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EVALUATION OF WATER SUPPLY TO DEVELOPING URBAN COMMUNITIES IN SOUTH AFRICA

PHASE 1 – OVERVIEW

Report to the
Water Research Commission
by the
Palmer Development Group

WRC Report No KV 49/94

REPORT TO THE WATER RESEARCH COMMISSION

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In association with

University of Cape Town

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Preface

The Water Research Commission appointed Palmer Development Group in association with the University of Cape Town's Water Research Group to carry out an evaluation of water supply to developing urban communities in South Africa in May 1992.

The broad objective of this project is: to carry out a strategic evaluation of the present status of domestic water supply to developing communities in the urban areas of South Africa with a view to providing relevant and up to date information and analysis upon which rational policy and practice may be based so that the large and increasing demand for basic water supply services in poor / low-income / developing urban communities may be met in an economically efficient and equitable manner.

The project was conceptually divided into three phases as follows:

Phase 1: Overview

a. A review of the current status with water supply to developing areas internationally.

b. Execution of a survey of water supply to the urban areas of South Africa, based on questionnaires and interviews, to determine who has access to adequate water supply, what type of systems are being used, and to obtain as much operating and cost information as possible.

Phase 2: Evaluation

a. Evaluation of water supply systems from the point of view of acceptance by communities, health impact, cost, ease of construction and operation and environmental impact.

Phase 3: Strategies

a. Development of a strategy for dealing with water in these developing urban areas over the next decade.

b. Preparation of guidelines for the selection, implementation, operating and maintenance of water supply systems.

This report presents the results of the work carried out under Phase 1 of the project.

This project is closely related to the Urban Sanitation Evaluation project which has recently been completed for the Water Research Commissionby by the same team of consultants. It is intended that the two projects complement each other because domestic water supply and sanitation are closely related and coherent joint policies and strategies are required to meet the demand for both of these services in an effective manner that takes cognisance of the full spectrum of technological options, financial and economic costs and affordability, environmental impacts and social acceptance.

List of Documents

This report is a summary of the findings relating to Phase 1 of the project and is based on detailed information collected throughout South Africa. Fuller reporting of this information has been prepared, taking each of the development regions in the country separately. These reports are listed below and, together with this summary report, represent the full reporting for Phase 1 of the project.

The reports listed below are in draft form at the time of printing of this summary report. They will be edited and made available in final form early in 1994.

Domestic Water Supply : Regions A - J

1.	Region A	:	Western Cape
2.	Region B	:	Northern Cape
3.	Region C	:	Orange Free State, including QwaQwa and part of Bophuthatswana
4.	Region D	:	Eastern Cape, Ciskei and portion of Transvaal
5.	Region E	:	Natal / Kwazulu
6.	Region F	:	Eastern Transvaal
7.	Region G	:	Transvaal, Gazankulu, Lebowa and Venda
8.	Region H	:	PWV and the Adjacent Areas of KwaNdebele and Bophuthatswana
9.	Region J	:	Western Transvaal including Bophuthatswana

Bulk Water Supply to Metropolitan Areas

1. Bloemfontein
2. Cape Town
3. Port Elizabeth

Acknowledgements

The research in this report emanated from a project funded by the Water Research Commission and entitled:

"Technical, socio-economic and environmental evaluation of water supply to developing urban areas in South Africa".

The Steering Committee for this project included the following people:

HC Chapman	Water Research Commission (Chairman)
BM Jackson	Development Bank of Southern Africa
C Croeser	PLANACT
C Sweigers	Department of Water Affairs
B Myrdal	Development Action Group
M van Ryneveld	University of the Witwatersrand
JP Rodrigues	Municipality of Durban
S van der Merwe	Rand Water Board
A Fourie	Cape Provincial Administration

The financing of the project by the Water Research Commission and the contribution of the members of the Steering Committee is gratefully acknowledged.

In carrying out the work for this report an extensive survey was undertaken of organisations involved in the provision of water throughout South Africa. The success of this survey has been due largely to the efforts of the numerous people who responded to it, be they in local authorities, other public authorities, water boards, consulting firms, non-government organisations or community-based organisations. Their assistance and support is also gratefully acknowledged.

The project team for the project was drawn from members of Palmer Development Group and the Water Research Group at the University of Cape Town. In addition, the data collection and analysis for Region E (Natal/KwaZulu) was carried out by Davies Lynne and Partners and their contribution is appreciated.

Certain key inputs to the project were also provided by final year students at the University of Cape Town: Gus Hojem, Michael McCartan, Kobus Heigers and Stewart Heather-Clark. Their assistance has been invaluable.

Finally the authors would like to acknowledge the support given to the project by the World Bank and their consultants, particularly in making information available on experience in the field of water supply worldwide.

1. INTRODUCTION

"AN ADEQUATE WATER SUPPLY FOR ALL"

Water is essential to life, to social development and to economic progress. Yet in South Africa there exists a large number of people (in both rural and urban areas) without adequate water supplies. Considering the economic resources at South Africa's disposal this is inconsistent and indicative of failed previous policies. Based on the findings of this study it is considered that providing an adequate and safe supply of water to all of South Africa's urban residents is an achievable and affordable aim. The key to achieving this is the development of a coherent national and regional policy framework, the development of sensible financial policies for the construction and ongoing operation of water supply infrastructure, the establishment of economically sustainable water tariffs with proper cost recovery and the rationalisation of institutions so that these goals can be most effectively achieved.

AIMS AND SCOPE OF PROJECT (PHASE 1)

The objective of this project is to contribute to the development of the necessary conditions (as outlined above) for the realisation of the goal of ensuring and facilitating the provision of an adequate water supply to all urban residents in South Africa (both now and in the future).

The development (and implementation) of appropriate and realistic policies requires a careful analysis and proper understanding of all aspects the existing situation. Phase 1 of this project contributes to this understanding by providing the following base information and analysis:

- **summary of the lessons that have been learnt from international experience in the provision of water supply to poor communities (institutional and financial)**

  Recent world-wide initiatives to improve water supply to poorer communities are reviewed, and the way these have been related to South Africa by international agencies are discussed.

- **quantitative analysis of the need for basic water supply services in the urban areas of South Africa**

  Presentation of the results of a survey conducted in all the urban areas to determine number and distribution of people without adequate access to safe water supplies and the levels of service currently available.

- **qualitative description of the current water supply arrangements in the urban areas of South Africa (at a macro / institutional level)**

  Overview of the institutions involved in the management of water supply arrangements, bulk water supply arrangements in the main metropolitan areas, domestic water consumption patterns, tariff and tariff policy and operating and maintenance problems typically experienced.

- **overview of domestic water demand in South Africa, current and future**

  Summary of current water demand in the major urban areas of South Africa and review of demand projections, including the relationship of domestic demand to water demand for other uses.

- **forecast of the demand for water supply services in the future**

  An estimate of the demand for water supply services up to the year 2000, calculated on the basis of the existing need, a demographic projection model and an income distribution model.

- **initial assessment of the cost of providing adequate water supply to all people living in the urban areas of South Africa**

  Calculation of the capital cost of providing the basic infrastructure required based on initial cost estimates.

- **review the current water supply design standards, in the urban areas of South Africa (at an micro / project level), comparing this with international practice**

The current standards affecting service level and functioning of water delivery arrangements are reviewed in the light of a literature survey and the relative merits of various standards are discussed.

- **discussion of the role of water conservation in the context of water scarcity and the socio-economic and political imperative to extend and upgrade water supply networks**

  Water as it affects the environment is dealt with in general terms and the importance of water conservation is addressed with examples of conservation measures.

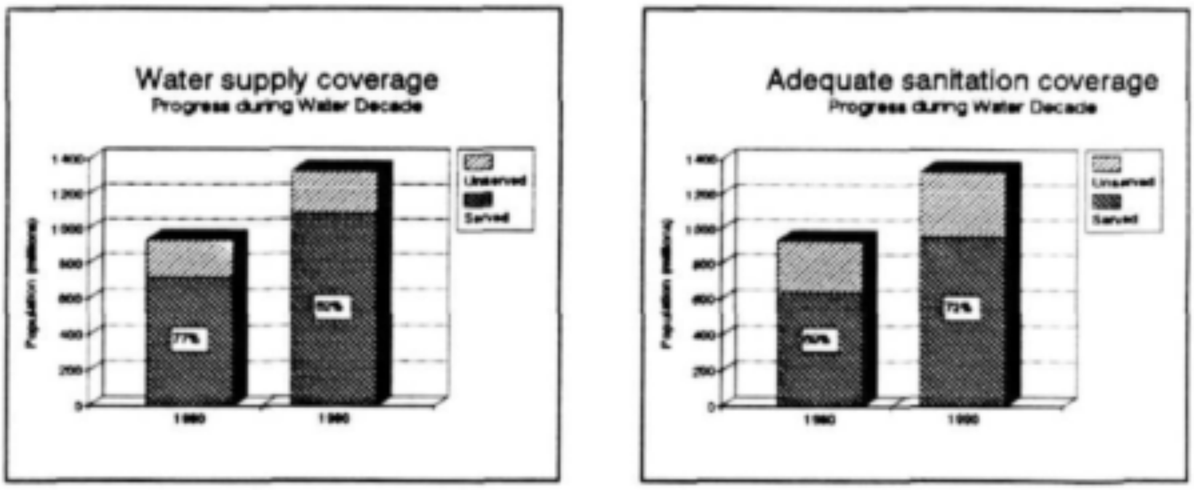
2. LESSONS FROM INTERNATIONAL EXPERIENCE

2.1 INTRODUCTION

In response to the critical situation with regard to poor people's access to safe water supply and adequate sanitation, the United Nations declared the 1980's as the **International Water Supply and Sanitation Decade** with the goal of providing everyone in the world with a supply of safe water and adequate sanitation by the end of the decade.

Although much has been achieved in the past 10 years, the task ahead is still huge. The following figures graphically illustrate the water and sanitation coverage figures in urban areas reported to the United Nations General Assembly at the conclusion of the International Water and Sanitation Decade (UNDP, 1990)

Figures 2.1 and 2.2: Water and sanitation coverage - Water Decade



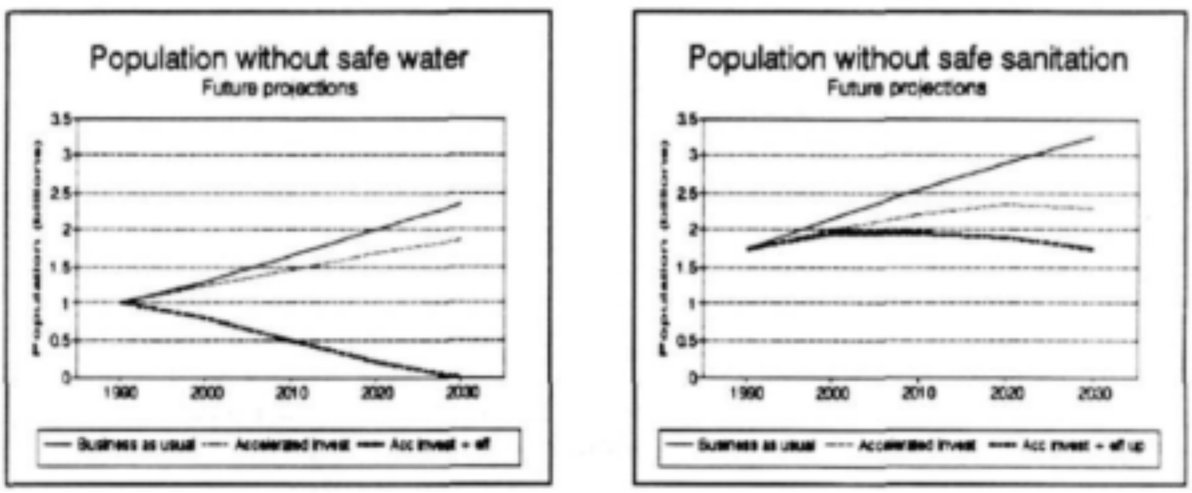
Source: Kalbermatten, 1992

The figures show that, although advances were made in providing many more people with water supply and sanitation services during the decade, population growth meant that little headway was made in reducing the total number of people without water and sanitation services.

It is possible that these figures are underestimates because information on the quality of service provided is not included and they also assume that systems, once constructed, remain in good working order.

The World Development Report (World Bank, 1992) provides three scenarios for future access to safe and adequate sanitation, graphically illustrated below:

Figures 2.3 and 2.4:



Source: World Bank, 1992 a

In South Africa it has been estimated that:

- one in every four people (10 million) lack access to a safe water supply[1];

- one in every two people (19 million) lack access to adequate sanitation[2]

Given the immensity of this task, it is vitally important that the lessons learnt from initiatives around the world are incorporated and integrated into any local initiative aimed at improving the access to adequate sanitation and water supplies to poor people in South Africa.

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1 Sources: Urban: 4.6 million people (Section 3)
Rural: 6.10 million people (Pearson, 1991)

2 Sources: Urban: 7.67 million people (PDG/UCT, 1992)
Rural:11.1 million people (Pearson, 1991)

This chapter provides an overview of the key lessons learnt from water supply and sanitation initiatives around the world. Specific examples of project failures and / or successes are not given here as they may easily be found in the references listed at the end of the section.

Although the present study concerns urban water supply only, water supply and sanitation issues are integrally connected and the international literature usually discusses both of these services together. Therefore much of what is stated here applies equally to the sanitation sector.

2.2 LESSONS FROM THE WATER AND SANITATION DECADE

The New Delhi Statement

The New Delhi Statement (UNDP, 1990) is an appeal to all nations for concerted action to enable people to obtain two of the most basic human needs: safe drinking water and adequate sanitation.

The statement was adopted by 600 participants from 115 countries at the Global Consultation on Safe Water and Sanitation for the 1990's organised by the United Nations Development Programme (UNDP) and held in New Delhi, India, from 10 to 14 September 1990. The aim of the consultation was to review the successes and failures of the water and sanitation decade, to set new goals and targets, and to draw out principles that would facilitate the achievement of these targets.

The key consensus arising from the consultation was the principle of:

"Some for all rather than more for some" [3]

This consensus arose out of the context of the great demands being placed on governments in the Third World whose resources are being stretched to the limit. Rapid urbanisation coupled with low economic growth is giving rise to high unemployment, collapse of urban infrastructure, environmental degradation and depletion of water resources.

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[3] This principle requires qualification : 'some' is not meant to refer to a 'little' with no regard to any minimum health standards. This is made clear by the goal of providing adequate water supply and sanitation to or by the year 2000. For definition of 'adequate' see section 3.

To meet the needs of safe water supply and adequate sanitation for all people by the year 2000 would require a five fold increase in the current levels of investment would be required. In the context just sketched, this is clearly unrealistic. Fundamentally new approaches are needed to prevent this broad scale deprivation from turning into an unmanageable crisis.

The consultation identified what it believed to be a realistic two-pronged approach:

(1) ***Substantial reduction in costs of services***

through - increased efficiency
- low-cost appropriate technologies

(2) ***Mobilisation of additional funds***

through - existing sources
- new sources

including - government
- donors
- consumers

If costs were halved and financial resources doubled, the consultative conference believed that universal coverage would be within reach by the end of the century.

Guiding Principles

The conference recommended the following guiding principles:

1) ***Protection of the Environment and safeguarding health***

through - integrated management of water and wastes (solid and liquid)

2) ***Institutional reforms***

through - adopting an integrated approach
- full participation of women at all levels
- changing attitudes, behaviours and procedures

3) ***Community management of services***

supported by

- measures to strengthen local institutions in implementing and sustaining water and sanitation programmes

4) ***Sound financial principles***

achieved through

- better management of existing assets
- widespread use of appropriate technologies

These principles are amplified below.

(1) Environment and Health

Safe water and proper means of waste disposal are essential for environmental sustainability and better human health, and must be at the centre of integrated resources management.

Human health and the sustainability of the bio-physical environment are being threatened on a global scale. The poor, especially the women and children, are most affected by these threats.

Water related diseases pose a particular threat to the poor. Safe water supplies and access to adequate sanitation can significantly reduce these threats.

Toxic and industrial wastes pose increasing dangers to the environment and threaten the long-term sustainability of the bio-environment and human health. Measures must be adopted by governments and responsible agencies to control these hazards.

Improvements to the household environment are only possible through community participation, social mobilisation and education, building on indigenous experience and knowledge, and when governments and agencies engage in an equal partnership with the local communities

Integrated water resource management is necessary to combat increasing water scarcity and pollution. The nature and cost of water supply and the impact of water pollution will, to a large extent, determine the choice of sanitation technology.

(2) People and Institutions

Strong institutions are essential for sustainable development.

Institutional development takes time. The short term achievement of production targets should not take precedence over the need for building the capacity of institutions.

A changing role of government is envisaged, from that of provider to that of promoter and facilitator. This implies a decentralisation of service provision, demanding a strong policy and support role from central government and allowing local public, private and community institutions to deliver better services.

The role of non-government organisations is important because of their credibility, flexibility and willingness to innovate. Governments should support NGOs and enter into partnership with them in projects where appropriate.

Human resource development, at all levels, is essential to institutional development. Women should be trained and guaranteed equal employment opportunities at all levels of staff and management.

Education is the key to the success of the new approach. The principal of "some for all rather than more for some" and the importance of health, safe water supply and adequate sanitation for all people should be taught in the schools. The training of engineers involved in infrastructural services design and implementation should incorporate substantial elements of community development, communications, appropriate technology and project management.

(3) Community management

*Community management is about **empowering and equipping** communities to **own and control their own systems.***

Community management is the key to sustaining services for the rural poor and is a viable option for poor urban settlements. Governments should support community management.

Communities should play a prominent role in planning, resource mobilisation, project implementation and ongoing resource management. Women should be encouraged to play a leading role. Capacity building is essential to achieve these goals.

Linkages must be developed to ensure that national plans and programmes are responsible to local community needs and desires.

(4) Finance and Technology

*Given the number of people unserved and the growing demand, **more effective financial strategies** and **more innovative low-cost technologies** must be adopted to ensure the long term sustainability of the sector.*

Current levels of investment in the sector are about US$ 10 billion per year. It is estimated that approximately US$ 50 billion a year would be needed to reach full coverage by the year 2000, using conventional approaches. Such a five-fold increase is not immediately feasible.

New strategies should aim towards two key objectives:

- increased efficiency in the use of available funds;
- mobilisation of additional funds from existing and new sources, including governments, donors and consumers.

Substantially increased effectiveness in the use of financial resources can yield major gains in sustained coverage. This will require changes in the way service agencies operate, to make them more cost-effective and responsive to consumer needs and demands. Involving consumers in choice of technology and service levels has proved to have a positive impact on cost recovery and sustainability.

A higher proportion of funds should be allocated to affordable and appropriate projects in rural and low-income areas, where needs are greatest.

Choices of **technology** and levels of service are major factors in determining construction, operation and maintenance costs of new projects. Due attention should be given to operation and maintenance arrangements which will ensure sustainability before investments are made.

Research and development in developing countries has resulted in widespread application of much improved water supply and on-site sanitation technologies. The momentum established during the 1980's must be maintained and increased in the next 10 years. Among the **priority** needs for the 1990s are improved household technologies for **protecting water quality from source to mouth** and low-cost wastewater disposal systems for low-income areas. Exchange of information and experience among developing countries must be further developed.

2.3 THE ABIJAN ACCORD

Delegates from 45 African countries met in Abijan, Côte d'Ivoire in May 1990 and reached agreement on approaches and strategies need to tackle their formidable problems in meeting the water supply (and sanitation) needs of the continent's population in the 1990s. The outcome of their deliberations are recorded in the paper titled "Guidelines for the Development of Country Strategies for the 1990s" (Abijan Accord, 1990). A summary of the key strategies suggested by the conference is presented below:

Suggested strategies for the 1990s

- Each country should formulate a sector development strategy, defining. *inter alia*, sector objectives, institutional responsibility and authority, resource allocation, and cost recovery policies.

- Investments should be based on **effective demand** and long term **sustainability**. Tariffs, set to recover the costs of the service, should ensure financial viability of the service organisation, economic efficiency and social equity.

- Priority should be given to the **rehabilitation and maintenance** of existing **assets**.

- **Community participation** should be an integral part of all project development and implementation.

- **Institutional** arrangements should promote **accountability to the end user**, the use of market principles and the financial autonomy of institutions as far as is possible.

- **Technologies** should be applied appropriately taking into account, amongst others, social-cultural preferences, affordability and long term sustainability.

- The strategies should aim at **maximising coverage** with a basic level of service before giving attention to upgrading existing adequate services.

- Water and sanitation investments should be **integrated** with primary health care strategies and solid waste and sullage disposal and stormwater drainage. [Kalbermatten, (1992) uses the term "environmental services" for these services and proposes an approach to the integrated delivery and management of these services].

- There should be regular regional meetings to promote the **exchange** of experience and expertise among African countries.

2.4 LESSONS FROM THE WORLD BANK

2.4.1 World Development Report (1992)

The World Development Report of 1992 (World Bank, 1992a), in its chapter on sanitation and clean water, argues that large gains - in environmental quality, health, equity and direct economic returns - can be realised by adopting an approach that comprises four key elements:

- managing water resources better, taking account of economic efficiency and environmental sustainability

- providing, at full cost, those "private" services that people want and are willing to pay for (including water supply and the collection of human excreta, wastewater, and solid wastes)

- using scarce public funds only for those services (specifically treatment and disposal of human excreta, wastewater and solid wastes) that provide wider community benefits

- developing flexible and responsive institutional mechanisms for providing these services, with a larger role for community organisations and the private sector.

Willingness to pay and level of service

The report notes that most developing countries cannot afford to provide all people with in-house piped water and sewerage connections. The policy has, in the past, often been to provide a high (and subsidized) level of service to a few people at the expense of a lack of even a basic level of service for many others. The report notes further that, in urban areas, most people want on-site and reliable water supplies and are willing to pay the full cost of these services. There will however be communities who cannot afford this. In these cases a "social tariff" may be implemented whereby the better-off cross-subsidise the poor. Another option is to finance the connection cost by allowing consumers to pay over a number of years. The World Bank comments that such policies are both sensible and compassionate, but that care should be taken that these subsidies remain within the parameters of the original intention.

Institutional arrangements

A comprehensive review of World Bank projects (World Bank, 1992b) came to the conclusion that "institutional failure" was the most frequent and persistent cause of poor performance by public utilities. The World Development Report (1992a) identifies the following key areas for institutional reform:

- **Improving the performance of public utilities**

Some examples of poor institutional performance noted in the report are:

- The number of employees per 1 000 water connections is between 2 and 3 in Western Europe and about 4 in a well-run developing country utility, but between 10 and 20 in most Latin American utilities.

- Unaccounted for water, which amounts to 8% in Singapore, is 58% in Manila and about 40% in most Latin American countries.

- Low cost recovery as the result of tariff policies dictated by political considerations rather than source economic principles, necessitating large injections of public money into the water sector. In Brazil, about $1 billion of public money was invested in the water sector annually over a decade.

The Bank notes that an essential requirement for effective performance is that both the utility and the regulatory body be free from undue political interference. In the case of the utility, managerial autonomy is key, and for the regulatory body, freedom to set reasonable tariffs. Although this practice is simple in concept and easy to implement, and has been well tested in developed countries, the Bank experience has been that it is extraordinarily difficult to implement in many developing countries.

- **Separating provision and regulation**

This is important for two primary reasons:

- Water supply is a natural monopoly and therefore some external control must be exercised to ensure that the utility operates efficiently <u>and</u> to the benefit of the users.

- Environmental protection can only be effective if carried out by a separate body because a natural conflict of interest exists between the provision of water (and treatment of wastes) and the protection of the environment.

- **Expanding the role of the private sector**

  The Bank is of the opinion that there is scope for increased private sector involvement in two areas:

  - The provision of engineering and other professional services to public utilities. The rationale is that competitive tendering ensures efficiency. (Of course a competitive engineering consultancy sector is a pre-requisite).

  - Private involvement in the operation of water (and sewerage and solid waste) companies. *[This is a contentious point and its inclusion here is solely for the purpose of recording the Bank's perspective on this matter.]*

- **Increasing community involvement**

  It is by now well recognised that community groups and other NGOs have an important role to play in the provision of water and sanitation services.

  Because many water and sanitation services are monopolies, consumers cannot force suppliers to be accountable by giving their business to a competitor. It is therefore important that accountability of the service utilities be built into the institutional structures, for example through consumers' associations.

2.4.2 World Bank Involvement In South Africa

A team from the World Bank's Urban Reconnaissance Mission visited South Africa in 1991 to assess the current state of urban infrastructure and to make policy proposals for arriving at more efficient and equitable services. The team included recognised experts in the field of urban services provision (including water supply and sanitation) and their findings are therefore made with the weight of international experience supporting them.

The mission addressed three principle questions:

- What level of service might be provided?

- How might these services be financed? and

- How might such services be delivered and maintained?

Their conclusions and recommendations are summarised below (World Bank, 1991):

(1) Level of service

Availability of choice

A wide range of technical solutions exist, each with quite different financial and institutional implications. A central element of policy choice is the definition of mechanisms whereby local governments and local people choose the appropriate type and level of service.

Choices from correct information

Incomplete information exists on:

- the current conditions in black areas;

- performance of technologies under South African conditions;

- technical alternatives;

- relative economic and financial short term and life cycle costs of technical alternatives.

Choices must be based on complete, correct and relevant information. There is therefore a definite need for focused research in the above areas.

With regard to policy the World Bank warns against a supply driven approach with standards set in a paternalistic way as this locks people into an inappropriately low or high level of service.(For example, everyone should have a full water-borne sanitation system, or only site-and-service schemes with VIPs should be provided).

The following are suggested as key points relating to sound policy relating to the level of service:

- demand driven;
- facilitate choice of service level;
- facilitate choice of location;
- rationalise infrastructures ("one city" approach);
- build in possibility of upgrading services over time;
- ensure consistency (avoid hidden unjustifiable subsidies);
- build in flexibility;
- ensure transparency and accountability in decision making.

(2) Financing of services

The financing of services should be evaluated in the following context:

- The revenue bases in South African cities have been historically skewed to favour "whites". This means that there is justification for public spending to redress this disparity. Furthermore, the rationalisation of the city tax base is urgently required, ie. one city, one tax base.

- Costs (capital and recurrent operating and maintenance costs) vary widely for different levels of service. The choice of the level of service therefore has major implications for local, regional and central government financing.

- Water and sanitation services are quasi-private services and make up a large proportion of the total financing required for services.

- Tariff structures for water supply induce large financial and real distortions which in turn affect the choice of sanitation technology.

The World Bank recommends the following policies relating to the financing of services:

- rationalise a city's tax base and provision of services;
- apply non-distortionary subsidies;
- charge for services as this is essential for accountability, replaceability and poverty alleviation;
- price water economically and sanitation close to economic pricing;
- encourage the use of a high level of service through financing connection costs [provided that on-going operating and maintenance costs are affordable]; and
- deregulate the selling of water from private connections.

(3) Institutional arrangements

Key elements highlighted by the Bank with regard to institutions were the following:

- competition plays a role in reducing prices but does not eliminate the role of public institutions and
- transparency and accountability are vital to the legitimacy of institutions and their effective rendering of services.

They warn against replacing local authority responsibility for service provision with sector-specific utilities (with the exception of water which lends itself to regional catchment management) as this results in loss of accountability.

In setting policies for institutions, the following suggestions were made:

- **increase accountability and efficiency of local authorities;**
- define the role of the private sector; and
- give communities choices.

2.5 OTHER KEY POINTS ARISING FROM INTERNATIONAL EXPERIENCE

2.5.1 Promotion of good management practice

Yepes (1990) in a review of management and operational practices of municipal and regional water and sewerage companies in Latin America and the Caribbean stresses the importance of good management practice. He notes that this normally results in the development of distinctive organisation cultures, high esteem for the managers by company employees which can be translated into a mandate for company excellence, job stability, organisational continuity and good customer relations.

The World Bank's review of its own experience in water and sanitation projects (1992b) makes the point that "management may be the most critical concern for effective delivery of water supply and sanitation services". It goes on to say the effective management requires an autonomous mandate from government, a capability to independently select its staff, to establish and operate salary, wages and benefit systems for the skills required, and to establish economic and financial management criteria that enable it to compete effectively for the required equity and loan capital. The Bank recommends that "policy efforts in this area should, in priority, address the corporatization of public owned utilities [that is, mould them to "act like" private corporations] and the design of regulatory frameworks capable of dealing efficiently with both these and privately owned utilities."

Financial autonomy of water supply institutions is noted in much of the international literature as being vitally important to good institutional performance.

2.5.2 Implementation of performance measures

Yepes (1990) also notes the importance of using performance measures as a tool in improving institutional performance. These measures may be used both internally by the organisation itself and externally (by the watchdog agency). However, he cautions that performance indicators may be easily misinterpreted as they represent only a part of the picture and they may also be manipulated to suit an organisation's own goals.

The USAID's Water and Sanitation for Health Project (WASH) has written a guideline document for assessment of institutions involved in water (and sanitation) supply (WASH, 1986). Some of the performance measures they recommend for water supply institutions are:

- percentage population served
- percentage unaccounted for water
- quality of water delivered
- service interruptions
- minimum pressures during peak usage
- response to leakages and other maintenance and breakdown tasks
- storage capacity as a function of daily demand
- ability to provide adequate service during peak season and peak hourly demands and the ratio of peak hour to average daily flow
- per capita water consumption
- extent of enteric diseases within the area.

Financial indicators are equally important and should be implemented and reported on periodically. Examples are: management of assets, level of accounts receivable and cash flow analyses.

It should be noted that the setting up adequate information systems is necessary for the measurement of performance and internal and external financial auditing.

2.5.3 Development of institutional capacity

Weak institutional capacity was highlighted in much of the international literature as being a key contributor to project failure. Despite the World Bank's efforts to promote institutional development within its own programmes, reviews of the success of these initiatives have not been encouraging (Paul, 1990; World Bank, 1992b). Paul (1990) warns against overly complex institutional development designs in projects and recommends that more resources be given to institutional development both during project implementation, but more importantly, in the project preparation.

The implementation of timeous and well designed training programmes would appear, from international experience, to be essential to the development of effective organisations and the efficient implementation, operation and management of water supply systems.

2.5.4 Cost recovery and tariff policies

The importance of achieving cost recovery and implementing tariff policies that are based on sound economic principles is stressed in almost all of the international literature in this field. In particular, the principal of economic costs (as apposed to financial costing), using shadow pricing and taking into account externalities, to ensure the efficient allocation or scarce resources is often overlooked in water and sanitation projects. Although much has been written in the literature about setting tariffs equal to (or at least related to) marginal costs, in practise there is little evidence of this being implemented, and furthermore, there is a noted lack of availability of good manuals / practical guidelines to help people managing water utilities to calculate their tariffs and how to relate these to marginal costs.

It should, however, be borne in mind that tariff policies also need to take into account policy goals other than economic efficiency, the most important of which is equity. This is particularly important in the South African context given the severe inequity that has developed, largely as a result of apartheid policy.

Where a basic level of water supply cannot be afforded, consideration should be given to the implementation of social or life-line tariffs.

The continual review of tariff policies and levels requires particular attention in an inflationary environment.

2.5.5 OTHER OPERATION AND MAINTENANCE ISSUES

Other important operation and management issues, which largely speak for themselves, but are in many instances given insufficient attention are:

- **Unaccounted for water / water losses management**
- **Water conservation**
- **Preventative maintenance**

2.6 SOUTH AFRICAN RESPONSE TO INTERNATIONAL LESSONS

The current water supply arrangements in South Africa are described in sections 3 and 4. In these sections it will become clear that South Africa has much to learn from international experience. However, there are South African initiatives to address these issues, the more important of which are described in section 4.

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3. ACCESS TO WATER SUPPLY - AN OVERVIEW

3.1 INTRODUCTION

A survey of the water supply arrangements in the urban areas of South Africa was carried out as part of this project. This section summarises a portion of the results of this survey, namely:

- The number and distribution of people without adequate water supply services in the urban areas of South Africa.
- The levels of water supply service currently being used in the urban areas of South Africa, specifically, how many people have access to what level of service, and the geographic distribution of the level of water supply service.

The full information collected in the survey is presented and discussed in separate profiles written for each of the development regions of South Africa (as defined by the Development Bank of Southern Africa). These documents are titled: "Domestic Water Supply in Region A: The Western Cape - An Overview" etc. (See document list at the beginning of this report).

The survey was carried out through questionnaires and interviews directed at local authorities and regional services councils. It was not exhaustive and therefore the results should not be used as firm indications of local conditions. Rather they should be used as a way of interpreting the overall situation within regions and sub-regions, and as a way of demonstrating trends.

In order for the results of the survey to have greater meaning, particularly with regard to trends, it is desirable for further surveys to be carried out in the future.

3.2 METHODOLOGY

Method of data collection

The review was conducted primarily through a questionnaire survey of:

- Local authorities and
- Regional Services Councils

Examples of these questionnaires are included in Appendix A. However, reliance solely on the questionnaire returns would have led to an unbalanced overview for a number of reasons:

- uneven response to survey
- the complexity of the metropolitan areas not adequately reflected in the questionnaire returns
- inaccuracies in information reported
- TBVC states, self-governing territories and previous trust lands were largely excluded from the questionnaire survey

To overcome these limitations, extensive use was made of telephone calls and interviews with relevant people in local authorities, homeland governments, civic associations, consultants etc. Effort was concentrated on the larger urban populations in this process, while at the same time, every effort has been made to, at least, develop a representative picture of water supply arrangements in the more scattered smaller urban settlements.

Definition of urban

The Urban Foundation's definition of urban has been used, which includes metropolitan areas, towns and dense settlements. Towns are generally, but not in all cases, proclaimed towns. Dense settlements are "closer" settlements in peri-urban or rural areas (mostly in "self-governing states" , TBVC states and previous Trust lands) where people are reliant on the urban economy through commuting on a daily or weekly basis. Further, people in these dense settlements do not derive significant income from agriculture. The distinction between rural villages and dense settlements is somewhat vague; nevertheless every attempt was made to maintain compatibility with the dense settlement estimates as provided by the Urban Foundation model.

Population figures

The 1991 urban population census (adjusted) information was unavailable at the time of conducting these regional profiles. Settlement population data (obtained from primary sources: local authorities etc.) was therefore aggregated and checked against the macro population data from the Urban Foundation Population Projection Model (1991), using 1990 population figures as a basis. (This model is based on the 1985 Census.)

It became evident in analysing the results of the survey that there is a great tendency for local authorities to over estimate the population within their area of jurisdiction. In the absence of reliable alternative population figures, these figures have, in most cases, had to be accepted. The macro-population adjustment counters this tendency to overestimate populations.

Definition of adequate water supply

The issue of what represents an "adequate" water supply is a complex one. The approach taken in this report is not to firmly define what is adequate but rather to refer to other sources of information and to discuss the factors which affect the adequacy of a water supply. In the further phases of the project, of which this report forms a part, firmer recommendations relating to what is "adequate" will be made. However, there has been a need in analysing the results of the survey to classify the results and this has meant that an interim position on how a level of service should be grouped needs to be taken. This position is put forward at the end of this sub-section.

Adequacy of a water supply has three components:

- **Reasonable access to a water source.**
- **Availability of a sufficient quantity of water.**
- **Acceptable quality of water.**

Dealing firstly with **access**, the key factors are:

- Distance to the water supply point.
- Ease with which this distance can be walked (slope being an important factor).
- Waiting time at a water point.

With regard to **quantity**, key factors are:

- The needs of the household which will relate to their socio-economic circumstances and the type of service they are used to.
- The ease with which water can be carried; typically people will use less water if it is harder to transport, which relates to the access factors.
- The amount which people have to pay for water.

Finally, with regard to **quality** the extent to which water can be consumed directly without a health risk is of primary importance.

Many water authorities in South Africa and internationally have their own approach to defining what is adequate. This is generally done through the standards which they apply. This is dealt with in Section 7 of this report which includes information on the relationship between the quantity of water used and the level of service provided.

It is notable that it is generally not possible to have a single definition of what is "adequate", particularly in a developing country, as one needs to deal with the transition which exists with some people having very poor supplies and others who have a history of living in urban areas with very good supplies. In order to provide for this situation, the approach taken in this report, as an interim position, is to have a two-tier classification, as follows:

- Proclaimed urban areas: at least 1 water point (standpipe) per 25 households, or within 50m of each household, with provision for at least 30 litres of water per capita.

- Dense settlements: in such cases it is arguable that a water point within 250 metres, or possibly 500 metres, providing at least 15 litres per person per day, is adequate in a transitionary situation. However, for the purpose of this report this level of service is referred to as "rudimentary" and reference to "adequate" conforms with the supply situation for proclaimed urban areas.

The difficulties with the survey information for dense settlements is discussed further in the sub-sections below.

Relationship between definition of adequate and service levels used in survey

The following levels of service were used in the questionnaire survey:

On-site: House connection
Yard tap
Other on-site source

Off-site: Communal standpipe
Wells / boreholes
Other off-site source (eg tanker)

In assessing the adequacy of these levels of service, the above categories were reorganised as follows:

Adequate: House connection
Yard Tap
Communal standpipe:
- planned provision of water,
- at least one standpipe per 25 households,
- communal standpipe within 50m

and quantity and quality of water adequate.

Rudimentary: Communal standpipe:
- ad hoc provision of water,
- more than 25 households per standpipe
- standpipes further than 50m

Well, borehole or other source, not reticulated

or inadequate quantity
or unacceptable quality of water.

None: No water supplied to community, community reliant on water in neighbouring areas.

Guidelines used in the assessment of adequate water supply in the dense settlements

Although every effort was made to conform to the project definition of adequate access, this was not always possible in the case of the dense settlements for a number of reasons. This survey had to rely on secondary information (reports of consultants, knowledge of local experts, statistics collected by various authorities) for much of the data on levels of water supply in the dense settlements. Hence, the assessment of adequate water supply in the dense settlements was very dependent on the way in which this data had been collected. For example, data collated for dense settlements and villages in Bophuthatswana was only available in the following categories:

Yard connection
Water point within 500m
Water further than 500m

An assessment of adequate water supply according to this project's definition is clearly impossible given this data set. This problem was replicated in varying forms for almost all of the dense settlement populations in the different self-governing and "independent" states and the former trust territories. The approach adopted in each of these areas was therefore a function of the form in which the data was available and is explained in each of the separate regional profiles. Generally the figures are reported using the classification in the form in which the information was received. A general assumption was then made on the level and adequacy of service with respect to the definitions used in this project in order to maintain compatibility in the figures between all of the urban areas.

3.3 DEMOGRAPHIC OVERVIEW

This section provides an overview of the South Africa urban population. The information is based on the Urban Foundation Demographic model[1]. All figures are for 1990 and include the TBVC states unless otherwise stated.

Total population	37.5 million
Total urban population	24.5 million
Percentage urban	65%

The total population given by the model is quite close to that reported by the 1991 Census (plus TBVC population from DBSA figures) of 37.6 million.

A key characteristic of the Urban Foundation model is its broader definition of 'urban' (see Section 3.2) and hence the extent of urbanisation reported is much higher that the 50% calculated from 1991 Census information (CSS, 1992) and data for the TBVC states (DBSA, c1991).

TABLE 3.1 Distribution By Settlement Type (millions)

	Metro	Town	Dense Settlement	Total
RSA	13.0	3.8	0	16.8
TBVC	1.8	0.44	0.93	3.17
Self-governing	2.6	0.64	1.3	4.54
TOTAL	17.4	4.9	2.2	24.5
%	71	20	9	100

[1] The model is based on 1985 census figures, with corrections made for undercounting. Although the 1991 Census figures are now available, this project has not made use of these for the reason that their consistency and accuracy are still a matter of debate.

Table 3.1 shows how the population is distributed by settlement type and between political boundaries. The institutional fragmentation of the metropolitan areas (for example, East London / Mdantsane) and the exclusion of dense settlements from the Republic of South Africa are clearly illustrated by the figures. Both the TBVC states and the self-governing territories have relatively small populations living in proclaimed urban towns, but large populations living in dense settlements. The metropolitan areas "allocated" to the TBVC states and self-governing territories are, in most cases, essentially dormitory "suburbs" heavily reliant on the "neighbouring" metropolitan area for economic activity (for example, Botsabelo (Bloemfontein) and Winterveld (Pretoria)).

Most of the dense settlements are widely dispersed, typically ranging in size from 5 000 to 16 000 people. The majority of the 2.2 million people living in dense settlements are situated in Boputhatswana (± 1.1 million) and Lebowa (± 730 000) and are remote from larger urban areas.

About 70% of the urban population is concentrated in the metropolitan areas, and is distributed as follows:

TABLE 3.2 Metropolitan Populations

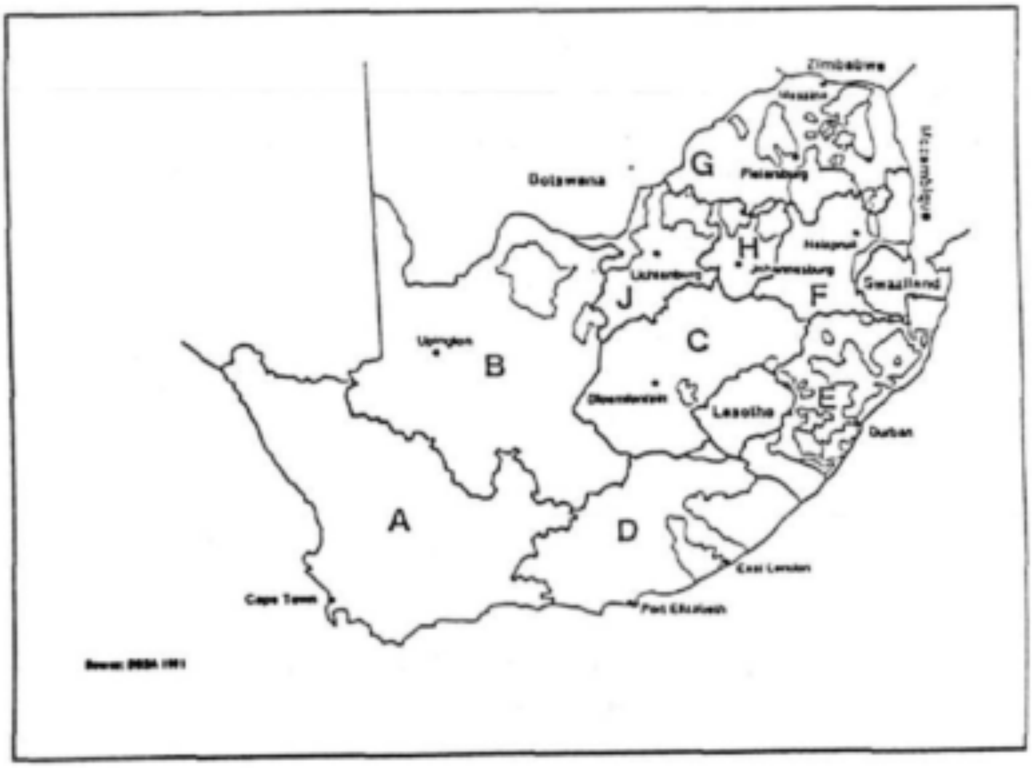
Metropolitan area	Total Population
PWV	8 740 000
Durban / Pietermaritzberg	3 580 000
Cape Town	2 560 000
Port Elizabeth	984 000
Bloemfontein	602 000
OFS Goldfields	468 000
East London / Mdantsane	451 000
TOTAL (metropolitan)	17 390 000

The PWV, Durban and Cape Town metropolitan areas together account for 61% of the total urban population and 86% of the total metropolitan population.

The data gathered in the survey has been aggregated by Development Region (as defined by the DBSA). These development regions are depicted in Map 3.1 below. The distribution of the urban population between regions is summarised below:

TABLE 3.3: Urban Population By Development Region

Development Region	Urban Population
A: Western Cape	3 160 000
B: Northern Cape	706 000
C: Orange Free State	1 700 000
D: Eastern Cape	2 410 000
E: Natal	4 440 000
F: Eastern Transvaal	911 000
G: Northern Transvaal	1 309 000
H: PWV	8 744 000
J: Western Transvaal	973 000
TOTAL	**24 400 000**



3.4 RESULTS OF THE SURVEY

3.4.1 Inadequate Access To Water Supply

Overview

The results of the survey indicate that there are approximately 4.7 million people living in the urban areas of South Africa without adequate access to a safe water supply. This represents 18 % of the urban population.

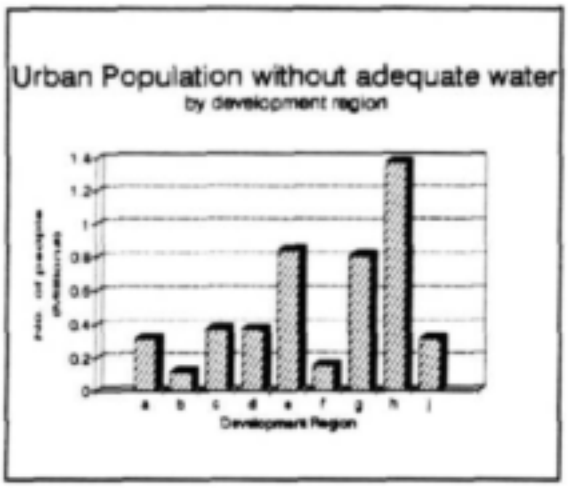
A breakdown of this figure by development region is given in Table 3.4 below.

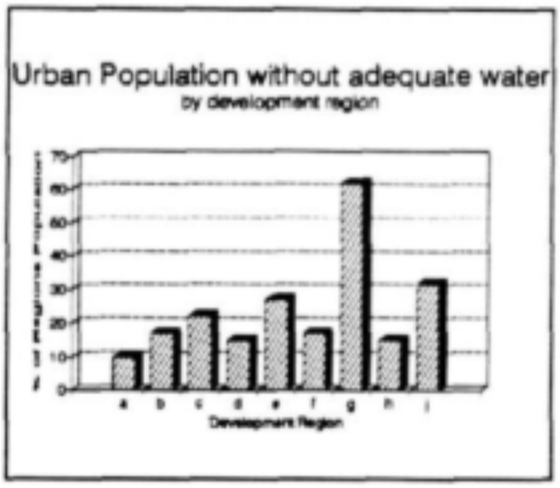
TABLE 3.4: Urban Population With Inadequate Water Supply - By Region

Development Region	Total Urban Population	Population without adequate water supply	Percentage
A: Western Cape	3 160 000	315 000	10 %
B: Northern Cape	706 000	117 000	17 %
C: Orange Free State	1 720 000	374 000	22 %
D: Eastern Cape	2 460 000	366 000	15 %
E: Natal	4 550 000	845 000	19 %
F: Eastern Transvaal	910 000	154 000	17 %
G: Northern Transvaal	1 310 000	813 000	62 %
H: PWV	8 740 000	1 366 000	15 %
J: Western Transvaal	972 000	311 000	32 %
TOTAL	**24 500 000**	**4 660 000**	**18 %**

The distribution of people without adequate water supplies is graphically illustrated in Figure 3.1. It should be noted that the quality of the data available was, in many cases, poor, and the data should therefore be treated with due circumspection. Nevertheless, these overall figures may be regarded as fairly representative of the existing situation. Information on the extent of survey coverage and confidence in the data for each region and within each region is provided in the respective regional profiles.

Figure 3.1: People without adequate water supplies in urban areas





Metropolitan areas

The situation with respect to water supply in the metropolitan areas is summarised in the table below:

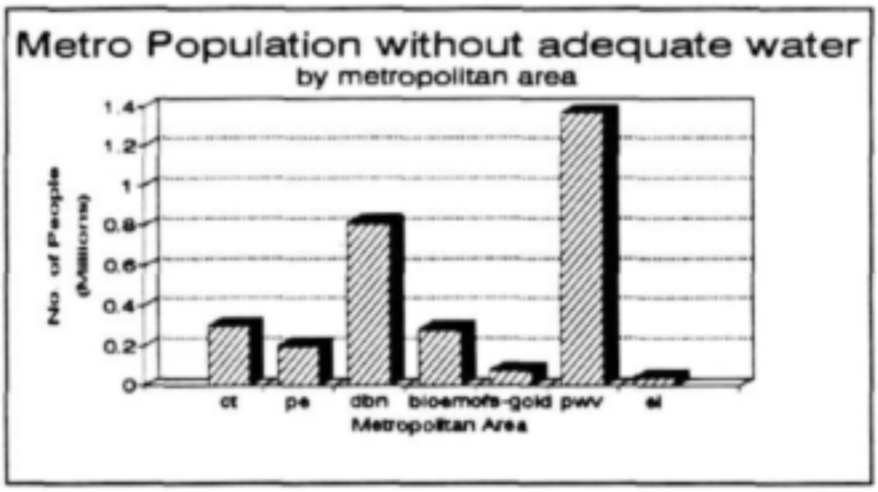
TABLE 3.5: Metropolitan Population With Inadequate Water Supply

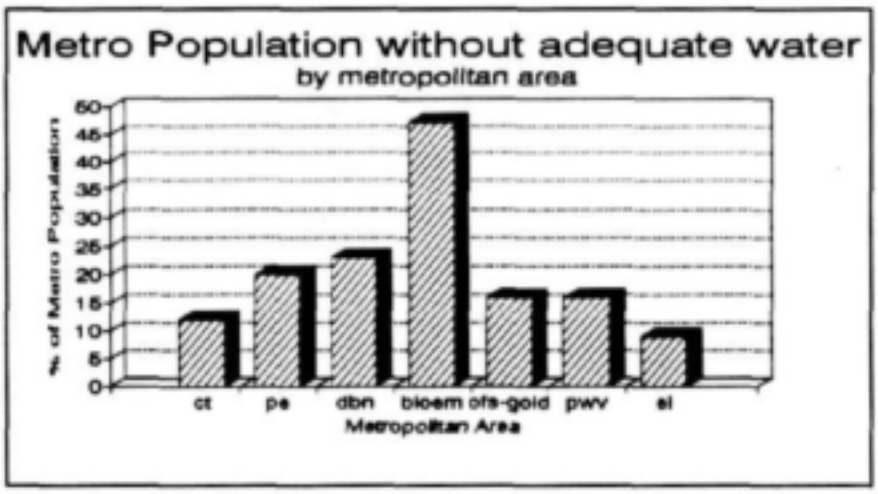
Metropolitan Area	Total Metropolitan Population	Population without adequate water supply	Percentage
Cape Town	2 556 000	300 000	12%
Port Elizabeth	984 000	200 000	20%
Durban / Pietermaritzburg	3 577 000	811 000	23%
Bloemfontein	602 000	280 000	47%
OFS-Goldfields	468 000	77 000	16%
PWV	8 744 000	1 366 000	16%
East London	451 000	40 000	9%
TOTAL	17 382 000	3 074 000	18%

These figures are graphically represented in Figure 3.2.

A major portion (66%) of the people without adequate water are living in the *metropolitan areas. Almost all of these people are living in informal settlements* and the lack of an adequate water supply is directly related to the backlog in housing / services provision in these areas.

Figure 3.2: People without adequate water supply in metropolitan areas





Towns

Of the 4.9 million people living in towns, about 268 000 (5%) don't have an adequate water supply. The populations in many of the smaller towns are relatively stable and service provision is generally adequate. However,an influx of people into towns from rural areas as a result to the drought has been reported in some areas, for example, the Orange Free State, and this affects services provision. Larger towns, such as Kimberley, are experiencing similar problems to the metropolitan areas; a backlog in service provision has developed, and significant capital investment is required to make this up and to cater for new demands.

Dense settlements

A summary of the situation in dense settlements in South Africa is tabulated below.

TABLE 3.6: People Without Adequate Access In Dense Settlements

Dense settlements	Dense settlement population	Population without adequate water supply	Percentage
Bophuthatswana	497 000	330 000	65
Venda	87 000	72 000	83
Ciskei	219 000	66 000	30
QwaQwa	125 000	50 000	40
Kangwane	187 000	115 000	62
Gazankulu	133 000	85 000	64
Lebowa	732 000	600 000	82
Subtotal	**1 980 000**	**1 318 000**	**67**
KwaZulu	119 000	[1]	[1]
Transkei	124 000	[1]	[1]
TOTAL	**2 223 000**		

1 Note: No information on dense settlements in KwaZulu and Transkei were found and these populations were aggregated with the respective town populations.

There are at least 1.3 million people living in dense settlements without adequate water supplies, representing about 20% of the total number of people without adequate water. Within the dense settlements, more than two-thirds of the population do not have access to an adequate water supply. These dense settlements are widely dispersed geographically, but are exclusively situated in the TBVC and self-governing territories. Institutional capacity in these areas is universally weak and is a key factor, along with the lack of local resources, limiting the provision of adequate services.

3.4.2 Level Of Water Supply

Overview

The level of water supply provided to people living in the urban areas of South Africa is summarised in Table 3.7 below.

TABLE 3.7: Level Of Water Supply - By Development Region

HC = House connection
YT = Yard tap
ST = Standpipe
ADE = Adequate (1 standpipe to less than 25 households or within 50m)
RUD = Rudimentary or unplanned (1 standpipe to more than 25 households or greater than 50m)
OTH-INAD = Other inadequate. Minimal or no water supply

Development Region	Total Urban Population	HC	YT	ST ADE	ST RUD	OTH INAD
A: W Cape	3 160 000	74	12	5[1]	[1]	9
B: N Cape	706 000	37	27	23[1]	[1]	12
C: OFS	1 720 000	53	11	29[1]	[1]	7
D: E Cape	2 460 000	58	11	17[1]	[1]	13
E: Natal	4 550 000	58	-	23		19
F: E Transvaal	910 000	64	7	12	9	8
G: N Transvaal	1 310 000	23	1	14	45	17
H: PWV	8 740 000	63	11	11	6	9
J: W Transvaal	972 000	54	1	15	11	19
TOTAL	24 500 000	59	9	15	5	12

Notes: 1. No distinction made here between adequate and inadequate standpipe provision. Note that for the calculation of number of people with inadequate water supply, the number of people with inadequate standpipe provision was included in the total.

Metropolitan areas

TABLE 3.8: Level Of Water Supply - Metropolitan Areas

Development Region	Total Urban Population	HC	YT	ST [1]	ST RUD [2]	OTH [3]
Cape Town	2 560 000	72	12	5		11
Port Elizabeth	967 000	53	18	8		21
Bloemfontein	587 000	46	-	39		14
OFS Goldfields	485 000	66	11	14		8
East London	443 000	88	1	11	-	-
Durban	3 086 000	66	-	28		5
PWV	8 744 000	63	11	11	6	9
TOTAL	16 870 000	64	9	14	3	9

Notes:
1. Standpipe supply
2. Rudimentary standpipe provision. Note that the distinction between adequate and rudimentary standpipe only made for PWV in this aggregated table. Note that calculation of number of people without adequate water in table 3.2 did include evaluation of the level of standpipe service provided for all of the metropolitan areas.
3. Other - inadequate minimal provision. Note that inadequate water supply will also include a proportion of those included under standpipe supplies. See Table 3.2 for total number of people in each metropolitan area without adequate water supplies.

It should be noted that the data for East London may not be representative and the situation could be worse than is indicated here (see regional profile). Also, collection of comprehensive and good quality data in the PWV and Durban areas was difficult but, nevertheless, it is felt that overall figures presented here are representative of the actual situation.

3.4.3 Extent of Survey Coverage

Region	Urban Population	% Coverage	Comment
A	3 160 000	93%	Good coverage achieved
B	706 000	75%	Good coverage (+90%) of towns (513 000). Little data available for dense settlements (193 000) and poor agreement between Urban Foundation model and detailed settlement information.
C	1 702 000	80%	Good coverage in Bloemfontein metropolitan area (602 000) except data for Botshabelo (214 000) coarse. Coverage in Goldfields metropolitan area good but information from various sources varied widely. Information for 43 out of 68 towns with a population coverage of +90%. Qwa Qwa settlement data good.
D	2 460 000	85%	Fairly representative coverage of all areas. Good coverage in Port Elizabeth metropolitan area (602 000).
E	4 550 000	94%	Good overall coverage achieved, however some of the data, especially informal settlements in Durban metropolitan area, is very coarse.
F	910 000	80%	Coverage in Transvaal (649 000) towns good - information for 33 out of 72 towns, but population coverage > 80%. In Kangwane (262 000) good coverage, but no distinction made between dense settlements and towns.
G	1310 000	62%	Good coverage (+90%) in Transvaal towns (149 000), poor agreement in survey and UF Model population figures in Gazankulu (161 000), reasonable coverage (55%) in Lebowa (894 000) and poor coverage (20%) in Venda (105 000).
H	8 744 000	93%	Good coverage (95%) of Black Local Authorities (4.6m), good coverage (100%) of White Local Authorities (2.46m), good coverage (85%) of Bophuthatswana (1.2m) from Bophuthatswana Water Plan and reasonable coverage (70%) of KwaNdebele using DBSA data base.
J	972 000	90%	Good coverage (+90%) of Transvaal towns (590 000), good coverage (+90%) of Bophuthatswana towns (79 000) and dense settlements (304 000) using Bophuthatswana Water Plan.

3.5 RELATION TO OTHER STUDIES

3.5.1 The number of people in urban areas with inadequate water supplies was estimated by van Ryneveld (1992) for the Water and Sanitation 2000 initiative. These figures are compared with figures from the survey done for this project below:

TABLE 3.9: Inter-Study Comparison

	Total urban population (millions)	Number of people with inadequate water	Percentage
Total urban			
This study	24.4	4.66	19
van Ryneveld (1992)	22.3	3.95	18
Metropolitan			
This study	16.8	2.73	16
van Ryneveld (1992)	15.9	2.95	16
PWV			
This study	8.74	1.4	15
van Ryneveld (1992)	8.75	1.8	21
Durban			
This study	3.1	0.47	15
van Ryneveld (1992)	3.6	0.8	22
Cape Town			
This study	2.56	0.3	12
van Ryneveld (1992)	2.55	0.2	8
Port Elizabeth			
This study	0.97	0.2	21
van Ryneveld (1992)	1.0	0.15	10

Discussion

van Ryneveld (1992) used a different breakdown of services, namely:

House connection
Yard tap
Standpipe with 250m
Water kiosk
Minimal provision

His figures for minimal provision have been quoted in the above table. The definition used for this study was more stringent, 1 standpipe per 25 sites (which for an average site size of 200 m² would translate to a distance of approximately 100 m).

The difference in the total urban population figures is accounted for by the fact that van Ryneveld did not include dense settlements in his study. As the level of service was generally much lower in this settlements, the close agreement between the two overall percentage figures is misleading. This study found less people without inadequate water supplies than estimated by van Ryneveld if the dense settlement figures are excluded from the summary, as follows:

	Urban population	Population without adequate water	Percentage
This study	21.5 million	2.8	13
van Ryneveld	22.3 million	3.95	18

3.5.2 CSIR Service Questionnaire

The CSIR has recently initiated an annual survey of local authorities requesting information on housing and levels of service for water supply, electricity, sanitation and roads. The CSIR survey and this overview should be regarded as complementary. The CSIR survey is more limited in scope than this overview, nevertheless it will provide a valuable cross check on much of the data collected in this overview.

These regional profiles of domestic water supply are also complementary to the regional profiles of urban sanitation provision, conducted by the University of Cape Town in conjunction with Palmer Development Group for the Water Research Commission during 1991.

3.5.3 Census Information

The South African census does not enquire as to whether or not a household has access to water on its site even though it requests information on the number of lounges in each house.

4. CURRENT WATER SUPPLY ARRANGEMENTS - AN OVERVIEW

4.1 INTRODUCTION

An overview of the current water supply arrangements in the urban areas of South Africa (from a macro / institutional perspective) is given in this section of the report. The following aspects are covered:

- overview of institutional and financial arrangements
- the cost of water
- the pricing of water
- operating and maintenance problems experienced

Domestic water demand and consumption is described separately in section 5.

Most of the information used here has been obtained from the separate "Domestic Water Supply" profiles written for each development region of South Africa (see document listing). Other sources are referenced.

4.2 OVERVIEW OF INSTITUTIONAL AND FINANCIAL ARRANGEMENTS

The institutions and organisations involved in the provision of water supplies to people living in the urban areas of South Africa are discussed under the following key tasks/functions:

- policy related:

  (a) national
  (b) regional
  (c) local

- financing / management

  (a) capital / infrastructure development
    - bulk water infrastructure development
    - "housing" infrastructure delivery (water supply component)

  (b) operating and maintenance

4.2.1 Policy Related

a) National policy

(with respect to providing basic water supply services to all urban residents in South Africa in a cost effective, efficient, affordable and sustainable manner)

The Department of Water Affairs and Forestry (DWAF) acts as the custodian of the water resources in South Africa and is the most important body influencing national policy on water supply. The department has recently published a draft policy document on water supply and sanitation for developing communities (DWAF, 1991). Although the Department has little direct involvement in the provision of water to poor communities, it has nevertheless recognised that there exists at present no national policy and strategy for the provision of basic domestic water supply services in South Africa. The DWAF therefore has recommended the formulation of a national strategy as an essential first step to begin to address the problem effectively. The DWAF recommended the establishment of an inter-governmental task group (ITG) to determine policy, advise government and monitor the water supply and sanitation problem and the progress towards its alleviation. It also recommended that an independent national development organisation (INDO) be asked to receive funds from the state, the private sector and international development agencies and foreign governments, allocate these funds to water supply and sanitation projects and oversee the implementation of these projects. The DWAF recommended that the ITG and INDO develop a standard financing approach, guidelines and procedures for the development of the projects and implement a monitoring and assessment component.

The Department of National Health and Population Planning has an interest in water supply in so far as it impacts on health. The Department has recently developed a Strategy for Primary Health Care in South Africa (DOH, 1992), Goal 3 of which states:

"To ensure adequate supply of safe water and basic sanitation"

The associated objective is to take appropriate steps to ensure that 70% of the population has access to adequate safe drinking water by the year 2000. The Department's definition of an adequate supply is the provision of safe water for oral intake and food preparation such that (i) the distance between the residence and water point is < 50 m in urban areas and < 100 m in rural areas. The Department, however, does not have a specific and adequate budget with which to implement this policy goal.

The Department of Local Government and National Housing carries out the following functions which may impact on the way water is provided to communities living in urban areas:

- sets national housing policy
- regulates the allocation of land
- formulates policy on squatting
- formulates guidelines for the development of "black" townships

Housing policy has been complicated by the existence of "Own Affairs" administrations in the Tri-cameral parliament, each with their own housing departments which have defined their own housing policies and strategies within the general national policy framework.

The government, recognising the need for a more unified and coherent housing policy, commissioned De Loor to put forward proposals on a policy and strategy for housing in South Africa. The recommendations of the De Loor commission are currently the subject of debate with extra-parliamentary organisations, in particular within the National Housing Forum (NHF), which has been recently constituted (third quarter of 1992) and comprises all the major actors and interest groups in the field of housing and services. This forum will play an increasingly important role in developing housing policy during this transitional period and this will undoubtedly have an impact on policy with respect to the provision of basic water supply services. To date, no national policy proposals concerning water supply have been developed by the NHF.

A Local Government Negotiating Forum (LGNF) has also been constituted (first quarter 1993) to discuss the restructuring of local authorities, rationalising the tax bases and finances of local authorities, extending services and other related matters. Decisions made in this forum are likely to impact on the way water is provided in urban areas, at least in the short term during the transitional period.

The Department of Foreign Affairs handles South Africa's development assistance to the TBVC states and therefore indirectly controls and/or affects housing and water supply policies in these areas.

The Department of Finance advises on the relative priority of housing and housing services in the national budget and therefore has an important influence on policy formulation and implementation.

A Standing Committee on Water Supply and Sanitation (SCOWSAS) was formed during 1992, with the task of bringing together all parties interested in addressing policies and strategies on water supply and sanitation, promoting data gathering and research designed to increase the general understanding of the problem, to coordinate the activities of each participating organisations, to identify key areas of intervention and to produce a report on policy options identified and proposals on appropriate strategies for discussion by all interested parties within nine months of its establishment. The standing committee is broadly representative of government and non-government bodies interested in and affected by water supply issues and represents an important initiative to address policy issues.

Various sub-committees, including finance and institutional committees, have been formed which are in the process of preparing discussion papers with the view to taking forward the policy debates. As yet there is no formal link between SCOWSAS, the NHF and LGNF, and it should be considered a matter of urgency that such a link be formed so that water and sanitation sector interests may be adequately represented at the NHF and LGNF.

The Local Government Policy Project (LOGOPOP) funded a study on water and sanitation policy which was conducted by PlanAct (Fowler, 1992). This paper makes an important contribution to the policy debate.

In summary, no coherent national policy and strategy, with the means of effective implementation, exists at present to address in a meaningful way the present shortfall (and future demand) for basic water supply and sanitation services in South Africa. However, three important initiatives *(SCOWSAS, NHF and LGNF) have recently been launched and should substantially address this shortcoming.*

b) **Regional Policy**

(with respect to providing basic water supply services to all urban residents within the region in a cost effective, efficient, affordable and sustainable manner, and within the national framework)

The 10 TBVC and self-governing states are, for the purposes of this discussion, treated as regional bodies, although in many respects they have adopted the functions that would normally be carried out by a central government.

Each independent homeland and self-governing state has developed its own policy with respect to water supply. For example, the Bophuthatswana's Department of Water Affairs has the goal of supplying all of its resident's with reasonable access to safe water by the year 2000, where reasonable is defined as access to safe water within 500m of each household, and has developed a Water Plan by which this may be achieved. The Transkei government set itself the objective that eventually the whole population should have access to a safe and adequate water supply for household use and commissioned a water supply prioritization study recognising that the goal would only be able to be met in the long term. The Ciskei developed a National Water Plan in 1991, which focuses primarily on bulk water supply. No policy had been formulated by Venda at the time and it would appear that little is being done in terms of a coordinated effort to improved domestic water supply in the region.

The QwaQwa government developed a four phase plan with the ultimate aim of providing safe water within 250m of every household in all of the villages in the region. Phases 1 to 3 (bulk supply, storage and basic reticulation) have been completed and the final phase is commencing this year.

Lebowa have a water plan with the aim of supplying water to within 500 m of every household as does KaNgwane, but with the distance set at 200 m of every household. In Gazankulu there is at present no specific plan for the upgrading of water supply to unproclaimed towns.

In practice, the policy goals in these regions are constrained by financial affordability which is to a large extent controlled by the South African government.

Although the four Provinces do not, in theory, develop policy relating to the provision of water supplies to urban communities, they nevertheless exert an important influence on policy formulation and implementation through their role of assisting black local authorities with development projects, exercising control over land use and finances of Black Local Authorities (BLAs) and providing financial assistance to these local authorities.

Water boards have, to a large degree, the freedom to development their own policy with respect to the extension of water supplies to poor communities in areas under their jurisdiction. There are a total of fifteen water boards, four of which have large populations within their respective supply areas, namely:

	Supply area population
Rand Water Board	± 7 - 8 000 000
Umgeni Water Board	± 3 000 000
Bloemarea Water Board	± 1 000 000
Goldfields Water Board	500 000

The stated goals of these water boards are summarised below:

Rand Water Board:

"to provide a consistent and reliable supply of good quality, clean and healthy water at an economic cost to meet the present and future needs of all consumers within our supply area, and to meet the needs of consumers by readily assisting them to identify their needs, advising them on the most cost effective manner in which a suitable supply can be made available to them and the way in which they can ensure the public receives the water at the lowest possible cost, and by acting promptly to satisfy their needs"

Umgeni Water and
Bloemarea Water Board:

"to manage water services in response to the socio-economic needs of the population within the organisation's region, with the aspiration of providing purified water cost-effectively to satisfy the needs of the community."

Although these stated goals and objectives are admirable, the Water Boards are not in a position to directly and significantly influence the provision of basic water supply services in their areas as this is the function of local authorities.

However, the Umgeni Water Board is involved to a small extent in supplying some communities with water directly. This is taking place where local authorities are not in existence or are unable to provide these services. It is a debatable point whether or not water boards should be involved in the direct supply of water to households.

The remaining eleven water boards have relatively small urban populations within their areas of supply. They are:

Albany Coast
Duivenhoks and Rûensveld
Kalahari-East
Kalahari-West
Karos-Geelkoppan
Magalies
Mhlatuze
Pelladrift
North Transvaal and Phalaborwe
Springbok
Western Transvaal Regional Water Company

c) **Local policy**

(with respect to providing basic water supply services to all urban residents within the local authority area in a cost effective, efficient, affordable and sustainable manner, and within the national and regional policy framework)

Regional Services Councils (RSCs)were introduced into the local government system after 1985 with the intention of:

- increasing the efficiency of service provision by avoiding duplication and allowing economies of scale to be achieved, and
- facilitating the improvement or upgrading of service infrastructure in the poorer and less developed areas

As part of this project a questionnaire was sent to all RSCs. Of the 28 RSC's which responded , 10 had some role to play in the provision of bulk water to local authorities within their area. The functions of these RSC's with respect to water were varied, including

- coordinating bulk water supply
- acting as local authority where no authority exists
- financing bulk water infrastructure
- financing extension and upgrading of water supply services
- water connections in rural areas
- provision of water to farming communities
- no involvement in water supply

The RSCs' policy on water, as reported by them, varied in accordance with the above functions.

Local authorities play the most important function in proving urban household with adequate water supply. Most local authorities would regard it as their task to provide an adequate water supply to all residents within their local area. Again, financial and administrative constraints mitigate against this in many instances, largely because of the unequal manner in which the local authorities are structured, with white local authorities having the privilege of obtaining significant income from commercial and industrial areas, which is largely denied to the black local authorities.

In the TBVC and self governing states, government departments act as the effective local authority in many of the towns. This situation is not ideal as there is often little accountability of the (usually remote) "regional" government to the residents living in the town.

4.2.2 Financing / Management

a) Infrastructure development (capital expenditure and management)

Bulk water infrastructure development

Historically, the Department of Water Affairs was formed to oversee the development of water for irrigation purposes (urban water supplies were managed by local authorities). However, as urban water demand grew and the need for larger (urban) water schemes arose, the DWAF has become increasingly involved in the development of water resources for urban areas. Almost all large new water resource development schemes are financed and managed by the state. Total capital expenditure on the establishment of government water schemes amounted to R167 and R244 million in 1990/91 and 1989/90 respectively.

It is the DWAF's policy that water supply to urban areas is supplied at full cost. The tariff is structured to recoup the full capital costs of the scheme over 45 years. Initial deficits are carried by the state, but these are recovered from the consumers over the life of the scheme.

Housing infrastructure delivery (water supply component)

Most white local authorities have historically had the financial resources to fund water supply services within their areas of jurisdiction and consequently a very high level of service predominates. The situation will, in many instances, change in the future when neighbouring black local authorities with low levels of service are incorporated into non-racial local government structures. Where internal financial resources are not sufficient to extend a basic but adequate level of service to all people in the area, loan finance from other sources will need to be made available.

Historically black local authorities have had, almost without exception, insufficient financial resources to extend a basic level of service of residents within their respective areas. This situation has arisen as a result of a large number of factors, amongst which are the following:

- poor economic base within the local authority area
- weak institutional capacity
- lack of legitimacy
- rent and service boycotts
- low levels of payment
- uneconomic tariff structures
- inability to raise loan finance

The BLAs have therefore had to rely on a number of sources of finance, namely:

- The Provinces
- Regional Services Councils
- The National Housing Commission finance and other government housing funds
- Independent Development Trust
- South African Housing Trust, and
- Development Bank of Southern Africa

The total funds spent on housing and related services development (capital expenditure) was estimated by the De Loor Commission to be R2.8 billion in 1990/91 (De Loor, 1992). Of this only a small proportion would have been made available for water supply services development.

Information for 28 RSCs was obtained during the survey. These 28 RSCs have budgeted to spend a total of R230 million on water services in the 1992/93 financial year, accounting for 11.5% of their total expenditure. Four of these RSCs (Western Cape, Central Witwatersrand, East Rand and West Rand) account for 71% of this expenditure. Detailed figures on RSC expenditure are given in Table 4.2 at the end of the section.

b) **Management and financing of operating and maintenance of water supplies**

Bulk water

Bulk water supplies may be managed by any combination of the DWAF, water boards, regional services councils and local authorities.

The average costs of operating and maintaining bulk water supplies are recovered in the tariff charges for bulk treated water. In the case of the large local authorities acting as the regional supplier within the metropolitan area (for example Cape Town and Port Elizabeth), the bulk water "should" be sold at "cost" to the other local authorities, after allowance has been made for contributions to a capital reserve fund. It would appear, however, that this is not always done in practice. The arrangement by which local authorities sell and purchase water from each other is usually governed by a formalised agreement between the respective parties. The Water Act of 1956 provides that water boards should cover their costs, without profit, so that users obtain maximum advantage. Regional services councils, if entrusted with bulk water supply functions, manage and finance these functions in a similar manner to water boards.

Water distribution to households

Most white local authorities operate financially autonomously with respect to water trading services. Tariffs are normally structured to cover the average costs as well as generate a (usually moderate) surplus. The surpluses generated are placed in a capital reserve fund and/or made available for the cross-subsidisation of other services within the local authority such as rates.

Black Local Authorities operate their water trading services, almost without exception, at a loss. The deficits generated have historically been covered by so-called "bridging" finance from the respective provinces, although this practice is now being halted, hastening the demise of the black local authority system and precipitating the unification of integrated white and black local authorities. The "bridging finance", originally intended as a repayable loan, has become a significant annual expenditure, amounting to an estimated R650 million in 1990/91 (De Loor, 1992). This money is in effect a subsidy of the operating costs of Black Local Authorities, and reduces the amount of money available to extend infrastructure to people without services and to upgrade existing services.

The reasons for these trading service losses are numerous, but echo those already mentioned in section 4.2.2 (a) above.

4.2.3 Summary Of Current Deficiencies

The shortcomings in the present system are summarised by the SCOWSAS Institutional Framework sub-committee in their draft document (SCOWSAS, 1992) as follows: [this author's comments in brackets]

General

- national policy with regard to quality, service standards and conservation of resources is inadequately defined

- there is no national authority with clear accountability for the setting of policies and standards

- there is no comprehensive auditing system in existence [specifically no watchdog body overseeing the financial and institutional performance of regional water supply authorities - viz. water boards and major metropolitan local authorities]

- the shortage of trained manpower and expertise extends across the spectrum of water supply (and sanitation) authorities [and existing distribution of resources highly imbalanced]

- there is a lack of co-ordination between different authorities responsible for water supply (and sanitation) [resulting in ineffective overall management of water resources]

- there is inequitable resourcing of different institutions [particularly between local authorities]

- many local authorities are deprived of adequate resources and are unable to adequately administer, maintain and extend water supply (and sanitation) services within their areas

Metropolitan water supply

- the provision of services in homeland areas is constrained by the artificial delimitation of authority boundaries [for example the separation of Winterveld from Pretoria, Botshabelo from Bloemfontein and Mdantsane from East London], the shortage of trained personnel and limited accountability of the supply authorities to the consumers. [The artificial delimitation of authority boundaries constrains the efficient use of the scarce skilled manpower]

- the level of accountability of regional authorities is not necessarily acceptable to consumers [water boards do not necessarily have direct accountability to the (domestic) consumers within their area]

- local authorities may be compelled, without option in certain circumstances, to obtain their bulk water from a regional authority [for example, Durban Corporation]

- the accountability of a major city providing regional supplies to other local authorities may not always be satisfactory [an imbalance of power may exist, for example between Cape Town City Council and Ikapa]

- a major city undertaking regional water supply functions might have other priorities thus disadvantaging certain consumers. [A municipality's accountability is to its rate payers , and not to other local authorities.]

- the response to rapid urbanisation in the provision of water supply to informal settlements is less than satisfactory.

- in general the accountability for bulk and individual supplies from a metropolitan authority is too diffuse

- the sources of finance for water for informal settlements do not meet requirements. [It is almost impossible, or at the least would require an extensive study in itself, to determine the actual capital expenditure on water supply services in South Africa. This also points to the lack of a coherent strategy for extending water supply services.]

Small town and isolated areas water supply

- the individual undertakings are frequently too small to justify employing the necessary full-time expertise for adequate supply

- local authorities lack the financial and manpower resources to cope with the rapidly increasing population in some towns [due to the large movement of people from farms as a result of the drought]. Only limited funds are available from regional governments. Revenue systems are inadequate.

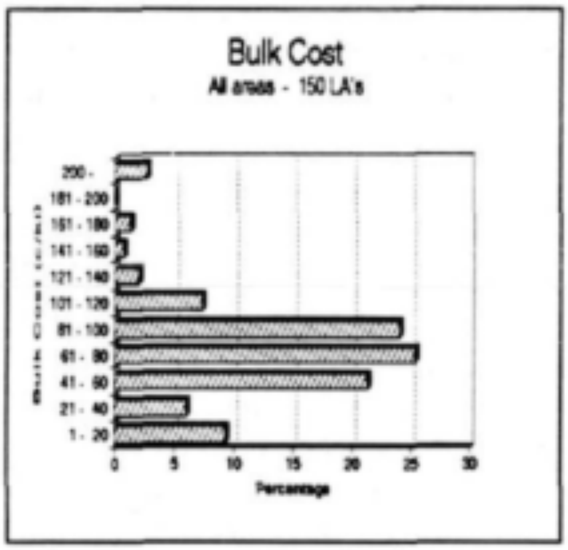
- the accountability for supply to existing black townships is not specific enough [poor relationships and inequitable resources between white and black local authorities in many areas, pointing to the need for the rationalisation of local authority structures]

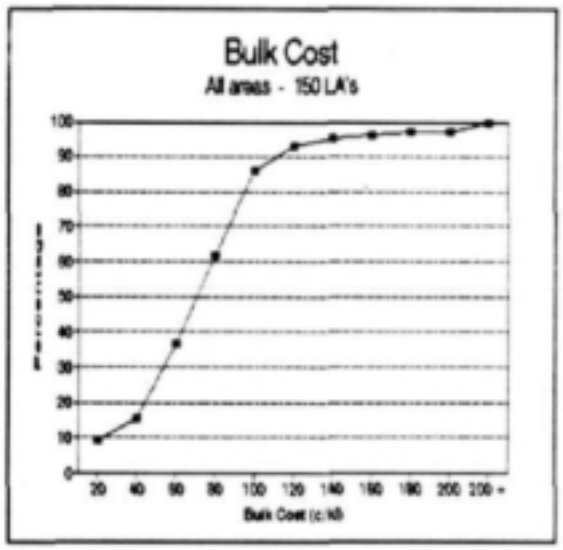
4.3 THE COST OF WATER

4.3.1 Introduction

The cost of domestic water in various urban areas in South Africa is highly variable. This is not surprising given that water costs are sensitive to a large number of parameters - rainfall, topography, distance from source, economies of scale and nature of treatment to name a few - which vary greatly across the urban settlements in South Africa. Based on the survey carried out for this project, a frequency distribution of the cost of bulk treated water in the urban areas of South Africa is given below:

Figures 4.1 and 4.2: Bulk water costs - frequency distribution





Of the 150 local authorities which provided information on bulk treated water supply costs / purchase price, 90% reported a cost /price of below 110 c/kl and 60% a cost / price below 80 c/kl. 70% of the local authorities reported bulk costs prices of between 40 and 100 c/kl. These costs / prices are surprisingly low if the relative scarcity of water is taken into account and if compared to the cost / price of water in other countries (see Section 4.3.2 below).

4.3.2 Cost of bulk treated water in major metropolitan areas

About 90% of the total urban water demand in South Africa is consumed in the 8 major metropolitan areas of South Africa, which in turn "house" 64% of South Africa's total urban population.

The average costs of bulk treated water in the major metropolitan areas are summarised in the table below:

TABLE 4.1 Average Water Costs - Metropolitan Areas

Metropolitan Area	Bulk Water Supply Authority	Cost of Bulk Treated Water (91/92 actual)
Cape Town	Cape Town Municipality	39
Bloemfontein	Bloemarea Water Board	54
Port Elizabeth	Port Elizabeth Municipality	61
PWV	Rand water Board	67[1]
Durban	Umgeni Water Board	70[2]

Notes to table: The above are average costs of water as supplied by the regional water authority based on actual 1991/92 total expenditure (including contributions to capital reserves) and total water sales, except for PWV and Durban which are based on bulk water tariffs (see notes 1 and 2 below). Bulk tariffs should be set equal to actual water costs as the Water Boards should not operate at a profit.

1. based on preference consumer tariff:

Feb - Sep 91:	62.2	
Oct 91 - Mar 92:	71.3	(tariff revised end Sept 91)

2. bulk tariff in Umgeni's water supply region varies between 70 and 92 c/kl. Most of the population is supplied with water costing 70 c/kl (bulk, treated).

The following points with regard to the above average costs may be made:

- Bulk water in Cape Town is the least expensive of all of the major metropolitan areas by a significant margin.

- It is surprising that the cost of / charge for water in the water scarce PWV area is lower than for the Durban / Pietermaritzberg area (a water rich region) (Briscoe, 1991).

- The relative costs of water in the PWV and Durban regions are, however, likely to change in the future as the result of the introduction of the Lesotho Highland Water Project scheme in 1997.

- Raw water currently makes up about 22% of the total cost of water to the end user. As more expensive sources of water are developed the raw water cost, and hence the percentage of the end user price, will increase progressively. "The days of relatively cheap water in the Vaal River supply area are over and consumers will have to prepare themselves for higher costs" (Krige, 1992).

- The price / "average cost" of water in South Africa, a water scarce country is amongst the lowest in the world - less than $0.30 kl, compared with the United States - $0.90, and Western Europe - $1.40.

- Bulk water tariffs are based on average and not marginal costs. See marginal costs below.

4.3.3 Marginal costs

Although information on the marginal costs of newly implemented or planned urban water schemes was sought, little information was forthcoming. It would appear that this information is not generally available, which is surprising as it should be normal practice for water tariffs to be related to marginal costs. Setting the tariff equal (or close) to marginal cost ensures that resources are allocated efficiently by pricing the service at its "true" value. This is discussed further in Section 4.4.1.

The only marginal cost information obtained was for Cape Town. The preliminary marginal cost calculations done for future bulk water supply options for the Cape Town metropolitan area show that the marginal costs of bulk raw water are in the range of 2.5 to 8 times the current bulk treated cost. It may be expected that marginal costs for Port Elizabeth and Bloemfontein are equally high, and almost certainly higher for the PWV where additional water sources are immensely expensive due to the remoteness of the sources and the very high capital investments and long project lead times required to exploit these resources.

South Africa is a water scarce country. The current average bulk water costs (as presented in Table 4.1 above) do not reflect the true economic cost of water and are almost certainly far below the marginal costs of the water. The result of this is that water is undervalued in South Africa.

4.4 WATER PRICING

4.4.1 Charging for urban water services - the issues

(The following section outlines the basic economic and related principles upon which water pricing policy should be based. The discussion is borrowed from Bahl (1992)).

In general, pricing policy should be designed to meet the following goals:

- economic efficiency
- financial viability
- equity

The relative weight of these goals will be determined by the particular circumstances with regard to the existing extent of coverage, wealth distribution, consumption patterns etc. Allowance should also be made for institutional arrangements which may influence the feasibility of pursuing these goals.

Water charges can be grouped into four categories:

- lump-sum development charge (included in cost of the property and independent of whether or not connected)
- lump-sum connection charge
- periodic fixed payment (not necessarily related to water use)
- periodic payment linked to (metered) water consumption

It is usual to design a pricing policy on the basis of efficiency and then to adjust this as necessary taking into consideration the other policy goals. The effectiveness of using price as a tool in efficiently allocating resources is dependent on the price elasticity of demand, that is, the relative responsiveness of demand to changes in price. It should be noted that there are three dimensions of water supply services to which prices are applicable, namely access, connection and consumption. In general, the demand for water (consumption) is moderately price elastic, but possibly less so for low- than high-income groups. In contrast, the demands for water connections are likely to be more price elastic for low-income households and show little price elasticity for high income households. These general remarks are, however, highly conjectural and should be tested during the development and implementation of a pricing policy.

*The basic rule of **efficient** public service pricing is to set price equal to marginal cost.*

A three-part water tariff is likely to be required for the efficient pricing of water:

- A consumption charge should be related to the quantity consumed and set equal to average incremental cost (AIC) .

  The AIC is calculated by discounting the incremental costs which will be incurred in the future to provide the estimated additional amounts of water which will be demanded over a specific period, and dividing that by the discounted value of incremental output over that period. The AIC is used because investments in increasing bulk water supply system capacity is usually lumpy and therefore marginal costs calculated over a shorter time span would vary widely giving rise to price instability.

A consumption charge requires metering. However, for small residential consumers, particularly if only a yard tap is installed, the cost of metering may outweigh the benefits.

- A connection charge may be a lump sum charge upon connection and/or it may be a periodic fixed fee. The former is appropriate for the actual connection and the latter for the recurrent costs of maintaining the reticulation system.

- A development charge should be applied to cover the marginal cost of the distribution system.

Fiscal considerations (**financial viability**): Self-financing urban water supply systems are attractive for a number of reasons:

- fairness: people pay for what they get
- reduced risk of distortions which may arise when raising revenues from other sources
- promotes local autonomy and accountability
- encourages appropriate standards in service provision
- associated with efficient management of public utilities

In principle no conflict arises between the objectives of efficiency and financial self-sufficiency if average historic costs are below marginal cost or AIC (long run marginal cost). If this is the case, a surplus will be generated which may be used selectively to subsidise selected classes of consumers provided the subsidies are efficient and equitable. For example, life-line[1] tariffs for small, poor consumers, subsidised connections in poor neighbourhoods, and subsidised provision of water from public taps are likely to be efficient (and socially equitable) uses of surplus funds. Additional surpluses generated may be transferred to other urban services (for example sanitation) or water systems in other regions of the country where self sufficiency cannot be achieved.

[1] Life-line tariffs consist of a heavily subsidised low tariff for an initial consumption block of say 20 to 40 l/cap/day. Consumption above this amount is charged at the full marginal cost.

Equity considerations are frequently embodied in water tariff structures in developing countries. Various methods may be used to build redistributive effects into pricing schemes, amongst which are:

- rising block rates
- user fees linked to the value of the connected property
- financing through a general property tax
- making charges a function of wealth of neighbourhood
- higher charges for industrial and commercial consumers
- cross-subsidies with other urban services

- inter-regional or urban-rural cross-subsidies
- transfers between national and local general fund accounts
- making charges a function of connection pipe diameter or number of taps
- subsidising consumption from public taps

The point of reference should remain efficiency, which consists of marginal cost prices for the consumption, connection and access dimensions of the service. The redistributive affect should have to do only with the excess relative to the marginal cost price. The above redistributive mechanism should be evaluated in terms of the tax burden placed on the wealthy, the extent of subsidies created for the poor, the effect of the redistributive pricing on efficiency and the difficulty of implementation.

Externalities: Water supplies may be justified on the basis of health benefits for the community of reducing the incidence of water-borne diseases. Between 20 and 40 l/capita/day of readily available water (together with adequate sanitation and sound hygienic practice) are sufficient to attain the main benefits of water use. This benefit may be considered an externality, possibly to be paid for in part by a broader community-grouping (perhaps regional), even though the specific community may be unwilling or unable to pay the marginal cost price. This is a rationale for the introduction of a life-line tariff (previously described).

Shadow pricing: Distortions in market prices (of input costs to water supply schemes - eg the cost of capital, skilled and unskilled labour, electricity etc) should be accounted for by using shadow pricing techniques. Unfortunately, the sensitivity of water charges to shadow prices has not been widely explored.

Administrative considerations: Efficient water tariff structures can only achieve their purpose if they can be administered effectively. For example, it may be costly or simply not feasible to meter all water supplies in an informal low-income area. Similarly, the inability to effectively collect charges renders tariff policies worthless.

Institutional considerations: In principle, water pricing systems can be designed to provide services that are efficient, financially viable and equitable no matter what the institutional context. In practice, however, the institutional framework cannot be so easily disregarded. Systematic relations exist between the institutional setting and pricing structures, and it may be expected that pricing policies will be structured in such a way as to reflect the institutions goals. Institutional autonomy will usually result in pricing practices which give rise to financial autonomy, however, there is no necessary link between this and sound financial management, efficient pricing and the absence of (equity related) inter-agency transfers.

4.4.2 Tariffs Policies in South Africa

A large number of different tariff structures are in existence in the urban areas of South Africa, reflecting different financial and economic policies. *However, almost without exception, tariffs are not based on, or related to, marginal costs.*

The typical approach to setting tariffs is described below:

a) Bulk treated water

Bulk treated water tariffs in South Africa are almost universally based on average historical costs (so called because the tariff is based largely on the repayment of capital borrowed in the past). The bulk treated water tariff is set equal to the average historical cost plus a set margin. The average historical cost is made up as follows:

- current operating and maintenance costs
- interest charges on borrowed capital
- repayment (by instalment) of borrowed capital (capital redemption component)

The margin is a function of the amount of surplus that the institution wishes to generate. This surplus can be placed in a capital reserve fund and/or be used for other purposes.

This method bears little relation to the marginal costing principles outlined in section 4.4.1 above.

b) **Domestic tariff structures**

The most common tariff structures in use on the urban areas of South Africa, identified in the course of the survey, are outlined below: (The distribution of these tariffs as reported in the survey are shown in Figure 4.3)

i **Flat rate service charge**

This is a very common form of tariff found in many of the black local authority areas. The tariff is attractive because it is relatively easy and inexpensive to administer. In many instances the tariff was implemented in response to difficulties being experience with meter-reading, the high cost of administering a meter reading and accounting system, restricted access into the local authority areas as a result of violence, antagonism towards the meter readers, rent and service boycotts etc.

The authority would hope to achieve adequate cost recovery if the service charge is set at the right level and there are high rates of payment. It would, however, seem to be common practice for the service charges to be set below the rate required for cost recovery.

The service charge, is moreover, inefficient and inequitable because it does not encourage prudent consumption.

ii **Consumption charge**

This tariff structure is most commonly used by local authorities. The tariff is equitable because everybody pays the same unit rate for the water. But the tariff does not specifically encourage water conservation. It could be said to be economically efficient if it is set equal to the average incremental cost of new planned water supplies.

iii Service charge plus consumption charge

This tariff structure is applied by certain local authorities, particularly white local authorities. Although this tariff can be economically efficient, if the tariffs are set at the correct level, it is usually regressive, especially if the service charge component is relatively large and where consumption is low. This arises because the lower the consumption, the higher the unit rate paid for water.

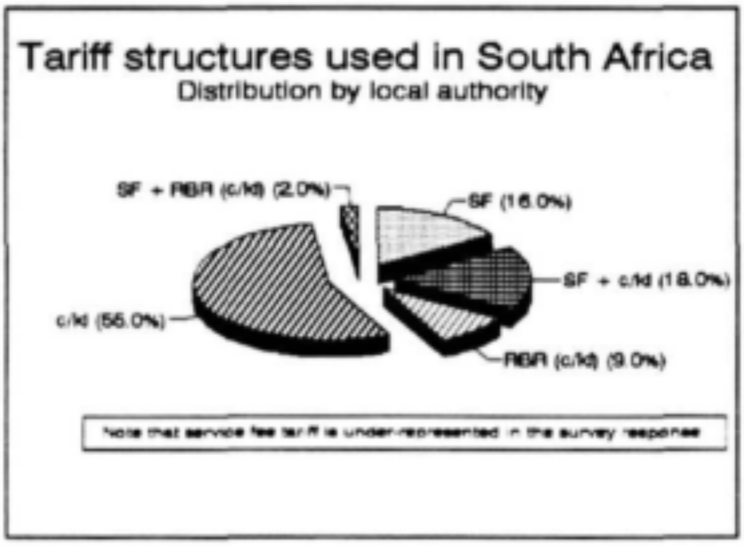
iv Rising block rate consumption charge

This tariff structure is relatively uncommon. Unit consumption rate increases as consumption increases and the tariff thus encourages water conservation and can be efficiently structured. It would therefore make sense for this tariff to be implemented in South Africa on a wider scale.

iv Service charge plus rising block rate

Variation of tariffs iii and iv, but not in common use.

Figure 4.3: Distribution of tariff structures in South African Local Authorities



Source: Questionnaire survey

Notes: SF = flat rate service charge

c/kl = consumption charge

RBR = rising block rate consumption charge

v Water vending/kiosks

In addition to the tariffs reported in the survey, water vending (especially kiosk) arrangements are in existence in a number of informal settlements. Typically, a kiosk "owner" would buy water from a metered connection from the supply authority and resell the water to customers at a fixed rate per volume purchased, for example 8c per 20 litre bucket. The price of water in these informal settlements can be many times more expensive than in other areas where a much higher level of service is provided. This topic is discussed further in Section 8.4.

4.4.3 Some important features of domestic tariff policy and application in South Africa

a) Domestic tariffs not based on marginal costing principles

No instances were found of domestic tariff policies being based explicitly on marginal costs.

b) Tariffs are often set below the level of financial viability

Many of the tariffs in the black local authority and homeland areas are set at a level that is too low to generate sufficient income to cover the costs of managing the water supply system, and in many cases no tariff is levied at all.

c) Tariffs are in many cases inequitable and regressive

In some of the metropolitan areas of South Africa, poor people have to pay more for their bulk water supply than do the neighbouring wealthier areas. Examples of this are presented below:

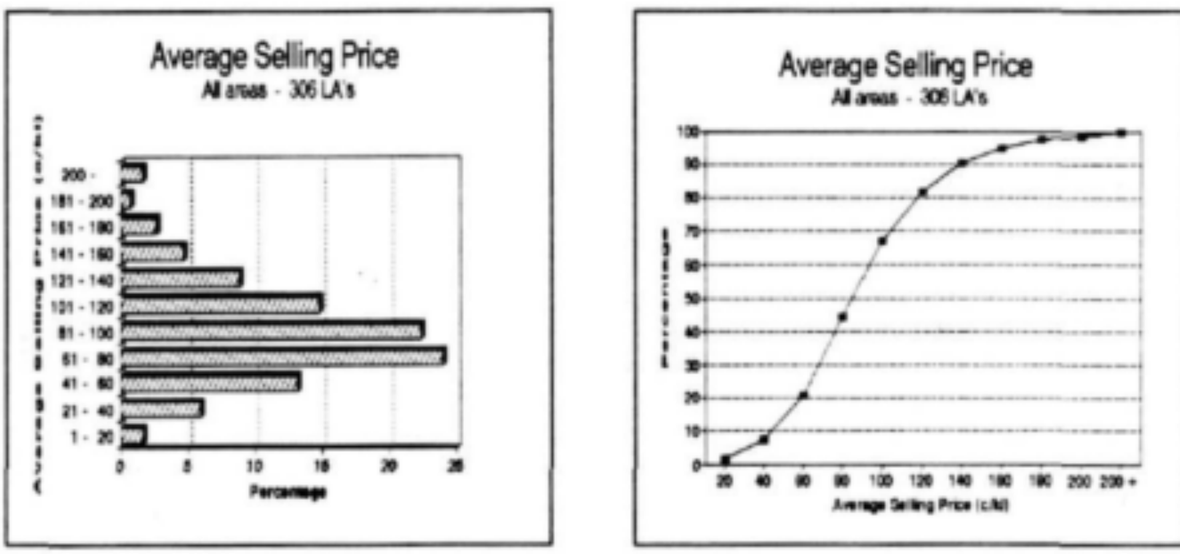
In Cape Town, the Ikapa black local authority (population 350 000) pays 78 c/kl compared to Durbanville, a wealthy white local authority which only pays 57 c/kl. Both local authorities purchase their water from the Cape Town City Council.

Durban Corporation purchases water from Umgeni Water at 79 c/kl, whereas Umlazi and KwaMashu, the large neighbouring local authorities, pay 98 c/kl for water from the same source.

4.4.4 Average tariffs in South Africa

The range of average domestic tariffs charged in South Africa is illustrated graphically below:

Figure 4.4: Average selling price - all urban areas

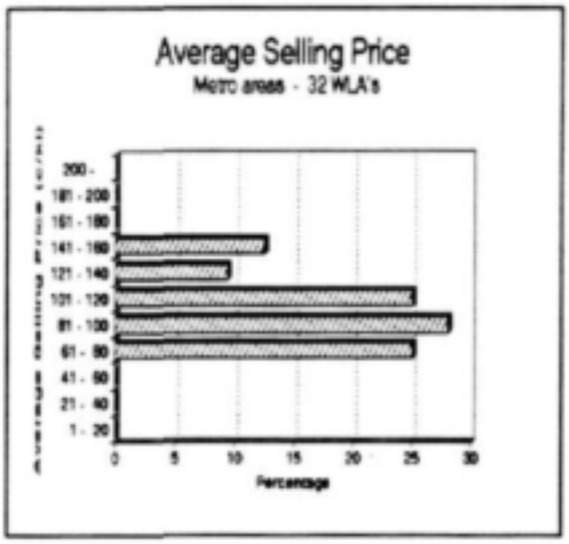


The data shows that a wide range of average tariffs are charged, from below 20 c/kl to over 200 c/kl.

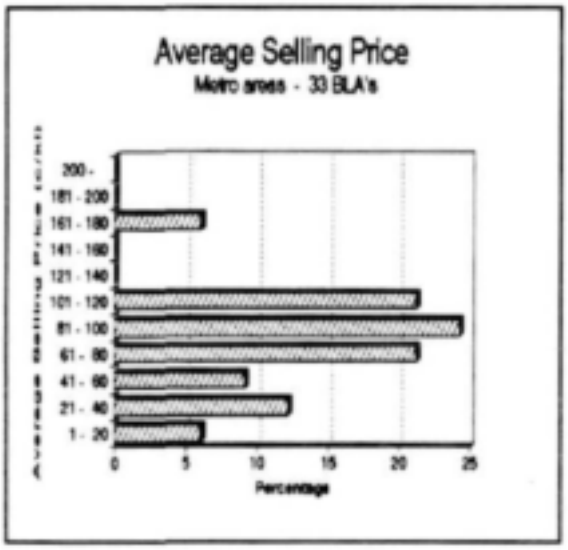
The different tariff policies between black and white local authorities in metropolitan areas is clearly illustrated in Figures 4.5 to 4.8 overleaf. Although *in most instances the bulk treated water costs / prices are nominally the same* for the black and white local authorities, the average tariffs charged by black local authorities are significantly lower than for white local authorities. In most instances, these low tariffs render the water services uneconomic (financially not viable).

This is further illustrated in Figure 4.9 which graphically depicts the losses experience by black local authorities arising from setting tariffs lower than the cost of purchasing the bulk treated water. The contrasting situation in the white local authorities is shown in Figure 4.10

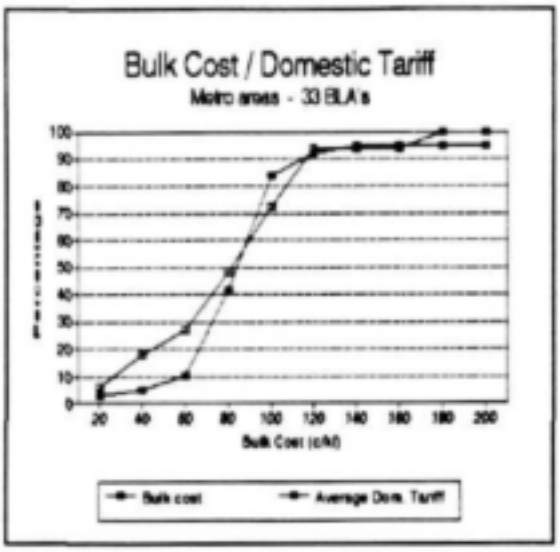
Figures 4.5 and 4.6: Average selling price - WLAs in metropolitan areas

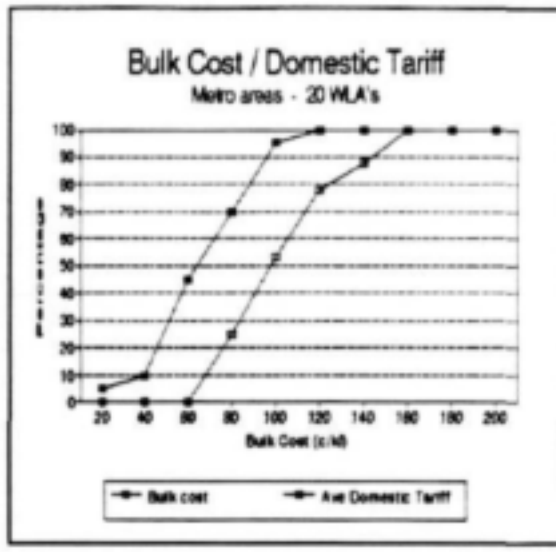


Figures 4.7 and 4.8: Average selling price - BLAs in metropolitan areas



Figures 4.9 and 4.10: Comparison of bulk water costs and average domestic selling prices





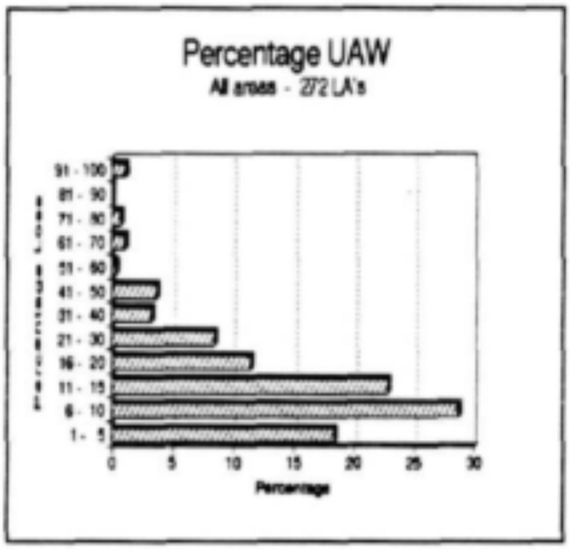
4.5 OPERATION AND MAINTENANCE ISSUES

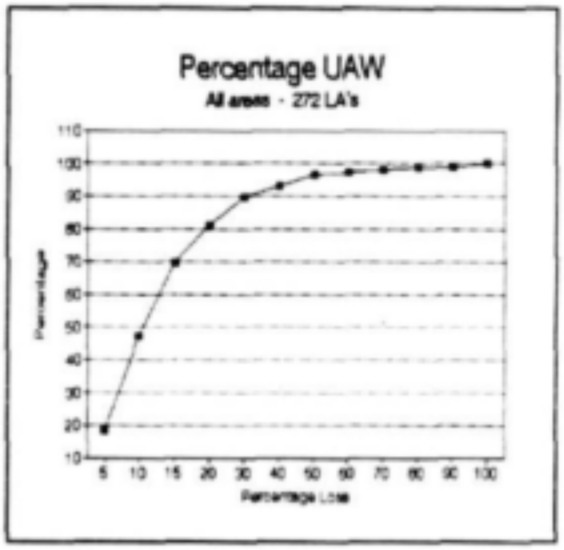
4.5.1 Unaccounted For Water (UAW)

Unaccounted for water (UAW) is the difference between the volume of water purchased in bulk by the local authority and the volume of water paid for by consumers.

Typical unaccounted for water rates as reported by local authorities in the questionnaire are graphically illustrated below:

Figures 4.11 and 4.12: Unaccounted for Water - all urban areas

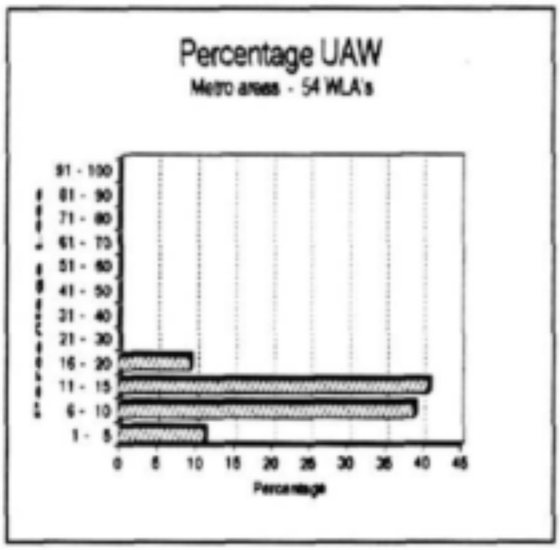


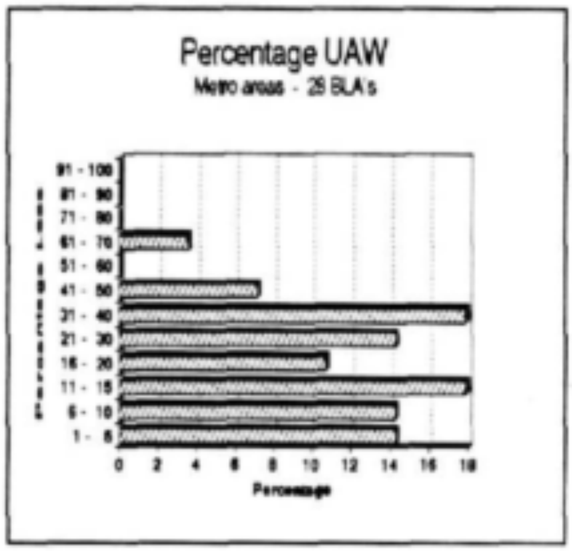


The median unaccounted for water rate, based on the information received from the questionnaire, was about 12%. However 20% of local authorities reported losses of greater than 20%, and 10% of local authorities higher than 30% unaccounted for water.

A comparison between UAW reported for white and black local authorities in metropolitan areas is given in Figures 4.13 and 4.14. The data presented is these figures would seem to indicate that the unaccounted for water rates reported by the black local authorities can largely be attributed to the management of the water supply systems.

Figures 4.13 and 4.14: Reported unaccounted for water in white and black local authorities in the metropolitan areas





4.5.2 Reported Problems From Questionnaire

The responses obtained in the questionnaire to questions requesting an evaluation of the seriousness of various problems experienced are summarised in Table 4.2 below.

TABLE 4.2: Problems Reported By Local Authorities

	Number of responses	Frequency/Severity of Problems			
		None	Few	Moderate	Serious
Meter reading & acc	259	26	50	17	7
Reticulation	279	7	43	42	8
Treatment works	239	30	50	17	3
Raw water supply	212	43	35	15	7

The second category refers to reticulation breakages and leaks and is clearly the key area that needs attention on the operation and maintenance side. It is perhaps surprising that more local authorities did not report moderate or serious problems with meter reading and accounting. However, it should be borne in mind that responses from black local authorities to this question is under-represented and also that many of these authorities operate flat rate service charges.

Table 4.2 RSC involvement in water - part 1

	Name of RSC	Total pop	Black Pop	Expenditure 90/91	91/92	92/93	% on water 90/91	91/92	92/93
A	Breerivier	303 000	252 000	23 704 000	34 120 000	37 066 000	0.0	0.0	0.0
A	Central Karoo	60 000	50 000	7 600 000	9 100 000	13 300 000	3.3	4.2	4.0
A	Namaqwaland	60 000	51 000	3 570 000	3 780 000	3 620 000	0.0	0.0	0.0
A	North West								
A	Overberg	109 000	88 000	10 700 000	12 800 000	16 500 000	20.0	24.0	26.0
A	South Cape	213 000			835 000	1 070 000		0	0
A	West Coast	181 000	144 000	8 700 000	16 200 000	19 300 000	0.0	42.0	42.5
A	Western Cape	1 334 000	1 100 000	516 000 000	629 000 000	759 000 000	9.9	9.4	11.1
B	Benede Orange								
B	Bo-Karoo	87 700	76 000						
B	Diamantveld	390 000	323 000	500 000	1 000 000	1 300 000	8.8	10.0	6.1
B	Kalahari								
B	Stellaland	63 000	58 000						
C	Bloem-area								
C	East Free State								
C	Goldfield	690 000	588 000	22 800 000	22 700 000	24 600 000	27.0	23.0	18.0
C	Northern Free State	444 000	361 000	14 400 000	19 020 000	20 860 000	14.5	27.6	23.3
D	Algoa	860 000	427 000	96 000 000	102 000 000	104 000 000	0.6	0.7	1.0
D	Amatola	118 000	103 000	13 200 000	21 800 000	26 800 000	1.0	12.9	4.6
D	Camdeboo	69 000	60 000	7 900 000	7 290 000	9 600 000	0.0	0.0	2.4
D	Drakensberg	98 000	88 000	700 000	720 000	720 000	39.3	60.7	60.7
D	Midland								
D	Stormberg	157 000	125 000			400 000			0.0
E	Natal Midlands (JSB)								
E	Port Natal (JSB)								
E	Southern Natal (JSB)								
E	Thukela (JSB)								
E	Zululand (JSB)								
F	East Vaal	633 000	567 000	21 200 000	33 160 000	35 000 000	30.0	35.3	23.3
F	Lowveld + Escarpment	291 000	217 000	15 879 000	28 300 000	31 200 000	10.0	33.0	21.0
F	Highveld	458 000		28 200 000	23 800 000	19 900 000	23.0	16.0	19.0
G	Bosveld								
G	Northern Transvaal	273 000	194 000	17 050 000	18 340 000	18 900 000	10.2	12.8	12.3
H	Central Witwatersrand	2 800 000	177 000	416 300 000	390 000 000	490 600 000	10.0	7.5	7.5
H	East Rand	2 290 000	1 600 000	152 000 000	166 000 000	202 000 000	12.6	12.3	9.2
H	Pretoria	2 500 000		100 000 000	123 000 000	143 000 000	25.0	27.0	12.5
H	Vaal Triangle	1 160 000	946 000	18 100 000	26 100 000	27 900 000	13.0	8.0	29.0
H	West Rand	925 000		59 900 000	62 500 000	106 300 000	43.3	20.3	23.9
J	Rustenberg-Marico	170 000	116 000	14 010 000	17 514 000	22 108 000	41.0	31.0	45.0
J	West Vaal								
	Walvis Bay	30 000	23 000		2 660 000	2 660 000		0.0	0.0
		16 766 700	7 734 000	1 568 413 000	1 791 759 000	2 139 946 000	12.7	12.1	11.6

Table 4.2 RSC Involvement in water - part 2 (Policy)

	Name of RSC	POLICY
A	Breeriver	
A	Central Karoo	The Central Karoo RSC's policy is to supply every community in our region with access to abundant water.
A	Namaqwaland	Most bulk water from Orange River. RSC not involved in bulk water supply.
A	North West	No involvement in water and sanitation.
A	Overberg	
A	South Cape	
A	West Coast	Bulk water supply to Municipalities. Water connections in rural areas
A	Western Cape	To provide potable water to all formal and informal residentioal areas as as funds permit. (Acts as local authority to many areas)
B	Benede Orange	
B	Bo-Karoo	
B	Diamantveld	The Council supplies water and sewage services only to Windsorton, Kutlwano
B	Kalahari	
B	Stellaland	
C	Bloem-area	
C	East Free State	
C	Goldfield	
C	Northern Free State	This RSC places a high priority on the provision of water and funds are readily for such projects in the region.
D	Algoa	Function has not been entrusted.
D	Amatola	The ARSC is only responsible, as agent to the Local Councils, for the bulk wate and sewerage treatment, as those authorities do not have the expertise to oper
D	Camdeboo	
D	Drakensberg	
D	Midland	
D	Stormberg	This RSC is not directly involved in the supplying of water. We only assist finan
E	Natal Midlands (JSB)	
E	Port Natal (JSB)	
E	Southern Natal (JSB)	
E	Thukela (JSB)	
E	Zululand (JSB)	
F	East Vaal	When funds are allocated, water is still considered as the highest on the priorit
F	Lowveld + Escarpment	
F	Highveld	
G	Bosveld	
G	Northern Transvaal	To co-ordinate the function of bulk water supply in the region. including investi water sources, the standardisation of water tariffs, allocation of NTRSC funds f
H	Central Witwatersrand	
H	East Rand	
H	Pretoria	To enhance the quality of life of residents by co-ordinating and providing region creating infrastructure at local government level. Joint decision making by LAs of levy funds ensures this.
H	Vaal Triangle	
H	West Rand	
J	Rustenberg-Marico	Use is made of various water supply sources i.e. RWB, Magalies WB, rivers, da Our objective is to obtain sufficient pure water for all urban inhabitants in the re
J	West Vaal	

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5. DOMESTIC WATER DEMAND IN SOUTH AFRICA - AN OVERVIEW

5.1 INTRODUCTION

An overview of domestic water demand in South Africa is presented here with the following aims:

- to relate urban / domestic demand ~~to demand~~ for water by other users
- to show the geographic distribution of urban water demand in South Africa
- to illustrate urban domestic water consumption patterns, in particular:
  - typical per capita water consumption figures in the urban areas of South Africa
  - the relative share of water being consumed by high and low income groups
- to summarise the current estimates of future water demand in the major metropolitan areas of South Africa and to relate this to population growth and the proportion of this increased water demand that is likely to arise from extending basic water supply services to all urban residents in South Africa over the next 10 years (based on the figures presented in section 1 of this report).

It is pertinent to note here that South Africa is essentially a water scarce country. South Africa has an average annual rainfall of about 500 mm which is well below the world average of 860 mm. Total runoff into South Africa rivers is estimated at 53 000 million m^3 per annum of which about 33 000 million m^3 can be exploited at present levels of technology. Approximately 5 400 million m^3 can be extracted from ground water sources giving a total supply of 38 400 million m^3, or 2 800 l/cap/day based on the 1990 population estimate of 37.5 million. The limited nature of South Africa's water resources is illustrated by comparing South Africa's total exploitable water resources to the annual flow of the Zambezi River which is 60 000 million m^3 per annum. It therefore is an obvious point that looking at the demand for water based on historical consumption and predicted population and economic growth is only one side of the coin. Water conservation and more efficient use of water will become increasingly important. This is discussed further in section 8.

The major conclusion from this overview is that the imperative of providing an adequate supply of water to all people living in South Africa does not have a significant impact on the overall pattern of water demand. Nevertheless, the general scarcity of water in South Africa means that consideration should, in all circumstances, be given to the efficient use of water and to reducing water losses.

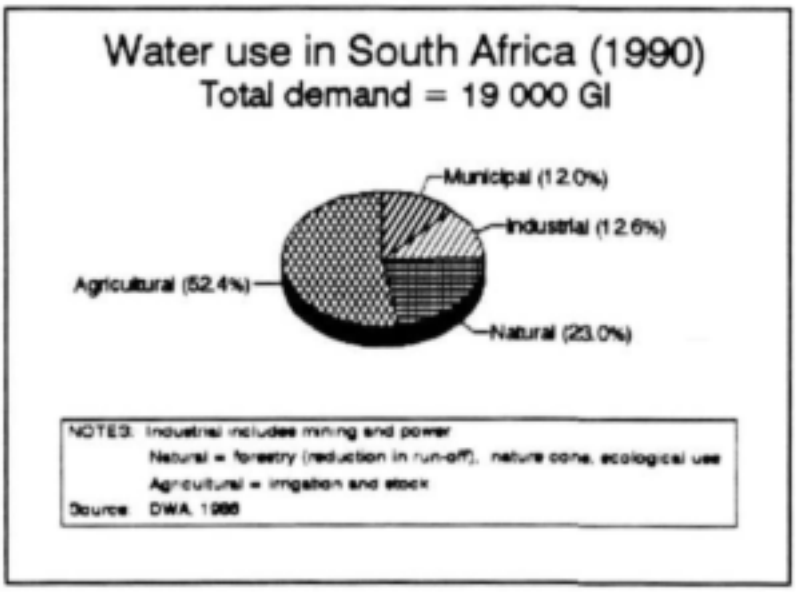
5.2 TOTAL WATER DEMAND IN SOUTH AFRICA

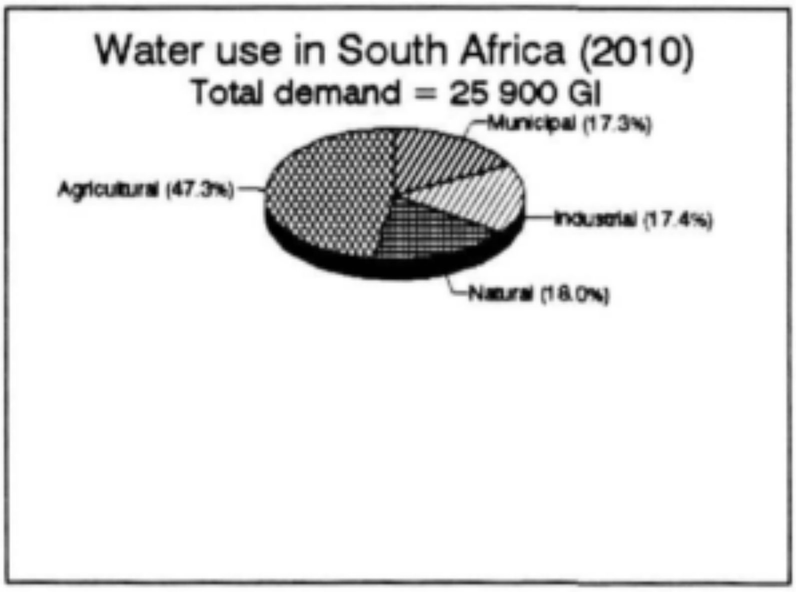
Estimates of the total water demand in South Africa for the years 1990 and 2010 are summarised in Table 5.1 and Figures 5.1 and 5.2 below:

TABLE 5.1 Total water demand in South Africa (Source: DWAF, 1986)

Sector	1990		2010		Growth
	million m^3	%	million m^3	%	% pa
Direct use					
Municipal / domestic	2 281	12.0	4 477	17.3	3.4
Industrial	1 448	7.6	2 961	11.4	3.6
Mining	511	2.7	649	2.5	1.2
Power generation	444	2.3	900	3.5	3.6
Irrigation	9 695	50.9	11 885	45.9	1.0
Stock-watering	288	1.5	358	1.4	1.1
Nature conservation	182	1.0	191	0.7	0.2
Indirect use					
Forestry runoff reduction	1 427	7.5	1 700	6.6	0.9
Ecological use	2 767	14.5	2 767	10.7	-
TOTAL	**19 043**	**100**	**25 888**	**100**	1.5
SUMMARY					
Urban / domestic	2 281	12.0	4 477	17.3	3.4
Industrial / Mining / Power	2 403	12.6	4 510	17.4	3.2
Agricultural	4 376	23.0	4 658	18.0	0.3
Ecological / nature cons.	9 983	52.4	12 243	47.3	1.0

FIGURES 5.1 and 5.2: Distribution of water demand in South Africa





Source: Table 5.1
Note: 1 Gl = 1 million m^3

Municipal water demand (mostly domestic) accounts for approximately 12% of the total current water usage in South Africa and is forecast to grow at an average of 3.4% per annum over the next 20 years at which point it is expected to account for 17% of the total water usage. As with all long term projections, these estimates should be treated with caution.

5.3 WATER USE IN MAJOR METROPOLITAN AREAS

Current water demand in the major metropolitan areas is summarised in Table 5.2 below. The figures, which include industrial demand, but not water used by mines, were obtained from the respective bulk supply authorities (see the notes to the table). *Water demand is sensitive to a large number of parameters* and these figures are therefore presented only to give an indication of the distribution of water consumption between the different metropolitan areas. The per capita water consumption figures are based on the total demand for each area (excluding mining) and are order of magnitude estimates only.

TABLE 5.2 Current water demand in the major metropolitan areas

Metropolitan area	Total demand 1991/2 Ml/day	Percentage of total metropolitan consumption	Total Population in Supply Area[1] 1990	Average Consumption[5] l/cap/day
PWV (RWB supply area)	2 032[4]	53	7 700 000[2]	264
Durban / Pietermaritzberg	670	17	3 577 000	187
Cape Town	710	19	2 560 000	277
Port Elizabeth	160	4	984 000	163
East London / Mdantsane	78	2	451 000	173
Bloemfontein	102	3	602 000	169
OFS Goldfields	79[3]	2	467 000	169
TOTAL METRO	3 830	100	16 341 000	235

Notes:
1. Population figures based on Urban Foundation population model, 1990 figures.
2. PWV population is for the Rand Water Board (RWB) supply area. The population figure quoted by the RWB in their annual report has however been adjusted on the basis of the Urban Foundation model. It should be noted that the RWB supply area does not correspond with Region H boundaries and that this was taken into account in the adjustment.
3. Total water supplied to local authorities in the region, excludes the water supplied to the mines which is supplied directly. The total amount of water supplied in 1991/92 including the mines was 196 Ml/day.
4. 1991 figure including power stations (4 Ml/d) and excluding water supplied directly to the mines. Total sales = 2 328 Ml/day.
5. Average consumptions based on total water demand (excluding mining). The figures are calculated on the basis of bulk water delivered and distribution losses have not been deducted.

The PWV, Durban and Cape Town metropolitan areas together account for almost 90% of the total demand for water in all of the metropolitan areas of South Africa as listed in the table.

In turn the metropolitan areas consume approximately 60% of the water demand for all urban areas in South Africa. This share is proportionate to the corresponding population share of 64%. This is surprising given the concentration of industrial and other economic activities in the metropolitan areas and it is possible that total urban usage as reflected in Table 5.1 is an overestimate. *The above figures were calculated on the basis of the following* estimates (for 1990):

Total metropolitan demand:	1 398	million m^3 / annum
Total urban demand:	2 281	million m^3 / annum
Total metropolitan population:	16.3	million
Total urban population:	25.4	million

Source: Demands: DWAF, 1986 (no updated information available)
Populations: Urban Foundation, 1991

5.4 FUTURE WATER DEMAND IN MAJOR METROPOLITAN AREAS

Current estimates of future water demand in the metropolitan areas of South Africa are summarised below. It should be noted that these estimates are continually revised on the basis of ongoing analysis of, amongst others, current water consumption patterns and updated population and economic growth projections.

TABLE 5.3 Future water demand in the major metropolitan areas

Metropolitan area	Total Population in Supply Area[1] 1990	Total demand 1991/2 Ml/day	Predicted growth % per annum	Estimated demand 2000[2] Ml/day
PWV	7 700 000	2 032	3.5 - 8.0[3]	2 800 - 4 000[4]
Durban/Pietermaritzberg	3 577 000	670	2.6 - 3.2[5]	840 - 890
Cape Town	2 560 000	710	3.4 - 4.4[6]	960 - 1050
Port Elizabeth	984 000	160	2.6 - 3.0[7]	200 - 210
East London/Mdantsane	451 000	78	2.6 - 3.0[8]	98 - 102
Bloemfontein	602 000	102	3.6 - 4.0[9]	145 - 180[10]
OFS Goldfields	467 000	79	3.0 - 3.5[11]	103 - 108
TOTAL METRO	16 341 000	3 830	3.3 - 6.1[12]	5 150 - 6 540

Notes:
1. Population and total demand figures from Table 5.2
2. Annual growth applied to actual 1991/92 demand, that is, over a 9 year span
3. Based on least and most severe maximum 7 day demand scenario projections of the Rand Water Board, applied to average daily demand.
4. This data very approximate. Demand excludes mining.
5. Based on Umgeni Water Plan 2025. These estimates are in the process of being revised.
6. *Based on Spies and Barriage, 1991.*
7. Port Elizabeth Municipality estimates
8. Assumed to be the same as for Port Elizabeth
9. From Bloemarea, 1992. They estimated 3.8% ± 5%
10. The 3.8% growth was applied to actual 1991 demand (102 Ml/d) and Ninham Shand's estimated 1991 demand (126 Ml/d) respectively.
11. From Goldfields Water Board. Forecasts exclude mining demand which is predicted to decline by -1.9% pa over the period 1993 to 2002.
12. Derived from above figures (weighted average growth).

Total future urban demand is highly sensitive to the growth in urban demand in the PWV (Rand Water Board Supply area).

5.5 PER CAPITA DOMESTIC CONSUMPTION

5.5.1 Global estimates for major metropolitan areas

Average per capita consumptions for the major metropolitan areas based on total water demand and an estimated percentage domestic consumption are summarised in Table 5.4 below. These figures should be regarded as very approximate order of magnitude figures only. Note that these figures exclude losses.

TABLE 5.4 Average per capita consumptions - major metropolitan areas

Metropolitan area	Total Population in Supply Area[1] 1990	Total demand[1] 1991/2 Ml/day	Estimated percentage domestic consumption %	Estimated per capita consumption[9] l/cap/day
PWV	7 700 000	2 032	73[2]	193
Durban / Pietermaritzberg	3 577 000	670	70[3]	131
Cape Town	2 560 000	710	70[4]	194
Port Elizabeth	984 000	160	60[5]	98
East London / Mdantsane	451 000	78	60[6]	100
Bloemfontein	602 000	102	68[7]	115
OFS Goldfields	467 000	79	68[8]	115
TOTAL METRO	16 341 000	3 830	71	166[10]

Notes:
1. Population and total demand figures from Table 5.2.
2. RWB gives consumption breakdown as 1477 (73%) residential and 555 (27%) industrial.
3. No figures obtained. Assumed to be the same as for Cape Town.
4. Based on estimates and calculations set out in "Bulk water supply to the Cape Town metropolitan area - an overview", written as part of this project.
5. Source: Ninham Shand, Cape Town. Estimate for the PEM municipal area. This was assumed to be representative of whole metropolitan area.
6. No figures obtained. Assumed to be the same as for Port Elizabeth.
7. Based on estimates and calculations done in "Domestic water supply in Region C - an overview"
8. Assumed to be the same as for Bloemfontein. Note that total demand figure excludes water supplied to the mines.
9. Consumption figures exclude losses.
10. Weighted average.

The average consumption in the Durban area is lower than might be expected when compared to the PWV and Cape Town because of the very large number of people living in the region with minimal water supplies and consequent low consumptions.

5.5.2 Per capita consumption by income group in metropolitan areas

Per capita consumptions by income group[1] are depicted in Table 5.5 below.

TABLE 5.5 Per capita consumption by income group

Metropolitan area	Population		Per capita consumption		Total domestic demand			
	%		l/c/day		Ml/day		%	
	Low	High	Low	High	Low	High	Low	High
PWV	68	32	120	350	629	861	42	58
Durban/ Pietermaritzberg	72	28	80	260	204	265	44	56
Cape Town	76	24	140	370	272	227	55	45
Port Elizabeth	75	25	80	150	59	37	62	38
East London/ Mdantsane	77	23	90	170	31	18	64	36
Bloemfontein	78	22	75	260	35	34	51	49
OFS Goldfields	82	18	75	300	29	26	53	47
TOTAL	71	29	108	315	1259	1468	46	54

See notes over page.

[1] Race groups were used as a very crude approximation of income groups as follows: whites, coloured and indians were taken to represent the middle and high income groups, and blacks the low income group (with the exception of Cape Town where whites only were taken to be high income, and Port Elizabeth where low/high split assumed similar to East London and Cape Town). This categorisation was used for the sake of convenience only. Water consumption information had already been collected by local authority (which at present are still largely racially defined) and hence it made the most sense to match this data with a broad racial classification of income groups along racial lines which is (unfortunately) a fair approximation.

Notes to Table 5.5: *Average per capita consumption figures are based on information from the survey and reported on in the regional profiles. These were adjusted in order to match the total domestic consumption figures per metropolitan area which can be calculated from Table 5.4. The figures probably provide optimistic estimates for low-income per capita consumptions as, where there was doubt, these figures were adjusted up in favour of the high income per capita consumption, which consequently are likely to be conservative. This conclusion is also supported by the fact that unaccounted for water (distribution losses) was not taken into account when calculating average per capita consumption figures for black local authorities in the regional profiles.*

The figures in Table 5.5 indicate that the wealthier 29% of the population use 54% of the water.

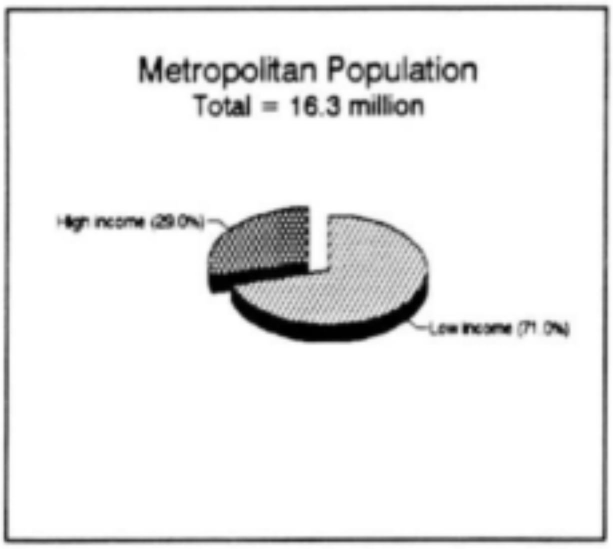
The average domestic per capita consumption figures presented in the table above (for metropolitan areas) are tabulated together with previous DWAF estimates of average per capita consumption figures (for the whole country) in the table below:

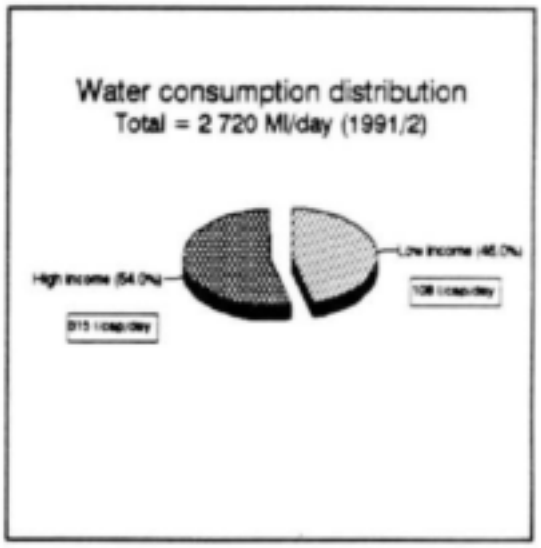
TABLE 5.6 Estimates of per capita consumption

	Consumption (l/cap/day)		
	(DWAF estimate)	(DWAF estimate)	(Estimate from Table 5.5)
	1970	1980	1990
Low income	27 - 41	55 - 101	108
High income	315	460	315

The distribution of domestic consumption between low and high income groups in the metropolitan areas is graphically illustrated in Figures 5.3 and 5.4.

Figures 5.3 and 5.4: Population and Domestic Water Demand by income group





The above figures show clearly that the high income group accounts for a disproportionate share of domestic water in the metropolitan areas in South Africa. It may be argued that the domestic water consumption is excessive in high income households in South Africa in the context of the scarcity of water resources in South Africa and future water needs for low-income communities which at present have inadequate supplies.

5.6 THE IMPACT OF PROVIDING ADEQUATE WATER SUPPLIES TO ALL URBAN RESIDENTS ON URBAN WATER DEMAND

5.6.1 Metropolitan areas

The figures presented in Section 2 indicate that approximately 3.1 million people (18%) living in the metropolitan areas do not have adequate water supplies at present. If it assumed that these people are, on average, consuming 25 l/capita/day, and that the provision of an adequate level of water supply will translate into an increase in consumption to 100 l/cap/day, then the total increase in water demand arising from improving the level of service will be 223 Ml/day (8% of total current metropolitan domestic demand, and 6% of total metropolitan demand). This figure is probably on the conservative side, that is, the increase in domestic demand is likely to be less than estimated here.

TABLE 5.7 Additional demand arising from full coverage.

	Population without adequate water supply[1]	Additional demand[2] Ml/day	% of existing demand[3] %	% of population without adequate water[4]
PWV	1 366 000	102.0	5%	15%
Durban/Pietermaritzburg	811 000	61.0	9%	23%
Cape Town	300 000	22.5	3%	12%
Port Elizabeth	200 000	15.0	9%	21%
East London/Mdantsane	40 000	30.0	4%	9%
Bloemfontein	280 000	14.0[5]	14%	48%
OFS Goldfields	77 000	5.8	7%	16%
TOTAL METRO	3 074 000	223.0	5.8%	18%

Notes:
1. From Table 3.2
2. Assuming additional demand of 75 l/cap/day
3. Column 2 as a percentage of total demand from Table 5.4
4. From Table 3.2
5. Existing consumption in Botshabelo 40 l/cap/day. Assume additional 40 l/cap/day for an adequate supply of 80 l/cap/day for 200 000 in Botshabelo and additional 75 l/cap/day for remaining 80 000 people

5.6.2 Other urban areas

Total domestic water demand in the other urban areas will be increased (at most) by approximately 96 Ml/day if a basic level of service is extended to the 1.6 million people who do not at present have an adequate level of service, assuming an adequate supply of 75 l/cap/day in these areas, and existing supply of 15 l/cap/day.

5.7 THE CONTRIBUTION OF LOW INCOME DOMESTIC DEMAND TO TOTAL DEMAND IN THE FUTURE

The Urban Foundation forecasts of urban population growth are summarised below:

(figures in millions)	1990	2000	absolute increase
Metropolitan Population	17.4	24.1	6.7
Other urban	7.1	9.3	2.2

The Urban Foundation estimates that approximately 50% of all urban residents will earn less than R1 500 per month in 1995 (in 1990 rands). The increase in demand arising from low-income domestic consumption may therefore be roughly estimated as follows, assuming an average per capita demand of 100 l/cap/day:

	Increase in low-income population 1990-2000 millions	New water demand (2000) Ml/day	% of estimated demand in 2000
Metropolitan	3.3	330	5-6% (ex Table 5.3)
Urban	1.1	110	
Total	4.4	440	

These figures also indicate that providing adequate water supplies to everyone living in urban areas of South Africa will have little impact on water resources.

5.8 INEQUITABLE WATER CONSUMPTION - AN ILLUSTRATION

Information on per capita water consumption obtained from the questionnaire returns is graphically illustrated below.

Figure 5.5 Per capita consumption - white local authorities (metro areas)

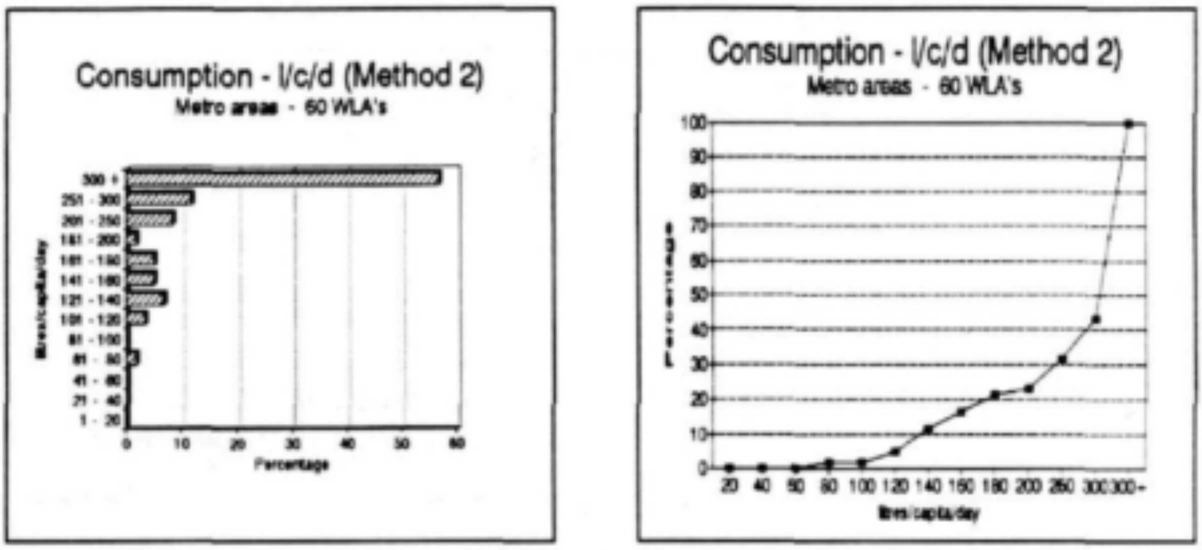
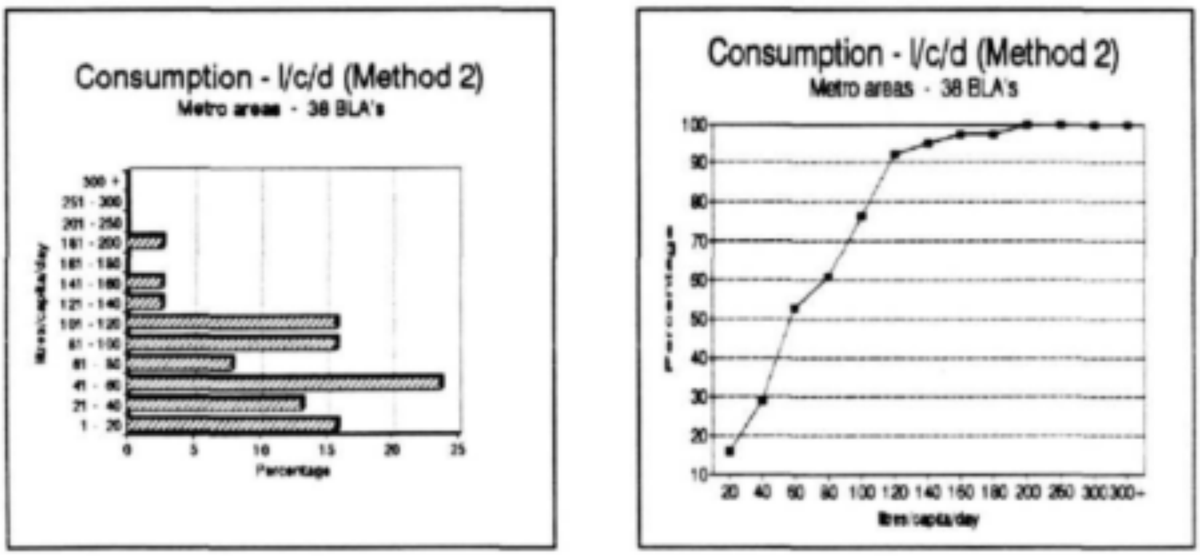


Figure 5.6 : Per capita consumption - black local authorities (metro areas)



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6. FUTURE DEMAND FOR WATER SUPPLY SERVICES

6.1 DEMAND FOR SERVICES

The current and future demand for water supply services may be crudely estimated on the basis of:

- Current access to water supply (Section 3):
  4.6 million people without adequate water supply.

- Future population forecasts (Section 5.7)
  8.9 million new urban residents during period 1990 to 2000.

- Predicted household income distribution (Section 5.7)
  50% of all urban residents will earn less than R1 500 per month in 1995 (1990 rands).

and assuming an average household size of 5.5.

Estimates of current and future demand based on the above information and assumptions are summarised below:

Current backlog	: 850 000 households
New low-income demand for basic urban services (1990 - 2000)	: 810 000 households

Therefore to clear the backlog and meet the new demand for services by the year 2000 will require the provision of approximately 210 000 water supplies per annum. This figure may be compared with De Loor's estimated new housing requirements of 200 000 to 330 000 per annum.

6.2 COST OF SERVICE

van Ryneveld (1992) estimated the cost for water supply services as follows:

Yard Tap - metered	:	R 600 / site
Bulk services	:	R1 000 / site
Total	:	R1 600 / site

Based on these costs the annual capital investment needed to provide for the backlog in urban water supply services is R320 million per annum. This is 11% of the R2.8 billion estimated by De Loor as the current annual expenditure on housing.

If an alternative level of service was provided, comprising:

60% yard taps
40% standpipes at 250m

the required annual expenditure is estimated at R256 million. This figure is calculated assuming that the standpipe supply would cost R800 / site.

6.3 SENSITIVITY OF DEMAND AND COSTS

The above figures represent only an order of magnitude estimate and need to be refined in terms of sensitivity to different policy frameworks, cost structures, future demand projections and subsidy / cost recovery paradigms. These aspects will be dealt with further in later phases of the project upon which this report is based and in parallel Water Research Commission projects.

REFERENCES

De Loor	1992	Housing in South Africa
Urban Foundation	1991	Demographic Projection Model
Urban Foundation	1991	Income Distribution Model
van Ryneveld, M B	1992	The Current Extent of Coverage and the Costs of Water Supply and Sanitation Provision in the Urban Areas of South Africa

7. WATER SUPPLY STANDARDS

7.1 INTRODUCTION

This section deals with the standards for supplying water to communities and is orientated towards practical aspects. In general terms "standards" define what level of service is to be provided and how this is provided. As such, they have a major impact on the cost and efficiency of a water supply system.

For the purposes of this discussion a water supply system is divided into:

- **bulk water supply** which includes the provision of a dam, boreholes or other abstraction arrangement, and raw water transfer.

- **treated water delivery** which includes treatment and treated water transfer to the area to be served, which may include pumping.

- **distribution system** which includes service reservoirs, connector pipelines from such reservoirs to the residential area, the reticulation internal to the residential area and the delivery arrangement.

In this section the focus is on the distribution system only. It is not the intention of the project as a whole to deal with the physical aspects of bulk water supply, treatment and transfer.

In dealing with the distribution system there are a number of factors which influence the design and functioning of the system. For the purposes of this discussion certain key parameters are selected as the most relevant, as listed below. They include service standards which relate to what the consumer experiences, and design standards, which are set down in order for the system to function properly.

- Level of service including domestic water consumption
- Peak factors
- Future increases in consumption
- Unaccounted-for-water
- Reservoir storage capacity
- Residual pressure
- Fire fighting requirements

- Minimum pipe sizes

Each of these parameters is discussed separately in the following sub-sections. The discussion for each one deals first with the standards applicable to the system, then with specific factors associated with the particular component of the system.

Before this discussion, the issue of standards generally is dealt with and a listing and brief description of published standards is given.

7.2 PUBLISHED STANDARDS

Published standards, as referred to here, define the level of service which people receive and the way in which the service is designed. In this report the orientation is more on service standards and the primary standards affecting design, rather than on detailed specifications.

The work done by Heigers (1992) serves as a primary source for this discussion.

7.2.1 Relationship to socio-economic factors

Engineers, who are primarily responsible for the application of standards to water supply systems, have tended to approach such provision from the point of view of what they believe "works best", rather than what "works and is affordable". This approach has been backed up by many of the older published standards in South Africa (such as the "Blue Book" and the Department of Water Affairs and Forestry (DWAF) standards - see below) which do not sufficiently consider the variety of options which are needed if water supply systems are to made affordable.

7.2.2 Relationship to township size and layout

In considering standards the size of the township or settlement to be served needs to be taken into consideration. Generally, in larger settlements there are economies of scale and thus standards can be higher while costs per household remain the same. The effect of peak factors and fire fighting requirements is also less marked in the case of larger settlements. This also means that per capita costs are lower for the same level of service.

The density of households within the area to be served also influences the standards to be applied. The greater the density the higher the level of service is that can be offered for the same cost. Also the township layout, particularly the arrangements of the road network, may affect the options available for planning the reticulation. These factors indicate the importance of coordination between the team of people planning the area.

7.2.3 Current design standards

This section is an overview of the various water storage and reticulation design standards, from which the key design parameters discussed in the next section were extracted. The emphasis here is on local (South African) standards, with limited reference to international standards for the purpose of comparison.

The following standards are considered:

- **"Blue Book"**: The full title of this publication is "Guidelines for the Provision of Township services in Residential Townships". It was prepared by the CSIR for the then Department of Community Development and has been used extensively by design engineers in South Africa over the last decade. Currently it remains the most widely used source of design standards in South Africa. The document includes practical formulae, graphs and detail.

- **"Green Book"**. This document has the full title "Towards Guidelines for Services and Amenities in Developing Communities". Also prepared by the CSIR, it takes a different approach to the "blue Book" in that it includes more of a planning overview, with little quantitative information. This has meant that it is not widely used for design purposes.

- **"Red Book"**: Also prepared by the CSIR, this document has the full title: "Guidelines for the Provision of Engineering Services and Amenities in Residential Township Development". It was prepared in 1990 but has not been distributed yet. The document combines elements of the blue and green books, giving both a general approach to planning and specific quantitative design information. The information in it is very close to that of the two parent documents.

- **"Brown Book"**: This document has recently been prepared by the Cape Provincial Administration. It has been written in Afrikaans but is being translated and will have the title "Proposed Development Guidelines for Housing Projects". In the tradition of naming design guidelines after colours, the authors of the book refer to it as the "Brown Book". It is not currently available for distribution.

- **British Standards**: The "Manual of British Water Engineering Practice" is used in Britain primarily as a reference for developed world applications. In 1983 a companion to it was published, orientated more towards the developing world, which implies a limitation of resources. This is titled: "Water Supply and Sanitation in Developing Communities".

- **RSA/Kwazulu Guidelines**: This document was drawn up for the RSA/Kwazulu Development Programme (RKDP) which has the role of coordinating the provision of services in the Durban and Pietermaritzburg metropolitan areas. It lays down design standards for a variety of situations, drawing primarily on the "Blue Book", with modifications to allow services to be provided at lower cost.

- **Department of Water Affairs and Forestry (DWAF)**: The Department does not have a comprehensive design guideline and does not exert overall control over the standards of services provision through the vehicle of such a guideline. However, where the DWA provides a subsidy for a water supply scheme, primarily in small towns, it does exert control over design standards.

- **Hebert et al, Philippines Case Study**: (See reference list). This document is not a standard itself but is a review of the effect of design and service standards on water distribution costs. It includes an analysis of standards and therefore is a useful reference for the purpose of this discussion.

- **Botswana Standards Study**: This report was prepared in 1990 for the Botswana Ministry of Local Government and Lands, by Brian Colquhoun and Partners. It is not referred to by Heigers.

Each of the key parameters relating to the distribution system are discussed in the following sub-sections, with reference to the recommendations of the published standards listed above.

7.3 LEVEL OF SERVICE (INCLUDING DOMESTIC WATER CONSUMPTION)

From a technical point of view the primary consideration in supplying water to communities is the level of service. The options here are numerous and separating them becomes an issue of classification which is dealt with differently in all the standards considered.

In dealing with level of service it should be recognized that the published standards can not rigidly lay down what should be provided as the factors to be considered are too complex. These factors include the income levels of the community, availability of bulk water supply, size and density of settlement, availability of finance, and so on. However, what the standards do is suggest the rate of water consumption associated with a particular supply arrangement. Here again the figures need to be treated with caution as the amount of water people consume is a complex issue.

7.3.1 Recommendations from published standards

The approach in the different standards is given below.

The unit for domestic water consumption is dealt with differently in the various standards, either as:

- litres per capita per day (l/c/d)
- litres per household (or site) per day (l/h/d)

or

- kilolitres per hectare per day.

"Blue Book"

The basic standard for water consumption is given as 600 l/h/d to 1 200 l/h/d depending on the climate, income level etc. There is no differentiation made with regard to the supply configuration and presumably house connections are assumed.

For low cost housing of a temporary nature the recommended figure is 5 kl/ha/d, which for typical stand sizes of 200 sq.m. would convert to 170 l/h/d or about 30 l/c/d. This implies a low level of standpipe supply.

"Red Book"

Similar to the "Blue Book" for house connections, but includes the following recommendation:

- Standpipes 250 to 1 000 m maximum distance:	10-50 l/c/d.
- Standpipes within 250 m from dwellings:	20-50 l/c/d.
- Yard connection:	20-80 l/c/d.
- House connection:	70-250 l/c/d.

As a practical standard these figures need to be questioned as they do not seem to be consistent with other standards and have very broad ranges. It is difficult to see how a community could use 50 l/c/d if they have access only to a standpipe more than 250m away, for example.

Department of Water Affairs (DWAF)

The DWAF figures do not recognize alternative water supply arrangements and apparently assume house connections. The recommended water consumption rates are given below:

- Minimum of 500 l/h/d.
- 250-500 l/c/d for "white" communities.
- 100-180 l/c/d for "coloured" communities.

This standard suggests high rates of consumption and uses a racial classification which is outmoded.

RKDP Guidelines

RKDP have been innovative in providing for a variety of supply configurations and differentiate water consumption figures as follows:

- Water vending (kiosk): 15 l/c/d.
- Unmetered communal standpipe: 30 l/c/d.
- Metered yard tap: 50 l/c/d.
- House connection: 950 l/h/d.

It seems as if the figure for a house connection is too high for a low to middle income household. However, this may be a deliberate recognition of the high house occupancy figures in the formal areas of greater Durban.

CPA "Brown Book"

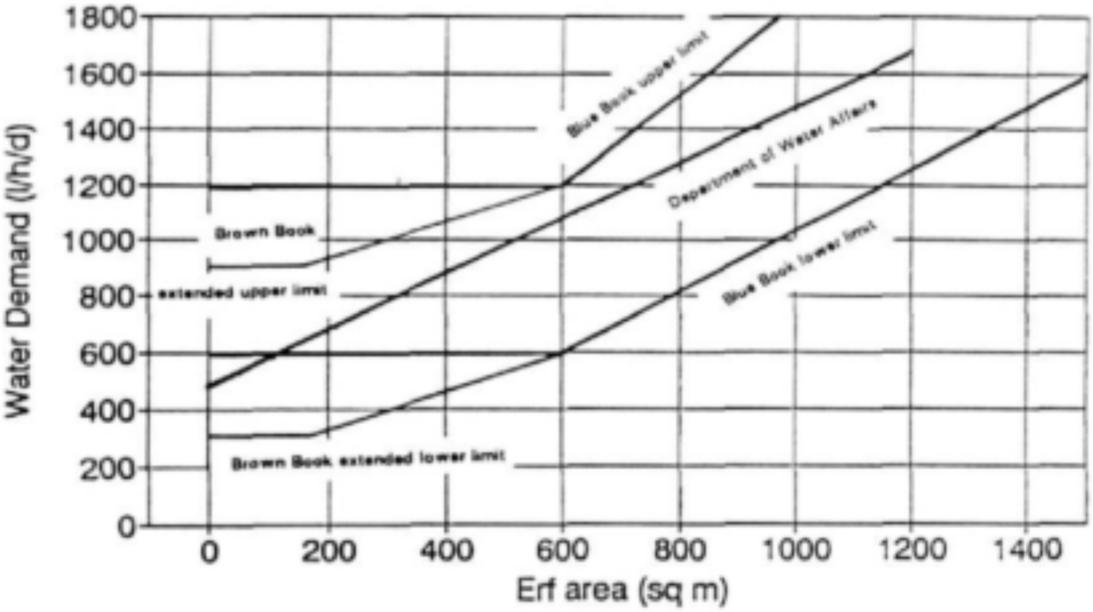
CPA have proposed the level of service and water consumption standards of the World Health Organisation, as follows:

- If no water is readily available but has to be carted to the community, the minimum provision should be 15 l/c/d.
- If a specific source is available, the standard should be one standpipe/well per 30-50 dwellings, supplying 20 l/c/d.
- If a pipeline can be afforded, the applicable standard is one standpipe per 20 dwellings supplying 50 l/c/d.
- If ample water is available the supply should be increased to 90 l/c/d.
- If ample water is available at sufficient pressure, standpipe density can be increased to one per 6-10 dwellings @ 90 l/c/d.
- With the highest standpipe density and no metering, provision should be increased to 120 l/c/d.
- The next step is to provide individual domestic connections. In this case consumption can increase to 170 l/c/d.

The WHO also recommends that the rate of flow for standpipes should be limited to 15-20 l/min and the distance to standpipes should not be more than 150 m.

Using the information from the "Brown Book" to adjust the recommendations from the "Blue Book" a plot of the combined recommendations is shown on Figure 7.1.

Figure 7.1



Philippines case study

The standards applied by authorities in the Philippines ranged from 30 - 175 l/c/d for urban communities and 20 - 60 l/c/d for public standpipes in rural areas and 40 - 150 l/c/d for house connections in rural areas.

7.3.2 Factors affecting domestic consumption

There is extensive reference in the literature to domestic water consumption studies, both in South Africa and internationally. Unfortunately in the South African context studies on consumption patterns for communities without stand connections is limited.

As demand is linked primarily to the water supply configuration and to the socio-economic characteristics of the users, this discussion follows this sub-division.

a) Rudimentary service

Based on his literature review, Heigers noted that the basic requirement for survival relate to bodily requirements which is about 2,2 l/day for an adult in a temperate climate. In a hot, humid climate the requirement can exceed 9 l/day.

However, in all but exceptional circumstances, people in **urban areas** do have access to water for bodily washing and washing of clothes and eating utensils. Here the quantity used will depend on how far away the water is and the adequacy of the source. It is therefore difficult to generalize. However, reported studies from various parts of the world give the following (from Heigers):

- E1 Obeid, Sudan: area using low density standpipes and private wells. Average use: 16 l/c/d
- International Reference Centre for Community Water Supply and Sanitation has recorded use of 7 - 12 l/c/d where wells or standpipes are further than 250 m from a house.
- *In Male, in the Maldives, consumption from private wells was found to* be 43 - 73 l/c/d.
- In a British study in Central Africa the figures for water usage by a community supplied by tankers was 30 l/c/d.
- Another British publication relates the amount used to the distance water has to be carried. With a level of service comprised of either hand pumped wells or public standpipes with water carried 100 - 500 m and each tap serving 200 - 500 persons, water use is estimated to be 15 l/c/d.

These figures can be compared with those reported by Rivett-Carnac (1989) for communities in the Durban Functional Region using a rudimentary water supply based on standpipes:

Area	Type of supply	Ave water use (l/c/d)
Inanda (Released area 33)	Kiosk	18
Sankotshe/Geargedale	Uncontrolled standpipe	12
Molweni, Embo, Nqcolosi, Qadi	Controlled standpipe	15

In these Durban examples, the standpipe density was generally less than one per 50 households.

It is apparent from the above figures that consumption rates of the order of 15 to 20 l/c/d are applicable to communities provided with this level of service.

b) Planned urban standpipe supply

In this case it is assumed that an adequate level of service will be provided for an urban environment which implies both that the distance to the standpipe will not exceed 250 meters and that there will be more than one standpipe per 50 households.

Heigers, *in his literature survey found the following:*

- In El Obeid in the Sudan, with "medium density" standpipes water use was measured at 21 l/c/d.

- International Reference Centre for Community Water Supply and Sanitation has recorded use of 20 - 30 l/c/d where wells or standpipes are within 250 m from a house.

- In the British publication referred to above the estimated use for standpipes within 100 m and serving not more than 200 people is 20 - 35 l/c/d.

This level of service is becoming common in South Africa for planned site and service schemes where waterborne sanitation is not provided. Here water demand must be related to the on-site sanitation system used. If a dry system is used such as a ventilated pit latrine (VIP), obviously no water will be used for flushing. However, if LOFLOS (aqua-privies) are used, with water carried, about 20 - 15 litres per household per day needs to be added, assuming a flush volume of 1 to 1.5 litres.

The above figures would suggest consumption rates for this level of service as follows:

- With dry sanitation system: 20 - 35 l/c/d
- With LOFLOS sanitation: 35 - 50 l/c/d

c) Yard connections

Here a connection to each site is provided which generally means one tap per household. In estimating water demand the type of sanitation system used is obviously important; this is not always reported in the literature.

Again using Heigers' work the following international examples are relevant:

- E1 Obeid, Sudan: area using medium density standpipes and yard taps: Average use: 64 l/c/d

- International Reference Centre for Community Water Supply and Sanitation has recorded use of 30 - 60 l/c/d for yard taps.

- In Thailand areas using 80% stand connections and 20% standpipes used an average of 80 l/c/d.

The rate at which water is consumed in this situation depends on the type of sanitation system used. Full flush toilets may use 30 to 50 l/c/d under South African conditions and this needs to be added to consumption for other purposes.

Appropriate consumption rates would therefore be:

- Yard taps with dry sanitation: 30 - 60 l/c/d
- Yard taps with LOFLOS sanitation: 45 - 75 l/c/d
- Yard taps with full flush sanitation: 60 - 100 l/c/d

Once a stand connection is provided the householder will generally have the freedom to connect the water to a formal house should he/she build one. There is therefore the probability that water consumption will increase as the area develops.

d) **House connections with multiple taps**

Where house connections are provided, the per capita consumption of water can vary widely, depending on income levels and many other factors.

Looking at developed countries' consumption the figures were typically:

USA	243 l/c/d
Britain	110 l/c/d
Belgium	128 l/c/d
Canada	103 l/c/d
Denmark	212 l/c/d
West Germany	118 l/c/d

which gives a range of 103 - 243 l/c/d.

It is generally accepted that, with house connections, a per capita consumption rate of 75 to 100 l/c/d represents essential or "non-luxury" use. Consumptions rates greater than this are therefore associated with convenience use.

The above figures and the results of the survey carried out as part of this study indicate the sensitivity of water consumption to income levels and habits. Therefore, while it is necessary to make predictions, considerable variability should be expected.

7.3.3 Discussion

It is apparent that South African standards for water consumption do need to be reviewed and rationalized, making specific allowance for different levels of service, income levels, and types of sanitation.

7.4 PEAK FACTORS

Peak factor or, more specifically, instantaneous peak factor can be defined as the ratio of the highest hourly flow anticipated to the average daily flow.

In general, South African standards make use of a straight line graph which relates "equivalent erven" (erven, or stands, with an assumed consumption of 1000 l/day) to the peak factor.

7.4.1 Recommendations from published standards

Most of the published South African standards use a minimum peak factor of 4 and factors bigger than 4 only when there is less than about 2000 equivalent erven.

To illustrate how the various standards apply peak factors, an example will be used with the following distribution of stands (residential only):

1000	erven of size 180 m^2
800	erven of size 250 m^2
200	erven of size 500 m^2
Total =2000	

This example is used to calculate peak factors in the table over the page for the Blue, Red and Brown books and for RKDP Guidelines. All of these standards use "equivalent erven" and the same graph.

The figures in the table show that the variation in peak factors, for the same size area, is substantial and indicates both that South African standards give high figures and that the various standards are inconsistent.

Guideline	Flow per erf		No of equiv	Peak factor
	Erf size (sq.m.)	Flow (l/erf/d)	Erven (for example)	
Blue and Red book	>600	1 000		
	<600	600	1 200	4.7
CPA Brown book	180	310		
	250	360		
	500	540	706	5.5
RKDP Guidelines	All	950	2 000	4.2
Philippine case study				2 - 3
DWA				4
Botswana				3 - 3.5

Note:

1) RKDP Guidelines require another 15% adjustment, after the peak factor has been calculated from the graph.

7.4.2 Conditions influencing peak factors

The instantaneous peak factor is made up of two components:

- Peak day factor (peak daily flow for the year divided by average flow over a year)
- Daily peak factor (peak hour for a day during a high flow period divided by flow for that day)

Peak day factors are likely to be related to climatic conditions and income level, as water for gardening would have a major effect. Peak hour factors would be affected primarily by the daily habits of people and would therefore vary widely.

Heigers looked at peak factors, both by reviewing the literature and using an analysis for three small towns in the Western Cape. He reports as follows:

Peak day factor:		
British Standards	:	1,2 - 1,4
Philippines	:	1,1 - 1,2
S A case studies	:	1,8
Peak hour factor		
British Standards	:	1,3 - 1,5
Red Book	:	1,5 - 2,5
Philippines	:	2 - 2,5

To get the instantaneous peak demand the above two factors need to be combined, and this gives a range of factors from 1,4 to 4,5. Great Variability is indicated.

7.4.3 Discussion

Based on this evidence, and a review of the literature, it is apparent that South African standards currently use peak factors which are too high. It is also evident that the "equivalent erf" concept is not well founded as water consumption patterns are not strongly related to stand size.

7.5 FUTURE INCREASE IN CONSUMPTION

In estimating water consumption for design purposes a design period needs to be selected and projections need to be made regarding population growth.

7.5.1 Recommendations from published standards

An approach to dealing with this is given in several of the standards, as follows:

Guideline	Planning Horizon (years)	Growth rate (%) Population	Water Demand
Blue book	20		2
Red book	10		
CPA Brown book			
- Coloured		1.0 - 1.5	
- Black		1.5 - 2.0	
DWA	25		
Philippines study			
- Developing	5 - 10		
- Developed	10 - 30		

Note:

1) In the Brown Book it is stated that even when higher population growth figures are found compared with those given in the table above these should only be applied for 4 - 5 years and the above figures used for projecting beyond this period.

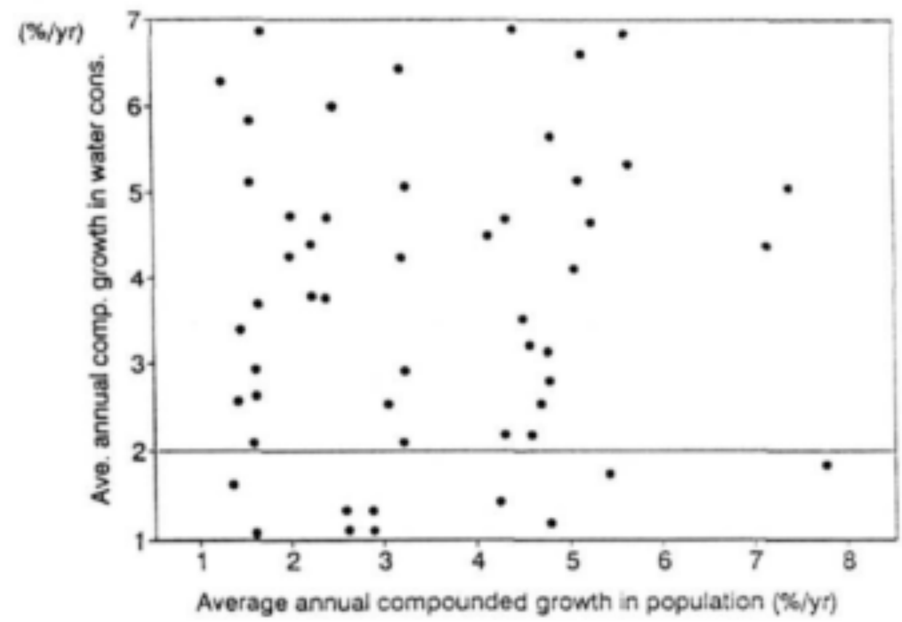
7.5.2 Factors affecting Projections of water demand

Projection of demand is a complex issue and existing guidelines appear to be too simplistic in their approach. The complexity is compounded in South Africa at present, with a situation of both demographic and economic transition. There are substantial population movements and changes in consumption patterns. The willingness to pay for water also affects water use and this too is a largely unknown factor.

In order to gain some understanding of current trends, Heigers analyzed a sample of 56 South African towns and cities using information from the Municipal Yearbook (1990). The sample included the non-residential component of municipal water use (commercial and industrial).

Figures were abstracted from the Yearbook for both population and actual water demands for the years 1979 and 1989. These were converted to growth rates for the 10 year period and the results plotted to determine if there was a trend.

The results are given here as Figure 7.2.



From this analysis the following is evident:

- There is effectively no correlation between increase in population and increase in water consumption.

- Only 13 towns (23%) had an annual growth rate of water demand of less than 2%

- The range for rate of water consumption increase is between 1% and 8%.

It should be noted that the drought which occurred over much of the country between 1983 and 1987 will have been an additional complicating factor. However, the analysis supports the notion of complexity in the area of local water demand projections. This would suggest that shorter time horizons should be chosen for planning and that more detailed guidelines are necessary to assist engineers in estimating demand.

Shorter planning horizons would also be supported where there is a shortage of capital. In this situation it is better to plan for upgrading at intervals.

7.6 UNACCOUNTED-FOR WATER

The issue of unaccounted-for water (UAW) and water losses is dealt with later, in Section 8 of this report, under water conservation. However, this is a factor in designing water distribution systems as estimates need to be made at the design stage. Therefore it is referred to briefly here.

Estimated losses from reticulation networks vary widely depending upon factors such as layout, pressure, age and maintenance of a system. A British study showed that only in exceptionally well maintained systems will UAW be less than 15%. However, in South Africa the bulk water authority, the Department of Water Affairs, has stipulated that UAW may be no more than 10% of total demand for schemes it is prepared to subsidize. This implies a high level of management skill by the local authority, something which is seldom available in developing areas.

Actual losses which have been metered or recorded, have been investigated as part of the project on which this report is based, using figures for 47 municipalities from the Municipal Yearbook (1990), and from the questionnaire survey. In the latter case the results are based on 272 responses. These results are given in the table below and compared to the figures from a survey of 31 municipalities carried out by de Leuw Cather (de Leuw Cather 1993).

Losses (% of total)	MUNICIPAL YEARBOOK % of total	THIS PROJECT % of total	de LEUW CATHER % of total
<5%	27	18	10
6 - 10%	30	28	29
11 - 15%	19	23	29
16 - 20%	11	12	22
>21%	13	19	10
TOTAL	100	100	100

In the de Leuw Cather survey and in all but three of the cases abstracted from the municipal yearbook the municipalities are "white". The sample for this project included a much larger proportion of black local authorities, but these authorities are also under-represented.

It is clear that UAW of over 20% is common in South Africa, probably occurring in more than a third of municipal systems in the country.

As a general conclusion it can be said that, based on the figures given here, planning for losses should be based upon a percentage of:

- 15% for well managed areas.
- 25% for areas where management is unlikely to be good.

7.7 RESERVOIR STORAGE CAPACITY

The retention volume of the service reservoir in relation to the demand from the area it serves is a key design parameter.

With regard to published standards, this storage parameter relates the volume of the supply reservoir to the average daily demand from the distribution network. The unit of measurement is hours (hrs) of annual average daily demand.

The published standards recommend the following figures:

GUIDELINE	RECOMMENDED STORAGE (hrs)			
	Pumped supply		Gravity supply	Elevated storage
	Single	Multiple		
Blue book	48	36		2-4
Red book	48	36		2-4
RKDP Guidelines	48	48		
DWA	48	48	24	
Botswana	24 - 48 (no specifics)			

Note:

1) The Red Book recommends the same standards as the Blue Book but also makes provision for system breakdowns where the water stored in the system itself is utilized to reduce the required storage capacity. It advocates the use of intermediate storage reservoirs which should reduce the size of main water lines which would then not have to provide for peak demand.

2) British standards place strong emphasis on the use of service reservoirs with a typical capacity of 5 - 10 hrs of average daily demand.

In considering storage, it is clearly necessary to base the requirement on the type of delivery to the reservoir, as pumped supplies are less reliable than gravity supplies. Also, the need for fire flows may have a substantial impact. There is, once again, an inconsistency in the South African standards and this needs to be addressed.

7.8 RESIDUAL PRESSURE

Residual pressure can be defined as the surplus head or pressure available at any point in the network during instantaneous peak draw-off conditions. The pressure unit of measurement is usually metres of water (m).

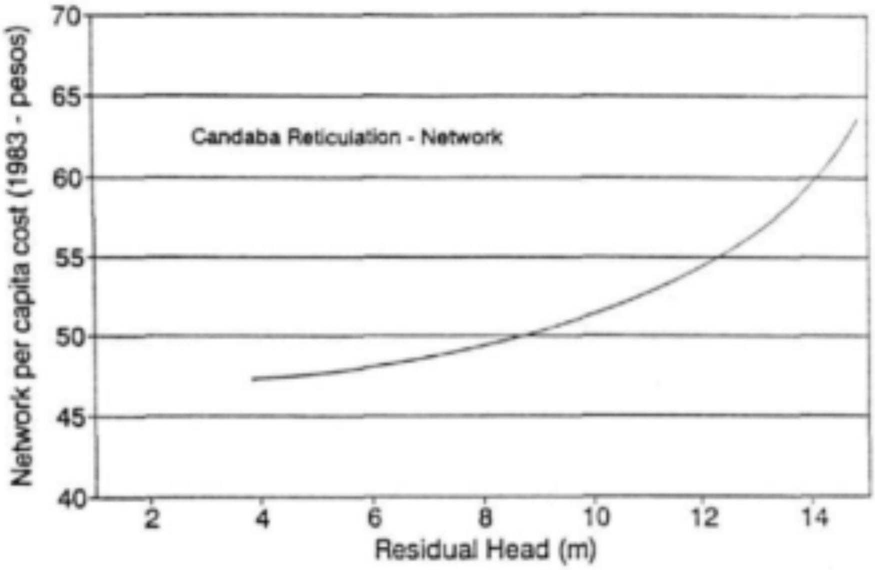
The published standards have the following recommendations:

GUIDELINE	RECOMMENDED HEAD (m)			
	Minimum for income level:			Maximum
	Low	High	Standpipe	
Blue book	12	24		90
Red book	6-8	24		90
RKDP Guidelines	12	12	6	None
Philippine case study	8-12			70-80
Dept. of Water Affairs	15	15		100
Botswana	10	15		

The pressure which occurs in a reticulation system is clearly a key design parameter and residual pressure, the lowest pressure occurring in the system at peak draw-off periods, is a key determinant.

The work done by Hebert (1986) in the Philippines gives a useful indication of the influence of residual pressure on the cost of a reticulation system. The results of this work for a particular town are shown graphically on Figure 7.3. Although the cost-scale is in 1983 pesos the trend is clear, indicating a 30% reduction in cost of the reticulation with a reduction in residual pressure from 14 to 7 meters.

Figure 7.3



In the discussion in section 9 of this report on losses, it is also indicated that lower pressures lead to lower losses in the system. This will also bring direct economic benefits.

In making decisions regarding residual pressure, the type of consumer needs to be considered. In areas where there is substantial commercial and industrial activity and where there are likely to be double storey houses, residual pressures need to be higher. These situations seldom occur in low-income settlements and therefore lower pressures can be accepted. This is particularly true where standpipes and yard taps are provided, although the probability of these being upgraded to house connections with multiple taps needs to be considered.

7.9 FIRE FIGHTING REQUIREMENTS

In general the South African standards are based on SABS Code of Practice 090-1972: Community Protection Against Fire. The need to design for fire fighting requirements greatly affects all parts of a distribution system. This is due to the fact that fire fighting draw-off is usually seen as an extra over normal domestic demand and the flow rates required at the point of abstraction are high.

This discussion will again concentrate on requirements for lower income communities.

7.9.1 Recommendations from published standards

As the Red Book and Brown Book apply the same standards as the Blue Book, only the latter will be discussed.

Blue book

Areas that are to be protected against fire are classified according to fire-risk categories. Residential areas are grouped together in the low-risk category. This category is again split into four groups, based on gross floor area of dwelling houses:

- low risk Group 1 : > 200m^2
- low risk Group 2 : 100 - 200 m^2
- low risk Group 3 : 55 - 100 m^2
- low risk Group 4 : 55 m^2

Based on gross floor areas, South African townships generally fall into groups 3 and 4.

Group 4 has no specific provision for fire fighting requirements in the network. The standards require trailer-mounted water tanks or fire-appliances which, if necessary, can be replenished from hydrants situated on mains with a minimum diameter of 75mm situated at centrally located points. Hydrants are thus only used as "filling points".

In the case of group 3 areas the minimum design fire flow should be 350 l/min or about 6 litres per second. This is extra over instantaneous peak demand.

The water storage required over and above normal domestic demand for group 3 areas is specified as equivalent to the demand for a fire lasting one hour. (This will mean an extra 350 x 60 = 21 000 l) The minimum residual head, during instantaneous peak demand, for fire fighting requirements is specified as 3 m.

Spacing of fire hydrants for group 3 areas are limited to no more than 2 000 dwellings per hydrant and a distance > 240m apart.

RKDP Guidelines

This standard does not require networks to be designed to carry fire-flows but also advises that hydrants should be used as filling points.

Philippines case study

The Local Water Utilities Administration (LUWA) in the Philippines required a design fire flow of 11 l/s from a hydrant with a residual head of 14 m. USA standards of up to 63 l/s/hydrant were encountered.

Botswana standards

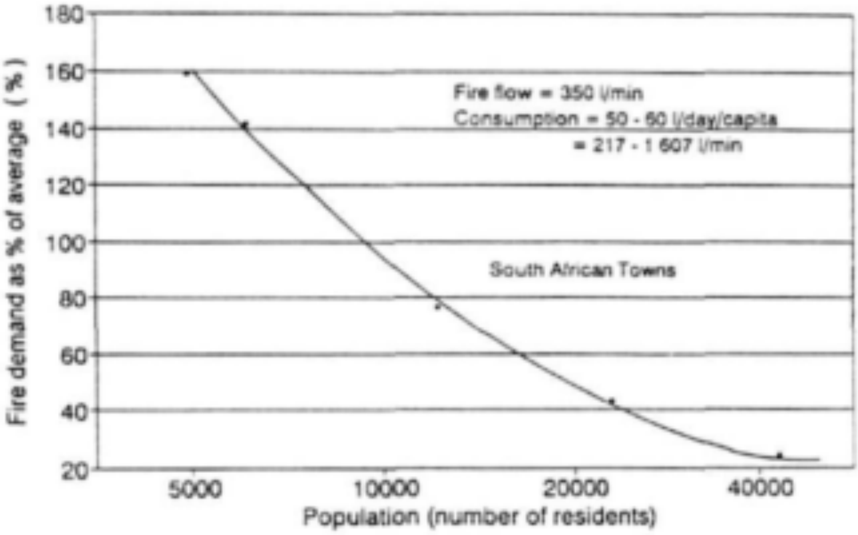
No special provision for fire fighting is recommended in the case of low-income settlements.

7.9.2 Factors affecting fire fighting requirements

Requirements for fire fighting can also have a substantial influence on the cost of water distribution systems. This is indicated in an analysis done by Heigers, based on the fire requirements of the Blue and Red books (350 l/min from any hydrant).

Heigers used five towns which had average domestic consumption rates of 50 - 60 l/c/d. Using the population numbers the total domestic demand in the towns was calculated and compared with fire flow requirements. Figure 7.4 shows the relationship between size of population served and the percentage demand related to fire requirements. The impact in the case of smaller towns is clearly substantial, with towns smaller than 8 000 residents requiring equal flow provision for domestic demand and fire requirements.

Figure 7.4



If costs are to be saved, the issue of water for fire fighting in low-income settlements is obviously an important one. Fires often occur in these areas as inflammable fuels are used and wooden building materials are common. Loss of life under these circumstances is common as fires can start quickly. However, as the materials are light they also are unlikely to burn for long. This represents a specific fire fighting situation.

In order to gain insight into methods of fighting this type of fire, Heigers spoke to various fire-fighting authorities. The general opinion was that the water carried in a fire engine is usually sufficient for the kind of fires found in South African townships. The irregular township layouts that are sometimes encountered also made the coupling of fire-hoses to hydrants difficult. Therefore the usual method used is to employ a smaller, more manoeuvrable fire vehicle, backed up by a large fire vehicle, depending on the severity of the fire. In extreme cases, where hydrants are available, these are used as a means of replenishing the vehicle's water. The two vehicles are then used alternatively.

The approach taken in the RKDP and Botswana standards of having no specific volumetric fire fighting requirements does therefore have a sound basis for informal settlements. However, as the housing standards improve there needs to be a parallel improvement in the water reticulation to provide water for fire fighting.

There are also other methods of cutting the cost of providing water for fire fighting. (Location of hydrants on larger lines, for example).

7.10 MINIMUM PIPE SIZE

This standard usually defines the internal diameter of the various pipe sizes in the reticulation network. The unit of measurement is millimetres (mm). The following terms need definition:

- Trunk mains: The mains within a distribution system that convey water in bulk form, from the reservoir to the reticulation network.
- Secondary mains: They are the pipes that provide the basic structure of the system and are used to link the service mains (see below) to the trunk mains.
- Service Mains: These pipes are laid with the prime purpose of conveying water from the secondary mains to the smaller consumers. They include pipes laid in the roads and streets of a residential area.
- Service pipes: The pipes that connect the consumer's plumbing to the service main. They are subdivided into the portion from the service main to the consumer's boundary (communication pipes) and the portion inside the boundary (supply pipes).

The standards deal primarily with pipe sizes for service mains and service pipes as, for the largest pipes, site-specific hydraulics are the controlling factor.

Recommendations from published standards

GUIDELINE	RECOMMENDED MINIMUM DIAMETER (mm)	
	Service main	Service pipe
Blue book	75	19
Red book	75	15
CPA Brown book	75	19
RKDP Guidelines	75	16
Philippine study	100	
British standards	100	25
Botswana	50	

Note:

1) The Blue Book differentiates between service pipes across a road and pipes on the near side of the road. A table is given where sizes are scaled down for lower income-level areas. The minimum internal diameter in both cases mentioned above is specified as 19 mm. This is allowed to be scaled down to an internal diameter of 13 mm if the residual head under instantaneous peak draw-off is not less that 30 m.

2) In the Brown Book it is recommended that if the supply is to be unmetered a length of one metre of 13mm pipe should be substituted by a 6 mm pipe. It is claimed that sufficient water will be available for a flush sanitation system but losses will be reduced.

7.11 CONCLUSION

Following the above analysis, it is clear that South African standards need review. Their major shortcomings can be summarized as follows:

- Inadequate attention given to the spectrum of water supply arrangements, water demands and payment arrangements.
- A tendency to over-specify and not to consider progressive upgrading which may be more appropriate in a capital scarce environment.
- Conflicts between various standards.
- Reliance on the "equivalent of" concept which is no longer well-founded

The issue of standards, or guidelines, will be addressed again as part of the project of which this report forms a part. Ultimately it will be advantageous if a new, commonly accepted, guideline document was available.

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8. WATER DELIVERY ARRANGEMENTS

8.1 INTRODUCTION

This section deals with the physical and organisational arrangements for delivering water to consumers, with the orientation at project level.

In order to indicate the importance of each part of the system the relative costs are of interest. Based on figures from Hebert (1986) and Lauria (1987), a typical breakdown for a low-cost system with metered stand connections is as follows:

Storage	28%
Reticulation network	30%
Metered stand connections	42%

Each of these components of the system is dealt with in this section.

In discussing water delivery arrangements, it is notable that there are many options other than the conventionally accepted metered stand connections. The more important of these other options are also dealt with in this section.

8.2 WATER STORAGE ARRANGEMENTS

The typical cost distribution for water delivery systems, as given above, indicates the importance of optimizing storage in the system as a whole. Partly this is related to the volumetric requirements which are discussed in the previous section. There are also issues of configuration and construction methods, which are dealt with here.

Distributive storage

The conventional approach to storing water is to use centralised service reservoirs. However, under certain circumstances there may be advantages to using distributive storage: storage provided by each consumer. This is generally associated with a "trickle feed" reticulation system, where the rate of delivery of water to each consumer is limited.

A review of this water supply option has been carried out by Hojem (1992). His primary conclusion is that the option is not applicable to areas where the density of dwellings is fairly high, which is the situation in the majority of new planned urban areas in South Africa (densities of 15 stands per hectare and above). However, it can offer an economic solution for dispersed settlements and small-holdings which have lower densities. Here the economy arises because the proportion of the piping cost becomes a greater part of the total cost and the "trickle feed" system allows smaller pipes to be used as the peak flow upon which the design is based will be lower.

The system may also be viable as an upgrading option. For example, there may be a reticulation system sized for standpipes which needs to be upgraded to individual connections. The use of distributive storage could allow this upgrading to take place without new reticulation.

Based on Hojem's report, other positive factors which influence the applicability of this option are:

- It promotes fair allocation of water as each stand has a limited rate of supply.
- It promotes water conservation for two reasons: total supply form the network is limited, and the consumer would generally be aware of the rate of water use on his/her property as the storage tank on the property will empty if the daily quantity used is too great.
- As the flow which can be delivered is constrained, the arrangement can work reasonably well with flat rate charging. It is possible to expand the options by including various flow limits, to be chosen by the consumer, with appropriate flat rates.
- It allows for lower pressures in the reticulation system.

However, the system does have certain major drawbacks:

- It requires a higher level of consumer sophistication than a conventional system as the consumer is normally responsible for the on-stand storage.
- It offers a limited service level.

The system is also not as able as a conventional system to deliver fire fighting flow rates but this is generally not as important in more dispersed settlements.

The on-site components of a trickle feed system need particular attention: the tank and the flow controlling device. Hojem notes two ways of controlling flow:

- Using an in-line device such as an orifice or a constant flow valve.

- Using a flow control box which is a small tank or box with an orifice at the bottom of it. The level in the box is controlled by a float valve and thus the flow from the orifice is under constant head and delivers a constant flow.

There is a disadvantage in that both these systems can be easily bypassed.

Finally, it should be noted that the "trickle feed" system has been applied in South Africa: Hojem reports on systems in Buysdorp in the Northern Transvaal and at a farming area near Mossel Bay. However, it appears that the system has limited application in the developing **urban** areas of South Africa.

Options for constructing service reservoirs

Storage cost is dependent on a number of factors, including the size of the distribution system, the required storage capacity, site conditions and the method of construction of the reservoir.

Heather-Clark (1992) has carried out a review of service reservoir construction options, looking particularly at the following methods of construction:

- Reinforced concrete
- Prestressed concrete
- Plastic lined

He has separated the type of roof construction into:

- Conventional reinforced concrete
- Reinforced concrete roof floated into position
- Dome-shaped prestressed concrete
- Floating plastic
- Precast concrete

All these options have been fairly widely applied in South Africa and innovative technical solutions have been developed in the country.

Heather-Clark's conclusions are complicated by the fact that he analyses the floor and wall structure separately from the roof. However, under typical conditions it is indicated that:

- Reinforced concrete construction is most cost effective for smaller reservoirs (capacities up to 8 Ml).
- Prestressed concrete construction is cost effective for medium sized reservoirs (from 8 Ml to 50 Ml).
- Plastic lined reservoirs become cost effective for medium to larger reservoirs (30 Ml and above).

In the case of larger reservoirs (50 Ml and above), concrete lined reservoirs, perhaps with prestressed flat roofs, are an option. In this size range the issues are obviously complex and need detailed studies for particular projects.

8.3 RETICULATION ARRANGEMENTS

Optimisation of the reticulation network can also lead to substantial savings in both the capital and operating costs of a water supply system.

The influence of standards has been discussed earlier in this report, particularly limitations on the minimum diameter of the pipes and fire fighting requirements.

Pipe materials

The most commonly used pipe materials in South Africa for new systems are:

- Larger diameters	(> 300)	Steel
- Medium diameters	(100 - 300)	Asbestos cement
- Small diameters	(< 100)	uPVC and HDPE

In contrast to American and European practise, little ductile iron and caste iron is used.

The decision as to which material to use is dictated largely by cost. However, durability is also a factor. In this regard a Swedish study reported by van Duuren is of interest. This study was apparently undertaken in the mid 1970s to look at the incidence of pipe failures. The results are given in the table below.

COMPARATIVE STUDY OF PIPE FAILURES				
Pipe Type	Number of Failures		Pipe	Failure
	Trunk mains	Networks	length (km)	per km
Reinforced concrete	1	-	296	0,003
AC	1	1	46	0,054*
Cast Iron	193	164	3 585	0,100
Ductile iron	2	3	333	0,015
Steel	23	32	488	0,113
PVC	49	55	302	0,344
*Sample too small to be representative				

The sample of asbestos cement pipes in this study were too small to consider the result. However, the study does show the sensitivity of PVC pipe to failure although this may have changed with development of the material over the last 15 years.

8.4 WATER DELIVERY ARRANGEMENTS

The term water delivery is used here to describe the combination of the technology and sales procedure used to deliver water to consumers. The arrangements can be classified as follows:

Communal systems: The following arrangements are identified by Rivett-Carnac (1989):

- Water kiosks
- Controlled public standpipes
- Uncontrolled public standpipes with flat rate levy
- Concession sales from individually metered houses
- Coin-operated taps

Rivett-Carnac does not include the option of a metered standpipe with shared account. While there is no record of this type of arrangement being used in South Africa, it has been used with some success elsewhere and should therefore be included.

Individual systems: The following options have been applied in South Africa or seem to have potential:

- Conventional metered connection with individual account
- Unmetered connection with fixed monthly payment
- System with electronic pre-paid meter

Each of the above arrangements are discussed below:

Water kiosks

The "water kiosk" system is based on the contracting of water sales from a standpipe to a private individual who runs the operation as a business. The contractor pays the supply authority on the basis of metered water purchased in bulk and then sells it to consumers who normally purchase on the basis of a container-full (normally 25 litres).

Rivett-Carnac (1989) reports on a survey done in the Durban metropolitan area evaluating public water vending arrangements. The report includes information on the water kiosk systems in the following areas:

- Sankontshe/Mapela
- Inanda (Released area 33)

Water kiosks were first installed in Released Area 33 in Inanda in May 1983. Since then the numbers have increased to 81 in August 1984 and 106 in November 1989, indicating that the operation has been a reasonable success.

The rate which kiosk contractors may charge was laid down by the authority responsible for the system (Department of Development Aid at the time). In 1989 this rate was 5 cents per unit of 25 litres (R2.00 per kl). However, the survey showed that some kiosks were asking more than this, up to 8 cents per unit. The volume of water dispensed from kiosks varied from 21 to 614 kl per month, with an average of 194 kl/month. With average household consumption of 3 000 litres per month, the average number of households served per kiosk was 66. On this basis the "average" kiosk operator would be earning about R280 per month (after paying for bulk water). This would indicate that an operator would need more than one kiosk, or more customers per kiosk, if a reasonable minimum household income of about R500 per month was to be earned.

There were difficulties with the Inanda system, largely associated with the fact that there were uncontrolled standpipes in the vicinity. Kiosks also tended to be open for a limited number of hours per day and this caused inconvenience to consumers.

The issue of kiosk density is an important one. If there are too many, the contractors can not make sufficient income. If there are too few the inconvenience to consumers becomes excessive: in Inanda it was indicated that a walk of about 250 metres was the limit. Rivett-Carnac refers to the International Reference Centre recommendation of one kiosk per 100 households.

It is also notable that water from kiosks is expensive, with figures as high as R10.00 per kl being charged (See Region E regional profile). However, Rivett-Carnac notes that there was no evidence of anyone making excessive profits in the areas covered by his survey.

Controlled public standpipes

With this option water is paid for on the basis of a fixed unit and the dispensing from the standpipe is supervised by someone present at the standpipe. A coupon system can be used for payment with coupons bought at local community offices or stores.

Rivett-Carnac includes an analysis of this type of system which was in operation in Molweni, Embo, Ngcolosi and Qadi/Nyuswa, all in the Durban metropolitan area. In these areas the water supply is controlled by water and sanitation development committees who arrange for water distribution, including payment using coupons which can be purchased locally. The standpipes are individually metered so that a check can be kept on sales from any dispensing point.

In these Durban examples, people pay between 5 and 7 cents per 25 litre unit (1989 prices) and use just over 3 000 litres per month per household (15 litres per capita per day). The standpipes are open for limited times every day and the survey indicated an average of 5 hours per day, seven days a week. The quantity of water dispensed per standpipe ranged from

21 to 228 kilolitres per month. Taking a reasonable median of 100 kl/month this gives a median number of households served per standpipe as about 30.

The takings per standpipe were in the range of R275 to R730 per month. Of the 19 standpipe attendants approached as part of the survey, five were children. Based on interviews with nine of the adults, salaries were in the range of R60 to R80 per month.

The issue of standpipe density is as relevant here as it is in the case of kiosks. There is a substantial fixed cost associated with the operation of each individual standpipe and the quantity of water distributed through each standpipe needs to be sufficient to justify this cost. Therefore comparatively large numbers of households need to receive water from each standpipe.

Uncontrolled public standpipes

In this case the water from the standpipe is drawn by people as it suits them and payment is made on the basis of a flat rate to be paid by all households who have access to the standpipe system.

This option has also been reported on by Rivett-Carnac, in the Shongweni, Georgedale and Sankontshe areas, also in the Durban metropolitan region. In these areas the levy is in the range of R2 to R4 per household per month. This is not sufficient to recover the cost of water supply and people are getting the water on a subsidized basis.

The Durban experience with this delivery arrangement has not been particularly good, with problems occurring in the following areas:

- Difficulty in collecting the levy
- Use of water by outsiders
- Difficulty in keeping the standpipes operational

A further difficulty is that the system is not equitable, with high water users paying the same levy as those using small quantities.

Metered standpipe with shared payment (group connections)

In this case the water to an individual standpipe would be metered and the account sent to the group of households sharing the unit. This is referred to by van Wijk-Sijbesma (1987) as "group connections".

There is no known arrangement like this operating in South Africa but examples are quoted by van Wijk-Sijbesma for Malawi. Here the option has had only moderate success, with the major difficulty being disputes between people over how to share the payment. In order to assist in the process, there are options for the water supply authority to assist water groups in the dividing of payments based on family size etc. There is the possibility of each group having categories of payments which can be agreed upon with the water authority.

This arrangement obviously requires a high degree of organisation, both by the supply authority and the consumers. However, it offers the benefit over the other standpipe systems of being more equitable and allowing for a higher level of service, as the standpipe density can be higher, with perhaps 10 to 20 households in the "water group".

Concession sales from individual houses

This option is similar to a water kiosk but has an advantage in that the concession holder can also run some other business or just combine the duties of a householder with that of selling water. van Wijk-Sijbesma (1987) notes that the concessions need to be controlled by the water authority and that they should be given to poorer members of the community.

This arrangement is probably practised quite widely in South Africa on an uncontrolled basis, in situations where squatter communities live adjacent to those with services. However, this has not been documented.

Coin operated taps

Recovering the cost of water from standpipes, using kiosks and controlled standpipes is expensive as it requires attendance at the meter which is likely to cost at least R200 per month per standpipe (Rivett-Carnac, 1988). Therefore a coin operated system has attractions. However, the experience with them has not been positive as the units are subject to breakdowns and vandalism (van Wijk-Sijbesma). However, it seems that improved technology, combined with a cooperative community and a well organized water authority, could make this an attractive system in the future.

Conventional metered connection with individual account

For individual stand connections this is the most common practice in South Africa, both in well established areas and new areas. A high level of service is required and it has the advantage of being equitable and not requiring a high degree of social organisation. However, it does require a high degree of organisation on the part of the supply authority, something which has been lacking in most low-income urban settlements in South Africa.

Also, the cost of this system is not necessarily justified in the case of consumers who use small quantities of water. This is discussed by Habitat (1989) who refer to Middleton (1978) for a methodology for determining when water metering is viable. (Also see "Water Conservation in Section 8).

In South Africa there have been difficulties with this arrangement in townships, both because of poor management and because of political resistance to paying for services. In the former case this leads to a situation where meters are not properly read and accounts are not sent out properly. In the latter case the accounts are simply not paid. Often the two factors are inter-linked with consumers being unwilling to pay for a service which is poorly rendered.

The option of contracting the meter reading to a private company is used in South Africa fairly extensively.

Under-reading of water meters is one of the largest components of unaccounted-for-water (UAW). Therefore if water metering is to be applied, their maintenance is of critical importance to the proper operation of this water delivery option. Accuracy of water meters tends to decrease with age. An indication of this loss of accuracy of water meters can be obtained from a Hong Kong study which showed that, after 3 years, meters on 25mm connections were under-reading by 5.2% and those on 13mm connections by 4.8%. After 5 years there was little change in the case of

25mm meters but those on 13mm connections were under-reading by 10.1% (from IWES, 1983).

Unmetered connection with fixed monthly payment

This arrangement is in comparatively wide use in South Africa. In the survey of towns in non-homeland South Africa carried out as part of this project, 332 responded with water charging information. 53 of these towns (16%) did not meter water. This figure is likely to be higher as this practice is applied mostly by black local authorities and the response rate of these authorities to the questionnaires was substantially lower than that for "white" municipalities. In many situations this arrangement is being applied by default as the supply authority has been unable to operate the meter reading and accounting system effectively.

The advantage of the arrangement is that it is simple to administer. The cost of keeping meters operational can also be substantial. However, it is no easier to collect the levy for the water than is the case with a metered supply.

The system has the disadvantages in that it is not equitable and it is not possible to monitor water losses.

System with electronic pre-paid meter

Pre-paid meters using a card system or a keypad, integral with pre-paid electricity meters, have recently been applied in South Africa.

The original concept was developed by AEG for Bloemanda for implementation in Mangaung (Bloemfontein) in 1989. Approximately 1 000 were installed. These did not work very successfully and the project was abandoned. The same original model was also implemented in Ladybrand (coloured area) and Mfuleni (Cape Town).

The original concept was refined and the redesigned and improved meters have been installed in Jackalsfontein (±40 - private high income development, reported to be working well), Richard's Bay (high-income housing test only, 7 meters, March 1992, with excellent feedback, the intention is to install these meters for all new installations and it is also planned to replace old meters over the long term), Khayelitsha (but water meter component not operational as water meters not installed) and Modderfontein (500, high-income housing, in process of being installed).

The water pre-payment meter is combined with the electricity pre-payment water. The LED display gives the remaining credit from water and electricity alternately every 10 seconds. If the water credit is used up, the electricity is cut off and the water credit reading moves into debit readings. The electricity is only reconnected when the water debit has been fully paid and a credit exists.

The reasons for cutting off the electricity rather than the water are:

- water solenoid valve expensive
- health reasons

If the water signal cable is tampered with, the electricity is also automatically cut off.

The water meter (Kent) has two magnets on the shaft sending two pulses for every revolution. The ratio of the number of pulses per kl can be adjusted inside the pre-payment meter (restricted card key access)

The costs of the unit are estimated as follows:

	Single purchase	Bulk orders
Electricity only:	R375	R315
Electricity + water:	R400	R340

The water meters themselves are about R20 more expensive than conventional meters.

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9. WATER CONSERVATION AND OTHER ENVIRONMENTAL FACTORS

9.1 INTRODUCTION

Over the past two decades the world has become increasingly conscious of the sensitivity of the environment to man's activities. Individuals even in out-of-the-way places are aware of global environmental issues such as depletion of the ozone layer, deforestation and global warming. And at a local level people are concerned about water pollution, refuse dumping and air quality.

However, an issue which is only beginning to be faced is the relationship between environmental sustainability and development. These have been two of the great issues of modern society over the latter half of the century. Yet, on the face of it, they oppose each other: development involves the use of resources to provide for the new population of the world while environmental concern often implies the conservation of these resources.

The contradiction is particularly marked in poorer countries where development needs are greatest and the financial capacity to provide for environmental conservation is least available. (While there are exceptions, the implementation of projects in an environmentally sensitive way is more costly in the short term).

The above contradiction applies to the water environment. Water is a key resource and a basic human need, while it is also intimately part of the natural environment. Using water is a necessity for development and protecting it is a necessity for the environment.

9.2 ENVIRONMENTAL ISSUES RELATING TO WATER

Many of the environmental issues relating to water are associated with water resources development, bulk transfer and treatment. For example, water abstraction arrangements from catchments and aquifers may have serious consequences. However, these issues are not dealt with here, as the orientation of this project is on the user end of the water supply system, on local issues and those associated directly with consumers.

In this regard the two central issues relating to water use are: the quantity of water taken from the environment for human use and then the way in which this is returned to the environment after it has been used. The first is referred to here under the general title of "water conservation" and the second under "water return".

9.3 WATER CONSERVATION IN SOUTH AFRICA

It has been noted in Section 5 of this report that municipal and domestic use of water currently represents 12% of all water use in the country, a proportion which is likely to increase to 17% by the year 2010. This indicates that domestic use is a comparatively small proportion of total water use in the country, but that it is growing fast. It has been noted that such use is growing at a rate of about 3.4% per annum.

Section 5 also gives a breakdown of domestic water use into income groups, with the following breakdown:

- Middle to upper income 1 468 Ml/day(54%)
- Lower income 1 259 Ml/day(46%)

The above figures indicate firstly that it is non-domestic water uses, and particularly agriculture, which should be the primarily targets of water conservation practise. The Presidents Council (1991) states " according to evidence, irrigation consumes more water than the contribution of this sector to Gross National Product (GNP) justifies, particularly compared to the contribution of other water users". Here it is also notable that real costs of irrigation water have in the past not been reflected in tariffs. The World Bank (1992) also singles out agricultural water use, noting that agriculture, which is responsible for 73% of water use worldwide, is unresponsive to conservation measures, primarily due to the political leverage exerted on governments by farmers.

It is clear from the above figures that at present water conservation strategies need to be targeted at upper income group people. It should not be the new-comers to urban areas - the poorer people - who should be held primarily responsible for conserving water. Poorer people tend to use water sparingly, both through habit and an inability to afford more.

9.4 WATER CONSERVATION METHODS

Although it has been mentioned that the primary focus of domestic water conservation measures should be on upper income communities, the measures necessary apply all domestic water consumers and the discussion here is therefore applicable to all income groups. The primary reference for this section is Habitat (1989) an excellent overview of techniques for water conservation.

Habitat divide water conservation methods into four groups:

- Structural methods
  - flow control devices
  - metering
- Operational methods
  - leakage detection and repair
  - reduction of excessive line pressure
- Financial methods
  - pricing (tariff) policy
- Socio-political methods
  - legislation (including building and plumbing codes)
  - public education

Each of these methods is discussed below, in the South African context.

Structural methods

a) Flow-control devices

Flow control devices are also referred to in the literature as water-saving plumbing fixtures. The extent to which they can be set up to conserve water depends on the level of service to the household which may be:

- House connection with multiple taps
- Yard tap, often associated with a site and service scheme using waterborne sanitation
- Standpipe supply

House connections with multiple taps

Figures from the Habitat report for in-house domestic use (excluding garden) are compared with those proposed by Malan (1983) for the RSA below:

Fixture	**USA**	**Britain**	**Ibadan**	**RSA**
Toilet	97	36	40	48
Personal washing/bathing	85	28	20	65
Laundry	37	14		23
Drinking, food preparation and dish washing	24	29	25	24
Car washing and other	-	3	5	-
TOTAL	**243**	**110**	**90**	**160**

The figure for Ibadan in Nigeria is for a middle income area. Those given by Malan are clearly for upper income households in South Africa. No reliable figures are available for lower income families in South Africa. However, in this case it is important to note that, typically, where such families have access to formal houses with house connections there are also larger numbers of people sharing the house. This means that household consumption may remain reasonably high while per capita consumption is low.

Water saving measures relating to each type of fixture typically used in-house is discussed below:

Flush toilets: Malan notes that flush volumes in the RSA were in the range of 11 to 13 litres in 1983. This can be compared with European countries which generally use volumes of 9 litres and the USA where higher flush volumes of 13 to 30 litres are used.

There are important new innovations in flush toilet design and in Europe toilets with flush volumes of 6 and 3 litres have been developed. The issue of low flush toilets is dealt with in more detail in the PDG/UCT sanitation report. The impact of such low flushes on sewer systems has also been studied by Simpson (1991), who has found that there is no adverse effect on sewer flows with low flushes.

Baths and Showerheads: Both Malan and Habitat note that showering uses far less water than bathing (80-100 litres for a bath in comparison with 10-30 litres for a shower). In 1983 Malan reported high flows for showerheads available in South Africa, several delivering above 15 l/min at a pressure of 100 kPa. In the USA the flow is limited by regulation to 11 l/min and Habitat note that flows should be in the range of 3 to 5 l/min. Malan recommends 5 l/min.

In the case of bathing, water use obviously depends on the frequency of bathing and depth of water in the bath. This can only be changed through education or pricing policy.

Taps: The flow rate from a tap is conventionally as high as 30 litres/min (Habitat). However, newer designs are available using spray or aerating nozzles which can reduce the flow to 3-10 l/min depending on the pressure. This is sufficient for hand washing but not for filling sinks and baths. Malan recommends the following:

- Wash basin or sink 12 l/min
- Bath 25 l/min
- Public wash basin 6 l/min

The effect of line pressure is important. If the pressure is too high there is a greater tendency to waste water. Malan notes that pressures in South African municipal sewers sometimes exceed 1 000 kPa. He recommends a maximum of 600 kPa.

Yard taps

Where the water supply level of service is based on yard taps generally only one tap is provided, often attached to the wall of the privy for a flush toilet. This would represent a typical arrangement for site and service schemes being implemented in South Africa in the late 1980s to early 1990s.

The arrangement at the yard tap is important, considering that clothes washing, dish washing and some personal washing is done at this point. Yet experience with 104 projects implemented under the Independent Development Trust's Capital Subsidy Scheme indicates that little attention is given to this aspect. The availability of a sink at the tap offers greater convenience and also allows water to be conserved. If only a gully is provided, the tendency would be for washing to take place with flowing water.

The design of the tap itself needs to be considered. Habitat recommends the use of self-closing taps. However, this may create unnecessary inconvenience for the user who, after all, is the owner of the tap and pays for the water. Such a selection could only be made in consultation with the community.

If a full waterborne sewer is not provided, the disposal of the grey water from the yard tap becomes an important issue. This is dealt with under water return.

Standpipes

The primary issue with water conservation at standpipes is related to paying for the water. If people pay for it on the basis of quantity consumed, they will obviously waste less. "Waste" in this situation must, however, be kept in context. Standpipe users typically consume only 30 l/c/d in relation to people who have household connections who may be using five times as much. Therefore waste at standpipes is not a significant issue nationally although it may be one locally.

In South Africa at present by far the greatest majority of standpipe users do not pay for their water on the basis of units consumed and therefore other conservation methods may be appropriate. Some options are discussed below:

- Self-closing taps: this option has not been successful as it causes inconvenience to users who will then find ways of keeping the tap open permanently or bypassing it in some other way.

- Siphon dispensing: with this option a tank elevated above ground level is provided, with the water level controlled by a float valve. Water is drawn from the tank by siphoning, with each user having their own siphon hose which is attached to one of a number of outlets. This arrangement has the advantage of having no moving parts and of minimizing waste as when the person leaves the unit the siphon is broken and no water flows. It is being used at Madadeni (Newcastle) in Natal.

Whatever the standpipe design, there will always be some excess water around the standpipe and this must be disposed of properly, through a soakaway or some other method. This is dealt with in more detail under "return water".

b) Metering

Metering of water supplies can achieve substantial water savings, provided the meter reading and billing is done properly and the meters are properly maintained. Habitat refer to studies in the USA which indicate that 30% less water is used if metering is implemented on a previously unmetered supply. Another study is referred to in Rangoon, where meter installation again reduced consumption by 30%. However, after 15 years 90% of the meters were no longer working.

Keeping meters operational in low-income settlements can be difficult, both because of abuse and vandalism of meters and because the supply authority may lack the financial and organisational resources to maintain and replace meters.

The issue of meter installation in low-income settlements is therefore not a simple one. The costs of keeping meters operational, reading meters and operating the accounting system may not justify the benefit of water saving. The critical factor is the quantity of water typically consumed by households. The lower this is the less viable metering becomes.

Habitat recommend that a cost benefit analysis should be carried out to determine viability of metering in relation to flat rate charging, and refer to Middleton (1978) for an example of methodology.

Operational methods

a) Leakage detection and repair

Before discussing leak detection and repair it is necessary to define the various water loss categories.

van Duuren (undated) define the term **"unaccounted-for water" (UAW)** to include:

- Actual losses due to leaks that are economically repairable.

- Unavoidable losses caused by small leaks which are not economically reparable and cannot be traced. These leaks can amount to 1.5 to 4.5 l/min/km pipeline and are independent of the pipeline diameter.

- Apparent losses caused by under-reading stand meters on the delivery side. (Network meters are taken to be correct).

- Unmetered draw-offs via hydrants and flushing valves. Values for these draw-offs vary form 0.3% to 1% of the average monthly flow.

This definition does not include water lost through illegal connections, which can be a major component of UAW in low income settlements.

Van Duuren reports UAW figures for large cities in South Africa (presumably "white" middle to upper income areas), over the period 1968 to 1977, to be in the range of 8 to 22%. Results of the survey carried out for this project is given in Section 4 of this report. It is indicated that 31% of municipalities experience UAW of greater than 16%.

Part of these losses are unavoidable and van Duuren gives an indication of how extensive this could be. These unavoidable losses are dependent on a number of factors, including pipe material, age of system and reticulation pressure. Tests reported by van Duuren indicate typical figures of between 3% and 8%.

Control strategy

Habitat suggest that where UAW exceeds 25% it becomes viable to implement a loss control programme. This figure should not be seen as absolute; the larger the town or city, the more viable a loss control programme will be. van Duuren considers that the cut-off figure should be 15%.

In the six tests reported by van Duuren, high UAW figures (>20%) were measured in three cases. In all three the major component of the UAW was associated with poor meter performance, which could be dealt with as part of a loss control programme.

The control programme itself would typically have the following components:

- Improvement of documentation on flows
- Meter testing, initially on the bulk meters and then on the stand meters.
- Repair and replacement of meters, where necessary.
- Leak detection and repair.

Should a loss control programme be planned, a comprehensive guideline has been published by the Word Bank (Jeffcoate, 1987).

Some final points relating to loss control:

- The procedure needs to be carried out and controlled by skilled people.
- The return from the loss control programme is likely to be a declining one with major leaks and metering problems found early on. The programme therefore needs to be monitored to determine the correct level of input.

b) Reduced line pressure

Line pressure has a significant influence on losses. van Duuren reports on a test which indicated that minimum night flow in a section of reticulation was reduced from 10 to 6 kl/h with a reduction in line pressure from 950 kPa to 550 kPa. This may be a difficult parameter to control once the system is in operation. However, it is an important design consideration.

Financial methods of water conservation

The issue of charging for water and water tariff policy is a complex one and is not dealt with here in detail. However, it is important to note the importance of this in water conservation programmes. The obvious point also needs to be made that this method of water conservation can only be effective if people do pay for their water.

With regard to tariff policy, there is a good argument, particularly in South Africa, for a progressive tariff, where the tariff is increased as household water consumption increases. A reasonably low rate can therefore be charged for people using water as a basic need and a relatively high rate for people using it as a luxury item.

The use of water charging can also be used in a more punitive way in emergency situations. This has been applied in the severe drought which occurred over large areas of South Africa during the period 1983 to 1987.

Socio-political methods of water conservation

a) Legislation

Legislation to reduce water consumption can be applied in two ways:

- Through building codes which specify the use of water saving plumbing fixtures.
- Through legally restricting water use, possibly with the application of penalties for transgressors.

An extreme example of the application of this type is suggested by Malan (1983) in research being done for proposed National Water Regulations. Limits on toilet flush volumes, showerhead delivery volumes and the delivery capacity of other fixtures are recommended. Such an approach is potentially controversial as it can be argued that it infringes on people's rights and it suggests that water cannot be used as a luxury good.

Once again the case of water restrictions during the 1983-87 drought are evidence of the effect severe legislative restrictions can have. For example, the per capita water consumption figures of the Rand Water Board. changed substantially: people in the RWB supply area consumed an average of 183 l/c/d in 1985 but only 157 l/c/d in 1989.

b) Public education

The potential for public education has again been demonstrated under drought conditions in South Africa. However, it also has potential under normal weather conditions, to make people aware of issues related to water and water conservation.

9.5 ASPECTS RELATING TO WATER RETURN

The second central issue relating to the environment and domestic water use relates to the way in which water is returned to the environment after it has been used. This is primarily associated with water quality but the point of return can also be important.

Only domestic water use is considered in keeping with the focus of this project. In this situation there are four routes through which the water can be returned:

- Through a sewered sanitation system, and hence to a river after treatment.
- Through an on-site sanitation system, and hence into the groundwater.
- Directly onto the ground, to flow off the site on the surface or to be washed off by rainwater.
- Into the ground either by seeping from the surface or via a soakaway.

The first two options are not dealt with here as they are covered under sanitation.

The latter two options are related primarily to situations where there is no sewered sanitation system. The situation normally arise at a public standpipe or a yard tap where excess water from the tap runs to the ground. The problems which arise in this circumstance are primarily related to health, as standing water attracts mosquitoes and other insects and can also result in infection of children through direct contact.

It is therefore essential for a soakaway to be provided in such situations. In this situation the water entering the ground would normally be clean and will have little impact on groundwater quality.

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10. CONCLUSIONS

This report, representing an overview of the current situation with domestic water supply in South Africa, is part of an ongoing project. The final aim of the project as a whole is to identify key issues relating to domestic water supply and to suggest ways of making improvements. Therefore, it is premature for conclusions of this nature to be drawn here, based on the findings of this overview report. Thus the conclusions drawn here are those that indicate the issues being faced by the domestic water supply industry, many of which are the subject of more detailed investigation as part of the whole project.

10.1 THE CURRENT SITUATION

Access to water supply

Of the 24,5 million urban dwellers in South Africa in 1990, an estimated 18% (4,7 million people) did not have access to an adequate water supply. In relation to the resources available in the country, this indicates a serious under-supply. Providing this large number of under-served people with an adequate water supply must then be a central issue to be addressed in the country.

The situation with access to water supply is variable. In terms of regional variations, the Northern Transvaal is by far the worst off, with the best situation occurring in the Western Cape. Variability is also experienced in relation to the type of urban area: while in percentage terms the metropolitan areas are best off, their dominance as demographic centres means that the majority of people without adequate supplies live there (3,1 million people).

In terms of the proportion of people without adequate supplies, the dense settlements are worst off, with 67% of people having inadequate supplies. This represents 1,3 million people.

59% of urban South Africans have a water connection to their houses, with internal taps. The remainder have yard taps or rely on communal water supplies.

Current water supply arrangements

Short-comings with the present arrangements for supplying water to urban South Africans were found.

In the first instance it is apparent that water is under-priced. Based on the survey, bulk treated water tariffs / costs ranged between 41c and 100c per kl for 70% of local authorities. This is low in international terms, particularly when it is considered that South Africa is a water scarce country.

The under-pricing of water is also reflected in the tariffs paid by domestic consumers: consumers pay between 41c and 120c per kl in the case of 73% of local authorities.

There are two central issues associated with water pricing:

- Water is generally not priced on the basis of marginal costs, which, especially where there is a large discrepancy between marginal and average historical costs, leads to the inefficient allocation of resources.

- Many local authorities (especially in poorer areas) are not recovering the full cost of distributing water in their areas. This is largely related to affordability and willingness to pay issues, but the current political milieu exerts a strong influence on willingness to pay.

Based on the survey, short-comings were also evident with the management of water supplies by local authorities. An indicator of this is that in 20% of cases unaccounted-for water exceeded 20%, a figure which is likely to be an under-estimate.

Domestic water demand

At present it is estimated that municipal demand (primarily domestic) represents only 12% of the demand for water in South Africa. This figure may increase to 17% by the year 2010.

Based on an investigation of consumption in metropolitan areas, an average per capita water consumption of 166 l/cap/d is estimated, with figures for Cape Town being 194 l/cap/d and for Port Elizabeth 98 l/cap/d. Consumption patterns are very different for low and higher income groups and the indication is that the wealthier 29% of South Africa's population uses 54% of the water.

In considering the situation with future domestic demand, it is estimated that 210 000 new households will need to be supplied with water per year for the next ten years. This could cost of the order of R320 million per year (1990 Rands).

Water supply standards

If all South Africans are to have an adequate water supply within a ten year period, the issue of the standards of such supplies will need to be addressed. It is indicated that the current standards applied in South Africa are outmoded and not well suited to dealing with developing areas and varying levels of service. These standards generally will lead to unnecessarily expensive water supply systems, meaning that fewer people will get supplies.

Water delivery arrangements

It is also apparent that more cost-effective ways of delivering water to people need to be used. In this regard it could be argued that increasing use will need to be made of communal supplies, particularly via standpipes. In the report various options for doing this are investigated and it is shown that cost recovery in this situation has to be considered carefully. The arrangements to be used here need to be implemented taking economic and social factors into consideration.

Water conservation

Although domestic water use accounts for a small proportion of overall water use in the country, conservation measures need to be addressed. Based on the distribution of water use, conservation measures should be focused on higher income groups, possibly through the use of flow control devices, tariff structures and education programmes.

10.2 FURTHER WORK NECESSARY

Based on the findings of this report, further research work is clearly necessary to address the issues which have been identified. As part of this project, more detailed investigations are to be carried out to look at specific problems on a case study basis. Here the intention will be to show how improvements can be made in getting supplies to those who do not currently have them, in improving management arrangements and making such arrangements economically sustainable.