TOWARDS A GROUNDWATER SOURCE AND AQUIFER PROTECTION ZONING POLICY IN SOUTH AFRICA: ASSESSMENT OF THE LEGAL, SOCIO-ECONOMIC AND INSTITUTIONAL ARRANGEMENTS

by

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DECLARATION

I declare that *"Towards a groundwater source and aquifer protection zoning policy in South Africa: Assessment of the legal, socio-economic and institutional arrangements"* is my own work, that it has not been submitted for any degree or examination in any other tertiary institution, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

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ABSTRACT

Towards a groundwater source and aquifer protection zoning in South Africa: Assessment of the legal, socio-economic and institutional arrangements

H. H. Pienaar, PhD Thesis, Department of Earth Sciences

The need for a fundamental change in our approach to water management in South Africa is largely underpinned by the country's Constitution (Act 108 of 1996). Section 24 in Chapter 2 of the Constitution is perhaps the most relevant to be considered when developing a groundwater source and aquifer protection zoning policy, as it explicitly endorses the right to have the environment protected. The mandate required to give effect to the overall protection of South Africa's water resources spans across several sectors and government departments, with expected roles and responsibilities not always clearly defined. The Department of Water Affairs and Forestry (DWAF) is primarily responsible for water resource management. However, the Department of Environmental Affairs and Tourism (DEAT), the National Department of Agriculture (NDA) and the Department of Provincial and Local Government (DPLG) are all key role-players because of their respective responsibilities for biodiversity conservation, land management and development planning across government.

The above role-players, and most probably other spheres of government (particularly in the case of the DPLG), have to be engaged in the process of developing a groundwater source and aquifer protection zoning policy. However, their respective policy initiatives are mostly built on and reflect contexts, concepts and terminology that are in many instances specific to one of the departments or sectors. This could complicate collaboration between the departments or sectors, and the challenge is to find common ground for the development and implementation of such a policy initiative, where all the relevant parties can combine their skills and resources towards scientifically sound protection zoning designs and feasible implementation plans. The Department of Water Affairs and Forestry therefore presents the most logical 'home' for taking the lead in developing the groundwater source and aquifer protection zoning policy as reflected in its water legislation, in particularly Chapter 3 of the National Water Act, Act 36 of 1998 (NWA).

Important principles have been developed during the country's water law reform process, with the following set of principles to be strongly considered when embarking on a groundwater source and aquifer protection zoning policy:

- Principle 2 – which recognizes the fact that all water is linked in the hydrological cycle, with all water having consistent status ion the law, irrespective of where it exists within that cycle.
- Principle 5 – in a relatively arid country such as South Africa, it is necessary to recognize the unity of the water cycle and the interdependence of all its elements.

- Principle 6 – the variable, uneven and predictable distribution of water in the water cycle should be acknowledged.
- Principle 7 - states that the objective of water management is to achieve long-term environmentally sustainability with social and economic benefit to accrue for the overall benefit of society.
- Principle 26 – links the regulation of water services to broader local government frameworks.

Despite the above principles, water resource protection elements of the country's water law are often regarded by stakeholders as being in direct competition with socio-economic needs. This has resulted in much debate and varying interpretations of the meaning and purpose of water resource protection. It is therefore important to investigate the relevance of balancing the socio-economic short to medium needs with that of water resource protection for long-term sustainable use. One of the biggest challenges confronting us in South Africa is that we are redressing current inequitable distribution of water emanating from the past and ensuring equity between generations simultaneously. At the same time, coping with our current capacity to implement integrated water resource management (both in terms of institutional arrangements, policy and skilled labour) remains a big challenge.

This research therefore emphasizes that in moving away from the mindsets entrenched by previous legislation, people need to be empowered by a common understanding of the intent of water resource protection, to which groundwater source and aquifer zoning is inextricably linked. In order to achieve this goal, we have to ensure that the need for developing a groundwater source and aquifer zoning policy is in support of both socio-economic needs and ecological sustainability especially terrestrial ecosystems. Relevant implementing agencies across the water sector should be fully engaged in this process in order to ensure a proactive approach in implementing water resource protection elements enshrined in the Constitution as well as the following enabling legislation:

- National Water Act, Act 36 of 1998 (NWA);
- National Environmental Management Act, Act 107 of 1998 (NEMA);
- Environmental Conservation Act, Act 73 of 1989 (ECA);
- Conservation of Agricultural Resources Act, Act 43 of 1993 (CARA);
- National Forests Act, Act 84 of 1998 (NFA);
- Mineral and Petroleum Resources Development Act, Act 28 of 2002 (MPRDA);
- National Veld and Forest Fire Protection Act, Act 101 of 1998 (NVFFPA); and
- Water Services Act, Act 108 of 1997 (WSA).

The major findings out of this research can thus be summarized as follows:

- The absence of a policy that directly addresses groundwater protection used for drinking water, poses a number of serious water management challenges to water sector institutions as well as all spheres of government (i.e. national, provincial and local level);

- A lack of adequate geohydrological monitoring systems and resulting poor quality data and information on groundwater appears evident countrywide;
- Existing water legislation, i.e. the NWA and WSA, as well its implementation frameworks (i.e. the National Water Resources Strategy and Strategic Framework for Water Services respectively) offers limited opportunity for a comprehensive approach towards groundwater protection and management at a national scale;
- An ad hoc approach to groundwater pollution incidents to date (at municipal level in particular) has shown little success in drastically curbing this problem which poses a big threat to human health; and
- Existing implementation tools should be revisited in order to ensure that all groundwater aspects are addressed in the interim while embarking on a more comprehensive approach towards groundwater management and protection as suggested through this research.

The development of a groundwater source and aquifer protection zoning policy initiative should therefore not aim at realizing its own set of goals, but also complement existing policies and strategies in order to give effect to certain compliance and regulatory aspects as prescribed by the NWA among others. It is recognized in some instances that the implementation of such a policy might exceed well beyond the Department of Water Affairs and Forestry's mandate and requires the active pursuit of cooperative governance arrangements required to support the groundwater source and aquifer zoning initiative. This will lead to a costly and challenging process in some instances, and a phased approach should be considered for roll-out (i.e. areas experiencing water stress). It is therefore believed that the assessment of the legal, socio-economic and institutional arrangements (through this research study) represents an important component in making this policy initiative a reality.

Key words: water resource, water services, policy, legislation, groundwater, zoning, assessment, aquifer, institutions, source, protection, social, economic, sustainability, principles.

EXECUTIVE SUMMARY

Water resource protection in perspective

It is a well-known fact that our future relies on balancing economic development with protection of those environmental functions that are essential for our survival. This recognizes that, world-wide, poverty remains one of the most significant threats to geopolitical stability and is a growing source of global health threats. However, certain ecological functions, such as carbon sequestration and the maintenance of biodiversity, are also seen to be critical for survival.

This is captured in the concept of sustainable development, which underpins the growth and development policies of most nations. South Africa as a signatory to the Rio Convention, and as host to the World Summit on Sustainable Development in 2002, has a special obligation to ensure that sustainable development underpins the utilization of all our resources. Water resource protection gives effect to sustainable development with respect to the development and utilization of water resources. It recognizes that the ecological functioning of water resources provides goods and services that allow for the beneficial and economic use of water, but also ensure that these uses of water remain economically viable far into the future.

Water resource protection and sustainable development

Sustainable development is defined as the process of meeting the needs of the current generation, without compromising the ability of future generations to meet their needs. Sustainable development therefore recognises that South Africa has special needs, not only for rapid economic growth and development, but also to take proactive corrective actions to ensure equity. This will provide the social stability on which the country can grow, and which allow us to provide the resources required for protecting the environment. However, sustainable development also requires that the current efforts to secure economic growth, equity and to eradicate poverty should not compromise the ability of the current and future generations of South Africans to make economically beneficial use of our resources. The protection of water resources is given effect to by the DWAF through its water resource protection strategy, i.e. Resource Directed Measures (RDM) as prescribed in the NWA. The next step is to highlight the need for linking water services provision to water resources management and protection. However, integrated water resource management do not necessarily require making all needed changes at once, but can often best be initiated by a phased approach or specific program of action, as in the case of this groundwater source and aquifer protection zoning initiative.

The case of groundwater

In South Africa, the estimated abstraction of groundwater in the country is about 1,100 Mm3/a, equivalent to 10% of the 10,340 Mm3/a surface water abstraction and it has been estimated that it could be increased to 6,000 Mm3/a. This, significant potential, although mainly a diffused source in many separate hard rock aquifers, is making groundwater sustainable management a prominent activity in the Department of Water Affairs and Forestry (DWAF). The establishment of protected areas is widely regarded as the single most important tool used to minimize or prevent the degradation of natural resources throughout the world. In South Africa, the establishment and management of formal protected areas has usually focused on protecting terrestrial ecosystems, with very little emphasis on an integrated water resource management that is necessary simply because of the inextricable nature on how ground and surface water is linked. A new form of protection is therefore required, where the contribution of protected areas is complemented with alternative forms of protection. Off-reserve protection of terrestrial ecosystems also implies the control of land-use practices, since land use practice has both a direct and indirect influence on the status of terrestrial ecosystems of that area.

A catchment is technically 'in balance' when the amount of water allocated for distribution and use (this may be to different users but also for 'downstream use') is equal to the amount of water available for use. A catchment is stressed when allocations exceed the available water, i.e. the amount of water the regulator actually has to allocate. We then have a negative balance. Catchments also move into negative balance when users are taking more water than there actually is. This may be possible in good (wet) years but otherwise leads to deficit situations. The balances reflected above are based on estimated and actual water requirements and not on allocations and therefore provide a better picture of reality. It is thus important to note that various water stress catchments in South Africa negatively impacts on the groundwater systems especially in those areas where water users are directly dependent on the groundwater source.

Constitutional, legal and policy context

Groundwater management in South Africa has been evolving from the previous legislation under which control areas were declared in some stressed areas where use of groundwater was strictly controlled to a more proactive groundwater management and protection, thanks to the solid information and technical bases established since 1990 in preparation for the changes to come, the most important of which was in the legislation – from 'private water' in the Water Act of 1956 to 'significant' resource in the NWA of 1998. One of the remarkable features of the South African approach to IWRM is the consistency with which the imbalances with regard to social, economic and ecological needs are being addressed by the Constitution. This attempt to maintain the balance between societal needs is further enshrined in the country's water policy and its translation into a statutory mandate in the National Water Act, Act 36 of 1998 (NWA), with the country's first edition of its National Water Resources Strategy (national plan for implementing the Act) been gazetted in 2004 (DWAF, 2004b).

Institutional arrangements

Traditionally, 'Water Institutions' were designed to accomplish a very important development mission whose main aim objectives were linked to developing new water resources and providing expansion of water services (water supply and sanitation, irrigation, hydropower generation, etc.) to new users. These 'Water Institutions' were primarily 'managing the supply'. At the beginning of that time, water resources were plentiful, relatively easy to obtain, not affected by contamination, and relatively cost effective to develop and managed. However, over the last few years the resources became scarce (in terms of both quantity and quality), difficult and complex to obtain and conserve, and much more expensive to deliver and expand. A new concept came into place shifting from 'managing the supply' into the required 'managing the demand'. Private operators of water services also came onto the scene and somehow added complexity to the new water resource management functions.

Water management institutional arrangements work within existing structures, providing strategic reinforcement of capacity where required to harness and leverage the full potential of the DWAF and its delivery partners. Water management institutions were called for to improve integrated water resource management and to develop accurate and reliable water availability and water use data for future planning and management. DWAF has established 19 WMAs across the country and is currently in the process of setting up Catchment Management Agencies (CMAs) for each WMA. DWAF will delegate considerable powers to these CMAs in order to ensure effective and efficient management of the said WMAs. The arrangements will provide for structured, systematic assignment of responsibility in both the arenas of 'managing supply' and 'managing demand' and will add value to existing structures of DWAF and it's newly established 19 WMAs.

Consideration will also be given to the mobilization of stakeholders because of the central function that this will play in integrated water resource management (IWRM) practice. The delivery of effective and efficient services rendered by the CMAs is seen as the catalyst for bringing about the social, economic and environmental sustainability in the 19 WMAs. The widest range of interest groups will be mobilized around the CMA establishment, ranging from the targeted rural poor communities or the beneficiaries on the one hand, and service providers and policy-makers on the other. A critical assumption of the existing water management institutions is the fact that there has been significant delivery with respect to development in general, but its impact has been limited because of the fragmented and uncoordinated approach to date. Hence the first phase of CMA establishment involves the consolidation and integration of existing programmes and initiatives in each WMA respectively. This focus will reduce duplication and ultimately effect major savings.

The outcomes of coordinated long-range planning will translate into innovative, special integrated services and programmes. The CMAs should be embedded in a system of integrated water management with empowered multi-stakeholder basin organisations managing surface and groundwater. This is to be underpinned by systems of water rights that recognize existing registered users, safeguards existing unregistered uses, enhances the water access of poor and disadvantaged groups, and allows a minimum flow for basic needs and development of irrigation. Sufficient qualified and skilled people are needed to develop and manage existing and future water management institutions.

Moreover, the envisaged people and service orientation may require changes in attitudes and skills of staff and management processes. Motivated staff with sufficient knowledge and skills has to be developed through education, training and human resources management. This involves further development of local capacity for education and training on water and food production for professional water managers and the establishment or strengthening of linkages between education institutions and water research organisations. Attractive career development programs are needed for water-related professionals to ensure and retain sufficient capacity and capability for planning, regulation and policing related to water resources use and management. Preference is to be given to women professionals to improve their participation in water management, particularly at higher levels of governance and management.

Important to stress now while undertaking this groundwater protection zoning initiative is that the recent Directorate: Geohydrology was split in order to integrate the groundwater dimension into different areas in the DWAF; the challenge is now to consolidate the specialty in a programmatic way under focused leadership. The devolution of all water services to local government means groundwater development and maintenance by about 200 District and Local Municipalities (who are all still learning), requires an enormous support and capacity building task. It also means that universities will need to complement their scientifically and technically oriented curricula with more pragmatic resource management courses.

Socio-economic dimension

In order to assess the impact of undertaking groundwater source and aquifer protection zoning on job creation and income levels, land use alternatives and socio-economics must be known to both the landholder and decision-maker. Impacts of decisions will always be variable given the variability in alternative use options and in costs. There are the 'hard' considerations – reflected through gross margins which are an indication of potential profits to be made, and 'soft' considerations including the relative difficulty of entry into each considered land use, and the risk involved in terms of production and price yield. General economic budgets require adjustment to reflect spatial variables in yield, transport and irrigation costs (as in the case of agriculture).

Implementation and jurisdictional powers

The very uneven development in some catchments is going to require a high degree of cross-subsidization. This is likely to increase the political uneasiness. The institution of new civil structures which result in a diminution of the powers of Traditional Leaders creates uncertainty and conflict. The addition of new administrative boundaries (the WMAs) adds to this uncertainty in the eyes of local people and is not easily accepted. Sound legal foundation, political will, domestic technical expertise, strong links between groundwater protection and water service provision and specialty leadership are therefore required to achieve successful implementation of this groundwater protection zoning initiative. The process to establish CMAs is complex (i.e. it cannot be achieved overnight) and its establishment process should not be underestimated.

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Without the support and endless patience of my wife and family, this would not have been possible. Thank you Heidi, auntie Hilda and uncle Dickie!

This is for Mitha Magdelena 'Dolly' Pienaar (1938 – 1990), Haygen Harrison Pienaar (2000 - - -) and Heinrich Hursiney Pienaar (2006 - - -).

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ACRONYMS

AEV	Acute Effect Value
ARL	Acceptable Risk Levels
ASGI-SA	Accelerated Shared Growth Initiative of South Africa
AWQG	Acceptable Water Quality Group
BBBEE	Broad-Based Black Economic Empowerment
BHN	Basic Human Needs
BPG	Best Practise Guidelines
BWP	Berg River Water Project
CEV	Chronic Effect Value
CMA	Catchment Management Agency
CMS	Catchment Management Strategy
CSA	Constitution of South Africa, Act 108 of 1996
CSIR	Council for Scientific and Industrial Research
DEAT	Department of Environment Affairs and Tourism
DEEEP	Direct Estimation of Ecological Effect Potential
DFID	Department for International Development
DWAF	Department of Water Affairs and Forestry
DPLG	Department of Provincial and Local Government
EC	Ecological Category
ECA	Environment Conservation Act (Act 73 of 1989)
ECLA	Economic Commission for Latin America and the Caribbean
EIA	Environmental Impact Assessment
EGSA	Ecosystem Goods, Services and Attributes
ELMS	Environment and Land Management Sector
ELU	Effluent on Land Use
ESBC	Ecological Sustainability Baseline Configuration
ESKOM	Electricity Supply Commission
EWR	Ecological Water Requirements
GDP	Gross Domestic Product
GIS	Geographical Information System
GWP	Global Water Partnership
GWS	Government Water Schemes
Ha	Hectare
HDI	Historically Disadvantage Individual
IAP2	International Association for Public Participation
IIMA	Interim Inco-Maputo Agreement
ISP	Internal Strategic Perspective
IUA	Integrated Unit of Analysis
IUCN	International Union for the Conservation of Nature
IWRM	Integrated Water Resources Management
IWRP	Integrated Water Resources Planning
KOBWA	Komati Water Basin Authority
KRC	Komati River Catchment
KRS	Komati River System
LHWP	Lesotho Highlands Water Project
MFMA	Municipal Finance Management Act (Act 56 of 2003)
Mm^3/a	Million cubic metres per annum
NDA	National Department of Agriculture
NEMA	National Environmental Management Act (Act 107 of 1998)
NFA	National Forests Act (Act 84 of 1998)
NGO	Non-Governmental Organisation

NOEL	No Observed Effects Level
NVFFA	National Veld and Forest Fire Act (Act 101 of 1998)
NWA	National Water Act (Act 36 of 1998)
NWRI	National Water Resources Infrastructure
NWRIA	National Water Resources Infrastructure Agency
NWRIB	National Water Resources Infrastructure Branch
NWRS	National Water Resources Strategy
ORWDP	Olifants River Water Resources Development Project
PAH	Poly-Aromatic Hydrocarbon
GSAPZ	Groundwater Source and Aquifer Protection Zoning
PFMA	Public Finance Management Act (Act 1 of 1999)
P & R	Policy and Regulation
RDM	Resource Directed Measures
RDP	Reconstruction and Development Programme
RDWQM	Resource Directed Water Quality Management
REC	Recommended Ecological Category
RQOs	Resource Quality Objectives
RSA	Republic of South Africa
RSAP	Regional Strategic Action Plan
SAAWU	South African Association for Water Utilities
SABS	South African Bureau of Standards
SADC	Southern African Development Community
SAM	Social Accounting Matrix
SALGA	South African Local Government Association
SARPN	Southern African Regional Poverty Network
SAWQG	South African Water Quality Guidelines
SAWQG-AE	SAWQG for the Protection of the Aquatic Environment
SEA	Strategic Environmental Assessment
SFWS	Strategic Framework for Water Services
SDC	Source Directed Controls
TBL	Triple Bottom Line
TCTA	Trans-Caledon Tunnel Authority
TWQG	Target Water Quality Group
UNCED	United Nations Conference on the Environment and Development
UNDP	United Nations Development Program
US EPA	United States Environment Protection Agency
WAR	Water Allocation Reform
WDCS	Waste Discharge Charge System
WMA	Water Management Area
WRA	Water Research Act (Act 34 of 1971)
WRC	Water Research Commission
WrC	Water Resources Classification
WRCP	Water Resources Classification Process
WRCS	Water Resources Classification System
WRM	Water Resource Management
WRIM	Water Resources Information Management
WRYM	Water Resources Yield Model
WSA	Water Services Act (Act 108 of 1997)
WsA	Water Services Authority
WSSD	World Summit on Sustainable Development
WQOs	Water Quality Objectives
WUA	Water User Association
WWAP	World Water Assessment Program
WWDR	World Water Development Report

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1. INTRODUCTION

1.1 Preface

Agenda 21, the statement of principles for the sustainable management of forests, and the Rio Declaration on Environment and Development were adopted by more than 178 governments at the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. Protection of the quality and supply of water resources, and the application of integrated approaches to the development, management and development, are specifically dealt with in chapter 18 of Agenda 21. Being a global initiative, South Africa's own approach towards the protection and efficient use of its water resources, is therefore guided by Agenda 21. Management of water resources needs to allow for sustainable utilization, whilst providing for their protection. Protection principles are contained in Chapter 3 of the country's National Water Act, Act 36 of 1998 (NWA).

The Department of Water Affairs and Forestry (DWAF), as custodian of the nation's water resources, is mandated to ensure that the protection, use, development, conservation, management and control of the nation's water resources is achieved in a sustainable and equitable manner. The establishment of a National Water Resources Strategy (NWRS) as required by the NWA was first published in September 2004. This NWRS represents a framework as to how the above onerous mandate of DWAF will be achieved over time. Integrated water resources management (IWRM) is defined in the NWRS as a process which promotes the co-ordinated development and management of water, land and related resources in order to maximise the economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. Groundwater represents an important source of water supply countrywide and it is deemed a crucial instrument by water managers and policy-makers because of its significant role in alleviating poverty.

The NWA introduces a number of useful instruments to protect and conserve groundwater. These include both source based and resource based tools. Source based measures include licensing and authorisations. These focus on controlling groundwater users, polluters and potential pollutants. Resource based measures relate to managing aquifers, and include the Reserve, resource quality objectives and classification. Important groundwater protection procedures include:

- **Public involvement** – awareness among the citizenry is seen as the only permanent guard against degradation of groundwater resources. This requires the public to be empowered to understand hydrogeological issues and appreciate the value of the resource;
- **Reserve determinations** – allow for the role of groundwater in sustaining aquatic ecosystems to be understood and promoted within the context of a balance between use and protection;
- **Aquifer classification** – provides a framework for implementing differentiated protection, and should be implemented at a catchment level;
- **Land-use zoning** – an effective source based control that restricts potentially polluting developments on important or sensitive aquifer systems. Urban planners, for example, must be made aware of risks related to groundwater pollution and encouraged to plan town developments with due regard for hydrogeological issues; and

- **Environmental impact assessments** – should be mandatory for activities known to induce groundwater contamination, or in areas of important or sensitive aquifer systems.

Processes involved in aquifer depletion and pollution, and related aquifer protection and conservation, are complex and require specialist input for correct management. While IWRM is considered essential for ensuring comprehensive water resource management, it should be implemented in a phased manner with particular emphasis on groundwater source and aquifer protection zoning. This is deemed necessary given the historical lack of focus on groundwater as part of IWRM. At the same time, the implementation of groundwater source and aquifer protection zoning requires informed stakeholder participation and particular emphasis should be placed on creating awareness on this subject taking into account the highly dependant nature of groundwater as a source of water supply among many rural communities across SADC countries.

1.2 Synoptic problem and need statement

The NWA also fully recognizes groundwater as part of the water cycle. This progressive and enabling water law is also globally acclaimed especially for its promotion of the utilisation of water resources in a manner that is efficient, equitable and sustainable. Eight years have passed since the promulgation of the NWA, and its functioning has faced many obstacles to date particularly with regard to the conceptualisation and practical implementation of IWRM. Moreover, the management of groundwater within the IWRM context, especially its protection elements, has not been fully appreciated albeit its importance and recognition by law. This is not surprising, since the objectives of legislation are ambitious and the changes required to achieve them are largely unprecedented. It has become clear that giving effect to progressive new legislation cannot be achieved without addressing the associated implementation requirements to a large extend.

The increased need for service delivery (water supply and sanitation) has created the perception that 'unnecessary' requirements such as water resource protection are perceived as a low priority by stakeholders. This perception is a result of the rather elusive link between water resource protection and sustainable service delivery to the poor. Also, the link between water resource protection, IWRM and sustainable development is not always well understood by many. Water resource protection is therefore seen as a legislative requirement that will delay development and the delivery of services and that it is only intended to protect aquatic ecosystems. We have, therefore, migrated from a situation where the change in the legislation was easy.

The changes that are now required in the way in which we conduct our business to successfully implement the provisions of the NWA, are more complex from a political perspective. The failure to link IWRM to ensure sustainable delivery of services (given a specified level of protection) is becoming increasingly evident. However, there is increasing understanding internationally that water resources can be managed successfully only if the natural, social, economic and political environments in which water occurs and is used are fully taken into consideration. The need for implementing IWRM has been articulated at a number of important events both nationally and internationally.

In the recent budget speech for 2006 by the Minister of Water Affairs and Forestry, the importance of water for human survival, health and productivity was again emphasised. The environmental deterioration of the earth and its natural resources, especially during the last century of the second millennium, has two main causes. The exponential increase in the world's population, the growing sophistication of its needs and activities for the maintenance of present-day lifestyles, and the process of industrialisation, have not only resulted in a vastly increased pressure on and depletion of the earth's essential natural resources, they have also caused the increased generation of enormous quantities of waste (Fuggle & Rabie, 1994 and Barnard, 1997). The production of waste, an unavoidable and unwanted by-product of all man's activities, is characteristic of mankind, and inevitable in an industrial society (Asante-Duah, 1993).

It has been shown throughout the world that the direct or inadvertent disposal of waste on land is a major contributor to the degradation of aquifers (Parsons and Jolly, 1994), and the discharge of water containing waste (effluents) into surface water resources has lead to the deterioration of these resources. In order to protect these resources, it is of utmost importance to prevent this type of disposal or discharge and where prevention is not achievable, to ensure that such disposal or discharge is conducted in a sustainable manner that will not cause pollution and irreversible damage to ground and surface water resources. South Africa's water resource management policy does not aim to prevent the disposal or discharge of waste into the environment at all costs, since especially in a developing country context, the prevention of any impact is simply not justifiable. This would not allow the country to achieve much-needed social and economic growth (DWAF, 2000b).

What is needed is to find the right balance between using a water resource for the sustainable disposal or discharge of waste, and protecting a water resource against the potential harmful or polluting impact of such disposal or discharge. Groundwater protection and conservation are essentially components of groundwater management, and relate to both quantity and quality issues. Groundwater protection will occur within an IWRM framework through prescribed tools such as a resource classification system and the Reserve. Pollution of groundwater resources can affect both groundwater and surface water quality in streams fed by base-flow. Further, remediation of polluted aquifers is expensive and technically difficult. As a result, groundwater quality management and protection must be proactive. As protection of all aquifers is considered impossible in South Africa, a differentiated protection policy, where priority is given to important and vulnerable aquifers, has been proposed as the optimum solution (DWAF, 2000b).

1.3 Aims and objectives

The ultimate intend of this research is to provide an overarching IWRM framework that enhances a phased approach for implementing groundwater protection zoning in South Africa. It is important to note that this investigation will not diverge from the aims and intentions of the NWA and NWRS in addressing IWRM; instead, it aims to complement the founding principles (i.e. efficiency, equity and sustainability) on which the country's water law is based, by addressing the pressing need for groundwater protection within the context of sustainable development.

The objectives of this research can thus be outlined as follows:

i. Outlining the current limitations in addressing groundwater protection;
ii. Highlighting the fundamental principles for groundwater protection;
iii. Evaluate the socio-economic, institutional and regulatory milieu for undertaking groundwater protection zoning;
iv. Providing an overarching IWRM framework that enhances groundwater protection; and
v. Application of elements of an all-encompassing methodological IWRM framework to assess its feasibility in relation to groundwater source and aquifer protection zoning.

1.4 Scientific context

As much as the proposition that justifies this study has been highlighted (Section 1.2), it is necessary to place the research in its appropriate scientific context. There are essentially only two approaches to scientific investigation: inducing a universal premise from many particular observations, or deducing particular statements from a universal premise (Harvey, 1969). The inductive approach requires numerous individual pieces of evidence, which, by analysis, lead the researcher to an intuitive generalisation. Analysis is understood as the interpretation of data in order to understand their relevance to some decision. Deductive reasoning, on the other hand, requires a major premise, as it is based on logical reasoning (Leedy, 1980).

In compiling the necessary theoretical framework for this study, a major premise is offered, as it is argued by the researcher that no current policy that directly addresses groundwater quality for domestic consumption purpose exists in South Africa. However, the approach followed by the researcher also relied on elements of a qualitative approach, since the proposition described in Section 1.2 is problem oriented rather than statistically oriented. Thomson (1990) regards the evaluation of experience gained from applied environmental assessments practice as a useful means of improving environmental management practises. The research method employed in the present study mainly subscribes to this approach. The study is based on the assumption that groundwater management can be vastly improved in South Africa by introducing a policy on groundwater source and aquifer protection zoning. The researcher further argues that elements of a groundwater source and aquifer protection zoning policy can be enhanced through existing initiatives and instruments, by contextualising the legal, socio-economic and institutional arrangements relating groundwater management in South Africa. Moreover, groundwater protection zoning cannot be developed and implemented independently as practised in the past, but should be undertaken as a phased approach within an overall integrated water resources management (IWRM) framework with full stakeholder participation and in conjunction with other key water resources instruments.

This chapter has contextualised the perceived problem, provided it in a synoptic statement (Section 1.2), described the aims and objectives (Section 1.3) and stated the scientific context (Section 1.4) for examination. The next chapter describes the methodology of the study.

2. METHODOLOGY

2.1 Introduction

This research was conducted to investigate the development of a groundwater source and aquifer protection zoning policy for South Africa. The initial review undertaken of the general literature on groundwater protection has allowed the research problem to be contextualised (Section 1.2). Various shortcomings in addressing groundwater source and aquifer protection zoning coherently at both policy development and implementation level appears evident in a number of countries, despite many initiatives and activities relating to groundwater protection in general. In carrying out this research, the following methodical approach is being adopted:

- Investigate international and local trends on groundwater protection zoning through a review of the general literature underpinning groundwater protection zoning (Section 2.2);
- Propose fundamental principles for undertaking groundwater protection in South Africa through:
    - Identification of fundamental principles and its importance in relation to the development of a groundwater source and aquifer protection zoning (GSAPZ) policy (Section 2.3)
    - Highlighting policy gaps created by fundamental principles in relation to groundwater protection and management (Section 2.4)
- Contextualise the current IWRM practise in relation to groundwater in South Africa (Section 2.5)
- Propose an overarching IWRM framework within which GSAPZ can be realised (Section 2.6);
- Provide an overview of the general water resources management trends in relation to groundwater (Chapter 3);
- Assess the socio-economic, legal and institutional arrangements for undertaking GSAPZ (Chapters 4, 5 and 6);
- Evaluate the policy process and operational preparedness for implementing GSAPZ (Chapter 7);
- Assess the relevance of the proposed framework through pilot testing of its elements in the Inkomati Basin (Chapter 8); and
- Make recommendations for advancing a formal and phased approach when implementing GSAPZ (Chapter 9).

The abovementioned research was conducted in collaboration between the DWAF and the University of Western Cape's Department of Earth Sciences. It is inevitable that the protection of groundwater encompasses more than just groundwater quality management, hence the importance that its availability and environment-dependency be included when addressing groundwater related problems. It is also important to consider a phased approach through different options (i.e. protection at all cost or as reasonably practical) once a policy development initiative is considered for enhancing adequate protection of groundwater in particular.

In South Africa, a differentiated approach for the protection of groundwater quality is adopted (risk-based). This means, in practice, that the relative stringency and acceptable risk levels for impact minimization measure which will be required for potentially polluting sources, will depend on the nature of the affected groundwater resources in terms of its importance and vulnerability. A differentiated approach to protection is not an objective (protection is the highest level objective for the nation) but merely a strategy to target available protection resources at the most critical contaminants and the most beneficial and vulnerable water resources. Some of the most important or immediate functions of groundwater management within the South African context can be summarised as follows (Braune, 2005):

- Abstraction and discharge licensing;
- Groundwater source protection zoning;
- Monitoring and compliance; and
- Training, awareness and capacity building.

2.2 International trends on groundwater protection zoning

The concept of a 'zone of protection' for areas containing groundwater has been developed and adopted in a number of countries (Chave *et al,* in WHO, 2006). Many have developed guidelines for water resource managers who wish to delineate protection areas around drinking water abstraction points (Adams and Foster, 1992; NRA, 1992; US EPA, 1993). A number of countries (e.g. the United Kingdom, Australia and Ireland) have also introduced vulnerability assessment of groundwater into their respective protection policies. These can refine protection categories defined by fixed distance and / or travel time approaches and allow a differentiated management response within a protection area. Such systems are also useful outside of drinking water protection zones for long term planning of the protection of groundwater resources (Chave *et al,* in WHO, 2006). Some countries also consider a risk assessment approach for delineating protection zones. The Netherlands for example, has incorporated a new policy on the production of safe drinking water into legislation in 2001. This approach is based on a maximum acceptable infection risk of one per 10^4 persons per year associated with drinking water consumption and dose-response relationships for pathogens and has resulted in using maximum allowable concentrations in drinking water (Regli *et al,* 1991).

Delineation of the protection zone is the process of determining what geographic area should be included in a protection zone program. This area of land is then managed to minimize the potential of groundwater contamination by human activities that occur on the land surface or in the subsurface. In general, the degree of restriction becomes less as the distance from the abstraction point increases, but it is common to include the area of the whole aquifer from which the water is derived in one of the zones, and to restrict activities in such areas in order to give general long-term protection. Aquifers such as fractured bedrock and gravel aquifers among others are identified as sensitive to faecal contamination by the United States Environment Protection Agency's proposed Ground Water Rule (US EPA, 2000). These aquifers have in common that more permeable pathways exist that allow very high flow rates of viruses (Chave *et al,* in WHO, 2006). In such pathways, attachment will be very low. Due to the high transport rate (short travel times), inactivation will also be minimal. It is obvious that preferred pathways, like fractures and breaches, will contribute greatly to the uncertainty in assessing the removal capabilities of a certain aquifer.

Prioritisation of schemes for groundwater protection is also practised in a number of countries notably Western Australia, Tunisia, Denmark and the United States of America. This practise is mostly considered in situations where land use pressures are high. The benefit of prioritisation approaches is that they promote cost-effective application of protection zones to take into account the need to balance economic development and resource protection. Thus they may be used as a further criterion in defining management responses, supplementing hydrogeological criteria such as travel times and vulnerability assessments (Chave *et al,* in WHO, 2006).

Although some protection zoning initiatives include prioritisation schemes for land-use, all concepts and principles historically used, aimed to control polluting activities around abstraction points in order to reduce the potential for contaminants to reach the groundwater that is abstracted. Criteria commonly used for these include the following (Chave *et al,* in WHO, 2006):

- Distance – The measurement of the distance from the abstraction point to the point of concern such as a discharge of effluent or the establishment of a development site.
- Drawdown – The extent to which pumping lowers the water table of an unconfined aquifer. This is effectively the zone of influence or cone of depression.
- Time of travel – The maximum time it takes for a contaminant to reach the abstraction point.
- Assimilative capacity – The degree to which attenuation may occur in the sub-surface to reduce the concentration of contaminants.
- Flow boundaries – Demarcation of recharge areas or other hydrological features which control groundwater flow.

Approaches using such criteria can range from relatively simple based on fixed distances, through more complex methods based on travel times and aquifer vulnerability to sophisticated modelling approaches. Uncertainty of the underlying assessment of contamination probability is reduced with increasing complexity. The most sophisticated approaches to groundwater protection zone definition are based on calculated log-reductions in microbial concentrations or reductions in chemical concentrations that can be achieved through attenuation and dilution as contaminants move through the soil, unsaturated zone and through the saturated zone. These approaches require much greater knowledge of local conditions and the expected reductions that may be achieved through attenuation. They do, however, provide much more realistic estimates of the land area where control should be exerted on polluting activities, and thus may be components of quantitative risk assessments. These may involve assessment of hazard arising from a particular activity, examination of the vulnerability of the underground water to pollution, and consideration of the possible consequences which would occur as a result of contamination (Chave *et al,* in WHO, 2006). A comparative table of examples of protection zoning in different countries is also illustrated in Table 2.1 further below.

2.2.1 Ghana

In crystalline rock terrains such as that found in Ghana, the protection of boreholes cannot be simply achieved by establishing protection zones. This is because heterogeneous materials developed in the weathered zone and in fractures in the bedrock, provide viable flow paths or contaminants from indiscriminately located latrines, waste dumps and other sources. The high groundwater velocities would result in groundwater protection areas covering the major parts of communities' aquifers and hence may make them impractical to achieve (Bannerman, 2000).

In Ghana, a pragmatic time-of-travel approach has been adopted with which to define protection area boundaries. Three protection zones are designated. Zone I covers an area of radius 10-20 metres around a production well and is designed to protect it against short-circuit contamination as the well site. Zone II is situated around the Zone I and comprises the zone between the well field and a line from which the groundwater will flow at least 50 days until it reaches the production well. The choice of this travel time for Ghana was developed from experience elsewhere though it may not be applicable under all conditions. Zone III is a buffer zone between the recharge area and Zone II. If the water is produced from a spring, the zone should not be less than 20 metres on the upstream (upside hill) of the water source (Chave *et al,* in WHO, 2006).

2.2.2 Ireland

In Ireland, individual public water supply sources are identified and protection zones established around them, termed 'Source Protection Areas'. Two source protection areas are delineated, i.e. an inner protection area and an outer protection area. Both areas may be identified either on the basis of a simple zoning using an arbitrary fixed radius where scientific and geological data is in short supply, or using hydrogeological methods based on local data or modelling. Inner protection areas ate intended to protect the source from the effects of an activity tat could have an immediate effect on water quality, and is defined as a 100-day time of travel from any point below the water table. A 100 days were chosen by Ireland as a conservative limit to allow for the heterogeneous nature of Irish aquifers and to allow for the attenuation of bacteria and viruses which may live beyond 50 day. In some karstic areas it is not possible to identify 100-day boundaries, in which case the whole aquifer becomes a source protection area. If the arbitrary fixed radius is used, 300 metres is taken as equivalent distance. The outer protection areas cover the zone of the aquifer, the recharge which supports the long-term abstraction of the individual source or the complete catchment if this is the contributing area (Chave *et al,* in WHO, 2006).

2.2.3 United Kingdom

In the United Kingdom, decisions on protection zones are taken on the basis of assessing the likely impact of pollutant and the degree to which attenuation occurs in the geological strata influencing the source. According to the national groundwater protection policy (NRA, 1992), three distinct protection zones are recognized in the vicinity of abstraction points. Firstly, the inner source protection zone (Zone I) is located immediately adjacent to the groundwater source, and is designed to protect against the effects of activities which would have an immediate outcome on the source, in particular in relation to the release pathogens into groundwater (Chave *et al,* in WHO, 2006).

It is defined as the area within which water would take 50 days to reach the abstraction point from any point below the water table, subject to a minimum of 50 metres radius from the source. Secondly, the outer source protection zone (Zone II) is an area defined by a 400 day travel time to the source. It is based upon the time needed for the attenuation of slowly degrading pollutants. In England and Wales this is further modified for aquifers of high water storage capacity, such as sandstones, to allow for Zone II to cover either the area corresponding to 400 days, or the whole of the recharge area, calculated on the basis of 25 percent of the long term abstraction rate of the source. There is a third zone (Zone III) which covers the whole of the catchment area of the source, based on the area needed to maintain abstraction assuming that all water will eventually reach the abstraction point. In some cases, where the aquifer is confined, it is possible that the protection area is remote from the site of the source (Chave *et al,* in WHO, 2006).

Table 2.1 Comparative table of examples of protection zoning (Source: After Chave *et al,* in WHO, 2006)

Country	Wellhead protection zone for inner zone	Middle zone *Travel time radius of zone*	Outer zone
Australia	50 m	10 years	Whole catchment
Austria	<10 m	60 days	Whole catchment
Denmark	10 m	60 days or 300 m	
Germany	10-30 m	50 days	Whole catchment
Ghana	10-20 m	50 days	Whole catchment
Indonesia	10-15 m	50 days	Whole catchment
Ireland	100 days or 300 m		Whole catchment or 1000 m
Oman	365 days		Whole catchment
Switzerland	10 m	Individually defined	Double size of middle zone
United Kingdom	50 days or 50 m minimum	400 days	Whole catchment

2.2.4 Denmark

Denmark has used a protection system which takes account of existing abstraction wells and utilises two zones. The first is a fixed radius zone of 10 metres radius immediately surrounding the abstraction point to provide for technical and hygienic protection. A further zone of 60 days travel time or 300 metres radius is considered as an outer protection area to take account of contaminants which degrade more slowly. Problems in dealing with pesticide contamination have also led the consideration of a 10-20 years zone in which pesticides would be controlled. Evidence of continuing problems with groundwater quality, particularly in respect of pesticide contamination and rising nitrate levels has led the Danish Government to adopt a three zone system in 1998 to prioritise the expenditure of money and effort in controlling point sources of pollution (Stockmarr, 1998).

2.2.5 Germany

In Germany, guidelines on the definition of zones are available through a code of practise (DVGW, 1995). It defines the three zones. The 'Well Field Protection Zone' (Zone I) is designed to protect individual wells and their immediate environment against any contamination and interference and has fixed dimensions of 10 metres. A 'Narrow Protection Zone' (Zone II) aims to provide protection against contamination by pathogenic bacteria and viruses and is based a 50 day travel time. Due to the area of land required to meet the 50-day criterion, fixing a boundary is often not possible in karst terrains, mainly for economic reasons (e.g. where existing development would have to be removed). A 'Wide Protection Zone' (Zone III) serves to protect wells against long-range impairments, notably against contamination by non-degradable or less readily degradable chemical or radio-active substances, and usually covers the entire subsurface catchment area. If the catchment area is very large, with a boundary more than 2 km from the well, it may subdivided into Zone III A and Zone III B, with different levels of land use restrictions (Chave *et al,* in WHO, 2006).

2.2.6 Australia

The Australian wellhead protection plan is a system of groundwater protection which involves four components. These comprise a set of actions to ensure that the well is properly designed and constructed (known as 'well integrity assurance'), the setting up of wellhead protection zones, an appropriate monitoring system and contamination or land use control (ANWQMS, 1995). The wellhead protection zones are based on the definition of concentric protection zones around the wellhead. The nearest zone (Zone I) encompasses the operational compound surrounding the well, and is often, but not always, defined as a 50 metre radius area within which the most stringent controls on land use and materials apply. The second zone (Zone II) is arbitrarily defined as the maximum distance a contaminant particle would have travelled if it took 10 years to reach the well. The third zone (Zone III) corresponds to the regional protection area where greater than 10 years travel time is available. This is usually the catchment area of the contributing aquifer (Chave *et al,* in WHO, 2006).

2.2.7 Oman

In some countries, where water is in short supply and resources are very limited, protection zones are used primarily to ensure that there is adequate control over abstraction rates. This applies particularly to arid countries. The Water Resources Council in the Sultanate of Oman for example, decided in 1983 that no wells should be constructed within 3.5 km of a motherwell of a water supply system. The choice of size of the protection zone was a pragmatic solution rather than based on hydrogeological principles. Since that date the protection of groundwater has been accomplished by the adoption of the 'National Water Development Area', a scheme which stipulates water protection zones designated for the general protection from contamination, over-abstraction, intrusion by seawater and adverse development. The schemes used a colour-coded zoning system to identify specific limitations on future developments and progressively on existing activities. Such zones were a response to already perceived potential problems and were useful in providing guidance on future developments within the water protection zones (Government of Oman, 1991).

However they had limited success in dealing with existing development due to the problems of applying retrospective controls. In response, a new scheme using technically derived zones based on time-of-travel periods has been developed to this. The establishment of major government wellfields in urban areas to meet public water supply needs was followed by the recognition that these needed careful protection both as a water resource and from pollution. As a further development of the earlier water development area zoning system described above, a revised water protection zone concept utilising three distinct zones with relevant regulation of activities within them has been adopted. The three zones use 365 days as the time of travel to define the boundary of an innermost protection zone surrounding an abstraction point such as a well. A second tier protection area which uses a 10 year time travel to define the boundary is established as middle protection zone whilst the extent of the third and outermost zone is delineated by the catchment boundary (Government of Oman, 1991).

2.2.8 Indonesia

An integrated approach to ensure proper drinking water quality in urban centres of Indonesia has been developed by the Indonesian-German Governmental cooperation on drinking water quality surveillance. This concept includes protection zones to protect and maintain water resources in their initial function and allotment by a natural and preventative approach. The zones are based on fixed distances for Zone Category I and on travel time for Category II, using hydrogeological mapping and flow path model where zones of different categories are defined. The following zones are applied (Chave *et al,* in WHO, 2006):

- Zone Category I – This zone is defined as the area surrounding the spring / well within a radius of 10-15 metres, which is fenced and where any activity that has interaction with the aquifer is prohibited.
- Zone Category II – Comprise of the boundary that is defined by 50 days travel time, to provide protection against bacteriological contamination. In order to determine the boundaries, a hydrogeological survey is conducted for each spring and well. All possible activities causing bacteriological contamination are prohibited under this zone despite the restrictions highlighted under Category III hereafter.
- Zone Category III – This zone includes the whole catchment area based on the topographical boundaries, where the application of water hazardous pesticides, the infiltration of liquid waste, human settlements with unorganised discharge of waste water within the catchment area and waster disposal are restricted. Clustering of several springs / wells in one catchment area is also possible under this zoning category.

2.2.9 Groundwater protection within the South African context

Groundwater protection and conservation are essentially components of groundwater management, and relate to both quantity and quality issues. Groundwater protection should occur within an IWRM framework through prescribed tools such as a resource classification system and the Reserve (DWAF, 2000b). Pollution of groundwater resources can affect both groundwater and surface water quality in streams fed by baseflow. Further, remediation of polluted aquifers is expensive and technically difficult. As a result, groundwater quality management and protection must be proactive (Xu *et al,* 2005).

However, there is currently no policy in South Africa that directly addresses the protection of groundwater used for drinking water (Xu *et al,* 2005). As protection of all aquifers is considered impossible in South Africa, a differentiated protection policy, where priority is given to important and vulnerable aquifers, has been proposed as the optimum solution (DWAF, 2000b). The groundwater component of the Reserve is the part of the groundwater resource that sustains basic human needs (which is calculated at 25 l/d/person) and aquatic ecosystems. Because groundwater is far more widespread geographically than surface water resources, that component of the geohydrological system which sustains the Reserve is only a part of the greater system considered under groundwater resource directed measures. To be able to quantify the groundwater component of the Reserve, we need to be able to estimate the volume of groundwater needed to satisfy basic human needs (BHN) and groundwater discharged to surface water bodies (Xu *et al,* 2003).

Groundwater can only be allocated to users and potential users once the volume of groundwater that contributes to sustaining the Reserve has been quantified and RQOs have been met. It is however important to highlight that RQOs can be based on both the Reserve and Classification. A water resources classification system delineates a groundwater management unit within a significant aquifer resource, into the following classes: 'Protected', 'Good', 'Fair' or 'Severely Modified'. These four classes imply different levels of protection and impact acceptable to stakeholders of the resource. They provide a framework of reference for the implementation of groundwater protection, use and management plans for that groundwater management unit. Figure 2.1 below (from Xu *et al,* 2003), summarises the RDM for groundwater protection.

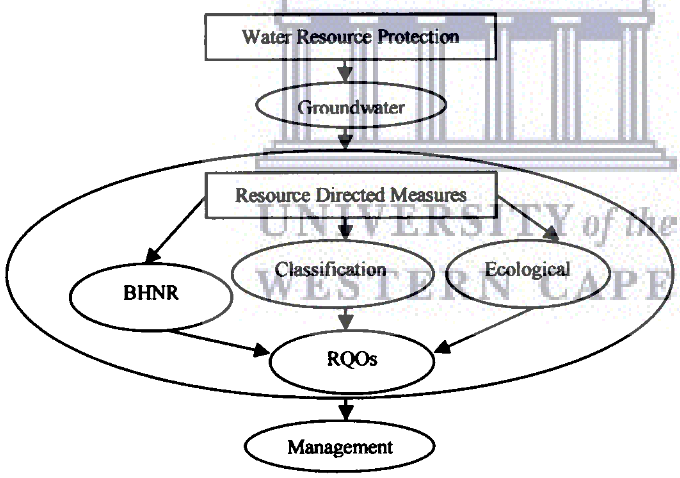

Figure 2.1 RDM for groundwater protection (Source: Xu *et al,* 2003).

Determination of the Reserve for aquatic ecosystems therefore entails investigation of the relationship of major interactive components of the hydrologic cycle, namely groundwater and surface water bodies including rivers, lakes and estuaries (Xu *et al,* 2003). A Reserve determination of the total water resource should be undertaken if a license application for water allocation is processed. RQOs provide goals within the management classes. They are set by the Minister during the process of classification of significant water resources. They may be seen as goals to aim for, if the management class represents an improvement on an impacted resource, or thresholds or safety nets, which represent the limit of acceptable impact. They may be numeric or descriptive (Xu *et al,* 2003).

2.3 Fundamental principles for undertaking groundwater protection in South Africa

2.3.1 Public consultation and transparency

Public participation in decision-making concerning water resource protection is one of the basic principles of IWRM in South Africa. Public participation must actively engage the need for participation of all segments of society, including those that have historically been disadvantaged and marginalised, in accordance with the principles of a proposed policy on groundwater protection. In particular, effort must be made to include women, rural communities and the poor in all decision-making structures and consultation processes. In order to sustain public participation and stakeholder involvement in overall groundwater management, transparency and openness is required. Information on groundwater resources and management decisions must be freely available to all stakeholders, albeit considering strategic interests and sensitivities of certain industries.

2.3.2 Differentiated and risk-based approach

A differentiated and risk-based approach to groundwater protection should be strongly considered and its implementation can be achieved through careful consideration of the following legal provisions reflected in NWA:

- Implementation of source-directed controls measures to prevent wherever possible and minimise, at source, the impact of development on groundwater quality by imposing regulatory controls and by providing incentives (i.e. Chapter 4 of the NWA);
- Implementation of resource-directed measures in order to manage such impacts as do inevitably occur in such a manner to protect the Reserve and ensure suitability for beneficial purposes (i.e. Chapter 3 of the NWA); and
- Remediation of groundwater resource quality where practicable, to protect the Reserve and ensure at least fitness for the purpose served by the remediation (i.e. Chapter 3 of the NWA).

In terms of water resources protection it is necessary to recognise that dependencies in the system exist particularly in a downstream sequence. These dependencies may require that the idea of sequencing be implemented in the protection zoning process where a problem at a specific point in a system is addressed by controlling the upstream factors. It must also be recognised that certain aspects in terms of groundwater resource quality and quantity may not be obtained due to the dependencies of that particular location on other areas in a catchment. It must also be recognised that not all aspects can be implemented immediately but will need to be implemented in a sequential manner requiring a transformation over an extended period of time.

2.3.3 Practicable and phased implementation

As there is a legislated requirement for the protection of water resources (i.e. both ground and surface water as required under Chapter 3 of the NWA), groundwater source and aquifer protection zoning initiatives must be sufficiently practical and robust to be implemented at a catchment level by trained the DWAF staff. There should also be a sound equilibrium between the costs of implementation and the confidence levels associated with the determination of a class. It is likely that different methods resulting in increased levels of confidence in the determination of classification will eventually evolve (i.e. low, medium and high confidence versions of the same system). It has been suggested that the most basic of these methods be used in a preliminary classification of all significant resources country-wide.

2.3.4 Sustainability

The concept of a safe or sustained yield for aquifers has been widely used when assessing groundwater resources, both locally and internationally. Safe yield and sustainability are conceptually similar, and share the characteristic of being difficult to quantify. Bouwer (1978) defined safe yield as the 'rate at which groundwater can be withdrawn without producing undesirable effects'. He noted safe yield is equal to average rate of replenishment or recharge, but accepts this concept has been stretched beyond its hydrological meaning. More recently, the concept of safe yield and sustainability has been debated in the literature (Bredehoeft, 1997; Alley & Leake, 2004 and Jacobs & Holway, 2004), with much of the argument requiring that we move away from regional water balance approaches, and focus more on local issues such as groundwater levels when considering sustainability.

Understanding the role of groundwater in sustaining the environment is still in its infancy. Promulgation of the NWA and its recognition of a unitary hydrological cycle have resulted in closer working relationships between surface water hydrologists and geohydrologists (Parsons, 2003); more detailed consideration of the groundwater contribution to baseflow (Hughes, 2004 and Sami *et al,* 2005) and consideration of ecosystems dependent on groundwater (Hatton & Evans, 1998; Brown *et al,* 2003 and Colvin *et al,* 2003). As a result, the sustainable volume of groundwater available for abstraction has to be considered in a wider context than recharge and rates of abstraction.

2.3.5 Analysis of scale

If a process (such as a groundwater protection zoning policy initiative) is to be legally defensible, it will be required that it is scientifically rigorous, and that all the concepts and information provided can be backed up by hard science that is able to provide a defendable and transparent decision. It is therefore important to assess the level of scale at which groundwater protection needs to be undertaken, especially in a country like South Africa, where technical or geographical boundaries (i.e. aquifers in this case) are not always aligned with that of water resource management boundaries (i.e. WMAs).

Different information available in various areas of the country and different levels of risks are associated with decisions. It is therefore prudent to have a number of methodological options that would assist in decision-making accounting for these factors. It is suggested that a set of methodologies be adopted for different levels of information available when decisions are made with respect to the level or approach for protection zoning to be undertaken within a catchment. The following three levels of decision-making could perhaps be introduced at this stage as suggested by Braune (2005):

- Protection at all costs;
- Protection as best as possible and reasonably practical; and
- Pollution is acceptable where absolutely necessary.

It may be important to have each of the three levels interacting in such a way as not to compromise the estimates of the other two. However, a consistent framework is necessary to ensure that the needs for each level (as outlined above) are considered comprehensively.

It must also be recognised that the framework for groundwater protection needs to embody the changing physical and base conditions in a particular WMA. It is from this perspective that a differentiated and risk-based approach is suggested (Section 2.3.2). It is also recognised that the groundwater protection process needs to have a set of consistent measures which allow stakeholders in the catchment to assess the current situation and the future situation in terms of RQOs. The protection process should also characterise three different entities namely:

- Where we currently are;
- Where we want to be; and
- How do we intend to reach a planned destination.

The measures in the first two elements will basically be the same but measures in the third element on 'how we intend to reach planned destination' may signify a whole different set of measures. Aspects associated with protection and utilisation should be separated and later combined through a formal process. This will distinctly allow the people involved in the protection zoning process to objectively assess the existing position in terms of protection and utilisation and their future position and the consequent impacts on resource sustainability and economic and social development.

2.4 Policy gaps created by fundamental principles

In spite of being a guiding principle, sustainable water use is not defined in the NWA. By definition, sustainable water use implies ongoing use of water over an extended period of time. In setting levels of use, consideration needs to be given to current water needs and to those of future generations, as well as social, economic and environmental factors and the benefits of use. South Africa is unique, as water must be made available to citizens disadvantaged under the previous political dispensation, who did not have access to water.

The National Environmental Management Act, Act 107 of 1998 (NEMA), defines sustainable development as 'the integration of social, economic and environmental factors into planning, implementation and decision-making so as to ensure that development serves present and future generations'. Currently there is no policy that directly addresses the protection of groundwater used for drinking water in the country. Parallel to this thesis, a methodology for the delineation of aquifer protection zoning is being assessed, as part of an overall policy feasibility study (Xu *et al,* 2005).

2.5 Integrated water resources management and groundwater

It is believed that the protection of groundwater under IWRM as adopted by the DWAF (Figure 2.2) is adequately addressed under the resource directed measures (RDM), and that mitigating measures dealing with associated impacts on groundwater is dealt with under source directed controls (DWAF, 1999). In practise however, this presumption carries little weight as there is no champion for direct overall groundwater management at senior management level within the DWAF.

The ongoing restructuring of the DWAF has led to groundwater management being addressed in a rather fragmented manner, as a result of groundwater expertise being absorbed by different chief directorates of the Department following a management decision that groundwater be 'integrated' into the bigger organisation as a whole.

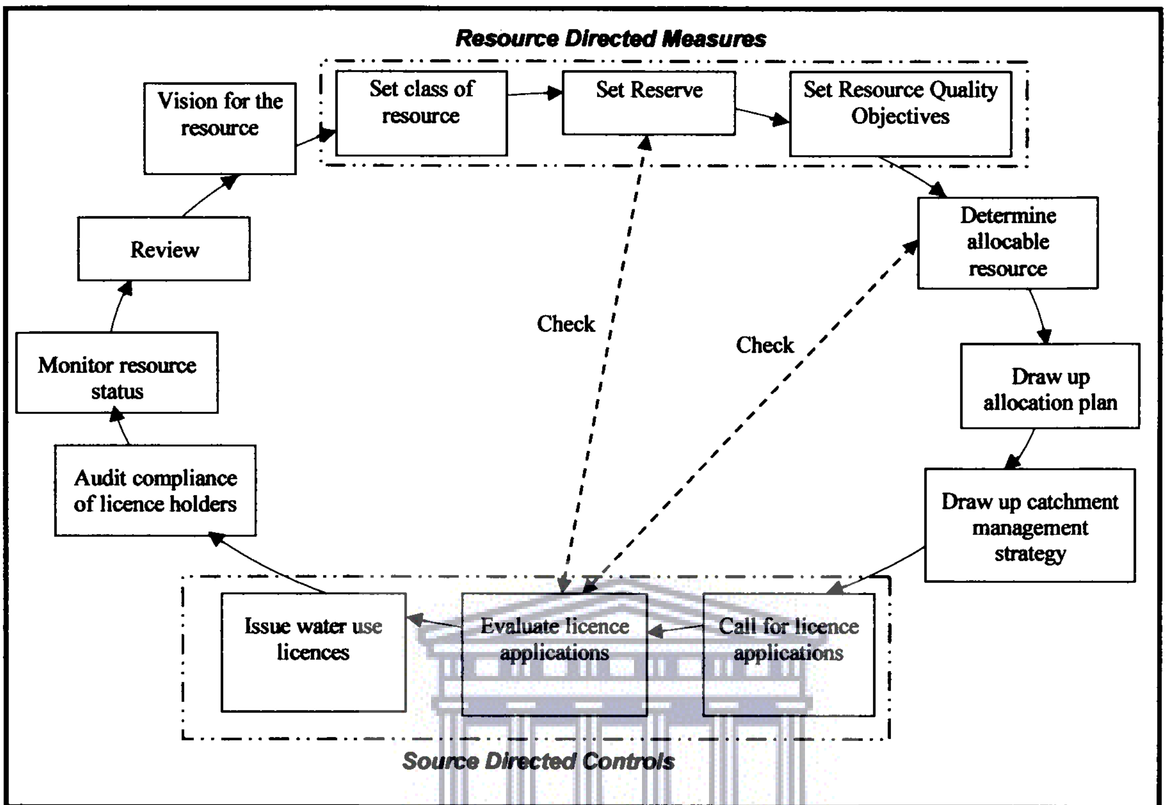

Figure 2.2 IWRM as adopted by the DWAF (Source: After DWAF, 1999).

The intention of this approach was to ensure that groundwater is adequately incorporated into other IWRM disciplines. However, it appears that this approach was a bit premature given the lack of sufficient groundwater expertise throughout the DWAF and the water sector, let alone the limited understanding of this subject. Furthermore, the adopted IWRM approach by DWAF assumes an integrated approach to water resource management that excludes groundwater. It is therefore necessary to propose an overarching framework that clearly illustrates groundwater management and its relevance to effective IWRM. This will ensure a better understanding on the role of groundwater within the context of IWRM and that real meaning is added to its meaningful contribution in making IWRM a reality.

2.6 Proposed overarching IWRM framework

Figure 2.3 below illustrates how water resources protection within an overarching IWRM framework should unfold. More important to note is the iterative process required for developing a cross-sector policy for groundwater protection zoning in particular. A further parallel process is also proposed whereby a strategy for groundwater protection zoning could be developed simultaneously while establishing a water resources classification system (WRCS). The various linkages between other IWRM processes are also outlined to illustrate that groundwater protection initiatives are considered during the planning processes of IWRM (i.e. water availability and Reserve scenarios).

The ultimate outcome of such an approach is that elements of both the policy and strategy development process are being considered for the establishment of interim or preliminary guidelines for undertaking groundwater protection zoning. The anticipated involvement of CMA's during both the development and implementation stages of such policies and strategies are also highlighted. It is however important to stress that those functions of future CMA's are currently being performed by DWAF (i.e. Regions in particular).

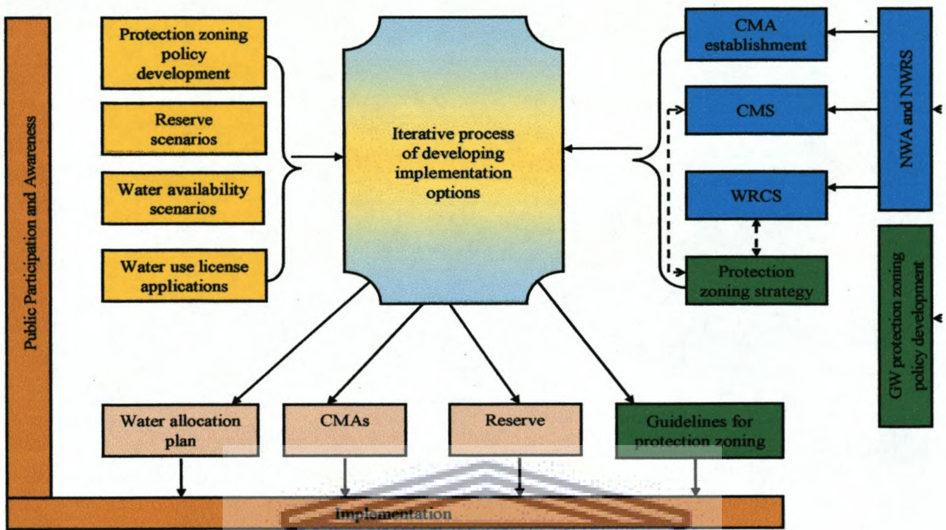

Figure 2.3 Overarching IWRM framework

The following three-tier approach as suggested by Braune (2005) should be considered in undertaking this mammoth task of groundwater protection zoning in South Africa:

- Implementation of guidelines/regulations to ensure that potential sources of contamination, such as inappropriate sanitation and poor borehole construction are dealt with immediately;
- An area planning and site-specific licensing of abstraction and discharges based on an aquifer classification system, which can differentiate between the required levels of groundwater protection. This classification will focus firstly on the importance of the aquifer and secondly on its vulnerability; and
- A programme of special protection for vulnerable groundwater sources supplying domestic water to communities.

3. WATER RESOURCES OVERVIEW AND TRENDS

3.1 Introduction

The average rainfall in South Africa's 1.2 million km^2 area is about 450 millimeters per year (mm/a), well below the world average of 860 mm/a, and the combined flow of all the rivers in the country amounts to approximately 49,000 million cubic meters per year (Mm^3/a). Because of the predominantly hard rock nature of the South African geology, only about 20 per cent of groundwater occurs in major aquifer systems that could be utilized on a large scale. With only 1200 m^3 per person per year, South Africa is rated as the 26th most water stressed country in the world. The poor spatial distribution of rainfall and runoff is compounded by the strong seasonality of rainfall, as well as high within-season variability, over virtually the entire country, causing water-related disasters such as floods and droughts. To aggravate the situation, most urban and industrial development, as well as some dense rural settlements, have been established in locations remote from large watercourses, dictated either by the occurrence of mineral riches or influenced by the political dispensation of the past (DWAF, 2004a).

As a result, in several river basins the requirement for water already far exceeds its natural availability, and widely-spread and often large-scale transfers of water across catchments have, therefore, already been implemented in past decades. The inter-linking of catchments gives effect to one of the main principles of the NWA, which designates water as a national resource. To facilitate the management of water resources, the country has been divided into 19 catchment-based WMAs and grouped in four clusters, which are shown in Figure 3.1 along with the nine provinces of South Africa. Four of South Africa's main rivers are shared with other countries and eleven of the 19 WMAs share international rivers, hence the NWA emphasis on the importance of fulfilling the country's international obligations (DWAF, 2004a).

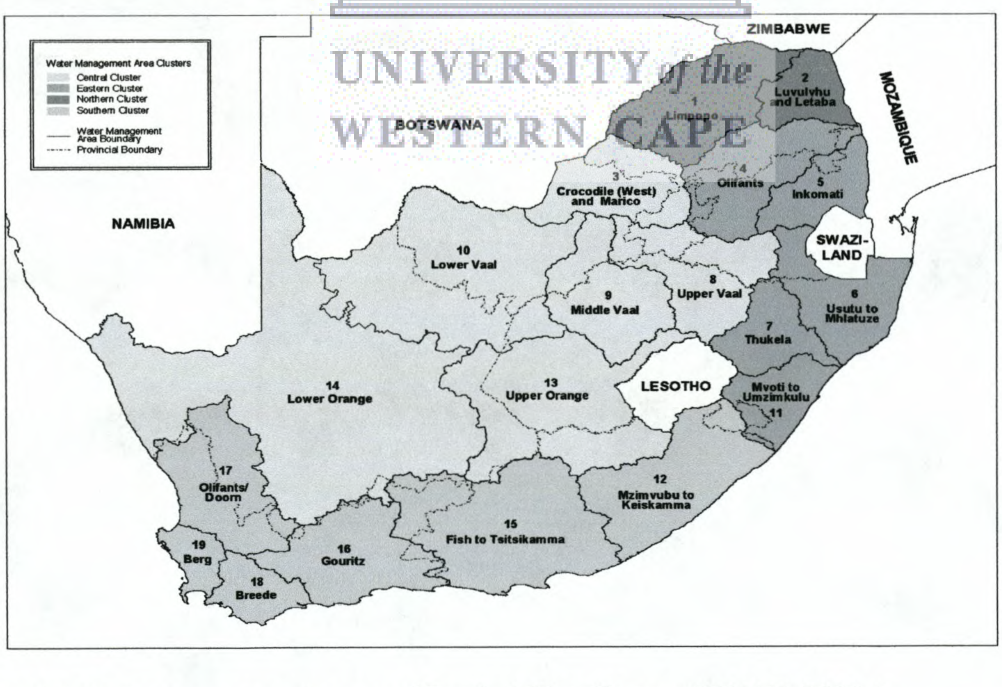

Figure 3.1 Water management areas of South Africa (Source: DWAF, 2004a)

3.2 Human impact on water resources

3.2.1 Global trend

Policy-makers worldwide are not unaware of the increasing impacts caused by human behaviour and activities on water. International conferences over the past twenty-five years have raised a number of pressing water issues, including the provision of basic water supply and sanitation services. Of these, two seminal conferences in 1992 were instrumental in mobilising change and initiating a new approach to water management DWAF, 2003). The *International Conference on Water and the Environment* in Dublin identified what have come to be known as the four Dublin Principles:

- **Principle 1** – Water is a finite and vulnerable resource, essential to sustain life, development and the environment.
- **Principle 2** – Water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels.
- **Principle 3** – Women play a central part in the provision, management and safeguarding of water.
- **Principle 4** – Water has an economic value in all its competing uses and should be recognised as an economic good.

That same year in Rio de Janeiro the *United Nations Conference on the Environment and Development (UNCED)*, also referred to as the Earth Summit, produced Agenda 21, which, among others, recognised that the development, management and use of water resources needed an integrated approach. Various other global policy development meetings set targets to improve water management, culminating in 2002 with the World Summit on Sustainable Development (WSSD), where United Nations Secretary-General Kofi Annan focused on five integral areas for a consistent international approach to sustainable development: Water and sanitation, Energy, Health, Agriculture, and Biodiversity (WSSD, 2002)

Since water resources now feature so prominently on the international agenda, we would expect the situation to have improved. And yet at the start of the twenty-first century, according to the United Nations World Water Development Report the earth, with its diverse and abundant life forms, including over six billion humans, is facing a serious water crisis (WWDR, 2003). All the signs suggest that it is getting worse and will continue to do so, unless corrective action is taken. This crisis is one of water governance, essentially caused by the ways in which we mismanage water. Information on and understanding of the ecological processes of aquatic ecosystems and the impacts of changing flow regimes on these processes and species assemblages are gradually being accepted as an aid to good water governance. This becomes apparent when we look at concepts such as water scarcity (UNDP, 1997).

3.2.2 Regional trend

South Africa and its neighbouring states form the Southern African Development Community (SADC), where water is considered to be an indispensable resource for all sectors of the national economies concerned, and used for (SADC-EC, 2006):

- Generation of hydropower;
- Agricultural, commercial and industrial development;
- Preservation of wildlife and national parks;
- Terrestrial and aquatic ecosystems;
- Sanitation; and
- Navigation.

In South Africa, four major river systems are shared with Lesotho, Swaziland, Botswana, Mozambique, Zimbabwe and Namibia. The quantity and quality of available water influences where economic development or social upliftment can or cannot take place in the region so it is vital that there is agreement on water governance issues. SADC places a high priority on the need to achieve sustainable utilisation of natural resources and effective protection of the environment, and this objective was incorporated into policy in the 1992 SADC Treaty (SADC-EC, 2006).

With this explicit introduction of an environmental use, SADC recognises the right to stipulate water for the protection of ecosystems. The governments of southern Africa are working together to maximise water management through initiatives such as (SADC-EC, 2006):

- The establishment of the SADC Division for Water (replacing the SADC Water Sector);
- The Ratification of the Protocol on Shared Watercourse Systems (2001); and
- The Regional Strategic Action Plan (RSAP) for Integrated Water Resources Development and Management in the SADC Countries (1999–2004).

For example, the Interim IncoMaputo Agreement between Mozambique, Swaziland and South Africa for co-operation on the protection and sustainable utilisation of the Incomati and Maputo watercourses was signed at the WSSD in August 2002 (WSSD, 2002). Based on the framework provided by the Revised Protocol on Shared Watercourses in the Southern African Development Community, which came into force in September 2003, the countries have agreed to develop and adopt various measures, either individually or jointly, to prevent, reduce and control pollution of surface and ground waters, and protect and enhance the quality status of the waters and associated ecosystems for the benefit of present and future generations. The Agreement specifies the water withdrawals that are allowed in each of the three countries and also defines the targets in stream flows for the Sabie, Crocodile, Komati, and Incomati rivers to ensure that the water requirements of the ecosystems are protected. The exchange of information between the three countries and the development of human and technical capacity to manage and protect shared water sustainably for economic and social purposes is also seen as a major objective. Two important corollaries of the Agreement are that Mozambique, as the most downstream riparian country, will be protected from upstream overexploitation of the rivers, and that any proposed infrastructure developments will have to be assessed to ensure that the water resources are protected against significant adverse consequences (SADC-EC, 2006).

The comprehensive agreement for the Incomati River Watercourse should be concluded during 2006 and that for the Maputo River Watercourse during 2010. Such international agreements impact locally upon issues such as the operating rules of existing dams, exchange of information, capacity building and institutional development. We can therefore not only be concerned as to what happens inside the borders of South Africa and is critical that we strengthen regional co-operation with neighbouring states over IWRM. The SADC Environment and Land Management Sector (ELMS) and the SADC Water Sector have commissioned a technical report on *Defining and Mainstreaming Environmental Sustainability in Water Resources Management in Southern Africa* (Hirji *et al,* 2002).

The report supports the integration of environmental quality objectives into the implementation of the SADC Protocol on Shared Watercourse Systems and the RSAP. The essential declarations in this report are that (Hirji *et al,* 2002):

- Sustainable growth and poverty reduction in the SADC region depend upon effective development and effective management of water resources; and
- Sustainable water resources management must balance the short-term needs of the people for their social and economic development and the long-term protection of the natural resource base.

The report describes a theoretical foundation for the sustainable management of water resources that is embedded in the following three principles:

- Acknowledge the environment as the resource base;
- Acknowledge the economic value of goods and services provided by water resources; and
- Mainstream environmental sustainability criteria into water resources policy and management.

Compared to most developing regions of the world, SADC is ahead of the curve in the search for environmentally sustainable solutions for managing its limited and fragile water resources. However, much needs to be done to have in place both an operationally effective policy and an institutional framework, and practices that reflect effective integration of sustainable management principles. One of the issues highlighted by the SADC technical report is the emphasis on misconceptions about water and water-dependent ecosystems (Hirji *et al,* 2002). The report highlights the following false impressions that are so prevalent that many sectors and individuals, even at high levels of decision-making, believe them to be facts:

- Water originates from pipes, and not from watersheds, springs and aquifers;
- Water flowing into the sea is wasted water;
- Downstream impacts of major water projects are insignificant and therefore should be ignored;
- Environmental management is a concern of outsiders and not of the region's people;
- Environmental management provides few benefits to society, but is costly and poses a huge economic burden; and
- Existing environmental impact assessment policies and laws are sufficient for integrating environmental sustainability criteria into water resources planning and management decision-making.

3.2.3 National trend

South Africa is a semi-arid country with climatic conditions ranging from desert and semi-desert in the west to sub-humid along the eastern coast. We are classified as a water-scarce country because we receive less than 500 mm of rain each year, well below the world average of about 860 mm. A mere 8.6 % of the rainfall is available as surface water, one of the lowest conversion ratios in the world. This constraint is compounded by the uneven natural availability of water across the country; a spatial variation that sees some areas receiving more rain than others. Since most rain falls in a narrow strip along our eastern and southern coasts, the western regions receive only 27 % of South Africa's total rainfall. Rainfall is strongly seasonal over virtually the entire country and even within regions regular droughts alternate with periods of good rainfall. Consequently, streamflow in South African rivers is comparatively low much of the time, with high flows taking place intermittently (DWAF, 2004d).

In addition, the hot, dry conditions prevalent over much of the country result in a high rate of evaporation. The country has not been blessed with great or even navigable rivers. Combined, the total flow of all our rivers totals about 49 200 million cubic metres per year. Similarly, natural lakes are few and we rely on rivers, dams and groundwater to meet our water requirements. About half of South Africa's annual rainfall is stored in 550 government dams, with a total capacity of 37 000 million square metres. However, our landscape does not lend itself to the construction of dams. Ecological considerations apart, we lack the deep valleys and gorges that are the ideal sites for these storage facilities. Since most South African dams are shallow with large surface areas, a great deal of water is lost through evaporation in our hot, dry, climate (DWAF, 2004d).

In addition, the arid climate, steep river gradients and poor farming methods result in a high silt load in almost all of our rivers, which rapidly reduces dam capacity. While groundwater plays a fundamental role in rural water supplies in particular, our groundwater resources are poor compared to world averages. The predominantly hard rock nature of South African geology, although rich in minerals, does not contain groundwater aquifers that can be used extensively. Water is thus a very scarce resource in South Africa. Population growth, increased economic activity and the escalation of land-use practices all lead to a growing water demand that places the freshwater resources of the country under stress. Almost all of our major rivers have been dammed to provide water for development and our wetlands are being converted for other land-use purposes, with more than 50 % already lost. At the projected population growth and economic development rates, by 2025 it is expected that South Africa will no longer be water stressed, but will face absolute water scarcity. Water will increasingly be the limiting resource in South Africa, and supply will constrain the future socioeconomic development of the country, both in terms of the quantity of water available and its quality (DWAF, 2004d).

3.3 Groundwater characteristics of South Africa

3.3.1. Occurrence of groundwater resources

The groundwater resources of South Africa differ from those elsewhere in the world, as about 98% of groundwater is found in fractured, hard rock aquifer systems (Kok and Simonis, 1989). Figure 3.2 below illustrates that groundwater's contribution to baseflow and springs is conceptually well understood, but difficult to quantify. Recognition by the NWA of a unitary hydrological cycle has forced a better appreciation of surface-groundwater interaction and much research is being undertaken to quantify and predict the contribution of groundwater to surface water bodies (Hughes, 2004).

Major primary aquifers are restricted to coastal sand deposits along the west and south coast of the Cape and along the KwaZulu Natal coast. Good examples include aquifers at Atlantis, on the Cape Flats and around Richards Bay. Secondary aquifers whose hydrological properties are enhanced by weathering, fracturing and faulting of hard rock are by far the most dominant, with major aquifers being associated with dolomitic rocks, quartzite and sandstone of the Table Mountain Group and sandstone and shale of the Karoo Sequence (DWAF, 2004d).

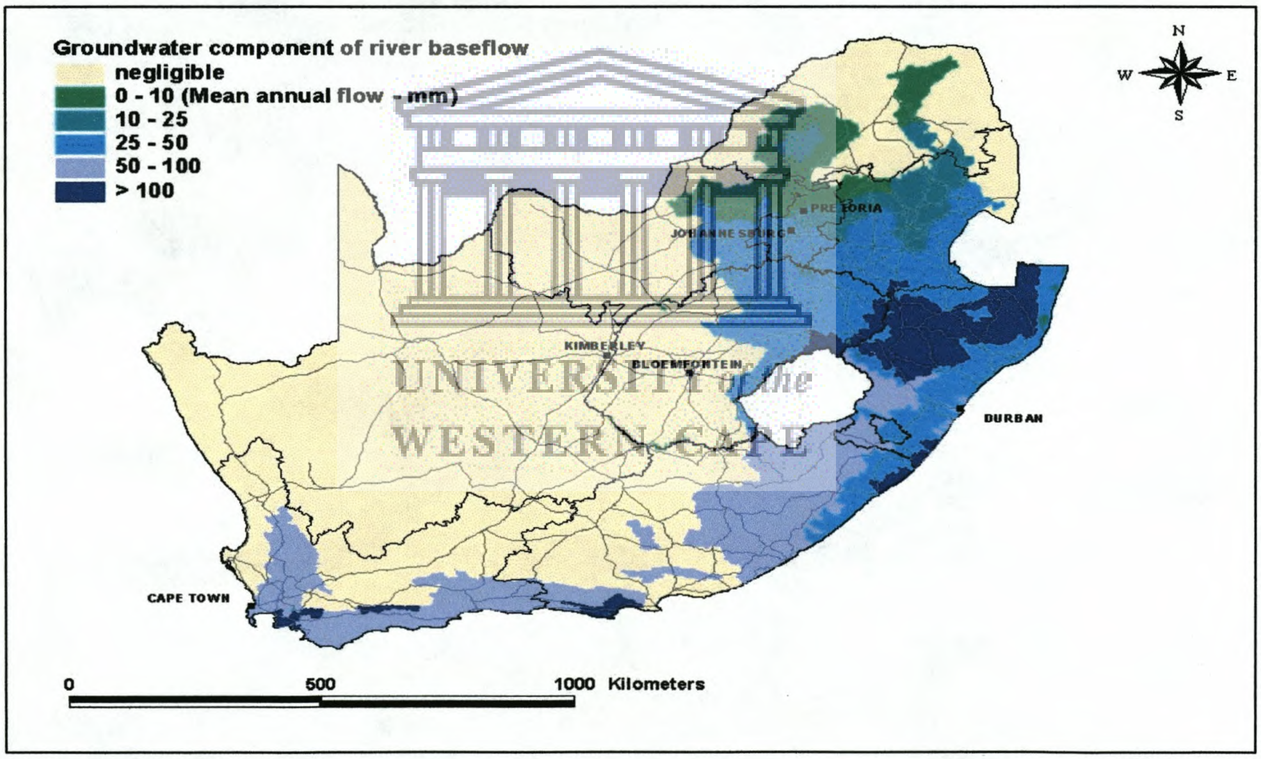

Figure 3.2 Estimation of groundwater contribution to river flow (Source: Vegter, 1995).

The implication of the dominant occurrence of groundwater in secondary aquifers is that secondary aquifers are more difficult to manage and protect than primary aquifer systems. It is also more difficult to generalise about appropriate drilling sites, aquifer yield and local management requirements. It is only in recent years that an attempt has been made to characterise groundwater resources on a national or regional scale.

Publication of a set of national-scale hydrogeological maps by Vegter (1995) provided impetus to the mapping initiative currently being completed by the DWAF. According to Parsons (1995), about 18% of aquifers in South Africa are categorised as major aquifer systems. Such aquifers are distinguished by high yielding boreholes producing good quality water. They consist of mainly primary coastal aquifer systems, dolomitic rocks, rocks of the Table Mountain Group and some parts of the Karoo Sequence. Cities and towns dependent on groundwater from major aquifer systems include Pretoria, Atlantis, St Francis Bay, Beaufort West and Graaff-Reinet. Poor aquifer systems, comprising 15% of the total, are found mainly in the dry northern and western parts of the country. Though boreholes sited in such aquifers are generally very low yielding and / or produce poor quality water, they could still play a critical role in supplying water to small rural communities in the arid parts of South Africa (Parsons, 1995).

Minor aquifer systems are widely spread and comprise 67% of South Africa's aquifer systems. Rocks of the Karoo Sequence and older rocks in the north-eastern parts of the country dominate. Borehole yields and groundwater quality are variable, but these aquifers have proven themselves capable of producing sufficient quantities of water of acceptable quality for both domestic and agricultural purposes. Towns dependent on minor aquifer systems include Nylstroom, Williston, Carnavon and Richmond (Parsons, 1995).

3.3.2. Different aquifer types

Aquifer types play a significant role when determining the transport processes involved as possible pathway contaminants can follow from a contamination source to a potential receptor. Moreover, from a water bearing point of view, geological formations can be divided into groups based on primary openings (intergranular) and secondary openings or fractures. (Vegter, 2001). The occurrence of groundwater further depends on the existence in the rock formation of a thick weathered zone, usually the uppermost (i.e. between 10 – 30 metres), and the occurrence of deeper fracture zones (MacDonald and Davies, 2000).

In South Africa, aquifers were classified into four main types (Jonck and Meyer, 2002), namely:

- Intergranular aquifers, which comprise of different combinations of unconsolidated to semi-consolidated material ranging from boulders through sand to clay size particles;
- Fractured aquifers, which are found within hard rock aquifers and are characterised by negligible primary porosity with groundwater movement controlled by zones of faulting, fracturing and jointing;
- Karstic Aquifers, that are formed by the dissolution of a carbonate rock by circulating groundwater containing carbonic acid; and
- Intergranular aquifers, which are generally considered to form dual-porosity fractured rock aquifer systems, where it is difficult to simultaneously quantify the groundwater flow within fractures and the rock matrix.

3.4 Groundwater use perspective

No definitive study has been undertaken to quantify groundwater use in South Africa. However, it is widely held that groundwater accounts for approximately 13% of all water used in the country while some 320 towns and villages are dependant on groundwater to some degree. Recent work by the DWAF suggests almost 60% of rural communities surveyed are groundwater dependent. It is further quoted urban groundwater use accounts for only about 4% of groundwater abstracted, while the agricultural sector abstracts about 84% for irrigation and stock-watering. It has been estimated groundwater contributes about 16% of all water used for irrigation in South Africa (DWAF, 1986). The current validity of these estimates is questionable, particularly in light of the recent development of groundwater resources to supply some 4 million people with water as part of the Reconstruction and Development Programme. Vegter (2000) estimated groundwater use may have doubled between 1980 and 1999 (Table 3.1). Recent estimates of groundwater use made by Baron (in DWAF, 2004d) and Haupt (2000) differ significantly. Baron (in DWAF, 2004d) estimated current groundwater use in South Africa is in the order of 1 920 m^3 while Haupt (2000) estimated it may be as much as 3 200 m^3.

It is interesting to note Haupt (2000) set the groundwater harvest potential at 19 250 Mm^3/a, suggesting less than 20% of South Africa's available groundwater resources are currently used. Because of the low level of confidence in the estimate of groundwater use and the need to consider local conditions when abstracting groundwater, these estimates should be treated with caution. As groundwater considerations have gradually been included in water resource management, it has become more and more clear it is not the volume of groundwater contributed that is important, but rather the role and timing of the contribution. It is accepted groundwater cannot compete with the volume of water supplied from large surface water supply schemes. However, the groundwater contribution to streams during low flow periods, for example, plays a critical role in sustaining the ecological function of streams during such periods (Parsons, 2003). Similarly, the location of groundwater resources in relation to potential users and the cost of developing groundwater are also factors requiring consideration. Use of groundwater to supply water to De Aar is an example of the value of groundwater becoming apparent as the cost of developing a pipeline from the Orange River proved to be prohibitive.

Table 3.1 Historic perspective of groundwater abstraction in South Africa (Source: After Vegter, 2000; Haupt, 2000 [1] and Baron *et al,* (in Parsons, 2003) [2].

Year	Total groundwater abstraction (Mm^3/a)	Groundwater as a percentage of total water used in SA (%)	Groundwater used for urban supply, as a percentage of total groundwater used (%)	Groundwater used by the agricultural sector, as a percentage of total groundwater used (%)
1950	684			71
1960	1 062	11		68
1970	1 128		4	84
1980	1 790	15		
1990				
2000	3 500[1] / 1900 [2]			

Development of groundwater, either using springs or boreholes, is the only viable means of supplying basic human water needs to millions of rural South Africans who currently do not have adequate access to potable water. It is for this reason that it is believed groundwater can play an important role in the national governments initiative to eradicate poverty. Integration of groundwater and hydrogeological expertise into CMAs is considered critical, therefore, if the water resources of a catchment are to be managed in a sustainable and cost effective manner.

Table 3.2 Summary of sectoral and total groundwater use (Source: After Parsons, 2003)

Sectoral Groundwater Use (Mm³/a)	Urban Domestic / Municipal	Rural Domestic / RDP	Irrigation	Stock watering	Mining	Industry	Other	Total
DWAF (1986)	70	120	1400	100	100			1790
Baron *et al*, (1998)	131	306	1424	106				1968
Haupt (2000)								3500
NWRS/(WSAM)								1100
CSIR (2004)	153	144	1137	111	156	65	5	1771

Whilst there is a significant degree of variability between the estimates made over the last twenty years, with the exception of Haupt (2000), the estimates are in a range of 300Mm³/a. The greatest variability is in the Rural and Agricultural Irrigation sectors.

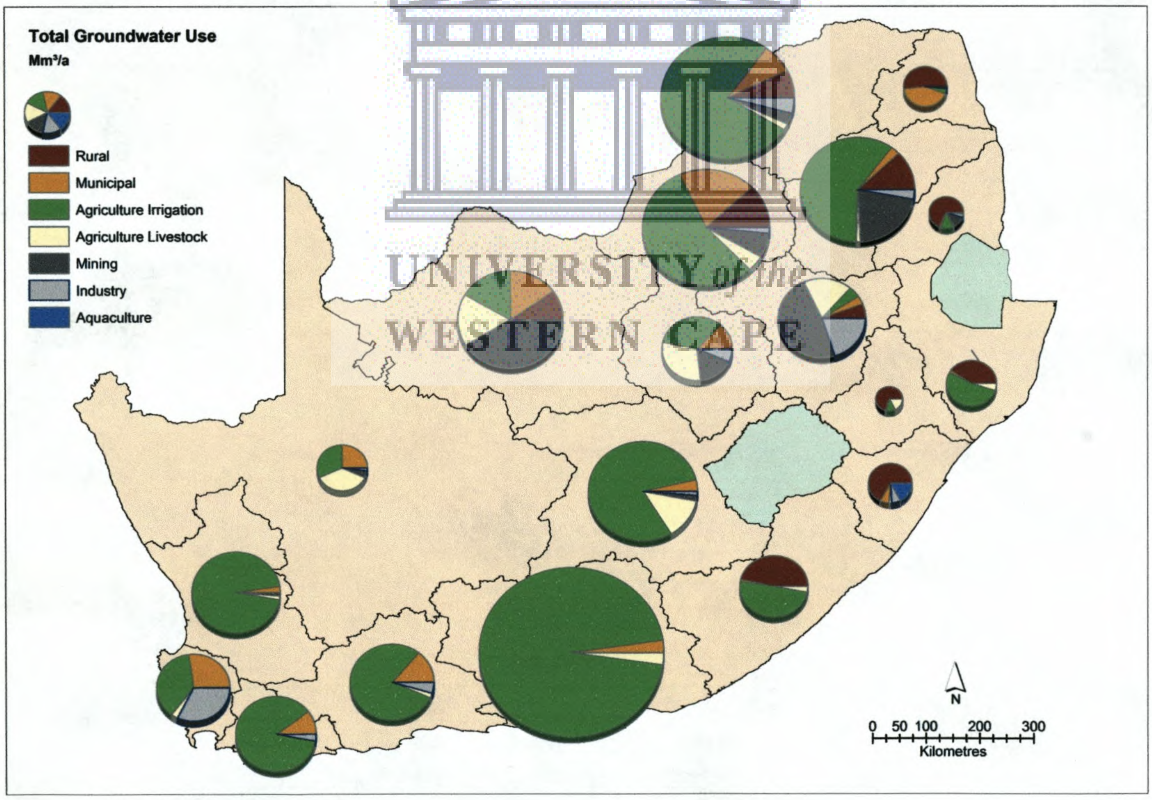

Figure 3.3 Groundwater use per WMA (Source: DWAF, 2005a)

Figure 3.3 above is a summary of sectoral groundwater use per WMA. The major groundwater users are the Fish to Tsitsikamma, Crocodile and Limpopo WMAs, with the smallest users being the Thukela and Inkomati WMAs. The Total Groundwater Use map displays the combined results of the sectoral groundwater use estimates. As has been stated a number of times throughout the different reports of this project, these results are of low confidence and care must be taken when using them as anything other than a general guide. Whereas the methods used are sound, the input data are, in many cases, highly suspect (DWAF, 2005a).

3.5 Socio-economic perspective

Water is recognised worldwide as the most indispensable of all natural resources, and neither the maintenance of biological diversity, nor the promotion of social and economic development, is possible in its absence. Today, countries have to face the growing challenge of meeting rapidly rising demands for water that are driven by increasing population numbers coupled with growing urbanisation, industrialisation and mechanisation, in the face of dwindling water supplies due to resource depletion and pollution. The situation is particularly acute in the more arid regions of the world, such as Africa and in particular northern and south-western Africa, where water scarcity and associated increases in water pollution hinder social and economic development and are closely linked to the prevalence of poverty, hunger and disease (Blignaut and De Wit, 2004).

Throughout Africa, the distribution of water resources is spatially and temporally unequal, resulting in seasonal variability and unpredictable supply; furthermore, though as yet unverified, evidence suggests that projected trends in global climate change could worsen this situation and exacerbate local and regional water shortages. Recent estimates suggest that almost half of the countries in Africa (24 out of 53) will exceed the limits of their economically usable, land-based water resources before the year 2025. These disturbing statistics emphasise the urgent to find sustainable solutions to the problem of securing adequate access to water supplies in Africa, highlighting the fact that the manner in which water resources are used and managed is an increasingly controversial and urgent reality (Blignaut and De Wit, 2004).

Groundwater sources are being tapped to the extent that some of the world's largest aquifers are being depleted much faster than their recharge rate. This has severe consequences for the economic and social sectors dependent on the water from these sources. The ecosystems of natural lakes are also becoming severely degraded due to overuse and pollution and this, in turn, results in economic and social decline in the human communities relying on these water sources (DWAF, 2005a).

The majority of the 10 million South Africans that have been provided with water since 1994 have been supplied from groundwater resources. The Reconstruction and Development Programme (RDP) instituted a programme of drilling, testing and equipping boreholes. Because groundwater is generally found near the point of need, boreholes drilled close to villages and rural settlements could be used to establish basic water supplies. There are indications that 14 000 rural villages could be served from groundwater. In the Eastern Cape alone, the water supply to more than 80% of the 5 700 communities in the province could be groundwater-based (DWAF, 2005a).

The Constitution of South Africa recognises that everyone has a right to have access to sufficient food and water, and the state must take reasonable legislative and other measures within its available resources to achieve the progressive realisation of these rights. A basic supply of water is one of only two rights to water enshrined in the National Water Act. Groundwater is now recognised as a strategic resource that can play a major role in the fight against poverty and in easing the burden of women in rural areas. The sustainable use of groundwater is paramount in attaining the goal of each South African having access to at least 25 ℓ/cap·d of water (DWAF, 2005a).

3.6 Protection zoning and sustainable development

There is long recognised relationship between development practises (i.e. land use planning in particular) and pollution of groundwater, although this may take decades to be noticed. Once pollution of an aquifer has occurred, it is extremely difficult to clean up and it is rarely possible to return an aquifer to a pristine condition. For this reason, the best practise is prevention trough the regulation of land use in areas that overlie groundwater flow systems. Regional and national development strategies should therefore ensure that development in a given area is compatible with the long-term use of groundwater for public water supply and ecological sustainability, especially in areas where groundwater serves as a direct and/or only source of supply. Controls on land zoning and subdivision imposed by local governments can be very effective tools for protecting groundwater. Zoning can be used, therefore, to direct future development towards defined objectives (WHO, 2006).

In 1987, the United Nations World Commission on Environment and Development released its landmark report, *Our Common Future*, often referred to as the Brundtland Report, after the Chairperson of the commission. This report warned the world of the urgency of making progress toward economic development that could be sustained without depleting natural resources or harming the environment. The commission outlined a direction for sustainable development based on the acknowledgement of the inseparable connections between economic growth, human development and environmental protection: Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their needs. The concept of sustainable development does imply limits – not absolute limits but limitations imposed by the present state of technology and social organisation on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organisation can be managed and improved to make way for a new era of economic growth (Brundtland, 1987).

Seven years later, the World Summit for Social Development (in their *Declaration and Programme of Action* report) stated that they were deeply convinced that economic development, social development, and environmental protection are interdependent and mutually reinforcing components of sustainable development, which is the framework for achieving a higher quality of life for all people. Equitable social development recognises that empowering the poor to utilise water resources sustainably is a necessary foundation for sustainable development. Also important to highlight is the recognition that broad-based and sustained economic growth in the context of sustainable development is necessary to sustain social development and social justice. Protecting groundwater resources is therefore not an end in itself. This important source of water supply can be viewed as a life support system.

Viewed from this perspective, groundwater is as essential to sustainable development as it is to life. Groundwater has social, economic and environmental values that are interconnected and mutually supportive. The aim is not merely to conserve or protect it, but rather to look for better lives for the poor and a country that is sustainable for future generations (Brundtland, 1987).

It should be clear by now that sustainable development or sustainability involves three broad interdependent spheres: the natural environment, social well-being, and economic stability. These three draw on the concept of the triple bottom line (TBL), an accounting term coined in the late 1980s by John Elkington to describe a way of measuring and reporting corporate performance against economic, environmental and social parameters. This shift in corporate thinking recognised that the long-term health of ecosystems is critical to human society and provides practical benefits not only for companies but also for their stakeholders, society and the environment – aptly summed up by the catchphrase "People, Profit (or Prosperity) and Planet". These three aspects are indivisible and require us to develop economic and social systems that are built on the environmental stewardship of resources for the future. Degradation of any one aspect worsens the condition of all three (Brundtland, 1987).

3.7 Groundwater-dependent ecosystems

In addition to recognising the right to a basic water supply, the NWA recognises the need to set aside water for aquatic ecosystems. Groundwater is generally interpreted as falling outside the definition of aquatic ecosystems, except where groundwater discharges and sustains surface water bodies. However, groundwater provides an important linkage between terrestrial ecosystems and aquatic ecosystems (Parsons, 2003). For example, springs are an expression of subsurface water discharging at surface. In addition to providing the groundwater contribution to river flow, they play a critical role in providing fauna and flora with a source of water. Unique ecosystems develop around springs in response to the permanency of available water (DWAF, 2005a).

Similarly, the hyporheic zone is contained within the land–water ecotone and is functionally a composite between surface and groundwater ecosystems. It provides a number of ecologically important services, including thermal, temporal and chemical buffering, habitat, flow augmentation and refugia. The zone may be significantly different from the overlying surface water body and the underlying aquifer system. Brown *et al* (2003) noted that upwelling (or discharge) of groundwater creates patches of high productivity in the hyporheic zone and aquatic ecosystems, supporting greater animal densities and diversities when compared to non-upwelling situations.

Riparian zones – especially in arid and semi-arid areas – are important for maintaining biodiversity, offering refugia and habitat to a variety of organisms not able to survive in adjacent terrestrial and aquatic ecosystems (Brown *et al*, 2003). They create a buffer between terrestrial and aquatic ecosystems, protect rivers from the effects of activities in adjacent terrestrial environments, and stabilise river banks. These zones are typically sustained by a combination of surface and subsurface water, with the contribution of groundwater being critical during dry periods. Salt marshes in estuarine environments provide a further example of the important role of surface – groundwater interaction.

While the marshes are regularly inundated by saline water, the continual discharge of fresh groundwater (often in small quantities) provides refugia for freshwater organisms by maintaining relatively low salinities (DWAF, 2005a). The Australians first developed a system to classify groundwater-dependent ecosystems (Hatton & Evans, 1998 and Merz, 2001). This was linked to a classification where groundwater-dependent ecosystems are ranked in terms of their conservation value, vulnerability to potential threats and the likelihood of these threats being realised. Colvin *et al* (2003) and Colvin (2004) are currently researching this issue from a South African perspective. The groundwater classification approach by Colvin *et al* (2003) recognises the following groundwater-dependent ecosystems:

- In-aquifer systems;
- Springs and seeps;
- Riverine systems;
- Riparian systems;
- Wetlands;
- Terrestrial systems; and
- Estuarine and coastal systems.

While it is important to recognise the dependence of ecosystems on groundwater, it is equally important to recognise that not all aquatic or terrestrial ecosystems are groundwater dependent. Furthermore, demonstration of groundwater use does not necessarily equate to groundwater dependence while groundwater abstraction will not necessarily affect the supply of groundwater to groundwater-dependent ecosystems. In this context, it is also important to distinguish between facultative and obligate systems, since the former should readily adopt if groundwater is not readily available Colvin *et al*, 2003).

It is also important to recognise the degree and significance of the dependency. A fundamental tenet of ecology is that ecosystems generally use a resource in proportion to the availability of the resource (whether it be water, light, nitrogen or some other resource), and the availability of the resource will be a significant determinant of the structure, composition and dynamics of an ecosystem (Tilman, 1998). Where groundwater is accessible, ecosystems will develop some degree of dependence on it, and the degree of dependence is likely to increase with increasing aridity.

The current challenge facing geohydrologists is how to identify groundwater-dependent ecosystems and to distinguish between facultative and obligate systems. Few documented case studies exist in South Africa where groundwater abstraction has measurably impacted groundwater-dependent ecosystems. Some anecdotal accounts exist, few of which have been properly investigated. The only known study where it has been investigated in detail was the Sandveld catchment situated in the Western Cape Province of South Africa (Conrad *et al*, 2005).

4. LEGAL AND POLICY CONTEXT

4.1 Introduction

While assessing the feasibility of an overall policy that directly addresses groundwater source and aquifer protection zoning South Africa, it is important to mention that a three-year process of review was launched in 1994 to look at policy development for overall water resources management. This encompassed a thorough process of nationwide consultation, reaching those who had traditionally been excluded, notably rural communities, especially women in deep rural areas who had never enjoyed access to safe water resource and who used to spend most of their day fetching water (DWAF, 1997). The new Water Policy was adopted in 1997 and the NWA was promulgated in 1998. The process of water policy design in South Africa, as recorded by De Coning and Sherwill (2004), also shows the high political profile water had since the dawn of democracy.

4.2 Purpose and scope

This chapter deals with the legal and policy environment within which the development and implementation of a groundwater source and aquifer protection zoning (GSAPZ) policy should be considered. It contextualises the international, regional and national policy milieu in relation to groundwater protection and examines existing regulatory tools and instruments through which elements of a GSAPZ policy could be fast tracked. In this instance, current approaches, mechanisms and initiatives relating to groundwater protection are being scrutinised, followed by a critical evaluation of the current approaches that are being applied to date (Section 4.6). A stepwise flow chart for developing a GSAPZ policy is subsequently designed (Figure 4.1), followed by a thorough discussion on the anticipated cross-sector collaboration deemed necessary when developing a policy for the protection of groundwater (Section 4.8).

4.3 International policy context

The UN Convention on the Protection and use of Transboundary Watercourses and International lakes, signed in Helsinki in 1992 (UNDP, 1997) recognises the difficulties of protecting water bodies, including groundwater, which cross international borders. The Convention requires all signatory countries to:

- Prevent, control and reduce pollution of water which may have a transboundary impact;
- Ensure that these waters are used with the aim of ecologically sound and rational water management;
- Use such waters in a reasonable and equitable way; and
- Ensure that conservation of ecosystems is achieved.

The Convention requires the adoption of prevention, control and reduction programmes for water pollution and the establishment of monitoring systems. Bilateral and multilateral cooperation is essential to the successful protection of such waters. Riparian countries are also expected to enter into agreements over such issues and conduct joint programmes for the prevention, control and reduction of transboundary impacts (WHO, 2006). The concept of a 'zone of protection' for areas providing groundwater has been developed and adopted in a number of countries (Chave *et al* in WHO, 2006).

Many have developed guidelines for water resource managers who wish to delineate protection zones around drinking water abstraction points (Adams & Foster, 1992; NRA, 1992 and US EPA, 1993). Internationally a wide variety of techniques has been recognized to determine protection zones ranging from very simple non-analytical methods to complex numerical transport models (US EPA, 1993 and Chave *et al* in WHO, 2006). The implementation of these methods is based on user expertise, available resources, existing and field collected data, and the desired degree of confidence in meeting protection goals. It is clear from international experiences on groundwater protection zoning that numerous efforts were focussed on exploring methodologies, guidelines, plans, programs and modelling systems in addressing groundwater protection zoning. However, a lack of an overall policy that directly addresses groundwater protection appears evident not only in South Africa, but worldwide. However, the evolving international approach to IWRM has been influenced by the tensions between the trend to address water issues from a holistic perspective and a more pragmatic recognition that society's pressing needs in the developing countries must be addressed soon.

The four Dublin Principles (ecological, institutional, subsidiary and economic) set the base for the Global Water Partnership (GWP) definition of IWRM, namely the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. A next step was stressing the need to link water services provision to water resources management and protection. However, the GWP recognized that IWRM approaches do not necessarily require making all needed changes at once, but they can often best be initiated by focusing on specific issues. The World Bank has stated that the main management challenge is not a vision of IWRM but a pragmatic but principled approach that respects principles of efficiency, equity and sustainability, but recognizes that water resources management is intensely political, and that reform requires the articulation of prioritized, sequenced, practical and patient interventions (World Bank, 2005). These principles and definitions make a useful background for supporting the development of an overall policy that directly addresses groundwater protection zoning in South Africa, followed by anticipated and distilling lessons useful for other developing countries.

4.4 Regional policy context

There are a number of factors that impact on the availability and management of groundwater resources in the SADC region, including extreme climate variability and the impacts of climate change; population growth and migration (between and within countries); unsustainable water and land use practices and increased water demands due to economic development. Moreover, groundwater abstraction for agriculture, mining and domestic purposes is contributing to a decline of aquifers. While effective water governance is critical to managing these challenges, the region is facing a number of governance related challenges, particularly with respect to clear policy, legislation and strategy. It is therefore absolutely crucial to assess the regional policy initiatives (if any) relating to groundwater protection zoning, since more than half of South Africa's water resources are shared with neighbouring countries. Furthermore, the NWA legally obliges South Africa to meet their international obligations with respect to water resources.

The Southern African Development Community (SADC), regional grouping of 14 sovereign member states, comprises Angola, Botswana, the Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. SADC brings it member stases together with one common goal of regional integration on the basis of balance, equity and mutual benefit for all the peoples of the region. SADC was formally established through the signing of the SADC Treaty on 27 August 1992 in Windhoek, Namibia. Since the early 1990s, most (but not all) of the SADC countries have revised their water legislation, bringing them more in line with international best practice, with SADC policy, and with IWRM. However, most of the countries are currently either revising or amending their legislation, and some countries still have to promulgate their revised legislation. While most of the countries have recent policy in place which reflects the principles of IWRM, some countries still have to finalise and adopt IWRM policies. Interestingly, only Angola and Swaziland do not appear to be currently involved in a revision or amendment of the water legislation. This makes the national policy and legislative environment within SADC relatively dynamic, which is advantageous for the ongoing evolution of IWRM practice in the face of change and uncertainty that will be experienced over the next decade (SADC-EC, 2006).

At a regional level, SADC has embraced IWRM through the development of the Regional Water Policy and Strategy, has linked this with other sectors to some degree through the Regional Indicative Strategic Development Plan, and has developed the Regional Strategic Action Plans to focus on key enabling, institutional, strategy/instruments and infrastructural dimensions of water resources management at the national and transboundary levels. There has been progress with the imperative for regional integration and cooperation through the establishment of interbasin institutions as well as the formulation of transboundary basin strategies. Regional groundwater challenges are being engaged through focused attention and the establishment of a Regional Groundwater Institute, while a regional Climate Change Adaptation process is attempting to build resilience in water, food, health and energy across the region (SADC, et al., 2005). However, a key challenge remains in the sustainable management of groundwater, which have to date failed to feature prominently in the national and regional water agendas in Africa, except for countries which are virtually dependent on underground water resources. Overcoming this major (world-wide) hurdle to the sustainable utilisation of a crucial part of water resources is seen as a global challenge. In Africa, the African Ministers Council on Water (AMCOW) has responded with a Roadmap and the establishment of the Africa Groundwater Commission (AMCOW, 2008). In 2007, it was also resolved that AMCOW would become the custodian of a continent-wide strategic groundwater initiative towards a vision of 'An Africa where groundwater resources are valued and utilised sustainably by empowered stakeholders'.

4.5 National policy context

Early water policy, implemented by the previous Water Act, Act 54 of 1956, was not equitable and did not recognise and respond appropriately to the country's limited water resources. It was supply driven, developing structures and systems to store and transport water, such as dams, tunnels, pipelines, weirs and pump stations. Water was also managed for the benefit of small sections of the population, such as industry and irrigation farmers. This meant that many people, particularly rural communities and subsistence farmers, had access neither to a basic water supply nor to water for development.

In 1994, the South African government began to consider social, environmental and economic approaches in the development of water policy and legislation (mainly through its Constitution) to deal with the limitations of the previous water legislation, i.e. the Water Act, Act 54 of 1956. Table 4.1 below is a summary of important chapters of the Constitution of South Africa, Act 108 of 1996, which guided the development of country's water legislation, notably the National Water Act, Act 36 of 1998 (NWA) and the Water Services Act, Act 108 of 1997 (WSA). The NWA places strong emphasis on IWRM, particularly the protection of water resources and the relationships between different spheres of government to execute this important mandate. Furthermore, the commitment from local government to serve local communities are also emphasised within this context. The NWA and the WSA together provide an integrated enabling regulatory framework within which South Africa's water resources can be managed and water services can be provided. This enabling framework has required a paradigm shift from water experts, as it place people and ecosystems firmly in the centre of water policy and has shaped a multidisciplinary and cross-sectoral approach that has moved from engineering towards social, environmental and technological solutions.

Table 4.1 Sections of the Constitution relevant to IWRM (Source: After RSA, 1996)

CHAPTER 2: BILL OF RIGHTS

Section 24 Environment

Everyone has the right -
(a) to an *environment that is not harmful to their health* or wellbeing; and
(b) to have the *environment protected, for the benefit of present and future generations*, through reasonable legislative and other measures that -
(i) *prevent pollution and ecological degradation*;
(ii) *promote conservation*; and
(iii) *secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development*.

CHAPTER 3: COOPERATIVE GOVERNMENT

Section 41 Principles of cooperative government and intergovernmental relations

(1) All spheres of government and all organs of state within each sphere must -
(h) cooperate with one another in mutual trust and good faith by -
(i) fostering friendly relationships;
(ii) assisting and supporting one another;
(iii) informing one another of, and consulting one another on, matters of common interest;
(iv) coordinating their actions and legislation with none another
(v) adhering to agreed procedures; and
(vi) avoiding legal proceedings against one another

CHAPTER 7: LOCAL GOVERNMENT

Section 152 Objects of local government

(1) The object of local government are -
(b) to ensure the *provision of services* to communities in a sustainable manner

4.6 Existing regulatory tools and initiatives

The National Water Policy for South Africa (i.e. the White Paper of April 1997) is a national constitutional and legislative requirement which implied that DWAF had to develop water and forestry policies for implementing a sustainable approach to integrated IWRM. In consequence, water resource management shifted from the supply-based approach of building major structures towards a more balanced approach of equitable access to water, water conservation and demand management. During that stage of the policy development process, it became evident that if water and the services provided by water resources were to be available to people on an equitable basis in the long term, then DWAF would have to put structures in place to protect the water resources as well (DWAF, 1997).

In response, the National Water Policy for South Africa was revised completely in the context of three main issues (DWAF, 1997):

- There should be a sustainable balance between the use and the protection of water;
- Water, land use, the environment and human activities are inextricably interwoven; and
- Partnerships must be developed between stakeholders, communities and government bodies.

During 1998, the DWAF set in place the following three new policies and four new laws that reflected these fundamental changes in managing the water and forest resources of South Africa:

- Water Supply and Sanitation Policy, White Paper, November 1994;
- Policy on Sustainable Forest Development in South Africa, White Paper, March 1996;
- National Water Policy for South Africa, White Paper, April 1997;
- Water Services Act, Act 108 of 1997 (WSA);
- National Water Act, Act 36 of 1998 (NWA);
- National Forests Act, Act 84 of 1998 (NFA); and
- National Veld and Forest Fire Protection Act, Act 101 of 1998 (NVFFPA).

In Table 4.2 below, a brief overview of the current regulatory approaches, mechanisms and initiatives (within the DWAF) related to groundwater protection are outlined. A comparison of the regulatory criteria set by different methodologies is illustrated; this highlights the need to develop consistent risk-based regulatory criteria, assessments and decision-making methodologies that share a common rational departure point. These approaches therefore need to be critically and holistically evaluated if one embarks on the development of an overall policy that directly addresses groundwater protection zoning. The decisions on risks of the source contaminant and views of sensitivity of a particular receptor should be common to the level of water resource protection, resource quality objectives, waste disposal, effluent discharge or remediation of historic contamination, or any other issue.

Table 4.2 Current approaches, mechanisms and initiatives (Source: After DWAF, 2005c)

Name of approach	**Methodology**	**Application**
Domestic Water Supplies: Assessment Guide	Shows the nature of the effects of water quality on the domestic user for a range of concentration values for those substances commonly encountered in water using a simple colour and number code ranging from ideal to totally unacceptable water quality. The effects of water quality on the domestic user are divided into acute and chronic effects. The effects themselves could be serious and long lasting, or they may be insignificant and only temporary. The classification of water quality to determine its suitability for domestic use.	Assessment of water for domestic use by using a simple classification system.
SABS Drinking Water Standards	List of standards based on international standards.	Compare to determine if water is suitable for drinking purposes.
Development of Pilot Guidelines for Selected Organic Toxicants/ toxicity Effects for Domestic Use.	Determination of Guidelines based on human health risk (both cancer slopes and toxicity) for selected organic toxicants.	Decision-making guidelines.
South African Water Quality Guidelines (SAWQG)	Specification of quantitative and qualitative criteria for chronic and acute toxic effects for toxic, non-toxic constituents and system variables based on international and local sources of information and expertise to develop guidelines for each constituent selected.	Primary source of information and decision support to judge the fitness for use of receiving water and other water quality management purposes
South African Water Quality Guidelines for the Protection of the Aquatic Environment (SAWQG-AE)	Developed using a 1985 USEPA method. This approach uses laboratory derived toxicity data to generate two clear benchmarks – one representing sub-lethal effects (rèsulting in the chronic effect value or CEV) and the other representing lethal effects (resulting in the acute effect value or AEV). There is an increasing likelihood of observing adverse effects in an assemblage of organisms moving from the TWQR through the CEV to the AEV. The TWQR has arbitrarily been assigned as ½ the CEV.	Used extensively for establishing instream water quality objectives for protection of aquatic ecosystems. The method used for the water quality reserve for the aquatic ecosystem is very similar in principle to this method although the technical details are somewhat different.
Resource Directed Measures (RDM)	The resource quality objectives (RQOs) are based on a classification system that aims to provide a set of nationally consistent rules to guide decision-making about water resources. RQOs for a water resource are set on the basis of acceptable risk, i.e. the less risk we are prepared to accept of damaging the Resource and possibly losing the services provided by the water resource, the more stringent would be the objectives. A higher risk to the resource base might be accepted, in return for a short term utilisation, and then the RQOs would be set at less stringent levels.	The NWA states that no water use license may be issued without at least a preliminary determination of the Reserve having been undertaken. The Resource Quality Objectives for a water resource are a numerical or descriptive statement of the conditions which should be met in the receiving water resource, in terms of resource quality, in order to ensure that the resource is protected.

Name of approach	Methodology	Application
	The extent, availability and condition of instream and riparian habitat was identified as the endpoint for water quantity Reserve Determinations, since the relationship between biota and changes in flow rate or flow volume is not yet sufficiently quantifiable with available tools. For water quality Reserve Determinations, the endpoint is the ecosystem 'no observed effects level' (NOEL) as described in the SAWQG-AE.	
Minimum Requirements for Classification of Hazardous Waste	The Minimum Requirements define an aquatic toxicity measurement, termed Acceptable Risk Levels (ARL's) for hazardous substances. An ARL is represented by 10% of the concentration at which a substance would kill 50% of aquatic organisms, if the substance were disposed of directly into a water body. This is compared to an Estimated environmental concentration, calculated as a dose in a assumed body of water directly below the area on which the waste is disposed, as grams per hectare per month that can be disposed. Comparison of the ARL's from the 'Minimum Requirements' with the Acute Effect Value (AEV) and Chronic Effect Value (CEV) values used in the SAWQG-AE is an impossible task as these values have no apparent mathematical relationship with one another, and ARL's are based on a non-referenced toxicological database. In general, ARL's for metals are too low and represent an extreme view of aquatic ecosystem exposure, with layers of spurious safety factors added, and the ARL's for carcinogenic organics are too high to be fully protective of human health (this pathway is not part of the assumptions on which the calculations are based).	The documents contain a waste classification system, which is aimed at determining the harmfulness of waste streams, with regard to both the safety and health of humans and the potential hazard it poses to the environment when such waste is disposed on land. This classification procedure contains a mechanism for determining potential risk to the environment when the waste is disposed of, and the potential risk it poses to the environment, particularly the ground water resource, may be sufficient reason for it to be classified as hazardous.
1984 General Effluent Standards	Criteria established by determining what is achievable by available technology – referenced in many ELU's for discharge of wastewater.	General effluent standards and individual discharge permits after calculation of the Reserve and comparing RQOs with these standards, as well as the application of water quality guidelines.
Waste Discharge Standards	Values for variables were based on the development of 'National' quality objectives that were derived from the South African Water Quality Guidelines documents, specifically the Aquatic and the Domestic guidelines. The limitations of treatment technology and achievability of the standards was also considered.	Uncertain, in relation to RQOs and water quality guidelines.
Complex Waste Discharges through Direct Estimation of Ecological Effect Potential (DEEEP)	This tool for the assessment complex waste discharges uses biotic resonances directly to assess the effect of complex mixtures on ecosystems.	No South African assessment criteria have as yet been developed and neither has it been formally adapted for local use.

Name of approach	Methodology	Application
	DEEEP consists of a suite of biotic and abiotic tests Its development was stimulated by the difficulty (and often impossibility) of estimating the hazard of complex mixtures, either because of analytical or toxicological complexity, sometimes both. Conceptually, this tool is on par with chemical analysis as a tool and should be used in conjunction with it.	
Groundwater Decision Tool	The Groundwater Decision Tool aims to aid groundwater resource managers in the task of optimizing the utilization of groundwater. The decision tool includes a framework for risk assessments based on fuzzy logic to assist in decision-making by systematically considering all possibilities. The tool takes into account the sustainability of a groundwater resource, the potential contamination of groundwater, human health risks and the impacts of changes in groundwater (quantity and quality) on aquatic ecosystems.	Uncertain.
Sludge Guidelines	Make provision for a full element analysis to determine which elements could be of concern to the environment. Benchmark metal values are set for all elements although only 8 metal limits are set for South African wastewater sludges.	In formulating recommendations for ar total investigation levels above which sludge application to the soil is permitted with monitoring. The 1991 Sludge Guidelines had no scientific validation for any limits or restrictions except for the calculation of the limit values from DWAF.
Geohydrological assessment, planning & management for Dolomitic areas	Uncertain	Set water quality guidelines for disposal of tailings on dolomitic areas.
Best Practise Guidelines (BPG) for Mining – Pollution Prediction	Unsure – modeling as input.	Mining discharges.
General Authorisations	Compare lists of values contained in the General Authorizations against values of effluent and water quality.	Determine if General Authorizations apply, or if person needs to apply for a license.
Resource Directed Water Quality Management (RDWQM) Policy and Management Tools.	The objective of the policy is to provide effective guidance for decision-makers to achieve a water quality meeting quality of life and concurrently aquatic ecosystem health requirements on an ongoing basis by suitable protection of the country's water resources.	Uncertain.
Compulsory Licensing Risk Assessment & Decision Support Tool	The methodology used in the Compulsory Licensing and Decision Tool is based on a matrix analysis of impact on the water resource in relation to socio-economic development. The decision-making matrix is based on the benefit of a water use to society in relation to the impact on the environment.	Uncertain.
Water Resources Systems Simulation	• Specifications for assessment studies • Modeling framework concepts Assessment of way forward with Water Quality Models	Water resource planning.

Table 4.3 below illustrates the regulatory values pertinent to water resources. From these comparisons, it is evident that there is no clear cut-off point between sustainable use and pollution. For example, the target water quality group (TWQG) for domestic use for zinc is 3mg/l, and substances containing this amount of zinc can be discharged into a water resource. The Minimum Requirements for Hazardous Waste Classification specify that a substance containing zinc at a concentration of more than 0.7 mg/l must be disposed of in a hazardous waste disposal site equipped with a two-metre thick protective lining system. Another example is aluminium, where the acceptable water quality group (AWQG) for aquatic ecosystems is set at 0.15 mg/l, although the element is found naturally at concentrations of up to about 0.5 mg/l owing to its incidence in geological formations characteristic of many parts of the country (DWAF, 2005c). There are many similar examples, including those specified at levels lower than the detection limits of most laboratories.

Table 4.3 Regulatory values pertinent to water resources (Source: After DWAF, 2005c).

Constituent	**Arsenic**	**Cadmium**	**Manganese**	**Mercury**	**Lead**	**Selenium**
Unit	**ug/l**	**ug/l**	**ug/l**	**ug/l**	**ug/l**	**ug/l**
Target WQG: Aquatic Ecosystems	10	0.07	180	0.04	0.2	2
Acceptable WQG: Aquatic Ecosystems	130	1.8	370	1.7	16	30
Target WQG: Domestic Use	10	5	50	1	10	20
Acceptable WQG: Domestic Use	200	10	150	5	50	50
General Effluent Standard	500	50	400	20	100	50
Special Effluent Standard	100	50	100	20	100	50
SABS Drinking Water Standard	100	10	50	5	50	20
Minimum Requirements ARL	430	31	300	22	100	260
Minimum Requirements Hazard Rating	2	1	2	1	2	2
Constituent	**Aluminium**	**Ammonia**	**Chromium (VI)**	**Copper**	**Phenols**	**Zinc**
Unit	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
Target WQG: Aquatic Ecosystems	0.01	0.007	0.007	0.0003	0.03	0.002
Acceptable WQG: Aquatic Ecosystems	0.15	0.1	0.2	0.012	0.5	0.036
Target WQG: Domestic Use	0.15	1	0.05	1	0.001	3
Acceptable WQG: Domestic Use	0.5	2	1	3	0.01	5
General Effluent Standard	-	10	0.05	1	0.1	5
Special Effluent Standard	-	1	0.05	0.02	0.01	0.3
SABS Drinking Water Standard	-	-	-	0.5	0.005	1
Minimum Requirements ARL	10	2.4	0.02	0.1	2.3	0.7
Minimum Requirements Hazard Rating	3	1	1	2	3	2

Ragas and Leuven (1999) state that such different emission limits specified under comparable conditions may be regarded as unequal treatment of waste generators (unjust administrative action). The point is, however, that these discrepancies are the result of the lack of a harmonised philosophical basis for a policy on what is acceptable, from which optimum use and threshold levels can be deduced. As indicated earlier, the fragmentation of regulatory responses and different regulatory criteria, the proliferation of medium- and issue specific legislation and inconsistencies in procedural approaches is a phenomenon that is not limited to South Africa. In South Africa, however, there has traditionally been a differentiation between the disposal of waste on land in a waste disposal site (known as 'waste disposal'), and the disposal of industrial effluent or water containing waste (known as 'effluent discharge'), usually into a water body.

In has been shown (Bosman, 1999 and Ragas *et al,* 1999), that having different approaches aimed at protecting an indivisible resource can lead to ineffective decision-making, and that the outcome of such fragmented assessments can lead to decisions that can be regarded as unreasonable. The current measures aimed at determining the lawfulness of the disposal or discharge of a waste into the environment, were not always developed after the Constitutional changes that occurred in the country, or did not take cognisance of the policy implications of these changes, as well as the principles underpinning new legislation, and their effectiveness in distinguishing between sustainable use and pollution of the water resources in a developing country context is open to much discussion.

4.7 Harmonization of fragmented approaches

Internationally, as governments started to become aware of the impact of industrialisation and other human activities on the environment, their various sectors and agencies responded with concern, but in an uncoordinated manner, in establishing mechanisms for the assessment of impacts to facilitate decision-making regarding the acceptability there-of, as well as the level of control required. This is also the case in South Africa, where various assessment- and decision-support mechanisms have been, and are being, developed to assist with the determination of the acceptability of impacts of waste disposal or discharge activities on water resources. These mechanisms are however not co-ordinated, often contradict one another, contain different regulatory criteria which can be made applicable to the same or similar scenario's, and their use under different circumstances leads to inconsistency in decision-making (Kamrin, 1997).

The reason for the proliferation of mechanisms and their uncoordinated nature lies in the fact that different philosophies and principles are used when translating policy into science, and when attempting to align science with policy. It is therefore imperative to review the current policy and legislative frameworks if it exist, otherwise a The establishment of harmonised national regulatory criteria is a major step in developing effective resource protection policies and strategies as well as management programmes for waste discharge or disposal and the remediation of contaminated sites (Asante-Duah, 1997). The approach for water resource management as contained in the NWA entails a water use licensing system for various water uses, as defined in section 21 of the Act. Most of these water uses, to some extent, has an impact on the water quality of the resource. The NWA requires that both source and resource directed measures must be taken into consideration during the issuing of a water use licence. Before a licence may be issued under the procedures outlined in Chapter 4 of the NWA, resource directed measures (the resource management class, the Reserve, and relevant resource quality objectives) must be determined for the resource in question, as set out in Chapter 3 of the NWA. Also, in accordance with Chapter 4 of the NWA, source directed measures implemented by the applicant must be taken into consideration when evaluating licence applications (DWAF, 2006a).

Implementation of these provisions during the past eight years was often done in an isolated manner, resulting in the development of various assessments and decision-making mechanisms, and the establishment of resource-directed regulatory criteria and source directed regulatory criteria that often are not based on the same philosophies and principles.

Recently, with the restructuring of the Department, it has become more and more evident that aspects such as resource protection and resource quality management cannot be appropriately addressed, unless it is done in a harmonised manner at the interface of source- and resource directed measures (DWAF, 2005b). It has been recognised, for example, that giving effect to the Reserve and RQOs goes way beyond RDM functions, and that implementation of the various strategies (i.e. source directed controls, resource directed measures and remediation must be integrated to achieve the overall objective of sustainable groundwater utilization (Xu *et al,* 2003). The problem is that the philosophy and policy, on which the establishment of regulatory criteria is based, are not aligned and approaches to resolve problems are often too fragmented. There is therefore a proliferation of regulatory criteria, which are not applied and implemented in a consistent manner. This will lead to further complications once the institutional reform (i.e. through the CMA establishment process) is nearing completion.

4.8 Anticipated cross-sector policy collaboration

The development of a GSAPZ policy will result in many water users across different sectors to be effected, and attention to policy coherence would be a critical success factor to consider when implementing such a policy. The overall process of developing and implementing policies and strategic management for groundwater protection may follow the stepwise route shown in Figure 4.1 (WHO, 2006).

Policy coherence has two dimensions, namely vertical coherence and horizontal coherence. Vertical policy coherence entails ensuring that local authorities pursue policies that support, and do not undermine, national policies; and that nations pursue policies that support regional and/ or international policies and treaties. Horizontal policy coherence entails achieving a complementary consistency of policies across related sectors at any particular level. As an example, the cross-sector policy approach for groundwater protection zoning (suggested through this thesis), would require coherence in the expression of objectives regarding land use and ecosystem protection from across, water, biodiversity, environmental management and agricultural sectors (Turton, 2004).

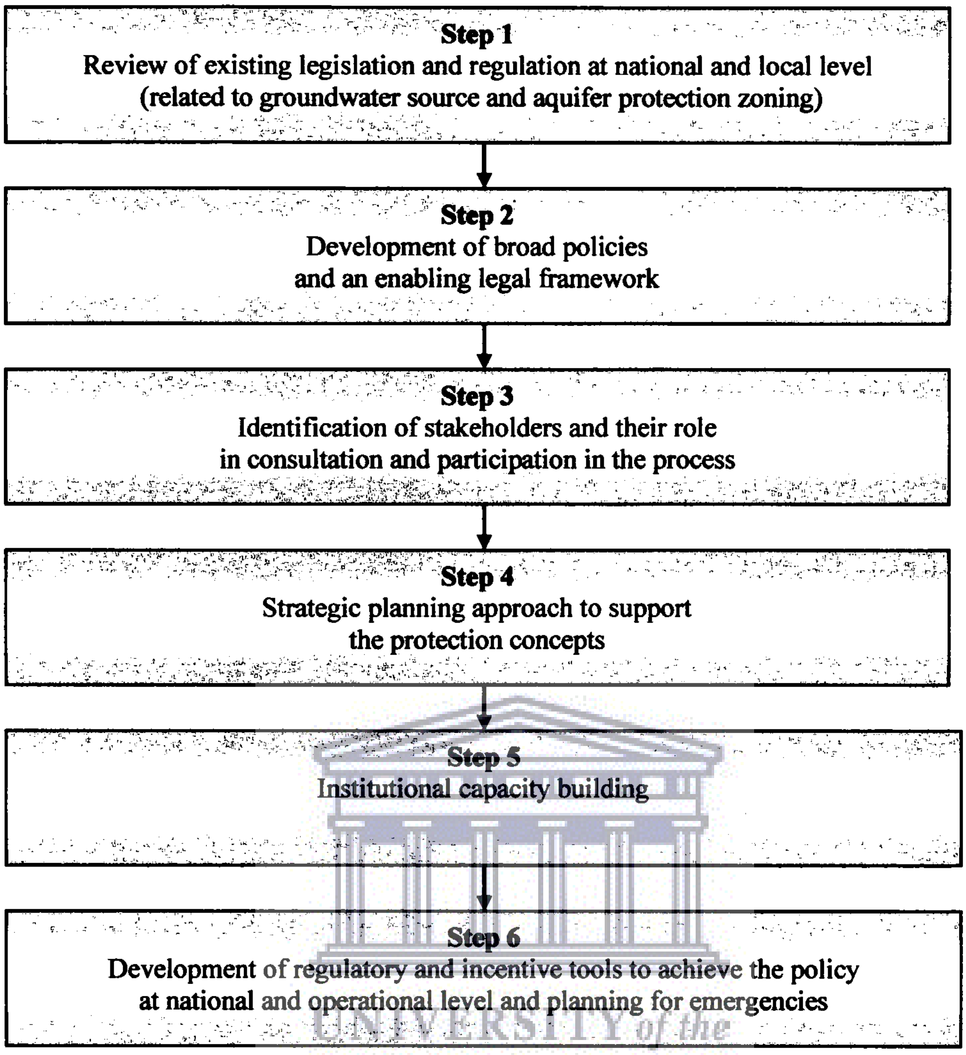

Figure 4.1 Flow chart for developing groundwater protection policy (After: WHO, 2006)

It is expected from the DWAF as sector leader in the water sector to develop polices that be applied at a cross-sectoral level. This leading role of the DWAF certainly calls for sector-wide approach in developing a policy that directly addresses groundwater protection zoning in South Africa. Figure 4.2 below illustrates the high-level requirements for effective policy implementation with a more in-depth discussion in chapter seven, dealing with the policy process and its operational preparedness. A number of obstacles in corporate governance are experienced mainly due to the fact that managers (water resource managers in this case) are not necessarily natural decision-makers and that several factors may hinder the decision-making process. Mezher *et al* (in Turton, 2004) mentioned that these factors may include the following but not limited to:

- Cognitive biases;
- Accidents;
- Cultural motivations and
- Missing knowledge.

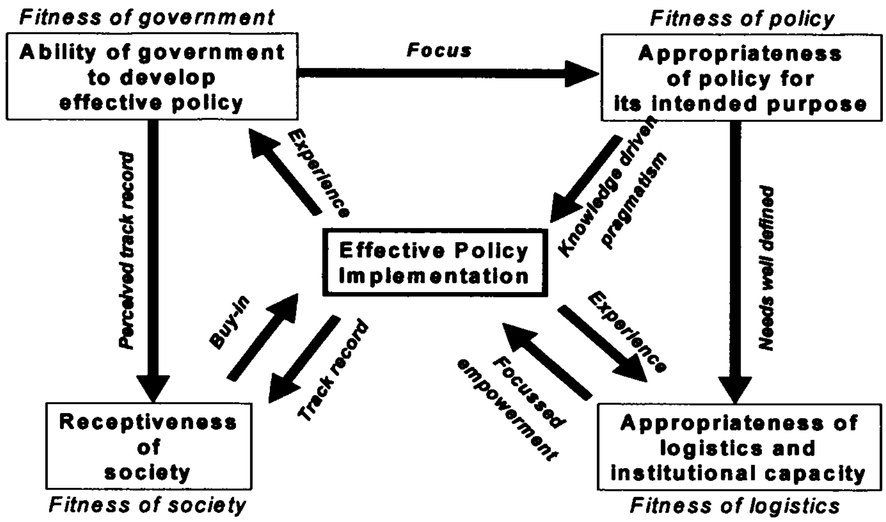

Figure 4.2 High-level drivers relating to policy implementation (After Turton, 2004)

Other obstacles were also identified in implementation of strategies within the information technology and health industries by Southon *et al* (in Turton, 2004). These factors include the following:

- Nature of organisation and its interaction with the implementation strategy;
- Organisational change;
- Politics;
- Leadership;
- Training;
- Resistance;
- Practice changes;
- Commitment; and
- Communication.

The capacity of the public service is conceptualised in general systems thinking terms as the structural, functional and cultural ability to implement the policy objectives of the government. In other words it is the ability to deliver those public services aimed at raising the quality of life of citizens, which the government has set out to deliver, effectively as planned over time in a sustainable manner, according to Cloete (in Turton, 2004). Capacity refers to the availability of and access to concrete or tangible resources (human, financial, material, technological, logistical, and so on). It includes the intangible requirements of leadership, motivation, commitment, willingness, fortitude, endurance, and other intangible attributes needed to transform rhetoric into action. The political, administrative, economic, technological, cultural and social environments within which action is taken must be sympathetic or conducive to successful implementation (Turton, 2004).

5. CONTEXTUALISING THE SOCIO-ECONOMIC ENVIRONMENT

5.1 Introduction

Sustainability and equity are recognised as central guiding principles in the protection, use, development, conservation, management and control of water resources. These guiding principles recognise the basic human needs of present and future generations: the need to protect water resources, the need to share water resources with other countries, the need to promote social and economic development through the use of water and the need to establish suitable institutions in order to achieve the purposes of the National Water Act, Act 36 of 1998 (NWA).

The transition to democracy in South Africa in 1994 has been significant in socio-economic and political terms, as the country managed to replace a system that denied basic economic and political rights to the majority of its population with a true market democracy. This transition period was equally complemented by noticeable efforts in strengthening peace, creating macroeconomic stability, trade openness and property rights. Inflation was brought down considerably (despite an increase in international price of energy and raw materials) and the country's rating in external credit markets became one of the best among emerging markets. Economic growth has accelerated well since 2004 (after a decade of decline that started in around 1980) in per capita terms while employment expanded, resulting in the unemployment rate to decline considerably despite a rapid increase in the number of South Africans searching for jobs (The National Treasury, 2007).

However, despite these impressive socio-economic achievements in the context of daunting political challenges, much of the apartheid legislation was still on the statute books. The allocation of water resources that was regulated by the previous Water Act, Act 54 of 1956, resulted in limited access to the use of the country's water resources by assigning so called 'riparian water use rights' – in other words, priority was given to land owners whose properties were alongside rivers or streams. Since land ownership was regulated by the Native Land Act, Act 27 of 1913 (also known as the 'Black Land Act') which restricted the rights of non-white South Africans to own land in certain areas, only a select group of (mostly white) South Africans enjoyed significant access to water resources.

Further, as the 1956 Water Act was concerned mainly with water supply (i.e. the water resource development mode) it made no provision for intergenerational equity, nor did it provide for a decision-making system (let alone a lack of a transparent decision-making process) to manage water resources with the goal of reducing poverty or of achieving ecological sustainability. This situation was clearly untenable in a democracy, and a water sector reform process was initiated in 1995 (DWAF, 1997) by Professor Kader Asmal, the then Minister of Water Affairs and Forestry. The timing for this was good: the transition to democracy had created a near-euphoric optimism about major changes, and this provided a golden opportunity to address all aspects of the water cycle within the socio-economic context of the South African landscape. Cognisant of the fact that growth was uninspiring and inequality still evident, the national government introduced the Accelerated Shared Growth Initiative for South Africa (ASGI-SA) in 2005. Consequently, the Department of Water Affairs and Forestry (DWAF, 2006) identified and consolidated a number of key projects and programmes in support of ASGI-SA (DWAF, 2006b).

5.2 Purpose and scope

The development and implementation of a policy on groundwater source and aquifer protection zoning must equally be well understood within its socio-economic context. This Chapter depicts various economic measures that could be applied to ascertain whether it has sufficient impact to constitute an effective incentive to use groundwater rationally or be a disincentive to polluting aquifers. The abstraction of groundwater could be subjected to differentiated fees in proportion to the volume abstracted, in relation to the available resource or according to the anticipated use of the abstracted groundwater, while complying with legal provisions and regulations (Chapter 4) governing the applied permit system. Certain economic measures could also be applied to determine the costs attributable to pollution that should be borne by the polluter whenever the latter can be identified. This Chapter therefore seriously considers a number of possible economic instruments which could have an influence on preventing, mitigating and counteracting damage as well as those bearing on remedying critical situations caused by pollution or over-exploitation.

5.3 Socio-economic perspective on water allocations in South Africa

Water allocations in South Africa are governed by national policy and legislation which are set out in the White Paper on National Water Policy of 1997 and the NWA. The institutions which allocate water in terms of these policies and legislation are the Department of Water Affairs and Forestry (DWAF), in the first instance, either at the national or regional offices. Where Catchment Management Agencies (CMAs) are established, and where the right to make water allocations has been delegated, then CMAs will also be involved in the water allocation process (DWAF, 2006a).

There are some specific policies that affect or delimit the role of economics in water allocation in South Africa. These include (DWAF, 2006a):

- **Recognition of use** - all other water uses will be recognised only if they are beneficial in the public interest. Water use may be recognised in the following ways:
  - Through general authorisations;
  - Through special time limited authorisations (licenses); and
  - Existing use until such time as it is recognized (or not) in terms of the above two mechanisms.
- **Pricing** - the allocation and use of this water for other uses will be subject to pricing and other economic tools and mechanisms (see pricing below).
- **End-user costs** - water allocations will recognise private investments in infrastructure and hence, by implication, the costs borne by the end user for water use.
- **Phasing** - the new system of allocation will be implemented in a phased manner, beginning in water management areas which are already under stress. This system of allocation will use water pricing, limited term allocations and other administrative mechanisms to bring supply and demand into balance in a manner which is beneficial in the public interest.
- **Transitional arrangements** - these will, over time, ensure an orderly, efficient and gradual shift in water use allocations as and when necessary.
- **Trade** - there is scope for the Minister to enable the transfer or trade of these water use authorisations between the various water users.

Water Allocation Reform (WAR) therefore refers to a range of processes, not only addressing the allocation of water, but also to the creation of an enabling environment to promote the productive and most beneficial use of water and to promote applications that address race and gender reform, as well as those that support the establishment of viable water using enterprises. On the other hand, allocating water without ensuring that all users have the capacity to use this water productively would limit these benefits. Consequently, water allocation should not only aim at realizing the above goals, but must work closely with all spheres of government to promote the productive and responsible use of water. Likewise, water allocations should try to minimize the impacts on existing lawful users of water who are already contributing to our development. As such, water allocations should promote shifts in water use patterns that are equitable but also gradual and carefully considered (DWAF, 2006a).

In order to address these challenges the DWAF have commenced on a project, with financial assistance from the United Kingdom's Department for International Development (DfID) to review existing and develop alternative approaches to water allocation in South Africa. One of the outcomes of this project is the development of a comprehensive Toolkit (DWAF, 2006a) with detailed processes and information on related initiatives, aimed at supporting the technically demanding and contentious process, particularly where water has to be re-allocated between users to realize equity. The DWAF's WAR programme is equally aimed at supporting Government's poverty eradication and economic development strategic objectives. Within this context, the DWAF's role is to:

- Indicate where water is available to support growth;
- Influence and be part of the planning processes in water stressed areas to promote and support growth and development initiatives; and
- Where appropriate it should encourage the establishment of enterprises that are less water intensive.

The WAR programme must also promote the beneficial use of water in the public interest. This does not mean that the water allocation process will focus solely on issues of equity; it will also support water uses that generate employment and growth. Similarly, where water must be re-allocated between users, the impacts of curtailing existing beneficial uses of water will be carefully considered and, where appropriate, re-allocations could follow a phased approach. Beneficial use also means promoting a broad range of uses of water across variety of sectors to support a diverse, robust and stable economy. The WAR programme is one of the best balanced and realistically phased proposals for addressing water allocation reform in the developing world. However, the following anticipated implementation challenges should be taken into account:

- Making stakeholder participation meaningful and sustainable;
- Ensuring a balanced approach;
- Streamlining the water use licensing and authorisation process;
- Dealing with unlawful use;
- Improving the legal competence to deal with licensing and appeals;
- Improving the performance of the Water Tribunal; and
- Ensuring cooperative government.

5.4 Water pricing

The NWA, gives power to the Minister of Water Affairs and Forestry with the concurrency of the Ministry of Finance (from time to time by notice in the Gazette) to establish a pricing strategy for charges for any water use within the framework of existing relevant government policy (DWAF, 2004b). The DWAF's first pricing strategy was published in November 1999 and has since been revised due to various developments that necessitated such a review process. These developments include the following (DWAF, 2004a):

- The implementation of the Municipal Finance Management Act, Act 56 of 2003 (MFMA);
- Further developments to the Departmental computer system for charge administration;
- The incorporation of the Waste Discharge Charging System (WDCS);
- Requests from stakeholders for a review of the pricing strategy; and
- Capital projects funded by private sector funding

The now revised pricing strategy in addition to the above must also takes into consideration the development of catchment management agencies (CMAs) which will have a significant bearing on the way water resources are managed and protected.

The DWAF's revised pricing also serves as a strategy for implementing water management practices according to the user pays and polluter pays principles and is the result of a process of consultation as required by the NWA. Stakeholders have consulted on the revised pricing strategy and the measures adopted have resulted in a strategy that takes into consideration the diverse and sometimes competing interest of various sectors while at the same time promoting efficiency and redressing the imbalance in access to water (as a result of past laws) simultaneously. The following key objectives were of principal importance to the DWAF and its stakeholders when amending its water pricing strategy:

5.4.1 Social equity

The Pricing Strategy for water use charges coupled to the granting of financial assistance will contribute to social equity and redress of the imbalances of the past, both with respect to equitable access to water supply services and direct access to raw water.

5.4.2 Ecological sustainability

In terms of chapter 3 of the NWA, the water needs for the effective functioning of aquatic ecosystems must be protected. The water required for the ecological Reserve must be safeguarded and the cost of managing the Reserve must be paid for by all registered and billable users in terms of section 56(2) (a) (iv) of the NWA. To promote the preservation of resource quality, the polluter pays principle for waste discharge will be adopted into this pricing strategy.

5.4.3 Financial sustainability

In order to ensure financial sustainability adequate revenue must be generated to fund the annual cost related to the following:

- Management of the country's water resources;
- Operations and maintenance of existing Government water schemes; and
- Development of augmentation schemes.

The revised pricing strategy also makes provision for the financial autonomy of CMAs. It further prescribes that the full financial cost of water resource management and supplying water should be recovered from water users, including the cost of capital. While is important to keep water prices as low as possible, the DWAF has to ensure that water is priced at levels consistent with efficient and effective delivery of services. This approach could be phased in by taking account of constraints by various sectors to adapt quickly to price increases.

5.4.4 Economic efficiency

In the context of water scarcity, ensuring an efficient allocation of scarce water resources requires that the price of water is set to reflect its scarcity value, to ensure firstly that water is conserved and secondly that some water used for low-value purposes is redirected to alternative high value purposes. This can be done administratively or by using market related mechanisms. It is also critical to ensure that the water resource management systems implemented are cost effective and do not become an unnecessary financial burden on the water users.

5.4.5 Water requirements not subject to pricing

The revised pricing strategy also allows for the following water requirements not to be subject to pricing:

- Permissible use in terms of Schedule 1 of the NWA, including reasonable use for domestic, small (non-commercial) gardening, stock watering where individuals have lawful access to a water resource including emergency use during fires.
- The Reserve related to basic human needs for drinking, food preparation and personal hygiene defined as 25 litres per person per day.
- The ecological Reserve to protect the aquatic ecosystems of the water resource to ensure sustainability.
- Water required to meet South Africa's commitments regarding international waters obligations.

5.4.6 Water requirements subject to pricing

In terms of Section 21 of the NWA the Minister may charge for the following abstraction and waste discharge related activities while the DWAF in the process of developing a strategy to also charge for recreational use of water:

- Taking water from a water resource;
- Storing water;

- Impeding or diverting the flow in a watercourse;
- Engaging in stream flow reduction activity;
- Engaging in a controlled activity which negatively impact on the water resources;
- Discharging waste into a water resource;
- Disposing of waste which may detrimentally impact on a water resource;
- Disposing of water which contains waste from any industrial;
- Altering the bed, banks, course or characteristics of a watercourse;
- Removing, discharging or disposing of water found underground; and
- Using water for recreational purposes.

5.5 Waste discharge charge system

The DWAF has also introduced a market-based or economic instrument, as a vital component of its pricing strategy for the use of raw water, called the waste discharge charge system (WDCS). The WDCS aims to attach a cost to the use of water for disposal or discharge of waste. The WDCS suggests a novel approach towards environmental management and governance, since traditional economic systems regarded natural resources simply as inputs for production by overlooking the fact that not all natural resources renew themselves at a rate that matches their use. Furthermore, natural resources have a certain ability to absorb contaminants without adverse impacts. This so called 'carrying capacity' of the environment, has not been recognised as a service provided to which a cost can be attached. One of the ways in which resource economics and law may correct these oversights, is by looking at the costs associated with the use of resources, in comparison with their renewal rates and carrying capacity services (Bosman and Kotze, 2006).

The WDCS facilitates the above by essentially associating a cost to the impact caused by the discharge and the waste that it contains, with the intention to reducing the damaging effects of waste on water resources. This system therefore entails the use of economic instruments to, *inter alia*: promote sustainable development and the efficient use of water resources; promote the internalisation of environmental costs by impactors; recover some of the costs of managing water resource quality, and create financial incentives for dischargers to reduce waste and use water resources more optimally. The WDCS is still in the process of being developed and it is nearly completed. It is envisaged that the system will be implemented in the due course. The use of economic instruments is relatively new in the environmental law and governance discourse (Bosman and Kotze, 2006).

The application of economic instruments may sometimes be a specifically useful strategy for regulation by government, especially in those instances where regulation pertains to the protection of public goods, such as water resources. In this context, it is important to distinguish between the charge to use a product or service, including charges paid for emissions to the environment ('user pays principle'), as opposed to a payment made for the prevention of rectification of the effects of pollution, i.e. 'polluter pays principle'. Although both resort under the broad umbrella of market-based instruments, there are distinct principles and philosophical differences (Bosman and Kotze, 2006).

5.5.1 The Polluter Pays Principle

The polluter pays principle plays a central role in economic instruments. De Sadeleer (in Bosman and Kotze, 2006) observes in this regard that not all 'users' of resources are necessarily 'polluters'. For all substances, there will be a 'carrying capacity' where a disposal or discharge into the environment may be deemed acceptable, and where this level of acceptability for each substance will depend on the inherent properties of the particular substance as well as on the characteristics of the receiving resource, and the pathways of transport and exposure. Above this level of acceptability, a disposal or discharge will pose a risk of harm, which is unacceptable. Dischargers or disposers introducing substances into the environment above these levels of acceptability are not users, but are polluters, and are liable to carry the cost to prevent such harm (for example, by constructing and operating waste treatment facilities), and liable to carry the cost of remedying the effects of pollution, for example, by rehabilitating the damage caused (Bosman and Kotze, 2006).

5.5.2 The User Pays Principle

In many countries, including South Africa, public environmental services and goods are provided by government. This is because public goods are not subject to ownership and may be used by the public at large for their benefit. Government may arguably be best suited to regulate public environmental goods through its normal governance functions which are aimed at promoting the public benefit, and to collect revenue by way of taxes, levies and charges to enable regulation and protection of public environmental goods. Economic instruments, such as taxes, levies and subsidies, may be usefully employed in these instances to facilitate regulation of human activities and the effects thereof on public goods (Bosman and Kotze, 2006).

Regulation by means of economic instruments as charges for the use of environmental resources may be done either directly or indirectly. Whilst direct regulation may include charges, taxes or subsidies aimed at producers or consumers using services provided by government (for example payment for municipal services), indirect regulation relates to the situation where charges, taxes or subsidies apply to, for example, indirect products or services provided by government, such as the protection of resources, which are public goods. An environmental 'charge' to use a product or service may therefore be defined as: 'A payment for discharge of a pollutant into environmental media based upon approximate pollutant loading' (Bosman and Kotze, 2006).

The idea behind the use of economic instruments as payment for services provided by the environment is that regulation directed at one variable must influence another variable. In other words, attaching a cost to the use of a natural resource will, when the cost is set at a competitive enough ratio, cause an improvement in the quality of discharges, or will result in a minimisation of waste production. User charges are thus incentive-based since, notwithstanding the obvious environmental benefits or environmental incentives resulting from less pollution; any charge therefore, gives an incentive to avoid the charge so to speak. The charge under the WDCS is a typical example of an environmental charge, whereby an amount of money is paid to government for the provision of environmental public goods or services, in this instance, services and goods relating to use of water resources within its carrying capacity.

5.6 Water Trading

If water is an economic good then it should be possible to govern its allocation through the market. A much considered solution is to place as great a reliance as possible on prices and, therefore, on markets in the process of allocation of water and the related investments in productive services. Under such an approach the role of administrative allocation would be restricted to those few areas where markets cannot be developed and to the regulation of natural monopolies. Lynne (1988) notes that there appears to be little evidence which suggest that administrative approaches can result in allocation of water even with only minimal efficiency among the processes that result in marketable goods. Lynne (1988) went further stating that it is not reasonable to expect a staff or board member to know what water is worth in every water use, which is necessary in order to know the economic efficiency of each board's decision. The solution to the information problem will likely necessitate applying a market-like process for allocating water to produce market goods. The regulatory approach and the limited funds can then be focused on the areas where they are needed, which is in deciding water needs for the non market goods (Lynne, 1988).

The notion of water trading is certainly not new internationally and water trading has occurred in other countries, such as Chile, for many years (ECLA, 2004). More recently in South Africa a number of authors have noted that the NWA provides for the framework for water markets (for example, Armitage, 1999 and Farolfi & Perret, 2002). The country's water legislation therefore makes provision for water rights trading as an option for water allocation. Farolfi and Perret (2002) note that even under past legislation, water-rights trading occurred and still exists between commercial irrigation farmers and has proved efficient in certain instances. They emphasise that DWAF has played an important role in the successful cases, assuring transparency, supervising and recording transactions.

5.6.1 Pre-conditions for effective water trading

The basic economic rationale for water trading is that efficient markets are the simplest way to allocate limited supplies of any good between different users to as to equate marginal social benefits across the different users. Achievement of comprehensive and effective water requires attention to a range of issues without which water trading is likely to not occur, or to fail to deliver desired outcomes. According to Freebairn (2003), these issues include:

- **Specification of water rights** - users of water can only make good decisions on the transaction of water rights if the water rights are clearly and transparently defined;
- **Initial allocation of rights** - an important issue in setting up an effective water market is the initial allocation of the property rights;
- **Recognition of external costs where relevant** - the associated costs attached to a water authorisation license (such as waste-water discharge costs) would have to be made clear and transparent;
- **Low cost and transparent mechanism for transferring rights between buyers and sellers and for maintaining a public record of these transactions** - a single independent and transparent registry of water rights is needed to officially record ownership, and changes in ownership following sales and purchases; and
- **A flexible mechanism for conflict resolution** - aligned with the above is a flexible and cheap mechanism to deal with conflicts and disagreements.

A review of the Chilean Water Code, which made water trading possible in Chile (ECLA, 2004) recently outlined some other 'fundamentals' for water trading to occur successfully. Many of these are addressed above but additional conditions of importance include:

- **A resource shortage** - In the absence of a resource shortage there is no scarcity price for the water and hence no incentive to trade; and
- **A social and cultural context that is in harmony with the economic system** - This is a particularly important issue in the South African context. If the social context is too far out of alignment with the economic system a trading system will fail. For example, if people in a particular area view water resources as a right rather than an economic good then they are unlikely to engage in a water trading system.

In summary, efficient construction of any market requires the existence of the necessary conditions for trading to occur:

- Well-defined property rights;
- Public information on the supply of and the demand for water rights; and
- The physical and legal possibility for trading to take place.

Most authors tend to agree that of these three necessary conditions, the most important appears to be the existence of well-defined property rights. In the case of water, property rights define and limit the rights and duties of their holders relative to one another and to the rest of society to the use of a certain amount of water, which may be defined either volumetrically or in terms of shares of a stream or canal flow. If rights are poorly defined, market processes cannot be relied upon to allocate water resources efficiently. It is a basic responsibility of governments, as far as markets are concerned, to define, allocate and enforce property rights in water. Government policies play a critical role in defining the institutional setting for market operation and provide the basis for market activity by defining, allocating and enforcing water rights (Lee and Jouravlev, 1998).

5.6.2 Systems of trading in water authorisations

There are a plethora of different water trading systems that are possible. Many different institutional and market design issues will need to be taken into account when finalising such a system. For example, some systems divide the tradable instrument into two parts, i.e. the water entitlement or water use authorization itself (which can be seen as long term asset) and the annual volumes of water arising from that right (which can be traded on a much shorter time-frame). There have also been systems proposed that incorporate water quality considerations into the tradable license for ecological protection reasons. For example, the removal of a unit of water in an upper catchment may have more ecological impact than the removal of the same unit near the river mouth. In such cases an 'exchange rate' can be established between such units of water for the purposes of trading. There also exists the possibility that different catchments will require different types of trading systems. Young (1997) provides a set of useful principles for evaluating any particular proposed economic instrument:

- **Economic efficiency** - having regard to implied and actual values, the chosen trade-off between objectives is achieved at least cost (productive efficiency) and so that no reassignment of property rights would improve objectives without making some-one worse off (allocative efficiency);

- **Dynamic and continuing incentives** - the mechanism used continues to encourage technical innovation, improved water efficiency beyond the official policy target; and automatically adapts to changing technology, prices and climatic conditions;
- **Equity** - no group of people, including future generations, is unfairly disadvantaged or favoured by the instrument's operation;
- **Dependability or certainty** - the instrument will deliver the desired target, even when knowledge about likely responses is uncertain;
- **Precaution** - the instrument avoids the chance of serious or irreversible consequences especially when there is scientific uncertainty about outcome;
- **Administrative feasibility and cost** - monitoring and information costs are minimal (low information cost);
- **Government enforcement is cost effective** - can be financed from available revenue and self enforcement is encouraged (low administrative cost), the instrument's requirements are simply explained (communicative simplicity), and the decision-making processes associated with the instrument can be understood by all parties (transparency); and
- **Community and political acceptability** - the policy instruments motivate the community to ensure that the objectives are achieved, are perceived as being legitimately formulated and delivered, adds to social harmony, are consistent with government commitments and attracts widespread support.

5.6.3 Mechanisms to address economic effects of water trading

One of the possible concerns with water trading is the potential for some participants in the market to have so-called market power which allows them to dominate a market to their advantage. There are concerns that these kinds of problems may arise in South Africa.
A model of potential water trading in the Olifants catchment (Farolfi and Perret, 2002) clearly reveals that there can be substantial difference in economic power between the sectors bidding for water – in this case mining and semi-commercial agriculture. This means that a direct negotiation of water rights transfer between mines and smallholders is likely to end up with an almost complete transfer of water rights to the mining sector. This would certainly have positive consequences in terms of strict economic efficiency, water productivity, and even formal employment in the area. On the other hand, such a transfer would challenge certain objectives of the government, which go beyond mere economic perspectives and include equity, sustainable rural development, environment protection, and the like.

Certain economic or regulatory policy tools may be implemented, as alternatives towards a more balanced allocation of water. Such systems have been used extensively elsewhere in the world. For example, if there is the fear that market power will lead to dominance there can be a taxation on license purchases (i.e. a tax on an authorisation trade) at an amount aimed at reducing the marginal return on water to the purchaser to a level which will curtail trades and which will have the additional benefit of revenue raising for catchment management. Other options are a 'return to the community' system achieved by the periodic surrender of part, say 2.5%, of each share-holding to a tender pool with the revenue realized being returned to the local community; and hypothecation of revenue to a local council or catchment management committee (Farolfi and Perret, 2002).

5.6.4 Impacts of water trading on areas-of-origin

The potential economic effects of water transfers are usually ignored in economic efficiency analysis on the grounds that they constitute 'pecuniary' externalities and therefore resources that are affected (labour, land or capital) can easily move to other uses and because transferring water to a higher-value use should generally result in as larger or greater positive pecuniary externalities elsewhere in the economy. Empirical evidence supports the theory and suggests that typically negative economic effects of water transfers on the area-of-origin appear to be small and can be often compensated by benefits in importing areas according to Lee and Jouravlev (1998). They also claim that in Chile, rural to urban transfers have rarely resulted in negative effects in the exporting areas, because farmers usually sell small portions of their water rights and are able to maintain agricultural production by adopting more efficient on-farm irrigation technology.

Because of structural problems in economies this is not always the case, and in some countries real economic losses may occur in the presence of long-term, structural unemployment of resources, immobility of resources, and the existence of economies of scale in related economic sectors. South Africa shares all these characteristics. Since rural and urban transfers often take place from depressed areas characterized by long-term unemployment of human and other mobile resources and there can be impediments to resource mobility, pecuniary externalities usually involve some real costs that should not be ignored. In addition, income redistribution from rural exporting to urban importing areas may be undesirable from a policy standpoint. It is in part for these reasons that some countries have adopted strong policies to safeguard the needs of exporting communities. Many examples of such constraints can be found in the United States. For example, in Idaho, a statute provides that transfers from agricultural use should not be approved where such changes would significantly affect the agricultural base of the local area (Lee and Jouravlev, 1998.

If the ultimate objective of a system of water trading is to ensure that water moves to its highest value use it is important, when considering any restrictions on water transfers, to avoid protectionist policies which lock water into historic uses or specific locations and perpetuate antiquated water use patterns that run contrary to efficient water allocation and modern demands, rather then encourage reallocation as economic and social conditions change. Lee and Jouravlev (1998) note that 'inefficiency is inconsistent with the notion of maximizing water contribution to aggregate welfare and can result into substantial economic losses'. In other words, too many restrictions on water trading would undermine the very objectives sought by using such a system.

5.7 Water Auctions

The NWA makes provision for the auctioning of water remaining after the requirements of the Reserve, international obligations and corrective action have been met. The rationale for auctioning is two-fold. The one reason is that it is likely to provide a more efficient means of allocation of water to productive users than an administrative allocation. A second reason is that auctions ensure that the wealth represented by water rights is transferred to the society as a whole and windfall profits are avoided. Lee and Jouravlev (1998) note that the auction solution gives some concrete meaning to the vague proposition that national water resources belong to 'the public'. An auction enables the public to realise on this purported ownership in the form of receipts flowing into the state treasury.

The theory and practice of auctions has generated a substantial economics literature which cannot be addressed here. Suffice it to say that careful consideration needs to be taken of the manner in which water authorisations are auctioned, since different approaches can have very different financial outcomes for the state.

5.8 Tools for calculating the economic value of water

In the absence of water markets a range of tools exist that can be used to approximate the kind of information that water markets would provide. In essence an administrator at the DWAF's regional offices or a CMA would use these types of tools to make decisions on water allocations that would simulate the functioning of an efficient water market. These tools include the different approaches, as outlined below.

5.8.1 Catchment level economic and bio-physical models

There are a range of computer models that combine water resource planning and economic models of water use at a catchment or sub-catchment level. These typically work off a GIS platform and have an integrated economic model attached. Typically the economic models attached have some form of optimisation programme which enables the user to determine an economically optimal allocation of resources given a set of bio-physical resource constraints. Some models may also include the use of input/output analysis to determine the indirect impacts of re-allocations of water away from current uses. Typically, to be effective, these models are resource intensive both in the need for sound GIS and technical data and in the need for economic information on the current water uses in the catchment. It is likely that the latter data will be more difficult to come by in South Africa, with very limited research having been conducted on such key parameters as demand functions for water use and elasticity of demand amongst various water users (Farolfi and Perret, 2002).

5.8.2 Micro-level estimations

At points it is sufficient to assess the economic demand for water from individual users or categories of users. In such cases simpler economic methods can be used such as net-back-analysis or other methods to determine the demand curve for water. In a net-back approach the information requirements are predominantly information on the economic of production of the user – generally the economics of agricultural production. This type of information, including farm-level budgets is fairly readily available in many areas of the country. In analysing farm level budgets which are based on historical practice it is also important to understand the future technological options available to irrigators, i.e. whether they irrigate more efficiently, switch to different crops or dry-land agriculture (Farolfi and Perret, 2002).

5.8.3 Simulation by linear programming

Linear programming models are typically exclusively economic models used to determine 'efficient' market clearing prices. Such models require information on the economic demand for water amongst various user categories and the long run marginal costs of water supply in a particular catchment. In some cases where this type of detailed economic information is lacking 'quasi-linear programming' models using simple functions are sometime used (Farolfi and Perret, 2002).

5.9 Financial considerations

The financial considerations affecting water use are crucially important as well and there is limited value in only considering the economics of water allocations without some understanding of the financing of water supply and consumption. Key components of the financial framework are financial costs, revenues and subsidies. The basic financial framework for water resources management and development is set out below (Farolfi and Perret, 2002):

- **Water resource management** - the costs of water resource management (including the allocation function) are recovered from water resource management charges.
- **Water resource development** - the costs of water resource development are recovered from water resource development charges. These include a return on assets which creates a financial surplus (financial revenues exceed direct financial costs)
- **Waivers** - water resource management and water resource development charges may be waived for emergent farmers. Emerging farmers are irrigators of historically disadvantaged groups, who will access existing or new government water schemes (GWS) through land reform programmes or will be registered or licensed under ex-homeland GWS, or become members of Water User Associations (WUAs).
- **Conservation charge** - users may be charged a conservation charge. This charge is intended to reflect the scarcity or economic value of water in a catchment. This charge has not yet been implemented and could be implemented in a number of different ways.
- **Discharge** - a wastewater discharge charge system is being developed.

In addition to these water resources related charges, users are required to pay for the related water services infrastructure costs (including infrastructure on their own properties). Because water users are expected to pay for the water they use (and the attendant water resource development and management costs) making allocations of water available to new users for productive use is a necessary but not sufficient condition to ensure that they actually will be able to access that water. In addition to having a right to use a volume of water new users will require:

- **Infrastructure** - to transport, store and use their authorised water use; and
- **Financial resources** - to pay for the costs of infrastructure and other water resource costs.

The available subsidies for agricultural water use have been prepared by the DWAF (DWAF, 2000a) and the National Department of Agriculture (NDA, 2002). The most important points outlined by DWAF (2000a) are that for emerging farmers full recovery of operating and maintenance costs will be phased in over a five year period (20% in year one, 40% in year two, etc), commencing in the financial year following on the year in which the relevant water use has been registered or licensed. Under-recovery of costs will be subsidised from the DWAF budget. Catchment management and water resource management charges will also be phased in over a five year period, together with operating and maintenance charges (DWAF, 2000a).

The operating and maintenance charges for emerging farmers who will access GWS which are operated and maintained by WUAs can be subsidised to the same extent as the relevant charges for emerging farmers on GWS which are managed by the Department. This will be accomplished via an operational subsidy payable to the relevant WUA and phased out over a five year period. Capital cost subsidies are also available from the Department for emerging farmers who are members of a WUA which intends developing a new irrigation scheme or wants to rehabilitate or upgrade an existing scheme. Although the development of a business plan for new potential water users will be channelled to the appropriate department or agency for funding, it is unlikely that subsidies for water use at any significant scale will be available for much longer than a five year period. It is also unlikely that any significant sources of subsidies for water will come from sources other than the DWAF (DWAF, 2000a).

Local government, despite some increasing focus on local economic development, is highly unlikely to be in a position to provide ongoing subsidies to any commercial activities. At present, most local authorities outside of the metropolitan areas are struggling to even provide free basic water at the domestic level. The current infrastructure and operating grants available to local government are not designed to support on-farm infrastructure or to support any operating costs beyond basic needs. For this reason allocations of water must be realistic.

6. INSTITUTIONAL ARRANGEMENTS

6.1 Introduction

The Constitution of South Africa specifically distinguishes between different spheres of government versus tiers of government to promote interaction, co-operation, synergy and more importantly effective and efficient governance. The Constitution defines spheres of government, but not tiers of government. Catchment management agencies (CMAs) are not local or provincial government, but central government. However, there are major challenges in the way to making this dual approach a reality. Government uses government tools to facilitate good governance. These tools include policies, strategies, guidelines, procedures, legislation, regulations and by-laws (DWAF, 2006d). However, the lack of effective implementation renders these tools ineffective and weakens governance.

Due to fundamental changes in the South African political environment, South Africa has been going through a period of rigorous revision and development of government tools. A number of the government tools that has been developed, have not been implemented successfully. Government offices, for a number of reasons, are experiencing difficulty to effectively implement various government tools that have been developed since 1994. Previously, limited research has been done to investigate possible reasons for the lack of making of policies specifically operational (DWAF, 2006d). Strictly speaking, it is not about making policies operational. It is about translating new policies into new operational practices and then to implement the new practices. If the reasons for the lack of implementation can be established and verbalised, solutions can be formulated to address the specific problem areas and government tools can be streamlined or developed in such a way to facilitate implementation. The challenge here is to separate causes from symptoms and to design interventions for addressing the causes.

6.2 Purpose and scope

An effective step for developing a groundwater source and aquifer protection zoning policy is to establish a policy task force that draws together key institutions with an interest in the use and management of groundwater resources. This Chapter presents an overview of the water sector in South Africa, and considers rationalising the institutional environment to allow for a flexible and effective approach when giving effect to groundwater source and aquifer protection zoning. This rationalisation involves identifying the most appropriate organisation and focal institutions, as well as instruments through which elements of groundwater protection zoning can be complemented and enhanced. Rationalisation often results in removal of organisational responsibilities or power from some organisations, which is often a difficult process. However, in this Chapter, the focus is more towards the DWAF (as water sector leader in South Africa) and its implementing agents in the wider sector, since the Department is guided by a sound legislative mandate (i.e. Chapter 3 of the NWA) relating to the protection of water resources. A succinct evaluation on the legal, socio-economic and institutional arrangements (i.e. Chapters 4, 5 and 6 of this thesis) is provided at the end of this Chapter in Section 6.11, followed by a detailed discussion on the policy process and operational preparedness relating to groundwater protection zoning in Chapter 7.

6.3 The water sector of South Africa

The NWA also recognises that, in order to implement international agreements, specialised institutions may need to be created for this purpose, as well as institutions of support to the DWAF's mandate. In this regard the NWA gives the Minister power to establish bodies to implement international agreements if and when the need arises. To the extent that it may not compromise its primary objective, the NWA gives the Minister the power to direct such a body to carry out additional functions. Regional cooperation is important because South Africa shares four major river basins (± 60% of land area, ± 40% of total runoff) with six neighbouring countries (DWAF, 2006b). The DWAF works according to a matrix management system in which policy, strategy, regulatory and implementation activities combine to achieve the key focus areas and strategic objectives of the Department as a whole. There are nine regional offices (one in each province of the country) that are responsible for water resource management and water services provision. These regional offices also deal with forestry issues in the northern, eastern and southern parts of the country.

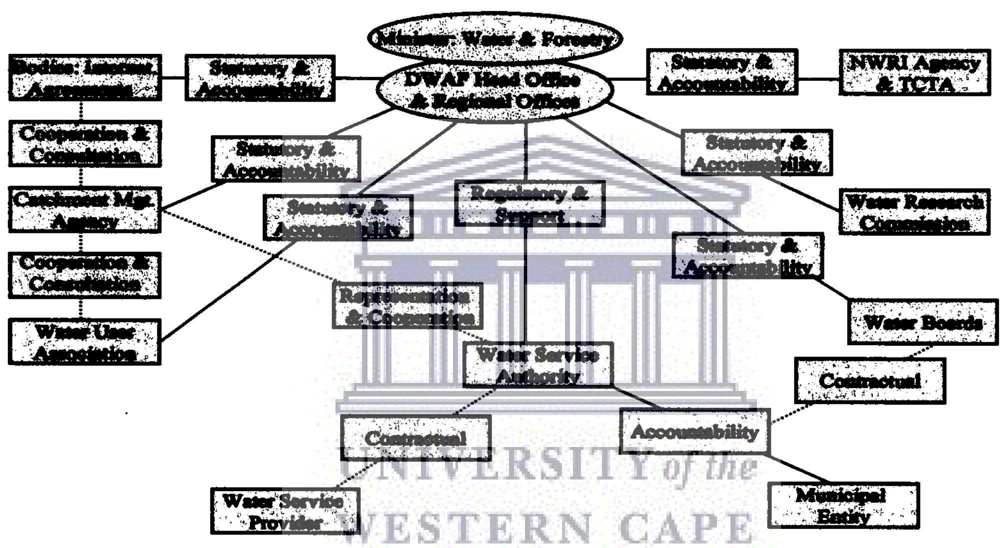

Figure 6.1 Water sector institutional setting (Source: After DWAF, 2006b)

Figure 6.1 above illustrates the institutions that are major role players in the water sector, and that are part of transformation of the water sector. The respective roles and responsibilities are as set out in the various policies and legislation including the following:

- **Catchment management agencies (CMAs)** - are responsible for management of water resources at catchment and water management area (WMA) level;
- **Water user associations (WUA)** - consist of an association of water users that operate within a given allocation of water at a localised level;
- **Water services authority (WsA)** - implies a municipality with powers to ensure delivery of water services;
- **A municipal entity** - a public entity at municipal level intended to carry out a municipal mandate; and
- **Water services providers (WSPs)** – these are organisations that provide water services on behalf of the water services authority.

6.3.1 Water resources

The process of establishing new institutional arrangements for water resource management (i.e. regional and local institutions to manage national water resources and a new institution to manage water resources infrastructure) is in its relative infancy. The South African government has approved the establishment of a national water resources infrastructure agency (a Public Entity) in 2005, and the agency is expected to be fully functional in the near future. This institutional reform process serves two principle purposes. Firstly, to decentralise the responsibility for managing water resources to regional and local levels in order to facilitate wider public involvement in water matters, and secondly, to move the DWAF away from day-to-day water resource management activities towards its ultimate role of developing policy, regulation, planning, monitoring and providing institutional support. As part of its support role the DWAF has recently embarked on the development of a capacity building strategy to address capacity limitations in the water sector (DWAF, 2006b).

6.3.2 Water services

Various government policies and legislation relating to water services and the role of local government have been developed and implemented since 1994. The strategic framework for water services (SFWS) which the South African government approved in 2003, provides a comprehensive summary of policy with respect to the water services environment in the country and sets out strategic framework for its implementation over the next ten years. The changed role of the DWAF is defined in the SFWS as that of sector leader and its key responsibilities entails policy formulation, support, regulation and information management.

The function of infrastructure implementation and water services scheme operation previously performed by the DWAF is being transferred to local government and/or appropriate water services institutions in line with the Constitutional mandate. Strategies to put the SFWS into practice are being developed and implemented and include the institutional reform of water services provision as well as regulatory and sector support strategies (DWAF, 2006b). Important delivery targets established in the SFWS are:

- An end to the bucket system by 2006;
- An end to the water supply backlog by 2008;
- All assets of water services schemes transferred to municipalities by 2008; and
- An end to the sanitation backlog by 2010.

The DWAF's main role is to ensure that water and sanitation services and the agencies that manage these services are sustainable and contribute to social and economic goals. As sector leader the DWAF is therefore actively engaged in programmes such as Project Consolidate (i.e. government's attempt to enhance high standard service delivery), to improve water management capacity in the sector in support of economic growth and development. Ensuring access basic water supply and sanitation services remains a core priority of the DWAF and extra effort is put in place to ensure that targets set by government is achieved (DWAF, 2006b).

6.3.3 Water Research Commission

The Water Research Commission (WRC), classified as a schedule 3A Pubic Entity under the Public Finance Management Act, Act 1 of 1999 (PFMA) was established in terms of the Water Research Act, Act 34 of 1971(WRA) with the mandate to coordinate, promote, encourage, finance and manage research in respect of the occurrence, preservation, utilisation, conservation, control, supply, distribution, purification, pollution or reclamation of water supplies or water resources. The WRC is given further responsibility to accumulate, assimilate and dissimilate knowledge with regard to the results of such research and the application thereof, and to promote development work for the purposes of such application. To enable the WRC to carry out its mandate, the WRA makes provision for a Water Research Fund to be administered by the WRC, the income of which is composed of rates and charges levied either on land irrigated, or on water supplied to users by the State, water boards and local authorities (DWAF, 2006b).

6.3.4 Water Boards

Chapter 6 of the Water Services Act, Act 108 of 1997 (WSA) provides the legislative framework in which water boards operate. In terms of the Act, the primary activity of a water board is to provide water services to other water services institutions within its service area. Water Boards must enter into formal service provision agreements with the water services authorities (municipalities) in their service areas. Water Boards are public-sector water service providers, whose primary activity is to provide bulk water to municipalities. Many water boards have developed relations with local municipalities but others have still not established formal agreements. The DWAF work in partnership with the South African Local Government Association (SALGA), Department of Provincial and Local Government (DPLG) and the South African Association for Water Utilities (SAAWU), in order to ensure that water boards continue to play a meaningful role in service provision. There are currently 15 water boards across South Africa, namely (DWAF, 2006b):

- Albany Coast Water Board;
- Bloem Water;
- Bushbuckridge Water Board;
- Lepelle Northern Water;
- Mhlathuze Water;
- Overberg Water;
- Rand Water;
- Umgeni Water;
- Amatola Water Board;
- Botshelo Water;
- Ikangala Water;
- Magalies Water;
- Namakwa Water;
- Pelladrift Water Board; and
- Sedibeng Water

6.3.5 Trans-Caledonian Tunnel Authority

In terms of the 1986 treaty on the Lesotho Highlands Water Project (LHWP) between Lesotho and South Africa, South Africa was obliged to establish the Trans-Caledonian Tunnel Authority (TCTA) to implement the LHWP on the South African side. The actual establishment was done under the 1956 Water Act. Since the completion of of phase 1A of the project, the TCTA's treaty functions have been limited to the operation and maintenance of the project on the South African side. This has, over time, become a minor, which no longer requires full-time staff. The TCTA was directed by the Minister of the DWAF in 2001 to undertake the treasury management of Umgeni Water, and in May 2002 the Minister directed it to implement the Berg River Water Project (BRWP), which will augment the water supply to the Western Cape Water System (DWAF, 2006b).

In May 2004 the Minister directed the TCTA to provide financial and treasury management services to Umgeni Water, other water boards, water management institutions and the DWAF. On 26 November 2004, it was issued a directive to implement and fund the Vaal River Eastern Sub-system Augmentation Scheme (VRESAP). Government also approved a memorandum, assigning it the task of advising on funding options for phase 2 of the Olifants River Water Resources Development Project (ORWDP). It is anticipated that the TCTA and the National Water Resources Infrastructure (NWRI) branch of the DWAF will ultimately merge into the NWRI Agency (DWAF, 2006b).

6.3.6 Water management institutions

Whilst water resources management is a function of exclusive national competence, it is recognised that it is necessary to separate the regulatory functions from the actual management functions. To this end, the NWA provides for the establishment of various institutions, most of them at local and regional level, to facilitate the management of water resources at the catchment and water management area (WMA) levels. The most important of these are the CMAs. The entire country is divided into 19 WMA and it is anticipated that a CMA will be established in each of these areas. A CMA is a local institution, which comprises stakeholders in a catchment area (including water users and municipalities) to govern water resources in their catchment. The Minister of the DWAF may also delegate powers to a CMA. The CMA is therefore accountable to the Minister for carrying out its functions and is funded through water charges to water users as well funds from the national fiscus. Four of the 19 CMAs have formally been established and it is anticipated that the remaining fifteen will progressively be established by 2010 (DWAF, 2006b).

6.3.7 Komati Water Basin Authority

The Komati Water Basin Authority (KOBWA) is a bi-national water authority of the Kingdom of Swaziland and the Republic of South Africa, formed under the treaty on the *Development and utilisation of the water resources of the Komati River Basin,* ratified in 1992. KOBWA is tasked with the implementation of phase 1 of the Komati River Basin Development Project, which comprises the Driekoppies Dam (phase 1A) near Schoemansdal in South Africa and the Maguga Dam (phase 1B) near Pigg's Peak in Swaziland. The purpose of the project is to promote rural development and alleviate poverty in the lower Komati Valley, by increasing the productivity of the land through irrigated agriculture (DWAF, 2006b).

Following a request from the DWAF, KOBWA took over the implementation of the Driekoppies Dam relocation programme during 2004 (DWAF, 2006b).

6.4 Government and governance in perspective

The Global Water Partnership (GWP) defines water governance as different political, social and administrative mechanisms that must be in place to develop and manage water resources, and the delivery of water services, at different levels of society. The concept of government and governance has been used interchangeably with one another and often leads to confusion or misunderstanding thereof. While government can be defined as the 'structures of rule making, rule application and rule adjudication in a given society', the concept of governance has meant different things to different people and institutions, and has long been discussed in both the political and academic dialogues. Generically, governance refers to the task of running a government, or for that matter any other appropriate entity. According to Turton (2002), the British Council states that: 'Governance involves interaction between the formal institutions and those in civil society'. Governance refers to a process whereby elements in society wield power, authority and influence and enact policies and decisions concerning public life and social upliftment (Turton *et al,* 2002).

The concept of governance has been linked to three types of authorities, economic, political and administrative. It comprises the mechanisms, processes and institutions, through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences. For example, economic governance includes decision-making processes that affect a country's economic activities and its relationships with other economies. This clearly has major implications for equity, poverty and quality of life. Political governance, on the other hand, is the process of decision-making to formulate policy, while administrative governance is the system of policy implementation. Technical assistance governance refers to access to high-level short-term strategic advice, particularly on issues of economic reform and governance. This can contribute to poverty reduction indirectly, through addressing public sector constraints and contributing to the establishment of a public sector framework that supports economic growth and improvement of the delivery of government services (Turton *et al,* 2002).

'Good governance' encompasses all three the above-mentioned authorities (economic, political, and administrative) and can be defined as the processes and structures that guide political and socio-economic and ecological relationships. Therefore, 'good governance' can be characterised by, among others, participatory behaviour, transparency and accountability. It is also effective and equitable and it promotes the rule of law. Good governance ensures that political, social and economic priorities are based on broad consensus in society and that the voices of the poor and the most vulnerable are heard during decision-making processes relating to the allocation of development resources. 'Poor governance' (on the other hand) is characterized by arbitrary policy making, unaccountable bureaucracies, unenforced or unjust legal systems, the abuse of executive power, a civil society unengaged in public life, and widespread corruption' (Turton *et al,* 2002).

The World Bank's focus on governance reflects the worldwide thrust toward political and economic liberalisation. Such a governance approach highlights issues of greater state responsiveness and accountability, and the impact of these factors on political stability and economic development. Nthunya (2002) provided the following link between governance and environmental governance: 'Governance refers to the laws, policies and institutions through which a society manages its environment'. Environmental governance can only be achieved through compliance with a country's laws and regulations governing the protection of the environment. In summary, the concept of 'governance' not only encompasses, but also transcends the collective meaning of related concepts such as the state, government, regime and good government. Many of the elements and principles underlying 'good government' have become an integral part of the meaning of 'governance'.

Healey and Robinson (in Turton *et al,* 2002) define 'good government' as: 'A high level of organisational effectiveness in relation to policy-formulation and the policies actually pursued, especially in the conduct of economic policy and its contribution to growth, stability and popular welfare'. Good government can be characterised as implying, amongst others, accountability, transparency, participation, openness and the rule of law. Much has been written about the characteristics of efficient government, successful businesses and effective civil society organisations, but the characteristics of good governance defined in societal terms, remain elusive.

The following represents a few elements associated with good governance (UNDP, 1997; Rogers & Hall, 2003 and SARPN, 2002):

- **Participation** - All men and women should have a voice in decision-making, either directly or through legitimate intermediate institutions that represent their interests. Such broad participation is built on freedom of association and speech, as well as capacities to participate constructively.
- **Rule of law** - Legal frameworks should be fair and enforced impartially, particularly the laws on human rights.
- **Transparency** - Transparency is built on the free flow of information. Processes, institutions and information are directly accessible to those concerned with them, and enough information is provided to understand and monitor them.
- **Responsiveness** - Institutions and processes try to serve all stakeholders.
- **Consensus orientation** - Good governance mediates differing interests to reach a broad consensus on what is in the best interests of the group and, where possible, on policies and procedures.
- **Equity** - All men and women have opportunities to improve or maintain their well-being.
- **Effectiveness and efficiency** - Processes and institutions produce results that meet needs while making the best use of resources.
- **Accountability** - Decision-makers in government, the private sector and civil society organisations are accountable to the public, as well as to institutional stakeholders. This accountability differs depending on the organisation and whether the decision is internal or external to an organisation.
- **Strategic vision** - Leaders and the public have a broad and long-term perspective on good governance and human development, along with a sense of what is needed for such development. There is an understanding of the historical, cultural and social complexities in which that perspective is grounded.

- **Coherent and integrative** - Coherence requires political leadership and strong responsibility on the part of the institutions at different levels to ensure a consistent approach within complex system. Institutions will have to consider all uses and users within the 'water sector' and also their interconnections with and impacts upon all other potential users and sectors.
- **Responsive and sustainable** - Policies must deliver what is needed on the basis of demand, clear objectives, an evaluation of future impact and, where available, of past experience. Furthermore, policies should be incentive-based. This will ensure that there is a clear social and economic gain to be achieved by following the policy.

The aforementioned characteristics are reinforced by the Constitution of South Africa (CSA), Act 108 of 1996, which states in section 195 that public administration must adhere to the following principles:

- Efficient, economic and effective use of resources must be promoted;
- Public administration must be development-orientated;
- Services must be provided impartially, fairly, equitably and without bias;
- People's needs must be responded to, and the public must be encouraged to participate in policy-making;
- Public administration must be accountable; and
- Transparency must be fostered by providing the public with timely, accessible and accurate information.

In the traditional 'Westphalian' concept, government is the central actor in the domestic and international political context, and is seen as the answer to most governance problems (Sampford, 2002). Today, this concept is constantly being challenged by the increasing participation of civil society in decision-making in domestic and international political issues. This is especially so in South Africa, where democracy is relatively new and civil society is increasingly participative in decision-making processes or issues facing the country. A clear link between government and governance is therefore evident. Examination of these linkages provides the rationale for the construction of a dimensional matrix to describe the interaction between government and governance.

Government is representative of the first dimension of a democratic administration. Table 6.1 shows the progression followed by government to implement the process of government or administration of a country. Government consist of three structures, namely rule making, rule application and rule adjudication. In South Africa the three structures of government are devolved into the three tiers of government, namely national, provincial and local government. The first tier, the national departments, formulates policy, legislation and regulation, which can be defined as "government tools". The provincial and local government structures are responsible for the implementation of the government tools. We refer to the overall process of formulation and implementation of government tools as the government process.

Table 6.1 Matrix comparing government and governance (Source: After Turton *et al*, 2002).

	STRUCTURES	PROCESS	PRODUCT	
GOVERNMENT	Government Departments at 3-spheres, namely national, provincial and local.	Formulation of Policy & Legislation	Policy Legislation Regulation	
GOVERNANCE	Civil Society	Testing Monitoring Auditing Feedback Reflexivity	Authenticity: • Buy-in • Accountability • Trust Transparency • Consensus • Predictability • Adaptability (incremental)	Instruments: • EIAs • SEAs • RDM • Public Participation

The first dimension illustrates the progression followed by government departments to formulate policy, legislation and regulation. Government is responsible for the implementation of the products formulated. As government has not always been held accountable for their actions, these products have not always been implemented effectively. Government can be defined as the management structures of a country, which consists of elected officials who represent the 'official' or physical structures of the administration of a country.

In a democratic society, the government process should reflect the aggregation of interests that have been articulated by interest groups and civil society. In the second dimension, governance refers to the increasing participation of civil society in testing, monitoring, auditing and providing feedback on policy, legislation and regulations produced by government. In essence, interest groups (involved-public), corporate and non-government organisations (NGO's) at international and local levels test the fiduciary trust. The products of governance are transparency, predictability, adaptability, buy-in and trust, all of which legitimises policy, legislation and regulations. Opportunities for the development of, amongst others, transparency, buy-in and trust regarding policy, legislation and regulations are created with the utilisation of instruments of good governance such as environmental impacts assessments (EIAs), stragegic environmental assessments (SEAs), RDM and public participation.

Government is de-legitimised when the governance process is deficient in government processes, structures and products. As a result, the governance process does not address the needs of civil society and the people of the country, which are vital for democracy in a country (Table 6.1). Notwithstanding the interchangeable use of the terms 'government' and 'governance', it is important to note that there is a distinct difference between these. Governance is a process determining the legitimacy of government processes and holds the government accountable for the aggregation of interests articulated by different interest groups. Government and governance processes are interlinked but distinctly different.

6.5 Custodianship of groundwater resources

The Department of Water Affairs and Forestry (DWAF), as custodian of the country's water resources, is undertaking institutional transformation in water resources management, water resources development and water service delivery, which being South Africa a developing country, implies five simultaneous complex and interrelated tasks:

- Transforming the institution and gradually devolving both water resources development and management to the lowest appropriate level;
- Maintaining service delivery;
- Developing the resource through infrastructure development and refurbishment;
- Redressing past inequities, both making the staff composition reflect the national demography and reforming water allocation to improve the livelihoods of historically disadvantaged individuals (HDIs); and
- Developing capacity.

Water resource managers in other developing countries may argue that they do not have to deal with the last point because they did not have a traumatic apartheid experience, but the history of racial and social injustice in South Africa has to be traced back since 1652 at the outset of colonialism and not since 1948 when apartheid was formally established. Since many developing countries face similar skewed income distribution to South Africa's due to a comparable colonial history, should their governments decided to deal with these inequities, the South African experience would certainly be enlightening.

The NWA also introduces a number of useful instruments to protect and conserve groundwater. These include both source based and resource based tools. Source based measures include water use licensing and authorisations. These focus on controlling groundwater users, polluters and potential pollutants. Resource based measures relate to managing aquifers, and include the Reserve, resource quality objectives and classification. Important groundwater protection procedures include:

- **Public involvement** - awareness among the citizenry is seen as the only permanent guard against degradation of groundwater resources. This requires the public to be empowered to understand hydrogeological issues and appreciate the value of the resource;
- **Reserve determinations** - allow for the role of groundwater in sustaining aquatic ecosystems to be understood and promoted within the context of a balance between use and protection;
- **Aquifer classification** - provides a framework for implementing differentiated protection, and should be implemented at a catchment level;
- **Land-use zoning** - an effective source based control that restricts potentially polluting developments on important or sensitive aquifer systems.
  Urban planners, for example, must be made aware of risks related to groundwater pollution and encouraged to plan town developments with due regard for hydrogeological issues; and
- **Environmental management plans and environmental impact assessments** - should be mandatory for activities known to induce groundwater contamination, or in areas of important or sensitive aquifer systems.

Processes involved in aquifer depletion and pollution, and related aquifer protection and conservation, are complex and require specialist input for correct management. IWRM is considered essential, therefore, to protect the country's groundwater resources. Groundwater source and aquifer protection zoning, however, is a public issue, and all water and land users have a role to play therein.

6.6 Water resources classification and groundwater

Chapter 3 of the NWA makes provision for the determination and implementation of RDM (i.e. the Reserve, classification and RQOs). In the context of RDM and the ongoing development thereof, the term 'classification' is being used to refer to the class assigned to a water resource after catchment visioning. The class is based on both the state of a water resource and the state to which stakeholders want the resource to be managed. Until the public participation process has been conducted, the term 'category' is being used to distinguish between groupings based on technical considerations and the classification based on the catchment visioning process. The key outcome of this phase is to define the water resource category for each groundwater resource unit ('natural', 'good', 'fair', and 'poor'). In essence, the classification process aims to define a resource with respect to the current impact on the resource. A range of factors can be considered, including recharge, groundwater use and contamination or expected contamination status (DWAF, 2006c).

The difference between reference conditions and present status is used to assess the sustainability of current groundwater use and the stress status of the groundwater resource. A single present status category is assigned to each groundwater response unit, which in turn is used to determine the water resource category of each unit. This technical geohydrological information is then fed into the broader RDM classification process that aims to set management classes for each water resource unit. The ultimate goal of the water resources classification system (WRCS) is to recommend a normative desired condition for each water resource in a given catchment. To do this, the WRCS lays out a set of procedures, grouped together into seven major steps as indicated in Figure 6.2. These steps are mostly followed in sequence, although where feasible, some of the steps can be done in parallel. In the first step, the team responsible for classifying the catchment(s) water resources begins by identifying and describing all potential water resources (e.g. rivers, wetlands, aquifers) and all existing lawful water users, and then develops a representation of the catchment as a simplified network of spatial management units. The second step defines methods for linking different water use scenarios within a region to the social well-being of the people who live there, the region's economic prosperity and to the overall health of its ecosystems. Steps 1 and 2 occur in parallel for most catchments (DWAF, 2006c).

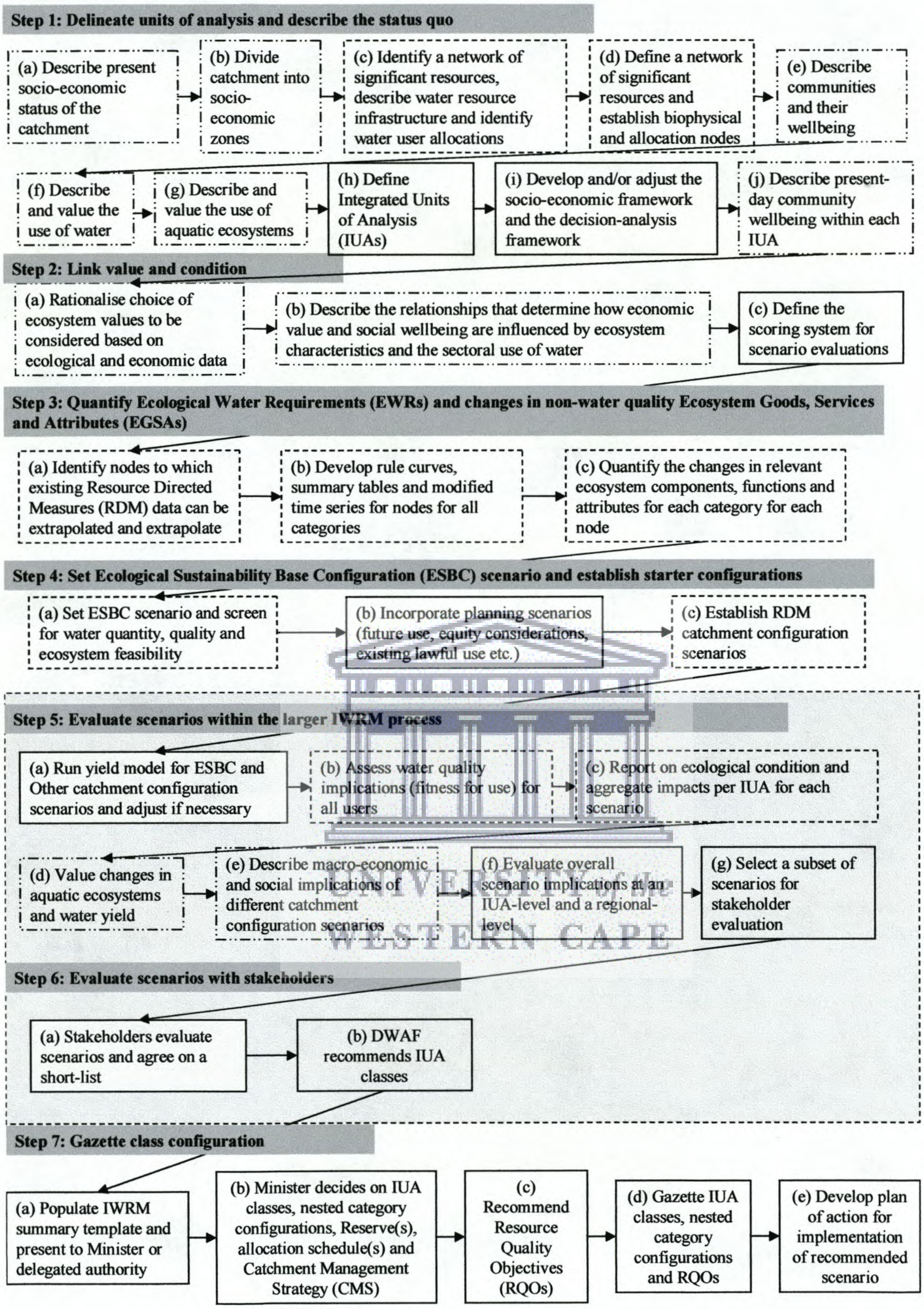

Figure 6.2 Proposed classification procedure (Source: After, DWAF, 2006c)

The third step involves quantifying the volume, distribution and timing of categories of ecological water requirements (EWRs) at each of the nodes identified in Step 1. In order to provide the information needed in Steps 4 to 6, flows are calculated for four increasing levels (or categories) of ecological sustainability at each node. In the fourth step, a set of approximately six to ten different scenarios are developed that capture a range of possible future desired conditions for the catchment's water resources. The fifth step provides guidelines for evaluating the economic, social and ecological implications of each of these scenarios. Although stakeholders are involved throughout the water resources classification process, they play a more prominent role in Step 6. Accordingly, this step provides guidance for stakeholder consultation on the scenarios and their implications. The seventh step then allows for the final selection of an overall catchment configuration of classes by the Minister of Water Affairs and Forestry. When published in the Government Gazette, this decision about the desired condition of water resources in the catchment becomes legally binding (DWAF, 2006c).

6.6.1 Organisational responsibilities relating to water resources classification

A number of key issues arise out of the institutional analysis of the classification process which in turn has a direct bearing on policy development with respect to water resource protection initiatives. During the development of a water resources classification system (WRCS as well as the classification process, further consideration should be given to clarify the following questions:

- What triggers a classification process, who coordinates the initiation of the process and how (i.e. protocol)?
- Who leads the WRCS initiative?
- Linkage to institutions and other IWRM processes
  - How should such linkages be established?
  - Who takes institutional responsibility for these linkages?
  - At what stage (phase) of the WRCS should such linkages be established?
- Consultation and engagement of stakeholders
  - Who takes institutional responsibility for stakeholder consultation / engagement?
  - At what stage (Phase) of the classification process should such consultation/ engagement be undertaken?
- How does the WRCS generate scenarios, and how are scenarios evaluated and discarded?

The roles and responsibilities for the WRCS and its implementation largely fall out of the Sections above. For the sake of brevity and to prevent repetition, the proposed division of roles and responsibility are summarised in Table 6.2 in list format. It is essential that the framework for developing the WRCS within the context of operational policies and regulations be clarified. The chief directorate: RDM in the DWAF will take the lead in the development of the NWRCS but must interface with other directorates in terms of integrated planning for IWRM. Accordingly, relationships between the RDM directorate and the following directorates will have to be developed, around the WRCS (DWAF, 2005b):

- **Integrated Water Resource Planning (IWRP)** - on issues of water resource planning;
- **Water Use (WU)** - on issues of quality, quantity and instream use, and source directed controls (SDC);

- **Water Resources Information Management (WRIM)** - on information needs and monitoring; and
- **National Water Resources Infrastructure Branch (NWRIB)** - on impacts of the class on development and infrastructure.

Table 6.2 Outlining responsibilities for the WRC process (Source: After DWAF, 2006).

Stage of the WRC process	**Responsibility**
Motivation for a WRC process	RDM, IWRP, Water Use, Regional Cluster, CMA
Coordinate initiation of WRC process	RDM
Project leadership of WRC process:	
resource of national significance	RDM or Regional Clusters
resource of local significance	CMAs
Recommendations on class configuration:	
resource of national significance	RDM or Regional Clusters
resource of local significance	CMAs
Review of recommendations	RDM, with IWRP, Water Use and Regional Clusters
Recommendation to the Minister	RDM
Legal establishment of class	Minister: Water Affairs and Forestry
Development of RQOs:	
resource of national significance	RDM or Regional Cluster
resource of local significance	CMAs
Monitoring:	
water resources and implementation of CMS	CMAs
CMS compliance with class configuration and RQOs	RDM, IWRP, Strategic Coordination with Clusters
Monitoring achievement of class configuration	RDM or Cluster
Audit and review of WRCS	RDM

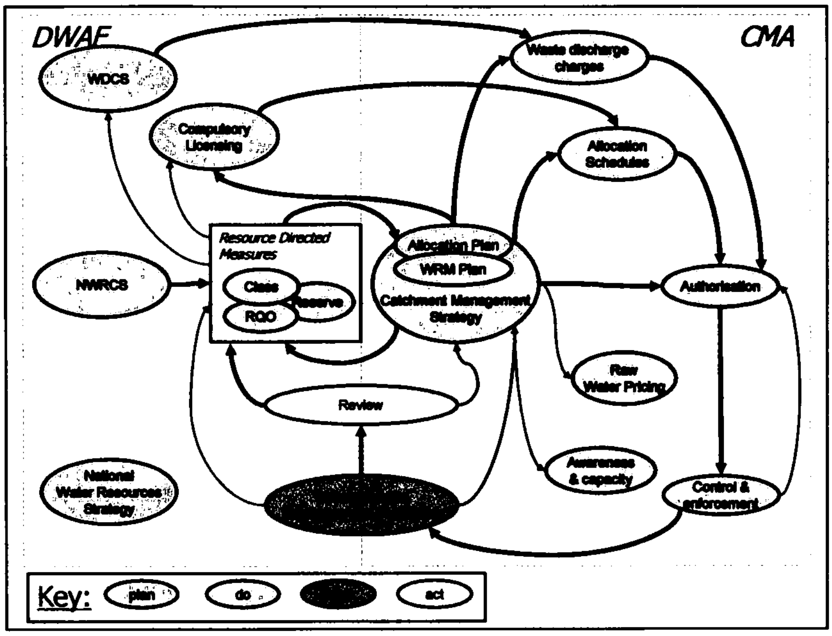

Figure 6.3 WRCS and WRM cycle interfacing at a catchment level (Source: DWAF, 2005b)

Figure 6.3 clearly differentiates the systems, strategies and plans for planning WRM from the instruments for managing the resource, the assessment of the resource through monitoring and evaluation, and the adaptation of planning through audit and review. This process (plan, do, check and act) describes the key elements of the WRM cycle. Figure 6.3 also demonstrates the institutional split in roles and responsibilities between the DWAF and the CMA. The CMA assumes responsibility for WRM through the application of instruments, and the monitoring and evaluation of the resource, while the DWAF assumes the role of custodian of the nation's water resources through custodianship of the systems and strategies. However, introducing some complexity in this division of roles and responsibilities is the CMAs responsibility for the catchment management strategy (CMS), including the WRM plan, and the DWAF's lead on RDM (DWAF, 2005b).

Figure 6.3 also demonstrates the iterative nature of setting the class of the resource, the ecological Reserve and associated RQOs with the CMS, WRM plan and allocation plan – the objectives can only be set with an understanding of the management implications of those objectives on the social, cultural, ecological and economic components of the system. Similarly, as both Compulsory Licensing and the Waste Discharge Charge System (WDCS) are premised on the class, Reserve and RQOs, iteration exists between these systems and the WRCS to ensure that the objectives that inform the class and the CMS take adequate cognisance of the drivers of the associated processes. Figure 6.3 therefore serves to demonstrate the interconnectedness of the WRM cycle and the central role that the WRCS and the class play within that cycle. This illustrates the importance of aligning the objectives of the WRCS, and of the water resources classification process (WRCP) within a given catchment or WMA, with the objectives and drivers of the other elements of the WRM cycle. The WRCS must be designed such that adequate cognisance is taken of this interconnectedness and such that the objective of associated WRM processes are incorporated in the determination of class (DWAF, 2005b).

In summary, an assessment of the WRCS and RDM within the IWRM cycle leads to the following institutional recommendations:

- The potential institutional split emphasises the need for an iterative process between the RDM, the CMS and the water allocation and WDCS processes.
- Given the iterative nature of this process, and the need to understand the implications of a class (without independently developing strategies and allocation plans), the Classification Process should not be done independently of either a CMS allocation plan, a WDCS or Compulsory Licensing process.
- The Classification Process needs to specifically engage the outcomes of linked CMS, Compulsory Licensing and WDCS processes, and to build the procedures to do this into the WRCS (noting the methodologies being developed).
- The Classification Process should only be delegated to a CMA for local resources with limited national implications and which are not likely to require either a WDCS or a Compulsory Licensing process in the short- to medium-term (i.e. relatively unstressed).
- The WRCS is premised on a balance between the need to protect and sustain water resources, and the need to develop and use them. Accordingly, the WRCS should outline a process by which scenarios for resource protection can be compared with the scenarios for water allocation to derive this balance. This emphasises the iteration with the CMS process (and the Compulsory Licensing and WDCS processes), by which the strategies and plans for allocation (quantity and quality) are developed.
- Given the need to strike this balance, the institutional separation of responsibility for RDM from the allocation responsibility provides an institutional balance that should work in the public interest. This means that the CMA cannot independently adopt lower class configuration to achieve revenue collection, or respond to powerful sector voices that may demand over- utilisation and development of the resource.
- From a strategic perspective, it is critical that the class and RQOs be defined in a progressive manner where they are not currently being achieved, to enable strategies for meeting them to be developed and implemented over a reasonable timeframe.

A further key issue throughout the water resources classification process (WRCP) is the linkage to associated WRM processes, such as Compulsory Licensing, the WDCS and the CMS (see Figure 6.3). The objectives of the WRCP project must take cognisance of these associated processes, and of the objectives of those processes. In addition, the evaluation and recommendation of scenarios should consider the impact of the proposed class configuration on the associated processes and should ensure complimentarity in this regard. Accordingly, it is proposed that the WRCP and other WRM processes be iterative.

Evaluation of the recommendation on class configuration scenarios is undertaken by RDM. The evaluation is to ensure that the recommendations put forward are consistent with Government's objectives of redress, poverty alleviation and economic growth, participation and sustainable development. The recommendations must also be consistent with the strategic objectives of the DWAF, and the spirit of the NWA in ensuring equity, sustainability, efficiency and representivity in the protection, development and management of the nation's water resources. Following a particular protocol, RDM will make recommendations to the Minister of DWAF, who will ultimately decides on, and Gazette, the class configuration (DWAF, 2006c).

6.6.2 Institutional linkages outside DWAF

The WRCS must be consistent with Government's objectives of meeting basic human needs, human resource development, economic growth, and ensuring ecological and environmental sustainability, amongst others. This implies that the WRCS must strike a balance between resource protection and utilisation, and that the class must represent this adequate and appropriate balance. In achieving this balance, a need exists to create linkages with other government processes within national, provincial and local government (including within the DWAF), and with civil society and the wider stakeholder base. The acceptability of the WRCS is fundamentally hinged on achieving and demonstrating this balance, and on cooperation and communication of the linkages employed in achieving the balance.

6.6.3 Acceptability of WRCS to Government

Acceptability of a water resources classification system to Government, especially Local Government, around issues of integrated planning, development planning and service delivery, and in supporting Government's broad strategic objectives are very important issues to consider when developing such a system. Central here is the issue of balance – the WRCS has to strike a balance between protection and utilisation of the resource.

Further, in striking a balance, the WRCS has to take cognisance of the mandate, objectives and processes of other Government departments, in particular:

- Local Government's development and spatial planning and water services delivery mandate, Provincial Government's integrated development planning, National Government objectives of economic growth (Department of Trade and Industry, Department of Public Enterprise and others) and service delivery (Department of Local Government, Department of Public Administration and others); and
- Provincial Government Department of Environmental Affairs, National Department of Environment and Tourism, South African National Botanical Institute, National Parks (SANParks) and other statutory institutions dealing with ecological sustainability and conservation.

6.6.4 Acceptability of WRCS to civil society

The acceptability of the WRCS and the WRCP to civil society and to the wider stakeholder base is again an issue of balance and an issue of consultation. Stakeholder participation is a key element of the catchment visioning process, the development of the CMS and of defining the objectives of the WRCP. Strong and representative stakeholder consultation is required to ensure that the issues of society are engaged, the process is recognised as inclusive and representative, and that capture of the process through a particularly organised stakeholder constituency does not occur. Acceptability to society-at-large is also an issue of mandate. The CMA has a mandate to engage civil society and the wider stakeholder base on issues of IWRM. While the class is fundamentally a water resource issue, it is also a wider issue of socio-economic development and of environmental protection. This highlights again the necessary linkages with the appropriate government institutions to enable this wider mandate.

There exists a contested space in the struggle for power between government, civil society and the people of the country. People experience problems at the grassroots level. However, the voice of an individual (people) is not easily 'heard'. Civil society is responsible for 'interest articulation', that is establishing interest groups to articulate the voice of the people. These groups seek to have and to apply power, to provide different sources of scientific and practical advice, to provide economic incentives, to discuss values and to make normative rules. The articulation of interests by civil society provides the impetus for people to have their 'voice' heard. In response to this, government is responsible for 'interest aggregation', in other words government decide which interest groups' articulated interest takes priority above others. Thus, the contested space relates to governance issues of the country, and as such, government and governance are integrally linked in the articulation of issues that the country is facing (Sampford, 2002).

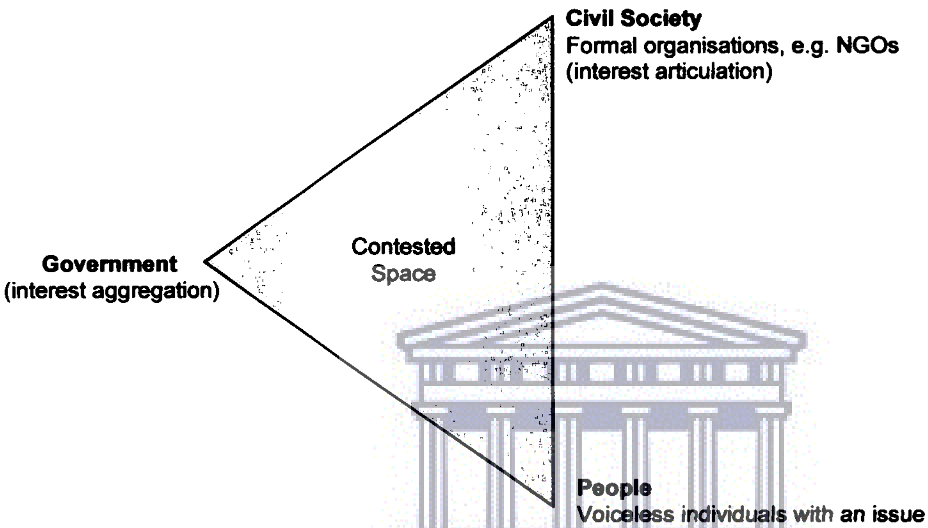

Figure 6.4 Interaction between government, people and civil society (Source: After Turton *et al,* 2002).

The critical point is that good governance in an era of democracy is not achieved by any one rule, institution or economic policy, but requires a multi-sectoral approach, where government, civil society and people take part in the decision-making processes of a country. Governance specifically refers to the participation of civil society in testing, monitoring, auditing and providing feedback on government tools. In essence, interest groups, corporate organisations and NGOs at international and local levels test the fiduciary trust. Governance is a process that establishes the legitimacy of government processes and holds the government accountable for the aggregation of interests articulated by interest groups. Government and governance processes are interlinked, but are also distinctly different (Turton *et al,* 2002).

6.6.5 Key institutional issues

The purpose of this section is to highlight key institutional issues to be considered for institutional and organizational arrangements when developing and implementing a WRCS. It focuses on institutional and organisational issues, with the objective of clarifying the key institutional issues to be considered in the development of the WRCS, and the institutional process of classification (i.e. the classification process), with the associated roles and responsibilities. While the discussion is aligned with the specific areas of focus of the WRCS project, it has to engage the broader IWRM environment, because organisational and institutional issues cannot be viewed in isolation.

6.6.6 Financial implications of setting a class

A key issue is the financial implications of the proposed class configuration. A lower class with less stringent RQOs will allow for proportionally higher water allocations and discharge and, therefore, increased revenue to the CMA through the WRM charge. Accordingly, the class configuration fundamentally affects the availability of financial resources for the CMA and for partner institutions engaged through the cooperative governance arrangements. Unless there is some form of payment for environmental services from society-at-large or from the State (including other CMAs), there will be a perverse incentive for CMAs to recommend lower resource class configurations. Although the DWAF, through its support and oversight role is required to ensure that such perverse incentives are countered, the institutional arrangements to prevent such perverse incentives from arising are hinged on the iteration between the CMS and the WRCP. Accordingly, the institutional arrangements to support this iteration are of importance and require careful consideration.

6.6.7 Social implications of setting a class

A further issue is the social and economic implications of the proposed class configuration. Although the WRCS seeks to define and balance the first order impacts of the proposed class configuration, in reality the effects of the class configuration on societal process and on the economy will be far reaching, particularly as the class configuration will interface with parallel process in the DWAF, Government generally and the wider stakeholder base. These effects are both beyond the scope of the WRCS and beyond the mandate of the DWAF and the CMA. Although it is likely that these impacts cannot be considered in advance, they should be carefully monitored and considered during subsequent reviews of the class. This is particularly pertinent as the drivers for the class and the nature of the catchment or WMA are temporally and spatially variable. Changes over time and space will, therefore, possibly require commensurate changes in the class.

6.6.8 Managing acceptability of proposed class

A further key issue is ensuring structures and processes to managing acceptability of the proposed class to government and to the stakeholders. Important in ensuring such acceptability is a rigorous process of stakeholder engagement and the development of cooperative governance arrangements to facilitate linkages with the development and planning process, and the conservation mandate and initiatives within the catchment. The accessibility, understandability and simplicity of the WRCS and of the WRCP are fundamental in managing acceptability of the system.

The WRCS must be therefore designed and implemented to ensure that government and all stakeholders understand the system and concur with the principles and process of the system. This is critical to ensure wide buy-in to the WRCP and, therefore, the resultant output of the process, (i.e. the class).

6.6.9 Managing linkages with the DWAF processes

The class configuration has a key influence on associated systems and processes within the DWAF, notably compulsory licensing and the WDCS. Linkages around these issues (both during the development of the WRCS and during the WRCP) between the relevant directorates within the DWAF will be critical to ensure that the objectives and the requirements of these parallel systems / processes are given adequate consideration during the implementation phase. To promote an adequate linkage, the WRCS must be sufficiently accessible, understandable and simple to implement to ensure that the relevant manager within the DWAF can engage on issued pertaining to the WRCS, the WRCP and the implications of the class configuration. It is extremely important to recognise that the WRCP (together with the WRCS) is one of the key measures that the DWAF will have to influence IWRM at a WMA scale and, therefore, should be adequately comprehensive in its scope, while being sufficiently simple to enable effective and efficient implementation given capacity and mandate constraints.

6.7 Institutional capacity

The implementation of groundwater protection zoning in South Africa requires a paradigm shift, for water resources management and decision-making, from a centralised management approach based on command-and-control, to a decentralised participatory model based on cooperative governance and coordination. The greatest need for capacity building is therefore to support this paradigm shift while developing skills and providing information to stakeholders and officials that must take responsibility for water resources management in the various WMAs.

In particular, previously disadvantaged and marginalised groups must be targeted for capacity building, so that they can meaningfully participate in the groundwater protection zoning process. Capacity building should not only be seen as developing skills, but rather as a broader process of developing financial, organisational, procedural and networking capacity, both at a personal and organisational level. Capacity building for groundwater protection must focus on the DWAF's regional offices and newly established water management institutions (particularly CMAs). By doing this, these institutions may build capacity in the organisations and groups with which they interact, such as catchment management fora, water user associations, water services institutions and other organs of state. Although DWAF will coordinate and facilitate capacity building, it may not necessarily be the organisation responsible for implementing capacity building programmes. Partnerships between the DWAF and other organisations should be authentic, particularly universities, technikons and non-governmental organisations.

6.8 Institutional conduit for cross-sector policy collaboration

Recognising that the national accountability for the protection of South Africa's groundwater resources resides directly with the DWAF, and implementation responsibilities within the broader water sector, a common and coordinated approach is needed. The overall objective of a sector-wide policy that addresses groundwater protection should be aimed at instilling a guiding framework within which the DWAF and the broader water sector can, through a shared vision and coordinated actions, give effect to the strategic protection of groundwater resources. In specific, the policy must be focussed on the need for:

- Setting national-level, explicit and quantitative targets to ensure that groundwater receives a high protection status;
- Assessing and managing groundwater protection in a systematic fashion across the national landscape as opposed to an ad hoc or site/ catchment-specific basis;
- Establishing a bridge between existing complementary national policies from within the water resource management sector and the environmental management sector respectively (particularly protection of groundwater resources); and
- Engaging hydrogeology and policy specialists as well as practitioners from across the water sector in debating policy options for the systematic management and protection of groundwater in South Africa.

6.9 Institutional conduit for implementing groundwater protection zoning

At present, groundwater management is driven at a national level (DWAF, 2007a). Though research and ambient monitoring of the country's groundwater resources could be managed at a national level, most groundwater management issues need to be dealt with locally (DWAF, 2004e). These include:

- Resource assessment;
- Reserve determinations;
- Setting resource quality objectives;
- Development of catchment management plans;
- Water use licensing and allocation;
- The management and monitoring of groundwater abstraction schemes; and
- Resolving groundwater contamination and related issues.

In earlier attempts (in the form of strategies) by the DWAF to address the change from national to regional groundwater management, emphasis was placed on management of groundwater quality (DWAF, 2000b). These include:

- A precautionary approach, which allows for current knowledge gaps;
- Differentiated protection, which recognises that important or vulnerable resources must receive priority; and
- General awareness building.

The aforementioned strategies are applicable to groundwater management as a whole and, accordingly, form an important approach to groundwater management nationally. In future, management of South Africa's water resources will take place at three levels, namely: national, catchment and local. Effective management (in the context of IWRM) requires trained and experienced staff, proper planning and data upon which management can be based. While ultimately the national government is the public trustee of the nation's water resources, water resource management in the future is to be delegated to regional or catchment levels. Within the catchments, water service authorities (usually municipalities) are to be responsible for ensuring access to water services. The national government has the obligation to ensure that water is protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner (RSA, 1999). Consequently, the national water resources strategy (NWRS) is being developed as the framework for water use in the country as a whole. It will be reviewed at 5-yearly intervals. Through the process of developing the NWRS in South Africa, groundwater has a unique possibility to become an equal partner to other water resources. This will be made possible through a number of planning, institutional and administrative changes that will take place during the next few years of transition.

It is imperative that the revised NWRS (i.e. in three year's time) adequately recognises the vital role groundwater plays, both in catchment management and as a strategic resource, especially in the drier areas and in smaller scale water supply schemes. A key element of the NWRS is the establishment of decentralised catchment management agencies (CMAs). These will take over the responsibility for managing water resources in 19 water management areas. Sustainable use of water resources will not take place unless resources are well managed, a fact well recognised in the NWA. Consequently, all CMAs will be required to develop and implement catchment management strategies. Historically, groundwater has been very poorly managed in South Africa, resulting in the resource being wrongly discredited as unsustainable. Various factors account for the history of poor management. These include:

- A lack of hydrogeological knowledge on the part of most users; and
- The historical private status of groundwater, which resulted in limited control of abstraction.

Conjunctive water use is the simultaneous use of both surface and groundwater as a source of water and clearly subscribes to the principles of IWRM. Inclusion of this practice, in the revised NWRS will stimulate awareness of how conjunctive use can be applied to water supply systems and promote greater discussion about alternative solutions to water problems facing South Africa. Conjunctive use could be used to address a number of issues including developing more groundwater based-urban water supplies, land subsidence, groundwater quality deterioration and provision of water during periods of prolonged drought when surface water supplies are diminished. The WSA which requires the development of a water services plan, is a tool CMAs will use to ensure proper planning and management of municipal groundwater resources. The CMAs and the DWAF must therefore ensure that local water services plans have adequate monitoring provisions to ensure sustainable use. To give effect to adequate groundwater protection through management practise, water user associations (WUAs) must be established and encouraged to assist CMAs with joint management of communal aquifers.

Guidelines for adequate aquifer management should be established and distributed by DWAF. These guidelines should cover, among others, sustainable use, abstraction scheduling, pump settings and monitoring requirements. The number of Reserve determinations being undertaken should be increased. This will reduce or eliminate the current backlog in Reserve determinations, which is retarding the issuing of licenses for groundwater use. A clearer definition of bulk water supply should be developed, possibly at CMA level, after consultation with environmental authorities. The formulation of guidelines related to EIAs for groundwater should also be strongly encouraged as educational tools for both the groundwater and environmental management communities. Research related to the impact of groundwater abstraction on ecosystems, together with the identification of groundwater dependant ecosystems must be emphasised. The DWAF and CMAs should proactively participate in the decision process related to land-use planning. In general, the aim should be to place high-risk activities in areas with no or little groundwater potential. Improved public awareness and involvement as a guard against degradation of groundwater resources remains pivotal. The public must be empowered to understand groundwater issues and appreciate the value of the resource.

The involvement of groundwater institutions and specialists in the debate and decision-making processes regarding South Africa's resources and environment will ensure sound groundwater management. Information about pollution, as well as pollution prevention must be included in a general awareness campaign regarding water use and water resources. National aquifer classification and Reserve determinations should be used by CMAs to identify important areas requiring more detailed classification. Special attention must be paid to sole source aquifers (aquifers that are the only source of water supply) and those where groundwater is important for aquatic and terrestrial ecosystems. Water and land-use licensing should be enforced vigorously, particularly in areas underlain by important or vulnerable aquifers. The regional offices of DWAF and the CMAs should, in a proactive manner and in co-operation with other authorities, track all new developments in areas underlain by important or vulnerable aquifers (DWAF, 2006d).

The DWAF (regional staff in particular) should participate in the evaluation of EIAs and intervene when impact assessments identify the potential for neglect or damage of the resource. DWAF, CMAs and groundwater specialists should pro-actively participate in land-use planning and strive to influence the planning so activities with a high groundwater pollution risk are placed in areas with low or no groundwater potential. Compulsory environmental management plans (including groundwater) must be provided for potentially polluting enterprises such as heavy industry, mining, waste disposal and waste water treatment. Sound management of all water resources depends on decisions being based on facts rather than beliefs and assumptions. For this reason, monitoring and information systems are critical for successful water resource management. Efficient and sustainable use of a catchment's groundwater resources cannot take place without adequate monitoring (DWAF, 2005a).

6.10 Strategic intervention through cooperative planning

The Department of Provincial and Local Government (DPLG) emphasizes an intergovernmental integration and coordination approach to ensure basic services, improve the quality of life and to eradicate the dualistic nature of the South African economy.

Intergovernmental integration and cooperative planning still require improvement so that the desired developmental outcomes of a groundwater source and aquifer protection (GSAPZ) zoning policy can be fully realised. Critical in this regard is to eliminate the inequalities, inefficiencies and wastage of the apartheid space economy and to ensure alignment and harmonization of all processes. Alignment and harmonisation imply greater consistency and synergy in the implementation of government policies (Figure 6.5). Integrated approaches where processes are aligned and harmonized are very relevant when it comes to institutional reform, especially in the case of the DWAF and the Department of Land Affairs (DLA) when undertaking water and land reform processes respectively.

In implementing the Government's development agenda, both the DLA and the DWAF should proceed from the premise that the challenges of coordinated resource protection prioritisation, resource allocation and implementation of a GSAPZ policy among other, would require the following:

- Alignment of strategic development priorities and approaches in all planning and budgeting processes;
- A shared agreement on the nature and characteristics of the space economy; and
- Strategic principles for infrastructure investment and development spending.

Figure 6.5 Cooperative planning (Source: After NDA, 2002)

With regard to alignment and harmonization within government and across spheres the challenges are to ensure that the processes should:

- Be structured and systematic not ad-hoc;
- Be sufficiently robust to facilitate integrated and coordinated action; and
- Have a positive and decisive impact on the common goals and objectives of government.

Alignment and harmonisation will be incomplete or hollow if any one of the three aspects is absent.

6.10.1 Integrated development plans

From the perspective of district and local municipalities' products, services and resources of various line function departments should be used to effectively implement a GSAPZ policy, as well as promoting effective communication and coordination with key role-players on the potential socio-economic benefits that will derive from its successful implementation. Improved integrated development plans (IDPs) guidelines are therefore necessary. Methodologies for better incorporating groundwater protection and sustainable use into the IDP processes should be piloted in a few municipalities, in order to refine systems and procedures and to inform the revised IDP guidelines. The recommendations in this regard are fourfold:

- Improved information and communication;
- Improved institutional coordination;
- Improved guidelines for IDPs; and
- Policy on service delivery on private land.

6.10.2 National spatial guidelines

National spatial guidelines can bring about cross-sectoral and intergovernmental policy integration by:

- Facilitating dialogue and exchange of information and understanding about the impacts of a GSAPZ policy given different social, economic, spatial, demographic and environmental contexts;
- Promoting the compatibility of such a policy with common objectives of government; and
- Making the connections between various water resource protection and related policies and actions more transparent.

6.10.3 National spatial development perspective

An overarching spatial framework and guidelines clearly spelling out the spatial priorities of government are critical to focus government action and provide the platform for alignment and coordination. Between 1999 and 2003 the Presidency prepared the National Spatial Development Perspective (NSDP), which was approved by Cabinet in January 2003 as an indicative planning tool to encourage interaction and coordination between departments and spheres of government. The NSDP provides a framework to deliberate on the future development of the national economy and recommends mechanisms to bring about optimum alignment between infrastructure investment and development programmes within localities and will enable government to answer two critical questions:

- One: *'If government were to prioritise investment and development spending in line with its goals and objectives, where would it invest/spend to achieve sustainable outcomes'?*
- Two, given the apartheid spatial configuration, *'What kinds of spatial forms and arrangements are more conducive to the achievement of our objectives of democratic nation building and social and economic inclusion'?*

6.11 Research findings on legal, socio-economic and institutional arrangements

The sequential examination of literature on groundwater protection zoning in general (Section 2.2) and on evaluating the legal, socio-economic and institutional arrangements in particular (Chapters 4, 5 and 6), culminated in the conclusion that social, economic and regulatory measures should be coordinated with best available technologies in order to give effect to comprehensive groundwater source and aquifer protection zoning in South Africa. It appears from the discussion in Chapters 4, 5 and 6 that a strong relationship exists between the socio-economic aspects (lets say 'the people' and institutional and legal dimensions of groundwater protection zoning. The institutional and legal dimensions are not just abstract autonomies being independent from the people living there. On the contrary, it's the people that determine and shape those institutions and laws. In South Africa, a certain level of good governance is experienced as a result of the country's Constitution which requires cooperative governance, representation and participation from among different government departments including water sector institutions. In this instance, various water sector institutions, policies and laws can be used as instruments to influence groundwater use behaviour of the people. However, the success of a groundwater source and aquifer protection zoning policy to regulate groundwater use is strongly dependent on people's willingness to comply with it. Hence within the institutional and legal dimension of groundwater protection zoning, the participation of and commitment of the people is of utmost importance.

As groundwater should be recognised as a natural resource with economic and ecological value, groundwater strategies should aim at sustainable use of groundwater and preservation of its quality. These strategies should be flexible so as to respond to changing conditions and various transboundary and local situations. In some cases, it is already too late to talk about the sustainable development of groundwater because the aquifers are already depleted, polluted or salinized beyond the regenerative capacity of their natural hydrogeological regimes. In this instance, technical regulation, economic incentives and participatory management approaches may offer the means to address groundwater management in the common interest. However, the character of the initiatives will be determined by the local realities of the groundwater occurrence and the associated groundwater economy. Therefore, it is essential to examine the scope for groundwater management not only in the strictest sense, but also as a prerequisite for integrated water resource management.

In South Africa, though not always easy and cost-effective, the Department of Water Affairs and Forestry (DWAF) is the central authority that controls all the operational and regulatory functions related to water. Here, the purpose of the Department's intervention is the protection of the broader public interest in the country's water resources. While the DWAF is guided by equity, sustainability and efficiency principles of the NWA, this tendency in centralised water resource management risks ignoring the important but highly distributed physico-chemical and socio-economic buffering roles for groundwater. The approach may also rely heavily on regulatory measures as opposed to economic incentives to achieve desired results. More significantly, the array of different stakeholders with whom the Department tends to engage may differ markedly from the so-called 'groundwater stakeholders'. Thus, it can be argued that integrating groundwater protection within a comprehensive IWRM framework becomes not only an environmental necessity but also a political imperative where policies of decentralisation and subsidiarity are adopted.

7. POLICY PROCESS AND OPERATIONAL PREPAREDNESS

7.1 Introduction

In order to understand the complexities relating to the implementation of a potential groundwater source and aquifer protection zoning policy, it is necessary to contextualise the situation in which policy is made and applied. Research has shown there are two main drivers at work globally within the policy-making environment (Turton, 2004). These two drivers relate to two specific aspects of policy-making, namely the locus of management (the place in which policy-making and implementation is undertaken) and the focus of management (the subject of the policy-making and implementation).

A further investigation by Turton (2004) resulted in the identification of four high-level drivers of effective policy implementation as illustrated earlier in chapter four, with each driver consisting of constituent components (see Table 7.1 below).

Table 7.1 Four high-level drivers of effective policy implementation (Source: After Turton, 2004)

Ability of government to generate effective policy • Political maturity; • Holistic thinking; • Acknowledgement of limitations; • Focus within government; • Mindset flexibility • Agility; • Transformational leadership; • Understanding of society; and • Vision.	**Appropriateness of policy for its intended purpose** • Integration of creation and implementation of policy; • Identification of the implementer; • Understanding of governance; • Pragmatism (of policy); • Appropriateness of communication mechanism; • Sound policy and clarity of goals; • Performance measurement; • Enabling instruments; and • Knowledge driven.
Receptiveness of society • Realism of expectations; • Addressing of needs; • Confidence in government; and • Societal responsibility and lawfulness;	**Appropriateness of logistics and institutional capacity** • Practicality of action plans; • Performance measurement; • Implementer's support of action plans; • Existence of implementation champions; • Availability of resources; • Effective policing and sound legislation; • Cultural alignment; • Implementation instruments; • Alignment of doctrine and policy; and • Effectiveness of management procedures.

7.2 The Constitution and intergovernmental relations

The context of the Intergovernmental Relations Framework (IGRF) Bill is Section 40 of the South African Constitution, Act 108 of 1996; that recognises that much as the political power has been decentralised; and that the process of decentralisation has led to a fragmentation of government institutions; the various centres of political power need to work together in order to fulfil the mandate of government as a whole of policy making, implementation and service delivery. In other words, despite the fact that government power has been divided between the three spheres of government, government should still operate as one business unit, for the simple reason that all spheres of government impact on the same citizens. There are other reasons that make it imperative for the different spheres of government to work together in a co-ordinated manner; these include:

- Avoiding duplication of actions, which could result in wastage of resources;
- Avoiding a possibility of conflicting policies and interpretation of policies; and
- Avoid re-inventing the wheel, to minimize conflict, etc.

In cases of disputes, as there might be intergovernmental relations disputes from time to time, the Bill also provides for a dispute resolution mechanism and procedures to facilitate the settlement of such intergovernmental disputes. The Bill by and large also recognises that intergovernmental relations had been part of the day-to-day business of government since 1994, and therefore seeks to build on that foundation. The Bill does not necessarily prescribe structures of intergovernmental relations; it creates an environment within which various intergovernmental relations activities can take place with a degree of predictability.

The environment of intergovernmental relations that the bill is promoting includes the recognition of the importance of each sphere to consult with other spheres; coordination of actions in the implementation of policy, legislation or decisions affecting the interests of other spheres of government; avoiding duplication and there avoiding wastage of resources; cooperation in the sharing of information; and speedy resolution of intergovernmental disputes. The role of certain structures such as the President's Co-ordinating Council, the composition thereof and its role are set out in Chapter 2 of the Bill. Much as the membership that is indicated under Section 6 (1) the Bill, it excludes the Minister of Water Affairs and Forestry. The membership of the Council that is ordinarily provided for includes the President, who is the chair of the Council; the Deputy President; the Minister in the Presidency; the Minister of Provincial and Local Government; Minister of Finance; Minister of Public Service and the Premiers of the nine provinces. However, Section 6 (3) (a) of the Bill provides that any other Cabinet member could be invited by the President to a meeting of the Council.

7.3 Departmental mechanisms and structures

It is essential that the framework for developing a groundwater source and aquifer protection zoning policy within the context of operational policies and regulations be clarified. The chief directorate: Resource Directed Measures (RDM) within DWAF is currently taking the lead with respect to the development and implementation of protection policies, with strong interfacing with other chief directorates in terms of IWRM.

Accordingly, relationships between the RDM chief directorate and the following chief directorates will have to be developed, around the development and implementation of a potential groundwater source and aquifer protection zoning policy:

- **Integrated Water Resource Planning** - on issues of integrated national planning and options analysis (e.g. reconciliation and compulsory licensing);
- **Water Use** - on issues of quality, quantity and instream use, and the deployment of source directed controls (e.g. the waste discharge charge system);
- **Information Management** - on information needs for the resource assessment process, and for the monitoring and evaluation of the resource; and
- **Infrastructure Branch (Infrastructure Agency)** - on the impact of the protection zone configuration on off-take agreements and the development of water resource infrastructure.

7.4 DWAF as sector leader and custodian of groundwater resources

The Department Water Affairs and Forestry's (DWAF) involvement with respect to groundwater source and aquifer protection zoning should be focused on enhancing the capacity of local government to address the challenges in the water sector and deliver on its mandate to protect water resources as stipulated in Chapter 3 of the NWA. The implementation of a local government support strategy by the DWAF's Policy and Regulation branch, in partnership with the South African Local Government Association (SALGA) and the Department of Provincial and Local Government (DPLG), should emphasise the importance of groundwater source and aquifer protection zoning to ensure effective and sustainable water services through:

- Capacity building and skills development in the sector, including training programmes for new councillors;
- Deployment of technical expertise in municipalities;
- Implementation of priority actions emanating from the presidential engagements;
- Monitoring the implementation of plans developed by municipalities during the Water Summit; and
- The creation of a knowledgeable sector by promoting information and knowledge sharing.

7.5 Financial implications of future implementing agencies

A great deal of change in government processes and systems has characterised the move to a democratic South Africa. Changes invariably have a number of implications for the way things are done and managed. A critical problem with the implementation of government tools in South Africa today has been poor administration, poor change management and a lack of a clear path to the destination. As a result there is inadequate knowledge on how to 'get things done'. Every change has a cost. Transaction costs in terms of financing are an inevitable result of the change management process. The extent and implications of these costs are often not fully understood at the beginning of any change process, so adaptability must be built into any changing government structure and / or process. Change management is also a symptom of all the above strategic level obstacles. Consequently, change management is based on managing and accounting for the impact of obstacles to the implementation of government tools.

7.6 Availability of skilled human resources

The political imperative of the anti-apartheid struggle dictated that all former government structures should be restructured. While this is a necessary condition for the democratic transformation of South African society, it has a number of unintended consequences. The most profound of these was the widespread and, in places, complete loss of institutional memory. Institutional memory is particularly important where management of a technical nature is concerned. The result of this has been the emergence of a set of government structures that differ fundamentally from their former arrangements, without the time needed to capture and save the institutional memory and norms relevant to the future. A second dimension to this obstacle is that in an attempt to re-dress the gross social inequities of the past, rapid attempts have been made to fast track representativity. Known under different names such as affirmative action or transformation, this has placed relatively inexperienced people into senior management positions, confronted by high levels of complexity, without the individual's prior sufficient knowledge or capacity to act. An individual's knowledge is a component of institutional memory (Turton, 2004).

The inexperienced manager suffers from two shortcomings, namely lack of personal knowledge (capacity to act) and lack of connectivity with institutional memory (and sometimes complete absence of such a memory where the transformation has been too radical). Institutional memory is somewhat outside the individual, but the connectedness and access that an individual or manager has to this memory is important and is a valuable resource. Institutional memory also has a down side. It is this memory that makes it difficult for you do unlearn old habits and do things in new ways. People tend to fall back to what worked in the past – partly due to institutional memory. In a society, where the core principles on which decisions are based have changed, the reluctance to accept and/or inability to internalise these principles due to 'old norms and standards', will hamper implementation. This issue links to the change management and succession planning on a tactical level (Turton, 2004).

7.7 Stakeholder engagement in the policy process

In a democratic society, government processes should reflect the aggregation of interests that have been articulated by interest groups and civil society, which is a participative style of government. Developing an accepted culture of participative government takes time and a deeper understanding of the needs and wants of society. Prior to 1994 government was based on a top down approach, whereas after the 1994 democratic elections government is embracing a participatory and decentralised approach. Government is thus moving towards more decentralised forms of decision-making. This is reflected in the devolvement of decision-making power to provincial and local government structures as stipulated in the Constitution and various Acts. However, the resources including the various skills, knowledge and capacity, required for such decision-making powers, are not evident in some of the local and provincial government structures as of yet. South Africa is currently in the throes of implementing a very enabling and progressive water law. Ironically, the very fact that the act is enabling makes it open to multiple interpretations and thus diverse and sometimes conflicting approaches and philosophies to implementation. Generating a shared vision and understanding of what the act must achieve is very important. It is useful to use a step-wise approach to implementation – one that moves along in phases where every phase requires reflection and consolidation of learning before the next phases are tackled (MacKay *et al*, 2003).

7.8 Guidelines for participation in water resource protection through RDM

The NWA requires participation of society at large in the progressive development of the national water resource strategy (Chapter 2, Part 1 of NWA, explanatory note). It further requires that the public be enabled to participate in managing the water resources within its water management area (Section 9 of the NWA). The Department of Water Affairs and Forestry (DWAF) is currently working towards a holistic process that will integrate the public participation processes for licensing, resource directed measures for water resource protection and catchment management.

The advantages of such an integrated approach are likely to be as follows:

- Better understanding by stakeholders of the 'bigger picture' (i.e. IWRM framework);
- Optimising public participation time and costs; and
- Reducing public participation fatigue among stakeholders.

In the interim, these guidelines should be considered as a phased approach since it has its focus on public participation for water resource protection through resource directed measures (RDM), particularly those most vulnerable and stressed water resources that are on the critical path for water use licensing that cannot wait until a fully integrated process has been developed. The International Association for Public Participation (IAP2) differentiates between five levels of public participation, each with different objectives and with an increasing public impact on decision-making (www.iap2.org):

- **Inform** - The objective is to provide the public with balanced and objective information to enable people to understand the problem, alternatives and/or solutions.
- **Consult** - The objective is to obtain public feedback on analysis, alternatives and/or decisions. It involves acknowledging concerns and providing feedback on how public input has influenced the decision.
- **Involve** - The objective is to work directly with the public throughout the process to ensure that public issues and concerns are understood and considered at every stage and directly reflected in the planning, assessment, implementation and management of a particular proposal or activity.
- **Collaborate** - The objective is to work with the public as a partner on each aspect of the decision, including the development of alternatives and the identification of the preferred solution.
- **Empower** - The objective is to place final decision-making in the hands of the public (note that the word "empower" refers to a level of participation and not to the concept of 'empowerment' in the sense of capacity building).

No two public participation processes are the same. They have different stakeholders, take place in different areas, apply different public participation methods and apply them in a different order, and are conducted in different languages by different people. Some take a long time and are very costly; some take barely two or three months and cost little.

7.8.1 Criteria to determine level of effort

Experience shows that the level of technical assessment and public participation effort is a function of a combination of the following (Greyling, 2001):

- The anticipated scale of impacts;
- The scale of sensitivity of water resources; and
- The anticipated scale of public sensitivity.

Figure 7.1 below illustrates this concept. When both the scale of anticipated impacts and the scale of public sensitivity are expected to be high, the process will be complex, with higher cost, higher publicity and more time-consuming iterations. Conversely, when both the scale of anticipated impacts and the scale of public sensitivity are expected to be low, the process will be simple, less costy, take little time and is not likely to attract much publicity. The degree of confidence of Reserve determinations is also indicated in the diagram. Broad criteria for determining the scale of predicted impacts, the scale of sensitivity of water resources and of public sensitivity, are provided below.

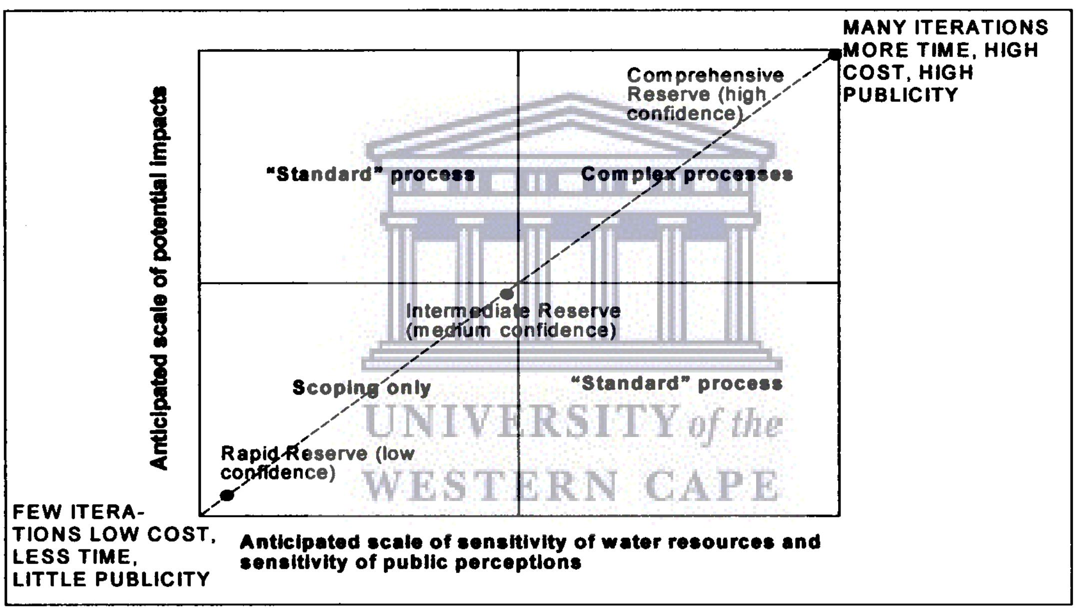

Figure 7.1 Level of public participation for RDM (Source: After DWAF, 2005b)

7.8.2 Scale of anticipated impacts

The level of effort for technical evaluation and public participation will increase with the following:

- How stressed the catchment is in terms of water use;
- A high population density relative to the assurance of water supply in the catchment;
- The level of planned development and the degree to which people rely on water as a sole stimulus for economic growth;
- The degree of trade-offs that may be required, i.e. the demand for water between different water user sectors within a catchment;

- Aggregate and cumulative impacts, for example planned future industrial or mining development in an area where water quality has already deteriorated due to industrial or mining effluent; and
- The number of issues expected to be raised by authorities and stakeholders that would need to be incorporated into the technical assessments.

7.8.3 Sensitivity of water resources

The sensitivity of the water resources is a major determinant of the effort required in both technical evaluation and public participation. If any of the following is present, the level of effort will increase:

- Catchment areas where multiple users rely on water as the principal source of making a living;
- Stressed catchments with multiple sectors of water users are already in conflict;
- Catchments which are the source of inter-basin transfers;
- Sensitive mountain catchments;
- Catchments with internationally shared water courses;
- Nature Reserves, National Parks, Ramsar sites or World Heritage Sites, as well as areas with the potential to be recognised as such; and
- Areas with a spiritual, traditional or religious value based on water (e.g. in some initiation ceremonies, the water level of a resource must be at a specific height before initiation can commence; baptism in some religions require full submergence).

7.8.4 Sensitivity of public perceptions

The sensitivity of public perceptions is often linked to the sensitivity of the water resources. In addition, public sensitivity will be higher where the following current or historic factors are at play:

- Perceived inequity, e.g. where users in a catchment that is the source of an inter-basin transfer or where the water course is shared internationally perceive that 'their' water is being taken away;
- Current or past conflict and mistrust among users or between users and the Department in regard to water use and water rights, or in regard to management of water quality;
- Perceived fears of a reduced future water supply especially in the case of catchments where multiple users rely on water as the principal source of making a living, and especially where this involves land that has been in families for generations;
- Past incidences of pollution and deterioration in water quality;
- Recent negative press for the DWAF;
- Insufficient or non-existent water supply and sanitation for local communities (although the process focuses on water resource management, water supply and sanitation issues will surface);
- The presence of vociferous and empowered stakeholders with their own agenda, or that mistrust the Department; and
- Time pressure during the process.

7.8.5 Other considerations

The following considerations will also influence the level of effort required for public participation during Reserve determination studies:

- **Previous public participation processes** - When little or no previous public participation took place in the area, more effort and iterations will be required to explain the purpose, process, rights and responsibilities of stakeholders. If previous processes resulted in mistrust, fears and unmet expectations, or if stakeholders felt excluded from previous processes, more effort, information and iterations will be required.
- **Degree of trust in the authorities** - If major stakeholder groupings mistrust the authorities, more effort, information and iterations will be required.
- **Degree to which stakeholders empowered** - When the level of understanding and experience is low, more information and iterations will be required.
- **Degree to which stakeholders are already organised** - If most major stakeholder sectors are represented by efficient, organised structures such as local environmental and water forums, the process will be easier and less costly.
- **Sectors of society represented in catchment area** - The more sectors of society, the more effort will be required to ensure that spokespeople for all water user sectors are captured on the database.
- **Number of languages** - If not possible to conduct the process only in English, time and cost for translations will increase.
- **Size of catchment or sub-catchment** - If the catchment is large, the size of the initial stakeholder database, logistics and advertising costs will increase.
- **Number of provinces involved** - If a catchment spans more than one province, the stakeholder database needs to include the same provincial government departments in both provinces.
- **Degree of prior capacity-building** - If no previous capacity building related to water resource management has taken place in the catchment, capacity-building will have to start from scratch.
- **Range of education levels of stakeholders** - If the education levels of stakeholders in a catchment range from highly sophisticated to totally disempowered and illiterate it will necessitate more effort.

7. 9 Land tenure opportunities and implications for protection zoning

Land tenure in South Africa is regarded by many as posing a major challenge to all spheres of Government (i.e. national, provincial and local level), as well as civil society. The land tenure system is the basis on which the rights to occupy, use and benefit from land are held, for example by permission, lease private or communal ownership. The tenure system also determines who has or who can get these rights. Following the detailed earlier discussion on policy and legal matters relating to water resource management in chapter four of this research study, it is clear that numerous legislation have emerged in the last few years attempting to address natural resources management. It must however be stated that no single piece of legislation administrates natural resources governance per se. The introduction of new institutional arrangements (such as CMAs), together with principles, policies, laws and planning instruments have all added uncertainties as to where the locus of power for natural resource management resides (Pollard & du Toit, 2005).

In terms of land reform, two new pieces of legislation have direct bearing on local level governance of natural resources: the Traditional Leadership and Governance Framework Amendment Act, Act 41 of 2003 (TLGFA) and the Communal Land Rights Act, Act 11 of 2004 (CLRA). Although water reform has not specifically addressed the issue of legal pluralism, opportunities do exist for embracing local-level governance regimes within the formal, institutional arrangements derived from national statutes, as discussed earlier in more detail in Chapter 6 of this thesis. Overlaid on this legal pluralism is a South African State and society in transition. This means that policies and statutes, together with associated planning instruments are changing. Included in this changing landscape are both water and land reform programmes which will bring changes to governance and management. Emerging from this is uncertainty around the concepts of ownership, trusteeship, custodianship and stewardship. Further, the drive to democratise and decentralise the responsibilities for natural resource management is confounded by the disaggregation of issues (i.e. water, land and environment) and responsibilities (Pollard & du Toit, 2005).

The policies and legislation of South Africa have been developed also in such way as to provide an enabling environment that ensures diverse groups, perspectives and practises can be accommodated in a meaningful way. The NWA clearly locates the powers and functions for both surface and groundwater resources management. As discussed earlier in chapter six, certain functions are held by the Minster of Water ad Forestry whilst others are devolved to CMAs. However, the NWA does not specify community governance per se, which reflects the lack of discourse on this issue in the water sector during the consultative process that preceded the drafting of the Act, rather than any pejorative stance on the issue. In contract, participation in water resource management is a key feature of the NWA. Nonetheless, opportunities do exist for the devolution of governance responsibilities within the overarching proposed IWRM framework for undertaking groundwater source and aquifer protection zoning, as discussed in Chapter 2 of this research study.

The devolution of certain functions to civil society has been illustrated and discussed in Chapter 6 (Figure 6.2) within the context of water resources classification, taking into account both surface and groundwater dynamics. Furthermore, the criteria to determine RDM is also directed to take into account civil society initiatives. Nonetheless, this engagement should not be confused with governance: the former talks to issues of participation whilst the latter places the locus on power in the hands of a community and embraces the notion that the power to control rights of access and use is locally-based. Thus, it is important to develop a GSAPZ policy that is meaningful and appropriate, with the requisite simplicity – and no more. Moreover, the *de facto* control over natural resources in communal areas is derived from locally-based common property regimes. The un-integrated nature of western statues compounds already vulnerable governance systems. Therefore, the two aforementioned laws on land tenure may further complicate the implementation of a GSAPZ policy in the communal lands of South Africa, should the process of developing such policy not take into account the importance of land tenure.

7.10 Application of an overarching IWRM framework

Figure 7.2 below illustrates how an overarching IWRM framework was applied on a catchment scale (i.e. the Komati River Catchment). Of particular importance in this study was the inclusiveness of most IWRM aspects which have been addressed throughout a high confidence ecological water requirements (EWR) study conducted by the chief directorate: resource directed measures (RDM) in the DWAF. This case study is discussed in more detail in the Chapter hereafter.

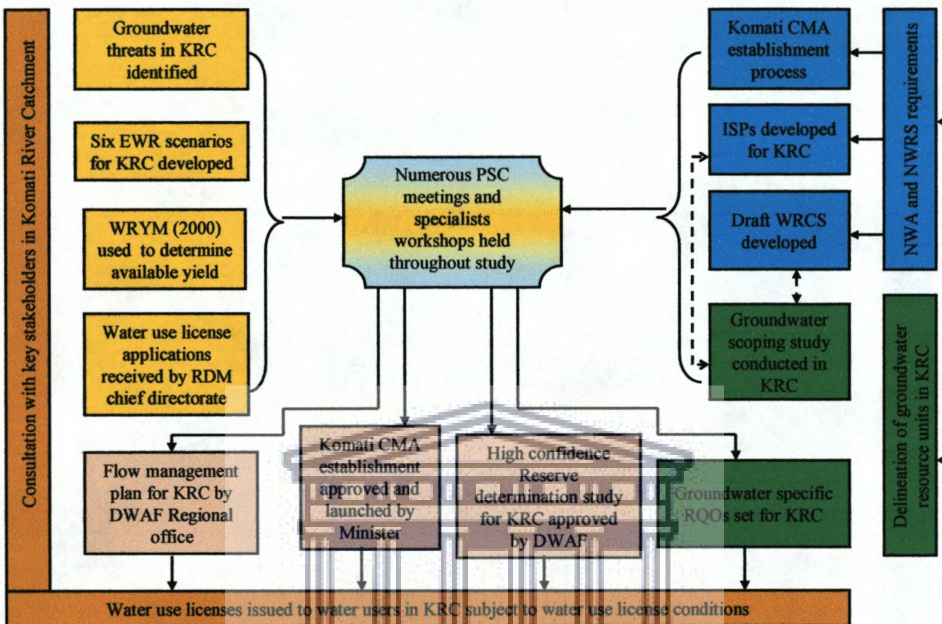

Figure 7.2 Application of an overarching IWRM framework

8. THE INKOMATI CASE STUDY

8.1 Introduction

The Inkomati Basin (Figure 8.1) comprises of the Komati, Crocodile, Sabie and Sand River catchments which are all part of the Incomati shared watercourse between the Republic of Mozambique, the Kingdom of Swaziland and the Republic of South Africa. Because the Inkomati Basin is a shared watercourse, the principle of 'equitable and reasonable utilisation' between the three countries is applicable. The interim Inco-Maputo agreement provides for the water sharing (and to a limited extent benefit sharing) of the available resource by cooperation through the joint mechanism of the Tripartite Permanent Technical Committee formed between the three countries.

The available water in the Inkomati water management areas (WMA) has been allocated for use by the existing users in the WMA as well as transfer for strategic use in power generation in the Upper Olifants catchment. However over the years there has been increasing growth in water demand in all the water using sectors of the Inkomati and the need to meet the Reserve (both ecological and basic human needs) in order to ensure ecosystems maintain water flows and supplies in the long as required by the National Water Act, Act No 36 of 1998 (NWA). This has put severe strain on the water available for allocation to existing users as well as future potential water users.

8.2 Purpose and Scope

The selection of this case study was based on the complex and challenging nature of water resource management aspects, particularly from a legal, institutional and socio-economic context relating to groundwater protection zoning. Through this case study, the overall water use and allocation reform in the Inkomati Basin is evaluated from an IWRM perspective (Section 8.3). Subsequently, a more in-depth discussion then followed of the ecological water requirements (EWR) of the Komati River catchment (Section 8.4), in relation to groundwater protection zoning with an emphasis on the legal, socio-economic and institutional arrangements.

8. 3 Water use and allocation reform in the Inkomati WMA

The water available for allocation in the Inkomati WMA was determined from the Internal Strategic Perspectives (ISP) of the Inkomati WMA. An estimate of the ecological water requirements (EWR) of the Crocodile, Komati and Sabie was determined from a preliminary ecological Reserve determination desktop study. However, the comprehensive Reserve determination study conducted for the whole of the Komati River Catchment (Section 8.4), determined that the present ecological state of the various river reaches should be maintained except the lower Komati which is highly degraded, where improvement of the current ecological water resource status was recommended. Since the ecology is degrading, this would require additional environmental flows to be left in the river. The present ecological status of the Komati River catchment varies from a good ecological condition, in the upper Komati and some tributaries, to a bad ecological condition in the lower reaches of the Komati. This indicates that the lower Komati is highly degraded. This is attributed to the number of weirs regulating the flows (DWAF, 2004c).

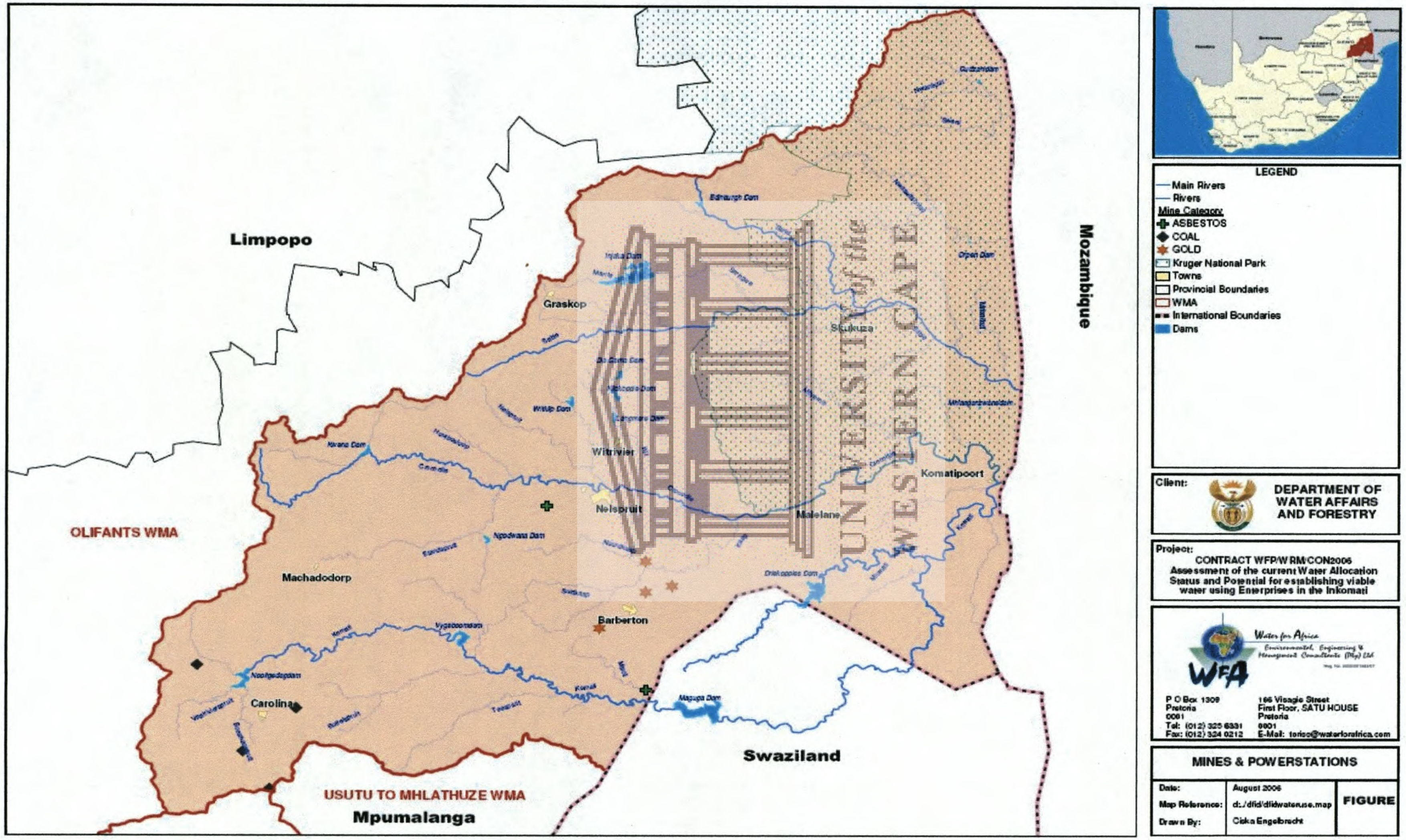

Figure 8.1 Overview of the Inkomati Basin (Source: DWAF, 2004c)

Furthermore, because the Inkomati is a shared watercourse, the water requirements from the interim agreements were taken out of the available water to determine the water available for allocation to the water users in the Inkomati WMA. The water available for allocation as at 2004 updated from the ISP to include transfers from Maguga Dam is indicated in Table 8.1 below. As can be seen from Table 8.1, the available water is estimated to be 861 million m^3 per annum. This is the reliable or safe yield that the Inkomati can provide, which allows one failure to supply in 50 years. This comprises water transferred from the Maguga Dam which is situated in the Kingdom of Swaziland. The dam is part of the shared project including Driekoppies Dam between South Africa and Swaziland (DWAF, 2004c).

The major sector using water for beneficial uses in the Inkomati WMA is the irrigation sector which is located mainly in the lower Komati, the middle and lower Crocodile and the Sabie Catchments. Irrigation water requirement accounts for about 83% of the demand as at 2004 followed by urban water requirement (2%) and reduction water flowing in rivers due to commercial forestry plantations (6.9%).

Table 8.1 Available water (in million m^3/a, in 2004) for allocation (Source: After DWAF, 2004c)

Resource	Upper Komati	Lower Komati	Crocodile	Sabie/Sand	Total
Surface water	118	259	252	159	788
Groundwater	1.4	9.1	8.4	0	18.9
Transfers in	0	39	12	2.7	53.7
Total available	**119.4**	**307.1**	**272.4**	**161.7**	**860.6**

About 8% of the water available for allocation in the Inkomati WMA is being transferred out of the catchments for use in power generation in the Olifants WMA. This water is considered as strategic water use because of the importance of power generation in driving the economic growth. The water available for allocation in the Inkomati WMA is currently 177% allocated. This means that the WMA is over-allocated based on the reliability of supply determined for the existing water users, and assuming the Reserve and international requirements are being met. At present this situation is masked by the fact that the water users are abstracting water meant for the ecological Reserve which has priority over all other users and is meant to be left in the rivers to maintain the ecology. Furthermore the water required to meet international obligations is not always reaching the downstream country of Mozambique and is being abstracted for use water by users in the Inkomati WMA.

The figures in Table 8.2 represent the water requirements and/or allocation as at 2004 and do not represent the actual water use. It is however important to note that it is not correct to use the allocation. The difference between water use and water allocated is attributable to a range of factors including (DWAF, 2004c):

- Allocations are generally based on maximum demand (e.g. irrigation allocation based on a dry year, entire area irrigated/planted and crops which use most water) and it is calculated taking these factors into account. This may not necessary be the case with some years being wet years and the use being far less than the allocation.

- Allocated volume will not be required every year (e.g. some land not irrigated, industrial plant production being less than 100% for a period).
- Allocated amounts are in excess of what can be actually used.

Table 8.2 Water use by sub-catchment and sector in the Inkomati WMA (million m^3/a) at 2004 (Source: After DWAF, 2004c)

Category	Water Requirements	Percentage of Total	National Average[1]
Irrigation	1 369	83%	59%
Urban	31	2.0%	25.1%
Rural	3	<1%	4.3%
Mining/industrial	4	<1%	5.7%
Afforestation	114	6.9%	3.67%
Transfers out	126	7.7%	
Total	**1 647**	**100%**	**100%**

The current water requirements in all the three catchments of the Inkomati WMA indicate that it is more than the available water for allocation at much lower risk of not getting the full water allocation in some years. This deficit is indicated in Table 8.3 below.

Table 8.3 Current water balance in million m^3/a (Source: After DWAF, 2004d)

Sub-Catchment	Total available for allocation	Water Requirements	Balance
Komati	426.5	883*	(456.3)
Crocodile	273	664*	(391)
Sabie/Sand	162	101	61
Total	**861**	**1 648**	**(786.3)**

** Includes the transfers out of the catchment as well as afforestation.*

The water requirements figures increased significantly in the Komati and Crocodile catchments due to (DWAF, 2004c):

- Illegal water use by some of the existing water users; and
- There may have been improvements in water use efficiency by the irrigators.

The Inkomati WMA represents a river system nearly fully utilised under present development conditions. The WMA represents a significant portion of economic activities in the Mpumalanga province. If the economic activity is expressed in terms of Gross Domestic Product (GDP), the WMA represents 2.3% at the national level and 33.9% at provincial level (Mpumalanga) respectively. The number of direct employment opportunities in the WMA is around 211 000 which represent 1.7% of the national and 26.4% of the Mpumalanga province totals. In terms of a sub-regional perspective, Figure 8.2 represents a graphical presentation which demonstrates the position of the four sub-regions namely Komati West, Komati North and Sabie/Sand (DWAF, 2004c).

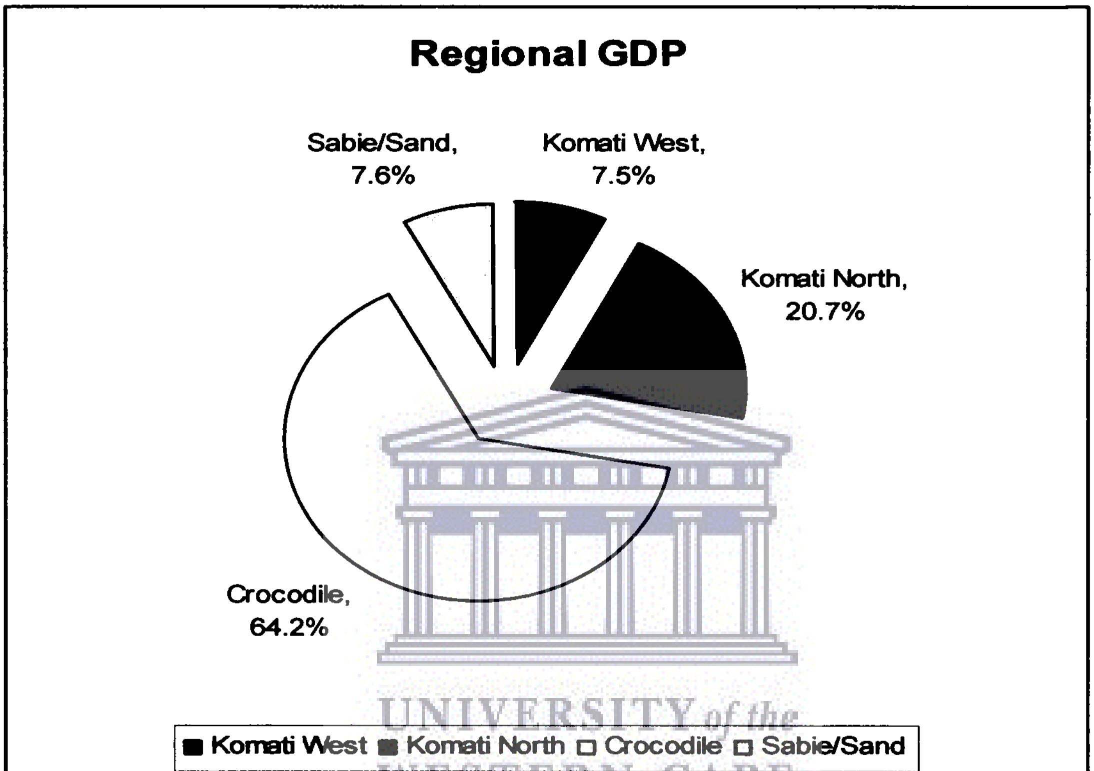

Figure 8.2 Regional gross domestic product (Source: After DWAF, 2004c)

Figure 8.2 demonstrates that the Komati catchment represents the second largest percentage (after the Crocodile sub-catchment catchment) of the economic activity in the WMA if expressed in terms of gross domestic product (GDP). Figure 8.3 below, further illustrates that the Komati catchment sustains the second highest number of employment opportunities after the Crocodile catchment (DWAF, 2004c).

In the different economic sectors, 34% of the gross domestic product (GDP) is in the manufacturing sector, which represents the largest sector. However, as far as employment is concerned, irrigation agriculture represents 34.2% of the total and together with forestry it represents 45.2% of all employment in the sub-catchment. If it is taken into consideration that agro industries are classified with manufacturing, it then emphasises the importance of irrigation agriculture and forestation in this context (DWAF, 2004c).

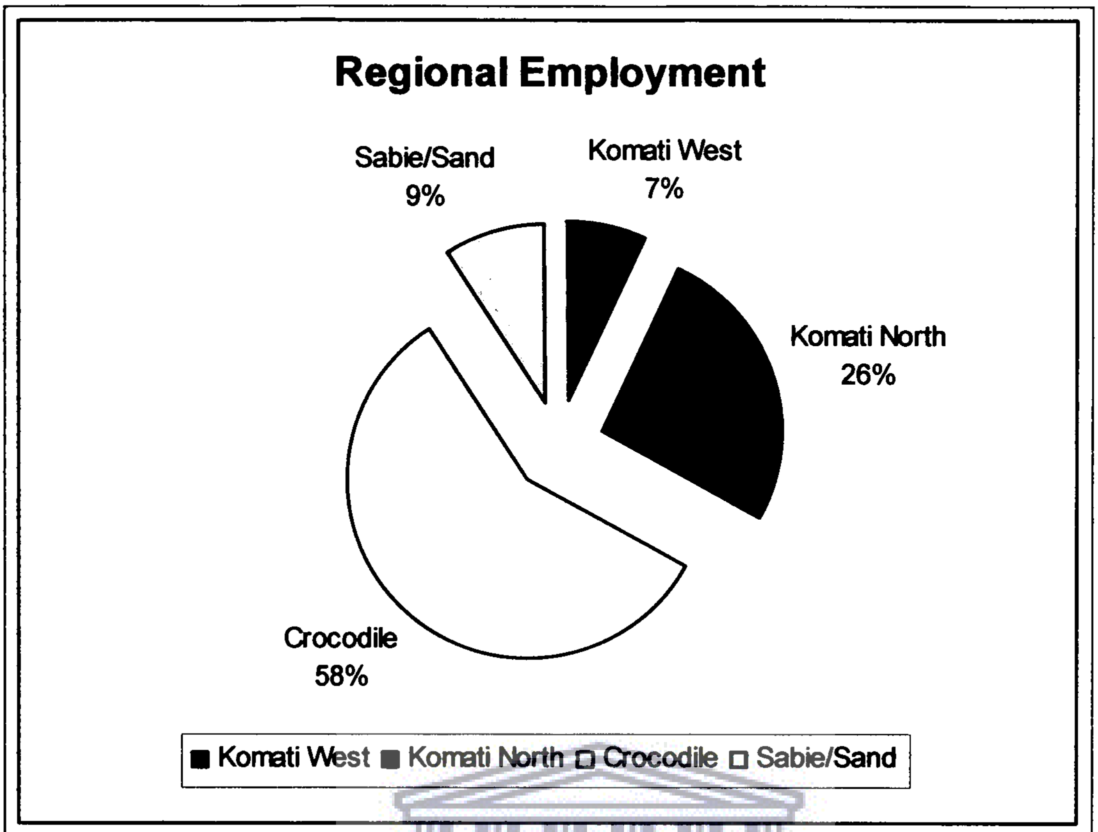

Figure 8.3 Regional employment (Source: DWAF, 2004c)

As a result of the relative importance of irrigation agriculture and forestry in terms of job creation, it is also necessary to put the economic importance of the other sectors into perspective by using GDP as a measuring instrument. Also, from Figure 8.4, it can be deducted that manufacturing is by far the largest single contributor to GDP, namely 34 % with agriculture and forestry contributing 13%. Although agriculture, specifically irrigation and forestry are by far the biggest water users and contributes 45% to employment creation, their contribution in terms of GDP is relatively small at only 13%. The value of water must also be evaluated against the importance of water for social development. This specifically applies to irrigation agriculture where the contribution to the GDP is relatively small but its contribution to employment creation is very important. Together with forestry these two sectors normally employ large numbers of unskilled workers in the rural areas, and are very often the only sectors that create employment in this specific area (DWAF, 2004c).

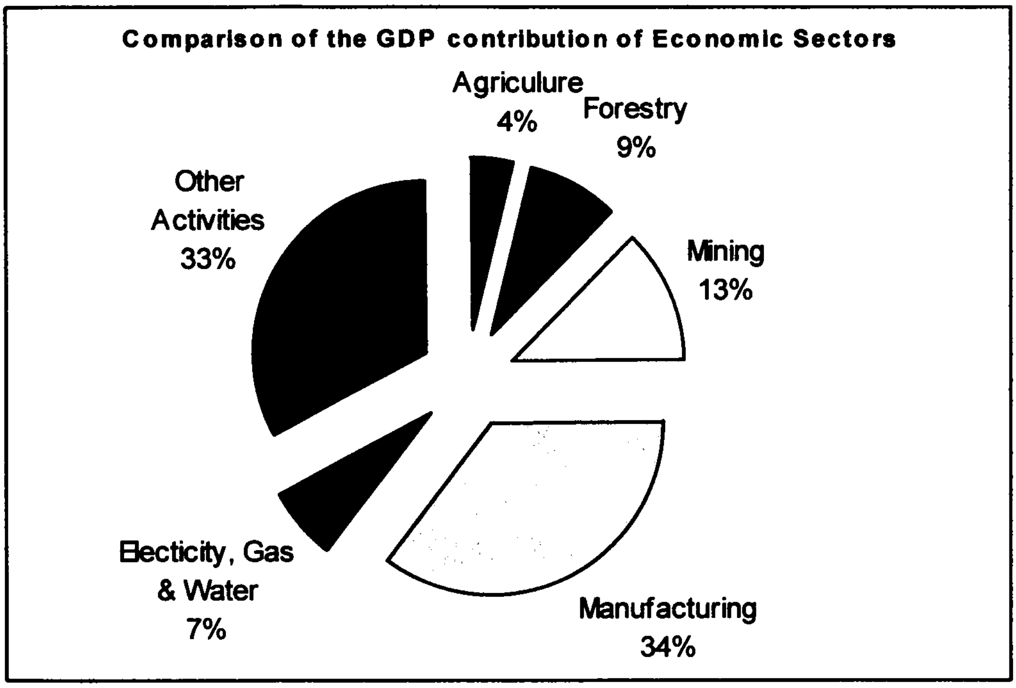

Figure 8.4 Comparison of GDP contributions by economic sectors (Source: DWAF, 2004c)

In the Komati North sub-catchment in the Komati River from Mananga to Komatipoort, 7327 out of 22 213 hectares or 33% of hectares irrigated is cultivated by black farmers. Below the Driekoppies dam 2 561 out of 11 424 hectares or 22.4% is cultivated by black farmers. According to information supplied by the Sugar Mills in the Nkomati area the sugar cane yields produced by black farmers are on par with there white neighbours. Although both groups have suffered during the past recession period and in a certain sense the black farmers more so because of their smaller production units.

It has since emerged that the black farmers are better off in the Komati than elsewhere in the WMA. The reason for this is basically twofold; firstly, that sugarcane production is a relatively easy crop to introduce new farmers to the intricacies of irrigation schedules, and secondly, the direct contribution from sugar mills through support services to the farmers. The main negative comment in the Komati is that the allocated production unit per farmer is too small as profit margins per hectare are very thin. The quantitative analysis of the current water allocation status has shown that (DWAF, 2004c):

- 191% of the available water for allocation has been allocated indicating that the Inkomati WMA is in general over-allocated;
- 83% of the water allocated is for irrigation, 9% is for rural, municipal and domestic uses, and 8% is water allocated for industrial production purposes;
- There is approximately 25 million m^3 available from the Inyaka Dam that was earmarked for transfer to the Sand River Catchment for use by the emerging farmers;
- There is 120 000 hectares of irrigated land in the Inkomati WMA. The area of irrigated land has been increasing at around 8% per annum since 1998; and

- Apart from the sugar industry, there are no emerging farmers involved in farming of other high-value crops. This is attributable to a range of factors which include the following:
    - Lack of skills in irrigation agricultural management practices;
    - Lack of access to financial markets as a result of security of tenure; and
    - A lack of access to markets and the support structures such as extension services.

With the exception of the Sabie and Sand River catchments, where water has been earmarked for transfer from Inyaka Dam, there is no additional water available in the Inkomati for allocation. If anything, the available water is likely to reduce if the EWR is implemented and international obligations are to be met consistently as required by the agreement. However, additional water can be made available through the implementation of water conservation and demand management (WC/WDM) measures among the different water use sectors. The most savings will be realised in the irrigated agriculture sector. The allocation required to achieve social equity can only be realised through reallocation from existing water users and / or trading of existing lawful water use between sectors. This is part of the DWAF's compulsory water use licensing process which is extremely necessary and urgent for the Inkomati WMA (DWAF, 2004c).

8.4 Ecological Water Requirements of the Komati River Catchment

8.4.1 Topography

The topography of the Komati River Catchment is highly variable, with the catchment rising in the west at an elevation of about 1,850 m in the Carolina area on the Highveld to a minimum of about 170 metres near Komatipoort (Figure 8.5). The western extent of the catchment is dominated by the flat to undulating topography of the Highveld plains, which give way to the steep to very steep contours of the escarpment, typified in the Badplaas area. These contours form a horse-shoe to the southeast, the escarpment continuing to the east along the Barberton Mountain Lands, which terminates near Malelane and forms a finger of high ground at 1100 metres that extends into the Lowveld. The Lowveld continues to the east at an elevation of 496 metres, falling to an elevation of 170 metres at Komatipoort. The north-south trending Lebombo Range rises to an elevation of about 600 metres at the Mozambique Border and truncates the eastern border of the catchment.

8.4.2 Geology

The geological formations underlying the Komati catchment have a chrono-stratigraphic age, with Figure 8.1 illustrating the general locality map of the Komati catchment of which the geology is broadly delineated into the following five distinct zones:

i) Escarpment Complex

The geology in the western portion of the catchment, near Carolina, is typically represented by the Ecca Group consisting of the Dwyka and Vryheid formations. These formations consist mainly of shales, sandstones and coal beds. Dolerite sills intrude these formations. The Pretoria Group of the Transvaal Sequence underlies the area to the northeast of Carolina. The Pretoria Group consists of formations of quartzite, mudstone, shales and agglomerate, along with basic and andesitic lavas.

The dolomites of Malmani Subgroup of the Chuniespoort Group, occurs at the base of the Pretoria Group. Some quaternary sediment cover sequences of the Pretoria Group. Dolomites form interfacing outcrops on the contacts between the Pretoria Group and the Nelshoogte Pluton.

ii) Gneiss

The gneisses (Nelshoogte and Stolzburg Plutons) and granites occur immediately to the east of the dolomites.

iii) Barberton Mountainland System

The Barberton Sequence occupies most of the central areas and the north-eastern parts of the catchment. The sequence consists of the Moodies, Fig Tree and Onverwacht Groups. The Moodies Group consists of shale, sandstone, quartzite, conglomerate and basaltic lavas. The Fig Tree Group consists of tuff, siltstones, shales and greywacke. The Onverwacht Group is made up of the Geluk and Tjakastad Sub Groups. These consist of mafic and felsic lavas and volcanics, undifferentiated rocks, mafic and ultramafic schist's and basaltic and peridotitic komatiites. Some quaternary deposits are scattered across the Barberton Sequence.

iv) Lowveld Granites

The area to the north of the South African-Swaziland border forming the lower-lying topography is underlain by the Nelspruit Suite of rocks. These consist mainly of potassic gneiss and migmatites. Intrusives include diabase sills and dykes as well as micro granite and syenite.

v) Lebombo Group

The area to the far east of the catchment, forming the Lebombo Range, is underlain by lithologies of the Ecca and Lebombo Groups. The Ecca Group consists of undifferentiated Karoo Sequence, predominantly sediments (red beds), while the Lebombo Group consists of the Letaba and Jozini formations. These formations consist of mafic and rhyolitic lavas respectively.

8.4.3 Climate

Records of rainfall, temperature and humidity were obtained from the South African Weather Bureau for the period between 1980 and 2002. Very large variations in the climatic variables from the highveld to the lowveld regions were noted. In the east of the catchment the town of Carolina had a mean annual rainfall of 637 mm. Badplaas (central location in catchment) had a mean annual rainfall of 808 mm/annum. In the northeast of the region at Tunzini and Border Gate the average rainfall was 718 mm/annum. A strong relation was found between elevation and rainfall: mountain areas were classified as 'wet', the Highveld areas were generally classified as 'moist', whereas the Lowveld areas were classified as 'dry'. Air temperatures were given as average daily minimum and maximum values. Data were only available for the town of Carolina within the catchment. For the summer season the minimum temperature was 13.4°C and the maximum 25.1°C. The winter months had an average daily minimum of 1.4°C and an average daily maximum of 24.8°C.

The data for the Komatipoort area will yield significantly lower rainfall figures and much higher temperatures. Humidity readings were available for the town of Carolina only. The readings taken at 14h00 are considered. During the summer the average humidity was 52.8 % and in the winter the average humidity was 28.8 %.

8.4.4 Vegetation

Vegetation cover gives an indication of the soils present and hence the nature of the unsaturated (vadose) zone. In addition, an understanding of the potential recharge from the surface features, including wetlands, can be obtained from the vegetation cover and nature of the soil and weathered rock profile. No interpretation was attempted in this study and this aspect should be assessed in detail when conducting an Intermediate level EWR assessment. Two broad categories of vegetation are found in the study area namely: Sweet Grassveld and Bushveld (Acocks, 1975).

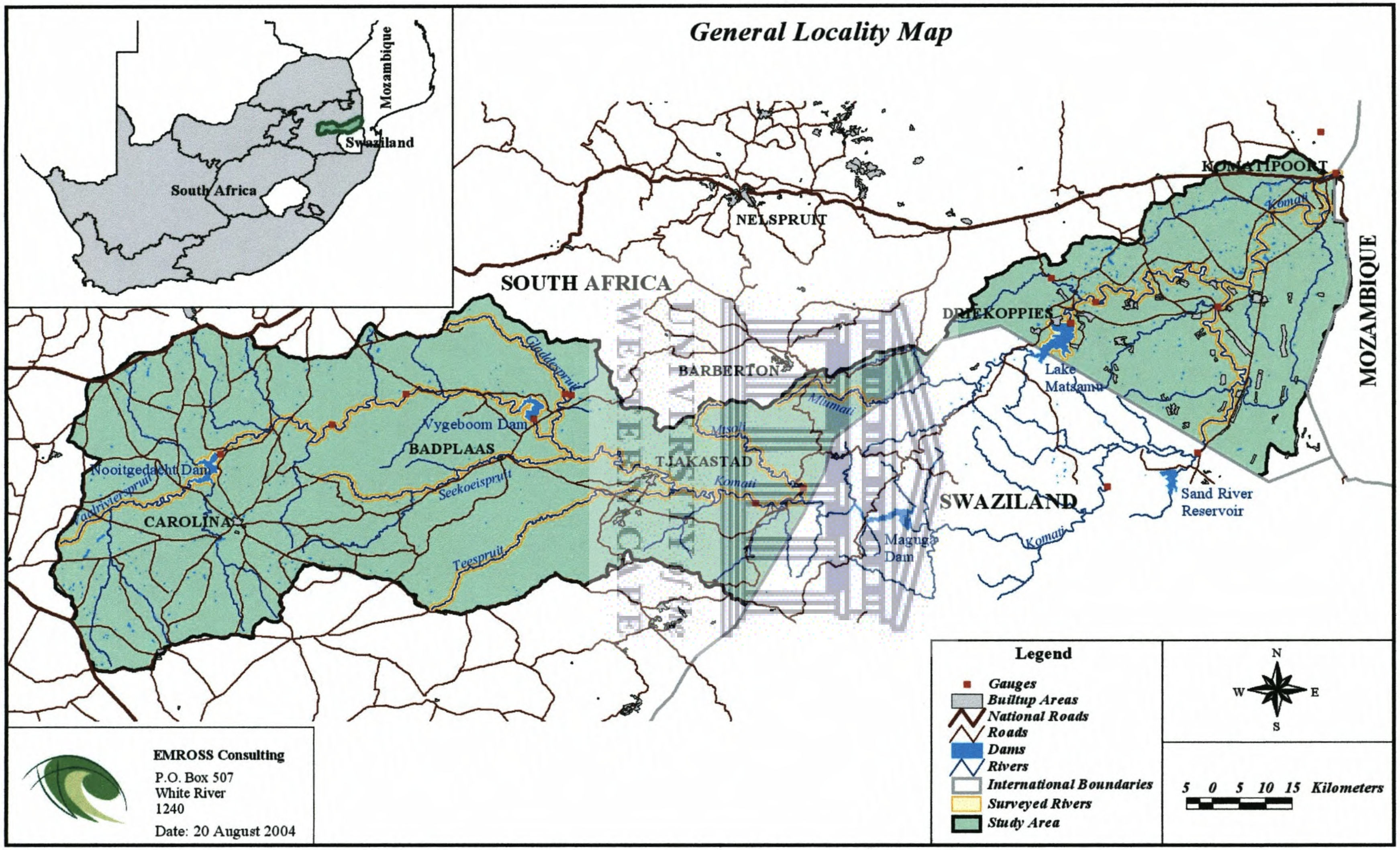

Figure 8.5 General locality map of the Komati catchment (Source: DWAF, 2004c)

8.5 Pertinent stakeholder views during the Reserve determination process

Views expressed by key stakeholders (ranging from water quantity and quality issues to policy gaps and international obligations) through public consultation with key stakeholders in the study area are summarised in the table 8.4 below. These comments by stakeholders are deemed absolutely necessary when embarking on a protection zoning initiative for groundwater in this particular study area (i.e. the Komati River Catchment).

Table 8.4 Summary of stakeholder views during Reserve determination process

- There is no access to clean drinking water in certain local communities. About 70% of people living in the rural and urban areas is using groundwater for a living, what is the Reserve process doing in terms of improving the water quality? What is the Reserve process doing to prevent cholera and other diseases in the rural areas? Where does the municipality play a part in terms of disaster management? How do we build the grassroots communities? Toxicity of the Inkomati River at Komatipoort is a common known for the past several years; the Department knows its origin but little appears to have been done in this regard. This Reserve determination should encourage the Department to take the necessary action. It should be noted that the Crocodile River, in the lowveld, can approach toxic levels at times, especially in the late winter. In respect of the environment and water pollution around the Inkomati River, how is the Reserve process going to ensure the quality and integrity of surface and groundwater resources?
- Where are the policies that focus on the communities and their inclusion in the water resource protection process? How do you involve and educate the community in water conservation and water demand management?
- DWAF must realise that the mismanagement of groundwater use for rural supplies in India has led to a groundwater drought due to over-exploitation. DWAF should acknowledge that, in some parts of the Inkomati region, groundwater potential is high in relation to rural water supply needs; this situation requires that DWAF should develop a specific strategy for groundwater development.
- In respect to biodiversity conservation, while a river can be managed sustainably, it may lose some of the more sensitive species. The ecological portion of the Reserve should not be used for economic purposes such as water sales in the Kruger Park camps and to tourists, this requires quantification by DWAF. Why can't the ecological water requirements for Kruger Park not be the river through-flow (to sustain the ecology) to Mozambique?
- With the tightening balance of water requirements and supply, alternative sources of water become more important, what are the realities and economics of desalination in this regard? Swaziland has a plentiful supply of water and only 40% of the country's 60% allocation from the Maguga Dam is used, with return water being sent to the Mbuluzi River where the water cannot be used. This should be sent to the Inkomati River where it can be re-used. In terms of the overall water situation, there appears to be an over-emphasis on inter-basin transfers which is somewhat confusing and contradictory.

8.6 Addressing policy and legal gaps

Shared watercourse systems such as the KRC have the potential to create serious tensions between riparian countries (i.e. South Africa, Swaziland and Mozambique). These tensions may lead to different reactions ranging from situations that are relatively easy to control and manage, on the one hand, to serious problems that may lead to violent reaction with its concomitant results, on the other. The fundamental difference in the reactions of SADC different countries (in this case South Africa, Swaziland and Mozambique) in situations where tensions may arise as a result of the shared KRC lies in the nature of the interaction between these three countries. If these countries view a situation as a threat to its respective perceived interests, it will react very differently from a situation where threat perception is low. If water-related problems and relations are perceived to develop into a threat, the issue will of necessity become a priority and will move up on the agenda of issues to be addressed.

Regional development and stability therefore demand a different approach to problems such as international threats. However, a signed agreement between South Africa, Swaziland and Mozambique exist whereby these countries have committed themselves to cooperate with each other to ensure the protection and sustainable utilisation of the Inkomati and Maputo watercourses. A tripartite technical committee has also been established between these three countries to ensure the exchange of information and water quality of the shared watercourse. The establishment of the joint Komati Basin Water Authority (KOBWA) ensures oversight and sound management of the Komati River System (KRS) by all three countries. The high confidence Reserve determination study has been presented to KOBWA and various consultations with members of KOBWA (led by DWAF) took place since the inception of this study to ensure a transparent approach. This approach led to smooth information and data sharing between water resource managers and officials of these three countries, and hence the results of the study were considered as reasonable by members of KOBWA.

8.7 Addressing institutional shortcomings

The Inkomati Basin, which is the area to be served by the Inkomati Catchment Management Agency (ICMA), consists of 3 major catchments as well as a further 2 minor catchments. The major catchments are the Komati, Crocodile and Sabie-Sand Catchments, while the minor catchments are the Nwaswitsontso and Nwanedzi Catchments. The irrigation farmers in this water management area (WMA) are organized in established institutional structures which constitute a powerful force and could potentially derail the processes. It remains a challenge, during the establishing phase as well as the operational phase of the CMA, to keep this stakeholder group on board. While the water availability for further allocations is currently limited in this catchments and will remain limited until the compulsory licensing process have been completed, alternative measures had to be taken and arrangements made to make water available for emerging farmers in the interim. The catchment crosses international boundaries and therefore cooperative protocols will have to be negotiated with Mozambique and Swaziland.

The ICMA is the only operational and fully functional CMA to date. It is well set, well organised and professional and highly committed and it accounts for an area that include eight local municipalities and six district municipalities. The ICMA is being operated as a business with clear and transparent business principles. The organisational structure is simple but effective. The ICMA also acknowledge the Premier's drive 'Water for All in Mpumalanga' and adopted the 'water for all' approach in Inkomati area - reflecting the ICMA's vision and intent. Over and above the core business and values of ICMA, they displayed eagerness for professional innovation.

The ICMA is supported by a strong knowledge base, especially organised farming groups (i.e. the Sabie Sands farming group). The Governing Board of the ICMA is well representative of all the stakeholders in the area, with both a strong CEO and chairperson. The Board consist of thirteen members spread across the various water users, with the Governing board providing a strong voice and balance. Strong lobbyist groups contributed to the establishment of the CMA, again with a strong knowledge base among these "activist" groups. The capacity, technical expertise, financial resources and commitment exist in the Inkomati Basin for the eventual assumption of all the functions listed in schedule 3 of the NWA, as well as the water use licensing functions which can be delegated or assigned by the Minister of Water and Forestry. The emphasis of the Schedule 3 powers and duties prescribed by the NWA is on water resources monitoring, management and protection, as well as the implementation of the catchment management strategy. Organised Agriculture is a strong representative of the ICMA Board, with 67% of jobs created in agriculture and two Board members from commercial farming. The ICMA constantly examine its roles and responsibilities, even to the extent of benchmarking with international agencies. It also sees part of its role for ensuring the following:

- Provide input to integrated development plans (IDPs) and water services development plans (WSDPs) of Local Government;
- Advice and support water user associations (WUAs) on water resource management issues; and
- Involve the Human Rights Commission to ensure that the rights of water users and consumers are being met.

8.8 Socio-economic dimension

Water resources provide important benefits to society, both as input capital for production and ecological goods and services. Due to the increasing scarcity of water for both production and environmental benefits and scarcity of resources to develop water infrastructure, it is necessary to make decisions about conservation and demand management and reallocation of the resource among competing uses that are compatible with government social objectives such as achieving equity, economic efficiency and sustainability. Economic valuation plays an increasingly important role in decision making between socioeconomic development and protection of the resource for long term sustainability. Therefore, development and management of water resources cannot be interpreted without some idea of the value of water to the socioeconomic activities taking place in a catchment, and the value of ecological goods and services provided by the catchment.

The water resources of the KRC which is a shared watercourse are now all allocated. In order to ensure the water resources of the Komati are managed in a sustainable manner, EWRs will be required. The NWA provides that these flows have priority over all other water using sectors. However, allocation of flows to the ecology will mean reallocation of the available water in the KRC from existing water using sectors. The purpose of valuing the water for production and socio-economic activities and ecological goods and services is to assess the preference of communities in the catchment for or against environmental change.

8.8.1 Economic value of water for commodity use

The KRC was divided into five economic zones or subsystems (Figure 8.6). For each zone, a customised Water Impact Model was developed to calculate the economic value of water. The model was based on a Social Accounting Matrix (SAM) that was developed separately for Swaziland and South Africa. The underlying principal of the model was that water is scarce, and so its allocation among competing users needs to be structured to ensure that positive socioeconomic impacts are maximised. The model distinguished four water user sectors as follows:

- Irrigated Agriculture
- Domestic including commercial and industrial
- Commercial Forestry
- Transfers for ESKOM Power Generation

Not all scenarios were investigated. The range of scenarios investigated was such that the worst case and base case for socio economy could be determined. The scenarios that were investigated therefore were scenarios 2, 6.2 and 6.2a. These were compared with the base scenario (scenario 1), which was the socioeconomic value of the present water available to the above water user sectors. The model was structured to provide a detailed description of the water availability in sub-catchments for various scenarios. Given the water availability for a new scenario, the model determined the economic and socio-economic impacts emanating from the change in water availability. The Water Impact Model determined the different impacts that the various scenarios will have on the economy. The marginal differences in socio-economic impacts were calculated by subtracting the impact of these situations from each other. This made it possible to quantify the impact that the various scenarios will have on the community, as well as the broader economy.

The factors that were used to determine the implication of the EWR scenarios were the following:

- The incremental change in the economic surplus or profit to the users in each sub-catchment and per water user sector;
- The incremental change in the Gross Domestic Product for each EWR scenario; and
- The number of jobs that would be generated or lost for each EWR scenario.

8.8.2 Economic value of goods and services

A specialist workshop was held where the ecological goods and services in each sub-catchment were identified. The following ecological goods and services were identified:

- Fishing by community and fish farming;
- Thatch grass, reed harvesting and medicinal plants;
- Wood gathering, recreational fishing and swimming; and
- Recreational boating, cultivated floodplains and sand mining.

It should be noted that the above goods and services are from direct and indirect use of the river. The specialist workshop also identified the indirect use of the in stream water namely waste assimilation, waste dilution, black flies, livestock diseases, malaria, bilharzia and cultural activities.

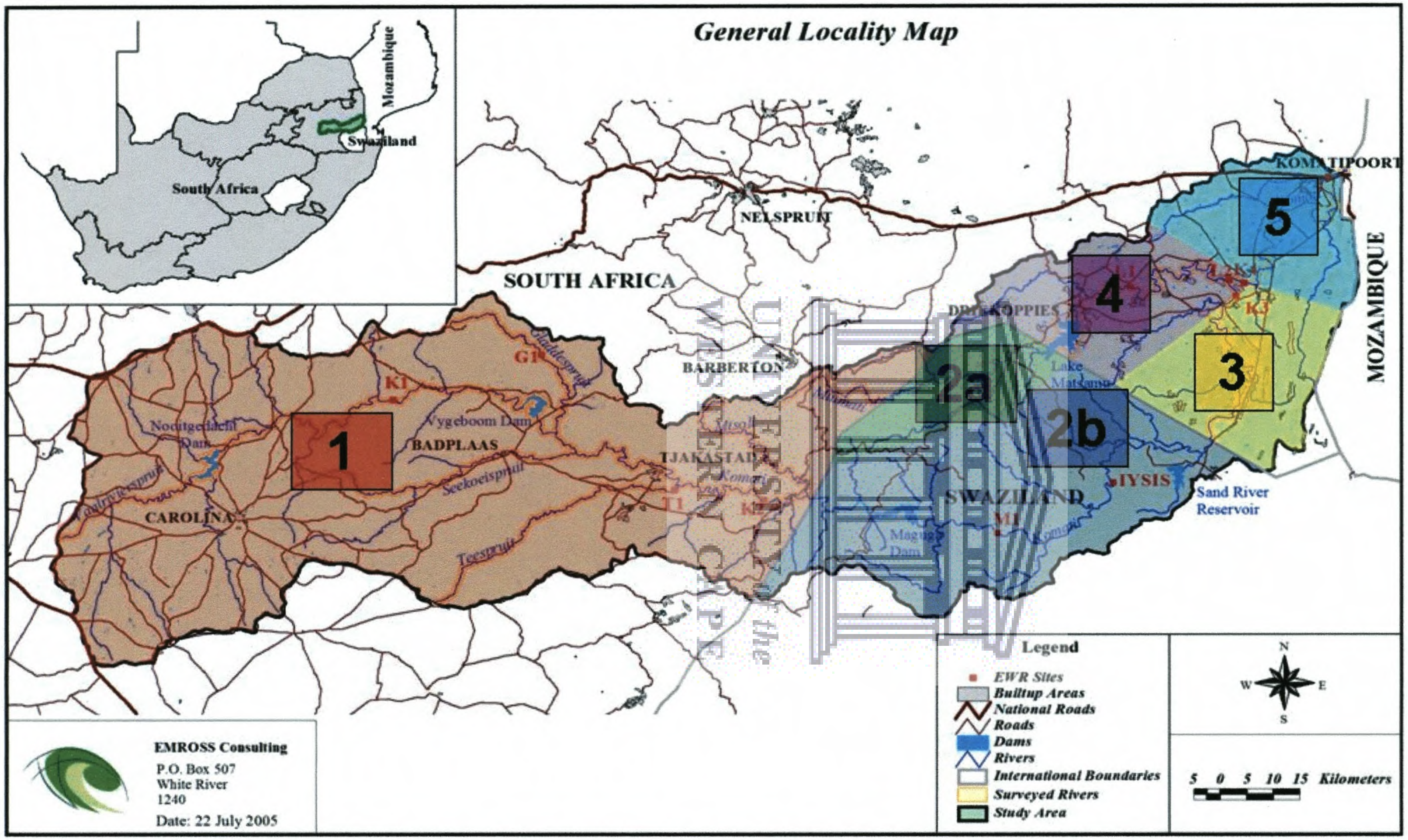

Figure 8.6 Delineation of Komati River catchment into five economic sub-systems (Source: DWAF, 2004c)

8.8.3 Overall economic valuation of flow scenarios on market benefits

Various techniques were used to measure the economic value of direct and indirect goods and services provided by the Komati River because of the different volume of ecological water left in the river to protect the resource. These ranged from use of surrogate markets to contingency valuation methods. The objectives of this task were to develop a range of operational scenarios that result in different impacts on different users. The impacts of incorporating the ecological water requirement (EWR) on the ecology, system yield, goods and services and overall economic activities could then be assessed. Operational scenarios refer to flow scenarios that are designed to incorporate the availability of water, operational constraints and user demands.

The development of operational scenarios is the next logical step that follows the quantification of the EWR. The development of operational scenarios is an iterative process in which the severity of impacts, complexity and budget constraints determined the number of iterations required. The EWR (quantity) scenarios for a range of ecological categories (ECs) were used as the basis for developing an initial set of scenarios, and modified as required. The Water Resources Yield Model (WRYM 2000) was used to assess the impacts that the EWR scenarios will have on the available yield of the system. A summary of the various scenarios considered is shown in Figure 8.7 below.

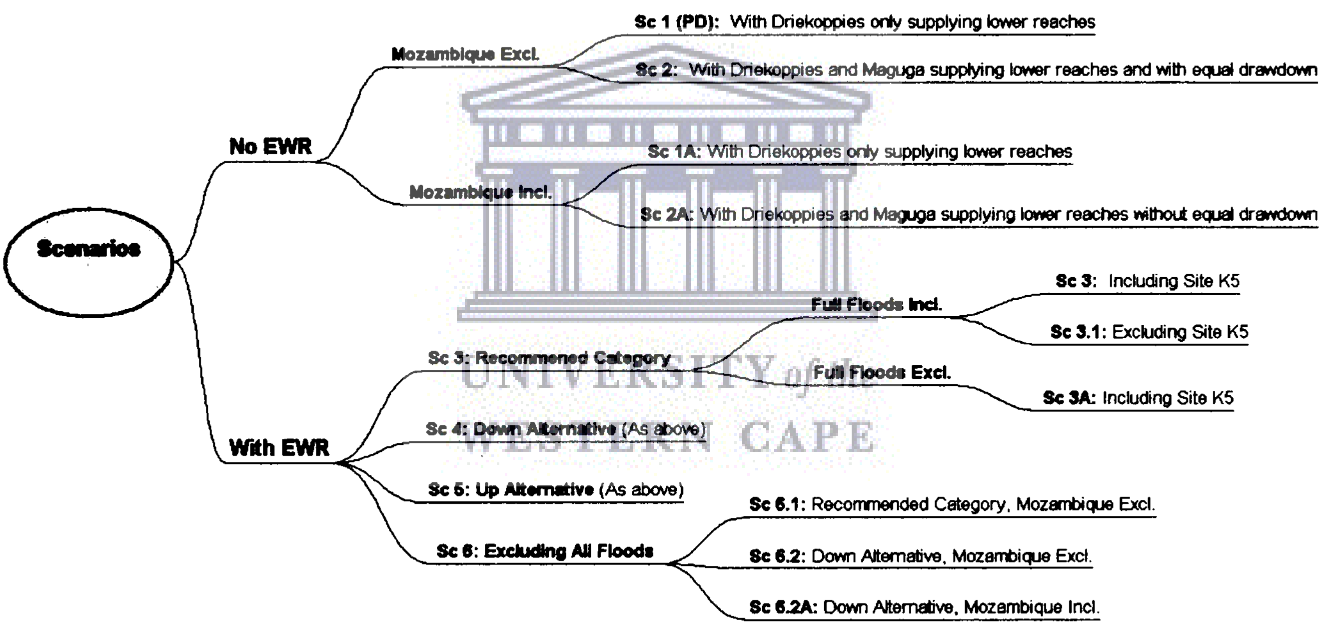

Figure 8.7 Operational scenarios developed for the Komati River catchment (Source: After DWAF, 2004c)

Four scenarios without EWR requirements were evaluated: two including Mozambique requirements and two excluding Mozambique requirements. The reason for various scenarios without the EWR requirements was that the operational management of the system is subject to phased implementation. The system is unlikely to be managed like this in future as once Maguga Dam has sufficient water it will be managed together with Driekoppies Dams, and international treaty requirements will need to be adhered to. Three scenarios with the EWR requirements were assessed initially: the Recommended EC and the alternative categories 'up' and 'down'.

These scenarios were further split into those that included full floods, and those excluding floods that could not be met because of system constraints. The following scenarios were considered:

- **Scenario 1** - No EWR, excluding Mozambican requirements and with Driekoppies Dam only supplying the lower reaches. This is unlikely to be a future scenario but it was included because the baseline data collected for this study were collected under these conditions;
- **Scenario 1A** - As above, but including Mozambican requirements;
- **Scenario 2** - No EWR, excluding Mozambican requirements, but including Driekoppies and Maguga Dam supplying the lower Komati River. This scenario was considered with and without equal drawdown of Maguga and Driekoppies Dams (scenario 2 and 2A respectively);
- **Scenario 3** - With EWR at recommended ecological category (REC), and including full flood requirements. This scenario was considered with and without the hypothetical dummy site K5 as a demand on the system (scenario 3 and 3.1 respectively);
- **Scenario 4** - As above, but with EWR in 'down' alternative;
- **Scenario 5** - As above, but with EWR in 'up' alternative. The 'up' alternatives were included to determine sensitivity and the impact on the yield, but these were not evaluated ecologically because they are unlikely to be implemented. This scenario was subsequently removed from further analysis because it was considered unlikely to be implemented; and
- **Scenario 6** - With EWR requirements but excluding floods that could not be met because of system constraints. This scenario was considered for the REC and the down alternative (scenario 6.1 and 6.2 respectively). An additional scenario (6.2.A) was the same as scenario 6.2, but included Mozambique's requirements.

In Table 8.5 the total impact of a specific scenario is compared to the other scenarios in the KRC. From Table 8.5 it is clear that scenario 6.2a will have the most severe influence on the economy in the KRC if implemented and specifically on irrigated agriculture where a possible 95% of present cultivated lands will have to be curtailed. Scenario 6.2 is as far as economic impacts are concerned the least severe and if decided upon, only 1.6% of the irrigation area will have to be withdrawn when the water is reallocated for ecological flow requirements. This does not take into account the potential for improving the current efficiency levels through improving the conveyance infrastructure for the irrigation system and reducing water losses in the domestic sector.

8.8.4 Overall economic valuation of flow scenarios on ecological benefits

The value of ecological goods and services were determined for the whole of the Komati River catchment for each flow scenario. The results are presented in Table 8.6 and the outcomes of each scenario mirror the positive impact that each flow scenario has in each sub-catchment. The overall incremental benefits are significant for scenario 6.2a but they tail of towards the base scenario. This indicates that any further optimisation will not realise significant benefits in the ecological flows which is the water regime provided within a river zone to maintain ecosystems and provide goods and services where there are competing water uses. Scenario 6.2a therefore provides the optimised scenario for ecological goods and services in the Komati River Catchment. Although this is not the scenario with the least impact on the socio-economic growth of the catchment, the overall impact is not as severe as only 1.62% of irrigation agriculture will be affected.

Table 8.5 Macro-economic impacts for each flow scenario for the Komati River catchment (Source: After DWAF, 2004c)

Scenario	Total Surplus Rand million	GDP Rand million	Capital Formation Rand million	Low income households Rand million	All households Rand million	Employment Numbers	Change in irrigated area ha	% Irrigation withdrawn
Baseline	3 796	15 597	41 033	10 606	19 031	113 538	53 323	
Scenario 2a	-3	-35	37	-24	-44	-1 000	-1 102	-2.07%
Scenario 6.2	-7	-9	122	-11	-11	-414	-864	-1.62%
Scenario 6.2a	-24	-128	-194	-89	-153	-1 584	-2 051	-3.85%

Table 8.6 Valuation of benefits on ecological flows (Source: After DWAF, 2004c)

Socio-economic variable	**Baseline - Current situation (R*1000)**	**Scenario 2a**	**Scenario 6.2**	**Scenario 6.2a**
		Incremental benefit (R *1000)	**Incremental benefit (R *1000)**	**Incremental benefit (R *1000)**
Surplus value	48 130	3 400	4 731	5 434
GDP	54 810	4 020	4 880	5 470
Low income households	24 590	3 590	5 040	5 790
Employment generated	**4 342**	**261**	**368**	**432**
Percentage change from baseline of the surplus value		**7.06%**	**9.83%**	**11.29%**

8.8.5 Incremental and phased implementation of ecological flows

As explained in the conceptual framework of the water impact model, the model makes provision to measure the impacts if certain changes in management and technology are introduced in the irrigation-farming sector. It was therefore decided to apply some of these improvements to the farming sector over a 5-year period and to calculate whether the improvements are meaningful if compared to the results of the immediate introduction of water cutbacks. In Table 8.7 the possible benefits of the phased option to the region is compared to the immediate applied option.

Table 8.7 Benefits derived from phased implementation of flow scenarios (Source: After DWAF, 2004c)

Ecological flow scenario	Benefits from the Phasing Options			
	Employment Opportunities	Percentage Improvement	Irrigation Hectares	Percentage Improvement
Scenario 2a	971	97.1%	1 349	122.5%
Scenario 6.2	888	214.4%	1 303	150.9%
Scenario 6.2a	1 028	64.9%	1 509	73.6%

Phasing will have definite benefits to the farming community (Table 8.7). In the case of scenario 6.2a the hectares (ha) to be withdrawn, decrease to approximately 579 ha if water use efficiency measures and improved management practices are put in place before the ecological flows are implemented. This is compared with the 1584 ha that will be lost under current water use efficiency levels and management practices. In order to take consideration of these other scenarios, the overall impact of flow scenarios on the KRC with phased implementation of flows are summarised (Table 8.8). Scenarios that exclude the EWR have limited ecological impact on unregulated tributaries, but have a major impact on regulated rivers, particularly in the lower reaches. Scenarios that include the EWR generally meet the ecological objectives and enhance ecological goods and services.

The recommended flows for the lower Komati are designed to restore perenniality through improved baseflows. The Inkomati catchment management agency (ICMA) could play a vital role in co-ordinating efforts to improve the riparian zone as a buffer, control deforestation, control cultivation and grazing in riparian zone, and reduce fragmentation caused by weirs. The present water requirement for input into economic production is currently not being met without the EWR. This is because of over-allocation at the level of assurance of supply to the various user sectors. The best practical scenario for the protection of the water resources of the KRC therefore is scenario 3. However, this scenario will have a significant impact on the economic contribution to Swaziland and South Africa and reduced employment. The scenario with the least impact on the economy and employment is scenario 6.2 (EWR high flow requirements removed). However because of the requirements to meet the Interim Inco-Maputo Agreement (IIMA), which requires a minimum flow of 2 m^3/s, scenario 6.2a is considered the optimal option.

Table 8.8 Overall impact of flow scenarios (Source: After DWAF, 2004c)

Scenario	**Total Surplus**	**GDP**	**Capital Formation**	**Low income households**	**All households**	**Employment**	**Change in irrigated area**	**% irrigation withdrawn**
	Rand million	**Rand million**	**Rand million**	**Rand million**	**Rand million**	**Numbers**	**ha**	
Baseline	3 796	15 597	41 033	10 606	19 031	113 538	53 323	
Scenario 2a	13	24	151	16	29	-29	248	0.46%
Scenario 6.2	23	50	233	29	62	474	429	0.82%
Scenario 6.2a	-11	-73	-83	-53	-84	-579	-764	-1.4%

8.9 Groundwater RDM approach

8.9.1 Delineation of groundwater resource units

In the KRC it appears that both surface and groundwater have strict geological controls. This has led to the division of the catchment into resource units that are geological in nature. The geological map can be sub-divided into five distinctly different zones based on the way in which the groundwater contributes to the surface flows. These geological units are the Barberton Mountainland system/group of rocks, the Lebombo Group, the Lowveld Granites, the Highveld Sediments (inclusive of the dolomites, quartzite's and other related lithologies), and the Gneisses and Migmatites. These divides can also be closely related to the chronological divides (Figure 8.8) - with the Highveld Sediments tying up very closely with the Palaeozoic, the Mountainland lithologies with the Swazian, etc. The preliminary delineation of groundwater resources has been determined as follows:

i) Escarpment Complex (Ecca and Pretoria Groups and Dolomites)

Further coal mining and industrial activities in the Karoo aquifers pose a further problem to the on-going deterioration of the water quality in the catchment. The dolomites are important as a future groundwater resource. The Escarpment requires a comprehensive level of study.

ii) Gneiss; iii) Barberton Mountainland System; iv) Lowveld Granite

The weathering depths for these rocks is very shallow resulting in weathered aquifers that have very shallow water levels. These aquifers are susceptible to contamination from the surface. There is an increase in the population using septic tanks, pit and bucket latrines (Census data for Carolina Local Municipality). This in addition to uncontrolled livestock grazing in the catchment, poses a direct risk to the groundwater quality in terms of nitrate and organic compound concentrations. These Resource Units require a comprehensive level of study.

v) Lebombo Group (includes Karoo lithologies)

Karoo aquifers in the Kruger National Park requires management in terms of volumes abstracted. Census data for the Nkomazi and Umjindi local municipalities show an increase in the use of septic tanks, pit and bucket latrines and that part of the population having no sanitation. There are an increased number of people engaged in agriculture and forestry. This will lead to the increased use of fertilisers, livestock grazing which is uncontrolled and removal of natural vegetation. There is immediate risk to the groundwater system where livestock grazing occurs along riverbeds. The groundwater quality is poor in terms of conductivity and nitrates. Contaminated groundwater will ultimately reach river courses as baseflow.

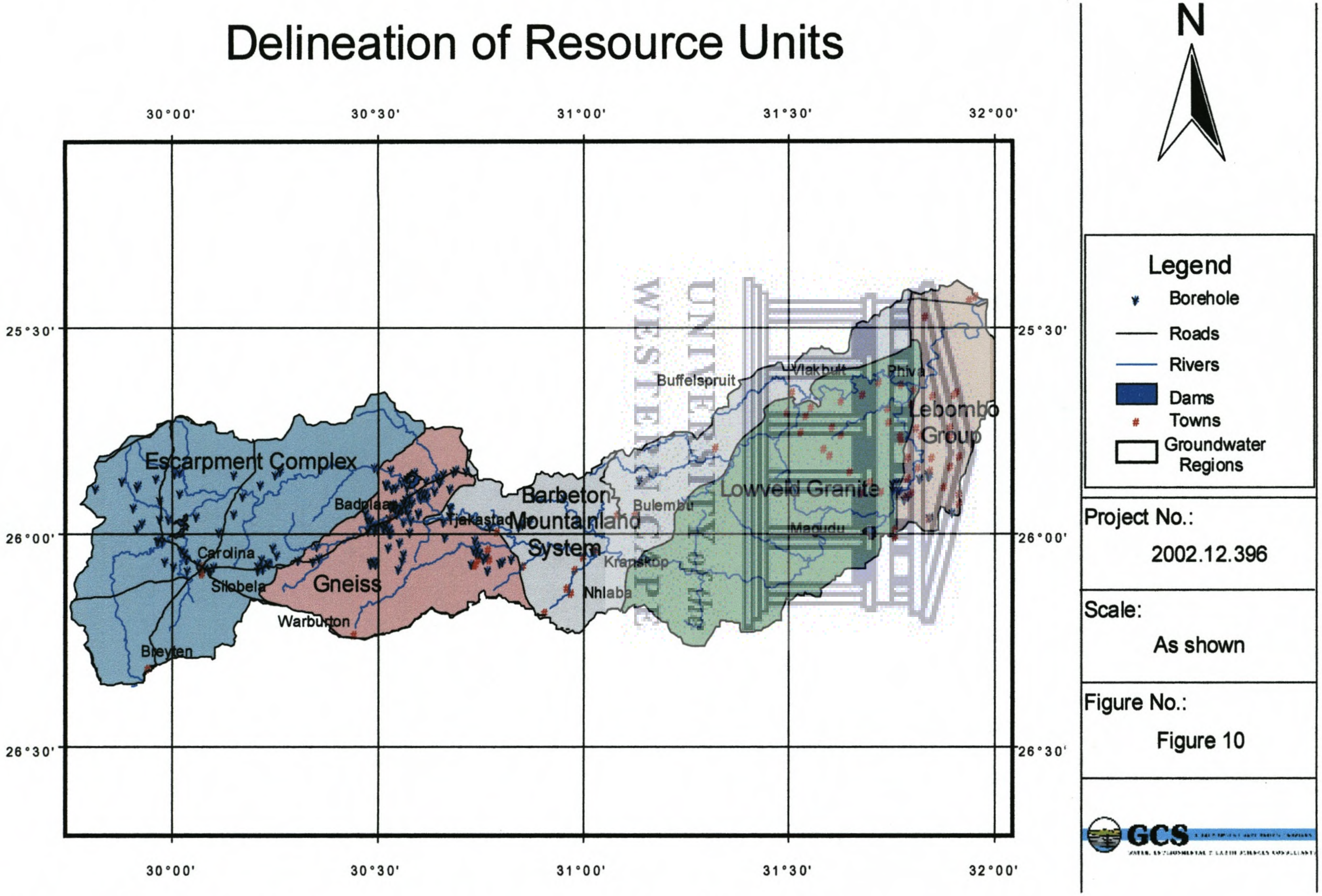

Figure 8.8 Delineation of groundwater resource units (Source: After DWAF, 2004c)

8.9.2 Groundwater use

Only a few of the groundwater users in the catchment have been identified in a study conducted previously (Kotze and Xu in DWAF, 2004c). The study classified the Karoo aquifers near Carolina as minor aquifer systems with a medium susceptibility to contamination. Groundwater use for domestic or irrigation in these aquifers is minimal. Abstraction of groundwater is primarily by borehole pumps from shallow wells and drilled holes, with only a low percentage utilizing springs. There is not much information concerning utilization of the dolomite aquifers. This can be confirmed by a hydrocensus in the dolomite locality areas. There is also no information available on the use of the quaternary aquifers along the river courses within the catchment. Trends observable from the sparse boreholes distribution indicate the following:

- There appears to be very little groundwater abstraction in the migmatites, gneisses and granites to the west; and
- The areas underlain by the Barberton lithologies and Lowveld Granites also show little or no utilization of the groundwater resource.

8.9.3 Threats to groundwater

Census data for 1996 and 2001, as well as previous studies undertaken by Groundwater Consulting Services for a reconnaissance sanitation survey in December 2001, were used to provide a first approximation of the potential impacts of population and land-use on groundwater in the Komati River catchment. The Komati River catchment includes three municipal districts and six local municipalities. The statistics for each of the local municipalities in terms of the industry, sanitation and water use is provided in Tables 8.9 and 8.10 respectively. The figures for the different sectors are given as percentages of the total population of the local districts. The sectors chosen for investigation indicate that there is a potential threat to the groundwater system. The manufacturing and industrial sectors may also impact on the groundwater system but these are too varied and need to be assessed individually. The percentage of the population utilizing natural sources of water i.e. boreholes, springs, dams and rivers gives an indication of the communities' reliance on these sources.

Groundwater Abstraction: From the census data there was a clear decreased reliance on groundwater from 1996 to 2001. However, this does not specifically relate to quantities abstracted by the existing users, as not much information was available on abstraction volumes in the different aquifers. Additional information will be needed to clarity this situation.

Agriculture and Forestry: In the Nkomazi Local Municipality (Lebombo lithologies), the number of people involved in agriculture and forestry doubled between 1996 and 2001. Increased nitrate concentration in groundwater for this part of the catchment can be related to the increased use of fertilizers and livestock grazing along riverbeds. The remainder of the catchment shows a decreasing number of people employed in the agriculture, forestry and mining sectors.

Sanitation: The use of flush and chemical toilets increased across the catchment between 1996 and 2001. Increasing trends in the use of septic tanks, bucket and pit latrines and no sanitation was observed for three local municipalities (Nkomazi, Umjindi and Carolina). This can account for the increased nitrate concentrations in the groundwater in the east of the catchment. Rural communities and informal settlements (Mpumalanga Lowveld) would have an impact on the groundwater system in terms of elevated nitrate and organic compound concentrations if there were no management systems in place.

Mining: There is a substantial amount of coal mining around Carolina and on the Highveld in general. An estimated 85 % of the recorded boreholes in this area had water levels shallower than 15 m. The coal mining areas and their use of the surface and groundwater resource pose a serious threat to the water quality in the area. This threat is lessened by slow migration rates and low aquifer permeability. Long-term effects on the base flow could however be severe (Kotze and Xu 2003).

The current and future status of mining activities within the catchment can be determined through a detailed and extensive desk study that will form part of the methodology used for the Intermediate EWR assessment.

Alien Vegetation: Encroachment of alien vegetation, particularly within Swaziland, is a concern that needs to be addressed in further studies.

Table 8.9 Census data of 1996 (Source: After DWAF, 2004c)

DISTRICT MUNICIPALITY	*EHLANZENI (DC32)*				*NGANKALA (DC31)*		*EASTVAAL (DC30)*			
LOCAL MUNICIPALITY	*NKOMAZI MP324*		*UMJINDI MP323*		*HIGHLANDS MP314*		*CAROLINA MP301*		*MSUKALIGWA MP302*	
		%		%		%		%		%
POPULATION	**277967**		**48577**		**37012**		**182348**		**106017**	
INDUSTRY[1]										
Agric./Forestry	14758	5.3	6312	12.9	2858	7.72	5540	3.03	7704	7.26
Mining	1414	0.50	2059	4.2	644	1.73	1964	1.07	2576	2.43
SANITATION										
Flush &Chem. Toilet	4070	1.46	6125	12.6	5259	14.2	4496	2.46	15354	14.48
Other[2]	48813	17.5	5474	11.2	3933	10.6	30781	16.8	9568	9.02
WATER										
Borehole	2456	0.88	262	0.54	432	1.17	2230	1.22	2284	2.15
Spring	5532	1.99	1231	2.53	1549	4.18	7697	4.22	1709	1.6
Dam	-									
River	-									

[1] Sectors in which people are employed (the fishing sector has been included with agriculture and forestry to maintain the integrity of the statistics).
[2] Septic tanks, pit and bucket latrines and no sanitation.

Table 8.10 Census data of 2001 (Source: After DWAF, 2004c).

DISTRICT MUNICIPALITY	***EHLANZENI (DC32)***				***NGANKALA (DC31)***		***EASTVAAL (DC30)***			
LOCAL MUNICIPALITY	*NKOMAZI MP324*		*UMJINDI MP323*		*HIGHLANDS MP314*		*CAROLINA MP301*		*MSUKALIGWA MP302*	
		%		%		%		%		%
POPULATION	**334416**		**53743**		43007		**187936**		**124812**	
INDUSTRY										
Agric./Forestry	25678	7.67	5329	9.9	3023	7.02	5556	2.9	7285	5.8
Mining	999	0.29	1013	1.88	624	1.45	685	0.36	1845	1.48
SANITATION										
Flush &Chem. Toilet	7717	2.3	8275	15.3	6794	15.79	6100	3.2	19260	15.43
Other	64054	19.2	6183	11.5	2929	6.8	33575	17.87	10429	8.35
WATER										
Borehole	498	0.14	109	0.2	193	0.45	1554	0.82	369	0.29
Spring	583	0.17	40		24	0.05	1708	0.91	425	0.34
Dam	545	0.16	145	0.26	291	0.67	657	0.34	828	0.66
River	2520	0.75	1184	2.2	271	0.63	3409	1.81	610	0.49

8.10 The importance of setting groundwater specific RQOs

Xu *et al* (2003) noted that resource quality objectives (RQOs) provide goals within a management class, or goals to aim for and state RQOs must maintain a balance between the need to protect water resources and the need to use them. RQOs include any requirement – numeric or descriptive – required to ensure a water resource remains in a desired state. It is specifically noted RQOs must be set in consultation with stakeholders. The stress index, as related to the management class, is a useful regional scale RQO, for example, if the desired management class of each resource unit in the Komati River catchment is set at its current resource category, a certain amount (in Mm^3/a) in groundwater usage is expected to be allocated. However, if stakeholders of the Komati River catchment decide that all resource units be used to their sustainable limits, an anticipated management class of 'Fair' will be set, resulting in a different amount (in Mm^3/a) to be allocated for groundwater use.

It does not appear possible to set RQOs at a regional scale. This is particularly true in the Komati River catchment where groundwater abstraction by the domestic and irrigation sectors appears minimal (particularly around the Karoo aquifers near Carolina), but a medium susceptibility to contamination cannot go unnoticed. While some general aquifer management philosophies can be specified, detailed RQOs needed to be set on a site specific basis and may have to be set per water use license application.

9. DISCUSSION AND CONCLUSION

Ensuring access to basic water supply and sanitation remains a core priority of the Department of Water Affairs and Forestry (DWAF) and extra effort through groundwater protection measures in particular, must be put in place to ensure that targets set by government is achieved. Concerted efforts by some national government departments to assist local government structures (i.e. municipalities in particular) on matters pertaining to water resource protection (groundwater in particular) should be strengthened and encouraged as benchmarking for others (including the private sector) to act on those needs and requirements by these local structures to give meaning to the concept of integrated water resources management (IWRM). This thesis has highlighted the need for such a strategic intervention (in the form a groundwater source and aquifer protection policy development) and at the same time also explored various existing mechanisms and tools through which a number of short to medium and long-term challenges facing groundwater management in South Africa could be addressed in the interim, while addressing shortcomings in current legislation (i.e. the National Water Act, Act 36 of 1998).

The emergence of groundwater-related problems countrywide could certainly be used as an indicator of unsustainable utilisation of a resource often neglected as a result of capacity (expertise) constraints. It is therefore an absolute necessity to identify intervention opportunities through existing programs to address shortcomings in groundwater management (parallel to the development of a policy on groundwater source and aquifer protection zoning), especially taking account the cumbersome process to develop a policy as orchestrated by the author in chapters four and seven respectively. On the other hand, a number of existing regulatory tools and initiatives (highlighted and discussed by the author) also present various opportunities for groundwater related problems to be addressed swiftly, with the following most pertinent (but not limited to) existing programs to be strongly considered:

- **National water resources strategy (NWRS)** - A NWRS was gazetted and published by DWAF in September 2004. This strategy sets out a comprehensive approach as to how DWAF as sector leader will implement the country's NWA to ensure that the protection, use, development, conservation, management and control of water resources can be achieved in an equitable, efficient and sustainable manner, to the benefit of society at large. It is also a common known that the current NWRS is weak on particularly groundwater management within the context of IWRM. However, the opportunity presented by the NWRS (i.e. to address the groundwater shortcomings) is that this strategy remains a dynamic document, as it is due for review in two-year's time (i.e. NWRS subject to review on five-yearly basis).

- **Draft water resources classification system (WRCS)** – A draft WRCS by the DWAF was published in 2008 for public comments. Pienaar (2005) indicated that elements of groundwater protection can be achieved through the application of the WRCS, as the NWA prescribes that all significant water resources must be classified using this system. A framework approach towards the development of this system was applied and tested through a pilot study (i.e. The Thukela River System) where groundwater specific resource quality objectives (RQOs) were set to ensure that groundwater as a vital source of water supply is taken into consideration when giving effect to IWRM (Pienaar, 2005).

- **Internal strategic perspectives (ISPs)** – The DWAF has developed guideline catchment strategies (i.e. internal strategic perspectives) countrywide as a 'forerunner' to assist established and forthcoming catchment management agencies (CMAs) in the development of catchment management strategies (CMS). Of particular importance is that these CMSs must include elements of water resource protection measures as a means of ensuring sound water resource management (i.e. giving effect to IWRM). The intervention opportunity for addressing groundwater protection is that some (if not most) ISPs have identified the need for a better understanding and consequent improved management of the country's groundwater resources.

- **Resource directed measures (RDM)** – The author has illustrated through a case study (i.e. Komati River Catchment) in chapter eight, the importance of RDM to ensure the inclusiveness of groundwater management when adopting an IWRM approach. The current IWRM approach as adopted by DWAF (Chapter 2) has been criticized and a proposed overarching IWRM framework (inclusive of groundwater) has been applied and tested in the Komati River System to assess its soundness. The outcome of this pilot study (i.e. high confidence Reserve determination) resulted in the following:
  - Groundwater threats been identified;
  - Setting of groundwater specific RQOs (within the of the socio-economic dimension of the Komati River catchment) in order to address groundwater threats;
  - Delineation of groundwater units - which highlighted the need for a groundwater specific approach when classifying water resources as prescribed by the NWA;
  - Groundwater scoping assessment study - which clearly highlighted the need for strategic advocacy (i.e. consideration of policy development for protection zoning); and
  - Groundwater importance within the Komati River Catchment (KRC) - which confirms that the classification of water resources is not subject to issues of spatiality only.

- **Source directed controls (SDC)** – Mitigating measures dealing with associated impacts on groundwater is dealt with under SDC by DWAF. This presumption needs to be vigorously applied and tested in practice to ensure that impacts on groundwater resources are diminished.

- **Waste discharge charge system (WDCS)** – The WDCS complements both the WRCS and SDC as it adopts a 'polluter pays principle' approach. The interconnectedness and iterative nature of these three tools is explained in much detail in chapter five by the author. The opportunity presented to groundwater protection (with respect to its several shortcomings) lies in the current developmental stages of establishing the WDCS.

It is also important to emphasise the lack of adequate monitoring systems for groundwater management and the accompanied human and financial resources required to achieve compliance and enforcement by the DWAF as water sector leader and national Regulator. The DWAF's current compliance norms and standards with respect to its water use licensing process must be well explained to water users; this will result in water users not perceiving these compliance conditions and standards negatively but rather observe these as an attempt by the DWAF to instil self-discipline among its various water users, as no single entity will be able to police all aspects of IWRM implementation.

National and provincial governments are obliged to support the municipalities to ensure that they effectively perform their mandate. The DPLG is responsible for coordinating all the support targeted towards local government. DWAF as the water sector leader has a responsibility to ensure a fully functioning water sector. In particular, that the link and dependencies between service delivery and a healthy water resources management environment is understood, supported and integrated at the local level. DWAF however also has the responsibility to ensure that Local Government is able to eradicate water services backlogs in a manner that ensures the long term sustainability of water services business. In this regard, sustainability and service delivery become synonymous. Furthermore, key considerations through the entire service delivery chain are critical, hence support must be provided to local government (skills, financial and other) at every stage of developing and implementing a groundwater source and aquifer protection zoning policy for South Africa.

Such support also contributes to a shared vision of sustainable local government institutions wherein all managers with water and sanitation responsibilities adopt service excellence and sustainability as a primary objective and obligation to the people of South Africa. The author is also of the view that institutional interventions are costly and should be kept to a minimum, and that, where possible, existing institutions should be levered into additional functions and responsibilities that might arise as a result of developing a groundwater source and aquifer protection zoning policy. One issue of concern (irrespective of whether this is a perception by the general public) has been the relatively slow progress made in the implementation of some provisions of both two pieces of water legislation (i.e. the National Water Act, Act 36 of 1998 and the Water Services Act, Act 108 of 1997) particularly in areas concerned with the implementation of regulatory aspects, sector leadership, institutional and water resource protection related matters.

This research which focussed on assessing the legal, socio-economic and institutional arrangements for the development and implementation of a groundwater source and aquifer protection zoning policy, reveals that we can no longer take our endowment of groundwater resources for granted. It is clear that we are rapidly using up our groundwater resources as we pursue growth and seek to eradicate poverty. Indeed, it is the poor who often experience the economic costs of groundwater resource degradation most directly because a significant number of poor households depend directly on groundwater resources availability and ecosystem goods and services. Similarly, the poor people often pay the heaviest price in urban areas when it comes to groundwater pollution, expensive water, and long travel distances.

Growth and poverty eradication strategies are not decoupling from unsustainable groundwater resource use and exploitation. This means that our democratic South Africa has not broken away from the natural resource exploitation model put in place by colonial conquest and refined during the apartheid era. We need to act rapidly and decisively to change this. This research outcomes also confirm that thresholds are now being reached which if ignored will generate dysfunctional economic costs that will undermine investments in growth and exacerbate poverty as poor people experience the loss of supportive ecosystem services (let alone the groundwater dependant nature of some ecosystems). Fortunately, it is also clear that technologies and practices do exist that open up opportunities for decoupling unsustainable groundwater resource use from growth and poverty eradication strategies, hence the importance of embarking on and supporting an initiative such as this i.e. groundwater source and aquifer protection zoning.

10. GLOSSARY

Abstraction	The removal of water from a resource, e.g. the pumping of groundwater from an aquifer.
Activity	A development action, either planned or existing, that may result in environmental impacts through pollution and/or resource use.
Affected environment	Those parts of the socio-economic and biophysical environment impacted on by the development
Aquatic ecosystems	The abiotic (physical and chemical) and biotic components, habitats and ecological processes contained within rivers and their riparian zones and reservoirs, lakes, wetlands and their fringing vegetation.
Aquifer	A geological formation, which has structures or textures that hold water or permit appreciable water movement through them.
Assessment	The process of collecting, organising, analysing, interpreting and communicating data that are relevant to some decisions.
Auditing	The process through which an assessment study is inspected which then provides an opportunity and mechanisms to learn from experience and to refine the project design and implementation procedures.
Basic human need	The least amount of water required to satisfy basic water requirements; this is currently set at 25 ℓ/cap·d.
Basic sanitation	Means the prescribed minimum standard of services necessary for the safe, hygienic and adequate collection, removal, disposal or purification of human excreta, domestic waste-water and sewage from households, including informal households.
Beneficial use	Benefit of legitimate users.
Benefits	The social, economic or environmental benefits generated by protecting the environment or associated with a particular development which may induce associated costs.
Catchment	In relation to a watercourse or watercourses or part of a watercourse, a 'catchment' means the area from which any rainfall will drain into the watercourse or watercourses or part of a watercourse, through surface flow to a common point or common points.
Class	This represents boundaries within which the variable you are examining falls within. When the variable examined creates a continuous gradually changing spectrum in response to other variables the definitions of classes are essentially arbitrary chosen at equal or other intervals according to the distribution. However in some cases discontinuities exist and thresholds can be determined in such cases it is possible to define class boundaries in a less arbitrary manner.
Classification process	Process of implementing the classification system to actually classify the resource into different classes.
Classification system	A system for classifying water resources that establish the guidelines and procedures for determining different classes of water resources.
Compliance	To act in accordance with the rules and regulations.
High confidence Reserve determination	An assessment of the Reserve based on detailed data and observation; may include numerical modeling; also referred to as a full reserve assessment.

Conjunctive use	Combined use of surface and groundwater.
Conservation	In relation to a water resource, "conservation" means the efficient use and saving of water, achieved through measures such as water saving devices, water-efficient processes, water demand management and water rationing.
Contamination	The introduction of any substance into the environment by the action of man.
Co-operative governance	Co-operative Governance refers to the collaboration between Government, the Private and Public sectors and Civil Society in governing the country and addressing the needs of the nation. It also refers to the collaboration between all spheres of government and organs of state to provide effective, transparent, accountable and coherent government for the Republic as a whole.
Costs	The social, economic or environmental consequences associated with a certain impact or hazard realization.
Desired ecological status	The future desired status of groundwater within the resource unit as used in setting the groundwater component of the ecological Reserve.
Development	The act of altering or modifying resources in order to obtain potential benefits.
Differentiated approach	Recognises that some resources require different levels of protection or even no protection at all.
Ecological category	A letter ranging from A to F that is assigned to a resource that reflects the ecological condition of the water resource in terms of the deviation of its biophysical components from a pre-development condition.
Ecological sustainability	This concept captures the view that there is a need to treat ecological protection and continuing economic growth as mutually compatible rather than as necessarily conflicting objectives.
Ecological sustainability baseline	The lowest acceptable level of protection required for the sustainable use of the entire integrated unit of analysis (IUA).
Ecological water requirements	Water that is specifically left in a water resource or released from an impoundment to maintain the said water resource in a desired ecological category.
Ecology	The study of the interrelationships between organisms and their environment.
Economic efficiency	A condition that is achieved when resources are used over a given period of time in such a way as to make it impossible to increase the welfare of any person without harming another.
Economic value	The cost that represents the scarcity value of a good which would prevail in competitive markets.
Ecosystem	An organic community of plants, animals and bacteria and the physical and chemical environment they inhabit.
Ecosystem goods and services	The goods, services and attributes that ecological systems provide that are critical to the functioning of the earth's life-support system, and which contribute both directly and indirectly to human welfare, and therefore have economic value.
Effluent	Liquid waste or sewage discharge, usually discharged in rivers or the sea.

Fractured Aquifer	An aquifer that owes its water-bearing properties to fracturing caused by folding and faulting; see secondary aquifer.
Framework	An interim overarching structure that allows for the testing of various principles before formally implementing a groundwater source and aquifer protection zoning policy.
Geohydrology	The study of the properties, circulation and distribution of groundwater; in practice used interchangeably with hydrogeology; but in theory hydrogeology is the study of geology from the perspective of its role and influence in hydrology, while geohydrology is the study of hydrology from the perspective of the influence on geology.
Gneiss	A highly metamorphosed rock of a granular texture and with a banded appearance.
Granite	A course-grained igneous rock that consists largely of quartz, alkali feldspar, and plagioclase feldspar.
Groundwater	Subsurface water in the zone in which permeable rocks, and often the overlying soil, are saturated under pressure equal to or greater than atmospheric.
Groundwater dependent ecosystem	An ecosystem, or component of an ecosystem, that would be significantly altered by a change in the chemistry, volume and / or temporal distribution of its groundwater supply.
Groundwater region	A broad geohydrological grouping based on dominant aquifer type (primary, secondary), lithostratigraphy, physiography and climate.
Groundwater resource unit	A groundwater body that has been delineated or grouped into a single significant water resource based on one or more characteristics that are similar across that unit; also referred to as a groundwater unit.
Groundwater resource	All groundwater available for beneficial use, including man, aquatic ecosystems and the greater environment.
Hazard	A naturally occurring, or human induced, event that has the potential to create loss.
Hydrological cycle	The continuous circulation of water between oceans, the atmosphere and land. The sun is the energy source that raises water by evapotranspiration from the oceans and land into the atmosphere, while the forces of gravity influence the movement of both surface and subsurface water.
Hydrology	The study of the properties, circulation and distribution of water.
Impact	Means any effect on the environment caused by an activity; such effects on the environment include effects on human health and safety, flora, fauna, soil, air, water, climate, landscape, socio-economic environment or the interaction among these factors and cultural heritage or socio-economic conditions resulting from alterations to these factors.
Integrated unit of analysis	A catchment that incorporates a socio-economic zone, but is defined by a watershed.
Integrated water resources management	Includes all the components of the water resource, i.e. surface water, groundwater, wetlands, etc. taking account water quantity and quality aspects in management considerations.

Interested party	Individuals or groups concerned with or affected by an activity and its consequences. These include the authorities, local communities, investors, work force, consumers, environmental interest groups and the general public.
Key stakeholders	People who stand to be directly affected, influential people, respected people, spokespeople for their sectors, people with the authority to say 'yes' or 'no', people whose local knowledge is important, people who may want to derail the process for personal gain, and all those who *think* they are key stakeholders.
Market approach	This is an accepted means through which buyers and sellers can communicate and trade at mutually agreed terms.
Mitigation	Measures designed to avoid, reduce or remedy adverse impacts.
Monitoring	The repetitive and continued observation, measurement and evaluation of environmental data to follow changes over a period of time to assess the efficiency of control measures.
National scale	This scale covers the total area of South Africa and would be measured in millions of square kilometres.
National water resource strategy	Provides the framework for the protection, use, development, conservation, management and control of water resources for the country as a whole.
Point source of pollution	Pollution from discrete and definable points as opposed to pollution from broad areas.
Polluter pays principle	A principle that ensures that a charge per unit of pollution emitted into the ecosystem is charged to those responsible for such pollution in order to internalise the cost thereof.
Pollution	Any detrimental alteration in the composition or quality of the waters of a shared watercourse, which results directly or indirectly from human conduct.
Precautionary Principle	Promotes the adoption of a conservative approach, particularly in those cases where knowledge is limited or risk unknown; requires that people err on the safe side when taking decisions.
Preferential Flow	The preferential movement of groundwater through more permeable zones in the subsurface.
Preliminary class	An interim resource class that the resource must be managed to meet until such time as a more formal classification process can be implemented in a region.
Preliminary classification	The process of temporarily classifying the resource in the lack of a formal classification system or as yet unimplemented formal classification process.
Preliminary Reserve determination	Because strategies, methods and tools are still in the process of being developed and refined, all reserve determinations are considered preliminary (in a legal context) until methods to be used for determining the Reserve are published in the Government Gazette.
Present ecological status	Current status of any water resource within the resource unit as used in determining the ecological Reserve.
Prevention	To defend from harm, decay or loss; implies limited or no use of a resource.

Protection	A set of measures to ensure that the resource is maintained at a level which preserves certain environmental functions, such as water purification, thus ensuring sustainable development while conserving the cultural, ecological, and biophysical fabric of the resource.
Remediation	To restore to health; requires that impact is reduced to some acceptable level.
Reserve	The quantity and quality of water required to supply the basic needs of the people to be supplied with water from that resource, and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of water resources.
Resource	A substance or item available for use. A natural resource is a resource that man can use but not manufacture or create.
Resource quality	The quality of all aspects of a water resource including (a) the quality, pattern, timing, water level and assurance of instream flow, (b) the water quality, including the physical, chemical and biological characteristics of water, (c) the characteristic and condition of the instream and riparian habitat, and (d) the characteristics, condition and distribution of aquatic biota.
Resource quality objectives	The requirements in terms of both water quality and water quantity to maintain a resource in a specific class. This could be defined for the entire system (resource) as well as for various users in the system.
Resource units	Areas of similar physical or ecological properties that are grouped or typed to simplify the reserve determination process.
Risk	The probability of specific hazard occurrence. Alternatively in a less scientific definition could be severity versus likelihood.
SADC protocol	The revised protocol on shared watercourses in the Southern African Development Community signed on 7 August 2000 in Windhoek.
Sanitation	The treatment and disposal of waste from the human body and grey water generated through household activity.
Significant water resource	A water resource that is deemed to be significant from an economic, social and ecological perspective.
Social equity	In the context of water resources, social equity implies that all user groups have fair and reasonable access to the nation's scarce water resources, and that the allocation of water resources facilitates universal and affordable access to a basic water supply.
Surface water	Bodies of water, snow or ice on or above the surface of the earth (such as lakes, streams, ponds, wetlands, etc.).
Sustainable development	Use, development and protection of natural resources in a way and at a rate that allows for social, economic and cultural needs of people and communities to be met without compromising the ability to meet the needs of future generations.
Utilization	Anthropogenic interventions which through usage can influence the nature and characteristics of a water resource (flow regime, water quality, etc) which can be detrimental to other users and the ecology.
Vulnerability	The tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer.

Water course	A river or spring; a natural channel in which water flows regularly or intermittently; a wetland, lake or dam into which, or from which, water flows.
Water management area	Water management areas are established as management units in the NWRS within which a CMA will conduct the protection, use, development, conservation, management and control of water resources.
Water resource	Includes a watercourse, surface water, estuary, or aquifer.
Water resource classification procedure	A stepwise procedure that is applied in the water resource classification process.
Water resource classification process	The application of the water resource classification system to determine the class of a water resource.
Water resource classification system	The stepwise procedure for determining the class of a water resource, together with a definition of the classes that are to be used.
Water services authorities	Any municipality, including a district or rural councils, responsible for ensuring access to water services.
Water services provider	Any person who provides water services to consumers or to another water services institution, but does not include a water services intermediary.
Water stress	Relates to instances where demands for water are approaching or exceed available supply, where water quality problems are imminent or already exist, or where water resource quality is under threat.

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