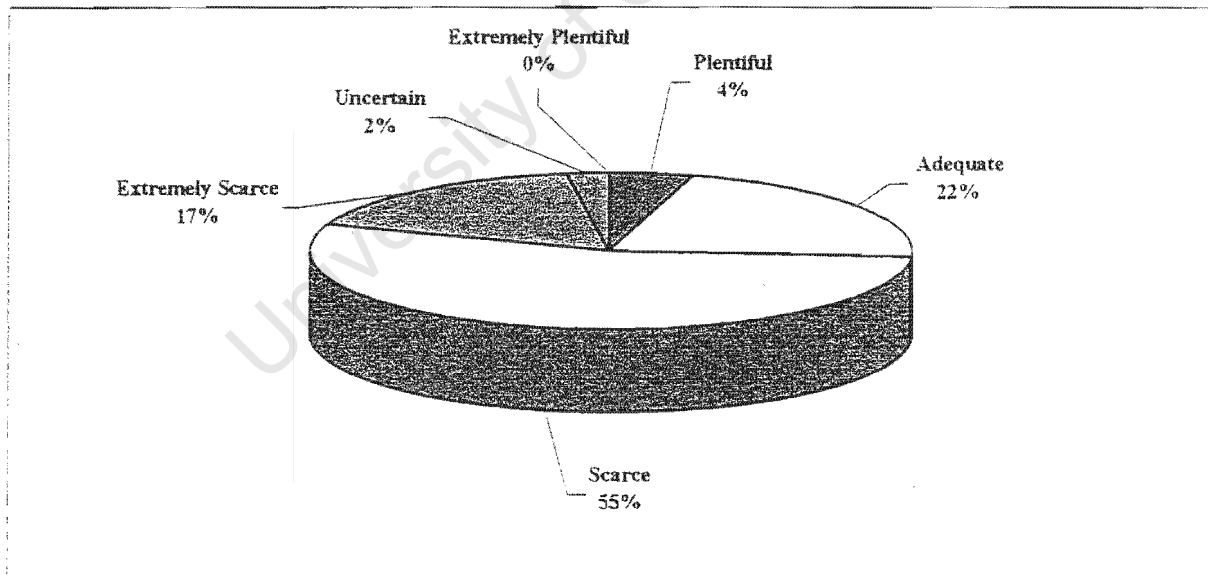


Figure 3.3: Respondents' perception of freshwater resources in the Western Cape Province

Question 1c) In your view, natural fresh water resources in the Cape Metropolitan Area (CMA) are... (Please ✓ choice)

Extremely plentiful	Plentiful	Adequate	Scarcely	Extremely scarce	Uncertain
---------------------	-----------	----------	----------	------------------	-----------

Respondents: 45

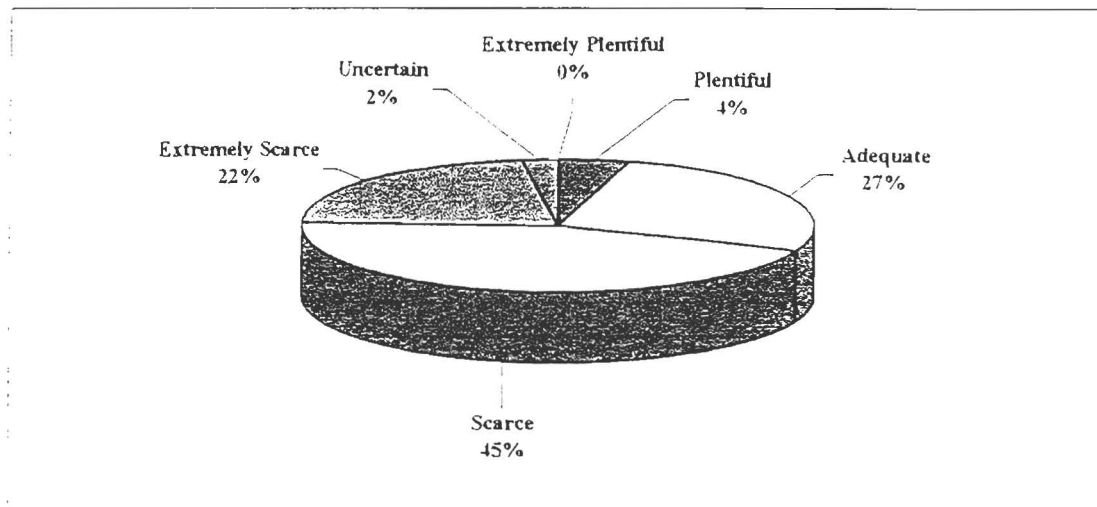


Figure 3.4: Respondents' perception of freshwater resources in the Cape Metropolitan Area

#### Discussion:

The aim of this question was to establish the perception of respondents towards fresh water resources in the CMA. The most noticeable result was that the largest proportion of the respondents perceives natural freshwater resources to be scarce at a national, provincial and at local level. However, it is interesting to note that 33% of respondents perceive freshwater resources in the CMA to be adequate, plentiful or uncertain as to the status of water resources. This perception is unlikely to contribute towards water savings amongst large water users.

Question 2) If you were challenged with solving a water shortage problem in the CMA, what do you think would be the most suitable alternative to solve the problem? Suitability should cover feasibility, effectiveness and environmental sensitivity. Of the options provided below, please rank your best alternative 1, your second best alternative 2 and your third best alternative 3, etc.

- Construct more dams in the catchment areas
- Pump water from other areas
- Desalinate sea-water
- Water loss management and control (leakage detection and repair programme)
- Implement escalating block-rate tariff (the greater the amount of water used, the greater the charge for each additional unit.)
- Recycle more water
- Implement water restrictions
- Promotion of the use of water saving fixtures and fittings (retrofitting).
- Use groundwater resources (e.g. aquifers)
- Tow icebergs from the Antarctic
- Clear more invasive trees from the catchment areas
- Other

If other, please elaborate further:

Respondents: 46 (First Choice), 44 (Second Choice) and 45 (Third Choice)

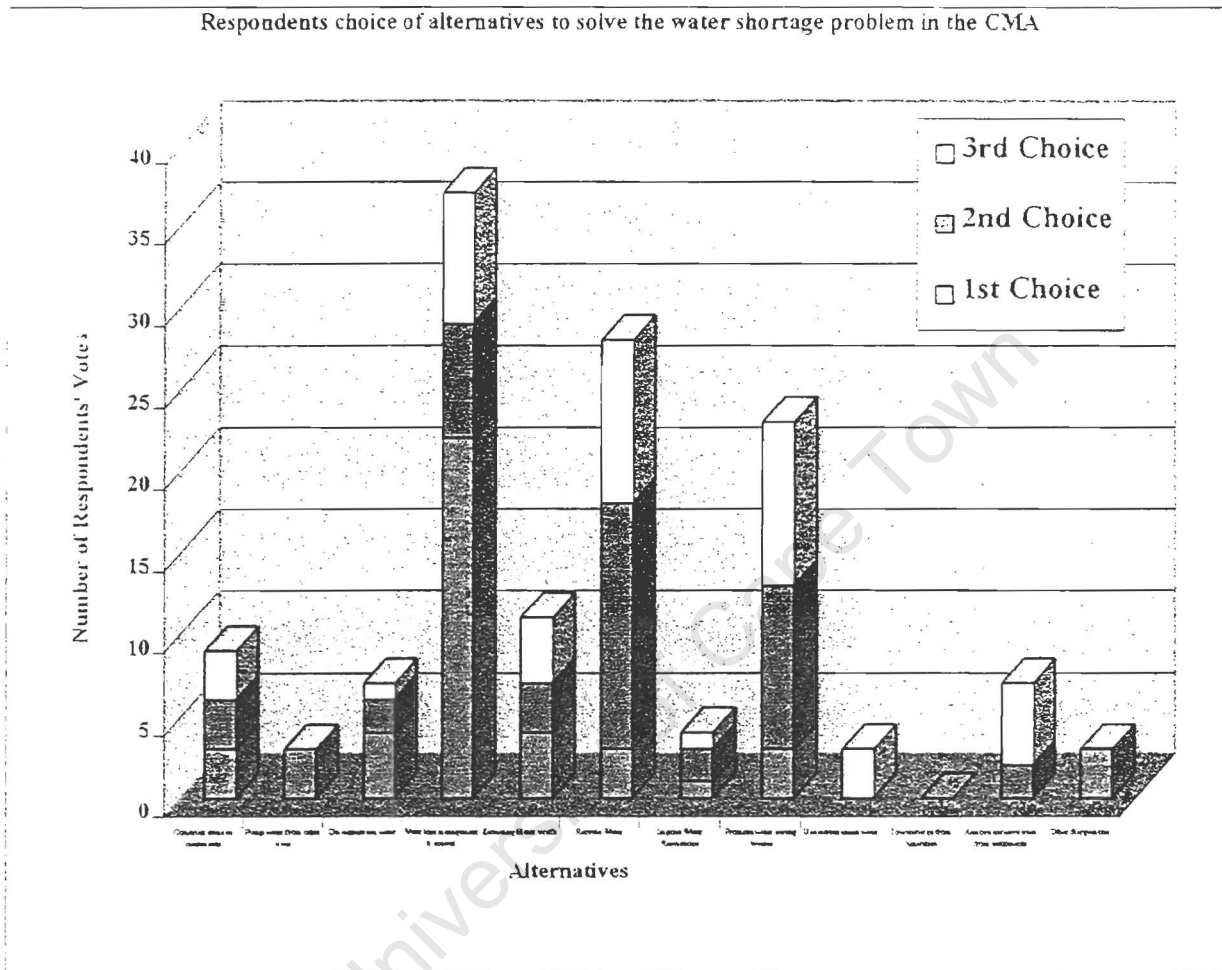


Figure 3.5: Respondents' choice of alternatives to solve the water shortage problem in the CMA

#### Discussion:

The aim of this question is to investigate where respondents perceive water is being used and where they believe opportunities exist for water savings. Criteria used in deciding the best alternative could include cost of augmentation, environmental damage or volume of water. If challenged with a pending water crisis, the majority of representatives of the large potable water consumers in the CMA believe it is best solved by implementing a water loss management and control system. A water loss management control system would be the responsibility of the water supply authority, and not the users. This option illustrates that most users perceive the

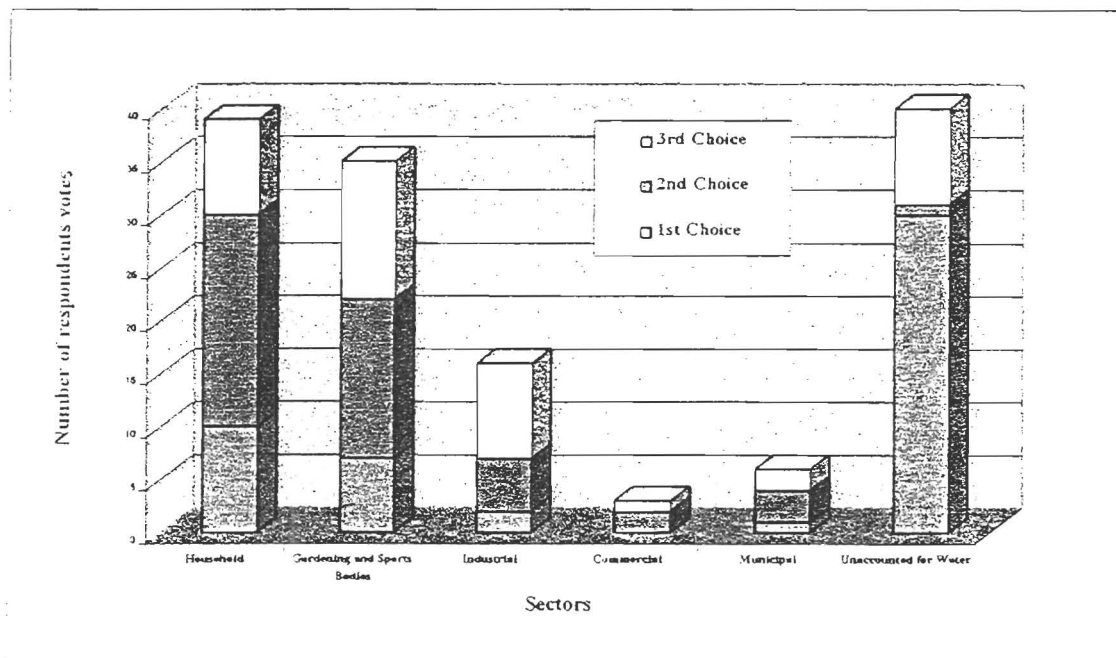


Figure 3.6: Respondents' perceptions as to which sector has the greatest ability to save water

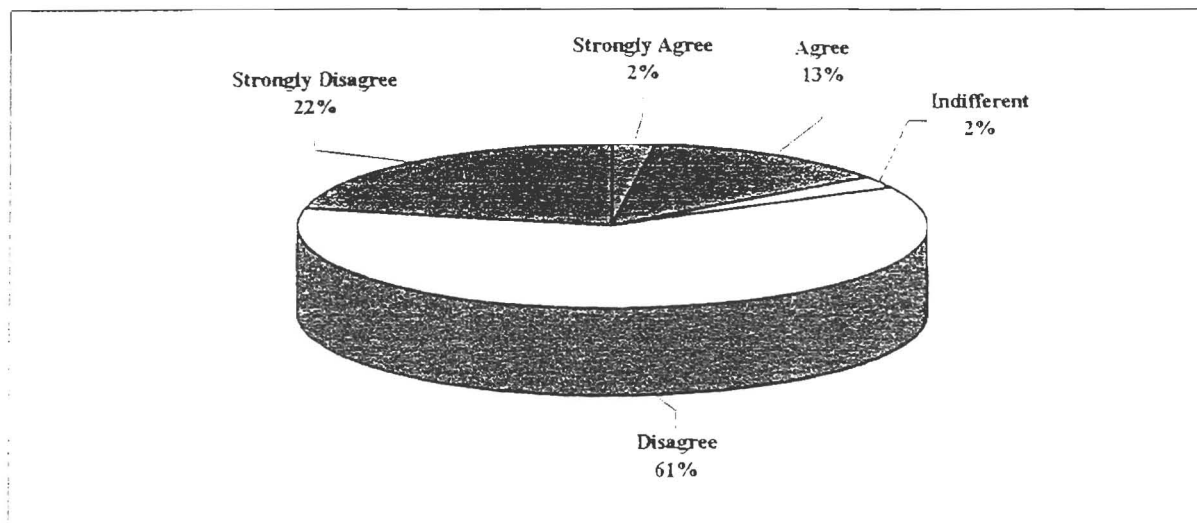
#### Discussion:

The aim of this question was to determine which sectors the respondents considered held the greatest scope for water savings. Large water savings indicates inefficient usage of water and hence wastage. The perception exists that the greatest potential for water savings is within the realm of UAW. As in question 2, users perceive the greatest wastage and potential for water savings is in the hands of the water supply authorities and not the private user. This reaffirms the idea that the water authority is seen to waste water, there is little motivation or incentive for users to act conservatively, and this will thwart any attempts by the authorities to encourage water savings amongst users.

There is also an opinion that significant water savings can be achieved by focussing on water consumption in the domestic and gardening/sports body sectors. Municipal, commercial and industrial users are considered to offer the smallest scope for water savings, however the large potable users are predominantly amongst these three groups.

Question 4) Below is a map of the CMA, showing the six Metropolitan Local Councils (MLC) boundaries. In your opinion, where is most of your organisation's water sourced from? (*Please ✓ one choice*)

	Within your organisation's municipal boundary
	From a number of municipal areas, but within the CMA
	From outside the CMA
	Uncertain



**Figure 3.8:** Respondents' perception of the statement that "Water use and water resource development in the CMA has little effect on the environment"

#### Discussion:

The aim of this question was to assess if large water users had made a connection between increased water use and the environmental effects on catchment areas, or if water extraction was seen as having little or no effect on the environment. A significant percentage of the respondents disagree or strongly disagree with the statement referred to in Question 6. These sentiments show an understanding and recognition that the extraction of water from natural areas in and around the CMA is having a detrimental effect on the environment. This attitude should contribute to a more conservation orientated water consumer, but whether this recognition and attitude has any effect on water consumption is unknown. 15% of the respondents either agreed to this statement or were indifferent. This small sector is however significant and could contribute to water wastage. This problem could be solved with better education. Comments received include:

#### Environmental:

- *If we run out of water, this will in turn affect the environment;*
- *Over-use/abuse of water resources definitely affects the environment and its ecology;*
- *Bad planning, could destroy wildlife due to a change in the environment;*
- *It is obvious that taking water from the environment will have an effect on it;*
- *Dams have an impact on the environment;*
- *Water is critical to every facet of our lives. The excessive consumption of this resource will impact natural vegetation and rivers;*

Source: Copied from the Baseline Report, 2000 pp. 84-89, 92.

# APPENDIX C

## Table C-1 : Future water supply options in the CMA

SURFACE WATER SUPPLY SCHEMES		
Scheme	Proposal	Yield per annum excluding the cost of treatment (R.0.18 per m <sup>3</sup> )
Eikenhof Dam Raising – Upper reaches of the Palmiet River	Raise Eikenhof Dam Wall to provide more water to farmers in the Palmiet Basin	Increase from 26 x 10 <sup>6</sup> m <sup>3</sup> to 42 x 10 <sup>6</sup> m <sup>3</sup>
Palmiet Phase 1 -	Water pumped from Kogelberg Dam on the Palmiet River to Rockview Dam then to Upper Steenbras Dam through the Steenbras Pumped Storage Scheme to the Faure Treatment Works	Between 31 x 10 <sup>6</sup> m <sup>3</sup> and 35 x 10 <sup>6</sup> m <sup>3</sup> . Unit reference value is R0.15 per m <sup>3</sup>
Palmiet Phase 2	Water from Palmiet River to Kogelberg Dam to Steenbras Dam and then on to Faure Treatment Works. Scheme divided into two groupings. <b>Lower Hangklip Scheme</b> Placing a large Dam on the Palmiet River, upstream of the estuary, severe environmental impacts. <b>Upper Campala Scheme</b> Moderate sized dam north of the Kogelberg State Forest boundary on the Palmiet River. Small weir downstream of the Kogelberg State Forest	93 x 10 <sup>6</sup> m <sup>3</sup> . Unit reference of R0.39 per m <sup>3</sup>  93 x 10 <sup>6</sup> m <sup>3</sup> . Unit reference value of R0.51 per m <sup>3</sup>
Skuifraam Dam	Dam site in a valley upstream of the Berg and Franschoek Rivers. Water would not have to be released from Theewaterskloof. Environmental Impacts fairly large	72 x 10 <sup>6</sup> m <sup>3</sup> . Unit reference value R0.36 per m <sup>3</sup> .
Skuifraam Supplement Scheme	Will exploit high rainfall catchment immediately downstream of Skuifraam. Will be affected by Molenars scheme.	29 x 10 <sup>6</sup> m <sup>3</sup> . Unit reference value R0.39 per m <sup>3</sup>
Voelvllei Scheme	Pumping additional water from the Berg River to Voelvllei. Raising Voelvllei Dam and constructing a second abstraction, treatment and delivery system. Skuifraam would decrease yield somewhat.	120 x 10 <sup>6</sup> m <sup>3</sup> . Unit reference R 0.69 per m <sup>3</sup>
Misverstand Scheme	Construction of a dam at Misverstand on the Berg River. This water will be pumped into the canal from Twenty Four Rivers supplying Voelvllei. Voelvllei enlarged with pipeline.	70 x 10 <sup>6</sup> m <sup>3</sup> assuming Voelvllei and Skuifraam have been built. Unit reference value of R0.78 per m <sup>3</sup> .

<b>Olifants River</b>	Developing a dam on the Doorn River for Clanwilliam irrigation needs, and then using Clanwilliam Dam for CMA.	90 x 10 <sup>6</sup> m <sup>3</sup> . Unit reference value of R1.03 per m <sup>3</sup> .
<b>Molenaars Scheme</b>	Construction of a low weir downstream of the confluence of the Elandspad and Molenaars Rivers. Then pump water through the Huguenot Tunnel Portal and then to Skuifraam.	37 x 10 <sup>6</sup> m <sup>3</sup> . Unit reference value of R0.26 per m <sup>3</sup>
<b>Brandvlei-Theewaterskloof Scheme</b>	Water transferred from Breede River via Greater Brandvlei Dam to Theewaterskloof Dam where it will be conveyed through the Riviersonderend/Berg River tunnel system.	100 x 10 <sup>6</sup> m <sup>3</sup> . Unit reference of R 0.47 per m <sup>3</sup> .
<b>Michell's Pass – Voelvlei Scheme</b>	Transfer from the Breede River to the Klein Berg River and via a canal to Voelvlei.	15 x 10 <sup>6</sup> m <sup>3</sup> . Unit reference of R 0.19 per m <sup>3</sup> .
<b>Eerste River</b>	A low weir has been proposed near the Faure treatment works on the Eerste River	19 x 10 <sup>6</sup> m <sup>3</sup> . Unit reference of R0.21 per m <sup>3</sup> .
<b>Lourens River Scheme</b>	Increasing the efficiency of a diversion of the Lourens River by means of a weir. Water will be injected into the Steenbras- Faure Pipeline	13 x 10 <sup>6</sup> m <sup>3</sup> . Unit reference value of R0.27 per m <sup>3</sup> .
<b>Diep River</b>	Construction of a dam at Platberg near Vissershoeck. Desalination necessary. Environmental considerations of Rietvlei nature Reserve.	12 x 10 <sup>6</sup> m <sup>3</sup> . Unit reference value of R1.34 per m <sup>3</sup> .

#### GROUNDWATER SUPPLY OPTIONS

<b>Scheme</b>	<b>Proposal</b>	<b>Reference Value</b>
<b>Cape Flats Aquifer</b>	A number of Boreholes used for abstraction and then delivered to a treatment works. Various options include pumping water to Faure treatment works for CMA use, or local use for irrigation purposes or finally, using the aquifer at a high rate intermittently.	Storage is 128 x 10 <sup>6</sup> m <sup>3</sup> per annum, and recharge of 18 x 10 <sup>6</sup> m <sup>3</sup> per annum R 0.33 per m <sup>3</sup>
<b>Newlands Aquifer</b>	System of boreholes in the Newlands Area	10 x 10 <sup>6</sup> m <sup>3</sup>
<b>Lower Berg Aquifer</b>	Saline Water would require blending. Proposal is for water to be delivered from Lower berg aquifers to the Glen Garry in the CMA	78 x 10 <sup>6</sup> m <sup>3</sup> per annum. Unit reference value of R0.60 per m <sup>3</sup>

#### RE-USE OF SEWAGE WATER

Four large treatment works are present along the False bay coastline, including the Cape Flats Works, The Zandvliet Works, the Mitchells Plain Works and the Macassar Works. Almost all of this sewage is of a domestic nature, with minimal industrial chemicals.

<b>Irrigation</b>	<b>Yield and Reference</b>
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Only large scale use of effluent dependent on the crop and treatment after harvesting. 20 x 10 <sup>6</sup> m <sup>3</sup> has been allocated from Riviersonderend-Berg river catchment to Stellenbosch and Helderberg	For an annual yield of 20 x 10 <sup>6</sup> m <sup>3</sup> , unit reference is R 0.87 per m <sup>3</sup>
<b>Fresh water supplement</b>	<b>Yield and Reference</b>
This is only possible if blending ratio does not exceed 1:4. This may be possible in conjunction with Faure Water treatment Works.	For an annual yield of 36.5 x 10 <sup>6</sup> m <sup>3</sup> , unit reference is R1.51 per m <sup>3</sup> (Includes treatment cost)
<b>DESALINATION OF SEA WATER</b>	
<b>General</b>	<b>Yield and Reference</b>
Possibly unlimited supply for the CMA. Koeberg is the most favourable site due to warmer water, no additional intake facilities and close to electrical reticulation network	For an annual yield of 100 x 10 <sup>6</sup> m <sup>3</sup> , unit reference is R3.20 per m <sup>3</sup> , which includes treatment.
<b>MAINTENANCE OF CATCHMENT AREAS</b>	
<p>Spread of Exotic invasive vegetation is a threat to the regions water resources and leads to reduction in streamflow. Two scenarios have been created.</p> <p><b>Scenario A:</b> Future mature dense infestation assumed to be 28% of catchment resulting in 23.7 x 10<sup>6</sup> m<sup>3</sup> streamflow reduction per annum. Clearing and maintenance of the affected areas could yield 18 x 10<sup>6</sup>m<sup>3</sup> at a unit reference value of R 0.27 per m<sup>3</sup>.</p> <p><b>Scenario B:</b> Future mature dense infestation assumed to be 62% of catchment resulting in 63.9 x 10<sup>6</sup> m<sup>3</sup> streamflow reduction per annum. Clearing and maintenance of the affected areas could yield 46 x 10<sup>6</sup> m<sup>3</sup> with a unit reference value of R0.17 per m<sup>3</sup>.</p>	
<b>UNCONVENTIONAL SOURCES OF WATER</b>	
<b>Importation by tanker</b>	<b>Yield and unit cost</b>
Water could be loaded from the mouths of rivers, using Supertankers as fresh water floats on sea water.	Supertankers capable of carrying 280 000 m <sup>3</sup> from the Zaire River, would result in a unit cost of R 7.00 per m <sup>3</sup> . Additional costs could also be for offloading and payment to countries, with total costs not exceeding R 8.00 per m <sup>3</sup>
<b>Rainwater Tanks</b>	<b>Yield and Unit cost</b>
With a storage of about 2 m <sup>3</sup> , a household could obtain about 20 m <sup>3</sup> per annum for toilet flushing and miscellaneous use. The storage tanks, pump and elevated tank would cost about R1250.	Reference value would be over R 3.00 per m <sup>3</sup>
<b>Towing Icebergs</b>	
Capturing and towing Icebergs to a place where they could be converted to a supply of fresh water. Various logistical implications exist and it is not a feasible option.	

Source: DWAF,1 994; Baseline Study, 20000.

# APPENDIX D

## Methodology & procedure for conducting a comprehensive water-use auditing as presented in the Baseline Report (2000).

The existing literature does not present a clear-cut methodology on how to carry end-user audits. However, it is possible to identify 3 stages for carrying a complex water use audit:

- Preparations to do an audit,
- Implementing the Audit Analysis, and
- Evaluation of the audit results/data.

### Preparations to do a Water-use Audit

#### A. Setting a Goal

This step includes articulating the purpose and the target of the audit initiative.

Goals for reducing water consumption can be set only if the quantity of previous of water consumption and wastage is known. Data/ information on previous audits or surveys can be used if present, otherwise, it is necessary to perform a preliminary review of consumption and to estimate the potential savings.

In the case of CMA, consumers targeted for water audits were selected to represent categories from industrial codes as used by CTC. The major categories are the following:

- Factories and industries
- Local Authorities Buildings
- Hotels
- Private office Buildings
- Shopping malls
- Schools
- General

#### B. Requesting Support and Getting Commitment

A full commitment and full endorsement of senior management of organisations, or heads of households is absolutely necessary before any water audit could be conducted. There is a need to “sell” the idea by explaining the savings and financial implications of the whole exercise from top to down.

This could be achieved by following a set of steps:

- **Clear Communication.** A letter requesting support is a necessity. In this letter one should communicate an understanding of the water issue, e.g. water balance, potential quantity of water savings and financial savings, future water demand and financial implications therein.  
Express your enthusiasm for pursuing the opportunity.
- Explain how your auditing initiative fits into corporate priorities as regards to environmental compliance, conservation efforts, and other efficiency programs, such as energy saving.
- Demonstrate the cost-benefit of water efficiency. Financial Considerations are very important to organisations, more to business organisations and households, than public organisations. Present a preliminary estimate of realistic savings, and show how this is could affect the bottom line.

#### C. Assembling a Water Auditing Team

Assemble a team of specialists on various aspects of water conservation, and qualitative and quantitative aspects of water management.

An industrial water audit, for example should include members from plant management, shift supervisors, boiler plant supervisors, maintenance personnel, support areas such as laundries, grounds keepers, cafeterias, and accounting staff.

This team should be lead by an expert on water efficiency evaluation, and technical aspects of water meters, and retrofitting devices.

## **BASIC PROCEDURE FOR IMPLEMENTING WATER-USE AUDITS**

### **A. Defining the Water System**

Specific steps that may be used to define the system at a given facility include:

- A visual inspection of the facility in order to get a general picture,
- An inspection of plumbing drawings and transferral of key information to the base maps, and
- An extensive site investigation to verify information.

In some instances, such as where there is a decrease in the presence of water flow, it may be necessary to identify detailed design components in the reticulation system such as:

- Pipe sizes,
- Valves,
- Joints and splits,
- Elbow turns, and
- Any other component beyond standard plumbing.

The purpose of these steps is to define the system in terms of:

- Where water goes once it passes through the main meter and enters the premise/building/house,
- How much gets consumed, and
- By what devices or processes it is consumed.

### **B. *A priori* actions**

Collect written bill information, locate building drawings, and circulate survey sheets/questionnaire/ to the interviewees so that the water usage information will be ready during the actual audit.

### **C. Prepare a site plan and a system schematic**

An area/premise site plan should be prepared in order to show the facilities' water meters, along with a schematic representation of the meters in use in that premise. The plans of each section of the facility are supposed to show the water distribution system elements (AWWA Manual M 36,1990;Environmental Canada,1996;Makar et al,1999).

The purpose of the schematic system as shown in Figure...is to depict the place of entrance of water, the position of the meters, how it is used, and where the water goes.

The level of details included in the system schematic depends on the purpose of the water audit, and the nature of the facility – a complex industrial building, or a simple office building will have complex and simple schematic respectively.

The information included in the system schematic is collected from site inspection, plant drawings, previous audits, and staff interviews.

A system schematic shows:

- Distribution of water (usage) within the facility,
- Location of meters, sub-meters and potential areas for sub metering, and
- Opportunities for water re-use or recycling within the facility.

### **D. *In situ* Specific Steps in a Water-use Audit**

The actual water-use audit protocol can be summarised into 5 key steps:

#### **Step 1: Facility Inventory**

Observe and note don processes, take flow or volume measurements, inventory of equipment and fixtures (note their type, make, capacity, pressure or absence of water saving devices), identify leaks or any other water losses.

#### **Step 2: Compare drawings to actual plant layouts**

Identify discrepancies, check and note changes or improvements.

**Step 3: Document operation procedures and verify operating schedule**

Determine how often or for what period equipment is being used, establish how long building areas are occupied.

**Step 4: Calculate water consumption**

Calculate volume of water used by each fixture or equipment.

**Step 5: Analyse data**

Correlate water consumption with operational parameters such as output or plant production, or in the case of buildings, occupancy rate.

**Step 5: Prepare & present an Audit Report**

**Conclusion**

The primary objective of WDM as explained in the previous section is to reduce the amount of water wastage by the end-users.

This could be achieved by using administrative and behavioural strategies. These are those strategies that aim at restricting demand through reticulation of use and/ or water-use fixtures, reduce demand by the use of retrofit of fixtures and water- conserving devices, or encourage water conservation behaviour by users. A Water-use Audit is therefore the first step towards achieving WDM goals. Water-use Audit surveys the consumers' premises, plumbing/reticulation system and water devices and uses in order to determine whether water has been used diligently or not; to explore the possibilities of arresting the situation. The final output of a water audit is to establish the amount of water that could be saved and at what price in a given place in a specific period of time.

In organisations, water audits can be determined if and where excess water is being used and recommend ways in which its use can be reduced.

It involves the definition of the water distribution system infrastructure, development of an inventory of water use operations at the facility, and preparations of a water balance for the facility.

The results of a water-use audit will give an account of water volumes used by and discharged from, and flow variations for each operation summed up for the whole facility.

Consequently, a facility-wide water efficiency program can be designed to optimise the water usage and water savings by identifying potential water reduction alternatives, and their potential socio-economic, technical, environmental and financial implications.

Ultimately, a water efficient program is recommended and later implemented, its progress monitored and follow-up activities (such as user education) are devised to ensure its success.

**Source:** Baseline Report, 2000.

# APPENDIX E

## Methodology for conducting a Leak Detection Survey

Leak detection is a process of elimination and discovery. The goal is to eliminate the contact points where leak sounds are not heard. A contact point is any suitable connection to the water main that will transmit sound vibrations. This can be a fire hydrant, service stop, valve, or probing rod. Methodology for conducting leak detection can be divided into 2 stages, namely, the preparatory stage and the actual procedure for carrying out the audit as summarised below.

### STAGE 1: Initial Preparations

#### A. Inventory of distribution system

Before conducting a leak detection survey, review the specifics of your distribution system, including the following:

- Results of the water audit: How much water is lost from the system?
- Mains and services: types, ages, diameters, joints, installation methods, inspections, leak histories, and operating pressures.
- Meters and meter-box assemblies: types, brands, and sizes of meters; ages; types of installations; meter shutoffs; couplings; and meter reading frequency.
- Valves: locations, types, left or right-handed, number of turns to exercise, and how often exercised.
- Blow-off and air-release valves: locations and how often they are exercised.
- Distribution-system maps: What is shown on maps, how current is the information, and how often is the information updated?

#### B. Obtaining Leak detection Equipment

Provide leak detection equipment for survey team members, including sonic listening probe and a low-frequency ground microphone for pinpointing leaks. When using the ground microphone on turf areas, a "thumb tack" will help to provide better quality sounds. There are many simple devices to measure flow rates, including varieties of stopwatches, buckets, measuring cups, pressure gauges, and measuring tapes. Working tools include meter-box lid lifters, valve-cover keys, curb-stop keys, bailing cans or small manual pumps, or spray paint, pipe locators, and wrenches for tightening meter-spud (AWWA, 1990).

#### C. Selecting Team Members

When selecting team members, consider whether each person has a keen sense of hearing, ability to discern different sounds, familiarity with water matters and the distribution system, a sense of responsibility, ability to estimate leak flows, ability to complete leak forms, and ability to work independently.

One person can usually conduct the initial listening survey, unless more than one person is needed for safety.

#### D. Planning the Survey

When planning how the leak survey will be conducted, consider the following:

- What type of noise problems exists within the system?
- What effect will traffic have on the survey?
- What type of protection is required for the leak crew?
- What time of day or night will be most effective to conduct listening survey?
- What time will be most effective to pinpoint suspected leak?
- Is the crew a compatible group that will work together?
- How will the crew's tasks be divided?

- What is the most effective route to follow in the initial listening survey?
- Which are the most effective leak survey and pinpointing forms, and how are these records to be completed?
- How will leak detection team communicate and work with repair crews to ensure effectiveness and resolve dry holes?

### **E. Prepare a Leak Detection and Repair Plan**

A leak detection and repair plan can be prepared by using forms such as the ones attached as sample in Appendix E. The plan must include the following elements: training and equipment tune up in order to familiarise with the functions of the leak-detection equipment.

#### Team Training

Training team members before conducting a leak detection survey. This will build team members' confidence and help to ensure that the survey is accurate. Training may also be available from consultants.

#### Equipment Tune-up

Prior to conducting the survey, leak detection team members should familiarise themselves with the equipment to be used. Consult instruction manuals, exchange ideas and review instructions. Check the equipment to be sure that they are working.

### **STAGE2: Procedure for conducting a Leak Detection Survey**

This sub-section briefly describes in general terms, how to conduct a leak detection survey. The leak detection daily log (see Appendix...) can be used to record the results of the survey.

#### Initial Listening Survey

The objective of the initial listening survey is to listen for leak sounds on all contact points in the distribution system. Use the high-frequency contact microphone to listen for leak sounds on all meters, valves, hydrants, blow-off, air-release valves, and other contact points. Note the address of all locations where water use, meter sounds, or possible leak sounds exist. This initial search through each area of the system can be conducted quickly.

To determine whether we need to listen directly over mains in addition to contact points, the following test can be performed:

1. Listening over the main with a ground microphone.
2. Turning on a hose bib at customer's service.
3. Determining how far away along the main we can hear the sound of water escaping from the hose bib.

If the distance between contact points is greater than the distance that the sound travels along the main, then we can use the ground microphone to listen over the main at intervals between about 4 and 20 meters.

#### **Interference**

There can be a number of sound interference with leak detection equipment therefore there is a need for re-listening to suspect sounds. The correct thing to do is to return to each location noted in the initial listening survey; and listen again for the sounds heard early by using a high-frequency contact microphone. If the location is quiet, there is no leak. If there is any sound, check to see if the meter is running; a running meter indicates water use. If there is sound and there is no water use, a leak probably exists. The leak must be pinpointed.

## **Pinpointing Leaks**

There are two objectives of pinpointing a leak:

- to determine whether the leak sound is leakage, water use, or some other noise; and
- to determine the leak's exact location.

The procedure is as follows:

- Return to the suspected location and again listen for the leak sound. Inspect the area, paying attention to both sight and sound. Use a sonic amplifier, if possible. Note that what may be believed to be a leak sound may actually be caused by a pressure-reducing valve, or sound from other sources, such as an electrical transformer, or come from other sources.
- Review detailed distribution system maps and locate pressure reducers, forgotten valves, or other system apparatus that might make the suspect sound. If when inspecting the area, we found another possible cause of the sound, we can then try to isolate and identify the sound, or quiet it temporarily.

If the leak noise is heard on a water meter we should listen carefully for leak sounds on both sides of the meter in order to determine if the sound is louder on the customer side or the utility side of the meter. We can as well search/look for obvious signs of customer's use, such as sprinklers operating. In this case, the meter we can hear the meter turning even if the meter hand is not moving. Then, check the meter indicator for movement; the leak may be in the area of the meter box.

### **Methods of pinpointing leaks**

If a leak is on the main or the service line, the leak sound may be detectable on adjacent service meters, valves, or hydrants. We can listen for sounds of leakage on services adjacent to the suspected meter and determine where the sound is the loudest. Then we can pinpoint the exact location by using either the correlator, ground microphone or probe methods discussed below.

#### ***Correlator method.***

A correlator is a package of electronic equipment used to pinpoint leaks. It usually includes the following items:

- Transducers (two or more) to pick up the noise from the pipe and convert it into an electronic signal;
- Two sets of cables or radio transmitters/receivers to carry the electronic signal from the transducers to the correlator;
- Amplifiers and a correlator that compare the signals received from two or more signal sources;
- A microcomputer;
- A speaker (and headphones) to recreate the leak sound for the operator;
- A video display;
- A paper-tape printer to provide a permanent written display of the leak wave form and the distance of the leak from the contact points; and
- A power supply (often a 12 – V automobile battery is sufficient).

#### ***Ground-microphone method.***

The objective of this method is to find the location of the loudest leak sound over the main or service line.

The first step is to determine the exact location of the main or service. An electronic pipe locator can be used to locate the buried main or service line. Precisely mark the location of the main or service line on the pavement. Locate other nearby pipes from which the sound might be coming.

Ground microphones are either monophonic or stereophonic, depending on the manufacturer. The stereo models can discern differences in intensity between two microphones. However, most models have only one microphone.

The ground microphone can be used to listen for leak sounds 2 – 4 metres away. Jot down some notes on the exact sound intensities and the meter readings if the equipment has a meter. After pinpointing the leak, its location can be verified with a second listening using the ground microphone.

# APPENDIX F

## Leak Detection and Repair Forms

### LEAK DETECTION AND REPAIR PLAN

Name of Agency: ----- Date: -----

#### A. Area to be Surveyed

A-1. Using the results of the water audit, show on a map which areas in the distribution system will be surveyed. Indicate which areas have the higher potential for recoverable leakage. Consider records of previous leaks, type of pipe, age of pipe, soil conditions, high pressures, ground settlement, and improper installation procedures.

Describe each area to be surveyed under item B-2 of this plan.

A-2. Total miles of main to be surveyed: -----

When calculating the miles of main, include the total length of pipe and exclude service lines.

If only a portion of the system is being surveyed, calculate the benefit-to-cost ratio to reflect only the portion included in the survey.

A-3. Average number of main surveyed per day: -----

The average survey crew can survey about two miles of main per day. Items to consider include

Distances between services, traffic and safety conditions, and number of listening contact points.

Explain if more than three miles per day are surveyed. -----

A-4. Number of working days needed to complete survey ( divide line 2 by line 3): -----

#### B. Procedures and Equipment

B-1. Describe the procedures and equipment you will use to detect leaks. Experience shows that the best results obtained by listening for leaks at all system contact points (such as water meters, valves, hydrants, and blowoffs). -----

B-2. Describe why the areas noted on the map in step A-1 have the greatest potential for recovering leakage. -----

B-3. If you will not be listening for leaks at all system contact points, describe your plan for effectively detecting leaks. -----

B-4. Describe the procedures and equipment you will use to pinpoint the exact location of the detected leaks. -----

B-5. Describe how leak detection team and the repair crew will work together. How will they resolve the problem of dry holes?-----

B-6. Describe the methods you will use to determine the flow rates for excavated leaks of various sizes.

-----  
-----  
-----

**C. Staffing**

C-1. How many agency staff will be used? -----

Staff costs including wages and benefits:

Person 1 R/hour ----- R/day -----

Person 2 R/hour ----- R/day -----

TOTAL R/hour ----- R/day -----

**D. Leak Detection Survey Costs**

Leak detection surveys:	R/day	#days	Cost
D-1. Agency-crew costs	-----	-----	-----
D-2. Consultant-crew cost	-----	-----	-----
D-3. Vehicle costs	-----	-----	-----
D-4. Other cost	-----	-----	-----
D-5. Total survey costs	-----	-----	-----

**E. Leak Detection Budget**

E-1. Cost of leak detection equipment	-----
E-2. Leak detection team training	-----
E-3. Leak detection survey costs	-----
E-4. Total leak detection costs	-----

**F. Leak Survey and Repair Schedule**

Indicate realistic, practical dates.

F-1. When will the leak survey begin?-----

F-2. When will the leak survey be completed? -----

F-3. When will leak repairs begin? -----

F-4. When will leak repairs be completed? -----

Prepared by:

Name ----- Date -----

Title -----

**LEAK DETECTION SURVEY DAILY LOG**

Agency: ----- Date -----

Leak Detection Team Members: -----

Manufacture and Models of Equipment Used: -----

Area surveyed: ----- Map Reference: -----

Sheet and Block Numbers: ----- Page & Coordinates -----

Leak Number	Location or Address of Suspected Leak	Agency or Customer (A or C)	Leak Pinpointed (Y or N)	Leak to be Rechecked (Y or N)	Leak Repaired (Y or N)	Not a Leak (date)
----------------	--	-----------------------------------	--------------------------------	-------------------------------------	------------------------------	-------------------------


	Meters	Hydrants	Valves	Test Rods	Other
Indicated Number of Listing Points Use -----	-----	-----	-----	-----	-----
Miles of Main Surveyed -----	Survey Time -----		hours		
Number of Leaks Suspected -----	To be checked -----		(number)		
Number of Leaks Pinpointed -----	Pinpointed Time -----		hours		
Remarks:					


**LEAK REPAIR REPORT**

Agency: ----- Date -----

W.O. No.: ----- Foreman: -----

**LEAD IDENTIFICATION**

Map Reference: -----

Refer to Leak Discovery Report

Page and Coordinates:-----

Discovery Date: ----- Leak No: -----

Location (included street name and number): -----

**FOR MAIN AND SERVICE LATERAL LEAKS ONLY**

Sketch a map of the site including:

If Main or Service Leak, Attach Three Photos

- 1. Street name; north arrow.
- 2. Meter number (if applicable).
- 3. Mains and hydrants in shutdown area
- 4. All valves (give valve numbers and show which were closed during repair
- 5. Locate leak to nearest intersection or house With address.

- 1. Straight down over leak or damage
- 2. Close-up of leak and damage.
- 3. Any other photo which you feel help.

Show distance to property lines  
Or street centreline

Leak found? -----(yes/No)

**TYPE OF LEAK**

Meter Leak ----- Main Line Leak ----- Joint Leak -----  
 Meter Spud Leak ----- Service Lateral Leak ----- Other Leak -----  
 Meter Yoke Leak ----- Fire Hydrant Leak ----- Describe -----  
 Curb Stop Leak ----- Valve -----

**DESCRIPTION OF REPAIR**

Damaged part was: ----- Repaired ----- Replaced ----- If replaced, what material was used? ----  
-----

If repaired, what repairs were made?  
 -----Leak Clamp ----- Replaced Valve  
 -----Welded ----- Recaulked Joint  
 ----- other (describe) -----  
 -----

Repair Time -----  
 Crew Size -----(persons)  
 Equipment Used for Repair  
 ----- Backhoe  
 -----Dumptruck

Repair Costs (R):  
 Materials -----  
 Labour -----  
 Equipment -----  
 Other -----  
 Total -----

Size of Leak:  
 Measured ----- lpm  
 Estimated -----lpm  
 Method Used -----  
 -----

**DESCRIPTION OF DAMAGE FOR MAINS AND SERVICES**

What part was damaged?

-----Pipe Barrel ----- Flange Nuts, Bolts, Tie Rods  
 -----Joint ----- Other (describe)  
 -----Valve -----

Type of Break

-----Split  
 -----Hole  
 -----Circumferential Split  
 -----Broken Coupling  
 -----Service Pulled  
 -----Cracked at Corporation Stop  
 ----- Gasket Blown  
 ----- Crushed Pipe  
 -----Cracked Bell  
 -----Other (describe) -----

In your opinion, what caused the damage?-----  
 -----  
 -----

Estimated Age of Leak in Months -----  
 How Determined -----  
 Diameter of Main or Lateral in metres -----  
 Depth to Top of Pipe in metres -----

Pipe Material:

-----Galv. Iron ----- Ductile Iron -----A.C.P.  
 -----Black Iron ----- Steel ----- P.V.C.  
 -----Cast Iron ----- Copper ----- Polybutylene

System Pressure -----  
 How Determined -----  
 -----

Examine broken edge of cast-or ductile-iron pipe:

Original Thickness -----metres	Min Thickness of Good Grey Metal Remaining -----metres	Deterioration is on: ----- Outside -----Inside
--------------------------------------	--	---

Is there evidence of previous leak  
 Or repairs in same general area? -----Yes ----- No  
 Last Repair Date (if known) -----

Number of Previous Leak -----  
 Repair Clamps Present -----  
 Cause of Leak -----  
 -----

In your opinion, should pipe be replaced? ----- Yes ----- No ----- Do not know

If yes, explain extent: -----  
 -----

**FOR EXCAVATIONS, INDICATE GROUND CONDITIONS**

Type of Soil:	Existing Bedding:	Type of Cover
----- Rocky -----Sandy	----- Gravel/Sand	-----Concrete
----- Clay ----- Hard Pan	-----Native Soil	-----Asphalt
-----Adobe ----- Loam	----- Pea Gravel	----- Soil
----- Other -----	----- Other -----	----- Other -----

**LEAK DETECTION AND REPAIR PROJECT SUMMARY**

Agency: -----

Name of Report Preparer: -----

Date:-----

**LEAK DETECTION SURVEY**

Total Number of Days Leak Surveys Were Conducted: -----

First Survey Date: ----- Last Survey Date: -----

	Metres	Hydrants	Valves	Test Rods	Other
Number of Listening points:	-----	-----	-----	-----	-----
Number of Suspected leaks:	-----	Number of pinpointed leaks: -----			
Survey time: -----	hours	Miles of main surveyed: -----			
Pinpointing time: -----	hours				

Average Survey rate = kilometers of main surveyed x 8 / (total survey and pinpointing hours) = ----km/day.

Total number of visible leaks reported since survey started, from other sources (not discovered during leak detection survey): -----

**LEAK REPAIR SUMMARY**

First leak repair made: ----- Last leak repair made: -----

Number of Repairs Needing Excavation: -----	Number of Repairs not Needing Excavation: -----	Total Number of Repaired Leaks: -----
--	--	--

Total Water Losses From Excavated Leaks: -----	Total Water Losses From Nonexcavated Leaks: -----	Total Water Losses: -----
litres/month	litres/month	litres/month.

	Excavated Leak Repair Costs (R )		Nonexcavated Leaks Repair Costs (R )		Total Repair Costs (R )
Materials	-----	Materials	-----	Materials	-----
Labour	-----	Labour	-----	Labour	-----
Equipment	-----	Equipment	-----	Equipment	-----
Other	-----	Other	-----	Other	-----
Subtotal	-----	Subtotal	-----	Subtotal	-----

**LEAK DETECTION PROJECT COST-EFFECTIVENESS**

**Step 1.** Calculate the value of water recovered (Vwr) from all repair leaks.

$$Vwr = (\text{total leakage recovered in lpm})(\text{conversion factor})(\text{water cost, } Wc)$$

$$Vwr = (\text{---+---lpm})(\text{---ac-mitres/l/month})(R \text{ ---/ac-mitres})$$

$$Vwr = R \text{ ---}$$

**Step 2.** Determine the total cost of the leak detection survey.

Leak Detection Survey Costs ( R )	
Equipment	-----
Training	-----
Survey Costs	-----
Total	-----

**Step 3.** Divide Vwr (from step 1) by the total costs (calculated in step 2)

$$\text{Benefit: Cost Ratio (B:C)} = \text{Value of water recovered/ total cost leak detection survey}$$

$$= \text{-----}$$

For planning future leak detection effort, you calculate average survey cost per mile

**Step 4.** Determine average survey costs per kilometre of main surveyed (Cost/km)

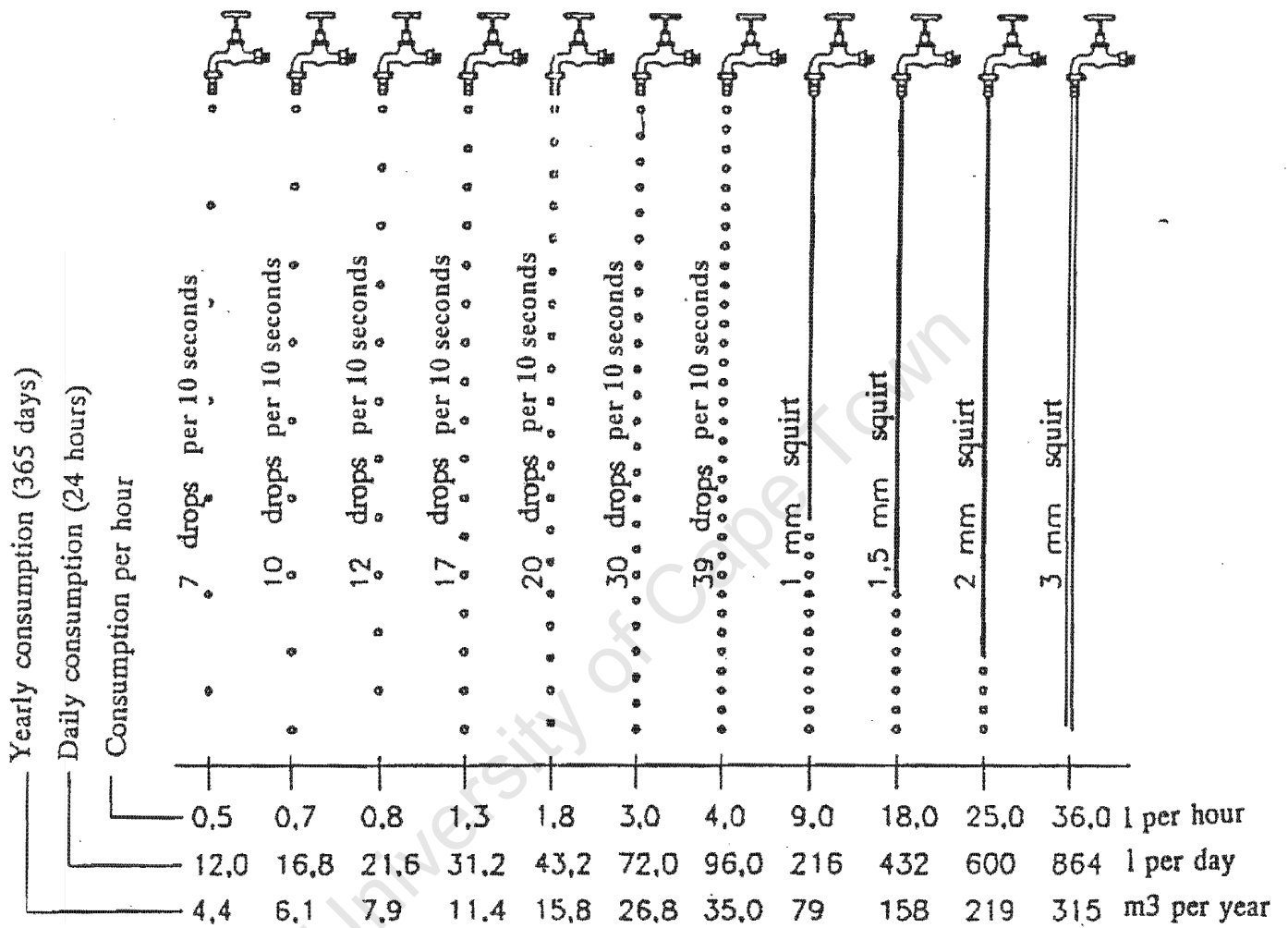
$$\text{Cost/km} = \text{total cost of leak detection survey/total number of kilometres surveyed} = (R / \text{km}) \text{-----}$$

$$C/\text{km} = R / \text{km} \text{-----}$$

**Source:** Modified from American Water Works Association Manual M36 (1990)

# APPENDIX G1

## The impact of water leaks



Source: SADC- IEMP, 2000

## APPENDIX G2

### Water leak equations & drips/time conversions

Drips/Second to GPM Conversion	
No. drips per second	Gallons per minute
1	.006
2	.0012
3	.018
4	.024
5	.030

Five drips per second is a steady stream.

### Water Leak Equations

Rates of water loss for a roughly circular hole can be estimated using the Greeley equation (See Figure 45.):

$$Q = (30.394)(A)(\text{square root of } P)$$

Where Q is leak rate in gpm, A is the cross-sectional area of the leak in square inches, and P is the line pressure in pounds per square inch (psi)

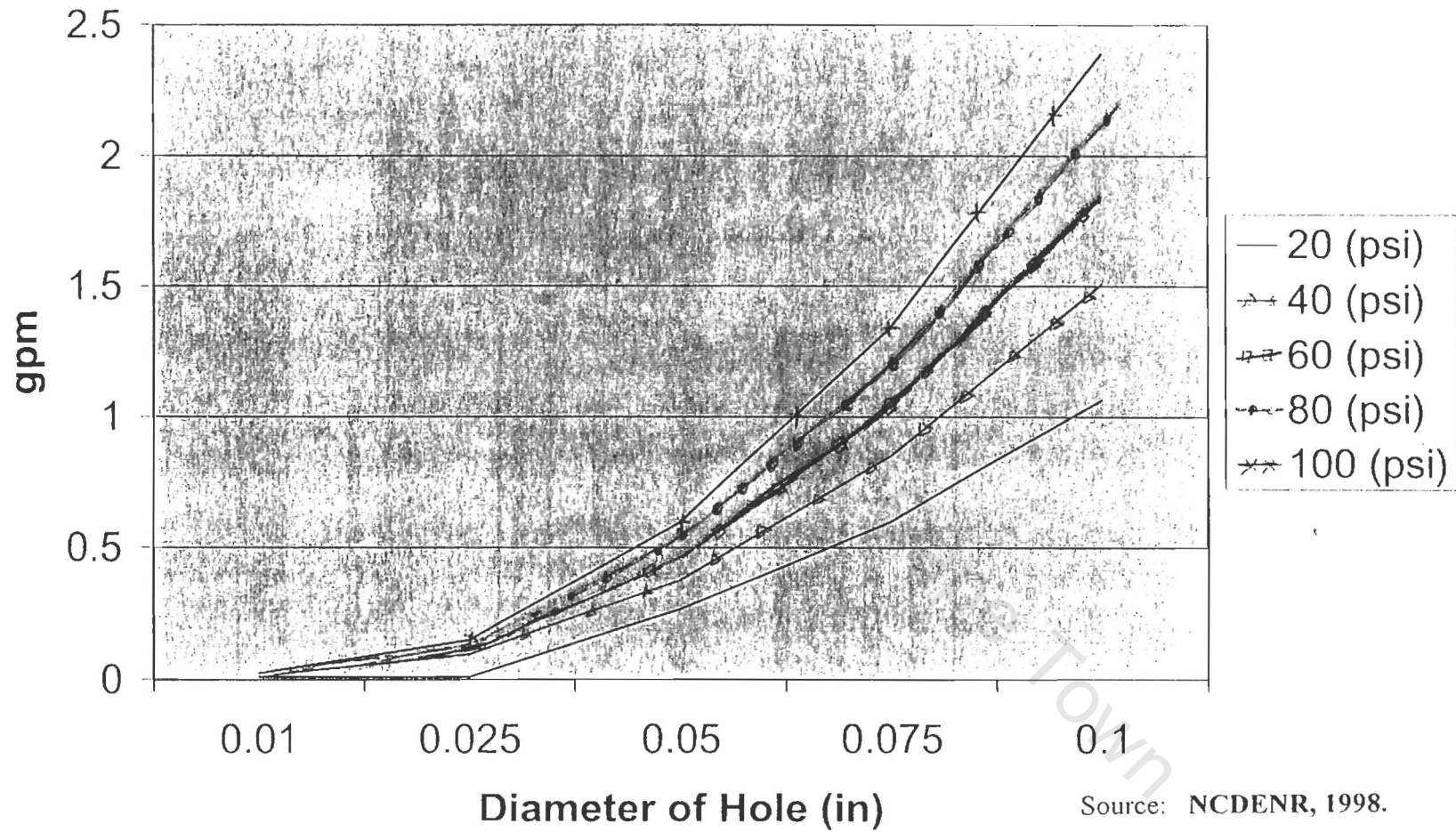
Leaks in joints or cracks can be estimated by this equation:

$$Q = (22.796)(A)(\text{square root of } P)$$

Where Q is leak rate in gpm, A is the area of the leak in square inches, and P is the line pressure in psi. For example a 1/32" wide crack, 1" long will lose 4.5 gpm at 40 psi.

Source: Division of Pollution Prevention & Environmental Assistance, North Carolina: Water Efficiency Manual, 1998.

# APPENDIX G<sub>3</sub> Leak Losses for Circular Holes



## APPENDIX H

### Procedure for conducting cost-benefit calculations for a water conservation programme.

Cost-benefit analyses can be done only after all the respective databases have been established as discussed in Section 9. The following steps are essential in calculating water savings, benefits, and costs of a conservation programme. The sequence of calculations is depicted in Figure H-1.

1. Multiply the total service area population by the measure's market penetration in order to get an estimate of the number of people that will be affected by this measure. For example - 100,000 population x 50% penetration = 50000 affected population.
2. Multiply the affected population by the measure's unit water savings to determine total water savings per measure. Example - 50000 x 5 L/cd = 250000 L/d.
3. Multiply affected population by any other savings, such as energy, to determine total other savings per measure.
4. In cases where the measure saves exterior water, multiply the total water saved by the cost of water to determine total Rands savings. Use the variable component of the retail cost for the customer and the marginal cost of the water and wastewater.
5. In cases where the measure saves interior water multiply the total water saved by the sum costs of water and wastewater.
6. Multiply total other savings (e.g. R/k W.h) to get the total Rand savings. At this point, all the benefits have been calculated.
7. The annual costs to the customers as a whole are calculated by multiplying the affected population size by the annualised costs to the individual customer. (Annualised costs are calculated by multiplying current individual costs times the capital recovery factor, found in standard compound interest tables).
8. To the utility the costs are the equivalent, uniform annualised costs determined in the section on developing the measures database.
9. Finally all costs and benefits, including water savings, should be combined into one table for evaluation as discussed in Chapter 8.

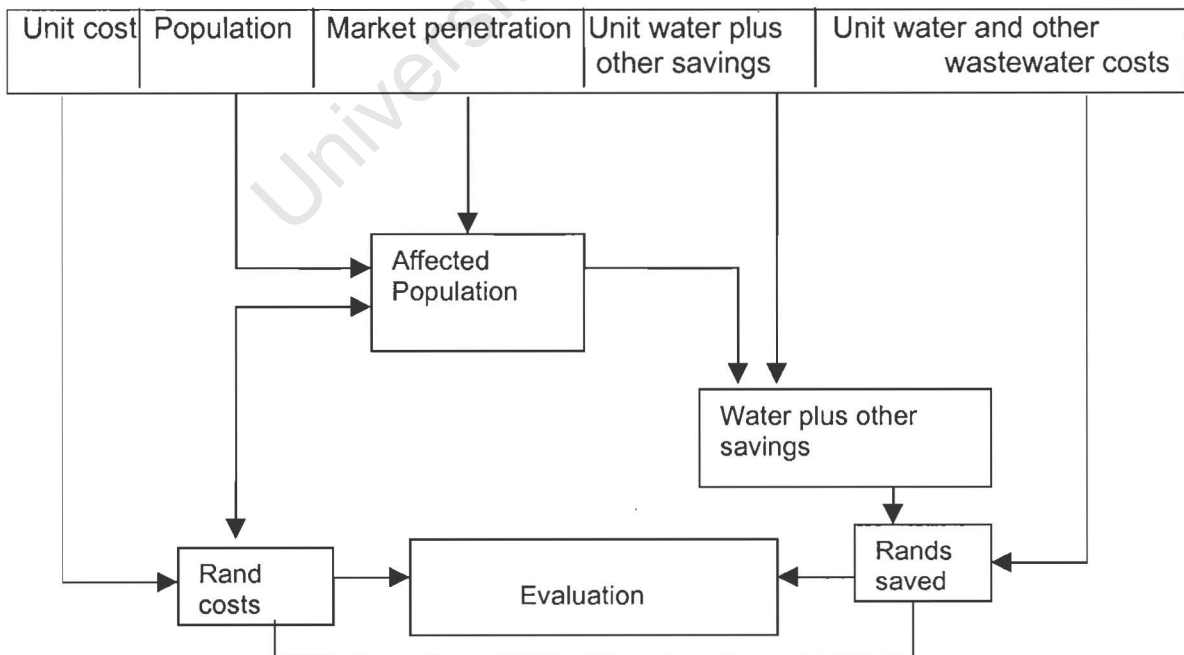
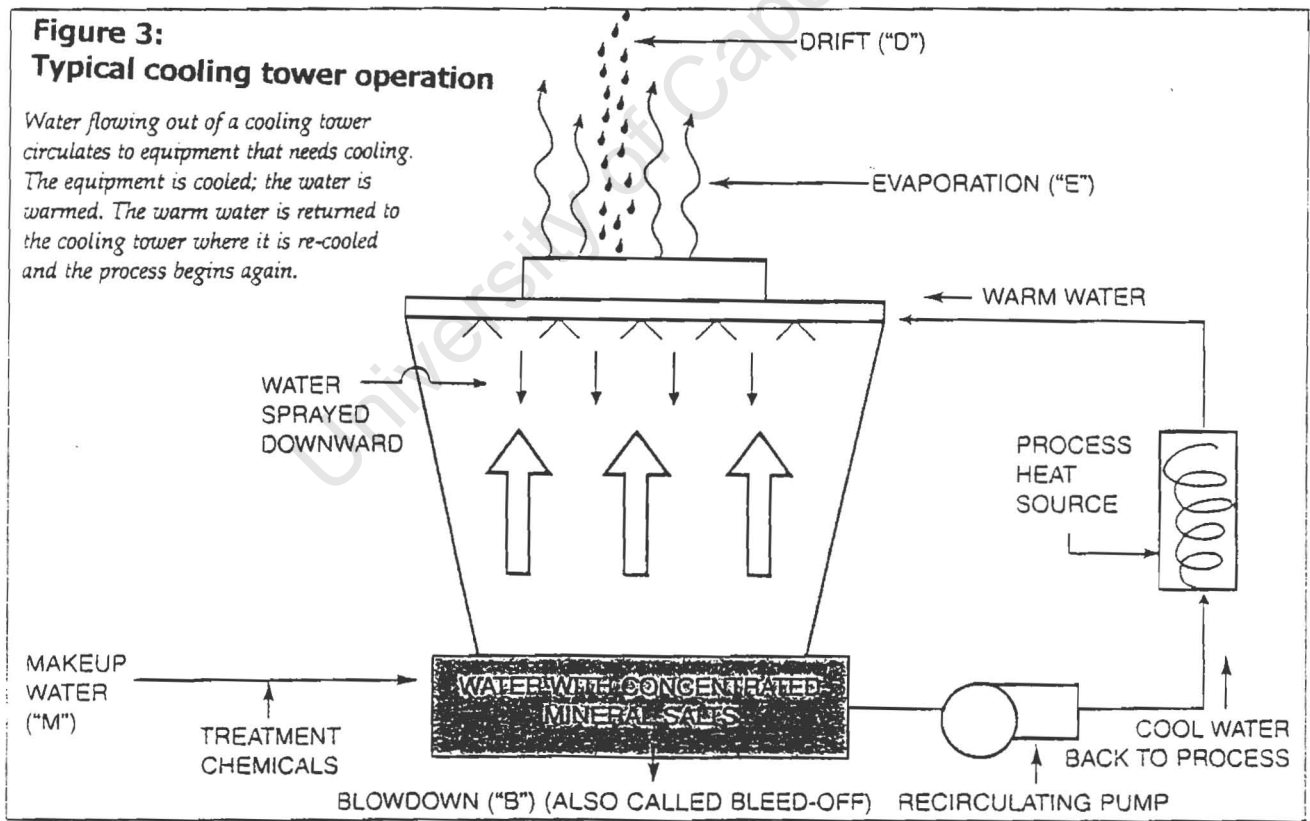
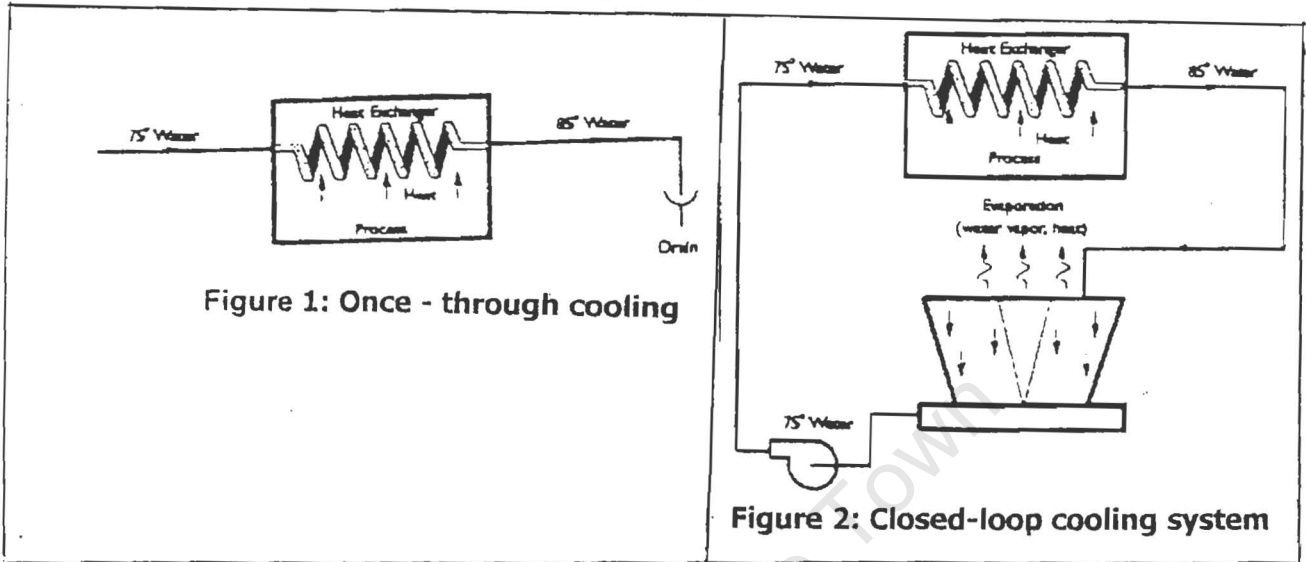


Figure H-1: Cost - Benefit Analyses Flow Chart of a Conservation Programme  
Source: Peter Macy & William Maddaus, 1989.

# APPENDIX I

Schematic comparison between once-through cooling and cooling tower systems (Figure 1 & 2), and typical cooling tower operations (Figure 3).



Source: Massachusetts Water Resources Authority, 1995; NMOST, 1999

## APPENDIX J

### The key variables and equations for a cooling tower

#### 1. CONCENTRATION RATIO (CR)

CR, otherwise referred to as Cycles of concentration is an indication of how many times water circulates in the cooling tower before it discharged as bleed-off/blowdown. The CR is a relationship between the concentration totals of dissolved solids of blowdown CB and the concentration of total dissolved solids in the make-up water (CM).

$$CR = CB/CM$$

CR can as well be obtain by using conductivity of the incoming make-up water (M) and the conductivity bleed-off/blowdown (B)

$$CR = B/M$$

#### 2. EVAPORATION RATE (E)

$$E = M - B$$

#### 3. BLEED-OFF/BLOWDOWN VOLUME (B)

$$CR = E / (CR - 1)$$

4. To determine the percentage of cooling tower water consumption that can be saved by increasing the CR the following equation is used:

$$V = M1 \times (CR2 - CR1) / CR1(CR2 - 1) \times 100\%$$

Where: V = Volume of water conserved

CR1 = Concentration level before increasing cycle and

CR2 = Concentration ratios after increasing cycles

M1 = Initial make-up water volume (before modification)

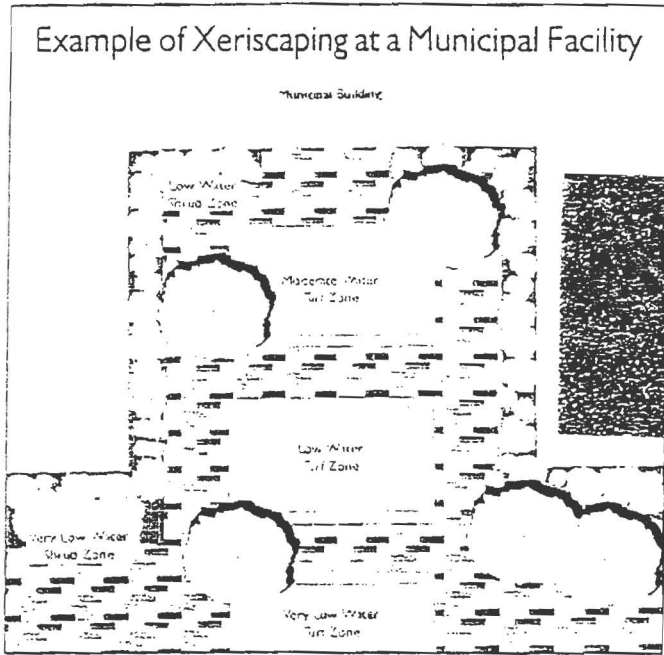
#### Water Balance in a Cooling Tower

Water added up to the cooling tower to replace water lost through evaporation, drift, and blowdown/bleed-off is called "make-up water" (NMOSE, 1999) (M). Therefore, the water balance in a cooling tower system is the relationship between Evaporation (E), Bleed-off (B), & Drift (D)

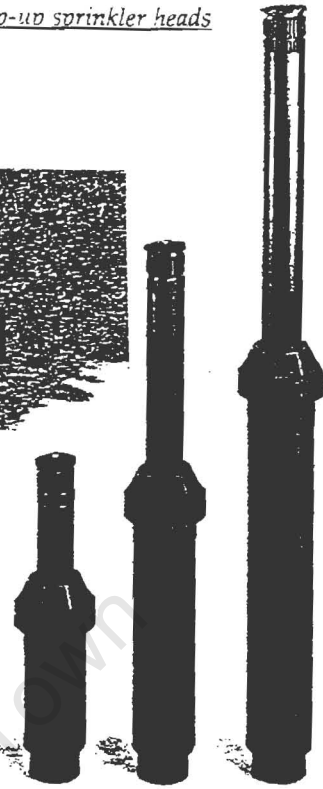
$$M = E + B + D$$

Source: Compiled from different sources, including (NCENR, 1989; MWRA, 1995; MNOSE, 1999; and SADC-IEMP, 2000).

# APPENDIX K "Xeriscape" zones & watering equipment



*Pop-up sprinkler heads*

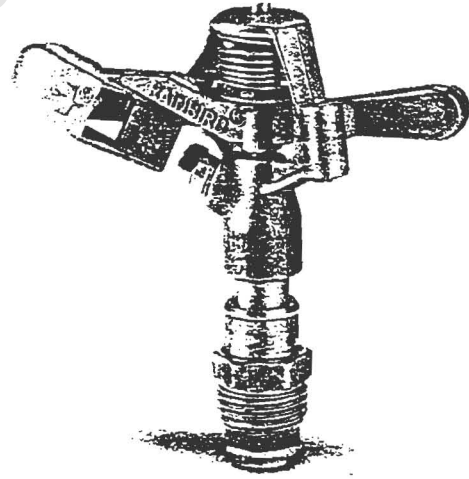


*Multi-emitter Hydrant*



Drip emitter:

*Impact rotor*



Source: NCDENR, 1998; NMOSE Water Conservation Guide, 1999.

## APPENDIX L

# Mondi craft mills in Piet Retief - an example of water reduction by recycling wastewater

*Water Sewage & Effluent* <sup>news</sup> December 1994 Vol. 14 No. 4  
Mill's water consumption reduced by 40%

*The Mondi Kraft mill in Piet Retief produces about 1 700m<sup>3</sup> of wastewater a day. This wastewater consists primarily of excess paper machine water and pulp washing water. Before the commissioning of the new wastewater purification plant, wastewater from the mill was pumped into holding ponds before being irrigated on to 192ha of fields.*

This disposal system was unacceptable for a number of reasons, the two most important being:

- The wastewater contained a high salt content (over 1000ppm sodium). Over a long period, sodium builds up in the soil and could eventually lead to permanent damage.
- Piet Retief is subject to heavy thunder storms and long periods of wet weather. Once the soil was saturated, runoff flowing over the fields picked up wastewater and carried it into the Blesbokspruit.

In order to effectively deal with the wastewater problem, the mill built the wastewater purification plant.

This plant receives wastewater from the holding ponds and through a combination of ultrafiltration, ion exchange and reverse osmosis, produces clean water (for re-use in the mill) and a concentrated effluent.

The concentrated effluent is evaporated and incinerated in a fluidised bed reactor to produce salt cake which is sold to the Usutu and Sappi pulp mills.

By re-using the clean water in the mill the intake of river water has been reduced by 40%.

Prof Kader Asmal, Minister of Water Affairs and Forestry, when opening the unique R25-million water purification

plant at the Mondi Kraft mill early in November, said that the most important government statement on water issues for generations will be tabled in parliament during this session.

He was referring to his White Paper on Water Supply and Sanitation Policy. In what he called a 'sneak preview', Prof Asmal said there would be exciting policy changes that would 'chart the way ahead'.

He added that the White Paper would empower women to play their 'proper role' in all spheres and at all levels of the water sector.

"This means ensuring that, at the very minimum, women make up 30% of the membership of structures for which I am responsible. In appropriate cases they will be the majority."

"This empowerment of women must replace the reality of their being fobbed off and patronised. It must apply from the top, right down to local levels."

Men, he said, should take note. "Their days of sheltered employment and assumed superiority are over."

The minister then questioned the future of the Forestry Council, which includes representatives of the forestry industry, individual tree farmers and the processors.

"South Africa has changed funda-

mentally since April 1994, and one can reasonably ask whether the Forestry Council should continue in its present form.

"In the past the council has advised the minister and collected and distributed levies to promote and research forestry."

"The levy has since fallen by the wayside and the Forestry Council should therefore reconsider its future at its next meeting."

He suggested that it could be replaced with a Forestry Forum which could meet twice a year and function throughout the year via sub-committees — each assigned specific fields of the wide forestry spectrum.

"Such a body could not only represent growers and processors. Other sectors of the broader community should have their voices heard."

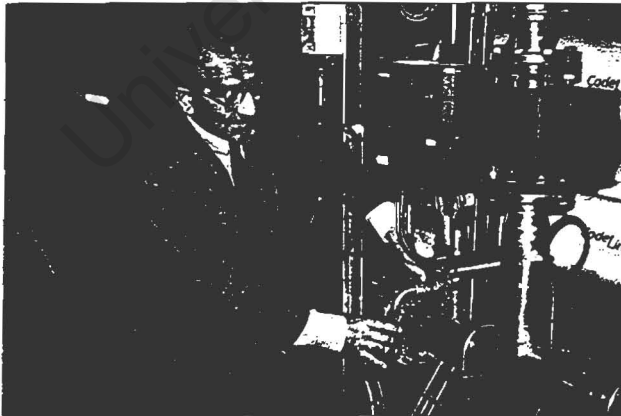
"I believe that consumer groups, persons or bodies affected by the forestry industry such as landowners, local communities, water users and particularly those people affected by large afforestation in their catchment areas, should be represented."

Such a forum, he added, could seek consensus, and give a much clearer picture of the problems, views and proposals of all.

Referring to the new water treatment plant at Piet Retief — a technology developed by Mondi and de Beers subsidiary Debex that has reduced the mill's water consumption by 40% — the minister said it was the first of its kind in the world and could become an important earner of foreign currency.

"Other pulp and paper mills in the world should take note and start implementing this technology to conserve the world's water resources."

Mondi, he said, deserved congratulations for taking the bold step to implement this costly system which would benefit the environment and eventually the country as a whole. ■



*The Minister of Water Affairs & Forestry, Prof Kader Asmal, taps off a beaker of clean, treated water at the new R25-million water treatment plant at Mondi Kraft's Piet Retief mill.*

## APPENDIX M

# Water-wise Species list

The following species  
are water-wise  
plants which require  
minimal water once  
established.

Latin name	common name	height	spread	position	colour
				● sun ◐ semi-shade	
<b>SMALL SHRUBS</b>					
<i>Acmadenia heterophylla</i>	Acmadenia	30 cm	60 cm	●	pink
<i>Agathosma ovata</i> Kluitjieskraal	False buchu	50 cm	1 m	●	pink
<i>Anchusa capensis</i>	Cape forget-me-not	60 cm	30 cm	●	blue
<i>Arctotis stoechadifolia</i>	Witgousblom. Bietou	15 cm	40 cm	●	white/orange
<i>Asparagus densiflorus</i>	Cat's tail asparagus	45 cm	60 cm	◐/●	white
<i>Cineraria saxifraga</i>	Wild cineraria	15 cm	40 cm	●/◐	yellow
<i>Cliffortia ferruginae</i>	Glastee	15 cm	40 cm	●	foliage
<i>Cliffortia odorata</i>	Wilde wingerd	75 cm	1 m	●/◐	white
<i>Dymondia margaretae</i>	Silver carpet	5 cm	30 cm	●	yellow
<i>Felicia aethiopica</i>	Bloumagriet	30 cm	30 cm	◐/●	blue
<i>Felicia echinata</i>	Bloublommetjie	30 cm	30 cm	●	mauve
<i>Felicia erigeroides</i>	Felicia	50 cm	75 cm	●	mauve
<i>Felicia filifolia</i>	Draaibossie. Wild aster	1 m	1 m	●	mauve
<i>Gazania rigens</i> var. <i>uniflora</i>	Trailing gazania	15 cm	40 cm	●	yellow
<i>Geranium incanum</i>	Bergtee. Vrouebossie	30 cm	30 cm	●	mauve
<i>Helichrysum cymosum</i>	Goue tapyt. Everlasting	10 cm	30 cm	●	yellow
<i>Helichrysum argyrophyllum</i>	Yellow everlasting	10 cm	30 cm	●	yellow
<i>Hermannia saccifera</i>	Komynbossie	20 cm	50 cm	●	yellow
<i>Osteospermum jucundum</i>	Bergbietou	20 cm	60 cm	●	mauve/purple
<i>Pelargonium betulinum</i>	Maagpynbossie	50 cm	40 cm	◐/●	mauve
<i>Pelargonium cucullatum</i>	Wildemaiva	1 m	1 m	●	mauve
<i>Pelargonium peltatum</i>	Ivy-leaved geranium	30 cm	2 m	●	varied
<i>Pelargonium radens</i>		1 m	1 m	●	mauve/purple
<i>Pelargonium reniforme</i>	Rooirabas	15 cm	30 cm	●	mauve/pink
<i>Pelargonium tomentosum</i>	Peppermint-scented pelargonium	30 cm	60 cm	◐	white
<i>Phylica ericoides</i>	Phylica	50 cm	50 cm	●	white
<i>Plectranthus ciliatus</i>	Plectranthus	50 cm	1 m	◐	white
<i>Plectranthus ecklonii</i>	Mauve plectranthus	1.5 m	1.5 m	◐	white/pink/blue
<i>Plectranthus fruticosus</i>	Muishondblaar	1.25 m	50 cm	◐	pink
<i>Plectranthus madagascariensis</i>	Variiegated plectranthus	30 cm	50 cm	◐	white
<i>Plectranthus neochilus</i>	Spur flower	30 cm	60 cm	◐/●	mauve
<i>Rumohra adiantiformis</i>	Seven weeks fern	1 m	1 m	◐	foliage
<i>Scabiosa africana</i>	Koringblommetjie	60 cm	60 cm	●	mauve
<i>Scabiosa incisa</i>	Koringblom. Wild scabious	30 cm	30 cm	●	mauve
<i>Stoebe plumosa</i>	Slangbossie	60 cm	40 cm	●	foliage – grey
<i>Ursinia sericea</i>	Silver ursinia	30 cm	30 cm	●	yellow

Latin name	common name	height	spread	position	colour
<i>Ornithogalum thyrsoides</i>	Chinkerinchee	50 cm	30 cm	●	white
<i>Tritonia ssp.</i>	Viooltjie	35 cm	20 cm	●	varied
<i>Ixia spp.</i>	Ixia	30 cm	10 cm	●	varied
<i>Sparaxis spp.</i>	Harlequin flower	20 cm	10 cm	●	varied
<i>Tulbaghia violacea</i>	Wild garlic	40 cm	25 cm	●	mauve
<i>Veltheimia bracteata</i>	Sandui	45 cm	45 cm	▶	pink/yellow
<i>Watsonia borbonica</i>	Suurkanol	1.5 m	0.3 m	●	pink

## SUCCULENTS

<i>Aloe arborescens</i>	Krantz aloe	3 m	3 m	●	red-orange
<i>Aloe ferox</i>	Bitter aloe	3 m	1 m	●	orange
<i>Aptenia cordifolia</i>	Aptenia	10 cm	30 cm	● / ▶	pink
<i>Cotyledon orbiculata</i>	Pig's ears	50 cm	50 cm	●	orange
<i>Carpobrotus edulis</i>	Sour fig, Suurvly	15 cm	1 m	●	yellow
<i>Crassula coccinea</i>	Klipblom	40 cm	30 cm	● / ▶	red
<i>Crassula perfoliata</i>	Sickle crassula	30 cm	30 cm	●	red
<i>Crassula multicava</i>	Fairy crassula	20 cm	30 cm	● / ▶	light pink
<i>Crassula ovata</i>	Plakkies	1.8 m	1.5 m	●	pink
<i>Drosanthemum speciosum</i>	Bergvygie	50 cm	50 cm	●	red
<i>Delosperma spp</i>	Vygies	15 cm	30 cm	●	varied
<i>Lampranthus spp</i>	Vygies	45 cm	45 cm	●	varied
<i>Portulacaria afra</i>	Spekboom	4 m	3 m	●	pink
<i>Tylecodon paniculatus</i>	Botterboom	1 m	70 cm	●	red

## ANNUALS

<i>Dimorphotheca pluvialis</i>	White Namaqualand daisy	30 cm	30 cm	●	white
<i>Dimorphotheca sinuata</i>	Orange Namaqualand daisy	30 cm	30 cm	●	orange
<i>Dorotheanthus bellidiformis</i>	Bokbaaivygie	10 cm	25 cm	●	varied
<i>Heliophila coronopifolia</i>	Blue flax	60 cm	30 cm	●	blue
<i>Nemesia strumosa</i>	Nemesia, Cape jewels	30 cm	30 cm	●	varied
<i>Senecio elegans</i>	Purple senecio	60 cm	60 cm	●	white/purple
<i>Ursinia cakilefolia</i>	Calvinia ursinia	30 cm	30 cm	●	yellow
<i>Ursinia anthemoides</i>	Magriet	30 cm	30 cm	●	yellow/orange

## CLIMBERS

<i>Jasminum angulare</i>	Wild jasmine			●	white
<i>Podranea ricasoliana</i>	Port St. Johns creeper			●	pink
<i>Rhoicissus digitata</i>	Baboon grape			● / ▶	yellow-green
<i>Senecio tamoides</i>	Canary creeper			●	yellow
<i>Senecio macroglossus</i>	Natal ivy			●	yellow
<i>Thunbergia alata</i>	Black-eyed Susan			●	orange/yellow

Latin name	common name	height	spread	position	colour
<i>Salvia africana-lutea</i>	Bruinsalie	1 m	1 m	●	brown
<i>Salvia africana-caerulea</i>	Bloublomsalie	1 m	60 cm	●	blue
<i>Strelitzia juncea</i>	Crane flower	1.5 m	1.5 m	●	blue/orange
<i>Strelitzia reginae</i>	Crane flower Bird-of-paradise flower	1.5 m	1.5 m	●/D	blue/orange
<i>Tecomaria capensis</i>	Cape honeysuckle	3 m	3 m	●	varied
<i>Thamnochortus insignis</i>	Albertinia thatching reed	1.5 m	1.5 m	●	texture plant

## TREES

<i>Acacia karoo</i>	Sweet thorn	8 m	8 m	●	yellow
<i>Brachylaena discolor</i>	Coastal silver oak	7 m	10 m	●	cream
<i>Brabejum stellatifolium</i>	Wild almond	over 5 m	over 5 m	●	cream
<i>Cassine peragua</i>	Cape saffron	over 5 m	5 m	●	cream
<i>Celtis africana</i>	White stinkwood	10 m	10 m	●	green
<i>Cussonia paniculata</i>	Mountain cabbage tree	5 m	2 m	●	green
<i>Dais cotinifolia</i>	Pompon tree	6 m	6 m	●	pink
<i>Dovyalis caffra</i>	Kei apple	5 m	3 m	●	cream
<i>Dodonaea angustifolia</i>	Sand olive	4 m	3 m	●	yellow
<i>Diospyros whyteana</i>	Bladder nut	5 m	3 m	●	cream
<i>Encephalartos altensteinii</i>	Eastern Cape cycad	1.5 m	1.5 m	●	
<i>Grewia occidentalis</i>	Cross-berry	5 m	4 m	●	mauve
<i>Kiggelaria africana</i>	Wild peach	12 m	11 m	●	yellow
<i>Olea europaea subsp. africana</i>	Wild olive	8 m	6 m	●	green
<i>Podocarpus falcatus</i>	Outeniqua yellowwood	15 m	12 m	●	
<i>Rhus pendulina</i>	Witkaree	8 m	7 m	●	green
<i>Strelitzia nicolai</i>	Natal wild banana	8 m	4 m	●	blue/cream
<i>Tarchonanthus camphoratus</i>	Wild camphor bush	5 m	5 m	●	white
<i>Virgilia divaricata</i>	Keurboom	5 m	3 m	●	pink/mauve
<i>Widdringtonia nodiflora</i>	Bergsipres	5 m	4 m	●	

## BULBS

<i>Agapanthus praecox</i>	Agapanthus	1.5 m	0.7 m	●/D	blue/white
<i>Amaryllis belladonna</i>	March lily	50 cm	50 cm	●	pink
<i>Aristea ecklonii</i>		1.5 m	1.5 m	●	blue
<i>Aristea major</i>	Blousuurkanol	1.5 m	1 m	●	blue
<i>Babiana angustifolia</i>	Vleibobbejaantjie	30 cm	20 cm	●	blue
<i>Bulbine frutescens</i>	Snake flower	30 cm	40 cm	●	orange/yellow
<i>Babiana villosa</i>	Rooibobbejaantjie	20 cm	10 cm	●	red
<i>Chasmanthe floribunda</i>	Suurkanol	1 m	30 cm	●/D	orange/yellow
<i>Crocasmia paniculata</i>	Crocasmia	80 cm	30 cm	shade	orange
<i>Clivia miniata</i>	Boslelie, Clivia	80 cm	80 cm	shade	orange
<i>Dietes grandiflora</i>	Wild iris	1 m	1 m	●/D	white
<i>Freesia alba</i>	Duine-aandblom, Freesia	20 cm	15 cm	●	white
<i>Lachenalia aloides</i> var. aurea	Geelvooitjie	25 cm	10 cm	●	yellow
<i>Lachenalia splendida</i>	Viooltjie	25 cm	10 cm	●	purple
<i>Nerine sarniensis</i>	Guernsey lily	45 cm	30 cm	●	red

# LARGE SHRUBS

Latin name	common name	height	spread	position	colour
<i>Agathosma glabrata</i>	Buchu	60 cm	50 cm	●	mauve
<i>Agathosma ovata</i> 'Glentana'	False buchu	1.5 m	1 m	●	white
<i>Anisodonteia scabra</i>	Pienk kiesieblaar	1 m	1 m	●	pink
<i>Athanasia crithmifolia</i>	Klaaslouwbossie	1 m	1 m	●	yellow
<i>Barleria obtusa</i>	Bosviooltjie	1 m	1 m	●	purple/pink
<i>Bauhinia galpinii</i>	Pride-of-de-Kaap	3 m	4 m	●	orange
<i>Buddleja auriculata</i>	Weeping sage	4 m	4 m	●	cream/yellow
<i>Buddleja salviifolia</i>	Sagewood. Bergsalie	5 m	4 m	●	mauve/purple
<i>Carissa macrocarpa</i>	Groot num-num	3 m	2 m	●/●	white
<i>Chrysanthemoides monilifera</i>	Bietou	2 m	2 m	●	yellow
<i>Chondropetalum tectorum</i>	Dakriet	1 m	1 m	●	texture plant
<i>Coleonema album</i>	Confetti bush	1 m	1 m	●/●	white
<i>Coleonema pulchellum</i>	Pink confetti bush	1 m	1 m	●/●	pink
<i>Erica baccans</i>	Berry heath	1 m	60 cm	●	pink
<i>Erica bauera</i>	Albertinia heath	1 m	60 cm	●	pink/white
<i>Erica coccinea</i>	Vlakteheide	1 m	60 cm	●	orange/red
<i>Erica mammosa</i>	Nine-pin heath	1 m	1 m	●	red/pink
<i>Erica plukenetii</i>	Hangertjie. Tassel heath	1 m	60 cm	●	red/pink
<i>Erica versicolor</i>		2 m	2 m	●	red & green
<i>Erica verticillata</i>		1.5	1 m	●	mauve/purple
<i>Eriosephalus africanus</i>	Wild rosemary	1 m	1 m	●	white
<i>Euryops pectinatus</i>	Wolharpuisbos	1 m	1 m	●	yellow
<i>Euryops virgineus</i>	Rivierharpuisbos	1.5 m	1.5 m	●	yellow
<i>Helichrysum petiolare</i>	Kooigoed	1 m	1.5 m	●/●	white
<i>Helichrysum splendidum</i>	Yellow everlasting	1 m	1 m	●	yellow
<i>Hemizygia obermeyeriae</i>	Soutpansbergsalie	1 m	1 m	●/●	pink
<i>Leonotis leonurus</i>	Klipdagga. Wild dagga	1.5 m	1 m	●	white/orange
<i>Leucadendron Safari Sunset</i>		2 m	1.5 m	●	foliage – red
<i>Leucadendron tinctum</i>	Bergroos	1.5 m	1.5 m	●	foliage – yellow
<i>Leucadendron coniferum</i>	Duinegeelbos	4 m	2 m	●	foliage – yellow
<i>Leucadendron salignum</i>	Geelbos	1 m	1 m	●	foliage – yellow
<i>Leucospermum cordifolium</i>	Pincushion	1.5 m	2 m	●	peach-orange
<i>Leucospermum conocarpodendrum</i>	Kreupelhout	3 – 5 m	3 m	●	yellow
<i>Leucospermum reflexum</i>	Rocket pincushion	3 m	3 m	●	yellow/red
<i>Leucospermum muirii</i>	Bloukoolhout	1.5 m	1.5 m	●	yellow
<i>Metalasia muricata</i>	Blombos	1.5 m	1 m	●	white
<i>Phyllica pubescens</i>	Featherhead	2 m	1 m	●	foliage – yellow
<i>Plumbago auriculata</i>	Plumbago	3 m	3 m	●	blue/white
<i>Podalyria sericea</i>	Silver podalyria	1 m	1 m	●	mauve
<i>Polygala myrtifolia</i>	September bush	2 m	2 m	●	purple/mauve
<i>Protea aurea</i>	Geelsuikerkan	3 m	3 m	●	white/pink
<i>Protea repens</i>	Sugarbush	3 m	3 m	●	white/pink
<i>Protea neriifolia</i>	Blousuikerbos	3 m	3 m	●	pink-peach
<i>Protea obtusifolia</i>	Bredasdorp sugarbush	2 – 4 m	1.5 m	●	pink/white
<i>Protea compacta</i>	Botrivier protea	2 – 3 m	2 m	●	pink
<i>Rhus crenata</i>	Dune crow-berry	3 m	3 m	●	cream
<i>Rhus glauca</i>	Kuni-bush	1 – 3 m	3 – 5 m	●	cream
<i>Rhus lucida</i>	Blinktaaibos	2 – 5 m	2 – 4 m	●	white

Source: Copied from pp.21-24: National Botanical Institute & DWAF -SA, (1998) *Water-wise Gardening for winter-rainfall regions*. CTP Book Printers, Caxton Street, Parow.

## APPENDIX N

### Benefit -Cost Analysis: Discounting & Interest Rate Relationship Equations

One of the major challenges to conduct CBA is how to resolve the problem of comparing benefits and costs occurring in different years. There is a need to take into account changes in the value of money and interest because these two variables do change in time and this can escalate the original value, or investment costs. And thus change the net benefits. How then can we compare a one-time investment with, say 20 years of benefits? In benefit -cost analysis, economists use discounting techniques to evaluate benefits and costs that occur in different years. (Chapman, 1999). Without going into the intricacies of discounting methods used by economists, the most direct methods and formulae are summarised below.

Assume each amount  $A_t$  is paid in at the indicated year. PV means present value at the end of "Period 0," which is also the beginning of Year 1.  $F_n$  means a future value at the end of Year n.

1) Future Value of a Current Value, at Compound Interest:  $F_n = (1 + r)^n C_0$

2) Future Value of a Variable Income Stream:  $F_n = \sum_{t=1}^n (1 + r)^{n-t} C_t$

3) Future Value of a Constant Annual Income Stream:  $F_n = \frac{(1 + r)^n - 1}{r} * C$

4) Present Value of a Future Amount:  $PV = \frac{F_n}{(1 + r)^n}$

5) Present Value of a Variable Income Stream:  $PV_0 = \sum_{t=1}^n \frac{C_t}{(1 + r)^t}$

6) Present Value of Constant Income Stream:  $PV_0 = \frac{1 - (1 + r)^{-n}}{r} * C$

7) Levelized Annual Cost of Present Value:  $LAC = \frac{r(1 + r)^n}{(1 + r)^n - 1} * PV$

8) Levelized Annual Amount of Future Amount:  $LAA = \frac{r}{(1 + r)^n - 1} * F_n$

You may wish to note that the 'factors' are always derived from the part of the equation on the right side of the equal sign. For example, the levelised cost factor Equation 7 is  $r(1+r)^n / [(1+r)^n - 1]$ .

Source: Chapman, D., (1999). *Environmental Economics*. Cornell University, Addison-Wasley.

# APPENDIX O

## Procedure for economic appraisal of capital investments

There are a number of steps commonly agreed to in the literature to be followed in conducting an economic appraisal for any capital investment.

1. Define objectives and scope of the project.

In the case of the CMA - AWOP, the objective is to reduce the costs of water supply and the need for immediate (near future) augmentation (CMA - AWOP, 1999)

1. Identify options

Efficiency of water use, and reducing the demand on water use have a range of potential options. The possible means to implement these options and to deliver these savings as discussed in Chapters VI and IX are: Retrofitting, water conservation campaign, pricing (tariff) allocation mechanisms, economic incentives, and retail campaign). One often ignored option is of course the "do nothing" option, and this needs to be identified and considered with others.

2. Identify quantifiable costs

Quantifiable costs include the following costs: capital costs - i.e. costs for buying water-efficient equipment; expenses for planning, administration, management, advertising and evaluation costs) for the water authority; and cost of revenue loss for the water authority where customers improve their efficiency of water-use.

3. Identify quantifiable benefits

A number of avoided costs are considered as benefits to the water authority. They include avoided costs for pumping and treatment, for constructing new storage, service reservoirs or pipelines. They will also include additional revenues from sales of equipment or services or interest on loans (White, 1994).

To the participating customers benefits will include reduced water and energy from improved efficiency of water use and lost water use respectively.

4. Calculate net benefits

The quantifiable costs and benefits over the planning period (usually about 20 years) are expressed in net present value terms. The costs and benefits are first valued in real terms; that is, expressed in constant money value (Rands); then discounted by a predetermined real discount rate (range 4% - 10%). Net Benefits to the Water Authority = Reduced Operating Costs + Savings from Deffered Capital Expenses - Program Costs.

5. Identify, quantify factors and summarise environmental and social costs and benefits.

6. Identify un-quantifiable aspects.

Some aspects such as public relations, distribution of costs and benefits of a community cannot be quantified, but they can be appraised without quantification.

7. Summarise Results.

**Source:** White, 1994; CMA - AWOP, 1999; Parkin et al, 2000.

# APPENDIX P

## Procedure for estimating water flows

Past local and international experience suggest that although during the audit, descriptions of water uses are readily attainable, in most areas volumes of water used are not measured. If a flow estimate is needed, published values or field measurements may be acceptable.

Tabulated values from published information are available for most conventional water uses to estimate flow use by specific operations.

These may be augmented by estimates regarding the number of users per day or duration of use.

Estimation of flows might be based on field measurements, which may be more appropriate for some water use operations. Methods of field measurement include:

- Flow meters on either the water distribution system or the water-using equipment (e.g., cooling water pipe)
- Bucket and stopwatch measurement of water extracted for a specific operation
- Volume/frequency measurement of water used for a specific operation

Indirect methods of flow measurement (such as logging the operation of water pumps, and displacement tests on water storage tanks) are likely to produce lower quality data.

It is important to measure flows over the same general time period, because the productivity and seasonality of flows may affect the water balance equation. Part of the margin error at a pilot site may be due to unknown flows for irrigation and lawn watering. If outdoor use is suspected, the water audit should be carried out during the rainy (winter) season.

### Flow Meters

An essential element of any water audit is the measurement of the main flow entering the facility. Additional flow measurement into sub-areas is occasionally warranted when significant portions of the total flow need to be ascertained.

Flows can be measured by either permanent flow meters, which give the most reliable results both during the investigation and after the water audit is finished, or temporary recorders, typically situated at a specific location for the short audit period. Temporary flow meters, if not installed correctly, may give corrupt results.

Permanent flow meters are costly and have to be fitted into the pipe run. However, they will give highly accurate daily, weekly, monthly, seasonal, and unusual-event data during the water audit, and then continue to give long-term results and trends.

There are two basic types of temporary flow meters, namely, external clamp-on-devices and insertion flow recorders.

External clamp-on meters send ultrasonic signal through the pipe wall and across the water flow. They are useful where only an indication of the flow range is required and they need no pipe work modifications. However, they require a straight section of pipe at least 30 diameters in length for installation.

The insertion flow meter requires a point of entry into the main via a small (5 cm diameter) tapping. An electromagnetic head, or a small turbine, measures the velocity of flow at one point in the pipe. The pipe has to be traversed to obtain a flow profile, from which the relationship between measured point velocity and total flow can be calculated.

Varying flow profiles and internal pipe corrosion can cause distortions. Results from insertion meters are likely to be more accurate than those from clamp-on meters.

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#### Bucket and Stopwatch Estimation

If flow is constant and free flowing, as in some cooling waters, a bucket and stop watch approach can be used to estimate flow. The time it takes a bucket of a known volume to be filled by the free-flowing source is measured and a flow can be calculated.

#### Volume/Frequency Estimation

If the is not free flowing but fills a known volume, the frequency with which the volume (tank) is emptied or replaced can be used to estimate flow.

Occasionally, logging the operation of a domestic cold water pump is the last resort to obtain a set of (indirect) flow measurement. The method produces lower quality of data but gives an understanding of the water-using pattern at a facility and provides information on the operation and control of the pumped system.

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**Source:** White, 1994b; Massachusetts Water Resources Authority, 1995;

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# APPENDIX Q

## Estimations of Devices Water Consumption

### 1. Boiler (open system):

Boiler make-up water is often metered. If this is the case, use this figure directly. Otherwise, estimate consumption as in the following two steps:

- 1.1 Estimate boiler energy in one of two ways. If the boiler's rated capacity is known, and the annual operating times and approximate load factor is known:

$$\text{Boiler Energy (kJ/y)} = \frac{\text{Boiler Capacity}}{\text{line loss}} \times \frac{\text{Annual Operating Time (s/y)}}{100} \times \text{Load Factor} \times \{(100 - \text{Percent loss})/100\}$$

If the annual fuel consumption of the boiler is known:

$$\text{Boiler Energy (kJ/y)} = \frac{\text{Fuel Value (kW)}}{\text{line loss}} \times \text{Boiler Efficiency} \times \{(100 - \text{Percent loss})/100\}$$

- 1.2 Estimate evaporation as follows, including an allowance for blowdown water. This is the steam purged from the boiler to keep suspended solids at or below approximately 3500 mg/l. You will need to know the approximate suspended solids of your supply. This will be available from your municipal treatment plant.

### 2.0 Chiller:

Cooling water flows should be measured directly, or estimated based on manufacturers data. This is then multiplied by the duty cycle (hours per day and days per year) to give a flow estimate.

### 3.0 Cooling Tower:

Cooling tower usage is often metered directly for control purposes, and thus consumption can often be determined directly. However, if this information is unavailable, a heat balance can be conducted to estimate usage.

- 3.1 Estimate heat energy dissipation in one of two ways. If flow rate and temperatures in and out of the tower are known:

$$\text{Operating Heat Energy (kJ/y)} = \text{Temperature Difference } ^\circ\text{C} \times \text{Recirculation Rate (L/s)} \times 4.2 \text{ kJ/L } ^\circ\text{C} \times \text{Annual Time (s/y)}$$

If the rated capacity and annual operating time, and load factor can be estimated:

$$\text{Heat Energy (kJ/y)} = \frac{\text{Rated Capacity (kJ/h)}}{\text{line loss}} \times \frac{\text{Annual Operating Time (h/y)}}{100} \times \text{Load Factor}$$

- 3.2 Estimated evaporation as follows:

$$\text{Volume of Water Evaporation (L)} = \frac{\text{Heat Energy Supplied (kJ)}}{2466 \text{ kJ/L}}$$

- 3.3 Estimated drift (loss of air-entrained droplets):

$$\text{Drift (L/y)} = \text{Recirculation Rate (L/s)} \times 0.0001 \times \text{Annual Operating Time (s/y)}$$

3.4 Calculated total water demand (evaporation + drift + 20-30% blowdown loss):

$$\text{Water Demand(L/y)} = \left[ \frac{\text{Heat Energy (kJ/y)}}{2,466\text{kJ/L}} + \text{Drift(L/y)} \right] \times 1.25 \quad (\text{for blowdown loss of 20 - 30\%})$$

4.0 **Dishwasher, home:**

15-30 L/load depending on model, cycle and efficiency. Savings by changing to a high efficiency model are estimated at 19 L/load, however, this reference gives no base consumption for a conventional model, only a typical family of four usage of 1200 L/month.

5.0 **Dishwasher, commercial, conveyor-type:**

15-32 L/min depending on model and efficiency.

Dishwasher, commercial, stationary rack: 25-35 L/min depending on model and efficiency.

6.0 **Drinking Fountain, continuous flowing:**

4-5 L/min.

7.0 **Faucet, Lavatory/Kitchen:**

Flows range from 2 to 10 L/minute. Usage is estimated at 5-10 L/use.

8.0 **Convention faucets:**

average 13.5 L/minute. Low-flow aerators can reduce this by 50% or more. Satisfactory flow rates are estimated at 6-9 L/min for kitchens and 2 L/minute for bathrooms.

9.0 **Fire Hose - 38 mm, 13 mm nozzle, 20 m head:** 40-160 L/min

10.0 **Fountain, Ornamental:**

If metering or other flow estimation data is not available for outdoor fountains, net evaporative losses can be estimated from pan evaporation data and rainfall data. If other significant outflows or air entertainment is occurring, it may be necessary to meter the make-up water.

$$\text{Evaporative Loss (L/y)} = \text{Net Evaporation(mm/y)} \times \text{Surface Area of pond (m}^2\text{)}$$

10.0 **Garden Hose, 16 mm, 8 m head:** 10-12 L/min.

11.0 **Garden Hose, 19mm, 8 m head:** 16-20 L /min.

12.0 **Humidifier:**

Should be estimated from manufacturers data or measured directly, and multiplied by operational year (e.g. 7 months).

13.0 **Ice Machine, Water Cooled:**

Meter or consult manufacturer.

14.0 **Laundry Machine, home:**

Today water-saving models are available in the market. These include some models which use rinse water as wash-water for the next load. Front loading machines use approximately 40% less water than top-loading washers.

15.0 **Laundry Machine, Continuous:**

7-12 L/kg depending on cycle used, laundry is added in 50 kg lots.

16.0 **Lavatory, Usage:**  
Usage is estimated at 3 washroom visits per employee per 8 hour shift. Duration may be estimated at 10-30 seconds.

17.0 **Lawns/gardens:**  
Water consumption for landscaping can vary widely, depending on watering practices, frequency, losses to runoff and watering of paved areas, soil type, and rainfall. Therefore, if irrigation is a significant use at your facility, consider estimating flows from meter readings, or from estimated frequency and duration of watering as well as measured flows (bucket and stopwatch). Having said this, a theoretical first cut at lawn consumption (L/year) can be made to determine whether it should be investigated further:

$$\begin{array}{l} \text{Irrigation Requirements} \\ \text{For lawns (L/y)} \end{array} = \frac{0.4}{\text{m/season}} = \frac{\text{Lawn Area (m}^2\text{)}}{1,000} \times 1,000$$

Lawn sprinklers consume 6-8 L/min.

Providing 25 mm/wk to a 280 m<sup>2</sup> lawn will consume 6000-7500 L/wk. A typical suburban lawn (350 m<sup>2</sup>) can consume up to 200 000 L during a single season.

18.0 **Pressure reducing valves:**  
These can be used to reduce water pressure at the point of consumption to approximately 40 psi (275 kPa). Higher pressures (up to 80 psi) are common, and allow increased flows and waste at sinks and showers.

19.0 **Pressure Washer (Aladdin 3000):**  
Large commercial power washers use 12-20 L/minute.

20.0 **Product Consumption:**  
Moisture content of products is often known before and after drying units. This information can be used in combination with annual production rate to calculate both water lost in drying, and water sold with the product. (e.g. pasta, paper). For liquid products, water sold with the product may approach 100% of the annual production (e.g. beverages).

21.0 **Refrigeration:** Walk-in refrigerators, freezers, and other water cooled refrigeration devices.

22.0 **Shower Head:** Conserving versions use 8 L/minute, or less. Low flow showerheads are available in the range of 6-10 L/minute. Older versions can use 22-45 L/min.

23.0 **Shower Usage:** Shower duration is estimated at an average of 10 minutes. Residents are estimated to use the shower 4 times per week, and the bath 2 times per week.

24.0 **Toilet, Usage:** Usage by employees is estimated at 3 per employee per shift for women, and once by men if urinals are available. Residents are estimated to make 5 visits per day.

- 25.0 **Toilet, Valve-type:** Older versions use up to 19 L/flush, while water conserving models use 4 to 6 L /flush.
- 26.0 **Toilet, Tank-type:** Older versions use 15-25 L/use while high-efficiency models, which may use the water supply pressure to compress air, which is used in turn to increase flushing velocities, use 6 L/flush. Some toilets use a separate electric air compressor, as little as 1 L/flush. In North America, the plumbing codes typically specify 6 L/flush for tank toilets.
- 27.0 **Leaking ball cocks and flapper valves:** They are estimated to waste 91 L per day per toilet on average.
- 28.0 **Urinals, Usage:** Usage by male employees is based on an average of 3 washroom visits per shift, once to the toilet and 2 to a urinal.
- 29.0 **Urinal, Flushometer:** Older versions use 6 L/flush, water conserving models use 3.8 L/flush.
- 30.0 **Urinal, Waterless:** As the name suggests, these use no water.
- 32.0 **Water softeners:** Residential water softeners typically use 350 L per regeneration cycle, typically 3 times per week.

**Source: American Water Works Association Manual M36; Van der Merwe et al, 1999; SADC-IEMP, 2000.**

# APPENDIX R

## Principles for Tariff Policy in the CMA

It is recommended that the following principles with respect to tariff policy for water and sanitation should be adopted:

### **1. Affordability**

Water is essential for the maintenance of life and is therefore a basic necessity. Adequate sanitation is also a necessary (though not sufficient) condition for the maintenance of health in (especially urban) communities. All South Africans therefore have a right to reasonable access to a set minimum amount of safe water and a safe (from a health point of view) sanitation service. Tariff policies should take into account the fact that all people may not be able to afford the cost of these minimum levels of service.

### **2. Fairness**

Tariff policies should be fair. Individuals or groups of individuals should not be discriminated against and all people be treated equally.

### **3. Sustainability**

Adequate water supply and sanitation services are not necessary now, but also in the future. Tariff policies that are reliant on unsustainable subsidies will mean that essential maintenance of infrastructure is not carried out and there will be inadequate services in the future.

### **4. The efficient allocation of resources**

Water is a scarce resource in South Africa and should therefore be used with care. Tariff policies should aim at reducing wastage and inefficient water usage.

### **5. Economic development**

Tariffs applied to mining, industrial and commercial enterprises should take into account their impact on economic development. Negative impacts could affect employment, lowering overall levels of affordability and increase pressure on the sustainability of water supplies. Economic development must also be balanced against the conservation and sustainability of the physical environment.

### **6. Transparent subsidies**

Any subsidies which exist must be transparent (visible and understood by all those affected – both givers and recipients), and sustainable (see sustainability above).

### **7. Accountability**

Supply agencies should be accountable to the people within their areas of supply (both the served and unserved).

### **8.Price stability**

Significant fluctuations in prices should be avoided where possible

### **9. Simplicity and acceptability**

Tariff policies and how they work in practice should be able to be easily explained and understood by all households/ parties affected by the policy. The tariff policy should also be acceptable to consumers.

These principles are largely in agreement with those proposed by the SCOWSAS Institutional Sub-Committee (SCOWSAS, 1993) and with leading international expert opinion.

Tariffs should be designed in such a way as to meet, as far as is possible, all of the above goals, with a minimum of trade-off between goals.

**Source: Eberhard , 1995; Mirilees et al, 1995; DWAF, 1999a.**

University of Cape Town

## APPENDIX S

# " South Africans undervalue water " - Article in the Water Sewage & Effluent 1994 vol.14 No. 4.

~~Water Sewage & Effluent, Dec 1994, Vol. 14, No. 4~~

## South Africans undervalue water

*Many South Africans, particularly those living in the middle to upper class suburbs, are unaware of just how scarce a resource water is in this country, and they will probably remain unaware unless their supplies suddenly dry up or become extremely expensive.*

As long as water remains available in the developed areas at its current low price, even extensive information campaigns may have little success in increasing awareness.

That is the view of Simon Forster of Economic Project Evaluation consultants, who undertook in-depth research on behalf of the Water Research Commission (WRC) to determine the value people place on water — particularly groundwater.

The results showed that many people largely take water for granted because it is so readily available.

However, they are prepared to attach a value to water when the resource becomes so scarce that their survival is threatened.

In a middle-class suburb studied by the research team, where water is available at the turning of a tap, most people do not know the origin of this water, its unit cost or even what they pay monthly for it.

On the other hand, the people of a poor community in the south of KwaZulu — where a walk of several miles to obtain water from a polluted river or borehole is not unusual — are willing to pay a large percentage of their meagre income for access to a clean and adequate water supply.

The survey was part of a project aimed at determining the monetary value people attach to water resources.

The idea was that if people were aware of the value of water, it would be easier to convince them of the need for improved management of the resource to ensure it is not exhausted at a later stage.

The survey of the middle-class sub-

urb showed that most residents were largely unaware that their town even had a groundwater resource.

More than 70% of female and over 30% of male respondents did not know the origin of the town's water.

In total 59% of those questioned did not know whether the water in their suburb came from Rand Water or from underground resources.

In addition, 96.3% of women and 90.8% of men were unaware of the cost of municipal water per 1 000l, while 59% of participating women and 34% of the men did not even know what their monthly water bill was.

An attempt to determine how much people were prepared to sacrifice in order to reduce their water consumption did not produce definitive answers either.

Indications were that even a doubling in the price of water would not reduce present consumption levels.

In KwaZulu/Natal, where people sometimes queue for hours to fill their water containers at a single tap, similar questions revealed that these people were willing to attach a higher value to water.

Here the people interviewed — more than half of whom earn less than R500/month — said they would be prepared to pay between 5c and R1.00 for a 25l container of clean water supplied on a regular basis.

This works out to between R2 and R40/kz. According to Forster, it is clear that people are willing to attach a higher value to water if their survival depends on it.

As long as people simply have to open a tap to obtain clean water, at a cost which is considered trivial, it will be very difficult to convince them that the resource they take for granted is really valuable.

The fact that water is available so cheaply is one of the reasons why people don't attach much value to this resource.

The scarcity of any other product is usually reflected in its price.

"With water supplied at virtually no cost, it will therefore be extremely difficult to convince consumers of the reality that water is a scarce resource," he added. ■

# APPENDIX T

## Water services laws & ordinances for water-use regulation as applied in the South Peninsular Municipality



SOUTH PENINSULA  
MUNICIPALITY

ARGUS

21-12-99

### NOTICE TO ALL WATER CONSUMERS:

Notice is hereby given in terms of Section 11(6) of the Water Services Act 108 of 1997 read with Section 184 of the Municipal Ordinance No 20 of 1974 that, with effect from the date of publication hereof and until further notice, the following water restrictions, subject to the exemptions provided for in paragraph 3 hereof, shall apply within certain listed areas of the South Peninsula municipal area.

1. The use of sprinklers, including automatic sprinkling systems, connected directly or indirectly to Council water mains for the purpose of watering gardens and lawns, is prohibited.
2. The use of hosepipes connected directly or indirectly to Council water mains for the purpose of irrigation, washing vehicles, paths, pavements and paved areas, regardless of the nature of the material used for paving such areas, is prohibited.
3. The restrictions referred to in paragraphs 1 and 2 shall not apply:
  - (i) for the purpose of watering of plants in nurseries which are conducted for gain, plants in nurseries owned by the Council or the State, plants in collections maintained for research purposes, dune rehabilitation projects, cricket pitches, bowling greens, golf greens, croquet lawns, artificial turf fields and major sports stadia;
  - (ii) for the washing of paved areas in premises used for the processing of food (including restaurants) and to car valet services;
  - (iii) where special exemptions have been granted in writing by the Chief Executive Officer

Any person who contravenes the provisions of this notice shall commit an offence and could be liable to prosecution in terms of the Ordinance.

These restrictions are applicable in the following areas:

KOMMETJIE, LLANDUDNO, SCARBOROUGH, HOUT BAY, NOORDHOEK, SUN VALLEY, SIMON'S TOWN, CLOVELLY and FISH HOEK.

JAN KOEKEMOER  
Chief Executive Officer  
South Peninsula Municipality

17 December 1999

91120045

# APPENDIX U

Provision of water for all in the CMA is a necessity & priority, but...

TUESDAY CAPE TIMES 29-2-2000

## Free water not yet in pipeline for city's poor

**BUNTY WEST and MONICA HILTON-BARBER**

CAPE TOWN will not follow Durban's lead and provide a free six kilolitre water lifeline for the poor as part of a multi-step tariff — at least not until after the unicity becomes a reality.

Durban is leading the way for local councils around the country in terms of its innovative water tariffs structure which offers free water for the poor.

The government proposed this month to follow Durban's lead and provide free water for basic needs — while charging for "luxury" use. The new system is set to be presented to the national cabinet next month.

Cape Town, with its six municipalities and differing tariff structures, will have to wait until a common tariff can be charged across the whole metro before supplying free water to the poor.

The unicity commission has recommended there be a lifeline tariff for the first 6kl of water used. In the next few months the commission will investigate ways in which all tariffs in the metropolitan area can be made uniform.

At present the different municipalities provide water at varying rates per kilolitre, but they buy water in bulk from the Cape Metro Council at the set price of 103,65c per kilolitre.

- In Blaauwberg, consumers pay just 87c per kilolitre for the first five kilolitres. Between 6kl and 15kl the rate is R1,37, from 16kl to 40kl R1,93, and for over 41kl the rate is R2,46.

- In Tygerberg there is a five-step tariff in place. Up to 6kl the rate is R1,18, 7kl to 30kl R1,55, 31kl to 50kl R2, 51kl to 80kl R2,55 and over 80kl the rate is R3,10.

- At the South Peninsula Municipality the domestic rate is R1,13 for up to 10kl, 11kl to 50kl R2,40, and over 50kl costs R3,94.

- In Helderberg the first 10kl will cost R1,67 per kilolitre and afterwards the cost is R3,28.

- In Oostenberg the rate is R1,46 for the first 5kl and from 6kl upwards it is R2,27.

- Cape Town City Council bills consumers on a five step tariff basis charging just 50c a kilolitre for the the first five kilolitres. Between 6kl

and 15kl the cost is R1,60, 16kl to 30kl R2,70, 31kl to 50kl R3,80 and over 50kl the price is R5.

Two years ago Durban Metro Council dropped the cost of water for the poor, making the first 6kl of water a month cheap, but costing more between 6kl and 30kl per month. People who used in excess of 30kl each month were further penalised in an effort to discourage wastage.

The council found that costs exceeded the income from poor homes because it was costing more than the value of the water used to run an account and bill those householders who used less than 6kl per month.

Tariffs were restructured last July and people using less than 6kl received free water with prices starting at 6kl-plus and escalating according to the amount used.

Director of the Durban Metro Water Services Neil McLeod felt the council dealt adequately with domestic users who couldn't afford to pay as council provided double the amount of water recommended as a basic necessity by the RDP for free.

However McLeod said it was not a model without problems. The system was not for every council area. Before considering such a scheme, each local authority had to ensure that it had sufficient industry and enough high-water users to subsidise the needs of the poor. Comparative figures showed that the average Durban user did not pay much more or less than other major centres for water. Prices for both domestic and industrial use in Durban were slightly more expensive than in Cape Town.

Speaking at the Union of African Water Supplies conference last week, Water Affairs and Forestry Minister Ronnie Kasrils said people were happy to pay for the water they used. He said his research showed that most people were willing to buy into the system.

"If you want to use 1 900kl a month, as do some wealthy households in leafy suburbs, then you can afford to pay for it," said Kasrils.

The Department of Water Affairs has set itself the target of providing water according to RDP standards — 25 litres a day from a tap within 200m — to 12 million people.

## APPENDIX V

### “Government Approves R850m Skuifraam Dam”

# Government approves R850m Skuifraam Dam

*Saturday Argus, 23 2000.*

#### WILLEM STEENKAMP

A new dam is to be built near Franschoek at a cost of R850-million.

The Ministry of Water Affairs and Forestry has given the go-ahead for the huge Skuifraam Dam on the Berg River.

It will take at least five to six years

for the dam to come on stream, but even when completed its reserves may not be enough to meet the rising demand.

This week Minister of Water Affairs and Forestry Ronnie Kasrils said water restrictions would have to be put in place within six weeks and thereafter applied on a regular basis

until the dam was operational. The details of the restrictions will be worked out with local authorities.

The Skuifraam Dam will be one of the biggest water schemes of its kind in the province. At its highest point the wall will be 60m (20 storeys) high. It will be 1km long.

The catchment area will cover a

huge 77km<sup>2</sup>. The dam will be built in the La Motte state forest, about 5km west of Franschoek.

Arthur Clayton, a Cape Metropolitan Council executive, said the department would not be paying for the construction of the dam through its budget and it would have to be funded from other sources.

University of Cape Town