INTEGRATED WATER DEMAND MANAGEMENT FOR LOCAL WATER GOVERNANCE

by

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DECLARATION

By submitting this dissertation electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the owner of the copyright thereof and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Date: 27 October 2010

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SUMMARY

South Africa is facing serious water shortages within the next twenty-five years. The new political dispensation, following the 1994 general election, provides excellent opportunity for the implementation of new legislation that not only addresses the previously inequitable allocation of the country's water resources, but also focuses on more effective, integrated, catchment-based management of its limited water resources.

South Africa's Constitution provides for the allocation of various functions to different levels of government. The delivery of water services was allocated to the local government sphere, the municipalities, and the new legislation provides for integrated development planning, with water services development plans being an important aspect thereof.

To understand the present water situation, and to involve all stakeholders at all levels of decision-making, forms the cornerstone of the new legislation and the associated planning processes. With limited water resources, the effective use of water, through appropriate water demand management and water conservation steps, plays an important role. This approach is in line with the declaration at the Rio Earth Summit in 1992 in support of sustainable development, and further reinforced by the declaration formulated at the World Summit on Sustainable Development in Johannesburg, South Africa, in 2002.

Municipalities in South Africa are, for a variety of reasons, challenged by limited funding opportunities and a lack of capacity, specifically in the water sector. The main objective of the research presented in this document was to develop tools for guiding the municipalities through the decision-making process. These tools will enable them to manage their water situation in a more sustainable and integrated manner. The full municipal water management cycle was addressed by the development of five decision support systems, one for each of the following stages:

- Water resources
- Purification of water
- Distribution of water
- Use of water by consumers
- Treatment of the waste water

The decision-making process, presented as a water demand management model in Figure E1, is supported by the development of an implementation process for water demand management as well as a process to ensure more effective public participation in water management, while the institutional aspects in support of water demand management were also evaluated. The role and responsibility of political decision-making to assist with water demand management was

highlighted, and the water demand management model was evaluated and tested within the framework of decision-making in public governance structures.

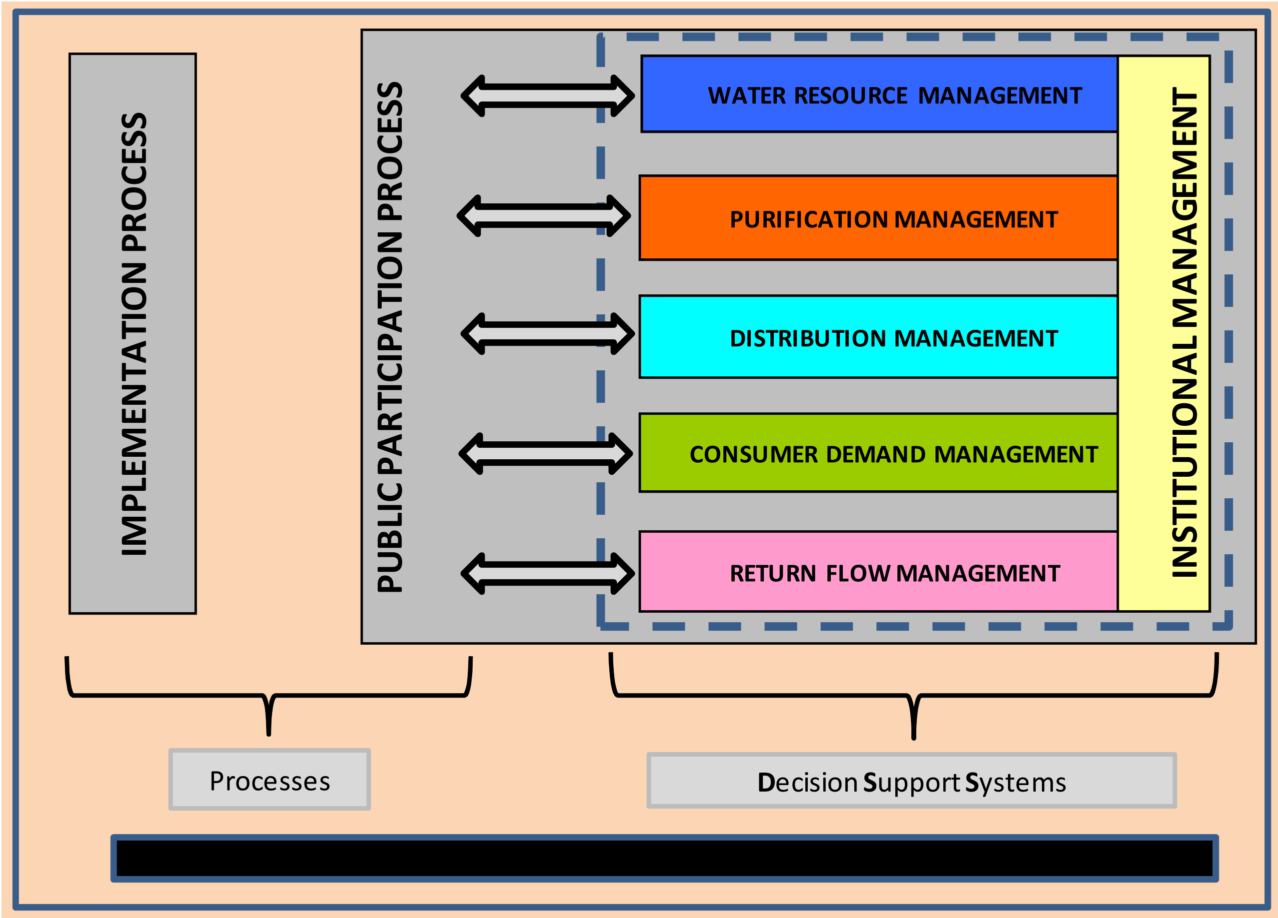

Figure E1: The model

The importance of benchmarking to measure progress and provide guidance for decision-making in the model was highlighted, with the result that a number of benchmark values were developed for municipalities. The water audit is described with specific reference to the identification of water losses and water use categories.

The use of the model was illustrated in a case study, which successfully highlighted the advantages and shortcomings of the model. An evaluation system was also developed which provided a municipality with a tool to measure its progress towards a complete implementation programme for water demand management. This model can be used by national government to prioritise funding and capacity support in water demand management to municipalities.

Based on the findings of the case study, it is clear that the model developed, and presented in this document, can contribute significantly towards effective and integrated water demand management across the full water cycle at a municipal level in South Africa.

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OPSOMMING

Suid-Afrika is blootgestel aan moontlike ernstige water tekorte binne die volgende 25 jaar. Die nuwe politieke bedeling na die 1994 verkiesing het ŉ uitstekende geleentheid gebied vir die implementering van nuwe water wetgewing. Hierdie wetgewing moet nie net die onregverdige verdeling van water hulpbronne van die verlede regstel nie, maar ook verseker dat effektiewe geïntegreerde opvanggebied gebaseerde bestuursbeginsels op waterbronne toegepas word.

Suid-Afrika se Grondwet maak voorsiening vir die verdeling van funksies tussen die verskillende sfere van regering. Die lewering van waterdienste is een funksie wat aan munisipaliteite toevertrou is en nuwe wetgewing vereis geïntegreerde ontwikkelings-beplanning met die waterdiensteplanne ŉ belangrike deel van hierdie proses.

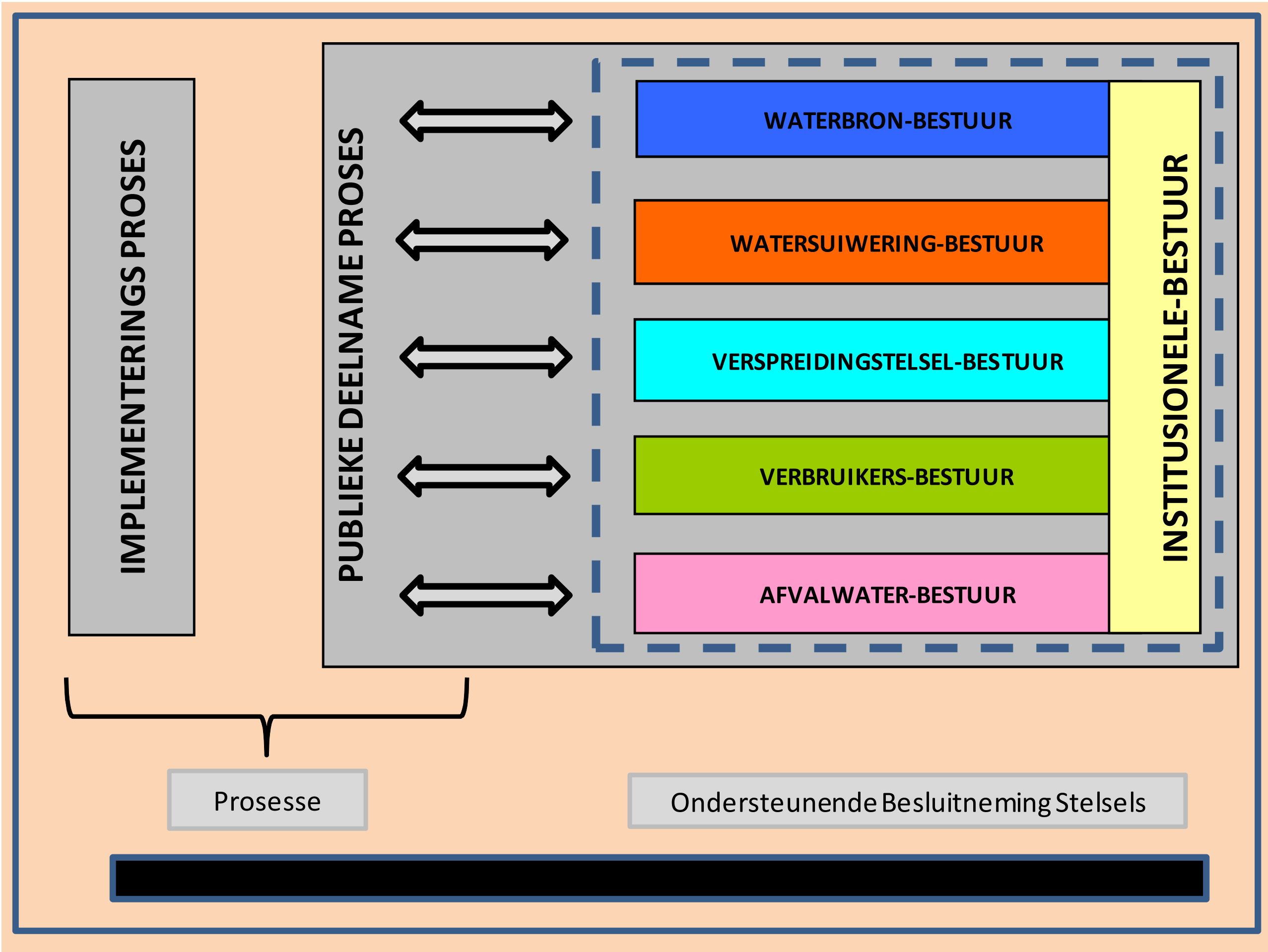
ŉ Goeie begrip van die water situasie en die betrokkenheid van alle rolspelers in besluitneming vorm die basis van nuwe wetgewing en die beplanningsprosesse. Met beperkte waterbronne speel die effektiewe gebruik van water deur toepaslike wateraanvraagbestuur en water besparings-aksies ŉ belangrike rol. Hierdie benadering word versterk deur die verklaring wat uitgereik en aanvaar is by die Rio Beraad in 1992 ter ondersteuning van volhoubare ontwikkeling en verder versterk deur die besluite van die Wêreld Beraad oor Volhoubare Ontwikkeling in Johannesburg, Suid Afrika, in 2002.

Beperkte fondse en kapasiteits-probleme in spesifiek die water sektor bied verskeie uitdagings aan munisipaliteite in Suid-Afrika. Die hoof doelwit van die navorsing wat in hierdie dokument aangebied word was om hulpmiddels vir munisipaliteite te ontwikkel wat hulle kan ondersteun in die besluitnemingsproses om hul water situasie meer effektief en geïntegreerd te bestuur. Die volledige munisipale watersiklus is aangespreek deur ondersteunende besluitnemingstelsels te ontwikkel vir elk van die volgende fases van die water siklus:

- Waterbronne
- Watersuiwering
- Verspreiding van water
- Gebruiker van water deur verbruikers
- Afvalwatersuiwering

Die besluitnemingsproses, soos aangetoon in Figuur E1, is verder ondersteun deur die ontwikkeling van ŉ implementeringsproses vir wateraanvraagbestuur, asook ŉ proses wat meer effektiewe publieke deelname sal bevorder. Die institusionele aspekte geassosieer met water-aanvraagbestuur is ook evalueer. Die rol en verantwoordelikheid van politieke besluitneming is

beklemtoon en die model is ook binne die raamwerk van openbare besluitneming geëvalueer en getoets.



Figuur E1: Die model

Die belangrikheid van verwysingswaardes om vordering te meet en om die besluitnemings-prosesse in die model te rig, is uitgelig. Vir die doel is verskeie verwysingswaardes vir munisipaliteite bepaal. Die waarde van 'n goeie waterbalans, met spesifieke verwysing na verliese en water gebruiks-kategorie, is bespreek.

Die gebruik van die model word deur middel van 'n gevallestudie bespreek en geïllustreer. Die voordele en beperkings van die model is uitgelig. Om die vordering met die implementering van wateraanvraagbestuur te meet, is 'n evalueringstelsel ontwikkel wat die munisipaliteit se vordering as 'n persentasie aantoon. Die evalueringstelsel kan ook deur die nasionale regering gebruik word vir die prioritisering van fondse en ondersteuning met die implementering van wateraanvraag-bestuur deur munisipaliteite.

Gebaseer op die gevallestudie is dit duidelik dat die besluitnemings model wat in die navorsing ontwikkel is en hier aangebied is, beduidend kan bydra tot ’n meer effektiewe en geïntegreerde bestuur van die watersiklus deur munisipaliteite in Suid-Afrika.

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LIST OF ABBREVIATIONS

BRWM	Breede River/Winelands Local Municipality
CMA	Catchment Management Agency
COD	Chemical Oxygen Demand
DSS	Decision Support System
DWAF	Department of Water Affairs and Forestry
DWA	Department of Water Affairs
EU	European Union
ELECTRE	Elimination et choix trduisant la relitè, meaning elimination and choice expressing the reality
GEAR	Growth, Empowerment and Redistribution
IDP	Integrated Development Plan
IAP2	International Association for Public Participation
IBNET	International Benchmarking Network for Sanitation Utilities
IWA	International Water Association
l/c/d	litres per capita per day
l/p/d	litres per day
MCA	Multi Criteria Analysis
MCDM	Multiple Criteria Decision Model
MSP	Multi-Stakeholder Process
NGO	Non-Governmental Organisation
NOLIMP	North Sea Regional and Local Implementation of the Water Framework Directive
NPM	New Public Management
NTU	Nephelometric turbidity unit
NWA	National Water Act
NWRS	National Water Resource Strategy
PI	Performance Indicator
RSA	Republic of South Africa
RDP	Reconstruction and Development
SADC	Southern African Development Community
SANOW	**S**outh **A**frican - **N**etherlands co-operation **O**n **W**ater management
SANS	South African National Standards
UAW	Unaccounted-for-water
UNCED	United Nation Conference on Environment and Development
UNDSD	United Nations Department of Economic and Social Affairs
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNPF	United Nations Population Fund
WC	Water Conservation
WDM	Water Demand Management
WFD	Water Framework Directive
WHO	World Health Organisation
WMA	Water Management Area
WRC	Water Research Commission
WR90	Water Resources 1990
WSDP	Water Services Development Plan
WUA	Water User Association

CHAPTER 1
RESEARCH OBJECTIVES

1.1 Introduction

The well being of mankind has always been linked to the availability of water, and it does not need a great deal of scientific knowledge to understand the importance of water as a general commodity. For years the availability of water was taken for granted, but as the human population on Earth increased, so too did humans' awareness of the availability of water develop. Arguments can be supplied for this new-found sense of responsibility towards water as a resource but, in its most elementary form, it is a matter of survival.

To understand what needs to be done to ensure sustainability, it is necessary to take one step back and assess the present water situation in the world, and more specifically in South Africa. Various viewpoints can be presented, all with different end results in mind. The aim of the research presented in this dissertation is to focus on practical management tools that can be used by everyday practitioners to make a contribution towards sustainability. These practical management tools will focus specifically on the South African local government environment, but reference will also be made to the situation in the Netherlands. This is to emphasise the diversity inherent in the motivation behind the need for a serious approach towards the management of water resources on an international level, as an example.

During the research period a significant amount of time was spent aligning the different approaches utilised in the Netherlands and South Africa respectively, in an attempt to ensure that lessons learned in the past will be incorporated into new decision-making processes. While no specific attempt will be made to compare the South African situation to those experienced during various interactions with the Netherlands situation, the highlighting of specific aspects will put the research results in South Africa into context within the bigger picture.

1.2 Objective and Main Research Questions

Officials in municipalities in South Africa frequently need to manage a wide variety of portfolios simultaneously, resulting in the neglect of some of these management responsibilities. The main objective of this dissertation is to provide a methodology, and supporting tools, for managers in municipalities to utilise in the integrated planning of their water resources so as to ensure sustainability through more effective and efficient water use. To achieve this objective, it is required that an understanding of the water management cycle is reached, and that a number of related issues be investigated in more detail.

An assessment of the present water situation, and the potential water resources available, needs to be conducted. The first question in SA to be addressed is whether or not adequate water resources are available to satisfy the need. In order to consider this question, it is obvious that the manager needs to know the capacity of the resources available, and all the relevant components of the water network, such as water treatment works and reservoirs. Even when this data is available, however, the manager frequently does not have any idea whether these known values are within acceptable limits or not, or whether problems might soon develop. To address this, the data needs to be evaluated against generally accepted values, referred to as benchmarks. These benchmarks will therefore need to be investigated and incorporated into the public decision-making tools.

Once the strong and weak points of the integrated water system have been identified, appropriate steps need to be implemented to ensure that these resources can be managed on a sustainable basis. To be able to address this, the manager needs to understand water demand and usage patterns. Decisions are made based on present and predicted water usage levels, and to put these consumption levels into context will again necessitate benchmarks, set through the careful evaluation of similar situations.

An overview of all the relevant technical- and policy-based methods available is required, as this will ensure the selection of the most appropriate building blocks for the water demand management model. Specific Water Demand Management (WDM) criteria will be presented and evaluated, with the aim of providing adequate information to the municipal managers so as to enable the implementation of appropriate techniques.

Municipalities function within a specific political and legal framework, and public decisions need to be taken within these frameworks. This dissertation specifically evaluates the public decision-making processes available to municipalities when decisions need to be taken that concern any aspect of the water management cycle. Since municipalities are public structures, the involvement of all of the role-players and stakeholders, in making appropriate public decisions that will directly affect their lives, is important. The role and function of appropriate public participation during the decision-making process needs investigation and inclusion in the final public decision-making models.

Municipalities are public policy execution institutions that also need to function within the wider public management framework of South Africa. Over the last decade many changes have occurred in the way public enterprises are managed, and the decision-making tools need to be developed with these changes taken into consideration. The changes within the public management framework are evaluated within the context of water management, and appropriate WDM tools developed with these new approaches in mind.

Although finance always plays an important role when public decisions with cost implications need to be made, this dissertation will only briefly refer to the financial considerations where applicable. No detailed analysis will be conducted regarding the available methods that can be used to assist the managers with their decision-making process.

The main objective of this dissertation will be achieved through the development of a public decision-making framework in the form of flow diagrams or models, which contains all of the critical conditions to be considered during the decision-making process within the WDM framework. The models will have to be implemented within a public management environment, and suggestions are therefore made regarding the structures required to ensure the successful implementation of these models. A case study (Robertson) is used to illustrate the typical problems experienced in municipalities in South Africa, and the decision-making tools used to illustrate the advantages and possible shortcomings that can be expected while using these tools.

1.3 Methodology

Since the public decision-making process in local government is not a technical process, it was important to initiate the study with a literature review that did not focus only on the technical aspects of the research, but also specifically on the public management and decision-making processes. The literature review provided the guidelines for an appropriate decision-making tool, which needed to be developed while taking a number of technical issues into consideration.

After the building blocks of public decision-making tools have been researched though a literature review, data was collected through various studies to provide the information that was used to transform the theory into practical, but sound, measures that can be used to support the main objective of the research.

Three different focus areas were used during the research period for the development of the model. They are: the setting of benchmark values in the water sector applicable to municipalities; the expectations and involvement of the public in making decisions about water related aspects; and lastly, the evaluation of the model using inputs from municipalities, but specifically testing the model in a case study.

For the evaluation of the model, the inputs from a process followed during an international cooperation agreement between the Department of Water Affairs (DWA), previously called the Department of Water Affairs and Forestry (DWAF), and water institutions in the Netherlands were used. The author was appointed as the project manager for the implementation of WDM during this cooperation agreement period, thus enabling him to collect relevant data on a wide variety of topics at a municipal level over a three year period. Data collection at this level consisted mainly of the viewpoints raised during various meetings, as well as specific interviews held with a wide range of stakeholders. The author was also able to collect data from the finance department of the Breede River/Winelands local municipality for the town of Robertson, as well as the un-edited data from the meter readers' logbooks for the purpose of verifying discrepancies reported in the water meter readings between the technical and financial departments, presented by the Municipality for use in the case study analysis. During this process it was also important to evaluate the model within a specific timeframe. The flow data used for the model and the case study was therefore synchronised to cover the same period, between 2004 and 2005.

The same cooperation agreement was also used to gain further insight into the functioning of water structures in the Netherland, which resulted in the author visiting and working for a number of weeks at a water institution (Fryslân Wetterskip) in the Netherlands during 2007 and again in 2008 as part of his data collection process. The visits included numerous meetings with key personnel responsible for the strategic planning of water structures in the Netherlands, as well as with various municipalities in the Netherlands. This agreement, and the associated data collected, was used to provide an international perspective, although it was not the intention of the research to provide an international comparative study.

The setting of benchmark values to be used during the public decision-making process can only be done if adequate data is available, and furthermore if this data is then evaluated on an acceptable basis for future comparisons. To ensure a reliable database that could be used in the development of the model proposed in this study, the author collected and analysed water infrastructure data from fifty-six towns in the Western Cape Province. This data was used to compile the benchmark values for critical water related issues, including criteria such as per capita consumption figures, treatment and storage capacities. These benchmark values played an important role in the decision-making process, enabling the municipal managers to focus on the most critical aspects first.

The involvement of the public during decision-making is of critical importance, specifically when the decisions that need to be taken concern each and every individual, and all individuals are not equally informed about the factors involved for appropriate decision-making in the water sector. Data regarding the expectations of different role-players, collected during a water saving awareness campaign in 2002 initiated by a district municipality on the West Coast of South Africa, which the author managed and implemented, was revisited and incorporated into the public decision-making process. Discussions were held with key managers within municipalities, and their views have been presented and incorporated into the tools presented in the dissertation. International experience in public participation was also gained through the attendance of an international workshop in the Netherlands, where the author discussed, on invitation, the role of the public during the institutional changes in South Africa.

As part of the cooperation agreement between the DWA and the Netherlands water institutions, the model developed was tested as a case study and a number of workshops, chaired by the author, were held with officials from various municipalities. During these workshops, critical aspects were debated and new viewpoints expressed that were then incorporated in the final model. Information was also obtained from the minutes of water saving discussion groups (identified as part of the cooperation agreement) held in the case study area, and their viewpoints were evaluated and will be presented as part of this dissertation.

Besides the new information obtained through the research work that was conducted, the literature study and the attendance of conferences and workshops dealing with some of these issues all contribute to a better understanding by the author of the public decision-making challenges facing the water sector in South Africa. This information, combined with the author’s personal experience in the field of water management in a local government environment over a period of twenty years, was used to compile the model presented in this dissertation.

1.4 Presentation of Research

The research conducted on more effective and integrated WDM is presented in eight chapters, each addressing a particular aspect of the research. The first chapter identifies the main objective of the study and presents the research questions to be answered in this study. It highlights the methods used to collect the information on which the final results are based.

The second chapter focus on public management, decision-making and public participation theory. A comprehensive literature review provides the guidelines for the development of decision support tools. Cooperative governance to ensure an integrated approach towards water management forms a critical aspect of the literature review, and there will be a specific focus on public participation in decision-making. The main focus of this chapter is to provide the pointers for more effective integrated decision-making within the public management environment to be used in the development of the proposed Decision Support System (DSS).

The chapter also discusses the interaction between a municipality, as a public decision-making and implementation structure, and the public. It focuses on the responsibilities of all the parties involved, and it defines all the relevant role-players. It will provide mechanisms for municipalities to ensure more effective public participation in the public decision-making process within the context of effective WDM, and highlight the importance of public participation to achieve the required level of awareness among the public to ensure the success of the implemented WDM steps.

The third chapter relates a general overview of the water situation in the world, but focuses specifically on the situation in South Africa. It addresses the reasons why it has become crucial for the world, and specifically South Africa, to get involved and proceed with WDM. The chapter defines the fundamental issues, namely WDM, water conservation and water restrictions, and the relationships between them. These concepts will be placed within the public policy and legal framework of South Africa, and forms the basis for the discussion in the ensuing chapters to support the ultimate objective of this research: to supply a model for municipalities in South Africa for the more effective implementation of WDM. Public decisions regarding the management of water by local authorities also need to be taken within the available policy and legal framework, such as the National Water Resource Strategy (NWRS). Chapter 3 therefore discusses the policy and legal water framework in municipalities in South Africa.

In addition, the importance of an integrated approach is highlighted, and an examination of the differences in the motivation for an integrated approach towards water management in different countries presented, focussing specifically on the European Union (EU) as an example.

The fourth chapter looks into the available interventions for effective WDM, and concentrates on some of the most important technical tools available to municipalities in South Africa that can assist them with the implementation of WDM. This chapter discusses the different approaches and their applications within the municipal environment. It refers the reader to appropriate results that can be achieved with these techniques. The issues that might influence these techniques will also be evaluated. Some of the techniques that will be analysed can be implemented directly by a municipality, while others need only be managed by a municipality. In the latter case the implementation rests with the public, and requires well-structured coordination between a municipality and the public.

It is unlikely that any public decision-making tool will be able to incorporate all possible options available to municipal managers, so Chapter 4 specifically provides the background to all available options that can be implemented if the model calls for specific WDM steps to be taken. The selection between the different available options presented in this chapter almost always involves the use of appropriate public financial decision-making tools. The financial models and techniques that can be used by municipalities were not the focus of this study, but some of the well-accepted models in South Africa will be presented in this chapter. Chapter 4 therefore serves as a reference guide for the model.

Chapter 5 provides the background and some of the results obtained from three different studies completed as part of the research project. This information is used as building blocks for the development of DSSs as part of the model. This includes a study related to performance indicators (PIs), a study regarding public participation in implementing a WDM project and a study of the implementation process followed in a specific case study.

This chapter highlights the reasons and methods used in collecting the information from fifty-six different towns to provide the benchmark values that form an important part of the public decision-making process for specific phases in the water management cycle. The chapter also provides insight into the various viewpoints expressed during discussions held with different role-players and stakeholders in the implementation process of WDM at a municipal sphere. It further provides the background of the selection of Robertson, a town in the Western Cape Province in South Africa, as a case study to illustrate the value of the DSSs presented in this dissertation.

The case study described in Chapter 5 also put the public decision-making framework in local government, with respect to the implementation of WDM, into perspective, and it presents the typical problems experienced at a municipal sphere. It also highlights the challenges municipal managers face in managing the water resources and systems.

The sixth chapter of the dissertation discusses the DSSs required for integrated WDM. The chapter highlights all of the aspects to be included in the decision-making process, and will make provision for public decision-making at different spheres of government, where appropriate. The DSSs for each of the main phases in the water management cycle, namely water resources, purification (potable water) management, distribution management, consumer demand management and return flow (waste water) management are presented and evaluated. Institutional management, which includes aspects such as training, by-laws and credit control, are also described and placed in the context of the public decision-making process.

The DSSs are presented with the knowledge that a general lack of reliable information at a local government level exists in South Africa specifically. The use of the benchmark values compiled in Chapter 5 therefore provides valuable information to enable reasonable public decision-making. An evaluation system to be used for monitoring the implementation of WDM in a municipality is also provided.

In Chapter 7, the Robertson case study is used to critically evaluate the implementation of the DSSs proposed in Chapter 6. Background information on the case study will be presented, and the decisions taken by the Municipality will be evaluated against the steps proposed by the DSSs. This process will be used to demonstrate the use of the DSSs, as well as to highlight the strengths and weaknesses of these tools.

The implementation of the DSSs are illustrated as practical guidelines, and focuses on the relevant procedures rather than specific end results. The chapter provides proof that a well-structured DSS prevents possible pitfalls and subsequent problems and delays in the successful implementation of an effective WDM programme. The evaluation system (score card) proposed in Chapter 6 was also applied to the Robertson case study to illustrate the municipality's level of readiness towards the full implementation of WDM in and by the Municipality.

In the concluding chapter of the dissertation the development of the model is summarised and the model weighed against the theory presented in Chapters 2 and 3. The results obtained from the implementation of the model are summarised and the success of the model, developed to improve and support effective WDM in a municipality's area of jurisdiction, evaluated. The strong and weak points of the model are highlighted and the applicability of the model as a tool within the governance framework analysed.

The limiting factors in applying the model are identified and listed for further research. This future research can improve the value of the contribution of the model to WDM in municipalities.

CHAPTER 2

INTEGRATED PUBLIC GOVERNANCE AND MANAGEMENT

2.1 Introduction

WDM is frequently seen as a process followed by technical decision-makers (engineers) to ensure that existing water resources can be used to full potential. While specific definitions will be dealt with in Chapter 4, Brooks (2006:522) stated that WDM has become so complex that it is necessary to deal with it both from a technical as well as a governance point of view. It is, however, not possible to develop any tools that will be of value to municipalities without understanding the framework within which decisions need to be taken at a local government level, as well as the building blocks of appropriate DSSs.

The literature review intends to produce the latest scientific work on how decisions are being made within a local government environment, and this chapter will present these findings. It will first address the main governance issues, followed by the intergovernmental challenges influencing decision-making. Emphasis will be placed on analysing decision-making at a local government level. Thereafter the availability of tools to support decision-making in the water sector, with the aim to developing a DSS for WDM at a local government level, will be investigated.

The implementation of WDM issues unavoidably involves end-users, and the importance of public participation in the related decision-making cannot be underestimated. The literature review will therefore also address public participation in the water sector specifically, with the aim to provide guidance towards the development of a process that ensures the effective implementation of WDM at a local government level.

The technical building blocks required for appropriate decision-making will be described in Chapter 4, and the practical implementation thereof in Chapter 5.

2.2 Making Decisions within Government Structures

Decision-making tools for municipalities as part of government need to be evaluated and presented within the wider contexts of public management. In this regard, an understanding of the institutional structures and management models used by these institutions is essential.

Service delivery, with reference to water supply, by definition involves the management of the public sector, although the water sector is certainly not the only aspect in need of management within the public sector. With water one of the fundamental requirements for sustainable growth it is unavoidable that the government will have to ensure that they do control the management thereof. The question is to define the level of control required to ensure a balance between effective service delivery and the level of public management it can afford (Salamon, 2002:13).

The challenge with the management of the public sector is that the public sector is huge and requires well-structured systems to be effective and to ensure that objectives are achieved. History has proven that management of large organisations often occurs through slow, ineffective and inefficient decision-making processes that result in unhappy end-users, or tax payers in the case of the public sector (Batley and Larbi, 2004:31). These large structures become bureaucracies, which seldom serve the goal of the structure. Since these public structures (government departments) are the vehicle of any country's political sustainability, the non-performance of the structure usually results in the loss of control by the political party in charge, over the long run.

There is therefore a need for all public structures to adapt to the changing political and social environment so as to ensure sustainable and effective service delivery. This has been dominated by the general concept that these objectives can only be achieved through the creation of smaller, more cost effective structures, which can respond quickly to problems. In the water sector specifically, this idea has resulted in a move towards partnerships and the privatisation of key components of the water management cycle which can be done more effectively by "outside" structures. The challenge for governments is therefore to maintain control over these functions, since the responsibility for most of these outsourced functions remains legally with the different government structures.

2.2.1 The functioning of government structures

While the policy and institutional framework of the water sector in South Africa will be described in more detail in section 3.5, it is important to provide a brief overview of the relationship between the different government structures at this stage. In addressing the institutional and policy framework for regulation in South Africa, Müller (2004a:239–240) provides such an overview, with the *Constitution of the Republic of South Africa, 1996* (Act 108 of 1996) providing the "map" of the government structures in South Africa. According to his overview, governance is implemented through institutions on three different levels, namely the national level, with Parliament the main institution, the provincial level, with nine provinces and the local sphere of government, consisting of the 283 municipalities.

The water sector addressed in this research falls under local government according to the Water Services Act (Act 108 of 1997)(RSA, 1997). Local government, as part of government in general, function through a number of well-documented behaviour theories. The overview presented by Hughes (2003:20) views decision-making at government level from the so called "golden age" (1920 to 1970), where it was believed and practiced that a well-structured public sector will provide a better level of service to all. Government was, according to this viewpoint, responsible for providing services to the public. To achieve this, it was therefore important to control the public sector rather strictly through the administrative system responsible for service delivery. It was, however, soon realised that these rather large administrations do not ensure that the inputs result in the expected outputs. Bureaucracies were soon no longer seen as effective structures, nor were they considered to be time efficient and definitely not willing to take risks.

The 1980s saw changes in government structures in line with business principles, which were more market orientated, while the 1990s experienced changes relating to the involvement of third parties, such as the private sector (Lowndes and Skelcher, 2002:321).

According to Hughes (2003:21), the last two decades before the end of the twenty-first century saw governments changing their administration to allow more freedom to individuals for decision-making, and to decentralise power. Concepts such as principal-agency theory, the changes in the private sector, transaction cost theory and technical changes all contributed to the change.

In essence, governance is measured by what the clients (population) expect against the ability of government to deliver the required service. In an attempt to find a balance, there is a constant tension, according to Minogue (1998:17), between making governments more efficient, while keeping them also accountable.

2.2.2 New public management

Batley and Larbi (2004:31–38) discuss governance theories and conclude that, due to the failure of governments to produce what is expected from them, based on the economic crises experienced by both rich and poor countries as well as the general public criticism concerning the effectiveness and efficiency of public services, a number of specific interventions are required. These interventions involve a shift from the traditional bureaucracy experience in public administrations towards a New Public Management (NPM), which includes some principles present in the private sector. The term NPM was introduced in 1989 by Hood (1989:347) after an evaluation of the administrative procedures followed in various countries, including Canada, United Kingdom, New Zealand, Australia and the United States of America.

The main reason for the introduction of NPM theory was the understanding that effectiveness and efficiency as experienced in the private sector is more important to the main objective of governance than adherence to the rules and regulations on which public management is traditionally built. There are, however, other reasons, according to Minogue (1998:19), why NPM has become important, namely:

- Rising government expenditure, often without the expected associated economic growth, becomes difficult to defend and cost reduction is therefore unavoidable (Manning, 1996:2).
- Consumers of services become more aware of the quality of the service they are supposed to receive for the ever-increasing costs.
- The need for policy makers to manage the conflict between improvement and reducing the state, which results in an ideology to change for the better (Manning, 1996:2).

The debate whether NPM does constitute a new thought within the public management environment is well-discussed. Some arguments, and a theoretical background, are presented by Hughes (2003:1–15) in his book *Public Management and Administration*. A number of authors, such as Holmes (1995:552), argue for the so-called paradigm shift in governance, while others, for example Lynn (2001:150), argue that it is actually nothing new, and an inherent part of governance. What they do all agree on, however, is that significant changes did take place in governance.

2.2.3 Managing government structures

Batley and Larbi (2004:45) focus on the decentralisation of the public service. This can be achieved in a number of different ways, but the main objective is to give managers more freedom to manage the operational functions, and therefore to effectively separate the policy issues from the implementation issues. The principle is to allow more management freedom, but expect greater accountability from the manager. In doing so, mechanisms need to be put in place to ensure that the required outcomes are achieved. This calls for the development of proper performance management systems. These performance management systems include the necessity for a performance contract, with well-defined goals set for the manager to achieve. These performance contracts can be exposed to problems if governments do not allow for appropriate budgets, good management of information and support of decisions and implementation strategies.

The establishment of agencies (Manning, 2001:299), where greater flexibility in the allocation of funds and resources exist in exchange for greater accountability, is another way of achieving the objective. The assumption is that these agencies will have the necessary know-how, and will be "specialist" in the execution of the function they are appointed for. Because such an arrangement can easily be confused with privatisation, it is important to focus on the reason why such an arrangement is made. Batley and Larbi (2004:46) discuss two divergent possibilities. The one objective that they put forward is mainly to increase revenue, while the other objective proposed is to ensure a more effective service to the end-user. It is, however, the author's opinion that these two options do not necessarily need to be seen as one against the other, but that one could also lead to the other.

The employment of agencies is, however, not the only means of bringing reform into public management, and market-type mechanisms such as the contracting out of services and user fees or charges were also presented and described by Batley and Larbi (2004:49). In the case of outsourcing, it is the responsibility of the public sector to remain in control of the regulatory capacity of government, but to allow activities previously done in-house to be managed by the private sector if those activities can be carried out more effectively by the private sector.

The concept of user fees focuses on the retrieval of the actual cost of delivering a specific service, as opposed to levying a charge just for the sake thereof. The main objective is to create a consciousness among end-users, and to ensure that they also insist on better value for money.

Milward and Provan (2002:359) discuss the management of the so called "hollow state", which refers to the government structure that makes more use of third parties to deliver services to the tax payers. They present the argument that no single organisation can provide all of the services to all of the individual clients, such as the tax payers, as the obvious reason why third parties are used by governments. Although the "hollow state" theory provides for flexibility, coordination and accountability remain huge challenges – to such an extent that these authors question whether the "hollow state" theory can provide any better solution than the bureaucracy experienced in governments (Milward and Provan, 2002:363).

2.2.4 Ensuring a change in government structures

Minogue (1998:21–30) identifies four practical ways in which governments can be restructured to achieve the expected outcome of NPM. They are listed as follows.

- The restructuring of the public sector relates, debatably, to privatisation. Shirley (1996:11; 1997:856) found that political obstacles are the main reasons why privatisation does not succeed in the public sector as anticipated. Rhodes (1996:217) adds a number of additional problems when privatisation is associated with a smaller public sector. These problems include fragmentation, steering, accountability and the need to be monitored closely. Privatisation in itself is an unacceptable concept to the political environment, and for the concept to succeed, three political conditions (Minogue, 1998:22) were identified as being essential:
  - political benefits must be more than the political cost;
  - reform must be politically feasible and
  - reform must be politically credible.
- The restructuring of the public sector results, effectively, in the creation of a more effective and efficient public management system that includes an improved institutional environment, better economic management and a coherent civil service management. This will, among other aspects, require an agency-based structure where performance is evaluated on measured outputs, financial and service quality targets and other performance-based incentives.
- Restructuring also needs to be done with the objective to provide public services in the most appropriate and cost effective manner. The introduction of performance management therefore plays an important role in the restructuring process.

Performance management, on the other hand, is not possible without the introduction of performance indicators (PIs). Important key PIs are those associated with the relationships between cost and resources (economy), resources and outputs (efficiency) and outputs and outcomes (effectiveness).

It also becomes important that criteria been put in place against which the level of satisfaction of the citizens can be measured. Unless customer satisfaction can be measured, it will not be possible to judge if the services are matching the expectations. In the water context, customer satisfaction can possibly be measured against the willingness to pay appropriate tariffs, which will be described in more detail in section 4.15. Within the public management environment, the model developed in this research will be used to derive a list of PIs against which the performance of a municipal water manager can be measured.

A number of useful principles underlie guidelines produced for the United Kingdom. These principles include (Minogue, 1998:27)

- setting standards for service delivery;
- openness on how the service is run;
- consultation with end-users;
- choice as to the available service;
- value for money and
- remedies if something go wrong.

- Competition needs to be introduced into the public sector to ensure effectiveness. The assumption is made that privatisation and the contracting out of services will result into a more competitive environment, which will lead to more effective and efficient service delivery. The problem that needs to be kept in mind is that efficiency is not the only value in government and that aspects such as equity, community involvement, democracy and constitutional protection, all play an important role in the objectives of a government. These aspects are rarely incorporated in a competitive environment, when it comes to service delivery.

Batley and Larbi (2004:45) agree with Salamon (2002:1) who stated that a surge of government reforms was enforced due to an increasing number of problems with governance associated with cost effectiveness. This is mainly due to the perception that governments are tightly-structured hierarchies removed from market forces. The involvement of third parties to assist governments was targeted as the possible solution to the problem.

The involvement of third parties in the management of government functions will require a new focus in their day-to-day activities to ensure that they will move away from their excessive administrative bureaucracy, which is most of the time highly inefficient.

2.2.5 Networking between different role-players

To manage government's interdependency on a host of third parties, networking has become essential. The notion that it is government versus the private sector needs to be managed to ensure that it becomes government and the private sector in close cooperation. Government needs to move away from its position as a "commander" who wants to control a specific situation, towards a structure that must negotiate and convince third parties to reach the required outcome, as expected by the public. The focus needs to shift away from managing skills and large staff components to that of enablement skills. Skills will also be required to ensure that third parties do get involved, and government needs to be able to sustain these partnerships. At the same time governments need to evaluate the value of smaller government structures (NPM) against the possible loss of the legitimacy of these governing structures due to privatisation. Rewards and penalties need to be included in the management approach required by new governance to be able to ensure success (Suleiman, 2003:284).

In this study, the main objective is to develop management tools within the water sector. Salamon (2002:22–24) defines tools, as opposed to policies and programmes, as an 'identifiable method through which collective action is structured to address a public problem'. Five criteria to evaluate the impact of tools are identified:

- Effectiveness
  Measuring the extent to which an activity achieves its intended objectives.
- Efficiency
  Balancing the results (benefits) against the cost.
- Equity
  The even distribution of the benefits and the costs among those who are eligible. This might also include the re-distribution of benefits to redress previous imbalances.
- Manageability
  The tools used need to be easy to implement to be successful. This is evident in the present situation in South Africa particularly, where a host of useful and valuable tools are available, but the present government structures are, for various reasons, not able to implement the tools to achieve the intended end results. The net effect is a set of unused tools that are not adding value to the management structures.
- Political Feasibility
  The tools implemented can only be successful if they can be seen as part of a legal and fair process, and at the same time receive acceptance by the political decision-makers. The implementation of a free basic water supply in South Africa is an example of a tool that can be considered as politically feasible, as the end result is huge support for the political decision-makers.

  On the other hand, the attempts to implement pre-paid water systems cannot be seen as a politically feasible tool, since the impact on the political decision-makers is seen as being negative, with the consequence of vandalism.

2.2.6 Measuring the impact of changes in government structures

Different tools have different impacts, and four characteristics of these tools have been identified by Salamon (2002:25) against which specific tools can be evaluated:

- Degree of coercion
- Directness
- Automaticity
- Visibility

The degree of coercion measures the extent to which a tool restricts individual or group behaviour, as opposed to merely encouraging or discouraging it. On the low end of the scale are tools that depend on the voluntary participation of entities, while at the high end of the scale are those regulations that impose formal and legal restrictions on entities. It is clear from the theory that tools developed to promote effective WDM associated with the voluntary participation of the public will need to contain regulatory aspects to ensure an appropriate impact.

Directness of a tool indicates how completely a specific tool can be implemented by a specific entity. If the tool is fully implemented by a single specific entity, then the tool is considered to be high on the directness scale. In contrast, the more the functions of a specific tool are executed by third parties, the more indirect the tool becomes.

Automaticity is an indication of how well a specific tool can utilise an existing administrative structure, as opposed to necessitating the creation of a new structure. This, however, implies that a specific tool is considered to be highly automated while dependant on the effectiveness of existing systems, which in itself is considered to be negative. Automated tools generally lack political acceptance, and have been found to be difficult to implement.

Visibility refers to how clearly the specific tool, or the resources required by the tool, appears in the budgeting and policy review process. Within the WDM environment, problems are anticipated with the development of tools that can be considered as high on the degree of visibility, since such development usually involves the re-engineering of existing systems in contrast to the development of new water systems, which is supply driven.

2.2.7 Making changes work through collaboration

While the theory regarding a move towards NPM on an international scale is valid and needs to be understood, Schwartz (2008:49) highlights specific concerns regarding African countries, which pose unique viewpoints and approaches on the generally acceptable international theory. The first aspect highlighted by Schwartz (2008:49) is that, in African countries, despite the move away from the traditional bureaucratic government management in the water sector, the dependence on government and often international donor funding for the delivery of services, and specifically water services, is almost non-negotiable. Schwartz (2008:52) further argues that other factors also play an important role in the improvement of service delivery, and that it is difficult to simply isolate the move towards NPM as the sole reason for some improvements. For example, he lists factors such as top management leadership, professional staff, support from national government structures at a political level and international donor funding as some of the contributing factors for success in Uganda.

Müller (2009:87) concurs with Salamon (2002:8) that the future of the successful governance of natural resources rests with collaboration between government and a wide range of third parties and, as such, it involves a combined approach between sharing responsibilities at a local level and decentralising governance. Müller (2008:89) specifically refers to the need for an evaluation of cooperation between these role-players, with specific focus on cooperative management with different partnerships. Müller (2004b:409) further concludes that, for sustainability, the most promising institutional arrangement seems to focus on a decentralised set of formal and informal agreements among a diverse group of role-players, but that it is unlikely that any single "blue print" exists to address all governance problems, with specific reference to environmental governance.

Governments, as public institutions, have been forced over a number of years to move away from being large bureaucracies towards being more streamlined, performance-based service delivery institutions. These changes, as reported in the literature described in this section, focus on making decisions for the benefit of the public more effectively and in such a manner that the tax payers feel that they do receive value for money or, in other words, the services that they pay for.

With cost being a major consideration in the supply of water, economic tools have been developed and the role of economists in the decision-making process has been strengthened. The need for an appropriate charging system arose as water came to be viewed as a marketable commodity as opposed to a public good (Gandy, 2004:371). With governments failing to supply basic services to the public, the issue of agencies or privatisation surfaced within the context of water being a marketable commodity. Ward (2007:23) states that: 'nothing should be done at a higher level of governance that can be done effectively at a lower level', effectively supporting privatisation where no capacity exists at a local government level.

Gilbert, (2007:1562) quotes Marin and Izaguirre (2006:3), who state that the World Bank accepts private partnerships (Ward, 2007:23) as a means to address some of the service delivery issues, recognising that these partnerships do have significant problems. It was, however, also accepted that private partnerships within the water environment need to be addressed differently due to the inherent nature of being a monopoly (Kessides, 2005:90), while some governments still consider water to be too strategic a sector to privatise (Gilbert, 2007:1562).

From a WDM point of view, where the main focus is to deal effectively with available water resources, the danger always exists that a private company may consider the cost of repairing leaks, as one way of addressing a more effective water system, to be higher than the cost of the loss of water, and as such leaks will not be dealt with. This is specifically a possibility where the water needs to be supplied to poorer communities where little means of paying for the service exists (Gilbert, 2007:1570).

These governance approach changes need to be implemented across the different government institutions (departments), and it is therefore important to review the literature for the steps required for the implementation of changes within the existing structures to ensure successful outcomes. These intergovernmental changes will be reviewed in the next section.

2.3 Intergovernmental Management

While the literature on public management, specifically within the framework of NPM, discusses the issue of cooperation between different stakeholders to facilitate partnerships, these principles can also be made applicable to cooperation between different departments within government structures.

The need for intergovernmental management in the water sector is clearly highlighted by Müller (2004a:244) when he discusses the policy setting for regulation in South Africa. He highlights the importance of the Reconstruction and Development Programme (RDP) and the Growth, Empowerment and Redistribution Plan (GEAR) that were implemented by the post-apartheid regime in South Africa. These policies formed the cornerstone of the government, with a focus on job creation and the spreading of wealth. The RDP specifically targets the provision of housing to the poor.

Within the national level of government in South Africa, such a project would involve a number of different national and provincial departments, such as the National Treasury and the current departments of Human Settlements and Water Affairs, to name only a few. While the National Treasury needs to provide the funding and the Department of Human Settlements would be responsible for the execution of the project, the DWA would need to ensure that adequate water services will be delivered, through the local government structures, to these houses. For these policies to succeed, a clear understanding of the working relationships between the government structures involved is required. It should be noted that these relationships are further complicated by the inclusion of private partnerships (Müller, 2004a:241; Radin, 2003:608), which require not only an intergovernmental relationship but also a workable relationship between the different governmental departments and the private sector.

Radin (2003:610–614) lists some of the fundamental requirements needed when decisions regarding the structure of intergovernmental management are made. These requirements include formal structures, specific programmes, capacity building and lastly, the behaviour of role-players. In terms of structure, it is essential that all role-players understand their role and responsibility. The policies that govern the way the different role-players function in close co-operation with each other need to be set clearly.

Secondly, to ensure successful intergovernmental cooperation, resources, grants and programmes need to be redesigned to enable the specified functions. It often requires that the higher order structure needs to set specific priorities, with associated incentives, for others to ensure that the desired outcomes are reached. For intergovernmental cooperation to be successful, it is important that capacity exists at all levels within the structure to execute the tasks allocated to a specific level. It is therefore appropriate that proper research, data collection, storage and evaluation of the information, with the associated training to build the required capacity, be applied.

2.3.1 Challenges within intergovernmental decision-making

The decision to increase or decrease accountability and/or autonomy determines a specific behaviour philosophy within intergovernmental management structures. Either way, governments' inability to control the outcome of a specific project remains a sensitive issue. Some of the important reasons for this lack of control are (Radin, 2003:615):

- the scarcity of baseline data;
- that it is difficult to quantify specific results;

- that it is difficult to link programmes with specific results and
- the high level of resources needed to develop a proper performance management system.

In an attempt to understand the complexity of coordination required in intergovernmental decision-making, Wollmann (2003:597–599) evaluated the situation in five different countries. He defines coordination as an attempt to optimise the coherency and consistency of political decision-making and policy implementation, which, according to him, became important due to the downward devolution of functions within government structures (Wollmann, 2003:594) and the ever changing public governance environment, where the roles of semi-public and private role-players are becoming more acceptable (Wollmann, 2003:603).

He highlights the need to combine different policies and resources in order to support local economic development, but also warns that this multi-functionality of local governments by definition also provides some challenges. To act on a multi-functionality basis, different role-players with different expectations, different political backgrounds and different professional and social-economic interests may all be combined in one committee or structure, which is difficult to manage (Wollmann, 2003:601).

Wollmann (2003:604) concludes that, although these challenges are huge, these over-arching structures need to function mostly within the existing elected local government structures. This prevents the structure from functioning with a specific group-orientated goal, as opposed to having a common-good-orientated goal in mind.

O'Toole et al. (2002:357) discuss the difficulties with decision-making within government structures during the implementation phase of specific projects, with reference to the role of the political decision-maker in these structures. While their discussion targets mainly national programmes, they highlight two ways in which higher level decision-makers can be involved during the implementation phase of a project, methods that can also be applied to decision-making regarding WDM issues at a local government level.

The first option is that they (politicians) become involved in the policy decisions prior to the setting of structures responsible for the implementation of the project and, secondly, that they can be directly involved in the implementation itself. At the local government level, it is highly unlikely that politicians will became directly involved in the implementation of a WDM project, but their involvement at a policy stage can prove to be of the utmost importance.

2.3.2 Decision-making in the public water sector

While intergovernmental co-operation refers to the relationship between different role-players within government structures within the framework of the NPM concept, many of these relationships and steps can also be applied to the water sector within municipalities, specifically when reference is made to the relationship between different departments within municipalities, or between a specific municipality and the public it serves, or the department and the agencies supporting them. In ensuring that effective use of water through appropriate WDM steps are achieved, decision-making tools need to be developed which also allows for the measuring of performance and progress, taking the lessons learned from the literature review into consideration.

Hudson et al. (1999:347) list a number of components that they consider important when inter-agency collaboration in the public sector is evaluated. While these authors discuss these components in detail concerning agency collaboration, they can be applicable to the collaboration between different role-players within the WDM and water conservation field within a municipality.

Components or factors of interest during inter agency collaboration include:

- Contextual factors – ensuring that everyone understands his/her part in the relationship;
- Recognition of the need to collaborate – understanding how each party can contribute and what is to be expected from each;
- Identification of a legitimate basis for collaboration – the reason and purpose must be clear to all and specifically the benefits expected from the collaboration need to be discussed and understood;
- Assessment of collaborative capacity – can the collaboration be sustainable and what needs to be provided to ensure sustainability;
- Clear sense of purpose – all parties need to have the same vision, mission and objectives;
- Trust – without trust between different parties, collaboration can fail and
- Ownership – clear and well-defined links between all levels of the different organisations.

Milward and Provan (2002:379) add a number of elements for successful cooperation that are relevant to governance of the “hollow state” (third party involvement), which can also add to the effectiveness of intergovernmental management. These elements include:

- A clear principal-agent relationship.
- Principals who provide services will be more effective in governance than those that only govern.
- These principals' contracts preferably need to be long term agreements.
- Adequate and appropriate resources. Funding needs to be in line with the complexity of the task, and money alone will not provide all of the solutions.
- Stability.

Within the water sector, these principles or elements can be used to successfully develop WDM decision-making tools. Public participation, which will be described in section 2.8, will play a key role in this process, since WDM can be seen as collaboration between a municipality and the end-users.

Collaboration between different role-players to ensure workable partnerships in multi-organisation structures is well-researched. Some of the critical issues identified by Lowndes and Skelcher (2002:315) include the level of trust between role-players and the mutual benefits for the participants.

With trust and cooperation identified in the literature as important potential stumbling blocks for successful intergovernmental cooperation, of which the successful management of the water sector forms an integral part, it becomes clear that well defined steps incorporated into decision making tools can assist with open decision making which can support effective WDM. These tools need to be generic and able to ensure trust between the decision-makers and the implementation staff. They also need to provide a mechanism to ensure that mutual benefit can be achieved, not only in many of the departments involved in a municipality, but also among political structures.

Before these tools are developed, the literature regarding decision-making tools will be described in the next section with the objective to provide the essential building blocks for these tools within a public management framework, with a specific focus on water management.

2.4 Decision Support Systems

The process of making a good decision, in general, is based on a number of critical factors. Gough et al*.* (1996:1) highlight two main criteria. Firstly, they state that it is important to ensure that the process is 'good', and secondly, that the outcome or end result is 'good'. To provide a sound basis for ensuring that these two criteria can be achieved, it is important to provide appropriate decision support. This was described by Gough et al. (1996:1) as 'data, information, expertise and activities' that can assist the decision-maker. DSSs, therefore, combine decision analysis and the available information to provide clear guidance to the decision-maker.

In practice, the analysis is frequently based on economic values, operational research and management science. All participants in the decision-making process therefore need to agree on the original goals to set for the process. Gough et al. (1996:2) highlighted the importance for the participants to identify all alternatives available in the process of decision-making. They concluded that the essence of a DSS is the integration of information and methodologies from different sources to enable appropriate decision-making. This was also pointed out by Andriole (1989:15) and Davis (1988:10–13).

Sprague (1980:6) provides an overview of the building blocks of any DSS, addressing specific issues regarding the functions of DSSs, the different aspects to be considered and the expectations from different participants. He defines a DSS as a 'class of information system' that, with the aid of existing data, 'interacts with other parts of the overall information system to support the decision making activities of managers and other knowledge workers in the organisation.' He highlights the fact that people from different backgrounds will interpret the use of DSSs quite differently. This statement stresses the importance for the development of a DSS with a specific target group in mind, so as to ensure no uncertainties regarding the presentation of the results.

Sprague (1980:6–7) furthermore identifies a number of characteristics that need to be included in a DSS. These include factors such as flexibility, adaptability, decision focused, user initiated and simplicity. He identifies three levels in DSS development:

- Specific DSS
  This is referred to as an information system application, which might be hardware or software that allows a specific decision-maker to deals with specific problems.
- DSS generator
  The DSS generator provides a set of capabilities to quickly and easily build a Specific DSS, as defined above. These capabilities include aspects such as reporting, graphics displays and statistical analysis subroutines.
- DSS tools

DSS tools are referred to as computer program languages such as Fortran/Visual Basic or Matlab. These programs are used to develop the DSS generator or Specific DSS.

During these different stages of development, the DSS must be able to respond quickly to user feedback, and must accommodate changes. It is suggested by Sprague (1980:10) that a DSS should be developed interactively with the users, and that it needs to allow for changes as it is developed, until it is relatively stable. He warns that a DSS will in all likelihood never be completely stable, but the frequency of changes might be reduced significantly over time.

Although it was made clear that a DSS can be used by a number of different levels of responsibilities within an organisation, the focus of this study is on the manager of a municipal water department. As such, Sprague (1980:12–14) identifies the following performance objectives for a DSS for managers:

- Support decision-making, specifically with unstructured decision processes.
- Assist with integration of decision-making between different levels of decision-makers.
- Support decision-making that is interdependent as well as that which is independent.
- Support all phases of decision-making. These phases are defined as:
    - intelligence – inspect data and identify problems;
    - design – develop possible steps to be taken to address identified problems and
    - choice – select a specific step from those available and implement it.
- Support a variety of decision-making processes, but not be dependent on any one.
- Ease of use.

While Sprague (1980:6) focuses on the value of DSSs against other information management systems, and specifically refers to the value of computer-aided DSSs, the findings of the research presented in this dissertation show that few municipal managers use complex computer-aided support systems during their decision-making processes. The focus for the development of a DSS for municipalities was therefore based on a simple approach in which the different requirements for an appropriate decision-making process will be included, but without the need to develop a specific computer program. Computer programs are used during the decision-making process as tools to provide information on which decisions can be based, but the DSS itself will be limited to a decision flow path, ensuring that all of the aspects required are included.

Morais et al. (2006:229) argue that, in most instances, decisions are based on intuition. In these cases, decisions are taken without considering all the components of the problem in an organised way.

2.5 Models of Decision Support Systems

Froukh (2001:364) developed a decision support model for domestic water demand forecast, including WDM as a management option in the model. He defines WDM as the task of selecting specific actions from a range of available options for meeting target demands. Water conservation on the other hand, was defined by Baumann et al. (1980:125–126) as the social beneficial reduction of water use or water loss. The DSS model developed by Froukh (2001:364) is, as with many other models, a computer-based model that needs a significant amount of input. He defines a DSS as being a computer-based system aimed at investigating the possibilities of realising a pre-defined goal or objective, given a set of pre-defined constraints. Although he touches on some of the criteria that do have the potential to reduce domestic demand, it still remains with the user to define what criteria need to be included for evaluation.

This research will focus on the inclusion of all the possible criteria to be evaluated, without providing a single model against which the economic value of the outcome can be measured. Emphasis will be placed on the integration of all these steps, and the objective will be to provide a “checklist” that can be used by the manager of the department responsible for water management in the municipality to ensure that all factors in the water management cycle are evaluated during the process of decision-making, so as to ensure effective and efficient water use.

Pietersen (2006:119) uses the multiple criteria decision model (MCDM) to provide management strategies for dealing with the unique characteristics and roles of groundwater in water resource management. He concurs that the development of decision-making frameworks to address wide-ranging technical and socio-economic issues will promote sustainable development and effective use of water resources. He identifies the problem decision-makers face in deciding how to best use limited resources, and suggests that a well-structured critical pathway be developed to allow decision-makers to deal with complex problems.

The MCDM techniques recently reported in the literature are evaluated by Pietersen (2005:121), following Belton et al. (2002:80), and include the following methods:

- Value function method
  Assessing the performance of alternatives against set criteria, taking the relative importance of each criterion into consideration.
- Goal and preference point methods
  Goals are specified, against which specific actions are measured.
- Outranking methods
  Pairs of actions are compared against each other in a process of eliminating alternatives, based on all available information.

These methods differ from each other in the way criteria are considered: the application and computation of weights; the level of uncertainty; and the participation of different stakeholders, just to name a few highlighted by Pietersen (2005:121).

Experience gained from the researcher's time spent in municipalities highlights the lack of available expertise in selecting an appropriate MCDM technique, and specifically the implementation thereof. Most of the municipalities investigated in this research indicated that they depend on support from outside of their own structures to assist them with the compilation of their Water Services Development Plans (WSDPs), one of the most fundamental management tools in the water sector.

With a lack of internal capacity to use MCDM, the focus at a municipal level will be to develop the critical pathway for appropriate decision-making, as identified by Pietersen (2005:121), while the need for appropriate data to be used in the decision-making process will also be addressed. The application and use of models in the water sector can also have an influence on the development of these models. To provide guidance towards the usage of models to make decisions, the literature on the use of models will be evaluated in the next section.

2.6 Use of Decision Support System Models

Dent (2000:514) describes the use of models for integrated water resource management in South Africa, and focuses on a number of relevant problems. He highlights the shortage of skilled personnel in South Africa, specifically in the water science field, and the general lack of adequate data needed for these models to be effective. He states that, twenty-five years ago, expertise in water management in South Africa was consolidated within state departments, while currently this expertise is to be found almost exclusively in the private sector. This general statement regarding the available skills was confirmed by research conducted among a significant number of municipalities in one province (Western Cape) of South Africa, which will be described in more detail later.

Dent (2000:514) then continues to argue for the integration of models to aid decision-making in the water sector. While Dent refers to highly complex models that can be used, the lack of adequate and appropriated trained staff is a stumbling block at municipal level. Dent quotes Quadir et al. (1999:3), who state that ‘the impacts of information technology on the water sector are not inherent in the technology but largely depend on the way society chooses to use the technology’. It is therefore clear that communication will play an important role in any form of modelling. It is even more obvious if the model needs to involve end-users in the water sector, frequently right down to the individual consumer level. Schulze (2001:12), however, warns that the use of models for policy decision-making makes it necessary for scientists to not only think from a research outcome point of view, but to think more towards a policy outcome perspective, taking the needs and demands of the stakeholders into consideration when designing the model.

Communication does not only refer to the flow of information to the public or any specific stakeholder, but it also includes the way in which municipalities communicate within themselves. In a case-study conducted by Smith et al. (2005:445) involving the failure of water services delivery in a community in Pietermaritzburg, South Africa, the failure to communicate sufficiently within the local municipality itself was highlighted as one of the contributing factors for the failure to implement policies, including WDM issues. These were, according to Smith et al. (2005:445), poorly prioritised, with negative financial and environmental implications for the municipality.

This dissertation will provide a model, presented as a set of DSSs and a number of decision processes, to ensure integrated decision-making within municipalities while recognising the lack of adequate and appropriately trained staff. Individual DSSs can be used if and where required, but the dissertation will also provide a set of baseline data that can be used in support of the decision-making process.

Dent (2000:517) also warns users of simplified models, as will be presented in this dissertation, stating that they need to understand and know the limitations of these models in order to avoid a misunderstanding of the results obtained through the application of such models. In other words, models must not be used beyond their limitations. This is indeed a valuable statement that needs to be incorporated and included in the decision-making path.

2.7 Integrated Approach

Otieno et al. (2004:120) present a clear picture of the need for proper management tools to avert a possible water crisis in South Africa. They offer primarily four solutions, which function on a catchment basis, that involve the evaluation and development of alternative systems. These four proposals include: the development of alternative resources (re-use of water, rainwater management, desalination and cloud seeding) to supply the demand; the implementation of special management techniques to ensure that poor quality water (if available in a natural state) can be made available; the reallocation of water from low benefit to high benefit areas and lastly, the implementation of WDM to improve water use efficiency in all sectors.

Otieno et al. (2004:122) conclude that the availability of models that function on a catchment basis to analyse the “what if” scenarios is of importance to address the water crises not only in South Africa, but also in many water scarce areas in the world. It is suggested that multi criteria analysis (MCA), similar to MCDM described in section 2.4, be used to select one alternative over another. Otieno et al. (2004:122–123) include the management of all water use sectors, including agricultural, industrial and domestic water use.

Morais et al. (2006:229) explain that the single-criteria decision-making process normally only concentrates on the selection of the option with the maximum benefits as against its competitors, while the MCA, like the ELECTRE (**El**imination **E**t **C**hoix **T**rduisant la **RE**litè, meaning ‘elimination and choice expressing the reality’) method used by Morais, also facilitates an understanding of the inherent features of the decision problem.

No specific solutions to the challenge of an integrated approach to avert a water shortfall in South Africa are presented at this stage by Otieno et al. (2004:120), but they provide a broad overview of the needs and the possible direction in which research needs to be focussed. The most important aspects highlighted by Otieno et al. (2004:120) are the conformation of the water problems in South Africa and the need for integrated management of the water cycle with the help of appropriate decision tools.

MacKay et al. (2004:1) investigated the reasons for the apparent failure of the implementation of water policies in South Africa, and found that the lack of appropriate integration at all levels of decision-making is one of the biggest contributors to the lack in progress.

Of specific interest is the so called “second ring”, which highlights non-engineering programmes that focus on water. These programmes include aspects such as water pricing, water tariffs, water conservation, demand management programmes, education, eradication of invasive plants and institutional structures such as Catchment Management Agencies (CMAs) for all Water Management Areas (WMAs) in South Africa.

MacKay et al. (2004:7) argue that any decision-making tool in the water sector will have to include at least all of these identified considerations in order to ensure an integrated approach to decision-making. These factors will all be incorporated into the DSS developed for municipalities and presented in this dissertation.

2.8 Multi-stakeholder Processes

When an appropriate set of tools needs to be designed to ensure effective WDM, it is essential that stakeholders from different environments need to be mobilised to ensure an effective implementation. WDM is about changing the demand to ensure a sustainable supply, and not simply about designing more supply systems.

Demand is a result of a number of different role-players, such as industrial, household, recreational and agricultural water users. These different sectors all need to be role-players in a system where the main aim is to change their use patterns. Public participation therefore plays an important role in WDM. In fact, public participation has been defined by various authors to mean different actions.

Canter in DEAT (2002:6) defines public participation as a two-way information exchange and consultative process, without reference to the sharing of responsibilities or the delegation of authority to interested and affected parties, while Greyling (1999:3) regards public participation as a joint effort by stakeholders, technical specialists and authorities to work together to produce better decisions than those that would have been taken had they acted independently.

Pollitt (2003:58) and Moynihan (2003:170) provide well-defined structures or models, which vary from consultation to full iterative participation, while Hemmati (2002:210) highlights the fact that multi-stakeholder processes (MSPs) deal with the collaboration between different role-players. The need for a core coordinating group to do the initial planning is highlighted. Once an appropriate and representative structure, as suggested by the core coordinating group, has convened, this structure needs to agree on the suggested planning from the core group as a starting point. Sufficient time for preparation is essential for an MSP, and it is advisable that an appropriate memorandum of understanding be agreed upon at the beginning of such a process. This will ensure a focussed and well-informed group of stakeholders. Schwartz (2008:55) reported that the role of stakeholders changed as a move towards an NPM structure progressed in Zambia. Consumers organised themselves into so-called “consumer water watch groups”. The involvement of different role-players in such a manner can be of significant benefit to the implementation and sustainability of effective water management structures, as will be illustrated later.

Warner (2006:15) argues that the communication and information process itself might be sufficient for some stakeholders, but that some might have significantly higher expectations, with the idea that they will gain in some way from the process. Hemmati (2002:213) warns against having a group of stakeholders that is too big for effective discussions, but it stresses the importance of representation over a wide spectrum. The necessity of including members who truly represent their specific interest group has been stressed. This will avoid duplication and the loss of time during discussions if new individuals need to be informed each time stakeholders meet.

Public participation is described by Hophmayer-Tokich (2005:23) as a process that can reduce the level of uncertainty in decision-making through the improvement of decision-making and an increase in social acceptance and support. Hophmayer-Tokich (2006:2; EU, 2002:15) also refers to public participation as public involvement, and defines it as a process of allowing people to influence the outcome of plans and working processes. Figure 2.1 (Hophmayer-Tokich, 2006:2) on the following page illustrates this process.

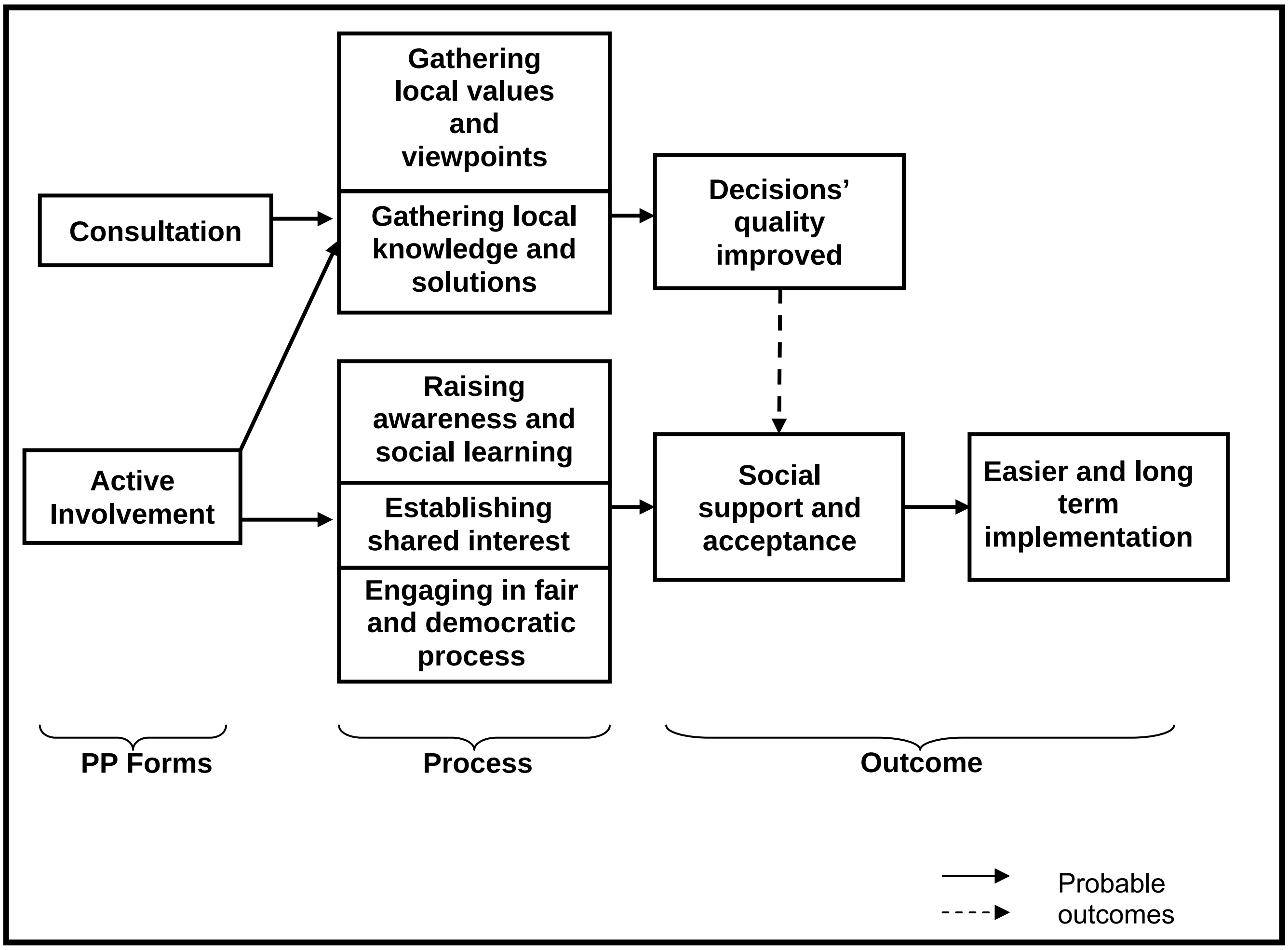


Figure 2.1: Different processes to occur during public participation

Hophmayer-Tokich (2006:3) reports further that, in Europe, the Water Framework Directive (EU, 2000/60/EC) refers to the involvement of both the "general public" and "interested parties" (more commonly used as 'stakeholders'). He then defines "general public" as 'one or more natural or legal persons, and, in accordance with national legislation or practice, their associations, organisations, or groups'. The term "stakeholders" refers to 'any person, group, or organisation with an interest or "stake" in an issue, either because they will be directly affected or because they may have some influence on its outcome…' (EU, 2002:18)

There is a great deal of agreement among these and other authors (International Association for Public Participation, [s.a]) that the outcome of this process is a more informed decision, with not only acceptance, but specifically the acceptance of the responsibility to implement a specific project. The gathering (exchange) of information, on which to base decisions, is also evident in these definitions.

The use of the term "stakeholders" instead of "public" has been proposed (Canter, 1996:14) to avoid a possible misunderstanding that the public excludes the private sector. The term “stakeholders” is defined by Beckenstein et al. (1996:2) as being groups ‘that have an involvement or an investment in the company’s decisions and in its social and economic exchanges’, while Fox and Meyer (1995:122) define the term “stakeholder” as ‘a person or group of people, such as shareholders, employees, customers, creditors, suppliers, trade unions, government and the community’. Van Rooyen (2003:128) concludes that stakeholders can be defined as groups whose existence may somehow be impacted upon by decisions and actions taken by organisations or institutions.

It was furthermore suggested by Canter (1996:23) that participation be replaced with engagement, since all of the different steps of participation do not necessarily directly refer to a process where stakeholders actually have a specific input to make.

To illustrate the reasoning behind this, it is necessary to define the different steps of participation or engagement. The process (DEAT, 2002:7; International Association of Public Participation, [s.a]; SAIEA, 2005:14) is illustrated in Figure 2.2 on the following page, and consists mainly of the following steps:

- Persuade
  This process aims to manipulate attitudes and to influence decision-making through challenging specific targets. It is also referred to as protest (DEAT, 2002:7), and involves the transfer of information and viewpoints.
- Inform
  This stage involves the improvement of awareness and support through the transfer of information.
- Consult
  A consultation process reflects an exchange of information between stakeholders.
- Involve
  Working together to ensure that all viewpoints are taken into consideration.
- Collaborate
  Joint decision-making, stakeholders constructively explore their differences to develop a joint strategy or decision.
- Empower
  The full responsibility of decision-making and the accountability of these decisions have been delegated by the authority to the interested and affected parties.

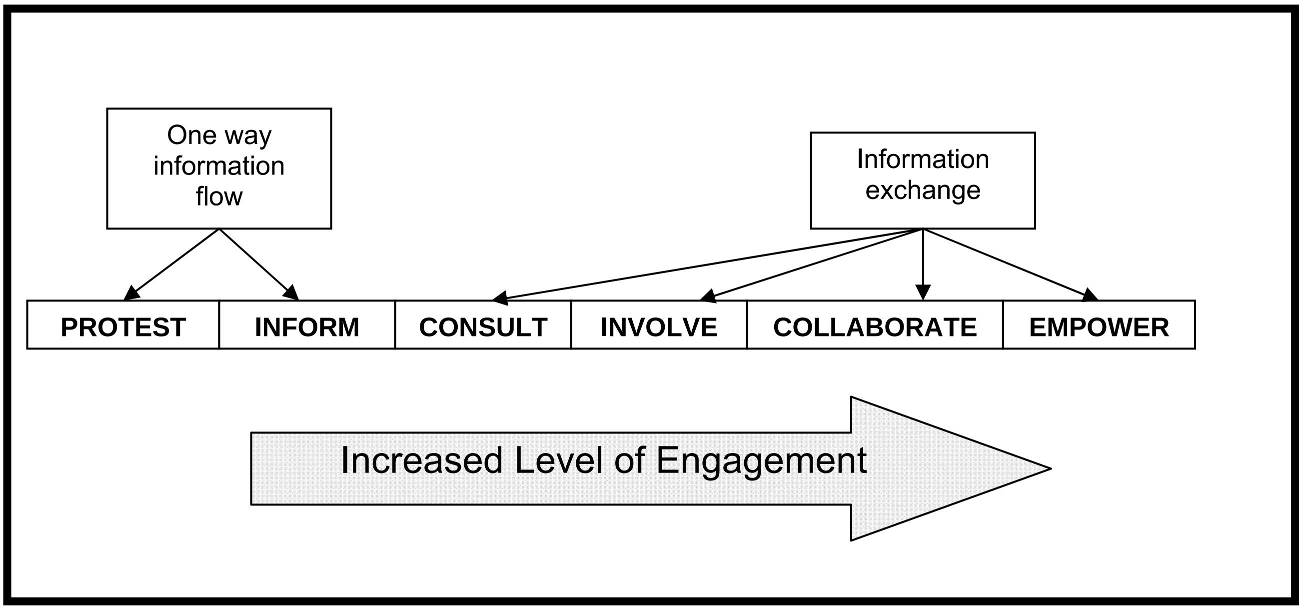


Figure 2.2: Stakeholder engagement spectrum

In this process, the first two steps involve the transfer of information and do not necessarily imply participation between stakeholders, hence the motivation to use the term 'engagement' as opposed to 'participation'.

McDaniels et al. (1999:499) analyse behaviour decision research done by a number of researchers, and quote Simons, who stated that, for the successful implementation of public participation, decision-making structures and workable tasks need to be pre-determined and that the structures at executive and administrative level must implement the steps coming from the process without pre-conditions. In the context of the water industry, given the different integrated steps in the full water cycle, all stakeholders need to be involved in the process as early as possible. McDaniels et al. (1999:498) conclude that, when no prior structures or public participation procedures are in place before the 'actual' process starts, the initiative is prone to failure.

Stakeholders do not need to be groupings or representatives of organisations, but can also be individuals. The identification of the stakeholders will also depend on the specific issue to be analysed, and their inclusion in the process needs to be balanced against the need to manage the process effectively (Beckenstein et al., 1996:2).

During previous WDM programmes held in the West Coast District Municipality (CopyCat, 2002:1-31), a list of sectors at local government level that do have an interest in WDM was compiled. These sectors all have either a responsibility towards political decision–making, or will be closely impacted through ineffective service delivery linked to the water management cycle. In some instances, such as schools, their participation is considered of great educational importance, and therefore provides a base from which the message can be conveyed.

The sectors identified, and which need to be included in WDM projects, are:

- National government departments
- Provincial government structures
- Local government structures: local and district municipalities
- Industries
- Business (Chamber of Commerce)
- Non-governmental organisations (NGOs)
- Political representation
- Schools
- Hospitals
- Rate-payer associations or home-owners associations
- Cultural and community based organisations
- Interested and affected individuals
- Trade unions
- Sport and recreational bodies

It is, however, advisable to follow a process in advance to identify the relevant stakeholders. This can be done through a number of different ways:

- Integrated Development Plan (IDP) meeting profiles;
- Brainstorming between the municipality and DWA or CMAs;
- Consulting all existing databases held by authorities;
- Public announcements, advertisements or notices and
- Networking with already identified stakeholders.

Once the stakeholders have been identified, the objective of the public participation process will determine which method or approach can be used to ensure effective engagement. The three basic categories into which these methods can be divided are (DEAT, 2002:8):

- Information transfer

  This can be achieved through various methods, including notices at municipal offices, newsletters to rate payers, advertisements in newspapers, brochures, flyers and pamphlets, posters, radio talks, websites, e-mails, sms's, visits to treatment facilities, exhibits and displays, informative billing, calendars, T-shirts, bill boards and water week activities.

- Consultation

  Consultation can be achieved through public meetings, open days, information or complaint centre hotlines, questionnaires, surveys and interviews, to name a few.
- Collaboration and empowerment

  This can be achieved through workshops, focus groups, advisory panels, and committees.

Hophmayer-Tokich and Krozer (2005:7–8) provide a list of possible limitations to be aware of when a process of public participation is followed, based on experience gained during the *North Sea Regional and Local Implementation of the Water Framework Directive* (NOLIMP) project, conducted under EU water directives. These lessons learned should be incorporated in the design of any stakeholder engagement process, specifically when models are developed that depend on public participation for successful implementation. Points of interest include:

- Stakeholder engagement is time and resource consuming, and needs good coordination. It needs to be facilitated and organised.
- Stakeholder engagement programmes need to be suited to the target audience, so as to make them easier and more attractive for people to participate. Otherwise, people may not be interested. The programmes should also be suitable for the project and the local conditions.
- Expectations of participants must be managed. Participants need to know upfront that the process will not be able to meet all stakeholders' expectations or solve all conflicts. Participants need to know that the process only provides a good opportunity to promote a solution that will be acceptable to most sides.
- Historical conflicts and hostilities take a long time to be resolved and, in some cases, difficult personalities prevent successful results. In such a case, direct co-operation may not be possible and a neutral mediator will be required.
- Stakeholders should be capacitated to understand the technical terminology.
- As a result of stakeholder engagement, expectations of the community are raised and agencies need to deliver. Delivery will probably be slower than community expectation, and this should be communicated to the community to avoid disappointments.
- Politicians are used to speaking for the public. They need to change their frame of mind and allow people to have real influence. Otherwise, the process will lead to disappointment.

The expected outcome of a stakeholder engagement process has already been identified as being the improvement of the decisions to be made. A number of outcomes arising from a well-structured public participation process include the following (Hophmayer-Tokich and Krozer, 2005:14-20; Hophmayer-Tokich, 2005:23):

- The gathering of important local knowledge and alternative solutions that cannot be gathered any other way.
- Defining problems and goals for actions more comprehensively, based on the understanding of all relevant stakeholders' viewpoints and concerns.
- Broader acceptance and support for measures, and thus promoting a successful implementation, by:
  - raising awareness of the problems and the need for action;
  - allowing all sides to communicate their needs and concerns, thus promoting better understanding of the different sides;
  - assisting in defining shared goals and interests as a base for collective, joint and coordinated action;
  - improving working relationships among the different parties;
  - possibly reducing levels of conflict and
  - being perceived as fair.

Hophmayer-Tokich and Krozer (2005:20) conclude, from their findings during the NOLIMP experience, that public participation is not an "all-fits-one" solution. Based on three different approaches used in three different NOLIMP member states (Scotland, Norway and Germany) – which varied from a board and working groups, to an individual approach and even participation through a mediator to allow all parties to communicate – the outcome, if managed appropriately, results in a more acceptable end result, which is to the benefit of all parties involved. Anderson et al. (2008:440) warns, however, that participation alone is not necessarily a guarantee for a transparent, representative and democratic outcome.

The importance of a well-structured public participation process, or MSP, has been highlighted in this section. Different approaches and possible problem areas, as well as the important factors to include in the development of such a process, were analysed. The possible outcomes of a well-structured process were also highlighted.

It is important to realise that these structures will need institutional back-up and funding, most probably supplied by the relevant authority responsible for the implementation of a project. Capacity building will play an important role, and education regarding WDM constitutes an integral part of the MSP required to ensure effective WDM.

2.9 Summary

WDM is a function of local government in South Africa. Local government is, however, only one level of government, and decisions taken within this framework need to be evaluated within the bigger context of governance. The literature evaluated in this section provides the reasons why government structure is constantly changing. Governments have changed from large bureaucracies to more market-orientated management structures, and eventually have become organisations that make extensive use of third party involvement. These changes, according to NPM theories, were enforced over time to ensure more effective government and hence service delivery.

NPM borrows from lessons learned in dealing with structures outside government during decision-making processes. The objective is mainly to provide managers with more flexibility in decision–making, and in exchange for this flexibility, an evaluation system needs to be implemented to ensure progress. These changes are important in the development of decision-making tools for WDM, and the lessons learned from the literature will have to be incorporated into these tools. Of considerable value is the close relationship between the different government structures and the tax payers, and how, over time, this relationship has changed.

WDM is, in the first instance, a management intervention between the government structures which is legally responsible, through The Constitution of the Republic of South Africa (Act 108 of 1996), for the delivery of water services and the end-user or public. The literature highlighted the important ingredients needed for a workable relationship, and it also provided some thoughts on how third parties might become involved. The criteria for management tools and the methods to determine the impact of these tools on governance have been presented, and need to be considered when decision support tools for WDM are developed.

With governments moving away from directly managing specific aspects, the importance of them remaining in control of the decisions taken by third parties has been emphasised, and the need to give managers more freedom to manage necessitates a performance management system to ensure that the perceived outcome is achievable and sustainable. The literature provides key aspects to be included in a performance management system, such as the clear defining of goals and the development of benchmark values. For this purpose, data gathered as part of this research will be evaluated to provide a number of benchmark values as set PIs to be used with the proposed model.

The literature specifically draws attention to the stumbling blocks for good decision-making practices within government structures, with specific reference to the cooperation between the different role-players. This is important where the implementation of policies becomes increasingly difficult due to a lack of adequately trained staff, as is the case in the South African local government sector. The need to also keep the political decision-makers involved at different levels was also identified, and the literature provide some key conditions required before political acceptance can be expected. These are valuable guidelines that will play an important role in developing the structures that need to take responsibility for the implementation of WDM.

It is clear from the literature that different models exist to aid decision-making. These models varied from complex computer models to simple flow paths. The literature investigated presents the requirements for these different models, their uses and applications. The different steps in the development of a DSS were outlined. It was also noted by a number of authors that DSSs need to ensure that no decisions in the government sector are taken in isolation, specifically in the water sector. An integrated approach has become a cornerstone for effective and efficient water management.

A number of authors present the criteria against which decisions need to be evaluated. These varied from complex MCDM methods to single-criteria decision-making processes where the main objective is to maximise the benefit between two options.

Decision-making within the water sector involves the end-users, and as such, the public. The importance of proper communication processes in the development of appropriate tools has been highlighted. Dealing with end-users immediately brings the way in which decisions are taken within government structures to the fore. The end-users are also the voters, and therefore the ultimate test for the evaluation of a decision taken and implemented by local government structures.

Based on the literature study it is clear that, within the context of South Africa being a water-scarce country, tools are needed to aid decision–making. This is to ensure that the water use behaviours of the end-users are changed. WDM is the responsibility of each end-user and local government, as the water authority, is responsible for the successful implementation of WDM. The need for a change in water use behaviour was also strengthened through considering intergovernmental cooperation. While the provision of housing and job creation were identified as key focus areas, programmes like RDP and

GEAR, which were implemented by government to ensure growth and wealth, came with pre-conditions of training in water-related topics, linked to the infrastructure associated with the projects. The opportunities for intergovernmental cooperation triggered by the projects strengthened the need for tools to ensure that resources (water, human resources and finances) will be used to serve as many people as possible.

With limited financial and human resources, local governments are faced with a difficult task to ensure that WDM is implemented within the context of sustainable regional planning. This research will aim to develop a model that consists of a set of integrated DSSs and specific processes, which will ensure effective implementation and appropriate stakeholder involvement in the water sector. The DSSs will focus on the provision of a set of criteria to be used to ensure that all aspects relating to WDM are taken into consideration. It will specifically steer away from complex computer programs, and it will provose an institutional process that will aid the implementation of well-defined WDM steps. The literature identifies the need for tools that are easy to use and flexible. A critical flow path approach was suggested, which provides the basis for the "checklist" approach suggested by the author for the further development of decision-making tools in the water sector.

The literature highlights the importance of ensuring that, once a model is developed, it can be implemented effectively through proper public participation. The challenge in combining many different viewpoints in one decision-making model was highlighted, and although it is important to involve the full spectrum of participants, the size of the structure responsible for the implementation needs to be kept as small as possible to ensure effective decision-making. The necessity of guaranteeing, through appropriate public participation steps, that the role-players will not only participate and accept the outcomes, but will also take responsibility for the implementation, was discussed.

The need for a core group to discuss the key issues prior to the implementation of the model has been highlighted in the literature, and a list of possible role-players in the water sector has been suggested. Lessons learned from previous public participation projects have been analysed, and the fact that no "one-fits-all" process exists, was stressed.

In conclusion, the literature review provides an understanding that the model will have to be evaluated in the broader context of public management. If adequate financial resources need to be provided by different government departments, then Government needs to evaluate the different municipalities on an equal basis to assess their readiness or progress with WDM before funding for further infrastructure development can be allocated. Such an assessment can in itself then be used for the reallocation of budgets and the coordination of different functions, such as the building of houses and other development options where water plays an important role. This aspect needs to be incorporated into the proposed model.

Fundamental to the development of appropriate DSSs, implementation processes and the evaluation thereof, is the need to understand the different WDM techniques, which will be described in Chapter 4. The government structures responsible for water-related decision-making in South Africa, and South Africa’s water situation in context of the global water problems, also need to be understood before an appropriate model can be developed. This perspective will be presented in the next chapter.

CHAPTER 3
Water Demand Management in South Africa

3.1 Introduction

Chapter 2 has provided the theoretical background for appropriate decision-making processes within the public management environment, as well as the importance of, and steps required for, appropriate public participation. Chapter 4 will focus on the theoretical and practical background information required to implement different and effective WDM interventions. Both of these chapters are important for developing a model that will be appropriate for enabling local authorities in South Africa to carry out effective WDM.

Such a model needs to be applicable to the institutional and legal framework regulating water management for municipalities in South Africa. This chapter will discuss WDM within this context, and will provide the reasons for the drive towards WDM in South Africa. In doing so, it will use the EU, and specifically the Netherlands, to provide an international perspective regarding the implementation of WDM. The decision to use the Netherlands situation for an international perspective was based on a cooperation agreement between South Africa and the Netherlands, which focused on effective water use at a local government level.

3.2 The Global Water Perspective

Seventy per cent of the Earth's surface is covered by water, resulting in a volume of approximately 1.385 billion km^3 of water. The majority of the water, approximately 97.5 per cent, is available in the sea, and only 2.5 per cent is fresh water, of which only 0.035 per cent is available to mankind. The polar ice caps and glaciers hold a further 2.05 per cent, with groundwater resources claiming 0.68 per cent. Lakes, soil moisture and the atmosphere hold a further 0.016 per cent, with only 0.0001 per cent available in rivers, the water resource most utilised by mankind (Hunt, 2004:42).

The population of the world has tripled (UNPF, 2001) over the past seventy years, and although the per capita use did stabilise, approximately 77 million more people need to be supplied annually with water from the existing available resources. Worldwide, 54 per cent of the available fresh water had been used in 2001. If usage patterns stay the same, then 70 per cent of the available water will be used by 2025, and if all of the countries in the world reach a per capita consumption of a typical developed country, then this figure will increase to about 90 per cent. Figure 3.1 shows the projected increase in water stress areas in the world.

Even though this might not seem to be a serious problem, the available resources are not evenly distributed, adding to the challenge facing the world. Europe, for example, receives 8 per cent of the global runoff, but has 13 per cent of the global population. Likewise, Asia receives 36 per cent of the runoff, which needs to serve 60 per cent of the global population (UNPFA, 2001). Seasonal variations add further to the problem of available water, with water only in good supply for a number of months.

It has been estimated (Hunt, 2004:45) that the bulk of water used in the world in 1995 was being used for agricultural purposes (84.3 per cent), with 3.6 per cent for industrial use, 2.4 per cent for municipal use and 9.6 per cent lost through evaporation from dams and lakes. The focus for this study, however, is on potable water, including domestic and industrial use. No attempt had been made to investigate the problems or requirements for specific industries, such as forestation, power generation or any other specific industrial sector use.

It is also important to recognise the sensitivity prevailing concerning the supply of basic water services to the poor and the need to manage water resources, with the quality thereof a major focus point, not only for the benefit of mankind, but specifically also for the environmental health of river systems.

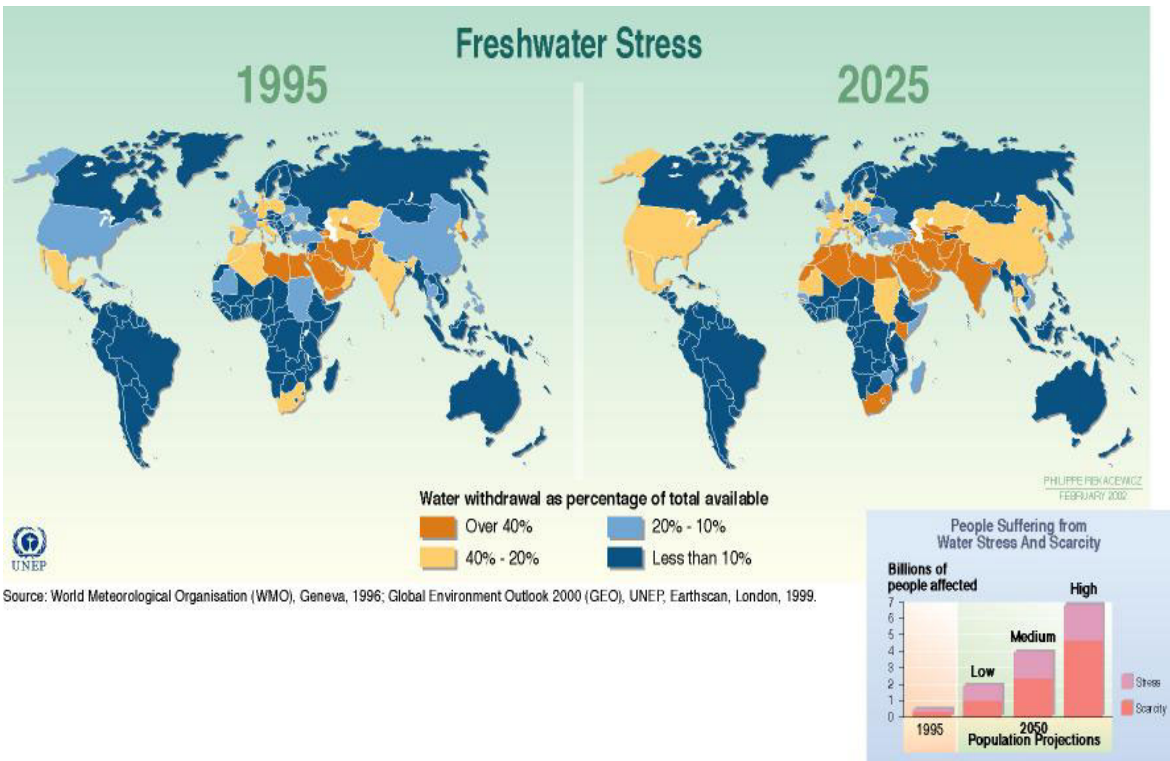


Figure 3.1: Projected increase in water stress areas in the world

3.3 South Africa in Context

Every country in the world will have its unique problems and possible solutions to address effective water management. While no attempt was made to compare different approaches in the world with each other, water management challenges in South Africa and the EU, specifically the Netherlands, as an example, do show similarities worth noticing. Consumption figures, the institutional changes over time in the management of water institutions and the reasons for requiring an integrated approach are some of the aspects that illustrate that South Africa is not the only country faced by to the need for changes.

To emphasise the importance of the need for integrated WDM, a general overview of the water situation for the two areas, highlighting the need for integrated decision-making, will be given. No attempt will be made, however, to compare the two different areas for any reason other than to give a wider perspective regarding the water management environments.

3.3.1 South Africa

South Africa is a land with unevenly distributed water resources and huge climatic differences. According to the United Nations (UNPF, 2001), a country can be considered as water stressed if the available resources are less than 1,700 m^3 per person per year. Southern Africa's estimated available water is only 1,289 m^3 per person per year. In general terms, South Africa can be classified as an arid or semi-arid region, with 21 per cent of the country receiving less than 200 mm/year, while 44 per cent receives between 200 and 500 mm/year. South Africa's evaporation rate exceeds its precipitation rate. The rainfall distribution, as shown in Figure 3.2 (DWAF, 2004:18), highlights the diversity of the rainfall in South Africa.

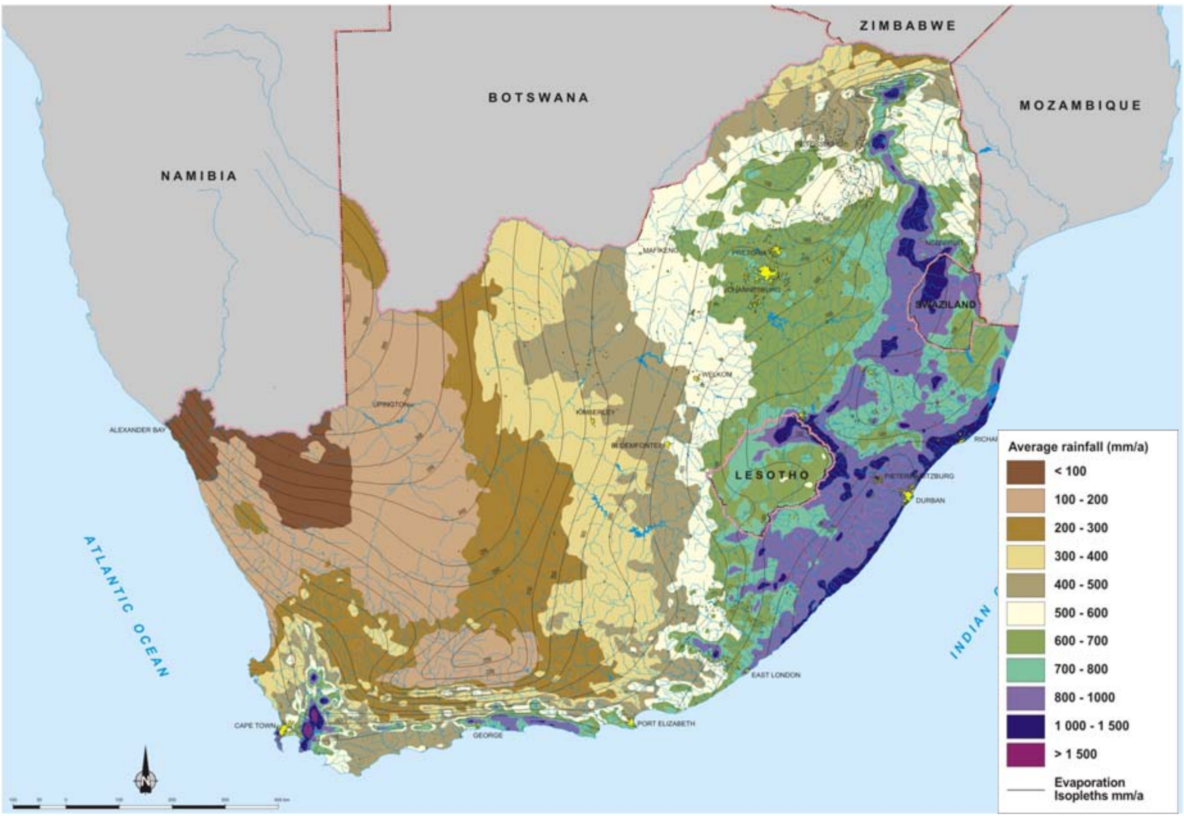


Figure 3.2: Rainfall distribution in South Africa

Conditions are furthermore distorted by the fact that access to these available resources was not guaranteed to all in the past. As a developing country, the lifestyle of a large part of the population in South Africa started to change, specifically after the democratic elections held in 1994, and with it, their demand on water resources increased. Developments and growth centres were historically established around the mineral deposits in South Africa, which are not close to any of the major available water resources. In order to address these issues, and to ensure economic development in South Africa, the water resources are constantly being put under pressure.

South Africa is already sharing water from neighbouring countries like Namibia and Lesotho, and large inter-basin transfers already form part of the NWRS. The extent of these transfers is shown in Figure 3.3 (DWAF, 2004:19).

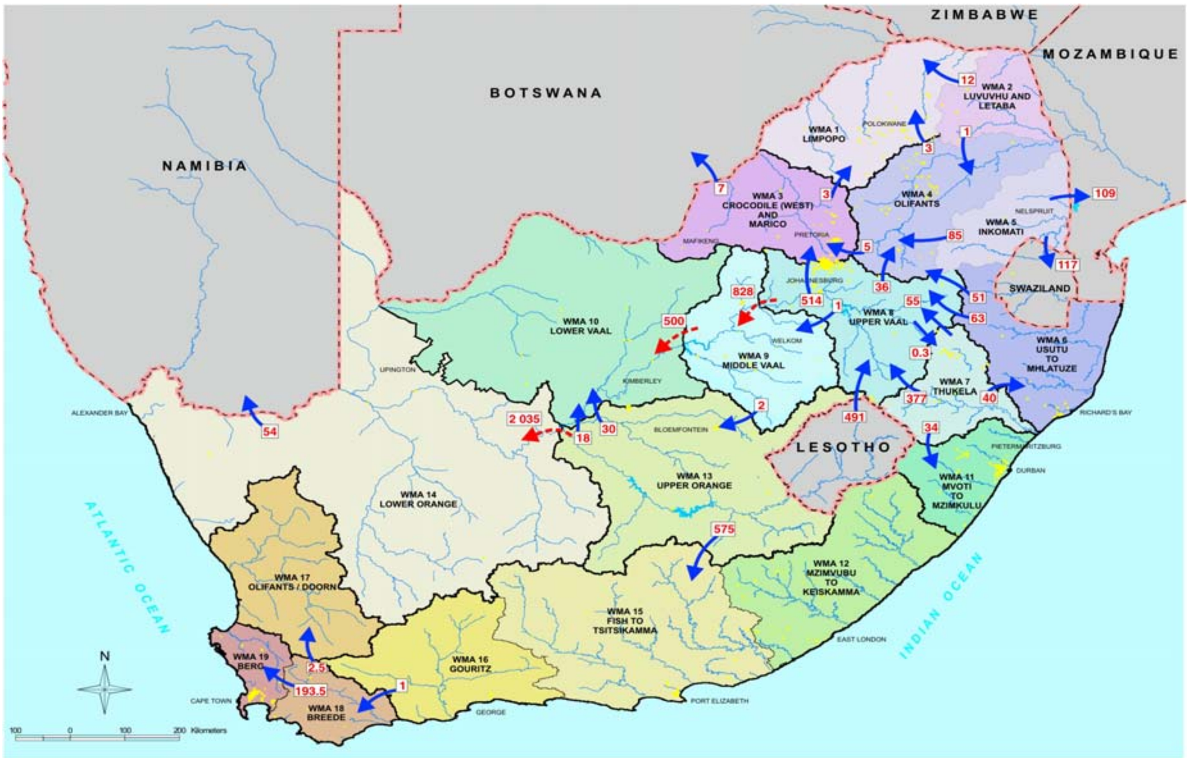


Figure 3.3: Inter basin and border transfers

Within South Africa, approximately 62 per cent of the water is used for agricultural purposes. The other main users are urban (23 per cent), rural (4 per cent), bulk industries and mining (12 per cent), cooling water for power generation (2 per cent) and forestation (3 per cent). The reserve, which will be described soon, to allow for basic needs is included in these figures (DWAF, 2004:7).

Only about 60 per cent of the water used for agriculture reaches the root system of the plants. Huge potential savings can be achieved in the agricultural sector, mainly through more effective irrigation methods, and much has already been done to address this issue. Figure 3.4 (Roux, 2004:2) illustrates how more effective irrigation systems have been implemented over the last two to three decades, with the purpose of achieving more efficient water use in the agricultural sector.

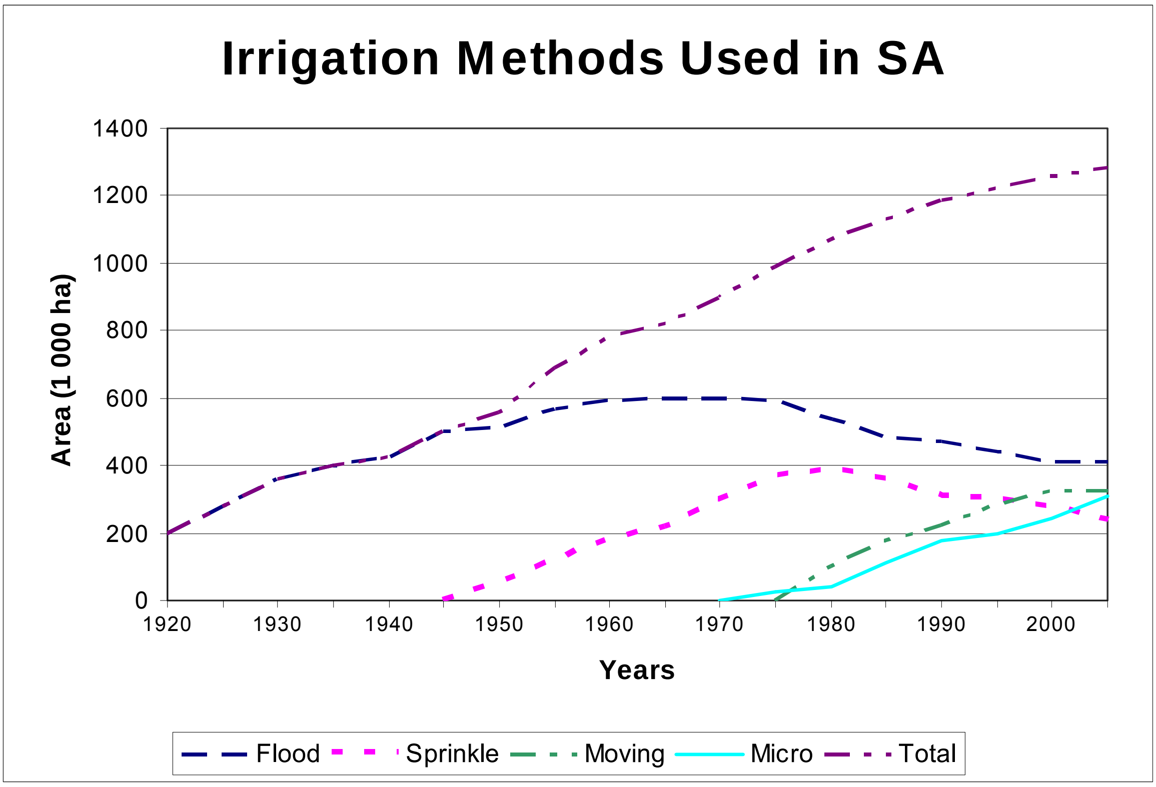


Figure 3.4: Change in irrigation methods

The improvement of irrigation efficiencies on a catchment basin scale can result in significant water savings. These savings can prevent over-exploitation of groundwater resources normally used as alternative supply options by the agricultural sector. The more effective use of water can also result in more water being available in the natural river systems, which will help to relieve the pressure on the environmental needs of these river systems (Rosegrant et al., 2002:7,13).

A closer look at the regional distribution of available water resources, illustrated in Figure 3.5 (DWAF, 2004:38; Thompson, 2007:2–3), against the predicted increase in water demand shows that South Africa is running out of its available resources at an alarming rate in certain areas, and already has a deficit in specific regions.

Possible solutions, as proposed by Otieno et al. (2004:120), include WDM, the development of alternative resources, the implementation of special management techniques to address water quality problems, reallocation of water from low benefit to high benefit users and the transfer of water from a water surplus area to a water deficit area.

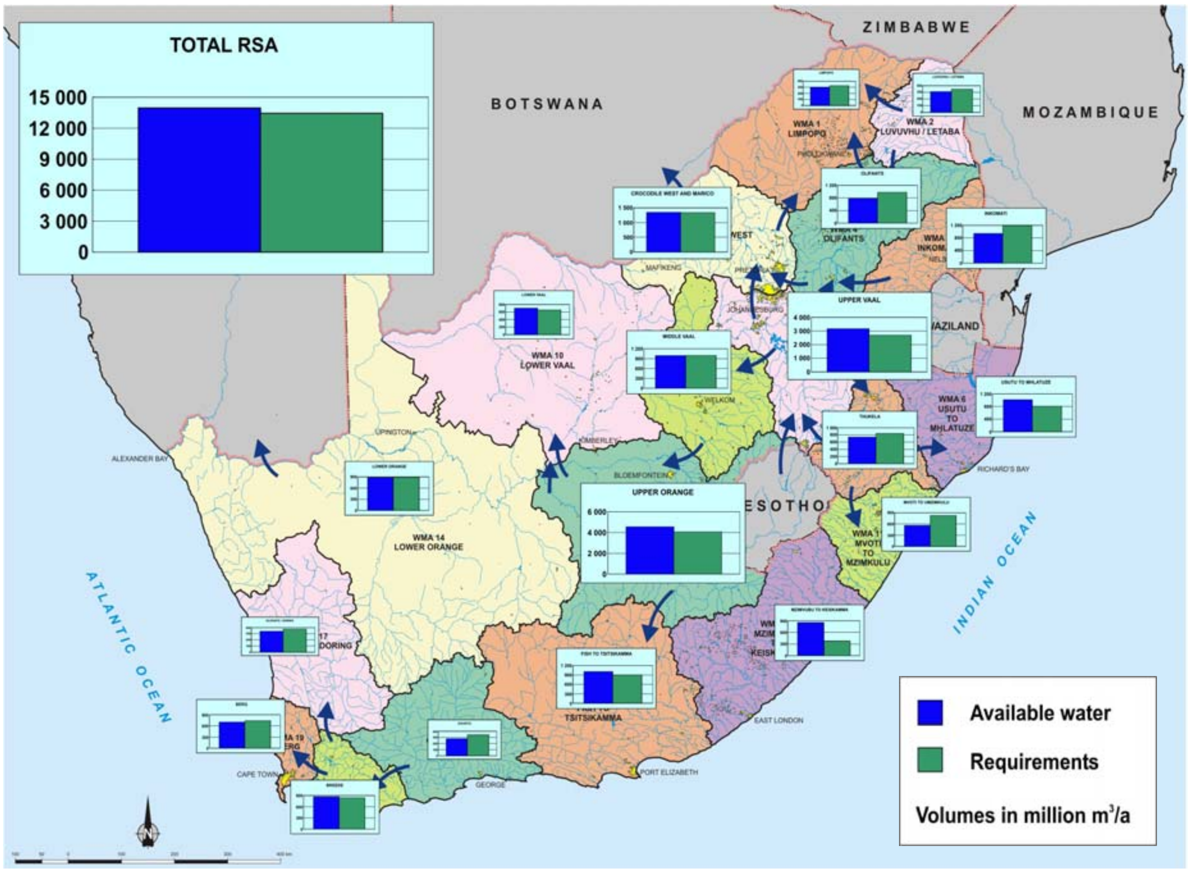


Figure 3.5: Comparison between available and required water resources for SA

The DWA predicted in 2004 that the water resources in South Africa will only be sufficient, at the present rate of consumption, until 2020. Although it is recognised that these decisions are taken within the framework of existing available technologies, the possibility that the country will soon experience serious water problems cannot be disregarded.

Based on a number of possible water demand scenarios, the critical situation with the availability of water resource in South Africa is illustrated in Figure 3.6 (Turton and Henwood, 2002:55). Turton et al. (2006:329) further stated that, in the SADC region, it is not only South Africa that faces serious water problems; Botswana, Namibia and Zimbabwe are all reaching a point where economic growth can be put under pressure due to water scarcity.

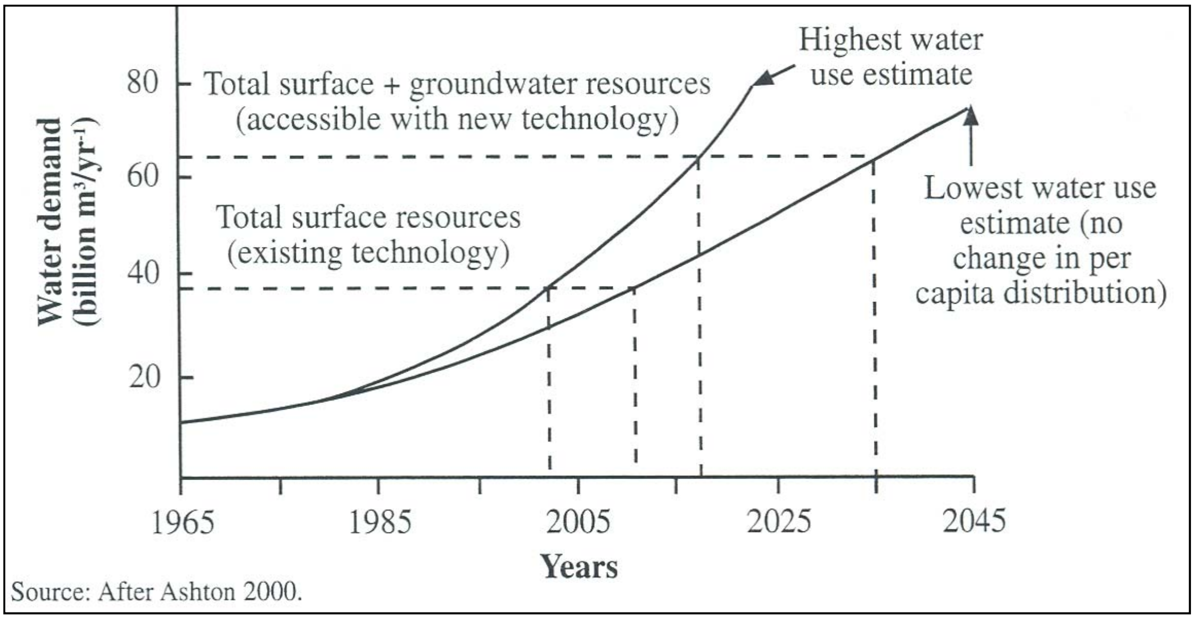


Figure 3.6: Projected water demand for South Africa

The situation at a local government level also provides serious challenges, with a number of towns already abstracting more water than is available from their resources. In a study, which will be presented in more detail in section 5.2, it was concluded that more than 25 per cent of the thirty towns investigated in the study were already using almost all of their available water in terms of their licence agreement with the DWA.

Legislation in South Africa makes provision for the environment as a water user, which was not routinely included in the management of the existing water resources before about 1990. These ‘additional’ claims on the existing water resources result in a shortfall in the available water reserves in catchments where the water situation was previously considered to be fine. Communities and the government now find themselves in a position where additional infrastructure needs to be considered just to provide for the needs and requirements of the environment.

3.3.2 European Union

The EU is, in general terms, a water-rich ‘country’, with southern Europe being classified as a semi-arid region. While southern Africa (UNPF, 2001) has to cope with approximately 1,289 m^3 per person per year, northern and eastern Europe has between 14,800 and 11,500 m^3 per person per year. Southern and western Europe are less fortunate, receiving between 3,700 and 2,200 m^3 per person per year. Approximately 75 per cent of the total water abstraction in the EU is from surface water resources, with the remaining 25 per cent mostly from groundwater resources.

In general, about 30 per cent of the EU's water consumption (Thyssens, 1999:5) is used for agricultural purposes, while 32 per cent is used for power generation. Urban usage accounts for about 14 per cent of the total use, as illustrated in Figure 3.7.

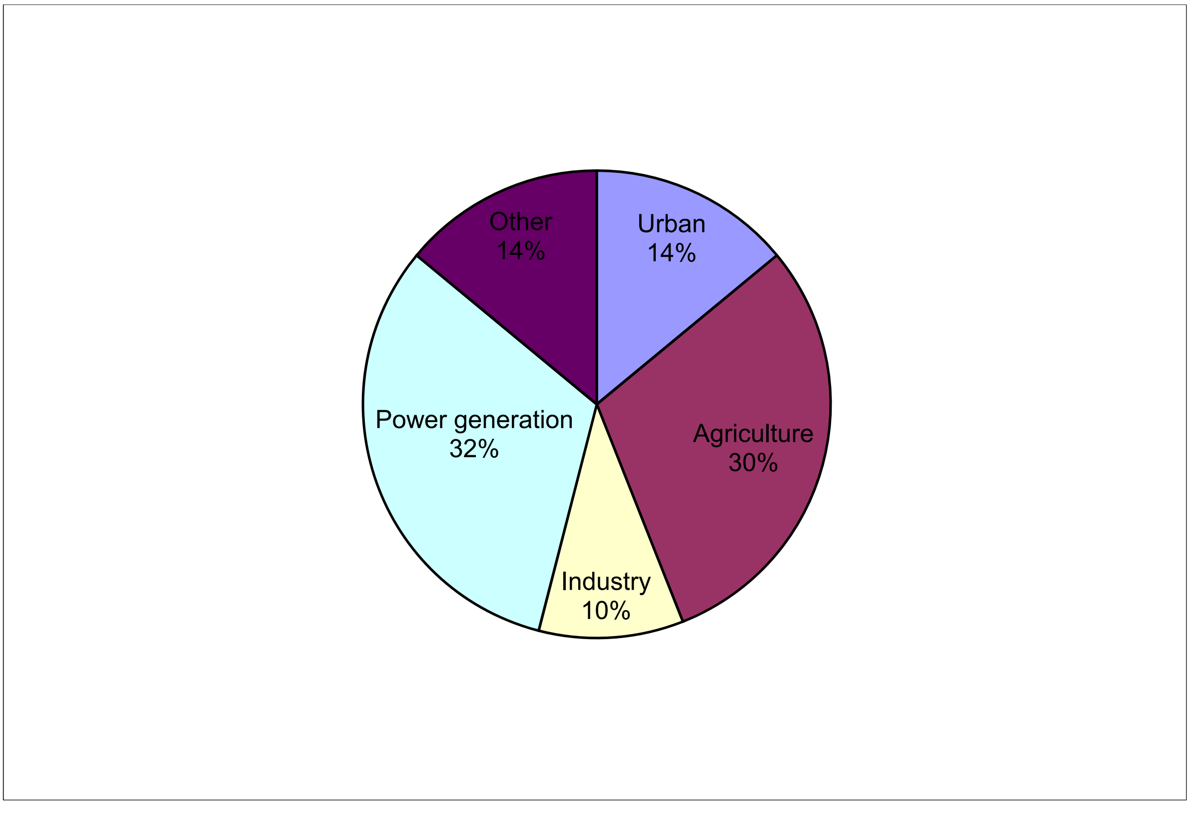


Figure 3.7: Water consumption in the European Union per sector

It is difficult to provide a general tendency of water abstraction in the EU, but a number of droughts in recent years have heightened the general awareness of the limited nature of water resources. In general, it can be said that the water usage has stayed stable over the last couple of years.

In the Netherlands the major issue regarding water resources is that of securing a good quality resource for future use, since a number of resources are being shared with other EU partners. The environment is also a high priority, and an integrated water resource management (Björklund, 2001:6) approach is promoted. The recent effects of an integrated approach, as promoted by the European Water Framework Directive (WFD), were researched by Bressers and Kuks (2004:7). They concluded that many factors play important roles in an integrated approach, and that these factors are quite often in competition with each other. They listed the main objectives of the European WFD as follows:

- expanding the scope of water protection to all waters: surface water and groundwater;
- achieving a ‘good status’ for all waters by a set deadline;
- water management based on a river basin approach; combined approach of emissions limit value and quality standards;
- getting the price right;
- getting the citizens involved more closely and
- streamlining legislation.

The Netherlands studies conclude that water management on a catchment scale has indeed changed over the years from a mono-functional and economic-driven use orientation into a multi-functional perspective that focuses not only on the resources, but also on resource protection. They highlight the necessity for public participation in this process, and the important role co-operation plays between the different levels of government and their associated legislation.

In the Netherlands approximately two thirds of the drinking water comes from groundwater resources, while the rest is obtained from surface water resources (The Rhine-, Meuse-, Ems- and lesser degree, Scheldt-Catchment). Per capita use is approximately 126 l/p/d (2001), with this figure gradually dropping from 135 l/p/d in 1992 (*Water in the Netherlands*, 2004:58). The main problem, however, is to ensure water of an acceptable quality, and the importance thereof is illustrated in Table 3.1 below, which shows the increase in the number of equivalent residents (defined as a volume of waste water a single person produces) treated at waste water treatment works (Water in the Netherlands, 2004:51). This drive towards a cleaner surface water resource started in 1970, with the implementation of the Public and Surface Water Act.

Table 3.1: Increase in waste water treatment in the Netherlands

Year	1950	1960	1970	1980	1990	1995	2000	2004
Resident equivalents (x10^6)	1	2	8	20	24	26	26	27

From a governance point of view, the number of water boards responsible for the management of the water-related issues in the Netherlands dropped from 2,700 in 1940 to 129 in 1990 (Netherland, 2004:60), and to 26 in 2007. There are a number of reasons for this, but the changing of the functions assigned to these water boards over the years is the biggest contributing factor. The integrated management of water, to include both ground as well as surface water, was introduced in 2005 through legislation, while the added function of the treatment of all waste water was assigned to the water boards in 1970.

The water boards can be considered to be at a level of governance equal to the status of a South African municipality. In the Netherland three levels of governance exist, as in South Africa, i.e., national, provincial and municipal governance. The situation is more complicated, however, with the EU water framework directives, which deal with all shared responsibilities in Europe.

While the importance of water quality has already been highlighted, other functions of the water boards include (Havekes et al., 2008:20-22):

- Flood protection
- Water quantity
- Water quality
- Groundwater
- Waterways
- Roads (in some cases – six water boards)
- Sewerage
- Drinking water supply

In the Netherlands, board members serving on and managing these water boards are elected through a national election process in the same manner as municipal councillors, further highlighting the importance of water management in the Netherlands.

In principle, though the starting point may differ, the aims and objectives remain the same for both the EU and South Africa, namely, integrated management to achieve sustainability.

3.4 The Importance of Appropriate Steps

Even though the projection for future water demand scenarios indicates that South Africa is approaching the limits of its utilisable freshwater resources and that the EU, and specifically the Netherlands, needs to ensure a secure clean future resource, the question of why specific steps are required to reduce the water demand is not only a response to these figures. There is, as suggested in the introduction, a moral obligation to manage Earth's natural resources effectively.

Knowing that the amount of water available on a global scale will remain constant, but will vary in its availability in the different stages of the hydrological cycle (sea, vapour, rainfall, runoff or groundwater), an increase in population will result in an increase in demand and eventually a shortfall in supply. Until recently, a lack of water supply was addressed through effectively increasing a water services provider's capacity to supply more water through the development of new infrastructure. In many countries this is still the case today. The shift in how the world sees these developments comes from the United Nations Conference on Environment and Development (UNCED) in 1992, also known as the Rio Earth Summit, on sustainable development. During this meeting, twenty-seven sustainable development principles were adopted by the biggest gathering of heads of state.

One of these principles, Agenda 21 (UNDSD, [s.a.]), is an action plan for sustainable development, according to which new partnerships need to be formed to work together. The roles and responsibilities of specifically municipalities were emphasised in this plan. One of the important outcomes following the implementation of Agenda 21 adopted at the Rio Earth Summit was the Kyoto Protocol, which came into force in February 2005. According to this agreement, developed countries agreed to limit their greenhouse gas emissions, relative to the 1990 levels. It again stresses the importance of co-operation between different role-players to achieve set targets.

The 1992 conference was followed by the 2000 Millennium Summit, at which the United Nations General Assembly committed themselves to a number of goals with the aim of reducing poverty and improving living conditions. In 2002, ten years after the Rio Earth Summit, the World Summit on Sustainable Development was held in Johannesburg, South Africa. The goals of Agenda 21 were revisited and, because the event was hosted in South Africa, the focus was on the developing situation in South Africa.

South Africa has become focused on the sustainability of development, and the requirements of such development on the environment. With South Africa being a water scarce country, water resources and the management thereof, to ensure sustainability, became the focus. These events have forced the country to reassess its present situation regarding sustainable development and, with a limited budget at municipal level, the challenge was to select the most appropriate steps from a long list of important steps to be taken.

South Africa is facing a serious water availability problem in the near future and, due to international commitment to sustainable development and the alleviation of poverty, is challenged by the imperative of the effective management of its water cycle. The technical methods available to do this will be presented, but the basic problem facing any water services provider or municipality in South Africa today is to decide where to start and which steps to take, with all the factors taken into consideration. To provide an answer to this problem, it is important to understand and define the policy and institutional framework in which effective water management operates.

3.5 Policy and Institutional Framework

Prior to the first democratic elections in 1994 South Africa ownership of water rested with land owners and the management of the national water resources was left to the national government, almost exclusively through the DWA.

With the National Water Act (NWA) (Act 36 of 1998), ownership of water resides with the government, with a system of licensing introduced to authorise the water use rights on a five-year renewable term to individuals or organisations (RSA, 1998a). The main reason for this was to ensure that sustainable use of scarce water resources is maintained. Unless a user can prove that he or she utilises the resource effectively and to the benefit of the country, he now, for the first time in history, is running the risk of losing these water use 'rights'. The management of the water resources in South Africa was completely transformed to promote an integrated catchment-based management system. A three tier structure (DWAF, [s.a.]:6) was introduced, as illustrated in Figure 3.8.

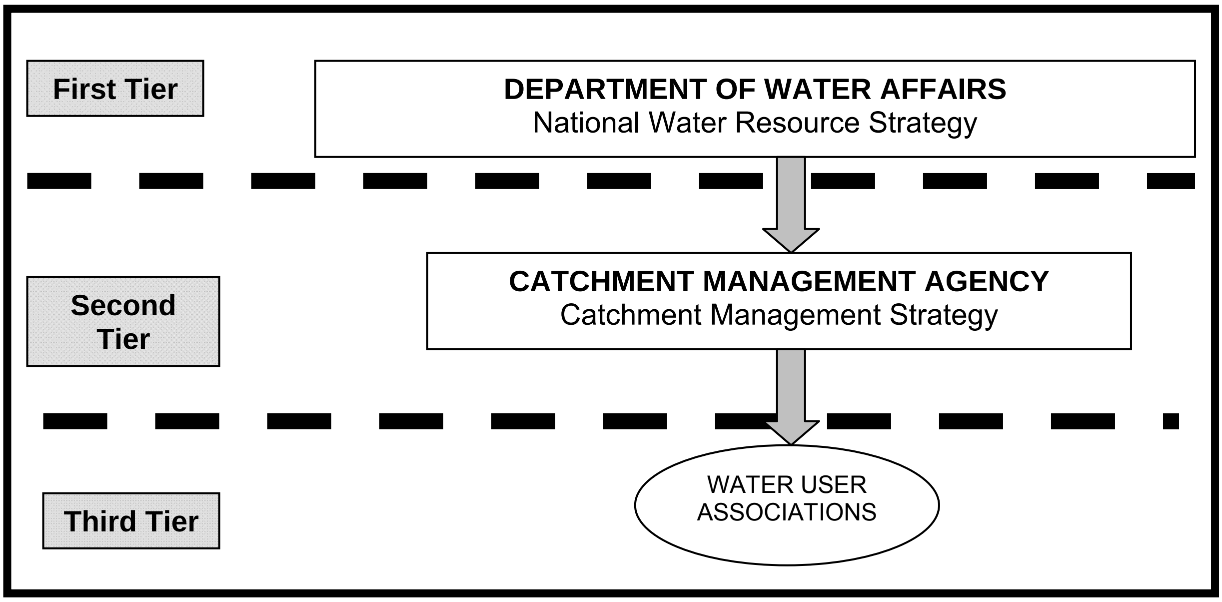


Figure 3.8: Three tier water resource management structure

In South Africa, nineteen Water Management Areas have been identified and Catchment Management Agencies (CMAs) are in the process of being established for each area, although there is at present some debate to reduce the proposed number of CMAs from nineteen to nine or less. The cornerstone of the CMAs is the Water User Associations (WUAs). WUAs are statutory bodies that normally involve a specific group of interested water users who need to share the same resource, and quite often develop around a specific water supply system. The NWA furthermore makes provision for the establishment of non-statutory bodies, called Catchment Forums. These forums are established by any grouping of interested and affected parties, which might be individuals or institutions. Their numbers and sizes are based on the geographical area and the number of activities based in these river basins, and are typically in the order of ten per river basin.

A number of Acts and Regulations play a role in the effective management of water resources by municipalities. Municipalities form the so-called third sphere of government in South Africa, with the national and provincial departments the first and second spheres respectively. In the case of water-related issues, the second sphere, or provincial government, plays a limited direct role. A municipality's main influence in the water sector is through the Integrated Development Plans (IDP), of which the WSDP forms a key chapter. Legislation governing the water-related issues is primarily seated in the national DWA.

Water conservation and WDM policies in South Africa are based on three main principles (Singh and Adams, 2003:14; DWAF, 2007:114):

- Water management and water services institutions should ensure that they reduce the level of leakage in any water works and promote water conservation and WDM on an ongoing basis.
- Consumers should not waste water.
- Water conservation and WDM should be considered as part of the water resources and water planning process.

These principles are all enforced at different levels through relevant legislation, which includes the following:

- The Constitution of the Republic of South Africa (Act 108 of 1996)
- Water Services Act (Act 108 of 1997)
- National Water Act (Act 36 of 1998)
- Municipal Structures Act (Act 117 of 1998)
- Municipal Systems Act (Act 32 of 2000)

The Municipal Finance Management Act (Act 56 of 2003) will not be presented in this project, but since it is the Act's main function to ensure transparency, accountability and appropriate lines of responsibility (RSA, 2003), while it also guides the budget and tariff-setting process in the delivering of services, it also serves as one of the important Acts to be used by municipalities in the effective management of water resources.

The involvement of the public in decisions related to their well-being is also well-defined in these Acts.

3.5.1 The Constitution of the Republic of South Africa (Act 108 of 1996)

The Constitution of the Republic of South Africa (Act No 108 of 1996) forms the cornerstone for community involvement in the decision-making process as described in Section 152 of the Consitution (RSA, 1996), while the Municipal Systems Act (Act 32 of 2000) strengthens this requirement (RSA, 2000a) and prescribes a number of steps to be included as part of the public participation process in Chapter 4 of the Act.

The Constitution of the Republic of South Africa (Act 108 of 1996) is further important since it assign functions to the different spheres of government already described. The functions of local government are presented in Part B of schedules 4 and 5 of The Constitution of the Republic of South Africa (Act 108 of 1996), and include potable water supply and domestic waste water disposal systems. It also tasks the government to provide Acts to ensure the implementation of the values stated in The Constitution of the Republic of South Africa (Act 108 of 1996).

3.5.2 National Water Act (Act 36 of 1998)

According to the NWA, water resources need to be shared in a fair and equitable way between:

- basic human needs and the environment (the reserve);
- international agreements;
- strategic usage and
- all other usages which are to the benefit of South Africa in general.

The NWA (RSA, 1998a) provides, in Section 2, for the adequate protection, use, development, conservation, management and control of the water resources of South Africa. It specifically sets the framework for the development of a National Water Resource Strategy (NWRS) as outlined in Section 5(1), and requires the NWRS to develop principles regarding WDM and water conservation in Section 6(1)(h).

The division of South Africa’s national water resources, and the institutions responsible for the management of each portion, are illustrated in Figure 3.9 (Redrawn from DWAF, [s.a.]:28).

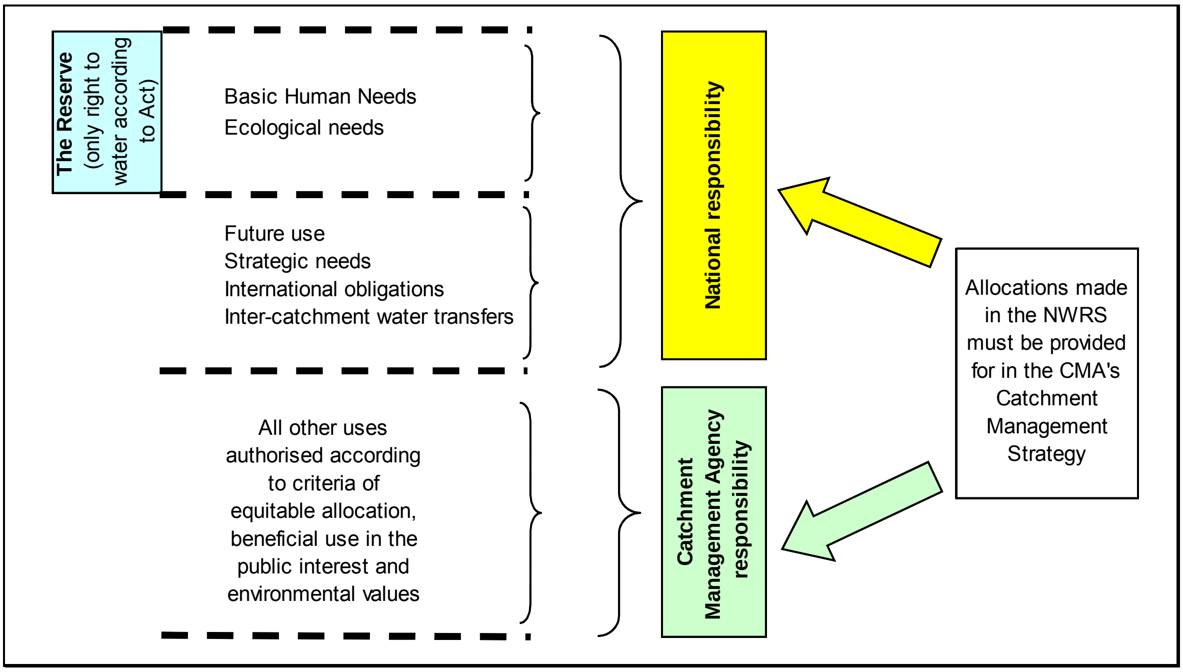


Figure 3.9: Water users and the responsible authorities

The NWA stipulates the role and responsibilities of different water management structures and specifically makes provision for the establishment of Catchment Management Agencies (CMAs). It regulates the municipalities' role as water users through a licensing process for the abstraction of water for supply to end-users, and it also governs the way in which a municipality can return effluent and other waste water back to the resource.

The first draft of the NWRS (DWAF, 2004:74) states the requirements for a national framework to manage water conservation and demand management, and the need for a National Water Conservation and Water Demand Management Strategy. It also stresses the importance of public participation in the process to formulate the different policies.

The National Water Conservation and Water Demand Management Strategy, as presented in Chapter 3 of the NWRS (DWAF, 2004:75), outlines the measures and interventions required for managing and consuming water effectively and efficiently. It acknowledges the fact that WDM is not only concerned with the reduction of water use, but also needs to result in social, economic and environmental benefits. The fundamental principles of this strategy are:

- Waste and losses should be minimised without affecting the quality of service, and communities should be informed and educated in WDM and water conservation.
- Technology to prevent waste and to re-use water should be used to ensure an effective water use environment.

- WDM and water conservation should be an integrated part of water services planning.

Based on these strategies, it is foreseen that CMAs will prepare by-laws to ensure that their catchments will be managed within the national strategy. In the absence of CMAs, it is the function of the DWA to do the fundamental catchment planning, but it is also evident that municipalities, such as that of Cape Town, are already taking steps to ensure that these national strategies are met. These steps include aspects such as:

- the banning of automatic flushing urinals;
- identification of high profile “champions” to drive their processes;
- compiling municipal policies;
- tariff, metering and credit control;
- promote and legislate water efficient fittings;
- water services by-laws and
- user education in water conservation.

3.5.3 Water Services Act (Act 108 of 1997)

The main purpose (DWAF, 2001b:8) of this Act is to assist municipalities in undertaking their role in the water sector. The Act provides for the establishment of a number of water institutions, such as a water authority (e.g. municipalities), a water services provider, a water board and a water services committee. The Act ensures that the provision of water services is done in a fair and equitable manner, and that it promotes effective resource management and conservation as highlighted in Section 2(j) of the Act. The Act further provides for (DWAF, 2001b:9):

- the right to access to basic water supply and sanitation services;
- the setting of norms and standards;
- the compilation of a water services plan;
- the drawing up of regulations to assist with the effective supply of water services;
- the establishment of water service bodies, such as water services authorities, water services providers, water boards and water intermediaries;
- the monitoring of water services through a proper water audit process;
- the gathering of information and transfer thereof to effected institutions;
- the provision of financial assistance and
- the promotion of effective water resource management and conservation.

The Act specifically requires that conditions for the supply of water by all water services providers, which is mostly the municipalities, must provide for water conservation and demand management (Section 4 (2)(c)(vi)).

All municipalities are water services authorities, and in this respect the Act also requires, in sections 11(1) and (2)(e), that they progressively ensure that all consumers in their area receive efficient, affordable, economical and sustainable access to water. The water services authorities (municipalities) need to make by-laws that must at least provide for unlawful connections and the unlawful or wasteful use of water (Section 21(1)(g)). Water services authorities are also forced by the Act to compile a WSDP that must contain proposed water conservation measures (Section 13(j)).

The Water Services Act (Act 108 of 1997) specifically states that municipalities, as water services authorities, need to ring fence their water services (Section 20(1)). This will enable proper control, and will eliminate an old habit of cross-subsidisation of local government functions, like the provision of community facilities, with money generated within the water services departments.

The Act provides an opportunity to the Minister, in Section 9(1) and 73(1)(j), to issue regulations regarding compulsory national norms and standards for the management of water and to conserve water. The regulations issued under these sections of the Act will be described in section 3.5.6.

The sections concerning the water audit and the compilation of a water services plan (Sections 12–16) constitute the most important piece of this legislation in the context of effective water use and water conservation. It is also under these sections that the requirement of proper benchmarking, as described in section 4.5, becomes evident.

3.5.4 Municipal Structures Act (Act 117 of 1998)

The Municipal Structures Act (Act 117 of 1998) primarily deals with the different types of municipalities and how they should function. Essentially, three different types of municipalities were established, namely metropolitan municipalities (Category A), local municipalities (Category B) and district municipalities (Category C). Chapter 5 of the Act deals specifically with the functions and the responsibilities of the different types of municipalities. Without discussing these different structures in detail, it is perhaps sufficient to say that the water function creates an unfavourable situation within the debate regarding who should manage which resources. The Municipal Structures Act (Act 117 of 1998)

(RSA, 1998b) stipulates in Article 84(b) that the “bulk supply” of water that affects a significant proportion of municipalities in the district becomes a district municipal function. A district municipality is defined as an area that includes a number of local municipalities, and can be seen as the structure with broader functions stretching over boundaries of local municipalities. This means that municipalities are responsible for the distribution of water within their own boundaries.

This was subsequently changed by the Municipal Structures Amendment Act (Act 33 of 2000) in Section 6, which took the word “bulk supply” out of the legislation (RSA, 2000b:7). The result was that all of the district municipalities became the responsible body for potable water systems and domestic sewage and wastewater systems by default. The Act, however, allows the Minister of Cooperative Governance and Traditional Affairs to authorise local municipalities to be responsible for the water and sanitation function. Although the intention was to ensure that services will be delivered in areas where a lack of capacity exists within the district municipalities, this section in the Municipal Structures Amendment Act results in a process whereby the aim and the objective of integrated water management are not always justly served if not applied carefully.

The problem with this approach is that it goes against the concept of an integrated catchment approach, where it was intended that all water-related matters from source back to source should be managed on a catchment basis.

Perhaps the problem stems from the fact that this Act and the NWA were drawn up by two different government departments. For example, factors such as the affordability for the residents of municipalities to maintain municipal structures without the cross-subsidising of services like water, sanitation and electricity, need to be acknowledged. It nevertheless does remain a step backwards in terms of developing an integrated approach to the holistic management of the water resources.

3.5.5 Municipal Systems Act (Act 32 of 2000)

This Municipal Systems Act (Act 32 of 2000) focuses on the internal systems and administration of a municipality and, among other things, specifically allows local government to establish a performance management system. In doing so, it forces municipalities to act on the requirements and needs of the communities they serve. To do that, the implementation of proper planning and the reporting on it become a critical issue. This is achieved through the IDP process, of which integrated planning forms the cornerstone.

In practice this means that, once the need for a new housing development has been identified by the public, the project can only be approved once approval for the water services has been granted. In doing so, local government would not be forced into decisions where they need to respond to a crisis, as has been the situation many times before. Approval for the provision of water is ruled by the Water Services Act (Act 108 of 1997), which should ensure that effective water use and proper WDM measures are in place.

This Act also stresses the importance of public participation and sets a number of rules to adhere to in the context of the formulation of the IDP. The Act specifically highlights the core components of the IDP, of which an assessment of the present level of services forms a critical part.

3.5.6 Regulations

Regulations (DWAF, 2001a) relating to *Compulsory National Standards and Measures to Conserve Water* (Government Notice 22355 June 2001) and the associated guidelines (DWAF, 2002:20-142) were issued by the DWA in 2002. These regulations were issued under Sections 9(1) and 73(1)(j) of the Water Services Act (Act 108 of 1997), while the guidelines were issued under Sections 9(1) and 10(1) to provide further background to these regulations. When the national DWA issues guidelines, the relevant municipality still needs to promulgate by-laws for these guidelines to become effective within its area of jurisdiction. The regulations and guidelines issued by the DWA deal with far more than only the issues pertaining to WDM, but only the latter will be dealt with in this section.

The guidelines (DWAF, 2002:20-56) address the following important water management issues (values in brackets refer to specific guidelines) for municipalities:

- Use of effluent (8)
    - must not pose a health risk.
    - access points need to be clearly marked.
- Quantity and quality of industrial effluent (9)
    - only obliged to accept the quality and quantity that can be handled by the treatment facility to enable the final effluent to be still acceptable according to the NWA.
- Water services audit (10).

  The water services development plan needs to include the following data:
    - Quantity of water services provided

  - Level of water services provided
  - Cost recovery figures
  - Meter installation and testing data
  - Water quality sampling data
  - Water conservation and demand management data
- Water and effluent balance analysis and determination of water losses (11)
  - Provide monthly water supply, unaccounted, effluent received and consumption figures.
  - Keep records of steps taken to reduce unaccounted-for-water (UAW).
- Repair leaks (12)
  - Leaks must be repaired within 24 hours.
- Measure or control water supply (13)
  - Provide all supply points with a measuring device or a flow control device.
  - Metering devices must comply with national standards.
- Pressure (15)
  - All areas or zones must be able to operate below 900 kPa, or a pressure control system must be installed.

Guidelines (DWAF, 2002: 60-106) relating to *Norms and Standards for Water Services Tariffs* issued by the DWA under Section 10 of the Water Services Act (Act 108 of 1997) address the following issues of relevance:

- Revenue requirements (2)

  The following must be taken in consideration in calculating the tariff structure:
  - Purchase cost of water.
  - Overheads, operational and maintenance cost.
  - Recovery of capital costs.
  - Replacement costs.
  - Access to basic supply.
- Supply of water to a household under controlled conditions (5)
  - An affordable tariff must be set for poor communities to have access to a basic supply.
- Supply of water to a household under uncontrolled conditions(6)

  Require the setting of a block tariff structure to include the following considerations:
  - Sustainability.
  - Discourage wasteful use.
  - Incremental water cost.
  - Three or more blocks.

    - Measured over a 30-day period.
    - First block to be the lowest tariff for first 6 kl.
    - Last block to discourage water use.
- Fixed Charges (8)
    - Tariffs can include a fixed charge.

Almost all of the methods that can be used to ensure effective water use and management have been included in the regulations issued by the DWAF under the Water Services Act (Act 108 of 1997), and have been explained in the guidelines. The implementation of these regulations rests with the municipalities.

3.6 Political Management

The Municipal Structures Act (Act 117 of 1998), as presented in section 3.5.4, prescribes the way in which municipalities must be managed (RSA, 1998b). Municipalities are managed by Councillors who have been elected, through different legal structures, to their position to be representative of the population that the municipality needs to serve. The most widely-used management system in South African municipalities is referred to as the "Executive Mayoral" system.

An executive mayoral committee is appointed by the mayor, who is also the chairperson of the committee, to act as the primary decision-making body of the specific municipality. Each member of the executive mayoral committee chairs a specific Departmental Management Committee. The departments, and hence the committees, differ from one municipality to another, but generally include Health, Infrastructure/Technical, Finances, Personnel, Administration and Social Services. Technical managers and Heads of Departments serve on these committees, and they thus act as the interface between political and technical decision-making. A typical executive mayoral committee system is shown in Figure 3.10.

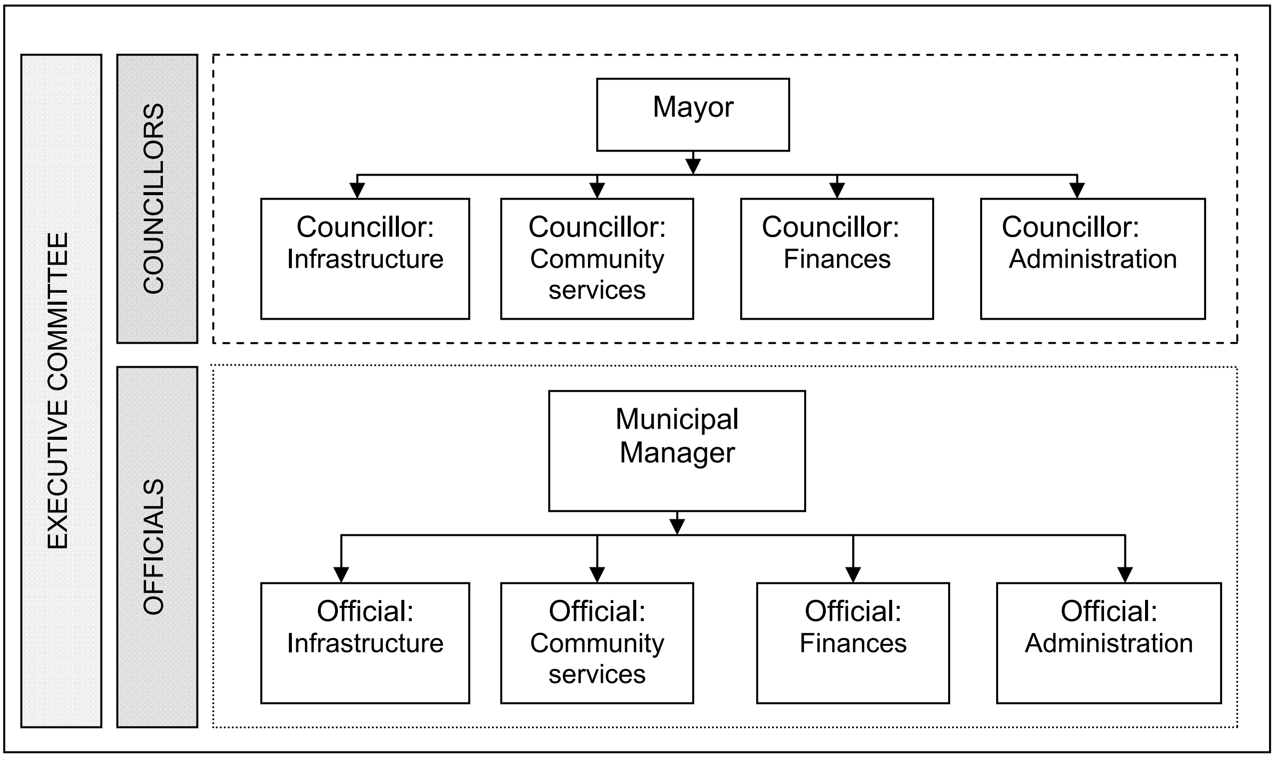


Figure 3.10: Typical executive mayoral committee structure

To bring governance closer to the public, extensive use is made of the "ward" system. A specific ward represents an area in which a councillor has been elected to Council through the original voting process. The elected councillor chairs a committee consisting of ordinary citizens in that ward. This committee serves as a discussion forum where valuable information can be collected regarding the needs of the communities to be served. It also fits well into the prescribed procedures of the Municipal Systems Act (Act 32 of 2000) to ensure effective decision-making through the IDP process as described before.

Municipalities in South Africa spent a lot of energy and money on the IDP process. In this regard, an IDP manager almost always forms part of the personnel in a municipality. Since the IDP process is an attempt to integrate all aspects of governance (from service delivery, education, health, housing), the IDP manager is rarely from a technical background, and therefore depends mainly on the WSDP to address the water issues, and hence WDM, during the planning process.

Unless specific attempts are made to maintain the link between councillors and WDM, water demand issues tend to disappear in the bigger picture of managing the municipality. WDM is a complex issue to manage from a political point of view. In South Africa the democracy brings a new focus on the delivery of services to the poor and, while politicians gain significantly from the official opening of a new infrastructure project with the "cut of the ribbon", WDM does not provide any opportunity for a "cut of the ribbon" exercise, and therefore political mileage (Turton et al., 2006: 327-328). This is not an acceptable situation, since WDM is closely linked to awareness and, unless the political decision-makers support this, few projects that depend on the broader public support will have a chance of success.

Political decision-makers do have a significant amount of decision-making power and responsibility with respect to WDM. It is therefore important that all councillors, but specifically the executive mayoral committee, be trained or at least be capacitated appropriately to enable effective decision-making regarding the effective use of water resources.

In practice, methods do exist for politicians to be part of WDM and to be seen as having a clear commitment to ensuring sustainable development. Typical actions focus mainly on the fact that politicians must be seen to care. These actions include the following:

- Politicians should be seen opening specific water projects as part of an awareness campaign.
- They should deliver the key-note address at conferences and workshops dealing with effective water management.
- They should act as judges for competitions relating to WDM.
- They should issue press releases in this regard.
- Politicians from municipalities must become part of the decision-making processes with national departments like the DWA, when strategic issues like water restrictions are discussed.
- WDM must be a clear and well-defined responsibility of one of the executive council members.
- Politicians should understand the value of supporting the commitment of financial resources to WDM projects, and should commit these resources at a political level.

The role and responsibility of political decision-makers in the water sector should never be underestimated, and specific attempts need to be made by officials to inform these decision-makers, and to keep them informed as situations develop, with specific reference to WDM.

While this section specifically deals with political structures and their responsibilities towards WDM, the capacity of the managers reporting to these political structures can also impact on the end results. The availability of well-trained and informed officials remains a challenge in South Africa. Lawless (2005:5) provides statistics that summarise the extent of the problem:

- 16.5 per cent of all municipalities in South Africa have only one civil technician on their staff.
- 16 per cent of all municipalities only have technical staff in service that are younger than 35 years in age.

Lawless (2007:79) focuses on the civil engineers who need to be in charge of the technical departments responsible for the implementation of WDM, and concludes that for the 278 local and district municipalities nationwide, there were only 141 engineers in service in April 2005, emphasising the serious shortfall in competent technical personnel to advise the political decision-makers.

3.7 The Responsibility of the Public

The importance of the role that the public needs to play in all decision-making within the water sector can be found in various Acts and policy documents. In Europe, the WFD, which was adopted in 2000, requires public participation for the preparation and implementation of policy. The WFD states, in Section 14, that 'the success of the Directive relies on close cooperation and coherent action at community, Member state and local level as well as on information, consultation and involvement of the public, including users' (EU, 2000). The Rio Declaration states that 'Environmental issues are best handled with the participation of all concerned citizens, at all relevant levels', enforcing the need for public participation (UNDSD, 2004) on issues of national and international importance. The institutional composition of the responsible management structures in the South African water resources environment, as described in section 3.5, further strengthens the need for public participation.

These structures (WUAs and CMAs) consist predominantly of ordinary citizens who are elected through prescribed procedures, as specified in the NWA. The transformation process in South Africa is still in progress, with a number of challenges described by various authors (Müller and Enright, 2006:17–19; 2009:25–27; Gouws, 2008:266; Schreiner and Van Koppen, 2002:974–975; and Du Plessis et al., 2009:20). Many of the management functions previously vested in the DWA are now decentralised to directly involve role-players in that specific river basin, with the main objective being to take decision-making closer to the citizens affected by these decisions. The importance of a well-informed and active public for the successful functioning of these structures is therefore clear.

The NWA specifically states that the statutory structures, as shown in Figure 3.8, can only be established after public participation and with adequate representation of all stakeholders.

For the water users and stakeholders to participate and contribute effectively, they need to be aware of the issues and difficulties, and must have an understanding of what is required. The role of national government in the context of WDM as part of the full water cycle is one of leadership, aimed at facilitating and coordinating the development and transfer of skills and assisting with the provision of technical advice and financial support. WDM needs to be implemented on different levels within society. It is not only the "technical" departments like the DWA that need to be involved, but it also requires input from the departments of Health and Basic Education, just to name two. The responsibility for coordination between these different role-players on a national and provincial level remains with national government. At national government level, the success of the implementation of these relevant strategies is directly linked to the capacity of government to govern the country through the allocation of the appropriate financial and human resources in government structures, and this should not pose a problem.

Local government, consisting mainly of municipalities, forms the fundamental building blocks of national government, and it is on this level where the real challenges for successful implementation of WDM exist. As described in section 3.5, the main planning mechanism at a local government level is the IDP. Water matters are addressed in this plan through a chapter referred to as the WSDP. These documents form the communication tool between political structures, local government structures and the community.

The input towards the IDP process from the community at large is obtained through public meetings that need to be convened on an annual basis. Interim meetings within the political structures (referred to as ward-meetings) normally precede these public meetings. While this structure might work for general issues such as health, education and infrastructure, it lacks a number of important characteristics before it can be used successfully as a proper mechanism to address WDM issues through the public. These considerations include:

- WDM is a continuous process that needs to receive regular feedback to enable effective future planning. A once- or twice-a-year meeting is inadequate.
- Political independence is of utmost importance, but almost impossible to ensure, if these formal political structures must be used.

- WDM needs to be executed at a grassroots level. It influences the day-to-day lifestyles, and is therefore arguably difficult to reconcile with political structures that deal mostly with policy issues.
- "Political structures" is by definition a divisive term (one either belong to a specific political party, or are seen as opposition), while WDM needs to be a jointly-driven community exercise to be able to succeed.

In this section, the importance of the involvement of the public in water-related matters, both in national and local government structures, is illustrated and the reasons why existing political structures might not be the full answer and will not necessarily be the most successful structures to use, are highlighted. Specific organised civil society groupings within the wider definition of the public do exist. These groupings or organisations need special attention, and will be described in the next section, based on their ability to act as a structured, organised group.

3.8 The Role of Non-governmental Organisations

In this section the importance of non-governmental organisations (NGOs) in integrated water management (including WDM) in South Africa will be presented. The political decision-making structures and the importance of the public's engagement have been described in the previous two sections. Deleon (2005:122), however, stresses the point that exaggerated emphasis rests on political participation when reference is being made to public participation. Social and economic participation are also important, and reference is specifically been made to the role of NGOs.

During a stakeholder engagement process to establish a CMA for the Berg River in the Western Cape Province, South Africa, in excess of 200 people declared their interest to be represented on the CMA. This figure was scaled down to a smaller group, called the "Reference Group", which consisted of seventy members, from which a committee of no more than approximately fifteen people could be elected onto the CMA. Taking into consideration that some of these positions are prescribed by legislation, it is obvious that civil society needs to be well organised to be able to participate in the decisions regarding water management in South Africa.

It is difficult to limit civil society to only a number of predetermined groupings. The possible list of NGOs will never be complete, since these organisations seem to appear and disappear as needs arise or change. NGOs relating to water management include groupings such as emerging farmers, river rafters, angling associations, labour, industries, river quality working groups, taxi associations, researchers, commercial farmers, cultural groups and rate-payer associations, just to name a few.

NGOs are considered to be essential conduits for civil society concerns, and are valuable barometers against which the success or otherwise of the implementation of any water-related project may be measured. They also provide a wide collective group of people who can provide valuable feedback if organised properly.

They do, however, normally lack the resources to participate in the different processes designed to ensure inclusivity, and authorities need to take that into consideration. The monetary value associated with the steps to ensure their participation (i.e., transport costs) and input is normally small in comparison with the associated benefits.

3.9 Summary

Chapter 3 has highlighted the need for water management in South Africa, given the general concerns regarding the available water resources. The NWRS highlights the seriousness of the situation, with many areas likely to face water shortages within the near future. It is furthermore generally accepted that global warming will have a negative impact on the natural water regime in parts of South Africa, contributing towards the likely fresh water scarcity.

A global awareness, through international co-operation and agreements, acknowledges the seriousness of the environmental problems facing Earth. In this respect, a number of statutory requirements have been written into the relevant legislation in South Africa, which aims to secure a sustainable environment. An aspect such as the introduction of a Reserve contributes towards this objective. Similar actions were taken in the EU countries where water quality became one of the major focus areas. The water situation in the Netherlands was presented to illustrate the fact that South Africa is not unique and isolated in attempts to manage water resources and use in a sustainable way. Fundamental to the legislation discussed in Section 3.5 is an integrated approach, as demonstrated in related local government legislation in South Africa, where the requirement of formulating an IDP was introduced into decision-making at a local government level.

WDM and water conservation play an important role in ensuring sustainability, and these aspects have been captured within the various statutes applicable to the South African water and local government situation. The importance of public participation in appropriate decision-making structures has been highlighted, with specific emphasis on the role of NGOs as stakeholders.

Given the importance of the need to do research regarding effective water management as motivated in this chapter, the different WDM techniques available will be presented in Chapter 4. A number of research studies, conducted to strengthen the framework for the proposed water demand management model, will be presented as building blocks for WDM in Chapter 5.

CHAPTER 4
WATER DEMAND MANAGEMENT METHODS

4.1 Introduction

Chapter 2 provided the theoretical background for the development of DSSs within a public management and governance framework. It focussed on the need for the development of a model, and it provided the theoretical building blocks for DSSs that will enable improved decision-making, with the focus on the water sector in local government. The importance of, and the requirements for, an appropriate public participation process to ensure effective implementation of WDM was highlighted.

Chapter 3 describe the South African water situation, and provide the legislative decision-making framework for the water sector in all spheres of government. It highlights the role of political management in the water sector, and specifically emphasis the role of public participation in appropriate decision-making processes.

This chapter will provide the background and technical building blocks for WDM. It will focus on the methods available, and will highlight the inputs required to enable effective WDM. Besides the need to understand the WDM field prior to an attempt to develop a model to ensure effective implementation, it will also serve as a reference for appropriate steps that can be taken during the process of implementing WDM.

4.2 Water Demand Management and Water Conservation

WDM and water conservation are generally considered to be the same concepts by ordinary water users. There are, however, well-defined differences and, although both are being dealt with in this study, it is important to take note of these differences.

WDM has been described (Johnson et al., 2002:3; Vairavamoorthy and Mansoon, 2006:184) as follows:

> "The adaptation and implementation of a strategy by a water institution or consumer to influence the water demand and usage of water in order to meet any of the following objectives:
> - Economic efficiency
> - Social development
> - Social equity

- Environmental protection
- Sustainability
- Political acceptability"

Brooks (2006:524) provided a more pragmatic approach, and defines WDM as being any action, whether of a technical, economic or social nature, which will achieve at least one of the following targets:

- Reduce the quantity or quality of water required;
- Adjust a specific task to ensure that it requires less water for the same outcome;
- Reduce losses between resource and outcome;
- Shift the timing of use from peak to off-peak periods and
- Increase the ability of water resources to maintain society during times of short supply.

Water conservation, in contrast, is described (Johnson et al., 2002:3; Vairavamoorthy and Mansoon, 2006:184) as 'The minimisation of losses or waste, care and protection of water resources and the efficient and effective use of water.'

Efficiency refers to the ratio of useful output measured against the total extend of work done to achieve a specific objective. This can mean either that better (more) results are obtained, or that the same results are obtained with fewer or lesser inputs. If an action or a policy results in a specific goal being achieved with the lowest extent of inputs (financial, human resources), such an action or policy can be considered as efficient. The same definition can also be given if a specific policy or action results in the achievement of better results or goals. In terms of water use, this will directly relate to the management of water resources in such a manner that the same community can be served with less water without necessarily reducing any standards.

Effectiveness in terms of the use of water would, however, be the measure or contribution of a policy or specific action to address the goal of the policy. This means that water needs to be used for the purpose for which it is intended.

All of the above definitions need to be put into practice in such a way that water resource utilisation will remain sustainable for generations to come. Although strategies and objectives need to be defined and policies need to be put in place, it is, in many situations part of the normal day–to-day decisions of the water manager and the man in the street that can ensure success.

Achieving an understanding of WDM also depends on the aims and objectives of a specific structure. The DWA and CMAs, responsible for the integrated management of water resources of South Africa, will specifically include aspects such as the effective management of the river catchments systems through, for example, appropriate releases from their dam systems. Criteria such as the eradication of alien vegetation in the catchments will be a high priority to them.

Water restrictions or water curtailments can also assist in reducing demand. While water restrictions is primarily a water-reduction focussed activity, WC/WDM focuses on demand optimisation. Restriction measures are seen as punitive measures which focus on short term reductions, while WC/WDM is a long-term measure to minimise or eliminate losses. Restrictions, achieved through the setting of curtailment levels (reduced demand) based on yield risk analysis, normally does have a negative impact on the financial situation of individual water users, but also specifically on the financial situation of municipalities due to a reduction in consumption and therefore in revenue. WC/WDM on the other hand does not have normally a significant financial impact on the consumers and will be to the financial benefit of municipalities in the long term (Ninham Shand and UWP, 2007:4).

A water curtailment plan will assist in managing water demand during a short term emergency water shortage due to draughts, natural disaster or human caused catastrophes. Management through curtailment needs to be planned well in advance of any specific crises situation and will require specific regulatory action, like By-laws. Curtailment also makes provision for different levels of interventions. The first level typical reference to voluntary measures that need to be taken to reduce water supply, while the second level refer to prohibiting times and types of water use. The third level prohibits more water consuming actions, with a banning of all outside watering activities as an example. The fourth and last level typically refers to the reduction of all water uses. (Oregon WRD, 2005:1-17).

For most water service providers and municipalities, WDM mean the taking of the necessary steps to reduce the volume of water purchased or allocated to them by the DWA or the CMA. Their focus will be on reducing losses in their distribution systems and treating raw water with the least possible water losses, convincing their end-users to reduce the water use for garden purposes and general use, and eradicating ineffective water-using devices such as automatic flushing urinals.

Stephenson (1999:117) suggests that WDM can contribute towards significant savings. He focuses mainly on ways to reduce water demand, and suggests that it can be achieved through either physical limitations of supply to the end-user or the implementation of economic methods to achieve the reduction in demand. Physical limitations suggested include cut–offs, restricted supply or pressure control.

Regarding economic methods, practical ways to achieve a reduction in water demand include water tariffs and metering. Stephenson (1999:115) also highlights the need to introduce methods which include a change in behaviour and public relation campaigns. He provides an overview of the likely outcome of measures based on economic factors, and deals with price elasticity, effective metering and the setting of appropriate water tariffs to deal with the actual cost of water. He also differentiates between a WDM tariff as opposed to a water scarcity pricing system. The latter is seen as a temporary measure during drought periods, but can also be permanent if freshwater availability is limited.

Stephenson (1999:121) highlights important considerations regarding some of the criteria for WDM implementation. He did not attempt, and it was also not the purpose, to provide an integrated approach towards addressing a possible water crisis. He simply stated that water tariffs can be used to significantly influence water use in the future. His viewpoint however, did not necessarily incorporate the challenges faced by South Africa to adhere to transformation at all spheres of governance.

WDM and water conservation objectives can be summarised as follows (Thyssen, 2001:13):

- To secure future supply.
- To protect the environment.
- To protect existing water resources.
- To achieve economic efficiency.
- To achieve social development, equity and accountability.

Problems with the implementation of appropriate WDM steps has been identified in a study (Mwendera et al., 2003:767) carried out in Southern African countries. Some of the main problems identified include:

- Lack of integrated planning policies;
- Inadequate knowledge about consumers;
- Lack of financial resources;
- Lack of human resources and

- Political pressure to supply quick-fix solutions.

WDM can be carried out at various levels within government structures, as suggested by Johnson et al. (2002:5). Figure 4.1 illustrates six different stages representing the full water management cycle. WDM can be implemented with different levels of success and impacts at each of these stages.

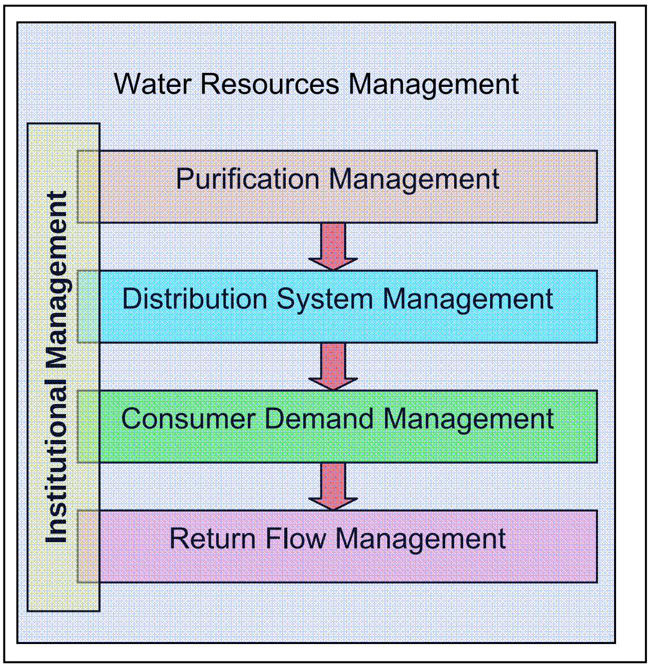


Figure 4.1: Water management cycle

To reduce the complexity of a single model for the full water management cycle, a DSS will be developed for each of the steps in the water management cycle as illustrated in Figure 4.1.

The background associated with effective WDM will be described under the following headings:

- Water resources
- Available data and the water audit process
- Benchmarking
- Water use patterns
- Metering
- Leak detection
- Awareness
- Pressure Management
- Retrofit

- Re-use of water
- Dual water supply systems
- Pricing strategy
- Regulations
- Water restrictions vs. WDM
- Political Management

4.3 Municipal Water Resources

The institutional arrangements and responsibilities have been described in Chapter 3. Interventions at national level include aspects such as resource protection measures, conditions of water use in general authorisations and licences, water pricing as an incentive for effective use, the management of land-based activities via stream-flow reduction and controlled activities, eradication of invasive alien plant species, a disaster management plan, national awareness campaigns such as national water weeks, communication and education (all discussed in a complete and effective NWRS).

In cases where municipalities have their "own" water resources, an effective water management plan needs to include the following aspects, which need to be investigated in more detail:

- Protection of water resource.

  This can be achieved through the protection of the catchment areas of these resources against over-development. Preferably, the catchments directly utilised by municipalities, which are typically not large areas, should be owned by the municipality and managed as an undeveloped protected area. Full control by the water services authority, in most cases the municipality, will result in easier management of the specific area. This will prevent issues such as the clearance of vegetation which can result in an increase in sedimentation loads in the streams, or the illegal dumping of pollutants into the streams.

  Ownership of the catchment by the authority will not automatically ensure an unpolluted source, but it will ensure access and fewer problems with cooperation between the authority and individual owners, who can be difficult to control. If developments in these catchments are unavoidable, then all participants should be included in a management structure so that proper control can be executed.
- Detailed yield analysis and associated risk analysis.

  It is impossible for a municipality to manage and plan its water resources without knowing the yield of the resource. It is usually boreholes (groundwater) that are not analysed in detail. Municipalities depend frequently on a “blow yield” test on a specific borehole, which gives an indication of the possible short term yield. This is, however, not sufficient for proper planning. A proper monitoring plan, which will not be presented in this study, is also essential. Few municipalities do anything relating to this exercise.

When municipalities do have their own surface water sources, an appropriate yield analysis is seldom done, mostly due to a lack of sufficient flow data, and it is therefore impossible for the municipality to manage the resource appropriately. It is also important to reassess the yield from time to time.

- Optimisation of the operating rules for these resources.

  Once the yields are known, it is important, through a proper risk assessment, to determine which resources in a multi-source system should be used on a priority basis, and what the priorities for the utilisation of these resources should be. The effect of water quality in the different resources also needs to be part of the operating decision making rules. Cost optimisation will play an important role here to ensure the most efficient water use scenario.
- A drought operating strategy.

  Each municipality that manages its own resources must incorporate the operating procedure during drought periods into its disaster management plan. In simple terms, the municipality must be able to know what steps need to be taken to minimise the risk of a resource failure. Restriction levels, linked to storage capacities, play an important role in this strategy.

In the water resource management step, the co-operation between the municipalities and the structures provided by legislation for the management of the resources, such as the CMAs, plays an important role. These structures and their institutional role have been described in Chapter 3.

4.4 Available Data and Water Audit

The responsibility to implement WDM measures in all of the other steps within the water management cycle rests, in South Africa, almost exclusively within the institutional framework of the municipalities. Some of the methods required for WDM can be classified as being on the end-user side of the water management cycle (focussed at individual households), while others are on the supply side of the water management cycle (focussed at the municipality), with a number of these methods applying to both the end-user and the supply side.

The main objective for a municipality, from a practical point of view, is to ensure that no unnecessary losses occur in the water system, and that the end-users use as little water as possible without sacrificing health and an acceptable life-style. A water audit through an evaluation or assessment of a particular water system forms the basis of any WDM plan or strategy.

Once a system has been analysed, the calculated “losses” need to be verified. The difference between the volume purchased and the volume sold (taking distribution losses into account) does not necessarily mean that the water has been lost due to leaks. A number of administrative reasons can also be responsible for the apparent losses, and it is therefore necessary to understand the possible reasons for these “losses”.

Figure 4.2 illustrates the grouping of different WDM methods in relation to each other, as proposed by the researcher.

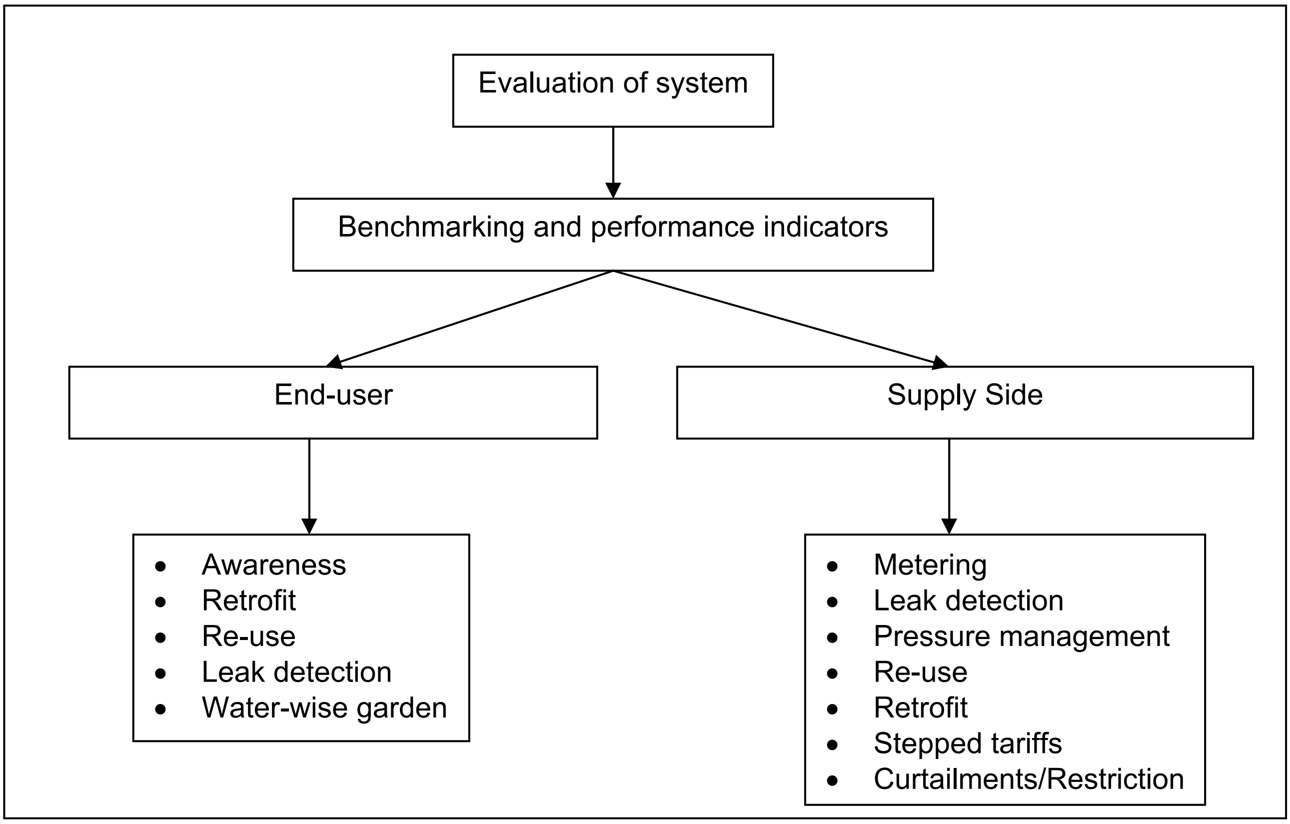


Figure 4.2: Water demand management methods

The Water Services Act (Act 108 of 1997, Section 13) provides guidance regarding the information required at a municipal level to ensure effective water-related planning. The information that needs to be supplied in the WSDP must include at least the following:

- Physical attributes of the area to be served.
- The size and distribution of the population in the area.
- Existing water services.
- Existing industrial water use.
- Existing industrial effluent disposal.
- Level of services.
- Arrangements regarding future water requirements.

The Water Services Act (Act 108 of 1997) (Section 62(1)(a)) also requires that water services authorities (mostly municipalities) be monitored by the Minister to ensure that the evaluation criteria, as highlighted above, are all adhered to. For this purpose, the DWA issued regulations (DWAF, 2001a) that provide guidance for effective WDM. These regulations is presented in detail in Section 3.5.6.

The monitoring process, which is governed by the regulations (DWAF, 2001a:6), is generally referred to as the water audit process. The water audit serves as a tool to allow municipalities to compare actual performance in the water sector against targets contained in the WSDPs. It will furthermore assist a specific municipality to identify possible problem areas and to improve the management of their full water cycle. The water audit (DWAF, 2001a, 6–7) requires the following aspects, listed in Section 10 of the regulations, to be monitored:

- Quantity and quality of water services supplied.
- Level of services provided.
- Level of cost recovery achieved.
- Progress with meter installations.
- Progress with water quality sampling and testing.
- Progress with water conservation and demand management measures.

Besides these listed aspects, the regulations (DWAF, 2001a:7) specifically require a monthly balancing of the water services provided by the municipality. A water balance evaluates the difference between the volumes of water that enter the system against the volume supplied to legal users. In this regard, every municipality is instructed to measure water distributed per zone, determine the unaccounted-for-water (UAW), measure the quantity of effluent received at a treatment facility and to determine the quantity of water supplied, but not discharged, to a treatment plant.

The well-known phrase "to measure is to know" forms a critical issue in effective water management, but it is not adequate to only know what one measure. It is also of critical importance to establish benchmark values against which progress can be monitored, and to understand the level of intervention required to ensure sustainability.

It does not make sense to spend a lot of time, energy and finances in the streamlining of a potable water treatment facility with recorded or measured losses of about 10 per cent, since this is a figure reflecting "normal" procedures, while on the other hand, a consumption figure for normal households of 600 litres per capita per day (l/c/d) does require an intervention.

The lack of co-operation between the team responsible for the water audit and the operational staff responsible for operating the works under evaluation also needs attention. Operational staff frequently fear that an ineffective system will automatically reflect as poor staff performance, which might result in promotion stumbling blocks in the future. The result is that operating information is not always completely honest, with a tendency to either claim a loss of data or to provide only the data where a good match between, for example, the volume of water received against the water treated, exists. Such actions prevent the visibility of the problem areas that might, if identified properly, result in the improvement of equipment or staff numbers, and therefore a more convenient working environment for the existing staff. Proper communication regarding the purpose and objectives of specific actions would greatly contribute towards resolving this problem.

Municipalities have been supplied with valuable guidelines and regulatory arrangements to assist them in their planning process to ensure an effective water service. Special attention should, however, be given to the availability of staff to execute these regulations and achieve effective management in the process.

4.5 Benchmarking to Identify Problems

It is not possible to make progress unless the present situation is known. In this regard benchmarking can be defined as the process (Pybus, 2002:1) whereby the effectiveness of achieving a particular goal can be weighed against a standard, which will have been set by a number of different organisations. The specific goal is referred to as a performance indicator (PI). It is not always necessary to measure only against other organisations, but once critical PIs have been identified, it is necessary to measure against previous values achieved within the organisation. This will assist in evaluating the progress made on a specific issue within an organisation.

Performance indicators can be identified and categorised depending on the objective of the benchmarking. Typical categories include the following (Pybus, 2002:12):

- Service delivery
- Financial credibility
- Technical effectiveness
- Human resources
- Effective water use

The need for setting appropriate PIs is also well-defined in the Municipal Systems Act (Act 32 of 2000). The Act provides for the implementation of a performance management system in Section 41 of the Act, which, amongst others things, includes the setting of appropriate PIs, measurable performance targets, the monitoring of the performance against set targets and the steps to ensure that progress is made.

There are, however, a number of problems with setting PIs that need to be considered closely before an indicator can be accepted. The main objective is to compare apples with apples. To illustrate a simple problem: a typical PI in the water sector that relates to effectiveness is loss of water, which is expressed in litres per km of supply pipeline. Rural areas quite often have in excess of 200 kms of main supply pipelines (200 mm diameter) to serve 2000-4000 people, while a bulk supplier to industrial areas might have only 80 km of supply pipeline (1,500 mm in diameter) to serve in excess of 100,000 people and industries. The value set for the PI chosen may not be the same for both types of pipeline, and is therefore considered to be site (size) specific.

To calculate an acceptable value for a specific PI will require objective and correct input from a number of organisations. These values will have a reflection on the performance of a specific organisation, and a method needs to be devised to ensure that reliable values (Pybus, 2002:35) are provided.

In order to address these issues, a number of initiatives have been established in the South African context. The Water Research Commission investigates and provides guidelines (Pybus, 2002:16) to water services providers for the implementation of benchmarking, while the South African Association of Water Utilities and the Institute of Municipal Engineers in South Africa have both established task teams to investigate benchmarking in the water sector. None of these initiatives could, however, produce simple benchmark values to be used at a local government level.

4.6 Water Use Patterns and Consumption

Just as it is not possible to make progress without knowing the present circumstances through a benchmarking process, it is also not possible to manage the water services effectively without knowing the end goal. In order to know the end goal or objective, it is important to know and understand the needs of the end-users.

The water needs can differ substantially from one municipality to another, and a basic knowledge of the prediction of future demand is required. In a smaller municipality, the industrial needs are quite often substantial, and can easily represent up to 50 per cent of the total demand of the specific municipality. In such cases, the nature of the industries will determine the possible future water requirements. A typical food-processing industry's water requirements will be dependent on the food production, which is in turn dependent on the weather and marketing forces. It is, however, possible to calculate accurate water requirements, based on a number of assumptions.

To determine accurate future water demand it is necessary to take the following factors into consideration:

- Population growth figures

  Many factors can influence population growth. The level of education is an example of such a factor, with a typical family unit of approximately six persons per family associated with a lower level of education, while 3–4 persons per household is associated with an upper level of education.

  Illnesses such as AIDS also have substantial influence on the general population growth, and can result in specific areas having a negative growth rate.
- Different user consumption figures

  Income levels are generally accepted as a sound indicator of the per capita water consumption figures. While figures as low as 10 l/c/d have been reported, typical figures vary between 100 l/c/d to over 500 l/c/d for the households in suburbs classified as rich.
- Tendencies towards urbanisation

  The availability (or perceived availability!) of work opportunities in urban areas result into a constant move of people, away from the rural areas, to the urban centres. The economic pressures on the agriculture sector also frequently results into mechanisation, which can result into job losses in the rural areas, with most of the workers then moving to the municipal areas in an attempt to at least secure housing for their families.

- Political stability

  Ethnic differences frequently result in a sudden move of specific communities to a different area of residence. These do not, however, take place on a large scale in South Africa, but small communities need to be aware of such possible actions when making decisions regarding future water infrastructure. A planned move of a specific community to a different area with limited infrastructure can have significant impacts on the available infrastructure.
- Economic climate

  The economic climate of a specific area can have a substantial influence on the growth of the area. Urbanisation is closely linked to the ability of a specific area to supply work to its people.

  In the rural areas, aspects such as drought can force large numbers of workers to work in towns to be able to sustain their families.
- Main economical focus of community (holiday towns/communities)

  Holiday or tourism-based communities experience unique water demand patterns, and these need to be incorporated carefully so as to not over-capitalise on infrastructure for only a small portion of the year. It is also to be expected that holiday-makers will have a substantially higher per capita consumption given their more relaxed state of mind.

For small municipalities, the tendency is to base future water demands on historical consumption figures. Curve-fitting is done on the existing data and changes for specific industrial or other specific development are incorporated.

The validity of this approach was tested in a study (Esterhuyze, 2003:10.1) where the future water demands were calculated for a specific municipality, a process which followed a detailed investigation into the growth patterns for a number of smaller groupings within the municipality, where these groupings included different income groups and industries. Each was analysed individually and their future water demands were individually projected. The total future demand was then calculated as the sum of all these individual projections. As an alternative, bulk consumption figures were used to simply project possible future demands based on trends observed from the bulk figures. The study found that the simple curve-fitting exercise resulted in a future prediction that was within 5 per cent of the more sophisticated approach where the consumption patterns of each user group were calculated and the different impacts, such as AIDS, were incorporated separately. It was concluded that, due to the level of detail required and the poor availability of reliable data, a more detailed approach did not justify the cost and time needed to obtain more accurate forecast figures, which differed little from the more robust approach.

World (IBNET) consumption figures are estimated to be between 300–600 l/c/d for larger cities in Europe and North America, while the per capita consumption figures for the Netherlands are reported to be approximately 126 l/c/d in 2001 (Water in the Netherlands, 2004:58) and that of Perth in Australia, 369 l/c/d (White et al., 2003:28).

The International Benchmarking Network (IBNET) for Water and Sanitation Utilities provide a comprehensive set of per capita consumption figures which are summarised in Table 4.1 (IBNET, 2009), showing the change in these figures over time.

Table 4.1: International per capita consumption (l/c/d)

	Year				
Country	**2003**	**2004**	**2005**	**2006**	**2007**
Australia	396	388	360	335	316
China	221	208	196	185	183
Hungary	194	184	178	159	158
Brazil	165	148	163	162	169
South Africa	190	182	180	188	186

4.7 Unaccounted-for-water

The objective to minimise water loss has already been highlighted and the setting of a PI relating to UAW to provide guidance on the management of these losses, was mentioned. Understanding these losses is important if they are to be managed effectively. Two general terms are used in this context and need to be clarified:

- Unaccounted-for-water (UAW)
  UAW is the difference between the volume of water purchased by an authority and the volume of water sold to consumers. The difference is mainly as a result of unauthorised consumption (illegal connections or theft) and real system losses, such as leaks and burst pipes.
- Non-Revenue Water
  Non-Revenue Water is the difference between the volume purchased by an authority and the volume for which bills are sent out. The difference here refers mainly to unbilled authorised consumption (free basic water supply) and the losses through illegal usage and real system losses.

Although McKenzie et al. (2003:169) suggest that the term UAW be generally replaced with Non-Revenue Water, it was decided to discuss these concepts in the context of internationally (IWA, 2000:5; Trow and Farley. 2006:145) accepted terminology. Figure 4.3 illustrates these different concepts.

<table>
<tr><td rowspan="9">System Input Volume in m^3/year</td><td rowspan="4">Authorised Consumption in m^3/year</td><td rowspan="2">Billed Authorised Consumption in m^3/year</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water in m^3/year</td></tr>
<tr><td>Billed Un-metered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption in m^3/year</td><td>Unbilled Metered Consumption</td><td rowspan="7">Non-Revenue Water in m^3/year</td></tr>
<tr><td>Unbilled Un-metered Consumption</td></tr>
<tr><td rowspan="5">Water Losses or Unaccounted-for-water in m^3/year</td><td rowspan="2">Apparent Losses in m^3/year</td><td>Unauthorised Consumption</td></tr>
<tr><td>Meter Inaccuracies</td></tr>
<tr><td rowspan="3">Real Losses in m^3/year</td><td>Leakage in mains and distribution networks</td></tr>
<tr><td>Leakage and overflows at Utilities Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to a point of Customer metering</td></tr>
</table>

Figure 4.3: Standard definitions for international usage

From a WDM point of view, all of the aspects highlighted in bold font in Figure 4.3 are important. The different categories of “losses” need to be identified and should be dealt with accordingly. It is important to meter the unbilled portion of the authorised water consumption (through zone or bulk meters) in order to succeed with the water audit.

The losses, or apparent losses, need specific interventions. Meter inaccuracies, which will be illustrated later, play an important role in identifying these losses and they must be addressed through a proper meter maintenance programme. Unauthorised consumption is difficult to address. The solution can be found in either a proper policing strategy or preferably social acceptance of individual responsibilities. The latter can be addressed within a public awareness campaign, an example of which will be described in section 5.4.1.

A global water supply and sanitation assessment was conducted during 2000 (WHO, 2000:25) to determine the mean rate of UAW. The results are shown in Figure 4.4.

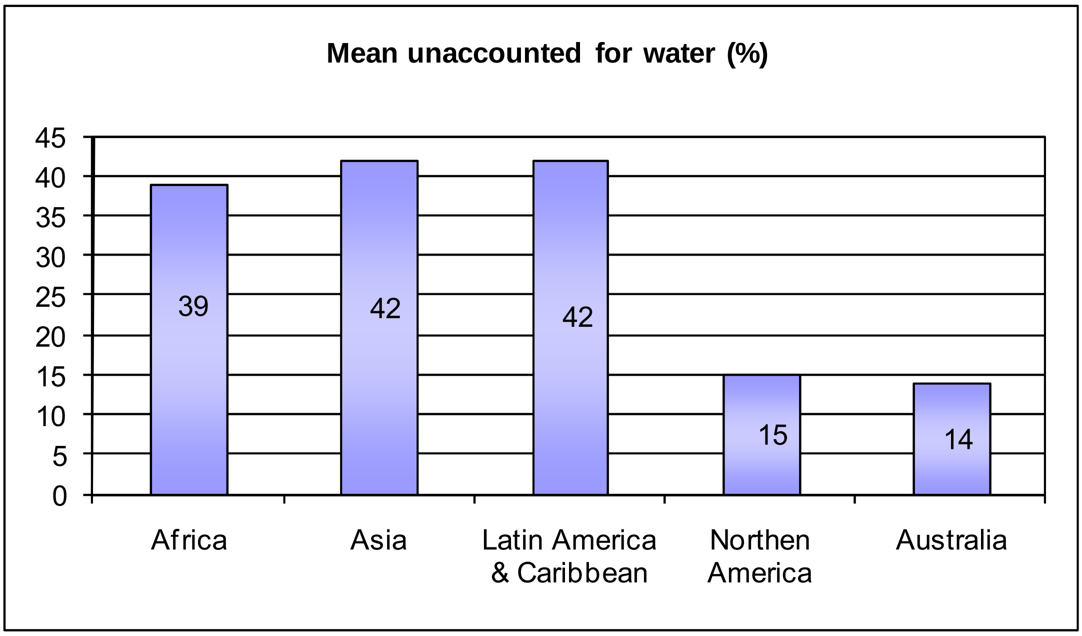


Figure 4.4: Mean unaccounted-for-water in large cities in the world

The value for North America was based on only 2 cities, while the low value for Australia is as a result of intensive WDM strategies implemented over the last decade. This value dropped from 20 per cent to the present 14 per cent.

The high values for Africa are a reason for concern, since the continent is considered to be water scarce. The situation in South Africa does not look any better (IBNET, [s.a.]). Figure 4.5 shows the rate of UAW in the major cities in South Africa.

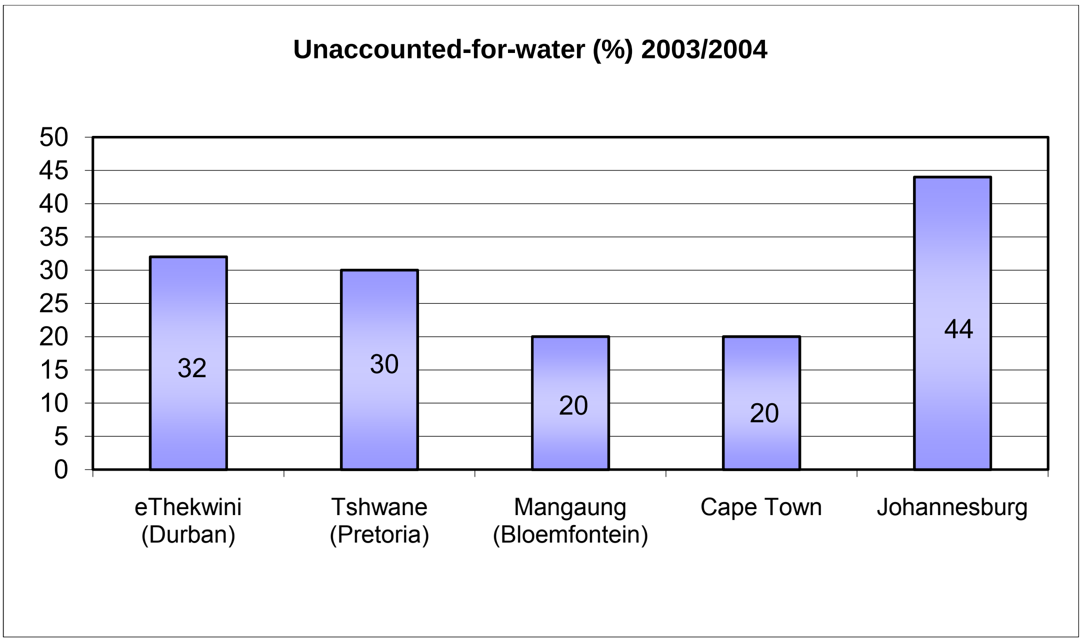


Figure 4.5: Unaccounted-for-water in South Africa.

In Johannesburg alone, the 44 per cent represents a volume of 165 billion litres of water per annum that was purchased, but not sold, highlighting the importance and value of reducing UAW. Turton et al. (2006:327) reported a loss of 2,700 kl between 02h00 and 04h00 in one specific township in Johannesburg, with a mean daily average demand of 3,500 kl per hour, highlighting the substantial losses possible in reticulation systems.

The IBNET for Water and Sanitation Utilities provide a comprehensive set of non-revenue water indicators, expressed as a percentage of net water supplied, as summarised in Table 4.2 (IBNET, 2009), showing the change in these figures over time.

Table 4.2: International per capita non-revenue water (%)

	Year				
Country	**2003**	**2004**	**2005**	**2006**	**2007**
Australia	6	6	6	7	6
China	20	27	27	27	21
Hungary	22	22	20	34	32
Brazil	40	46	40	41	40
South Africa	39	33	35	30	28

Taking note of the differences in the interpretation of “losses”, with reference to UAW and non-revenue water, the values listed in Table 4.2 and Figure 5.3 (still to be discussed) provide benchmark values as a starting point for assessing the status quo situation.

4.8 Metering

The principle and importance of a water audit was presented in section 4.4. It is clear that accurate data forms the basis of effective WDM, but accurate data can only be available if proper measurements take place. At municipal level, these measurements depend on a well-established metering system. The accuracy is of such importance that the DWA proclaimed regulations that force water authorities to set standards for all meter installations and the equipment used for metering (DWAF, 2001a:7).

The installation of water meters is often already a conservation measure, with savings of between 15 and 20 per cent as against non-metered values in Canada (Tate, 1990:22). It has, however, also been argued that these savings do not necessarily remain permanent, and that metering without a proper pricing strategy, which will be described in section 4.15, does not necessarily contribute towards effective WDM. It does provide important tools, however.

A distinction has to be made between bulk and household meters. Bulk meters, also referred to as zone meters, are required for the purpose of comparing the inflow towards a specific area with the combined household meter readings. This will provide the required data to assist in determining problem areas for further investigation.

Bulk meters are more sensitive to the correct installation configuration and proper maintenance. It is crucial that bulk meters be calibrated on a regular base to ensure effective water management. Most of the bigger municipalities consider the bulk meter readings important enough to link these readings electronically to a control centre where the meter's performance can be monitored continuously.

Household connections provide the interface between the end-user and the distribution system, and provide reliable data on which the billing system depends. Water meter can be considered as the most basic building block of any data collection system, and therefore it is important to take note of some of the typical problems associated with household meters and the reading thereof. Typical problems include (McKenzie et al., 2003:109-110):

- Incorrectly sized – with a too large meter, low flows will not be measured accurately.
- Incorrect readings from the dial.
- Human error – meter readings being estimated.
- Lost records.
- Meters installed incorrectly.
- Bad maintenance.
- Bad bookkeeping practices.

Once the meter readings have been collected and verified, an administrative system needs to be in place to ensure accountable recordkeeping. The meter reading programme must include at least the following steps:

- Effective control and accurate checks of meter readings, including bulk meters.
- Constant meter reading programming. Meters need to be read on the same dates of each month and be linked to the billing systems.
- Proper training of meter readers.
- Installations of meters in all areas where water is consumed, even in areas where the expected revenue will be small. Not knowing what is happening might cause more problems.
- Implementation of proper, auditable, management systems to ensure not only proper calibration and maintenance of existing meter installations, but also to ensure proper preventative maintenance.

Real time meter readings, the process whereby meter readings are transferred electronically to a control centre for immediate access, can supply valuable data regarding usage patterns in specific areas or zones.

This information can be used to identify problem areas in water supply through the recording of water flowing during low activity periods, generally referred to as night flows. These flows act as a sound indicator of the volume of water lost through leaks, both in the distribution system and at household level. Figure 4.6 (WRP, 2002:5) illustrates how easy it is to identify a possible problem in a specific zone through the logging of real time meter readings of flows into a specific area. The graph shows that a minimum flow of 1600 m^3/h is recorded during the night. Since the area used in the graph (Khayelitsha) is a residential area, it can be reasonably expected that the night flows should drop to close to zero if the system was without any leaks.

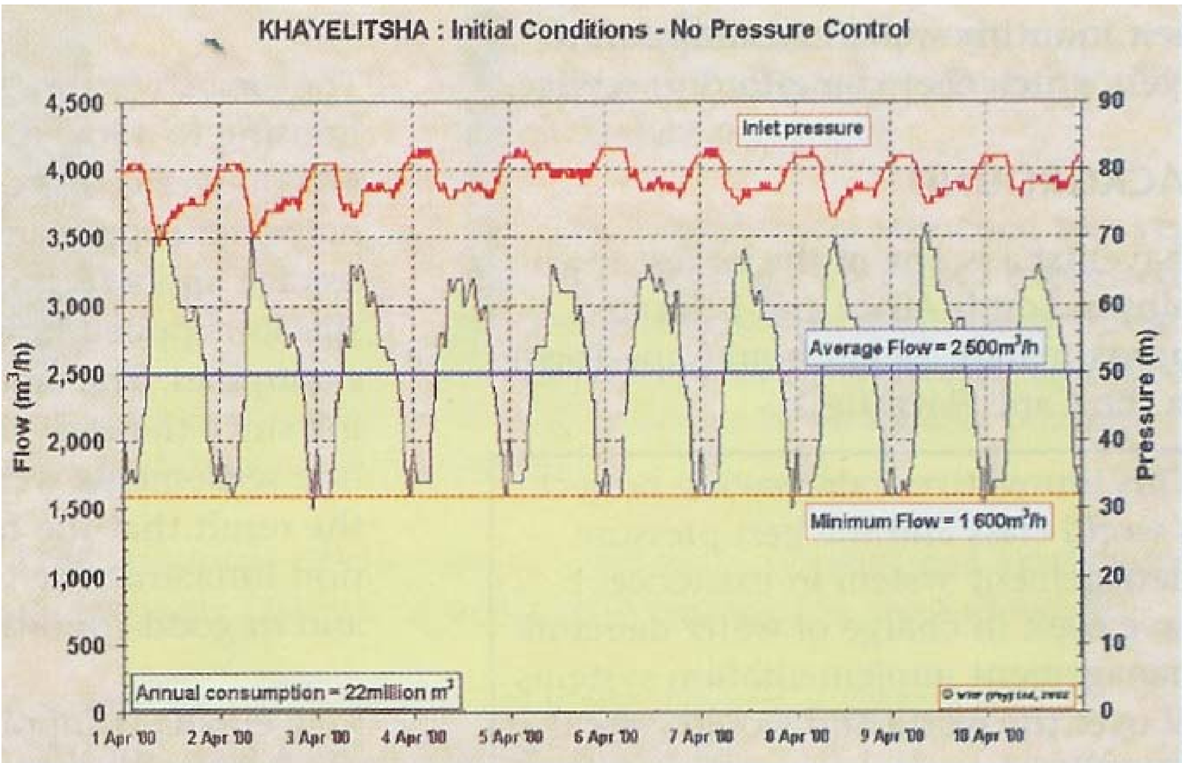


Figure 4.6: Time-related flow in Khayelitsha

The possible remedial process of leakage within the distribution system will be described in section 4.9. The losses as a result of overflows from reservoirs or leaks, are a management problem, and should be addressed within the proper infrastructure maintenance programme and operating procedures, combined with proper training of staff.

Further problem areas related to metering include the administrative problems associated with the handling of the metering data within a municipality.

- Meter readings are considered to be a financial issue and are therefore managed by the financial departments in most municipalities, since revenue is generated from this data. The technical departments, however, need this data for proper planning and to ensure that effective water usage can be implemented. There is not a well-established working relationship between the financial and technical (water) departments within most municipalities.
- The response time between an actual reading and the follow-up in case of discrepancies is usually long, due to a lack of appropriate systems and cooperation between the different departments.

Proper metering results in the understanding of the water situation within a municipality and forms the basis of the water audit. One of the main objectives, as presented in this section, is to identify the reason for water losses within a distribution system. Once this has been achieved, specific interventions need to take place to ensure effective WDM. These interventions will be discussed in the next sections.

4.9 Leak Detection

The question of water not being accounted for has been described in section 4.8, and it is clear that not all water not measured is lost due to leaks. This section will focus on the steps that can be taken regarding losses in a water system as a result of a physical leak. Leaks appear in the context of the water distribution system either on the end-user’s side of the water meter or on the supply side of the system.

The responsibility for leak determination and the repair thereof differs for the two scenarios. In the case of the supply side, the responsibility rests with the municipality, while the end-user is responsible for the end-users’ side. It is, however, important that the municipality understands the methods available to advise the end-users, or to apply the options themselves, depending on the circumstances.

4.9.1 Supply side

Leak detection within the supply side framework can be classified broadly in three categories, i.e., a physical searching approach, a water audit approach and a maintenance approach.

- Physical searching

  Most of the major leak problems in a system are reported by members of the public to a municipality through a control centre. These are the more visible leaks, and are quite often also spectacular (see Figure 4.7). The problem is, however, those that are not visible, but still leak away substantial volumes of water. Detection of these leaks can be done through various products available on the market, mostly sound-based.

  The listening sticks, or geophones (McKenzie et al., 2003: 118–119), are the most common instruments used, and are based on detecting the disturbance of sound generated by flowing water at a leak. The latest developments in this technology result in noise loggers that can be installed at various points to reflect disturbances in noise patterns over a wide area. The data from these loggers can then be analysed to direct the operator to a point of a most likely leak position.

  Ground penetrating radar can also be used to plot the profile below the surface. Water can easily be detected, but further investigation is required to identify the source of the water, as it might be natural groundwater.

Figure 4.7: Spectacular and visible leak

- Water audit

  The water audit has been described in full in section 4.4. During an audit process, areas can easily be identified through the zone metering system where leaks might be a problem. One of the more physical approaches can be used to try to locate the exact position of the leak. This is, however, a time-consuming and costly exercise.

Through the analysis of continuously logged bulk water meter readings during low flow periods, it is also possible to shut down specific zones on a rotation basis and to evaluate the bulk meter reading graph leading towards these zones. This is referred to as the step test, and attempts to identify the periods on the graph where a significant drop in water flow is recorded once that zone has been closed or isolated. Its application is specifically useful where a well-established zone-metering system is absent.

- Maintenance approach
  Specifically in areas using water resources that are situated some distance from the community, proper routine inspections are not conducted on a regular basis on the main bulk water supply pipelines. Leaks on these can therefore go unnoticed for weeks before steps are taken. Maintenance teams therefore need to be aware of any disturbances such as lush plant growth, or a vlei area, along these main supply pipelines. A proper logbook should also be kept of all reported leaks/repairs on a network, and these positions should be plotted on a map to facilitate easy understanding and future replacement programmes.

4.9.2 End-user side

The most reliable, and easiest, way to determine whether any leakages do occur within the property boundaries, is to ensure that all household activities linked to water usage are shut down and then have a look at the household water meter. If the meter is still running, then one can be sure of some sort of leakage somewhere in the system.

The most common form of leakage within a property boundary is associated with the plumbing of the household. Leaking joints, taps and damaged fittings are among the most general problems.

Property owners need, however, to also be aware of the risk of plumbing problems within walls and below surface level on the property. The problem is aggravated in low income and rural areas, where the level of the installation is frequently not up to standard (WRC, 2008:17) due to financial constraints, and where the pressure of the water in the system is high.

4.10 Awareness Campaigns

An awareness campaign is one of the less technical approaches towards WDM. It is, however, not only an approach that needs to be implemented once a water audit indicates that serious water losses occur, but also an ethical approach towards the effective management of valuable water resources. Quite often, an awareness campaign on its own can produce significant results towards sustainable water use. Many technical options to reduce water use can however not be implemented effectively without an awareness campaign. Retrofits such as the replacement of toilet flushing systems with dual flushing systems, will not be achieved if the user is not aware of the potential water savings of the decision.

The NWA promotes an integrated approach towards water management. In this process, the environment plays an important role, as well as all of the downstream users. It is important to understand that downstream users are not only those who specifically consume water (households, industries, agriculture), but also secondary users such as tourism, which depend on the surface area of dams and rivers for their business, or even water sport organisations like boat owners and canoe clubs. The challenge in the effective management of water resources is to allow all these different parties to be aware, to participate and to contribute towards the decision-making process. Effective participation was described in the section 2.8, and will be illustrated in more detail in section 5.4.1.

The creation of structures to ensure participation plays an important role in conveying messages regarding water-related issues to keep everyone informed. Awareness creation is a continuous process that involves the transfer of knowledge and information to as many parties as possible, and should not only be implemented to address a specific problem.

Awareness campaigns can be conducted through a number of different approaches, and it is frequently advisable to combine or make use of more than one approach simultaneously to strengthen the message conveyed. The methods include the following options (Still et al., 2008:141):

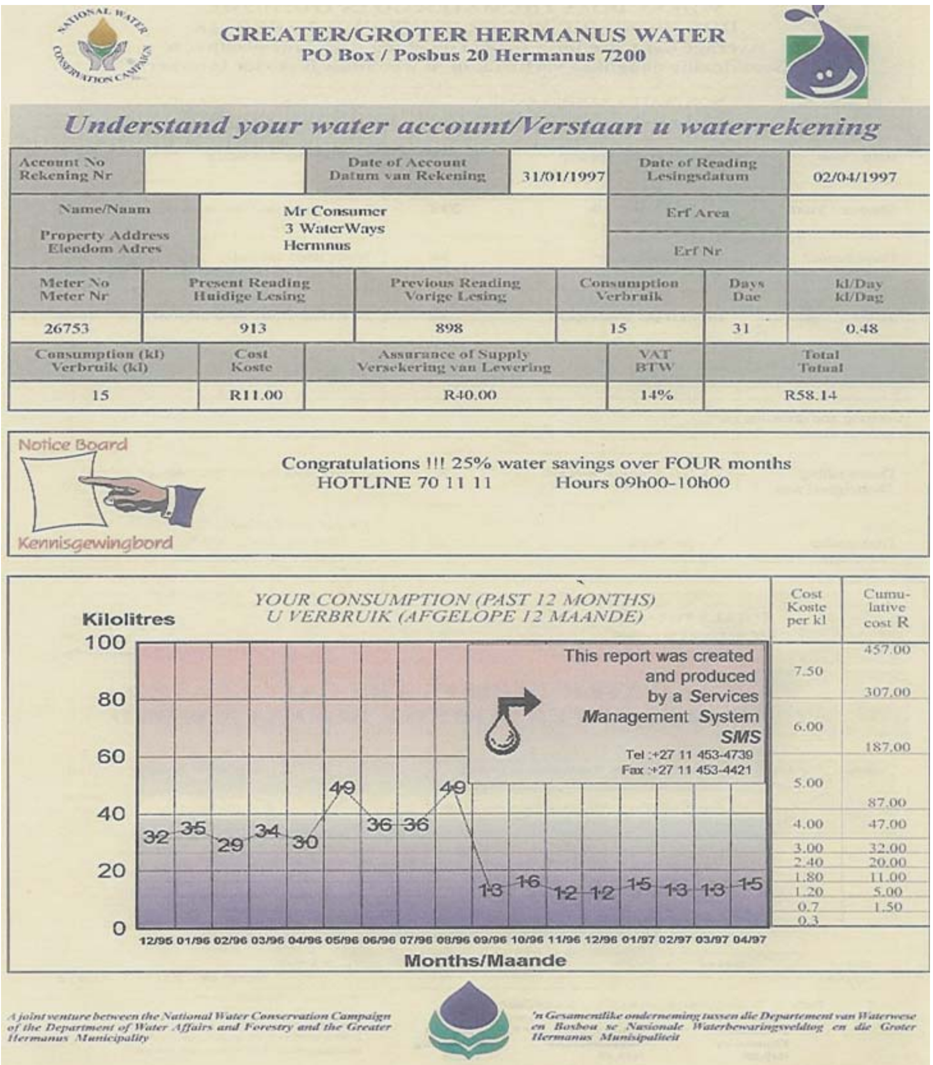
- Fliers and billing system

  In the water sector, the most basic approach towards awareness is to simply provide adequate information to the end-user. Within a municipality, this can be as simple as to include general information on the topic to be addressed as a flier in the bill sent to end-users.

Directly linked to the supply of information via the account system of a specific municipality is the actual upgrading of the account itself in order to supply additional information. This is being referred to as the “Informative Bill” system. Typically, this will result in a graph on the bill that reflects the specific user’s consumption over a period from at least three months up to one year, as illustrated in Figure 4.8.

- Bill boards

  Typically these boards are erected at the entrances to towns, and contain the main theme of a specific water issue. Additional information such as the level of supply dams can also be shown on these boards. Two examples are illustrated in Figure 4.9. They are limited to the information they can convey, but they serve as a constant reminder over a long period of time. The updating of the data conveyed through these boards needs to receive a high priority.



NATIONAL WATER CONSERVATION CAMPAIGN

GREATER/GROTER HERMANUS WATER
PO Box / Posbus 20 Hermanus 7200

Understand your water account/Verstaan u waterrekening

Account No Rekening Nr		Date of Account Datum van Rekening	31/01/1997	Date of Reading Lesingsdatum	02/04/1997
Name/Naam Property Address Eiendom Adres	Mr Consumer 3 WaterWays Hermnus			Erf Area	
				Erf Nr	

Meter No Meter Nr	Present Reading Huidige Lesing	Previous Reading Vorige Lesing	Consumption Verbruik	Days Dae	kl/Day kl/Dag
26753	913	898	15	31	0.48

Consumption (kl) Verbruik (kl)	Cost Koste	Assurance of Supply Versekering van Lewering	VAT BTW	Total Totaal
15	R11.00	R40.00	14%	R58.14

Notice Board
Congratulations !!! 25% water savings over FOUR months
HOTLINE 70 11 11 Hours 09h00-10h00
Kennisgewingbord

YOUR CONSUMPTION (PAST 12 MONTHS)
U VERBRUIK (AFGELOPE 12 MAANDE)

Kilolitres
100
80
60
40
20
0
32 35 29 34 30 49 36 36 49 13 16 12 12 15 13 13 15
12/95 01/96 02/96 03/96 04/96 05/96 06/96 07/96 08/96 09/96 10/96 11/96 12/96 01/97 02/97 03/97 04/97
Months/Maande

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Cost Koste per kl	Cumulative cost R
	457.00
7.50	307.00
6.00	187.00
5.00	87.00
4.00	47.00
3.00	32.00
2.40	20.00
1.80	11.00
1.20	5.00
0.7	1.50
0.3	

A joint venture between the National Water Conservation Campaign of the Department of Water Affairs and Forestry and the Greater Hermanus Municipality

'n Gesamentlike onderneming tussen die Departement van Waterwese en Bosbou se Nasionale Waterbewaringsveldtog en die Groter Hermanus Munisipaliteit

Figure 4.8: Informative billing: Hermanus

Figure 4.9: Informative billboards

- National Water Week

  The national DWA launched a campaign that involved the declaration of a specific week, on an annual basis, as “Water Week”. It is normally accompanied by a central theme, and all water sectors are requested to participate.

- Competitions

  Typical competitions include dramas with a water theme conducted by school children, songs and poster competitions. The main objective is participation and, while the end product is often small or short, the value of the exercise lies in the planning, discussions and interaction that takes place before the actual event.

- Sponsorships of road races and other sport events

  Marathons, with the accompanied fun runs, are popular social events that are well attended. The emphasis on an enjoyable event and a theme add substantial value to the effort to carry the message as widely as possible. Figure 4.10 shows how teams can convey the message of water saving during their participation in a fun run.

Figure 4.10: Photo on team work

- Calendars
- Advertisements in newspapers

  Advertising in newspapers is expensive and the target group limited. It does, however, lend itself to the transfer of a wide variety of information, and the amount of information transferred can be substantial if planned carefully.
- Radio talk shows
- Websites

  The electronic era can also play an important role in conveying information regarding WDM and water conservation to the public. A limited number of sites specifically developed for the broader community are available. The site for the city of Cape Town (Household Audit Challenge, [s.a]) is a good example of such a website.

4.11 Pressure Management

Water distribution systems are designed according to preset criteria. One of these criteria relate to the minimum pressure required at any given time for such a system to operate effectively. Minimum pressure is, for example, required to ensure that strategic facilities such as fire prevention services can be delivered.

Consumers also expect a specific level of service, an expectation that is directly linked to their living standards. Normal household appliances, such as geysers, washing machines and shower heads to name only a few, need specific minimum pressure levels to operate effectively. Once the system is designed to address these requirements at specific flow regimes, it is normally found that the flow requirements decrease during low flow periods, with the result that the pressure increases significantly during that period.

This increase in pressure results in a direct increase in losses due to possible leakages in pipe networks and on-site equipment such as taps and toilets. From the theory of flow through an orifice (Chadwick and Morfett, 1998:44), as described in Equation 1, it is clear that the flow through an orifice (or leak) is only a function of pressure, given the same flow area.

$Q = C_d A \sqrt{2gh}$ ……………………………………………………………... Equation 1

where

Q	= Flow
C_d	= Friction coefficient
A	= Cross section area
g	= Gravity
h	= Pressure head

It therefore follows that the flow through any orifice or leak can be reduced significantly if the pressure is reduced. This forms the basis of pressure management as a way to reduce losses in a water system.

Many factors play a role in pressure management. Daily fluctuations in demand occur normally, with peaks occurring in the mornings and evenings. Low flow situations occur mostly during the night, and seasonal fluctuations are also possible. It is therefore crucial that a proper understanding of the pressure variations over time in a particular system needs to be established through logging, before a decision can be made to manage the pressure in order to reduce losses. This process needs to be controlled carefully in order to prevent the level of service rendered to the end-user being affected negatively, and subsequently resulting in social equity problems.

Pressure control can be achieved in a number of ways, which include (Wegelin and McKenzie, 2002:3–7):

- Continuous constant pressure control

  This method uses a valve at the inlet side to a specific area to ensure that the pressure remains constant over time. The pressure at the critical point in the system will, however, vary with time, depending on the consumption, but will never exceed a specific maximum value.

- Time modulated control
  A simple time device is used to control a pressure-reducing valve at the inlet side to a specific area or zone. Typical applications can be found in areas where the usage pattern is well-known and defined. The timing device allows for a change in pressure at preset times. It is possible, with this system, to ensure that a higher pressure is maintained during the peak demand periods than during low flow periods.
- Flow modulated control
  The flow modulated pressure control system will control the pressure based on the flow at any given time. It will ensure a maximum pressure on a continuous basis towards the end-user at a critical point.

The decision regarding which method to use must be based on sound information gathered prior to installation. The following implementation steps are suggested (Wegelin and McKenzie, 2002:1–2):

- selection of suitable pressure management zones;
- capture of basic information;
- field investigation and retrofitting;
- logging of flows and pressures;
- analysis of logging results;
- selection and installation of pressure controllers and
- monitoring and auditing of the results.

Care needs to be taken to not see pressure management as the sole solution to the reduction of water losses. The real problem, in some instances, is actual bad plumbing workmanship, and leaks need to be repaired as the ultimate solution. Household fittings that cannot handle the system pressures are frequently installed, adding to possible leaks and water losses (McKenzie et al., 2001:31).

McKenzie et al. (2001:42) suggest a number of issues that need to be considered before pressure demand management can be evaluated as an alternative. These include the following:

- Areas with high-rise buildings are generally not suitable due to fire prevention regulations.
- Industrial areas frequently require high or constant pressure due to their specific processes, which are normally kept operational on a 24-hour basis (McKenzie et al. 2003:91).

- Low income areas mostly lack a proper level of standards for the installed household fittings, and are therefore prone to leakages.
- Flat areas frequently experience excess pressure during low flow periods.
- Areas with sandy soils make the detection of leaks difficult and should be evaluated.
- Areas where frequent pipe burst problems are experienced.
- Zones with a high recorded night flow. (McKenzie suggests a reference value where the night flow is more than 15 per cent of the average daily flow as an acceptable value before pressure demand management should be considered.)

The effectiveness of pressure management as a tool to reduce losses has been well-documented (Mostert, 2003; *Leak reduction through pressure management*, 2000:9–10; *Big Savings Through Leakage Reduction as part of Water Demand Management*, 2004:15–17), and software applications such as BABE (Burst and Background Estimate) exist to assist authorities in making informed decisions regarding pressure management.

Proof of the possible extent of savings is provided in the Khayelitsha case study (WRP, 2002:3). Khayelitsha covers an area of approximately 24 km^2 and is situated about 20 km from the CBD of Cape Town. Forty-five thousand serviced sites and 27,000 low cost houses with communal standpipes as water supply provide residence to about 450,000 people.

During 2000, the water supply to this area amounted to 22 x 10^6 m^3/year, with the minimum night flow measured to be in excess of 1,600 m^3/h. During 2001, pressure reduction and time modulated pressure control valves were installed. The pressure before the installation of these valves was measured to be about 80 m.

The installation of the pressure-reducing valves resulted in the lowering of the average daily flow from 2,500 m^3/day to 1,800 m^3/day as shown in Figure 4.11, while the minimum night flow was reduced from the 1,600 m^3/day to 1,200 m^3/day. These savings amount to about 6 x 10^6 m^3/annum.

The time modulated pressure control valves reduced the average daily flow to 1,500 m^3/day and the minimum night flow to 750 m^3/day. Without ever reducing the pressure to below 24 m at the most critical point, approximately 40 per cent of the original inflow to this area, amounting to 9 x 10^6 m^3/annum, was saved.

The project cost less than R4 million, but saved more than R27 million per annum based on 2002 water rates alone. A further secondary saving was achieved due to the deferment of the upgrade of a waste water treatment facility, at an estimated cost of R40 million.

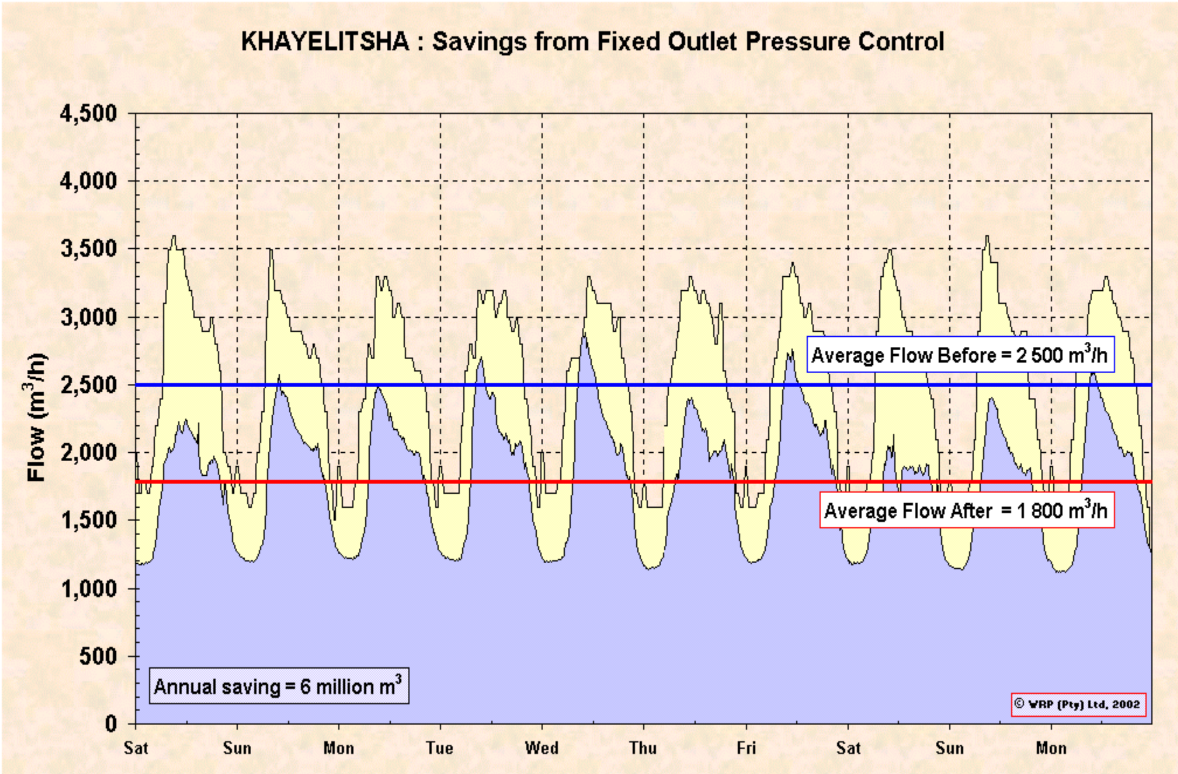

Figure 4.11: Pressure management: Khayelitsha

The management of pressure can therefore result in huge savings in specific cases. Cost saving is not only as a result of the actual volume of water saved due to reduced losses through leaks and bad workmanship at a household level, but also as a result of less maintenance due to lower frequencies in pipe bursts.

Smaller municipalities need to evaluate these options carefully. The decision requires a thorough understanding of its distribution systems, with enough data to evaluate, before a decision can be made.

4.12 Retrofit

Retrofit is the process whereby existing equipment at the household level is replaced with similar equipment that uses less water than the existing ones. While retrofitting in itself does have an awareness value, Deoreo et al. (2001:71) also find that the savings achieved initially do not reduce over time, such as is the case with awareness campaigns. Retrofit on its own is not likely to be successful as a WDM strategy, but needs to be seen, together with awareness and water audits, as an integral part thereof.

Since retrofitting can be expensive, it is important to start with those fittings where the best results are likely to be obtained with the least input. To identify the available options, an understanding of the different uses and use patterns at the household level is essential. These are not normally measured, and specific tests done by various organisations (Jacobs and Haarhoff, 2007:510) provided similar results. A typical water usage distribution for the Netherlands (2004:58) and Washington County (USA) (University of Arkansas, 2006) is shown in Figure 4.12.

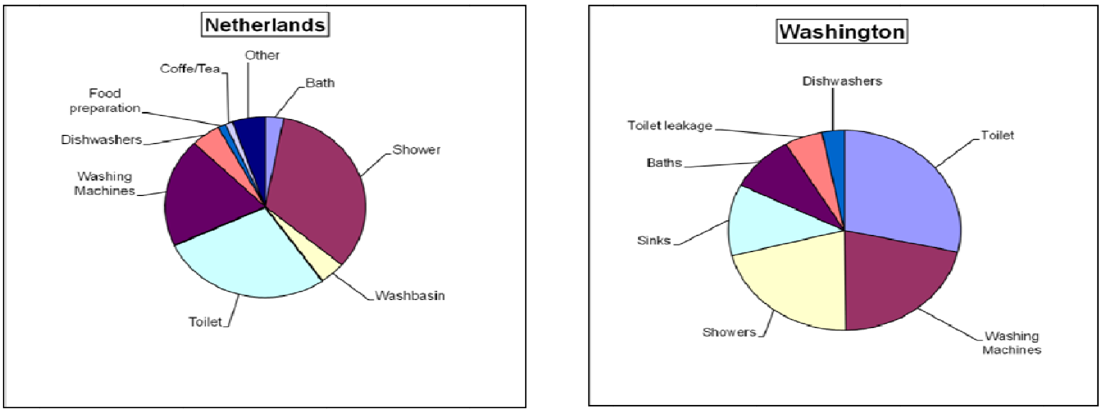

Figure 4.12: Sector water usage at a household level.

From Figure 4.12 it is clear that the biggest possible savings can be achieved by intervention at the toilet, shower and washing machine level of usage. These areas use approximately 28.5, 21.3 and 21.1 per cent respectively in the case of Washington County, USA, and 28, 33 and 20 per cent respectively in the case of the Netherlands, of the total water consumed within a household. Jacobs (2004:68) also reports significant saving figures (58 per cent for toilets, 4 per cent for showers, 27 per cent for baths and 40 per cent for washing machines) for South Africa. The appropriate retrofit alternatives for these usages will be presented briefly below.

4.12.1 Toilets

Water savings can be achieved by reducing the volume of water used for flushing. This can be achieved by either reducing the size of the holding tank or through control of the duration of flushing. Since it is frequently too expensive to replace the cistern already installed, the volume used can still be reduced by introducing a bag into the holding tank that will take up the space of the water used for flushing. These bags prevent the cistern from draining all the water in the holding tank quickly, and can save almost the full volume of the bag during each flush. Wilson (2004:94) reported savings of 0.37 per cent of the water supplied to schools in the City of Cape Town when these bags are used. New installations need to be limited to cisterns with a holding tank capacity of 6 litres, as opposed to the older 10 to 13 litre holding tanks.

A dual flush system controls the volume of water use for the flushing process. The flushing of liquids requires substantially less water than that required to flush away solids. Huge savings are possible, but care should be taken to not reduce the flush volume to such a low volume that it results in the clogging of the sewage collection system.

Waterless or dry toilet facilities also provide opportunities for water savings, not only from a water supply point of view, but also from the sewage collection side of the service to be rendered. It is however, unfortunately, still considered to be a service of a lesser standard and, as such, is not well-accepted by all communities. It will therefore be difficult to enforce through regulation. User education and public participation will play an important role in the implementation of this option.

A pilot project with thirty-two average households in the Netherlands, using vacuum suction-based toilets that were not connected to the traditional sewage system, proved that up to 84 per cent less water per toilet can be used (Van Schelting, 2008).

The replacement of all automatic flushing urinals with flushing "on demand" systems provides significant opportunities. The automatic flushing urinals typically use between 8 and 12 litres per flush, and are set to work continuously, even through the night and over weekends when no people are in the buildings to use them. Savings depend on the set frequency of flushing, but it can be substantial.

The installation of timers, push buttons or sensors to initiate flushing does contribute to significant savings. These devices are technically advanced devices, which need regular maintenance and are costly to install.

4.12.2 Showers and sinks

The installation of an aerator at the tap or shower head (Still et al. 2008:50-51) forces the water to be mixed with air, resulting in a perception of ample water, but effectively less in volume. In high pressure areas, the installation of low pressure taps and shower heads can also contribute to significant savings.

4.12.3 Waterless urinals

Waterless urinals have only recently become a more acceptable method. These devices use no water and are odourless. They require minimum maintenance, with the replacement of the sealing liquid the only maintenance cost after installation (Still et al., 2008:38). User education is, however, required to prevent anything other than liquid to be deposited in the bucket.

Municipalities, government buildings and other institutional working environments are often the easiest targets for the implementation of these devices.

4.12.4 Washing machines

The washing machine is the household appliance that uses the second highest volume of water at a household level (section 4.12). Up to 21.3 per cent of all water used in a household is used for washing purposes (University of Arkansas, 2006:2). The basic step required to save water in this regard is simply to ensure that washing is done with a full load rather than only a small load of clothing. New technology specifically focuses on automatic washing machines using less water more effectively in the process. A horizontal-axis design washing machine uses between 40–75 per cent less water than a vertical design washing machine.

The most likely opportunity for the implementation of these devices will be through appropriate by-laws or through an appropriately-stepped tariff structure, forcing participation through water tariffs.

4.13 Re-use of Water

Large quantities of treated potable water are used for irrigation purposes at the household and municipal levels, with specific reference to sport facilities. Applications do exist, specifically in industrial areas, for water that is not necessarily treated to potable standards, such as cooling water or water for dust control activities. In a number of specific situations, treated effluent is been used to supplement the main water supply of large towns or cities, for example in Windhoek, Namibia (Still et al., 2008:113).

Waste water at the household level can be subdivided in two groups, namely, “black water”, referring mainly to the effluent produced in the toilet and urinals, and “grey water”, referring to the effluent from baths, showers, dishwashers, washing machines, sinks, laundry tubs and hand basins.

Options do exist for the direct re-use of water through sanitation systems such as the so called “Aqua-privy” (see Figure 4.13) sanitation system (Department of Housing, 2003:12). With such a system, water used at the wash basin is utilised to flush the toilet. The implementation of such a system depends, however, on the level of service required, and is not always an appropriate option.

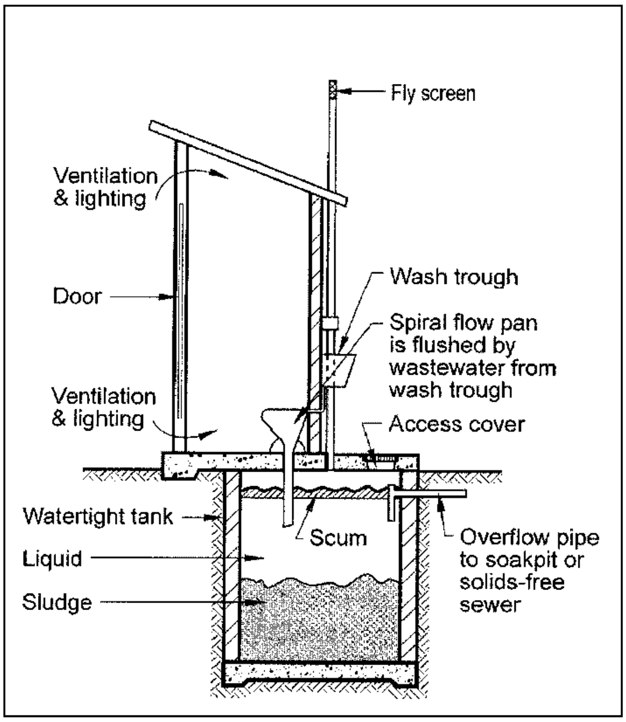

Figure 4.13: Aqua-privy sanitation system

Few re-use opportunities exist at a household level for black water, but the re-use of the treated final effluent produced at waste water treatment works where the black water needs to be treated, provides specific opportunities to a municipality.

The re-use of grey water and treated sewage provides a number of benefits, which include:

- Lower fresh water requirements.
- Fewer capital investments in bulk treatment infrastructure due to lower growth in the demand for treatment capacity.
- Plant growth and the reclamation of otherwise wasted nutrients, which reduce the needs for fertilisers.
- Less energy and chemical use during treatment.
- Groundwater recharge with treated effluent, after filtration, can increase the yield based on natural recharge through rainfall from this resource.
- Increased awareness of the scarcity of natural water resources.

A study done by Sydney Water in Australia (NSW, 2008:6) calculates that approximately 56 per cent of household water can be considered as grey water, while Hunt (2004:124) quoted a figure of 58 per cent. The figure calculated using the Netherlands as a case study (see section 4.12) was 66 per cent. The situation in low cost areas in South Africa is not well-documented, but it is estimated that up to 75 per cent of the water used in low cost areas, specifically non-sewer areas, can be considered as grey water (Carden et al., 2006:2–8). It is clear that a significant portion of household water can be considered as grey water with a potential to be re-used.

Important considerations for the use of grey water at the household level include:

- Irrigation of lawns and flower beds. Topsoil is the biologically active part of soil, and acts as an effective purification medium for grey water.
- Not to be used on vegetables that are eaten uncooked.
- Need to be used on a daily basis. Grey water cannot be stored without special treatment.
- Use preferably on flat areas where the soil has good infiltration properties to prevent a built-up of salts in the soil.
- Municipalities might have regulations, mostly related to health risks that need to be adhered to.

McKenzie et al. (2003:144-145) add to this list, focussing specifically on municipalities:

- Potential end-users might have seasonal demands.
- A separate distribution system will be required.
- Potential harmful effects on products and equipment (corrosion).
- Potential harmful effects on human health, and aesthetic impacts (odours).

Patterson (2007:254) warns that the solution to the increased level of impurities is not likely to be resolved easily, since it will require intervention through regulation from politicians to control the content of products used at a household level, like washing powders. It is suggested that the use of grey water should be done carefully on a rotation basis with treated (pure) water to assist with the drainage or flushing of these impurities.

Du Plessis (2005:156) highlights the lack of co-operation between a number of municipalities in the Western Cape Province to re-use final effluent, stating that only five of the twenty-five (less than 20 per cent) towns with formal treatment facilities utilise their final effluent to any extent.

The NWA (RSA, 1998a) requires an authority to apply for a licence to utilise final effluent, and the approval thereof depends on a number of factors, but specifically the quality aspects involved in the application of the effluent, again emphasising the importance of the management of the full water cycle.

Besides the already highlighted quality and technical problems, the social impacts associated with the use of treated effluent also needs special attention. Religious groupings, such as Muslims, might not find the re-use of effluent an acceptable alternative, and the implementation of such a project might therefore conceivably result in social difficulties. Jackson and Ord (2000:39) conclude that the challenge of re-using water at a household level is indeed a public attitude issue, which needs to be changes.

4.14 Dual Water Supply Systems

Certain water requirements at a municipal level can be satisfied with water of a lesser quality than what is normally expected for human consumption. At the household level, sanitation systems can be earmarked for a water supply of a lesser quality.

Irrigation at a household level and the irrigation of public open spaces maintained by municipalities can also be considered, although the quality of the water still needs to be of a sufficient standard to sustain plant growth without any long term negative impacts on the plants and soil. At an industrial level, water supplies for cooling and dust control are only two applications for water supply of a lesser quality.

Two options exist as alternative water resources when water of a lesser quality is considered. The first is the supply of treated effluent, which has been described under the re-use options. Secondly, water from an alternative resource, such as boreholes with a high mineral content, can be used to supplement the water requirements. In both cases, the water needs to be supplied through an additional distribution system, resulting in the implementation of dual water supply systems.

When a dual water supply system is contemplated, a number of considerations need attention (Pienaar, 2008):

- Pipes used need to be clearly marked (see Figure 4.14) and should be of a different colour to those pipes conveying treated drinking water.
- Markers and fittings such as air valves need to be clearly marked at the surface for public health reasons (see Figure 4.14).

Figure 4.14: A clearly marked manhole cover and warning sign

- When water of a lesser quality is supplied to households, like brackish water for sanitation purposes, the installation at household appliances needs to be adapted to allow for the corrosive nature of the water.

4.15 Pricing Strategies

Changing the pricing structure for water-related services can affect water consumption. Water tariffs are one of the tools available to municipalities to try and reduce water demand, but the setting of a tariff needs to adhere to legislation.

The NWA (Act 36 of 1998) (RSA, 1998a) makes provision for three types of water use charges:

- Water resource management.
  These charges deal with the information gathering, monitoring and the control of the water source, as well as protecting the environment through the Reserve.
- Water resource development and use of waterworks.
  Charges will be imposed on end-users like municipalities, industry and agriculture for the specific consumption of water, and will aim to recover capital and the operating cost of infrastructure.
- Equitable and efficient water allocations.
  As a last step, national government can introduce administrative charges to facilitate the most efficient use of water, through the process where water can be traded between different user groups.

All of the above-mentioned charges will, when implemented, form part of the actual price of water to be paid by the end-user. The main portion of the tariff will, however, be calculated to reflect the costs incurred by a municipality to supply this water to the end-user. This portion of the tariff consists of two components (RSA, 1998a):

- Fixed cost.
  These costs are independent from the volume of water used by the end-user, and include costs such as management and capital redemption costs.
- Consumption-based cost.
  These costs are directly linked to the actual volume of water used, and include aspects such as purchase cost, chemicals for treatment, electricity cost for pumping the required volume of water and other maintenance costs.

Any municipality therefore needs to ensure that it implements a tariff structure that will be fair to all end-users, but at the same time ensure the sustainability of the service. The free water policy implemented in South Africa by most municipalities aims to address the issue of affordability and the minimum level of service to be applied. In practice, this results in the delivery of 6 kl of water per household per month, free of charge, to households that cannot afford to pay this service.

The concept of free basic water will not necessarily support effective water use. In areas such as South Africa where there are limited water resources, it might be worthwhile to use water tariffs at all levels to ensure effective water use, and to support the indigent user through alternative financial means (Mohamed and Savenije, 2000:253).

Water tariff structures can be based primarily on two principles:

- Volumetric-based structures.
  The tariff structure is directly linked to the actual metering of the use of the water.
- Non-volumetric-based structures.
  No metering takes place and charges are based on a flat rate for a specific user group or area.

The non-volumetric tariff structure does not allow for any WDM incentives, and is quite often difficult to control. To manage possible over utilisation, flow control devices should be used in these areas.

A tariff structure based on measured volumes needs to take the free basic water principles and the difference between fixed cost and consumption-based cost into consideration, and therefore consists of at least two components: a basic monthly charge to cover fixed costs, as highlighted above, and a consumption based charge that depends on the volume used.

The most appropriate application of such a tariff structure in terms of WDM is the implementation of a block tariff structure where an end-user will pay progressively more per kl water used as his consumption increases. Table 4.3 illustrates a typical block water tariff structure.

Table 4.3: Block water tariff structure

Amount of water used in kl	Cost
0	R20.00 (fixed)
0-6	R 2.50 / kl
6-20	R 4.80 / kl
>20	R 6.50 / kl

The advantage of the block water tariff structure is that the tariff for specifically the higher consumption can be raised to such an extent that it will enforce water savings and effective water use at a household level for those households consuming significantly more water than can be considered reasonable. A study conducted in Australia (White et al., 2003:28) shows that pricing has little effect on indoor use, but that it does have a significant effect on outdoor usage.

The disadvantage of implementing a block tariff structure as a WDM method is the need for consistent and accurate water meter readings to enable the end-user to manage his use. In areas where people can afford the increased cost of water, the block water tariff might not have any effect on the actual water use patterns.

It is not only at the supply side of the water management cycle where water tariffs can be used to achieve water savings, but the same principle also applies to the return flow side of the water management cycle. Section 56(5) of the NWA provides for the applying of charges related to return flows, and more specifically to the quality of the return flows, with the objective to, among other aspects, promote the efficient use of water resources (RSA, 2005:26).

Municipalities should also follow the polluter pays-principle and ensure that the tariff structure for the discharge of waste water into the collection system reflects the volume and quality of the waste produced. One of the shortfalls of such a system at specifically the smaller municipal level is the ability of the municipality to manage these aspects through proper metering and water quality analysis. The principle assumes that, if the tariffs for the discharge of waste are set at an appropriate level, it might become feasible for the specific industry to look into recycling or onsite treatment of its effluent in order to either reduce the volumes produced or at least improve the quality of the waste produced.

4.16 Financial Considerations

The continuous increase in water demand results in a shortage of water supply or a limitation in the capacity of the existing infrastructure. This problem can be addressed by either increasing existing capacity or reducing demand. The increase of existing capacity implies the construction of capital projects, whereas the reduction in demand implies the implementation of WDM strategies.

The implementation of WDM has two primary economic benefits. It can reduce the operating cost of existing supply systems by reducing losses, but it can also delay the implementation of capital projects by reducing the current demand. Although the implementation of a WDM strategy will not eliminate the capital project, the delay will have a financial benefit due to the time value of money.

To evaluate these two alternatives, the cost/benefit ratio, or the unit reference value, can be calculated and the options compared to each other. The cost/benefit analysis evaluates the benefits received from a project against its cost, while the unit reference value allocates a unit value as a cost per kilolitre of water to each alternative scheme over the total life cycle of the scheme, which information can be used as part of the decision-making process.

Although different financial evaluation methods exist to support decision-making in the water sector, this section deals mainly with two well-used methods in the South African context. Decision-making through DSSs that will be illustrated in Chapter 6 cannot be implemented in isolation. The DSSs will present the manager with more than one possible option and, unless the tools presented in this chapter are applied, the risk exists that a WDM criterion or project will be implemented at a cost that might not be necessarily the most economical option available. With limited resources available at a local authority level, wrong decisions can have a serious impact on available funding, specifically in the smaller local authorities.

The relationship between water price and usage is important. The general perception of this relationship – that an increase in the price results in a decrease in the usage – is illustrated in Figure 4.15 (Veck et al., 2000:5–4, Stephenson, 1999:118). This relationship is known as price elasticity.

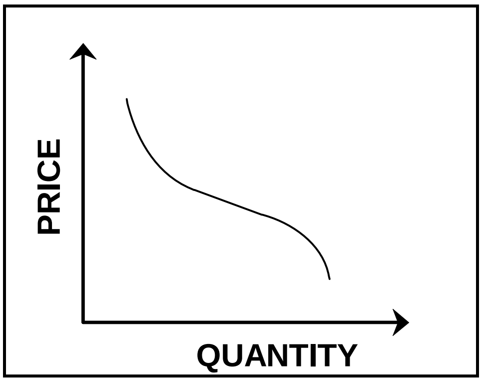

Figure 4.15: Price elasticity

The effect of price changes on water demand will differ depending on the position on the graph (Van Vuuren et al., 2004:3–8). This will be different for each consumer, as it is a matter of perception. The local authority must therefore know their consumer profile if they wish to understand the impact that an increase in the price of water will have on usage.

4.17 Summary

This chapter provided an overview of a number of methods that can be used as WDM tools, and information that can be used in the decision-making process. From the background information provided, WDM must be implemented at all levels of the water management cycle: from the source to the discharge of treated effluent back into receiving water bodies.

The value of adequate and reliable data on which water management should be based, has been illustrated. The basic principle is to first, through proper metering, establish the present conditions of the water supply system. The results need to be evaluated against external and internal PIs, so as to evaluate the present situation. New benchmark values can then be set as new objectives. The water audit is a tool that will enable all municipalities to identify problem areas on which they can focus.

It is unlikely that all WDM methods can be implemented at once in all communities with the same rate of success, and therefore careful planning must precede any WDM exercise. With limited funding, choices between the implementation of different options (pressure management, dual systems, re-use of water and retrofit) need to be made, and the importance of an appropriate financial evaluation has been highlighted.

The level of awareness among the general public plays an important role and needs to be evaluated carefully. A distinction has been made between water restrictions, water curtailments and WC/WDM and the impact with reference to duration of impact has been made.

Effective implementation of WDM can only be achieved through a systematic step by step approach that will be presented as a number of DSSs as part of the integrated model, in Chapter 6. These DSSs will then be evaluated against a case study, presented in Chapter 7.

In the next chapter, a number of studies conducted among local municipalities in the Western Cape Province to gain insight into the functionality and implementation of effective water-related decision-making, will be presented. Lessons learned from these studies will be used to develop the model for integrated decision-making in municipalities to ensure effective WDM.

CHAPTER 5
BUILDING BLOCKS TOWARDS A DECISION SUPPORT SYSTEM: THE BACKGROUND STUDIES

5.1 Introduction

Based on the theory and literature review on governance, decision-making, WDM and public participation, a number of DSSs, which will support the model for WDM decision-making in municipalities to ensure sustainable integrated development, will be presented in Chapter 6.

Chapter 4 provided the different technical options for WDM at a municipal level. In this chapter, the findings of the research on the three main areas (Performance indicators in Western Cape, implementation of WDM and public participation and the Robertson case study), conducted to ensure that the conditions at a municipal level are well-understood and that lessons learned from these studies can be incorporated in the model, will be presented.

Studies were conducted from as early as 2002 till 2006, to coincide with the practical implementation of projects at a municipal level and also to provide a case study opportunity during a specific time frame when water stress situations exist at a municipal level. The three main research projects included:

- A study to determine specific benchmark values at a municipal water supply level will be referred to as the Performance Indicator study (PI study). This study was conducted by the author, through the processing of data from questionnaires and WSDPs collected at different local authorities in the Western Cape. The data was analysed by the author, and will be presented in section 5.2.
- An investigation into the development of an implementation process for WDM, with the focus on how to initiate a WDM project at a municipal level, will be referred to as the West Coast Study (WC study). This study was done with the assistance of a communication agency, CopyCat.
- A study in co-operation with the DWA and water institutions in the Netherlands, in accordance with the SANOW (**S**outh **A**frican - **N**etherlands co-operation **O**n **W**ater management) agreement, to implement the model to be presented in Chapter 6 as a case study in Robertson, in the Western Cape, South Africa. During this process, the author was appointed by the DWA as the responsible person for the implementation of WDM at Robertson. The author collected the relevant data from the authority, analysed it and, through a number of workshops arranged by the author under the auspices of the DWA, presented the results to a wide variety of

stakeholders, which included almost all of the municipalities in the Western Cape. Their input during the stakeholder meetings was then incorporated into the DSSs that will be developed and presented section 5.4.

The implementation of the model in the Robertson case study will be analysed separately in Chapter 7.

5.2 Performance Indicator Study

The lack of reliable information frequently results in an absence of good decision-making. For this reason, a study into a number of PIs, used to set benchmark values, and related issues regarding the water sector at a local government level – generally referred to as the PI study – was executed in 2005. The need for these PIs has been discussed in section 4.5.

While it is recognised that benchmarking through PIs is a continuous process that can be improved as information becomes available, three basic indicators were identified to assist decision-making at a municipal level, based on the availability of information during the research period. They are:

- per capita consumption;
- per capita UAW and
- per capita re-use of treated water.

These PIs are expressed as a value per capita. The reasoning behind this approach is that the general tendency to express water losses, for example, as a percentage of consumption does not provide a proper method for evaluating actual figures on which to base planning. Losses of 25 per cent of the consumption for a particular area might be a small volume and not warrant any further investigation, in terms of priorities.

Even though it is agreed that a number of factors can influence these per capita benchmark values, it at least provides a starting point for a municipality to position itself with respect to other municipalities in the same area. Besides the actual value of the benchmark, the process of benchmarking and comparing one municipality against another will also support constructive debate as to what the reasons for differences might be, and hence facilitate discussions to improve management of the water cycle.

Most of the data required was originally retrieved from the relevant WSDPs as compiled by the municipalities, but it was soon clear that the available data in these plans were either not truly representative or not reflective of the data from the same reference year, which made comparison between municipalities difficult.

An understanding of the level of awareness regarding WDM among water managers in municipalities was also required. To achieve this goal, a questionnaire was prepared and distributed among fifty-six different communities or towns within two river catchment systems in the Western Cape, namely those of the Berg and the Olifants/Doorn rivers. Questions relating to population figures, consumption figures, capacity of resources and infrastructure, income levels, legal status of resources, tariff structures, awareness campaigns and the ability to adhere to legal requirements, were asked. An example of one of the responses to such a questionnaire is presented in Figure 5.1.

Besides the benchmark values calculated from the data analysed in the PI study (Du Plessis, 2005:158–159), the study also highlights the following concerns:

- Only 30 per cent of the communities investigated have sufficient water resources available to sustain them for more than a five-year planning period.
- Few authorities know their projected long term demand, and even fewer know the assumptions used to formulate these projections.
- The lack of available reliable information, specifically flow meter data, that can be used to do effective planning, was evident. Only seven of the 56 towns (12.5 per cent) investigated could provide figures for the volume of treated effluent returned to the source, while only sixteen of the 56 towns (28.6 per cent) were able to provide figures for the volume of sewage received at their treatment works.

Significant progress has been made since 2005 to improve the available information to do proper planning. It was, however, evident that only a small number of municipalities have access to sufficient human resources to evaluate or to do the proper planning with the available data. This statement can further be supported by the fact that only 50 per cent of the municipalities interviewed during the PI study were in a position to compile their own WSDPs, a legal requirement, using their own human resources. The rest used external consultants to compile their WSDP. The situation is reason for concern since the WSDPs were introduced to facilitate the planning process within the water sector at a local government level.

SALDANHA BAY MUNICIPALITY: WC0 14	Population (2002)	Consuption (kl/a)	Consuption (l/c/d)	Storage Capacity. (kl)	Storage Capacity. (kl/c)	Treatment Capacity for Potable water (kl/d)	Treatment Capacity for Potable water (kl/c/d)	Un-accounted for water (kl/a)	Un-accounted for water (l/c/d)	Treatment Capacity for Sewega (kl/d)	Treatment Capacity for Sewage (l/c/d)	Sewage Production for 2002 (kl/a)	Sewage Production for 2002 (kl/a/c)	Re-use of water in kl/a	Re-use of water in l/c/d	Discharge (kl/a)	Discharge (kl/c/d)	Abstraction approved by DWAF (kl/a)	Water Resource
SALDANHA	23 220	1 706 051	201	13 600	0.59		0.00	234 878	28	2 500	107.67			59 400	7.01				Bergriver System. Withoogte
VREDENBURG	38 700	1 376 783	97	8 750	0.23		0.00	504 832	36	4 200	108.53			360 000	25.49				Bergriver System. Withoogte
LANGEBAAN	5 295	854 340	442	6 100	1.15		0.00	98 249	51	1 400	264.40			299 160	154.79				Bergriver System. Withoogte
HOPEFIELD	5 136	275 530	147	1 193	0.23		0.00	58 976	31	480	93.46			10 800	5.76				Bergriver System. Withoogte
																			7 boreholes
PATERNOSTER	1 720	90 395	144	1 227	0.71		0.00	20 477	33	500	290.70			0					Bergriver System. Withoogte
ST HELENA BAY	8 600	1 346 282	429	7 150	0.83		0.00	177 682	57	1 800	209.30			108 000	34.41				Bergriver System. Withoogte
JACOBS BAY	500			1 000	2.00		0.00	Incl Vred		0				0					
TOTAL	**83 171**	**5 649 381**		**39 020**		**0**		**1 095 094**		**10 880**				**837 360**					
AVARAGE			243		0.82		0		39		179				45				
	72 994																		

POPULATION	1990	1995	2000	2005	2010	2015
SALDANHA	20704	25157	23220	30178	39254	51061
VREDENBURG	28125	34174	38700	50340	65481	85176
LANGEBAAN	3798	4615	3440	4474	5819	7569
HOPEFIELD	3826	4649	10320	13424	17461	22713
PATERNOSTER	823	1000	1720	2237	2909	3784
ST HELENA BAY	11833	14378	8600	11186	14550	18926
JACOBS BAY	316	384	500	650	845	1099
OTHER						

	R/kl/month					
2002 **TARIFF STUCTURE**	Basic	<20kl	20 - 30 kl	30 - 50 kl	50 - 100 kl	>100 kl
SALDANHA						
VREDENBURG						
LANGEBAA						
HOPEFIELD						
PATERNOSTER						
ST HELENA BAY						
JACOBS BAY						
OTHER						

WATER DEMAND MANAGEMENT

List all activities and discuss/doc those that work and those that did not.

Activities that do not work:
1.Targets for reducing unaccounted for water and water inefficiencies (Ml/year): Rural
2.Leak and meter repair programmes: rural
3.Working for water programme
Activities that do work:
1.Water restrictions: No irrigation between 10:00 - 16:00 - Good
2.Step tarriff water - Good
3.Wet industries tarriff - Good
4.Zone district and area controle meters - Good
5.Controle meter linked to telemery
6.Re-use of treated effluent - 37%
7.Flow enablers in conjunction with debit control - good
8.PRV - control
9.Flow control
10.Meter replacement program
11.Bulk water allocations to bulk users
12.Night flow monitoring

CUSTOMER CARE

What is in place?
All complaints is recorded
Average problem resolve time is 4 hours
24 hour service
Supply 98% of the time
Pollution awareness:
The WSA do have an pollution awareness programme

Beginner Farmers

Any Yes

Project Vredenburg Small Farmers
50 Members on a 100 ha for small stock breeding

Capacity of Operating staff and management staff:

Capacity of Operating staff and management staff:

Operating staff
Numbers per treatment facility and qualifications i.e. grade of operator (Class 1,…6)
Assistant Town Engineer - Mr Pierre Maritz (B. Tech Engineering Civil)
Senior Technical Assistant - Mr Wilfred Titus (National Diploma Civil Engineering)
No water treatment works but only sewer treatment works
1No x Superintendent (Diploma)
12No x Class 0 Operators

Management staff
Town Engineer - Mr Martiens Victor
Deputy Town Engineer - Mr Gerrit Smit
Assistant Town Engineer - Mr Pierre Maritz
Senior Technical Assistant - Mr Wilfred Titus

Time spent on WSDP?
90% - Mr Pierre Maritz
10% - Mr Wilfred Titus

Who/Capacity?
Assistant Town Engineer - Mr Pierre Maritz
Senior Technical Assistant - Mr Wilfred Titus

Access to Basic water and sanitation Services :

List communities still lacking and give numbers???
Water:
All residential and informal erven supplied with watermetrs and standpipes
Approximately 500 people use 3 standpipes supplying 25/l/c/d within a 200m radius

Sanitation:
All residential erven have sanitation facilities
292 informal erven need sanitationonly 15 toilets currently installed (Middelpos area in Saldanha)
Approximately 500 no. have no sanitation facilities

Institutional Arrangements
Water Service Authority:
Saldanha Bay Municipality is a Water Service Authority in terms of Act 41
The municipality is busy to investigate how the water for the area will be managed in terms of Act 78 of the systems law
A consultend is already appointed to deal with this issue

Disaster Management Plan

Yes
Water masterplans hvae been drawn up for all the areas in the municipality. All information is logged, telemetric controlled and their is enough manpower to deal with a disaster

Floodlines shown/known ?

Yes
This is indicated on all the stormwater masterplans and no developments will be approved if
is beneath the 1:50 floodline. There are two floodlines in the area Bokriver (10m) and the Zoutriver.

Figure 5.1: Typical questionnaire to municipalities

The PI study revealed that the most available data source from all the participating municipalities was the actual bulk water consumption, measured directly after treatment, as it enters the distribution network of each community.

No differentiation was made between the various end-users in the calculation of the benchmark values. The main assumption was that the ratio between industrial use and household consumption is more or less the same for all of the communities, and this approach needs to be kept in mind when applying the benchmark values.

The data gathered was used to calculate benchmark values for the per capita consumption, per capita UAW and per capita re-use of treated effluent. These three PIs were considered to be the most appropriate PIs to be used with the DSSs.

5.2.1 Performance indicator: Consumption

Research conducted during this study in a number of communities provided a wide range of per capita consumption figures, which are illustrated in Figure 5.2 below. These values were based on data that was considered and reported to be easily available, i.e., actual bulk water consumption, measured directly after treatment, as it enters the distribution network and population figures based on official census data. After a breakdown of the various types of end-users and income levels was attempted, it was found that only a limited amount of correct and acceptable data was available on which further analysis could be based.

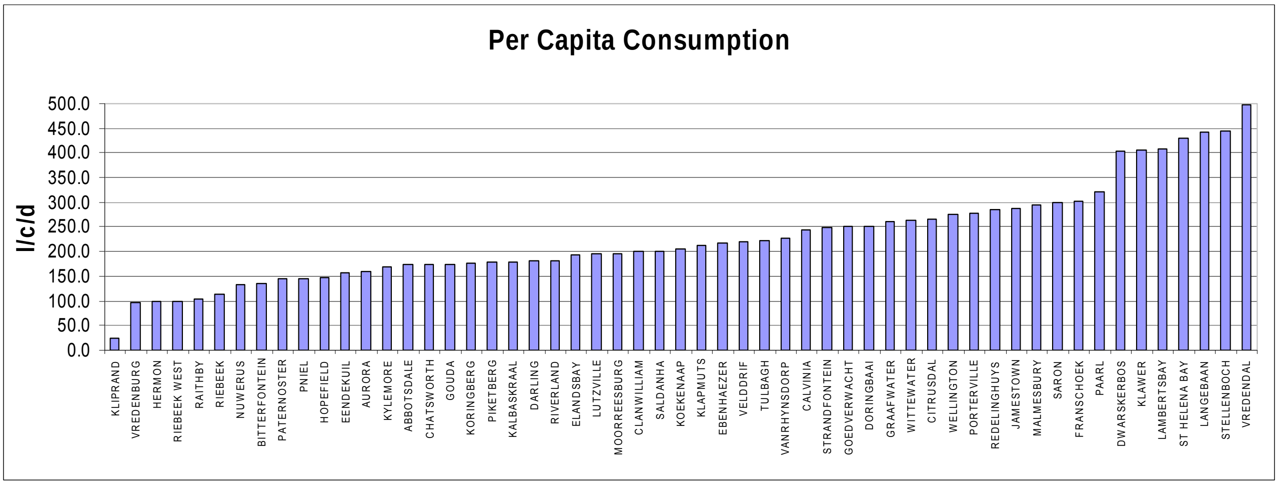

Figure 5.2: Per capita water consumption figures: Western Cape

Figure 5.2 provides a wide range of per capita consumption figures (between 200–300 l/c/d, with an average of 242 l/c/d) for communities in the Western Cape in South Africa, which compared well with international figures provided in the literature, as shown in Table 4.1.

5.2.2 Performance indicator: Unaccounted-for-water

Figure 5.3 shows the UAW expressed in litres per capita per day, for different municipalities, calculated during this research project. The calculated average value was 39 litres per capita per day, which represents 16 per cent of the average per capita consumption.

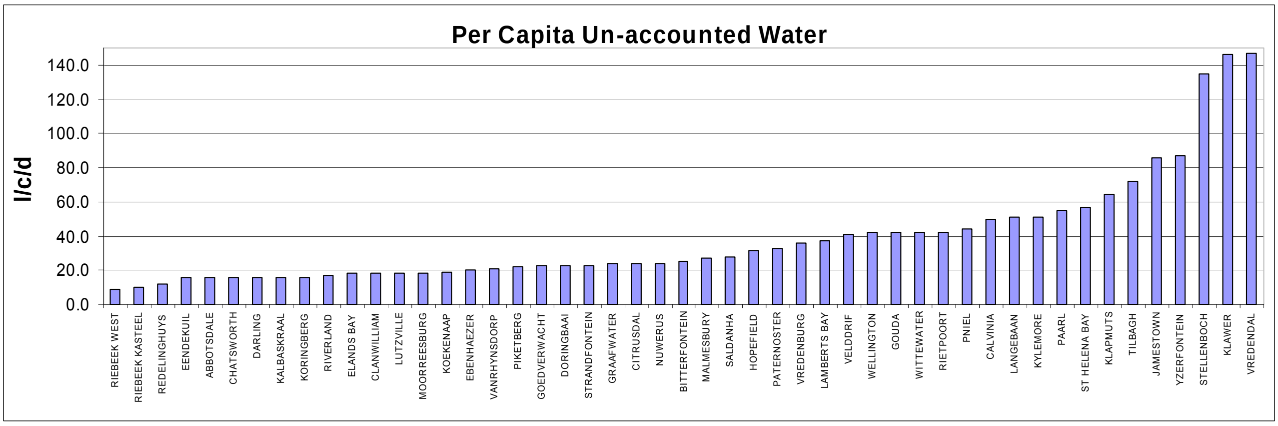

Figure 5.3: Per capita unaccounted-for-water

The UAW figures shown in Figure 5.3, expressed as a percentage of usage, varied between 8 and 38 per cent, which compared well with international (14–42 per cent) and main South African cities (32–42 per cent, see section 4.7). The average of 16 per cent was considered to be surprisingly low.

5.2.3 Performance indicator: Re-use of final effluent

Only five of the 25 (less than 20 per cent) towns with formal treatment facilities utilise their final effluent to any extent; they only re-use about 1 per cent of their effluent. The re-used water is almost exclusively used for the irrigation of either sports facilities or golf courses. Only one of these municipalities indicated that they consider their final effluent as a valuable resource that can be used to generate additional income.

The benchmark values for municipalities re-using their final effluent are shown in Figure 5.4.

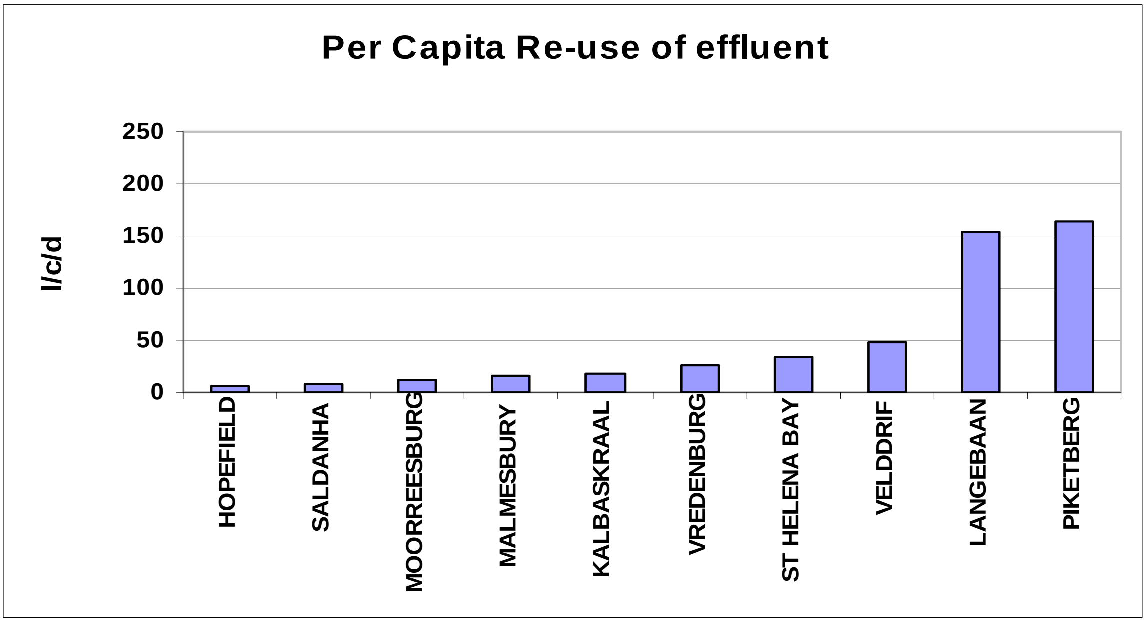

Figure 5.4: Per capita re-use of final effluent

5.3 West Coast Study

During a study in 2002/3, generally referred to as the WC study, a number of important lessons were learned regarding public participation at a municipal level, and specifically regarding the expectations of the different role-players regarding WDM.

During this study, which was conducted through thirteen interviews with key municipal officials and telephonic contact with a further twenty-two key role-players, done by an agency (CopyCat, 2002:2-14) commissioned by the author, a wider range of participants were questioned about their expectations and suggestions regarding the water situation in general. The participating area included the area that was used for the collection of data through questionnaires in fifty-six towns during the PI Study.

After an extended period of low rainfall and an increase in water demand due to local developments, the West Coast District Municipality was faced with serious water shortages. A number of immediate control measures, which included step water tariffs, penalties and the restriction on garden watering hours to mention only a few, were put in place. With "emergency" measures in place, it was decided to investigate the launch of a properly planned WDM strategy, and the need to involve the community was identified as critical to the success of such a project.

The main objective of this study was to produce a model for the implementation of a water awareness campaign for the area served by the author[1] at the time. The results provided important insights into the perceptions among role-players regarding water saving issues, which were incorporated into the DSSs. It will, however, not be correct to try and use it as a general model for all circumstances, and the model presented during this study must only be viewed as a guideline for such a process.

5.3.1 Municipal co-operation

The first step in the process of implementing WDM at all levels was to ensure co-operation between all the municipalities involved. The West Coast District Municipality, a category C municipality (refer to section 3.5.4), is responsible for the supply of bulk potable drinking water to approximately fifteen different towns or communities in its area of jurisdiction, and the water scheme can be considered to be a regional scheme. The supply area includes three different category B municipalities, which means that close co-operation needs to be in place between all the relevant role-players. The category B municipalities are responsible for all the water distribution and related aspects in their area of responsibility, and they are therefore the link with the end-user. They are also directly responsible for the return flows.

To ensure progress and cooperation within the supply area, a task team consisting of officials representing all the water sectors in the area of jurisdiction was established. This meeting convened on a monthly basis, and needed to collect and supply all the relevant data to do a proper water audit. Based on the audit, it was decided to embark on a WDM campaign to save approximately 15 per cent of the bulk water consumption.

The importance of the participation of the public was identified as a high priority; to understand the needs of the communities involved, it was important to get their input. This was done through discussions among a selected group of water users. These included groupings such as industries, authorities, schools and end-users. The names of initial role-players were collected from the different municipalities involved, and care was taken to allow for an even geographical spread of participants. The main objective was to establish the level of awareness among the users, and to get some initial input from a selected number to start the full process.

[1] Mr JA du Plessis was the Director of Water Supply at the West Coast District Municipality from 1996 till 2003, during which period WDM was implemented as a key strategy to ensure a sustainable water supply for the area.

The discussions were held on a personal interview basis and the following key points of interest were identified (CopyCat, 2002:5–14):

- Awareness
  Due to a drought, most people were aware of the water problem, but the level of awareness as to what could be done at a local level was low.
- Integrated Approach
  There was a good understanding that the problem could not be resolved only at any particular phase of the water management cycle, but that every aspect of the water cycle needed to be integrated into the process.
- Unique Approach
  Participants felt that WDM could easily become a buzz word, with every authority spending some money and attention on the issue. In order to really make a difference, it was considered essential to follow a new and a unique approach towards this issue in the area.
- Participation
  The need for participation on a broad basis was identified as a key element of the proposed procedure.
- Community-based
  It was set as a pre-condition that the project needed to be community driven, and not through the existing municipality structures.
- Management Committee
  The need for the establishment of a management committee was considered to be important.
- Promotional material
  A lack of good promotional material was identified as important.
- Volunteers
  It was a surprise finding that participants were not interested in money, although it was important, but that they considered themselves to be volunteers who must be seen to take part in the process because they believed in the need for the process to take place.
- People the main focus.
  The importance of changes in attitudes was highlighted. Although it was recognised that aspects like pressure management and leak detection were important, there was a strong feeling that these would automatically be addressed once the general attitude towards water consumption was addressed.

5.3.2 Results from the West Coast study

All of the issues raised by the different stakeholders during the process were evaluated by the officials[2], and the results were then summarised as follows:

- All of the participants were concerned about the water situation. There was, however, a clear lack of a person or institution to take responsibility for managing the situation.
- No two towns or communities shared exactly the same system regarding tariffs and water-saving measures.
- Some participants were worried that WDM might be implemented only in specific areas, resulting in a possible perception that only specific user groups are targeted.
- All municipalities were willing to participate, and some even confirmed their financial commitment to the project.
- Schools played an important role in the process of educating communities in proper water management behaviour. The media, tourism, industry, clinic and hospitals also need to be involved.
- The need for a management committee to coordinate all these activities was clear.
- A network of participants would be required to ensure sustainability.

The challenge was to produce a model that addressed all of these concerns. With these critical points in mind, a management structure was devised where people were the focal point. The roles and responsibilities of the different government structures in relation to the management committee are illustrated in Figure 5.5.

2 The results of the discussions held with the different stakeholders were recorded in various minutes of meetings between the individual municipalities during the investigation.

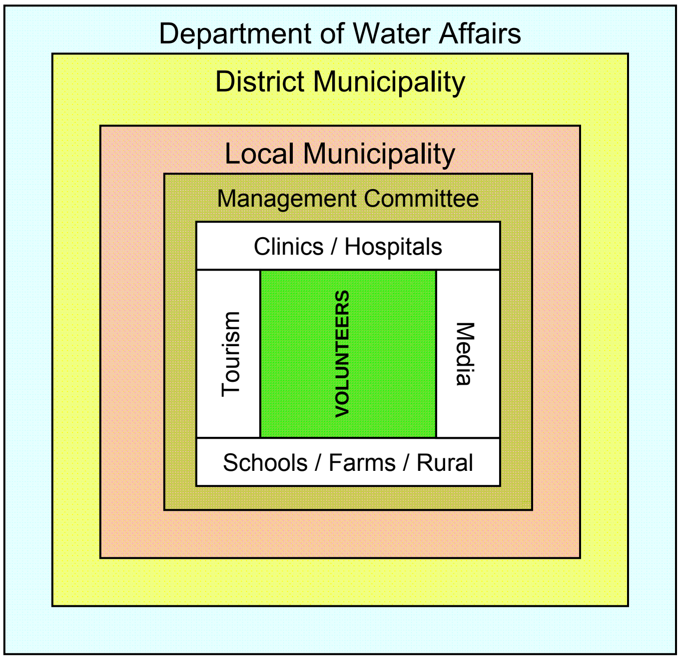

Figure 5.5: Management structure for managing WDM

The roles and responsibilities of each of these role-players within the model, to ensure effective stakeholder engagement in the water sector, were identified as follows:

- Department of Water Affairs
  Their support and financial assistance, where possible, were crucial.
- Municipalities: District and Local Municipality
  Within their areas of jurisdiction they needed to support the programme. Municipalities played an important consultative role and supplied resources where possible.
- Management Committee
  They were the focal point of the structure. The management committee consisted of volunteers from various groupings. They represented the campaign at grass roots level. They coordinated relevant information, analysed results and progress, and they ensured that participation took place at all levels of the structure.
- Volunteers
  The volunteers needed to accept the responsibility and the ownership of the project. As individuals, they interacted with the municipalities and the broader community.

Volunteers needed to be “appointed” based on their interest in the water sector and needed to be regionally well-represented to ensure effectiveness. Each volunteer was issued with an identification card, which identified him or her as a concerned citizen involved in the project. The aim and objective was to create an environment whereby the volunteer was honoured and privileged to carry the identification card. The card also gave a volunteer access to specific water-related information needed to manage the programme.

Once the volunteers were appointed, the management committee was elected from these volunteers. Financial support to facilitate travelling, telephone and other direct expenses was included in the budget. The management committee reported to the municipalities on progress, and identified problem areas.

After the different responsibilities of the various role-players were identified, a process was developed to illustrate how all these different aspects could be incorporated to ensure effective participation. The process was subdivided in two phases. The first phase required a preliminary intervention by municipal structures, while the second phase represented the operational stage, when the implemented structure started to function. The main aim of the process was to ensure effective stakeholder engagement. The flow diagram in Figure 5.6 illustrates the different phases of the process.

5.4 Robertson Study and Stakeholder Survey[3]

The inclusion of the Robertson case study flows from an international agreement between the DWA and the Netherlands, generally referred to as the SANOW-agreement. During the early stages of the study (2003/04), water supply problems were experienced in Robertson, from both a quantity and a quality point of view. To assist Robertson, the DWA offered their resources, through the SANOW-agreement, to provide support with the implementation of WDM on an integrated water resource basis and the improvement of the effluent produced by the wine industry, which is the major contributor to pollutants to the waste water treatment facility.

The municipality reacted to their water problems through the implementation of a number of steps to address them. During the implementation phase, five discussions were held with different role-players, and their opinions were requested as to how the problem could be addressed through meetings and workshops. The results of these meetings were used by the author to “map” the role players’ views and discuss the procedures used during the decision-making process. Lessons learnt from these exercises were incorporated into the DSS presented in this study.

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[3] The author was appointed by the DWA to be the manager responsible for the implementation of WDM as part of integrated water management in Robertson, a project funded and managed jointly between the DWA and water institutions from the Netherlands, as part of the SANOW-agreement. Most of the work reported under this section is based on the inputs from various role-players whose comments have been captured in various minutes of meetings held as part of this process.

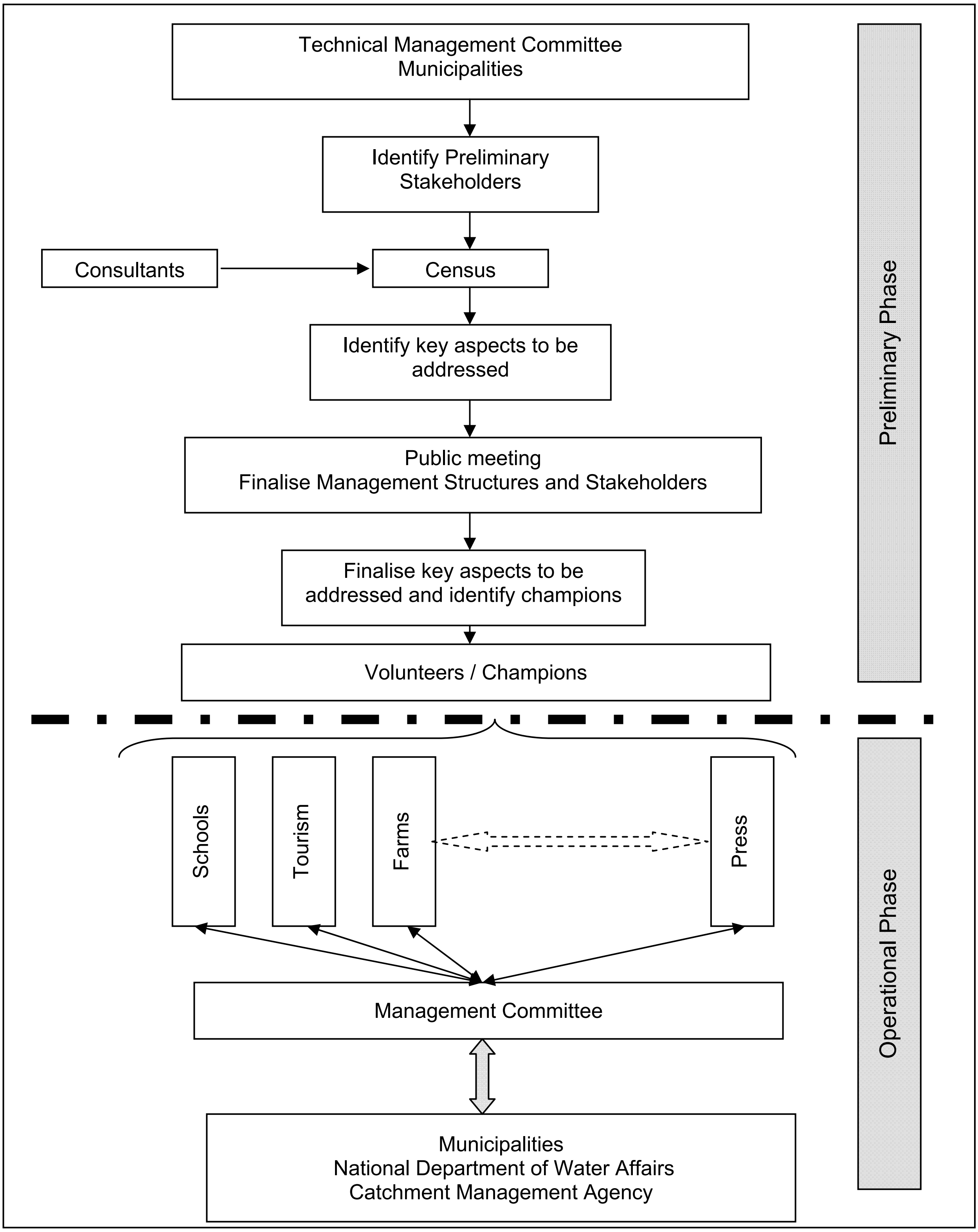


Figure 5.6: Two-phased process for stakeholder engagement

The resulting DSSs were again analysed towards the closing phase of the project, approximately two years after the original workshop. The author presented his views to the participants, and their responses and input were again incorporated into the DSSs.

The objective of the Robertson study was to incorporate all of the comments made during discussions with all the different role-players into the final DSSs, and to highlight specific issues such as benchmark values and awareness campaigns in the implementation phase of WDM. One of the areas also investigated during the Robertson case study is the actual decision-making process used to facilitate the implementation of the different projects, which will be described in the next section.

5.4.1 Implementation process

The decision-making process within the municipal framework starts, and is directly linked with, the IDP process. Municipalities are compelled by the Municipal Systems Act (Act No 32 of 2000, Section 16(1)), to hold public meetings in their communities to determine all the needs of the communities and assist with the prioritisation of these needs. Although the IDP for Robertson contains general references (BRWM, 2005:94) to a secure and safe water supply, no specific aspects were raised during the IDP meetings, which take place once a year. The projected capital expenditure list reflects that an upgrade of the waste water treatment works was required in due course, given the poor quality of water returned to the resource.

As part of the IDP process, the Breede River/Winelands Municipality (BRWM) implemented development forums. These forums provided a platform for the municipality to monitor its progress regarding service delivery. Although forum meetings, which were scheduled to be held on a monthly basis, were open public meetings, specific representatives of organised groups (municipalities, police, schools, museums, tourism, industries, labour unions, church groups, sport and community services) formed the basis of its membership.

These meetings provide the opportunity for the public to give their input on progress related to the implementation of the IDP. Although not the same, the development forums function in the absence of ward meetings, as previously described. Within the area of responsibility of the BRWM, a forum for each town was established, which was convened by the municipality under the guidance of the IDP manager, who is an official from the local municipality. Issues raised at these meetings were recorded and referred to the relevant municipality department for implementation, or would be included in the next IDP.

From these meetings, it was clear that the general public was not always aware of the technical challenges facing the municipality, and officials often have to “guide” the public towards understanding that, for example, an upgrade of a water treatment works is a prerequisite for the provision of additional low cost housing. The interaction and intervention of the officials in the identification of problem areas were once again evident.

At one of the earlier public meetings a number of possible water saving interventions were presented. Besides these proposed interventions, participants were also requested to provide some information on what they could do at ground level to reduce their water demand. After some changes to the original proposal, the BRWM Council approved a number of WDM steps as well as some water restriction steps, which will be described in Chapter 7.

After the SANOW-agreement was implemented, a workshop was convened to identify important aspects for further investigation. The workshop included presentations on institutional arrangements, integrated regional water planning, water use in agriculture, WDM and economic evaluation of water. The meeting was mainly attended by municipal officials and managers from industries in the area. The meeting concluded that the following aspects needed to be included in any future discussions[4]:

- Buy-in from council and establish appropriate committees.
- Awareness/public meetings driven by professionals.
- Pilot plans to build success stories and the establishment of champions.
- Do auditing.
- Water-saving devices.
- Use of recycled water.
- By-laws, e.g., rainwater harvesting.
- Pressure reduction.
- Leak detection.
- On-site dual systems.
- Management of backwash water in treatment works.
- Waste minimisation clubs.
- Tariff structures.
- Metering.

At a meeting, reporting on progress achieved with the SANOW-agreement, it was concluded that the lack of continuity at local government level was detrimental to the general progress, mainly due to the lack of leadership, since the technical manager was ill and not available to effectively participate; therefore follow-up or support did not exist. An

[4] Based on the minutes of the meeting held with representative from various municipalities who attended the workshop.

intervention was suggested by the project committee through the appointment of a so called "coach", who had to, through regular visits to the municipality, assist with the evaluation of data and gave some guidance, specifically relating to the water situation. The fourth progress meeting (in 2005) evaluated the incorporation of the identified issues into the WSDP.

All of these meetings were used to discuss the progress and findings regarding the development of the DSSs with the participants, and to give them feedback concerning the initiative to improve the final effluent from wineries. Input received through the discussions was also incorporated into the development of the DSSs. The fifth and final meeting during this research period took place in October 2005 and focussed mainly on the finalisation of the DSSs.

The main comments include[5]:

- All municipal water usage must be metered and billed.
- Tariff for industries can be low to enable economic growth.
- DSS can also apply to Metros and CMAs (larger authorities).
- Municipalities must set the example. A three-day waiting period before leakages are repaired is too long, and irrigation of lawns by citizens during the daytime must be banned.
- Water balances need to be done for each phase of the water cycle.
- Water audit must start at source.
- Industries dependent on the use of large volumes of water, e.g., car wash, should be policed by the municipality.
- Approval of rezoning and building plans must only be done if these plans are water conservation friendly.
- Cleaner production. Large industries have the staff available to attend to WDM, while smaller industries do not. Although small industries do not waste as much as the larger industries, there is a lot to be learned from one another and, with a combined effort, a great deal can be saved.
- Awareness about what (problem or solution)? Must be specified specifically to focus on public participation.
- The use of water tariffs to reduce water demand proofs to be effective.
- Communication problems exist between the Engineering Department and the Financial Department, which hampers an effective water audit.
- If one does not have personnel to handle the systems, the systems are useless.

[5] Taken from the unpublished minutes of the meeting held at Robertson.

- Benchmarking – municipality does not have access to benchmarking figures.
- Benchmarking must be used within the context of the how these values were calculated in the first place.

Figure 5.7 illustrates the decision-making process followed in the Robertson study.

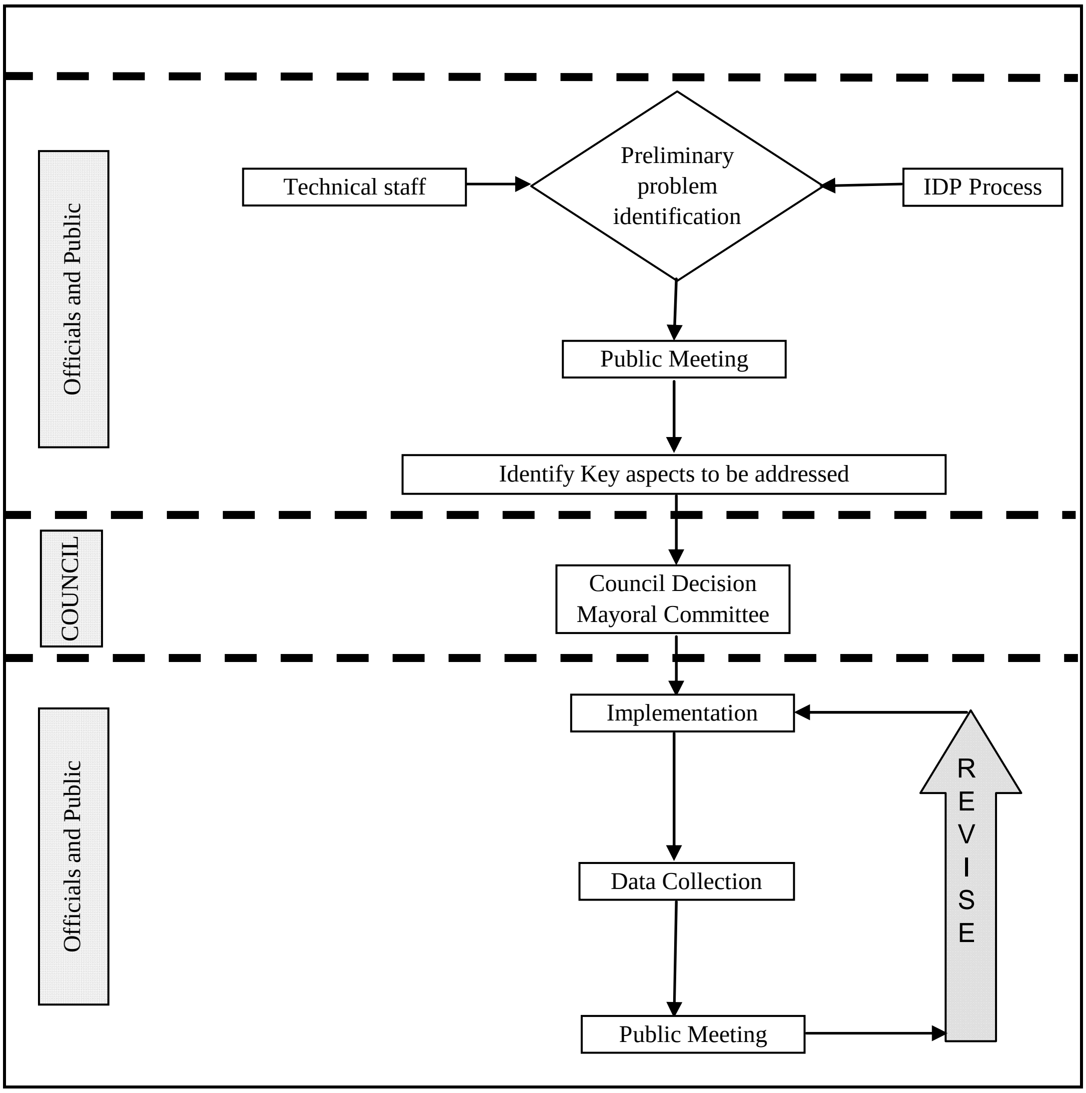


Figure 5.7: WDM implementation process

5.4.2 Awareness campaign

The first step undertaken by the BRWM to enhance awareness among all role-players was a public meeting, described in section 5.4.1, to discuss possible measures and contributions that can be made by the community. As a result of these discussions, a number of activities were suggested for implementation to promote this aspect.

- Involvement of schools.
  Visits to the treatment works were arranged, specifically during water week.

- Poster displays.

  Posters received from the national DWA were displayed in municipal buildings.

- Workshops.

  A number of workshops regarding effective water use and WDM were arranged for officials and main stake-holders at Robertson.

Other activities listed by specific individual user groups are summarised in Table 5.1 (KweziV3, 2005:8–9).

Table 5.1: Proposed WDM steps

Source	Proposed solutions
1. Montagu Springs	• Currently 60 per cent of parks are irrigated from the river. • Currently in the process implementing water-wise plants. • Any leakage on water mains and connections are immediately repaired. • Proposing a notice board for all visitors to promote water conservation.
2. Ashton Canning Company	• Installed a water saving irrigation system. • Frequent communication and monitoring between the cleaning staff on water conservation. • Investigations on re-use of water are being monitored through private consultants.
3. Parmalat South Africa	• Request integrated solutions from bulk consumers.
4. Excull	• Strive to notify employers about the implications of water conservation - query that the production rate will decrease. • Vehicles are only washed when necessary. • Currently no leaks at toilets, geysers and water mains.
5. Fleur Elite	• Tanks where compost is produced use irrigation canals (leiwater). • All leaking taps are repaired and monitored. • All employers have been informed about water conservation.
6. CoCo Residents	• Gardens are only watered once a week. • Vehicles are washed using buckets and not hose pipes. • Public awareness and participation is highly motivated. • Residents use showers instead of bathing.
7. Ashton Abattoir Bk	• Inspect all taps for leaks and report immediately. • Carcasses will only be rinsed at the necessary places. • Use bathing water for plants. • All taps are closed properly after every use.
8. Klein Karoo Baksteen	• Use brack water from boreholes, and liaise with Montagu Wineries to wet property, which controls the dust.
9. Robertson LOGOS	• Irrigation procedures are limited and only used during the night. • Information on water conservation is distributed amongst the children in all appropriate languages. • All leaking taps are repaired and monitored. • Tenants are requested to assist with the implementation of water conservation.

Source	Proposed solutions
10. KWV	• Continuous education for all employers occurs on water conservation. • Use brooms where necessary instead of hose pipes. • Leaks are reported and acted upon. • Tanks are washed using CIP trolley. • Rinsing and washing of vehicles is done conservatively. • Steam kettle uses the steam and transports it back to the kettle. • Use the wash water at the tanks.

These discussions contributed towards the general awareness among the participating users, a sense of willingness to participate was experienced and key aspects highlighted during the discussions were included in the DSSs.

Industries in the meantime created a “waste minimisation club” and began to benchmark water use in the different manufacturing processes used by the industries, which will be presented in the next section.

5.4.3 Industrial use

Wine cellars are the largest industrial water users in the BRWM area. Since all the cellars in the area are facing similar problems in terms of the effective use of water in their processes, they decided to form a working group (waste minimisation club) and jointly look into their different production processes.

A firm, BECO Institute for Sustainable Business, was appointed to analyse a number of cellars, in terms of their effectiveness with respect to water use, as part of the SANOW research work done at Robertson. These companies were not identified in the BECO report (Van Beoevenkamp et al., 2004:1) in order to protect their working agreements, and it was thus not possible to tell which cellars in Robertson performed well with effective water use and which did not. What is important, however, is that this structure was formed and that this initiative was working in close cooperation with the municipality. Not only does it make economic sense to streamline these processes, but one of the outcomes of such an investigation is also a well-logged water audit.

In summarising these results, it is interesting to compare the different companies’ water use in terms of tonnes of grapes processed and evaluate these figures against set benchmarks. Table 5.2 below lists the companies involved and their performance. Note the benchmark value (Van Beoevenkamp et al., 2004:6) provided in the last column.

Table 5.2: Process water used for different cellars

Company	A	B	C	D	E	F	G	H	I	BM
Water use in m^3/tonne grapes	0.34	0.81	2	1.26	0.73	1.2	0.49	0.35	0.63	0.87

Although all the processes used by the different cellars are not the same, it still provides valuable data regarding a reference value. This enables a specific cellar to understand its effectiveness in terms of its water use.

An analysis of where the water is typically used depends on the main focus of the specific cellar, but includes the following categories:

- Cleaning.
- Cooling.
- Boilers.
- Process.

Most of the water (50–60 per cent) was used in the cleaning activity, with cooling water the second highest consumption (40–50 per cent). Once again, it is a matter of understanding where the water is going, which results in successfully managing these processes.

The purpose of highlighting the wine cellars as a specific industry serves to provide an example of a benchmark for specific PIs. The importance of these benchmarks was incorporated in the DSSs.

5.5 Summary

Three significant studies were done during the research period, and their results have been reported in this chapter. These studies provide insight into the practical functioning of different municipalities and the wide range of viewpoints from role-players in water related decision-making.

The PI study provides a number of applicable PIs, and the analysis of data from fifty-six towns provides a sound basis for benchmarking in the WDM field. The WC study focussed more on the involvement of the public and their interaction with the municipality, but it specifically provided an implementation process to ensure that WDM can be implemented successfully at a municipal level. The role-players and the interaction between them were analysed. A two-stage implementation process for WDM was developed and presented with the specific aim of involving all of the role-players identified.

The Robertson study provided an opportunity to identify different practical aspects to be considered and included in any DSS developed for WDM. It also provided an opportunity to evaluate the development of the DSSs, and valuable input was gained through the feedback sessions. The study also provided a list of actions that can be implemented by individual end-users, and it, as an example, also provided benchmark values for a number of cellars participating in the exercise. Lastly, it provided an implementation process that can be compared and used in conjunction with that suggested in the WC study as part of the model, which is illustrated in Figure 5.8.

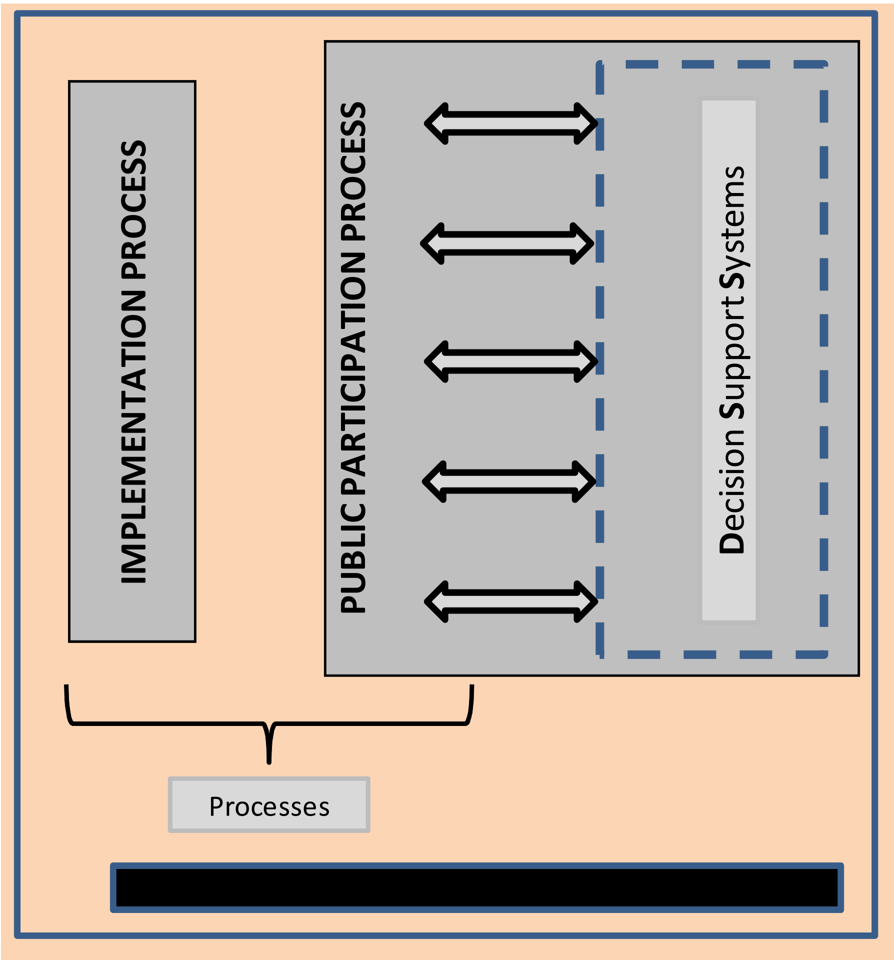


Figure 5.8: Model components

In the next chapter, the different DSSs will be presented, taking the lessons learned from these studies and the literature into consideration.

CHAPTER 6
INTEGRATED WATER DEMAND MANAGEMENT DECISION SUPPORT SYSTEMS

6.1 Introduction

The different methods that can be used to achieve effective WDM at different levels of the water management cycle have been highlighted in Chapter 4. Municipalities often implement these methods on an ad hoc basis and then fail to achieve sustainability due to a lack of proper planning or structure in their implementation programme. In three different studies, described in Chapter 5, the viewpoints from a wide spectrum of stakeholders in the water sector at a municipal level were analysed. These viewpoints will be used to develop the DSSs, which need to ensure effective and integrated water management.

The DSSs will be evaluated within the context of the demands and needs for models, as described in the literature review in Chapter 2. The DSSs will be developed to also accommodate a changing governance environment with specific emphasis on the availability of capacity at local government level. In this chapter, attention will be given to the different aspects to be considered during the decision-making process, and a set of DSSs will be presented that can be used and followed to ensure that WDM is implemented in a logical and easy-to-follow manner.

Most of the WDM decisions in the water management cycle do have financial implications. A number of different economic tools exist to assist with financial decision-making, but the main objective of this study is to ensure that all of the aspects that need to be considered during such a decision-making process are included and evaluated. Therefore no detail will be provided regarding the financial aspects thereof. The DSS will, for example, stipulate or highlight the need to consider a retrofit or an awareness campaign, but if both cannot be implemented, perhaps due to budget constraints, the decision will always have to be based on financial considerations. The requirement for an appropriate financial technique to be used when a choice between different options need to be made, will not be repeated in the DSSs, but needs to be considered as an integrated part of the decision-making process.

Besides the need to address WDM in a structured way, the Municipal Systems Act (Act 32 of 2000) described in section 3.5.5 also makes provision for the accountability of service delivery by municipalities. A performance management system forms part of this accountability, and the DSSs must therefore also be designed to serve as a “check list” against which the performance of the relevant municipal department or the manager of the relevant department can be evaluated.

All of the different WDM aspects, as part of each of the phases in the water management cycle as presented in Figure 6.1, need to be evaluated by the municipality during the implementation phase.

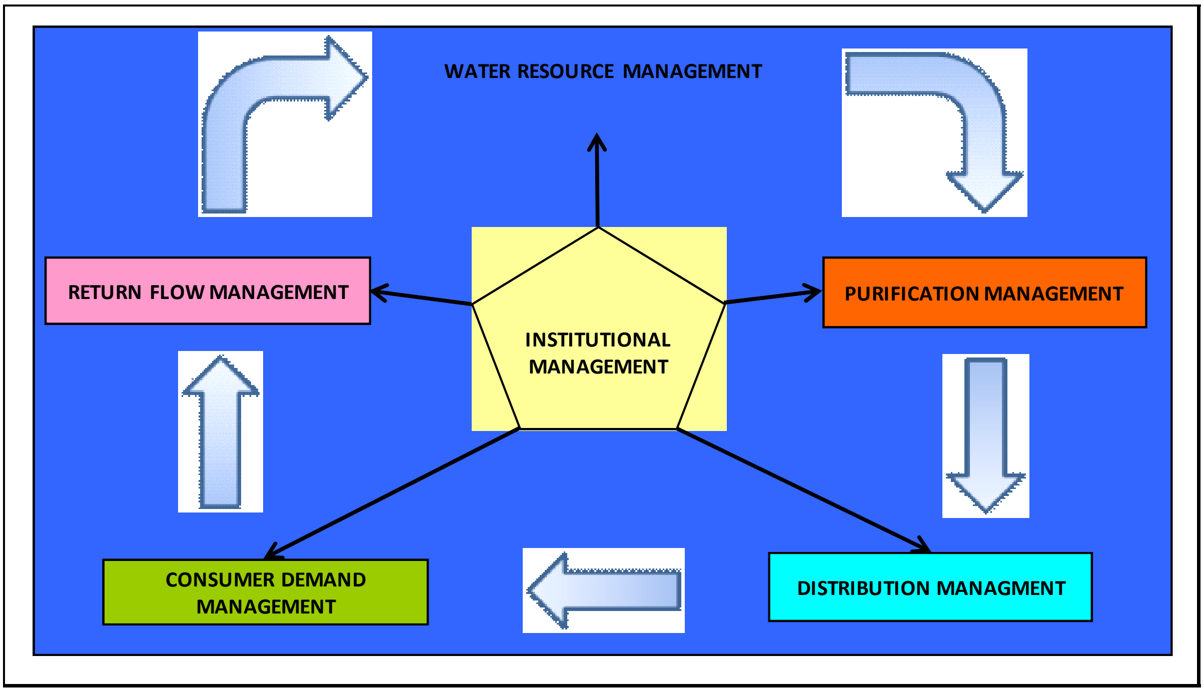


Figure 6.1: Water management cycle

A summary of these different aspects, which need to be evaluated as determined through the discussions with various key stakeholders, are shown in Figure 6.2. These aspects must all be included, and will be presented in this chapter in a set of different DSSs, one for each step in the water cycle.

These DSSs will consist of flow diagrams indicating the logical sequence or steps to be considered to ensure that all aspects of WDM are attended to at a municipal level. These logical steps are guided with conditional questions that need to be answered, i.e., either positive (Y=Yes) or negative (N=No). The content and actual criteria involved in these different steps have been provided, with PI values where applicable, in Chapter 4.

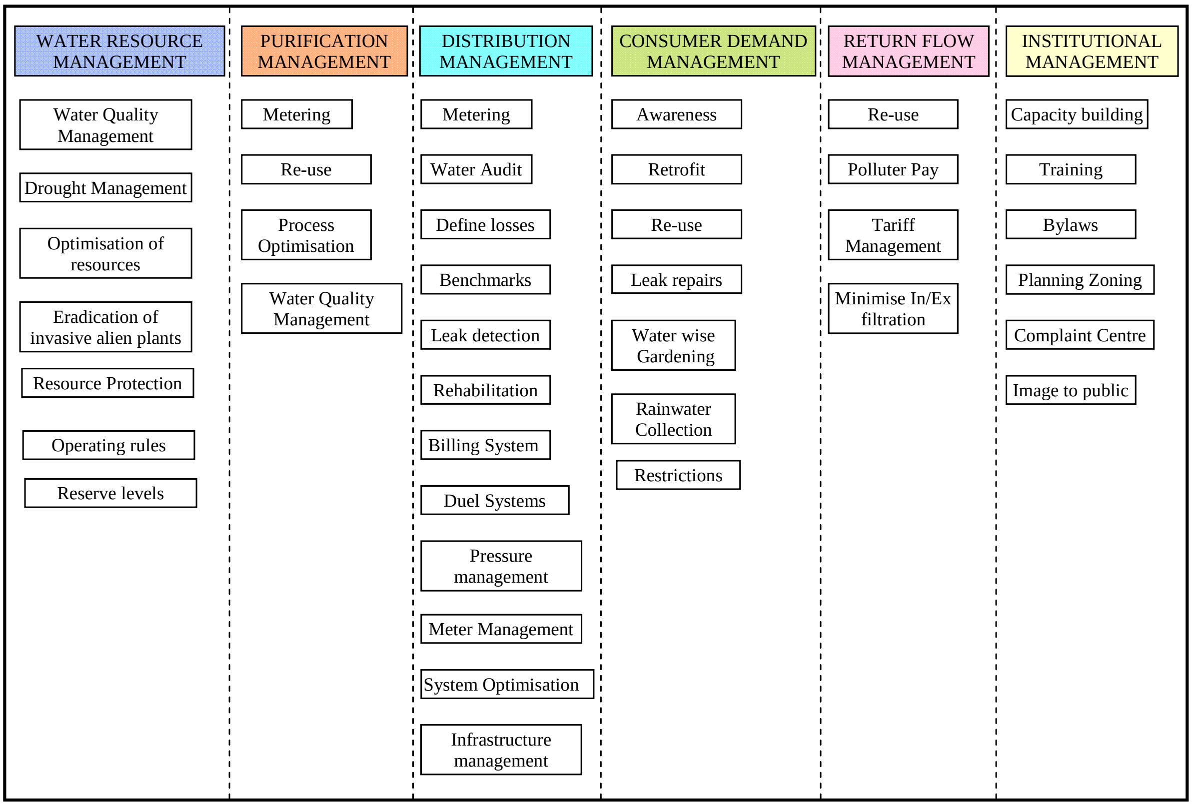


Figure 6.2: WDM aspects to be included in decision-making

Decision-making in the water sector does not always rest specifically and fully at the municipal level and it is therefore necessary to put the role and responsibility of water institutions regarding the decision-making process into context within the operating framework. These institutions have been described in detail in section 3.7, where their role within the public participation process has been dealt with.

The institutions functioning under the NWA will have a specific role to play during the first step in the water management cycle, namely, water resources, as described in section 4.3. A number of WDM actions will need input from these institutions, as well as those operating under the Water Services Act (Act 108 of 1997). Figure 6.3 illustrates the basic space of decision-making for the different institutions. It also highlights the Acts, as well as the main documentation that contains the information on which decision-making is based, as described in section 3.5.

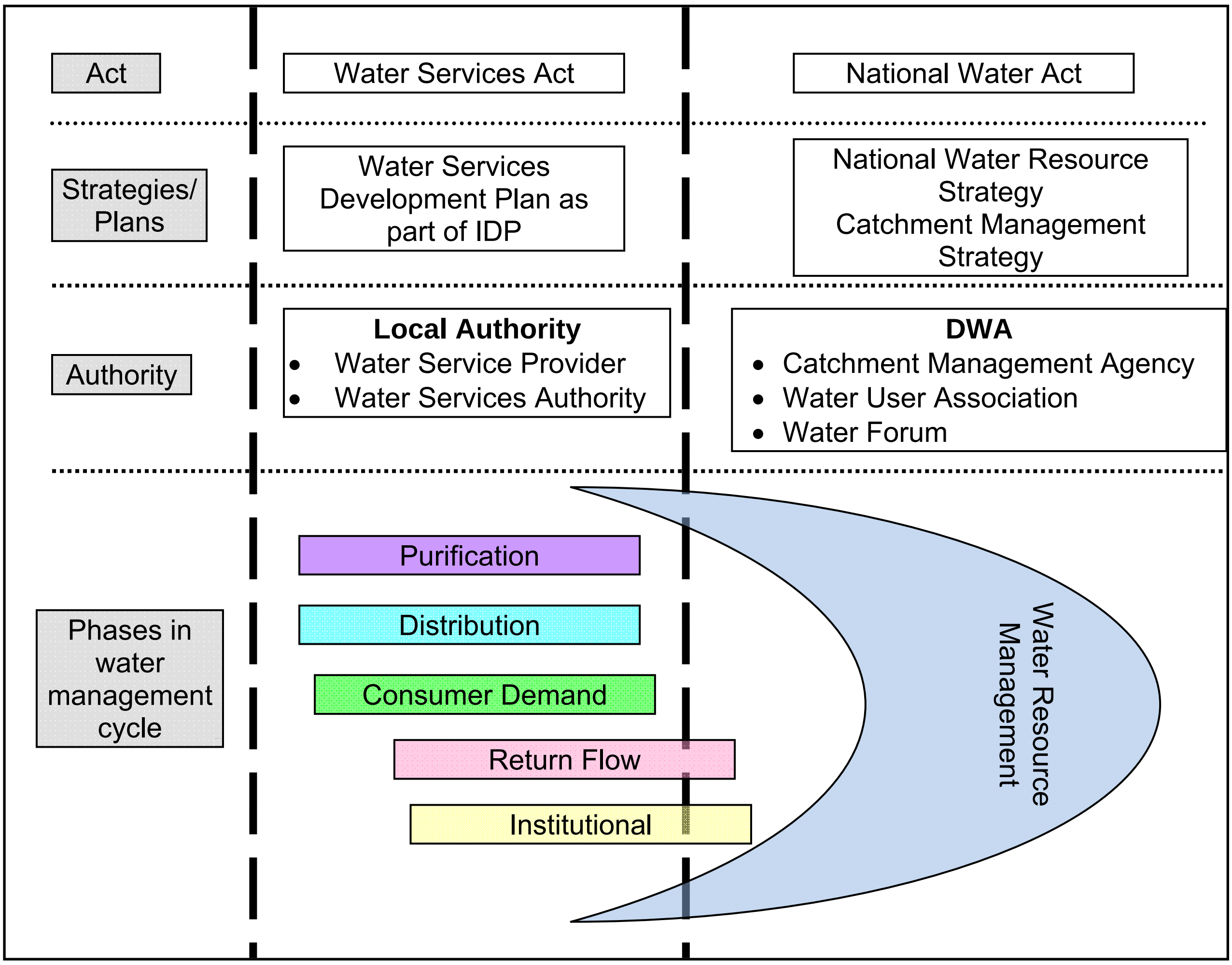


Figure 6.3: Decision-making responsibility

This chapter will conclude with a formal evaluation system that can be used not only to evaluate progress within a specific municipality, but also to provide a tool to be used by the national government structure to assess the relative progress made, comparing the performance of all the different municipalities with each other, for integrated planning purposes.

This evaluation methodology will be presented as a quantitative "readiness to implement" WDM method, applicable to each community in a municipality, in the form of a score card. For the score card to be of use as a benchmark value against which progress can be evaluated, evaluation criteria will be presented for each step in the water management cycle.

6.2 Water Resource Management

As illustrated in Figure 6.3, the decision-making regarding WDM aspects during water resource management rests with the national DWA or the associated institutions. In some cases, as in the Robertson case study that will be presented in Chapter 7, the resources also “belong” to the municipality. A decision-making process that includes all of the relevant aspects to be considered regarding water resources is presented in Figure 6.4.

Even though the water resource DSS presented in Figure 6.4 indicates that, once ownership of a specific resource has been confirmed as an own resource and that the specific authority can therefore proceed with the next WDM steps, it is still recommended that the municipality ensures that it has representation on the CMA or at least serves on the relevant WUA. It is unlikely that a specific municipality will own a full catchment as described in the NWRS, and it is therefore unavoidable that some of the WDM aspects, such as the eradication of alien invasive plant species and resource protection, will have to be done in collaboration with other role-players.

Determining the yield of a water resource is of utmost importance. It is impossible to manage a system without knowing the yield of the resource, which specifically includes groundwater resources. Groundwater resources are often neglected when it comes to the yield determination and the operational plan. According to the NWA, it is also compulsory to know what the Reserve requirements from the specific resource are. The Reserve determination is a function of the DWA, and steps need to be taken in collaboration with the DWA to determine the reserve.

The water use licence process, as required by the NWA, ensures that a clear catchment management strategy and subsequently a national water strategy can be compiled and, as such, ensures sustainable development.

The operational plan forms the basis of decision-making, and contains the critical levels at which steps need to be implemented to avoid a water shortage. These steps might include water restrictions as part of the WDM process. The monitoring of the water quality forms an integral part of this system and is therefore included in the operational plan. Municipalities are forced by the NWA to also ensure that a proper disaster management plan is in place, and the operational plan provides important input into this disaster management plan.

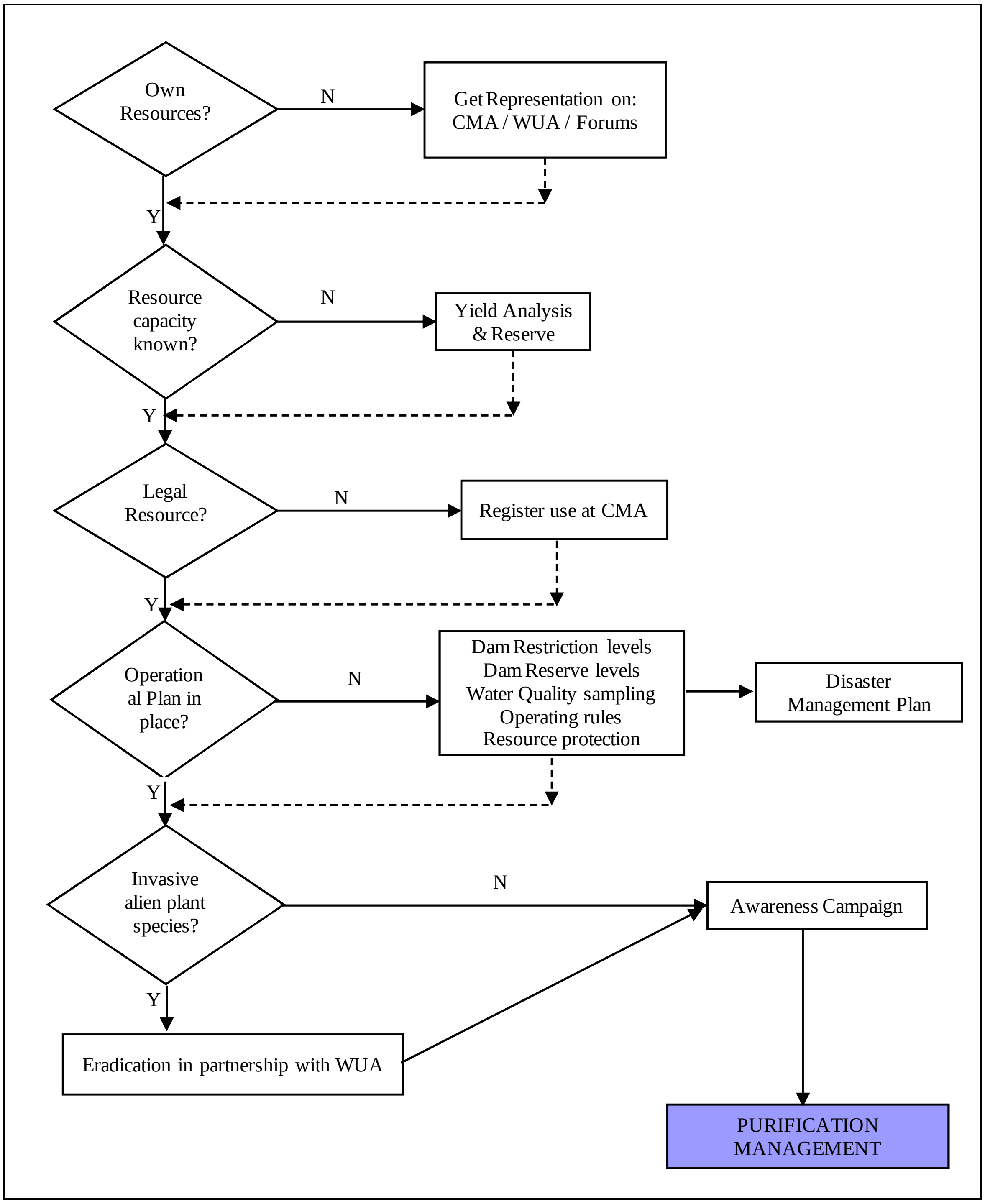


Figure 6.4: Water resource DSS

The eradication of alien invasive plant species in the catchment areas is an important WDM tool at a catchment level. Even though municipalities might have their own resources, the eradication of invasive alien plant species is an activity that needs to be implemented in a structured way at the catchment level. These processes are long term projects that require continuous input to remove new seedlings once the main clearing has taken place.

It can take up to ten years for such a project to become independent from external support and it needs to be approached from the upland of the catchment in a downstream direction in order to prevent the continuous spreading of seeds into already cleared areas. It is in this context that the water resource DSS accommodate the collaboration with the other catchment-based role-players.

Awareness campaigns can be implemented on a regional basis by the catchment institutions and basically serve to address unrealistic perceptions regarding the availability of water resources and the quality of the water. Awareness regarding the actual volumes used will be dealt with at the next level of the water management cycle.

6.3 Purification Management

The next step in the water management cycle, as defined in section 4.2, refers to the purification treatment processes, which provide a number of opportunities to support effective WDM. It might be considered to be effective operational management rather than demand management, but the large quantity of problems currently experienced at municipalities, justifies more detail on this part of the water management cycle.

The main focus of WDM at a treatment level is to optimise the purification treatment processes with regards to water savings. In this regard, a proper evaluation of the frequency of backwash cycles of the sand filter can contribute to huge water savings. It is also important to evaluate the need to treat all raw water to a potable water standard. In the case study done at Robertson (to be presented in Chapter 7), it was clear that a significant volume of treated water is used for irrigation purposes through the so-called “leiwater” system. In such a case, depending on the infrastructure required, it is advisable to provide this portion of the water through an alternative system, untreated to the end-user. Depending on the risk of using this water for possible alternative uses, it also might be appropriate to at least disinfect the water before distribution.

Depending on the variability of the quality of the raw water, the need for a facility to analyse water samples on a regular basis is obvious. These results need to be used to calculate the required dosing of chemicals used in the treatment process, which, if done effectively, will contribute to less water loss during the process. The procedure required for an effective analysis of domestic water is described in the *Water Quality Guidelines* prepared by the WRC (2001:9–56).

Measuring the flow through all stages of treatment is of critical importance. This enables the municipality to identify the areas where a more effective approach could be used, once these figures are compared with benchmark values in the industry.

The water audit of the treatment process must also include the difference between water entering the system and water leaving the system as potable or waste water. This will provide a general indication of the effectiveness of the specific treatment process. Figure 6.5 illustrates the DSS proposed for a structured approach towards effective WDM at the treatment level.

It is clear that not all measures in the process of good WDM practices will necessarily involve the public. Beside the exposure value of a treatment facility to increase awareness among the general public when visited during water week open days, the treatment of water is specifically an aspect that needs to be managed by the municipality itself, without an involvement from the public.

It is essential to analyse specific incidents and that a proper log be kept of all actions taken at the treatment plant. A typical log will contain information regarding the time a change in the quality of the water has been experienced, a backwash cycle executed or the change in shifts of the operators. All information that might be of value to assess the effectiveness of operational procedures at the plant needs to be logged.

The treatment cost of water plays an important role in determining the different tariff structures, and therefore forms part of the DSS. The most challenging stage of the water management cycle for municipalities is the distribution of the treated water, and this will be presented in the next section.

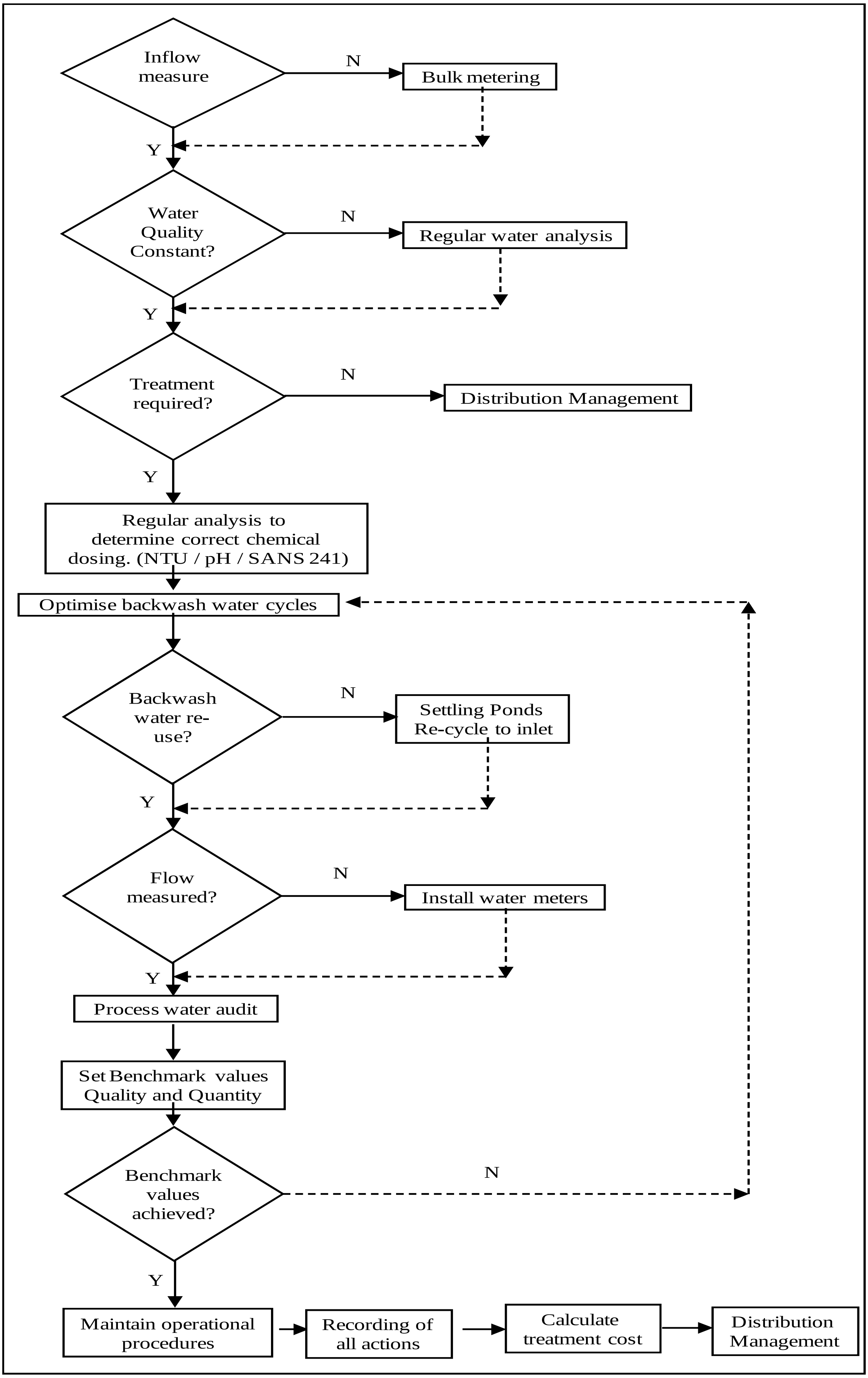


Figure 6.5: Purification management DSS

6.4 Distribution Management

The main focus of effective WDM during the distribution of the water from the bulk storage facility to the end-user is to limit possible losses. Metering plays, as before, a critical role in this process. The availability of measured (monthly) volumes of water is a prerequisite for obtaining a clear indication of the effectiveness of the distribution system.

The simplest form of a water audit is to measure the difference between water entering a water supply system against the volume of water received by the end-user. Municipalities are facing a serious challenge in measuring these differences, because it requires the technical departments to interact with the financial systems within a municipality. The importance to link the consumption figures used for the billing system with those figures collected at the bulk and zone meters, is obvious. The importance of aligning the reading of these two data sets has been highlighted before, and every possible attempt needs to be made to achieve this.

Once the readings from the different meter zones are available, a number of basic reference values needs to be calculated on a monthly basis. It is advisable that, in the cases of specific large water users within the distribution system, the meter readings be checked at shorter time intervals (weekly). The impact of a meter problem associated with the supply to a large water user might be significant in the context of the water supply to a zone within the water supply system.

These reference values need to be evaluated against preset benchmarks in order to make an optimal choice of possible actions to ensure effective WDM. It is important to note that, even though the distribution DSS based decisions on the performance of the system against set benchmarks, these benchmark values also need to be re-evaluated from time to time.

The principle is to try and identify the reason for system losses as soon as possible, and to rectify these causes one at a time. Although not included in the DSS, the need to do an appropriate financial analysis, if the cause of losses can be addressed with more than one intervention, is always a requirement.

The different procedures and methods available to rectify a problem have been presented in Chapter 4 and will not be evaluated in this section again. If the losses are identified during the distribution of water and the municipality knows where they occur, then the actual consumption of the end-user needs to be evaluated. If it is found to be too high in comparison with appropriate benchmarks, then the appropriate rectification steps, as discussed in Chapter 4, need to be taken to minimise the consumption.

If the consumption figures are within reasonable limits, then the attention can be focused on the next step in the water management cycle, namely, the return flow. The DSS illustrating the different decision steps to be considered during the distribution of the water is shown in Figure 6.6.

In the next section, the management steps that will have an impact on the end-users will be presented. These management steps can be implemented by either the end-use self or the municipality.

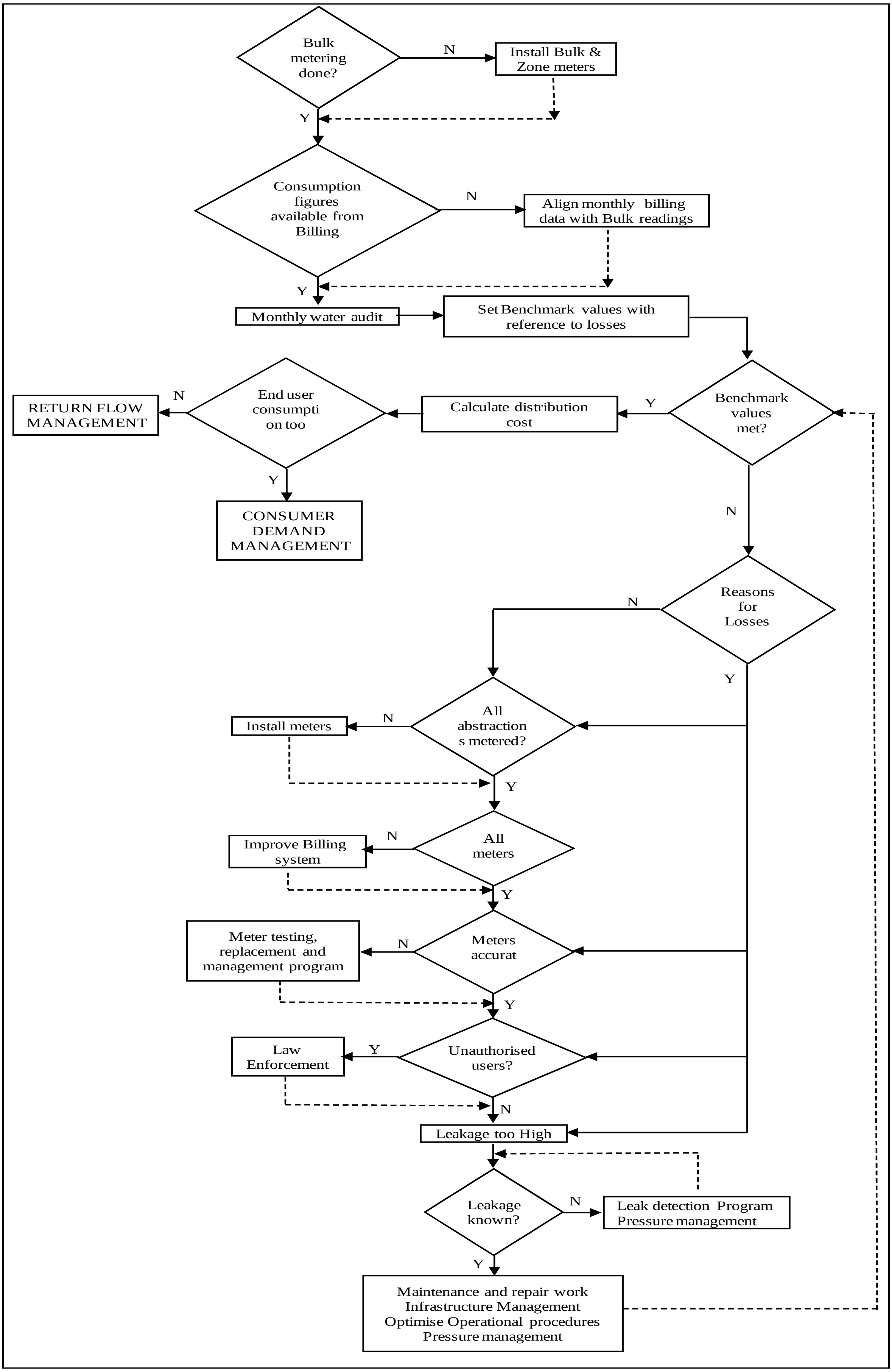


Figure 6.6: Distribution management DSS

6.5 Consumer Demand Management

An important issue to be addressed in the successful management of the water demands by the end-users is the end-user's awareness of the need for saving water. The implementation steps that will be presented in this section need to be initiated by the municipality, but implemented in and around households.

This section address the importance of changes in attitudes towards water consumption, but it will be illustrated that the municipality can play an important role in making these changes possible, with benefits to both the household and the municipality. Decisions made during this process will not always provide quick results, however, and the capital spent on these processes needs to be seen as long term investments.

Awareness is a broad topic, and it is difficult to provide a structured DSS in this domain that can be used in general. Factors such as the extent of the catchment and the communities that need to be reached play an important role in deciding whether, for example, radio broadcasts can be used as a means of communicating to enhance the public's awareness. The number of towns sharing the same resources will also influence the awareness strategy. The success of any awareness campaign is closely linked to the involvement of all stakeholders and their ability to accept responsibility and ownership of such a programme.

The implementation of public awareness programmes has been evaluated in detail in section 3.7. A proposed DSS is illustrated in Figure 6.7 and it is suggested that such a methodology be used to create a structure that will assist the municipality in identifying the level of awareness of the different role-players and the most important issues to be addressed, as well as the priorities of these issues. The identification process suggested through this model must be aligned with the IDP process of that specific municipality. The relationship between the different role-players and the political structures involved needs special attention in order to manage conflicts of interest.

The DSS illustrated in Figure 6.7 starts with the need to highlight the importance of awareness among the public in general. The DSS also makes provision for the situation where, even though consumption figures might be within acceptable limits, an awareness campaign should still be implemented due to limited water resources.

Although the DSS is structured to provide practical guidance to the end-user, individual cases might result in some of the issues being addressed more cost effectively than the sequence of implementation suggested in the DSS. In the case of a rather large garden, for example, the end-user might find it more appropriate to immediately, without any cost implications, reschedule the irrigation times for an automatic watering system in order to save water through less evaporation, than spending money on the repair of leaks as suggested by the DSS. There are reasons for specific case deviations, but the DSS provides a well-balanced approach that serves most situations well.

The DSS also makes a clear distinction between a number of actions that first need to be implemented by the municipality before progress can be expected at a household level. The responsibilities of each party are clearly marked in the diagram of the DSS.

These steps are closely linked to affordability, the level of services provided to the end-user and the willingness to pay for services. WDM cannot be seen in isolation without taking these specific circumstances into consideration.

Regulations require the setting of a step tariff structure that reflects the affordability, the actual cost and a cost added to discourage the use of large volumes of water. It is therefore important to ensure that accurate calculations to determine the cost for each of the different phases of the water management cycle are made.

Although the distribution DSS does not specifically reflect the need for a step tariff structure if consumption is within acceptable limits, it is still a requirement, stipulated in national regulations, that a basic step tariff structure needs to be implemented. This can, however, be a simple three step tariff structure, without the specific intention to further reduce consumption.

The DSS does not include suggestions regarding the implementation of WDM steps by a municipality regarding government buildings and public open spaces, office buildings, gardens and industries. The steps described under the household section of the DSS also apply to these entities, with the additional responsibility to save water, through the same procedures, in public amenities and buildings. In the case of industries, there is also a manufacturing process side that needs to be optimised in terms of water consumption, but these are specific situations and need to be dealt with on an individual basis. This principle has been illustrated in relation to the Robertson case study, in section 5.4.3.

The implementation of local resources at the household level, like a borehole or the collection of rainwater, is the last aspect to be considered. These resources are rarely a cost effective alternative at a household level.

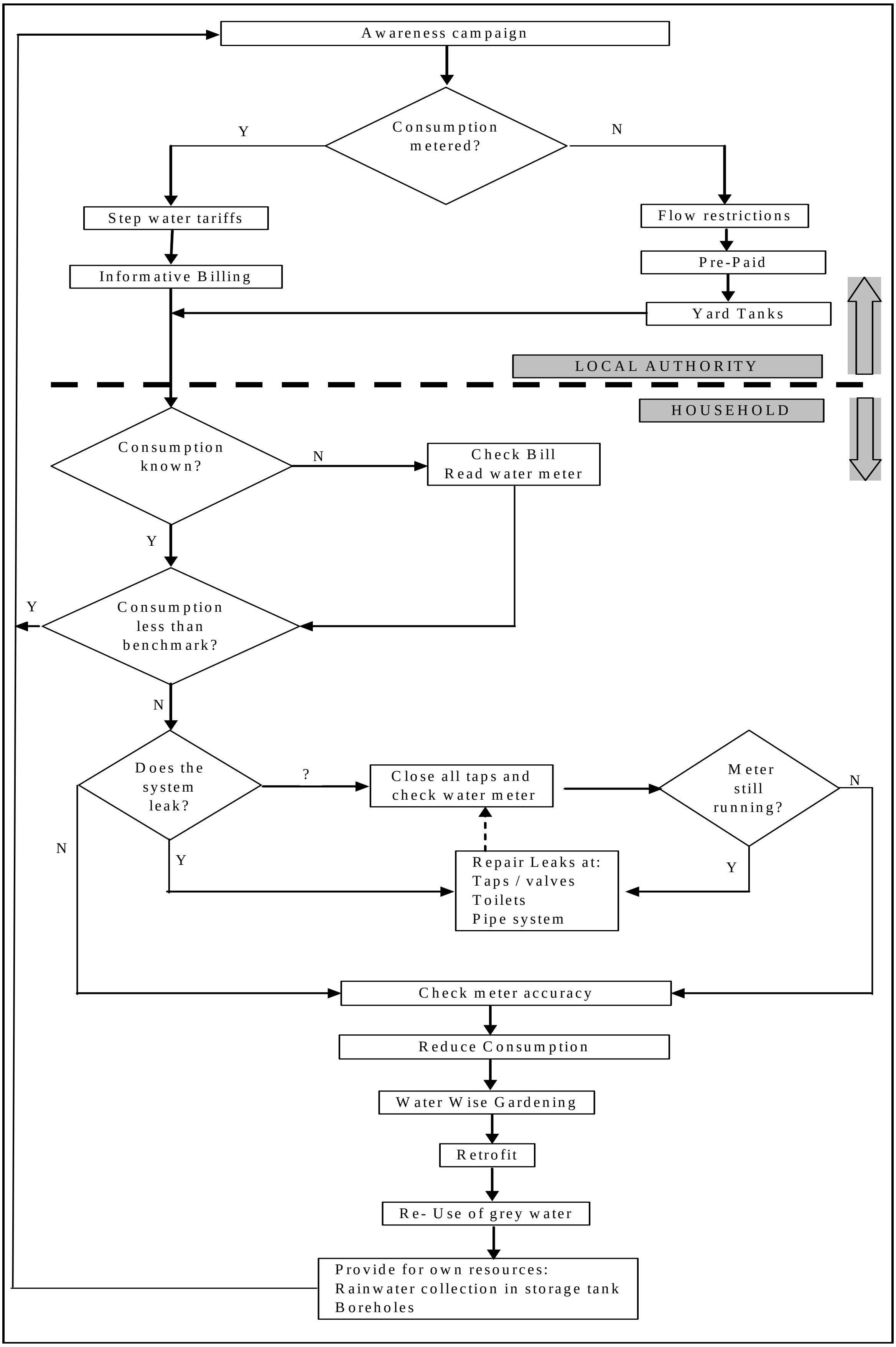


Figure 6.7: Consumer demand management DSS

6.6 Return Flow Management

In the previous section, the focus on WDM was on the need to reduce the demand and to operate the systems in such a way that losses are minimised. Once the water has been used, WDM on return flows focuses mostly on the management of the quality thereof to ensure that the waste water works stays operational. If a waste stream is received at the treatment works which include pollutants that can impact negatively on the effective functioning of the works due to design limitations, upgrading become essential long before the plant reach its design capacity. Not only the possible overload of treatment facilities, but also the actual flow volumes need to be consideration. The proposed DSS therefore provides two distinct routes, taking volume as well as quality of the waste water stream received at waste water treatment works into consideration.

Closely linked to the management of the return flow is the proper management of storm water. A serious problem regarding storm water is the diversion of rainwater from roofs and surfaces such as paved areas into sewage systems. This practice, results in high peak flows at the waste water treatment works, often resulting in the peak flow exceeding the design flow capacity of these treatment works.

The critical focal point for the management of the quality of the water to be returned to the water resource is the effective management of the quality of the water received at the waste water treatment works. Industries play a significant role in this respect, and the focus therefore is on mechanisms to be put in place to ensure that waste water received from industries does not fall outside the limits that can be dealt with at the waste water treatment works.

The "polluter pays" principle in the NWA is instrumental in managing waste water received from different industries. This principle results in a financial penalty based on the quality of water delivered to the waste water treatment works, and appropriate fines if the agreed quality standards are transgressed. It also makes the availability of a facility (laboratory) to analyse the quality of water received an essential part of the management system.

Industries can manage some of the quality aspects through the installation of equipment, such as "fat traps" which prevent fats from entering the sewage system. These technical options need to be built into the approval process for building plans.

Although awareness does play a role in the management of the return flows, it will not be included as a specific step in the DSS during this stage of the water management cycle, shown in Figure 6.8. The requirement for proper awareness programmes needs to be accepted as an integrated process for all of the DSSs.

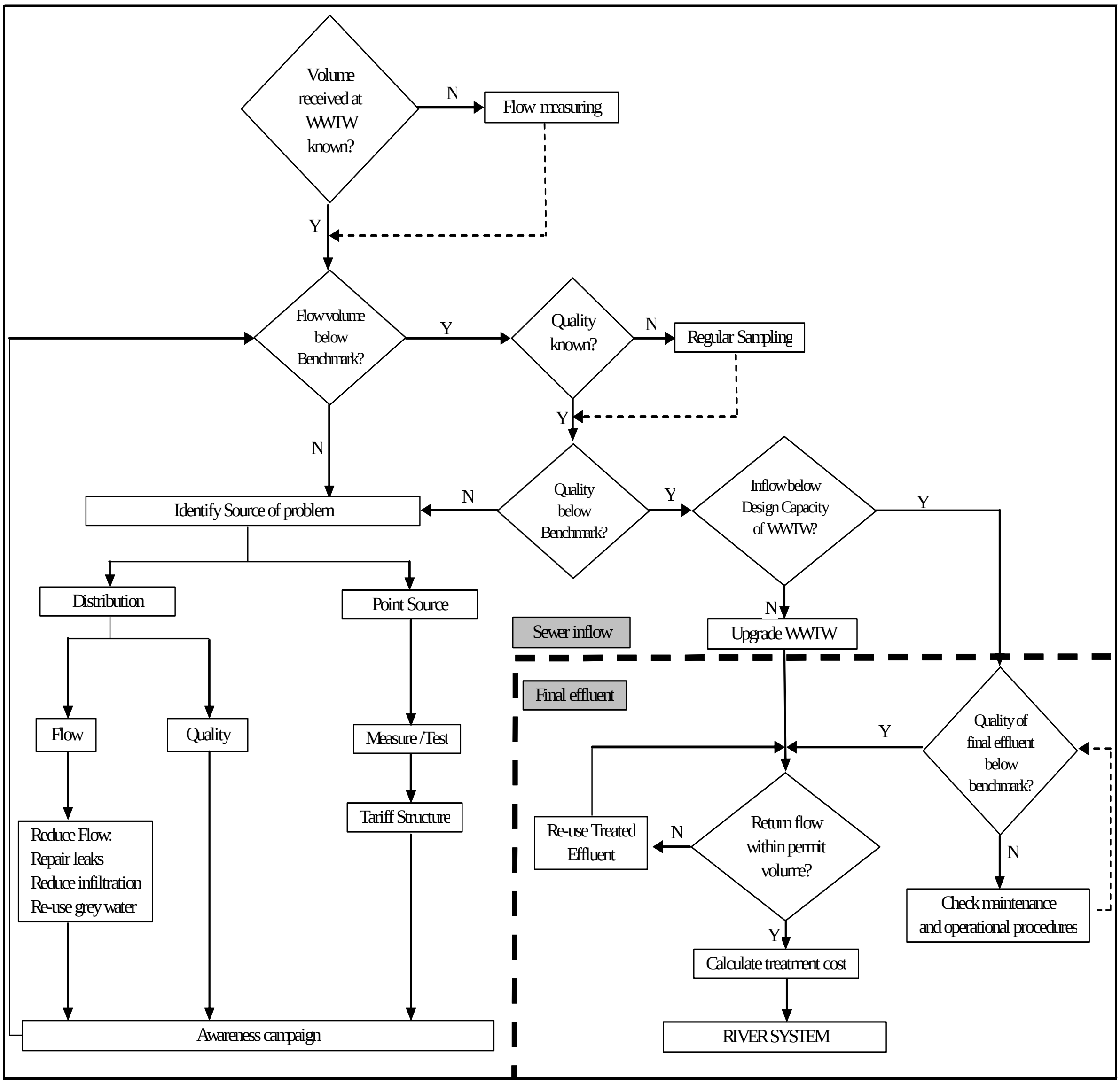


Figure 6.8: Return flow management DSS

An aspect that forms part of the management of the return flows, but which does not receive enough attention, is the proper maintenance of the sewage pipe system. Although the repair of leaks is included in one of management steps as a means to prevent infiltration from groundwater and storm water into the sewage system, the leakage of sewage into the groundwater can also result in the pollution of the surrounding water resources.

Decisions regarding the management of the return flows are mostly based on the raw sewage, as explained in the paragraphs above. Once the sewage has gone through the treatment works, the final effluent needs to be evaluated against set benchmarks to ensure that its quality is within the allowable limits set by the relevant authorities before it is returned to the river system. Proper maintenance and operational procedures are therefore of critical importance for the correct functioning of a waste water treatment works. In terms of an integrated catchment approach, it is also important to adhere to the licence conditions issued by the relevant authority, which will either be the DWA or the CMA.

Municipalities in South Africa have been under pressure to deliver services of an acceptable level due to the loss of experienced personnel during the last decade. Waste water treatment facilities specifically require well-trained and experienced staff to ensure that the water is treated adequately. The management of the return flows is specifically vulnerable to the shortfalls in well-trained staff. Training and other institutional arrangements form an integral part of WDM, and these aspects will be described in the next section.

6.7 Institutional Management

In the previous sections, the step-by-step procedure for each phase of the water management cycle has been illustrated using a DSS to enable structured decision-making within municipalities, either by municipalities themselves or by the households in their area of jurisdiction.

The sequence of steps in the DSSs, is important. The need to use sound economic principles to make specific decisions has also been highlighted. There are, however, a number of procedures that need to be implemented by the municipality that do not need to be done at any specific time or stage in the WDM process, but are critical to the sustainability and the legitimacy of such a process. These procedures include the following:

- Training, capacity and image.
- By-laws.
- Credit control.
- Complaint centre.
- Building plan and rezoning applications approvals.

These procedures are presented in sections 6.7.1 to 6.7.5.

6.7.1 Training and capacity building

Appropriate training of all staff members so that they are well-equipped to execute the tasks designated to them is a continuous process that needs proper planning. In South Africa, the training of personnel is promoted in all spheres of government and substantial amounts of money are available for this aim. It is, however, important that, in the context of WDM, officials should all be aware of their duty and responsibility as employees of the municipality to spread the message of effective WDM.

Training is not only essential for the personnel working in the technical departments. All staff need to be aware of and be pro-actively participating in such a process. A simple action of, for example, the gardener of the municipal buildings to irrigate the lawn in the middle of the day as opposed to during the early morning to reduce evaporation losses can result in an image to the public of: “If they (municipality) do not care, why should we (public)?”

The positive manner in which a maintenance team attends to a pipe burst problem, specifically in a public area, contributes enormously as a message to the public that water management is a priority in their town. Late response times and an almost “casual” attitude do not promote these processes.

The importance that political leaders be seen to participate in these processes cannot be over-estimated. In this respect, it is also important that WDM forms part of political leaders and representatives training and capacity building exercises.

6.7.2 By-laws

By-laws are enabling legislation that ensures that municipalities are legally in a position to execute the conditions set by national and provincial Acts and Regulations. By-laws take a considerable amount of time and careful planning to implement, but they are unfortunately also an aspect that is lagging far behind, as proved during the PI study. The end result of this inability of municipalities to finalise their by-laws in order keep up with the changing Acts is the lack of legal mechanisms to enforce the steps required to ensure effective WDM.

Various model by-laws exist and have been provided by national departments for municipalities to simply change or adapt to their specific circumstances.

6.7.3 Credit control

An effective credit control system needs to be put in place to ensure that, whenever the payment of services fall behind, the necessary steps can be taken to reduce the water supply to the specific areas. The credit control system also needs to allow for payment of "fines" in the case of return flow (waste water) which does not complying with the set standards.

The credit control steps also contain the rules in the case of doubtful water meter readings and the agreed steps to be taken in the case of disputes. It is important to realise that these control measures need to be put in place to assist with the practical implementation of WDM, even though the related water issues usually form only a small part of the credit control measures for a municipality.

6.7.4 Complaints centre

The value of a "one stop" service provided by a municipality to address all queries should not be underestimated. Almost all municipalities investigated during the PI study (Du Plessis, 2005:158) do have some arrangements in place to respond to public queries on a 24-hour basis. The proper logging and follow-up of these complaints will contribute significantly to acceptance that their town is serious about addressing issues such as burst pipes or leaks.

The additional value of such a centre for providing advice regarding water-saving devices to be used in and around households should be investigated. It may not be possible to implement such a centre in each municipality or town, but significant mutual benefits can be generated from such a service to the public, enabling them to make an input or lodge a complaint.

6.7.5 Approval of building plans and rezoning

Municipalities are specifically responsible for the approval of new developments and building plans in their areas of jurisdiction. This provides the municipalities with easy and unique methods to promote effective WDM. Some examples of how municipalities can introduce WDM at an early stage of any development include specific conditions for the approval of new developments and building plans to ensure that these buildings include aspects such as dual-flushing toilets, non-automatic flushing urinals, the use of grey water for gardening purposes or the use of recycled treated effluent for aspects such as cooling water for specific industries.

Municipalities unfortunately find themselves frequently in a position where they are dependent on new developments for the economic growth of their towns or areas, and they therefore do not always want to put many conditions in the way, fearing that it might discourage these new developments. This presents municipalities with difficult choices, knowing that an approval of a development now without strict conditions on water use for example, might present them with possible water problems in the future.

6.8 Time Frames for Implementation of Decisions

Municipalities are compelled, through the Municipal Systems Act (Act 32 of 2000), to implement a 3-year budget system (section 26(h)) for all projects. Projects need to be prioritised through the IDP process, which includes a public participation process. The result of these preconditions is that the planning of appropriate WDM steps becomes critical to ensure their implementation on time.

The first challenge for municipalities is to ensure that the need for WDM is addressed during the IDP process. Once this has been listed, the process whereby funding needs to be secured for the implementation can begin. Councillors play an important role in this respect, and officials need to present scientific facts to them to demonstrate the need for the project.

As illustrated before, the availability of good data is frequently one of the major problems within municipalities, with limited data logging taking place. If no reliable data exists, implementation is immediately set back by one to two or more years. If data is, however, available and funds can be made available through the normal budgeting process, the implementation normally goes hand in hand with a specific procurement procedure to obtain either equipment or services, which can take at least two to three months, depending on the relevant policies of the specific municipality.

Implementation will depend on the nature of the project. If it is the installation of a measuring device or pressure control system, it can take between two to six months, but if an awareness campaign needs to be implemented, it is unlikely that a structured programme can be undertaken in less than 3 years. In most cases, the results of such an action will only be evident after a number of years.

There is no simple time frame for the implementation of WDM, but Figure 6.9 illustrates the steps and the processes that need to be followed.

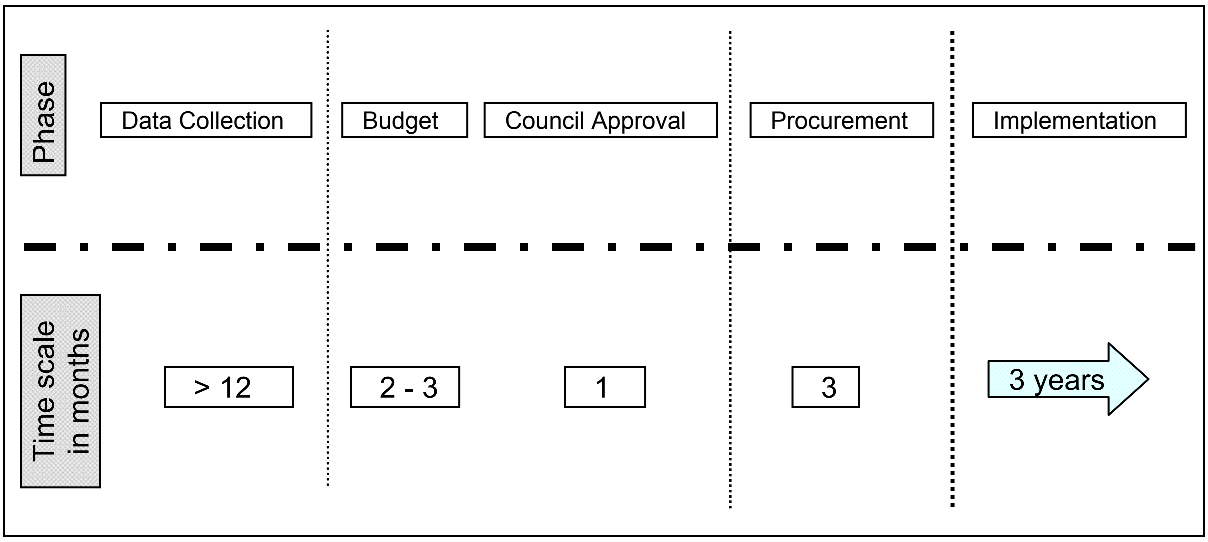


Figure 6.9: Implementation time table

Perhaps the most important point illustrated in this section is that WDM as a process can take a long period to implement. Specific steps within this process are easy to implement and well-defined, while others deal with perceptions. Although the initial process will take a great deal of money and time to implement, the focus of these processes is to ensure a mind-shift regarding water use, with sustainability as the most important outcome. Once this shift has been made, the process should, with limited maintenance, sustain itself.

6.9 Using the Decision Support Systems

The DSSs presented in sections 6.2 to 6.7 provide step-by-step decisions and procedures that, in general, need to be taken and followed in a specific sequence in the water management cycle. The different phases in the water management cycle have been separated since the implementation of steps in one phase in the water management cycle does not necessarily require the final outcome or the successful implementation of steps in a previous phase. In addition, the implementation of some of the steps is a long term intervention, with results only visible after years.

The importance of implementing all of the different steps within a specific phase in the water management cycle is, however, critical. The DSSs makes provision for concepts or specific sections to be implemented, but the manager still needs to decide which specific technique should be used to address any specific step suggested by the DSS.

To illustrate: the decision to focus on the implementation of leak repairs is well-defined in the consumer demand management DSS, but it does specify which specific action needs to be taken first. Economic evaluations must be implemented to decide whether the repair of leaks in taps versus toilets versus the reticulation or conveyance system should be given preference.

At a household level there are, however, practical aspects such as the ability of the households to do the repairs themselves that might influence the decision on what needs to be done when. With limited human resources and access to equipment available at municipal level, the same practical aspects might also dictate the sequence in which specific steps are implemented.

These DSSs can also act as a checklist that should be used to guide the WDM process at a municipal level, and can be used for planning purposes to ensure that all aspects of WDM are addressed. The DSSs specifically aim to prevent the implementation of specific steps, like the upgrading of the waste water treatment works, before an assessment has been done to determine the reason for the overload.

The DSSs frequently refer to benchmark values, and the importance of these values cannot be over-estimated. Municipalities do not always realise that they have a problem unless they are in a position to evaluate themselves against reference values. Benchmarks provide guidance to assist municipalities in their decision process, as illustrated in the DSSs. Once the DSS assists the municipality to focus its attempts on a specific issue, it always needs to be remembered that the benchmark values can differ from one situation to another, and that a closer evaluation might be required before huge capital investments are made.

The use of the DSSs needs to be seen in the context of the institutional arrangements described in section 6.8. These arrangements are not normally seen as specific WDM aspects and they do not fit into a specific stage of the step-by-step process illustrated in the DSSs, but they do form part of the foundation of the implementation phase and provide fundamental tools to assist with the decision-making process. Similarly, the imperative of public awareness of the need for WDM, although incorporated into the DSSs, cannot be seen in isolation and needs to be fully integrated during the WDM cycle.

6.10 Score card for WDM

While the model provides the specific steps and the sequence of events to be considered during an integrated WDM programme, it is also important to provide a tool for evaluating the combined progress of the process within the municipality, or in comparison with other municipalities.

For this purpose, a score card was developed that takes all aspects of the model into consideration. Evaluation criteria were also incorporated into the score card to provide guidance regarding the evaluation of the actual progress on each of the DSSs. No attempt is made to try and quantify the importance of each of the steps provide in the model, but the compliance is only recorded against the set criteria. The evaluation criteria however provides for different levels of compliance. The score cards are presented in Table 6.1 to Table 6.6.

In these score cards, the management steps or focus areas provide in the model are listed, and guidelines have been provided to facilitate the allocation of points, ranging from a value of 0 for no compliance to 3 for full compliance. The use of the score card will be illustrated in Chapter 7. It involves the allocation of one point (1) for each management focus area in the column that reflects the level of compliance, based on a value between 0 and 3. The score below the score card is then calculated by adding all the ones (1) in each column. The final scores for each water management cycle step are then calculated by firstly multiplying the number of ones with the category/column value (0 to 3) and then adding all of the values to provide a score per stage, shown as a single value to the right of the array of score values.

The performance ranges provided below each of the score cards are an indication of the maximum number of points (number of ones (1) multiplied by the column value) that can be achieved for a specific step in the water management cycle, which are used to express progress achieved as a percentage of the maximum expected value for full participation.

The score card for the water resource management phase in Table 6.1 makes provision for the possibility that a specific community receives most (qualified as 70 per cent) of its water from an external service provider. In these circumstances some of the steps in the water resource phase (labelled as own water resources in the score card) will not contribute towards the score during the evaluation.

Not all water treatment facilities allow for the same treatment processes. Therefore the score card for water treatment in Table 6.2 provides the opportunity to mark specific steps not present in a specific treatment facility as not applicable (N/A), in which case the item will be excluded from the scoring exercise.

The consumer demand DSS specifically differentiates between steps that must be implemented by the municipality and steps that need to be implemented by the end-user. The evaluation process which involves the end-users depends mainly on their awareness and their response to the need for reducing their demand. Their contribution towards WDM can only be evaluated using interaction opportunities with the end-users. With the focus of this research on the municipalities, it was decided not to evaluate the end-users' readiness towards WDM, but the important aspects to be evaluated are still shown to provide guidance for a management committee, as discussed in section 5.3.2, in evaluating the end-users (see Table 6.4).

Table 6.1: WDM score card: water resources management

WATER DEMAND MANAGEMENT READINESS SCORE CARD FOR:										
	Municipality:		Community:		DATE:					
Does community receive more than 70% of its water from own resources? If No, then respond only to "Purchase water from service provider", in all other cases complete full table.						YES	NO			
Water Cycle Step	Management Focus		Evaluation Criteria			None	Bad	Acceptable	Good	
			Bad	Acceptable	Good	0	1	2	3	
WATER RESOURCE MANAGEMENT	Purchase water from service provider	Representation on CMA/WUA and Forums	Establish, no representation,	Representation and participation in decisions	Taking the leading role					
		Awareness Campaign	Isolated steps in case of emergencies	Public constantly been informed in various ways	Management committee in place to manage Campaign, with budget allocated to activities					
	Own water resources	Managing catchment through eradication of invasive plant species, Working for water project	Serves on management committee	Provide funding in support	Managing and own funding					
		Yield analysis done	Yields known based on regional data or reservoir capacity	Hydrological analysis done	Yields known associated with risks					
		Reserve known	Allowance made without quantification	Rapid reserve done	Full Reserve approved by DWA					
		Use registered	Water use known	Application submitted	Registration Certificate available					
		Licence issued	Water use known	Application submitted / Waiting for verification (DWA)	License approved by DWA and available					
		Operational Plan	Operating done based on experience only with no formal plan	Basic plan available	Detail Plan available and implemented					
		Restriction levels set	Based on operational experience	Based on dam levels	Based on full hydrological analysis					
		Disaster Management Plan	No reference to drought situations and lack of supply	Addressing drought and supply problems	Detail steps available in case of drought and supply problems					
					Score	0	0	0	0	0
					Performance range	0	0	0	0	

Table 6.2: WDM score card: purification management

Does community treats more than 70% of its water? If No, then proceed to "Distribution Management Table"						YES	NO			
Water Cycle Step	**Management Focus**		**Evaluation Criteria: Bad**	**Evaluation Criteria: Acceptable**	**Evaluation Criteria: Good**	**None 0**	**Bad 1**	**Acceptable 2**	**Good 3**	**N/A**
PURIFICATION MANAGEMENT	Flow measurement	Inflow	Monthly/Weekly, only available at operator	Complete daily data, recorded at operating centre	Continuously and electronically available on demand					
		Backwash water								
		Recycled water								
		Final treated flow								
		Process water audit	Done on request	Monthly audit	Monthly, but available on request					
	Water Quality	Regular water sampling and analysis: Raw water	Monthly	Weekly	Daily / Continuously					
		Regular water sampling and analysis: Treatment process	Monthly	Weekly	Daily / Continuously					
	Backwash water	Re-used	Only None or Good							
	Benchmark values	Quality	Benchmarks on some aspects available	Most aspects comparable with own benchmark values	All aspects comparable with own and national benchmark					
		Losses								
	Administration		Recordkeeping intermittent	Recordkeeping at control centre complete and electronically available	Recordkeeping at control centre available and management feedback provided					
	Treatment Costs		Treatment cost estimated, seen as part of full water budget	Separate costing done and budget based on these figures	Separate costing done and water tariffs based on actual costs					
					Score	0	0	0	0	
					Performance range	0	0	0	0	

Table 6.3: WDM score card: distribution management

Water Cycle Step	Management Focus		Evaluation Criteria			None	Bad	Acceptable	Good	N/A
			Bad	Acceptable	Good	0	1	2	3	
DISTRIBUTION MANAGEMENT	Flow measurement	Bulk Inflow	Flow only measured from some sources	All bulk inflow measured and database completed	All bulk inflow measured and continuously electronically available					
		Sone Metering	Some sones measured	Systems fully subdivide in sones and most sones measured	Systems fully subdivided in sones and all sones measured electronically					
		Consumers	Most billed end-users measured	All billed end-users measured	All usage measured and recorded electronically in central database					
		Meter management	Replacement of meters when requested by users	Meter replacement program implemented	Meter replacement program implemented and calibration and test facilities used					
	Water audit		Annually	Monthly, compared with financial data	Daily and monthly values compared with financial data					
	Benchmark values		Benchmarks on some aspects available	Most aspects comparable with own benchmark values	All aspects comparable with own and national benchmark values					
	Losses		Only bulk losses known	Bulk and sone losses known	All losses identified					
	Leak detection		Reactive leak management	Visually inspected on regular basis	Leak detection program in place and annually monitored					
	Billing system		Most users receive a monthly accounts	All water users receive a monthly account and general informative information is provided	All water users receive a monthly account, including zero rates for own use and informative monthly water uses are provided					
	Pressure management		Set to constant fixed pressure	Set according to time variable	Sone and flow regulating					
	Distribution costs		Distribution cost estimated, seen as part of full water budget	Separate costing done and budget based on these figures	Separate costing done and water tariffs based on actual costs					
	Law Enforcement		Investigation done when complaints are received	Investigation based on water audit data	Law enforcement based on set program and water audit data					
	Maintenance and operational procedures		Repair work done when needed	Maintenance program in place, Asset management plan in place.	Maintenance program in place, Asset management plan in place all linked to budget					
					Score	0	0	0	0	0
					Performance range	0	13	26	29	

Table 6.4: WDM score card: consumer management

Water Cycle Step		Management Focus		Evaluation Criteria: Bad	Evaluation Criteria: Acceptable	Evaluation Criteria: Good	None 0	Bad 1	Acceptable 2	Good 3	N/A
CONSUMER DEMAND MANAGEMENT	Municipality	Flow measurement	Raising block step water tariffs	Fixed tariff rate based on volume used	Between 2-3 blocks, based on volume used	More than 3 blocks, based on volume used					
			Informative Billing	Only consumption and amount due	History of consumption and general information	Monthly consumption for at least 12 months and a breakdown of cost per tariff block					
		Flow NOT measured	Alternatives in place such as: flow restrictors, pre-paid or yard tanks	Limited alternative measures in place	Alternative measures in place for a significant portion of non-measured consumptions	Alternative measures in place for all non -measured consumption					
		Awareness Champaign		Only communication when problems is anticipated	Monthly feedback to all	Long term programmes in place and managed by a management committee					
	Household	Consumption known	Access to flow meter	The evaluation at a household level can only be determined through an evaluation among a representative group of end-users. This is only possible if a management committee is in place where all stakeholders are represented. The effectiveness in terms of an awareness campaign has been evaluated as a function of the municipality and will not be included in the evaluation again. It provide however aspects to be considered when a management committee evaluate the effectiveness of an awareness campaign							N/A
			Compare with Bill								
		Losses	Leaks: In-house								
			Meter accuracy								
		Water wise gardening									
		Retrofit									
		Re-use of grey water									
		Alternatives	Borehole								
			Rainwater								
						Score	0	0	0	0	0
						Performance range	0	4	8	12	

Table 6.5: WDM score card: return flow management

Water Cycle Step	Management Focus		Evaluation Criteria: Bad	Evaluation Criteria: Acceptable	Evaluation Criteria: Good	None 0	Bad 1	Acceptable 2	Good 3	
RETURN FLOW MANAGEMENT	Sewer system	Maintenance on sewage system	Removal of blockages on request	According to set program	Program in place and well funded					
	Point source pollution	Sampling	Once every 6 months	Every Month	Every month and during suspect conditions					
		Analysis	Sent samples to central lab (waiting time, weeks)	Sent samples to local lab (waiting time, days)	Analysis at own lab (Results immediately)					
	WWTW	Inflow measured	Irregular or Monthly	Daily and complete records	Continues electronic records					
		Quality of inflow	Samples analysed monthly	Samples analysed weekly	Samples analysed daily					
		Benchmark values	Available for some of aspects, but at least ratio between water sold against water received at WWTW	Available for most aspects, but at least ratios between water sold, water received and water returned to source.	Available for all aspects to be compared nationally and own benchmarks.					
		Capacity known	Only hydraulic capacity known	Hydraulic capacity and design loads known	Hydraulic capacity and design load measured against inflow data					
		Sampling	Irregular or Monthly	Weekly	Daily					
		Final Effluent Quality	Comply with licence conditions less than 70% of time	Comply with licence conditions more than 70% of time	Comply always with licence conditions					
		Re-use of treated effluent	Between 0 and 15% of annual final effluent	Between 15 and 50% of annual final effluent	More than 50% of annual final effluent					
		Maintenance program	Only during emergencies	On request	According to set program, including preventative maintenance					
	Treatment cost		Treatment cost estimated, seen as part of full water budget	Separate costing done and budget based on these figures	Separate costing done and sewage tariffs based on actual costs					
					Score	0	0	0	0	0
					Performance range	0	12	24	36	

Table 6.6: WDM score card: institutional management

Water Cycle Step	Management Focus		Evaluation Criteria: Bad	Evaluation Criteria: Acceptable	Evaluation Criteria: Good	None 0	Bad 1	Acceptable 2	Good 3	
INSTITUTIONAL	Training	Internal (Done by municipal official for municipal officials)	Provide a score between 0 and 3 on each of the issues depending on the completeness thereof							
		External (Done by external service providers for municipal officials)								
	By-laws									
	Credit Control									
	Complaints Centre									
	Building plan approvals subjected to water saving devices included									
	Rezoning applications depend on effective water management									
	Designated section responsible for Water Demand Management, preferable a separate Unit									
	IDP/WSDP									
					Score	0	0	0	0	0
					Performance range	0	9	18	27	

While it is possible to compare each stage in the water management cycle separately, the readiness of a specific municipality in terms of the implementation of the model provided can be expressed as a percentage in a summary table of all the scores as illustrated in Table 6.7. The "% complete" shown in Table 6.7 only serves as a reminder to the evaluator that all the listed management focus areas have indeed been evaluated or scored.

Table 6.7: WDM score card: summary

Water Cycle Step	% Complete	None	Bad	Acceptable	Good	Score	%
Water Resource Management	0%					0	
Purification Management	0%					0	
Distribution Management	0%					0	
Consumer Demand Management	0%					0	
Returnflow Management	0%					0	
Institutional Management	0%					0	
	Total	0	0	0	0	0	
	Total Performance range	0	0	0	0		

6.11 Summary

Chapter 6 provides the reader with five DSSs (water resources, water purification, distribution, consumer demand and return flow management), designed to enable a structured process of decision-making when WDM is implemented within a municipality. The roles and responsibilities of all parties involved in the decision-making process, specifically when resources are involved, were evaluated and the close cooperation between the different institutions, like the CMA and the municipalities, were highlighted.

The water resource management DSS focuses on the cooperation between all of the institutions responsible for water resource management, and it highlights the importance of appropriate yield analysis and comprehensive disaster management plans. Operational procedures form an integral part of the management of water resources.

The purification management DSS focuses the municipality's efforts on appropriate treatment practises to avoid water losses. The treatment process needs to be monitored at each step of the process, and water quality plays an important role in this DSS. Well-documented benchmark values are required to ensure a means to measure progress.

The distribution management DSS provides municipalities with a systematic procedure for ensuring that the water received from the water treatment works is delivered to the end-user in such a manner that water losses are minimised. It focuses on the need for the implementation of various, rather extensive, programmes, like meter and pressure management. The importance of a block tariff structure was highlighted, as well as the need for good cooperation between the financial and technical departments.

The consumer demand management DSS provides management guidance to both the municipality as well as the end-user. Metering plays an important role in the management of this step. While the main focus for the municipality is on administrative arrangements such as step water tariffs and informative billing, the end-user's focus is drawn to leak detection, re-use, retrofit and water-wise gardening principals.

In the return flow management DSS, the sequence of steps that need to be implemented to ensure that the water received from the end-users is treated to an acceptable standard before returning it to the river system, was presented. Attention was drawn to the importance of reducing the flow entering the waste water treatment works, and the need to make use of treated effluent, where applicable, was highlighted. It is clear that the management of return flows plays an important role when a decision needs to be made regarding the upgrading of expensive waste water treatment works from time to time. The tariff structure based on the "polluter pay" principle is one of the main tools available to municipalities, and requires accurate calculations regarding the treatment cost of sewage. The ability to measure flows and carry out proper quality assessment is fundamental to the management process and the importance of awareness among the end-users remains critical for success.

This chapter illustrates the importance of decision-making regarding WDM within the context of integrated water management and the IDP process. The DSSs can also be used as checklists to measure progress in terms of performance management of municipalities. The steps to be taken within the DSSs depend on benchmarks, which need to be seen in the context of the region or river system. Municipalities need to see the DSS as a guide and not as the only tool that will, if followed to the letter of the word, necessarily provide the full answer to WDM for that specific municipality. These DSSs will, however, save a lot of time and will guide a municipality away from investing significant amounts of capital before it understands the root of its water problem.

The importance of the different institutional arrangements, like by-laws and training, that need to be in place, has been described, and their relevance to the full process was highlighted. Aspects such as awareness campaigns and the related time tables for the implementation thereof, show that WDM is not a short term project.

A score card was also developed based on the DSSs to facilitate an evaluation of progress made on the management focus areas listed. The values indicate the readiness of a specific community or town with respect to its progress on the implementation of WDM, and in themselves provide for a benchmark value against which a municipality can measure its progress.

The DSSs presented in this chapter will be used in Chapter 7 to illustrate their practical implementation, based on the data analysed during the Robertson case study. The score card will be used to illustrate how well Robertson has progressed with the implementation of WDM initiatives.

CHAPTER 7

IMPLEMENTATION, EVALUATION AND FINDINGS

7.1 Introduction

The DSSs presented in Chapter 6 focus on all of the stages in the water management cycle as defined in Figure 4.1, and describe processes rather than specific actions to be taken. Specific actions were described in Chapter 4, while Figure 5.6 and Figure 5.7 in Chapter 5 described the role public participation plays and how WDM can be initiated as part of the decision-making process. At ground level, the circumstances differ from community to community and benchmarking, highlighted in section 4.5, is used as a measure to identify specific problems. A set of benchmark values were developed during the PI study, described in section 5.2, which will assist in this process.

To illustrate the difficulties that can be experienced during the process of WDM, the water situation in Robertson, a town in the Western Cape Province in South Africa (see locality map, Figure 7.1) was analysed and the WDM process that followed, as described in section 5.4, was evaluated. Workshops were held with the different role-players in Robertson, and the DSSs presented in Chapter 6 were evaluated with the situation in Robertson in mind. The lessons learned during the implementation phase in Robertson will be used to highlight the possible pitfalls of these DSSs. The case of Robertson will also be used to illustrate the importance of critical data in the process of WDM.

Before the steps and processes followed in the Robertson case study can be evaluated, a brief overview of the water supply system at Robertson will be provided. The WDM steps taken by Robertson will then be analysed, followed by the evaluation of the Robertson situation with the DSSs to illustrate the use of these DSSs.

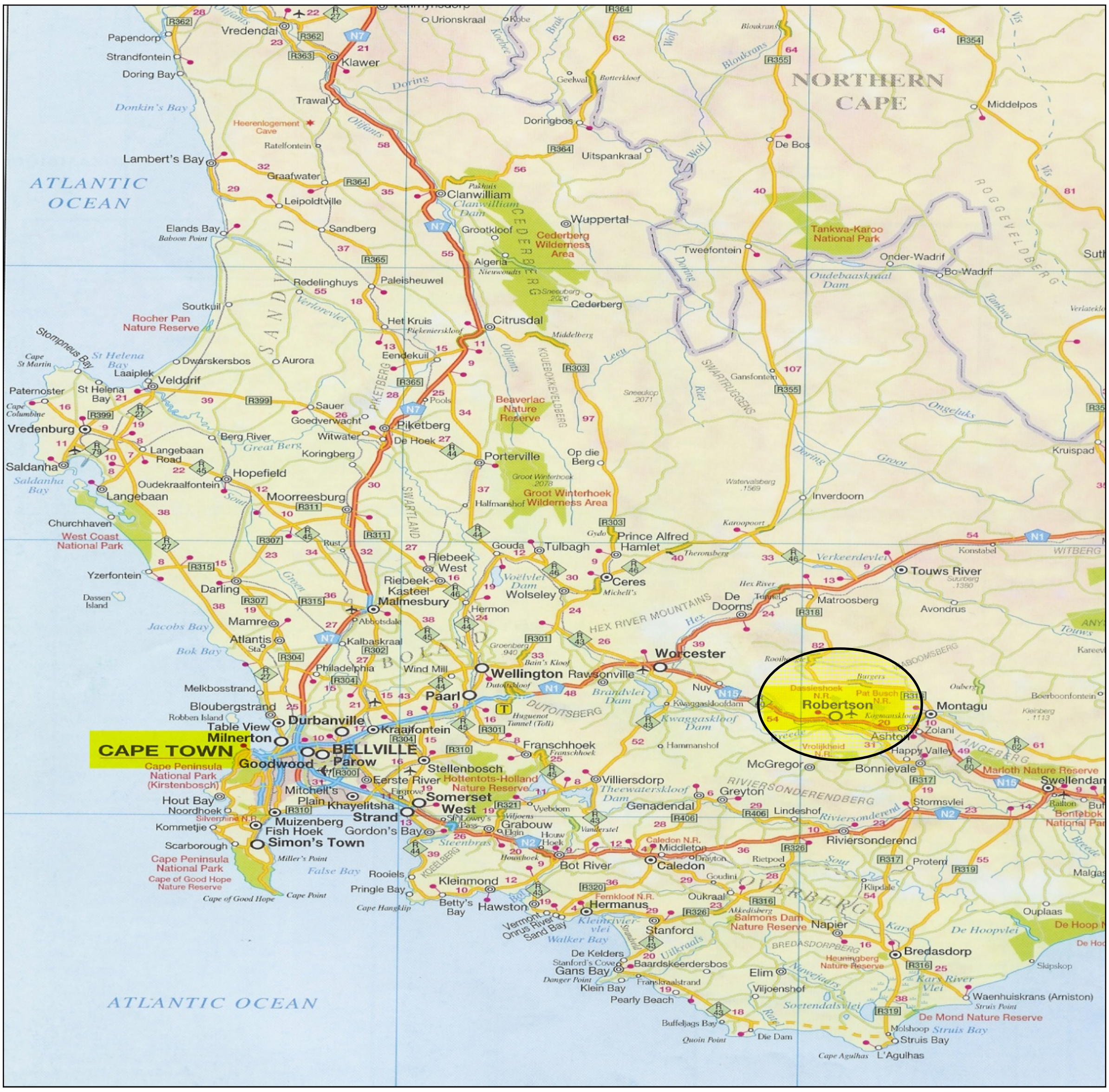


Figure 7.1: Locality Map

7.2 Water Supply to Robertson

During 2004, Robertson experienced serious water shortages when the levels in all of the supply dams dropped to low levels, with little inflow from the different water sources. The Breede River/Winelands municipality was faced with a possible crisis if it was not able to satisfy the water demand. Both residents and industries expressed their concern about the possible effect such a crisis might have on the town in terms of job losses due to water shortages in the industries.

Technical staff in the municipality also experienced problems with the water quality leaving the waste water treatment works, and the DWA raised their concern about the level of pollutants in the final effluent from the waste water treatment works returned to the resource. There was no formal plan in place to address these issues, and the technical manager was newly-appointed, following a long period during which the municipality was without a technical manager. Measures to secure continuous water supply to Robertson were urgently needed, and a number of steps were implemented by the BRWM Council to this end.

One of the critical issues identified during this period was the lack of usable data on which to base decisions in the water sector. Robertson lacks most of this management data, with only limited data available on raw water consumption and return flows. Robertson is, however, not unique in this respect and the situation can be considered as typical for many small towns in South Africa, as illustrated in section 5.2. The decisions made therefore need to be seen within the context of the limited available data.

7.3 Water Resources

For any planning in the water sector, it is essential that the water resources are well-understood and that the authority knows the yields of these resources. The resources supplying water to Robertson are integrated, with more than one water user group sharing more than one resource. It is therefore not a simple exercise to determine how much water a specific resource can deliver. Yield calculations, as it is normally referred to, depend on seasonal differences, storage capacities available and user preferences in terms of existing agreements. In order to successfully manage resources, it is required to determine if the available resources are adequate to supply the demand within the framework of these issues.

Robertson receives its bulk water supply from four tributaries of the Willemnels River, the Hoops River and all tributaries of the Breede River. Three of the tributaries of the Willemnels River are the Damkloof, Hoëdrukkloof and Vensterbankkloof, which are generally referred to as Vrekhoek, while the fourth tributary is called Kleinhoek. Water is also received from an irrigation canal, called the Central Breë River Irrigation Canal. The position of the different streams and some of the storage dams are shown on Figure 7.2.

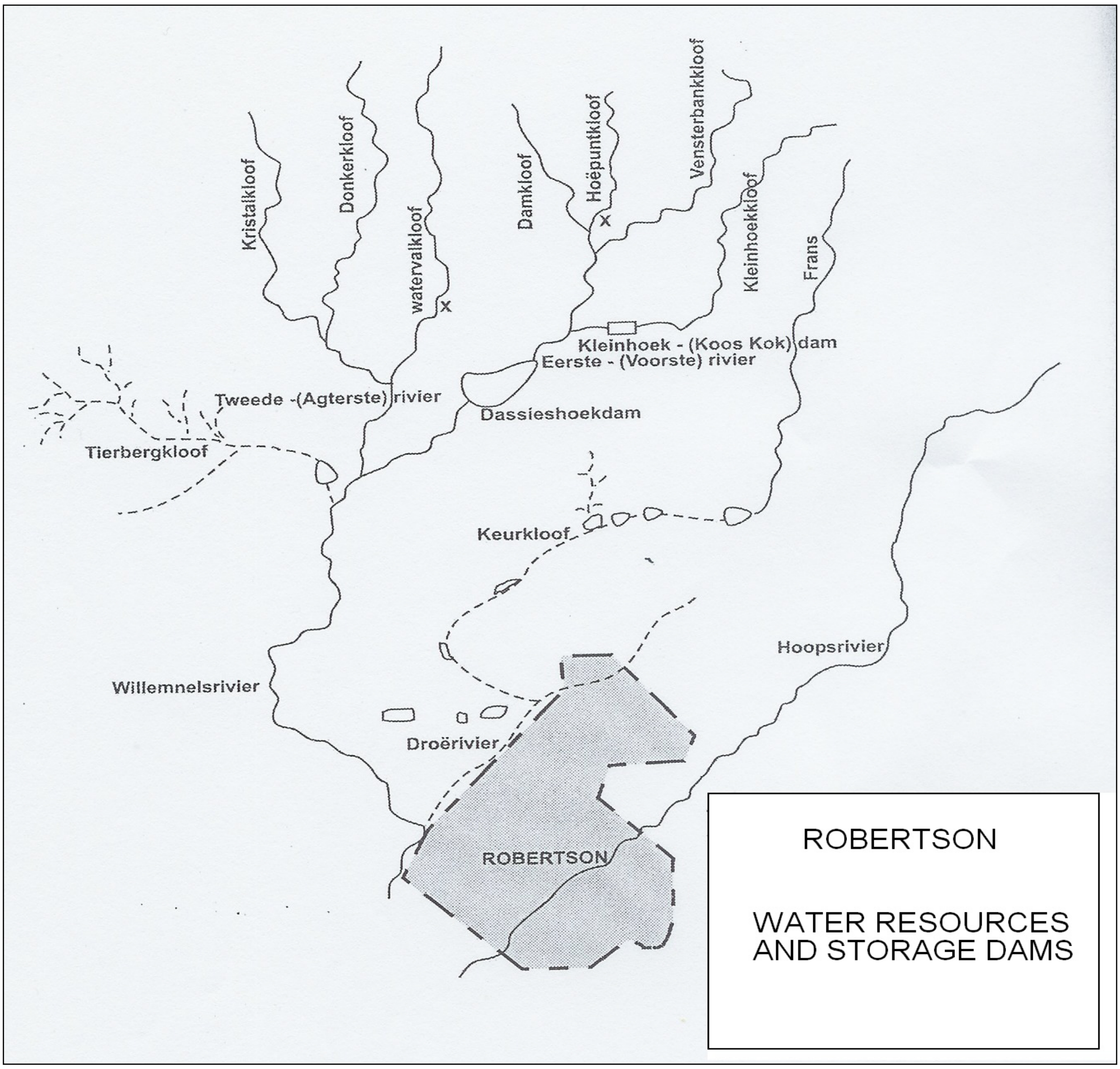


Figure 7.2: Locality of main water resources

The operational arrangement is completely integrated. Resources are utilised on a priority basis in the following sequence: Vredehoek/Kleinhoek, then Hoops River, then Central Breë River Irrigation Canal (mostly only available during summer) and lastly Dassieshoek Dam. Robertson still makes use of a system whereby residences receive a certain amount of water, based on a particular flow for a particular number of hours. The system is generally referred to as the “leiwater” system. Water used through the “leiwater” system is not treated, is supplied via a canal distribution system and is used exclusively for irrigation purposes.

Without detailed flow data available, it was necessary to make a number of assumptions to calculate the actual available volume of water from each resource. The available yield from Kleinhoek and Vrekhoek is based on the capacity of the two storage dams and the available low flow situation in the streams, which are diverted directly into the water treatment works. Table 7.1 summarises all the available volumes, and indicates whether flow is available as potable water, irrigation water or both, depending on the infrastructure available. These results will be used to illustrate how long the existing resources will still be able to supply in the projected demand under specific water use patterns.

Table 7.1: Available resources

Resource	Yield in m^3/year	
	Potable	**Irrigation**
Kleinhoek / Vrekhoek	1,103,760	
Kooskok/Dassieshoek Dam	815,000	
Hoops River	662,256	
Irrigation canal	1,552,500	
Van Dijks Dam		330,000
TOTAL	**4,463,516**	

One of the critical issues regarding the available water resources for Robertson is the lack of a proper yield analysis, based on the risks of supply. It is important for Robertson to know at what levels of the combined reservoirs capacities steps need to be implemented to restrict water demand. It is not only required to identify the levels from when restrictions need to be implemented, but the different sources do have different insurances of supply levels and different costs associated with the infrastructure to store and convey the water to the treatment facility. A proper risk assessment and cost-benefit analysis is outstanding, and is essential for the management of these resources.

7.4 WDM and Water Conservation Steps

The low water levels in the storage dams during 2003/04 forced the BRWM Council to take immediate decisions to ensure an uninterrupted water supply. WDM measures, as well as water restrictions, were imposed. With no funding available, the Council focussed on steps that, in their mind, produced the best possible savings in the shortest time, with the least cost. No emergency plans existed at the time and no economic evaluation of the different alternatives took place. Decisions were merely taken based on perceptions and within the limit of “no” budget.

The water restrictions approved were limited to the partial (50 per cent) banning of the use of the “leiwater” system for irrigation and the introduction of revised water tariffs. An awareness campaign, described in section 5.4, was also launched as a long term strategy, while the cooperation with the SANOW-agreement provided a basis for future possible measures to be implemented. The steps implemented, and which will be described in more detail, included:

- tariff structure;
- metering;
- preventative maintenance;
- garden water use.

7.4.1 Tariff structures

The tariff structure implemented at Robertson consists mainly of a fixed portion (basic tariff) and a portion related to consumption in excess of the first 6 kl, which is free in accordance with national policy. The basic tariff does not apply to those who cannot afford it if they register as indigent. Table 7.2 below summarises the tariff structure over the last number of years.

Table 7.2: Robertson water tariffs

Year	Basic Tariff R/month	Tariff for consumption >6 m^3
2001/02	R22-00	R3-55
2002/03	R19-00	R2-60
2003/04	R24-00	R1-90
2004/05	R28-00	R2-10

Table 7.2 illustrates that the consumption cost of water actually became cheaper for three consecutive years, before it rose again in 2004/05. This was due to the fact that a number of different towns, which were previously each managed by their own municipalities, were now managed by a single new municipality. To ensure easier administration and promote equity, it was decided that no differentiation would exist between the tariff structures of the different towns. All of the tariff structures were therefore brought to the same level over a period of three years, with the net result that the water in Robertson became cheaper.

A lack of proper water infrastructure planning was visible in Robertson. No attention was paid to the fact that the 2001/02 water tariff for Robertson was set to cover the actual related expenditure. A better solution would have been to raise the lower tariffs in the other smaller towns (now all part of the one new municipality) to the level of the tariff set for Robertson. Such a tariff was, unfortunately, not acceptable to the rest of the communities, and neither was it affordable. The result was a compromise where all water sales balanced all water expenditure for the area. The result remains a drop in water tariffs for Robertson, which did not promote water savings.

During 2004/05 an additional set of water tariffs were implemented, which were designed to ensure that high volume users paid more for their water. This tariff was approved by Council as “drought tariffs” to reflect the water situation at the time. The drought tariff structure is shown in Table 7.3.

Table 7.3: Drought water tariffs (2004/05)

Consumption	Tariff R/ m^3
Basic	R28-00
< 6 m^3	R 0-00
6 – 50 m^3	R 2-10
51 – 60 m^3	R 4-00
61 – 80 m^3	R 5-00
> 80 m^3	R10-00

The main reason for this new drought water tariff was to discourage the use of excessive volumes of water. One of the aspects of concern, however, was the level at which these tariffs begin to come into effect. The tariff of R2-10/m^3 for consumption between 6 and 50 m^3 per month is low, and it is debatable whether this tariff reflects the actual cost of the water. For a typical household of five people, the usage of 50 m^3 per month reflects a water consumption of more than 333 litres per person per day, which is more than the average per capita daily consumption for Robertson, calculated to be 206 litres.

The 2005/06 tariff structure makes provision for three additional blocks, but it reduced the rate for consumption between 81 and 90 litres to R4-00/m^3, while water in excess of 90 m^3 will cost R5-00, and in excess of 110 m^3, R10/m^3. It is therefore clear that the tariff structure as implemented by Robertson is unlikely to contribute towards a more effective use of water.

The 2003/04 water tariff for major industrial water usage is reflected in the WSDP as R2-10, which is the same as for individual use, with the exception that there is no block tariff structure in place. The fixed monthly charge is also the same. This structure provides no incentive to industries to reduce water consumption. The importance of industries for job creation opportunities cannot be ignored and unnecessary punitive steps need to be avoided, but the tariff still needs to be sustainable.

The tariff imposed through Council in 2004/05 went through a normal budget process. During this process, Council advertised all the tariffs and allowed for comments from the public. After a window period for comment from the public, the budget was submitted to the national government structure for approval, after which it was implemented. In the case of the revised “drought tariffs”, Council advertised these tariffs in the local newspapers and allowed a period of one month for comment before it was implemented. No comments were received and the tariffs were implemented as advertised.

7.4.2 Metering

The technical manager, who was appointed during this critical stage, requested a full water audit to be done, but a comprehensive water audit proved to be impossible with the limited existing database. Bulk water meter readings were not available at all of the critical points, with only limited data from the bulk supply to the water treatment works available. No data was available for the volume of water supplied, as irrigation water to the properties (“leiwater”) and the treated effluent was also not measured. There was no official metering replacement programme in place and the water meters were also not tested on a rotation base to verify their accuracy. Furthermore, replacement of inaccurate meters was only done at the request of the end-user.

Within the existing budget, a telemetry system was implemented, as a first step, to monitor the water levels at the main clear water reservoirs and the bulk meters, measuring inflow to the water treatment works. This information can provide valuable operating data to ensure that decisions resulting in possible water savings can be made in time.

During the first attempt to do a proper water audit, it was found that large differences existed between the financial departments database regarding the volume of water billed in comparison with the volume of water treated, provided by the technical department. Although staff shortages and the affordability for Robertson to put more human resources into the metering exercise plays an important role, it is important that the meter reading of the household meters done by the financial department should be synchronised with the bulk water meter readings done by the engineering staff. Without regular control over the data collected by the financial department, water audits will be difficult. Steps were therefore implemented to ensure that water meters are read on the same days by the technical and financial departments, and that the data is compared and evaluated on a monthly basis.

Robertson did not have access to any data loggers, and it was therefore difficult to evaluate the actual flow over time. The installation of data loggers will assist in providing valuable information regarding the losses in the distribution system.

7.4.3 Preventative maintenance

Robertson implemented a simple but effective way to deal with deteriorating pipe systems. All of the pipe bursts or related problems (leaks) reported were marked on a central map. A concentration of these markings gives a good indication of a problem that needs closer investigation.

The ability of municipalities to replace their existing infrastructure is, however, limited, and mostly depends on provincial or national government grants.

7.4.4 Garden water use

According to the "leiwater" system, a specific flow of un-metered water is supplied via an irrigation canal or furrow. Specific properties are entitled to a specific time slot, as requested, normally 15 minutes, in which the "leiwater" can be utilised by that property owner, almost always for irrigation purposes. Robertson supplies a stream of approximately 15 l/s for 15 minutes to each of the participating properties each week. This represents a volume of approximately 54 m^3 per month, supplied un-metered, which is more than the average monthly metered water use for households in Robertson.

The "leiwater" system is politically a sensitivity issue, and municipalities are often reluctant to suggest any changes to this practice. Changes might also be challenged because of complicating legal implications, due to the "legal rights" of the water attached to a specific property, which might be interpreted as an existing legal use.

Even with serious water shortages facing the municipality, the Council did not take the decision to ban this use permanently, but, instead, only applied a full ban for a short period and a partial ban of the "leiwater" supply thereafter. The method of supplying water in this way does not promote effective irrigation practice and the water is frequently allowed to flood a lawn or fruit trees. Since the water is available, it is applied whether weather conditions justify it or not. The ineffectiveness is also illustrated by a number of complaints, normally received from neighbours, regarding the spill of water from one property to another.

The intention of effective irrigation practices at a household level is not to let everything die, but rather to maintain a green and attractive garden, but with less water requirements. Robertson, like many other municipalities in similar situations, argues that the withdrawal of such a practice will result in the town becoming rather "grey" and unattractive, and therefore their unwillingness to abandon this practise permanently.

7.5 Results Achieved in Robertson

The calculations to determine the impact of the water saving measures implemented by Robertson were hampered due to limited bulk water meter readings. The water restrictions were based on the banning of all “leiwater” from February 2004 till November 2004. A 50 per cent ban was enforced on the “leiwater” from November 2004 till March 2005, after which the restrictions were lifted. Drought tariffs were also imposed during this period. A comparison between the raw water abstracted at the water treatment works between 2003 and 2004 (see Figure 7.3) shows that the water saving measures did not have any impact on the volume of water abstracted from the different resources until November 2004.

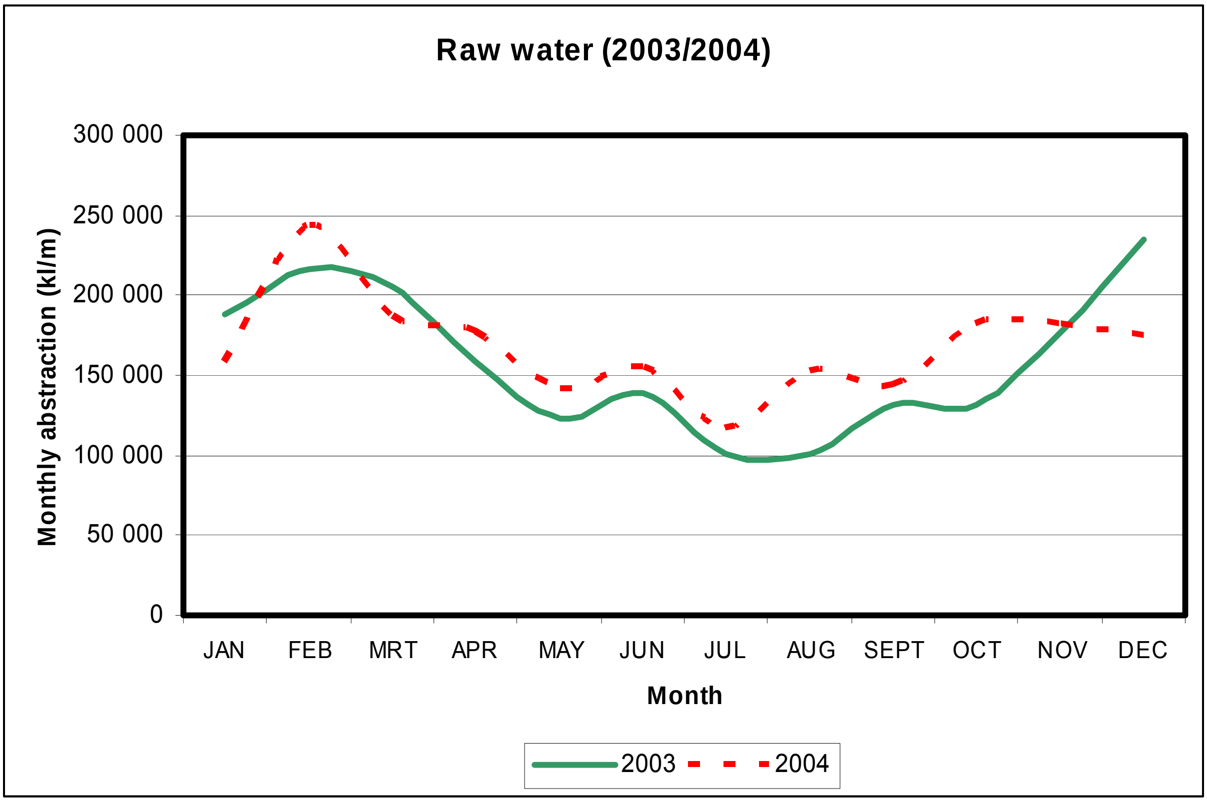


Figure 7.3: Raw water abstraction for 2003 and 2004

These abstraction figures do not include the “leiwater”, which was partially banned. There was a significant saving on the irrigation water, and it was to be expected that limited volumes of potable water were to be used for irrigation purposes. This will be described in section 7.6.5 as the reason why the ratio between treated (potable) water and sewage produced proved to be low.

The reduction in the usage during December might be attributed to the fact that an awareness campaign does not have an immediate effect on water consumption. Limited data, however, prevents further verification of the observed tendency.

Data from the financial system, which reflects the actual volume of water purchased by the consumers, was not easily available. An analysis of twenty-five arbitrarily selected household water consumption figures were analysed, and the results are presented in Figure 7.4.

The actual direct comparison between the pre-restriction usage (2003) and the usage during restrictions (2004) are shown on the left x-axis (bottom part of graph), while the % difference between these scenarios is shown on the right x-axis (top part of the graph). The negative % values are obvious, confirming that individuals did not really save water at a household level.

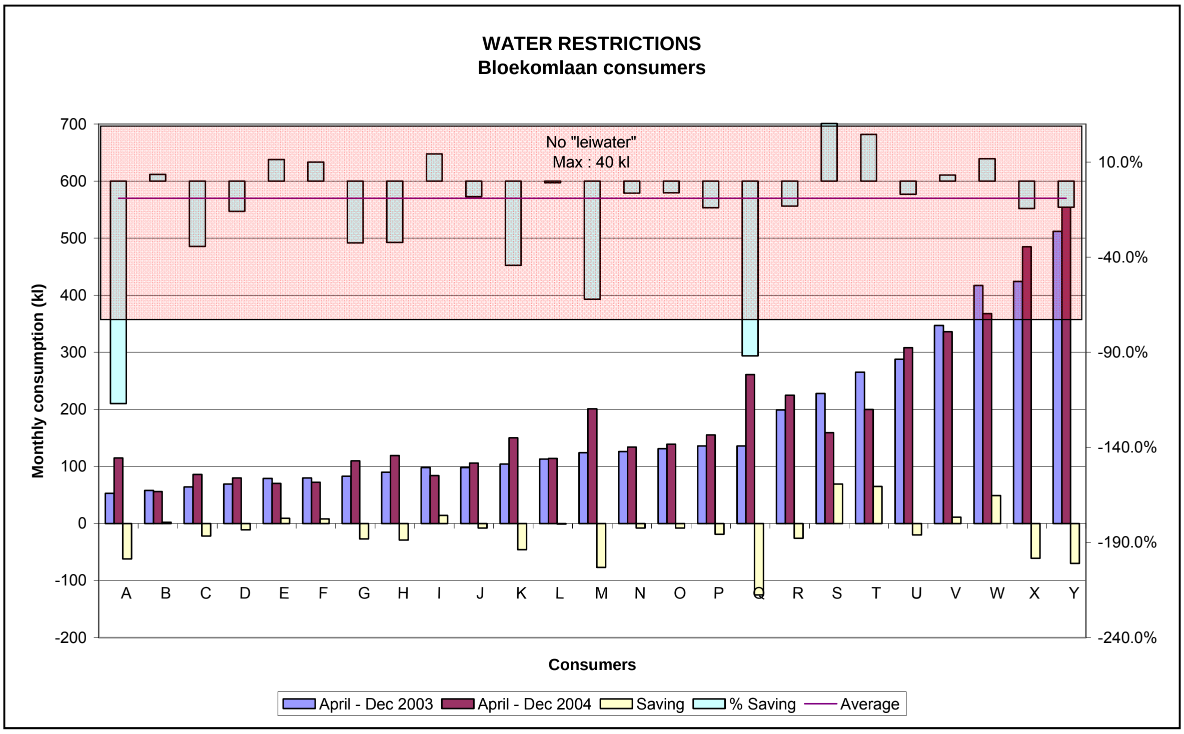


Figure 7.4: Restriction consumption

There was also no clear evidence of larger consumers saving more than smaller consumers. The limitations of such a small sample should not be ignored, but the results nevertheless confirm the bulk figures indication that the only real saving was with the banning of the irrigation water.

There are a number of important objectives that were achieved during the implementation of this project, even when the influence on water demand is difficult to calculate in the short term. These objectives[6] include the following:

- The banning of the "leiwater" did have a significant impact on almost every property owner, and the publicity received through the local press did contribute towards a better understanding of the value of water as a natural resource.
- The forming of a waste minimisation group to evaluate the water use patterns in industries and the cooperation between the different members is an important milestone and should be expanded.
- The value of good data and proper logging has been communicated, as a result of many discussions, to the officials.
- Workshops and meetings regarding WDM were well attended, which is also an indication of the commitment between different role-players to succeed in the fight against wasteful water use.
- The focus on the upgrade of the existing waste water treatment works came as a result of the awareness of problems facing the municipality in terms of the full water cycle, with specific reference to the quality aspects.
- At a municipal level, these discussions and meetings resulted in the management staff of different departments beginning to interact, share their resources and do joint planning exercises.
- Interaction achieved in the waste minimisation group between the public and private sectors during discussions resulted specifically in a more focused approach towards the reduction of waste products, with specific reference to the quality of effluent, leaving the industries.
- At an operational level, the officials planned and budgeted for leak detection equipment to assist them with the identification of problem areas.
- At the council level, the introduction of the drought tariff structure resulted in much debate, adding to the awareness of councillors of the responsibility they carry to ensure sustainable development.

A number of challenges were also been identified in the Robertson process that need attention in order to successfully implement WDM:

- The official route for the public to participate in water related issues within municipalities is the IDP process. The cornerstone of this process is the participation and involvement of all role-players. Robertson's ward system did not

[6] These objectives were identified during meetings held with a number of role-players and was recorded in various minutes of meetings held during the implementation phase.

function properly and the IDP, and therefore the WSDP, was only debated with the public once a year at a public meeting. Although the development forums serve well in identifying problems and needs, these forums are not attended by the role-players in the water use environment. The discussions held among water users during the research period proved to be valuable, but more interaction with the IDP process is required for WDM to succeed.

- Political leaders are still not 100 per cent committed to this process. Few attended the different meetings and workshops that were arranged.
- The interaction between the Financial and Technical departments needs to be improved. The billing system can go a long way in spreading the awareness message, while the data collected by staff of the financial department forms the basis of the audit process, without which WDM cannot succeed.
- The role and responsibility of the district municipalities to assist with these processes is still not developed to its full potential, and should receive more attention. Awareness campaigns are expensive and cannot only be supported in one or two towns. Expensive equipment like data loggers and leak detection equipment that can be used by more than one authority should be provided by these regional authorities. The opportunity to share knowledge between neighbouring authorities is also a typical function that can be managed by the district municipalities.

Although the results achieved through the implementation of WDM and water conservation measures by the BRWM Council provided a number of positive results and identified a number of possible problem areas, the question still to be addressed is: what could have been done within this framework to address the issues raised above? The DSSs were developed to assist the municipalities, and the success of the steps taken by the BRWM will be analysed and tested against the DSSs in the next section.

7.6 Applying the Model to Robertson

Applying the model to Robertson, with the analysis and evaluation of specific data, results in a number of suggestions that will be presented for each phase of the water management cycle. The main aim of this section is to show how, by following the DSSs, shortfalls are identified and what the possible results can be if the procedures are not followed. The site-specific analysis of the Robertson data will also highlight the challenges facing municipalities to implement effective WDM.

7.6.1 Water resource DSS

Robertson shares some of its resources with other WUAs, and official representation has been secured on their management structures. No action regarding WDM has, however, been initiated from these structures, mainly because these structures were newly established with no time spent on operational aspects yet.

The configuration of the available flow meters measuring the flow to the main storage reservoirs from the different resources is of such a nature that it is not possible to allocate volumes to specific resources in all cases. Without long reliable flow records for each specific resource, it is not possible to do proper yield analysis. A yield analysis, linking yields from different resources with their associated risks, is essential for the integrated management of the resources. Without this information, it is not possible to put management arrangements, like restriction levels, in place for the different storage dams. Alternatives do exist in the form of standardised regional analysis proposed by the WR90 analysis procedure, but this was not used in the Robertson situation.

Based on population figures and a per capita consumption of 206 l/c/d (to be described in section 7.6.3), the projected demand can be calculated, taking the present treatment and distribution losses of almost 30 per cent (to be described in sections 7.6.2 and 7.6.3) into consideration, as illustrated in Figure 7.5.

The capacity of the resources, as calculated in section 7.3, is also shown in Figure 7.5. If the irrigation supply (calculated to be approximately 976,544 m^3/year) is to be maintained, then the available resources for potable water will be reduced accordingly. Figure 7.5 shows that the water resources still seemed to be adequate during the research period (2004-2007), but that, unless the irrigation water is managed properly, Robertson might run into supply problems shortly after 2010.

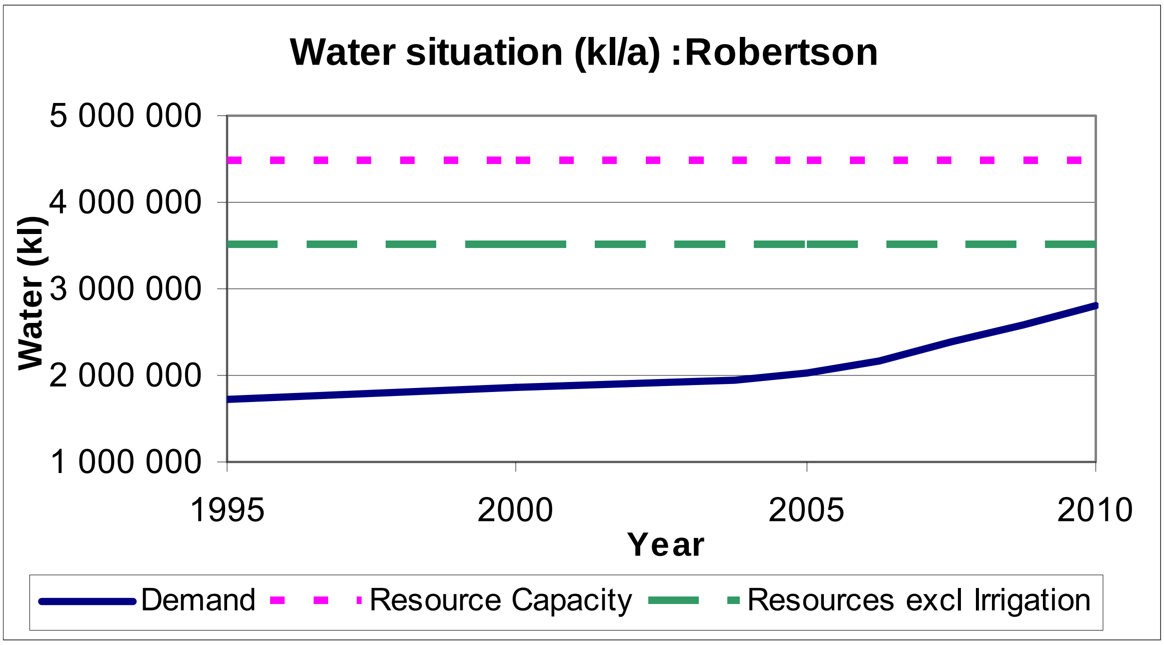


Figure 7.5: Projected future water demand

The water resource DSS highlights the importance of a proper management or operational plan for the resources. If such a plan was in place for Robertson, the need for measures to curtail water demand would have been identified sooner, allowing for more time to implement the required steps to prevent water shortages. The lack of such a plan resulted in the BRWM being forced into a situation where steps were required as an emergency arrangement, without proper funding to secure the planning and implementation of well-communicated steps. Disaster management plans, as part of the IDP as prescribed by the Municipal Systems Act (Act No 32 of 2000), are in place, but do not address the alternative procedures in an event of a major drought or water crises.

No formal attempt has been made to secure the catchment areas of the resources serving Robertson from an invasive plant point of view. Robertson and the relevant WUAs do not know the impact of these plants on their water resources and without a proper assessment, they do not know the potential of this possible action. If known, the data could be used to do a financial viability study comparing the eradication of alien vegetation with any of the other possible options available, resulting in the implementation of the most cost effective WDM measure.

A well-structured awareness campaign forms an integral part of the management of the full water management cycle, and will be analysed in more detail during the evaluation of the consumer demand management DSS. Robertson completely lacks awareness among the public in respect of the water resources, which is still being seen as the function of "someone else".

7.6.2 Potable water treatment management DSS

Limited data on the volume of water received at the water treatment works was available, but it was unfortunately not possible, due to the reservoir and pump configuration, to identify what volume was received from each separate resource.

Robertson does, however differentiate, between water supplied for drinking and irrigation ("leiwater") purposes. Water for irrigation purposes is not treated, which results in huge cost savings to the municipality. The associated risks with the use of the irrigation water in open furrows in the town need to be kept in mind, and disinfection could be considered a basic treatment option.

Water sampling takes place on a monthly basis. The quality of the water does not vary significantly. The operational procedures (backwash cycle) at the treatment works are optimised through the experience of the operators. More regular sampling for basic criteria such as NTUs and pH can assist with the further optimisation of the treatment process.

Robertson is fortunate to be able to redirect their backwash water back into the irrigation system and as such their treatment losses due to backwash wastages can almost be ignored. The volume of the backwash water is not measured and is assumed to be the difference between raw water received and potable water delivered. A more accurate audit on the treatment process will be possible if the backwash water is also measured. Metering of all the bulk water meters should also be coordinated to be read at the same time in order to facilitate an effective audit process.

Robertson does not have their own specific set of benchmark values, and the South African National Standards (SANS 214) guidelines are used for quality aspects. The per capita capacity amounts to 410 l/capita. Based on the PI study (see Figure 7.6), which reflects an average per capita treatment capacity of 504 l/capita, Robertson's potable water treatment works compare well, although it is important to also evaluate treatment capacity against peak daily demands, which are not measured or known for Robertson, due to a lack of real time flow measuring.

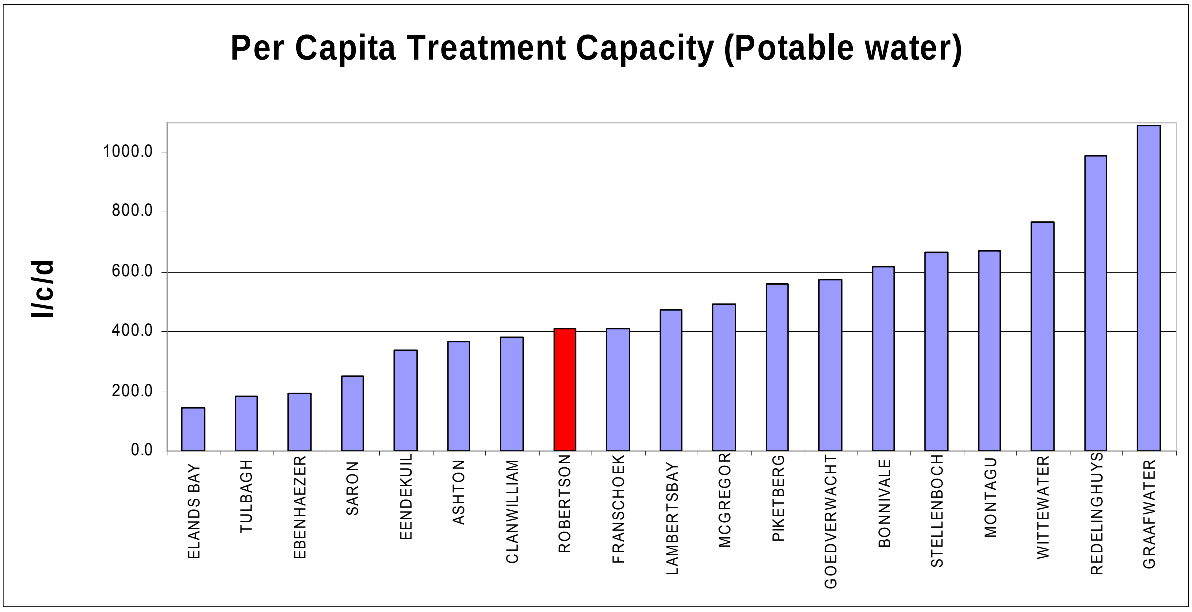


Figure 7.6: Per capita potable treatment capacity

The evaluation of the treatment losses on a month to month basis revealed significant discrepancies in the monthly loss figures. The main reason for these differences is the problem with the different reading times of the different meters. Figure 7.7 illustrates the difference between the raw water received from the resources and the treated water supplied to the distribution network. The total losses, measured over a period of one year (2004), result in a treatment loss of about 3.6 per cent, which is good.

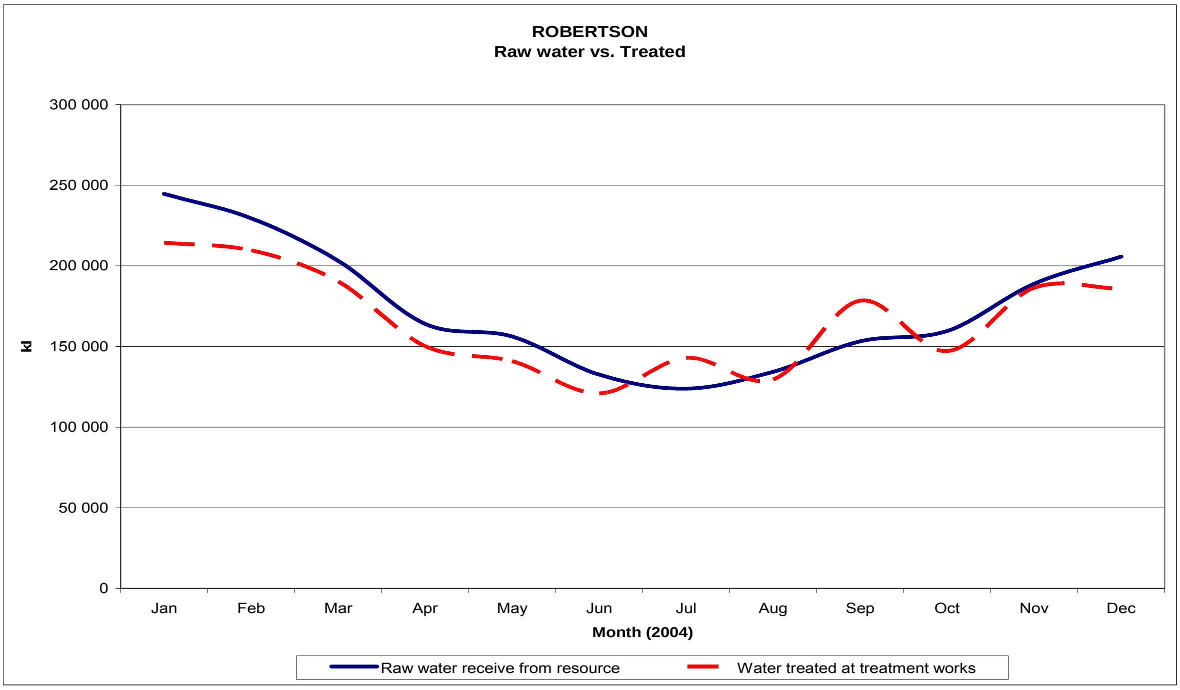


Figure 7.7: Resource vs. treated water

No individual costs are kept for the water treatment phase of the water cycle, and it is therefore difficult to assess the cost effectiveness of the treatment process.

7.6.3 Distribution management DSS

All bulk water meters in the distribution system and individual household meters are read on a monthly basis. The household meter readings are the responsibility of the financial department, which only supplies bulk sale figures to the engineering department for the monthly water audit. Once again, these meter readings are not necessarily taken at the same time, which makes the water audit difficult.

The first step in the water audit is to plot the monthly flow received from the treatment facility against the actual consumption figures over the same period of time. Figure 7.8 illustrates the monthly differences.

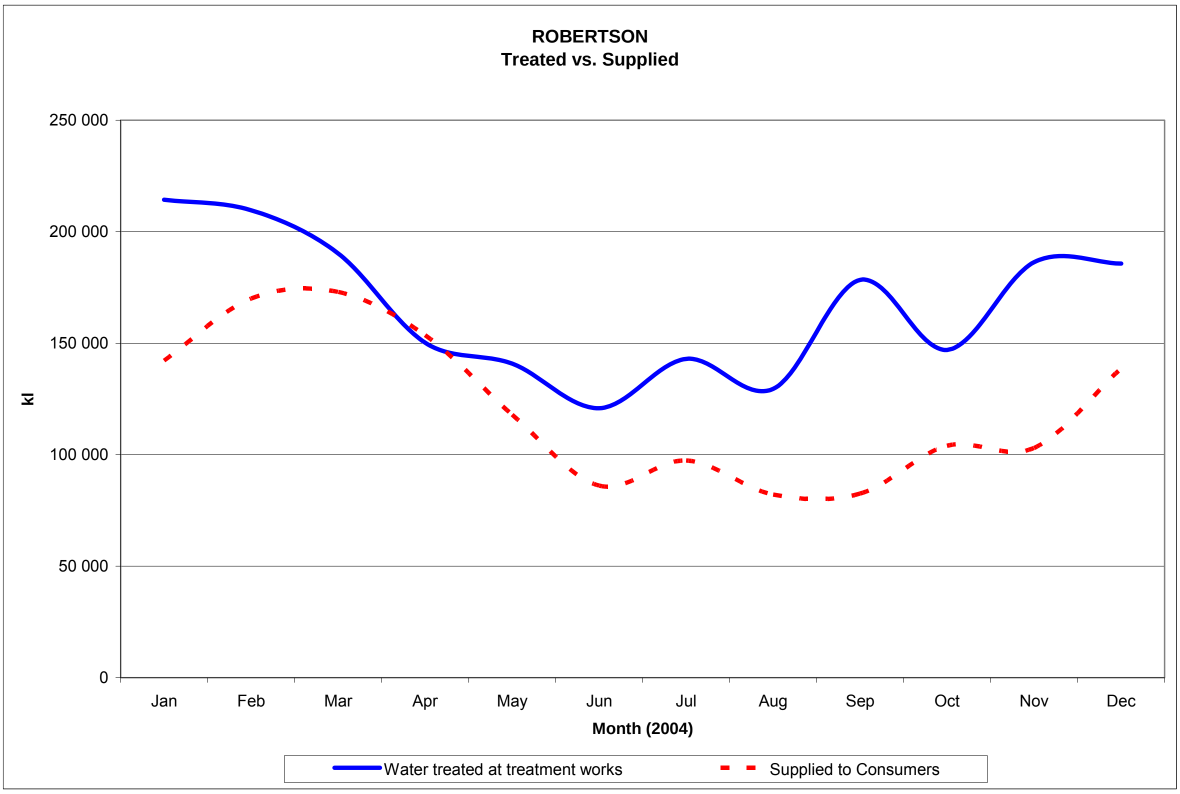


Figure 7.8: Monthly treated water vs. monthly consumption

The difference in reading times results in different monthly losses, which in turn results in an annual difference of 27 per cent, reflecting the UAW.

The unaccounted per capita daily loss for Robertson was plotted against the data obtained in the PI study, and the result is shown in Figure 7.9 . The average per capita UAW for the PI Study was 37.4 l/c/d, with Robertson's figure approximately 18 l/c/d.

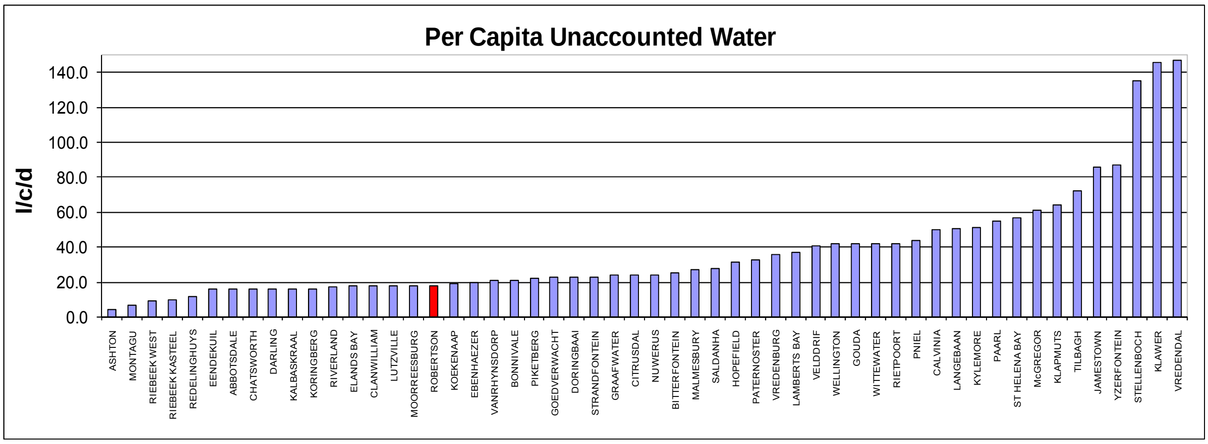


Figure 7.9: Per capita unaccounted-for-water

The low unaccounted per capita figure for Robertson has to be interpreted carefully when compared to the other towns. One of the aspects that need to be taken into consideration is the level of services provided to all the users. The measured flow data available did not reflect the situation for the individual serviced plots in Robertson alone, but it also includes informal settlements. If a large portion of the population only has access to basic services, this figure might be distorted due to their limited water use. These figures could not, however, be verified any further in the case study. Although the per capita unaccounted figure seems acceptable, even better than average, 27 per cent distribution losses are still high and need to be improved.

Based on the consumption figures, Robertson uses approximately 206 l/c/d. This consumption figure has been put in the context of the consumption figures calculated during the PI study. The results are shown in Figure 7.10 which shows that Robertson's per capita consumption is less than the average of 242 l/c/d calculated during the PI study.

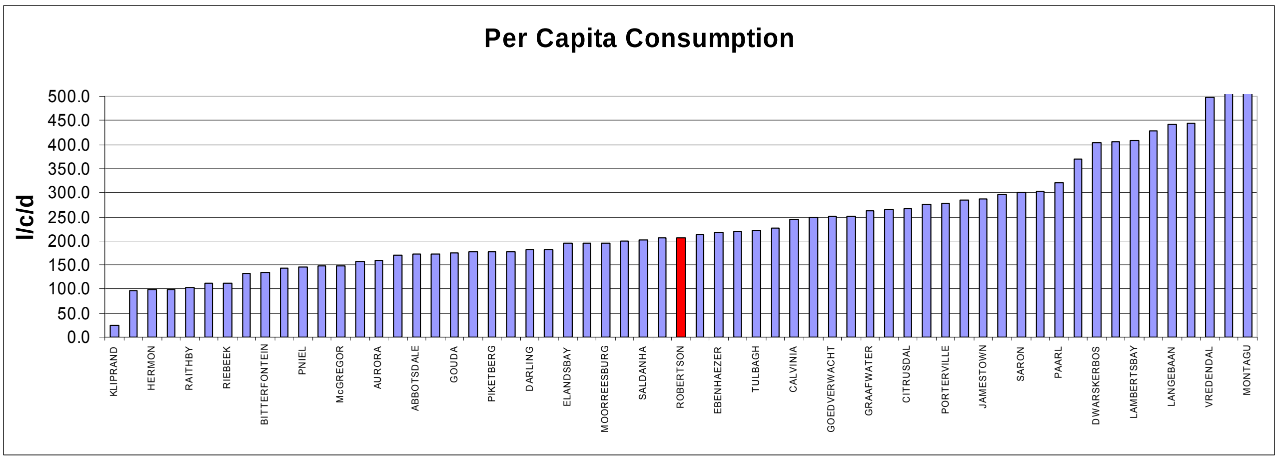


Figure 7.10: Per capita consumption

To assess the full water cycle for Robertson and evaluate the success of the WDM steps taken by them, it was necessary to evaluate all the monthly flow figures for an acceptable reference year. Due to limited data available it was decided to use 2004 as a reference year, since this was the only year with data available in almost all the required sectors, i.e., bulk water received, water treated, water distributed, water used and lastly water received at the treatment works. No return flow data was available, however.

All of the available flow data was plotted on a single graph, as shown in Figure 7.11.

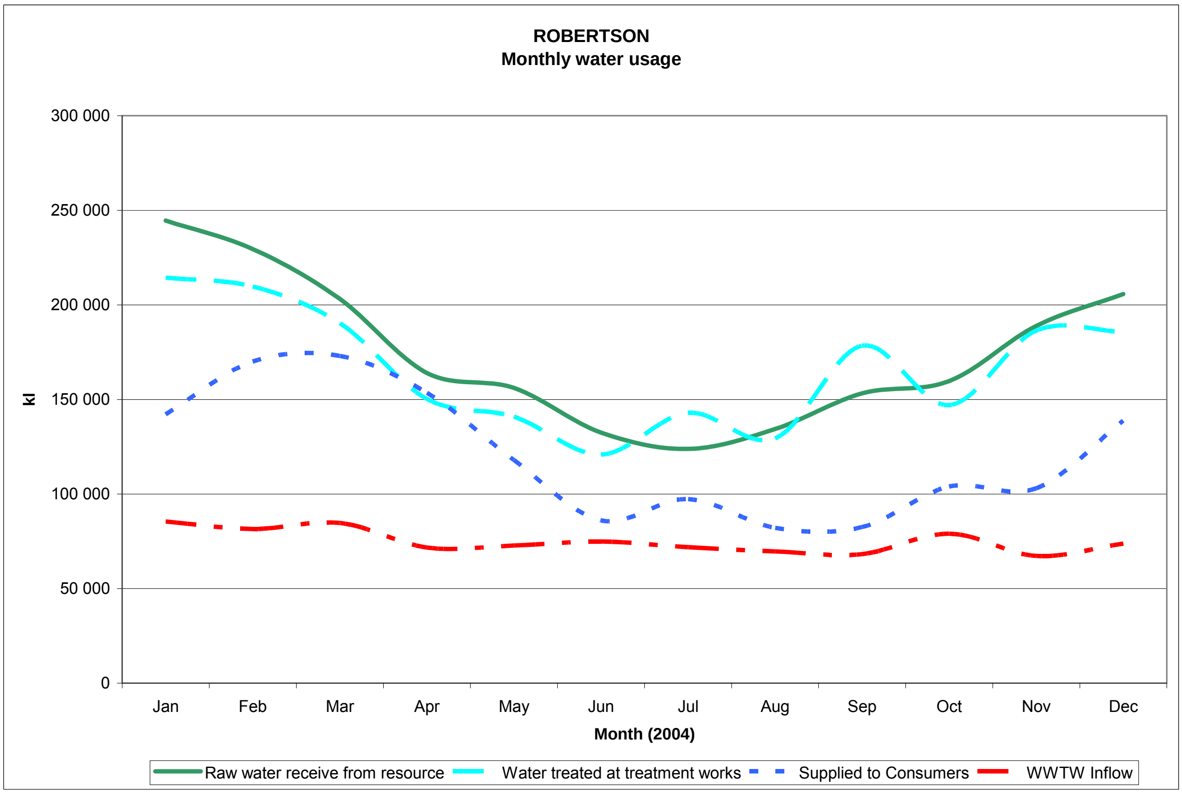


Figure 7.11: Monthly flow figures

Robertson does not have its own set of benchmark values but, compared to the PI study, its per capita consumption does not seem to be too high. It does, however, need to be remembered that these figures are being compared with benchmark consumptions in towns whose figures include garden use (irrigation), while irrigation water for Robertson is supplied through an alternative system. The interpretation therefore needs to be done carefully.

Robertson does not know where losses occur, since no detailed analysis of billed consumption figures has been done. A small percentage of their households do not have metered water and they are in the process of installing these meters. Robertson is, furthermore, not sure if all its installed meters are billed. A detail analysis needs to be done to verify this.

No testing facility exists to test the accuracy of the household meters, and there is no specific replacement programme in place to ensure accurate meter readings. Bulk water meters are, however, calibrated periodically. The municipality is not sure if there are any unauthorised connections, but regulations (old) are in place to act against culprits if such a situation is identified.

With so many uncertainties and with no clear benchmark values in place, Robertson is not in a position to determine if leakages in its systems are a problem or not. The municipality did, however, start the process to purchase some leak detection equipment.

Different pressure zones do exist, and pressures are kept below pre-set values in order to prevent expensive pump costs. No attempt has been made to reduce or control pressures with the aim of reducing losses in specific areas during periods of low flows. The scale and number of people involved that can be subjected to these control measures are relatively small, however, and it is unlikely that pressure management will play a role in any future WDM actions.

Reservoir levels are monitored with the aid of telemetry in order to prevent spillages, and a basic infrastructure maintenance plan has been implemented to identify critical areas in the distribution network.

It was clear from the DSS that a number of interventions need to be implemented to ensure that the municipality will be in a position to start addressing WDM in the context of the distribution network. Without well-defined benchmarks it is not possible to determine if losses occur in the system, and without knowing the losses, it is impossible to identify the areas where these losses occur and hence the steps to be taken to rectify them.

7.6.4 Consumer demand management DSS

Decisions affecting the end consumers can be influenced by steps taken by the municipality or implemented by the consumers themselves. In the context of the DSS, a consumer is identified as any individual, business, industry or the municipality itself.

Robertson did implement a step tariff structure, but it was proved in section 7.4.1 that this tariff structure did not necessarily have an influence on the consumption figures of the households evaluated. A critical shortfall with the implementation of the step water tariff was the lack of an informative billing system, guiding the end-user towards his/her performance measured against set benchmarks.

Without these benchmarks, it is unlikely that the end-user will go to the trouble of reading his/her own water meter or doing some control checks on leakage as suggested by the DSS. The block tariff structure linked with the lack of additional information ultimately did not contribute towards water savings or a change in use patterns.

Households in Robertson who do not receive a bill due to the policy that people who cannot afford to pay receive 6 kl/month free of charge, are not controlled by any means to ensure that they receive only the 6 kl/month they are entitled to.

No specific programme was launched by the municipality to motivate water-wise gardening, although the "leiwater" system was banned, resulting in some of the residences using potable water for gardening purposes.

The municipality did set an example by changing some of the water supplying devices in their own buildings to water saving devices. Special attempts to involve the industries did prove to be successful, with working groups being formed to discuss water use in the industrial environment. In Robertson, it was mainly the wineries that joined forces to implement process water auditing and investigate steps to improve the quality of their effluent.

An awareness campaign forms the starting point of the DSS, and Robertson did take a number of steps, as described in section 5.4.2. The lack of personnel and funding prevented the municipality from implementing meaningful projects, and the awareness was therefore done mainly at a basic level, involving general posters and news articles in the local press.

The basis of the process for effective public participation through which an awareness campaign can be implemented effectively has been illustrated in Figure 5.6. Volunteers form the core of such a process, but they need to be supported by the municipality in order to do their job. It was clear that some interest does exist in a public driven process through the establishment of the waste minimisation group and the discussion group. There was, unfortunately, a lack of participation from the political structures to proactively become involved in these initiatives. The WDM programme and the IDP processes were therefore never aligned, resulting in less success than anticipated in both processes.

7.6.5 Return flow DSS

The inflow of sewage at the Robertson waste water treatment works is measured on a regular basis, but not continuously. The quality of the sewage received is measured on a weekly basis and it therefore does not allow for the identification of point source problems. In order to address this, the municipality must invest in a more regular sampling programme and a system whereby infrequent samples can be analysed in the case of a suspected quality problem at the source.

During the PI study, it was found that only a few municipalities measure the sewage received at their waste water treatment facilities. It was therefore also difficult to determine a benchmark value for sewage production during the PI study.

The capacity of the waste water treatment works depends on the quantity and quality of the water received, which is reported (Kwezi V3, 2004:35) to be approximately 2,000 kl/d, based on an organic load [measured in chemical oxygen demand (COD)] of 1,450 kg COD/d.

If the measured flow (2,468 kl/d in 2002) is used as the capacity, then the per capita capacity amounts to 128 l/c/d, which is lower than the average of 192.3 calculated in the PI study, illustrated in Figure 7.12 .

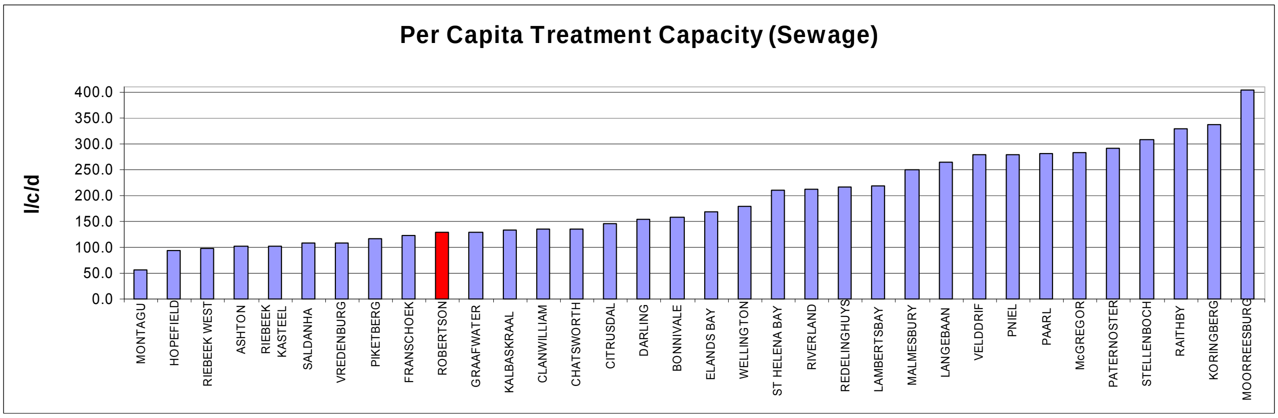


Figure 7.12: Per capita treatment capacity (Sewage)

The problem with the existing waste water treatment works is due to the COD, which has increased by approximately 37 per cent since 1986. In 2003 the flow was already 2,810 kl/d with a COD of 2,321 kg/d, significantly higher than the designed capacity of the existing system. This resulted in failure to achieve the required water quality of the treated effluent returned to the natural river system.

A small amount of treated effluent is supplied to a small farmer project, while some is also supplied to a compost plant. The bulk is, however, returned to the Breë River after chlorination. Unfortunately no records exist of the return flows and no metering devices are in place.

It is also not possible for the municipality to measure the waste stream received from individual industries and the tariff structure also does not allow for varying volume and quality of the return flow stream. The lack in regular sampling, flow measuring from different end-users and benchmarks makes it difficult for the municipality to identify any problems with their sewage collection system.

A graph of the monthly flows received at the waste water treatment works, illustrated in Figure 7.13 does not show any significant variations in the monthly flows to the treatment works, indicating that it is unlikely that groundwater infiltration plays a major role in the volume received at the treatment works.

The capacity of the waste water treatment works was analysed and it is also known from the weekly samples that the quality of the water is deteriorating significantly during the peak grape harvesting season. During this period, the designed capacity of the waste water facility is overloaded and alternatives to deal with the problem at the source of the pollution are under investigation. If attempts to address the problem at the point source fail, then an early upgrade of the waste water treatment works seems inevitable.

Without continuous flow records, it is not possible for Robertson to determine if quality is the only problem resulting in a possible upgrade of the waste water treatment works or if a possible solution can be found in the management of the sewage production. If high flows prove to be a contributing factor, the re-use of grey water and a well-planned awareness campaign can be investigated further before an upgrade of the waste water treatment facilities, at a high capital cost, is implemented.

A limited volume of treated effluent is presently used, but there is no effort to increase this volume. No separate costing is done for the waste water treatment works, and it will therefore be difficult to compile a realistic waste water charge that reflects the true cost of treatment.

The inflows to the waste water treatment works are measured at a single flow meter just before it enters the waste water treatment works. This flow was plotted together with the monthly volume of potable water treated and supplied to the end-users at the water treatment facility. The comparison is shown in Figure 7.13.

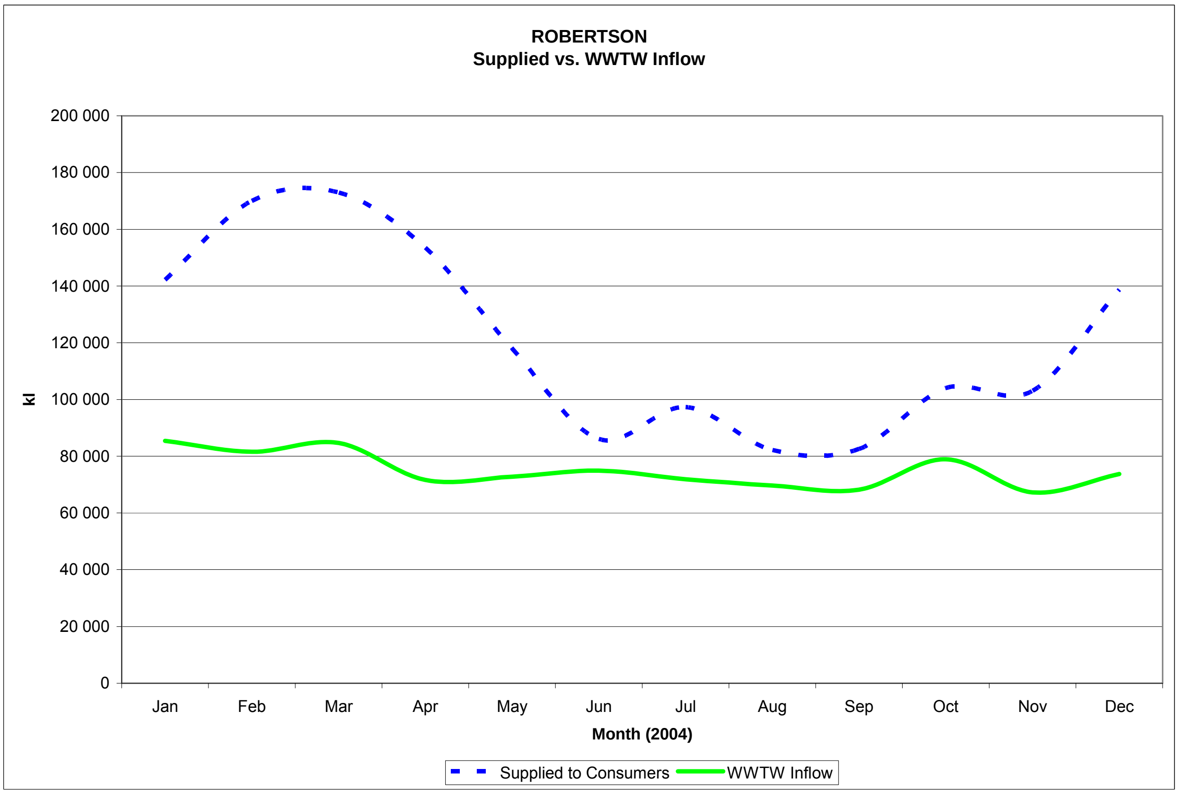


Figure 7.13: Monthly sewage inflow vs. treated water.

From Figure 7.13 it is clear that there is not a constant relationship between the volume supplied and the volume received at the waste water treatment facility on a monthly basis. To put these figures in context, the flow entering the waste water treatment works, expressed as a percentage of the treated potable water supplied, has been plotted in Figure 7.14. The average was calculated to be 45.1 per cent, which is considerably lower than the practical design criteria of between 60 and 85 per cent (Friedrich et al., 2009:79). The value for September (38.2 per cent) is suspect since Figure 7.7 shows that more potable water was supplied to the end-users than raw water received at the raw water treatment works to be treated (the same situation occurred in June, but to a lesser extent). It can be expected that the volume of water treated at the treatment works was less than shown on the graph, resulting in a higher percentage of sewage received for September than shown in Figure 7.14.

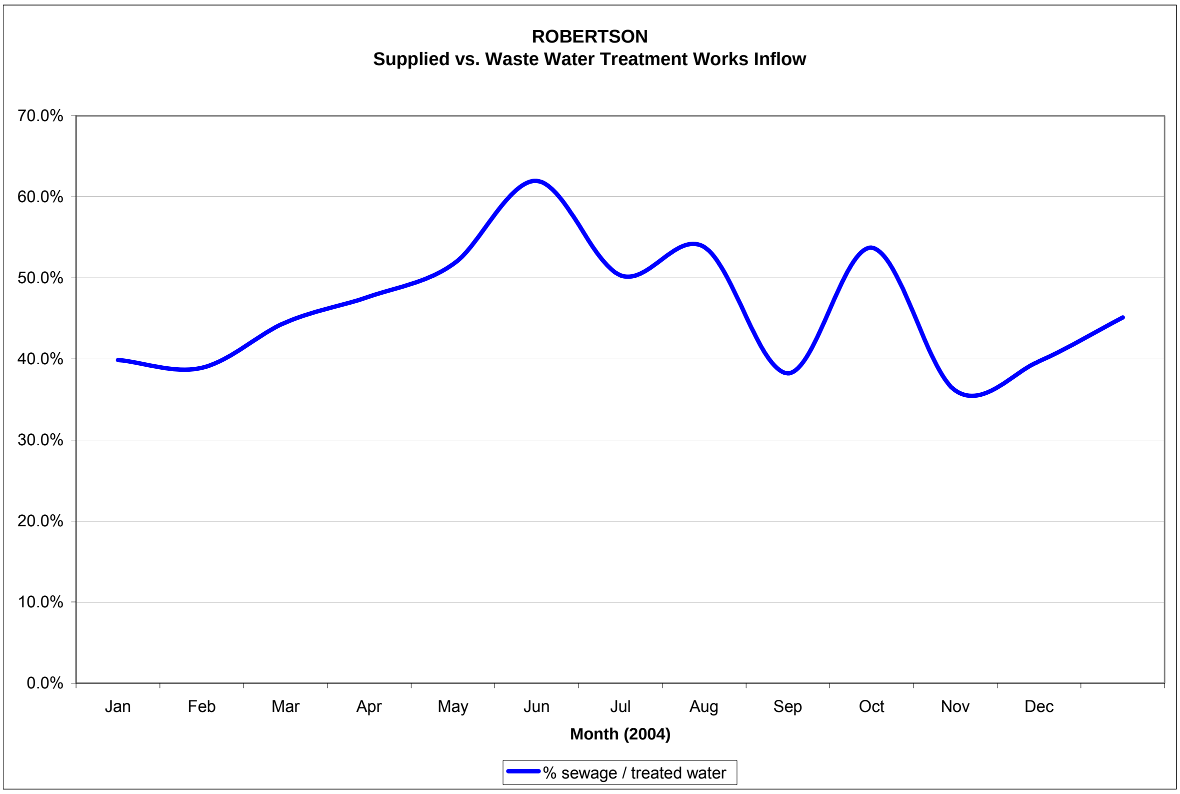


Figure 7.14: Sewage receives as % of potable water supplied.

It can be concluded, based on the data shown in Figure 7.14, that a significant amount of water entering the system has been "consumed". The figures used reflect the period when water restrictions were imposed in Robertson. One of the measures was the banning of the "leiwater" system and it seems clear that more treated drinking water was used during the summer months to compensate for the lack of water supplied for irrigation purposes.

The impact of the "leiwater" system therefore cannot be underestimated. The second possible reason for the relatively high percentage of sewage received during the winter periods can also be as a result of storm water entering the sewage system. This has been identified by the municipality as a possible problem, and an inspection of the management of storm water at a property level needs to be conducted to quantify the extent of this possible problem.

7.7 Robertson WDM Score Card

The WDM score card was used to evaluate the readiness of Robertson to implement WDM in all the steps of the water management cycle. The results are presented in Table 7.4 and the management issues requiring attention can easily be identified.

Table 7.4: Robertson WDM score card

WATER DEMAND MANAGEMENT READINESS SCORE CARD FOR:					
Municipality:	Winelands Breede River	Community:	Robertson	DATE:	2009/10/30

Does community receives more than 70% of its water from own resources? If No, then respond only to "Purchase water from service provider", in all other cases complete full table.	YES	NO
	1	

Water Cycle Step	Management Focus		Evaluation Criteria Bad	Evaluation Criteria Acceptable	Evaluation Criteria Good	None 0	Bad 1	Acceptable 2	Good 3	
WATER RESOURCE MANAGEMENT	Purchase water from service provider	Representation on CMA/WUA and Forums	Establish, no representation,	Representation and participation in decisions	Taking the leading role		1			
		Awareness Campaign	Isolated steps in case of emergencies	Public constantly been informed in various ways	Management committee in place to manage Campaign, with budget allocated to activities		1			
	Own water resources	Managing catchment through eradication of invasive plant species, Working for water project	Serves on management committee	Provide funding in support	Managing and own funding	1				
		Yield analysis done	Yields known based on regional data or reservoir capacity	Hydrological analysis done	Yields known associated with risks		1			
		Reserve known	Allowance made without quantification	Rapid reserve done	Full Reserve approved by DWA	1				
		Use registered	Water use known	Application submitted	Registration Certificate available				1	
		Licence issued	Water use known	Application submitted / Waiting for verification (DWA)	License approved by DWA and available			1		
		Operational Plan	Operating done based on experience only with no formal plan	Basic plan available	Detail Plan available and implemented			1		
		Restriction levels set	Based on operational experience	Based on dam levels	Based on full hydrological analysis	1				
		Disaster Management Plan	No reference to drought situations and lack of supply	Addressing drought and supply problems	Detail steps available in case of drought and supply problems		1			
					Score	3	4	2	1	11
					Performance range	0	10	20	30	37%

Does community treats more than 70% of its water? If No, then proceed to "Distribution Management Table"						YES	NO			
						1				
Water Cycle Step	**Management Focus**		**Evaluation Criteria**			**None**	**Bad**	**Acceptable**	**Good**	**N/A**
			Bad	**Acceptable**	**Good**	**0**	**1**	**2**	**3**	
PURIFICATION MANAGEMENT	Flow measurement	Inflow	Monthly/Weekly, only available at operator	Complete daily data, recorded at operating centre	Continuously and electronically available on demand		1			
		Backwash water								1
		Recycled water								1
		Final treated flow					1			
		Process water audit	Done on request	Monthly audit	Monthly, but available on request		1			
	Water Quality	Regular water sampling and analysis: Raw water	Monthly	Weekly	Daily / Continuously		1			
		Regular water sampling and analysis: Treatment process	Monthly	Weekly	Daily / Continuously	1				
	Backwash water	Re-used	Only None or Good						1	
	Benchmark values	Quality	Benchmarks on some aspects available	Most aspects comparable with own benchmark values	All aspects comparable with own and national benchmark		1			
		Losses					1			
	Administration		Recordkeeping intermittent	Recordkeeping at control centre complete and electronically available	Recordkeeping at control centre available and management feedback provided		1			
	Treatment Costs		Treatment cost estimated, seen as part of full water budget	Separate costing done and budget based on these figures	Separate costing done and water tariffs based on actual costs	1				
					Score	2	7	0	1	10
					Performance range	0	10	20	30	33%

Water Cycle Step	Management Focus		Evaluation Criteria: Bad	Evaluation Criteria: Acceptable	Evaluation Criteria: Good	None 0	Bad 1	Acceptable 2	Good 3	N/A
DISTRIBUTION MANAGEMENT	Flow measurement	Bulk Inflow	Flow only measured from some sources	All bulk inflow measured and database completed	All bulk inflow measured and continuously electronically available		1			
		Sone Metering	Some sones measured	Systems fully subdivide in sones and most sones measured	Systems fully subdivided in sones and all sones measured electronically	1				
		Consumers	Most billed end-users measured	All billed end-users measured	All usage measured and recorded electronically in central database		1			
		Meter management	Replacement of meters when requested by users	Meter replacement program implemented	Meter replacement program implemented and calibration and test facilities used		1			
	Water audit		Annually	Monthly, compared with financial data	Daily and monthly values compared with financial data		1			
	Benchmark values		Benchmarks on some aspects available	Most aspects comparable with own benchmark values	All aspects comparable with own and national benchmark values		1			
	Losses		Only bulk losses known	Bulk and sone losses known	All losses identified		1			
	Leak detection		Reactive leak management	Visually inspected on regular basis	Leak detection program in place and annually monitored		1			
	Billing system		Most users receive a monthly accounts	All water users receive a monthly account and general informative information is provided	All water users receive a monthly account, including zero rates for own use and informative monthly water uses are provided			1		
	Pressure management		Set to constant fixed pressure	Set according to time variable	Sone and flow regulating				1	
	Distribution costs		Distribution cost estimated, seen as part of full water budget	Separate costing done and budget based on these figures	Separate costing done and water tariffs based on actual costs		1			
	Law Enforcement		Investigation done when complaints are received	Investigation based on water audit data	Law enforcement based on set program and water audit data		1			
	Maintenance and operational procedures		Repair work done when needed	Maintenance program in place, Asset management plan in place.	Maintenance program in place, Asset management plan in place all linked to budget			1		
					Score	1	9	2	1	16
					Performance range	0	13	26	29	55%

Water Cycle		Management Focus		Evaluation Criteria: Bad	Evaluation Criteria: Acceptable	Evaluation Criteria: Good	None 0	Bad 1	Acceptable 2	Good 3	N/A
CONSUMER DEMAND MANAGEMENT	Municipality	Flow measurement	Raising block step water tariffs	Fixed tariff rate based on volume used	Between 2-3 blocks, based on volume used	More than 3 blocks, based on volume used				1	
			Informative Billing	Only consumption and amount due	History of consumption and general information	Monthly consumption for at least 12 months and a breakdown of cost per tariff block		1			
		Flow NOT measured	Alternatives in place such as: flow restrictors, pre-paid or yard tanks	Limited alternative measures in place	Alternative measures in place for a significant portion of non-measured consumptions	Alternative measures in place for all non -measured consumption					1
		Awareness Champaign		Only communication when problems is anticipated	Monthly feedback to all	Long term programmes in place and managed by a management committee		1			
	Househould	Consumption known	Access to flow meter	The evaluation at a household level can only be determined through an evaluation among a representative group of end-users. This is only possible if a management committee is in place where all stakeholders are represented. The effectiveness in terms of an awareness campaign has been evaluated as a function of the municipality and will not be included in the evaluation again. It provide however aspects to be considered when a management committee evaluate the effectiveness of an awareness campaign							N/A
			Compare with Bill								
		Losses	Leaks: In-house								
			Meter accuracy								
		Water wise gardening									
		Retrofit									
		Re-use of grey water									
		Alternatives	Borehole								
			Rainwater								
						Score	0	2	0	1	5
						Performance range	0	3	6	9	56%

Water Cycle Step	Management Focus		Evaluation Criteria: Bad	Evaluation Criteria: Acceptable	Evaluation Criteria: Good	None 0	Bad 1	Acceptable 2	Good 3	
RETURN FLOW MANAGEMENT	Sewer system	Maintenance on sewage system	Removal of blockages on	According to set program	Program in place and well		1			
	Point source pollution	Sampling	Once every 6 months	Every Month	Every month and during suspect conditions		1			
		Analysis	Sent samples to central lab (waiting time, weeks)	Sent samples to local lab (waiting time, days)	Analysis at own lab (Results immediately)		1			
	WWTW	Inflow measured	Irregular or Monthly	Daily and complete records	Continues electronic records		1			
		Quality of inflow	Samples analysed monthly	Samples analysed weekly	Samples analysed daily		1			
		Benchmark values	Available for some of aspects, but at least ratio between water sold against water received at WWTW	Available for most aspects, but at least ratios between water sold, water received and water returned to source.	Available for all aspects to be compared nationally and own benchmarks.		1			
		Capacity known	Only hydraulic capacity known	Hydraulic capacity and design loads known	Hydraulic capacity and design load measured against inflow data			1		
		Sampling	Irregular or Monthly	Weekly	Daily		1			
		Final Effluent Quality	Comply with licence conditions less than 70% of time	Comply with licence conditions more than 70% of time	Comply always with licence conditions			1		
		Re-use of treated effluent	Between 0 and 15% of annual final effluent	Between 15 and 50% of annual final effluent	More than 50% of annual final effluent		1			
		Maintenance program	Only during emergencies	On request	According to set program, including preventative maintenance			1		
	Treatment cost		Treatment cost estimated, seen as part of full water budget	Separate costing done and budget based on these figures	Separate costing done and sewage tariffs based on actual costs		1			
					Score	0	9	3	0	15
					Performance range	0	12	24	36	42%

Water Cycle Step	Management Focus		Evaluation Criteria			None	Bad	Acceptable	Good	
			Bad	Acceptable	Good	0	1	2	3	
INSTITUTIONAL	Training	Internal (Done by municipal official for	Provide a score between 0 and 3 on each of the issues depending on the completeness thereof				1			
		External (Done by external service providers for municipal officials)					1			
	By-laws						1			
	Credit Control							1		
	Complaints Centre					1				
	Building plan approvals subjected to water saving devices included					1				
	Rezoning applications depend on effective water management					1				
	Designated section responsible for Water Demand Management, preferable a separate Unit					1				
	IDP/WSDP							1		
					Score	4	3	2	0	7
					Performance range	0	9	18	27	26%

From the score card it is clear that significant opportunities still exist in Robertson to improve in their WDM implementation process. The results are summarised in Table 7.5.

Table 7.5: Robertson WDM score card summary

Water Cycle Step	% Complete	None	Bad	Acceptable	Good	Score	%
Water Resource Management	100%	3	4	2	1	**11**	37%
Purification Management	100%	2	7	0	1	**10**	33%
Distribution Management	100%	1	9	2	1	**16**	55%
Consumer Demand Management	100%	0	2	0	1	**5**	56%
Returnflow Management	100%	0	9	3	0	**15**	42%
Institutional Management	100%	4	3	2	0	**7**	26%
Total		10	34	9	4	**64**	**40%**
Total Performance range		0	57	114	161		

From Table 7.5 it is clear that the institutional aspects are in serious need of attention with a score of only 26 per cent, while the consumer demand management, with a score of only 56 per cent, has been attended to the best of all water management cycle steps. The total score of 40 per cent signifies serious shortfalls in the WDM implementation process for Robertson.

7.8 Summary

WDM should not be seen as a specific action to address a specific need, but instead as a process of achieving set objectives, which can also contribute significantly towards effective water use and integrated water management. The importance of managing the full water cycle in a sustainable way provides the key to success during the management of the water cycle in municipalities.

The decision-making process during the implementation of the WDM steps at Robertson was analysed and the shortfalls were highlighted through the use of the score card. The most critical aspect was the lack within the municipality to utilise the opportunities in the communities to ensure that these steps were implemented in a sustainable way. Political buy-in from councillors was almost non-existent and the municipality failed to link the political process of the IDP with the practical needs of the water users. Participants were divided between a group participating in the IDP process to identify needs such as housing and basic water and a group of water users that were able to make a difference in the water situation in Robertson.

Consumption figures were analysed that helped to identify the focus points of WDM in the future. The techniques implemented in Robertson to achieve water savings were evaluated. It was shown that reliable data is of utmost importance to succeed in the evaluating and monitoring phase of WDM. It was also shown that the results of these exercises cannot necessarily be measured in the short term, and that the impact of such an exercise stretches much wider than the technical departments.

Robertson's problems are typical of all small to medium municipalities. There is simply too much to do with too little money and human resources. Planning therefore plays an important role. The DSSs developed in Chapter 6 specifically aim to assist municipalities with this important planning process.

In this chapter the implementation of the different DSSs were illustrated with the aid of the Robertson case study. The problem areas were highlighted using the score card, which was developed to enable the monitoring of progress in all of the water management cycle steps. Many reasons for the lack in progress during the implementation phase of WDM were identified while applying the DSSs on the Robertson data. The DSSs were used to illustrate that the steps taken by Robertson were not necessarily the correct ones and that the lack of specific input parameters frequently resulted in decisions that were not necessarily the most cost effective.

It was illustrated in this chapter that the DSSs, and associated score card, are capable of providing a well-structured tool that can be used by municipalities to assist them with the integrated planning of the full water management cycle in an effective and efficient way to ensure sustainable water use.

CHAPTER 8
CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

Water is, for different reasons in different countries, a commodity that needs to be managed carefully with the specific purpose of ensuring sustainable and integrated use. Chapter 3 provided a broad overview of the water problem in the world, and highlighted the problems experienced in South Africa. It also provided information on the water situation in the Netherlands as part of the EU, proving that South Africa is not the only country with a challenging water situation. While South Africa needs to deal mainly with water quantity problems, water quality problems, as experienced in countries such as the Netherlands, also require an integrated water resource management approach to ensure sustainability.

Both the EU and South Africa responded with the implementation of different sets of legislation to address these problems, and both sets of legislation acknowledge the need for an integrated approach. Despite the well-defined need to use water effectively and despite well-structured legislation to deal with the WDM issues, research done by the author has found that significant challenges still exist with the implementation of effective WDM, specifically at a local authority level, which is the authority responsible for service delivery.

Within an environment where water resources are already under stress, the need for tools to support water-related decision-making in governance was identified. Based on governance theory, it was identified that these tools need to be able to involve all role-players, and that they need to be able to ensure politicians that they are still in control of the management of, in this case, the water cycle. The functions of different government departments have been stipulated in The Constitution of the Republic of South Africa (Act 108 of 1996), and it is clear that the bulk of the responsibility of service delivery rests with local government. The tools developed will, however, also need to allow for the interaction between the different government structures where needed.

The provision of tools to assist local government with the implementation of effective WDM was identified as a limiting factor within the present local governance environment. To develop tools to assist with this task, it was essential to understand the decision-making structure within the governance environment. After the governance and decision-making environments were studied, the specific water management structures within the South African context were investigated. The legal framework provides the available governance structures, which were used as the basis for developing the model, consisting of two processes and five DSSs, presented in this research and illustrated in Figure 8.1. The model was then reviewed critically to illustrate its use through a case study done in Robertson during a water stressed period.

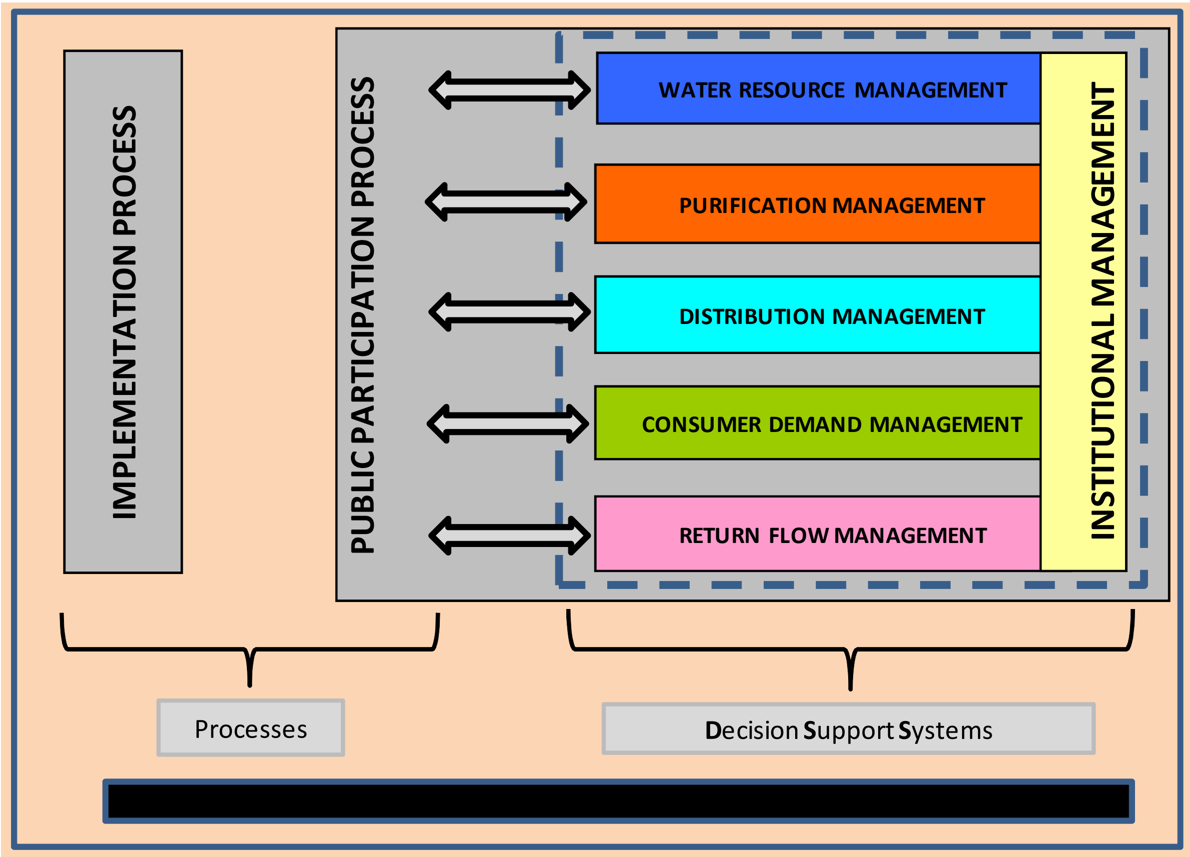


Figure 8.1: WDM model

In this chapter the findings of the literature research will be linked to the model developed, and its use will be illustrated within the available legal framework and governance structures in South Africa.

8.2 Governance and Decision-making

It was clear from the literature that governance has changed significantly during the last three decades. The reason for these changes was the failure of the “traditional” government structures to address the expectations from the tax payers. Government structures were seen as large bureaucracies where little freedom in decision-making existed. The focus was on the management of large organisations and the procedures created to deal with the decision-making process in these organisations.

NPM principles have dictated changes in the way large organisations function over the last decade, with an emphasis on third party involvement. These third parties became more and more responsible for the execution of specific government functions. The public management environment therefore needed to adapt to structures that focus on the management of the third parties responsible for the execution of the projects, as opposed to executing the projects themselves. The full “hand-over” of such a function eventually results in privatisation, which then needs to be regulated through appropriate regulations, resulting in the government structure taking on the role of regulator.

Privatisation in itself is a sensitive issue, since some of the government functions are so important that it is considered to be too risky to allow the responsibility or the control thereof out of the public management arena. The reason is quite simple. The ultimate responsibility of all government structures rests with politicians, and their success is directly linked to the execution of these governance issues, such as water supply.

With political changes in South Africa, the management structures in municipalities have changed, as described in Chapters 2 and 3, through the Municipal Systems Act (Act 32 of 2000) and Municipal Structures Act (Act 117 of 1998), ensuring that the control and responsibility of specific functions, such as service delivery, rests with municipalities. The end result of these changes was the implementation of a political management structure at the highest level in municipalities as discussed in section 3.6, which is contrary to the NPM principals, according to which more managerial skills need to be granted to managers as opposed to political power.

These political management structures were implemented quickly, with the new managers coming mainly from the previously disadvantaged groups, while most of the managers in the water sector were white prior to the political changes in 1994 in South Africa. With these changes in the management structures, the trust and cooperation between the different role-players were put under pressure, with the resultant negative impact on service delivery.

While the managers in the water sector were previously technically qualified, the new generation of managers was mostly not technically qualified, and the structures responsible for the implementation of projects question the validity of the management decisions. The new managers are under pressure to prove to the political structures that the political change in the country is to the benefit of all. A huge shift in expenditure took place between the maintenance of water-related infrastructure and new community facilities such as clinics, sport facilities and community halls. In evaluating water supply systems, the supply of accurate and adequate information became a problem, since line managers became worried that this would reflect badly on their work and performance, which in turn will provide more reasons for staff to be replaced with new, less experienced, staff to adhere to equity rules. The result was a massive loss in continuity, trust and eventually staff to ensure effective water management. This was also experienced during the case study at Robertson, with the position of the manager of the technical services vacant for more than 2 years. The lack of attendance of workshops and meetings by senior management during the implementation phase of the WDM in Robertson further contributed towards a lack of cooperation, and highlighted the need for the development of a model that will guide this process in a structured manner, as presented in this dissertation.

While it is clear from the literature that decision-making needs to be taken closer to the "man in the street" to ensure a more informed decision, assuming that this will result in more effective decision-making processes, the challenge remains to ensure that government (politicians) still control these processes. The consequences of such a structure is that appropriate performance management structures need to be implemented to ensure effective monitoring of the decision-making process.

The key focus area for an appropriate performance management process is the setting of benchmark values or PIs. These benchmark values can only be developed or set if adequate data is available and the need for an appropriate data set is identified.

Chapter 2 provides the theoretical background on governance issues, but limited literature was found that links the water governance issues (full water cycle) at a municipal level with these theoretical general governance principles. This dissertation applied these well-documented governance principles to the WDM field at a local government level. The South African water situation, the NWRS, water governance structures, the NWA and the Water Services Act (Act 108 of 1997) was described in Chapter 3. The management of the water cycle is well-researched in the literature, and the significant changes in the water management structures due to new legislation in South Africa are in the process of being implemented. The responsibility is shared between local authorities and national government, through the DWA, with national government mainly responsible for the management of the water resources. The new management structures for the water resources consist mainly of the CMAs, supported by WUAs and Forums, based on a catchment basin approach as illustrated in Figure 8.2.

It was concluded, however, that local government is the responsible authority for the delivery of water services and that national government, through the DWA, provides the regulatory governance structure to ensure water services delivery. In this regard, regulations have specifically been issued to ensure appropriate WDM steps.

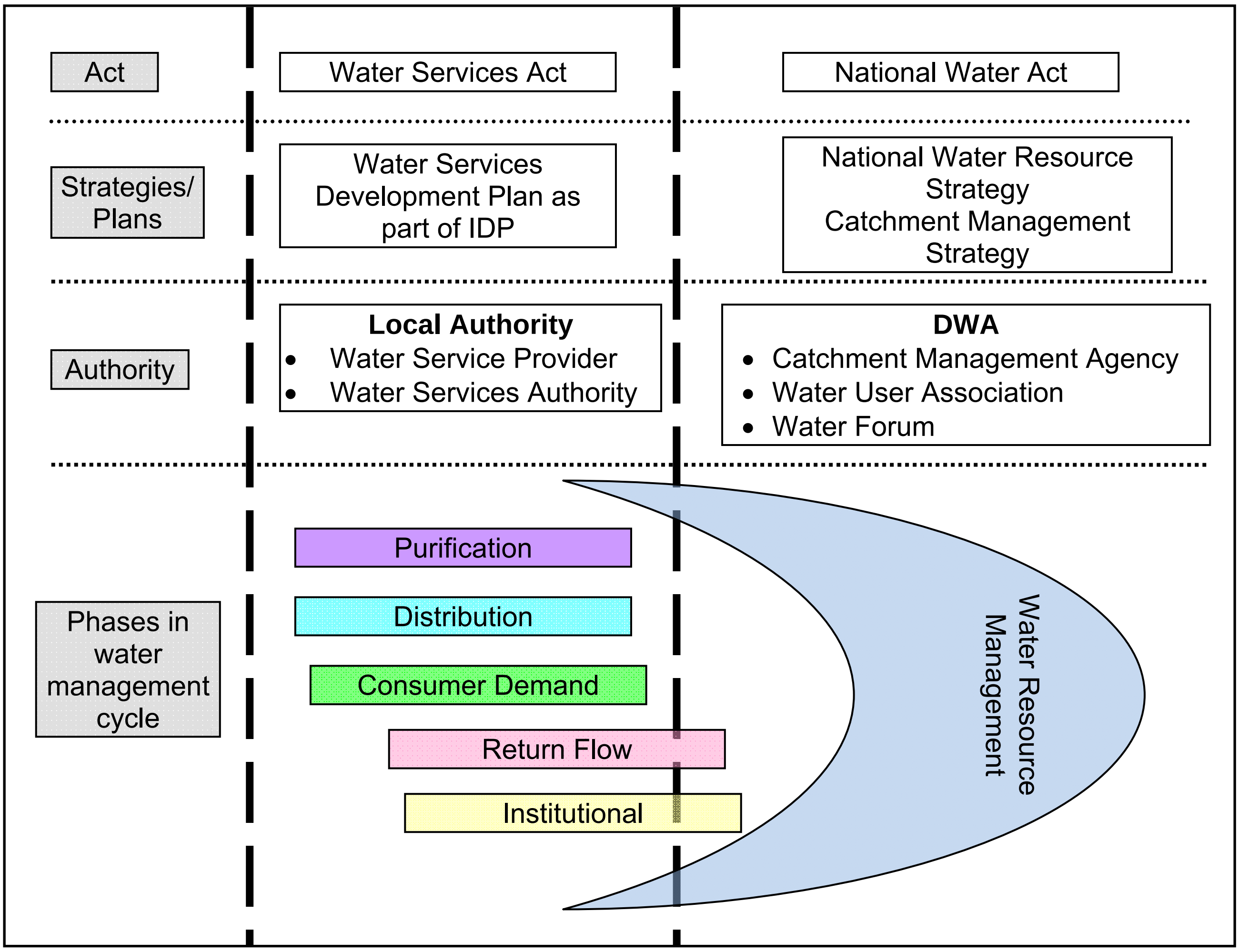


Figure 8.2: Decision-making responsibilities

These steps are closely linked with the IDP process, which is a function of all three spheres of government, i.e., national, provincial and local. The functioning of the DWA does not allow for a well-defined provincial structure and the link between the IDP, which is strongly tied to the provincial structures, and the WDM process, which is a strongly tied to the national structures, was identified as a weak link in the cooperation between the water governance structures. The implementation of the WDM legislation as provided by the DWA at a national level therefore remains a challenging process.

The research, based on the general governance and decision-making literature and a case study investigation, provides an implementation process (see Figure 5.7) for WDM at a municipal level. This approach focuses on bringing the decision-making process to the directly affected role-players, but within the political decision-making domain. The sensitive relationship between the political decision-making through the ward system to ensure political involvement and the protection of the process against political dominance was described in section 3.6. The role of politicians in the context of WDM was identified to include focus areas such as visibility through press releases, official openings of WDM projects, the acceptance of the responsibility to drive and support WDM initiatives and the participation in the budget process to ensure funding for the implementation of WDM projects. This implementation process, together with the literature, highlights the need for appropriate public participation processes.

Public participation was defined as a multi-stage process in the literature presented in section 2.8, depending on the level of engagement and responsibility of the end-users. These stages include protesting-, informing-, consulting-, involvement-, collaboration- and empowerment-steps. The main focus is to ensure that the responsibility of decisions made within the water management cycle remains with the affected parties. To ensure structured participation, it is essential that these “parties” are identified according to representative groupings. The core group was identified as schools, hospitals, trade unions, different levels of government, industries, business, rate-payers and NGOs. It was also highlighted that participation forms the key to success, to ensuring that everyone is seen as “part” of the process. WDM issues are not only a municipality-driven process, but constitute mainly the change in behaviour and attitude among the public towards water use in general. It is therefore important to ensure that a process is in place to enable public awareness and public participation.

To facilitate appropriate public participation, a two-phased process was developed (see Figure 5.6). The basis of such a process was the involvement of the public in the management thereof, with the financial assistance from the municipalities. The initial function of the municipality to initiate such a process has been highlighted. This public participation process was developed with the assistance and participation of a number of municipalities in the West Coast area, referred to as the WC study (section 5.3), as well as input from the literature on problems experienced with other projects that require public participation. The literature and case studies identified the need for the establishment of a management committee, which was recommended to function on the basis of the ward system, to link the implementation process with the public participation process. The WC study also revealed that the public consider the volunteers, as an integral part of the process, as essential.

The literature on decision-making provides criteria that can be used to evaluate the effect of the proposed decision-making model. In general terms it has been identified that models need to be effective, efficient, manageable, ensuring equity and politically feasible. The characteristics of decision-making tools can be used to measure the applicability of such a tool. Four characteristics i.e., degree of coercion, directness, automaticity and visibility can be used. These characteristics have been presented in the literature, and will be used in the conclusion of this chapter to determine how well the model adheres to these requirements.

While the decision-making process forms the cornerstone of successful implementation of WDM at a municipal level, the development of the model to provide guidance on the implementation of all of the aspects relevant to WDM remains the main focus of the study. The literature review in Chapter 2 provided the background towards the development of an appropriate model as a decision-making tool in the water management field. While most of the literature focuses on the national level of water management, it identified a number of clear pointers, such as simplicity, flexibility, the need for integrated decision-making, the need for cooperation between all role-players and an appropriate database.

The model presented in this dissertation consists of two defined processes and a number of DSSs. It was concluded that the DSSs need to consist of simple flow paths, as opposed to complicated technical tools that require a high level of input parameters. This was supported by the knowledge that the capacity of the technical staff in municipalities is severely under pressure. The DSSs, as part of the proposed model, were therefore developed as a set of logical decision-making flow paths, which will ensure that all steps in the WDM process will be considered.

From the governance literature the role of performance management was highlighted. The decision flow paths provided for in the DSSs were therefore also developed to be guided by benchmark values, where appropriate.

For national government to maintain control over the implementation of appropriate WDM processes, the need for an evaluation system was also identified. The main objective of this evaluation system was to determine the “readiness to implement” WDM at a municipal level. Such an evaluation system will provide guidance to the governance structures for the allocation of funds through the budget system to ensure a sustainable future growth.

8.3 Water Demand Management

The need for an integrated approach to manage water related issues within government structures was identified in Chapter 2. In the water sector, the first step was to identify the different stages involved and in need of management. The full water management cycle was analysed and six water management steps were identified, i.e., the water resources, purification of water to potable levels, distribution, consumer demand, return flows and institutional management.

Each of these steps were analysed and the different factors influencing decision-making in these areas were highlighted. Fundamental to the development of the model was a clear understanding of what is meant by WDM. The need for municipalities to know what is happening in each stage and to adapt behaviour in an attempt to reduce the water demand was illustrated. The water audit was identified as one of the important tools to assist municipalities with WDM and the different losses (apparent and real) experienced in the water supply system were described.

The need for a water audit in the management of all the steps in the water management cycle also requires that appropriate data sets are available to facilitate performance management through benchmarking. To provide these benchmark values, a number of critical PIs were identified, namely, per capita consumption, per capita unaccounted water use, per capita re-use of treated water, per capita treatment (potable water) capacity and per capita treatment (sewage) capacity.

The data available in the WSDPs of fifty-six different towns were analysed and a set of graphs for each of the PIs were provided. During this study, referred to as the PI study, the availability of good data was highlighted as a serious shortfall in WDM for municipalities. The results obtained from the PI study were used in the Robertson case study to illustrate the use of the benchmark values as pointers for good decision-making through the model developed in this research. The literature was also used to provide an international perspective on some of the key PIs, such as per capita use and UAW.

Problem identification through a well-structured model remains the main objective, but the different actions and available technical tools that can be used once a problem is identified were also presented. In this regard the research describes the methods and technical tools available in Chapter 4, but does not attempt to research all the available methods in detail. Technical tools include appropriate metering, leak detection, pressure management, retrofits and dual water supply systems at various levels. Different communities will also require different possible interventions, and it was therefore considered as sufficient to provide an overview, while examples and possible results were highlighted.

Decisions regarding WDM do have cost implications, and authorities need to manage this carefully since WDM will only be sustainable if it makes economic sense. The importance of evaluating different WDM options against each other based on sound financial considerations was highlighted. Although this research does not provide a comprehensive financial evaluation tool, it draws municipalities' attention to the need to evaluate different WDM options against each other to ensure a sustainable decision. General approaches such as cost/benefit ratio and unit reference value evaluations used in the South African context were, however, described in section 4.16. The development of any water resource, or the implementation of WDM, is, however, an aspect that needs to be placed in context with the environment, which is difficult to cost.

Chapter 5 provides the three main studies carried out within this research project. The PI study and the WC study have been highlighted already, and their findings were incorporated in the development of the model. The third study involves the Robertson case study, which was used to evaluate the model. The implementation of WDM in Robertson provided an opportunity to learn from practical experience, as well as to develop the guidelines that were used to develop the implementation process as part of the model. It also illustrated how specific groups, like the industries, can organise themselves, without any support from municipalities, to contribute towards WDM. The motivation from these individual groupings is frequently based on economic evaluation criteria, directly linking their products to market forces. In the Robertson case study, it resulted in benchmark values been created to compare the volume of water used per product, in this case, wine. These self-developed benchmark values enable the industries to position themselves against other similar industries in an attempt to provide a better product.

The Robertson case study further provides a number of practical solutions from a variety of stakeholders, which all contribute towards WDM. These solutions varied from the supply of yard tanks to utilise rainwater to the rescheduling of irrigation systems to irrigate only during the night to avoid evaporation losses. The Robertson case study was executed in collaboration with water institutions from the Netherlands as part of the SANOW-agreement. This brought an international perspective to the development of the model, with valuable input regarding public participation. The main focus of the SANOW-agreement was to, through appropriate knowledge transfer, provide a framework for WDM at a municipal level for municipalities with limited financial and human resources available.

8.4 Decision Support Systems

Five DSSs, one for each phase of the water cycle excluding the institutional management phase, were developed as part of the model and presented in Chapter 6. The institutional management phase consists of a number of programmes or steps that include training, by-laws, credit control, complains centre and the incorporation of WDM into the building plan approval process. These steps need to be implemented by the municipality, but without a specific sequence in the implementation thereof, and therefore it does not require a specific flow path or DSS.

The purpose of the DSSs is to guide municipalities with the decisions that need to be taken during the implementation phases of WDM, and to ensure that these decisions are taken in an integrated, logical and systematic manner. These DSSs were structured in such a way that the municipality will always be confronted with issues that have been dealt with or which are still outstanding. The methodology to address the outstanding issues was provided in the preceding chapters.

The context in which these DSSs need to be implemented, and the possible problem areas expected with the implementation of the DSSs, were highlighted. With WDM in need of an integrated process of decision-making, it was clear that some of the areas of decision-making do not always fall within the sole domain of the municipality. This was specifically the situation with the water resource DSS, where the responsibility is shared between local government structures and national structures, such as the DWA.

Problems include the use of the radio to promote WDM if the area of broadcasting is significantly larger than the area of application. This can cause confusion and uncertainty among end-users in “outside” areas, while the implementation of programmes to eradicate invasive plant species in a catchment, without attending to the upper reaches, which do not fall necessarily in the municipal area where the model is applied, can equally result in fruitless expenses. In the latter situation, action, as required by the DSS, is limited to participation in a specific decision-making structure, such as the CMAs, as opposed to the physical implementation of a programme.

The DSSs can only be implemented if they can be used to successfully link specific budgets to the steps still outstanding as identified by the DSSs. The implementation of the projects identified through these DSSs are, however, time consuming and need to adhere to municipal budget time frames. The municipal budget process, linked with the need to identify projects through a well-structured IDP process, is slow and requires careful planning to ensure success.

In the final stage of the development of an appropriate model, an evaluation system was developed, referred to as the “ready to implement score card” system, with the main objective to provide a quantitative evaluation of the progress made with the implementation of WDM. This evaluation system was developed as an MS Excel spreadsheet that provides a percentage value as an indication of how well a specific municipality has progressed with the implementation of WDM. The score card is also intended to be used by the DWA at the national level to provide guidance regarding the prioritisation of possible financial and capacity support to ensure sustainable water supply for future developments.

8.5 Evaluation

Robertson, a town in the Western Cape Province, was selected to illustrate the use of the model as a guide for decision-making with the implementation of WDM. The town experienced water shortages during 2004/05, and a number of measures were put in place to address these shortfalls. Chapter 7 evaluated Robertson’s water situation during this period, and illustrated the use of the DSSs within the specific circumstances associated with the water shortage. The DSSs were applied to illustrate the appropriateness of the steps implemented by the municipality, but they were also used to provide the reason for the failure of certain steps considered appropriate by the municipality.

In evaluating the Robertson situation using the DSSs, it was clear that the DSSs managed to identify a significant number of issues outstanding during the WDM implementation process. These issues include the lack of appropriate data to do proper resource planning and the lack of a management plan for the dams owned and operated by the municipality. These shortfalls result in the problems associated with limited water resources due to lower rainfall being identified too late for the implementation of appropriate restriction measures. The problems experienced with the management of water resources in Robertson, and at the municipal level in general, can to a certain extent be related to a lack of cooperation between the different role-players, one of the key elements required for effective and efficient management in government structures, as identified during the literature review.

The application of the model to the circumstances experienced by Robertson successfully forced the municipality to do a significant amount of data evaluation in order to address the issues raised by the DSSs, and the benchmark values calculated during the PI study provides valuable information and guidance to potential problem areas.

In applying the model, and specifically the DSSs, specific circumstances, not all necessarily highlighted by the model directly, were also encountered, resulting in the evaluation of aspects that would not have been raised under normal conditions. These items included:

- The timing differences between the reading of bulk meter readings and household meters, making a water audit difficult.
- The lack of real time flow measuring to determine peak load factors on the waste water treatment facilities, resulting in the uncertainty of the operating capacity level of the treatment works.
- The impact of "leiwater" on comparable benchmark values for per capita consumption.
- Limited communication with the end-users, which in turn limited their participation.
- The lack of appropriate quality monitoring on point source pollution, limiting their ability to address it. This does have a significant impact on the quality of their return flow from their waste water treatment works.

The need for the model to improve the effectiveness, efficiency, to be manageable, politically feasible and ensuring equity was highlighted in the literature review in Chapter 2 and put in the context of the decision-making process in section 8.2. The impact on effectiveness was demonstrated by the fact that the DSSs, as part of the model, with specific benchmark values been set and decisions on whether to proceed with a specific step or not, based on these values. For example, in the Robertson case study the DSSs clearly show that the actual water consumption of households was not the problem and that there was no further need to spent time and money on this aspect. The model's impact on effectiveness was further strengthened with the development of the score card to provide quantitative values against which to plan.

Efficiency is outcome based and frequently linked to the actual financial savings associated with the implementation of an intervention. While it was already stated that the economic evaluation of the different WDM steps was not the focus of this dissertation, it is safe to say that the model demonstrates efficiency through the effectiveness with which specific actions can be evaluated and on which decisions can be based. Following this process (as guided by applying the model) will limit time and financial resources spent on issues which will not contribute to the main objective i.e., the saving of water.

As far as the equity criterion is concerned, the model guides municipalities, specifically during the public participation process, to ensure that different sectors of the community will be involved. While it does not specifically address target groups in terms of race and gender, the focus of equity in this regard will be determined by local circumstances. The sharing of the responsibility among all water users is incorporated in the model through a specific focus on block water tariffs and by-laws which need to ensure aspects such as "polluter pay" principles. The involvement of different interest groups allowed for in the implementation phase of the model further strengthen the equity criteria.

The model was specifically developed to ensure that it will be easy to manage and the discussions among interested parties during the Robertson case study strengthen the insurance that it will indeed be the case. Political acceptance have been one of the key problem areas identified during the process, but the approval and acceptance process of the model will focus on their involvement. The management of the model was further streamline with well defined steps and benchmark values to guide decision-making.

The criterion of political feasibility is closely linked to the management aspects already highlighted. However, the legislation (regulations) and decision-making process, with reference to council decisions and by-laws, to be approved by political structures within municipalities (see section 3.6), will ensure that the model will be political feasible. The suggestions to manage the model under the guidance of a management committee, which can be linked to the ward system, strengthen the need to ensure political feasibility.

The ability of the DSSs to identify the technical issues that need to be addressed during the implementation of WDM was demonstrated in Chapter 7. The ability of the model to influence decision-making still needs further evaluation. The impact of the model on decision-making can be evaluated against the four main characteristics, i.e., degree of coercion, directness, automaticity and visibility, as identified in Chapter 2.

In evaluating the model, consisting of the implementation process, the public participation process and the five DSSs, for "coerciveness", the combined impact on WDM decision-making needs to be considered, as opposed to the impact of each DSS on its own. It is important to understand that, while the model might perform well or bad against a specific characteristic, certain individual aspects of the DSSs might differ from the model in this regard. The main test is if the model contributes to the objective of effective WDM, without enforcing decisions and steps on the public that may result in a lack of cooperation from the public and hence the failure of the decision-making process.

In the water sector, engineers are mostly responsible for the management thereof, and they typically provide technical solutions to supply an ever-increasing demand. It has become clear, however, that the solutions provided by technical options, as water resources became scarce, prove to be too expensive for many poor countries (Gilbert, 2007: 1560). The model presented therefore must not only address technical issues, but needs to include the public and political decision-making processes.

WDM strongly depends on the cooperation of the public to change their behaviour on a voluntary basis. The dependence on the public for the successful implementation of a project normally results into a decision process with low coerciveness. The DSSs frequently resort to a well-executed public participation process, but the model itself also includes a process specifically designed to ensure effective public participation. A number of steps have been included in the DSSs, such as appropriate tariff setting, to ensure that the full success of the model does not only rely on the “free will” of the public, but that certain processes included in the model provide for a regulatory basis for the decision to be made.

The political support for the implementation process has been stressed a number of times, but the model does not allow for any specific political intervention other than the approval of the process, as included in the implementation process. It can therefore be assumed that, due to the importance of the support of the public and the political role-players, the model might be difficult to manage, although effectiveness and efficiency are being provided through the structure of the model and the use of benchmark values, together with the evaluation system developed. The model can be seen as in support of public involvement, but also as having regulatory dimensions, which classifies the model in the medium category of coerciveness.

The criterion of “directness” of any model describes the ability of such a model to authorise, finance and implement a project to solve the problem of effective water use. The model developed for WDM addresses the criteria of directness well, with the understanding that the sphere of influence of WDM can be wide and involved.

The model provides for an opportunity to create a management committee in which the municipality and the national DWA are key stakeholders, together with the public. This management committee functions as a forum for the public to inform the DSSs, which are specifically designed to be implemented by the municipalities, which is also the financier of the project. Limited use is therefore made of support from third parties to implement WDM, other than the public, which is part of the decision-making process. The model presented provides for decision-making to take place in a single structure, which promotes effective decision-making. The model can be considered to fall between the medium to high degree of directness.

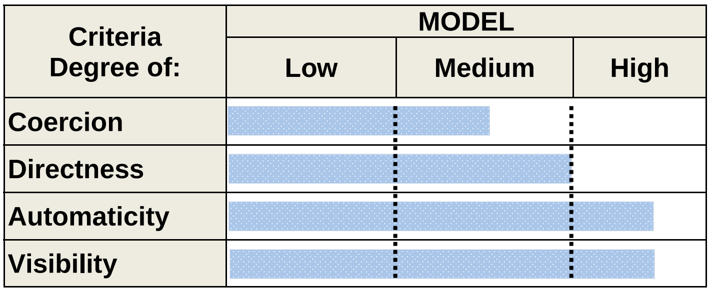
The criterion of “automaticity” describes the extent to which a specific model uses existing management systems and structures to achieve its own objectives. The need for the involvement of the public was identified various times during the research. The importance of their input might give the impression that it will result into a low level of automaticity. In addition, the need for the creation of a specific unit responsible for WDM within a municipality might create the impression that this criteria will be difficult to meet, and that it will therefore result into a less effective and efficient tool, difficult to manage. The integrated nature of the model presented, together with the management committee and suggested WDM unit, however, contributes towards the unified structure that will be able to identify, fund and implement WDM projects with ease without creating unnecessary additional bureaucratic structures.

With the municipality taking full responsibility for the technical implementation of projects, the existing management structure available within the municipality will be utilised for the execution of WDM projects. The model can therefore be considered to be high on the scale of automaticity, resulting into an effective, efficient and easy to manage model.

The “visibility” of any model describes the ability of the model to allow the main objective, in this case WDM, to have a visible influence, for example to appear in the budget system of the municipality. The difficulty of obtaining political buy-in in WDM projects has been highlighted, with community halls and clinics seen as being of much more value to politicians in terms of what they have achieved, than the upgrade of a leaking pipe or the reduction of water consumption through changing consumption patterns. If the model is weighed against the possible outcomes, however, it is clear that the model is able to identify ineffective systems, mainly with the help of the water audit process, which, if rectified, can result in significant savings to the municipality. The end result of the implementation of the model is the identification of projects to correct inefficiencies, which do have a direct impact on the budget of the municipality.

These projects mostly do not appear in the budget as WDM projects specifically, and it is therefore difficult to evaluate the model in terms of the visibility criteria. Even though the political support can be under pressure, the results from this model need to be classified as high on the visibility criteria, due to its integrated impact on all sectors of planning in a municipality. Table 8.1 provides a summary of the evaluation results based on the set criteria.

Table 8.1: Model evaluation



In Chapters 6 and 8, the limitations of the DSSs were highlighted. These include the knowledge that the DSSs cannot be used as the sole step to ensuring success, but that it needs to be used within the context of integrated decision-making, such as financial considerations and the availability of human resources for each step to be taken according to the DSS. Institutional arrangements, not necessarily addressed in a single DSS, were identified as being important for the successful implementation of WDM. Furthermore, issues like training and by-laws were put in context of these DSSs.

8.6 Conclusions

WDM at a municipal level can be difficult and expensive to implement. With limited capacity available at this level, a model was developed to assist municipalities with WDM. The model consists of two processes and five DSSs. The first process of the model guides the implementation of WDM, with political buy-in an important component. The second process presented as part of the model ensures effective public participation, which was identified as a key component of effective WDM. This process also provides for an internal implementation process to ensure effective stakeholder engagement.

Five DSSs, one for each of the water management cycle steps, to ensure an integrated approach, are presented to assist the decision-makers with a structured management process. The institutional framework for the implementation of WDM is presented, and building blocks for technical solutions towards WDM were highlighted. The DSSs were tested against the steps implemented during a drought situation in Robertson as a case study, and the results presented to illustrate the use of these DSSs.

The five DSSs provide a sequence of questions that need to be evaluated in a structured way to ensure that WDM can be implemented in the most appropriate and cost effective manner. No formal financial options are presented as an integrated part of the model to evaluate which water demand options need to be done when and where. Financial evaluation tools are, however, presented in section 4.16 and the application thereof will probably differ from one authority to another.

The model presented will ensure that the municipality stays focused on the main issue, and will prevent the implementation of WDM options on an ad hoc basis, with the possible spending of capital on aspects that might not be necessarily contribute towards water saving and sustainable decision-making. It might be argued that all of the aspects addressed in the model will have to be implemented at one or another stage, but with limited funds available, as proven in the Robertson case study, it might result in the "correct" steps been implemented too late, with significant water losses in the mean time.

The practical implications can be illustrated through an example regarding the resources supplying water to Robertson. If a yield analysis had been in place, Robertson would have been warned in advance of possible water problems and a different resource utilisation sequence could have been implemented, avoiding Robertson's main dam from running almost empty at a critical time. Similarly, it can be argued that, if the model was used, Robertson could have been in the position to know where losses had occurred in the system at an early stage, and capital could have been spent on law enforcement rather than on leak detection equipment, which might only prove that there are no leaks, while the reason for the losses was perhaps unauthorised connections.

To facilitate decision-making with the assistance of the DSSs, a number of important benchmark values, which form the basis for a number of decisions in the DSSs, were developed. These values are not well-established in South Africa and, if available, need to be used carefully, taking specific local circumstances into consideration.

The model was developed specifically with small to medium sized municipalities in mind, since they are most likely to lack the capacity to do a proper evaluation of their water situation. Although the steps will still be fundamental to the decision-making process in large Metro's or cities, the scale and financial evaluations might be different. Awareness campaigns will be more cost effective in cities than in smaller towns. Local radio stations can, for example, be successfully used to spread the message without running the risk of having large portions of the listeners not being affected by that specific situation.

The opportunities for a successful awareness campaign are significantly bigger in cities with its larger population. Contrary to small municipalities, the implementation of leak detection and pressure management in cities with large distribution networks is a far more viable option with huge opportunities for cross subsidising costs within the departments or sections experiencing problems, if needed. Larger cities are, however, more vulnerable to be exposed to the associated risks with huge informal settlements. Policy making and training is an exceptionally difficult process, with public participation an expensive and lengthy process.

The need for the model to be applied within the public management environment was highlighted and its impact as a decision-making tool was evaluated. The model was classified to be on the medium coerciveness scale, medium to high on the directness scale, high on the automaticity scale and high on the visibility scale. These indicators provide some degree of certainty that the tools, as presented in this study, will indeed impact positively on water demand at a municipal level.

To ensure effective progress and to provide a mechanism for the DWA to prioritise funding and capacity support to municipalities, a “ready to implement score card” system was developed that provides the status of progress made with the implementation of the WDM model, expressed as a percentage of complete and effective implementation of WDM.

8.7 Future Research

The model presented in this dissertation will enable municipalities to understand their present water situation, from source to tap and back to the source. It will assist them to use the available human and financial resources, which is always under pressure, effectively to ensure integrated WDM.

The need for the development of appropriate benchmark values has been illustrated, and should be listed as an input that does need further research. It is acknowledged that international values do exist, but that these need to be adapted to cater for local South African conditions.

Different techniques that can be used to promote WDM and evaluate its economic impact have been described. Some of these methods have already been available for a long time, while new initiatives to promote WDM in all phases of the water management cycle are continuously introduced as new local and international partners become more involved in the limited water situation in South Africa.

The research identified the lack of appropriate data to do a proper water audit. A number of initiatives, through the intervention of the DWA, have attempted to establish a sound database but, to date, no control over the correctness of the data exists. This needs to be developed further.

The role and function of provincial government in water issues in general, but specifically to facilitate the link between the IDP process and the long term planning for sustainable water services at a municipal level, need further investigation.

Although the research did not focus on the financial model to choose between different options, it was also clear from the research that limited data exists on the actual cost and associated savings of specific WDM initiatives. Many of these initiatives are also long term projects, which are therefore difficult to monitor.

The impact of models on political decision-making in the water sector is poorly researched with limited examples. Research on the effect of models, such as presented in this research, on the governance systems at the municipal level is required.

The model presented in this research does not address the impact of possible partnerships with service providers outside the governance sphere, or privatisation of certain components of the water management cycle in order to become more efficient. Municipalities still lack the confidence to go into partnerships with third parties. As a first impression, it might be seen as a careful approach from these authorities to ensure that they stay in control of this important commodity. Models to promote the cooperation between different role-players, specifically between local and international role-players, should be designed to enable an environment that is conducive to these approaches from support companies or institutions. Their fears and problems need to be investigated and incorporated into appropriate sustainable solutions in the water sector.

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