

**SITUATIONAL ANALYSIS FOR THE PREPARATION
OF INSTITUTIONAL ARRANGEMENTS FOR
GROUNDWATER MANAGEMENT IN THE NWDWA**

**A Stephens • L Newton • CA Mischker •
DB Bredenkamp • KO Reid**

WRC Report No. 1324/1/05



Water Research Commission



Situational Analysis for the Preparation of Institutional Arrangements for Groundwater Management in the NWDWA

Comprising five sections

1. Phase 2 Synthesis Report
 - Appendix A: Water Demand and Use Assessment
 - Appendix B: Geohydrological Assessment
 - Appendix C: Institutional Assessment

Report to the
Water Research Commission

by

A Stephens (Editor)
L Newton
CA Mischker
DB Bredenkamp
KO Reid

IUCN South Africa
PO Box 11536, Hatfield, Pretoria 0028
South Africa

Disclaimer

This report emanates from a project financed by the Water Research Commission (WRC) and is approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the WRC or the members of the project steering committee, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ACKNOWLEDGEMENTS

This report represents the completion of the situational analysis of a research project initiated to conceive institutional arrangements for groundwater management in the NWDWA. It has been a highly collaborative project, with support from an array of role-players.

Project Steering Committee

Dr Kevin Pietersen	Water Research Commission (Project Manager)
Eddy van Wyk	Department of Water Affairs and Forestry
Jaco Nel	Department of Water Affairs and Forestry
Graham Hubert	EMA/Department of Water Affairs and Forestry
Anthea Stephens	IUCN (World Conservation Union)
Saliem Fakir	IUCN
Ndileka Mohapi	Department of Water Affairs and Forestry
Sonia Veltman	Department of Water Affairs and Forestry
Rens Botha	Department of Water Affairs and Forestry
Dr Johan van der Merwe	Department of Water Affairs and Forestry
Gawie van Dyk	Department of Water Affairs and Forestry
Paul van der Merwe	Department of Water Affairs and Forestry
Ellis Thebe	Department of Water Affairs and Forestry
Mutsa Masiyindima	International Water Management Institute
S.J. Janse van Rensburg	Botshelo Water

Project Team

Anthea Stephens	IUCN (Project Manager)
Lutske Newton	Reid Management Consulting Services (Project Co-ordinator)
Claus Mischker	MCA Planning (Water Use/Demand Assessment)
Dr David Bredenkamp	Water Resource Evaluation and Management (Geohydrological Assessment)
Kabelo Reid	Reid Management Consulting Services (Institutional Assessment)
Ditse Motlana	IUCN (Administrator)
Marna de Lange	IWMI (Reviewer)
Dana Grobler	Blue Science Consulting (Workshop facilitator)
Christine Colvin	CSIR (Author: handbook)

Others

Gratitude is expressed to all those who made themselves available to be interviewed for the different assessments and supported the project by supplying information at their disposal.

TABLE OF CONTENTS

LIST OF TABLES	iv
LIST OF FIGURES	iv
ABBREVIATIONS	iv
EXECUTIVE SUMMARY	vi
1 INTRODUCTION	1
1.1 Background	1
1.2 Problem Formulation	1
1.3 Clarification of Terms and Concepts	2
1.3.1 Integrated Water Resource Management	2
1.3.2 Sustainability	2
1.3.3 Groundwater Management and accompanying functions	2
1.3.4 Institutional Arrangements	4
1.4 Project Objectives	5
1.4.1 Phase 1 Research Outcomes	5
1.4.2 Phase 2 Research Objectives	6
1.5 Methodology	11
1.5.1 Geohydrological Assessment	13
1.5.2 Water Use and Demand Assessment	13
1.5.3 Institutional Assessment	14
1.6 Phase 2 Research Products	14
1.7 Structure of Report	15
2 SITUATIONAL ASSESSMENT	16
2.1 An international context	16
2.1.1 Overview of international groundwater management literature	17
2.1.2 The global challenges in water management	17
2.1.3 Important issues to consider in groundwater management in South Africa	21
2.2 Policy and Legal Framework	22
2.3 Geohydrology Assessment	23
2.3.1 Summary	29
2.4 Water Demand/Use Assessment	30
2.4.1 Summary	34
2.5 Institutional Assessment	34
2.5.1 Regulatory bodies regulating activities that impact on water resources	36
2.5.2 Water Services Institutions	38
2.5.3 Facilitators and User Interest Groups	40
2.5.4 Summary	40
2.6 Concluding Comments	40
3 RESOURCE MANAGEMENT ISSUES	42
3.1 Measuring the resource and its uses	42
3.1.1 Geohydrological Assessment	42
3.1.2 Water Demand/Use Assessment	43
3.2 Status of the resource	44
3.2.1 Abstraction	44
3.2.2 Water quality	44
3.3 Existing institutional environment, capacity and resources	44
3.3.1 Status of participating organisations	45
3.3.2 Management boundaries	47
3.3.3 Management Systems and Tools	48
3.4 Conclusion	49
4 RESPONSE TO RESOURCE MANAGEMENT ISSUES	50
4.1 Scenarios for groundwater resource management	50
4.1.1 Scenario 1	51
4.1.2 Scenario 2	51
4.1.3 Scenario 3	51
4.1.4 Scenario 4	52
4.2 Coping Measures	57
4.2.1 Local water resource management: Establishment of WUAs	57

4.2.2	Co-management: the formation of an Aquifer Management Strategy and the Dolomite Water Area Management Committee (DWAMC)	57
4.2.3	Interim Co-Management	59
4.2.4	Strategic decisions for shared resources: Advisory Committee	60
4.2.5	The Decision Support System	61
4.3	Concluding Comments	62
5	CONCLUSION	63
6	REFERENCES	65
7	ANNEXURE A: Guidelines for the design of an awareness and educational strategy	68

LIST OF TABLES

Table 1:	Water Management Area and corresponding Regional Offices	1
Table 2:	Study Phases	5
Table 3:	Discussion on study objectives	9
Table 4:	Percentage of area under irrigation	30
Table 5:	Dolomite water units	31
Table 6:	Overview of major settlements and domestic water source	32
Table 7:	Levels of Access to Water per RDP standards	32
Table 8:	Water demand per dolomitic water unit	33
Table 9:	Categorisation of IWRM role-players	35
Table 10:	Information sources for the Water Demand Assessment	43
Table 11:	Comparison of components of the groundwater balance of the NWDWA groundwater units	44
Table 12:	Institutional progress relating the establishment of WUAs and CMA	46
Table 13:	Variables	50
Table 14:	Scenarios	53

LIST OF FIGURES

Figure 1:	Conceptual approach for the design of institutional arrangements	12
Figure 2:	Legislative framework for groundwater management in South Africa (MacKay 2000)	23
Figure 3:	Litho-stratigraphical sequence of the dolomite indicating the characteristics and thickness of the different formations	24
Figure 4:	Simplified conceptual presentation of the NWDWA	26
Figure 5:	Map showing the groundwater units and points where springs ooze from the NWDWA	29
Figure 6:	Groundwater Use per sector and dolomitic unit	30

ABBREVIATIONS

CDM	Central District Municipality
CMA	Catchment Management Agency
CMS	Catchment Management Strategy
DAMC	Dolomitic Aquifer Management Committee
DWAF	Department of Water Affairs and Forestry
IUCN	World Conservation Union
IWRM	Integrated Water Resource Management
NWA	National Water Act (Act 36 of 1998)
NWDWA	North West Dolomite Water Area
NWDWARM	North West Dolomite Water Area Resource Management
NWRS	National Water Resources Strategy

SDM	Southern District Municipality
WMA	Water Management Area
WMI	Water Management Institutions
WRC	Water Research Commission
WSA	Water Services Act (Act 108 of 1997)
WSDP	Water Service Development Plan
WUA	Water User Association

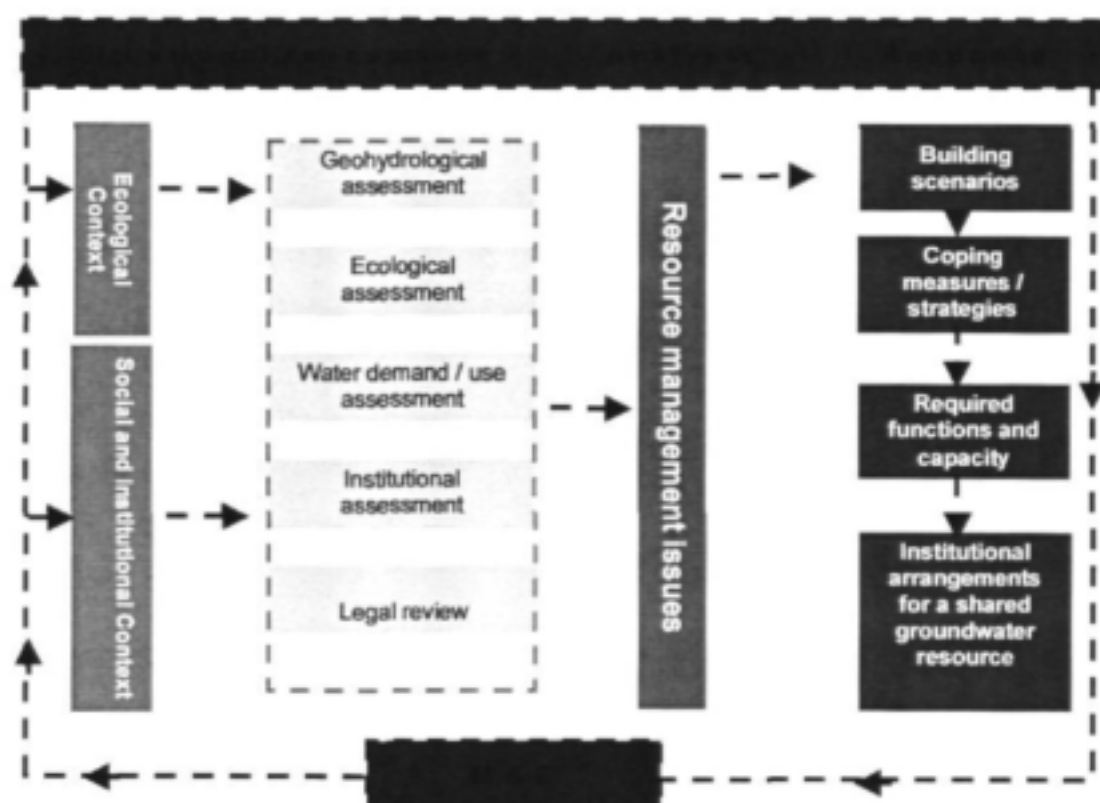
EXECUTIVE SUMMARY

1. Goals

A strategic groundwater resource in the North West province, referred to as the North West Dolomitic Water Area (NWDWA), is shared between three Water Management Area (WMAs). These are the Crocodile West-Marico, Middle Vaal and Lower Vaal WMAs. Concern about its management prompted the inception of a research study to consider institutional arrangements that would result in its sustainable and equitable management. The goals of the project are therefore that current users utilize the resource in an economical and efficient way, that marginal users gain better access to it, and that it can support both population trends and economic development initiatives.

2. Project Approach

A phased approach has been adopted and this is best captured in the following diagram:



This conceptual framework sketches the steps involved in designing institutional arrangements for groundwater management. It can best be described as a cyclical three-staged process starting with a situational assessment, leading into the analysis and then developing a response to the outcome of analysis. Since this is not a static process, one is required to monitor and evaluate the 'situation' or 'context' so as to stay abreast with the management issues and continually modify responses.

The situational assessment involves a description of the ecological as well as the social and institutional contexts. The ecological context primarily includes a geohydrological assessment. The social and institutional context includes a water demand/use assessment, institutional assessment and legal review.

The second stage of the process involves the identification of issues that affect water resource management and would need to be addressed and incorporated in a management strategy.

The third stage, which is comprised of a number of steps, encapsulates the response to the outcomes of the first two stages. In the context of water resource management, it is useful for stakeholders to be able to have **management alternatives**, which is considered to be an important part of the problem-structuring stage (Stewart et al 2001 cited in Pietersen, K 2004). The process of forming and considering scenarios is a means of developing these alternatives. In order to progress from a less to a more desirable scenario, **mechanisms** (coping measures or strategies) are required to stimulate the change and there should be sufficient resources (human and financial) to support these. Finally, the combination of these mechanisms and the allocation of resources represent the institutional arrangements equipped to manage a shared resource.

This report concentrates on the first two stages and its input documents embody the completion of the situational assessment and an identification of the water resource management issues arising from the assessment.

3. Results

3.1 Geohydrological Assessment

The geohydrological assessment, which was a continuation from Phase 1 (Stephens and Bredenkamp, 2002), has concluded with a conceptual model. This is a sound basis for a hydrodynamic (numeric) model as well as an educational tool to hone a wide range of stakeholders' knowledge of the North West Dolomite Water Area. Information on the resource was adapted for a handbook to be circulated to local water managers and users.

3.2 Water Demand Assessment

A Water Demand Assessment is typically structured according to main water uses, namely agriculture (irrigation and stock), industrial, domestic, and environment. Good results were generated for the domestic demand but there are concerns about the quality of data for the remainder of the uses. Of greatest concern is the data for irrigation as this use consumes three-quarters of the resource. The problem of quantifying and projecting irrigation demand requires high level attention and co-ordination.

3.3 Institutional Assessment

An array of organizations influences the use and management of groundwater. This assessment concentrated on the local and regional players and found that on the whole there is extremely limited capacity for sustained and intensive contributions in the process of

groundwater management. This would be less of a problem if the designated organizations, namely CMAs and Water User Associations (WUAs) were in place. But since they are not and there are problems with legal compliance, the study concluded that the Regional Offices should be better resourced, there should be stronger lines of communication between all the main role-players and that a campaign is required that will stimulate the formation of WUAs.

4. Resource Management Issues

Resource management issues are concerned with efficient and credible ways of measuring the resource and its uses. The discussion here centres on the availability of data for analysis. Both the Geohydrological and Water Demand Assessments noted concerns about the availability of certain data and in particular that on irrigation. Secondly, and in line with the measured approach, is an appraisal of the status of the resource both in terms of quantity and quality. Recharge and yield were calculated but with strong uncertainties about the rate of abstraction, it was difficult to predict which of the geohydrological units were being compromised. In terms of water quality, until nitrate testing is introduced, the quality of water is deemed good. Thirdly, and deviating somewhat from the 'measured approach', resource management issues also concentrate on the institutional landscape and the capacity and resources available for devolved management of the shared resource. There was a dichotomy in results where on the one hand severe institutional weaknesses were identified yet on the other tremendous opportunities for enhancing the management of the resource through the existence of institutional initiatives such as the North West Dolomite Water Area Management Project and the development of management tools that could easily be applied in the area.

5. Conclusions

During a process of scenario-building, which is the introductory step to thrashing out a 'response' to the arising water management issues, management alternatives were identified. Four scenarios were sketched, closely mirroring reality, and from these a range of coping measures was identified. These coping measures allow for both interim and long-term options. An interim option, while intense institution-building is underway, is to appoint a North West Dolomitic Water Area Management (NWDWAM) co-ordinator who can act in the interests of the aquifer, ensuring that it is represented in the plethora of organizations that exist and affect the management of and demand for this resource. In the long-term, the institutional arrangements that govern the resource may be the North West Dolomitic Water Area Management Committee (NWDWAMC), which will pull the different role-players together into one committee and serve to centralize decision-making around the aquifer. However for this approach to be effective, the participating organizations need to be strong and their strength will depend largely on how they are set up and to what extent stakeholders are capacitated to play a meaningful role in water management. Since this is the beginning of the third stage, steps to follow would include the identification of required functions and capacity for these coping measures to be effected. This leads the way to the proposal for the third phase, which focuses mainly on developing a plan of action for the NWDWAM co-ordinator.

1 INTRODUCTION

1.1 Background

The primary objective of this project is to develop institutional arrangements for the management of a water resource shared by three Water Management Area (WMAs). The resource is groundwater found in the dolomitic terrains of the North West province, hereafter referred to as the North West Dolomitic Water Area (NWDWA).

The overall goal of this project is to contribute towards the sustainable and equitable management of groundwater, which is recognised as a beneficial component of Integrated Water Resource Management (IWRM).

The dolomitic groundwater in the North West province is known to be a valuable natural resource, which provides the water supply to towns, rural settlements, industries, agriculture and other activities in an area where surface water resources are negligible. Its array of users resides both on and beyond the aquifer. Groundwater also sustains the flow of several springs, wetlands, and river channels, and sustains the ecology of these freshwater systems.

The terms of reference for this project were issued by the Water Research Commission (WRC) and Department of Water Affairs and Forestry (DWAF) in 2000 and awarded to the IUCN (World Conservation Union) the following year. The first phase of the project was completed towards the end of that year and the second phase, described in this report, began in March 2003.

1.2 Problem Formulation

The legislative framework governing water resource management requires that WMAs and Water Management Institutions (WMIs) be established to enable the decentralisation of water resources management. In this instance, the NWDWA crosses three WMAs. The following table displays these as well as the DWAF Regional Offices fulfilling the functions of the corresponding Catchment Management Agencies (CMAs) in WMAs:

Table 1: Water Management Area and corresponding Regional Offices

Water Management Area	Regional Office
Crocodile West-Marico	Gauteng/North West
Middle Vaal	Free State
Lower Vaal	Northern Cape

In addition to CMAs, Water User Associations (WUAs) are also important organisations in the decentralisation of water management. While none currently exist for the NWDWA, five WUAs could be establishing with their respective boundaries coinciding with five geohydrological units, drawn up by the Groundwater Resource Assessment and Monitoring

Subdirectorates in the late 1990s. The boundaries of the WMAs do not concur with the outer boundary of the dolomite or its internal geohydrological boundaries, which has resulted in the proposed WUAs crossing three WMAs.

The strategic value of the resource as well as its awkward institutional positioning pre-empted the current study, posing the central research question: what institutional arrangements would culminate in the sustainable and equitable management of the resource?

1.3 Clarification of Terms and Concepts

1.3.1 Integrated Water Resource Management

The promulgation of both the National Water Act (DWAF, 1998) and the Water Services Act (DWAF, 1997) is underpinned by the philosophy of Integrated Water Resources Management which can be understood as a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. Furthermore, the continuity of the hydrological cycle is recognised resulting in the promotion of groundwater as a public good and to be managed accordingly.

1.3.2 Sustainability

The sustainability of the resource is to be considered an outcome of IWRM. A definition of sustainability is "the management and conservation of the natural resource base and orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human [and environmental] needs for present and future generations" (Batchelor, 1999: 250). This project centres on what that institutional change should involve and how to go about it. It does that in a very systematic way by first describing the context in which that institutional change should happen and what the challenges are in achieving that change.

1.3.3 Groundwater Management and accompanying functions

There are two contrasting perspectives on what groundwater management entails. A technical perspective would be concerned with a measured approach based on the reinforcement of existing institutions to tackle hydrogeological problems in a logical progress way.

According to this approach, "Effective management requires:

- Awareness of the **status** of groundwater – both its quality and the available quantity for use. It follows that **monitoring** is a prerequisite in order to identify whether problems are occurring or are likely to occur;
- Sufficient understanding of the aquifer's characteristics to identify options (and targets) to remedy a problem situation;
- Water laws and rights in place, widely accepted and clear, or in their absence a practicable system of incentives/disincentives;
- Awareness in governmental planning and society at large of the importance of groundwater."

A second perspective regards groundwater management as a more holistic approach to sustainability in which coping strategies as well as technical measures form part of the groundwater problem-solving process. Here the environmental sustainability of the groundwater resource (groundwater volume and quality) is analysed in conjunction with concurrent economic and social issues.

In this project, a holistic approach to groundwater management is deemed necessary because water access and use is underpinned by a legal system that sought to exclude the majority of the population politically, economically and socially. Therefore the approach to groundwater management has to move beyond the technical measurements and factor in a range of contextual factors that affect the way it is perceived and used.

Any structure or process instituted for the management of the NWDWA needs to consider its role in fulfilling the following essential functions which have been defined for river basin management but are just as important for groundwater management (adapted from Svendsen et al., 2001):

1. Planning medium and long-term management and development of water resources ensuring that demand and supply are in line;
2. Allocating water to different sectors;
3. Distributing water (facilitating access to groundwater via boreholes);
4. Monitoring water quality and quantity;
5. Enforcing water quality and quantity;
6. Protecting against water disasters;
7. Protecting the ecology and provision for basic human needs;
8. Constructing facilities; and
9. Maintaining facilities.

Eventually, once a North West Dolomite Water Area Resource Management (NWDWARM) Plan has been drawn up, an accompanying plan detailing the human and capital resources required to execute these functions can be finalized.

1.3.4 Institutional Arrangements

In the first phase of the study the concept of institutional arrangements was discussed and a working definition was expressed. The discussion and definition proposed in Phase 1 follow (Stephens and Breidenkamp, 2002:4-5):

"Institutional arrangements depend on a country's prevailing cultural, social, economic and political conditions, and as these conditions change, the institutional arrangements need to adapt accordingly (UNEP/GPA, 2000). South Africa's political transition, and the recent process of water law reform, has resulted in the need for new institutional arrangements to organise water management in line with these changes....'An institution is a set of norms or effective rules used by a group of people in order to organise a certain sphere of their collective activities' (Aylward and González, 1998:60).

In the context of this project, we are therefore addressing the rules and norms used to organise the collective activities related to groundwater management. This is further defined by the rules and norms specific to a particular geographic area and a particular resource, namely groundwater in the dolomitic terrains of the North West Province...In South Africa, rules and norms are informed by the Constitution and by the legislation enacted under the Constitution. These institutions lay out the principles, objectives, and institutional approach and structure to be adopted in relation to, for example, water management. It remains to define the specific institutional arrangements for the resource, according to both the requirements set out at a national level and according to local needs.

In this case, the institutions provided at a national level do not cater for a critical aspect of the specific resource, namely that it transcends the management boundaries defined by the State for water resources. Institutional arrangements need to make provision for this characteristic, which is typical of groundwater. Then, the roles, responsibilities and functions of institutions within this structure need to be defined, and finally, the requirements, such as information or capacity building, needed to manage the resource effectively need to be identified.

Institutional arrangements therefore including the following:

- principles, objectives and institutional approach for groundwater management
- overall institutional structure and implementing agencies
- roles, responsibilities and functions of implementing agencies
- requirements and support needed to ensure functioning institutions."

Each WMA is home to a set of water management institutions that are established through the combined initiatives of DWAF, communities living and businesses operating in the catchment, and any other relevant organisation with a presence or interest in that catchment. Furthermore, national and provincial policies and laws as well as district and local municipality by-laws influence these institutions. In the absence of an integrated approach that addresses complex transboundary issues, aquifer management is seldom optimised, leading to the unsustainable and inequitable utilisation of groundwater.

It is in this multi-stakeholder environment, that an appropriate solution to the management of the aquifer, supporting the National Water Resources Strategy (NWRS) (DWAF, 2002b) and

the legal framework for water resources management, and optimising environmental sustainability, social equity and economic efficiency, is required.

1.4 Project Objectives

The objectives for the study identified by DWAF 2001 were to:

- Identify the management issues that may arise as a result of managing a resource that transcends water management boundaries;
- Establish institutional management principles and approaches to make groundwater a beneficial component in order to achieve IWRM;
- Propose a management structure for sustainable management of dolomitic aquifers; and
- Outline the information and system requirements of such new management bodies and the state support required leading to functioning institutions.

In order to achieve these broad objectives, a phased approach was adopted, with the scope and TORs of each phase being defined by the outcomes of the proceeding phase. Broadly, the following structure was envisaged:

Table 2: Study Phases

Phase	Result
Phase 1	Situation Analysis
Phase 2	Extended Situation Analysis
Phase 3	Workshops with key stakeholders
Phase 4	Development of detailed institutional arrangements

The first and second phases were envisaged as an extended situation analysis with the first phase examining the existing body of knowledge on groundwater, its use and management, specifically in dolomitic terrains of the North West Province.

1.4.1 Phase 1 Research Outcomes

Phase 1 (Stephens and Bredenkamp, 2002) highlighted the gaps and challenges in the existing knowledge base, which included:

- Geohydrological information related to the resource (e.g. delineation of groundwater units according to geohydrological boundaries; regional drainage according to peizometric levels and points of outflow);
- An understanding of groundwater management requirements and strategies;
- Institutional capacity to manage groundwater and undertake geohydrological management functions;
- Institutional capacity to address equitable and representative stakeholder involvement in groundwater management;
- The capacity of local communities and water users to participate equitably in groundwater management.

Phase 1 began the identification of management requirements that may arise as a result of managing a resource that transcends WMAs, including:

- A model that could reliably simulate the aquifer response to recharge, abstraction and inflow/outflow that would aid the technical management of the resource.
- Information on the aquifer such as groundwater levels, abstraction rates, rainfall, and groundwater quality that was deemed accurate and could be accessed by water managers and users as part of decision-making processes that affect the aquifer.
- Clarity on the roles, responsibilities and functions of different role-players as well as the institutional capacity to fulfil these.
- The representation of previously disadvantaged groups in decision-making processes and facilitating equitable access to resources that could enhance livelihoods. (The process of building this empowerment would need to take cognisance of internal power relations and address the contradiction of women's pivotal role in supplying water to their households yet being typically marginalized from management of the resource.)

Lastly, the Phase 1 report concluded with a preliminary institutional structure, referred to as the Dolomite Aquifer Management Committee (DAMC) that could address the management of the aquifer in a holistic manner.

1.4.2 Phase 2 Research Objectives

The second phase of the study set out to address the gaps in knowledge that emerged during Phase 1. The original objectives for Phase 2 of this project were therefore to:

1. Develop a conceptual model of the dolomite aquifer as a technical/geohydrological basis for the development of institutional arrangements;
2. Identify potential conflicts among different water users and uses as well as potential trends in water demand that will affect the aquifer's capacity in the medium term;
3. Assess the existing institutional capacity required to fulfil the role and responsibilities of both strategic and operational management of groundwater; and
4. Identify the financial and human resources required by newly established or establishing WUAs in relation to their involvement in groundwater management.

At the time of developing the objectives, at the end of Phase 1, it seemed likely that at least three of the five potential WUAs would be established and that at least one of the three CMAs would be operational. These assumptions underpinned the Institutional Assessment affecting Objectives 3 and 4, in particular.

In terms of the geohydrology, the development of a conceptual model was proposed that could assist in the demarcation of management boundaries, which would mean the refinement of the existing boundaries. It was also envisaged that the model could contribute to a management plan, by indicating parameters for sustainable abstraction. This would include the determination of the Reserve and Resource Quality Objectives. While the Geohydrology Assessment (Bredenkamp 2004) has attempted to work around geohydrological uncertainties to offer recommendations on the aforementioned issues, the results have been largely tentative because the assessment was never equipped with the resources required to undertake field work and has relied on available data for the formulation of the conceptual model.

Fortunately, a more accurate numerical flow model is in the pipeline as a result of a larger project, initiated by the Groundwater Resource Assessment and Monitoring Subdirectorate. Entitled the NWDWA Resource Management Project (NWDWARM Project), it took root in 2002 with its main goal being to co-ordinate the numerous technical studies on the NWDWA and to address gaps in scientific knowledge. A co-ordination committee and a programme with a budget have been established to achieve these ends. The ultimate objective, as with the current project, is that the co-ordinated management of the NWDWA is achieved. Since this project came into fruition after the second phase of this study was initiated, it has been necessary to establish how this research project contributes to and supports it, without unnecessary duplication.

In addition to the NWDWARM Project, other developments have been taking place at a national level, which have complimented the aims of the current study. While the first phase of the project was underway, significant work on a framework and strategy for groundwater management, under the auspices of the DANIDA/DANCED-funded programme entitled "Integrated Water Resource Management Strategies, Guidelines and Pilot Implementation in Three Water Management Area, South Africa". Two important documents were generated; the first was a Groundwater Management Strategy for inclusion into the National Water Resources Strategy, which was made public in August 2002; and the second was Guidelines for Groundwater Management. At a more generic level, a report exploring the institutional roles and linkages within a Water Management Area was drafted.

At the same time, a NORAD-funded programme was also underway aimed at addressing the challenge of ensuing sustainable community water supply via groundwater and designed to address institutional strategies, technology guidelines, an information system, and materials for awareness and capacity-building. Of particular interest and relevance is a document entitled "*A framework for groundwater management of community water supply*" and while it is intended only for community water supply schemes (i.e. it excludes the legal and management requirements for licensing, monitoring and assessing polluting activities in rural Area such as mining, industry and agriculture), it sketches out key responsibilities in terms of groundwater monitoring, which is an essential groundwater management function. As with the NWDWARM project, it has been important to assess how the current study contributes to and supports them.

The following table explains how the original objectives have been affected by the aforementioned issues:

Table 3: Discussion on study objectives

ORIGINAL OBJECTIVE	COMMENT	REVISED OBJECTIVE
Develop a conceptual model of the dolomite aquifer as a technical/geohydrological basis for the development of institutional arrangements.	The notion of the conceptual model was that it would serve two key functions. The first function was that it would enhance stakeholders' awareness and understanding of the aquifer as a means to stimulate a sense of its value and the importance of its management. The second function would be that it would serve as a tool to assist decision-making around the boundaries for the WMAs and WUAs since the boundaries for the former are aligned to surface water systems while the invisibility of the groundwater systems renders it difficult for water users to determine water resource boundaries. The first function has been achieved as a handbook has been developed, presenting the conceptual model in layman's terms. A strategy for its distribution and its implementation will need to be part of a broader educational strategy. The second function, which has been strongly affected and to some extent made redundant by the NWDWARM project and one that has a strong bearing on the management of the aquifer, has borne tentative results on the values for sustainable abstraction but no recommendations on the re-alignment of boundaries for WUAs and WMAs are proposed since the conceptual model lacks sufficient information on the existence of dykes and faults to assist in the determination of management boundaries. This outcome will be achieved when the broader study is completed and the generation of a numeric model.	Compilation of existing data on the aquifer into a conceptual model of the aquifer
Identify potential conflicts among different water users and uses as well as potential trends in water demand that will affect the aquifer's capacity in the medium to long term.	The ability to determine potential conflicts among users relies on 1) having reliable water use data; 2) population trends and 3) quantity of water available for exploitation. In terms of the first point, irrigation data is poor (pointing to the need for farmers to start monitoring their usage and reporting it to an appointed authority.) In terms of the second point, while data from 2001 Census became available during the study it was a limited sample (15%) and therefore the population projections would need to be revised once the completed data is made available. In terms of the third point, no reserve has been determined for	- Enhanced picture of the water use profile and in particular the demands on the water resource given the state of water services. - Identification of water resource management issues.

ORIGINAL OBJECTIVE	COMMENT	REVISED OBJECTIVE
	the aquifer and without this, it is practically impossible to calculate how much water is available for exploitation and whether current abstraction is sustainable or not. A guestimate for the reserve has been factored into calculations to ascertain whether current use is sustainable but the results are only indicative. However there is sufficient information to identify resource management issues, and to undertake a degree of planning by developing scenarios and accompanying coping measures.	Develop scenarios and coping measures on account of existing knowledge.
Assess the existing institutional capacity required to fulfil the role and responsibilities of both strategic and operational management of groundwater.	This aspect of the study was severely hampered by the absence of institutions designated to manage water resources. Nonetheless, existing institutions which do play a role in the management of groundwater, whether that be resource management or water services, were included in the assessment.	An enhanced understanding of the institutional constraints vis-à-vis the management of groundwater.
Identify the financial and human resources required by newly established or establishing WUAs in relation to their involvement in groundwater management.	Same as above. This was not accomplished.	
ADDITIONAL OBJECTIVES		
- The compilation of the information generated by the Situation Assessment into a handbook, to be used as a tool to raise awareness of the resource among; - To ensure that stakeholders are aware of the study and to provide fora through which they are able to communicate their views on the management of the resource.		

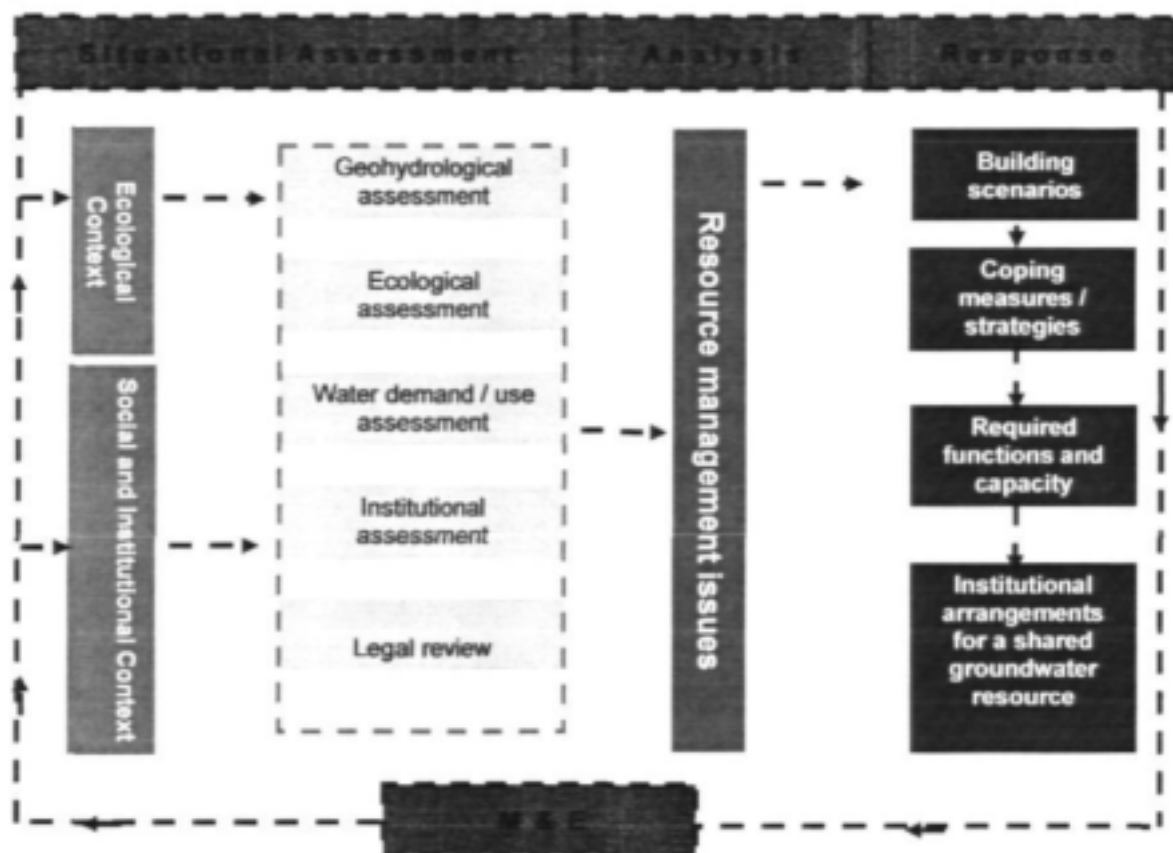
In essence, the role of this project has been to address social and institutional issues which were not factored into any of the ongoing projects in the NWDWA. Since the first two phases comprised a situational assessment, it was necessary to include a geohydrological assessment of the resource but confined to existing information. The results, which are largely a synthesis of the existing knowledge of the NWDWA, are solid foundation on which to prepare a process to develop appropriate institutional arrangements for the management of the resource. Furthermore, the transfer of knowledge to stakeholders is enabled by the synthesis and presentation of this knowledge to stakeholders, since, as argued earlier, effective groundwater management will be determined by the levels of awareness of the occurrence and value of groundwater among the range of users and managers.

As the project progresses, it is anticipated that its focus will sharpen since it may concentrate on the institutional aspects only since the geohydrological aspects will and are being addressed by the other studies comprising the NWDWARM project.

1.5 Methodology

Typically, groundwater management is the domain of scientists who are concerned with 'managing' a natural resource by finding ways to measure its parameters and maintain its cleanliness and flow. However, this research project has needed to break from that mould and incorporate social, economic and institutional realities by conducting a Water Use and Demand Assessment as well as the Institutional Assessment coupled with workshops with DWAF officials, and dominant and marginal water users.

The following figure illustrates the conceptual approach for the study. It illustrates that the study has adopted a multidisciplinary approach to ensure that the conceptualisation of institutional arrangements are responsive to biophysical, social and institutional realities.

Figure 1: Conceptual approach for the design of institutional arrangements¹

This conceptual framework sketches the steps involved in designing institutional arrangements for groundwater management. It can best be described as a cyclical three-staged process starting with a situational assessment, leading into the analysis and then a response to the outcome of analysis. Since this is not a static process, one is required to monitor and evaluate the situation so as to stay abreast with the management issues and continually modify responses.

The situational assessment involves a description of the ecological as well as the social and institutional contexts. The ecological context primarily includes a geohydrological assessment. The social and institutional context includes a water demand/use assessment, institutional assessment and legal review.

The second stage of the process involves the identification of issues that affect water resource management and would need to be addressed and incorporated in a management strategy.

¹ In terms of the ecological assessment, this was a desk-top study as with the water demand and geohydrological assessments; however, it lacks the depth of these assessments since the available environmental data was deficient and it was not within the scope of this project to undertake the required fieldwork to supplement the existing information. It remains a concern that environmental reserves cannot be calculated more accurately.

The third stage, which is comprised of a number of steps, encapsulates the response to the outcomes of the first two stages. In the context of water resource management, it is useful for stakeholders to be able to have **management alternatives**, which is considered to be an important part of the problem-structuring stage (Stewart et al 2001 cited in Pietersen, K 2004). The process of forming and considering scenarios is a means of developing these alternatives. In order to progress from a less to a more desirable scenario, **mechanisms** (coping measures or strategies), are required to stimulate the change and there should be sufficient resources (human and financial) to support these. Finally, the combination of these mechanisms and the allocation of resources represent the institutional arrangements equipped to manage a shared resource.

This report concentrates on the first two stages and its input documents embody the completion of the situational assessment and an identification of the water resource management issues arising from the assessment.

The following studies were undertaken as part of the extended situation analysis.

1.5.1 Geohydrological Assessment

The Geohydrological Assessment, which began in Phase 1 (Bredenkamp 2004), concentrated on developing a conceptual model of the NWDWA, utilising available data (i.e. no field research was conducted), incorporating the following parameters:

- Recharge and the factors governing recharge such as rainfall, geology and topology;
- Regional drainage;
- Aquifer storativity and transmissivity and the factors affecting these such as aquifer thickness and depth; and
- Groundwater quality;

Another outcome of Phase 2 is an estimation of abstraction versus aquifer yield so as to infer the sustainability of current use.

An indirect outcome of this assessment is the verification of a range of methods with which to determine aquifer parameters. These are documented in Bredenkamp (2004).

1.5.2 Water Use and Demand Assessment

The Water Use and Demand Assessment provides a sketch of groundwater's main uses and abstraction volumes per use. Where possible, it provides projections on the domestic patterns of water use and demand for a medium-term period of five years. This exercise, while yielding tentative results, is useful for identifying potential water shortages and hence

resource management issues that would have to be addressed by the institutional framework.

This component has also defined the status of access to water services according to the latest Census statistics and with the use of population projections, quantified future demand for water services. Apart from drawing attention to inequities in access to potable water, this component highlights the importance of institutional relations between Water Service Authorities and CMAs/DWAF regional offices. An indirect outcome of this component is an awareness of the gaps in existing data-sets, which affect the ability to undertake a Water Use and Demand Assessment that is considered to be accurate and therefore reliable.

The findings of this component are vital for a Management Plan for the NWDWA because decisions on groundwater allocations must be informed by the status quo and where and how much water will be needed for basic human needs, which combined with environmental use (i.e. the reserve) takes preference over all other uses.

1.5.3 Institutional Assessment

Any management design must take cognisance of the current institutional landscape and find creative ways of deploying current resources. The first phase of the study began to identify the existing institutions that influence groundwater management in terms of planning and operational management. This included an initial identification of the different role-players' roles and responsibilities. Among the role-players were the DWAF National and Regional offices, Water Boards and Local Government structures, and establishing water management structures such as the CMAs and WUAs.

The second phase of the study aimed to update and expand on the information on the role-players since there was a lapse of about a year and half between the end of Phase 1 and the beginning of Phase 2. An institutional capacity assessment was planned which undertook to assess the existing capacity and resources within institutions earmarked to manage water resources (Reid 2004).

This component also engaged with relevant stakeholders in two ways: firstly, stakeholders were informed of the study, which can be thought of as a form of consultation, and secondly, the research team played an educative role, exposing stakeholders to the features of the dolomitic aquifer. The workshops that were held are seen as the beginning of an ongoing learning process for stakeholders, a preferred approach to meaningful stakeholder involvement.

1.6 Phase 2 Research Products

The following research products have emanated from Phase 2:

- A conceptual model of the aquifer's geohydrological features (Bredenkamp 2004);

- A handbook (Colvin, Newton and Stephens 2004) designed as a layman's manual on the aquifer's geohydrology and an introduction to the water management regime;
- Consultation with stakeholder groupings (Reid 2004);
- Three separate input reports for each of the contributing components (Bredenkamp 2004; Reid 2004; Mischker 2004);
- Synthesis report, integrating the findings from the research components and thus completing the Situation Analysis initiated in Phase 1 (Newton 2004).

1.7 Structure of Report

The structure of the report closely follows the conceptual approach depicted in Figure 2. Chapter Two will therefore provide a summary of the outcomes of the Geohydrology Assessment (Bredenkamp 2004), Water Demand/Use Assessment (Mischker 2004) and the Institutional Assessment (Reid 2004). Chapter Three presents the water resource management issues that emerged from these assessments. Chapter Four features the third stage of the process of the model for shared resource management by sketching out the scenarios as a way of identifying management alternatives and the accompanying functions and resources required to actualise the management of the resource.

2 SITUATIONAL ASSESSMENT

This chapter is a summary of the issues that emerged in the three input reports, which were the Geohydrological Assessment, the Water Use/Demand Assessment and the Institutional Assessment. This chapter should also be considered an extension of the Phase 1 Synthesis Report (Stephens and Bredenkamp, 2002). The chapter starts off with an overview of the international literature on groundwater management. Since it is a new field to this country, the review highlights lessons from other countries where similar challenges to groundwater management have occurred. This is followed by an overview of the policy and legal context and then summaries of the findings of each input report mentioned above.

2.1 An international context

In this section, the international literature on groundwater management has been reviewed in order to provide an international context for groundwater resource management. As comprehensive as the review is, it relies on published work around groundwater and therefore does not explore fully the possible models and management tools used on the ground both in South Africa and internationally that have not been evaluated or made public through published sources. It underscores some of the aspects of the South African policy and strategy around water management that are particularly important for groundwater management and to suggest ideas for future development and research.

Globally, as in South Africa, it has been recognized that government agencies cannot manage water alone, as this tends to overlook the sometime complex needs of users. But it is also acknowledged that government must establish broader regulations to frame negotiations between users and administrators (Bruns and Meinzen Dick, 2000). The global trend is to devolve water management to local level, specifically to users and administrators within catchment management Area. The South African NWA (1998) has established what it calls Integrated Water Resources Management (IWRM) as the foundation of the country's water management policies. The principles of IWRM² are similar to those found in most recent water management strategies, in encouraging a management approach that integrates water sources and water uses and in emphasising values such as equity, sustainability and public participation. In most cases, however, this occurs at either catchment or watershed level. It is, therefore particularly hard to find comparable examples, especially where groundwater management is concerned. The shared principles, however, found in examples that attempt to integrate the management of water across different sources, uses and users, make it worthwhile considering the problems faced by these models and programmes.

² IWRM is a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (Global Water Partnership, 2000 <http://www.gwpforum.org>)

2.1.1 Overview of international groundwater management literature

Where social research has been done on groundwater management it has tended to focus on the sustainable and equitable use of groundwater by rural, subsistence and/or women farmers (Alders et. al., 1993, Pallett, 1997). A lot of research has been conducted on irrigation organizations, but little on what happens when other users are brought into the picture. Blomquist et.al. evaluated the implementation of conjunctive water management in Arizona, California and Colorado (2001). Conjunctive water management is the coordinated use of surface and groundwater so that groundwater is banked while surface water is exploited. In this way water storage and conveyance is managed without additional infrastructure. Groundwater in these US states is, however, largely managed on the level of private ownership based on property rights, so individuals are responsible for 'banking' groundwater. Such systems are, of course, dependent on the particular geohydrology of the aquifers being managed.

Research around the world, as in South Africa, is still needed on how to form and strengthen water management institutions as well as dealing with water crises and how to develop structures in an organic way as opposed to top-down processes of implementation (Bruns and Meizen Dick, 2000). This project begins to address some of the gaps in the literature. Although it is far from being in a position to evaluate the implementation of groundwater management for the NWDWA, we are in the process of developing groundwater management at the same time or ahead of many other countries.

2.1.2 The global challenges in water management

There is little substantive experience from anywhere in the world on which to base the proposed structures and guidelines for the management of the North West Dolomitic aquifer. A possible exception is Southern California, which has successfully managed its groundwater resources for the past thirty years through self-governing local institutions (Blomquist, 1995). What is clear across the world is that the management of groundwater raises similar challenges as those identified in the situational analysis for groundwater management in the North West (Stephens and Bredenkamp, 2002). These include: multiple stakeholders; conflicting interests; history of private ownership; and tensions between individuals and the market. Clearly a specific challenge in South Africa is to avoid entrenching structures that have been managing the aquifer on an ad hoc basis often without concern for many of its current and potential users.

These challenges are, however, not dissimilar from those facing the management of surface water. In water management projects in southern Africa, in general, it is clear that the typical top-down management does not work well in terms of efficiency and raising living standards (Pallett, 1997). Around the world the primary task of governance *"is to create an institutional framework within which strangers can peacefully agree to cooperate and coordinate their actions"* (Bruns and Meizen-Dick, 2000: 367).

The existing literature advocates integrated water resource management and devolving water management to catchment or basin level and among the challenges in effective devolution is the need to establish structures that are capable of managing the interface between government legislation and users. In addition to water resources management committees at catchment level, the establishment of community-led committees that provide forums for discussion to develop priorities and promote catchment level strategies is vital. In Java, for example, water management committees help the government carry out water allocations through:

- "determining the priority sequence of water and water resources utilization planning;
- determining the priority sequence of water usage or water resource utilization within the protection, development and utilization plan;
- regulating water and/or water resources utilization;
- regulating the discharge system of waste water and other waste materials;
- regulating the construction of irrigation and other structures at water sources;
- settling other problems which may arise." (Kurnia, et.al., 2000: 302)

However, it is equally clear that local communities by themselves cannot produce long-term solutions to water problems (Pallett, 1997). Any agency or association of users or representative must form the basis of partnership agreements between federal, state and local government and the community. This is incredibly complex both in terms of natural resource management and social and political management.

Difficulties in linking land management and water resource planning also require international lessons of Integrated Water Management (IWM) and Integrated Catchment Management (ICM). IWM emphasises the need for scientists to delineate input and output and other variables of the resource in ways that are understandable to users and policy makers (Rhoades, 2000). The combination of public participation with water management that takes into account multiple water sources and users is necessary to bring science and institutions, culture and economics together.

The greatest challenge to establishing successful water management that incorporates the needs of users is that they are most likely to succeed when based in indigenous in-situ management structures or at the least, local institutions (Rhoades, 2000). Clearly in South Africa where the goals of the government are essentially to move away from the highly problematic structures of the past, this presents particular challenges, as has been seen in the institutional evaluations conducted for this project.

Most observers of water management concur that the involvement of local users in negotiating water rights improves productivity and sustainability (Bruns and Meinzen-Dick, 2000). A key issue, and one that is very pertinent to the challenges facing the establishment of a model for managing the NWDWA, is how stakeholders are represented in negotiations.

WUAs do not always help, although federations seem effective at bringing a number of WUAs together while still allowing a local voice through (Bruns and Meinzen-Dick, 2000). Citizens Advisory Panels can work well as a structure in consultations. Advisory panels have a long history in water management in South Africa and were based on structures and power imbalances that any new model is required to avoid, even correct. The principles, however, of advisory panels as used elsewhere in the world may still be worth considering, even if they are called something else in future water management in South Africa. Senior managers who are prepared to listen are crucial. Negotiations work best when responding to recognized threats, not imposed sacrifices (Bruns and Meinzen Dick, 2000). Pallet underscores, however, that WUAs must fit in with local social or cultural institutions (1997).

"Generally speaking where water users have a common interest and do not have serious conflicts within themselves or with their neighbouring communities, especially those downstream, they make an appropriate level for management tasks" (Pallet, 1997).

This suggests that where such conditions do not prevail, as in the North West Province, WUAs are not an ideal management structure or require extreme care in their establishment.

In general, however, Rhoades strongly cautions against the establishment of new structures for managing water (2000). He suggests the following provisions be kept in mind should new structures be necessary:

- Recognize existing systems and leave them alone;
- Strengthen existing systems if they are inadequate;
- Assist in establishing new institutions only if they are necessary and pay attention to existing use and rights, be parsimonious, involve people with local interests;
- Where there are relatively separate populations with conflicting use rights, build new institutions, capable of mediating between and communicating with diverse stakeholders. This is the most likely case in terms of water management in South Africa and in fact this project was necessary because of the tensions that are inevitable when new institutions have to be established.

Since the first half or the 20th century groundwater has been managed in southern California through a web of independent, locally developed and enforced arrangements unique to each basin (Blomquist, 1995). Each institutional design was neither comprehensive nor did they simultaneously address all possible problems and issues. Their designs were, in fact, *"incremental and evolutionary, responding to water problems as they emerged and were understood"* (Blomquist, 1995; 43). Although southern California may seem to be far removed from the North West province of South Africa, it was not so different 50 to 70 years ago when these structures were first being established. It was suffering from possible over abstraction due to irrigation farmers assuming an unlimited and private supply of groundwater and its cities were about to explode dramatically in size.

In his evaluation of these management programmes in seven basins in the semi-arid but heavily developed Area of southern California, Blomquist (1995) found them to be successful

in terms of compliance, effectiveness, efficiency in basin administration, efficiency in resource use, equity in balancing costs with benefits, equity in distribution of pumping rights and adaptability. What seems to underlie the success of these management structures is that 'watermasters', no matter how they were constituted, were directly responsible to and paid for by the water users. Their success was also based on constantly providing ample information to water users on the conditions of the aquifer and on each other's behaviour. What this comparison lacks, of course, is the complicating factor of South Africa's history of land and water-rights distribution and the presence of small, but growing communities who do not have easy access to the resources that would allow them to participate easily in any management structure. The Californian experience, however, does emphasise the importance of focussing on participation and direct accountability between management and users, ahead of details about organizational structure. Process, suggests Blomquist (1995), is much more important than the structures, what water users agree to do is less important than how they agreed to it in the first place.

This, however, poses a major challenge for any water management programme based on wide participation. How to facilitate community involvement in what is essentially a scientific problem (Ewing et. al., 2000)? Two examples from the literature, although, possibly overly computerized for South Africa's needs, suggest some important principles for such a process. These advocate developing a management tool that collects and collates as all-inclusive a picture of the aquifer/groundwater resource as possible. The tool itself, which can be used over the long term, is developed through a participative process.

1. The comprehensive approach to groundwater management combines three kinds of information: (1) Physical characteristics of the water and land resource, (2) resource uses and (3) values placed on current and future resource uses (Meij and Abdalla, 1990). This method attempts to meet the problem already encountered in establishing the NWDWA management processes, which is incomplete understanding of the aquifer and especially disjuncture between technical and social knowledges.
2. The solution to a similar challenge in Australia has been the Decision Support Systems, DSS, specifically a system called Adaptive Environmental Assessment and Management (AEAM). AEAM recognizes the high level of uncertainty in environmental systems through the collaborative development of a computer simulation model of the system that takes into account all parameters, not just scientific ones. The challenge is that it requires a key driver, based locally who can coordinate the different modelling subgroups. AEAM is a tool not a substitute for judgement or management. It succeeds, however, as it develops:

"common understanding and expectations, a bridging of the gaps between disciplines, improved communication, the direct involvement of stakeholders, and a greater appreciation of the risks and uncertainties associated with management decisions" (Ewing et. al., 2000).

2.1.3 Important issues to consider in groundwater management in South Africa

The international literature raises some important points that need to be considered in the plans for the NWDWA:

- The devolution of water management to catchment or basin level is considered ideal throughout the world and especially where water resources are under stress.
- Integrated water resources management that takes into account multiple sources of water and multiple users is generally considered to be the ideal approach to water management.
- Groundwater has been poorly managed and generally unconsidered globally.
- Where groundwater has been a concern, the focus has been on local management, often at the level of the borehole and on cooperation between small-scale farmers sharing groundwater through separate boreholes.
- Groundwater is frequently left out of discussions of integrated water resources management as it often crosses the catchment or watershed boundaries that are used to manage water resources.
- Effective groundwater management must be integrated into surface water management.
- Historically groundwater management was often based on establishing groundwater rights based on land ownership. This means that, however one pretties it up for farmers, they no longer own something that they are used to considering theirs.
- This requires sound knowledge and understanding of the aquifer or source of groundwater by water users and managers at all levels.
- A conceptual model/hand book detailing the nature of the groundwater source, its parameters and the extent of its water resources, reserves and limitations, combined with social, economic and political factors is an essential management tool.
- Users and managers should develop this tool co-operatively.
- Caution against the establishment of new institutions; strengthen existing institutions where possible.

Some of the problems facing integrated water management identified in the international literature that may also become challenges in managing the NWDWA include:

- Facilitation by outsiders seldom leads to successful implementation (Rhoades, 2000). This is typical of most public resources³ but it is of course necessary to take into account local conditions and, as is the case in South Africa, where the goals are in fact to establish completely new management structures, facilitation is essential. However, wherever possible this should be sensitive to existing structures and community organizations.

³ Mathers, K. 1996. *Museums, Galleries and New Audiences. An investigation of what English museums are doing to attract new audiences.* London: Art and Society.
Attracting New Audiences. A Manual for Museum Professionals Center for Science Development. March 1997

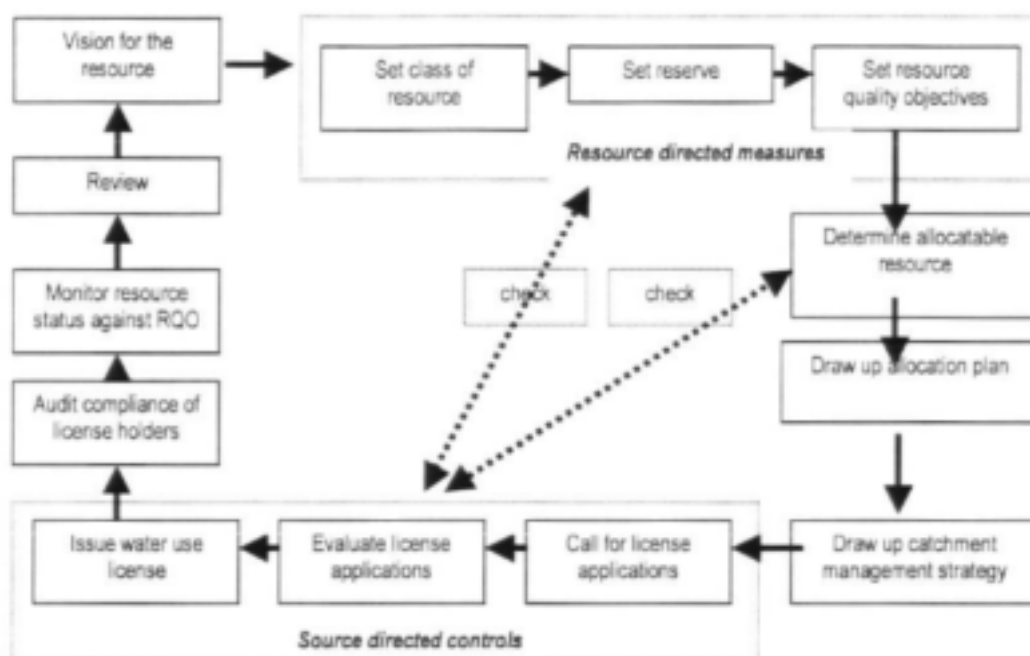
- Different players are dealing with very different scales, some work on the scale of the hydrological unit (catchment area, watershed, river basin, aquifer), others at the level of a local community or specific borehole. This can lead to "scale wars" between provincial governments, NGOs, district officers, scientists and communities (Rhoades, 2000).
- Identify and include all stakeholders⁴.
- Delivery mechanisms and policies that generate and maintain the interest and participation of local institutions and communities are hard to develop (Batchelor, 1999).
- A watershed is seldom a political or social reality except to scientists.
- Co-operative management often requires a great deal of bureaucracy and paperwork and the participants have insufficient expertise and resources (Batchelor, 1999).
- Experts are often not seen as being accountable to local people and their attitudes as well as existing institutional cultures often need to change (Batchelor, 1999).

2.2 Policy and Legal Framework

The legal framework governing water resource management and its implications for groundwater management was presented and discussed in Phase 1. The reader is referred to Stephens and Bredenkamp (2002) for further information.

The following diagram reflects the essence of the legislative framework for groundwater management in South Africa:

⁴ One project in Ecuador found only after a full household census that 43% of the local population had been left out of planning as they were landless and did not come to community meetings.

Figure 2: Legislative framework for groundwater management in South Africa (MacKay 2000)

2.3 Geohydrology Assessment

Dolomites, although forming flat and featureless terrains, are usually very productive aquifers throughout the world. The NW dolomite basin, with its large springs of perennial flows, is sustained by groundwater being recharged from rainfall. Boreholes with high sustainable yields are often intersected during drilling.

Since this study is concerned with the **availability of water** for primary human and environmental needs as well as economic development, the conceptual model concentrates on the ability of the aquifer to absorb and store water since this determines the volume of water that the aquifer can yield. The model therefore explores the factors that affect **a) recharge** – the proportion of rainfall that seeps through the ground surface and flows through the unsaturated soil until it reaches the watertable and **b) storativity** – the capacity of the aquifer to store water in its pores, voids, fissures and fractures.

The recharge of the dolomites is high in comparison to that of other aquifers and is controlled by rainfall intensity as well as by the infiltration characteristics and thickness of the surface material overlying the aquifer. The superficial covering ranges from variable thickness of good soil and mixtures with cherty gravel to outcrops of the different formations. The leached Area of these formations is usually in-filled by soil and gravel matrix. The flat topography enhances the infiltration of water and largely prevents runoff. However, accumulations of runoff in local depressions could occur and is probably responsible for the high recharge during periods of intense rainfall. There are also continual natural losses in the system due to lateral seepage to lower-lying area, appearing as base flow to rivers and seepages to wetlands. There are also evaporation losses from the groundwater by capillary

action and transpiration of the vegetation. It is estimated that more than half (55%) of the recharge is therefore dissipated in the form of underground lateral flow, evaporation and other losses.

These factors affecting the rate of recharge include geology, topography, rainfall and spring discharge. Storativity is determined by geology.

Geology

Dolomite consists of calcium and magnesium carbonates that were precipitated over 2000 million years ago from shallow freshwater lakes (Vegter 2001) to form thick calcareous deposits of dolomite, later on covered by younger sediments. The regional geology already determines the characteristics of aquifers. Some **dolomite formations** are more susceptible to recharge than others and their capacities to store water varies.

The NW dolomite sequence has over thousands of years tilted from its original horizontal layering to its present inclined dipping to the north underneath the Transvaal Formation. This tectonic movement and erosion has exposed the stratigraphical formations as depicted in Figure 4.

Figure 3: Litho-stratigraphical sequence of the dolomite indicating the characteristics and thickness of the different formations

System/ Erathem	SEQUENCE	GROUP	FORMATION	LITHOLOGY AND MEMBER	THICKNESS (m)
PERMO- CARBONIFEROUS	KAROO	ECCA	DWYKA	Sandstone	
				Mudstone	
				Carbonaceous shale, coal	
				Diamictite	
	TRANSVAAL	PRETORIA	TIMEBALL HILL	Shale Diamictite Klapperkop Quartzite Mb wacke and ferruginous quartzite Graphitic and silty shale	270 - 660
			ROOIHOOGTE	Quartzite Shale Bevets Conglomerate Member Breccia	10 - 150
		CHUNIESPOORT	ECCLES	Chert-rich dolomite with large and small stromatolites	380
			LYTTTELTON	Dark chert-free dolomite with large elongated stromatolitic mounds	150
			MONTE CHRISTO	Light coloured recrystallised dolomite with abundant chert; stromatolitic; basal part oolitic	700
			OAKTREE	Dolomite, becoming darker upwards Chocolate-coloured weathering	200
			BLACK REEF QUARTZITE	Shale Quartzite Arkosic grit	25 - 30

The North West dolomite aquifer is made up of the **Eccles, Lyttelton, Monte Christo and Oaktree formations**, which comprise the Chunespoort group. The implication of the different formations is that the storativity and transmissivity of the aquifer differ according to the formation. Higher rates of storativity and transmissivity (governing rates of flow) are found with the chert-rich Eccles and Monte Christo formations while these depreciate considerably with the occurrence of the chert-poor Lyttelton and Oaktree formations. Therefore while there is little difference in the *average* recharge of the various formations, it is highest for the Eccles and Monte Christo formations. In these formations, the highest yielding boreholes and largest springs have resulted from the secondary transformation of the dolomite i.e. the dissolution of carbonate rocks by infiltrating rainwater acidified by carbon dioxide (CO₂) present in the rainfall, to form the typical water bearing dissolution channels and cavities found in dolomite. If the formation overlying a large cavity collapses a **sinkhole** such as the Wondergat is formed.

The depth and thickness of the aquifer also influences storativity. The storativity plotted in relation to the inferred depth/thickness of the aquifer indicates that the storativity declines with depth/thickness and conforms best to a power function. For example; for an aquifer of 1 meter thickness close to surface, the storativity values are as high as 0.36. At a depth of 100 m below surface the S value would be 0.005. The relationship is remarkably uniform across boreholes representing different dolomite formations.

Another factor governing the ability of the aquifer to absorb and store water is the existence of **intrusions or dykes**, which subdivide the dolomite into smaller compartments. This subdivision by dykes is a distinct feature of the dolomite formations. They are thin vertical intrusions of magma that can extend laterally over large distances. The dykes, because of a much lower transmissivity restrict the flow of groundwater often causing a sharp drop in water levels across them. Furthermore, they retard the lateral outflow thereby retaining groundwater for extended use over longer periods. Certain dykes may become impermeable at depth and could impede or stop flow between adjacent compartments if water levels have been substantially depleted.

By damming up the water, the dykes cause the groundwater levels to rise, which results in the **formation of springs** – this is where the water levels rise higher than the surface levels. The major springs that occur in the area are indicated in Figure 5. Part of the outflow of some springs can re-infiltrate in the next compartment only to reappear or augment the flow of another lower-lying spring. The occurrence of fewer but larger springs is due to fewer dykes obstructing the groundwater flow and hence the recharge Area are larger and the yields of the springs correspondingly higher. The prevalence of springs is thus an indication of the complexity and barrier-effect of the dyke system. The larger number of springs in the Zeerust area, for example, is due to the many dykes that traverse the formations.

In the North West dolomite aquifer, the dyke intrusions are complex, especially in the Zeerust area and some shale horizons affect the **drainage** of groundwater. One major North-South fault cuts through the dolomite sequence. Very little is known about the fault although it seems to act as a groundwater barrier and a major North-South boundary with leakage to the east south and north. The Blaauwbank dyke is wide and forms an East-West boundary. These preliminary findings suggest that the management boundaries for WUAs may change from five to four.

The following simplistic diagram shows the different dolomitic strata and some of the dykes subdividing the dolomite into smaller compartments. The overall drainage of groundwater towards some of the main springs is also indicated.

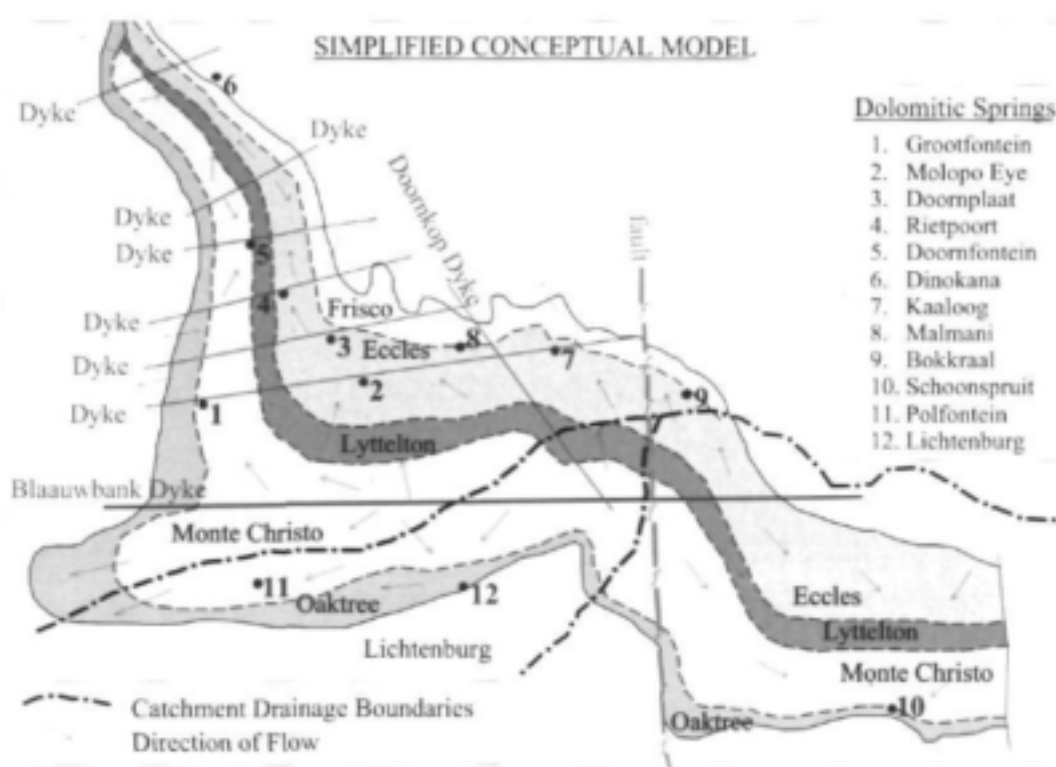


Figure 4: Simplified conceptual presentation of the NWDWA

The rate of infiltration of rainwater to recharge the aquifer is also affected by **overburden**, which generally comprises soil/gravel and rock outcrops. Higher recharge results in Area of shallow overburden where extensive leaching of the dolomitic formations has occurred. Occasionally, subsidence of the surface to form depressions or even sinkholes could occur. Any depression, even small ones, constitutes Area of preferential recharge.

Topographical relief and drainage

The drainage of groundwater overall corresponds to the general topography and is driven by gravity. Therefore groundwater always flows to topographically lower Area. However, a more

level groundwater gradient generally occurs within the boundaries of subunits bounded by dykes with distinct steps of the groundwater levels across the bounding dykes.

The recharge could be highly variable pending the local topographical relief, i.e. the occurrences of local depressions where ponding of surface water could occur. Such Area would also constitute Area of higher infiltration because of the underlying dolomite having been leached more extensively over time. The general flat topography of the dolomite reduces occurrence of runoff from the dolomite but enhances accumulation of runoff into the local depressions.

All the groundwater units to the east of the fault and south of the Blaauwbank dyke drain to the east and southeast. The Blaauwbank dyke traversing all the way from the west to the east of the area, is regarded to be a major barrier and separates the units draining to the south and the north. Groundwater units to the west of the fault would drain to the west, south and north

At this stage, the drainage of the Grootpan groundwater is uncertain but in part feeds the springs in the north. The heavy pumping in the area has probably already had an effect on the drainage of the groundwater. Drainage will also depend on whether or not the fault and Blaauwbank dyke are major barriers. Some exploration boreholes might have to be drilled for confirmation and to produce a more reliable drainage map.

Rainfall

In accordance with the long-term hydrological balance, recharge occurs when the average rainfall exceeds the long-term average precipitation over the same period. The impact on groundwater levels would be proportionally greater if above average rainfall conditions are sustained over several consecutive months and years as was experienced from 1975 to 1978. Similarly, the effects of subnormal rainfall would be cumulative and could extend for prolonged periods.

Rainfall is essential for recharge especially during intensities of monthly rainfall in excess of:

- A threshold value of about 14 to 20 mm per month for normal rainfall conditions with a corresponding lower recharge coefficient, which varies proportionally to the rainfall being lower or higher than the long-term monthly average rainfall.
- A high threshold value (about 42 to 60 mm per month) for which a higher recharge coefficient would apply.

For normal intensities of rainfall, the recharge would range from 6 to 8% of the average monthly rainfall as is reflected by the normal CRD/MA simulations. However the best results according to the FEFLOW model, indicates that recharge varies exponentially for rainfall

exceeding a threshold value and could reach a high of 80% if the monthly rainfall is 300 mm (Van Rensburg – provisional results).

Such high rates of recharge, although an infrequent occurrence, would rapidly replenish the aquifer, and effect a quick response via spring flows. This applies especially if the soil overburden and groundwater levels are shallow e.g. for Kareebosch eye. For thicker coverages of unsaturated aquifer (i.e. deeper water levels) the responses of water levels and spring flow to recharge extends over several years, as shown by Dinokana and Schoonspruit.

The Discharge of Springs

The combined total average flow of all the major springs in the region represents 45% of the average recharge of the total dolomitic area of 4500 km². Figure 6 represents a visual comparison of the equivalent recharge Area of the different springs that is required to sustain the spring flows.

Circles depict the average flows of the springs as an equivalent area of recharge that is required to maintain the flow.

More than half (55%) of the recharge is therefore dissipated in the form of underground lateral flow, evaporation and other losses. As the flow of a spring is directly proportional to the groundwater level of the aquifer that feeds it, as has been demonstrated by the Wondergat levels, any declining groundwater levels, whether by natural causes or impacted by groundwater levels, would diminish the flow of a spring.

The potential savings of the losses e.g. the difference between the natural outflow via springs and the total recharge provides scope for more effective utilisation and thus requires active management of the groundwater resource. Once again, the impact of such interactions can only be assessed reliably by means of a comprehensive hydrodynamic model of the entire NW dolomitic aquifer, similar to the FEFLOW model presently compiled of the Zeerust area (NWDWARM project).

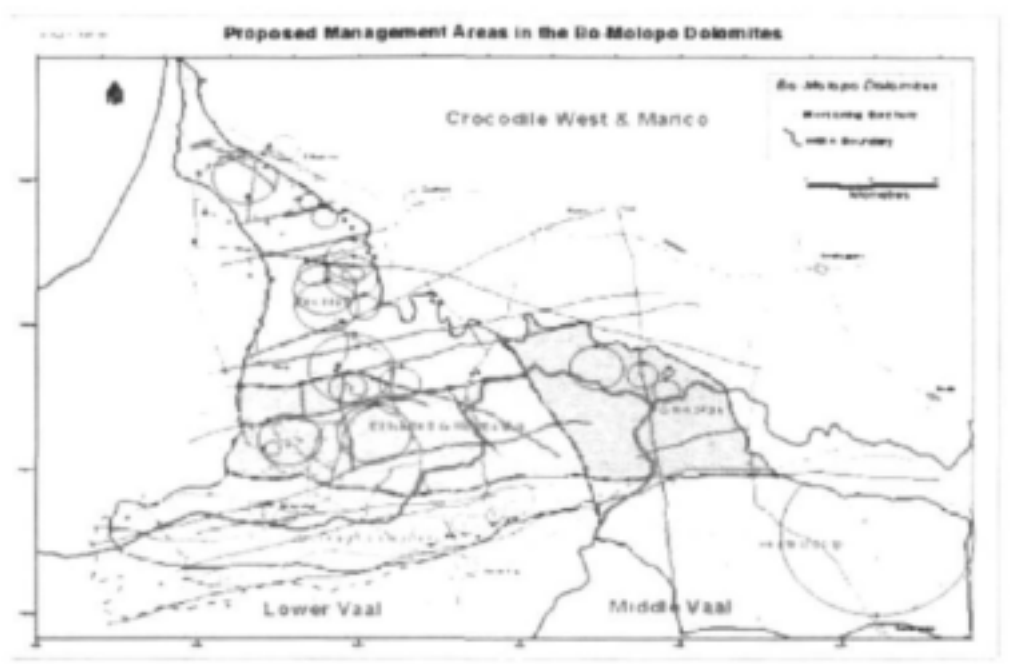


Figure 5: Map showing the groundwater units and points where springs ooze from the NWDWA⁵

2.3.1 Summary

In conclusion, the geohydrological assessment has resulted in the compilation of a conceptual model that enables a better understanding of the aquifer in relation to the occurrence of groundwater, replenishment of the resource and the flow dynamics of the system. The process of developing a conceptual model is an ongoing one, as a result of the application of new methods and data generated through field research and monitoring programmes. Another benefit of a conceptual model is that it can be applied to similar aquifers requiring only slight adjustments of the values of aquifer parameters and incorporation of local climatic conditions that control the recharge.

At this point, the conceptual model has insufficient information on the drainage and leakage through the dykes, the fault and the different formations. This is important to know for the delineation of the groundwater units as well as defining the optimal boundaries for the WMAs and Water Users Association Area. These boundaries will be adjusted according to the outcome of the hydrodynamic model.

This study has emphasized the importance of reliable monitoring data of rainfall and groundwater levels. Monthly rainfall totals and groundwater measurements are adequate to apply the CRD/MA methods and to model the aquifer. Of equal importance is the collection

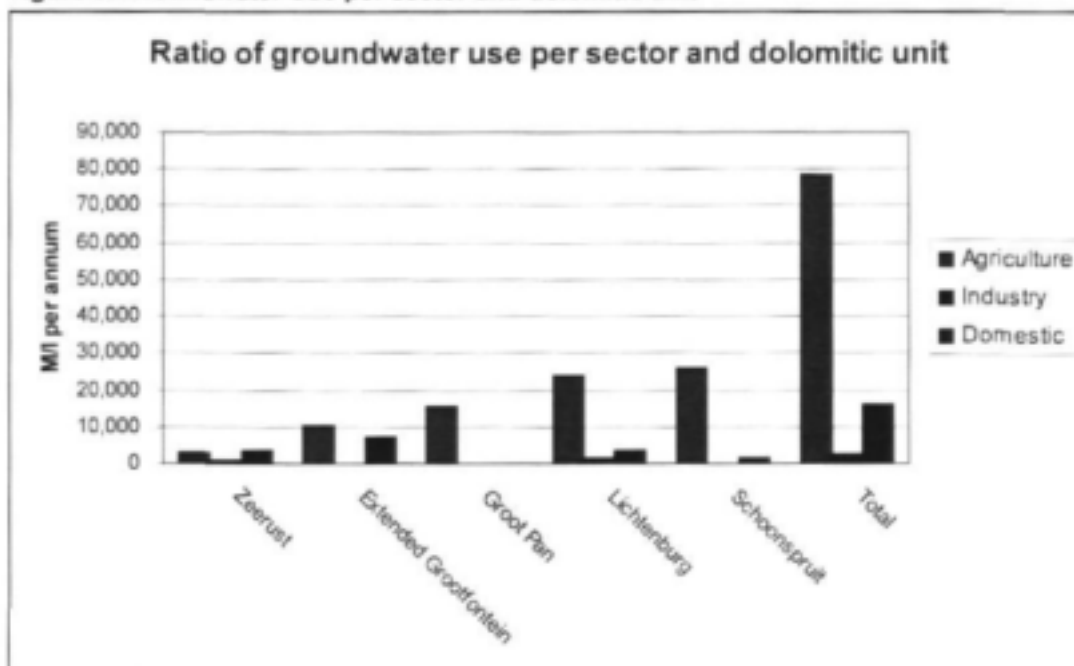
⁵ The sizes of the circles indicate the average discharge rate in terms of the equivalent area required to sustain the flow.

of monthly-accumulated rainfall samples at strategic positions over the catchments, either at rainfall stations spread over the area or at water level monitoring points.

2.4 Water Demand/Use Assessment

Phase 1 (Stephens and Bredenkamp, 2002), utilizing the Bigen Africa (2000) research on the augmentation of primary water supplies to Zeerust, Mafikeng and Swartruggens, illustrated the water demand, per sector. The following graph highlights the use patterns:

Figure 6: Groundwater Use per sector and dolomitic unit⁶



Apart from irrigation being the dominant use of groundwater, its use is also greatly disproportional to the surface area being irrigated. The following table demonstrates this very well:

Table 4: Percentage of area under irrigation⁷

Water unit	Area under irrigation (Ha)	Extent of Compartment (Ha)	% of Compartment area
Zeerust	295.6	29,402.2	1.0
Extended Grootfontein	998.9	38,855.1	2.6
Groot Pan	1,661.9	60,868.7	2.7
Itsoseng/Lichtenburg	2,452.6	55,549.1	4.4
Schoonspruit	2,863.6	141,314.1	2.0
Total	8,272.6	325,989.2	2.5

⁶ Please note that environmental use has not been included since a value was available for the Extended Grootfontein unit only. Its inclusion would then grossly underrepresent the environmental needs, a key determinant of the reserve.

⁷ Modified from Bigen Africa, March 2002

The table reveals that cultivation is very low as a percentage of surface area while abstraction for irrigation purposes is high. A cost-benefit analysis has not been conducted and therefore this ratio does not mean to imply that irrigation use is uneconomical although there are concerns about the efficiency of use (Veltman, 2003). However, the table illustrates that should Area under irrigation increase a few percentage points, which is possible given the ratio of cultivation to surface area, the sustainability of those water units not yet stressed may be compromised.

The Water Demand Assessment (Mischker 2004) did indeed explore whether there was an increase in irrigation and found that it was difficult to come to any substantive conclusion. Firstly, it found that there is no recent data to assist in the identification of irrigation trends. Secondly, irrigation trends tend to mirror the international maize price and its volatility means that irrigation fluctuates accordingly. Anecdotal evidence suggests that there is a substantial increase in irrigation based on a noticeable increase of pivot sales and interviews with farmers suggest that there is an increase in unlicensed irrigation. It would seem that the Bigen Africa Study (March 2002) experienced similar problems during its fieldwork where farmers were apparently unwilling to report on future irrigation plans. The report also noted that there was evidence that irrigation was on the increase but that this perception could not be supported quantitatively.

After irrigation, domestic use is the next greatest use of groundwater although it is considerably less than irrigation. In the course of the water demand assessment, close attention was paid to future demand for water services because this in turn will influence the allocation of groundwater for primary use.

The following table summarises the key settlements in the study area and which dolomitic unit they rely on for their water supplies.

Table 5: Dolomite water units

District Municipality	Local Municipality	Main Towns and Villages	Geohydrological water unit affected	Volume Abstracted per annum
Central	Mafikeng	Mafikeng, Peri-urban Area, Rooigrond	Extended Grootfontein, Zeerust	6,750Ml - ±9,070Ml/yr
	Ditsobotla	Lichtenburg, Boikhutso, Coligny, Itsoseng villages, Bodibe villages, Verdwaal villages, Ga-Motlatla	Extended Grootfontein, Zeerust, Groot Pan, Schoonspruit	3,900Ml/yr
	Zeerust	Zeerust, Groot-Marico, Lehurutshe villages, Dinokana villages, Gopane villages, Khunotswana	Zeerust	3,575Ml/yr

Southern	Ventersdorp	Ventersdorp, Goedgevonden	Schoonspruit	1,356Ml/yr
Bojanala Platinum	Kgetleng River ⁹	Derby, Koster, Swartruggens	Insignificant part of Schoonspruit	N/A

In essence, towns that rely on the aquifer for their supply of water are experiencing both population growth and a need to address service backlogs in order to comply with RDP standards⁹. With the available Census data 2001 and population projections calculated by the North West Population Unit, an estimation of the levels of water service needs in the future and thus the demand on the resource for primary use is possible.

Before these results are presented, the following table presents the main towns and villages within the study area and their source of water supply in terms of the five geohydrological units.

Table 6: Overview of major settlements and domestic water source

Village / Town	Water Source
Lichtenburg, Itsoseng and its villages (Verdwaal, Bodibe, etc)	Lichtenburg/Itsoseng unit
Coligny	A local granite aquifer
Mafikeng	75% Grootfontein unit
Ventersdorp	Schoonspruit unit
Zeerust and the Lehurutshe and Dinokana villages	Zeerust unit

The following table illustrates the number of households per town and the percentage of these households that have access to water at RDP standards and above. It then indicates the percentage of households that are serviced below RDP standards and whether this has been an improvement or not on the 1996 Census results.

Table 7: Levels of Access to Water per RDP standards¹⁰

Municipality	Hseholds	RDP standard and above		Change (96-01)	Below RDP standard		Change (96-01)
Ditsobotla	33,513	27,486	82.0%	35.1%	6,027	18.0%	34.3%
Mafikeng	64,497	43,936	68.1%	38.0%	20,561	31.9%	19.0%
Ventersdorp	8,778	8,477	96.6%	78.1%	301	3.4%	-46.8%
Zeerust	18,932	17,809	94.1%	32.0%	1,123	5.9%	-42.9%
Total	134,627	105,951	78.7%	39.9%	28,676	21.3%	13.0%

⁹ The Water Demand Assessment (Mischker 2004) included the settlements comprising the Kgetleng River Local Municipality (Derby, Koster and Swartruggens). While these towns are not currently abstracting from the aquifer, shortages have been predicted and the most cost-effective supply of water, even though an expensive option, would be piped water from the NWDWA.

⁹ 25l/capita/day, provided within 200m of household

¹⁰ Refer to Mischker (2004) for a detailed explanation of generation of results

The table indicates that Ventersdorp is managing to provide its residents with sufficient access to potable water since the number of households without acceptable access to water dropped by nearly fifty per cent. The figures indicate that Mafikeng and Ditsobotla Local Municipalities are struggling with their high levels of growth, and that despite catering for 12,099 and 7,145 additional RDP level households respectively, the number of households lacking services has increased by 19% and 34% respectively, since 1996.

Of the municipalities tabulated above, the population growth in Mafikeng, Ditsobotla, Zeerust and Ventersdorp, in descending scale of magnitude has most effect on abstraction from the dolomite aquifer. Despite Mafikeng's increase in households requiring water services, the 12,099 suitably serviced households place a four times higher demand on groundwater resources, in comparison to Ventersdorp, for example. Ditsobotla displays a similar trend to Mafikeng in that a high number of households have been upgraded to RDP and above standards (7,145) but with a concomitant increase in households requiring services (1,540).

In terms of RDP standards, most settlements in the study area have managed to provide their residents with potable water. The overall 39.9% increase in households being serviced at and above RDP standards between 1996 and 2001 implies increases in water consumption and therefore increasing demands on the aquifer.

In terms of population growth and concomitant demand for RDP standards of water, settlements in the study area have demonstrated an annualised growth rate of about 1.76% between the 1996 and 2001 Census years. This annualised rate of growth is expected to slow down in the next five years by 0.55%. Mafikeng still has the highest rate of growth, which means that the demand for additional water will increase substantially and it also has a substantial backlog to address. This in turn will have an effect on the Extended Grootfontein unit, which is reportedly stretched to its limit (Bredenkamp 2004).

Table 8: Water demand per dolomitic water unit

Dolomitic water unit	Towns	Annual Rate of growth
Extended Grootfontein	Mafikeng	1.53%
Grootpan	-	
Lichtenburg/Itsoseng	Lichtenburg/Itsoseng	2.31%
Schoonspruit	Ventersdorp	6.07%
Zeerust	Zeerust	-0.31%
N/A	Kgetleng River	2.85%
TOTAL		1.76%

While the average annual growth rate is not particularly high, domestic demand is on the increase and should it be that abstraction cannot be sustained by the aquifer as is suggested in the Geohydrological Assessment (Bredenkamp 2004), then non-Reserve uses will need to be scaled back to accommodate the Reserve.

In terms of **industrial use**, this is officially being supported by two of the five units, although there is knowledge of industrial activity (diamond mining) in the Ventersdorp unit as well. The future of groundwater use for industrial development is hard to estimate but there is evidence of unlicensed use and this would certainly need attention from DWAF. There are no concrete plans on the table for significant developments but nonetheless any proposed developments must factor in the availability of groundwater for exploitation, which at this point seems unlikely given the overall balance between abstraction and availability. The aquifer and its surrounds are characterised by a lack of industrialisation and it is not unlikely that efforts to boost the North West province's economy will hinge on industrial development, a historical and international approach to economic development. Water will be an essential element in such a process and thus there is a need to work closely with government departments that would initiate these planning processes so that the availability of water as well as a process for securing water are sensitised to the legacy of the aquifer and the relevant stakeholders.

The only figures available for **environmental water demand** are for the Extended Grootfontein water unit. The consumption is 7,455Ml per annum (Bigen Africa, 2002), although the specific use is not reported. Enhanced knowledge of the environmental water demand is likely to emerge with the outputs of the NWDWARM project but if it is not, this must be attended to by DWAF since without a determination of reserve, no water allocation plans can be drawn up and the status quo will remain.

2.4.1 Summary

The Water Demand/Use Assessment was successful in calculating population growth trends and the concomitant pressures on the aquifer system to supply communities with water simultaneously identifying water services backlogs. However the imperfect science of estimating water demand came to the fore in trying to estimate water requirements for irrigation, the largest consumer of groundwater by far, and then industrial requirements i.e. projecting economic development trends in the province that would need to draw water from the aquifer. Suffice to say economic development processes do not, at this point, seem to factor in water availability. Lastly, the environmental requirements of GDEs protected by the setting of a Reserve did not exist at all except for one geohydrological unit. A key outcome of this input report had less to do with the tangible results (although some useful indicators for water demand were generated) and more to do with the amplification of reality that integrated planning is yet to take account of the sustainable use of water.

2.5 Institutional Assessment

Since IWRM emphasises that water has multiple roles to play including basic survival, agriculture, industry, maintaining environmental integrity and recreation and tourism, groundwater management necessarily entails an array of stakeholders as presented in the following table:

Table 9: Categorisation of IWRM role-players

Category	Role	NWDWA Stakeholders
Regulatory bodies and enforcement agencies	Regulators are those organisations that make and enforce laws and monitor activities with respect to the management of water resources. Since the impact of human decisions and activities on land also clearly affect the nearby water resource and therefore IWRM requires consideration of regulation of land-use as well as activities around waste generation	Regulators regulating land-use • DLA • DTI • DEAT Regulators creating the framework for water services • DWAF • Department of Provincial and Local Government • Department of Agriculture Regulators regulating activities generating waste • DEAT • DME • DWAF • DLA • DoA • Dept of Health Regulators regulating activities that impact on water resources • DWAF • CMAs (none) • Catchment Management Committees • WUAs
Water Services Institutions	These institutions are responsible for ensuring that potable water is provided to communities. This involves abstraction, treatment and reticulation to local communities for household or industrial use. These organisations are also involved in the removal and treatment of wastewater before the effluent is returned to the environment.	• Water Service Authorities – Central District Council, Southern District Council, Botshelo Water • Water Services Provider – Botshelo Water
Facilitators and User Interest Groups	These are organisations and institutions from civil society that are not necessarily statutory yet play a very large role in the management of water resources either directly lobbying for and providing knowledge for the management and protection of the water resource itself, or indirectly by supporting sustainable development and/or conservation of the natural environment.	• The Molopo and Marico Catchment Fora (the fora involve traditional leaders, provincial government departments, local authorities, farmers) • The North West Agricultural Union
Conflict resolution bodies	The Water Tribunal is an example of a conflict resolution body and is designed to provide a forum for civil society to appeal a regulatory decision regarding water allocation or water rights.	• Water Tribunal

The institutional assessment, however, was limited to the stakeholders who are currently directly involved in water resources management, water services planning and provision. Here follows a summary of research findings for each of the institutions involved in the assessment:

2.5.1 Regulatory bodies regulating activities that impact on water resources

DWAF National Office: The opaque fate of WUA applications once they are submitted to DWAF for Ministerial approval is a source of frustration among stakeholder groups. The Department indicated that most applications from the study area were stalled due to the Minister's concern about inadequate levels of representation during WUA consultative and governance processes. The marginalised stakeholders' workshops suggested that these concerns were in many cases justified - mining and marginal users were not always adequately consulted or represented in the proposed structures. However, this issue has been poorly communicated to stakeholders although it is unclear whose responsibility it is to communicate this to stakeholders.

DWAF North West: The department's regional office in North West has experienced considerable capacity and human resource constraints in trying to support the development of institutions to support groundwater management. Urgent action is required to address stakeholder confusion regarding the establishment of the CMA and the WUAs. There is also widespread confusion relating to who should be policing the illegal abstraction of groundwater resources in the absence of the CMA and the WUAs. Other Area of stakeholder concern relate to the funding mechanisms for both the CMA and WUAs, the calculation of water use charges as well as the issues relating to representation on the CMA and WUAs.

DWAF Free State: The Free State Regional Office of DWAF is responsible for the Schoonspruit aquifer. As a result, it is also responsible for the establishment of the Middle Vaal CMA as well as the Ventersdorp WUA. Issues relating to stakeholder ignorance and confusion need urgent attention. The rural stakeholders from the marginalised communities around Ventersdorp indicated that their elected council officials (who have been representing these communities in the CMA and WUA establishment processes) had not briefed them about these important institutional developments. There were also serious stakeholder concerns relating to illegal water use and the licensing of water use by farmers.

DWAF Gauteng: The Gauteng office of DWAF is one of the major driving forces behind the establishment of the Crocodile West – Marico CMA. Such a deep level of involvement is in part due to the fact that the Gauteng province has such major stake in that particular Catchment Management Area. Awareness of the regional office among stakeholders such as commercial farmers and local government authorities was very prominent. The regional office was most closely identified with the WUA establishment process in the Zeerust,

Lichtenburg and Mafikeng Area. The flip side of this high profile is that those stakeholders tended to expect the regional office to clarify issues pertaining to the establishment of WUAs in those Area.

Lower Vaal CMA: The Lower Vaal CMA has not been formally proclaimed. Its establishment is driven by the Northern Cape regional office of DWAF, which intends to cede the portion of the dolomitic aquifer that is currently covered by the Lower Vaal CMA to the Crocodile West - Marico CMA.

Middle Vaal CMA: The Middle Vaal CMA falls under the bureaucratic jurisdiction of the Free State regional office. Respondents in this instance indicate that the CMA is only required to be established in four years. Therefore, the regional office is pursuing a different sequencing strategy and it is more concerned with studies to develop a better understanding of the water resources in the area under its jurisdiction. However consultants have been contracted to advance the formation of the CMA.

Crocodile-West Marico CMA: The establishment of this CMA has benefited from the participation of the Gauteng regional office of DWAF. DWAF has facilitated the implementation of a consultative process that should lead to a proposal to establish being submitted in 2003. However, the respondents from the forums and the WUAs have been critical of the time it is taking to get the CMA established.

Proposed Ventersdorp WUA: The Ventersdorp WUA is by far the most advanced WUA in the study area. Its establishment process is driven by the Free State office of DWAF. It was indicated that an application had been submitted to DWAF, and that the department responded in June 2003 that the Minister requires further information regarding the WUA's management committee. Some stakeholders believed that the proposed WUA had buy-in from all the relevant stakeholders- i.e. domestic users, industrial users, and agriculture as well as local government structures. However, this point is being disputed by both DWAF and marginalized stakeholders. The Ventersdorp WUA has in its application, requested a wide array of functions. These range from preventing the unauthorised use of water to controlling wastage and protecting water resources. This leads us to question whether the stakeholders have a clear appreciation of the capacity they will require to undertake all the activities that they intend to implement.

Proposed Zeerust WUA: The Zeerust WUA does not exist it is not to be confused with the Marico Bosveld WUA. A consultant was assigned by the DWAF Gauteng regional office to facilitate its establishment, but his contract ended before anything tangible was delivered. There has been very little progress since then.

Proposed Lichtenburg-Itsoseng WUA: A water management committee was established with the aid of a consultant from DWAF as a precursor to a WUA. An application was

submitted to the department in March 2002. However, a response from the department is still to materialize.

Proposed Grootpan WUA: The Grootpan WUA does not exist. However, a steering committee was appointed in 2001. This committee surveyed the area under irrigation and reported its findings to DWAF. The committee was unable to gain the support of the farmers because this stakeholder group was perturbed by the possibility of being involved with the technical responsibilities that are associated with the management of the NWDWA.

Proposed Extended Grootfontein WUA: Grootfontein is one of the WUAs that was assigned a consultant by DWAF. The application to establish was compiled with the facilitation of that agent. However, there has been no progress since and the local respondents demonstrated a strong reluctance to pay for water until a CMA or WUA is established.

2.5.2 Water Services Institutions

Ventersdorp Municipality: The municipality has taken an active interest in the formation of the WUA. Stakeholder meetings are often held at the municipal buildings. The municipality also makes some administrative equipment available to the WUA. The municipality rates the WUA as being the most important institution it relates to in terms of groundwater management issues, and significant levels of frustration with the promulgation process were expressed. The municipality also feels that the WUA operates in a state of legal limbo and the delays being experienced with regards to its formalization are costing it dearly in terms of stakeholder support. In this regard, the respondents were concerned by the lack of communication surrounding their WUA's application. Interestingly, they also tended to confuse the various water management processes that they participate in.

Ditsobotla Local Municipality: The Ditsobotla Local Municipality is made-up of a mixture of small villages, farming towns such as Lichtenburg and Coligny as well as Area that used to fall under Bophuthatswana such as Itsoseng and Gamotlatla. The research process discovered that the reliability of water supplies in Ditsobotla and surrounding villages is a major concern. In this respect, the supply of water is not reliable due to faulty or overburdened infrastructure. The quality of communication between the community and the local council is also inadequate. As a result, residents in the area complain of being marginalized and have developed a disparaging opinion of the municipality and the formal local government structures.

Central District Municipality: Mafikeng, Zeerust and Ditsobotla: The Mafikeng, Zeerust and Lehurutshe Area fall under the jurisdiction of the Central District Municipality which is based in Mafikeng. The municipality has serious financial and human resources challenges,

and thus struggles to operate at full capacity. Domestic users of ground water resources in the District Municipality depend upon water reticulated by Botshelo Water for most of their water requirements. Surface water is not plentiful in the area therefore the supply of water to domestic users has to be augmented by underground resources. The Dinokana and the Molopo eyes are significant groundwater outlets; however private boreholes (both legal and illegal) are widely used in the area.

Southern District Municipality: Klerksdorp, Orkney and Ventersdorp: The District Municipality is involved in the establishment of the Ventersdorp WUA, and it has been earmarked to participate in the management committee of the proposed CMA, which will exercise control over the Schoonspruit dolomitic compartment. The District Municipality expressed concern regarding the poor levels of communication between DWAF and local stakeholders. As a result, the respondents doubted the value of their continued participation in groundwater management structures.

Botshelo Water: This is probably one of the better resourced organizations in terms of planning for groundwater management. Its contribution, apart from being a bulk supplier of water, is the support it can offer local authorities as they prepare to take on their respective roles as Water Services Authorities especially since Botshelo Water has expertise in supplying water to domestic users in rural and peri-urban Area.

The picture that emerges from this research undertaking is one that shows the DWAF national office to be struggling to process WUA applications fast enough and to manage communication between the centre and the periphery. The DWAF regional offices were found to be similarly challenged. The Northern Cape regional office is working towards ceding its portion of the aquifer; the Free State regional office has human resource capacity constraints as well as the challenge of keeping the existing Ventersdorp WUA stakeholders on board while seeking ways of bringing additional stakeholders into the process. The Northwest regional office also has human resource capacity challenges. It has struggled to resuscitate the Molopo and Marico fora and maintain momentum with regards to the stakeholder interest in WUAs. The Gauteng regional office manages the establishment of the Crocodile West Marico CMA and has been spearheading the establishment of a number of WUAs in the province. However the delays in the process have resulted in many stakeholders losing interest.

The local government authorities in the area tended to have a poor service delivery image. Residents were negative about the quality of representation they get from their elected officials, namely councillors, in committees and fora that address water services and by implication water management. The research also suggests that the involvement of local government structures in groundwater management structures is often confined to a few individuals who have inadequate institutional support within the local government authority. Therefore, the understanding of the challenge that is posed by the resource is limited to a few individuals. These shortcomings are critical because when a major stakeholder group is in such disarray, the institutional establishment process is bound to suffer accordingly. It is

essential to highlight this issue because it raises important mitigating circumstances to charges of neglect that are often levelled against DWAF.

2.5.3 Facilitators and User Interest Groups

Other important stakeholder groups are the **traditional leaders and emerging farmers**. These groups suffer from serious human and material capacity constraints and were unable to participate in the research fully. However, the research process included three workshops with marginalised stakeholders. Many of these participants were involved in small-scale agriculture and came from traditional Area. They indicated that there were high levels of ignorance relating to how the aquifer functioned. They also suggested that people were generally ignorant of the new legislation and the institutional arrangements that it proposed. **Commercial farmers** are also major stakeholders. They are currently the dominant consumers of the groundwater resource and are usually more organised than other stakeholders. The participating farmers were very critical of the institutional formation process. They tended to complain about delays in establishing the CMAs and WUAs to the powers to the Minister with regards to his ability to veto decisions. Furthermore, many farmers indicated that levels of participation in stakeholder consultation process are decreasing because people are beginning to question the purpose of their participation.

2.5.4 Summary

The Institutional Assessment paints a bleak picture of an institutional environment that is plagued with weaknesses. These weaknesses affect all participating organizations and the ability of stronger organizations to participate in the management of the resource is compromised by the weaker organizations. It is important to identify these weaknesses because it ensures that any proposals on the institutional arrangements for the management of the NWDWA must align to the current institutional realities. The results of the assessment suggest that the way forward is to concentrate on institution-building (CMAs and WUAs), capacity-building (IWRM role-players) and generous support to these role-players.

2.6 Concluding Comments

The situational analysis represents the completion of the first stage of the process of developing institutional arrangements for the management of a shared resource. Read with the Phase 1 synthesis report (Stephens and Bredenkamp, 2002) it covers the following Area:

- International context for groundwater management;
- Legislative and policy framework;
- Water user profile and demand/use patterns;
- Conceptual model of the geohydrological features; and
- Identification of role-players and existing institutional environment.

In essence, the situational assessment points to the need to manage a highly productive aquifer in such a way that it meets existing needs while accommodating transformation in

the North West province. This task is set within the context of IWRM which necessitates the identification and inclusion of multiple role-players as detailed in Table 9. The process of IWRM also requires sound knowledge of the quantity of the resource that can be sustainably exploited as well as its quality. This knowledge needs to be continually supplemented by monitoring data, which is particularly weak for irrigation use, the predominant use of groundwater. Planning also requires data on water demand, which is also weak for all forms of economic development (agricultural activities included). The situational assessment therefore reveals that neither the organizations nor the systems (for example, monitoring networks) are in place to start co-managing the resource. The approach is not to overburden already stretched organizations and therefore a more effective approach is to start working individually with organizations (including directorates and units) to find ways to integrate concerns for the aquifer in mainstream business.

The following chapter will start to unpack the resource management issues that would need to be addressed in an aquifer management strategy. This process is considered to be the second stage of the design process and involves the analysis of the issues captured in the situational assessment. This allows for the identification of the sorts of functions that would need to be fulfilled and the capacity required to execute those functions. These are all critical steps in the process of designing institutional arrangements, more likely to culminate in a workable proposal.

3 RESOURCE MANAGEMENT ISSUES

In the context of this project, resource management issues that would need to be addressed in the design of the institutional arrangements for the management of a shared resource reflect a holistic approach to water resource management as prescribed by IWRM. Firstly, resource management issues are concerned with efficient and credible ways of measuring the resource and its uses. The discussion here centres on the availability of data for analysis. Secondly, and in line with the measured approach, is an appraisal of the status of the resource both in terms of quantity and quality. Thirdly, and deviating somewhat from the 'measured approach', resource management issues also concentrate on the institutional landscape and the capacity and resources available for devolved management of the shared resource. The following chapter presents then the resource management issues that arose from the situational analysis.

3.1 Measuring the resource and its uses

The successful management of the aquifer is dependent on reliable, up-to-date and long-term data that is also accessible and trusted by stakeholders. Both the methodologies employed by the geohydrological and water demand assessments are indicative of the sorts of data that would be required to set up management framework and therefore it is useful to reflect on the problems associated with the data.

3.1.1 Geohydrological Assessment

The ability to identify water resource management issues is heavily dependent on the availability of monitoring data of rainfall, groundwater levels and groundwater quality. There are four main issues at stake:

1. Irrigation abstraction is not measured. Indirect methods can be used to infer abstraction but these rely on rainfall measurements.
2. The distribution of monitoring boreholes. The Grootfontein area has a dense coverage of monitoring points but this is poorer in Zeerust. Schoonspruit and Grootpan appear to have an adequate supply of monitoring points.
3. The collection of monthly-accumulated rainfall samples at strategic positions over the catchments, either at rainfall stations spread over the area or at water level monitoring points. It is preferable to have a good spatial distribution of rainfall stations and to maintain measurements at stations with long series of measurements rather than closing them down.
4. The availability of water quality data. This data is readily available for springs and therefore offers a regional estimate of water quality but data from monitoring points would assist in identifying localised pollution. Nitrate pollution, which is usually associated with inferior sewerage systems and cattle watering, is not tested for and this should become part of the regular chemical analysis of groundwater.

According to the findings of the study, with monthly rainfall totals and groundwater measurements (including abstraction data), the aquifer can be effectively modelled through the application of the CRD/MA methods for which user-friendly software has been developed.

3.1.2 Water Demand/Use Assessment

The following table summarises sources of information pursued in the compilation of the water demand/use assessment.

Table 10: Information sources for the Water Demand Assessment

Information Type	Source	Comment
Land-use: coverages of LandSat7 analysis used in Bigen Study	University of the North West	Updated land-use distribution information, derived from satellite images captured in 2000, should be available from mid-2004.
Agricultural Land Use including Livestock	AGIS	None exists other than Land Cover – being updated till 2004 – livestock spreadsheet received.
Agricultural Census 1993	Statistics SA	Outdated
Agricultural Information (digital)	Institute of Soil Climate and Water	none, other than livestock potential, farming suitability (not useful)
Agricultural Information (digital)	Agricultural Research Council	None, apart from farming feasibility studies
Agricultural Information (digital)	National Department of Agriculture	None: deferred to AGIS
Agricultural information	Farm IT Solutions (Open Spatial Solutions)	none exists for the study area (apart from land cover). A project is underway to map all maize Area in the NW, FS, NC provinces, but end date is undeterminable.
Pivot sales, location of pivots	Agrico Machinery	Interview conducted. No locational information is available.
Water Services	DWAF NW	Referred to Bigen Studies
Census 2001	Statistics SA	Received Census 2001
Planned township extensions, levels of future water service provision, water consumption and source of water	Local Municipalities: Engineering and Planning Departments IDPs	Interviews conducted and information received in various levels of detail.
Water use and abstraction	Martinelli & Associates	Referred to Bigen study; made Coligny (PMA) study available and shapefile of dolomitic compartments.
Water Demand Assessment Phase 2 study (March 2002)	Bigen Africa	Received, and confirmed level of information available.
HELP database	ESKOM	Received but partial coverage around Mafikeng only (rest of info is being updated at present).
Land claims and resettlement	Provincial Land Claims Commission	Not available at time of study – process of verification.

The process of compiling the Water Use/Demand Assessment exposed significant gaps with regard to irrigation and livestock data, land restitution data, land use data and water services planning. The only primary data applied was drawn from the Census data and other data quoted in the report was inferred from existing studies such as the Bigen studies. Updated data is essential for quantifying abstraction and planning purposes.

3.2 Status of the resource

3.2.1 Abstraction

The water balance assessments resulting from the geohydrological assessment suggest that there is limited scope for extending the utilization of the different units, especially if the Reserve has to be established. These results also differ significantly from those of the Water Demand Assessment and due to the differences which could not be reconciled, these results are tentative. The real finding then is that different base data-sets and different methods of interpretation yield different results and since this research project is concentrating on institutional development, a review of the methodologies to assess groundwater availability in a way that consistency in the results is achieved, is suggested. The main reason for this suggestion is that a principle of institutional building is that information supplied to stakeholders, and in this case information on the resource must be trusted by them and they have a sound understanding of how information was collected and analysed. Ironing out these methodological processes and disseminating uniform information will be an important component of the next phase of this project.

Table 11: Comparison of components of the groundwater balance of the NWDWA groundwater units

Dolomitic unit	Irrigation	Domestic and Environmental Requirements	Industry	Total present estimated abstraction	Sustainable abstraction	Annual rate of town growth
Extended Grootfontein	21,000MI	16,700MI	0	38,000MI	38,000MI	Mafikeng 1.53%
Grootpan	7,000MI	7,090MI	0	14,090MI	22,100MI	
Lichtenburg Itsoeng	28,000MI	8,000MI	1,600MI	37,300MI	37,300MI	Lichtenburg 2.31%
Schoonspruit	26,000MI	8,100MI	300MI	34,400MI	38,400MI	Ventersdorp 6.07%
Zeerust	10,000MI	29,020MI	840MI	44,800MI	39,900MI	Zeerust -0.31%
TOTAL	21,000MI	16,700MI	0	38,000MI	38,000MI	

3.2.2 Water quality

Water quality of dolomite aquifers tends to be excellent because of high recharge and large storage capacity, which results in the dilution of contaminants. There are isolated cases of local nitrate pollution but these seem to be confined to dwellings and watering points for cattle. There is evidence of groundwater pollution from water samples taken at the Wondergat eye, which is attributed to the use of fertilizers. It is recommended that nitrate testing be introduced to water quality testing procedures.

3.3 Existing institutional environment, capacity and resources

The design of institutional arrangements must take into cognisance the existing institutional environment in the IWRM sector. The status of this environment will inform the approach to

managing the resource holistically, whether responsibility and functions can be completely devolved where institutions are strong or where the focus needs to be on institution-building, capacity-building and support to participating organizations.

3.3.1 Status of participating organisations

The establishment of groundwater water management structures in the North West is slowly being rolled out. The key DWAF regional offices that have been involved in the process are Gauteng, Free State and the North West, and to a lesser extent, the Northern Cape. The Northern Cape regional office is likely to play a diminishing role in the process if its request to cede the portion of the aquifer for which it is responsible is implemented.

The assessment of institutional capacity levels within the DWAF national and regional offices suggest that the knowledge of the groundwater system is limited to a few geohydrologists, who are employed in the national and regional offices. Furthermore, there were significant human resource constraints. As a result, there is a heavy reliance on contractors and this has the effect of limiting the accumulation of knowledge within institutions. Nonetheless, some regional offices still struggle to find the right expertise to contract or hire on a fulltime basis (vacancies were common). The responsibility of establishing WUAs and CMAs is essentially shared between the three regional offices with the national office providing additional support and processing of WUAs applications. This process has been characterized by delays and poor levels of communication with local stakeholders. As a result the local stakeholders were often confused about a number of critical issues relating to their structures and the management of water. Some of the key issues that were identified were:

- Who is responsible for preventing the illegal abstraction of water in the absence of CMAs and WUAs?
- Who is responsible for approving water use applications and verifying water use?
- How is money paid for water use utilized?
- Why it is taking a long time to establish CMAs and WUAs? and
- What support will be provided to proposed WUAs who could not submit applications before their assigned consultant was withdrawn?

The local government structures are experiencing even greater difficulties. They all indicated that their knowledge of the groundwater system was limited to a few experts. They also had serious financial problems in part due to the non-payment of rates. As a result, their ability to attract skilled employees is seriously compromised. Such institutional capacity constraints mean that the local government structures are likely to participate at sub-optimal levels in the establishment and management of water management institutions. In fact, most stakeholders were disparaging about the capacity of their local government authorities. Water services in places like Zeerust and Lichtenburg were poor and unreliable. Furthermore, stakeholders from traditionally black Area complained about the poor quality of

representation that their elected officials provide on water management structures and in consultative process. There was a strong sentiment that elected officials are not necessarily the best people to represent the black communities in water management structures. These people often had extensive demands on their time as a result of their party-political and council commitments, and respondents felt that they often allowed groundwater issues to slip from their list of priorities.

The following table provides an overview of the status of water management institutions at the time of the research:

Table 12: Institutional progress relating the establishment of WUAs and CMA

Name of organisation	Little progress	Consultation Stage	Application for establishment submitted	Gazetted	Fully functional Organisation
WATER USER ASSOCIATIONS					
Grootpan WUA					
Extended G'fontein WUA					
L'burg-Itsoeseng WUA					
Ventersdorp WUA					
Zeerust WUA					
CATCHMENT MANAGEMENT AGENCIES					
Croc West-Marico CMA					
Lower Vaal CMA					
Middle Vaal CMA					

There are three CMAs that need to get established, all of which are still at the consultation stage at present. The Crocodile West Marico CMA has made the most substantial progress although it is not expected to be fully established within the next two years. The Middle Vaal CMA is being supported from the Free State regional office. It too has made substantial progress, but it is not expected to become operational before 2005. The CMAs have not achieved enough progress to assess their capacity.

Among the WUAs, the Ventersdorp WUA is the most advanced in terms of establishment, while little progress has been achieved in Zeerust. Furthermore, it seems the Grootpan process may have lost significant momentum and stakeholder goodwill. The mood of helplessness, confusion and frustration among stakeholders can partly be explained by the slow pace of the establishment of these organizations. However it should also be pointed out that stakeholders may have had unrealistic expectations relating to the scope of the task and the time that would be required to implement it. This is attributed to the fact that the Department has not always communicated effectively with stakeholders or had the capacity to sustain stakeholder processes.

The breakdown in communication yielded two broad concerns:

- What will happen to WUAs that lost support in the form of an organizational development consultant before they could submit an application to DWAF?
- What is the fate of the WUA applications that were lodged with DWAF for Ministerial approval?

The capacity constraints that have been identified in the report have an important bearing on the co-management of groundwater. The Phase 1 report noted that in order to ensure water resource sustainability and to adhere to the principles of IWRM, it is also essential to equip the groundwater institutional framework in the North West to accommodate transboundary issues (especially how adjacent CMAs and WUAs will relate to one another). It was within that context that the report made a preliminary recommendation calling for the establishment of a DAMC to facilitate the management of the aquifer in an institutionally integrated manner. The main objective of the committee would be to ensure that despite the division of the aquifer into three separate Water Management Area (WMAs), it could still be managed as a single underground water system. Given the paucity of institutional capacity in the North West, it is essential to consider alternative mechanisms that can achieve the impact that a DAMC is likely to bring but with minimum resources and institutional complexity.

3.3.2 Management boundaries

In terms of the WUA boundaries, preliminary boundaries were supplied to local users towards the end of the 1990s while the WMA boundaries were defined along with the other 16 WMAs. It is not a typical practise to supply boundaries to WUAs since these are to be voluntary associations but due to the invisibility of groundwater, it was deemed necessary since local users did not, at the time, have access to the conceptual model which was being developed by DWAF and in particular, the Subdirectorate: Groundwater Resource Assessment and Monitoring.

The process of delineating groundwater management units for WUAs does not conform to social or political boundaries. It is a process that is informed by geohydrology and water demand. In terms of the geohydrology, a piezometric drainage map of the natural groundwater drainage over the entire dolomitic aquifer has been compiled based on the limited data available. This process has confirmed that the groundwater flow corresponds to the topography. According to this map, it seems that the CMA boundary could shift to conform to North-South fault. All the groundwater units to the east of the fault drain to the east and south-east and north. Those to the west drain to the west, north and south to feed springs and subsurface outflow. The Blaauwbank dyke, traversing all the way from the west to the east of the area, appears to be another major barrier and separates the units draining to the south and the north. At this stage it is uncertain where the Grootpan groundwater drains to, but part of its drainage should feed the springs in the north. (The heavy pumping in

the area probably already has had an effect on the flow of the groundwater.) The drainage will also depend on whether or not the fault and Blaauwbank dyke are major barriers. Some exploration boreholes might have to be drilled before a final decision can be made.

So while the conceptual model of the aquifer suggests that the boundaries of both CMAs and WUAs could be refined, there are still strong uncertainties as described above. However, with the initiation of the NWDWARM Project, fieldwork has been commissioned which can help to address these uncertainties and will facilitate the demarcation of boundaries for WUAs and CMAs with a greater deal of accuracy. An optimistic point of view suggests that the lack of WUAs establishment is fortuitous because a proper process can be embarked upon whereby boundaries for WUAs in particular can be developed in such a way that local stakeholders both understand the logic of the boundary and the groundwater resource management issues affecting each particular unit.

3.3.3 Management Systems and Tools

There is a growing move to develop management systems and tools that can be deployed by local users to manage their individual and collective use of groundwater. An excellent example is the Norwegian Agency for Development Co-operation (NORAD) funded groundwater management and monitoring programme, which aims to provide a strategy for the implementation of sustainable community water supplies from groundwater. To this end, DWAF and its consultants have designed a groundwater management system that includes a groundwater monitoring system, which includes both abstraction and water quality, and software to allow for the analysis of the data. Secondly, both Sonia Veltman (2003) and Dr David Bredenkamp have developed software programmes that can be used to monitor water abstraction and guide users on whether current abstraction is sustainable. Veltman's software was specifically designed for use by a Water User Association and was developed while working with Schoonspruit dolomitic unit's users.

Once the entire dolomite basin can be simulated by means of a hydrodynamic model, the regional impact of abstraction on the various groundwater units, especially within the boundaries of smaller sub-compartments, can be established. This will then inform decisions about how much water may be abstracted without compromising the reserve. However, it is not necessary to wait until then for a management plan to be initiated – monitoring can happen almost immediately. The system and tools developed by the NORAD programme for community water supply schemes can be utilised with ease by the irrigation farmers, which would go a long way to fill the gap with regards to irrigation data. Since irrigation is the greatest use of groundwater, it is all the more reason to start farmers on this monitoring system.

3.4 Conclusion

This chapter derived the resource management issues from the situational analysis. These issues were grouped into three categories. The first category focused on the measurement of the resource and its uses. The second focused on the status of the resource and the third on the existing institutional environment, capacity and resources. The measurement of the resource and the status of the resource were inextricably linked so weaknesses in the measurement of the resource resulted in the largely tentative findings on the status of the resource. Closer attention is required to (improve and) standardise methods of collecting, interpreting and disseminating data so that information received by water users and managers is considered to be trustworthy and useful. Only then will initiatives to improve the management of the groundwater resource be seen as necessary and hopefully sustained.

In terms of the institutional status, the CMA establishment process is slowly unfolding, there is a hiatus in the establishment of the Water User Associations and the Fora that affect the NWDWA. The organisations that are to be stakeholders in the CMAs are weak and there is concern about the participation of historically disadvantaged communities. An efficient communication system between water users and in particular, communities and landowners, and the DWAF regional offices is lacking and the dominant use of consultants does not necessarily further relationships between stakeholders and the department, especially since there is little continuity in the use of consultants. This exacerbated by a tendency to confuse processes, as stakeholders can often be consulted by different parts of the department on different issues, whereas stakeholders do not differentiate. While the organisations that are key constituents of the institutional landscape to manage the groundwater resource are establishing, it would not be prudent to establish a co-ordinating committee such as the DAMC yet. The options are then outlined in the final chapter of this report.

4 RESPONSE TO RESOURCE MANAGEMENT ISSUES

An approach to the process of designing institutional arrangements, which is captured by Figure 1, involves three broad stages. The first stage entails a situational analysis, which is incorporated into the first two phases of this project; the second stage is the identification of resource management issues, defined and described in Chapter Three; and the last stage, and partly dealt with in this chapter, is loosely termed the **response** to the situation analysis and the emerging resource management issues.

The response involves the development of scenarios based on its current status and its future as a resource that may be managed in a way that is sustainable and addresses inequities in access. The development of scenarios allows for the identification of coping measures or strategies to pursue an optimal management path. Once these have been pinned down, functions and tasks as well as the capacity required for their implementation can be extrapolated. Thereafter an institutional framework can be designed which is shaped according to a management vision, functions and required capacity.

The purpose of this chapter then is to introduce the response stage by sketching four scenarios, shifting from worst to ideal scenario and an opening discussion about the coping measures required to realise the optimal management of the resource. Required functions and capacity will, however, not be addressed in this report and will be a result of the project in its entirety.

4.1 Scenarios for groundwater resource management

Four scenarios, which are not necessarily a reflection of either past or present contexts, were developed (Table 12) and a range of variables was used in their assembly. The following table describes these variables.

Table 13: Variables

Resource	Groundwater levels
	Groundwater dependent ecosystems
	Water Quality
Demand	Legal productive use
	Illegal productive use
	Reproductive use
	Cost
User Profile	Equity
	Attitudinal/awareness
	Organisation/civil society
Regulation/management	Regulatory framework
	Institutions
	Integrated planning and co-operative governance
	Aquifer management
External factors	Environmental factors such as climate change which affect rainfall
	Economic factors such as international grain prices

4.1.1 Scenario 1

Scenario 1 represents the worst case scenario, one in which water rights are linked to private property and where there is very little accountability for its use, resulting in degradation of the groundwater resource. Integrated planning is not being practiced either so land use planning does not consider water availability. There are ineffective monitoring systems, so there is not much understanding of how the resource is being affected. Furthermore, individual water users are operating in a vacuum so there is little awareness of the shared aquifer and the compound effect of abstraction and water pollution. The issue of sustainability is not on the agenda of existing organizations and dominant users are content with the status quo. Since private property is linked to an unfair system of land distribution, the majority of the population can access water for reproductive purposes only. Scenario 1 is characterized by extensive water rights for few with little regard for the status of the resource.

4.1.2 Scenario 2

Scenario 2 is characterized by a legal overhaul of the system of water management with water being declared a public good. This scenario is characterized by policy formulation on the basis of this new regulatory framework. It is concerned with seeking out best practice from other places of the world and adapting them to a South African context. Knowledge on the geohydrology of the aquifer is improving. A monitoring network policy as well as notion of holistic aquifer management is deliberated.

However, channels of communication tend to be weak and implementation of policy is inefficient due to capacity constraints. There is a lot of misunderstanding about the mechanics of the new system as well as some resistance to change among a few local users. The dividends of change are paying off slowly for those people who historically had limited access to water in the form of improved services but on the whole the correlation between land ownership and abstraction volumes remains.

Scenario 2 is mainly characterized by the introduction of a new regulatory framework and accompanying policy processes with intermittent implementation.

4.1.3 Scenario 3

In this scenario, most policy is in place for the sustainable and equitable regulation and management of water resources. The focus is now on implementation of new policy, improving current implementation processes and improving co-operative governance and integrated planning. A monitoring network is implemented. A process of joint management of the aquifer is drawn up.

A communication system has been established and stakeholders are starting to understand how water regulation is to take place, what their rights and duties are with regard to water use and management, and the science of the aquifer. Civic organizations organized around water use and management are starting emerge and other interest groups, such as farmers'

unions and ward committees, are taking a keen interest in issues of sustainable use and are working with members to encourage sustainable practices. WUAs are starting to establish. There is a vast improvement in access to water services though productive use of water is still mainly confined to landowners.

Scenario 3 is characterised by the implementation of policies, enhanced co-operative governance, and a strengthening civil society.

4.1.4 Scenario 4

This scenario represents an ideal state. It is the coming together of many different processes: improvement in equity in land ownership via land reform, integrated planning with the availability of water informing land-use planning and integrated development plans; co-operative governance and civic engagement.

Informed decisions are made about water allocations from groundwater that accommodates both current and strategic use, effecting the vision for the management of a shared resource. This is done through sound knowledge of the aquifer and stakeholder involvement. The monitoring system is working well and results in rapid responses.

The institutions designed to facilitate water resource management are in place. WUAs are established and civil society organizations are supporting efforts to manage the resource. CMAs are established and through a joint committee that has all stakeholders involved in, joint decision-making on the resource is being facilitated.

The resource is in a good state and reproductive and productive demand is being satisfied: excellent access to water services, sufficient water for small-scale economic activities and an emerging class of black commercial farmers is taking root.

At this point in time, the state of IWRM in South Africa is located between Scenario 2 and Scenario 3 where a process to hone knowledge of the aquifer is well advanced but its joint management is somewhat compromised by the absence of WUAs and the long time-frames for the establishment of the CMAs. The last scenario presents the vision for the management of the resource where its sound management is only achieved through the establishment of suitable organizations.

The task at hand is to develop mechanisms that can achieve the broad goal of sustainable and equitable management.

Table 14: Scenarios

Variables	Scenario 1 <i>Worst case</i>	Scenario 2 <i>Current/interim</i>	Scenario 3 <i>Acceptable – grappling with implementation</i>	Scenario 4 <i>Ideal – comprehensive implementation</i>
RESOURCE				
Groundwater levels	Groundwater levels start dropping.	Groundwater levels drop in most places.	- State similar to Scenario 2. - Aquifer still to respond to integrated management – this is being monitored	- Water levels have stabilised - Status of aquifer elevated to that of a strategic resource
Groundwater dependent ecosystems	Most GDEs in an altered state.	GDEs begin to collapse.	State similar to Scenario 2.	All GDEs are being sustained and collapsed GDEs begin to be restored.
Water Quality	A few cases of contamination.	Frequent cases of contamination mainly due to high levels of pesticide and fertilisation.	State similar to Scenario 2.	Far fewer cases of contamination
DEMAND				
Productive	- Boom in commercial farming coupled with electrification of borehole pumps - Bulk of groundwater consumed is by irrigation farmers - Most irrigation is very inefficient and therefore wasteful use	- Similar to Scenario 2 - Unsustainable use in parts due to commercial farming - Irrigation demand fluctuates – see external environment	Farmers irrigating per agreements and attempts to irrigate more efficiently	- Sustainable and equitable abstraction/consumption - Efficient use (employment of water demand management, local recharge, rainwater harvesting, banking etc.) - Decrease in poverty and increase in employment
Unauthorised use		Increase in unauthorised use	Same as before but prosecution starts to take place	Under license with high compliance
Reproductive	- Towns and peri-urban settlements not yet abstracting from aquifer - Rural and peri-urban communities either have no water supply or ineffective water supply schemes	- Towns' growing water demands supplied by groundwater. - Increases in demand for water and sanitation services as well as improved services – RDP standards to be met - Lack of payment of services	- Same as Scenario 2 - Improvement in access to services and payment for services rendered.	- Equitable and efficient service provision (also efficient) – only authorised use, no unaccounted for water, no leaks, good reticulation 90% cost recovery
Cost	"Free" water and those paying not paying the true cost	- Still not paying real cost of water. - More water services for the	Cost of water closer to its economic value. Affordability scales	Cost of water relates to real value and affordability

Variables	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		poor but low cost-recovery	implemented	
USER PROFILE				
Equity	Productive use of water confined to white landowners – firm correspondence between land ownership and water rights	- Still very little productive use among historically disadvantaged individuals - Correspondence between land ownership and water rights shaken but in tact due to existing lawful use	Productive use of water among HDIs improving	- Subsistence farming supported through reliable and accessible water supplies hence a decrease in poverty, more resilient livelihoods, better able to withstand external shocks but still vulnerable - Emergence of black commercial farming – coupled with land reform
Attitudinal/ awareness	Widespread ignorance on the resource: a) occurrence of groundwater, b) impact of use on resource and hence on others	- Resistance to change in legal framework and distrust of DWAF - Emerging conflicts between users, exposing resistance to change, misconceptions about the resource, manipulation of facts. - Conflicts between users, suppressed	- Not much change but DWAF starts engaging with users via the groundwater co-ordinator/s through organised, formal communication process (i.e. not ad hoc) - Awareness of necessity to participate in water management and how to go about it	- Strong, organised civil society, structures - Conflict well managed - Full knowledge of rights and responsibilities - Local monitoring and management
Organisation/ civil society	- Weak civil society – no organisations or individual involvement in water management - Rural and peri-urban communities are unempowered, no opportunities for productive use	- Opportunities to participate in water management (WUAs and Catchment Fora) not readily taken up – confusion about how and why to participate in water management - Commercial farmers' unions strengthening – formation of water committees - Emerging farmers remain poorly organised - Domestic use – growing awareness of rights and obligations	- Strong moves to form WUAs organically - Commercial farmers, though the lobbying of agric union, are monitoring better, have a greater appreciation of resource, organised, improved compliance - Emerging farmers – better opportunities for productive use (an outcome of collaborative governance) and are better organised - Domestic use – forming water committees, improved access, better understanding (relates to quality issues),	- WUAs and CMAs are functioning - Trust of DWAF – mainly lawful water use

Variables	Scenario 1	Scenario 2	Scenario 3 improved payment of service	Scenario 4
REGULATION/MANAGEMENT				
Legislation	Water Act 1956: private ownership of water, no IWRM, highly centralised institution	- Water Act 1998 - new regulatory framework: water is a public good, IWRM and decentralisation (CMAs and WUAs) 19 Water Management Area – aquifer is now recognised as a shared resource, concerns about its management	National Water Resources Strategy (NWRS) – does not make provision for shared (ground) water resources	NWRS amended to deal with shared (ground) water resources
Institutions	- Centralisation of power and knowledge at the National office - Weak DWAF regions - National office has better understanding of groundwater than regions	- Head office and regions further weakened due to extent of institutional change and development - WUAs applications on aquifer, none approved - Regions display interest in aquifer but do not have sufficient capacity or resources to manage their portions.	- CMAs starting to emerge - Regional offices equipped with resources required to drive establishment of CMAs - WUAs – still a problem due to lack of civil society	- DWAF decentralised – HO maintaining/updating numeric model, strategic decisions - Excellent regional and local capacity - CMAs implemented and functioning - WUAs being supported and their capacity needs being addressed
Integrated planning and co-operative governance	- Science top-heavy, no participatory planning, no socio-economic concerns - No poverty alleviation frameworks	- Focus on policy development to realise goals and objectives of NWA - Socio-economic concerns and poverty alleviation part and parcel of management and delivery of services – launch of CWSS programme	Taking on social, cultural issues – appointment of social anthropologists	Full integrated planning (e.g. SDIs, IDPs planned in line with water available etc.
	No co-operative governance	Recognition of collaborative government and policy formulation	Limited implementation	Strong implementation
Aquifer management	No aquifer management except subterranean control Area	Recognition of the strategic value of the dolomite aquifer and the need for a management plan	- Geohydro parameters of aquifer management strategy established - Process for developing aquifer management strategy - addresses social/institutional	- Participative Aquifer Management Strategy - Implementation of a Decision Support System

Variables	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Some technical knowledge of part of the aquifer - fragmented information	- Unco-ordinated technical studies to be remedied through co-ordination programme - Incomplete information and capacity hinders RQOs and Reserve Determination	- awareness issues - Appointment of groundwater co-ordinator/s - Co-ordinated technical studies completed - numeric model in place knowledge levels good but limited to a very high level - RQOs set and Reserve determination complete, followed by issuing of licenses	Translation of information into lay terms
	Incomplete groundwater monitoring system	Design of a groundwater monitoring system	Implementation of groundwater monitoring system	Data generated from monitoring system used effectively to gauge sustainable use
	Poor communication with users	Erratic communication with users	Same as Scenario 2	Vastly improved communication due to appointment of groundwater co-ordinator/s
			Improvement in enforcement – unauthorised use addressed through court process	Efficient enforcement
Ext factors	- Drought - Maize price drops - Effects: drop in employment, increase in rural poverty - No resilience to effects of external factors	Beginning of strategies to cope with shocks/stresses	Starting to see improvements in livelihood resilience to external factors	Complete resilience and ability to cope

4.2 Coping Measures

4.2.1 Local water resource management: Establishment of WUAs

Scenario 2 represents the introduction of a new regulatory framework driving decentralization of water resources management. By Scenario 3, the WUAs are starting to establish and by the last scenario they are established and are working effectively. In the first scenario, there was an absence of civic interest, particularly regarding water resource management due to the private ownership of water. Therefore what coping measures are required to move from a state of civic inactivity to vital local involvement in water resources management?

There are certainly strong contradictions in the existing on localized groundwater management. On the one hand, it is believed that the "conscious design of improved institutions (to solve water problems) is a proactive approach that can shortcut the process of institutions evolving in response to problems (Dinar and Loehman, 1995:xxvii). On the other hand, it is argued by Rhoades (2000) that an approach to water management that incorporates the needs of users is success is most likely when based in indigenous in-situ management structures and that facilitation by outsiders seldom leads to successful implementation. In South Africa, where the goals of government are to move away from the highly problematic, unrepresentative structures of the past, it is necessary to design 'improved institutions' and the legacy of civic inertness necessitates facilitation. Therefore facilitation is required to establish WUAs and the process followed will be a critical factor in the establishment and sustainability of these organizations.

The literature provides some pointers that should guide the process of establishing WUAs:

- Identify and include all stakeholders.
- An aquifer is seldom a political or social reality except to scientists.
- Co-operative management often requires a great deal of bureaucracy and paperwork and the participants have insufficient expertise and resources (Batchelor, 1999).
- Experts are often not seen as being accountable to local people and their attitudes as well as existing institutional cultures often need to change (Batchelor, 1999).

4.2.2 Co-management: the formation of an Aquifer Management Strategy and the Dolomite Water Area Management Committee (DWAMC)

In Scenario 1, there is no conception of the management of the aquifer as a single resource. In Scenario 2, the resource is shared by three water management boundaries as part of the process of devolving water resource management. There are discussions about the need to manage the resource holistically and in the following scenario a process to achieve this is drawn up and successfully implemented in the last scenario.

The holistic management of the resource will only happen a) if there is a NWDWA Management Strategy and b) if there is an organization or institutional tier that is responsible for effecting the strategy.

An aquifer management strategy is important since the establishment of the CMAs and their Catchment Management Strategies (CMS) is happening at different intervals. Given the complexity of drawing up a CMS, the likelihood of CMAs co-ordinating planning among themselves around the aquifer is not guaranteed.

The strategy should be drawn up in the same way as a CMS and have the same content, as specified in the NWA Section 9a-l.

The implementation of the strategy, since it is shared by CMAs, requires an organization or institutional tier separate to but inclusive of the CMAs. An option presented at the end of Phase 1 (Stephens and Bredenkamp, 2002) consisted of a DAMC provided for by Section 82(5) of the NWA. (In light of changes in terminology it may now be referred to as the Dolomitic Water Area Management Committee (DWAMC)). The provision in the Act accommodates the establishment of committees within the CMAs to "perform any of its functions within a particular area, or generally to advise it" (RSA, 1998, Act 36). The intention of the clause was to set up committees within a WMA and does not state whether this may be done on an inter-catchment basis although it does not expressly prohibit the formation of such committees¹¹.

The Phase 1 report envisaged a committee comprising representatives of the affected CMA's, the WUAs, and DWAF national and regional offices. It also entertained the option of the establishment of various technical sub-committees that would fulfill particular functions in relation to the management of the NWDWA.

At the time of its conceptualization, the proposal addressed the shared nature of the aquifer by including all the main stakeholders and in particular, the affected CMAs and WUAs. The purpose of Phase Two was thus seen to be the elaboration of this model by expanding on its powers, responsibilities and functions. However, the second phase of the study has revealed a co-dependent relationship between the formation of the DWAMC, and the existence of the WUAs and the timetable for the establishment of the CMAs. In the absence of these water management institutions, a central question has been whether the establishment of the DAMC would make any sense at this point, given that its constituent parts would be missing.

Furthermore, the research process has established that it can be counter productive to co-opt local stakeholders into organisations that lack momentum or are not properly constituted.

¹¹ Legal opinion needs to be sought on this matter.

This is due to the fact that such organisations tend to suffer from institutional stagnation and squander stakeholder goodwill in the process. However, the need to get the basics right and be considerate towards stakeholders should not obscure the arguments for an integrated approach to the management of the NWDWA, that were advanced in Phase 1 of this project. These discoveries merely suggest that expectations need to adjust to the length of time it will take to form a DWAMC and responsibility for the aquifer may be assumed in the interim.

4.2.3 Interim Co-Management

It is therefore necessary to consider interim options. Such an approach may require that DWAF structures should play a leading role in the development of an integrated management approach of the NWDWA until appropriate mechanisms are in place. Furthermore, DWAF restructuring processes are giving rise to what is termed the **Central Cluster**. It so happens that the Central Cluster includes the regions that the resource is shared between, namely Gauteng, North West, Free State and Northern Cape. It is recommended that as part of Phase 3, discussions be held with the Cluster Manager and other relevant officials on the fate of the NWDWA and a proposal tabled to the manager by the Dolomite Project Co-ordination Committee on how responsibility for the aquifer can be taken up by the Central Cluster until it is feasible for a DWAMC to be established.

As part of the proposal, strong consideration should be given to establish a couple of posts to manage shared resources such as the NWDWA. This project has conceptualised the position as a **Groundwater co-ordinator**¹². It is not an original concept and simply echoes work-in-progress – the functions of such a coordinator within a WMA are described in the *"Guidelines for Groundwater Management in Water Management Area - Integrated Water Resource management in three different Water Management Area"*. The coordinator, armed with the knowledge of the entire aquifer, the restrictions on groundwater use imposed on his or her WMA, is in a position to represent the aquifer as a whole and in particular, during CMA and WUA decision-making processes. Part of such a coordinator's job should be to liaise with the co-ordinators from the WMAs also dependent on the aquifer.

The co-ordinator, who would serve as a **"roving" committee**, would be equipped with detailed knowledge of the entire aquifer, restrictions on groundwater use imposed on his or her WMA. Equipped with this knowledge, s/he would be able to represent the aquifer as a whole, particularly during CMA and WUA decision-making process. The **mission** would be, in short, to represent the aquifer. This would be at various levels ranging from the DWAF HO's central cluster down to villages' water committees.

Primary **roles** would be information-gathering, facilitation and communication. Information-gathering would entail information about alleged abuses of the resource, monitoring data,

¹² It could easily be more than one person and should not be a Geohydrologist but have an understanding of the geohydrology. There is sufficient geohydrological expertise with Dolomite Co-ordination Project and with a principal Geohydrologist in the National Office, responsible for the aquifer.

planning activities that would have an influence on the resource etc. Facilitation would involve ensuring that the vision of devolved decision-making regarding water use materialises by ensuring that WUAs are established and that stakeholders are adequately and effectively represented in the CMAs. Communication would involve ensuring open lines of communication between the DWAF head office and regional offices, and the local water users and managers. Communication would also require that corporate governance becomes a reality, as the aquifer representatives would attend every relevant committee and meeting that would have an influence on the current and future use of groundwater.

Main responsibilities would be as follows:

- to identify all the participants affected by and affecting the management of the aquifer;
- to ensure that a multi-dimensional model of the resource and its uses serving as a Decision Support System would be developed in a collaborative manner;
- to facilitate the set up of water management institutions¹³;
- generate recommendations on the primary (social and economic) values of the aquifer management through a consultative process; and
- to pool monitoring and evaluation data once the DSS is established.

The management principles driving this recommendation are that:

- the profile of the aquifer needs to be raised in a whole range of contexts;
- decision-making, to be effective, needs to be streamlined and it is imperative that our proposals set to support and strengthen the water management policies and strategies; and
- holistic management of the resource should be facilitated as far as possible by the latest technology available.

In short, the roles of the groundwater co-ordinator would be: In the short term to facilitate sound water management practice at the catchment level in all three WMAs dependent on the aquifer so as to ensure sound management of the aquifer; in the long term to be responsible for the monitoring of the aquifer, the negotiations of reserves and catchment area restrictions on abstractions that take into account the entire aquifer, and representing the aquifer in catchment level decision making processes. This ensures that catchments can manage their water effectively without having to constantly refer to another level of committee.

4.2.4 Strategic decisions for shared resources: Advisory Committee

It has been argued that the NWDWA is a *strategic* source of water, that it is a shared resource and that there are others like it. It has also been established that Kgetlengriver Local Municipality's water supplies will need augmentation and drawing from the dolomitic aquifer is a strong possibility. It is therefore recommended that an **advisory committee** be appointed to advise on strategic uses of water sources for all shared water sources. The

¹³ To this end, Graham Hubert (EMA) has supplied a list of questions that an educational strategy would be required to address. Refer to Annexure A.

establishment of an advisory committee is at the minister's discretion. An *Advisory committee (AC) is established by the Minister to provide him/her with advice or perform functions in a specified area*¹⁴. The NWA (1998) allows for the Minister of DWAF to establish advisory committees and to determine their terms of reference, membership, powers, duties and operation (NWRS August 2002).

4.2.5 The Decision Support System

Already in South Africa there is an awareness of needing an accessible and comprehensive picture of groundwater. A 'Groundwater Information systems for Integrated Water Resource Management' is already being developed¹⁵. There are also plans to set up a server-based, web-enabled National Groundwater Archive, to be linked to REGIS Africa that will provide management information by modelling groundwater recharge, the impacts of abstraction and contamination¹⁶.

The management of the NWDWA requires a conceptual model based on geohydrology **AND** that incorporates local water needs and values and is perceived as being credible. Such a model must be clearly understood by decision makers at all levels and it is, therefore, recommended, that, as with the AEAM, the model is developed through the participation of local stakeholders. Such a process would have to involve decision makers from all three WMAs dependent on the aquifer so that this approach will, in itself, facilitate co-operative management. All CMAs and WUAs have to be fully equipped to make decisions regarding groundwater management in their Area. The conceptual model will ideally and where possible provide:

- Complete and full knowledge of the aquifer and understanding of its limitations, resources, and requirements
- Established reserves for the aquifer as a whole as well as for each catchment
- Clear knowledge and understanding of the impact of abstraction from one area on the water levels in another
- Firm parameters delineating exactly what abstraction can occur in one catchment regardless of the apparent availability of water, based on impact across the aquifer.

Some of the factors that such a model may eventually have to manage include:

1. Establishing water rights;
2. Managing the distribution of water rights;
3. Establishing payment for water;
4. Drawing up policy that states how local management will deal with future pressures on the aquifer; and

¹⁴ Integrated Water Resource Management Series "Guidelines on the Establishment and Management of Catchment Forums" DWAF 2001

¹⁵ DWAF (2002) Groundwater Management Strategy; Integrated Water Resource management in three different Water Management Areas DANIDA.

¹⁶ DWAF (2002b) National Water Resource Strategy Proposed First edition DWAF August 2002.

5. Keeping all users fully informed of the aquifer's condition and of the actions and plans of other users.

4.3 Concluding Comments

This chapter represents the beginnings of the third stage of the process to design institutional arrangements for groundwater management. It is one in which management alternatives are identified through a process of scenario-building. Four scenarios were sketched, closely mirroring reality, and from these a range of coping measures were identified. These coping measures allow for both interim and long-term options. An interim option, while intense institution-building is underway, is to appoint a NWDWA co-ordinator who can act in the interests of the aquifer, ensuring that it is represented in the plethora of organizations that exist and affect the management of and demand for this resource. In the long-term, the institutional arrangements that govern the resource may be the DWAMC, which will pull the different role-players together into one committee and serve to centralize decision-making around the aquifer. However for this approach to be effective, the participating organizations need to be strong and their strength will depend largely on how they are set up and to what extent stakeholders are capacitated to play a meaningful role in water management. Since this is the beginnings of the third stage, steps to follow would include the identification of required functions and capacity for these coping measures to be effected. This leads the way to the proposal for the third phase, which focuses mainly on developing a plan of action for the NWDWA co-ordinator.

5 CONCLUSION

The research has established, or rather confirmed, that the existing institutional environment is in a poor state and this can be explained in a number of ways:

- The DWAF Regional Offices do not have the capacity or resources to implement the devolution of water management as effectively as they would like to;
- Policy is being generated by the Head Office to ensure that processes are stakeholder-based but since these processes are often consultant-driven, the relationship between local stakeholders and the Regional Offices is weakened;
- Channels of communication between Head Office and Regional Offices, and between Regional Offices and local stakeholders are lacking;
- WUAs do not exist, which may be overtly be explained by the fact that WUA applications submitted did not comply with policy but in fact is a reflection of the lack of civil society generally and particularly with regard to water management;
- CMAs do not exist, which is related to the great cost and length of time it takes to set up these organizations;
- The range of stakeholders who do have a role to play in IWRM are not aware of this and do not have the know-how to do so. This particularly affects Water Services Authorities (Local Government).

However, there are strengths to be noted as well and these include:

- A huge undertaking to consolidate and refine the technical knowledge of the aquifer via the NWDWARM Project;
- Active facilitation of Catchment Fora, in particular the Marico and Molopo Fora, some of whose members draw from the aquifer;
- Significant resources set aside for the establishment of the Crocodile West-Marico CMA, which affects a substantial portion of the aquifer;
- The formation of the DWAF Central Cluster, grouping the same regions that share the NWDWA and thereby lending itself to co-management at a Head Office and regional level.

In light of the above, it is argued that it is premature to establish an organization such as the DWAMC to foster integrated management of the NWDWA. This organization is unlikely to be established because it relies heavily on the existence of established and functioning water management organizations in the form of CMAs and WUAs. While CMAs functions are being executed by Regional Offices, their roles in establishing CMAs should take priority. A preferred approach is the appointment of groundwater co-ordinators whose responsibility it will be to represent the aquifer in strategic forums and to ensure that water management institutions such as WUAs are established and able to manage adequately their parts of the aquifer. Another important long-term role would be the establishment of the institutional arrangements for the resource in line with the evolution of the CMAs and WUAs.

It is also recommended that a decision support system be established based on a multi-dimensional model that is not confined purely to the geohydrological parameters but that is also able to factor social, cultural and economic factors.

If this approach is accepted, Phase Three should then plan for the following activities:

- A detailed workplan for the groundwater co-ordinator(s), and formulation of job description. This would include working closely with the project co-ordination committee of the NWDWARM Project to ensure that there is close alignment in planned activities of the co-ordinator/s and project outputs;
- Fundraising proposals and discussions for the financing of the groundwater co-ordinator(s) and negotiating support for these from affected parties;
- Detailed, secondary research on a) the concept of a Decision Support System in the realm of water management and b) approaches to using computerized technology where a wide range of computer literacy exists; and
- A strategy for communicating the findings of the current research.

6 REFERENCES

- Alders, Carine, Haverkort, Bertus and van Veldhuizen, Laurens (Eds.) (1993) *Linking with Farmers: networking for Low-External-Input and Sustainable Agriculture* London: Intermediate Technology Publications.
- Batchelor, Charles (1999) 'Improving water use efficiency as part of integrated catchment management'. *Agricultural Water Management* 40: 249-263.
- Blomquist, William (1992) *Dividing the Waters: Governing Groundwater in Southern California* Institute for Contemporary Studies.
- Blomquist, William and Ingram, Helen M. (2003) 'Boundaries Seen and Unseen Resolving Transboundary Groundwater Problems' *Water International* 28(2): 162-170
- Blomquist, William, Heikkila, Tanya and Schlager, Edella (2001) Institutions and Conjunctive Water Management among Three Western States *Natural Resources Journal* 41: 654-683
- Bruns, Bryan Randolph and Meinzen-Dick, Ruth S. (2000) Negotiating Water Rights: Implications for Research and Action In Bruns, Bryan Randolph and Meinzen-Dick, Ruth S. (Eds.) *Negotiating Water Rights* London: Intermediate Technology Publications pp.353-380
- Ewing, Sarah A., Grayson, Rodger B., Argent, Robert M. (2000) 'Science, Citizens, and Catchments: Decision Support for Catchment Planning in Australia.' *Society & Natural Resources* 13 (5)
- Kurnia, Ganjar, Avianto, Tenten W. and Bruns, Bryan Randolph (2000) 'Farmers, Factories and the Dynamics of Water Allocation in West Java' In Bruns, Bryan Randolph and Meinzen-Dick, Ruth S. (Eds.) (2000) *Negotiating Water Rights* London: Intermediate Technology Publications pp.292-314
- Meij, E. Gaynell McGary and Abdalla, Charles W. (1990) A comprehensive approach to groundwater management for rural local governments *Journal of Soil and Water Conservation* March-April: 226-229
- Pallett, John (Ed.) (1997) *Sharing water in Southern Africa* Windhoek: Desert Research Foundation Namibia
- Pegram, Guy and Mazibuko, Gugu (2003) *Evaluation of the Role of Water User Associations in Water Management in South Africa* Water Research Commission.
- Pietersen, K (2004) *A holistic approach to groundwater management of basement aquifers in South Africa* Unpublished.
- Rhoades, Robert E (2000) 'The Participatory Multipurpose Watershed Project: nature's Salvation of Schumacher's Nightmare' In Lal, Rattan (Ed.) *Integrated Watershed Management in the Global Ecosystem* Boca Raton: CRC Press pp. 327-343
- Sadeque, Syed Zahir (2000) 'Nature's Bounty or Scarce Commodity: Competition and Consensus Over Groundwater Use in Rural Bangladesh' In Bruns, Bryan Randolph and Meinzen-Dick, Ruth S. (Eds.) *Negotiating Water Rights* London: Intermediate Technology Publications pp.269-291

Stephens, Anthea and Bredenkamp, DB (2002) *Institutional Arrangements for Groundwater Management in Dolomitic terrains* Pretoria: Water Research Commission
Turton, Anthony and Henwood, Roland (Eds.) (2002) *Hydropolitics in the Developing World: A Southern African Perspective* Pretoria: African Water Issues Research Unit

Government Policies and Documents

Department of Provincial and Local Government and DWAF (2003) *Guidelines for implementing the division of powers and functions for water and sanitation* 19 January 2003.

DWAF (1994) *Water Supply and Sanitation Policy White Paper*, Department of Water Affairs and Forestry.

DWAF (1997) *White paper on a National Water Policy for South Africa*, Department of Water Affairs and Forestry.

DWAF (1999), *Resource Directed Measures for Protection of Water Resources Volume 2* Department of Water Affairs and Forestry.

DWAF (2000) *Policy and Strategy for Groundwater Quality Management in South Africa* Water Quality Management Series first edition Department of Water Affairs and Forestry.

DWAF (2000a) *Water Use Authorization Process for Individual Applications* Chief Directorate Water Use and Conservation December 2000.

DWAF (2001) *Integrated Water Resource Management Series "Guidelines on the Establishment and Management of Catchment Forums"* DWAF 2001
(CD includes: 1) *Establishing a Catchment Management Agency* Guide 1 in the CMA/WUA Series DWAF;
2) *The Catchment Management Agency as an Organization* Guide 2 in the CMA/WUA Series DWAF;
3) *Establishing a Water User Association* Guide 3 in the CMA/WUA Series DWAF ;
4) *Public Participation for Catchment management Agencies and Water User Associations* Guide 4 in the CMA/WUA Series DWAF)

DWAF (2001a) *"Roles, Functions and Inter-Relationships of Institutions Involved in the Management of Water Resources"* Prepared by AFROSEARCH.

DWAF (2002) *"Groundwater Management Strategy; Integrated Water Resource Management in three different Water Management Area"* Prepared by Carl Bro International and IZNA Consortium.

DWAF (2002i) *"Guidelines for Groundwater Management in Water Management Area; Integrated Water Resource Management in three different Water Management Area"* Prepared by Carl Bro International and IZNA Consortium.

DWAF (2002a) *Institutional Roles and Linkages: Phase 1 report. Integrated Water Resources Management, Strategies, Guidelines and Pilot Implementation in Three Water Management Area, South Africa.* Prepared by the IZNA Consortium, February 2002.

DWAF (2002b) *National Water Resource Strategy* Proposed First edition, August 2002.

DWAF (2003) *Strategic Framework for Water Service* DWAF 15 September 2003

DWAF (2003a) *Internal Strategic Perspective Crocodile West WMA Groundwater Overview*.

DWAF (2003b) "A framework for groundwater management of community water supply" June 2003. The development of Groundwater Management Support Services for Rural Water Supply Managers Norwegian-assisted programme for the sustainable development of groundwater sources for the community water and sanitation programme of South Africa (DWAF). Prepared by Ricky Murray and Phillip Ravenscroft, CSIR Environmentek.

EMA (2003) *Project Management and Technical Co-ordination of North West Dolomitic Groundwater Region Area* EMA 20th May 2003.

Republic of South Africa, (1997) Water Services Act, Act 108 of 1997: Regulations Relating to Compulsory National Standards and measures to Conserve Water.

Republic of South Africa, (1998) National Water Act, Act 36 of 1998.

7 ANNEXURE A: Guidelines for the design of an awareness and educational strategy

By Graham Hubert and Eddy van Wyk

AQUIFER FUNCTIONING
What the dolomite aquifer is?
What its resources are?
How the resources are replenished?
What happens when the aquifer is pumped?
What happens when over utilisation occurs?
What are dolines and sinkholes and how can they suddenly develop?
AQUIFER MANAGEMENT
Why management is essential to safeguard the aquifer to ensure long term sustainability?
What management involves?
What information is needed?
Why it is important that water use is registered, probably licensed and may be compulsorily licensed in the future?
What happens when someone applies for a license to abstract water?
Who are the decision makers in this regard and how is the decision made?
How and where do people (users) apply for a license?
Who needs to apply for a license?
What is the difference between general authorisation and a specific license?
What could happen if a license is refused?
What is the implication of compulsory licensing and possible allocation of water?
Why would this be a good thing?
Who will police all of this?
How the users can contribute to active/proactive management? How this is achieved? (What role can the stakeholders play in the management?)
How WUAs are an essential component in the aquifer management structure of the resource?
Are WUAs useful, how will the members be empowered to manage 'their' aquifer?
What support will they get from the Regional Office/CMA?
What is the CMS? How can users influence the CMS
How water quality can be impacted by human activity?
The crucial role of monitoring (possibly individual users can be encouraged to measure the water levels in their boreholes on a regular basis and record the abstraction)
Monitoring should also include the water abstraction figures – who will take these crucial measurements?

APPENDIX A

Situational Analysis for the preparation of Institutional
Arrangements for Groundwater Management in the
North West Dolomitic Water Areas

PHASE 2: SITUATION ANALYSIS

WATER USE AND DEMAND ASSESSMENT

by

Claus Mischker, MCA Planners

Anthea Stephens (Project Manager)

IUCN South Africa
P.O. Box 11536
Hatfield, Pretoria

Tel: 012 342-8304
Fax: 012 342-8289

TABLE OF CONTENTS

LIST OF TABLES	ii
LIST OF FIGURES	iii
LIST OF ABBREVIATIONS	iii
EXECUTIVE SUMMARY	iv
1 INTRODUCTION	1
2 RESEARCH RESULTS	1
2.1 Determination of Study Area	1
2.2 Nature & Location of Land Use, & Changes to Land Use in the Study Area	1
2.3 Population Growth	1
2.4 Access to Water	2
2.5 Future growth	2
2.6 Water Demand Assessment	2
3 RESEARCH METHODOLOGY	2
3.1 Research Methods	2
3.1.1 Determination of Study Area	2
3.1.2 Data Collection	4
3.1.3 Land Use Distribution	5
3.1.4 Domestic Demand	6
3.1.5 Agricultural Demand	6
3.1.6 Industrial Demand	7
3.1.7 Environmental Demand	7
3.1.8 Population Growth	7
3.1.9 Access to Water	8
3.1.10 Future Growth	8
3.1.11 Water Demand Assessment	9
3.2 Research challenges	9
3.2.1 Census Information	10
3.2.2 Community Land Claims	10
3.2.3 Agricultural Information	11
4 RESEARCH FINDINGS	11
4.1 Nature and Location of land Use	11
4.1.1 Water Units and Land Use	11
4.2 Overview of Water use	12
4.2.1 Domestic Water Use	12
4.2.2 Access to Domestic Water	15
4.2.3 Industrial Use	17
4.2.4 Agricultural Use	17
4.2.5 Environmental Use	20
4.2.6 Summary of Water Use per Dolomite Water Unit	20
4.3 Future Growth	21
4.3.1 Population Growth	21
4.3.2 Spatial Growth	23
4.3.3 Community Land Claims	25
4.4 Economic Growth – Industrial and Agricultural	25
4.4.1 Industrial Growth	25
4.4.2 Agricultural Growth	26
4.5 Water Demand per Water Use	27
4.5.1 Domestic Water	27
4.5.2 Agricultural Water	30
4.5.3 Industrial Water	31
4.5.4 Environmental Water	31
4.6 Water Demand per Dolomitic Water Unit	31
5 CONCLUSION AND RECOMMENDATIONS	33

5.1	Limitations	33
5.2	Key Findings	34
5.2.1	Access to water	34
5.2.2	Future Growth	34
5.2.3	Domestic Water Demand	34
5.2.4	Agricultural Water Demand	35
5.2.5	Industrial Water Demand	35
5.2.6	Cumulative Demand	35
6	REFERENCES	37
7	ANNEXURE 1: Maps	38
8	ANNEXURE 2: Additional Sources Consulted	39
9	ANNEXURE 3: Table of water compartments, 5 major water units and associated crop coverages (summer + winter 2001)	41
10	ANNEXURE 4: Detailed Census Tables with levels of access to water services	42
11	ANNEXURE 5: Telephonic Interviews with Municipal officials	44

LIST OF TABLES

Table 1.1	Dolomite water units	iv
Table 1.2	Overview of major settlements and domestic water source	v
Table 1.3	Domestic water demand per dolomite unit	v
Table 1.4	Calculated domestic water demand per dolomite unit	viii
Table 1.5	Livestock water demand	ix
Table 1.6	Calculated Combined Water Demand for 2008	ix
Table 3.1:	Water sub-compartments and associated major water units	3
Table 3.2	District and Local Municipalities, and related geohydrological units	4
Table 3.3	Land Cover Codes	5
Table 3.4:	Livestock numbers estimated to be sharing groundwater resources, 2001	7
Table 4.1	Summary table of domestic water use	14
Table 4.2	Summary table of domestic water demand per dolomite water unit	15
Table 4.3	Census categories of levels of access to water services	16
Table 4.4	Rates of Change (Census 2001) RDP Standard Levels of Access to Water	16
Table 4.5	Consolidated Water Demand Information 2008 (Ml/annum)	17
Table 4.6:	Irrigation consumption vs. yields	18
Table 4.7:	Sensitivity Overview: Impact on Irrigation increase on water unit yields	19
Table 4.8:	Livestock Numbers estimated to be sharing groundwater resources, 2001	19
Table 4.9:	Impact of livestock consumption on dolomite water units	20
Table 4.10	Consolidated Water Demand Information 2008 (Ml/annum)	21
Table 4.11	Summary Table Municipal Level in Study Area, 1996 vs. 2001	21
Table 4.12:	NWPPU Population Projections	22
Table 4.13:	NW Province Population Unit Calculations with Substitution for 2001	22
Table 4.14	Summary table of planned settlement growth	24
Table 5.1	Additional Domestic Water Demand per Dolomitic Water Unit	27
Table 5.2	High Scenario (kl per annum)	29
Table 5.3	High Scenario (kl per annum)	29
Table 5.4	Low Scenario (kl per annum)	30
Table 5.5	Low Scenario (kl per annum)	30
Table 5.6	Consolidated Water Demand Information 2008 (Ml/annum)	32
Table 5.7:	Total current and future water demand – aquifer source (Ml/annum)	33
Table D.1	1996 Census (Ward Level) and Levels of Access to Water Services	42
Table D.2	1996 Census: Summary of Levels of Access to Water	42
Table D.3 :	2001 Census and Levels of Access to Water Services	42
Table D.4	Rates of Change (Census interval 1996 - 2001) all Levels of Access to Water	43

LIST OF FIGURES

Figure 1	Study Area
Figure 2	Land Use Distribution
Figure 3	Summer Crops Correlation with Dolomitic Units and Compartments
Figure 4	Winter Crops Correlation with Dolomitic Units and Compartment
Figure 5	Livestock Districts
Figure 6	Water Use per Dolomitic Units and Compartments
Figure 7	Local Municipal growth rates 1996 - 2001
Figure 8	2008 Local Municipality growth rates
Figure 9	Spatial Growth Frameworks and planned future growth with domestic water sources
Figure 10	Gazetted Community Land Claims

LIST OF ABBREVIATIONS

DWAF	Department of Water Affairs and Forestry
GIS	Geographic information Systems
IDP	Integrated Development Plan
IDZ	Industrial Development Zone
LM	Local Municipality
NWPPU	North West Provincial Population Unit
SDF	Spatial Development Framework
SDI	Spatial Development Initiative
WSAM	Water Situational Assessment Model

EXECUTIVE SUMMARY

This study seeks to determine the future water demand patterns, predicted for 2008, in a confined area of the North West Province, which draws water from a dolomitic aquifer.

Initially, the basis of forecasting was to be presented by all available demographic information and through the use of GIS technology in order to enhance the analysis and provide clear and concise mapping products. Due to the paucity of appropriate visual information, however, this study involves collating and manipulating the most recent data available to project water demand scenarios.

Aims

The study aims to identify the level of population growth and where it is occurring or has occurred, as well as determining the population in 2008, which provides a short to medium term perspective. The historic growth of population and future growth is derived from the North West Provincial Population Unit's datasets and 2001 Census data. A comparison to 1996 census is included.

The study also seeks to quantify the current levels of access to water in both rural and urban environments, and what form that level of access takes. The research challenge experienced during this study is the lack of accurate irrigation water consumption figures. This makes it difficult to match dolomite water unit yields with actual abstraction. Data derived from satellite images has been used as a proxy method.

Study Area

The study area covers slightly over 12,000km² in the northeastern half of the North West Province.

The study area covers the five dolomitic water units and Municipalities as follows:

Table 1.1 Dolomite water units

District Municipality	Local Municipality	Main Towns and Villages	Geohydrological water unit
Central	Mafikeng,	Mafikeng, Peri-urban areas, Rooigrond	Extended Grootfontein, Zeerust
	Ditsobotla,	Lichtenburg, Boikhutso, Coligny, Itsoseng villages, Bodibe villages, Verdwaal villages, Ga-Motlatla	Extended Grootfontein, Zeerust, Groot Pan, Schoonspruit
	Zeerust	Zeerust, Groot-Marico, Lehurutshe villages, Dinokana villages, Gopane villages, Khunotswana	Zeerust
Southern	Ventersdorp	Ventersdorp, Goedgevonden	Schoonspruit
Bojanala Platinum	Kgetleng River	Derby, Koster, Swartruggens	Insignificant part of Schoonspruit

It was decided to investigate the inclusion of include certain settlements, namely Derby, Koster and Swartruggens, which now comprise the Kgetleng River Local Municipality (LM). These are not currently abstracting from the aquifer but may potentially suffer a

shortage in water supply and may have to abstract from the dolomitic aquifer at some point in the future.

Domestic Water Use and Sources of Water

Most of the settlements in the study area abstract water from the dolomitic aquifer. Some are supplied water by the aquifer for all their needs, while others such as Mafikeng augment existing supplies. A few are not currently reliant on the aquifer at all.

Table 1.2 Overview of major settlements and domestic water source

Village / Town	Water Source
Lichtenburg, Itsoseng and its villages (Verdwaal, Bodibe, etc)	Dolomite water- Lichtenburg/Itsoseng unit
Coligny	Supplied from a local granite aquifer
Koster	Mostly supplied from the Koster dam
Derby	2 local boreholes (not dolomite)
Swartruggens	Supplied from the Swartruggens dam
Mafikeng	75% of its domestic water is drawn from the aquifer (mainly Molopo Eye and Grootfontein Compartment)
Ventersdorp	Supplied from the Schoonspruit water unit
Zeerust and the Lehurutshe and Dinokana villages	Directly supplied from the Zeerust water unit
Villages further north (Gopane, Rodhikudu, etc)	Do not receive water from the dolomite aquifer
Groot Marico	Does not receive water from the dolomite aquifer

The current domestic water demand per dolomite unit is:

Table 1.3 Domestic water demand per dolomite unit

Water unit	Demand
Zeerust	3,575MI/yr
Extended Grootfontein	6,750 - ±9,070MI/yr
Groot Pan	None (or undocumented)
Itsoseng / Lichtenburg	3,900MI/yr
Schoonspruit	1,356MI/yr

Population Growth

A comparison of 1996 and 2001 census reveals that there is variance in growth rates in this area, but that overall a rate of **1.76%** is evident. The average household size within the study area is 3.9 people per household. The population growth in Mafikeng, Ditsobotla, Zeerust and Ventersdorp has the most effect on abstraction from the dolomite aquifer.

Current Levels of Access to Water Services

- Ventersdorp is providing its residents with good access to clean water.
- Mafikeng, serviced an additional 12,099 households to RDP and above standards, but it could not cope with its growth and 3287 additional households are now serviced below the RDP standard. (Refer to Table 4.3 Census categories of levels of access to water services for categorisation of standards.)

- The Census figures on 'levels of access to water' indicate that Mafikeng and Ditsobotla Local Municipalities are struggling with their high levels of growth, since the number of households serviced below the RDP standard has increased by 19% and 34% respectively, since 1996.

Future Growth

Interviews with municipal officials were undertaken regarding planned settlement growth and water infrastructure projects. This information was be supplemented with Integrated Development Plan (IDP) and Spatial Development Framework (SDF) information where necessary.

Information on gazetted community land claims was sourced from the Regional Land Claims Commission. Only 2 gazetted community land claims could be verified in the study area.

All major future growth is directed along the Provincial Spatial Development Initiative, as a corridor along the R47.

Ditsobotla Local Municipality:

The Lichtenburg Land Development Objective directs residential growth westwards from Lichtenburg Central and north of Boikhutso. But its long-term implementation gives it limited relevance to the time horizon adopted by this study. Current housing projects are planned for Bodibe, Verdwaal and Itsoeng, totalling 1000 erven each serviced above the RDP standard.

Kgetleng River Local Municipality:

Koster is providing for 700 additional serviced erven, Swartruggens 100 and Derby 400, with level of access to water services still being debated.

Mafikeng Local Municipality:

The town of Mafikeng, which receives its water from Botshelo Water, will experience substantial growth in the short-term:

- Provincial police headquarters relocating to Mafikeng; (1000 dwellings required)
- Provincial Justice Department will be relocating to Mafikeng (planned);
- Mmabatho East 9000 medium density residential units are planned between 2005 and 2035, amounting to 900 extra plots by 2008;
- Planned upgrade to the Mafikeng airport to support the establishment on an Industrial Development Zone (IDZ). Mostly non-manufacturing uses: warehousing, breaking of bulk goods, hi-tech industrial space and a petroleum blending plant, therefore additional water requirements are very limited.
- A new cement plant site is being investigated south of Mafikeng town centre.

Ventersdorp Local Municipality:

1000 new erven are being serviced within the next year, with individual erf connections.

Zeerust Local Municipality:

Approximately 1500 erven are to be formalised in the Lehurutshe and Dinokana villages, most likely to RDP standard of water service provision.

The anticipated total growth in all erven is 7600 but those to be serviced at different RDP standards, and from aquifer sources only, is 6400 by the year 2008. The backlog in providing adequate water service levels will increase, since the total 7600 planned provision compared to the 2008 number of households growth (to 8636) still leaves a 1036 household deficit.

Water Demand Assessment

The water demand assessment addresses all five water uses, and it matches settlement and population growth to anticipated levels of access to water services and concomitant consumption levels. Scenarios, variable to the level of water services provision, related to future settlement growth, are presented.

Domestic Demand

The number of planned serviced erven by 2008 at formal levels of water service stands at 7600 for the total study area. The projected total future population growth at 2008, however, is anticipated to be 33683 additional people, i.e. 8636 households (3.9 household size average used) still leaving a 1036 household deficit. The backlog to providing adequate water service levels will therefore actually increase.

Ditsobotla Local Municipality: increased abstraction

- Coligny has enough local granite aquifer water to last until 2015 at least.
- Lichtenburg and the Itsoseng towns and villages will continue to abstract from the aquifer, at an additional rate of 85 to 113Ml/annum.

Kgetleng River Local Municipality: possible future abstraction from dolomite aquifer

- Growth in Swartruggens and Derby will exacerbate existing water shortfall problems; augmentation from the aquifer (20km away) is highly likely.
- Koster reportedly has sufficient water supply for the next 20 years (Koster Dam).

Mafikeng Local Municipality: increased abstraction

- Mafikeng has already augmented its water supply from the Setumo dam. The planned future water demand clearly indicates that water demand will increase substantially enough to have an impact on its dolomite aquifer resources. Water supply from Setumo dam is to increase from 25 to 50% over the next five years.

Ventersdorp Local Municipality: limited increased abstraction

- No shortfall is anticipated.

Zeerust Local Municipality: increased abstraction

- The Dinokana villages are planned to be upgraded to RDP standard. Additional boreholes will have to be drilled, and the Zeerust compartment will be affected.

A high and a low scenario of water demand, 618 and 452Ml/annum, respectively, at varying levels of access to water services has been calculated for settlement growth.

The resultant impact per dolomite water unit is tabulated below

Table 1.4 Calculated domestic water demand per dolomite unit

Water unit	Demand	Municipality
Zeerust	75Ml/yr to 142Ml/yr	Zeerust
Extended Grootfontein	113Ml/yr to 140Ml/yr	Mafikeng
Groot Pan	N / a	Kgetleng River
Itsoseng / Lichtenburg	103Ml/yr to 131Ml/yr	Ditsobotla
Schoonspruit	49Ml/yr to 65Ml/yr	Ventersdorp

Industrial / Mining Demand

- The proposed new Mafikeng cement plant could draw from the Itsoseng/Lichtenburg compartment, or become part of the Municipal reticulation system via Rooigrond water plant. Water requirements for the new plant could be in the region of 399Ml/annum.
- The proposed IDZ will have a limited impact on the aquifer since its industry is non-manufacturing based. The anticipated slow roll-out of the IDZ will also have a limited impact on new housing requirements which in turn lead to domestic water pressures.
- No other industrial expansion is planned in the foreseeable future.
- Development, if contemplated within the Provincial Spatial Development Initiative Corridor, would affect the Zeerust compartment; any future industrial development proposal should recognise that it is situated above an aquifer.

Agricultural Demand

Sources consulted argue that it would be extremely difficult to establish any farming trends since farming practices were so sensitive to world agricultural market forces, among other influences, and farmers are reluctant to report on future irrigation plans. This is complicated by the paucity of current information to support trend identification.

The Bigen Study (March 2002) had determined the extent of land under irrigation correlating to the dolomite compartments, based on analysed LandSat7 images.

It is evident that cultivation coverage is very low (the highest percentage is 8.4%) and dolomite abstraction is quite high already. Consequently, if areas under irrigation were to increase in order of magnitude of a few percentage points, the sustainability of the aquifer would be severely impacted.

Livestock Demand

No information was available for trends or projections, but average water consumption figures for livestock were obtained from Agri North West. The resultant total calculated water consumption is thus 1,959Ml/year. In terms of the most direct impact on the dolomite units the water demand is spread as follows:

Table 1.5 Livestock water demand

Water unit	Demand
Zeerust	225MI/yr
Extended Grootfontein	700MI/yr
Groot Pan	N / a
Itsoseng / Lichtenburg	607MI/yr
Schoonspruit	426MI/yr

Environmental Water Demand

The only figures available for environmental water demand are for the Extended Grootfontein water unit at 7,455MI per annum (Bigen Africa, 2002).

Combined Water Demand

A consolidated table of the five water use groups aims to quantify total abstraction versus each water unit's estimated yield, so that it is possible to highlight those compartments that are under pressure in terms of recharge and abstraction.

Table 1.6 Calculated Combined Water Demand for 2008

Water Unit	LM	* Yield MI/annum	Total future water demand MI/annum	% change on current demand
Zeerust	Zeerust	27,390	7,385.6 - 7,452	1 - 1.9
Extended Grootfontein	Mafikeng	22,740	23,839 - 25,406	-8.2 to -10.2
Groot Pan	Kgetleng River	29,770	15,390	-
Itsoseng/ Lichtenburg	Ditsobotla	19,400	29,270.1 - 29,298.6	0.4-0.5
Schoonspruit	Ventersdorp	69,110	27,240.7 - 27,256.9	0.2
Totals		168,410	103,124.8 - 104,803.5	

* Yield: Bigen Africa, January 2002

The proper quantification of agricultural water usage still remains a problem. Since the correlation of land under irrigation and water use is high, roughly 1MI per 10 hectares irrigated, the consequence of increase in farming could be particularly severe on the water units since areas under irrigation are currently very low and pressure on the aquifers is already high.

Recommendations for Groundwater Management

It may be suitable to incorporate a water use education component into the aims of the broader study so that **sustainable practices for water use** by all users begins to be implemented.

The high levels of overuse in the Extended Grootfontein and Lichtenburg/Itsoseng water units need to be pinpointed, and measures put in place to control and reduce the unsustainable use.

Industrial Demand and Mining

Although no planned expansions or new establishments are foreseen, any development of this nature should encourage industries that do not have a high reliance on water.

Service and clean industries, as envisaged in the IDZ, should be pursued. Traditional heavy or major process industry should be carefully monitored.

It should be ensured that existing industries adhere to the principles of the National Environmental Management Act in terms of sustainable use of resources, and monitoring of and mitigation against groundwater pollution

Agriculture

Against the backdrop of the difficulties in accessing proper figures for actual water use for irrigation and livestock demand, it is crucial that some form of suitable **monitoring system** is established.

Similarly, **sustainable farming practices** should be promoted, such as hydroponics, drip irrigation and tunnel farming.

Domestic Demand

The use of water saving devices should be ensured and the provision of water dispensers in all new housing developments should be mandatory. Similarly, new housing developments should incorporate water-recycling opportunities.

Open space systems necessary in settlement expansion, commercial business parks and recreation areas should be landscaped with suitable indigenous vegetation only.

The 1036 additional households anticipated by 2008 not covered by planned township development needs to be addressed.

To address the residential growth taking place in Mafikeng, it is **recommended** that the capacity improvements and resultant easing of the conjunctive water use ratio to 50:50 surface to groundwater be implemented, and that alternative water source planning is undertaken.

In conclusion, in view of the problems presented to appropriate forecasting and trend development by limited information, it is **recommended** that an investment be made into improving the currency of appropriate information.

1 INTRODUCTION

The study seeks to determine the future water demand patterns in a confined area of the North West Province, which draws water from the dolomitic aquifer. The resource is currently known as the North West Dolomite Water Areas and its management is the cornerstone of a larger project referred to as the North West Dolomite Water Areas Management (NWDWARM) Project.

Integrated Water Resource Management requires that planning for water services become integrated with water resource management and this study contributes to that goal. It also highlights the vast discrepancies in access to water and the dominance of particular water uses. The process of compiling data illustrates the gaps and flaws in data which compromise the integrity of planning processes.

2 RESEARCH RESULTS

2.1 Determination of Study Area

In the previous phase, the study area was confined to the parameters of the dolomitic aquifer. However, since this study is a water demand assessment, it was important to define the study area according to the use of the resource. It was also important to include settlements that may need to draw water from the aquifer in the foreseeable future. The result was therefore the ability to determine which areas do or do not abstract from groundwater sources since users do not necessarily reside on the aquifer itself.

2.2 Nature & Location of Land Use, & Changes to Land Use in the Study Area

The study needed to determine the distribution of major land uses within the study area, since this would indicate the type of water users (agricultural, environmental, domestic, i.e. settlements) that exist. Furthermore, a map would inherently indicate the location of these uses in relation to each other, i.e. urban vs. rural, agricultural vs. industrial. A further use of this map would be to depict the proximity of these uses to the aquifer, and particularly proximity to groundwater sources that are under stress.

2.3 Population Growth

The study aimed to identify the level of population growth and where it is occurring or has occurred, as well as determining the population in 2008. This timeframe allows for identification of management issues on short to medium term basis.

A factor to take into consideration in determining future population is the impact of HIV/AIDS since this is likely to depress future growth rates.

Three sets of information were available for analysis:

- 1996 census;
- 2001 census; and
- North West Province Population Unit (NWPPU) demographic projections.

The 1996 census used was at ward level and included levels of access to water.

2.4 Access to Water

The study aimed to quantify the current levels of access to water in both rural and urban environments, and what form that level of access takes.

2.5 Future growth

The study aimed to identify settlement growth and economic development since these affect water demand. This included accessing:

- Integrated Development Plans (IDPs) and Water Service Development Plans;
- Information about the land reform process (land claims and land reform);
- Spatial Development Initiatives (SDIs); and
- Any other planned economic developments by the National, Provincial and Local Governments and the Private Sector that will impact on the study area.

Agricultural and mining growth trends were included in the investigation as well since these uses have proportionally higher water demand.

2.6 Water Demand Assessment

The future demand change in levels of access to water is the ultimate objective of this study. This would involve collating and manipulating the most recent data available to project water demand scenarios.

3 RESEARCH METHODOLOGY

3.1 Research Methods

This section discusses the methods and data sources used to achieve the results presented in Section 2. Section 4 presents the resultant findings.

3.1.1 Determination of Study Area

In determining the study area, the Focus Area and the five dolomitic water units as defined in the Water Research Commission (WRC) Phase One Report (Stephens and Bredenkamp 2002) served as the point of departure. These five geohydrological units are:

- Zeerust
- Extended Grootfontein
- Groot Pan
- Itsoseng / Lichtenburg, and
- Schoonspruit

The five major water units are further subdivided into sub-compartments.

Table 3.1: Water sub-compartments and associated major water units

Compartment Name	Compartment Number	Ttl Compartment Area (Ha)	Major Water Unit
SKILPAD EYE	1	9955.315	Zeerust
KHUNOTSWANE	2	6767.309	Zeerust
DINOKANA	3	6346.613	Zeerust
OLYVENBULT	4	6631.832	Zeerust
TWEEFONTEIN	5	4012.076	Zeerust
DOORNFONTEIN	6	5743.62	Zeerust
VANGGATBULT	7	2819.367	Zeerust
KAFFERSKRAAL	8	3241.409	Zeerust
KLIPPAN	9	6369.818	Zeerust
RIETPOORT	10	4342.189	Zeerust
SLURRY	11	2388.088	Zeerust
OTTOSHOOP	12	7330.811	Zeerust
BUHRMANSDRIF	13	5699.263	Zeerust
DOORNPLAAT	14	7318.774	Zeerust
MALAMANIE	half 18 ¹	5732.714	Zeerust
WONDERFONTEIN	half 19 ¹	5808	Zeerust
WONDERGAT	15	6257.746	Extended Grootfontein
WITKOPPIES	16	3359.693	Extended Grootfontein
KAREEBOSCH	17	4348.175	Extended Grootfontein
MALAMANIE	half 18 ¹	5732.714	Extended Grootfontein
WONDERFONTEIN	half 19 ¹	5808.206	Extended Grootfontein
GROOTFONTEIN	20	20377.37	Extended Grootfontein
MOLOPO	21	21855.64	Extended Grootfontein
BETHEL	22	8966.7	Itsoseng / Lichtenburg
MATLABES	23	4273.602	Itsoseng / Lichtenburg
ZAMEKOMS	24	12745.02	Extended Grootfontein
KATDOORNPAN	25	9284.351	Extended Grootfontein
NOOITGEDACHT	26	8938.182	Itsoseng / Lichtenburg
POLFONTEIN	27	5714.065	Itsoseng / Lichtenburg
HOUTHAALBOOMEN	28	10317.2	Itsoseng / Lichtenburg
DRIEHOEK	29	9687.79	Itsoseng / Lichtenburg
SPRINGBOKPAN	30	3653.664	Itsoseng / Lichtenburg
DUDFIELD	31	9961.149	Itsoseng / Lichtenburg
LICHTENBURG	32	16017.76	Itsoseng / Lichtenburg
MANANA	33	9885.219	Itsoseng / Lichtenburg
GROOT MARICO	34	47069.57	Groot Pan
DORINKOP	35	13799.13	Groot Pan
GROOTPAN	36	31716.04	Schoonspruit
SCHOONSPRUIT	37	109598.1	Schoonspruit

¹ These compartments do not coincide with water unit boundaries.

The study area for the water demand assessment component, however, needed to be more inclusive than the original Focus Area, for the reason that an objective of the water demand assessment study is to attempt to determine the location and nature of growth of settlements that are, or could in the future, abstract water from the aquifer.

The Focus Area followed the aquifer boundaries, yet abstraction should be planned for uses further a field. Transportation and reticulation of water to users not situated on or close to the aquifer should ideally be taken into account in terms of future growth scenarios.

The study area was workshopped with the Project Management Team after it was decided at the Inception Meeting (7 March 2003) to include the towns and surrounds of Dinokana, Lehurutshe, Zeerust, Mafikeng, Swartruggens, Koster and Coligny. It was decided to include certain settlements, namely Derby, Koster and Swartruggens, which now comprise the Kgetlengrivier LM, which are not currently abstracting from the aquifer but may potentially suffer a shortage in water supply and may have to abstract from the dolomitic aquifer at some point in the future. In short, the study area boundary should correspond with the area of dependence on the resource and this dependence extends well beyond the boundary of the aquifer.

The study area therefore covers slightly over 12,000km² and forms an approximately 160km long by 80km wide oblong shape in the northeastern half of the North West Province. A map of the study area is presented as Figure 1 (Annexure 1).

The towns and urban areas of Mafikeng Itsoseng, Lichtenburg, Coligny, Ventersdorp, Derby, Koster, Swartruggens, Zeerust and Dinokana delineate the area. The Central, Southern and Bojanala Platinum District Municipalities are affected by this area, as are the Mafikeng, Ditsobotla, Zeerust, Ventersdorp and Kgetleng River Local Municipalities. The following table encapsulates the areas of local government jurisdiction, the main settlements and the abstraction relationship to the dolomite water units.

Table 3.2 District and Local Municipalities, and related geohydrological units

District Municipality	Local Municipality	Geohydrological unit	Main Towns and Villages
Central	Mafikeng,	Extended Grootfontein, Zeerust	Mafikeng, Peri-urban areas, Rooigrond
	Ditsobotla,	Extended Grootfontein, Zeerust, Groot Pan, Schoonspruit	Lichtenburg, Boikhutso, Coligny, Itsoseng villages, Bodibe villages, Verdwaal villages, Ga-Motlatla
	Zeerust	Zeerust	Zeerust, Groot-Marico, Lehurutshe, Dinokana, Gopane villages, Khunotswana
Southern	Ventersdorp	Schoonspruit	Ventersdorp, Goedgevonden
Bojanala Platinum	Kgetleng River	Insignificant part of Schoonspruit	Derby, Koster, Swartruggens

3.1.2 Data Collection

The Bigen Africa reports (January and March 2002) form a basis of analysis for industrial, irrigation and environmental water use aspects of this study, mainly because it is a consolidated source of information and because similar information exists no where else. (It should be noted that these reports, however, refer to four dolomitic aquifer

water units only since the "Groot Marico – Schoonspruit" zone is equivalent to 2 units in this study, namely the Groot Pan and Schoonspruit units.)

Domestic water use, water source and conjunctive use information, economic and settlement growth, livestock figures and land use information were gathered from a host of sources. Annexure 2 shows the range of sources consulted.

3.1.3 Land Use Distribution

The current land use distribution was initially based on the ENPAT land cover dataset. It carries sufficient detail to indicate the relationship between the spatial distribution of settlements, mining and farming, and the extent of these uses within the study area. This information is dated 1995 and was derived from LandSat7 images. Currently the land cover database is being upgraded at national level based on year 2000 information and the North West Province is part of phase two which has commenced only recently and would be completed by mid-2004². No updated land use distribution information was thus available.

The level of detail contained in the land cover data is as follows (it only applies to the study area where these categories exist):

Table 3.3 Land Cover Codes

Forest and woodland (woodland and wooded grassland)
Forest (indigenous)
Thicket, bushland, scrub forest and high fynbos
Shrubland and low fynbos
Herbland
Unimproved grassland
Improved grassland
Forest plantations (exotic)
Waterbodies
Wetlands
Bare rock/ soil (natural)
Bare rock/ soil (erosion surfaces)
Degraded land (forest and woodland)
Degraded land (Thicket, bushland, scrub forest and high fynbos)
Degraded land (Unimproved grassland)
Degraded land (Shrubland and low fynbos)
Degraded land (Herbland)
Cultivated land (permanent crops – commercial – irrigated)
Cultivated land (permanent crops – commercial – dryland)
Cultivated land (permanent crops – commercial – sugar cane)
Cultivated land (temporary crops – commercial – irrigated)
Cultivated land (temporary crops – commercial – dryland)
Cultivated land (temporary crops – subsistence – dryland)
Urban / built up land (residential)
Urban / built up land (residential – smallholding – forest and woodland)
Urban / built up land (residential – smallholding – thicket, bushland, etc)
Urban / built up land (Shrubland and low fynbos)
Urban / built up land (grasslands)

² Hein Lindemann, AGIS, telephone communication, August 2003

Urban / built up land (commercial)
Urban / built up land (industrial / transportation)
Mines and quarries

Categories as defined in the South African National Land-Cover Database Project, Table 1 "Land-Cover Codes"

Supplementary land use information was sourced from the March 2002 Bigen Study which had determined the extent of land under irrigation correlating to the dolomite compartments, indicating summer (January 2001 baseline) and winter (August 2001 baseline) cultivation. Annexure 3 includes the full table of summer and winter crop use, arranged per compartment (at the time, there were 37 known compartments).

3.1.4 Domestic Demand

Domestic water demand was sourced from local municipal water services engineers and similar sources.

3.1.5 Agricultural Demand

3.1.5.1 Irrigation Demand

Agri North West confirmed that no figures for water consumption or extent of areas covered by irrigated cropland exist. Thus, for irrigation water consumption, this study used the calculations undertaken by Bigen Africa in their report dated March 2002.

Due to gaps in information, the report arrived at 4 scenarios regarding current total irrigation demand and Scenario 1 was considered to be the most likely. A table was presented showing the results, including a relationship to dolomitic yields; MCA have amended the table to accommodate the five dolomitic water units, and added the percentage for areas under irrigation for comparison.

3.1.5.2 Livestock Demand

The AGIS has proven to be the only source of relevant information on livestock. A list of districts, with livestock figures, covering the entire North West Province was provided. The districts relevant to the study were extracted.

Many of the districts did not correspond entirely with the study area boundary, i.e. they overlap, but the information was sufficient for this study. Note that bounding areas were not included in the dataset and therefore a "central" point is used to imply relationship to the study area.

Average water consumption figures for different livestock were obtained from Agri North West. No further figures for any other livestock were available.

Table 3.4: Livestock numbers estimated to be sharing groundwater resources, 2001

DISTRICTS	Cattle	Sheep	Goats	Horses	Donkeys	Mules	Ostriches
DITSOBOTA	51018	39883	37254	1710	3137	0	0
LEHURUTSHE	36000	2000	15000	20	800	90	0
LICHTENBURG	78846	44947	1597	546	632	6	139
MOLOPO	51287	25739	33252	1291	5106	40	0
VENTERSDORP	66531	32106	5335	270	63	3	16500
TOTAL	283682	144675	92438	3837	9738	139	16639

Source: AGIS

3.1.6 Industrial Demand

Industrial demand was sourced from local municipal water services engineers and the Bigen Africa Augmentation of Primary Water Supply Study.

3.1.7 Environmental Demand

Environmental demand was sourced from the Bigen Africa Augmentation of Primary Water Supply Study, January 2002.

3.1.8 Population Growth

The historic growth of population and future growth was derived from the North West Provincial Population Unit's (NWPPU) datasets and 2001 Census data, which would classify towns and their respective populations and anticipated increases. This information was tabulated into 4 time periods: 1996, 2001, 2003 and 2008. The reason for these intervals was:

- convergence with measurable population dates in this case 1996 and 2001 census years;
- current date of study – 2003;
- lastly, time horizon of study – 2008.

Inherent in this method was the spatial aspect meaning that the location of future growth in terms of population numbers can be depicted. Comparisons were made with the 1996 and 2001 census.

The NWPPU had assigned certain growth rates to the 1996 census to arrive at future projections, and these calculations were effected prior to the 2001 census being available. Since the latest census was now available it was possible to update the projections by substituting current 2001 census information into the Population Unit's table. Using the same estimated growth rates used by the Unit the 2008 population figure was adjusted, and resulted in a higher degree of confidence in the 2008 projections.

According to the NWPPU, the integrity of the data of population growth rates may be compromised by a) uncertainties around the rate of immigration to urban areas and the impact of HIV/AIDS.

3.1.9 Access to Water

This type of information was included primarily in IDPs and census information, the latter being more detailed. The recent availability of the 2001 census allowed for a meaningful comparison of rates of change regarding levels of access to water, and allowed for the analysis of implications for water demand.

3.1.10 Future Growth

Interviews with Local and/or District Municipality officials from the planning and engineering departments were undertaken as the preferred method of accessing information regarding planned settlement growth and proposed commercial/industrial expansion, as well as expected levels of servicing. This information was supplemented with IDP and SDF information where necessary. This information has been consolidated into Map 8 in Annexure 1. Water Services Plans are mentioned in the various IDPs as being required to be completed. Of the engineers interviewed, and who have responded, Kgetleng River has a water services plan and Mafikeng apparently does not have one. This is not surprising given the fact that Water Services Planning is a relatively new responsibility for the Local Authorities but a preliminary observation is that they would need a great deal of support in terms of the use of groundwater in the planning of services.

Information on gazetted community land claims was sourced from the Regional Land Claims Commission. It was anticipated that this information would indicate the establishment of possible new communities, potentially reliant on groundwater resources.

Screen Reports (Microsoft Excel spreadsheets) were obtained for the following areas, the dates refer to latest compilation:

- Coligny Land Claims – 30 September 2002
- Koster Land Claims – 30 September 2002
- Lichtenburg Rural Land Claims - 30 September 2002
- Lichtenburg Urban Land Claims - 30 September 2002
- Mafikeng Rural Land Claims - 28 March 2002
- Mafikeng Urban Land Claims – 21 June 2002
- Swartruggens Land Claims – 28 March 2002
- Zeerust Urban Land Claims – 28 March 2002

The information included individual and community claims. Only gazetted community land claims, which were not financially compensated, were extracted for further analysis since they have relevant spatial implications - re-settlement on farms by large groups of people impacts on the demand for water services.

The community claims were isolated, which narrowed the field down to 83 claims to be investigated. A link to the farm cadastral base - courtesy of the Surveyor General's office (Tshwane) - was undertaken to locate claimant farms.

3.1.11 Water Demand Assessment

A combination of information addressed this particular issue. The physical planning of growth as derived from the IDPs, SDFs and interviews with municipal officials identified location of growth. The population growth provided by the official Provincial Population Unit figures was combined with physical direction of settlement expansion to indicate the magnitude of growth encroaching the aquifer, or requiring future abstraction from the aquifer.

Any planned industrial growth was sourced from Local Municipalities and appropriate water consumption figures applied.

It was noted that agricultural trends information was non-existent and therefore the current water consumption stood proxy in the future demand assessment at year 2008.

Each of the five water use groups was analysed in terms of the current consumption and anticipated increases in demand and expansion of settlements and industry. Two scenarios, variable to the level of water services provision as per RDP standards, formed the future demand prediction, taking into account population growth - suitably adjusted for 2008 - and future settlement growth. A consolidation of the five water use groups quantified the total demand and for each dolomite water unit. The aim was to be able to quantify total abstraction versus each water unit's estimated yield, so that it is possible to highlight those compartments that are under pressure in terms of recharge and abstraction.

The figure for water use and demand used as a basis for scenarios in the calculation was the RDP reticulation standard. The RDP minimum standard for basic water supply services is (as gazetted in terms of section 9 of the Water Services Act)

- A minimum quantity of potable water of 25 litres per person per day or 6 kilolitres per household per month (based on a household size of 8 people);
- At a minimum flow rate of not less than 10 litres per minute;
- Within 200 metres of a household; and
- With effectiveness such that no consumer is without a supply for more than 7 full days in a year.

What needs to be highlighted is the fact that rural domestic use (classified as below RDP standard) is actually lower, approximately 12l/ capita per day while peri-urban use is estimated to be higher (60-80l) due to illegal connections³. For the purpose of this study the engineering standard, 25l, was used for projects at RDP standard and a variance between 60 – 80l was used for peri-urban and urban consumption figures.

3.2 Research challenges

The Inception Report of this study component aimed to cover the best-case scenario for data availability, collection and analysis. The process of accessing data sources has, however, revealed that the predicted dependencies and constraints have occurred. Specifically these are:

³ *Pers comm.* Eddie van den Heiden, DWAF NW Province

- Availability of digital datasets (e.g. aerial photography coverage, census datasets);
- Quality of information contained in IDPs, SDFs (information gaps) and other documents; and
- Problems of disaggregating coarse datasets, i.e. insufficient detail.

Some of the data issues relate specifically to information not being available at all. This was particularly the case for the digital aerial photography. Only a small coverage is available from the Department of Land Affairs: Surveys and Mapping.

3.2.1 Census Information

The recently released 2001 census was available on place name level only (place name is a consolidation of Enumerator Areas). Levels of access to water was also requested and included. The more detailed Enumerator Area level of census is not yet available for release. A sufficient match between 1996 and 2001 census was therefore not possible at town level since the unit of aggregation differs and overlaps were too large. The resultant information is therefore presented on a Municipal level adapted to the needs of the study area.

Information received from the NWPPU had to be requested by listing town names since the Unit has no GIS capacity, i.e. it is not geared to providing data based on maps. The information included trend projections from 1996 onwards beyond 2010, and included estimations on the impacts of HIV/AIDS on future population numbers. Future population growth up to the year 2008 is discussed in Section 4.7.3. This dataset is based on 1996 census figures and assumptions were used to project future populations. This is an accepted dataset for the North West Premier's office.

The tables that were generated on the basis of the three datasets are derived from spatial operations in ArcView 3.2a, performed on the three available datasets.

The first insurmountable obstacle, as mentioned above, was non-convergence of boundaries between the three data. The attempted remedy was twofold:

1. Grouping data by Municipal boundaries relevant to the study area;
2. Proportional allocation (spatial "split" operation in GIS) of population to areas contained within Municipal boundaries of study area. All of the polygons on the study area's periphery represented rural areas, and therefore an even spread of population density can be assumed. Similarly, since the same operation was performed on all three datasets, any error is consistent over all datasets and therefore diluted in its total effect on the figures.

3.2.2 Community Land Claims

An immediate compatibility problem presented itself during the joining of alphanumeric data to cadastral features: the location information, i.e. which farms/erven are subject to claims, was inconsistently captured. In the South African cadastre, each farm must be uniquely referenced and this reference is comprised of Registration District and Farm

Number. The Commission's data very often excluded the Registration District. The implication is that only 2 farms could be linked to the cadastral base.

The list of 83 farms was sent to the Commission for further information. Feedback has been received, indicating that validation of the community claims is underway. The issue of the missing Registration Districts is also still being dealt with, but remained unresolved at the time of the study.

The result of this exercise was therefore that no concrete information of the impact of land claims was accessible, and no justifiable conclusion could be offered, other than depicting the 2 farms that are subject to claims.

This research could not be pursued further at this point since the Commission was still engaged in assessing the number of persons to be resettled as well as discussing with the Surveyor General's office the need for better spatial information (completion date unknown).

3.2.3 Agricultural Information

Agricultural information was proven to be difficult to obtain beyond a generalised level. Particularly the future projection of agricultural activity – both irrigation and livestock – and its concomitant impact on groundwater resources remained untested, since no information was available for trends or projections.

4 RESEARCH FINDINGS

4.1 Nature and Location of land Use

The land use distribution, as per information currently available, is depicted in Figure 2 (Annexure 1).

Various similar land use categories have been combined to simplify the map. It is evident from the map that land under irrigation accounts for a very small portion of land covered. What is also significant is that settlements are located in and on the periphery of the total aquifer boundary. One of the four large settlement conglomerations, Itsoeseng, is situated within the aquifer boundary while the other three, Mafikeng, Lichtenburg and Dinokana/Lehurutshe are located outside.

In terms of agricultural use and production, there is a strong correlation between season and grain planted. The dominant summer crops are maize and sorghum; in winter wheat predominates.

4.1.1 Water Units and Land Use

The Zeerust water unit covers 29,402Ha. The Matlhase, Khunotswana, Ottoshoop, Slurry and Welgedacht settlements are located over this unit. Slurry also contains a cement plant. The Oog van Malamanie Nature Reserve is situated in the eastern portion

of the water unit. Not much irrigated farming occurs since only approximately 0.3% of the surface area is irrigated in summer and 0.2% in winter, in the order of 300Ha ⁴.

The **Extended Grootfontein** water unit covers 38,855Ha and contains very little settlement area. Bakerville is the only settlement appearing on maps. Little irrigated cultivation occurs since only approximately 1.1% of the surface area is irrigated in summer and 0.8% in winter, in the order of 1000Ha ⁵.

The **Groot Pan** water unit covers 60,868Ha and no settlement of note occurs. Relatively moderate amount of irrigated farming occurs as approximately 2.7% of the surface area is irrigated in summer and 2.2% in winter, to the order of 1660Ha ⁵.

The **Itsoseng/Lichtenburg** water unit covers 55,549Ha, and contains Lichtenburg, Itsoseng, and the villages of Verdwaal, Bodibe, Welverdiend, Sheila and Dudfield. Dudfield and Lichtenburg are the only towns with large industry (cement plants). The Lichtenburg Game Breeding Centre falls within the boundaries of the water unit. Relatively high amount of irrigated farming occurs since approximately 2.4% of the surface area is irrigated in summer and 2.8% in winter, in the order of 2450Ha ⁵.

The **Ventersdorp** water unit covers 141,314Ha, and contains the villages of Gamogopa, Ga-Motlatla, Goedgevonden and Tsetse. Ventersdorp lies immediately to the south of the water unit. A portion of the Schoonspruit nature Reserve falls within the water unit's area. A relatively high level of irrigated farming occurs since approximately 2.0% of the surface area is irrigated in summer and 1.5% in winter, in the order of 2860Ha ⁵.

Figures 3 and 4 (Annexure 1) indicate the distribution of irrigated summer and winter crops planted per water unit and the coverage of the unit's surface area.

4.2 Overview of Water use

Many of the settlements in the study area abstract water from the dolomitic aquifer. Some are totally reliant on this water source, other areas augment their surface water supply with aquifer abstraction and others are not currently reliant on the dolomitic aquifer. Agricultural users (irrigation) typically abstract from the aquifer if directly located above it. Agricultural areas outside of the Focus Area draw water from surface sources or boreholes not connected to the dolomitic aquifer.

4.2.1 Domestic Water Use

The current sources of domestic water per Municipality and their towns within the study area are discussed below.

⁴ Bigen Africa, March 2002

⁵ Bigen Africa, March 2002

4.2.1.1 Ditsobotla Local Municipality

Lichtenburg, Itsoseng and its villages (Verdwaal, Bodibe, etc) are supplied, and therefore metered, by the local authority. The water source is entirely drawn from groundwater sources, namely the Itsoseng/Lichtenburg unit. Coligny is supplied from a local granite aquifer, and water supply problems are currently being experienced⁶. Coligny's nearest contact point with the dolomitic aquifer is $\pm 20\text{km}$ to the east. All other villages, such as Sheila, are unmetered and draw from boreholes.

Lichtenburg has a water use of 3,600Ml/yr, while the Bodibe, Verdwaal, Itsoseng villages have a consumption of 300Ml/yr⁷.

4.2.1.2 Kgetleng River Local Municipality

Koster is mostly supplied from the Koster dam and limited boreholes that are not connected to the dolomitic aquifer. These boreholes are drying up⁸ but the dam can sufficiently cater for its demand. Koster's nearest contact point with the dolomitic aquifer is $\pm 20\text{km}$ to the south. Derby is supplied from 2 boreholes, and intermittent water supply problems are being experienced currently. Derby's nearest contact point with the dolomitic aquifer is $\pm 18\text{km}$ to the south. Swartruggens is being supplied from the Swartruggens dam. Swartruggens' nearest contact point with the dolomitic aquifer is $\pm 30\text{km}$ to the southwest.

4.2.1.3 Mafikeng Local Municipality

Mafikeng and its peri-urban villages are supplied via the Rooigrond Water purification plant. The plant has a 45Ml/day capacity although at the time of the study only approximately 27Ml was being utilised. According to the Mafikeng City Engineer⁹, three-quarters of the water supply to Mafikeng is dolomitic groundwater and the remainder is drawn from the Setumo Dam. However, this ratio changes from source to source but the bottom line is that there is a heavy dependence on the Grootfontein Compartment.

Only 25% of Mafikeng is serviced to above RDP standards¹⁰ (define RDP standard in footnote).

There is conflicting information of domestic water consumption for Mafikeng. The Deputy City Engineer provided a figure of 9,000Ml/yr¹¹, Botshelo Water provided 12,100Ml/yr¹² for 2003 and the Rooigrond Water plant manager stated that there was a 10,800Ml/yr allocation but that consumption was "way over that, closer to 14,000Ml/yr"¹³. This contradiction may be as a result of differing boundaries of measurement but whatever the reason an average reveals that Mafikeng is exceeding its allocation considerably.

4.2.1.4 Ventersdorp Local Municipality

Ventersdorp is supplied from the Schoonspruit water unit, as are the small rural settlements (Ga-Motlatla, Ga-Mogopa, Tsetse and Goedgevonden). The Ventersdorp

⁶ PMA Consortium, August 2003

⁷ Ditsobotla Municipality Water Services Engineer, Mr Dirk Lombard, telephonic interview, Sept 2003

⁸ Kgetleng River Municipal Engineer, Mr Piet Breedts; and Moedi Consulting Engineers, Mr Marks Jordaan, telephonic interviews, September 2003

⁹ Mafikeng Municipality Deputy City Engineer, Mr A Dube, telephonic interview, September 2003

¹⁰ 25l/capita/day, provided within 200m of household

¹¹ Mr A Dube, telephonic interview, September 2003

¹² Water Engineer Eric Rakumakwe, telephonic interview, September 2003

¹³ Vernon Olivier, telephonic interview, September 2003

town is metered at 1,356Ml/annum¹⁴; the consumption by small settlements is not metered.

4.2.1.5 Zeerust Local Municipality

The former Zeerust TLC area draws directly from the Zeerust water unit. The Lehurutshe villages have a high level of service with individual household connections. The Dinokana villages have been designed at below RDP standards in terms of domestic water supply, in that taps are within a maximum of 500m from households. Currently water supply is sufficient but a high number of illegal connections are suspected. Both Lehurutshe and Dinokana are fed from the Zeerust water unit. Khunotswana draws water directly from the Zeerust compartment. The villages further north (Gopane, Radhikudu, etc) do not receive water from a dolomitic aquifer source. Water supply is from the Motswedi Treatment Works (surface source – Sehuwane Dam) and some local boreholes¹⁵.

4.2.1.6 Summary of Domestic Water Consumption

The following table provides an overview of water sources and demand for the various towns and villages comprising the study area.

Table 4.1 Summary table of domestic water use

Municipality	Town / Village	Water Source	Water Unit Name	Water Demand	Comment
Ditsobotla	Lichtenburg	Aquifer: Dolomitic	Itsoseng Lichtenburg	3,600Ml/yr	
	Bodibe, Verdwaal, Itsoseng villages	Aquifer: Dolomitic	Itsoseng Lichtenburg	300Ml/yr	
	Coligny	Aquifer: Granite	N/ a	810Ml/yr (2,218kl/d)	Water supply problem being experienced currently
Kgetleng River	Koster	Mostly surface: Koster Dam, limited borehole (not connected to dolomitic aquifer)	N/a	671Ml/yr (based on August figure)	Boreholes are drying up, but surface supply is strong
	Derby	Aquifer 2 boreholes (not connected to dolomitic aquifer)	N/ a	96Ml/yr (based on August figure)	Intermittent water supply problem being experienced currently
	Swartruggens	Surface: Swartruggens dam	N/a	518Ml/yr (based on August figure)	Intermittent water supply problem being experienced currently
Mafikeng Municipality	Mafikeng, peri-urban villages, villages	Aquifer (75%): Dolomitic Surface (25%): Setumo Dam	Extended Grootfontein (Molopo Eye)	9,000Ml/yr ⁸ 12,100Ml/yr ⁹ 10,800Ml/yr ¹⁰ allocation	

¹⁴ Ventersdorp town engineer, Mr Terreblanche, telephonic interview, September 2003

¹⁵ Zeerust Town Council, Mr Patrick Gidiyang, telephonic interview, September 2003

Municipality	Town / Village	Water Source	Water Unit Name	Water Demand	Comment
Ventersdorp Municipality	Ventersdorp	Aquifer Dolomite	Schoonspruit	1,356Ml/yr	
Zeerust Municipality (5)	Zeerust	Aquifer: Dolomitic	Zeerust	1,466Ml /yr (07/02 – 08/03)	
	Marico Chrome Mine	surface	Marico dam	1,514Ml/yr (07/02 – 08/03)	
	Groot Marico	surface	Marico dam	70Ml/yr (07/02 – 08/03)	
	Dinokana and Lehurutshe villages	Aquifer: Dolomitic	Zeerust (Dinokana Spring)	2,109Ml/yr	
	Gopane, Rodikhudu villages	Surface water and some local boreholes (not dolomitic aquifer)	N/a	unknown	
	Khunotswana	Aquifer: Dolomitic	Zeerust	unmetered	
Total Domestic Water consumption abstracted from dolomite aquifer (year, to date), with Mafikeng @ 75% as per comment in section 4.2.1.3				Between 15,580Ml/yr and 17,906Ml/yr	

4.2.1.7 Summary of Domestic Water Demand per Dolomite Water Unit

The current domestic water demand can be tabulated per dolomite compartment as follows:

Table 4.2 Summary table of domestic water demand per dolomite water unit

Dolomitic unit	Domestic Water Demand
Zeerust	3,575Ml/yr
Extended Grootfontein	6,750 - ±9,070Ml/yr
Groot Pan	None (or undocumented)
Itsooseng / Lichtenburg	3,900Ml/yr
Schoonspruit	1,356Ml/yr

4.2.2 Access to Domestic Water

The basis for comparing levels of access to water is the 1996 and 2001 census. By definition, the level of access to water is related to potable water only, i.e. domestic water.

The categories contained in the census are:

Table 4.3 Census categories of levels of access to water services

Category	Application in this study
• within dwelling	Above RDP
• on stand (plot)	
• communal tap less than 200m from dwelling ¹⁶	RDP standard
• communal tap further than 200m from dwelling ¹⁷	Below RDP
• Natural, includes dam/pool/stagnant water, springs, rivers/streams, rain water tank as per 2001 census categories	
• Borehole	
• Tanker, includes "water vendor" definition of the 2001 census	
• Other	
• Unspecified	

Detailed tables of census years 1996 and 2001 with breakdown of categories of access to water are contained in Annexure 4.

A comparison between the two census years and corresponding levels of access to water in relation to RDP standard was undertaken.

Table 4.4 Rates of Change (Census 2001) RDP Standard Levels of Access to Water

Municipality	Households	Above & RDP standard		Change (96-01)	Below RDP standard		Change (96-01)
Ditsobotla	33513	27486	82.0%	35.1%	6027	18.0%	34.3%
Kgetlengrivier	8907	8243	92.5%	55.1%	665	7.5%	-38.6%
Mafikeng	64497	43936	68.1%	38.0%	20561	31.9%	19.0%
Ventersdorp	8778	8477	96.6%	78.1%	301	3.4%	-46.8%
Zeerust	18932	17809	94.1%	32.0%	1123	5.9%	-42.9%
Total	134627	105951	78.7%	39.9%	28676	21.3%	13.0%

The table indicates that Ventersdorp is excelling in terms of providing its residents with good access to clean water. Its number of households without acceptable access to water has dropped by almost 47%. Compared to the largest municipality – Mafikeng – Ventersdorp has managed to provide 3717 additional households with RDP or above standard access to water and 264 fewer households are not adequately serviced¹⁷. The figures indicate that Mafikeng and Ditsobotla Local Municipalities are struggling with their high levels of growth, and that despite catering for 12099 and 7145 additional RDP level households respectively, the number of households insufficiently serviced has increased by 19% and 34% respectively, since 1996¹⁸. Section 5.1.1.6 deals with the implications of future growth in terms of levels of water services on groundwater resources.

Of the Municipalities tabulated above, the population growth, in descending scale of magnitude, in Mafikeng, Ditsobotla, Zeerust and Ventersdorp has most effect on abstraction from the dolomite aquifer. Despite Mafikeng's increase in households serviced below RDP standards, the 12099 suitably serviced households place a four

¹⁶ Since the 1996 census does not make this distinction these two categories are consolidated to communal tap in this study

¹⁷ From table D3, Annexure 4

¹⁸ From tables D2 and D3, Annexure 4

times higher demand on groundwater resources, in comparison to Ventersdorp for example. Ditsobotla displays a similar trend to Mafikeng in that a high number of households have been upgraded to RDP and above standards (7145) but with a concomitant increase in households below RDP levels (1540).

The Zeerust figures are also worth highlighting: while there is a drop in total population, there is an increase in households combined with a substantial increase in individual erf connections (Table D5, Annexure 4).

In terms of RDP standards, most settlements in the study area have fared well in providing for their residents. The overall 39.9% increase in households being serviced at and above RDP standards between 1996 and 2001 implies increases in water consumption.

4.2.3 Industrial Use

Industrial and mining water use information relates to the Phelps Dodge mine, the Dudfield Alpha cement plant, the Lichtenburg Lafarge cement plant, the Slurry cement plant and the Marico Chrome Mine.

The Itsoseng/Lichtenburg compartment is subjected to a 1,569MI/annum water draw from the Dudfield Alpha and Lichtenburg Lafarge plants; the Zeerust compartment feeds the Slurry plant at 818MI/annum (Bigen Feasibility Study, 2002:47-48).

The Marico Chrome Mine has a consumption of 120MI/annum (Zeerust Town Council, 2003) but is not reliant on any dolomite aquifer water. The Phelps Dodge Mine was supplied from Zeerust Municipal boreholes at 1,407MI/annum. In 2000 the mine was "in the process of developing its own boreholes" (Bigen Phase 1, 2002, p 46). It appears therefore that this mine would not be reliant on dolomite aquifer water (it is located ± 20 km from the Zeerust water unit).

The current industrial water demand can thus be tabulated per dolomite compartment as follows:

Table 4.5 Consolidated Water Demand Information 2008 (MI/annum)

Water Unit	LM	Mm ³ /yr
Zeerust	Zeerust	0 818
Extended Grootfontein	Mafikeng	N/a
Groot Pan	Kgetleng River	N/a
Itsoseng/ Lichtenburg	Ditsobotla	1 569
Schoonspruit	Ventersdorp	N/a
TOTAL		2.387

4.2.4 Agricultural Use

4.2.4.1 Irrigation

The Bigen Africa study (March 2002) had identified the fact that areas under irrigation in the Lichtenburg and Groot Marico-Schoonspruit dolomitic zones increased by 39% during summer months. The Groot Marico-Schoonspruit water unit is equivalent to the

Groot Pan and Schoonspruit units in this study (the Bigen report uses 4 instead of 5 water units)

The most likely irrigation consumption scenario is presented in the following table.

Table 4.6: Irrigation consumption vs. yields ¹⁹

Water unit	Calc Irri. Consump- tion (Mm ³ /a)	Dolomitic Yields (Mm ³)	Irri. As a % of yield	(*)Area under irrigation	(**)Extent of Compartment (Ha)	% of Compartment area
Zeerust	2.692	27.39	9.83%	295.6	29402.2	1.0
Extended Grootfontein	10.662	22.74	46.88%	998.9	38855.1	2.6
Groot Pan	15.39	29.77	51.7%	1661.9	60868.7	2.7
Itsoseng / Lichtenburg	23.091	19.4	119.02%	2452.6	55549.1	4.4
Schoonspruit	25.41	69.11	36.77%	2863.6	141314.1	2.0
Total	77.254	168.41	45.87%	8272.6	325989.2	12.7

note: * Highest coverage is used, i.e. higher of the two summer and winter figures

** only sub-compartments currently "cultivated", not total area of water unit

On average every additional 100Ha of irrigated farmland ²⁰ requires 9.3Ml per annum²¹. In agricultural terms, a 100Ha farm is a fairly common size as a productive unit. There is one immediate conclusion that is to be drawn from the correlation between irrigation demands and extent of lands under cultivation. Since cultivation is very low (the highest percentage is 8.4% in winter – Polfontein sub-compartment) as a percentage of surface area and dolomitic yields are already quite high, if areas under irrigation were to increase by a few percentage points, the sustainability of those water unit not yet stressed would be affected.

As an illustration of this possible impact, the following table presents a sensitivity overview based on a hypothetical 100Ha increase in irrigated farmland per water unit, and its effect on the yield.

¹⁹ Modified from Bigen Africa, March 2002

²⁰ 100Ha used for sake of illustration

²¹ Calculation derived from table 4.6

Table 4.7: Sensitivity Overview: Impact on Irrigation increase on water unit yields

Water unit	Additional irrigated land	Revised Irrigation as a % of yield	Increase in yield	Likelihood of occurring
Zeerust	+100Ha	13.15%	+ 3.3%	Unlikely: farming coverage only at 295Ha, i.e. not highly irrigated farming area
Extended Grootfontein	10.662	51.58%	+ 4.7%	Unlikely: farming coverage only at 998Ha, i.e. relatively small irrigated farming area
Groot Pan	+100Ha	54.81%	+3.1%	Possible: relatively high irrigated farming coverage (1660Ha)
Itsoseng / Lichtenburg	+100Ha	123.9%	+ 4.8%	Possible: relatively high irrigated farming coverage (2450Ha)
Schoonspruit	+100Ha	38.05%	+ 1.3%	Possible: relatively high irrigated farming coverage (2863Ha)

4.2.4.2 Livestock

The following table provides an overview of the livestock numbers, types and their water consumption. Average water consumption figures for livestock were obtained from Agri North West²².

Table 4.8: Livestock Numbers estimated to be sharing groundwater resources, 2001

DISTRICTS	Cattle	Sheep	Goats	Horses	Donkeys	Mules	Ostriches
DITSOBOTLA	51018	39883	37254	1710	3137	0	0
LEHURUTSHE	36000	2000	15000	20	800	90	0
LICHTENBURG	78846	44947	1597	546	632	6	139
MOLOPO	51287	25739	33252	1291	5106	40	0
VENTERSDORP	66531	32106	5335	270	63	3	16500
TOTAL	283682	144675	92438	3837	9738	139	16639
Water consumption factor	15l/day	4l/day	4l/day	12.5l/day	10l/day	10/day	1l/day
Estimated total water consumption	1,553MI/yr	211MI/yr	135MI/yr	18MI/yr	36MI/yr	0.5MI/yr	6MI/yr

Source: AGIS, with modifications to the Lehurutshe figures of which only half were taken into account, due to limited overlap with study area

The resultant total calculated water consumption is thus 2,000MI/year, but variances in supply – during droughts, for example – are not factored in and neither are livestock mortality rates and restocking figures. Notably, in tribal areas livestock share domestic water supply with their handlers. Thus, water service projects based on numbers of households, or people, are possibly underestimating water demands and could be providing for unrealistically low demand. The areas where this could be an issue particularly are Lehurutshe / Dinokana villages, Mafikeng rural and peri-urban areas and the Itsoseng villages. The total figure water consumption figure reliant on groundwater is therefore reduced to 1,861MI/yr to account for the 75:25% groundwater to surface water split applicable to the Molopo district (i.e. Extended Grootfontein unit).

²² Please note that there are different opinions about the quantity of water consumed by livestock but the author has chosen to apply the Agri North West's rates.

The livestock districts are indicated in figure 5 (Annexure 1)

The ratio of livestock to persons is 1.05, with cattle, as largest water consumer in terms of livestock, being 0.53.

	2001	Ratio to people
Population	527063	
Cattle	283682	0.53
Total livestock	551148	1.05

In terms of the most direct impact on the dolomitic units the water demand load is spread as follows (Ditsobotla is split on a one-quarter three-quarters proportion to Itsoseng/Lichtenburg and Extended Grootfontein, respectively):

Table 4.9: Impact of livestock consumption on dolomite water units

Water Unit	Consumption (Ml/annum)
Zeerust	225Ml/yr
Extended Grootfontein	602Ml/yr
Groot Pan	N / a
Itsoseng / Lichtenburg	607Ml/yr
Schoonspruit	426.5Ml/yr

4.2.5 Environmental Use

The only figures available for environmental water demand are for the Extended Grootfontein water unit. The consumption is 7,455Ml per annum (Bigen Africa, 2002), but the report does not specify the actual use.

Numerous groundwater dependent eco-systems occur (GDEs) and are very sensitive to abstraction²³. The Zeerust unit contains the Dinokana, Rietpoort, Buffelsnek and Malamani Eyes; Extended Grootfontein the Wondergat and Molopo springs. The Groot Pan unit contains the Marico (Kaaloog) eye, Itsoseng/Lichtenburg has the Polfontein and Klipbankfontein springs and Ventersdorp contains the Bovenste Oog van Mooirivier eye. It is problematic that no environmental reserve has been set for these numerous (GDEs).

4.2.6 Summary of Water Use per Dolomite Water Unit

Figure 6 (Annexure 1) provides an overview of water use per dolomite water units and sub-compartment.

The following table consolidates the various water users per dolomite water unit at current state of consumption.

²³ Water Research Commission, November 2002

Table 4.10 Consolidated Water Demand Information 2008 (Ml/annum)

Water Unit	LM	Irrigation	Industry	livestock	environme ntal	domestic
Zeerust	Zeerust	2,692	818.1	225.3		3,575
Extended Grootfontein	Mafikeng	10,662	N/a	700	7,455	6,750 – 9,070
Groot Pan	Kgetleng River	15,390	N/a	N/a		N/a
Itsoseng/ Lichtenburg	Ditsobotla	23,091	1,569.2	607.3		3,900
Venters-dorp	Venters-dorp	25,410	N/a	426.4		1,355.7

4.3 Future Growth

4.3.1 Population Growth

Generally, population in the study area has grown at an annualised rate of 1.76% between the 1996 and 2001 census years. The following table indicates changes in population per local municipality within the study area for the 1996 to 2001 census interval.

Table 4.11 Summary Table Municipal Level in Study Area, 1996 vs. 2001

Municipality	Census 1996 (wards)	Census 2001 placenames	Growth Rate (ann. %)
	1996	2001	
Ditsobotla	121557	136290	2.31
Kgetleng River	27325	31448	2.85
Mafikeng	227747	245661	1.53
Ventersdorp	24986	33548	6.07
Zeerust	81386	80117	-0.31
Total	483001	527063	1.76

Figure 7 (Annexure 1) indicates the 2001 on 1996 growth rates by Local Municipality (refer to table 4.11).

In the case of Zeerust, its minus 0.3% growth rate is consistent with the DWAF policy of using a 0% growth population rate in such areas due to the effect of HIV/AIDS.

Ventersdorp displays a very high annual growth rate. The reasons for this are unknown but growth seems to have slowed down, since the Municipality has confirmed that there would be no housing backlog once the 1000 new erven are completed in due course (refer to section 4.7).

The average household size within the study area is 3.9, based on the census 2001 ratio of 134,627 households to 527,063 total population.

The estimation of future population in the study area rests on population projections, for which the North West Province Population Unit has supplied information, as tabulated below.

Table 4.12: NWPPU Population Projections

Municipality	1996	2001	2003	2008
Ditsobotla	138255	148912	152570	161132
Kgetlengriver	40480	42650	43319	44763
Mafikeng	211740	231105	238034	254700
Ventersdorp	35967	39045	40128	42709
Zeerust	75932	82010	84113	89076
Total	502,374	543,722	558,164	592,380

The update to projections by substituting current 2001 census information into the Population Unit's table is tabulated below. Using the same rates used by the Unit (as also shown in the table) the 2008 population figure was adjusted.

The adjusted calculation arrives at a future population of 574,938 people, which is 33,683 more than at year 2003 (current year), a total increase of 6.2%.

Table 4.13: NW Province Population Unit Calculations with Substitution for 2001

Municipality	2001	2002	2003	2005	2006	2007	2008	Change 03- 08	Ann. Growth
Ditsobotla	136290	137954	139638	143073	144823	146142	147474	7836	1.10%
Kgetlengriver	31448	31693	31941	32442	32697	32851	33005	1064	0.66%
Mafikeng	245661	249318	253027	260612	264488	267598	270743	17716	1.36%
Ventersdorp	33548	34010	34478	35435	35923	36308	36696	2218	1.25%
Zeerust	80117	81137	82172	84282	85360	86186	87020	4848	1.15%
Total	527063	534113	541255	555843	563290	569084	574938	33683	1.21%

Applied Growth Rates	1.22%	1.22%	2.46%	1.22%	0.91%	0.91%
(from NWPPU table)	0.78%	0.78%	1.57%	0.78%	0.47%	0.47%
	1.49%	1.49%	3.00%	1.49%	1.18%	1.18%
	1.38%	1.38%	2.77%	1.38%	1.07%	1.07%
	1.27%	1.27%	2.57%	1.28%	0.97%	0.97%
	1.32%	1.32%	2.66%	1.32%	1.01%	1.01%

Figure 8: 2008 Local Municipal growth rates as per table 4.13

The tabulated information highlights that there is expected to be a slow down in growth rate. The annualised rate of change decreases by 0.55% between 2003 and 2008. This is attributable to the NWPPU's view of HIV/AIDS impact on population growth, as is evidenced by the growth rates that the Unit has applied (see table 4.13). The percentage growth rate in table 4.13 is misleading: a 1 percent increase in Mafikeng's population equates to 2500 people, while a similar percentage amount only to 340 people in Ventersdorp.

Nonetheless, Mafikeng still has the highest growth rate as would be expected from its position as the region's economic growth centre. The impact thereof is that the levels of water service provision will constantly need to be addressed. Already a backlog of 20561²⁴ units exists, accessing below RDP standards of water services.

²⁴ From table 4.4

4.3.2 Spatial Growth

Few District or Local Municipal SDFs exist (only Mafikeng Local Municipality and Ventersdorp Local Municipality have a SDF). IDPs and interviews with Municipal officials were the main sources of information.

Telephonic interviews were held with Ditsobotla, Kgetleng River, Mafikeng and Ventersdorp officials (refer to Annexure 5) to ascertain planned township extension information and commercial and industrial development. Zeerust Municipality apparently does not have a town planning official and information from the IDP is used instead.

4.3.2.1 Ditsobotla Local Municipality

The Lichtenburg Land Development Objective directs residential growth westwards from Lichtenburg Central and north of Boikhutso. It is in this area that 3000 additional erven are planned to be provided but in the medium to long term (5 to 10 years). It thus has limited relevance to the time horizon adopted by this study. A similar long term extension is planned in Coligny's Tlhabologang township where approximately 2700 erven are to be provided in 10 years. Current housing projects are planned for Bodibe, Verdwaal and Itsoeng, totalling 1000 erven each serviced above RDP standard (water connection per plot).

4.3.2.2 Kgetleng River Local Municipality

Figures supplied by the Municipal planner, indicate that all three towns are planned to expand in the medium term. Koster would provide for 700 additional serviced erven, Swartruggens 100 and Derby 400. The level of access to water services was still being debated²⁵.

4.3.2.3 Mafikeng Local Municipality

The town of Mafikeng will experience substantial growth in the short-term. The Provincial police headquarter is moving from Potchefstroom to Mafikeng; housing for police staff and families will be required to the order of 1000 dwellings. These will all be provided at high standard of water provision, i.e. full services connections in each dwelling. In addition it is planned that the Provincial Justice Department will be relocating to Mafikeng increasing the town's need for accommodation. In Mmabatho East 9000 medium density residential units are planned between 2005 and 2035²⁶. This amounts to 300 new erven per year, and 900 extra plots convergent with the time horizon of this study.

4.3.2.4 Ventersdorp Local Municipality

The Ventersdorp Town Engineer confirmed that 1000 new erven are being serviced within the next year, to eradicate the town's formal housing backlog. These erven will have water borne sewerage and domestic water connections at every stand. These

²⁵ Kgetleng River Municipal Planner, Mr Wessel Bester, telephonic interview, September 2003

²⁶ Mafikeng Municipality Deputy City Engineer, Mr A Dube, telephonic interview, September 2003

erven are meant to cater for the town's 700 informal households and 300 backyard dwellings²⁷.

4.3.2.5 Zeerust Local Municipality

The only officially planned growth in Zeerust Municipality is to occur in the Lehurutshu/ Dinokana villages. Approximately 1500 erven are to be formalised²⁸.

Table 4.14 provides an overview of settlement growth plans and completion time frames.

Table 4.14 Summary table of planned settlement growth

Municipality	Town / Village	Growth	Implementation	Level of service	Source, refer footnote
Ditsobotla	Lichtenburg - Boikhutso	3000 erven	5 – 10 years	RDP (expected)	29
	Tlhabologang	2700 erven	+10 years	RDP (expected)	20
	Bodibe	400 erven	1 year	Erf connections	20
	Verdwaal	300 erven	1 year	Erf connections	20
	Itsoseng	300 erven	1 year	Erf connections	20
Kgetleng River	Koster	700 erven	Unknown (est 5 years)	Unknown	16
	Derby	400 erven	Unknown (est 5 years)	Unknown	16
	Swartruggens	100 erven	Unknown (est 5 years)	Unknown	16
Mafikeng	Mafikeng, peri-urban villages	1000 RDP erven	Unknown (est 5 years)	RDP (expected)	17
	Mafikeng, peri-urban villages	1000 middle income erven	Unknown (est 3 years – Police HQ)	Above RDP expected	17
	Mmabatho East	900 erven	3 years ('05-'08)	Above RDP expected	17
Ventersdorp	Ventersdorp	1000 erven	1 year	Above RDP	18
Zeerust (5)	Zeerust	-	-	-	19
	Groot Marico	-	-	-	19
	Dinokana and Lehurutshu villages	1500 erven	1 year	RDP (expected)	19
	Gopane, Rodikhudu villages	-	-	-	(5)
	Khunotswana	-	-	-	(5)

²⁷ Ventersdorp Town Engineer, Mr Terreblanche, telephonic interview, September 2003

²⁸ Zeerust Municipality IDP, 2000

²⁹ Urban Dynamics North West, telephonic interview, September 2003

The anticipated growth in erven to be serviced at different RDP standards, and from all water sources, is therefore 7600 by the year 2008. Of these erven, 6400 would be reliant on groundwater (Derby, Koster and Swartruggens are excluded).

Figure 9 (Annexure 1) depicts the elements of future spatial growth within the study area.

4.3.3 Community Land Claims

The main finding of this aspect of research is twofold:

- the Regional Land Claims Commission needs to verify the correct description of the claimed farms since only two farms have been successfully linked to the cadastre;
- the verification process in terms of size of community to be resettled, is still underway.

Consequently no suitable deductions can be made from this data with regards to the implications for water services provision, potential water needs, impact on water sources and timeframes to address those needs. However, a map has been generated to depict the two farms that could be successfully matched (refer to figure 10, Annexure 1).

4.4 Economic Growth – Industrial and Agricultural

4.4.1 Industrial Growth

The dominant regional growth policy is the Provincial Spatial Development Initiative. All major future growth is aimed to be directed towards and along this corridor. The Initiative, as a potential precursor for future industrial expansion, forms a corridor along the R27. The Deputy City Engineer for Mafikeng also confirmed that no developments are planned within this corridor in the foreseeable future.

Development if contemplated within this corridor would affect the Zeerust compartment, sub-compartments 9-14. Sub-compartment 10 (Rietpoort) already has a 43% mining (industrial) allocation; in other words, 43% of water abstracted is used for industrial purposes. Any future industrial development proposal should recognise that it is situated above an aquifer. Concerns of seepage and leakage of contaminants or by-products from industrial production into the aquifer compartment should therefore be a major aspect of an Environmental Impact Assessment prior to the establishment of new industry. Figure 4 (Annexure 1) indicates provincial growth directions and frameworks as per the SDI.

Discussions with a Member of the Mafikeng Mayoral Committee have revealed that it is planned to upgrade the Mafikeng airport (situated 20km north of the town) to support the establishment on an Industrial Development Zone (IDZ). The IDZ application is currently being negotiated by the North West Premier's office with Central Government. The IDZ is planned to cover approximately 3000Ha at a 50 year time horizon. For the short term, i.e. at initial stages of implementation a 200Ha development is anticipated, but this is more likely to be scaled down to 30Ha³⁰. It is important to note that the intention within

³⁰ Petro Naude, Member of Mayoral Committee, telephonic interview, September 2003

this industrial zone is to provide mostly non-manufacturing uses. Mainly warehousing and infrastructure relating to the breaking of bulk goods, some hi-tech industrial space and a petroleum blending plant are proposed. Therefore additional water requirements are very limited as is the need for additional residential space to house labour.

Furthermore, the location for a new cement plant is being investigated south of Mafikeng town centre³¹. This investigation will soon result in an Environmental Impact Assessment, but construction and implementation were not known at the time of the study, nor is it even assured that an application for a new cement plant would be approved. If approved, this plant could draw from the Itsoseng/Lichtenburg compartment, or become part of the Municipal reticulation system via Rooigrond water plant. Based on the available water demand figures for the three existing cement plants in the study area the water requirements for the new plant could be in the region of 66ML/month (798ML/annum).

According to the Phase 1 Bigen study (January 2002) and Municipal sources interviewed, no other industrial expansion is planned in the foreseeable future.

4.4.2 Agricultural Growth

4.4.2.1 Irrigation

There was a drastic increase in pivot sales in the region in the second and third quarters of 2002, when sales figure doubled on the previous year³². This was in direct response to record maize prices, which reached levels of R1900/ton. They have since returned to approximately R900/ton, and pivot sales have plummeted. Pivot sales, and therefore abstraction tracks world maize prices. It was noted that this way of farming was inappropriate and that many farmers had been ill-advised. According to Agrico Machinery, substantial portions of existing grazing had also been converted to crops to reap potential benefits from the high maize price.

The Agrico Machinery representative felt it would be impossible to establish any farming trends since farming practices were linked to world agricultural market forces. Agri North West was also contacted and questioned regarding farming trend prediction. It was confirmed that farming practice prediction is not feasible since many factors influence changes in production. The fluctuation of crops planted due to world agricultural prices was reiterated. In the short term, however, Agri North West did state that farmers are moving away from maize planting due to poor world prices. But this is related to the next maize planting season only, and therefore grazing areas are expected to increase for the next season.

Furthermore, the Bigen study highlights the fact that information on future irrigation increases is not readily available³³. Farmers have been reluctant to report on future irrigation plans. The report notes that from observations it is, however, clear that irrigation is on the increase, but this cannot be quantitatively supported and it is stated that no firm conclusion can be made regarding future irrigation planned developments.

³¹ Petro Naude, Member of Mayoral Committee, telephonic interview, September 2003

³² Theo Andrag, AgriCo Machinery, telephonic interview, September 2003

³³ Bigen Africa, March 2002

4.4.2.2 Livestock

No information was available for trends or projections.

4.5 Water Demand per Water Use

4.5.1 Domestic Water

The projected total future population growth at 2008 is anticipated to be 33,683 additional people, i.e. 8636 households (3.9 household size average used) leaving a 1036 household deficit.

Taking the figures from section 4.3 forward, the anticipated growth in erven to be serviced at different RDP standards, and from all water sources, is 7600 by the year 2008. 6400 of these could be reliant on the groundwater but Mafikeng's target of providing 50% surface and 50% groundwater ³⁴ could reduce this figure further.

This future planned growth in the number of formal erven is anticipated to be reliant on dolomite water as follows:

Table 5.1 Additional Domestic Water Demand per Dolomitic Water Unit

Water Unit	Additional Erven
Zeerust	1,500 erven
Extended Grootfontein	possible 2900, depending on future split of surface versus groundwater sourcing
Groot Pan	N / a
Itsoseng / Lichtenburg	1,000 erven to 2008, 5,700 additional erven for the 5 years following thereafter
Schoonspruit	1,000 erven

Domestic water demand up to 2008 in relation to abstraction from the dolomitic aquifer, and anticipated water provision issues, is discussed under the following headings

4.5.1.1 Ditsobotla Local Municipality: increased abstraction

Coligny has enough local water (granite aquifer) to sustain its estimated growth until 2015 at least. The PMA Consortium's recommendation is therefore "development of a wellfield in the dolomite aquifer, ... , is not recommended at this stage" (pii), but noting also that "the dolomite represents an important aquifer suitable for obtaining future bulk water supplies once the granite aquifer resources are fully exploited" (p13).

Lichtenburg and the Itsoseng towns and villages will continue to abstract from the aquifer, at an additional rate of 85 to 113Ml/annum. . This range is derived from two use intensity scenarios where water demand is pegged at 60l/c/day (low) to 80l/c/day (high), therefore giving a range of anticipated future use. The calculations are presented in tables 5.2 and 5.4, below.

4.5.1.2 Kgetleng River Local Municipality: possible future abstraction from dolomite aquifer

The growth of the towns in Kgetleng River Municipality, namely Swartruggens and Derby, will exacerbate the water shortfall problems already in existence, except Koster

³⁴ Bigen Africa, January 2002

which has sufficient water supply for the next 20 years. There is no budget available for a study into the augmentation of the water supply ³⁵.

Various alternatives had been discussed informally and abstraction from the dolomite aquifer is possible in spite of the reticulation cost issues (the aquifer is approximately 20 km away). Another solution to Swartruggens' water needs could be the construction of a 2m high weir in the Elands River to supplement the Swartruggens dam in times of shortfall ³⁶.

4.5.1.3 Mafikeng Local Municipality: increased abstraction

The Mafikeng Deputy City Engineer stated that it is policy to aim for access to clean water for all by the year 2020. Achieving this target could place additional strain on the aquifer, especially if all five municipalities aim to reach this 2020 target. Mafikeng has already augmented its water supply with the construction of Setumo dam.

The planned future expansion, as indicated by the number of new planned erven, the population growth rate and the level of civic facilities that are relocating there (Justice Department, Police Head quarters) clearly indicates that water demand will increase substantially enough to have impact on its dolomite aquifer resources. The high proportion of households (20561) serviced below RDP standards will exacerbate the situation. At the same time, the Bigen Africa Study, (January 2002:70), notes that "it is expected that the supply from Setumo Dam is expected to increase over the next 5 years to approximately 50% of the total". If this is the case, some of the pressure on the aquifer will be relieved but the affected groundwater unit will still be under considerable pressure.

4.5.1.4 Ventersdorp Local Municipality: limited increased abstraction

No shortfall is anticipated, but there would be additional pressure on the aquifer but at a limited scale due to provision of 1000 erven in total and a growth in population of 2200 persons only.

4.5.1.5 Zeerust Local Municipality: increased abstraction

The Dinokana villages are planned to be upgraded to RDP standard water reticulation (from 500m to 200m walking distance) with some yard connections included. Botshelo Water believe that the current number of boreholes will not be sufficient to achieve this raising of the standard ³⁷, and further holes will have to be drilled, i.e. a shortfall is anticipated in the near future. Thus the Zeerust compartment will be affected.

4.5.1.6 Additional water demand scenarios

The anticipated increase in domestic water demand abstracting from the dolomite aquifer source for year 2008 can be derived from establishing a set of scenarios based on stated planned developments. The reason for scenarios is mainly to account for affordability options for the target communities. As is stated in the Zeerust IDP, "service

³⁵ Marks Jordaan, Moedi Consulting Engineers, telephonic interview, September 2003

³⁶ Marks Jordaan, Moedi Consulting Engineers, telephonic interview, September 2003

³⁷ Water Engineer Eric Rakumakwe, Botshelo Water, telephonic interview, September 2003

provision at levels higher than the minimum appropriate levels (i.e. RDP levels should be on an economic basis, based on the principle of affordability)" (p49).

The **average household size of 3.9** is used to determine the number of persons per planned settlement extension, so that the series of water standards can be used to derive a future additional consumption figure. The water standards are 25l for RDP standard, 12l below RDP and range of 60 - 80l per person per day for above RDP standards (refer section 3.1.10).

The constants for the scenarios are the additional population (2008 on 2003), household size, 12l minimum standard for those not "assigned" to erven (shortfall) and the planned developments. The additional Mafikeng erven (2900) are furthermore adjusted according to the 50:50 surface to groundwater supply ratio (see Mafikeng LM, 5.1.1.3. above).

HIGH Consumption Scenario

Variables:

- Ditsobotla average demand 80l/c/d (above RDP); Mafikeng average demand at 80l/c/d (above RDP) and 25l/c/d (RDP); Ventersdorp average demand at 80l/c/d (above RDP); Zeerust average demand at 80l/c/d (above RDP).

Table 5.2 High Scenario

Municipality	Aquifer Abstraction	Pop change 03- 08	Planned erven	Above RDP	persons	Consumption 80litres	RDP	persons	Consumption 25litres	Remainder	Consumption 12litres
Ditsobotla	Yes	7,836	1,000	1,000	3,900	113MI				3,936	17MI
Kgetleng River	No	1,064	1,200								
Mafikeng (Adjusted) ³⁸	Yes	17,716	2,900	1,900	7,410	216MI 108MI	1000	3900	36MI 18MI	6,406	26MI 14MI
Ventersdorp	Yes	2,216	1,000	1,000	2,216	65MI				0	
Zeerust	Yes	4,848	1,500	1,500	4,848	141MI				0	
Sub-Total		33,683	7,600			536MI			36MI		45MI
Total						618MI/annum					

HIGH Scenario total additional water demand: 618MI/annum

The impact per dolomite water unit is tabulated below:

Table 5.3 High Scenario

Water Unit	Future Demand	Local Municipality
Zeerust	142MI/yr	Zeerust
Extended Grootfontein	140MI/yr	Mafikeng
Groot Pan	N / a	Kgetleng River
Itsoseng / Lichtenburg	131MI/yr	Ditsobotla
Schoonspruit	65MI/yr	Ventersdorp

³⁸ To account for the 50% reliance on groundwater source, only demand from half of the planned erven is included in total

LOW Consumption Scenario

Variables:

- Ditsobotla average demand 60l/c/d (above RDP); Mafikeng average demand at 60l/c/d (above RDP) and 25l/c/d (RDP); Ventersdorp average demand at 60l/c/d (above RDP); Zeerust split: average demand at 60 and 25l/c/d (RDP) - affordability

Table 5.4 Low Scenario

Municipality	Aquifer Abstraction	Pop change 03-08	Planned erven	Above RDP	persons	Consumption 60litres	RDP	persons	Consumption 25litres	Remainder	Consumption 12litres
Ditsobotla	Yes	7,836	1,000	1,000	3,900	85Mi				3,936	17Mi
Kgetleng River	No	1,064	1,200								
Mafikeng (Adjusted) ¹⁹	Yes	17,716	2,900	1,900	7,410	162Mi 81Mi	1,000	3,900	36Mi 18Mi	6,406	28Mi 14Mi
Ventersdorp	Yes	2,218	1,000	1,000	2,218	49Mi				0	
Zeerust	Yes	4,848	1,500	750	2,424	53Mi	750	2,424	22Mi	0	
Sub-Total		33,683	7,600			349Mi			58Mi		45Mi
Total						425Mi/annum					

LOW Scenario total additional domestic water demand: 452Mi/annum

The impact per dolomite water unit is tabulated below:

Table 5.5 Low Scenario

Water Unit	Future Demand	Local Municipality
Zeerust	75Mi/yr	Zeerust
Extended Grootfontein	113Mi/yr	Mafikeng
Groot Pan	N / a	Kgetleng River
Itsoseng / Lichtenburg	103Mi/yr	Ditsobotla
Ventersdorp	49Mi/yr	Ventersdorp

4.5.2 Agricultural Water

4.5.2.1 Irrigation

Due to the fact that there is no trend information the current irrigation is used in the future demand tabulation. Irrigation accounts for 77,254Mi/annum.

4.5.2.2 Livestock

Due to the fact that there is no trend information the current livestock consumption is used in the future demand tabulation. Livestock accounts for 2000Mi/year. In terms of scale the consumption is comparable to Ventersdorp's domestic consumption, for instance.

¹⁹ To account for the 50% reliance on groundwater source, only demand from half of the planned erven is included in total

4.5.3 Industrial Water

The potential Mafikeng south cement plant is the only confirmed indication of additional industrial water usage in the study area. The water requirements are estimated to be in the 798Ml/annum range (refer to section 4.4.1) but for consideration of source of future water a 50% supply from groundwater is assumed, i.e. 400Ml/annum.⁴⁰

4.5.4 Environmental Water

The only figures available for environmental water demand are for the Extended Grootfontein water unit. The consumption is 7,455Ml per annum (Bigen Africa, 2002).

4.6 Water Demand per Dolomitic Water Unit

From the preceding sections, a consolidated table (table 5.6, below) is created to display the current and added future water demand per dolomite water unit. An indication of Local Municipality is also included. In the absence of any projection for irrigation demand for 2008, the water consumption for 2003 is being used as future value. For the same reason environmental, industrial and livestock water consumption at year 2008 is kept constant, apart from water demand from the potential new cement plant in Mafikeng, which is used at half to account for the 50-50 ground to surface water split, i.e. 400Ml/annum instead of 798Ml/yr.

The reason for the two following tables is to establish which water units are currently stressed, over-abstracted or are likely to come under pressure in the study's time horizon, 2008. Note that the yields expressed in the tables are derived from the Bigen Africa report, dated January 2002, and these yields need to be confirmed by the geohydrological component of this current study.

⁴⁰ This accounts for the Mafikeng targeted 50 – 50 split between ground and surface water provision

Table 5.6 Consolidated Water Demand Information 2008

Water Unit	LM	Irrigation ⁴¹		Industry ⁴²		Livestock ⁴³		Environ. ⁴⁴		Domestic ⁴⁵	
		MI/annum		MI/a		MI/a		MI/a		MI/a	
		current	+ future	current	+ future	current	+ future	current	+ future	Current ⁴⁶	+ future ⁴⁷
Zeerust	Zeerust	2,692	2,692	818.1	818.1	225.3	225.3	Unkno wn	Unkno wn	3,575	3,650.2 – 3,716.6
Extended Grootfontein	Mafikeng	10,662	10,662	N/a	399 ⁴⁷	700	700	7,455	7,455	6,750 – 9,070	4,613 – 6,190
Groot Pan	Kgetleng River	15,390	15,390	N/a	N/a	N/a	N/a	Unkno wn	Unkno wn	N/a	N/a
Itsoseng/Lichtenburg	Ditsobotla	23,091	23,091	1,569.2	1,569.2	607.3	607.3	Unkno wn	Unkno wn	3,900	4,002.6 – 4,031.1
Schoonspruit	Ventersdorp	25,410	25,410	N/a	N/a	426.4	426.4	Unkno wn	Unkno wn	1,355.7	1,404.3 – 1,420.5
TOTAL (at 2008)			77,254		2,786.3		1,959		7,455		13,670 (LOW) – 15,358 (HIGH)
% (Low)			74.9		2.7		1.9		7.2		13.3
% (High)			73.7		2.7		1.9		7.1		14.6

Table 5.6 provides an overview of impact of different water users in relation to each other. Zeerust domestic use accounts for almost as much consumption as do the other categories combined. The Zeerust unit is therefore potentially sensitive to changes in rate of population and settlement growth. The Extended Grootfontein unit – serving Mafikeng – is also sensitive to increases in domestic consumption, since its magnitude is relatively similar to the agricultural demand.

Noteworthy in table 5.6 is that the future water demand on the Extended Grootfontein unit from Mafikeng will actually reduce due to the supply ratio of surface to groundwater changing from 25:75 changing to 50:50.

⁴¹ Bigen Africa, March 2002, and section 4.2.4.1

⁴² Bigen Africa, January 2002, except ⁴⁷

⁴³ From section 4.2.4.2

⁴⁴ Bigen Africa, January 2002

⁴⁵ From table 4.2

⁴⁶ From section 5.1.1.6

⁴⁷ From section 5.1.3, industrial water

Table 5.7: Total current and future water demand – aquifer source (Ml/annum)

Water Unit	LM	⁴⁸ yield	Total current water demand	Total future water demand	% change	Total future as % of yield
Zeerust	Zeerust	27,390	7,310.4	7,385.6 - 7,452	1 - 1.9	27.0
Extended Grootfontein	Mafikeng	22,740	25,966 - 28,286	23,839 - 25,406	-8.2 to -10.2	104.8 - 111.7
Groot Pan	Kgetleng River	29,770	15,390	15,390	-	51.7
Itsoeng/Lichtenburg	Ditsobotla	19,400	29,167.5	29,270.1 - 29,298.6	0.4-0.5	150.9 - 151
Schoonspruit	Ventersdorp	69,110	27,192.1	27,240.7 - 27,256.9	0.2	39.4
Totals		168,410	105,026 - 107,346	103,124.8 - 104,803.5		62.2%

5 CONCLUSION AND RECOMMENDATIONS

5.1 Limitations

This study does not take into account climate change, the effects of which could be negative on aquifers' rates of recharge. It is **recommended** that this be incorporated as a strategic issue in the geohydrological component of this study.

It is evident from the data-gathering phase of this report that there are still studies underway or datasets being compiled which could provide for a more detailed basis for demand estimation if the current levels of detail are deemed unsatisfactory. The compilation of an agricultural use database is being undertaken by firms such as Farm IT Solutions, and data such as this could help provide a clearer, more accurate understanding of farming activity. The proper quantification of agricultural water usage still remains a problem in this and future studies due to reluctance from farmers to provide information. This is problematic mainly since the correlation of land under irrigation and water use is high, roughly 1Ml per 10 hectares irrigated, and water units that are over-utilised could possibly be replenished from those that have spare capacity.

In addition there are aspects of this study that will remain unanswered, such as farming trends. This is because there is insufficient information available to assist in trend formulation. Water demand over time in agricultural industry can only be conclusively determined once a clearer idea is developed on what the future trends are. It is recommended that an investment be made in obtaining the appropriate information, which contribute towards identifying trends. A concomitant aspect to this is the level of research confidence in the use of satellite image analysis as a relatively accurate measure of irrigation water usage.

The land claims information is limited since it was not possible to (i) ascertain the size of verified communities to be resettled, and (ii) to locate the other 83 identified farms earmarked for restitution. It is **recommended** that the Regional land Claims Commissioner be consulted periodically to establish when information is completed.

⁴⁸ Bigen Africa, January 2002

It was beyond the scope of this study to investigate whether there are inefficiencies in water provision that cause higher than necessary use. It is untested whether the consumption figures are attributable to demand only or whether leakages, wastage, inefficient water use or poor education about water use contribute to figures.

In view of the problems presented to appropriate forecasting and trend development by limited information, it is **recommended** that an investment be made into improving the currency of appropriate information.

5.2 Key Findings

The water demand assessment component of this study has managed to express a view of future water needs and impacts on the five dolomitic water units, based on currently available information. It is **recommended** that this study be cross-referenced with the recharge and yield results of the geohydrological component, to ensure that the yield assumptions, and deductions, in the water demand study can be verified.

5.2.1 Access to water

The rate of household access to water at RDP and higher standards has risen by 39.9% between years 1996 and 2001. An impact thereof is higher abstraction from groundwater sources.

5.2.2 Future Growth

Population is expected to increase by 1.2% per annum within the study area. From available information an additional 7600 additional erven will be provided by the year 2008, of which 6400 would be directly reliant on groundwater resources.

Mafikeng has highest predicted population growth rate up to 2008, at 1.36% per annum, which could be influenced (upwards) by the planned introduction of the Civic and Government users.

Industrial growth plans are very limited. The IDZ at Mafikeng is the only definite incidence of industrial growth in the study area, but it is of a small scale up to year 2008. The additional cement plant south of Mafikeng is still being investigated. No agricultural growth is projected since this type of information has proven not to exist.

5.2.3 Domestic Water Demand

It is evident that the most heavily settled areas, and areas of highest urban activity within the study area directly correlate with high demand on nearby groundwater resources. Mafikeng and surrounds, and Lichtenburg and its settlements contribute heavily to the unsustainable abstraction from the Extended Grootfontein and Lichtenburg / Itsoseng compartments respectively.

The total additional domestic water demand from the dolomite aquifer in the year 2008 will range between 452 and 617Ml/annum. However, the backlog in providing adequate

water service levels will actually increase, since the 7600 planned provision compared to the 2008 number of households growth to 8636 still leaves a 1036 household deficit. It is recommended that this backlog be addressed.

HIGH Scenario total additional water demand: 617Ml/annum

<i>Groundwater unit</i>	<i>Domestic demand</i>	<i>LM</i>	<i>Households</i>
Zeerust	142Ml/yr	Zeerust	1,500 erven
Extended Grootfontein	140Ml/yr	Mafikeng	2,900 erven
Groot Pan			
Itsoeng / Lichtenburg	131Ml/yr	Ditsobotla	1,000 erven
Schoonspruit	65l/yr	Ventersdorp	1,000 erven

LOW Scenario total additional domestic water demand: 452Ml/annum

<i>Groundwater unit</i>	<i>Domestic demand</i>	<i>LM</i>	<i>Households</i>
Zeerust	75Ml/yr	Zeerust	1,500 erven
Extended Grootfontein	113Ml/yr	Mafikeng	2,900 erven
Groot Pan	N/A		
Itsoeng / Lichtenburg	103Ml/yr	Ditsobotla	1,000 erven
Schoonspruit	49Ml/yr	Ventersdorp	1,000 erven

5.2.4 Agricultural Water Demand

The consequence of increase in farming could be particularly severe on the water units since areas under irrigation are currently very low and pressure on the aquifer is already high. Compounding the issue is the amount of livestock and unknown increases in herd numbers and the concomitant water requirements. However, direct water demand from the aquifer for livestock, in terms of 2001 figures, is 2,000Ml/year, which is approximately 10% of domestic demand. It is therefore not as significant as suspected at the beginning of this study. Notably, in tribal areas livestock share domestic water supply with their handlers. Thus, water service projects based on numbers of households, or people, are possibly underestimating water demands and could be providing for an unrealistically low demand. The areas where this could be an issue particularly are the Lehurutshe/Dinokana villages, Mafikeng rural and peri-urban areas and the Itsoeng villages.

5.2.5 Industrial Water Demand

At present industrial water demand reliant on dolomite aquifer source is 3,267Ml per annum (Phelps Dodge mine, the Dudfield, Lichtenburg and Slurry cement plants).

5.2.6 Cumulative Demand

The cumulative impact of domestic, industrial, environmental, irrigation and livestock water use and future demand is that the Extended Grootfontein unit is being overutilised

by 14-24% currently, dropping to 5-12% over sustainable yield by 2008. This drop is attributed to the planned capacity improvements to Setumo Dam.

- The Mafikeng urban and peri-urban area is drawing more water than its allocation, leaving the Extended Grootfontein compartment increasingly vulnerable.
- In the Mafikeng Local Municipality, 31.9% (3287) of households are still serviced below acceptable RDP standards (2001 versus 1996 census).
- There is a target to provide access to clean and safe water to all households by the year 2020.

The Itsoeng/Lichtenburg dolomite water unit is also being unsustainably abstracted from and is the water unit under greatest threat. Abstraction occurs, and is predicted to occur, at 51% over its current yield.

In terms of cumulative water demand the Zeerust, Groot Pan and Schoonspruit units have, and will continue to have, spare capacity to levels of 73%, 48.3% and 60.6%, respectively. Groot Pan remains unaffected by any future settlement growth (Koster, Derby, Swaruggens), Ventersdorp remains relatively unaffected due to its inherently small population and Zeerust draws future water from the aquifer and sufficient surface water from its northeast.⁴⁹

⁴⁹ Please note that these conclusions contradict the Geohydrological Assessment but the results have been left as is since it displays the difficulty on calculating water demand in the absence of accurate and sufficient data.

6 REFERENCES

Augmentation of Primary Water Supply to Zeerust, Mafikeng and Swartruggens, Feasibility Study Phase 1, January 2002, Bigen Africa.

Augmentation of Primary Water Supply to Zeerust, Mafikeng and Swartruggens, Feasibility Study Phase 2, March 2002, Bigen Africa.

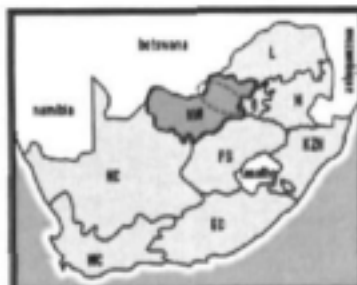
Institutional Arrangements for Groundwater Management in Dolomitic Terrains: Situation Analysis- Report KV140/02, November 2002, Water Research Commission.

Investigations into the Augmentation of the Bulk Water Supply for Coligny from Groundwater Resources, August 2003, The PMA Consortium.

Water and HIV/AIDS: Some Strategic Consideration, date unknown, extract from the North West Population Unit, unpublished (Draft) Population Trends and Development Report 2003/2004.

7 ANNEXURE 1: Maps

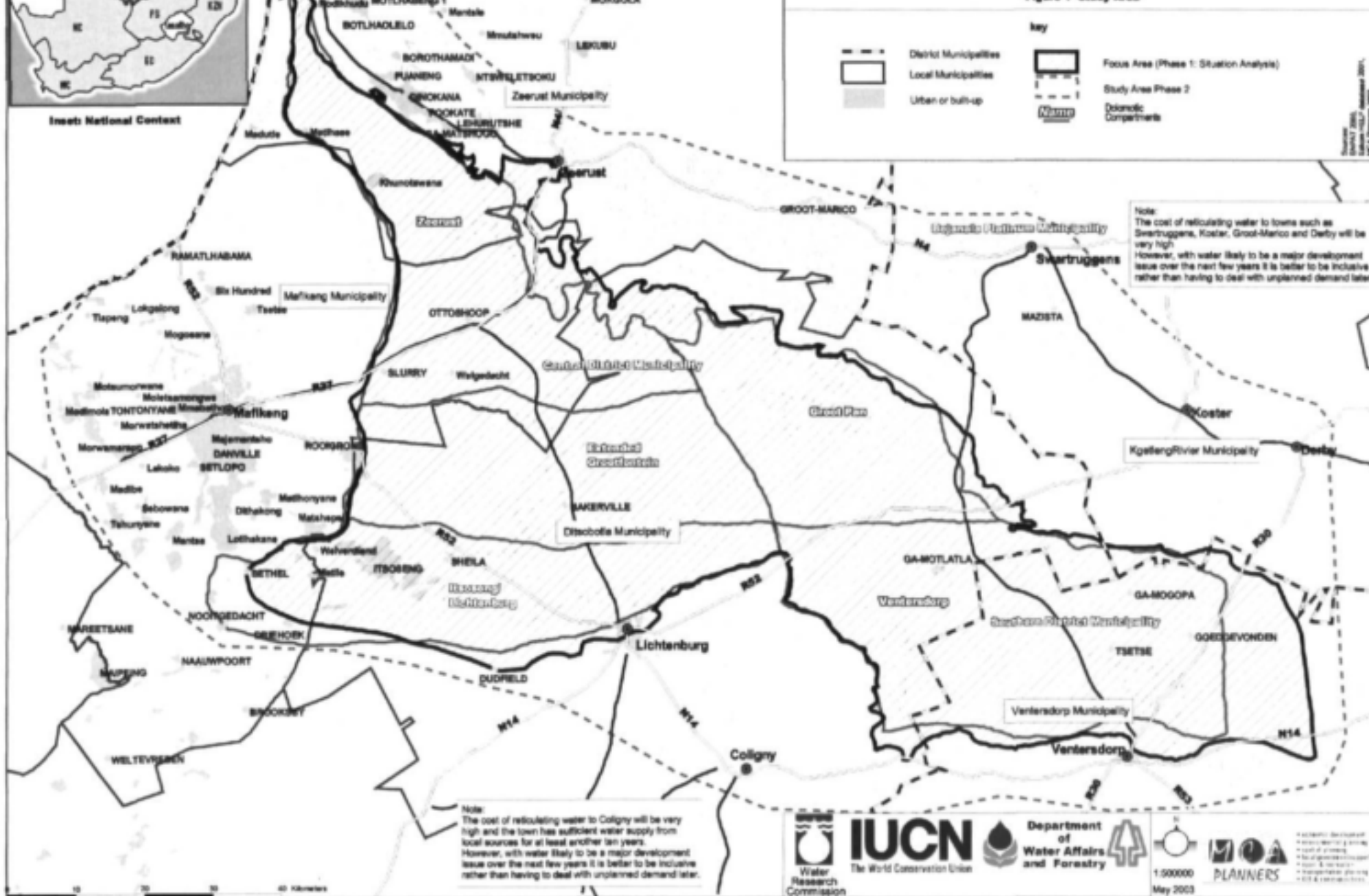
Figure 1	Study Area
Figure 2	Land Use Distribution
Figure 3	Summer Crops Correlation with Dolomitic Units and Compartments
Figure 4	Winter Crops Correlation with Dolomitic Units and Compartment
Figure 5	Livestock Districts
Figure 6	Water Use per Dolomitic Units and Compartments
Figure 7	Local Municipal growth rates 1996 - 2001
Figure 8	2008 Local Municipality growth rates
Figure 9	Spatial Growth Frameworks and planned future growth with domestic water sources
Figure 10	Gazetted Community Land Claims



Inset National Context

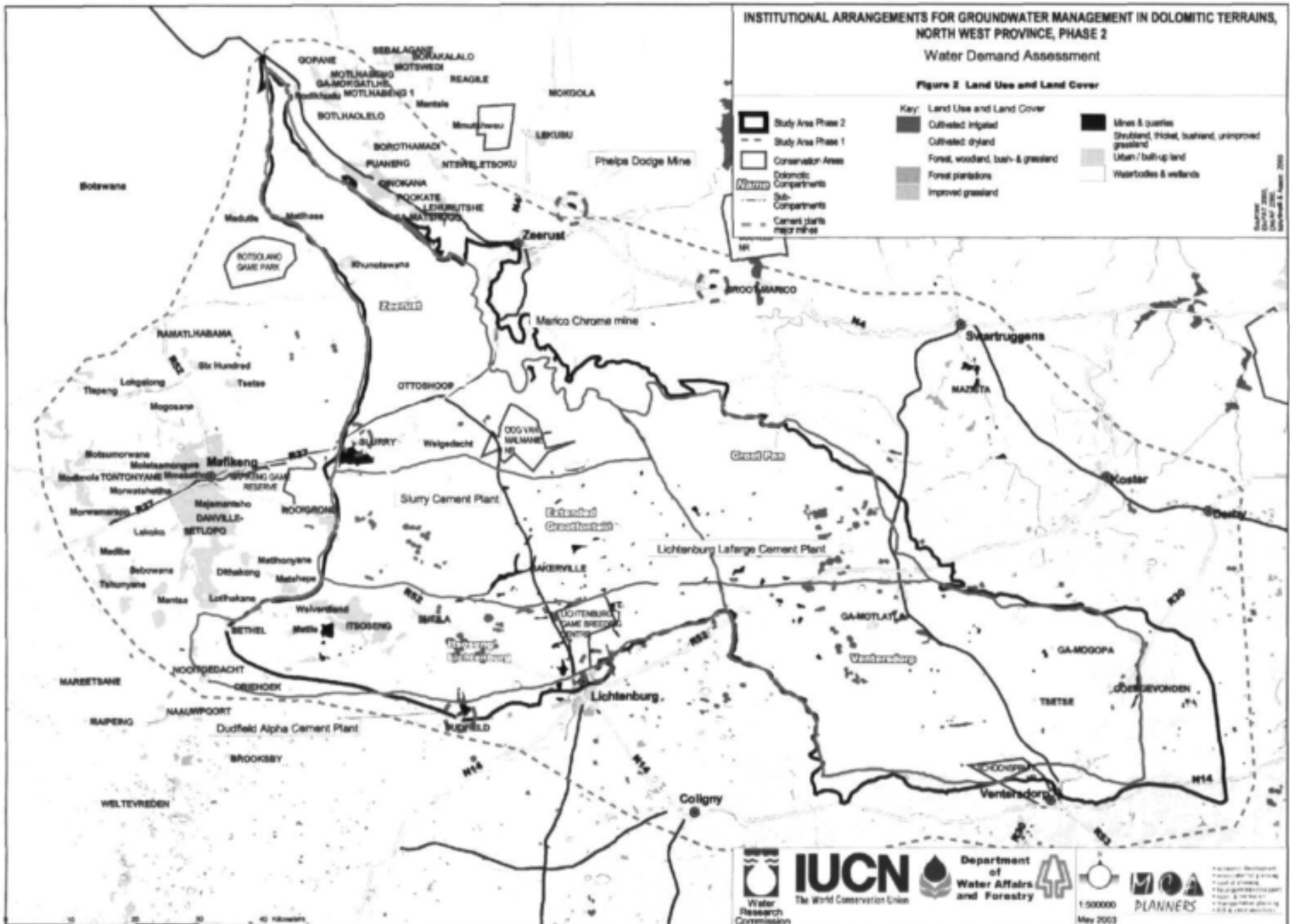
INSTITUTIONAL ARRANGEMENTS FOR GROUNDWATER MANAGEMENT IN DOLOMITIC TERRAINS, NORTH WEST PROVINCE, PHASE 2 Water Demand Assessment

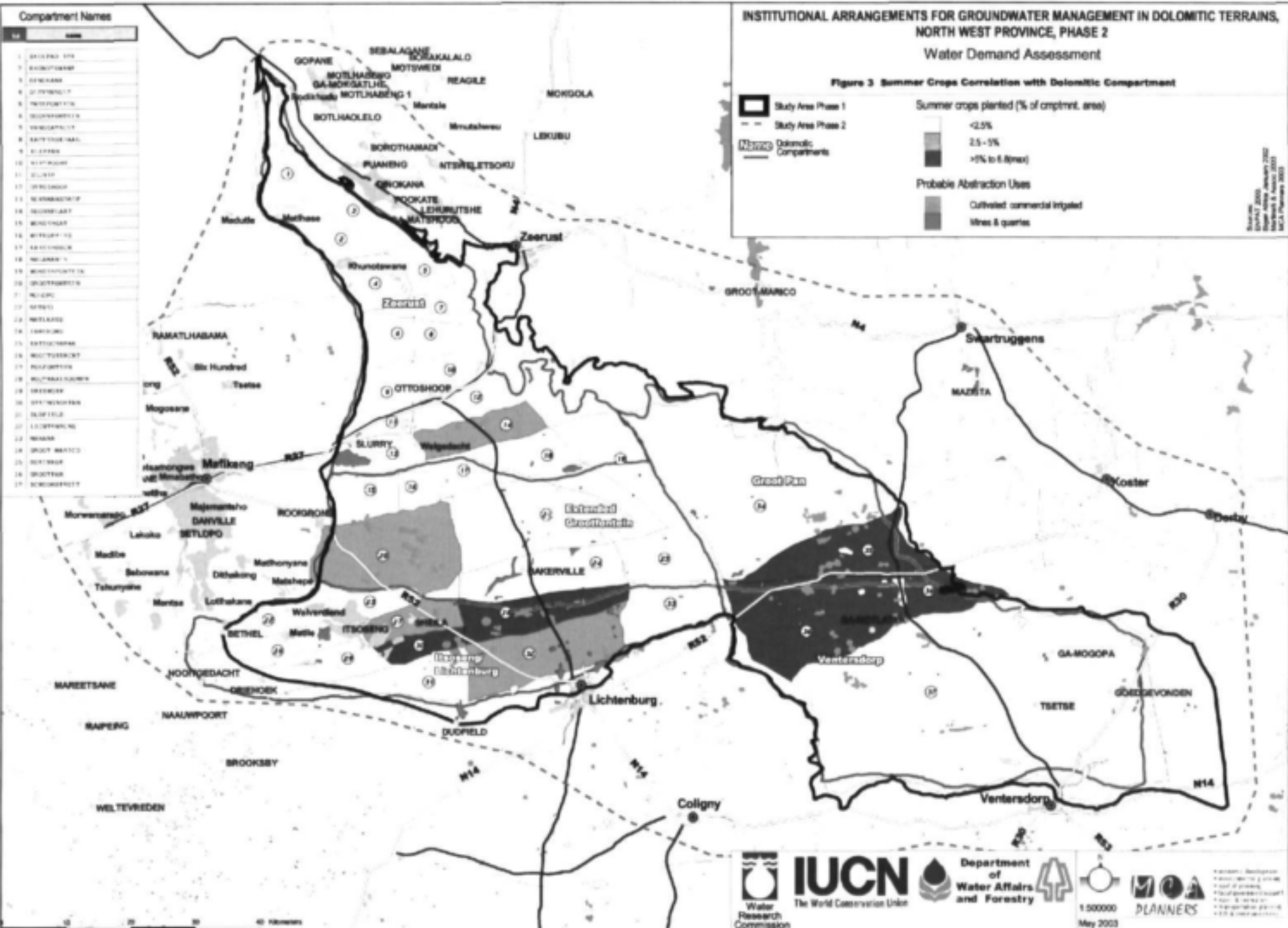
Figure 1 Study Area



INSTITUTIONAL ARRANGEMENTS FOR GROUNDWATER MANAGEMENT IN DOLOMITIC TERRAINS,
NORTH WEST PROVINCE, PHASE 2
Water Demand Assessment

Figure 2 Land Use and Land Cover

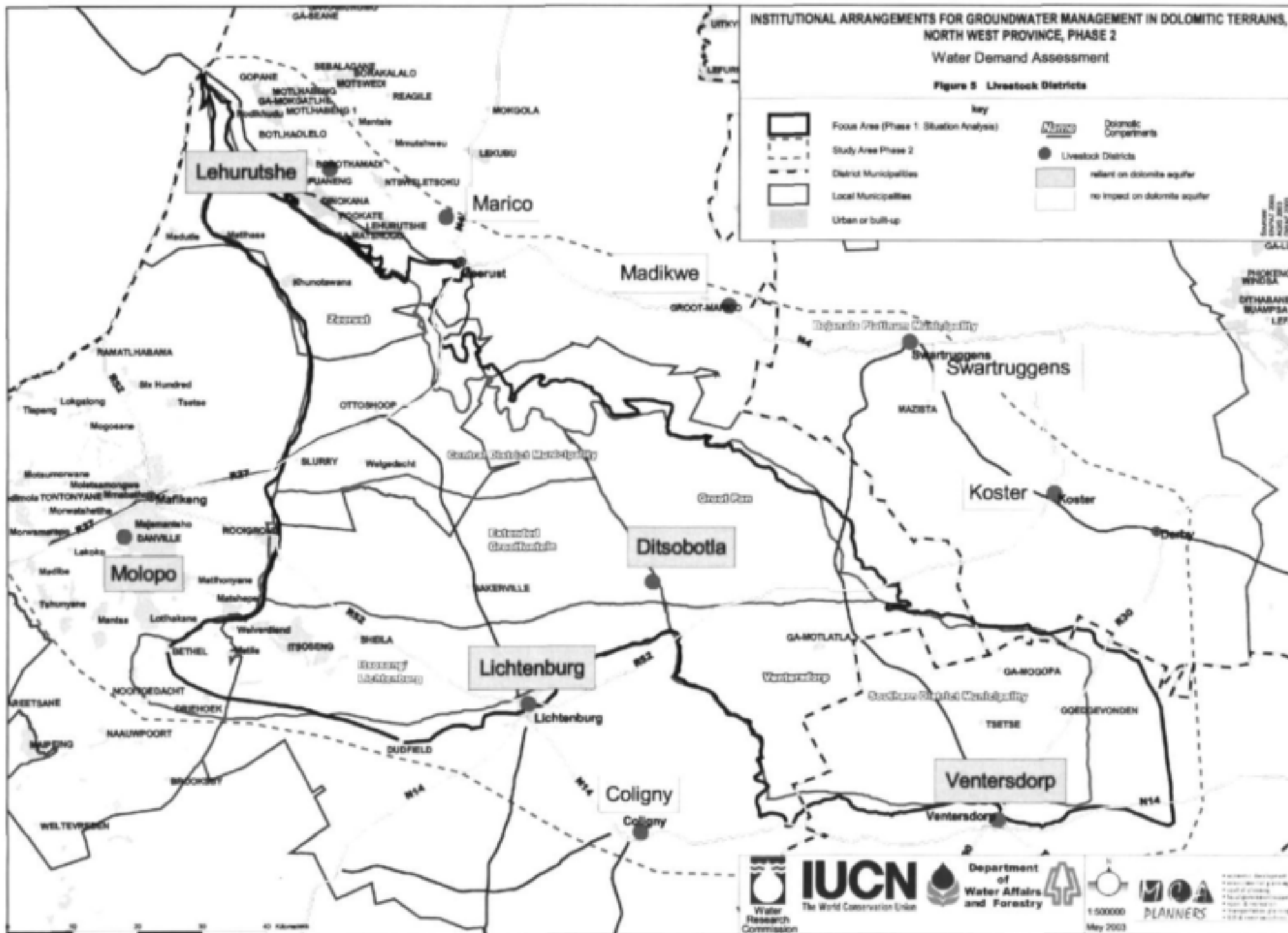
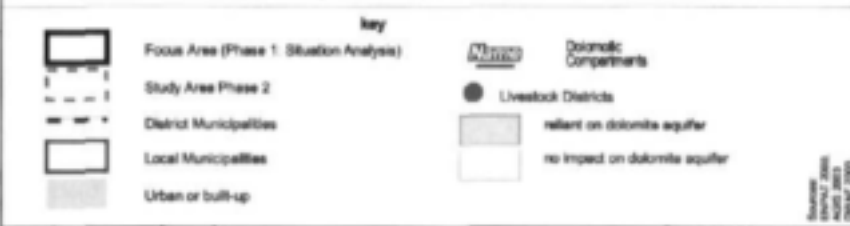




INSTITUTIONAL ARRANGEMENTS FOR GROUNDWATER MANAGEMENT IN DOLOMITIC TERRAINS, NORTH WEST PROVINCE, PHASE 2

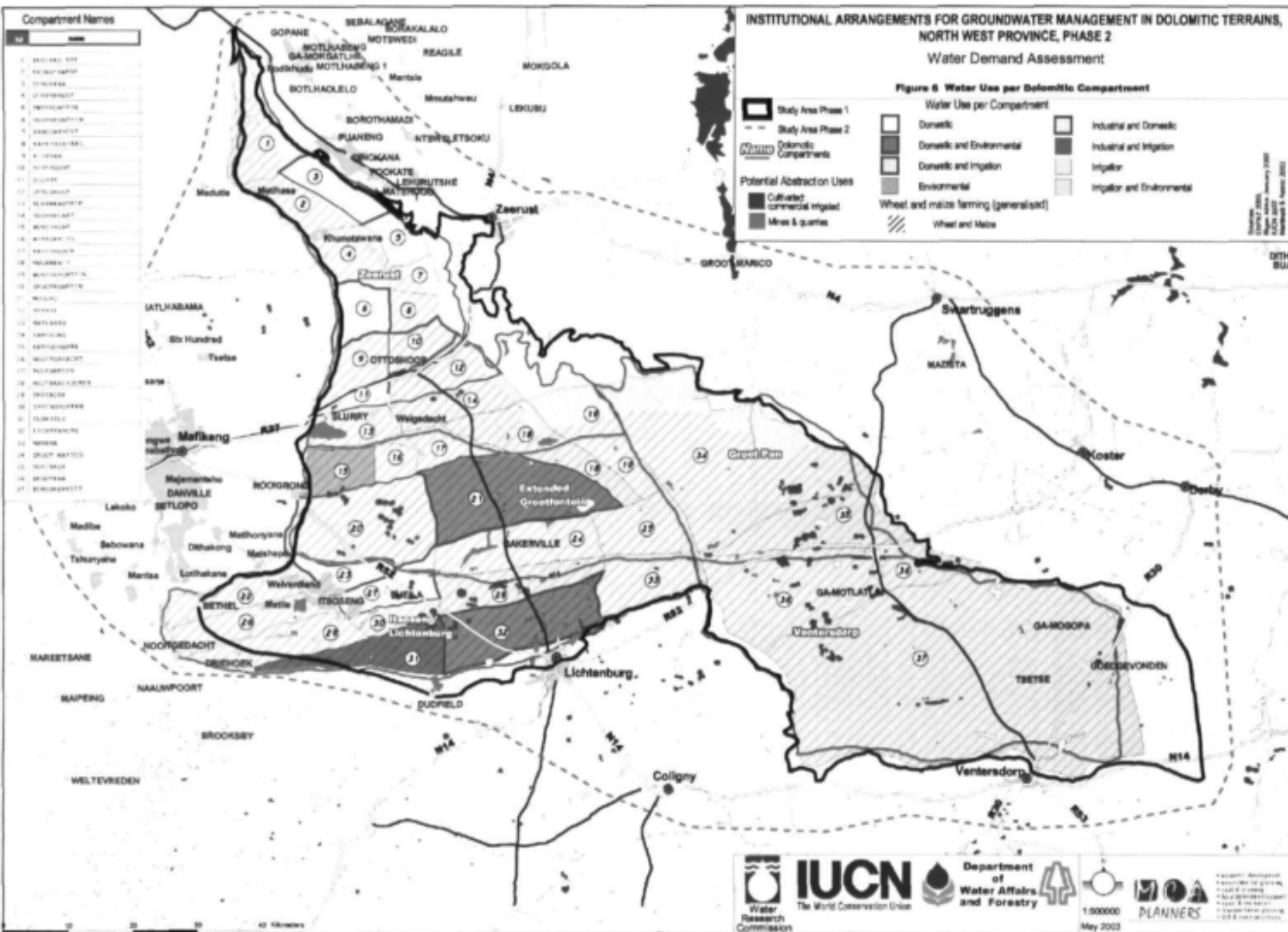
Water Demand Assessment

Figure 5 Livestock Districts



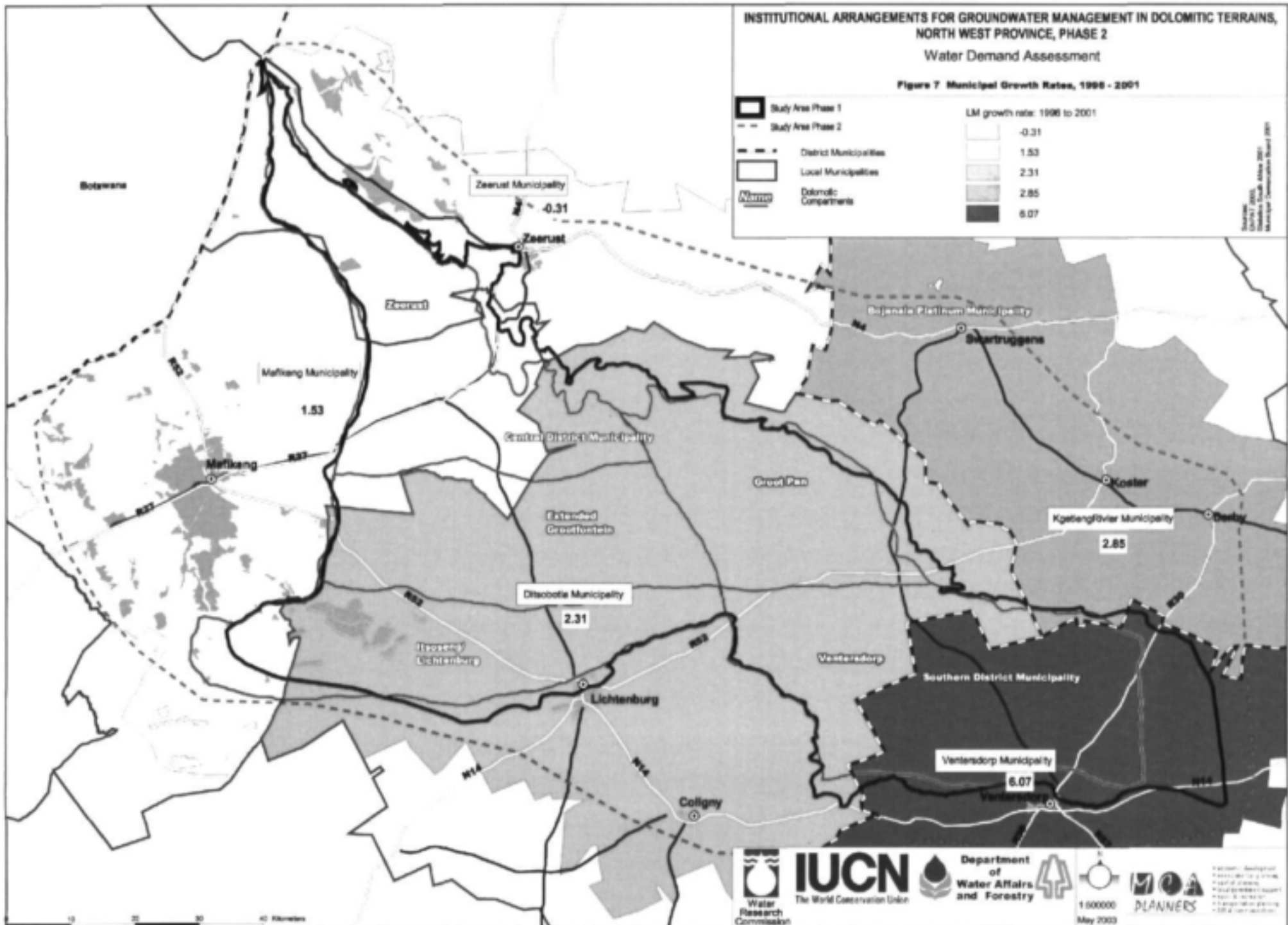
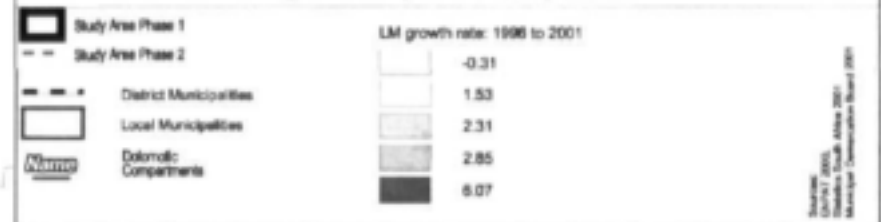
INSTITUTIONAL ARRANGEMENTS FOR GROUNDWATER MANAGEMENT IN DOLOMITIC TERRAINS,
NORTH WEST PROVINCE, PHASE 2

Figure 6 Water Use per Solomitic Compartment



INSTITUTIONAL ARRANGEMENTS FOR GROUNDWATER MANAGEMENT IN DOLOMITIC TERRAINS,
NORTH WEST PROVINCE, PHASE 2
Water Demand Assessment

Figure 7 Municipal Growth Rates, 1996 - 2001



IUCN
The World Conservation Union



Department
of
Water Affairs
and Forestry



1:600000
May 2003



PLANNERS

Water Demand Assessment

Study Area Phase 1
-- -- **Study Area Phase 2**
Local Municipalities
Dokomo
Dokomo Compartments
Provincial Spatial Development Initiative

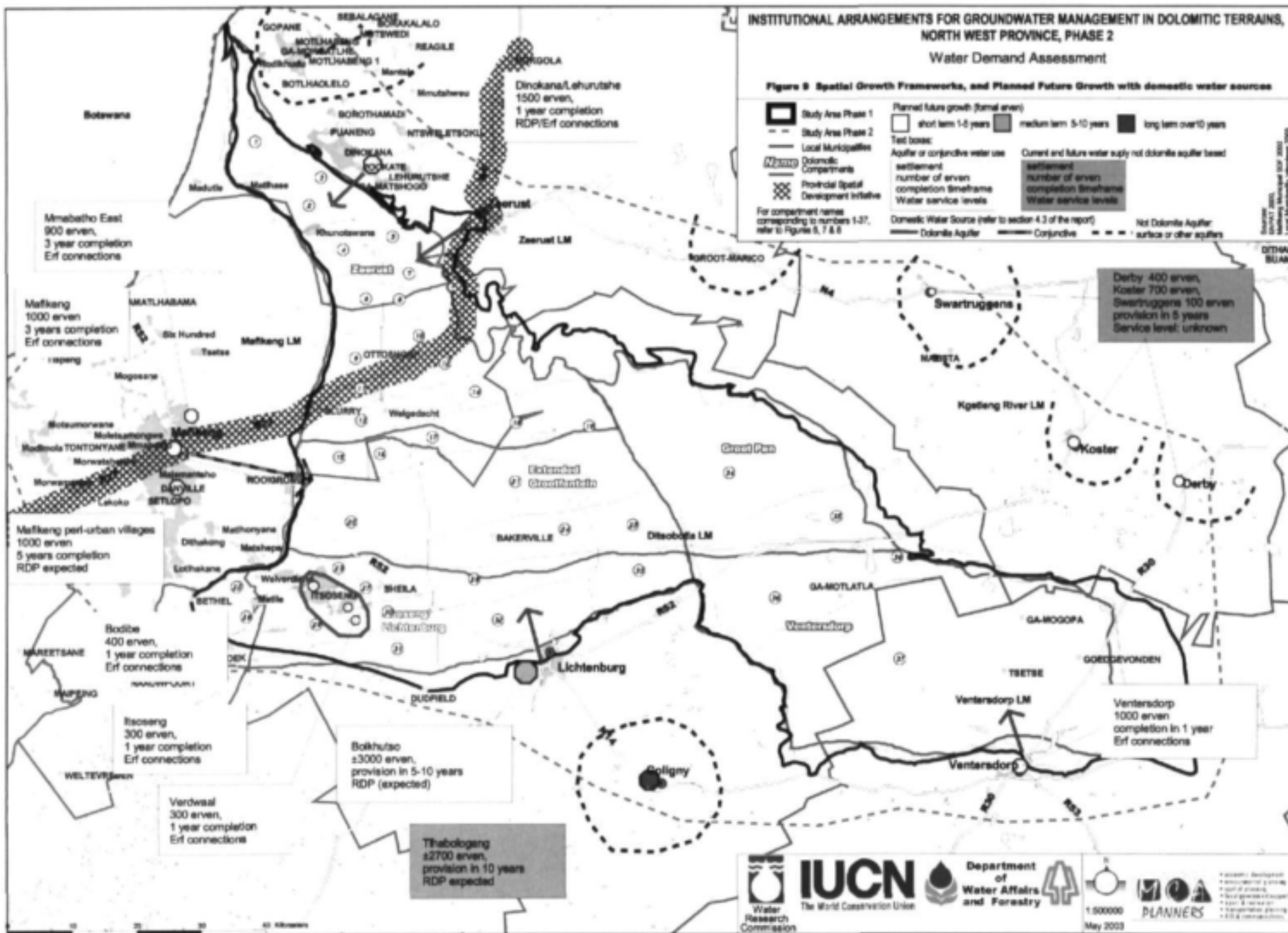
Planned future growth (formal erven)
□ short term 1-5 years ■ medium term 5-10 years ■ long term over 10 years

Test boxes:
Aqulifer or conjunctive water use
settlement
number of erven
completion timeframe
Water service levels

Current and future water supply not dokomo aqulifer based
settlement
number of erven
completion timeframe
Water service levels

Domestic Water Source (refer to section 4.3 of the report)
■ Dokomo Aqulifer ■ Conjunctive ■ Not Dokomo Aqulifer
surface or other aqulifer

For compartment names corresponding to numbers 1-37, refer to Figures 6, 7 & 8

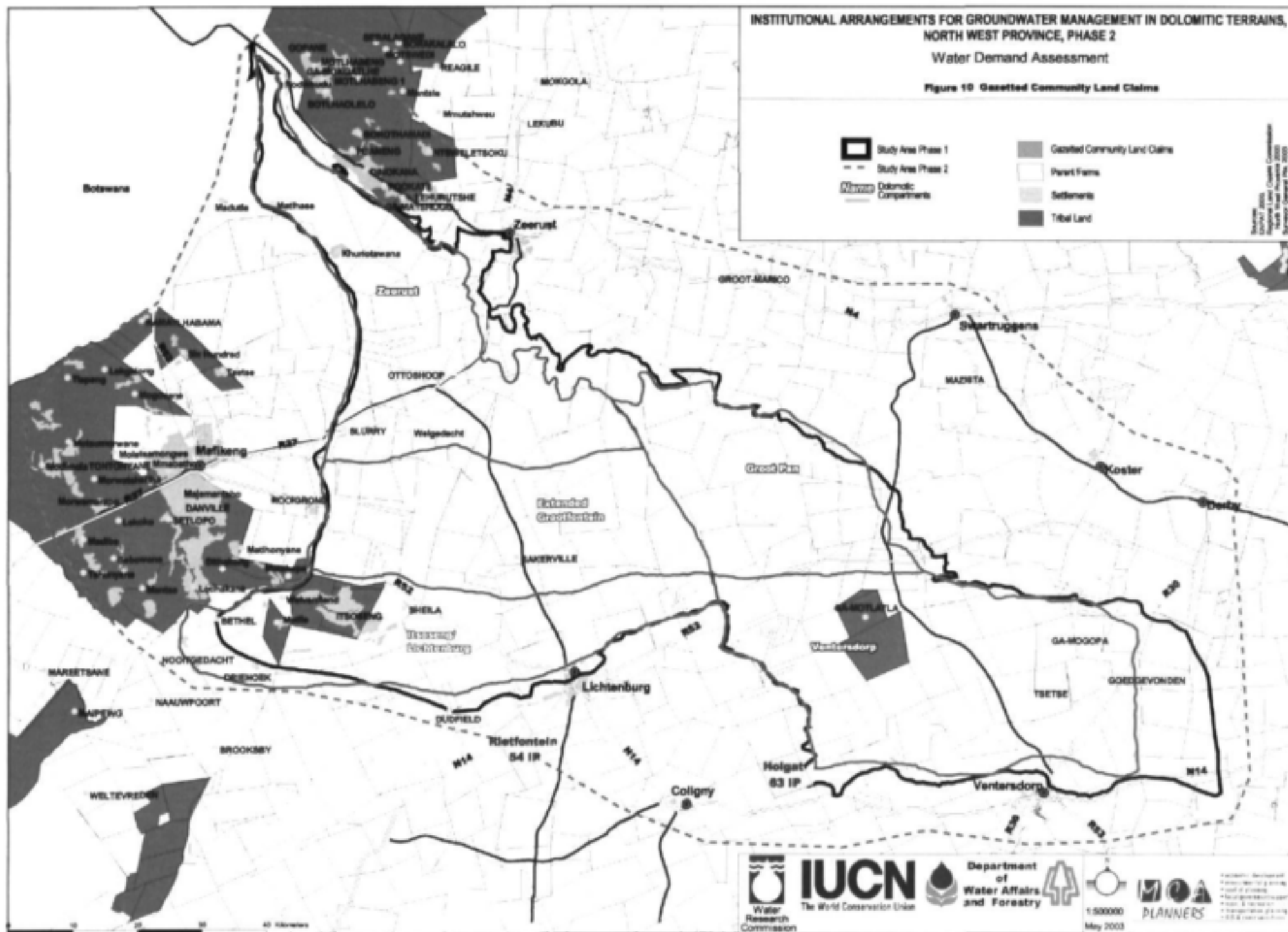


Water Demand Assessment

Study Area Phase 1
Study Area Phase 2
Dakotomic
Compartments

Gazetted Community Land Claims
Parent Farms
Settlements
Tribal Land

Source:
Lipshitz, 2000.
European Land Claims Commission
Held in Amsterdam 2000
Lipshitz, George M., 2000



8 ANNEXURE 2: Additional Sources Consulted

Source	Contact Number	Information anticipated	Result
Botshelo Water: Faan Janse van Rensburg	083 377-3388	Livestock information	deferred to AGIS
AGIS: Hein Lindemann	012 319-7548	Agricultural Land Use, Livestock information	none exists other than Land Cover – being updated till 2004 – livestock spreadsheet received.
Statistics SA: Kevin Perry, Ilse van Reenen	082 334-6795	Agricultural Census 1993, Census 2001	received census 2001, not AgriCensus. Also more detailed village names and locations received.
Provincial Land Claims Commission: Robertha van Schalkwyk	018 392-3080	Follow up information: number of claimants to be resettled	Not available yet, is being verified
Institute of Soil Climate and Water	012 310-2622	Agricultural Information (digital)	none, other than livestock potential, farming suitability (not useful)
Agricultural Research Council: Johan Karstens	012 427-9800	Agricultural Information (digital)	None, apart from farming feasibility studies
National Department of Agriculture	012 319-6000	Agricultural Information (digital)	None: deferred to AGIS
DWAF NW: Paul van der Merwe	083 628-5515	Water Services	deferred to Bigen Studies
University of the North West: Theunis de Klerk	018 389-2111	coverages of LandSat7 analysis used in Bigen Study	(unreachable)
Martinelli & Associates: Graham Hubert	082 853-2120	water use and abstraction	deferred to Bigen study; made Coligny (PMA) study available and shapefile of dolomitic compartments.
Bigen Africa: Bill Bosman	018 381-0500	Phase 2 study (March 2002)	received, and confirmed level of information available.
AgriCo Machinery: Theo Andrag	082 566-7199	pivot sales, location of pivots	interview conducted. No locational information is available.
ESKOM: Adri de la Rey	083 262-3389	HELP database	received but partial coverage around Mafikeng only (rest of info is being updated at present)
Farm IT Solutions (Open Spatial Solutions): Pieter Schoeman	011 324-3800	agricultural information	none exists for the study area (apart from land cover). A project is underway to map all

			maize areas in the NW, FS, NC provinces, but end date is undeterminable.
Local Municipalities: Engineering and Planning Departments	(see Annexure 5)	Planned township extensions, levels of future water service provision, water consumption and source of water	Interviews conducted and information received in various levels of detail

9 ANNEXURE 3: Table of water compartments, 5 major water units and associated crop coverages (summer + winter 2001)

Major Water Unit	Compartment Number	Compartment Name	Summer (Ha) crops	Winter (Ha) crops	Ttl Compartment Area	Summer Coverage (%)	Winter Coverage (%)
Zeerust	1	SKILPAD EYE			9955 315		
Zeerust	2	KHUNOTSWANE			6767 309		
Zeerust	3	DINOKANA			6346 613		
Zeerust	4	OLYVENBULT	32 186	24 29	6631 832	0.5	0.4
Zeerust	5	TWEEFONTEIN			4012 076		
Zeerust	6	DOORNFONTEIN			5743 62		
Zeerust	7	VANGGATBULT			2819 367		
Zeerust	8	KAFFERSKRAAL			3241 409		
Zeerust	9	KLIPPAN			6369 818		
Zeerust	10	RIETPOORT			4342 189		
Zeerust	11	SLURRY	15.15	11.43	2388 088	0.6	0.5
Zeerust	12	OTTOSHOO	14.47	10.92	7330 811	0.2	0.1
Zeerust	13	BUHRMANSDRIF			5699 283		
Zeerust	14	DOORNPLAAT	219.99	166.007	7318 774	3.0	2.3
Zeerust	half 18	MALAMANIE	13 555	6 26	5732 714		
Zeerust	half 19	WONDERFONTEIN			5808		
Extended Grootfontein	15	WONDERGAT			6257 746		
Extended Grootfontein	16	WITKOPPIES			3359 693		
Extended Grootfontein	17	KAREEBOSCH			4348 175		
Extended Grootfontein	half 18	MALAMANIE	13 555	6 26	5732 714	0.2	0.1
Extended Grootfontein	half 19	WONDERFONTEIN			5808 206		
Extended Grootfontein	20	GROOTFONTEIN	843 66	636 62	20377 37	4.1	3.1
Extended Grootfontein	21	MOLOPO			21855 64		
Itsooseng / Lichtenburg	22	BETHEL			8966 7		
Itsooseng / Lichtenburg	23	MATLABES			4273 602		
Extended Grootfontein	24	ZAMEKOMS	141.7	106 92	12745 02	1.1	0.8
Extended Grootfontein	25	KATDOORNPAN			9284 351		
Itsooseng / Lichtenburg	26	NOOITGEDACHT			8938 182		
Itsooseng / Lichtenburg	27	POLFONTEIN	243.84	480	5714 065	4.3	8.4
Itsooseng / Lichtenburg	28	HOUTHAAALBOOMEN	564.33	749.2	10317 2	5.5	7.3
Itsooseng / Lichtenburg	29	DRIEHOEK			9687 79		
Itsooseng / Lichtenburg	30	SPRINGBOKPAN	226.04	170.57	3653 664	6.2	4.7
Itsooseng / Lichtenburg	31	DUDFIELD	218.11	367.63	9961 149	2.2	3.7
Itsooseng / Lichtenburg	32	LICHTENBURG	611.71	572.66	16017 76	3.8	3.6
Itsooseng / Lichtenburg	33	MANANA	201.33	112.55	9885 219	2.0	1.1
Groot Pan	34	GROOT MARICO	734.57	505.1	47069 57	1.6	1.1
Groot Pan	35	DORINKOP	927.33	834.14	13799 13	6.7	6.0
Ventersdorp	36	GROOTPAN	1653.73	1007.16	31716 04	5.2	3.2
Ventersdorp	37	SCHOONSPRUIT	1209.9	1112.13	109598.1	1.1	1.0

10 ANNEXURE 4: Detailed Census Tables with levels of access to water services

Table D.1 depicts the levels of access to water as per the 1996 census, for the study area at Local Municipality level.

Table D.1 1996 Census (Ward Level) and Levels of Access to Water Services

Municipality	Population		Access to Water								
	Persons	Hseholds	In Dwelling	On Site	Com. Tap (1)	Borehole	Tanker (2)	Natural (3)	Other	Unspe c.	Flush Toilets
Ditsobotla	121557	24827	10163	5347	4831	3114	386	302	499	186	9084
Kgetleng River	27325	6395	2042	1383	1891	821	97	123	12	29	2372
Mafikeng	227747	49111	16454	7474	7909	12159	717	572	3561	265	13070
Ventersdorp	24986	5326	1425	1161	2174	257	222	62	3	21	1159
Zeerust	81386	15461	2849	1199	9443	1247	181	387	106	47	3213
Total	483001	101120	32933	16564	26248	17598	1603	1446	4181	548	28898

Notes: (1) includes within 200m distance (RDP standard) and more than 200m distance

(2) includes "water vendor" definition in 2001 census

(3) includes "dam/pool/stagnant water, springs, rivers/streams, rain water tank" definition

Table D.2 aggregates the levels of access to water services into RDP standard and above and below RDP standard.

Table D.2 1996 Census: Summary of Levels of Access to Water

Municipality	Hseholds	RDP standard and above		Below RDP standard	
Ditsobotla	24827	20341	81.9%	4487	18.1%
Kgetlengrivier	6395	5316	83.1%	1082	16.9%
Mafikeng	49111	31837	64.8%	17274	35.2%
Ventersdorp	5326	4760	89.4%	565	10.6%
Zeerust	15461	13491	87.3%	1968	12.7%
Total	101120	75745	74.9%	25376	25.1%

Table D.3 depicts the levels of access to water as per the 2001 census, for the study area at Local Municipality level.

Table D.3 : 2001 Census and Levels of Access to Water Services

Municipality	Population		Access to Water							
	Persons	Hseholds	In Dwelling	On Site	Com. Tap (1)	Borehole	Tanker (2)	Natural (3)	Other	Unspec
Ditsobotla	136290	33513	9905	9533	8048	4521	309	400	789	8
Kgetlengrivier	31448	8907	2002	4237	2004	101	66	147	348	3
Mafikeng	245661	64497	16216	14622	13098	13538	2798	931	3294	0
Ventersdorp	33548	8778	1774	3802	2901	72	21	96	112	0
Zeerust	80117	18932	2570	7395	7844	268	74	110	668	3
Total	527063	134627	32467	39589	33895	18500	3268	1684	5210	14

The detail categories of access to water and comparisons census year on census year are indicated below:

Table D.4 Rates of Change (Census interval 1996 - 2001) all Levels of Access to Water

Municipality	Population		Access to Water							
	Persons (*)	Hse-holds (*)	In Dwelling	On Site	Com. Tap (1)	Borehole	Tanker (2)	Natural (3)	Other	Unspec.
Ditsobotla	2.31%	6.18%	-0.51%	12.26%	10.75%	7.74%	-4.35%	5.78%	9.60%	-46.72%
Kgetlengrivier	2.85%	6.85%	-0.39%	25.10%	1.17%	-34.25%	-7.41%	3.63%	96.07%	-36.48%
Mafikeng	1.53%	5.60%	-0.29%	14.36%	10.62%	2.17%	31.30%	10.23%	-1.55%	-100.00%
Ventersdorp	6.07%	10.51%	4.48%	26.78%	5.94%	-22.45%	-37.60%	9.14%	106.11%	-100.00%
Zeerust	-0.31%	4.13%	-2.04%	43.89%	-3.64%	-26.47%	-16.38%	22.24%	44.50%	-42.32%
Total	1.76%	5.89%								

Notes: (*) Annualised Growth Rate; rest: simple growth rate
 (1) includes within 200m distance (RDP standard) and more than 200m distance
 (2) includes "water vendor" definition in 2001 census
 (3) includes "dam/pool/stagnant water, springs, rivers/streams, rain water tank" definition

Table D.5 Aggregated Rates of Change (Census interval) water access

Municipality	Population		Access to water		
	Persons(*)	Hseholds	Above RDP	RDP	Below RDP
Ditsobotla	2.31%	6.18%	4.62%	10.75%	6.08%
Kgetlengrivier	2.85%	6.85%	12.74%	1.17%	-9.29%
Mafikeng	1.53%	5.60%	5.20%	10.62%	3.55%
Ventersdorp	6.07%	10.51%	16.61%	5.94%	-11.85%
Zeerust	-0.31%	4.13%	19.74%	-3.64%	-10.62%
Total	1.76%	5.89%	7.80%	5.25%	2.48%

11 ANNEXURE 5: Telephonic Interviews with Municipal officials

Respondent	Position	Organisation	Contact number	Date of interview
Mr Dirk Lombard	Water Services Engineer	Ditsobotla Municipality	082 821 3657	8 Sept 2003
Mr Piet Breedt	Municipal Engineer	Kgetleng River Municipality	014 543 2005	8 Sept 2003
Mr Marks Jordaan	Consulting Engineer	Moedi Consulting Engineers	014 592 8504	9 Sept 2003
Mr A Dube	Deputy City Engineer	Mafikeng Municipality	018 389 0382	9 Sept 2003
Eric Rakumakwe	Water Engineer	Botshelo Water	082 447 5008	9 Sept 2003
Vernon Olivier	Plant Manager	Rooigrond water Plant	082 807 5383	12 Sept 2003
Mr Terreblanche	Town engineer	Ventersdorp Municipality	018 264 2051	15 Sept 2003
Mr Patrick Gidiyang		Zeerust Municipality	018 642 1095 082 808 9219	15 Sept 2003
Mr Wessel Bester	Municipal Planner	Kgetleng River Municipality	014 543 2006 082 511 1469	15 Sept 2003
Rinie Olivier	Planner (consultant for Ditsobotla Municipality)	Urban Dynamics North West	018 381 4230	15 Sept 2003
Ms Petro Naude	Member of Mayoral Committee	Mafikeng Municipality	018 381 7956 082 559 7210	17 Sept 2003

APPENDIX B

Situational Analysis for the preparation of Institutional
Arrangements for Groundwater Management in the
North West Dolomitic Water Areas

PHASE 2: SITUATION ANALYSIS

GEOHYDROLOGICAL ASSESSMENT

by

Dr David Bredenkamp, WREM

Anthea Stephens (Project Manager)

IUCN South Africa
P.O. Box 11536
Hatfield, Pretoria

Tel: 012 342-8304
Fax: 012 342-8289

TABLE OF CONTENTS

TABLE OF CONTENTS	1
LIST OF FIGURES	2
LIST OF TABLES	3
1 INTRODUCTION	3
1.1 Background to the study	3
1.2 Aims	3
1.3 Complementary studies	4
2 STUDY AREA	6
3 RESEARCH METHODS	9
3.1 Volume of Groundwater in Storage	9
3.2 Estimating Recharge	10
3.2.1 Chloride method	10
3.2.2 Bicarbonate method	10
3.2.3 Groundwater balance method	10
3.2.4 Equal volume flow method	10
3.2.5 CRD and MA Method	11
3.3 Estimating Storativity and Thickness	11
3.3.1 Groundwater balance method	11
3.3.2 Pumping test method	11
3.3.3 CRD/MA Methods	11
3.4 Estimating Transmissivity	11
3.5 Estimating Abstraction	12
3.6 Summary and Conclusions	14
4 RESULTS	16
4.1 Rainfall	16
4.2 Recharge	16
4.2.1 Chloride method	16
4.2.2 Bicarbonate method	17
4.2.3 Water Balance Method	18
4.2.4 CRD and MA Recharge Estimates	18
4.2.5 Discussion of recharge results	22
4.2.6 Rainfall-recharge relationships	23
4.3 Storativity and Transmissivity	23
4.3.1 Pumping tests interpretations	23
4.3.2 CRD/MA Results	24
4.4 Abstractions	28
4.5 Groundwater Quality	30
5 GROUNDWATER MANAGEMENT	31
5.1 Conceptual model of the aquifer and drainage of groundwater	31
5.1.1 Definition of Conceptual Model	31
5.1.2 Geohydrology	32
5.2 Water Balance and Groundwater Utilization per Groundwater Units	40
5.2.1 Zeerust groundwater unit	43
5.2.2 Grootfontein/Molopo Unit	43
5.2.3 Lichtenburg-Itsooseng Unit	44
5.2.4 Grootpan Unit	44
5.2.5 Schoonspruit groundwater Unit	45
5.2.6 Sustainable abstraction	46
5.3 Groundwater monitoring	47
6 CONCLUSIONS AND RECOMMENDATIONS	48
6.1 Conceptual model	48
6.2 Resource Assessment and Management	48
6.3 Delineation of Groundwater units and regional drainage	49
6.4 Present exploitation	49
6.5 Monitoring	50
6.6 Institutional Aspects	50
7 REFERENCES	51

LIST OF FIGURES

Figure 1: Map of the NW dolomite showing the network of dykes that subdivide the aquifer into smaller compartments.....	6
Figure 2: Positions of monitoring boreholes.....	13
Figure 3: Correlation between rainfall and distances separating stations.	16
Figure 4: Relationship of recharge versus rainfall based on the Chloride method applied to dolomitic spring waters.....	17
Figure 5: Graph showing the relationship between the bicarbonate concentrations of spring waters in relation to recharge coefficients that have been derived by the Chloride method.....	17
Figure 6: Regional values of the recharge that have been derived from the CRD/MA simulations of the groundwater level series.	20
Figure 7: The flow of the Schoonspruit eye with pumping which had to be introduced to obtain a good simulation between the measured and simulated groundwater levels.....	21
Figure 8: Graph showing the correspondence between the measured flows of Buffelshoek eye and those simulated by the new recharge formula.....	22
Figure 9: Exponential recharge in relation to the rainfall over the preceding 24 months which has yielded the best simulation of the Wondergat levels (see Appendix A).....	23
Figure 10: Decline of storativity with the MA-inferred depth of the aquifer.	25
Figure 11: Decline of storativity values in relation to the MA-inferred thickness of the aquifer.	26
Figure 12: Regional storativity and thickness of the NW dolomitic aquifer as derived from the CRD/MA simulations of the groundwater level series.	27
Figure 13: Contours of the main abstractions from the NW dolomite region. (Abstractions at the springs indicated in red.).....	29
Figure 14: Temporal changes in the water quality of the Buffelshoek and Wonderfontein eyes.	30
Figure 15: Litho-stratigraphical sequence of the dolomite indicating the thickness of the different formations.....	32
Figure 16: Simplified conceptual presentation of the NW dolomitic area.	33
Figure 17: Drainage of the groundwater levels in relation to the different dolomitic formations.	36
Figure 18: Water level contours indicating the drainage of groundwater over the entire NW dolomitic area. These contours smooth out the sharp steps that occur over some of the dykes.....	37
Figure 19: Topographical relief of the dolomite aquifer of the NW Region, which determines the regional groundwater drainage as shown in Fig. 18.....	38
Figure 20: Map showing the groundwater units and points where springs ooze from the dolomite.	40
Figure 21: Water levels of the Wondergat plotted in relation to the monthly recharge percentage derived from Equation 3.	41
Figure 22: Temporal fluctuations of water levels and spring flows of the Zeerust groundwater unit for natural and maximum sustainable yield of 40 mil cub m per annum as indicated in Table 4.....	43
Figure 23: Temporal fluctuations of water levels and spring flows of the Grootfontein/Molopo groundwater unit for natural and maximum sustainable yield of 38 mil m ³ per annum. (See Table 4).....	43
Figure 24: Temporal fluctuations of water levels and spring flows of the Lichtenburg/Itsoeseng unit for natural and maximum sustainable yield of 37.3 mil m ³ per annum (Table 4).	44
Figure 25: Temporal fluctuations of water levels and spring flows of the Grootpan groundwater unit for natural and maximum sustainable yield.....	45
Figure 26: Measured flow of the Schoonspruit eye in comparison to the simulated natural flows and the flows at maximum exploitation.....	45

LIST OF TABLES

Table 1: Different methods to estimate aquifer parameters.....	14
Table 2: Typical values of the storativity (S) and transmissivity (T) of the different Dolomitic Formations of the NW Region (Nel and Bredenkamp, 1997).....	24
Table 3: Recharge, storativity and inferred aquifer thickness of the different formations and units of the NW dolomitic region based on the CRD/MA interpretations.....	24
Table 4: Comparison of components of the groundwater balance of the different groundwater units of the NW dolomite.....	46

1 INTRODUCTION

1.1 Background to the study

A geohydrological assessment of the North West (NW) dolomitic aquifer is part of a larger project exploring the institutional arrangements for the management of this important resource. Its holistic management is especially important for an area with little surface water. According to Parson's criteria (1995) for strategic importance and quality of the groundwater, this dolomitic resource has the highest rating. Yet its holistic management is compromised by the fact that it straddles three water management areas. Given this institutional conundrum and the aquifer's importance, this is an ideal opportunity to design institutional arrangements that may help to resolve similar challenges elsewhere.

The relevance of the geohydrological assessment is two-fold. Firstly, such an assessment would help to identify resource management issues that needed to be addressed. There is a strong sentiment that unless there is a pending crisis in the use of the resource such as over extraction or pollution, support for and actualisation of its holistic management may never transpire. Secondly, should water management be devolved to a local level, local users and managers must have a thorough understanding of the functioning of the aquifer - they must be able to appreciate how their use of the resource affects it and be able to adjust their behaviour accordingly.

This report presents the findings of Phase Two, which is a continuation of the situational assessment that took place during the first phase of the study (Stephens and Bredenkamp 2002).

1.2 Aims

The present investigation has selected and applied different methods to determine both aquifer parameters and the impact of groundwater abstraction. Among the aquifer parameters or characteristics explored were recharge, storativity and transmissivity, drainage and water quality. This information was then compiled into a conceptual model, which could form the basis of a hydrodynamic model (to be discussed in Section 1.3). This information was also adapted for a handbook on the aquifer, which is part of the management methodology i.e. an understanding of the aquifer functioning will contribute significantly to the devolution of management to a local level.

The impact of abstraction, and whether this is sustainable or not, was also calculated. This is extremely important to know as it highlights whether there is mismanagement of the resource and how it should be remedied in quantitative terms.

In addition, the team interacted with DWAF officials and members of the public, communicating information on the resource – mainly on its functioning – and this too assisted in enhancing an appreciation for the aquifer and the need for its holistic management.

1.3 Complementary studies

Over the years, much hydrogeological information has been gathered through commissioned studies and historical monitoring programmes. However, many of the studies were un-coordinated and localized investigations failing to consider the broader implications for the aquifer. In an effort to plug the holes in knowledge and develop a detailed picture of the entire aquifer through the development of a hydrodynamic model, the Dolomite Project Coordination Committee has been established to oversee and provide guidance on:

- The coordination of all of groundwater management functions in dolomitic terrains;
- Resource assessment studies;
- Allocation of water permits and institutional arrangements;
- Protection of ecosystems;
- Management of information i.e. monitoring functions and storage of data;
- Adjudication of projects to ensure that the maximum benefit can be derived, with minimal duplication of effort and optimal use of financial resources.

Current studies of the NW dolomitic aquifer

A co-ordination consultant¹ has been appointed by DWAF to assist with the process of co-ordinating studies relating to the aquifer. This has involved identifying gaps in knowledge, co-ordinating existing projects and outlining future projects. Current studies underway on the NW dolomitic area include:

- 1) A detailed geohydrological study of the Zeerust dolomitic area by a consortium of consultants² and the compilation of a hydrodynamic model.
- 2) The current IUCN project (WRC 1324), and
- 3) The geohydrological study of the Schoonspruit area by the Free State Regional office of DWAF³ - the latter project addressing the requirements for the establishment and guidance of a Water Users Association for that aquifer (Veltman 2003).

IUCN's key contribution to the North West Dolomitic Water Are Resources Management Project is the development of the aquifer handbook which will convey fundamental knowledge of the aquifer to local users and managers and this will lay the ground for the introduction of the hydrodynamic model, which is an essential management tool. This model would allow for the testing of different scenarios of

¹ Graham Hubert of EMA Consultants – appointed co-ordinator.

² The PMA consortium comprising of EMA, VSA and Aquisim (Van Rensburg).

³ A methodology for groundwater management in dolomitic terrains with the Schoonspruit compartment as pilot area. MSc study by Veltman (2003). This study has been completed in December 2003 and is an excellent contribution and an essential complementary study to the IUCN project.

recharge and management of the resource and assess the significance of trans-boundary flows between different groundwater units. Importantly, it would assist in refining the groundwater management boundaries both for Water User Associations and Water Management Areas. As important as this model may be as a management tool, exposure to it without first understanding aquifer functioning may intimidate and even alienate stakeholders.

Another useful contribution made by this study is that it has refined methods to determine aquifer parameters and these may then be applied by the other studies for the estimation of recharge and aquifer storativity. This information has been used to put forward a conceptual model of the NW dolomite aquifers.

2 STUDY AREA

The NW dolomitic area extending from the boundary of Botswana to Ventersdorp in the East has provisionally been divided into five groundwater units (Fig. 1). The physiography and geological controls have been depicted in the previous report (Stephens and Bredenkamp 2002). Catchment Management Associations (CMAs) and Water Users Associations (WUAs) will be involved in the management of the different units. This however, means that five management structures will be responsible for controlling the exploitation of groundwater from the aquifer that crosses boundaries between the units. The delineation of the different groundwater units might have to be adjusted in view of new information and modelling currently being generated. Important information regarding compartmentalizing and trans-boundary flow is expected from the modelling of the Zeerust area. Shifting the boundaries of the groundwater units has also been postponed pending the outcome of a detailed study and modelling of the entire NW dolomite basin.

North-West Dolomitic Aquifers

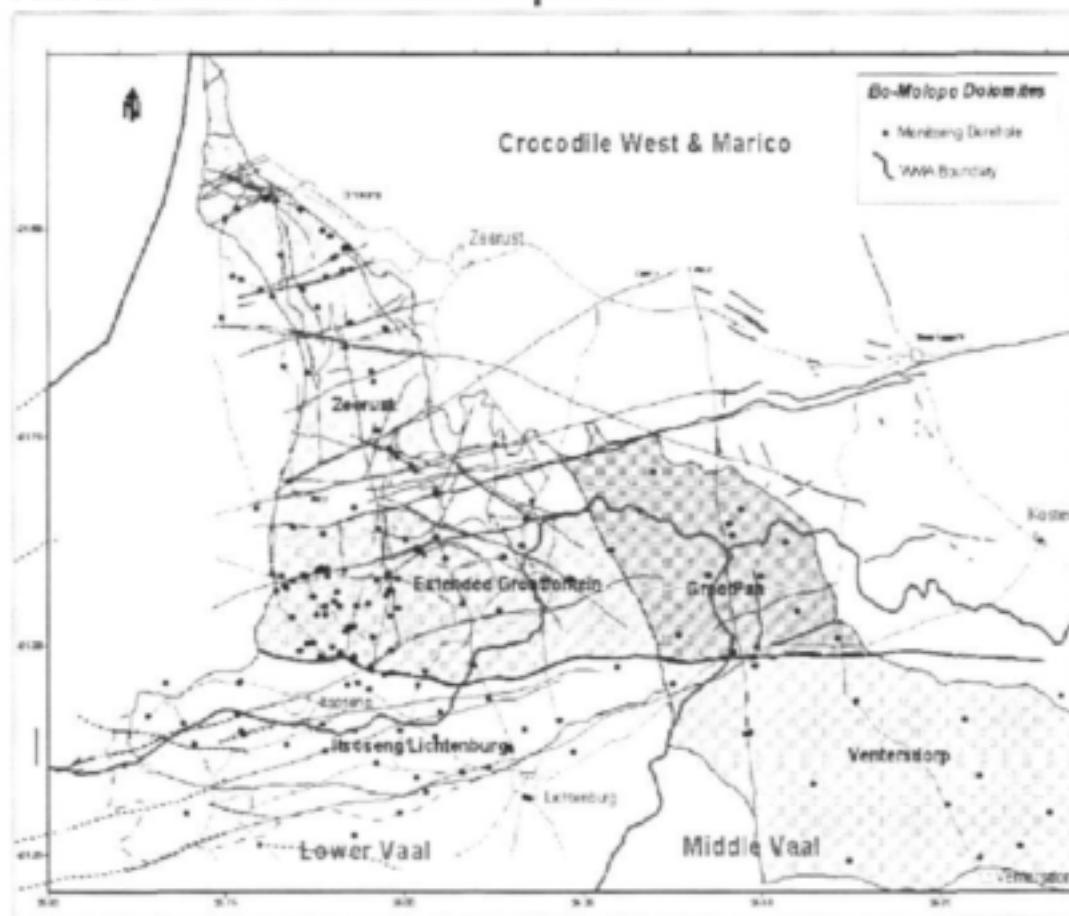


Figure 1: Map of the NW dolomite showing the network of dykes that subdivide the aquifer into smaller compartments. Positions of monitoring points are also shown.

Several smaller compartments have been grouped into groundwater units that could form logical areas of control and management.

The information gathered from previous studies of the Grootfontein, and the present studies of Zeerust and Schoonspruit have been comprehensive and can therefore be used to compile a simple conceptual model of the NW dolomite. For the NW dolomitic aquifer system the integration of all information into a conceptual model is essential to understand the intricacies of recharge and the flow dynamics of dolomitic aquifers. Stakeholders requiring a basic understanding of hydrogeological aspects and groundwater interactions with rainfall and abstractions can use this model.

A detailed hydrodynamic model of the aquifer would supersede a simulation tool such as the CRDIMA method, although the latter is a simple but still effective tool for the practical management of the groundwater resources at the lower institutional levels.

The devolution of the control of groundwater of the NW dolomitic aquifer to local stakeholders and the establishment of an appropriate institutional framework for ensuring equitable and sustainable utilization of the resources requires a basic understanding of the factors controlling the resource. Hence this part of the IUCN study was focussed on the technical evaluations and requirements to improve the reliability of the assessment of the resource. These specifically include an assessment of:

- Rainfall and its impact on water levels – the rainfall being the primary factor causing recharge.
- Groundwater levels to establish drainage and their fluctuations over time to determine aquifer characteristics e.g. recharge and storativity.
- Spring-flows in relation to rainfall and groundwater levels.
- Aquifer storativity and thickness. Storativity is the portion per unit volume of the aquifer that could store groundwater. Storativity and depth determines the reserve storage that could be relied upon in years of prolonged droughts
- Regional drainage systems.
- Transmissivity, which is a measure of the rate of flow of groundwater to lower-lying areas, to springs and to points of abstraction. Interpretation of pumping tests and modelling of the aquifer can determine transmissivity.
- Recharge of the aquifer and its delineation in relation to geological boundaries. The recharge is the portion of the rainfall contributed to the groundwater in storage.
- Water quality ingredients as an indicator of recharge - Chloride and Bicarbonate method – see Beekman and Xu (2003) whereas the temporal changes serve as a check on changing recharge, ambient quality and occurrences of pollution.

These parameters have facilitated:

- Compiling a conceptual model of the aquifer (see section 5.1)
- Demarcating logical boundaries of groundwater to form the interim basis for setting up institutional structures.
- Developing a simulation of the natural spring flows of the aquifer and derive the recharge. Identify the constraints and impact of abstraction, water quality and pollution.

- To contribute to the compilation of a hydrodynamic model that can simulate the effects of rainfall, abstraction, pollution and other factors on the aquifer.
- To establish the basis for effective allocation/revisions of licences to abstract groundwater and the control thereof as well as managing the aquifer.

The model and evaluation of simple methods are essential for decision concerned with determination of a reserve storage, allocating water rights to farmers, industry and for domestic use while ensuring sustainable water resources and minimizing environmental impacts.

All relevant data and assessments have been incorporated in Appendices in the electronic version of the report.

3 RESEARCH METHODS

A selection of methods is briefly presented here and greater detail can be found in the latest recharge manual (Beekman and Xu 2003). Hydrogeological studies of this kind benefit from intercomparison of results from various methods. Where possible the aim was to obtain comparable results simply and reliably.

By estimating the average storativity and aquifer thickness the volume of groundwater in storage could be determined. However, in order to estimate storativity, recharge was established first.

Table 1. Relevant information obtained from previous studies in the North-West dolomitic area.

Reference	Storativity	Recharge per annum	Comments
Recharge of a dolomitic aquifer as determined from tritium profiles (Bredenkamp et al., 1974)	0.03	25 – 35 mm 5,3% of Rain	Bo Molopo area Recharge underestimated
Initial simulation of the Grootfontein aquifer (Cogho et al., 1982)	0.025 – 0.05	46 mm 8,2% of Rain	Recharge derived from simple soil moisture model CI, SVF and regression methods
Estimation of the Zeerust/Rietpoort groundwater model (Botha, 1993)	0.025 – 0.05	22-123 mm 4%-22% of Rainfall	Highly variable soils
Chloride profiles in soil cover (Bredenkamp, 1993)	0.023		SVF method
Simulation of Grootfontein compartment (Bredenkamp et al., 1987)	0.024	8% -14% of Rainfall	
Marico dolomite (Polivka 1987a) Schoonspruit dolomite (Polivka 1987b)		71 mm 13% of Rain	Derived from spring flow
Grootfontein – Bo Molopo aquifer (Bredenkamp, 1999)	0.023	49 mm 8,7% of Rain	Interpretation of hydrographs-CRD method

3.1 Volume of Groundwater in Storage

The volumes of groundwater stored in the different groundwater units are calculated from the average storativity and thickness of the different dolomitic formations as inferred from the CRD and MA interpretations of hydrographs. The S values of the dolomitic formations vary as the depths of leaching are not uniform and storage varies spatially and are different for each formation.

3.2 Estimating Recharge

The following practical methods could be used to determine the recharge of an aquifer reliably. Greater detail on these methods may be found from Beekman and Xu (2003).

3.2.1 Chloride method

Recharge can be established by determining the ratio between the chloride concentrations of rainfall and groundwater. Application of this method to individual borehole quality data will yield point values of recharge. Estimates are obtained from the interpretation of spring water representing recharge that is integrated in time and space (Beekman and Xu, 2003). This method is particularly suitable for application in dolomitic aquifers because the chloride of the rainfall is concentrated in the groundwater on account of the recharge processes in accordance with the hydrology. Insignificant amounts of chloride are added from the dissolution of the dolomite. The recharge processes are different depending on the local conditions of soil type, outcrops, topography and vegetation. Spatial differences in recharge are, however, evened out by smoothing that occurs during infiltration, high transmissivities and drainage of the groundwater to lower areas.

3.2.2 Bicarbonate method

Recharge can be determined from the bicarbonate concentration of the groundwater, which is controlled by imbalances in the uptake of carbon dioxide generated in the root zone of vegetation during the infiltration of rainfall to recharge the aquifer (Bredenkamp 2000). The recharge relationship initially has to be calibrated against known estimates of recharge and could then be used in similar aquifers elsewhere. Based on recharge estimates obtained from spring flows, the bicarbonate concentrations conform to a linear relationship as is indicated by Fig. 5 in Section 4.

3.2.3 Groundwater balance method

This method involves using a simple water balance based on water level fluctuations of individual boreholes, or which is applied to the combined response of several monitoring boreholes over of an area. The water balance equation for a period dt is:

$$I - O + Re - Q = S \cdot dV/dt$$

I	= Inflow
O	= Outflow
Re	= Recharge
Q	= Abstraction
S	= Storativity
dV	= Change in saturated volume

Bulk estimates of recharge and can be calculated from the saturated volume fluctuations of groundwater levels integrated over an area according to the Saturated volume fluctuations (SVF integration) for periods of equal volume (EV method) i.e. $dV = 0$ which eliminates S from the equation above. The storativity could be derived as is indicated in 3.3.1. $(I - O)$ could be assumed to be zero.

3.2.4 Equal volume flow method

Rather than using the EV method the recharge could be derived from interpretations of periods of equal flow of springs as they respond to the recharge integrated over an effective area. If the spring flows have not been affected by abstraction, the recharge would be equal to the discharge of the spring plus the abstraction during identified equal EV periods. These are used to obtain a rainfall-recharge relationship for the

aquifer if the recharge area of the aquifer is known. The area could be inferred from a simulation of the spring flows by means of the MA method.

3.2.5 CRD and MA Method

The CRD and MA method, which has been a main focus in this study, is a simple yet effective method to derive recharge and other characteristics of an aquifer. The recharge (Re) of the aquifer is derived based on an interpretation of individual hydrographs. If it is applied to a series of groundwater levels, point-values of the parameters are derived. If applied to the spring flows or integrated water level fluctuations, bulk average values are obtained.

Special software has been developed for DWAF to facilitate the application of the CRD/MA methods (Bredenkamp and XU, 2002) and certain improvements have been added to make it user-friendly. The method is formulated in Beekman and XU (2003) and the software appears on CD in Appendix A.

3.3 Estimating Storativity and Thickness

3.3.1 Groundwater balance method

The storativity can be calculated from the groundwater balance if the recharge of the aquifer has been determined reliably. Also applying the SVF water balance for consecutive 12 month periods can also yield the storativity. In this case, the storativity for each period comprises the actual storativity of the aquifer and includes a component representing the recharge during the specific 12-month period. The latter component diminishes as the rainfall of the 12-month period declines. The actual storativity is obtained by plotting the apparent storativity values against the rainfalls during each 12-month period. The true S value of the aquifer is that value corresponding to zero recharge. In this way an integrated bulk average storativity of 0.023 for the Grootfontein spring compartment has been obtained (Van Rensburg, 1995).

3.3.2 Pumping test method

Interpretations of pumping test data using appropriate software as developed by Van Tonder and Xu (1999) could be used to obtain the aquifer storativity. The values in this case, however, represent localized aquifer conditions in close proximity around the borehole. More representative S values could be derived if the water levels of a more distant observation borehole are used, rather than measurements within the pumping borehole. This method has not been applied in the present study but should be used to check the validity of the CRD and MA results and validating the decrease of storativity with depth (see 3.3.3).

3.3.3 CRD/MA Methods

The thickness of the aquifer can be estimated by calculating the following:

- Total depth of the aquifer below surface, which can be inferred from the MA simulation
- Average depth of the saturated aquifer below the surface, derived from the CRD simulations.

3.4 Estimating Transmissivity

The transmissivity of an aquifer and hydraulic gradient determine the rate of flow through an aquifer. The piezometric gradient increases sharply over dykes, which have a low transmissivity. Transmissivity is usually derived from pumping tests.

Although only point values are obtained they could be used as initial values in a hydrodynamic model and could then be adjusted until the best regional simulation of the groundwater levels has been obtained. Transmissivity has not been determined in this study.

3.5 Estimating Abstraction

In the absence of measured abstraction data, indirect methods have to be used to derive this component of the groundwater balance. Large abstractions for municipalities and communities are usually metered, but pumping for irrigation not. However it could be inferred from the areas that are irrigated and the water demands of the various crops that are cultivated. This method has been applied in the Schoonspruit area to determine the irrigation abstraction (Schoeman and Partners).

In the present study, the abstraction was obtained from the CRD/MA interpretations of the water levels of monitoring boreholes spread throughout the aquifer. The distribution of the monitoring points is shown in Fig. 1 and 2. The quantity, distribution of monitoring boreholes and length of series determine the reliability of the regional estimations of abstraction. The reliability of the abstraction data was checked against pumping records/estimates from different sources (see Appendix B on CD attached) e.g.:

- 1) Available electrical consumption of the pumps in the Grootfontein compartment (Van Rensburg, 1987). For periods without electricity records, the abstraction was derived from an inverse relationship between the rainfall of the previous 12 months and the abstractions (see Fig. B1 in appendix).
- 2) Measured pumping by Lichtenburg municipality for the period 1994 to 2002 supplied by the municipality (Fig. B3).
- 3) Surveys by Schoeman and Partners (for the years 1994, 1998 and 2002) of the areas and types of crops being irrigated in the Schoonspruit unit (See Appendix B for details of these comparisons)

The inferred abstractions do not include the natural outflow of springs should they still be flowing. The groundwater levels sustain their flows and extraction thus reduces the spring discharge. The impact on the flow is proportionally greater in smaller sub-compartments bounded by dykes that restrict the inflow of water over a larger area.

North-West Dolomitic Aquifers

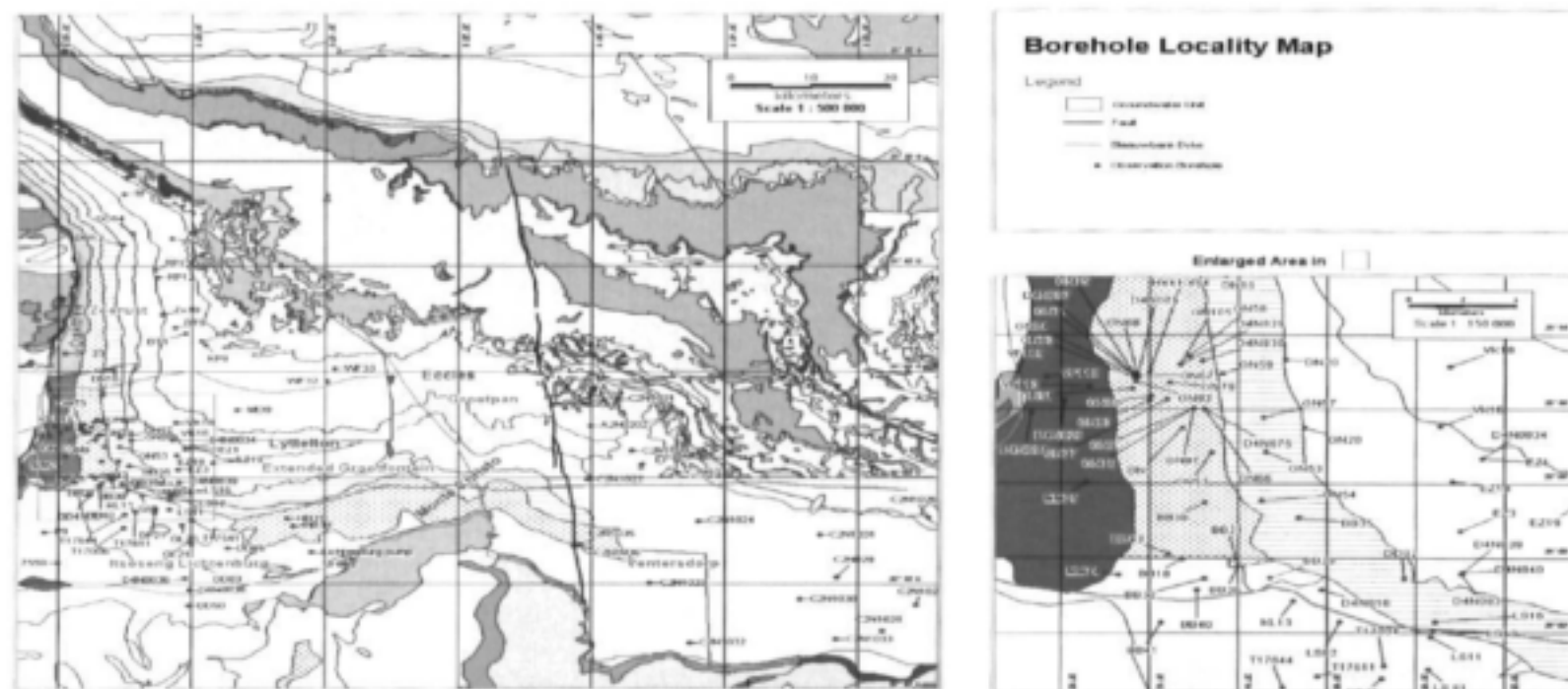


Figure 2: Positions of monitoring boreholes

3.6 Summary and Conclusions

Table 2 shows the different methods that have been used to determine the characteristics of the aquifers and it summarizes the main features of the methodologies. The results obtained are discussed in section 4 and the methodologies in Beekman and Xu (2003).

Table 2: Different methods to estimate aquifer parameters.

Parameter	Method applied	Comments
Recharge (Re) coefficient	1. Chloride method $Re = Cl_{rainfall}/Cl_{groundwater}$	Independent method to be applied in dolomite. Chloride concentration of rainfall to be measured or estimated from regional relationship. Best applied to chloride concentration of springs
	2. Bicarbonate method $Re = f(HCO_3)$	Recharge coefficient is linearly but inversely related to the bicarbonate concentration of the groundwater. Requires calibration.
	3. Water Balance method	Solving the water balance equation.
	4. Equal volume method Applied groundwater level fluctuations	Elimination of S from equation. Yield integrated values for a delineated compartment.
	5. Equal flow method	Special case of the water equal volume method – storativity eliminated from the equation.
Recharge (Re) & Storativity S	1. CRD and MA method $Re \& S = f(CRD)$ $Re \& S = f(MA)$	Applied to spring flow data Also applied to monitored series of groundwater levels.
Storativity S	1. Pumping test interpretations 2. Water balance	Yields point values if applied to water level series of individual boreholes. Solving for S with recharge included
Transmissivity - T	1. Pumping test interpretations	Solving the hydraulic equation governing flow in aquifer
Aquifer thickness	1. Interpretation of borehole logs	Yields point estimates
	2. CRD method – to derive top and bottom of the saturated aquifer MA method – will yield the total depth of the aquifer	Yield point estimates – better spatial values derivable from hydrodynamic modelling. Appears to be a reliable indirect method to estimate the aquifer thickness from the water level fluctuations.
Abstraction	1. Based on the areas irrigated and the water demands of crops	Requires surveying of irrigation areas and types of crops
	2. CRD and MA methods	Applicability depends on the availability of monitored groundwater levels and a good spread of such measurements.

On the whole, the dominant method in assessing aquifer parameters was the CRD/MA method. The successful application, however, relies on the reliable monitoring of relevant parameters such as rainfall and groundwater level fluctuations. Consistent aquifer parameter values have been obtained from an analysis of over 130 hydrograph data. The distribution of these monitoring points is shown in Fig. 2. Equally important is the monitoring of water quality in order to estimate recharge through the chemical characteristics of the groundwater.

The ability to estimate groundwater parameters through the CRD/MA methods allows for the simulation of groundwater levels and spring flows aided by a simple computer programme. This is a great advantage from a management perspective because it allows for the following:

- Deriving abstraction that has impacted the groundwater levels and natural conditions (see Fig. 14).
- The management impacts by simulations of groundwater levels and spring flow for different scenarios of recharge, rainfall fluctuations and abstraction (see Fig. 3 for water level simulation).

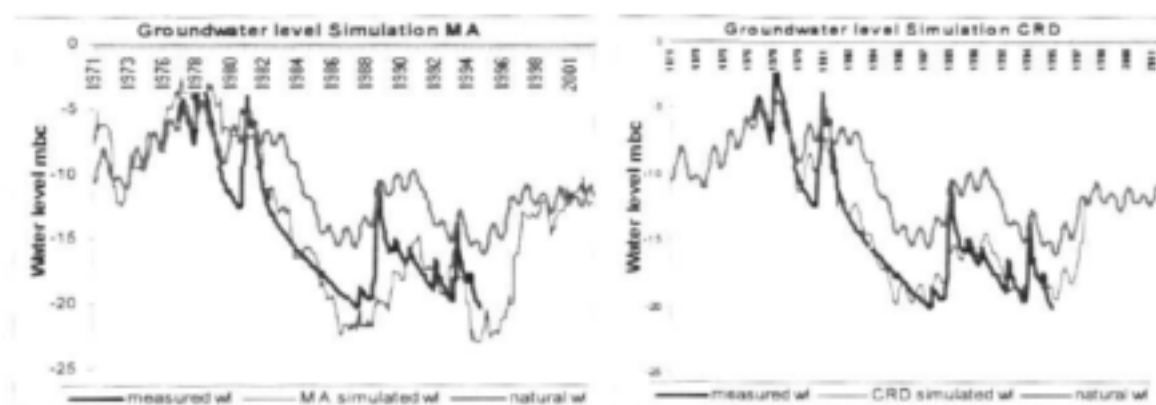


Fig. 3. Simulation of groundwater levels of borehole in the Zeerust area indicating the impact of abstraction and simulated natural levels.

RESULTS

The results obtained from the different methods to characterize the aquifer are essential for the determination of the exploitation potential of the groundwater resources of the area. It is also pivotal for water balance assessments, modelling and management of the aquifer.

3.7 Rainfall

The rainfall data from stations distributed over the area has been compared to establish the degree of correspondence between stations at different distances from each other. As expected, the highest correlations occur for stations that are in close proximity. The correlation coefficients in relation to the separation distance are shown in Fig. 4.

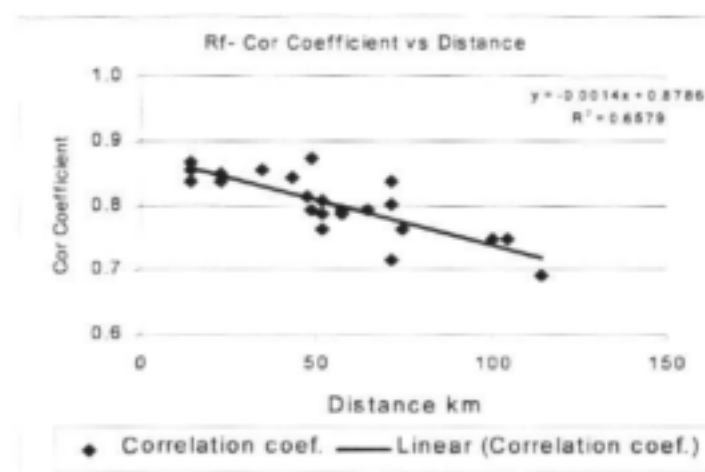


Figure 4: Correlation between rainfall and distances separating stations.

The correlation coefficient diminishes linearly but is still 0.7 at distances of 100 km. Thus fairly reliable interpretations by the CRD and MA methods could even be derived if rainfall data from as far as 50 km from the water level monitoring point are used and would allow interpolation of rainfall series if stations were in close proximity. At all times, it is preferable to have a good spatial distribution of rainfall stations and to maintain measurements at stations with long series of measurements rather than closing them.

3.8 Recharge

The recharge estimates are listed in Table 2 and have been grouped according to the methods that were used and the geological formations they present.

3.8.1 Chloride method

In view of springs representing recharge that is integrated in time and space, the chloride results of all the springs with water quality data, were derived. These results represent the average recharge in relation to the average annual rainfall. According to Fig. 5 the recharge increases exponentially as the average annual rainfall

increases. However it could also be represented by a linear recharge response in relation to rainfall in excess of an annual threshold value of 425 mm. The chloride concentration of the rainfall was derived from a regional relationship (Bredenkamp et al 1995) but it would have been more accurate to measure the chloride concentrations of actual rainwater samples collected over a minimum 12 months.

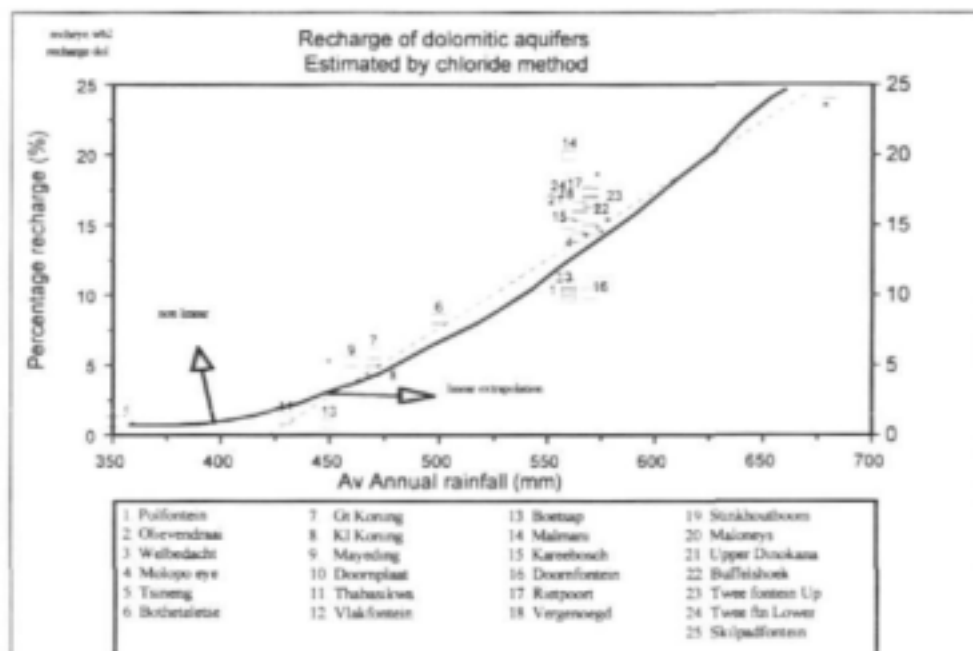


Figure 5: Relationship of recharge versus rainfall based on the Chloride method applied to dolomitic spring waters.

3.8.2 Bicarbonate method

This is a new method is derived from plots of bicarbonate concentrations of various springs in different climatic regions against rainfall (Bredenkamp, 2000), indicating that the bicarbonate concentrations of dolomitic groundwater are inversely related to the average annual rainfall of an area. Fig.6 has been compiled from known estimates of recharge obtained from spring water using the chloride method.

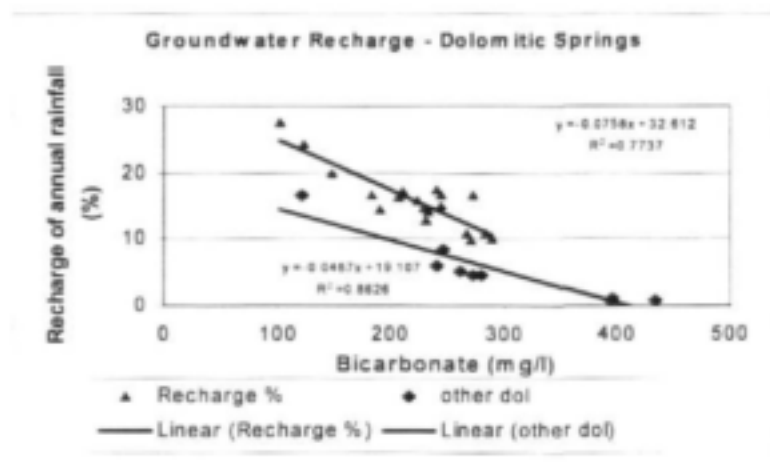


Figure 6: Graph showing the bicarbonate concentrations of spring waters in relation to recharge coefficients that have been derived by the Chloride method.

There is a different linear relationship for springs in the higher rainfall areas to those in lower rainfall regions. The regression lines fitted to the points indicate that the minimum recharge occurs for bicarbonate concentrations in the order of 440 mg/l. On the other end of the scale zero-bicarbonate concentrations indicate a maximum recharge of 32% for the higher rainfall set and 19 % for the lower rainfall regime. The high values represent a theoretical maximum recharge, which in practice could only occur during optimal rainfall and very favourable infiltration conditions i.e. probably in small flooded depressions. The recharge relationship is based on the following premises:

1. In areas of high rainfall the rate of infiltration would be higher and faster allowing less time for an equilibrium to set up between the biogenic CO₂ generated at the root zone of the local vegetation, and the dissolved carbonate from the aquifer matrix (Bredenkamp, 2000). Thus the bicarbonate concentrations would be low.
2. In lower rainfall areas the movement of infiltrating water to recharge the underlying aquifer is a slow process. Hence the larger contact time between the water dissolving the dolomite rock, and the biogenic CO₂ originating from the root zone of plants, effects a higher concentration of bicarbonate. Further increases of bicarbonate concentrations probably occur by evaporation. As is indicated the recharge for bicarbonate concentrations of about 440 mg/l correspond to almost zero recharge. At these concentrations the bicarbonate becomes supersaturated and precipitation of carbonates could occur. Although bicarbonate concentrations of 500 to 600 mg/l could be obtained in natural groundwater e.g. in the Kalahari aquifer (Severn area), such high bicarbonate concentrations are probably caused by evaporation losses from the aquifer without triggering the precipitation of carbonates.
3. Once properly calibrated the bicarbonate method could potentially be applied to all types of aquifers where carbonate could be dissolved during the recharge process. This usually applies to semi-arid regions.

The method would be more reliable as the concentrations of bicarbonate could be determined more accurately than the low chloride concentrations. For some aquifers e.g. Karoo Formations, there is chloride added from the aquifer matrix, which would yield unreliable recharge values. In such cases the bicarbonate method would be independent of this constraint and its application in different formations should be further investigated.

3.8.3 Water Balance Method

The ordinary groundwater balance equation (Beekman and XU, 2003)) has not been applied, as the results are inferior to that which had been obtained by the other methods. However, from the monthly spring flow series the equal-flow version of the water balance has been applied for various springs using EXCEL-software developed by Xu (2003). An exponential recharge relationship has been obtained for the Schoonspruit eye although the discharge response is not as pronounced because the recharge is a function of the average rainfall over a period of 72 months. In the case of Buffelshoek it is a function of the average recharge over 24 to 36 months. (See 4.2.3).

3.8.4 CRD and MA Recharge Estimates

The recharge results of the CRD and MA simulations are grouped into the following two sets of results

- 1) CRD recharge estimates derived from the simulation of groundwater hydrographs of individual monitoring boreholes. The best simulations have been obtained having introduced a low and high recharge component. This applied if the monthly rainfall exceeded a low and a high threshold value. For cases where the rainfall is higher than the high threshold the lower recharge component would automatically also apply. The outcome of these recharges for all the monitoring boreholes is shown in Fig. 7. It shows a surprisingly uniform recharge coefficient despite lithological differences in the geology and overburden material. The recharge in relation to the underlying formations is discussed in section 4.3.5.
- 2) MA simulations of spring flows using a modified recharge relationship. For this the recharge coefficient is weighted according to the ratio of rainfall over a shorter period relative to a long-term period. This weighted recharge coefficient is then used in equation 3 representing the MA equation without pumping.

North-West Dolomitic Aquifers

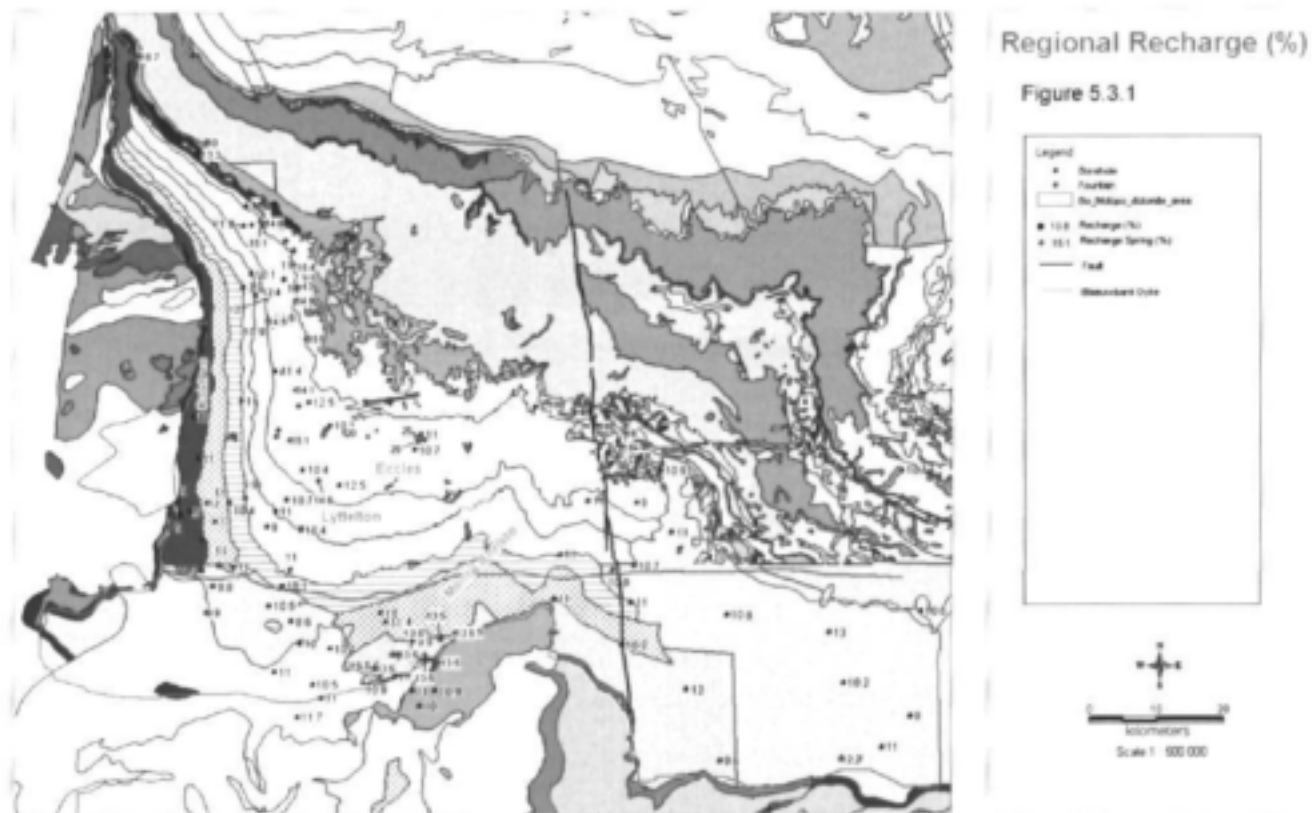


Figure 7: Regional values of the recharge that have been derived from the CRD/MA simulations of the groundwater level series.

The simulation has been further improved by the addition of a higher recharge coefficient that applies when the average rainfall over a characteristic period is exceeded. Thus a low and a high rainfall threshold have to be exceeded for the respective recharge components to occur. According to Equation 3 the recharge can be represented by the following relationship:

$$Rc(i) = b \frac{Rf_{36}}{Rf_{longterm}} (Rf_{72} - Rf_{threshold}) + p.(Rf_{72} - d) \dots \dots \dots \text{eq. 3}$$

Where

b = the normal recharge coefficient that applies to monthly rainfalls that exceed the threshold value.

$Rf_{36}/Rf_{longterm}$ = a weighting factor.

For Schoonspruit $b = 0.122$

p = the high recharge coefficient that applies to monthly rainfalls of the preceding 72 months that exceeds the high cut-off value $=d$.

From the simulation of Schoonspruit eye

$k = 0.48$ and $d = 42$ mm/month and

$Rf_{threshold} = 14$ mm.

The outcome of the MA simulation according to eq. 3 has been most successful as is indicated by Fig. 8 applied to the Schoonspruit eye discharge. Excellent correspondence can be seen up to 1992, which still represented close to natural conditions. However thereafter the irrigation abstractions have affected the flow of the spring. In section 4.5 the abstraction that has caused the diminishing flow has been quantified by the introduction of the abstraction component into equation 3.



Figure 8: The flow of the Schoonspruit eye with pumping, which had to be introduced to obtain a good simulation between the measured and simulated groundwater levels

3.8.5 Discussion of recharge results

The use of a weighted recharge coefficient stems from results published in the manual on recharge (Bredenkamp et al 1995), but the incorporation of a low and high recharge coefficient if the respective threshold rainfalls are exceeded, has been initiated from the preliminary results obtained by Van Rensburg (2003) as part of the modelling study of the Zeerust area. That study has obtained even higher fluctuating monthly recharges, which were then averaged to match the observed flows of springs. The responses were matched using different periods of averaging the rainfall with an exponential increase in recharge as rainfall exceeded a threshold value.

The surprisingly good simulations that have been obtained have prompted the application of equation 3 to simulate the groundwater level series. As is indicated in Fig. 9 an excellent simulation of the water levels of the Wondergat and Buffelshoek eyes has been achieved, though with different averaging rainfall periods.



Figure 9: Graph showing the correspondence between the measured flows of Buffelshoek eye and those simulated by the new recharge formula.

Excellent correspondence with the Wondergat levels is shown in Figure 9, with no lag incorporated.

Similarly a good simulation has been derived for the Dinokana flow data, which has also confirmed that the use of averaged rainfall values over longer periods could account for the lag in the response of the spring flows in relation to the water levels of the Wondergat. The latter levels respond to rainfall averaged over a shorter period (36 months) compared to a period of 120 months for the Schoonspruit eye.

Veltman (2003) has essentially adopted equation 3 with slight modification as the basis for effective management of the Schoonspruit groundwater unit, compiling Excel software that could be applied by the proposed WUA in view of its simplicity and good simulated results.

3.8.6 Rainfall-recharge relationships

It is common practice to express the average recharge coefficient in relation to the rainfall. In the simplest cases a linear relationship is assumed indicating that the recharge coefficient is constant but that monthly recharge increases as the rainfall increases. Application of equation 3 shows that an exponential relationship relative to the rainfall averaged over a longer period exists (see Fig. 10).

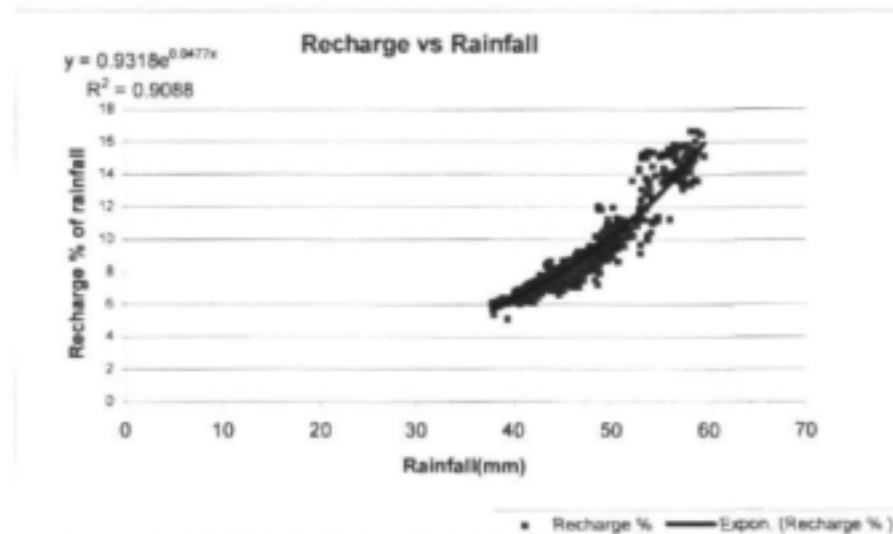


Figure 10: Exponential recharge in relation to the average rainfall over the preceding 24 months, which has, yielded the best simulation of the Wondergat levels.

The incorporation of a threshold rainfall value that has to be exceeded for recharge to occur, effectively produces the highly variable groundwater recharge and spring flow that occur if the groundwater levels are shallow. For springs being recharged from larger drainage areas and deeper circulation of groundwater, the highly fluctuating recharge events are evened out.

3.9 Storativity and Transmissivity

3.9.1 Pumping tests interpretations

Although storativity and transmissivity could be derived from pumping test interpretations, this method has not been applied. It will however produce point values of these parameters, which could be highly variable, whereas for the modelling of the aquifer and regional estimates of drainage, average values of recharge and storativity are required. Thus in view of previous modelling studies that have been conducted in the Grootfontein and Zeerust areas, the transmissivity values for the different geological units present a good comparison of the flow characteristics of the different formations and of the dykes, which act as partial boundaries (see Table 3).

As is evident from Table 3, the transmissivity and storativity of the Monte Christo and Eccles are the highest, which generally applies to all dolomite in this region.

Table 3: Typical values of the storativity (S) and transmissivity (T) of the different Dolomitic Formations of the NW Region (Bredenkamp, 1997).

Formation	Grootfontein T value m ² /d	Grootfontein S value	Zeerust T value m ² /d	Zeerust S value
Oaktree	35	0.025	87	0.01
Monte Christo	1200	0.08	1200	0.032
Lyttelton	1100	0.008	70	0.18
Eccles	3000	0.12	3000	0.18
Dykes	400	0.11	25	0.11

3.9.2 CRD/MA Results

The CRD/MA interpreted parameter values derived from the simulation of groundwater levels in the different groundwater units are indicated in Table 4.

Table 4: Recharge, storativity and inferred aquifer thickness of the different formations and units of the NW dolomitic region based on the CRD/MA interpretations.

Groundwater Units Formations	Zeerust AREA (km ²)	Grootfontein AREA (km ²)	Polfontein/ Lichtenburg AREA (km ²)	Grootpan AREA (km ²)	Schoonspruit AREA (km ²)
Oaktree	(2)	(7)			
Recharge	0.105	0.108			
S value	0.015	0.0095			
Aquifer thickness	18.5	45.7			
Monte Christo	(2)	(47)	(11)	(1)	(9)
Recharge	0.125	0.104	0.104	0.109	0.105
S value	0.04	0.014	0.012	0.028	0.03
Aquifer thickness	15.3	37.9	31.3	13.7	19.54
Lyttelton	(1)	(2)		(1)	
Recharge	0.12	0.109		0.11	
S value	0.022	0.017		0.044	
Aquifer thickness	7.45	22.3		10.5	
Eccles	(12)	(0)		(8)	(3)
Recharge	0.106			0.109	0.113
S value	0.034			0.035	0.029
Aquifer thickness	16.24			18.4	19.6

(X) = Number of CRD/MA interpretations in the respective unit

The average recharge of all the dolomitic formations is surprisingly uniform but the Eccles and the Monte Christo Formations have the highest storativity. Regional storativity values and inferred aquifer depths are plotted in Fig. 13.

Reliable and comparable characteristics of the formations in the different groundwater units will be derived once the detailed model of the entire NW dolomite has been completed. Information from all studies, however, indicates that groundwater occurrence is at its best in the Eccles formation followed by the Monte Christo formation and at its weakest in the Oaktree formation. This results from the karstification process of the Eccles and Monte Christo formations being higher as a result of higher infiltration and deeper penetration of rainfall to dissolve the carbonate of the dolomite. The higher infiltration is also related to surface depressions where runoff could collect as standing water. Both small and large-scale depressions constitute points of preferential recharge and dissolution of dolomite in the aquifer underneath.

The CRD/MA estimates of the aquifer storativity, recharge and depth are representative of the location of the monitoring boreholes. A plot of these shows the regional variability of the aquifer parameters. The storativity (S) plotted in relation to the inferred depth/thickness of the aquifer indicates that the storativity declines with depth and conforms best to a power function (see Figs.11 and 12). For example; for an aquifer of 1 meter thickness close to surface, the storativity values are as high as 0.36. At a depth of 100 m below surface the S value would be 0.005. The relationship is remarkably uniform across boreholes representing different dolomite formations. Validation of the relationship by another method is still required but could be tested by means of a 3-dimensional model of the aquifer. (Good simulations of groundwater levels have been obtained by Van Rensburg (2003) and previously by Bredenkamp (1999) using only a 2-dimensional model.

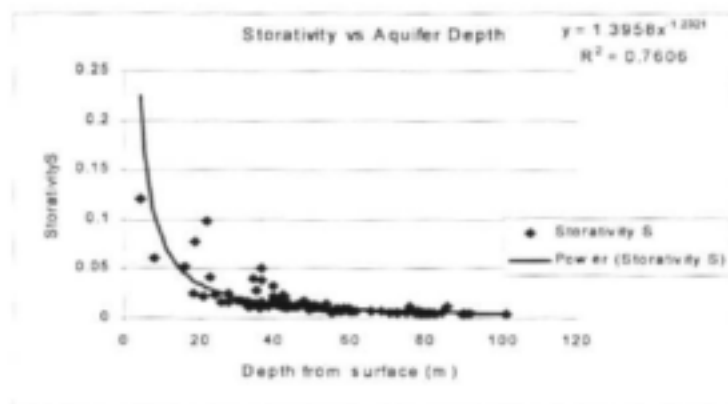


Figure 11: Decline of storativity with the MA-inferred depth of the aquifer.

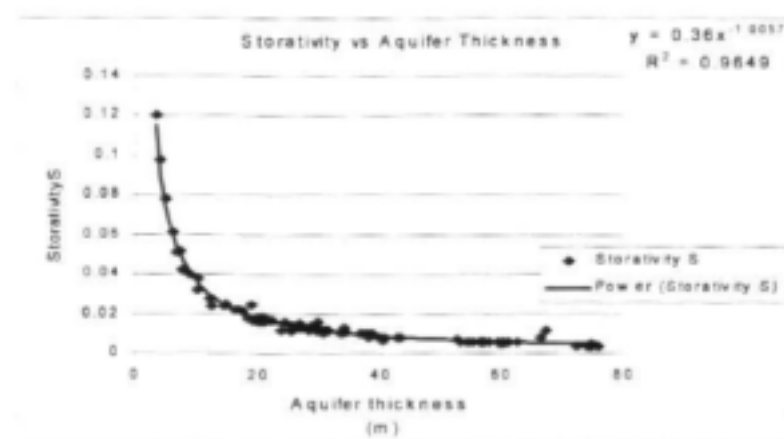


Figure 12: Decline of storativity values in relation to the MA-inferred thickness of the aquifer.

North-West Dolomitic Aquifers

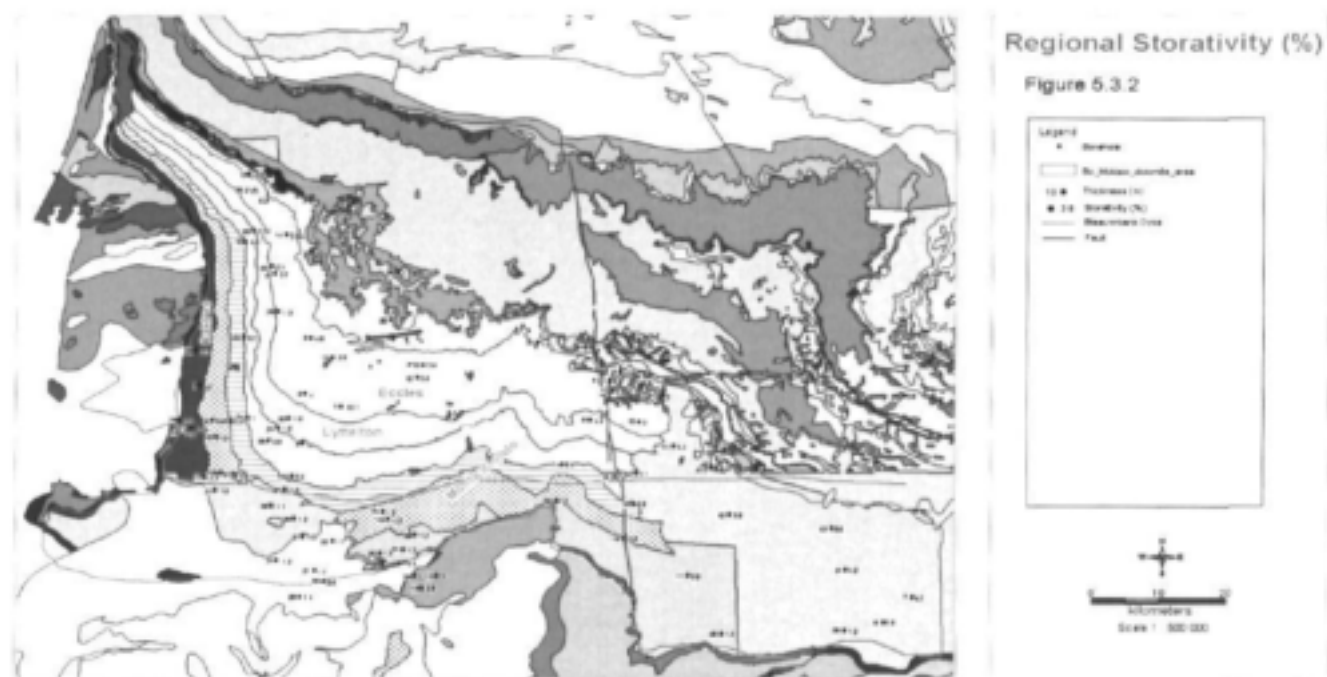


Figure 13: Regional storativity and thickness of the NW dolomitic aquifer as derived from the CRD/MA simulations of the groundwater level series.

Interestingly, if the *S* values are high the inferred aquifer depths are shallow and vice versa. The reason for this has not been fully resolved, however, in the author's opinion the response of the groundwater levels depends on the depth at which the main water strike has been intersected. The *S* values would thus correspond to the hydraulic pressure at that depth. Therefore at deeper levels the aquifer responds as if confined, thus yielding lower *S* values. If the water strikes are close to surface, higher storativity values are obtained, which correspond to unconfined conditions. At any locality the relationship between *S* and the aquifer depth indicates a sharp decline similar to that shown in Fig. 11 and 12. Although true *S* values could be derived from dewatering of the aquifer, this would only be representative of the dewatered zone.

3.10 Abstractions

Reliable estimation of abstraction is required to establish the water balance of the aquifer. In view of the abstraction being one of the components in the CRD/MA method much effort has been put into assessing the reliability of deriving it from these simulations (see Appendix B). An inverse relationship was established between the monthly abstraction by irrigation and the average rainfall over the preceding 12 months. A similar relationship for the town's abstraction appears to hold. In instances where CRD/MA abstraction simulations could not be obtained through lack of groundwater level-monitoring data, the relationship with rainfall has been used to obtain monthly rates of abstraction.

The reliability of the inferred abstraction values from the CRD/MA simulations is dependent on the distribution of monitoring points and the duration of the data series. Thus for the Grootfontein area with a dense coverage of monitoring data the inferred abstractions are reliable, but it is poorer in the Zeerust area where few monitoring points are available. In the Schoonspruit and Grootpan groundwater units, the estimates appear to be reliable as is evident from the pumping derived from the surveys of Schoeman and Partners in comparison to the CRD/MA interpretations (see Appendix B.). According to the CRD/MA pumping simulations the pumping figures for 2002 by Schoeman and Partners were too high.

The regional distribution of abstraction in 1998 over the NW dolomite aquifers is shown by the contoured values in Fig. 14. The contours - values in black/small font) are the abstractions (thousands of cub meters) , whilst those in red (larger font) indicate the flows at the various springs. The spring flows could have been affected, by pumping in the area. It is evident that the largest abstractions still occur at the springs, except for the high abstraction in the Grootpan area.

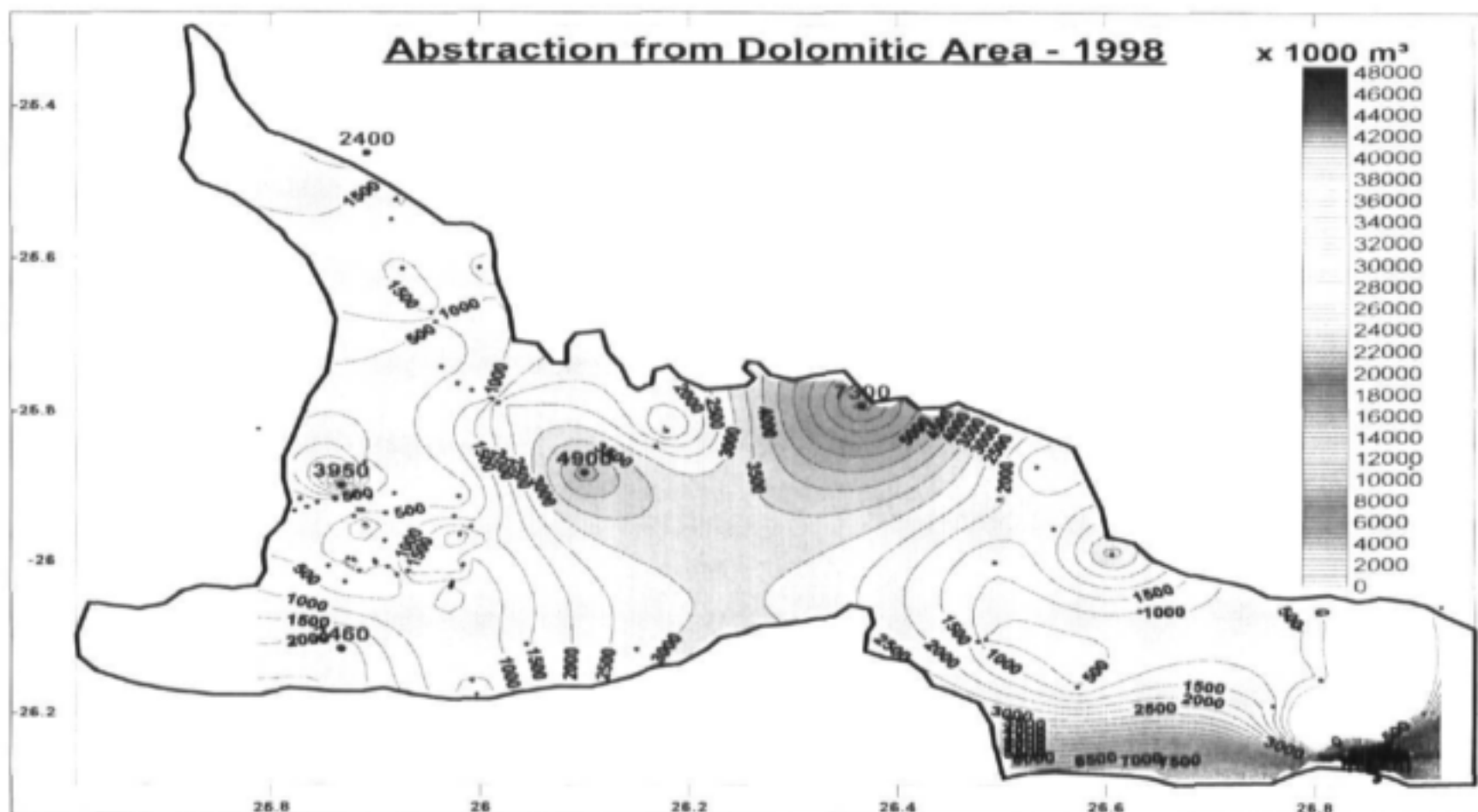


Figure 14: Contours of the main abstractions from the NW dolomite region. (Abstractions at the springs indicated in larger font.)

3.11 Groundwater Quality

The water quality derived from borehole samples has not been assessed, as this will be part of the larger study being co-ordinated by Graham Hubert of the PMA consortium. Instead, temporal series of some chemical ingredients of spring waters monitored over time has been considered.

Judging from this, the overall quality of the groundwater is good. These waters present an integrated sample of the recharge over the area feeding the springs. The time-series of chloride and bicarbonate concentrations of the quality of spring waters in most cases show that the water quality had not changed over many years in spite of large expansions of agricultural and irrigation in the area. An exception is the Renosterfontein eye, which clearly shows by pulses of chloride and sulphate concentrations that pollution had occurred although has mostly dissipated. However this spring is just outside the dolomite and is therefore not a typical example of the water quality of the dolomitic groundwater. For all other springs, the concentrations of the dissolved salts are low and have essentially remained constant over time.

Some interesting deductions could be made from the temporal variations of the different chemical signatures of the springs, most of which are discussed in Appendix A. In the case of Buffelsfontein eye (Fig. 15) stationary conditions of recharge is depicted. For Wonderfontein eye the slightly rising concentrations of bicarbonate indicate that changes in the recharge area must have occurred. This probably resulted from the increased irrigation in the recharge area which could also have changed the biological equilibrium of carbonate dissolution and thereby bicarbonate concentrations.

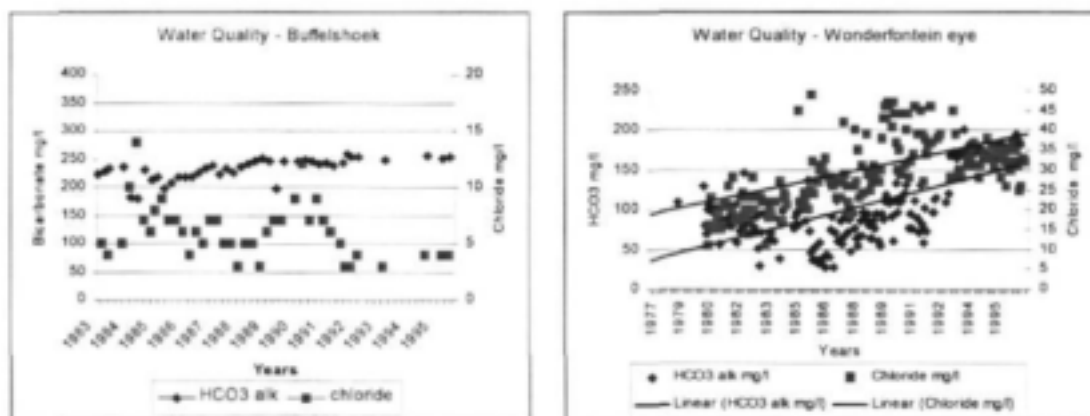


Figure 15: Temporal changes in the water quality of the Buffelsfontein and Wonderfontein eyes.

According to measurements of water from boreholes there are indications of local nitrate pollution in certain area e.g. in the Grootpan area (Veltman, 2003). This is attributed to cattle excretions at feedlots and drinking sites. More graphs of the temporal change in the bicarbonate and chloride concentrations appear in Appendix C.

4 GROUNDWATER MANAGEMENT

The basis for effective management of a resource requires the following:

- A conceptual model of the aquifer system, which is presented in Section 4.1;
- Reliable assessments of the aquifer characteristics e.g. recharge, storativity, depth, flow, drainage and water quality – discussed in Section 4;
- Different methods of addressing the groundwater balance and assessing impacts on the system e.g. water balances, CRD/MA simulations to hydrodynamic modelling of groundwater units within a regional aquifer; and
- The monitoring of hydrological parameters that is essential to the evaluation of the status and performance of the aquifer.

4.1 Conceptual model of the aquifer and drainage of groundwater

4.1.1 Definition of Conceptual Model

A conceptual model entails compiling a condensed assimilation and interpretation of geohydrological components and their interactions that controls the occurrence of groundwater and the sustained utilization of such a resource (Vegter 2001). Of significance is:

- **Occurrence:** Controlled by geological strata, tectonic deformations, intrusions and sedimentation, rendering capacity for groundwater to be stored underground and distributed by lateral flow.
High storage in the different dolomite formations resulting from the degree of dissolution of the dolomite by infiltrating rain water.
- **Recharge:** Being the process of rainfall infiltrating to be stored in the void space underground created within the geological matrix as 1) primary storage in alluvial sediments or 2) secondary storage caused by structural deformations or 3) matrix or chemical weathering of the geological formation. Although not the only it is an important component in the assessment of the sustainable yield of an aquifer.
- **Recharge controls:**
 1. Rainfall – volume, intensity, frequency and spatial/temporal distribution.
 2. Soil cover – soil cover i.e. type, thickness and infiltration capacity.
 3. Availability of surface water as another source e.g. streams, reservoirs, springs.
- Topographical relief – the regional gradient, which if flatter affects higher recharge; and occurrences of small/large topographical depressions effecting higher localized recharge.

The compilation of a conceptual aquifer model is a generic process, continually adding new information that becomes available, using different and new methods. A conceptual model facilitates a better understanding of the aquifer in relation to the occurrence of groundwater, replenishment of the resource and the flow dynamics of the system. This information is particularly useful for stakeholders who have limited knowledge of the functioning of the aquifer yet are expected to play a role in its management. Many of the concepts are universal to all aquifers, thus a handbook on dolomitic aquifers has been compiled (CSIR-Colvin 2004) as one of the deliverables of the present contract to enhance the level of knowledge and education. In addition the conceptual model could also be applied to similar aquifers in terrain requiring only

slight adjustments of the values of aquifer parameters and incorporation of local climatic conditions that control the recharge.

While these components are not discussed in full detail, there is sufficient detail to provide a hydrological overview of the system. (Information on certain aspects will improve with the findings of the detailed study and modelling being undertaken by the by the consortium of consultants.)

4.1.2 Geohydrology

Geology

Dolomites, although forming flat and featureless terrains, are usually very productive aquifers all over the world. The NW dolomite basin with large springs of perennial flows are sustained by groundwater being recharged from rainfall, is typical. Boreholes with high sustainable yields are often intersected during drilling. Dolomite consists of calcium and magnesium carbonates that were precipitated over 2000 million years ago from shallow freshwater lakes (Vegter 2001) to form thick calcareous deposits of dolomite, later on covered by younger sediments (see stratigraphical sequence depicted in Fig. 16).

System/ Erathem	SEQUENCE	GROUP	FORMATION	LITHOLOGY AND MEMBER	THICKNESS (m)
PERMO-CARBONIFEROUS	KAROO	ECCA	DWYKA	Sandstone Mudstone Carbonaceous shale, coal	
				Diamictite	
PROTEROZOIC	TRANSVAAL	PRETORIA	TIMEBALL HILL	Shale Diamictite Klapperkop Quartzite Mf. wacke and ferruginous quartzite Graphitic and silty shale Quartzite	270 - 660
			ROOIHOOGTE	Shale Bevets Conglomerate Member Breccia	10 - 150
			ECCLES	Chert-rich dolomite with large and small stromatolites	380
		CHUMIESPOORT	LYTTELTON	Dark chert-free dolomite with large elongated stromatolitic mounds	150
			MONTE CHRISTO	Light coloured recrystallised dolomite with abundant chert; stromatolitic; basal part oolitic	700
			OAKTREE	Dolomite, becoming darker upwards Chocolate-coloured weathering	200
			BLACK REEF QUARTZITE	Shale Quartzite Arkosic grit	25 - 30

Figure 16: Litho-stratigraphical sequence of the dolomite indicating the characteristics and thickness of the different formations

The regional geology already determines the characteristics of aquifers. Some dolomite formations are more susceptible to recharge than others and their capacities to store water varies. The overburden, generally comprising of soil/gravel and rock outcrops, controls the rate of infiltration of rainwater to recharge the aquifer.

Diabase intrusions (dykes – see Fig. 1 and Fig. 17) subdivide the dolomite into smaller compartments. The ability of the aquifer to absorb and store water is of crucial importance as it determines the volume of water that could be retained in storage to bridge periods of below-average recharge. The lag between the recharge events and utilization of the water provides a means to manage the allocations of water every season. Losses continually occur from the groundwater due to lateral seepage to lower-lying area, appearing as base flow to rivers and seepages to wetlands. There are also evaporation losses from the groundwater by capillary action and transpiration of the vegetation.

The NW dolomite sequence was tilted from its original horizontal layering to its present inclined dipping to the north underneath the Transvaal Formation. This tectonic movement and erosion has exposed the stratigraphical formations (see Fig. 16 and 17). The latter simplistic diagram shows the different dolomitic strata and some of the dykes subdividing the dolomite into smaller compartments. One major NS fault cuts through the dolomite sequence. Very little is known about the fault but it seems to act as a groundwater barrier.

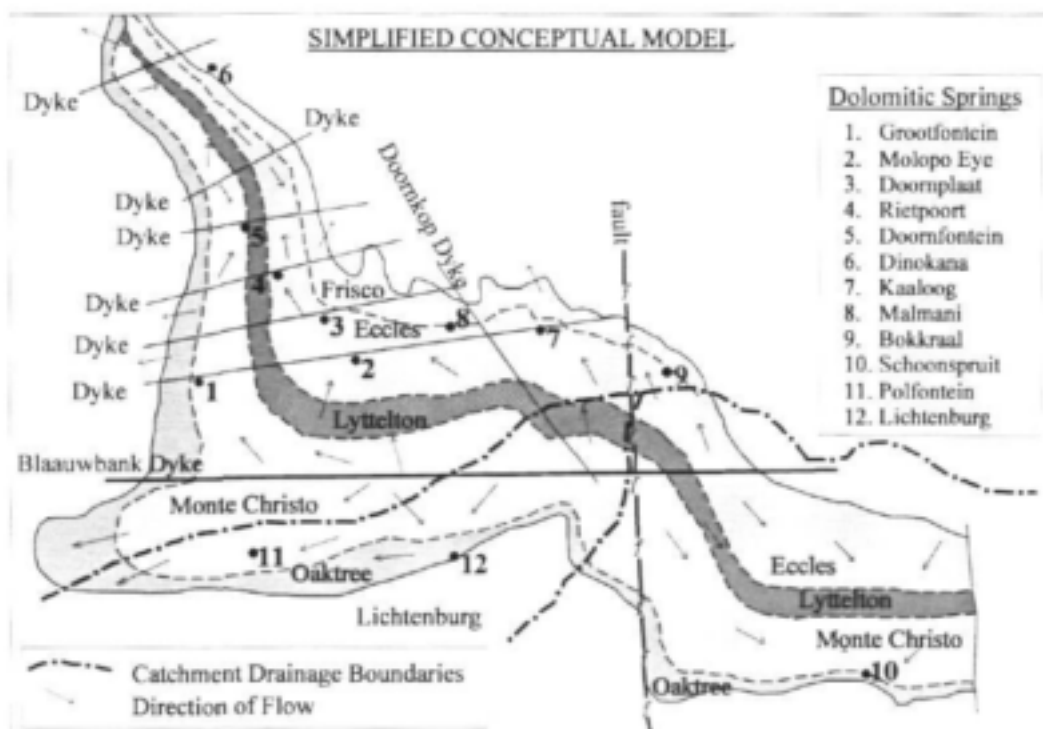


Figure 17: Simplified conceptual presentation of the NW dolomitic area.

Fig. 17 also shows the different formations of the dolomite, major springs and some of the major dykes that subdivide the dolomite into smaller compartments. The Blaauwbank dyke is wide and forms an EW boundary, whilst the fault constitutes a major NS boundary with leakage to the east south and north. The overall drainage of groundwater towards some of the main springs is also indicated.

Recharge of the aquifer

The recharge of the dolomites is high in comparison to that of other aquifers and is controlled by rainfall intensity as well as by the infiltration characteristics and thickness of the surface material overlying the aquifer. The superficial covering ranges from variable thickness of good soil and mixtures with cherty gravel to outcrops of the different formations. The leached areas of these formations are usually in-filled by soil and gravel matrix. The flat topography enhances the infiltration of water and largely prevents runoff. However, accumulations of runoff in local depressions could occur and is probably responsible for the high recharge during periods of intense rainfall.

Recharge is primarily determined by the rainfall and specifically during intensities of monthly rainfall in excess of:

- A threshold value of about 14 to 20 mm per month for normal rainfall conditions with a corresponding lower recharge coefficient, which varies proportionally to the rainfall being lower or higher than the long-term monthly average rainfall.
- A high threshold value (about 42 mm per month) for which a higher recharge coefficient would apply.

Thus the monthly recharge comprises a combination of recharge events that could be higher or lower than the average.

In accordance with the long-term hydrological balance, recharge occurs when the average rainfall exceeds the long-term average precipitation over the same period. The impact on groundwater levels would be proportionally greater if above average rainfall conditions are sustained over several consecutive months and years for example 1975 to 1978. Similarly, the effects of subnormal rainfall would be cumulative and could extend for prolonged periods.

Storage and flow characteristics

The water-storage capacity of the chert-rich formations (Monte Christo and Eccles) and the recharge is higher than that of the chert-poor Oaktree and Lyttelton formations. The highest yielding boreholes and largest springs have resulted from the secondary transformation of the dolomite i.e. the dissolution of carbonate rocks by infiltrating rainwater acidified by carbon dioxide (CO_2) present in the rainfall, to form the typical water bearing dissolution channels and cavities found in dolomite. If the formation overlying a large cavity collapses a sinkhole such as the Wondergat is formed.

A distinct feature of the dolomite formations of South Africa is that it is subdivided into smaller compartments by diabase dykes. The latter are thin vertical intrusions of magma that can extend laterally over large distances. The dykes have lower permeability than the dolomite and impede lateral flow losses through the aquifer. By damming up the water, the dykes cause the groundwater levels to rise, which results in the formation of springs where the water levels rise higher than the surface levels. The major springs that occur in the area are indicated in Fig. 17. Part of the outflow of some springs can re-infiltrate in the next compartment only to reappear or augment the flow of another lower-lying spring. The occurrence of fewer but larger springs is due to fewer dykes obstructing the groundwater flow and hence the recharge areas are larger and the yields of the springs correspondingly higher. The numerous occurrences of springs therefore are an indication of the complexity and barrier-effect of the dyke system. The larger number of springs in the Zeerust area is due to the many dykes that traverse the formations.

Groundwater drainage

The drainage of groundwater overall corresponds to the general topography and is driven by gravity. Therefore groundwater always flows to topographically lower areas. The rates of flow are determined by the transmissivity of the aquifer, which is different for the respective formations but also within a geological unit. The transmissivities of the Eccles formation is the highest; it is slightly lower for the Monte Christo and significantly smaller for the Lyttelton and Oaktree dolomites. The diabase dykes, because of a much lower transmissivity also restrict the flow of groundwater often causing a sharp drop in water levels across them. Furthermore, they retard the lateral outflow thereby retaining groundwater for extended use over longer periods. Certain dykes may become impermeable at depth and could impede or stop flow between adjacent compartments if water levels have been substantially depleted. This would limit the exploitation potential of smaller compartments.

The complexity of the groundwater drainage is clear from Fig.18 (Van Rensburg 2003). This represents the outcome of the detailed study of the Zeerust area recently undertaken. Although the overall drainage conforms to the topography, a more level groundwater gradient generally occurs within the boundaries of subunits bounded by dykes. The distinct steps of the groundwater levels across the bounding dykes can be seen.

The overall drainage pattern of the groundwater in relation to the topography of the entire area is depicted by figures 19 and 20. The topographical map has been contoured from the DTM data of the Zeerust area and of surface elevation of boreholes, which is less accurate. To construct the groundwater level contours, the groundwater levels following periods of high recharge have been used. For these periods the impacts of abstraction have been small.

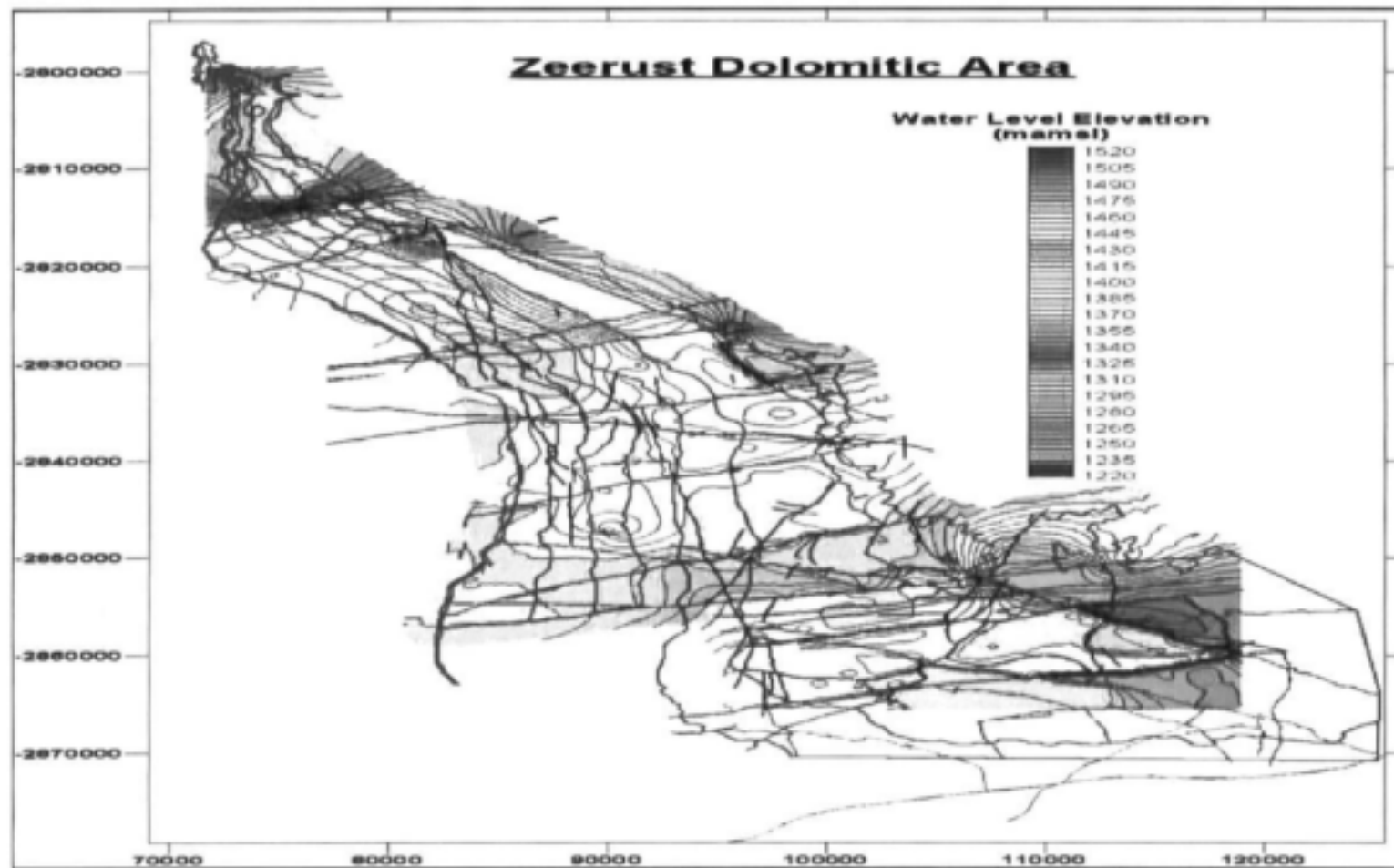


Figure 18: Drainage of the groundwater levels in relation to the different dolomitic formations.

Some of the dykes causes a significant step in the groundwater levels but the general drainage overall conforms to the topographical contour (see Fig. 19 and 20) (Figure 18 courtesy of PMA Consortium of Consultants – Van Rensburg 2003).

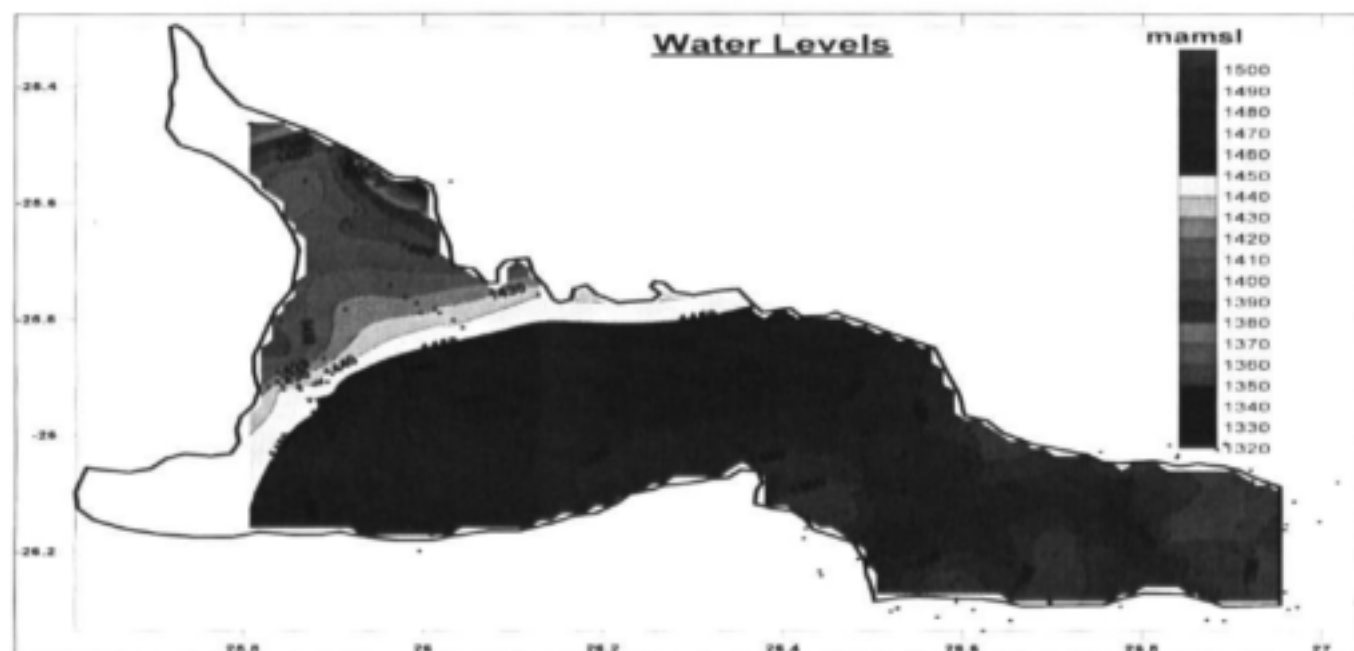


Figure 19: Water level contours indicating the drainage of groundwater over the entire NW dolomitic area. These contours smooth out the sharp steps that occur over some of the dykes.

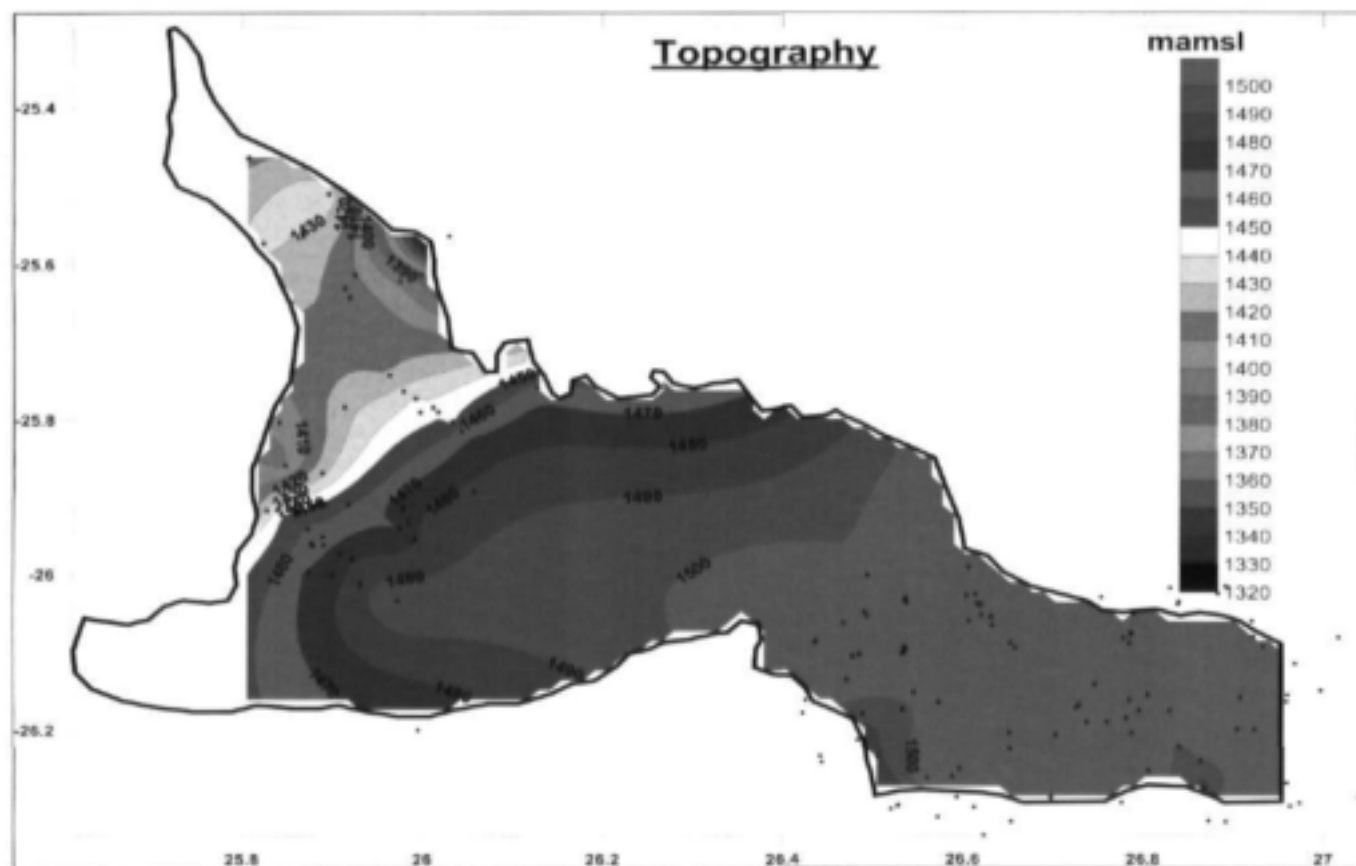


Figure 20: Topographical relief of the dolomite aquifer of the NW Region, which determines the regional groundwater drainage as shown in Fig. 18.

The drainage and leakage through the dykes, the fault and the different formations is important in the delineation of the groundwater units as well as defining the optimal boundaries for the WMAs and Water Users Association areas. (It seems that the WMA boundary may need to be shifted to conform to the N-S fault (see Fig. 1 and 17). All the groundwater units to the east of the fault and south of the Blaauwbank dyke thus drain to the east and southeast. The Blaauwbank dyke traversing all the way from the west to the east of the area, is regarded to be a major barrier and separates the units draining to the south and the north. Groundwater units to the west of the fault would drain to the west, south and north.

At this stage, the drainage of the Grootpan groundwater is uncertain but in part feeds the springs in the north. The heavy pumping in the area has probably already had an effect on the drainage of the groundwater. Drainage will also depend on whether or not the fault and Blaauwbank dyke are major barriers. Some exploration boreholes might have to be drilled for confirmation and to produce a more reliable drainage map.

While the conceptual model begins to explain the functioning of the aquifer, only once the hydrodynamic model is completed can the impact of abstraction on the various groundwater units be simulated, especially within the boundaries of smaller sub-compartments.

Recharge and Storativity estimated from CRD/MA

The regional recharge values that have been derived from the CRD interpretations of about 130 hydrographs are plotted in Fig. 7 in relation to the different geological formations. Similarly the storativity values and aquifer depths are superimposed on the geology (Fig. 13). The results of the CRD/MA interpretations are listed in Table 2 and the individual simulations appear in the Data Appendix D.

There is little difference in the average recharge of the various formations, but it is highest for the Eccles and the Monte Christo Formations (see Table 3). Higher recharge results in areas of shallow overburden where extensive leaching of the dolomitic formations has occurred. Occasionally, subsidence of the surface to form depressions or even sinkholes could occur. Any depression, even small ones, constitutes areas of preferential recharge.

The discharge of springs

The combined total average flow of all the major springs in the region represents 45% of the average recharge of the total area of 4500 km². Fig. 21 represents a visual comparison of the equivalent recharge areas of the different springs.

Circles depict the average flows of the springs as an equivalent area of recharge that is required to maintain the flow.

More than half (55%) of the recharge is dissipated in the form of underground lateral flow, evaporation and other losses. As the flow of a spring is directly proportional to the groundwater level of the aquifer that feeds it, as has been demonstrated by the Wondergat levels (see Fig. 9), any declining groundwater levels, whether by natural causes or impacted by groundwater levels, would diminish the flow of a spring (see Fig. 8).

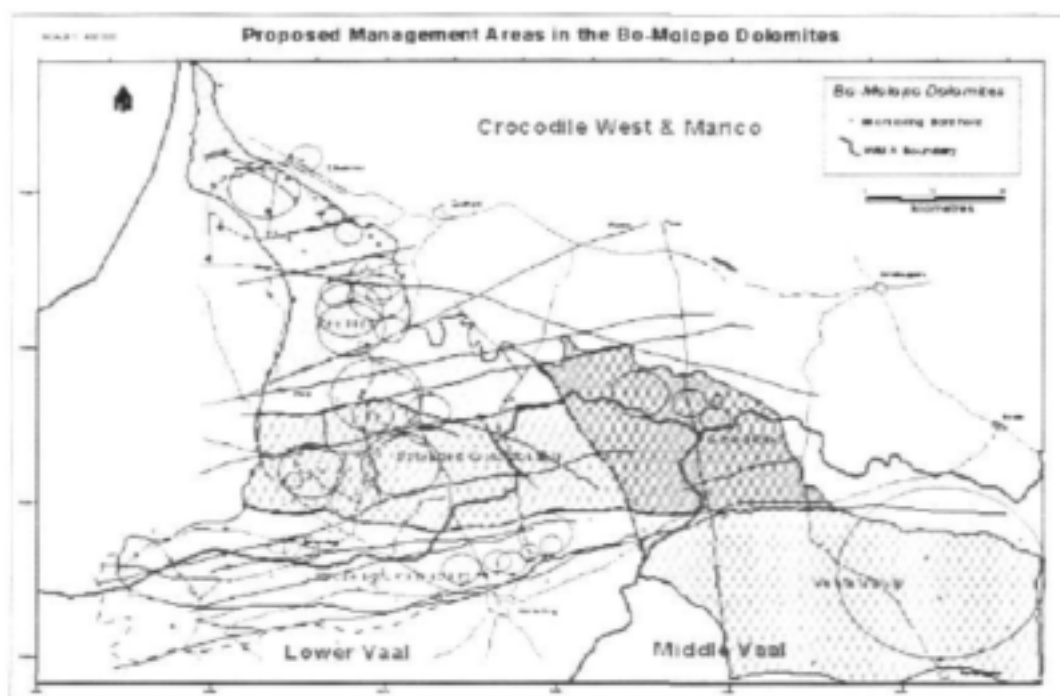


Figure 21: Map showing the groundwater units and points where springs ooze from the dolomite. The sizes of the circles indicate the average discharge rate in terms of the equivalent area required to sustain the flow.

The potential savings of the losses e.g. the difference between the natural outflow via springs and the total recharge provides scope for more effective utilisation and thus requires active management of the groundwater resource. Once again, the impact of such interactions can only be assessed reliably by means of a comprehensive hydrodynamic model of the entire NW dolomitic aquifer, similar to the FEFLOW model presently compiled of the Zeerust area.

For normal intensities of rainfall, the recharge would range from 6 to 8% of the monthly rainfall as is reflected by the normal CRD/MA simulations. However the best results according to the FEFLOW model, indicates that recharge varies exponentially for rainfall exceeding a threshold value and could reach a high of 80% if the monthly rainfall is 300 mm (Van Rensburg – provisional results). Such high recharge although occurring infrequently would cause rapid replenishment of the aquifer, especially if the groundwater levels are shallow e.g. for Kareebosch eye. For deeper water levels, the response of water levels and spring flow extends over several years, as shown by Dinokana and Schoonspruit.

4.2 Water Balance and Groundwater Utilization per Groundwater Units

For an assessment of the overall status of exploitation of groundwater in the NW dolomite region, a water balance has been prepared from the present information. However this is not a conclusive balance since better abstraction information is required for places where irrigation development is reportedly taking place. Lateral flow between the different units can only be incorporated by means of a dynamic

model and similarly for the impacts of abstraction on trans-boundary flows. The sustainable utilization of the different units depends mainly on the recharge they receive which could vary exponentially if above average rainfall for extended periods occur (see Eq.3). Likewise prolonged periods of below average rainfall have an accumulated negative impact on the groundwater resource.

Table 4 presents a comparison of the status of exploitation relative to the recharge, which was calculated according to equation 3. The abstraction figures were those derived from the CRD/MA interpretations of the hydrographs of monitoring boreholes that fall within the various units and sub units. The reliability of the estimated abstraction depends on the number of monitoring boreholes and their spatial distribution over the groundwater unit.

The discharge of the springs provides the best-integrated response of the aquifer to recharge. Local recharge following extreme levels of rainfall could be much higher because of flooding. However, such rainfall events have occurred in the past and thus are reflected in the response of the Wondergat level. Fig.22 indicates that for the period 1929 to 1973 the water levels have fluctuated within a lower range than that of the period 1974 to 2002. The extreme recharge in relation to the water levels of the Wondergat for the period 1974 to 1980 is evident from Fig. 22. The corresponding recharge coefficients (derived from equation 3) of the best simulation are shown in Fig.22. Similarly the impacts of low rainfall of the period 1960 to 1965, 1982 to 1984 and 1990 to 2000 can clearly be seen.

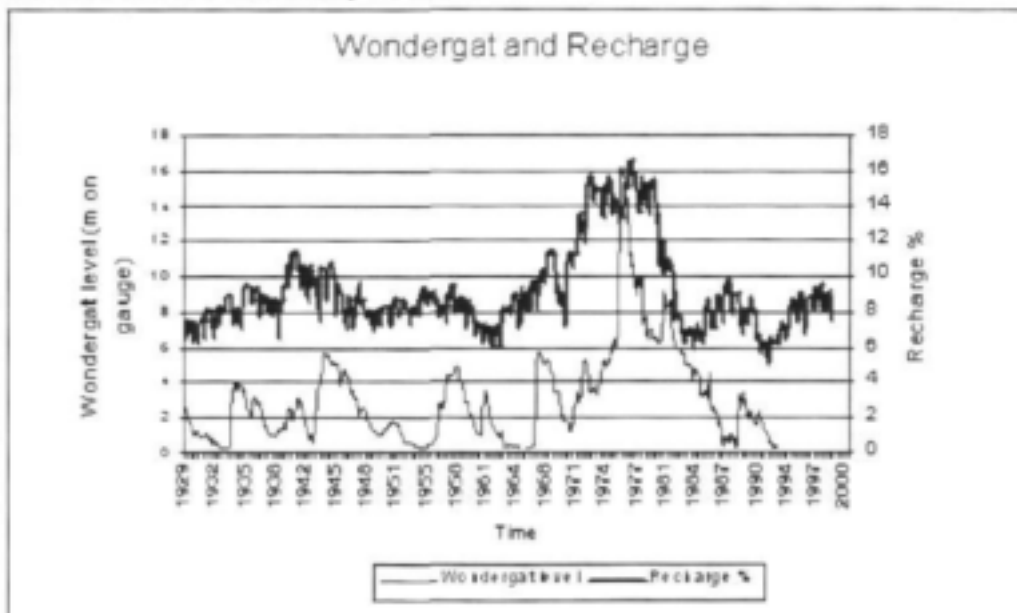


Figure 22: Water levels of the Wondergat plotted in relation to the monthly recharge percentage derived from Equation 3.

The fluctuating groundwater levels are a natural phenomenon causing the flow of springs to vary proportional to the water levels above the base of the aquifer. As the aquatic environment has to adapt to the natural variability, so do groundwater users. However, pumping superimposes an addition stress on the system that is the same as a reduction of rainfall (Bredenkamp and Xu, 2003). During such periods an unnatural stress is imposed on the aquifer and the flow of springs and aquatic systems. Assessment of the impacted conditions could best be obtained by means of a hydrodynamic flow model of the aquifer, similar to that which is presently being compiled for the Zeerust unit by the consultants. Nonetheless, a simplistic water

balance approach has been used to compare the natural response of the groundwater units to the maximum sustainable utilization of the aquifer.

To achieve this the following has to be incorporated in the water balance:

- Recharge based on equation 3, using the local rainfall record of a unit.
- Recession of the groundwater levels to accommodate natural outflows, which is determined by the groundwater levels above the base level.
- The flows of springs, which also fluctuate in relation to the groundwater levels.
- Preferential allocations from the resource to supply the reserve, domestic and cattle use, industrial and irrigation demands.

The water balance was performed on a monthly basis by means of an EXCEL-spreadsheet program for each of the five-groundwater units. This portrayed the temporal fluctuations of the groundwater levels over the period 1929 to 2002 for the maximum rates of abstraction with the preferential usage being secured. It is inevitable that any pumping would diminish the flow of the springs and any irrigation from spring water would thus be affected. The same applies to the base flow feeding stream and aquatic systems. For those groundwater units that have ecologically sensitive areas, such allocations have been provided for in the preferential allocations.

The assessment of the reserve requires a full study, preferably as part of the comprehensive study of the NW dolomite, for all of the groundwater units and even Schoonspruit for which it has been determined. The present outcome of the water balance is summarized in Table 4 and the outcome of the spreadsheet-water balance for the different units is plotted in

- 1) Fig. 23 for Zeerust
- 2) Fig. 24 for Grootfontein/Molopo
- 3) Fig. 25 for Lichtenburg/Polfontein
- 4) Fig. 26 for Grootpan
- 5) Fig. 27 for Schoonspruit.

The combined flows of all the springs and abstractions from a groundwater unit have been used in the overall water balance but a smaller effective area of recharge to sustain the spring flow has been used to calculate the impact on the springs and other outflows.

4.2.1 Zeerust groundwater unit

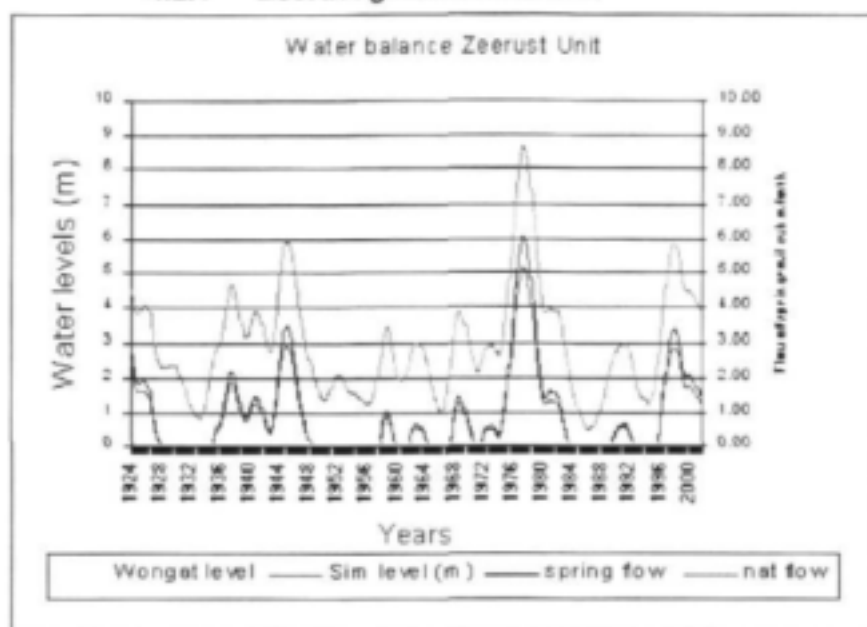


Figure 23: Temporal fluctuations of water levels and spring flows of the Zeerust groundwater unit for natural and maximum sustainable yield of 40 mil cub m per annum as indicated in Table 4.

For this unit the maximum sustainable yield of the aquifer is about 40 mil m^3 per annum. Most of this water is allocated for domestic use (29 mil m^3 per annum) and according to the irrigation requirements of 15 million m^3 /annum (from Bigen Africa report), the present total abstraction of the Zeerust unit exceeds the maximum sustainable yield and only 10 million m^3 per annum could be allocated to irrigation. The present irrigation component appears to be higher and needs to be checked.

4.2.2 Grootfontein/Molopo Unit

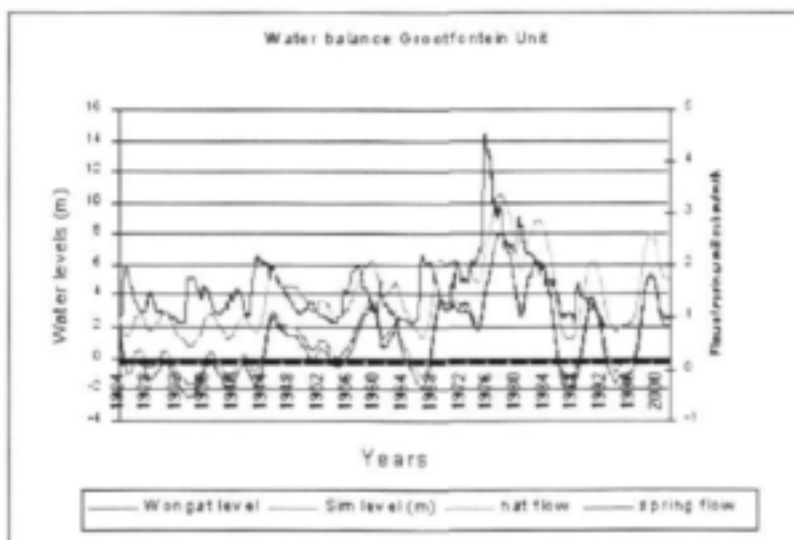


Figure 24: Temporal fluctuations of water levels and spring flows of the Grootfontein/Molopo groundwater unit for natural and maximum sustainable yield of 38 million m^3 per annum. (See Table 4).

The water level of the Wondergat, which is a good regional indicator of natural water level responses, also shows a good comparison to the simulated natural status. The overall improved response of the aquifer during the later part of the record is evident. This is due to the higher average rainfall that has occurred since 1974.

4.2.3 Lichtenburg-Itsoeng Unit

All the springs in the area have virtually stopped flowing as a result of abstractions taking place close to the springs but according to the water levels shown in Fig. 25 the springs would still have discharged (at a lower rate) in periods of high water levels, if the abstraction had been further away from the eyes.

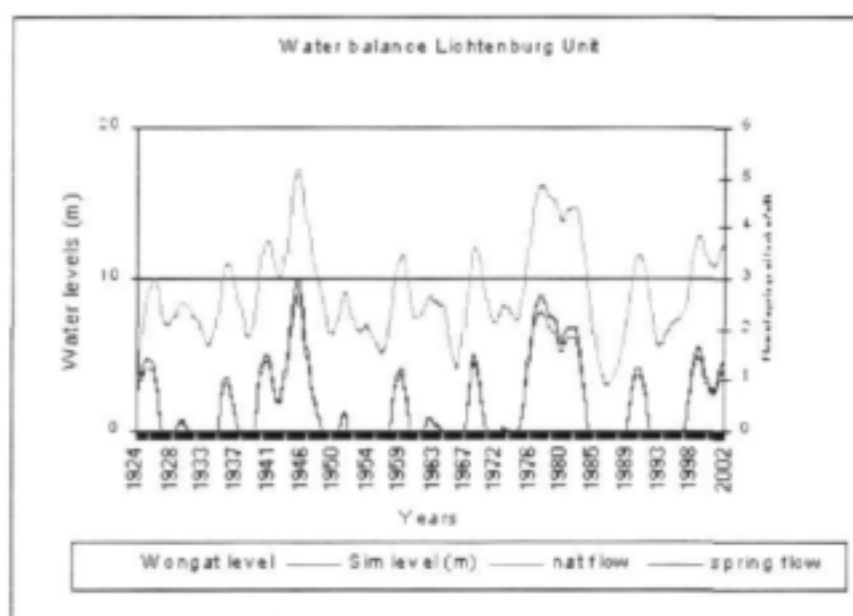


Figure 25: Temporal fluctuations of water levels and spring flows of the Lichtenburg/Itsoeng unit for natural and maximum sustainable yield of 37.3 mil m³ per annum (Table 4).

According to Table 4, this unit is fully committed and recent expansions of irrigation in the unit would have to be seriously scrutinized.

4.2.4 Grootpan Unit

This aquifer still has potential to increase its abstraction from the present 7 to 14 million m³ per annum (see Fig. 26). However the wetlands around the Kaaloog eye is an ecological sensitive area and it excess water drains to the Marico River, where irrigation is dependent on the flow. An escalation of pumping from the aquifer should only be considered once the impact on the water levels at the spring has been assessed by means of a hydrodynamic model of the system.

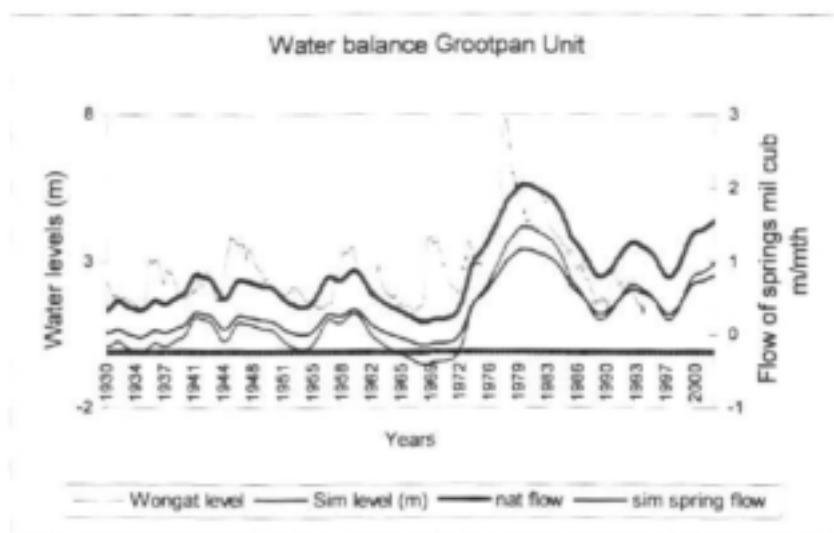


Figure 26: Temporal fluctuations of water levels and spring flows of the Grootpan groundwater unit for natural and maximum sustainable yield.

4.2.5 Schoonspruit groundwater Unit

This unit has been studied more extensively by Veltman (2003) and is a main focus in view of large extensions of irrigation from the dolomitic resource. The higher abstraction has already affected the flow of the Schoonspruit eye and the excess flow to the irrigation areas downstream of Ventersdorp. According to Veltman (2003) this unit is fully exploited. The results of the present assessment of the water balance of the aquifer are shown in Fig. 27 and the maximum exploitation potential is about 38 mil m³ per annum (see Table 4). The lower value in comparison to the area of the aquifer is due to the environmentally sensitive ecosystem that has to be sustained at the spring and wetland below it, as well as maintaining some base flow to the river.

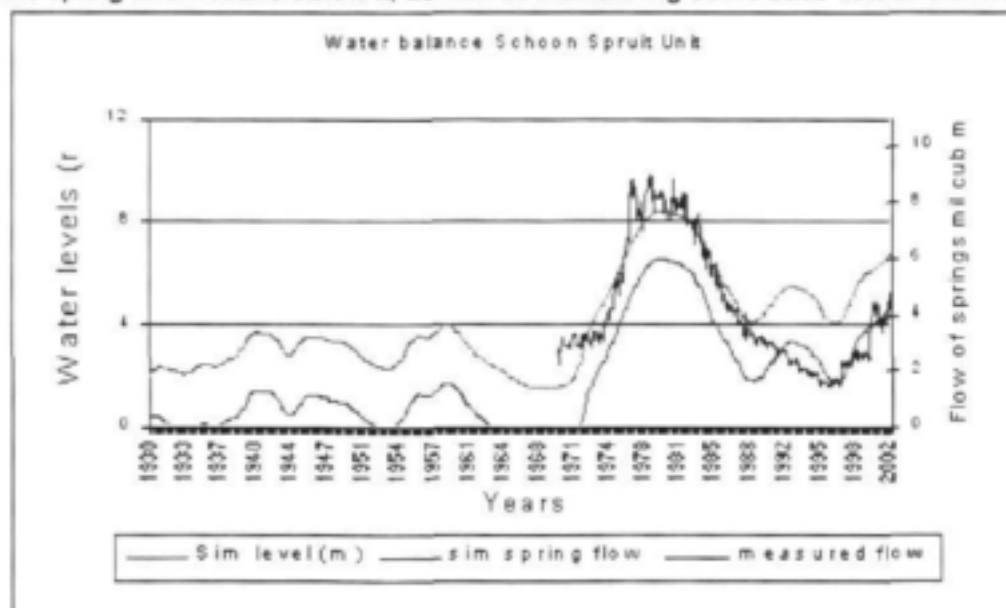


Figure 27: Measured flow of the Schoonspruit eye in comparison to the simulated natural flows and the flows at maximum exploitation.

This graph indicates the degree to which the aquifer has been depleted from the natural status at the present rate of abstraction (34 mil m³ per annum having almost reached the maximum sustainable yield of the aquifer of 38 mil. m³ per annum – refer to Table 4.)

Table 4: Comparison of components of the groundwater balance of the different groundwater units of the NW dolomite.

Dolomitic unit	Irrigation (million m ³ /annum)	Domestic and Environmental Requirements (million m ³ /annum)	Industry (million m ³ /annum)	Total present estimated abstraction (million m ³ /annum)	Sustainable abstraction (million m ³ /annum)	Comment
Schoonspruit	26	8.1	0.3	34.4	38.4	Could increase sustainable abstraction by 11.6%
Lichtenburg Itsoeng	28	8	1.6	37.3	37.3	No increased abstraction recommended
Extended Grootfontein	21	16.7	0	38	38	Abstraction should not be increased
Zeerust	10	29.02	0.84	44.8	39.9	Abstraction ought to be reduced by 11% to reach sustainable levels of abstraction
Grootpan	7	7.09	0	14.09	22.1	Could increase sustainable abstraction by 57% but ecological impact needstot be assessed

The apparently similar maximum total sustainable abstraction of the different units is ascribed to the fact that some of the larger units would still have significant outflow losses as lateral flow and spring discharge for example in the case of the Schoonspruit unit. Some of these losses could be reverted to abstraction. For the Zeerust compartment there is inflow from higher lying units e.g. along the Malmani River which increases its potential.

4.2.6 Sustainable abstraction

Zeerust unit

There is not scope for further expansion of the water resources, especially not the irrigation because the aquifer at present is being exploited beyond its capacity. This is probably due to water inflow from the higher lying areas e.g. from the Malmani spring and base in the river irrigable land in the rugged dolomite of the Zeerust area. Large volumes of groundwater, however, are being lost along the Malmani River downstream from the Malmani sanctuary area. These losses could be utilized if the water levels of the aquifer are lowered, however, at the expense of the ecology of the river system that could not be tolerated. More groundwater could be pumped from the lower end of the Malmani River to balance out deficits that might accrue during periods of sub-normal rainfall with excesses during high rainfall periods.

The Rietpoort and Doornfontein subcompartments are already fully utilized, as is the Dinokana compartment. The upper eye of Dinokana, which is being fed from highly permeable dolomite, is especially vulnerable. Any pumping within the boundaries of this compartment would in the long-term merely diminish the flow of the Dinokana spring. It is doubtful if much extra water has been gained from the present production boreholes within the compartment, although this contribution would be useful in periods of drought when the spring cannot supply enough water.

Grootfontein/Molopo groundwater unit

This unit has no scope for further abstraction especially in the proximity of the Grootfontein eye and the Molopo eye. Any increased water supply for domestic/industrial use would have to be accommodated through the reallocation of irrigation licences.

Lichtenburg – Itsoseng unit

Large expansion in irrigation has recently occurred in this unit and the total water balance needs to be reassessed once the extent of the new irrigation has been determined.

Schoonspruit and Grootpan units

The estimated surplus of water available in the Grootpan unit also has to be checked as the latest irrigation could have been underestimated.

In the Ventersdorp/Grootpan area it is alarming that, based on an average consumption of 8300 m³ per annum per hectare of irrigation, the total water requirements to irrigate all of the registered 8980 ha of irrigation land, would require 73,8-million cub m per annum. This demand cannot be sustained and would seriously affect the ecology around the Schoonspruit eye.

Management based on the variable-draft concept used in surface reservoirs would increase the utilization of the aquifer but its effect on the ecology would have to be assessed. This could best be achieved by means of a hydrodynamic model of the aquifer.

4.3 Groundwater monitoring

Monitoring entails collection of rainfall, water levels, abstraction and water quality at regular intervals. Maintaining the monitoring stations and ensuring a good spatial coverage of the aquifer is an essential component of effective management as well as the checking of drilling and unlawful abstraction. The distribution of groundwater level monitoring points is indicated in Fig. 1. It clearly shows too dense a coverage of the Grootfontein area whilst in other areas there are too few monitoring points.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conceptual model

A conceptual model of the geological characteristics of the aquifer matrix has been established based on information obtained from the present and previous studies. The same applies to improving the concepts regarding the hydrological interactions e.g. recharge in relation to rainfall variability, lateral flow and smoothing of recharge events by the soil overburden and averaging of groundwater level responses by the highly permeable dolomite. Recharge only occurs if the monthly rainfall exceeds a certain threshold value, in which case the recharge coefficient varies in relation to the deviation of the monthly rainfall relative to the long-term average rainfall. Much of the recharge merely maintains the natural losses from a groundwater system and effectively only recharge events from rainfall in excess of the long-term average precipitation causes a significant rise of water levels. During periods of drought with consecutive months of rainfall below the threshold value the recharge would be negligible and would cause a rapid decline of groundwater levels.

Current evidence suggests that the recharge conforms to an exponential function of rainfall, which has been obtained from the simulations of groundwater levels and spring discharge. This is in accordance with results derived by Van Rensburg 2003. The flows of some springs correspond to the average rainfall over longer periods e.g. 72 months in the case of larger springs for Schoonspruit eye, and 24 to 36 months for Buffelshoek eye.

Several methods are suitable for the determination the recharge. These range from interpretations of groundwater level fluctuations of monitoring boreholes by means of the CRD/MA method, to spring flow simulations using the MA method. Independent estimates can be obtained by means of the chloride concentrations of the groundwater in relation to that of the rainfall. Another promising method based on the chemical nature of the groundwater, is the bicarbonate method that needs to be further investigated. The application and calibration in different types of aquifers has to be examined, as that would avail a means to obtain regional as well as point estimates of recharge.

5.2 Resource Assessment and Management

The geohydrological component of the study has focussed on many of the aspects that are relevant to effective management of the resource e.g. reliable estimation of the aquifer characteristics and interpretations of the groundwater balance. Software that has been developed for DWAF has been applied and was improved in this study. New formulations of the CRD and MA methods complying better with the hydrological concepts, have shown a significant improvement of the simulations of hydrographs of boreholes and the flows of springs. This software is available as EXCEL spreadsheets and with little training could be used to derive recharge, storativity, and aquifer thickness, and to assess impacts of abstraction on groundwater levels and spring flow for variable rainfall series.

The CRD/MA methods are recommended, as they are able to simulate different scenarios of recharge and abstraction and can be used by local water users and managers.

5.3 Delineation of Groundwater units and regional drainage

The drainage and leakage through the dykes, the fault and the different formations is important in the delineation of the groundwater management units as well as refining the boundaries of WMA.

A piezometric drainage map of the natural groundwater drainage over the entire dolomitic aquifer has been compiled based on the limited data available. This confirmed that the groundwater flow corresponds to the topography. The drainage is however complicated by dissolution channels forming conduits of rapid flow. However the dykes restrict the flow and causes springs to form. The spring flow, contributions to river and wetlands and evapotranspiration are part of the natural losses causing the groundwater levels to decline. The water levels determine the gradient, which governs the flows and also the rates of dissipation by vegetation.

It seems that the CMA boundary should be shifted to conform to the N-S fault. All the groundwater units to the east of the fault drain to the east and south-east and north. Those west drain to the west, north and south to feed springs and subsurface outflow. The Blaauwbank dyke traversing all the way from the west to the east of the area, appears to be a major barrier and separates the units draining to the south and the north. At this stage it is uncertain where the Grootpan groundwater drains to, but part of its drainage should feed the springs in the north. The heavy pumping in the area probably already has had an effect on the flow of the groundwater. The drainage will also depend on whether or not the fault and Blaauwbank dyke are major barriers. Some exploration boreholes might have to be drilled before a final decision could be reached.

There is a strong argument in favour of managing the NW dolomite as a strategic resource on its own, rather than splitting its management and control into the various drainage regions. This seems to be a rational solution to the problems of reliable delineation of groundwater units. The provisional subdivision of the NW dolomite into groundwater units as indicated in Fig. 1 should be retained pending the outcome of the PMA/VSA consortium studies and further decisions on strategic issue.

5.4 Present exploitation

According to the water balance assessments, there is limited scope for extending the utilization of the different units, especially if the environmental demands have to be satisfied and maintaining spring flows at all times. By means of the hydrodynamic model, all interactions could be incorporated and different scenarios of management could test scope for higher yields from the aquifer. It might be no alternative to selecting areas such as the Grootfontein eye compartment and ignore the impact of pumping on the spring in favour of increasing the yield from the aquifer. Relying on periods of extremely high rainfall e.g. as that of the period 1975 to 1980 would be risky for it has been an extremely pluvial period with a low probability of recurrence, as can be seen from the water level series of the Wondergat.

In view of the impacts of over-abstraction being equivalent to a reduction of rainfall, and recharge corresponding to the average rainfall over several years, pumping would aggravate the impacts of any periods of prolonged subnormal rainfall. Such scenarios could however also be assessed by means of the model.

5.5 Monitoring

The importance of reliable monitoring data of rainfall and groundwater levels must be emphasized. Monthly rainfall totals and groundwater measurements are adequate to apply the CRD/MA methods and to model the aquifer. Of equal importance is the collection of monthly-accumulated rainfall samples at strategic positions over the catchments, either at rainfall stations spread over the area or at water level monitoring points.

Regarding the total water resources of the NW dolomite aquifer and the regional impact of abstraction on the various groundwater units, especially within the boundaries of smaller sub-compartments, it is essential for the entire dolomite basin to be simulated by means of a hydrodynamic model. Thus the modelling of the Zeerust area needs to be extended to include the entire NW dolomite aquifer. This is the only reliable way to simulate the natural status and the impacts of different management scenarios of abstraction and recharge in a quantitative way.

5.6 Institutional Aspects

The establishment of effective structures that would be representative of all stakeholders seems to be problematic, mainly because of inadequate knowledge of stakeholders about the geological and hydrological controls governing the occurrence of groundwater and its effective management.

The IUCN study has contributed to the compilation of a guide, which has been designed by the CSIR (Colvin 2003). Its main aim is to provide a simple overview of all aspects relevant to the characterization, utilisation and management of dolomitic aquifers. Local stakeholders would have to be educated and trained and directed in the use of practical methods and requirements for management of the resource.

6 REFERENCES

- Beekman H.E. and Xu Y. (2003) *Groundwater recharge estimation in Southern Africa, UNESCO IHP publication*, Paris.
- Botha L J (1993) *Estimation of the Zeerust-Rietpoort groundwater potential*. Appendix to Bredenkamp et al 1995.
- Bredenkamp, D.B., Schutte J M and Du Toit G.J (1974) Recharge of a dolomitic aquifer as determined from tritium profiles,. Proc. IAEA Conf. Isotope Techniques in Groundwater Hydrology 1974, Vienna.
- Bredenkamp, D B. (1992) *Estimation of the yield of the Polfontein compartment, Technical Report Gh3783*, Directorate Geohydrology, Dept. of Water Affairs, Pretoria 0001.
- Bredenkamp, D.B. (1996b) *Abstraction from the Grootfontein Compartment*, Report by WREM to the Department of Water Affairs and Forestry.
- Bredenkamp, D.B. (1997) *Modelling of the Zeerust-Dinokana Dolomitic Compartments with a view to more effective management of the groundwater resources*. WREM report.
- Bredenkamp, D.B. (1999) *Development of a hydrodynamic model of the Grootfontein and surrounding dolomitic compartments with a view to improved groundwater management and more effective control of abstractions*. Report by WREM.
- Bredenkamp, D.B. (2000) *Groundwater monitoring: A critical evaluation of groundwater monitoring in groundwater resources evaluation and Management*, Water Research Commission Report No. 838/1/00.
- Bredenkamp D.B., Van Rensburg H.J, Van Tonder G.J and Cogho V. (1987) *Quantitative estimation of the aquifer storativity and recharge by means of a water balance incorporating a finite element network*. Quantity and Quality Conference IAHS, Benidorm, Spain.
- Bredenkamp D.B., Van Rensburg, H. Janse., Van Tonder, G.J. & Botha, L.J. (1995) *Quantitative estimation of groundwater recharge and aquifer storativity*, Water Research Commission Contract.
- Bredenkamp, D.B. and Xu Y. (2002) *Excell software for CRD/MA interpretations for Department of Water Affairs and Forestry*.
- Colvin C. (2004). *Management for Water Users Associations of the Dolomite aquifers of North-western South Africa*. Publication prepared for Project WRC 1324
- Parsons, R. (1995) *A South African aquifer system management classification*. Report No. KV 77/95. Water Research Commission, Pretoria.
- Partridge Maud & Associates (1992) *Geohydrological study of the Ditsibotla - Polfontein Compartment*. Report to Boputhatswana Department of Water Affairs.

Polivka, J. (1987a) *Geohydrological investigations of the Groot Marico compartment in the dolomite area North-east of Lichtenburg*. Technical Report GH3590, Department of Water Affairs and Forestry, Directorate Geohydrology.

Polivka, J. (1987b) *An investigation of the Ventersdorp and Grootpan dolomitic compartments in the Western Transvaal*, Technical Report GH3524, Department of Water Affairs and Forestry, Directorate Geohydrology.

Schoeman & Partners. (1996) *Ventersdorp Oog – Ondergrondse Staatswaterbeheergebied*, Report B0307/2 to the Department of Water Affairs and Forestry.

Stephens, A. and Bredenkamp, D.B.(2002) *Institutional arrangements for groundwater management in dolomitic terrains*. WRC Report No. KV 140/02, Pretoria.

Taylor, C.J. (1983) *A geohydrological investigation in the Lichtenburg area, Bo Molopo Subterranean Water Control Area*. Technical report GH 3277, Department of Water Affairs and Forestry. Pretoria.

Van Rensburg, H Janse. (1987) *Die berekening van groundwater onttrekking aan die hand van elektrisiteitsverbruiksyfers in the Grootfontein kompartement*, Technical Report GH 3549, Department of Water Affairs and Forestry, Pretoria South Africa.

Van Rensburg, H Janse (1995) *Management of Southern African aquifers*. Ph D. Thesis, University of the UOFS.

Van Rensburg, H Janse (2003) *Results of the modelling of the Zeerust dolomitic area – unpublished*.

Van Tonder, G.J.1989) *PC Program*, Unpublished report. Institute of Groundwater Studies, UOFS, Bloemfontein.

Van Tonder G.J. and Xu,(1999) *Excel program to determine the transmissivity and storativity and sustainable yield of boreholes by an interpretation of pumping test data*. (Unpublished).

Vegter, J.R.(2001). *Groundwater development in South Africa and an introduction to the Hydrogeology of groundwater regions*. Report no. TT 134/00. WRC Pretoria.

Veltman S. (2003). *A methodology for groundwater management in dolomitic terrains with the Schoonspruit compartment as pilot area*. Thesis for M Sc degree in Faculty of Natural & Agricultural Sciences, Department of Geohydrology, University of the Free State , South Africa

Xu, Y (2003) *Excel software for application of Equal volume method to spring flow data*. Unpublished.

Xu, Y. & Bredenkamp, D. B. (2002) *Excel Software for Cumulative Rainfall Departures and Moving Average Rainfall to Simulate Groundwater Levels* (no report – Excel software).

Xu Y and Van Tonder G.J. (2001). *Estimation of recharge using a revised CRD method*. ISSN 0378-4738, Water SA, Vol 27 No 3 July 2001.

Appendix A: Descriptions of quantitative methods and comparisons used to establish geohydrological parameters of the NW Aquifer

Method 1. Chloride Method for establishing Recharge – see Beekman and XU (2003)

Method 2. Bicarbonate method of estimating recharge – a potential new method

The groundwater recharge is inversely related to the bicarbonate concentrations, which can be used to derive a quantitative recharge relationship for the dolomite (Bredenkamp, 1999). The bicarbonate in dolomitic waters accrues when slightly acidic rainwater dissolves the carbonate in the dolomite aquifer producing water that contains bicarbonate in equilibrium with CO_2 gas. The bicarbonate concentration is closely associated with the processes of CO_2 production in the root zone and the duration of contact with the infiltrating water. The final levels of bicarbonate are determined by the equilibrium between bicarbonate in solution and the partial pressure of the CO_2 gas in the groundwater. A lower concentration of bicarbonate in dolomitic aquifers would therefore reflect faster through-flow and thus a higher rate of infiltration resulting in a shorter contact time for full bicarbonate equilibrium to be attained. It is also possible that the bicarbonate concentrations could increase due to evaporation from the groundwater and thus the recharge in the areas of lower rainfall would appear lower. Recharge values derived from the chloride method have been used to calibrate the bicarbonate method.

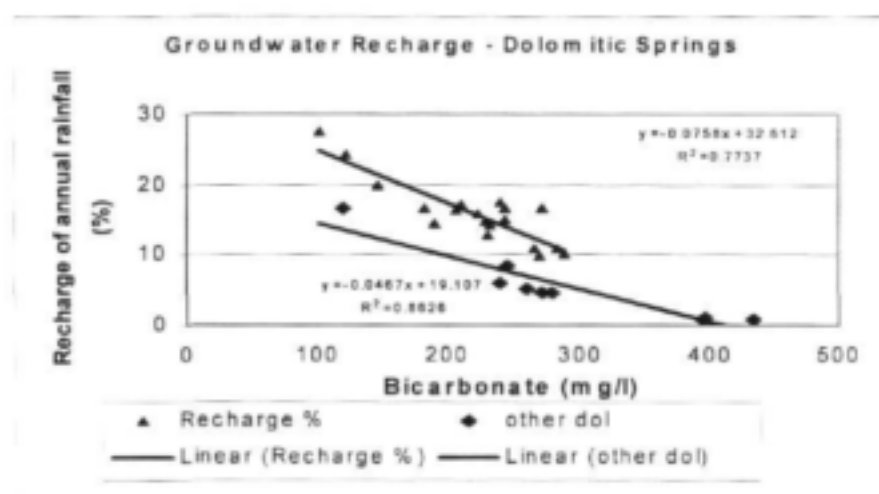


Fig. A. 1 Graph showing the relationship between the bicarbonate concentrations of spring waters in relation to recharge coefficients that have been derived by the Chloride method. Recharge values were derived from springs in the NW region and for the Kuruman dolomite and Rietvlei springs near Pretoria. In both cases the relationship is linear and yield high correlation coefficients ($R^2 = 0.77$ and 0.83) respectively.

Significance of the bicarbonate method

The bicarbonate relationship represents a new method with wider application for determining the regional average recharge and is significant insofar that:

- It is a simple yet effective means of estimating the average recharge of dolomitic aquifers, reliably on a comparative regional basis.
- The unsaturated levels of bicarbonate show that the contact time for groundwater to establish a complete equilibrium with the CO_2 is insufficient in dolomitic aquifers because of a fast infiltration rate. Also the effect of evaporation would be lower.
- The graph confirms that the recharge is virtually zero for bicarbonate concentrations in the range of 440 mg/l or more for both sets of values. The latter value represents the point at which precipitation of carbonates will commence i.e. when super-saturation of bicarbonate has been reached (Bredenkamp 2000).
- Zero bicarbonate concentrations correspond to a maximum recharge of 32,6% of rainfall in the NW dolomite area, in comparison to 19% for the Kuruman area. These maximum recharge values will probably only occur as point recharges where the conditions for high/fast recharge are ideal.

- The bicarbonate concentrations appear to be a more reliable indicator of recharge than the chloride estimations, because the concentrations of bicarbonate can be determined with higher accuracy and is less affected by contamination.

Postulation: For all dolomitic aquifers a similar relationship between bicarbonate concentrations and recharge should apply but the gradient would be larger in the areas of higher rainfall, but still the same cut-off (440 mg/l) would apply for zero recharge, although that is unlikely to occur in the high rainfall areas.

Method 3. Goundwater Balance Method – (see Beekman and Xu (2003).

The following equation is applied to balance the influx of groundwater against the losses from the system over a time interval dt. The equation is similar as that of a surface water reservoir, e.g.:

$$I - O + Re - Q = S \cdot dV/dt \dots\dots\dots \text{eq. A.2}$$

	For a groundwater system	For a surface water reservoir
I	=Inflow	=The runoff which is the dominant component
O	=Outflow	=The losses other than releases
Re	=Recharge	=The rainfall on the surface of the reservoir
Q	=Abstraction	=The releases from the reservoir
S	=Storativity	=1 for a reservoir
dV	=Change in saturated volume	=The change in volume of the reservoir

The solution of this equation for a groundwater system is possible if certain simplifying assumptions are made, for example: inflow and outflow could be assumed to be constant and therefore will cancel out.

Method 4. Equal volume method (special case of water balance method)

The change in storage dV (therefore S) could be eliminated by the selection of recurring periods of equal status of groundwater levels or spring flow (dV =0) known as the equal volume method (EV method). For each EV period the recharge would be equal to the abstraction that has occurred during that period. If pumping has affected the spring flows the abstractions during equal-flow periods have to be added to the impacted flow measurements.

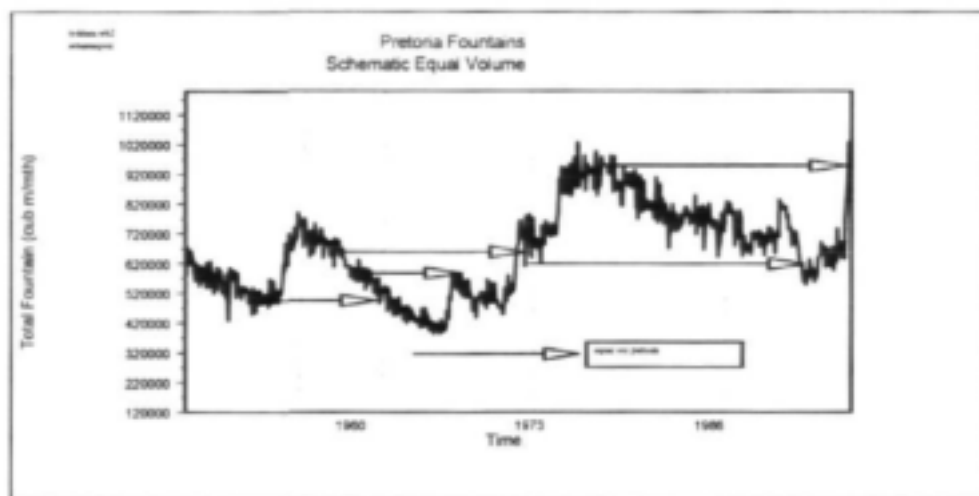


Fig. A.2 Principle of the equal volume applied to spring flows. A relationship between recharge and rainfall could be derived by means of the Equal Volume technique.

For longer equal-volume periods the recharge percentages would converge to the average long-term recharge factor, however the recharge coefficient follows a non-linear function when the rainfall over shorter periods exceeds a certain value

The EV method has been incorporated in an Excel spreadsheet program (developed by Xu, 2003) to be applied to springs flows. The full series of the monthly spring flows first has to be simulated by means of the CRD/MA method if only discontinuous measurements of the spring discharge are available.

Method 5. Improved Recharge Formula

More reliable simulations of water levels and spring flows by means of the MA method have been obtained by weighting the recharge coefficient in relation to the deviation of rainfall from the long-term average (Bredenkamp et al 2000). In addition a low and high-recharge component has been included to effect higher recharge when the rainfall exceeds a normal and high threshold value. The weighting factor is similar to using an exponential recharge relationship, which has been applied in the study of the Zeerust unit by the PMA consortium (Van Rensburg, 2003 – private communications). The effective area of recharge is incorporated to convert the recharge per month to spring flow values. The actual recharge area however is larger, as the recharge of the remaining area represents the losses that occur over and above the discharge of the spring (refer IUCN Report, Bredenkamp, April 2003). The following recharge formula has provided good simulations of recharge and of spring flow:

$$Re(i) = b \frac{Rf_{36}}{Rf_{longterm}} (Rf_{72} - Rf_{threshold}) + p \cdot (Rf_{72} - d) \dots \dots \dots \text{eq. A. 3}$$

where

b = the normal recharge coefficient that applies to monthly rainfalls that exceed the threshold value.

$Rf_{36}/Rf_{longterm}$ = a weighting factor. For Schoonspruit $b = 0.122$

p = the high recharge coefficient that applies to monthly rainfalls of the preceding 72 months that exceeds the high cut-off value. From the simulation of Schoonspruit eye $p = 0.48$ and $d = 42$ mm/mth and the $Rf_{threshold} = 14$ mm.

A significant improvement of the correspondence between the observed and simulated flows has been attained by the new formula; not only in terms of a better fit but also in effecting a lagged response of spring flow to the rainfall in the case of Dinokana en Schoonspruit eyes. The new recharge formula also yielded spring flows that correspond more closely to the water levels of the Wondergat, which proved to be linearly related to the flow of all the dolomitic springs (See Fig. A. 3 and A. 4).

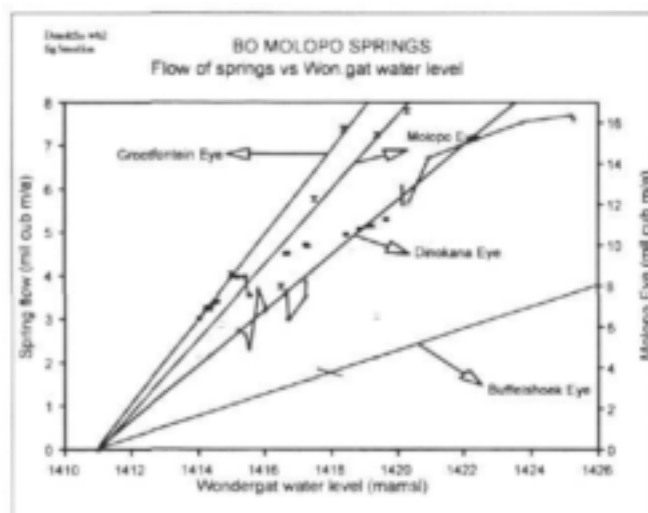


Fig. A. 3 Relationship between the water level of the Wondergat and the annual flows of several dolomitic springs in the NW region, indicating that the springs would stop flowing if the Wondergat reaches a level of 1411 mamsl. (Bredenkamp et al.1995).

The linear relationship stems from the fact that the Wondergat levels reflect the regional response of groundwater levels of the entire dolomitic area. This is due to the similarity of the dolomite aquifer and of the regional rainfall – see Fig. A4.



Fig. A. 4. Graph showing the good correspondence between the measured flows of Schoonspruit eye and those simulated by the new recharge formula. Excellent correspondence with the Wondergat levels is shown when the latter is lagged by 5 months.

Estimating Storativity

Application of the CRD/MA method using a reasonable estimate of the recharge (e.g. based on the chloride ratio method) and then optimising for both recharge and S.

It is also possible to plot the rainfall against an apparent S value that has been derived from 12 monthly groundwater balances with the recharge incorporated in the S value. For the Grootfontein compartment (Van Rensburg, 1995) an S value ranging between 0.016 and 0.03 has been derived. This represents a bulk average storativity representative of an area of 85 km² of mostly Monte Christo dolomite. The average storativity of 0.023 is slightly higher than the value of 0.018, which has been inferred by the CRD/MA methods.

Table A 1. Typical values of the storativity (S) and transmissivity (T) of the different Dolomitic Formations of the NW Region (Bredenkamp, 1999 and Bredenkamp and Nel (1997)

Formation	Grootfontein T value m ² /d	Grootfontein S value	Zeerust T value m ² /d	Zeerust S value
Oaktree	35	0.025	87	0.01
Monte Christo	1200	0.08	1200	0.032
Lyttelton	1100	0.008	70	0.18
Eccles	3000	0.12	3000	0.18
Dykes	400	0.11	25	0.11

Table A 1 shows typical transmissivity and storativity values of the different dolomite formations (modelling study by Bredenkamp, 1999). The CRD simulations are better, because they represent a more realistic

hydrological recharge model. According to the CRD/MA results the S values in Table 1 appear to be too high.

Method 6. Chemical quality of the groundwater

The following graphs of the temporal variations of groundwater from springs reveal the status of the recharge areas in respect of pollution and unchanging recharge conditions in time integrated over the recharge area.

Dinokana and Molopo (Fig. A5): These eyes represent uncontaminated conditions, as the concentrations have remained essentially constant.

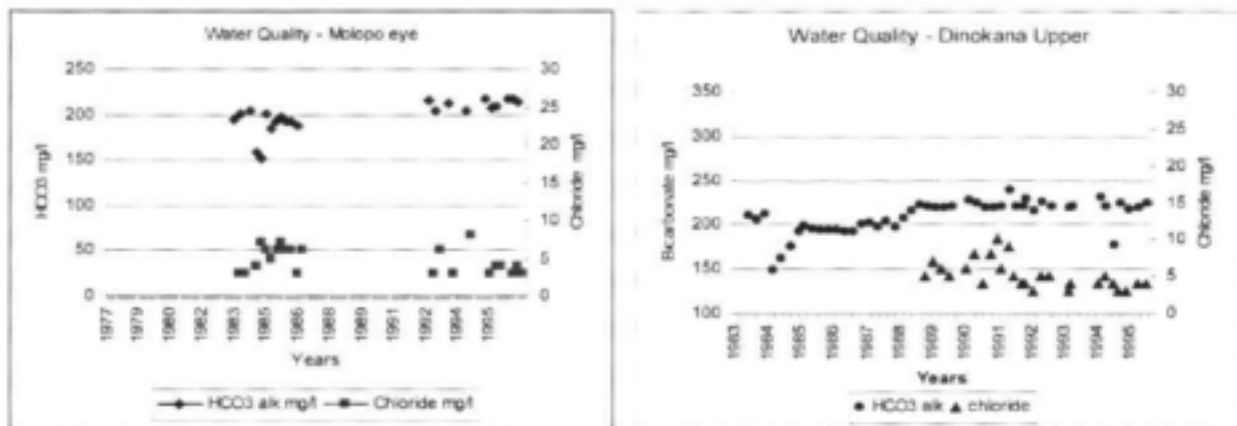


Fig. A5. Changes in chloride concentrations of chloride and bicarbonate with time for several springs of the NW dolomite.

Grootfontein, Schilpad, Upper and Lower Malmani and Tweefontein eyes (see Fig. A6): The bicarbonate concentrations have gradually increased, which reflects larger biological activity. The unchanging chloride values, however, show that contamination is absent and that the recharge has remained constant. Pristine conditions also prevail at the Upper and Lower eyes of Tweefontein.

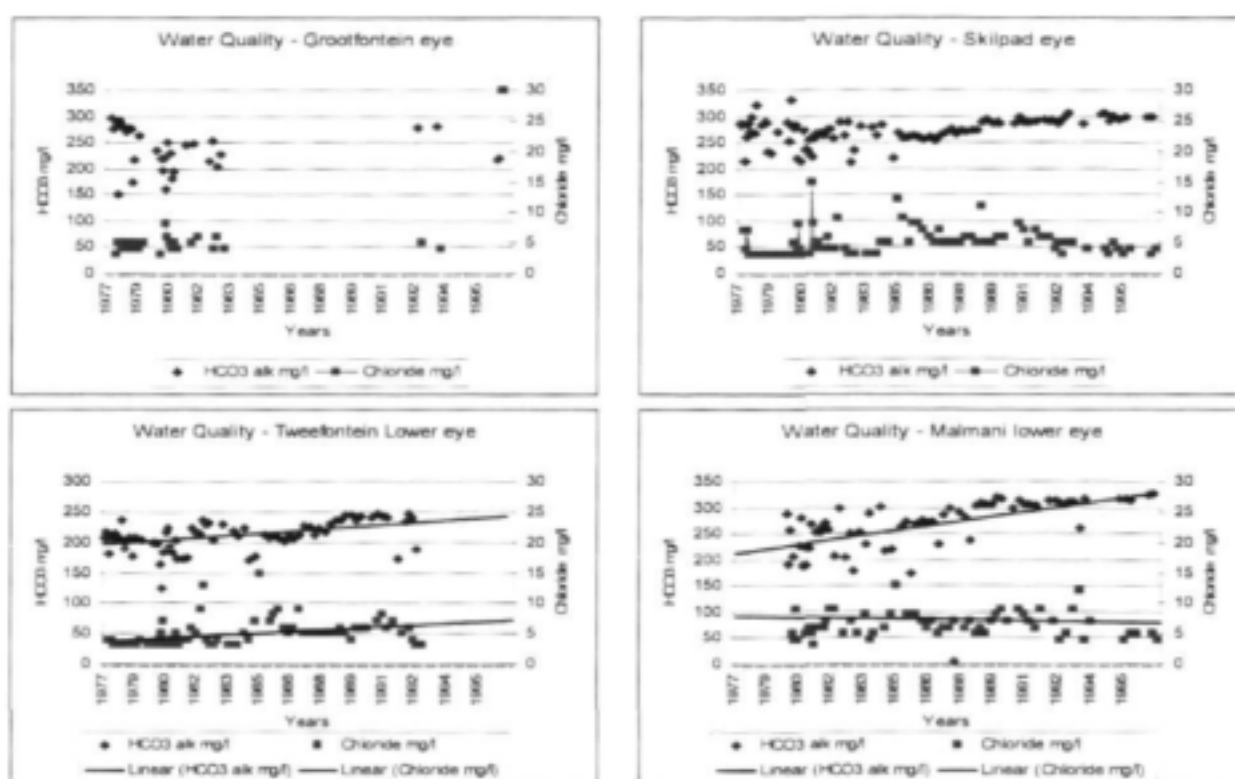


Fig. A6 Change in chloride and bicarbonate concentrations with time of more springs.

Wonderfontein (see Fig. A7): Contamination has definitely occurred. Not only have the chloride values increased but also the bicarbonate shows a gradual increase. Both increases are probably due to intensive irrigation in the catchment. It is clear from the Wonderfontein graphs that both the recharge and biological equilibrium have changed.

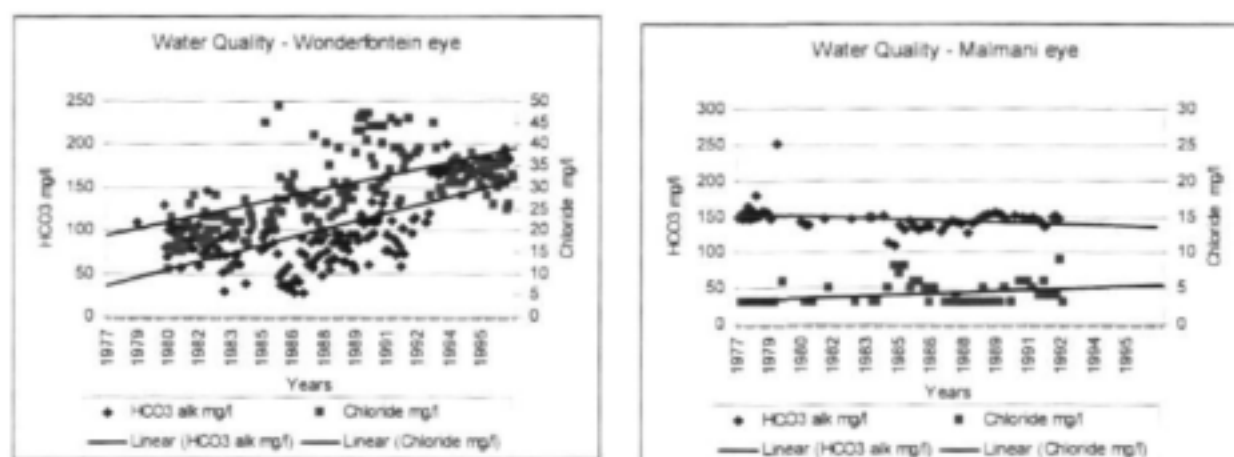


Fig. A7. Water quality variations of the Malmiani and Wonderfontein eyes

The temporal variations of the springs have to be monitored as that would reveal if changes to the average recharge and possible pollution over the recharge areas have occurred.

Method 7. Hydrodynamic Modelling

Regarding the total water resources of the NW dolomite aquifer and the regional impact of abstraction on the various groundwater units, especially within the boundaries of smaller sub-compartments, it is essential for the entire dolomite basin to be simulated by means of a hydrodynamic model. Thus the modelling of the Zeerust area, which is presently being undertaken as part of the study of the PMA consortium, needs to be extended to include the entire NW dolomite aquifer. This is the only reliable way to simulate the natural status and the impacts of different management scenarios of abstraction and recharge in a quantitative way.

The simulation of groundwater levels by means of a hydrodynamic model is similar to the CRD/MA simulations but is much more sophisticated and can simulate the dynamic groundwater level response of an entire aquifer incorporating recharge, flow, the bounding effects of dykes and geological formations. By means of the steady-state solution the equilibrium condition is first simulated 1) to yield the regional water level configuration, 2) to obtain the aquifer transmissivity and 3) to determine the drainage to springs/ rivers or other points of outflow. For the steady-state simulations the storativity of the aquifer does not come into play. The reliability of the model depends on how well the temporal changes of groundwater levels over the entire aquifer match the measured levels of the monitoring points spread over the aquifer. The dykes and formations are incorporated as elements with different permeabilities and recharge.

Appendix B: Estimating Abstraction

Deriving the abstraction of the different groundwater units reliably has been difficult. Although meters were installed prior to 1967 to record the pumping in the Bo Molopo Groundwater Control Area, their maintenance and replacement has been a problem. Farmers have claimed that the meters restrict the flow of water thereby increasing the pumping costs. Thus an indirect assessment of the abstraction had to be applied by evaluating the areas that are being irrigated and the water demand of cultivated crops. This posed a problem insofar that more than one crop per annum had been cultivated from the same irrigation pivot. Initially surveys of the irrigated areas had to be carried out to keep track of expansion of the irrigated areas. However satellite images can clearly reveal the irrigation pivots as well as the types of crops (See Fig. B1). Schoeman and Partners have applied this method in the Ventersdorp groundwater unit to estimate the abstractions.

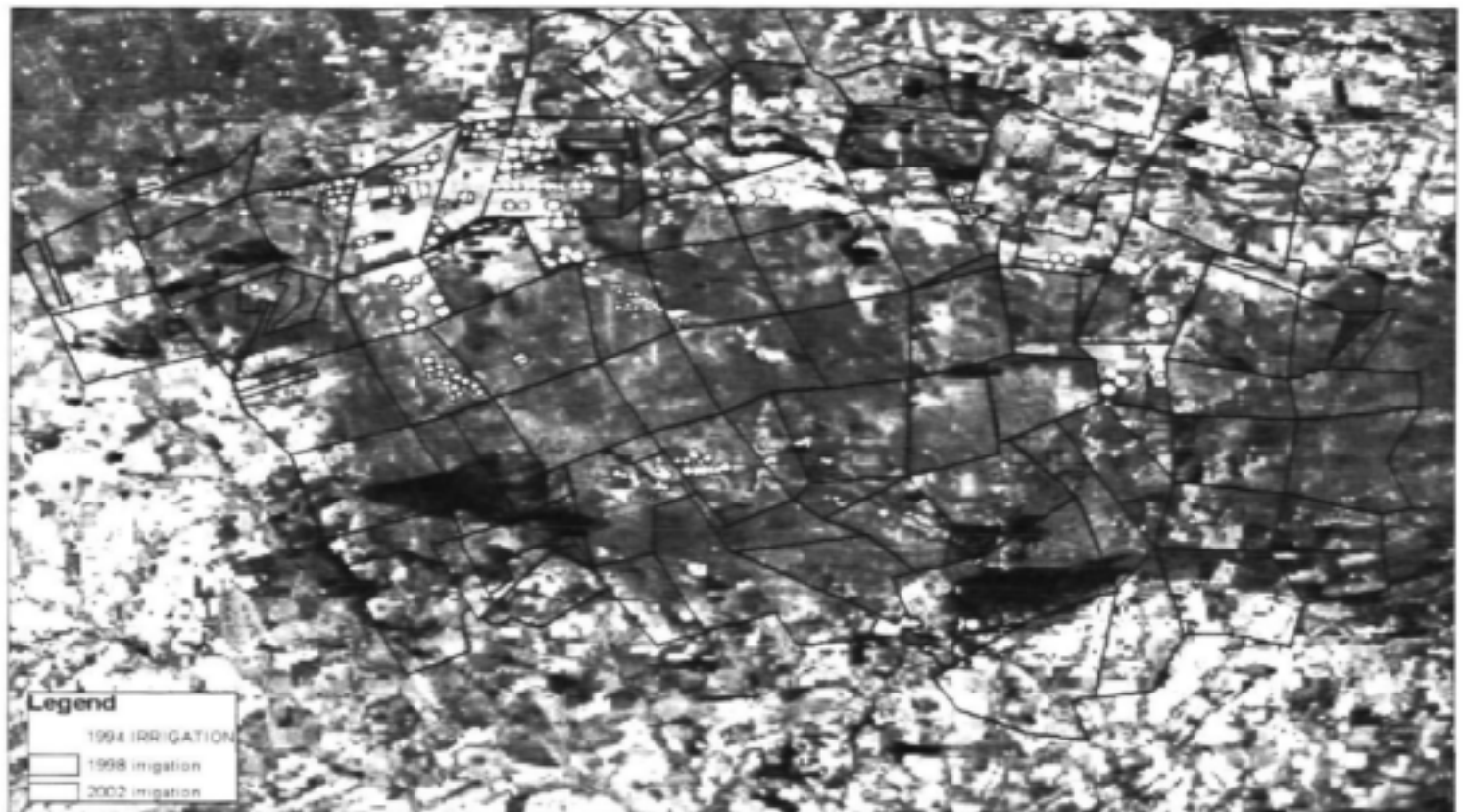


Fig. B1. Aerial view of irrigation pivots in the Ventersdorp area using colour codes to highlight the expansions from 1994 to 1998 and 2002 (from Veltman 2003).

The electricity consumption of the irrigation installations in relation to the pumping volumes, after a calibration of the pumping set-ups has been successfully used by Bredenkamp (1967) to infer the abstraction at the time and similarly by Van Rensburg (1987) to determine the abstraction for the period 1977 to 1983. For assessments during the period in-between, ESCOM or the farmers have not provided the electricity records. In fact the farmers have objected to this information being revealed to Water Affairs. This jeopardized utilizing the electricity consumption to assess the abstractions and also to control the pumping. It has been considered linking the abstraction permits to power consumption quotas, which would be cut off if, and when the allocations were exceeded. Alternatively the electrical consumption in excess of an allocated quota could be charged according to a sliding tariff scale. Prior to 1976 vibration meters have been used to record the hours of pumping but proved to be unreliable.

Evaluation of the reliability of abstraction estimates.

Grootfontein Eye: Electricity Consumption

The irrigation abstractions that were derived from the electricity consumption at the Grootfontein eye are believed to be reliable, and corresponded well with estimates based on the areas of irrigation and crop types (Fig. B.1).

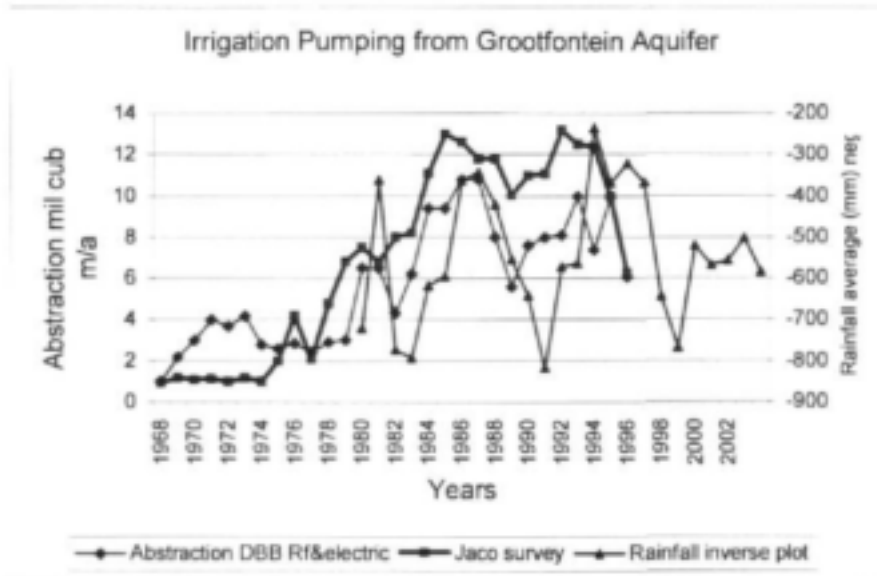


Fig. B2. Comparison of the abstraction estimated by Nel based on the areas of irrigation and estimates of Bredenkamp, which were derived from the electricity consumption of the pumps (Bredenkamp, 1999). The correspondence between the pumping estimates and the inverse average rainfall of the 12 preceding months is also indicated.

Abstractions for the period when there were no or only unreliable electrical records have been inferred according to a linear (inverse) relationship between the monthly abstractions and average rainfall of the preceding 12 months (Bredenkamp, 2000).

Blaauwbank pumping - CRD/MA method versus Electrical Consumption

The reliability of the CRD interpretations has been checked against abstraction that was derived from the electricity consumption of the pumps. For the CRD simulations the effective area of abstraction for each monitoring borehole is 1 km², but could be smaller if the monitoring borehole is close to a pumping borehole. The total abstraction has been calibrated against the average abstraction of the monitoring boreholes, using an effective area of 20 km². This area is only two thirds of the size of the Blaauwbank farm as the area south of the Blaauwbank dyke falls in the Lichtenburg/Polfontein compartment and therefore had to be excluded.

Fig. B.3 indicates the abstraction that was calculated from the electricity consumption and the pumping that has been derived from the CRD/MA method. The CRD/MA estimates initially appeared to be too high, however these estimates have been inferred from fewer production boreholes that do not represent the average status that well. The abstractions from 1970 to 1973 show good correspondence and thus the abstraction for the rest of the period up to 2000 seems to be reliable.

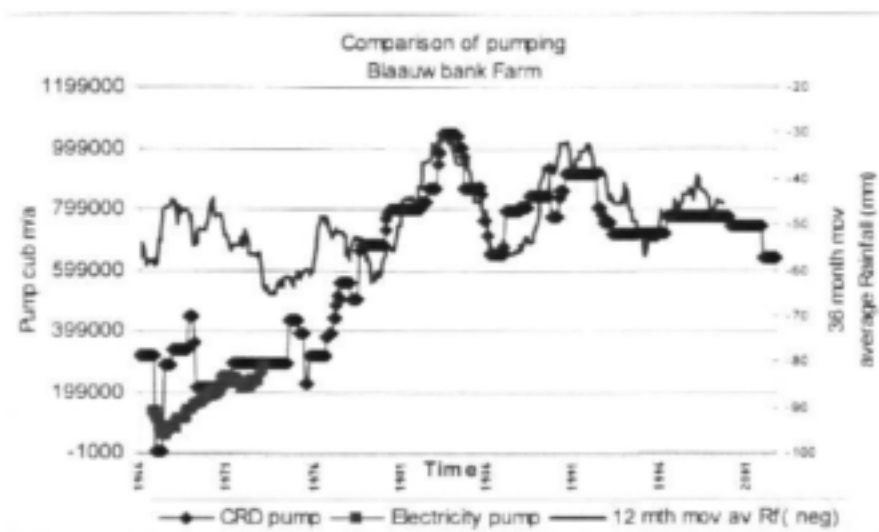


Fig. B. 3 Comparison of pumping determined by means of the electricity consumption of pumps with those derived from the CRD/MA method. The abstraction after 1979 shows an inverse relationship with the moving average rainfall over 36 months.

Lichtenburg Pumping

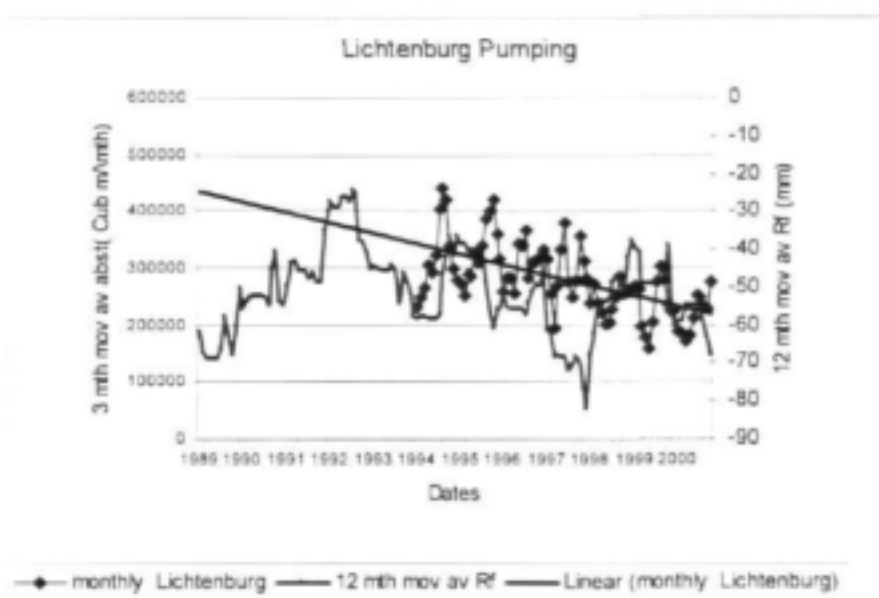


Fig. B.4 Graph of the abstraction from the well field of Lichtenburg in relation to the moving average rainfall of the 12 preceding months plotted inversely.

Based on the relationship with rainfall the abstraction of Lichtenburg has been inferred for the preceding periods. The measured abstractions and those simulated by means of the CRD/MA method has been compared, using only four monitoring boreholes as compared with the 11 to 13 pumping boreholes. The average abstraction per month per km^2 had to be calibrated according to the equivalent area of abstraction. The area was adjusted until the cumulative totals of the simulated and yielded measured abstractions were closely the same (see Fig. B.4).

The actual and simulated monthly abstractions are compared in Fig. B. 5 indicating reasonable agreement considering that the CRD/MA abstractions have been simulated from only four monitoring boreholes. This provides further proof that the CRD/MA method can yield a reliable estimation of abstraction, provided that

sufficient monitoring boreholes are distributed over the area. The sharp decline of abstraction according to the CRD/MA interpretations is probably due to the spring flows having increased.

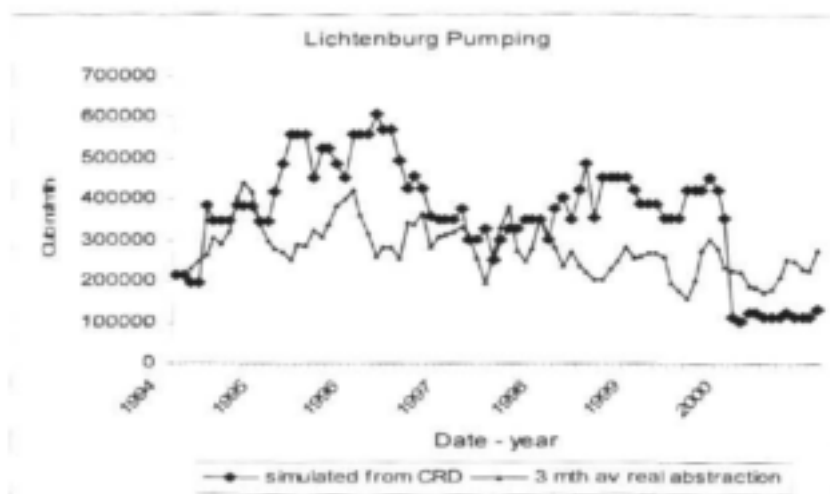


Fig. B. 5 Graph showing the correspondence between the CRD/MA simulated abstraction and the measured values.

Pumping from the Grootpan and Ventersdorp Groundwater Units

The irrigation abstraction for the Ventersdorp groundwater has been inferred according to the CRD/MA simulations of 12 monitoring boreholes. These boreholes are sparsely but evenly distributed over the area and for each the annual abstraction has been determined. The total abstraction was assumed to be equal to the abstraction multiplied by the total area.

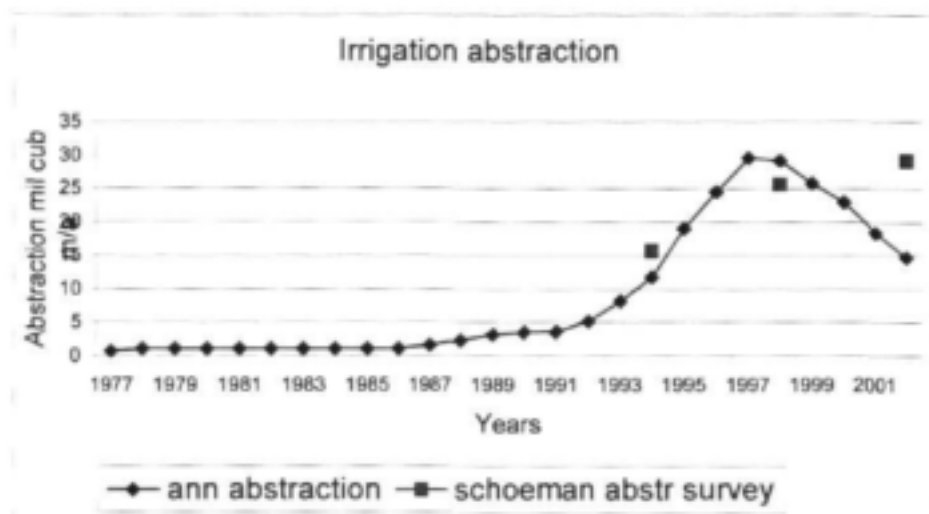


Fig. B. 6 Comparison of the irrigation abstraction according to Schoeman and Partners from surveys of irrigation; and those derived from the CRD/MA interpretations of observation boreholes.

Schoeman and Partners have estimated the irrigation abstraction based on surveys of the areas and the crops that have been grown. The irrigation areas as obtained from satellite images for 1994, 1998 and 2002 show the extent of the irrigation development (see Fig. B1). The correspondence between the annual abstractions based on the CRD/MA interpretations and that of the three years that have been surveyed by Schoeman and Partners, is shown in Fig. B.6. For 1994 and 1998 the abstractions compare quite well. The lower abstractions derived from the CRD after 2000 have been confirmed from the assessment of the

impact of the pumping on the Schoonspruit eye (see Fig. B.7), this is due to the higher rainfall and lower irrigation demand that had been experienced during the latter period.



Fig. B.7 The flow of the Schoonspruit eye with pumping which had to be introduced to obtain a good simulation between the measured and simulated groundwater levels

Fig. B.7 shows the simulated natural flow of the eye in comparison to the measured flows. The impact of the abstraction has been derived by means of the MA method by adjusting the quantities of abstraction until the impacted levels fitted the observed spring flows. It is also clear that the abstractions had been lower during the period 2000 to 2002 as have been indicated by the monitoring boreholes.

APPENDIX C:

Proposed structure and outline of a manual for users

It is envisaged that Water Users Associations will need a basic understanding of the occurrence of groundwater and of the dynamics of the aquifer, as well as how to conduct effective assessments of the resource so as to implement measures for sustainable utilization of the aquifer.

It is therefore advisable for the development of an educational/technical guide to outline the basics of methods to determine the exploitation potential of the groundwater. This should include a simplistic conceptual model of the aquifer and of the geohydrological parameters. The manual should also provide guidance in setting up an institutional framework for effective management of the resource. The compilation of a technical guide has not been part of the terms of reference of the present project, however aspects outlined in this appendix have been included in the manual by Colvin (2004).

Simplified conceptual model of the aquifer

The figure below schematically represents the conceptual presentation of the NW dolomitic aquifer. This shows the extent of outcrops of the different geological formations that store the groundwater and the drainage to the main springs and other points of outflow.

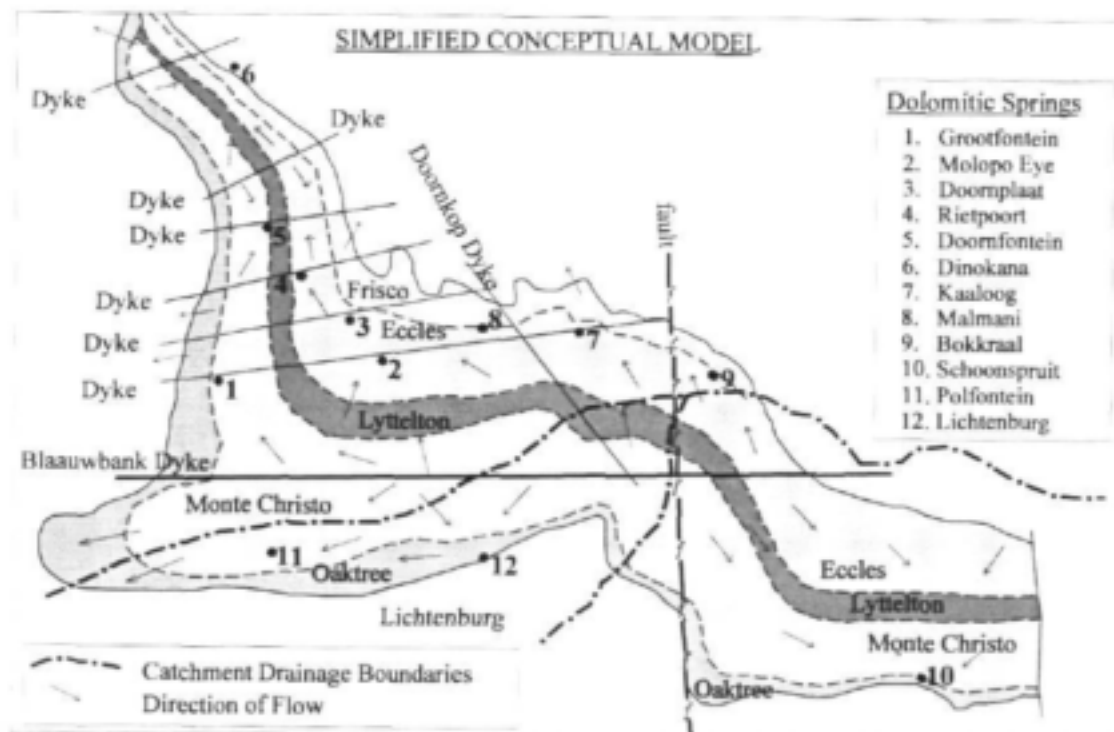


Fig. C.1. A schematic conceptual presentation of the NW dolomitic aquifer indicating the different formations, some dykes and the main springs emanating from the area.

The main boundaries of the aquifer are

- 1) The dolomitic basin of stratified formations, originally horizontal but now dipping to the North thereby exposing large areas of good aquifer formations.
- 2) The N-S fault that runs through the surface water divides.
- 3) The Blaauwbank dyke acting as a boundary running from west to east. The drainage north of the dyke is to the north and southwards to the south of it.

The drainage of groundwater is indicated by the arrows and is directed to the outflow points of the main springs. However part of the underground outflow is to the west along the Molopo River and along the Black Reef. The overall drainage corresponds to the topography. This is not surprising as the flow of water is gravity driven and is therefore directed to lower lying points and points where springs emanate.

The **geology** with its structural deformations and dissolution of dolomite by acidic rainfall determine the characteristics of the aquifer. Some formations are more susceptible to recharge than others and their capacity to store water varies. The overburden, generally comprising of soil/gravel and rock outcrops, controls the rate of infiltration of rainwater to recharge the aquifer. Diabase intrusions (dykes) subdivide the dolomite into smaller compartments. The ability of the aquifer to absorb and store water is of crucial importance as it determines the volume of water that could be retained in storage for use at a later stage. The lag between the recharge events and utilization of the water provides a means to manage the allocation of water every season.

Losses of groundwater continually occur due to lateral seepage to lower-lying areas, rivers and wetlands. There are also evaporation losses from the groundwater by capillary action and transpiration by the vegetation.

The combined total average flow of all the springs in the region is equivalent to the average recharge over an area of 1860 km² and the total recharge area of the dolomite is about 5000 km². Thus the spring flows represent only 40% of the total recharge indicating that 60% of the recharge is dissipated in the form of underground lateral flow and other losses. The flow of a spring is directly proportional to the groundwater level of the aquifer that feeds it and any decline in water levels due to pumping would cause an equivalent drop in spring flow.

Rainfall is the main factor that causes recharge. The recharge is a function of the amount, frequency, intensity and spread of rainfall spatially and over time. The recharge is the portion of the rainfall contributed to the groundwater in storage that causes a rise in water levels, whilst the losses effect a decline of the water levels. The balance between the average recharge, the losses and storage of the aquifer determines the sustainable yield of the aquifer. The CRD/MA method provides a simple method to simulate the groundwater balance and also to quantify certain aquifer parameters. The recharge could be highly variable and relates exponentially to rainfall exceeding a certain threshold value (Van Rensburg, private com. 2003).

Aquifer transmissivity - T is the property of an aquifer to transmit the flow of groundwater to lower lying areas, springs and points of abstraction. In this respect the dykes play an important role because due to their lower permeabilities, they restrict the outflow, resulting in higher groundwater levels that could cause springs to occur at the lowest topographical points. The T value also determines the rate of abstraction from a pumping borehole, whilst the sustainable yield is a function of the volume of water stored in the aquifer and of the recharge. If more than one borehole is being pumped there is interference, which could cause the yields in the cluster of boreholes to diminish.

Methods to estimate aquifer parameters

Several methods are available to quantify the recharge and determine other important parameters of an aquifer. The application and reliability of many methods depend on the availability of certain critical parameters and data, e.g. groundwater level fluctuations. Certain methods can only provide recharge pertaining to a specific point but the more reliable estimates are obtained when the recharge is integrated in time and space. Most methods are subject to a degree of error or uncertainty because of the variability of parameter values that cannot be determined reliably. Fortunately the reliable estimation of the natural flow of the springs could be derived by means of the MA method and groundwater levels could best be simulated with the CRD method.

The most reliable simulation of an aquifer's performance is by means of a hydrodynamic model. Various of these models are available but the FEFLOW model that is presently being used to simulate the Zeerust dolomitic area, can accommodate complex aquifer systems and has the capacity to model the entire NW dolomitic aquifer.

Aquifer management

The requirements to utilise and manage the different groundwater units in an effective way are the following:

- 1) Proper monitoring of groundwater levels, groundwater abstraction and rainfall at stations representing the respective areas. Keeping track of the response of the integrated water levels in relation to the CRD/MA relationship.

- 2) Periodic sampling of water for chemical analysis at points of major abstraction to check the status of pollution and to derive estimates of recharge.
- 3) Because of a lag between the recharge and the irrigation, the water that would be available for allocations for the following year could be estimated. A surplus recharge in a particular year should only be utilized during the next season. A model of the aquifer would be of great value to simulate the response of the aquifer to different scenarios of recharge and abstraction.
- 4) Periodically an overall reassessment of the water resources would have to be carried out, either by means of
 - i) The CRD/MA method, a simple water balance or
 - ii) By means of a sophisticated hydrodynamic model, which is the preferred option if funds are available

Simplistic Methods of Estimating Recharge

Although a sophisticated approach could be adopted the following simple methods would be effective and reliable to determine the main aquifer parameters (see Table C.1).

Table C.1. List of most practical methods to determine aquifer parameters

Parameter	Method	Comments
Storativity S	1. Water balance equation 2. Pumping tests 3. CRD and MA simulation	Needs an estimate of recharge
Recharge	1. Chloride mass balance (ratio of Cl concentrations in rain to that of groundwater) 2. Bicarbonate method 3. Equal volume interpretation of the water balance 4. CRD&MA methods 5. Hydrodynamic modelling is based on water balance and flow between grid elements.	Chloride in rainfall is required but could reasonably be estimated as a first approximation Has to be calibrated according to reliable estimates based on other methods e.g. the chloride method. Must have data of pumping or of spring flows or base flow Require an estimate of S and a fair series of monthly water level data. Requires a high degree of modelling skills and knowledge of the modelling software.
Aquifer depth and thickness	MA method and CRD method	Only method other than drilling
Pollution status	Chemical analysis and trends	Comparison of the change with time of dissolved salts specifically Bicarbonate and chloride

Overview of Methodologies for the Estimation of recharge

The chloride mass balance:

- 1) Apply this method to obtain the regional recharge
- 2) Determine the input chloride of the rainfall according to the regional graph (Bredenkamp et al. 1995).
- 3) The chloride input however needs to be further validated or improved by additional measurements of the chloride concentration of the rainfall at different places. This would require rainfall sampling at pre-selected areas, which would be representative of the typical aquifers and climatic conditions. Accumulative rainfall samples therefore have to be collected on a monthly basis for a period of about 3 years, to obtain the average input concentrations of chloride. If reliable estimates of the recharge have been obtained by another method, these recharge values could be used to check the chloride concentrations of the rainwater.

Bicarbonate method: Although this is a new method, it could be applied on a regional basis once it has been properly calibrated. Such a calibration could be achieved by comparison with other reliable estimates e.g. the chloride method, Equal Volume or CRD method. For all aquifers a linear relationship between the bicarbonate concentrations of the groundwater and the recharge should apply.

It is preferable to analyse water samples of springs, rather than of boreholes, to obtain representative concentrations of chloride and bicarbonate of the groundwater. This is because the spring water represents average water sample integrated in time and space. Differences in recharge as a result of irregular rainfall and varying conditions of the catchments will therefore be evened out. The chloride and bicarbonate concentrations of groundwater samples from boreholes that are spread over the recharge area have to be analysed to show the spatial variability of recharge.

Equal volume method: Recharge can be derived from identified periods starting and ending with the same flows. The total flow and pumping during the period would be equal to the recharge. In this way estimates indicating non-linear recharge, have been derived. Similarly the water balance for periods of equal water levels could be used, in which case the abstraction during the equal-volume periods presents the recharge.

Determination of abstraction from aquifers

It is preferable to install gauges to monitor the major abstractions. However this would add a significant financial and administrative burden to the budget to ensure that the meters are functioning properly and are not tampered with or vandalized. As most pumping installations are electrical, the abstraction could be derived according to the electricity consumption of the pump set-up. The recorded consumption figures first have to be calibrated against real abstraction data

By means of the CRD/MA method, the pumping rates could be inferred from the water level response. The method should however be calibrated relative to real abstraction data.

Management of an aquifer

The simplest way of managing an aquifer is to adopt the following approach:

- Derive the average recharge (could be annual) that is needed to sustain the licensed abstraction for each user.
- Calculate according to a rainfall/recharge equation the monthly recharge using the actual rainfall month by month, and convert to an abstraction volume, the user would be entitled to use.
- Maintain a monthly balance between the recharge and the abstraction; and by using average rainfall for coming months the expected outcome of the balance for the season can be calculated in advance.
- If the balance turns out to be negative the users' quotas for the next year or season should be reduced by that amount. If it is positive the surplus could be added to the normal allocation or could

be carried forward to the following year. This would encourage users to utilize their groundwater as effective as possible.

- At no stage should deficits in the water balance be allowed to exceed the equivalent of a temporary predetermined excess allocation. Should that stage be reached the abstraction should be reduced or stopped until the negative balance has been cancelled.
- The proposed management approach is considered to be the only effective way of involving the users in protecting the resource and having a basis to ensure an equitable allocation of the groundwater. The groundwater balance could be accommodated by an Excel spreadsheet allowing each irrigator/user to keep track of the abstractions in relation to the recharge.

Advance projections of the response of the aquifer overall could be assessed by means of the CRD/MA method for which software has been developed (in attached CD). Once calibrated for the entire aquifer or for groundwater units the impacts of different scenarios of recharge and abstraction could be simulated.

On a more sophisticated level an evaluation of the aquifer's response at the CMA level should be performed by means of a hydrodynamic model, such as the FEFLOW Model.

The main application of the software would be to predict the water levels responses of monitored boreholes at the end of the next season. The abstractions for the next season must be adjusted so as not to exceed the limits.

APPENDIX D:

This appendix includes the data sets and interpretations that have been derived form the application of the CRD/MA method and includes:

- 1) Rainfall series
- 2) Groundwater level data as part of the hydrograph interpretations
- 3) Spring flow data as part of the analysis of springs
- 4) Inferred abstractions

APPENDIX C

Situational Analysis for the preparation of Institutional
Arrangements for Groundwater Management in the
North West Dolomitic Water Areas

PHASE 2: SITUATION ANALYSIS

INSTITUTIONAL ASSESSMENT

by

Kabelo Reid, RMCS

Anthea Stephens (Project Manager)

IUCN South Africa
P.O. Box 11536
Hatfield, Pretoria

Tel: 012 324-8304
Fax: 012 342-8289

TABLE OF CONTENTS

EXECUTIVE SUMMARY	iii
1 INTRODUCTION	1
1.1 Background to the Study	1
1.2 Limitations of the Institutional Assessment and challenges of Methods and Results	3
2 RESEARCH METHODOLOGY	5
2.1 Updating of stakeholder database	5
2.2 Updating of stakeholder roles and responsibilities	5
2.3 The institutional assessment study	5
2.4 Stakeholder workshops	6
3 SURVEY RESULTS	8
3.1 Municipalities	8
3.1.1 Ventersdorp Municipality	8
3.1.2 Ditsobotla Local Municipality	10
3.1.3 Central District Municipality: Mafikeng and Zeerust Municipalities	12
3.1.4 Southern District Municipality: Klerksdorp, Potchefstroom & Ventersdorp	15
3.2 Water Management Institutions	16
3.2.1 Lower Vaal CMA	16
3.2.2 Middle Vaal CMA	17
3.2.3 Crocodile West – Marico CMA	17
3.2.4 Ventersdorp WUA	19
3.2.5 Zeerust WUA	22
3.2.6 Lichtenburg-Itsoeng WUA	22
3.2.7 Grootpan WUA	23
3.2.8 Extended Grootfontein WUA	23
3.3 Implementing Agencies	24
3.3.1 DWAF- The North West	24
3.3.2 DWAF- Free State	25
3.3.3 DWAF- Gauteng	26
3.4 Policy Development and Institutional Support	28
3.4.1 DWAF- National Office	28
3.5 Important role-players beyond DWAF	30
3.5.1 Botshelo Water	30
3.5.2 The North West Department of Agriculture	31
3.5.3 Agri-North West	32
3.6 Conclusion	34
4 CONCLUSION AND RECOMMENDATIONS	37
5 BIBLIOGRAPHY	44
ANNEXURE A: List of respondents	45
ANNEXURE B: Questionnaire	46
ANNEXURE C: Workshop report – marginal water users	50
ANNEXURE D: Workshop report – dominant water users	60
5.1 Participants	61
5.2 Summary of issues discussed in workshop	61
5.3 Summary of evaluation questionnaire	64
5.4 Participants	65
5.5 Summary of issues discussed in the workshop	65
5.6 Summary of the evaluation questionnaire	67
5.7 Participants	68
5.8 Summary of issues discussed during the workshop	69
5.9 Summary of the evaluation questionnaire	71
5.10 Participants	72
5.11 Summary of issues discussed during the workshop	73

5.12 Summary of the evaluation questionnaire.....	75
ANNEXURE E: Workshop report – DWAF Officials	77

EXECUTIVE SUMMARY

This report presents the results of an institutional assessment study of groundwater management institutions in the North West province. The study aims to assess the institutional environment and instruments that are employed to manage the dolomitic aquifer in that province. The purpose of the assessment is to develop institutional arrangements that can best guarantee the sustainable and equitable use of the groundwater resource.

This report presents the results of a research process that has involved activities such as the updating of a stakeholder database, the updating of stakeholder information (their roles and responsibilities), the development and implementation of a research tool to undertake the institutional assessment activities, conducting interviews with key respondents as well as the hosting of workshops with stakeholders. There were three types of stakeholder workshops that targeted DWAF officials, dominant water users and marginalised water users within the study area.

This study builds upon a previous study undertaken by Stephens and Bredenkamp for the Water Research Commission in 2002- i.e. Institutional Arrangements for Groundwater Management in Dolomitic Terrains: Situation Analysis (Water Research Commission, 2002). One of the key outcomes of that study was a proposal to establish a Dolomitic Aquifer Management Committee (DAMC), which would have the effect of ensuring that the North West aquifer is managed in a holistic and integrated manner.

However, building onto the work of the first phase of the project was not easy. One of the key objectives for this phase was to conduct an assessment of institutions involved in the management of groundwater resources in the North West. The institutional assessment is critical in mapping the institutional composition and capacity of groundwater management in that province. It is also required to inform the outline of the proposed DAMC. However, many of the institutions that required evaluation so that we could meet the objective of providing an effective link to the Phase 1 report are still missing. In this respect, none of the WUAs or the CMAs have been established. Therefore, the assessment was forced to focus on existing stakeholder organizations to determine the institutional capacity in the area.

Furthermore, the absence of fully operational WUAs and CMAs in the study area means that their institutional capacity could not be assessed and the research tool could not be fully utilised in that regard. As a result, the assessment of CMAs and WUAs was confined to establishing the progress that has been achieved in getting them off the

ground. In most cases, stakeholders could not indicate when they expected their respective WUAs or CMAs to be established, and it was necessary to talk to a multiple of respondents to develop a clear depiction of progress for any of these institutions.

Ventersdorp Municipality: The municipality has taken an active interest in the formation of the WUA. Stakeholder meetings are often held at the municipal buildings. The municipality also makes some administrative equipment available to the WUA. The municipality rates the WUA as being the most important institution it relates to in terms of groundwater management issues, and significant levels of frustration with the promulgation process were expressed. The municipality also feels that the WUA operates in a state of legal limbo and the delays being experienced with regards to its formalization are costing it dearly in terms of stakeholder support. In this regard, the respondents were concerned by the lack of communication surrounding their WUA's application. Interestingly, they also tended to confuse the various water management processes that they participate in.

Ditsobotla Local Municipality: The Ditsobotla Local Municipality is made-up of a mixture of small villages, farming towns such as Lichtenburg and Coligny as well as areas that used to fall under Bophuthatswana such as Itsoseng and Gamotlatla. The research process discovered that the reliability of water supplies in Ditsobotla and surrounding villages is a major concern. In this respect, the supply of water is not reliable due to faulty or overburdened infrastructure. The quality of communication between the community and the local council is also inadequate. As a result, residents in the area complain of being marginalized and have developed a disparaging opinion of the municipality and the formal local government structures.

Central District Municipality: Mafikeng, Zeerust and Lichtenburg: The Mafikeng, Zeerust and Lehurutshe areas fall under the jurisdiction of the Central District Municipality which is based in Mafikeng. The municipality has serious financial and human resources challenges, and thus struggles to operate at full capacity. Domestic users of ground water resources in the District Municipality depend upon water reticulated by Botshelo Water for most of their water requirements. Surface water is not plentiful in the area therefore the supply of water to domestic users has to be augmented by underground resources. The Dinokana and the Molopo rivers are significant groundwater outlets; however private boreholes (both legal and illegal) are widely used in the area.

Southern District Municipality: Klerksdorp, Orkney and Ventersdorp: The District Municipality is involved in the establishment of the Ventersdorp WUA, and it has been

earmarked to participate in the management committee of the proposed CMA, which will exercise control over the Schoonspruit dolomitic compartment. The District Municipality expressed concern regarding the poor levels of communication between DWAF and local stakeholders. As a result, the respondents doubted the value of their continued participation in groundwater management structures. The poor levels of communication between DWAF and stakeholders could also account for some of the misconceptions that exist regard the policing of illegal boreholes- which is an issue that DWAF is required by legislation to address.

Lower Vaal CMA: The Lower Vaal CMA has not been formally proclaimed. Its establishment is driven by the Northern Cape regional office of DWAF, which intends to cede the portion of the dolomitic aquifer that is currently covered by the Lower Vaal CMA to the Crocodile West - Marico CMA.

Middle Vaal CMA: The Middle Vaal CMA falls under the bureaucratic jurisdiction of the Free State regional office. Respondents in this instance indicate that the CMA is only required to be established in four years. Therefore, the regional office is pursuing a different sequencing strategy and it is more concerned with studies to develop a better understanding of the water resources in the area under its jurisdiction. However consultants have been contracted to advance the formation of the CMA.

Crocodile-West Marico CMA: The establishment of this CMA has benefited from the participation of the Gauteng regional office of DWAF. DWAF has facilitated the implementation of a consultative process that should lead to a proposal to establish being submitted in 2005. However, the respondents from the forums and the WUAs have been critical of the time it is taking to get the CMA established.

Ventersdorp WUA: The Ventersdorp WUA is by far the most advanced WUA in the study area. Its establishment process is driven by the Free State office of DWAF. It was indicated that an application had been submitted to DWAF, and that the department responded in June 2003 that the Minister requires further information regarding the WUA's management committee. Some stakeholders believed that the proposed WUA had buy-in from all the relevant stakeholders- i.e. domestic users, industrial users, and agriculture as well as local government structures. However, this point is being disputed by both DWAF and marginalized stakeholders. The Ventersdorp WUA has in its application, requested a wide array of functions. These range from preventing the illegal use of water to controlling wastage and protecting water resources. This leads us to question whether the stakeholders have a clear appreciation of the capacity they will require to undertake all the activities that they intend to implement.

Zeerust WUA: The Zeerust WUA does not exist it is not to be confused with the Marico Bosveld WUA. A consultant was assigned by the DWAF Gauteng regional office to facilitate its establishment, but his contract ended before anything tangible was delivered. There has been very little progress since then.

Lichtenburg-Itsoseng WUA: A water management committee was established with the aid of a consultant from DWAF as a precursor to a WUA. An application was submitted to the department in March 2002. However, a response from the department is still to materialize.

Grootpan WUA: The Grootpan WUA does not exist. However, a steering committee was appointed in 2001. This committee surveyed the area under irrigation and reported to DWAF. The committee was unable to gain the support of the farmers because this stakeholder group was perturbed by the possibility of being involved with the technical responsibilities that are associated with the management of the aquifer.

Extended Grootfontein WUA: Grootfontein is one of the WUAs that was assigned a consultant by DWAF. The application to establish was compiled with the facilitation of that agent. However, there has been no progress since and the local respondents demonstrated a strong reluctance to pay for water until a CMA or WUA is established.

DWAF North West: The department's regional office in North West has experienced considerable capacity and human resource constraints in trying to support the development of institutions to support groundwater management. Urgent action is required to address stakeholder confusion regarding the establishment of the CMA and the WUAs. There is also widespread confusion relating to who should be policing the illegal abstraction of groundwater resources in the absence of the CMA and the WUAs. Other areas of stakeholder concern relate to the funding mechanisms for both the CMA and WUAs, the calculation of water use charges as well as the issues relating to representation on the CMA and WUAs.

DWAF Free State: The Free State Regional Office of DWAF is responsible for the Schoonspruit aquifer. As a result, it is also responsible for the establishment of the Middle Vaal CMA as well as the Ventersdorp WUA. Issues relating to stakeholder ignorance and confusion need urgent attention. The rural stakeholders from the marginalised communities around Ventersdorp indicated that their elected council officials (who have been representing these communities in the CMA and WUA establishment processes) had not briefed them about these important institutional

developments. There were also serious stakeholder concerns relating to illegal water use and the licensing of water use by farmers.

DWAF Gauteng: The Gauteng office of DWAF is one of the major driving forces behind the establishment of the Crocodile West – Marico CMA. Such a deep level of involvement is in part due to the fact that the Gauteng province has such major stake in that particular Catchment Management Area. Awareness of the regional office among stakeholders such as commercial farmers and local government authorities was very prominent. The regional office was most closely identified with the WUA establishment process in the Zeerust, Lichtenburg and Mafikeng areas. The flip side of this high profile is that those stakeholders tended to expect the regional office to clarify issues pertaining to the establishment of WUAs in those areas.

DWAF National Office: The opaque fate of WUA applications once they are submitted to DWAF for Ministerial approval is a source of frustration among stakeholder groups. The Department indicated that most applications from the study area were stalled due to the Minister's concern about inadequate levels of representation during WUA consultative and governance processes. The marginalised stakeholders' workshops suggested that these concerns were in many cases justified - mining and marginal users were not always adequately consulted or represented in the proposed structures. However, this issue has been poorly communicated to stakeholders, and this requires an urgent remedy.

Therefore a picture that emerges from this research undertaking is one that shows the DWAF national office to be struggling to process WUA applications fast enough and to manage communication between the centre and the periphery. The DWAF regional offices were found to be similarly challenged. The Northern Cape regional office is working towards ceding its portion of the aquifer; the Free State regional office has human resource capacity constraints as well as the challenge of keeping the existing Ventersdorp WUA stakeholders on board while seeking ways of bringing additional stakeholders into the process. The Northwest regional office also has human resource capacity challenges. It has struggled to resuscitate the Molopo and Marico fora and maintain momentum with regards to the stakeholder interest in WUAs. The Gauteng regional office manages the establishment of the Crocodile West Marico CMA and has been spearheading the establishment of a number of WUAs in the province. However the delays in the process have resulted in many stakeholders losing interest.

The local government authorities in the area tended to have a poor service delivery image. Residents had a poor impression of the quality of representation they get from

their elected officials in water management structures. The research also suggests that the involvement of local government structures in groundwater management structures is often confined to a few individuals who have inadequate institutional support within the local government authority. Therefore, the understanding of the challenge that is posed by the resource is limited to a few individuals. These shortcomings are critical because when a major stakeholder group is in such disarray, the institutional establishment process is bound to suffer accordingly. It is essential to highlight this issue because it raises important mitigating circumstances to charges of neglect that are often levelled against DWAF.

Other important stakeholder groups are the traditional leaders and emerging farmers. These groups suffer from serious human and material capacity constraints and were unable to participate in the research fully. However, the research process included three workshops with marginalised stakeholders. Many of these participants were involved in small-scale agriculture and came from traditional areas. They indicated that there were high levels of ignorance relating to how the aquifer functioned. They also suggested that people were generally ignorant of the new legislation and the institutional arrangements that it proposed.

Commercial farmers are also major stakeholders. They are currently the dominant consumers of the groundwater resource and are usually more organised than other stakeholders. The participating farmers were very critical of the institutional formation process. They tended to complain about delays in establishing the CMAs and WUAs to the powers to the Minister with regards to his ability to veto decisions. Furthermore, many farmers indicated that levels of participation in stakeholder consultation process are decreasing because people are beginning to question the utility of participation.

The research observations thus suggest that the institutional milieu in the North West is particularly weak and this should serve as a deterrent against placing unsustainable burdens upon a struggling institutional formation machine. The institutions involved in the management of the aquifer in Northwest are weak, and their ability to create new institutions is similarly compromised. This realisation suggests that a priority should be to ensure that the institutions that already exist or are in the pipeline are supported to carry out their functions properly. This means:

- Strengthening DWAF regional offices by ensuring that vacancies are filled and technical support targeted at issues such as organisational development and public participation is availed.

- Improving communication between the DWAF's various offices and stakeholders to ensure that WUA applications can be easily tracked and feedback on the merits of the applications is properly communicated.
- Improving stakeholder understanding of the aquifer to ensure that people have a common understanding of the resource and the way it works.
- Improving stakeholder understanding of water management institutions to ensure that the misconceptions and confusion among stakeholders is addressed.
- Improving the ability of stakeholders to participate meaningfully and continuously in the management of groundwater resources by systematically identifying obstacles that prevent them from participating meaningfully and correcting them. Such interventions should include:
 - travel allowances,
 - Avoiding meetings that take place after hours,
 - The provision of food at meetings,
 - Capacity building on the functioning of the aquifer,
 - Being prepared to look beyond councillor as ideal representatives of marginalised communities, and
 - Reviewing current WUA membership lists to ensure that relevant representatives from marginalised communities have been engaged.

This approach will also require a greater dependence upon existing structures to engender a holistic approach to the management of the aquifer until the North West's institutions are mature enough. In this respect, the Dolomite Project Coordination Committee which brings together the DWAF regional offices and representatives from the various directorates of the Policy and Regulation Branch of the national department could play a useful intermediary role.

1 INTRODUCTION

1.1 Background to the Study

The institutional assessment study for groundwater management in the North West aims to assess the institutional environment and instruments that are employed to manage the dolomitic aquifer in that province. The purpose of the assessment is to develop institutional arrangements that can best guarantee the sustainable and equitable use of the ground water resource.

This report presents the results of a research process that has involved the conclusion of the following activities:

- The updating of a stakeholder database,
- The updating of stakeholder information (their roles and responsibilities) and,
- The development and implementation of a research tool to undertake the institutional assessment activities.

The institutional assessment study builds upon a previous study undertaken by Stephens and Bredenkamp for the Water Research Commission in 2002- i.e. Institutional Arrangements for Groundwater Management in Dolomitic Terrains: Situation Analysis (Water Research Commission, 2002).

The institutional aspects of that report identified a range of institutions that have either evolved or emerged to play a crucial role in the management of groundwater resources in the North West. These institutions can be divided into national, regional and local role playing categories:

Table 1: Institutional terrain for the management of groundwater resources in the North West

National Institutions	Regional institutions	Local Institutions
• Department of Water Affairs and Forestry (DWAF)	• Catchment Management Agencies (CMAs) • DWAF (Regional Offices)	• WUAs • District and local municipalities • Water Boards

The conceptual approach summed up the concept of institutional arrangements as entailing:

- Principles, objectives and institutional approach for ground water

- Overall institutional structure and implementing agencies
- Roles, responsibilities and functions of implementing agencies
- Requirements and support needed to ensure functioning institutions

(Stephens & Bredenkamp, 2002).

The study also identified a number of management challenges that will have a significant impact on the performance of the institutional milieu in the area:

- Geohydrological uncertainties: in this respect, further knowledge needed to be developed to fully appreciate the key components affecting the aquifer's water balance. This included factors such as the average recharge and its variability; estimation of the aquifer's storativity, the reliable estimation of abstraction and determining the depth of the aquifer.
- Social and institutional constraints: in this respect some key challenges that were identified include the lack of reliable information about the resource; the need to address the capacity constraints of institutions in the area; the need to address the constraints regarding the representation of emerging and marginalised user groups; competition and conflict among the various user groups; and the need to rationalise formal and informal management systems and bring them to the overall management fold for the aquifer.(ibid.)

The report also makes a significant recommendation with regards to the institutional approach that needs to be adopted for the management of the aquifer. In this respect, it is argued that the institutional structure that has been articulated by legislation and policy does not necessarily address transboundary management issues as they relate to the characteristics and role of groundwater resources (Stephens and Bredenkamp, 2002). Therefore a co-management approach that addresses transboundary issues is essential to address both equity and sustainability issues.

A co-management institutional approach, as identified by Stephens and Bredenkamp (2002) would have to be based upon principles that recognise the various values, interests and concerns of those who are involved in the management of the groundwater resource. This approach would have to take both local and outside stakeholders into consideration. The approach would also need to be based upon principles that seek and ensure equity and transparency in the management of the aquifer. This implies creating space for civil society to assume significant roles and responsibilities to underpin meaningful partnerships in the management of the aquifer. Partnerships of this nature will in turn create opportunities for the harnessing of complimentary capacities and comparative advantages of the various institutional role players.

The report also recognised that a blueprint to underpin this approach does not exist. As a result a considerable degree of flexibility will have to be adopted in the development of co-management institutional arrangements. This would require a process that can accommodate learning by doing and constantly revising management approaches to incorporate new developments and discoveries.

1.2 Limitations of the Institutional Assessment and challenges of Methods and Results

In building onto the work of the first phase of the project, one of the key objectives for this phase is to conduct an assessment of institutions involved in the management of groundwater resources in the North West. The institutional assessment is critical in mapping the institutional composition and capacity of groundwater management in that province. The assessment is also required to inform the outline of the Dolomite Aquifer Management Committee (DAMC), which was proposed in the previous phase as a *mechanism to facilitate the co-management of the aquifer*. However, this phase is also constrained by its timing. Many of the institutions that required evaluation are still not in place. Since CMAs are responsible for the management of water resources spanning large areas, the existence of WUAs, which would have a handle on localized issues, is critical. The terms of reference for Phase Two required that these missing institutions be in place so that they could be evaluated. Although we recognize that there are many resource and time barriers affecting this process, we are forced to consider the institutional challenges under circumstances that were far removed from what the terms of reference suggested would be in existence.

It was also difficult to refine our understanding of the challenges faced in both establishing the required structures and in ensuring their smooth functioning because the most general problem at all levels in these processes is poor communication. Although some outputs from this study will aim to address this issue, it is instructive to note that the stakeholder workshops that were conducted with the farmers and marginalised communities suggested that this is the case within the existing institutions, between these institutions and between the institutions and water users. The result is that DWAF processes to effect water management are not well coordinated and relations between national and regional offices are very poor. Good communication is vital as, for example, the Gauteng and the North West regional offices are mutually responsible for Crocodile West Marico, but Gauteng are specifically responsible for Water Resource Management (WRM) and the North West are specifically responsible for Water Services Planning.

Outside of the initiating institutions stakeholder fatigue and frustration are widespread. This is in part due to confusion about the process and the roles of different structures and committees. Local stakeholders are confused about the definitions; roles and responsibilities of WUAs and CMAs and Catchment Management Fora (CMFs), the regional offices and of course themselves¹. Where local stakeholders have made some progress in establishing WUAs, they have been given insufficient feedback on the problems with their proposals. These WUAs are considered insufficiently representative, a conclusion that was supported by deliberations in the marginalised communities' workshops. This raises an important consideration for DWAF, which is the extent to which it should be involved in establishing representative fora. There has been insufficient time for an institutional framework to be established and for people to get involved at grassroots level. But it is well known in the literature on water management that local groups need to feel ownership of the process and of new water management principles if they are to make them work. Stakeholder groupings need to be as organically developed as possible in order to be as effective as possible (Van Schalkwyk, 2001; Pegram & Mazibuko, 2003).

There is, clearly, however, some urgency in terms of the development of structures for managing water generally and the aquifer in particular in the North West. This begs the question of how much DWAF should be involved in establishing representative fora? The challenge of representivity, however, goes beyond water management. The reality on the ground is that most landowners and farmers are still white. Land ownership needs to shift before WUAs made up of farmers can possibly be representative. DWAF and the Department of Land Affairs (DLA) need to communicate on this issue. Equity in the short term is difficult because it doesn't exist on the ground. What is required is an institutional structure that can adapt as land ownership and industry ownership changes. Already 10 land claims have been gazetted in this area so things are going to change and any structures need to be flexible. Appearances of equity in water management should not be enforced at the expense of developing structures. The immediate goal needs to be a working management structure based on the current situation that, because of its organic formation, can adapt easily to changes external to water management itself.

¹ One of the associated outputs of this study into the management of dolomitic terrains will be handbook that aims to clarify many issues such as the differences between the various groundwater management institutions as well as clarify their roles and responsibilities.

2 RESEARCH METHODOLOGY

2.1 Updating of stakeholder database

Although updating a stakeholder database does not strictly fall within the usual definition of a research methodology, the undertaking of this task was an essential first step towards the fulfilment of the overall research task. A stakeholder database had initially been developed during Phase 1 of the project. This undertaking thus served to update data that had already been collected and thus ensuring that subsequent research activities will be working off an up to date database. The respondents were contacted by telephone and asked questions pertaining to:

- Their names, titles and the correct spelling thereof
- The organisations that they represent
- Their roles within those organisations and within the context of the project, and
- Their contact details.

2.2 Updating of stakeholder roles and responsibilities

The process to update the stakeholder information also relied upon the use of telephonic interviews with key respondents for each of the contacted stakeholder bodies. The Phase 1 synthesis report was used as the base document for this process. Respondents were requested to provide us with information that would indicate changes to their roles and responsibilities since the completion of Phase 1 of the project. The purpose of this was to deduce if there had been significant changes in the institutional development of the respondents since the Phase 1 report. The results of this undertaking are presented in the main body of the report.

2.3 The institutional assessment study

The assessment study was preceded by the design of an assessment tool that was structured to extract the following categories of information from the respondents:

- Name of organisation
- Date of establishment
- Founding (documents/principles/legislation)
- Governance provisions
- Functions and Activities

- Knowledge of groundwater system (i.e. its Geohydrological properties)
- Institutional linkages
- Premises
- Equipment & communications
- Human resources
- Finances
- Future trajectory

The respondents were typically contacted by telephone to set an appointment for a "face-to-face" interview. All such interviews were conducted at the respondents' places of work. However, 5 interviews had to be conducted over the telephone owing to the distant location of the respondents. It was sometimes necessary to follow up both the telephonic and the face-to-face interviews with telephone calls for additional clarity. A major weakness of the sampling process was our inability to secure an interview with an organisation representing emerging farmers. The contact numbers we had for this stakeholder group were often inactive, or calls were left unanswered. The sampling process also omitted to include government departments such as the Department of Land Affairs or the Department of Trade and Industry. These were left out because they have failed to date to participate actively in water management structures such as the Molopo and Marico for a despite numerous invitations by the fora coordinator for Molopo and Marico.

In total, 18 people representing 19 institutions were interviewed. A full list of respondents is provided as Annexure A. The interview questionnaire is also provided as Annexure B.

2.4 Stakeholder workshops

To complement the stakeholder interviews, the research process relied upon a series of stakeholder workshops. The stakeholder workshops were intended to add nuance to the responses of the stakeholder interviews by getting stakeholders to hold discussions around a few key points within the context of an interactive atmosphere and allowing more discussion time so that issues can be properly explored.

To facilitate the interactive nature of the discussions, the workshops series was split into three streams- the one stream comprised of four workshops and targeted commercial farmers and officials in institutions such as local government, provincial government and DWAF regional offices. These workshops were mainly conducted in Afrikaans and a little

English. Furthermore, these discussions were usually locality specific and followed the following structure:

- Water use registration, licensing, and payment of catchment management charges,
- Current status of water management institutions, and
- Institutional recommendations.

The other stream targeted stakeholders in marginalised communities such as emerging farmers, people in rural settlements, domestic water users in poor urban settlements and development agencies that serve these communities. In this respect, three workshops that were mainly conducted in Setswana were held. Once again, the discussions were locally specific and revolved around the following issues:

- The functioning of the aquifer
- The need for sound water management practices, and
- Participation in the management of water resource.

The third workshop category targeted DWAF officials from Head Office and the regional offices. One workshop was held and it focused on the following issues:

- Geohydrological challenges relating to the aquifer
- Institutional challenges relating to the aquifer's management, and
- The mainstreaming and integration of groundwater management.

The workshop reports have been attached as Annexures C, D and E. Furthermore, the results of the workshop series have also been integrated into the main body of the report.

3 SURVEY RESULTS

The absence of fully operational WUAs and CMAs in the study area means that their institutional capacity could not be assessed and the research tool could not be fully utilised in that regard. As a result, the assessment of CMAs and WUAs was confined to establishing the progress that has been achieved in getting them off the ground. In most cases, stakeholders could not indicate when they expected their respective WUAs or CMAs to be established, and it was necessary to talk to a multiple of respondents to develop a clear depiction of progress for any of these institutions.

3.1 Municipalities

3.1.1 Ventersdorp Municipality

Context: The Ventersdorp municipality draws its water from the Schoonspruit eye. The Ventersdorp WUA will (once proclaimed) represent the interest of people and organizations that depend upon the Schoonspruit eye for access to groundwater resources. The municipality has played an active role in the process to establish the WUA. This process has brought the municipality into close contact with various institutional role players who have a stake in the Schoonspruit eye:

- The Free State regional office of DWAF (which provided much of the human and technical resources supporting the establishment of the Ventersdorp WUA).
- Commercial and irrigation farming interests
- Local industrial and mining interests
- Domestic users, and
- Other sectors that use water for productive uses such as peri-urban communities that undertake small scale industrial and agricultural projects.

The municipality has taken an active interest in the formation of the WUA. Stakeholder meetings are often held at the municipal buildings. The municipality also makes some administrative equipment available to the WUA. The municipality rates the WUA as being the most important institution it relates to in terms of groundwater management issues, and significant levels of frustration with the promulgation process were expressed. The municipality feels that the WUA operates in a state of legal limbo and the

delays being experienced with regards to its formalization are costing it dearly in terms of stakeholder support.

- Name of organisation: The Ventersdorp Local Municipality
- Date of establishment: The local municipality was formally re-constituted after the local elections of 1995.
- Founding (documents/principles/legislation): The local municipality functions within the provisions of local government legislation, especially the Organised Local Government Act of 1997 and the Local Government Structures Act of 1998.
- Governance provisions: The governance provisions of the local municipality are stipulated by the legislation governing this tier of government. The legislation provides for an elected council to represent community interests and municipal staff to implement council, provincial and national government directives.
- Functions and Activities: In terms of water provision, the functions and activities of the local council are primarily informed by the Water Services Act of 1997. The Act makes specific reference to standards that have to be achieved with regards to the provision of water services which the local council strives to meet with the help of the district council:
 - The need for all citizens to have a reasonable quality of life will need to be considered
 - The need for equitable access to water must be respected
 - Operational efficiency and the economic viability in the provision of water services must be ensured, and
 - The impact of water services upon the environment must be recorded.

However, it is essential to note that the supply of water for farming and mining activities usually falls outside municipal activities.

- Knowledge of groundwater system: This is extremely limited and the local municipality's elected and employed officials rely heavily on the input of national government departments in this regard. The involvement of some municipal officials in the formation of water management institutions has improved the knowledge of those officials. However, they remain few and are all concentrated in the engineering department.
- Institutional linkages: The municipality has contacts with urban and agricultural pressure groups as well as NGOs such as Mvula Trust. The involvement of the local municipality in the formation of the Ventersdorp WUA has also brought them into contact with the Free State regional office of DWAF.
- Premises: The municipality operates from the council building in Ventersdorp. The premises are modest but also well suited to the municipality's scope of work.

- **Equipment & communications:** The local municipality does not own equipment to monitor groundwater and depends on DWAF for such information. Equipment is mainly limited to office equipment and hardware that is specifically required for water reticulation and monitoring (e.g. meter readers).
- **Human resources:** There is a major shortage of skilled technicians and personnel with a Geohydrological background. The municipality only employs 3 qualified technicians.
- **Finances:** The local municipality's finances are in a poor state due to high levels on non-payment by residents. The respondent could not provide a breakdown of the council's budget of R23 million for the 2003-2004 financial year. However, it was indicated that water services and related functions usually consume close to 25% of the overall budget.
- **Future trajectory:** A key challenge for the future is to improve the collection of rates to allow the municipality to meet its targets. Ensuring that the local municipality participates optimally in the WUA was also cited as another challenge for the future. Other challenges related to the attraction and retention of skilled technicians.
- **Issues to follow up:** The respondents from the municipality were greatly concerned by the lack of communication surrounding their WUA's application. Furthermore, they also demonstrated a disturbing tendency to confuse the various water management processes that they participate in. These issues serve to highlight the extent and impact of poor communication between and within institutions. Therefore there is a need to address issues pertaining to communication.

3.1.2 Ditsobotla Local Municipality

Context: The Ditsobotla Local Municipality is based near the Lichtenburg CBD. Lichtenburg is an agricultural service center in the North West. The local municipality's area is made-up of a mixture of small villages, farming towns such as Lichtenburg and Coligny as well as areas that used to fall under Bophuthatswana such as Itsoeng and Gamotlatla.

- **Name of organisation:** Ditsobotla Local Municipality.
- **Date of establishment:** The municipality was formally formed by the merger of the former Bophuthatswana entities and the towns of Coligny and Lichtenburg which took effect after the local government election of 1995. The Lichtenburg component of the municipality has been in existence since 1955.

- **Founding (documents/principles/legislation):** The local municipality functions within the provisions of local government legislation, and the Organised Local Government Act of 1997 and the Local Government Structures Act of 1998.
- **Governance provisions:** The governance provisions for Ditsobotla are the same as in any other local municipality. They are drawn from the legislation governing local government.
- **Functions and Activities:** The local municipality provides reticulated water services and billing for the area under its jurisdiction. It is also responsible for maintaining the infrastructure under its care. Given the shortage of water in some communities, the local municipality is also responsible for trucking water supplies to affected settlements.
- **Knowledge of groundwater system:** The knowledge the groundwater system is limited to mainly two officials within the water services division of the local municipality. This largely due to the fact that the local municipality does not treat groundwater resources any differently from other sources of water and the shortage of skilled workers within this function.
- **Institutional linkages:** The local council is in contact with a number of local and provincial institutional stakeholders who are either involved in the management of groundwater or depend upon it for their operations:
 - **Botshelo Water:** provides bulk water services to parts of the Ditsobotla area.
 - **DWAF:** The department has an office in the North West that has been involved in the stalled establishment of the WUA.
 - **Industrial water consumers:** There are significant cement and lime mining activities in the area. Given the high incidence of unemployment in they locality, these activities are viewed as important sources of employment. Their water needs are not the direct responsibility of the municipality. However, the local municipality comes into contact with these institutional stakeholders through their participation in water management stakeholder structures.
 - **Commercial agriculture:** Commercial farming activities are a major source of income and employment in the area. Commercial farmers are also the most significant consumer of groundwater in the area. They are well organized and a stakeholder in the proposed WUA.
 - **Domestic users:** These are often clients of the Ditsobotla Local Municipality who receive reticulated water via the local municipality. The domestic users in areas like Itsoseng have to rely on poorly maintained infrastructure and complain that the local authorities neglect their needs.

Surrounding settlements around Itsoseng often run out of water as wells dry up and infrastructure fails to satisfy demands.

- Premises: The local municipality operates out of the council offices which are located at the Lichtenburg Civic Center.
- Equipment & communications: The local municipality's equipment is mainly concerned with the reticulation of water services. However the local municipality also owns a number of mobile water tanks to provide water where supplies are unreliable.
- Human resources: The local municipality employs 25 people. 22 of them are labourers and there are only 2 qualified technicians. The respondent indicated that 50% of their posts are not filled due to financial and skills shortages.
- Finances: The Ditsobotla Local Municipality's operating budget for 2003-2004 is R81 million. The respondent indicated that if salaries are factored in, about 20% of the budget goes towards water services.
- Future trajectory: The key water management challenge that was identified in Ditsobotla relates to the proper integration of the peri-urban settlements and the areas that were incorporated from Bophuthatswana within the water reticulation infrastructure of the local municipality. Overcoming skills and financial shortages was also identified as a key challenge affecting the future trajectory of the local municipality. Both confusion and frustration was expressed regarding the fate of the WUA.
- Issues to follow up: the reliability of water supplies in Ditsobotla and surrounding villages is a major concern. In this respect, the supply of water is not reliable due to faulty or overburdened infrastructure. Communication between the community and the local council is considerably poor. As a result, residents in the area complain of being marginalized and have developed a disparaging opinion of the municipality and the formal local government structures.

3.1.3 Central District Municipality: Mafikeng and Zeerust Municipalities

Context: The Mafikeng, Zeerust and Lehurutshe areas fall under the jurisdiction of the Central District Municipality which is based in Mafikeng. Domestic users of ground water resources in the District Municipality depend upon water reticulated by Botshelo Water for most of their water requirements. Surface water is not plentiful in the area therefore the supply of water to domestic users has to be augmented by underground resources. The Dinokana and the Molopo rivers are significant groundwater outlets; however private boreholes (both legal and illegal) are widely used in the area.

- Name of organisation: The Central District Municipality.
- Date of establishment: The Local Government Structures Act of 1988 provides for the division of functions among the various categories of local government. The District Municipality was formally constituted after the signing of the Act.
- Founding (documents/principles/legislation): The Local Government Structures Act of 1997 and the constitution of South Africa (which provides for local government structures) constitute the primary enabling legislation.
- Governance provisions: The legislation provides for a District Municipality drawn from the political representative of the constituent municipalities. The District Municipality also employs officials on a fulltime and contract basis to implement functions.
- Functions and Activities: Consumers in the area under the District Municipality depend upon water reticulated by Botshelo Water for most of their water requirements.
- Knowledge of groundwater system (i.e. its Geohydrological properties): The knowledge of the groundwater system in the local municipalities was severely limited and they relied heavily on the District Municipality in that regard. The technicians within the Central District Municipality have developed a fairly good understanding of the groundwater resource. However, it was indicated that the presence of a geohydrologist within the District Municipality would greatly improve knowledge levels.
- Institutional linkages: The Central District Municipality is involved in various water management processes that, given the nature of water resources in the area, have a strong groundwater component. This involvement has also informed the nature of the institutional relationships that the District Municipality has developed:
 - Molopo Water Management Forum: this forum is supposed to bring together the major stakeholders in water management from the Molopo area. Its work is also intended to contribute to the formation of the Crocodile West – Marico CMA. However, the forum's impact has been limited and it is slowing losing momentum as participation wanes due to negative perceptions relating to progress.
 - Crocodile West – Marico CMA: The agency is still in the process of being established; therefore it is still far from being fully functional. However, the District Municipality will be a major stakeholder once the CMA is fully operational.

- Extended Grootfontein WUA: The WUA is still awaiting the approval of its application. Therefore it is not functional. The District Municipality is a major stakeholder in this WUA. It also participated in the consultative activities preceding the submission of the WUA's application.
- DWAF: The Department has a regional office in the North West whose personnel is involved in many of the water management structures that the District Municipality has participated in. The regional office is involved in the establishment of both the CMAs and WUAs.
- Botshelo Water: Botshelo Water is a water supply authority whose scope of coverage overlaps considerably with the area under the jurisdiction of the District Municipality. Botshelo Water provides bulk and reticulated water and sanitation services to rural and urban areas around the North West. As a result, it is a major service provider to the District Municipality. Botshelo Water also participates in all the water management structures in the North West
- Premises: The District Municipality operates from offices in Mafikeng.
- Equipment & communications: The District Municipality does not own equipment that is specifically intended for groundwater management.
- Human resources: The District Municipality had difficulties in providing an exact number of employees for water services planning due to its complicated organogram. However, the Mafikeng local authority employed 76 people to work on water and sanitation issues.
- Finances: The District Municipality spends over R10.5 million for water services per annum. However, spending is complicated by the high incidence of non-payment by consumers.
- Future trajectory: The establishment of the water management institutions is the key challenge affecting the future trajectory of the District Municipality and delays in this regard have caused some consternation. It was felt that establishment of these institutions would greatly improve the participation of local stakeholders in water management and improve communication between service providers and communities.
- Issues to follow up: The illegal use of groundwater resources in the area is a major concern- which is an issue that fall within the domain of DWAF. Therefore there may be a need for the District Municipality to develop a clear distinction between service delivery issues and resource management issues. These issues are further compounded by the District Municipality's concern about not knowing enough about the groundwater resource and the general breakdown of municipal services as a result of the problems faced by the Mafikeng Local Authority. One way of addressing the challenge of improving knowledge of the resource could

be to investigate the possibility of getting DWAF to second official to the District Municipality. However, this has to happen within the context of the District Municipality being crystal clear about the role that such people would play within its structures.

3.1.4 Southern District Municipality: Klerksdorp, Potchefstroom & Ventersdorp

Context: The Southern District Municipality incorporates the mining and industrial center of Klerksdorp and Orkney, the university town of Potchefstroom and the small agricultural town of Ventersdorp.

Compared to Potchefstroom and Klerksdorp, Ventersdorp is certainly the least developed center in the Southern District Municipality. However, the District Municipality has been involved in the establishment of the Ventersdorp WUA, and it has been earmarked to participate in the management committee of the proposed CMA, which will exercise control over the Schoonspruit dolomitic compartment.

- Name of organisation: Southern District Municipality.
- Date of establishment: The Southern District Municipality has been operating under its current form since 1998.
- Founding (documents/principles/legislation): The District Municipality operates under the Local Government Structures Act of 1998.
- Governance provisions: The governance provisions for the District Municipality are provided for by legislation governing local government structures in South Africa. These include the Local Government Structures Act and the Organised Local Government Act of 1997.
- Functions and Activities: The District Council mainly provides sanitation services to the area under its jurisdiction. However, some bulk water services are also provided.
- Knowledge of groundwater system (i.e. its Geohydrological properties): As in the other local government structures, the technical staff tend to have a better understanding of groundwater issues than the rest of the institution. However, as dependence upon groundwater resources increases it is expected that this knowledge base will spread to cover other sections of the technical and managerial staff as well as the councillors.

- Institutional linkages: This involvement has brought the District Council into contact with a number of important stakeholders that participate in groundwater management structures in the Ventersdorp area:
 - The Free State regional office of DWAF (which provided much of the human and technical resources supporting the establishment of the Ventersdorp WUA).
 - Commercial and irrigation farming interests in the Ventersdorp area
 - Industrial interests in the Ventersdorp area, and
 - Domestic users in the Ventersdorp area.
- Premises: The District Municipality operates out of its offices in Orkney.
- Equipment & communications
- Human resources: 52 people are employed by the water provision and sanitation function. Only 5% of the employees are skilled technicians.
- Finances: The operating budget for water and sanitation services is R5 million.
- Future trajectory: District Municipality views the WUA as an institutional development that will significantly improve the management of groundwater resources in the Ventersdorp area. However, it is also dismayed by the fact that the WUA is not yet operational. As a result, the District Municipality is under the impression that there is no structure in place to measure withdrawal rates from boreholes or look into possible pollution of water resources in the area. They also believe that absence of a formal structure operating within a clear legal framework means that it is difficult to enforce the law- which results in illegal boreholes continuing to be developed.
- Issues to follow up: The District Municipality is one of the key groundwater stakeholders who have expressed concern regarding the poor levels of communication between DWAF and local stakeholders. As a result, the respondents doubted the value of their continued participation in groundwater management structures. The poor levels of communication Between DWAF and stakeholders could also account for some of the misconceptions that exist regard the policing of illegal boreholes, which is an issue that DWAF is required by legislation to address.

3.2 Water Management Institutions

3.2.1 Lower Vaal CMA

The Lower Vaal CMA has not been formally proclaimed. Its establishment is driven by the Northern Cape regional office of DWAF, which intends to cede the portion of the

dolomitic aquifer that is currently covered by the Lower Vaal CMA to the Crocodile West - Marico CMA. This transfer is yet to be approved by DWAF.

3.2.2 Middle Vaal CMA

The Middle Vaal CMA falls under the bureaucratic jurisdiction of the Free State regional office. Respondents in this instance indicate that the CMA is only required to be established in four years. Therefore, the regional office is pursuing a different sequencing strategy and it is more concerned with studies to develop a better understanding of the water resources in the area under its jurisdiction.

However consultants have been contracted to advance the formation of the CMA. In this regard, significant progress has been made and consultative forums have been established to engage stakeholders so that they may inform and legitimise the process. Given the levels of confusion around the CMA (and WUA) establishment process, a lot of work needs to be done in this respect. Stakeholder workshops revealed that the delay in the establishment of the CMA is believed to allow entrenchment and tolerance of illegal use as well as the potential over-utilisation of the resource, which could prove costly to rectify. Stakeholders also believe that the delay in the establishment of the CMA is hampering the process of verifying water use. These beliefs are rooted in the widespread ignorance relating to the role of DWAF in combating illegal extraction and verifying usage among stakeholders.

3.2.3 Crocodile West – Marico CMA

The proposal for the Crocodile West – Marico CMA will cover a substantial portion of the North West dolomitic aquifer, which is the subject of this study. The Water Management Area is bordered by Botswana on its north-western side. There are two major rivers in the Water Management Area- i.e. the Crocodile West and the Groot Marico River. The area also incorporates the headwater of the Molopo River which is a tributary of the Orange River (Proposal for the Establishment of CMA in the Crocodile West – Marico Management Area, 2002). The Water Management Area also incorporates major urban centers such as:

- The northern suburbs of Johannesburg,
- The Ekurhuleni Metropolitan Council,
- The Tshwane Metropolitan Council,
- The Mogale City Council,
- The Rustenburg and Bela Bela Municipalities,
- The Central District Municipality, and

- Substantial rural portions of the former Bophuthatswana.

Most of the stakeholder participation in the consultative process has been via the nine forums established to inform the process:

- Molopo River
- Marico River
- Crocodile River
- Elands River
- Magalies River
- Jukskei River
- Hennops River
- Pienaars and Apies Rivers
- Crocodile River (Thabazimbi)

The Molopo and Marico River forums fall under the study's scope of coverage. The forums are an essential institutional development and legitimizing feature of the CMA and its establishment process. The institutional development of the forums has moved through a number of capacity building phases to ensure their viability and sustainability as integral components of the CMA.

However, owing to capacity constraints and locality specific characteristics, the progress made in this regard has been uneven. The Molopo Forum, for instance, has experienced substantial capacity problems which are now being partially addressed by support from DANIDA and the employment of a coordinating officer. The DANIDA funded coordinating officer had to undertake considerable efforts to resuscitate the forum by rekindling stakeholder interest and participation in the forum. Stakeholder participation had waned due to stakeholder frustrations emanating from a perceived lack of forward momentum within the forum. In the case of the Marico Forum, progress has been more impressive; however there are fears that it may have a bias towards urban areas as a result of the participation patterns that have unfolded (i.e. more enthusiastic participation from organized urban interest).

The process to establish the CMA has also benefited from the participation of the Gauteng regional office of DWAF. However, the respondents from the forums and the WUAs have also been vocal in their criticism of the time it is taking to get the CMA established. In this regard, it is essential to note that DWAF does not foresee the establishment process being completed for at least another two years. Some

respondents felt that this may present institutional and sequencing problems should WUAs be proclaimed before the CMA is formally in place. The National Water Act stipulates that WUAs are not expected to perform water management activities unless they receive explicit permission from a CMA. Although the regional offices of DWAF are currently fulfilling the role of the CMA, stakeholders are still uneasy about the possibility of WUAs getting established before CMAs or delays in the establishment of the CMA holding up the approval of the WUAs. However, it is essential to also point out that these concerns are largely unfounded because the non-existence of CMAs should have no bearing on the approval of WUAs.

3.2.4 Ventersdorp WUA

The Ventersdorp WUA is by far the most advanced WUA in the study area. Its establishment process is driven by the Free State office of DWAF.

At the time of the interviews, respondents indicated that an application had been submitted to DWAF, and the department had indicated in June 2003 that the Minister requires further information regarding the WUA's management committee.

It was suggested that the proposed WUA had buy-in from all the relevant stakeholders- i.e. domestic users, industrial users, and agriculture as well as local government structures. The Ventersdorp Local Municipality has been instrumental in availing resources and premises to the WUA for the time being. The municipality is also committed to playing this role until the WUA is formally established and is in a position to establish its own management structures.

The delays relating to the approval of the application have however had a demoralizing effect on most of the stakeholder groups. Meetings are now poorly attended and frustration with the principle of integrating the management of water resources is growing because stakeholders feel that their progress is being held hostage by institutions that they cannot influence.

The Ventersdorp WUA has in its application, requested a wide array of functions. These range from preventing the illegal use of water to controlling wastage and protecting water resources. The WUA also intends to monitor water levels and quality. In addition to these functions, the WUA also intends to play a prominent role in adjudicating the equitable distribution of water within its jurisdiction. The functions that the WUA intends to carry out are largely concerned with the management of infrastructure and resources for its stakeholder base. These activities fall squarely within the limits that the legislation

has prescribed for WUAs. However, it is essential to note that these functions are not automatically passed onto a WUA but need to be delegated by either DWAF or a CMA. This provision in the law allows the WUA to take local interest and capacity into account when determining its functions. It is important to highlight this because the Ventersdorp WUA seems to have opted to undertake almost every activity that the legislation says WUAs may perform.

This approach may suggest that the stakeholders believe their institution will have sufficient capacity to undertake these tasks or that they have not interrogated the question of what their institution should perform sufficiently.

The determination of local needs and capacity should be a transparent and inclusive process. In this regard, stakeholder tensions can arise from the uneven capacity and understanding of water management issues that exist among local role players. Local government and commercial farming stakeholders tend to be the most advanced and articulate in advancing their interests. Black rural and urban communities are by far the most disadvantaged in this respect. During workshops with members of the community in this area, the black rural section of the population was also found to be uninformed about the WUA and the CMA. To its credit, the WUA does intend to address this imbalance by engaging in training and capacity building activities directed at rural communities and emerging farmers.

Functions of the Ventersdorp WUA as stipulated in its Constitution

- To prevent water from any water resource and waterworks being wasted.
- To protect the Schoonspruit Dolomitic Compartment as an underground water source.
- To prevent any unlawful water use;
- To remove or arrange to remove any obstruction unlawfully placed in a watercourse or waterworks;
- To prevent any unlawful act likely to reduce the quality of water in any water resource or waterworks;
- To exercise general supervision over water resources and waterworks;
- To manage and regulate the flow of any watercourse or waterworks by –
 - Clearing its channel;
 - Reducing the risk of damage to the land in the event of floods;
 - Changing a water course back to its previous course where it has been altered through natural causes.
- To manage, regulate and conserve the abstraction of water from the Schoonspruit Dolomitic Compartment
- To investigate and record –
 - The water level readings of boreholes in the area of operation of the water resource;
 - The times when; and
 - The place where water may be used by any person entitled to use water from a water resource or waterworks.
- To construct, purchase or otherwise acquire, manage, operate and maintain waterworks considered to be necessary for-
 - Draining land; and
 - Supplying water to land for irrigation or other purposes.
- To establish the equitable division, distribution and use of water from a water resource and to regulate it according to the relevant water use entitlements, by erecting and maintaining devices, or requiring members to erect and maintain devices at their own expenses, for –
 - Measuring of water levels and dividing; or
 - Controlling total abstraction rates/volumes from boreholes in the Schoonspruit Dolomitic Water Resource.
- To suspend or reduce the abstraction of water from waterworks or water resources under its control in so far as it is needed for the execution of any of the functions or for reasons required for the proper operation and protection of the water work and water resource.
- To urge this Association and its members to be sensitive towards management practices in respect of conservation and sustainability of the source and finally the application thereof.

3.2.5 Zeerust WUA

The Zeerust WUA is the most underdeveloped and it is not to be confused with the Marico Bosveld WUA. A consultant was assigned by the DWAF Gauteng regional office to facilitate its establishment, but his contract ended before anything tangible was delivered. There has been very little progress since then. Stakeholder meetings do not get convened and the process appears to have completely lost its initial momentum. This is most unfortunate since the scarcity of water was a key issue that was raised during a workshop with members of the community in Lehurutshe. The communities around Lehurutshe also have fairly active water committees, however their representatives were not aware of the aborted process to establish a WUA in Zeerust. There is also the Marico Bosveld WUA, which is in fact not an official WUA but an organic stakeholder organisation that mainly targets farmers and plays a similar role as water committees in the high population density areas. This local authority is now participating in this organisation and its current list functions includes:

- Quality and quantity
- Control and management
- Community communication and capacity building.

The absence of real progress in establishing a WUA in Zeerust is even more regrettable when the desire and the need to have participative processes for managing groundwater resources is so clearly apparent.

3.2.6 Lichtenburg-Itsoeng WUA

There is a heavy dependence upon groundwater water resources in the Lichtenburg-Itsoeng area- particularly by the commercial agriculture sector which is a major employment and income generating sector in the economy of the Ditsobotla region. A water management committee was established with the aid of a consultant from DWAF as a precursor to a WUA. An application was submitted to the department in March 2002. However, a response from the department is still to materialize.

The committee is still nominally in existence; however, much momentum has been lost because they are not in contact with the department to the same extent as they were when the consultant was around. They have also stopped convening meetings because committee members see no point in continuing to participate in the absence of a legal proclamation of the WUA and a CMA to work with.

In the face of this institutional void, the overexploitation of the groundwater resource was said to be continuing. The respondent indicated that there is still a desire to work with the authorities to protect the resource; however it is also essential to fast-track the

establishment of the institutions to effect the collaboration. However, there was also widespread confusion regarding issues such as the boundaries of the WMA, the calculation of water use charges and the powers of the Minister with regards to his ability to veto nominations to the CMA. Furthermore, the residents of Itsoseng and surrounding villages indicated that they were not aware of the WUA establishment process and indicated that their elected officials (who usually represent them in such process) do not always provided proper briefings.

3.2.7 Grootpan WUA

The Grootpan WUA does not exist. However, a steering committee was appointed in 2001. This committee surveyed the area under irrigation and reported to DWAF. The committee was unable to gain the support of the farmers because this stakeholder group was perturbed by the possibility of being involved with the technical responsibilities that are associated with the management of the aquifer.

New irrigation schemes and boreholes are continuing to get established in the area, but without a WUA, the respondents felt that there isn't an authority to intervene. This issue also highlights the general levels of confusion relating to water resource management issues and the role of institutions because DWAF is in the position to enforce compliance to laws governing the installation of boreholes.

3.2.8 Extended Grootfontein WUA

The Extended Grootfontein WUA is not functional, as a result, no meetings have been held to date. Documentation for the establishment of the Grootfontein WUA has been submitted to DWAF. Grootfontein was one of the WUAs that was assigned a consultant by DWAF, and the documentation in question was compiled under the facilitation of that agent. Respondents highlighted the following key concerns:

- A reluctance to pay for water until a CMA is established,
- There is a perception that the North West regional office of DWAF is weak (which informed by the perceived absence of the regional office in the area),
- The illegal exploitation of the aquifer.

3.3 Implementing Agencies

3.3.1 DWAF- The North West

Context: Most of the study area for this report falls under the bureaucratic care of the North West regional office of DWAF. The department's regional office has experienced considerable capacity and human resource constraints in trying to support the development of institutions to support groundwater management in the area under its care. A significant component of the staff working with groundwater issues do not have the experience that other regional offices have. In this regard, respondents indicated that the skills that really need augmenting are not necessarily the engineering category but the softer skills that stakeholder support and institutional development processes usually require.

- Name of organisation: The North West regional office- DWAF
- Governance provisions: The Constitution and the Public Finances management Act of 1999. The department is also bound to the Batho Pele Principles
- Functions and Activities: The major institutional development pre-occupation of the regional office is the establishment of the Crocodile West Marico CMA, which is expected to have a major integrating institutional impact upon groundwater management in the province. The staff of the regional office is involved in the revitalisation and coordination of the Marico and the Molopo water management fora. This is being undertaken with financial assistance from DANIDA. The forums draw stakeholders from local, provincial and national government. Other stakeholders represent NGOs, CBOs, traditional authorities and commercial interests. There has also been substantial involvement with the Grootpan and the Grootfontein WUAs' establishment processes. In this regard, the regional office was equally frustrated by the lack of progress in getting these WUAs established. The regional office complained about the poor lines of communication between the national office and regional structures with regards to the WUA establishment process.
- Knowledge of groundwater system (i.e. its Geohydrological properties): There is a significant geohydrology capacity in the regional office, however it is not sufficiently developed to meet the significant groundwater challenges in the province. As a result, although there are some people with adequate qualifications, the groundwater system is not necessarily well understood through out the organisation.
- Institutional linkages: The regional office has also benefited considerably from support from donor agencies such as DANIDA and the Gauteng regional office of the department around institutional development issues.

- Premises: The regional office operates from offices in Mafikeng and Hartbeespoort.
- Human resources:
- Finances:
- Future trajectory: The establishment of the CMA and the continued viability of water management fora are the most pressing priorities for the regional office. The regional office is also looking into ways of revitalising the establishment of WUAs. An integrated approach to the management of the groundwater resource received favourable backing from the regional office.
- Issues to follow up: Urgent action needs to be directed to address stakeholder confusion regarding the establishment of the CMA and the WUAs. There is also wide spread confusion relating to who should be policing the illegal abstraction of groundwater resources in the absence of the CMA and the WUAs. Other areas of stakeholder concern relate to the funding mechanisms for both the CMA and WUAs, the calculation of water use charges as well as the issues relating to representation on the CMA and WUAs.

3.3.2 DWAF- Free State

The Free State Regional Office of DWAF is responsible for the Schoonspruit aquifer. As a result, it is also responsible for the establishment of the Middle Vaal CMA as well as the Ventersdorp WUA.

- Name of organisation: Free State regional office- DWAF.
- Functions and Activities: The regional office undertakes various tasks that are not within the scope of this study. However, the process to establish a CMA is underway with extra capacity from consultants having been sourced to direct the consultation phase and the establishment of stakeholder forums. The establishment of the Ventersdorp WUA is at an advanced stage and a motivation to DWAF has been submitted for approval.
- Knowledge of groundwater system (i.e. its Geohydrological properties): One of the biggest problems faced by the regional office is the lack of an entrenched understanding of groundwater issues among all the relevant officials in the regional office. This issue is now being addressed; groundwater issues are slowly beginning to be taken more serious.
- Institutional linkages: The Free State regional office maintains a range of institutional relations in the North West as a result of its involvement with the Schoonspruit aquifer. These institutional relations cover local government

authorities, the Department of Agriculture, commercial farming interest and relations with other DWAF regional offices- e.g. Gauteng, the North West and Northern Cape.

- Premises: The regional office operates from its Bloemfontein offices.
- Human resources: At the time of the research, the geotechnical unit was four appointments short. However, it employed six geohydrologists, one engineer and two hydrologists.
- Future trajectory: The introduction and enforcement of compulsory licensing once the CMA becomes fully operation is expected to increase tensions in the area. As a result, sound leadership will be required to navigate through such a challenge. Facilitating the establishment and sustainability of the CMA and WUAs will continue to require serious attention from the regional office.
- Issues to follow up: Issues relating to stakeholder ignorance and confusion need urgent attention. The rural stakeholders from the marginalised communities around Ventersdorp indicated that their elected council officials (who have been representing these communities in the CMA and WUA establishment processes) had not briefed them about these important institutional developments. The stakeholder workshops also uncovered concerns relating to:
 - Illegal water use and the licensing of water use by farmers.
 - Users are unsure of the future allocation of water, given the fact that current use and availability of water is not clear.
 - Confusion exists in terms of the need to obtain approval for the drilling of specific boreholes and the replacement of existing ones.
 - The control and monitoring of water use is not being done and this raises concerns, as there is the perception that DWAF only monitors sporadically, with the information never being provided to the users.
 - Mining development is being delayed as mines are often told that they need to obtain water through a process of transferring water rights. This is causing delays in an area requiring economic development.
 - The DWAF indicated earlier that the catchment management charges were to be used to fund the activities of the WUA. In the absence of the WUA the distribution of CMC funds within a CMA remains a "black box" to stakeholders.

3.3.3 DWAF- Gauteng

The Gauteng office of DWAF is one of the major driving forces behind the establishment of the Crocodile West – Marico CMA. Such a deep level of involvement is in part due to the fact that the Gauteng province has such major stake in that particular Catchment Management Area.

- Name of organisation: Gauteng regional office- DWAF.
- Functions and Activities: The institutional development and support work by the Regional Office affects the Crocodile West - Marico CMA, 13 new WUAs and 23 Irrigation Boards. Of these, the CMA is partly dependent upon groundwater while both the Grootfontein and the Lichtenburg-Itsooseng WUAs are almost wholly dependent upon groundwater resources. There is a heavy involvement with the water forums whereby the engagement revolves around water management issues of common interest, the CMA establishment process and allowing grassroots input to inform the institutional development process. The respondent for the Gauteng Regional Office conceded that progress has often been hard to achieve and forum deliberation often get dominated by the stakeholders with the "loudest voice". The institutional interventions usually take the form of helping the organizations to identify the need for a stakeholder driven water management structure. Other interventions cover issues such as:
 - Determining the roles and responsibilities of the various institutions;
 - Support with the compilation of proposals and applications to DWAF;
 - Water safety issues;
 - License applications and procedures;
 - Water use verification methods; and
 - Financial management.
- Institutional linkages: The regional office also has close working relations with the other DWAF regional offices in the North West, Free State, Limpopo and the Northern Cape as well as the Department of Agriculture.
- Premises: The regional office is located in Pretoria.
- Human resources: Role playing employees include a Chief engineer, two industrial technicians, and one senior water control officer.
- Finances: There is about R6 million for catchment management (which is mostly spent on service providers) and R1.3 million to cover personnel costs. However it is still a challenge to spend money allocated to contractors, and this has an impact on delivery issues.
- Future trajectory: The engagement with the North West is expected to continue until the CMA is fully operational. To facilitate that eventuality, some restructuring may be required. Technical support may be split into two- i.e. CMA support activities and regulatory environment activities.
- Issues to follow up: Awareness of the regional office among stakeholders such as commercial farmers and local government authorities was very prominent. The regional office was most closely identified with the WUA establishment process in

the Zeerust, Lichtenburg and Mafikeng areas. This flip side of this high profile is that those stakeholders tended to expect the regional office to clarify issues pertaining to the establishment of WUAs in those areas. This issue needs to be addressed urgently because stakeholders groups in these areas complained of not being updated about the WUA establishment applications that have been submitted to the Minister on their behalf. Another issue of concern relates to the fate of the WUAs whose establishment was stalled by the departure of the consultant that was facilitating their processes. Stakeholders affiliated to the stalled WUAs were desperate to know what the regional department was doing to restart their WUA formation processes.

3.4 Policy Development and Institutional Support

3.4.1 DWAF- National Office

Context: The National Water Act requires the establishment of a number of new institutions to actualize its prescriptions. As a result, the national office of DWAF had to develop measures to support the new institutions that were being proposed by the Act. The institutional support that gets rendered to these new institutions is mainly originating from the department's Institutional Oversight Chief Directorate.

- Name of organisation: The Chief Directorate for Institutional Oversight has three directorates:
 - Stakeholder empowerment
 - Water resources financing and pricing
 - Water management institutions and governance
- Governance provisions: The governance of DWAF is guided by the provision of the constitutions as well as the Public Finances management Act of 1999. The department is also bound to the Batho Pele Principles- which is a code of conduct covering the good governance of public resources and the delivery of good service to the public.
- Functions and Activities: The work of the Chief Directorate involves the provision of information to stakeholders with regards to the terms of reference for the establishment of water management institutions. The Chief Directorate also tries to sensitize engineers on the social aspect of their work. Due to capacity constraints, this work is usually delivered by a combination of contractors and staff (fees to contractors can account for up to 50% of the budget).
- Knowledge of groundwater system (i.e. its Geohydrological properties): There is only a basic understanding of groundwater in the chief directorate. The

groundwater function is actually the responsibility of another section of the department. However, DWAF is increasingly relying upon Internal Strategic Perspectives (ISP) as an instrument of documenting the way it manages resources. The ISPs should have the impact of improving levels of understanding across the department.

- Institutional linkages: The three directorates deliver services to water management institutions that cover the full scope of institutional development and capacity building. In the North West, the support has until recently been mainly directed towards the institutional development process relating to Catchment Management Agencies as there has been little in the way of a sustained institutional development momentum with regards to the establishment of WUAs.
- Premises: The Chief Directorate operates out of the head office premises in Pretoria.
- Human resources: The water management institutions and governance directorate is largely responsible for institutional development issues. It employs. It employs one director, two deputy directors and another 2 assistant directors. These are all role playing positions that require their occupants to be actively involved in providing support to the establishment of water management institutions.
- Finances: The available budget is about R8 million (of which 50% goes to contractors).
- Future trajectory: The Chief Directorate does not anticipate the institutional challenges of establishing the WUAs and CMAs to evaporate overnight. The respondent felt that some delays are inevitable because some applications get assembled in a rush. However, there was also a problem of high expectations from the public. Some of the problems that are expected to persist relate to the following:
 - Applications do not always meet the specifications outlined to justify the approval of applications;
 - There have instances where stakeholders have been uncooperative (especially those who perceive the National Water Act to be a threat to their access of water resources or those whose expectation have not been met);
 - The nature of the support is often demand driven, so it is difficult to deliver timely interventions if there is a lack of progress on the ground; and
 - Communication breakdowns at the stakeholder level are common.
- Issues to follow up: The opaque fate of WUA applications once they are submitted to DWAF for Ministerial approval is a source of frustration and anger among stakeholder groups. The Department indicated that most applications

from the study area were stalled due to the Minister's concern about adequate levels of representation relating WUA consultative and governance processes. The stakeholder workshops suggested that these concerns were in many cases justified- mining and marginal users were not always adequately consulted or represented in the proposed structures. However, this issue has been poorly communicated to stakeholders, and this requires an urgent remedy.

3.5 Important role-players beyond DWAF

3.5.1 Botshelo Water

Context: Botshelo Water is a water supply authority that operates within the study area and is headquartered in Mafikeng. Botshelo Water provides reticulated and bulk water as well as sanitation services to rural and urban areas around the North West. The respondent for the organization indicated that Botshelo Water provides up to 42% of the area in the province.

- Name of organisation: Botshelo Water.
- Date of establishment: Water Supply Authority was first established in 1988 as the Bophuthatswana Water Supply Authority. It was renamed the North West Water Supply Authority in 1998 and became Botshelo water in 2002.
- Founding (documents/principles/legislation): Botshelo Water operates under the guidance of the National Water Act of 1998 and the Water Services Act of 1997.
- Governance provisions: Botshelo Water is a public entity with a board that reports to the Minister of Water Affairs and Forestry. Its governance is informed by public sector regulations including the Public Finance Management Act of 1999.
- Functions and Activities: Botshelo Water is a bulk water supplier to 850 000 people over a 50 000 square kilometre area. As a result of the re-organisation of water services being brought about by the Municipal Infrastructural Act, Botshelo Water has to enter into new agreements with local authorities around the supply of water services and resources. Furthermore, Botshelo Water is negotiating with three other municipalities in the province around similar issues.
- Knowledge of groundwater system (i.e. its Geohydrological properties)
- Institutional linkages: Botshelo water is an active participant in the various water management structures in the provinces and it is expected to have a prominent role in the Crocodile West – Marico CMA once it is formed, and it is currently a participant in the Molopo and Marico Water Management Fora. Botshelo Water is

also playing a major stakeholder role in the formation of the Extended Grootfontein and the Lichtenburg-Itsooseng WUAs. As result of the nature of its services, Botshelo Water has extensive contacts with local government authorities.

- Premises: Botshelo Water has a head office in Mafikeng. It also has 4 other field offices.
- Equipment & communications: Apart from office and transport equipment, the infrastructure at Botshelo Water's disposal ranges from simple hand pumps to six hi-tech water treatment plants.
- Human resources: 388 people are employed at a cost of R34 million.
- Finances: The operating budget for 2003 is about R82 million.
- Future trajectory: The water authority is concerned about the capacity of local government structures and its impact on the future management of water resources. The supply of water is both labour and transport intensive. However, it is becoming increasingly difficult to hold on to the right skills due to financial constraints and the lack of upward mobility for the skilled people (they tend to leave for the larger cities). Botshelo water is an active participant in the various fora, CMA and WUA establishment process. It is eager to see some progress being achieved in this regard.

3.5.2 The North West Department of Agriculture

Context: The Department of Agriculture has an Irrigation Advisory Committee that is based in Potchefstroom. The committee was established to ensure the coordination of departmental activities with regards to irrigation activities. The department is also aware that irrigation for commercial farming in the North West will often depend upon groundwater resources. As such the committee takes a keen interest in groundwater management issues.

Meetings are held on a quarterly basis and officials from local government structures and DWAF are sometimes invited.

- Name of organisation: The North West Department of Agriculture- Irrigation advisory committee
- Date of establishment: 1994
- Founding (documents/principles/legislation): The committee was established to liaise between the Department of Agriculture and DWAF on agricultural and water

management issues and forms part of the North West's strategic prioritisation of groundwater resources.

- **Governance provisions:** The irrigation committee is part of the Agriculture Department. There it is bound by the policies and procedures of the North West Department of Agriculture.
- **Functions and Activities:** The objectives of the Irrigation Advisory Committee are:
 - To further the interests of the Department of Agriculture with regards to water management.
 - To assist DWAF with regards to the issuing of licenses to applicants who plan to develop irrigation schemes.
 - To contribute meaningfully to the management of water resources to ensure that all water users get enough water now and in the future.
 - To contribute to the implementation of National Water Act
- **Knowledge of groundwater system (i.e. its Geohydrological properties):** The department's engineers have a good understanding of the system- especially extraction methods and the application of the water for farming purposes. In this way, they can take a critical look into the agricultural viability of applications for new irrigation schemes and advise DWAF accordingly. However, people involved in the administrative sections of the Department of Agriculture have the least levels of understanding pertaining to groundwater and the management challenges it presents.
- **Institutional linkages:** The committee members interact extensively with DWAF, farmers and local government structures.
- **Premises:** The committee is based at the department's offices in Potchefstroom.
- **Human resources:** The committee is has representation from the Department of Agriculture and DWAF.
- **Future trajectory:** The committee members felt that new the National Water Act is a good intervention, but its implementation must be made to succeed. This will require the water user must get involved in the management process. However, such involvement can be costly and volunteers often lose their interest. The respondents also felt that water users should be allowed to plan their own structures instead of fitting into DWAF structures because users can implement the management function cheaper than the government if left alone.

3.5.3 Agri-North West

Context: The North West chapter of Agri-SA (i.e. Agri-North West) has a water affairs committee that coordinates the activities of members in water management processes in

the North West. The committee convenes meetings every two months, and members report on their activities within the various water management structures where they are represented.

- Name of organisation: Agri-North West Water Affairs Committee
- Date of establishment: 1992
- Founding (documents/principles/legislation): The committee is part of Agri-North West (which is affiliated to Agric SA). The committee was established to look after water related interest of farmers.
- Governance provisions: The committee operates under the governance provision of the Agri-North West constitution.
- Functions and Activities: According to respondents, the key activities of the committee are centered on:
 - To look after the interests of the farmers by meeting with policy making structures and to negotiate best outcomes for farmers.
 - To negotiate for the best prices with the government structures
 - To assist DWAF in establishing the WUAs and Catchment Management Agencies.
 - To contribute to the process of managing water resources in the North West wisely in order to ensure that all sectors of water users get enough water now and in the future.
- Knowledge of groundwater system (i.e. its Geohydrological properties): The farmers, as intensive users of the resource, do have a significant knowledge base of the groundwater system. Their understanding is formulated on observations they have made, some scientific input from farmers' support groups, meeting with DWAF and Department of Agriculture officials as well as knowledge that gets passed down from generation to generation among farming families. As a result, many of the farmers have come to develop a fairly good "layman's" understanding of the groundwater resource.
- Institutional linkages: The committee works closely with DWAF and local government structures. They are also keen participants in the establishment of CMAs and WUAs.
- Premises: Premises were acquired in Lichtenburg in 2000.
- Human resources: The committee is mostly dependent on volunteers, however Agri-North West employs 20 people are employed on a full time basis. These provide critical administration and technical support to the volunteers.
- Finances: The respondent would not give a response.

- Future trajectory: Agri-North West is pessimistic about the future of the proposed water management institutions. It notes that farmers are rapidly losing interest in a process that has resulted in long delays. As a result, managing water resources to the satisfaction of all stakeholders is likely to become more complicated.

3.6 Conclusion

The establishment of groundwater water management structures in the North West is slowly being rolled out. The key DWAF regional offices that have been involved in the process are Gauteng, Free State, the North West and Northern Cape to a lesser extent. The Northern Cape regional office is likely to play a diminishing role in the process if its request to cede the portion of the aquifer for which it is responsible is implemented.

The assessment of institutional capacity levels within the DWAF national and regional offices suggest that the knowledge of the groundwater system is limited to a few geohydrologists who are employed in the national and regional offices. Furthermore, there were significant human resource constraints. As a result, there is a heavy reliance on contractors and this has the effect of limiting the accumulation of knowledge within institutions. Nonetheless, some regional offices still struggle to find the right expertise to contract or hire on a fulltime basis (vacancies were common). The responsibility of establishing WUAs and CMAs is essentially shared between the three regional offices with the national office providing additional support and processing applications. This process has been characterized by delays and poor levels of communication with local stakeholders. As a result the local stakeholders were often confused about a number of critical issues relating to their structures and the management of water. Some of the key issues that were identified were:

- Who is responsible for preventing the illegal abstraction of water in the absence of a CMAs and WUAs?
- Who is responsible for approving water use applications and verifying water use?
- How is money paid for water use utilized?
- Why it is taking a long time to establish CMAs and WUAs? and
- What support will be provided to proposed WUAs who could not submit applications before their assigned consultant was withdrawn?

The local government structures fared even worse. They all indicated that their knowledge of the groundwater system was limited to a few experts. They also had serious financial problems due to the non-payment of rates. As a result, their ability to attract skilled employees is seriously compromised. Such poor institutional capacity

constraints mean that the local government structures are likely to participate at sub-optimal levels in the establishment and management of water management institutions. In fact, most stakeholder were disparaging about the capacity of their local government authorities. Water services in places like Zeerust and Lichtenburg were poor and unreliable. Furthermore, stakeholders from traditionally black areas complained about the poor quality of representation that their elected officials provide on water management structures and consultative process. There was thus a strong suggestion that elected officials are not necessarily the best people to represent the black communities in water management structures. These people often had extensive demands on their time as a result of their party-political and council commitments, and respondents felt that they often allowed groundwater issues to slip from their list of priorities.

Table 2: Institutional progress relating the establishment of WUAs and CMA

	Little progress	Consultation Stage	Application for establishment submitted	Fully functional Organisation
Grootpan WUA				
Extended G'fontein WUA				
L'burg-ltsoeng WUA				
Ventersdorp WUA				
Zeerust WUA				
Croc West-Marico CMA				
Lower Vaal CMA				
Middle Vaal CMA				

There are three CMAs that need to get established- all of which are still at the consultation stage at present. The Crocodile West Marico CMA has made the most substantial progress although it is not expected to be fully established within the next two years. The Middle Vaal CMA is being supported from the Free State regional office. It too has made substantial progress, but it is not expected to become operational before 2005. The CMAs have not achieved enough progress to assess their capacity. However, the delays in their establishment are resulting in the increase of frustration within the stakeholder base. Once again, interactions with local stakeholders indicated that communication from DWAF about the fate of these institutions has been poor. In this respect, the complaints fell into two broad categories:

- What will happen to WUAs that lost support in the form of an organizational development consultant before they could submit an application to DWAF?

- What is the fate of the WUA applications that were lodge with DWAF for Ministerial approval?

Among the WUAs, the Ventersdorp WUA is the most advanced in terms of getting established, while little progress has been achieved in Zeerust. Furthermore, it seems the Grootpan process may have lost significant momentum and stakeholder goodwill. There is in general a mood of helplessness, confusion and frustration among stakeholders due to the slow pace of progress in getting these organizations established. On the other hand, it appears stakeholders had unrealistic expectations relating to the scope of the task and the time that would be required to implement it. However, it was apparent that the Department has not always communicated effectively with stakeholders or had the requisite capacity to implement the stakeholder establishment process.

The capacity constraints that have been identified in the report have an important bearing. The Phase 1 report noted that in order to ensure water resource sustainability and to adhere to the principles of integrated water resource management, it is also essential to equip the groundwater institutional framework in the North West to accommodate transboundary issues (especially how adjacent CMAs and WUAs will relate to one another). It was within that context that the report made a preliminary recommendation calling for the establishment of a DAMC to facilitate the management of the aquifer in an institutionally integrated manner. The main objective of the committee would be to ensure that despite the division of the aquifer into three separate Water Management Areas (WMAs), it can still be managed as a single and coherent underground water system. Given the paucity of institutional capacity in the North West, it is essential to consider alternative mechanisms that can achieve the impact that a DAMC is likely to bring but with minimum resources and institutional complexity.

4 CONCLUSION AND RECOMMENDATIONS

The assessment of groundwater management institutions in the North West revealed that many of the institutions that have been earmarked to play a pivotal role in the management of the dolomite do not exist. In this respect WUAs and CMAs are yet to be established. In the case of the organisations that already exist, serious capacity constraints exist:

- The DWAF national office is not processing WUA applications fast enough and communication between the Department and applicants has been poor.
- The DWAF regional offices have similarly stretched:
 - The Northern Cape regional office is working towards ceding its portion of the aquifer.
 - The Free State regional office has human resource capacity constraints as well as the challenge of keeping the existing Ventersdorp WUA stakeholders on board while seeking ways of bringing additional stakeholders into the process.
 - The North West regional office also has human resource capacity challenges. It has also struggled to resuscitate the Molopo and Marico fora and maintain momentum with regards to the stakeholder interest in WUAs.
 - The Gauteng regional office also needs to put more skilled people in the field. It manages the establishment of the Crocodile West Marico CMA and struggles to keep stakeholder interested in WUAs.
- The local government authorities in the area tend to have a poor service delivery image. Furthermore, residents had a poor impression of the quality of representation they get from their elected officials in water management structures.

The local authorities are a major stakeholder group. They represent the bulk of domestic users. Furthermore, elected council officials attached to these councils have been expected to play a representative role for marginal users in various structures. However, the field research and interactions with stakeholders suggest that local government structures are straining under the weight of their mandate. Their representation of communities has sometimes been called into questions and they often suffer from a crisis of legitimacy owing to their poor water service provision levels.

Furthermore, the research suggests that the involvement of local government structures in groundwater management structures is often confined to a few individuals who have inadequate institutional support within the local government authority. Therefore, the understanding of the challenge that is posed by the resource is limited to a few individuals. These shortcomings are critical because when a major stakeholder group is in such disarray, the institutional establishment process is bound to suffer accordingly. It is essential to highlight this issue because it raises important mitigating circumstances to charges of neglect that are often levelled against DWAF.

Other important stakeholder groups are the traditional leaders and emerging farmers. The research process experienced major difficulties trying to access these stakeholder groups. These groups suffer from serious human and material capacity constraints and were unable to participate in the fully research. They failed to honour appointments to stakeholder workshops, and tended to not contribute fully to discussions when they did attend. However, we were still able to learn that traditional authorities in areas such as Zeerust are not fully supportive of participation in civic structures. In other areas (e.g. Molopo), they either lack the capacity to participate on a consistent basis or have not prioritised this issue sufficiently. Meanwhile, the emerging farmers are poorly organised as a stakeholder group. Furthermore, they have similar capacity constraints to traditional authorities and balk at the prospect of participating in structures that do not seem to be delivering anything concrete at the moment. These institutional constraints need to be viewed within the context of the institutional (and information) marginalisation of these stakeholder communities to have a meaningful impact on policymaking. For instance, the stakeholder workshops revealed that:

- There are high levels of ignorance relating to how the aquifer works,
- There are high levels of ignorance relating of the new water management legislation and the institutional arrangements that it proposed,
- There is a keen interest to learn about the legislation, the institutions and the aquifer,
- The non-payment of water is a serious and recurring problem,
- Water shortages are already common in many issues and affected communities regard them as a potent barometer of their marginalisation.

Nevertheless, people in these communities are still eager to participate in water management processes. However, policy makers need to find ways of ensuring that such participation is facilitated and sustained. In this respect, the following issues need to be taken into consideration:

- Marginalised stakeholders will need to be provided with a travel allowance that can be accessed immediately after a gathering because they often have very limited disposable cash.

- People in these communities struggle to meet commitments that require them to travel after hours because they rely on taxis for transport (there are very few taxis that operate after hours in rural areas and small towns).
- The provisioning of food is very important because many of these people will be coming from very impoverished backgrounds.
- Capacity building around the functioning of the aquifer, the water legislation and water management institutions is also required. In this respect, such capacity building should ideally target people in ward committees and water management committees.
- It is essential to note that local government councillors are not always the right person to represent a community. The stakeholder workshops suggested that they are often thinly stretched, they often lack up to date information on the communities they are expected to represent and they have thus far communicated very poorly with these communities. In this respect, it is essential to make direct contact with water management committees.
- Finally, it is also essential to review current WUA membership lists to ensure that relevant representatives from these communities have been engaged.

Commercial farmers also have a major stakeholder role to play. They are currently the dominant consumers of the groundwater resource. They are also usually more organised than other stakeholders. However, they are not necessarily a homogeneous stakeholder group. In this respect, many stakeholders pointed out that the farmers that currently participate in the process are the "converted" - i.e. those who have largely bought into the new water management dispensation. Therefore there is a whole section of the commercial farming community that is not being reached. The participating farmers also have their list of complaints. They range from the delays in establishing the CMAs and WUAs to the powers to the Minister with regards to his ability to veto decisions. Furthermore, many farmers indicated that levels of participation in stakeholder consultation process are decreasing because people are beginning to question the value of participation.

Therefore the assessment of groundwater management institutions and interactions with stakeholder groups in the area suggest that the delays in the establishment of CMAs and WUAs are not purely a supply or a DWAF challenge, by they are also a demand challenge. This means there are serious capacity challenges on both sides of the institutional divide. One conclusion that may be drawn from this observation is that delays in the establishment of CMAs and WUAs are likely to recur. In Table 3, we outline the current roles of the various institutions involved in the management of the aquifer and the roles likely to play in the future. Our assessment is that they are struggling to

fulfil their mandates fully at present, and this scenario is unlikely to change radically in the near future.

Table 3: Summary of current and planned stakeholder roles

Institution	Current Role	Planned Role
DWAF- National Office	• Institutional capacity building • Approval of CMA & WUA applications (Minister) • Policy formulation & coordination • Custodian of water rights • Adjudication of disputes • Member of Dolomite Project Coordination Committee	• Institutional capacity building • Approval of CMA & WUA applications (Minister) • Policy formulation & coordination • Custodian of water rights • Adjudication of disputes • Member of Dolomite Project Coordination Committee
DWAF- Free State Regional Office	• Responsible for the Schoonspruit dolomitic unit • Responsible for the establishment of Ventersdorp WUA and Middle Vaal CMA • Licence applications • Member of Dolomite Project Coordination Committee	• Responsible for the Schoonspruit dolomitic unit • Stakeholder in Ventersdorp WUA and Middle Vaal CMA • Member of Dolomite Project Coordination Committee
DWAF- Gauteng Regional Office	• Catchment management • Responsible for the establishment of the WUAs in Lichtenburg, Zeerust, Grootfontein • Responsible for Crocodile west Marico CMA • Licence applications	• Active stakeholder in CMA and WUAs • Member of Dolomite Project Coordination Committee
DWAF- The North West Regional Office	• Responsible for the Molopo and Marico Fora • Licence applications • Stakeholder in CMA and WUAs	• Member of Dolomite Project Coordination Committee • Active stakeholder in CMA & WUAs
DWAF- Northern Cape Regional Office	• Responsible for the Lower Vaal CMA	• Likely to cede its portion of the aquifer
Ventersdorp	• Water services authority • Stakeholder in WUA	• Water services authority • Active stakeholder in WUA
Lichtenburg	• Water services authority • Stakeholder in WUA	• Water services authority • Active stakeholder in WUA
Central District Municipality (including: Lichtenburg, Mafikeng, Zeerust)	• Water services authority in rural areas • Stakeholder in WUA • Member of Molopo Forum	• Water services authority • Active stakeholder in WUA
Southern District Municipality	• Water services authority in	• Water services authority

Institution	Current Role	Planned Role
(Orkney, Klerksdorp, Ventersdorp)	- rural areas - Stakeholder in Ventersdorp WUA & Middle Vaal CMA	Active stakeholder in Ventersdorp WUA & Middle Vaal CMA
Water Services Provider (Botshelo Water)	- Bulk provision of water - Retail provision to community (when requested by local government authorities) - Stakeholder in planned CMA & WUAs	- Bulk provision of water - Retail provision to communities - Active stakeholder in CMA & WUAs
WUAs	Do not exist	- Represent local stakeholders - Implement activities ceded by CMA- e.g. prevention of unlawful use; prevention of waste; monitoring of boreholes etc.
CMAs	Do not exist	- Develop and implement catchment management strategy - Authorisation of water use & water charges - Institutional and organisational supervision of WUAs

Therefore, the poor capacity and disorganisation of key stakeholder groups is unlikely to disappear with the promulgation of CMAs and WUAs. This suggests that current stakeholder weaknesses may affect the functioning of those organisations in ways that have not been fully unpacked. Added to this, are the observations that have been made elsewhere with regards to integrated water resources management that are equally relevant to the management of an aquifer:

- Facilitation by outsiders seldom leads to successful implementation (Rhoades, 2000).
- Different players are dealing with very different scales, some work on the scale of the hydrological unit, others at the level of a local community or specific borehole. This leads to "scale wars" between provincial governments, NGOs, district officers, scientists and communities (Rhoades, 2000).
- Identifying and including all stakeholders².
- Delivery mechanisms and policies that generate and maintain the interest and participation of local institutions and communities are hard to develop (Batchelor, 1999).

² One project in Ecuador found only after a full household census that 43% of the local population had been left out of planning as they were landless and did not come to community meetings.

- A watershed is not a political or social reality except to scientists.
- Co-operative management often requires a great deal of bureaucracy and paperwork and the participants have insufficient expertise (Batchelor, 1999).
- Experts are often not used to being accountable to local people and their attitudes as well as existing institutional cultures need to change (Batchelor, 1999).

In one respect, these observations strengthen the proposal for the development of an integrated management structure that may be in the form of a Dolomite Aquifer Management Committee (DAMC). There are various activities that could benefit from the existence of the DAMC such as:

- Ensuring consistency with regard to pricing policies
- Facilitating cross-subsidies between various Water Management Areas
- Managing information and communication systems
- Policy development, implementation and coordination
- Coordinating monitoring and evaluation
- Facilitating contact with and identifying issues to be brought to the attention of international stakeholders.

However, it is essential to note that the issues that have been outlined above do not necessarily require the creation of new structures. Existing structures that help to create a holistic understanding of the aquifer can easily fulfil this role until the North West's institutions are mature enough to contemplate an alternative structure. For instance the Dolomite Project Coordination Committee brings together the regional offices and representatives from the various directorates in the Policy and Regulation Branch of the national office. These directorates cover departmental functions such as Institutional Oversight; Water Use; Integrated Water Resource Planning etc. It meets four times in a year and provides a forum whereby issues that affect the aquifer as a whole can be discussed.

On the other hand, the research observations must also serve as a cautionary tale against placing unsustainable burdens upon a struggling institutional formation machine. The institutions involved in the management of the aquifer in the North West are weak, and their ability to create new institutions is similarly compromised.

Therefore the need to develop an integrated approach to the management of groundwater in the North West must then be approached with the firm realisation that the institutional milieu in the area is generally weak, and whatever is proposed must at least place minimal strain on existing institutions and at most strengthen them. One way of

going about this is strive to implement the NWRS while aiming to avoid creating new institutions as much as possible. In the context of the North West aquifer, this would suggest that the first priority should be to ensure that the institutions that already exist or are in the pipeline are supported to carry out their functions properly. This means:

- Strengthening DWAF regional offices by ensuring that vacancies are filled and technical support targeted on issues such as organisational development and public participation is availed.
- Improving communication between the DWAF regional and national offices to ensure that WUA applications can be easily tracked and feedback on the merits of the applications is properly communicated.
- Improving stakeholder understanding of the aquifer to ensure that people have a common understanding of the resource and the way it works.
- Improving stakeholder understanding of water management institutions to ensure that the misconceptions and confusion among stakeholders is addressed.
- Improving the ability of stakeholders to participate meaningfully and continuously in the management of groundwater resources by systematically identifying obstacles that prevent them from participating meaning fully and correcting them. These may range from transport allowances for stakeholders to the relocation of meeting venues to places that are more accessible.

5 BIBLIOGRAPHY

- Batchelor C, 1999 'Improving water use efficiency as part of integrated catchment management'. Agricultural Water Management 40
- Bredenkamp D, 2000, Groundwater monitoring: a critical evaluation of groundwater monitoring in water resources evaluation and management, Water Research Commission Report No.838/1/00
- Cain J et al, 1999, Case study management system for rural water supply: Matatiele District, Water Research Commission Report No. 895/1/99
- Department of Water Affairs and Forestry, 2000, Policy and strategy for groundwater quality management in South Africa
- Pegram G & Mazibuko G, 2003, Evaluation of the role of Water User Association in South Africa, Water Research Commission Report No. TT 204/03
- Rhoades RE, 2000 'The Participatory Multipurpose Watershed Project: nature's Salvation of Schumacher's Nightmare' In Lal, Rattan (Ed.) Integrated Watershed Management in the Global Ecosystem Boca Raton: CRC Press
- Stephens A & Bredenkamp D, 2002, Institutional arrangements for groundwater management in dolomitic terrains: situational analysis, Water Research Commission Report No. KV140/02
- Titus et al, 2002 Groundwater assessment and strategies for sustainable resource supply in arid zones: The Namaqualand case study, Water Research Commission Report No. 721/1/02
- Van Schalkwyk A, 2001, Institutional arrangements and support services required for sustainable community water supply, Water Research Commission Report No. 959/1/01

ANNEXURE A: List of respondents

Respondent	Nature of interview	Institution/s
N. Thulo	Phone	Consultant & Fora Coordinator-DWAF- The North West
E. Thebe	Phone	DWAF- The North West
R. Botha	Face-to-face	- DWAF- Gauteng - Crocodile West - Marico
S. Veldtman	Phone	- DWAF- Free State - Ventersdorp WUA
N. Mohapi	Face-to-face	DWAF- National
F. Van Rensburg	Phone	Botshelo Water
W. Swart	Face-to-face	Agri-North West (water affairs committee)
C. de Kock	Face-to-face	The North West Department of Agriculture (Rural Irrigation)
P. Bracken	Face-to-face	The North West Department of Agriculture (Irrigation)
J. Tsholo	Face-to-face	Zeerust Local Municipality (councillor)
M. Mokgathle	Face-to-face	Zeerust Local Municipality (councillor)
C. Lephoi	Face-to-face	Ventersdorp Local Municipality (councillor)
P. Terreblanche	Face-to-face	- Ventersdorp Local Municipality - Ventersdorp WUA
M. Mokgele	Face-to-face	- Central District Municipality - Molopo Water Management Forum - Grootfontein WUA
D. Lombard	Face-to-face	- Ditsobotla Local Municipality - Lichtenburg-Itsoseng WUA
F. Labuschagne	Face-to-face	Southern District Municipality
P. Greyling	Face-to-face	Transvaal Agricultural Association
A. Beyers	Phone	Lichtenburg-Itsoseng WUA

ANNEXURE B: Questionnaire

Groundwater Institutional Assessment Process: Assessment Tool

1. Name of organisation

- What is the organisation called?

2. Date of establishment

- When was the organisation established?

3. Founding (documents/principle/legislation)

- What initiated the establishment of the organisation (e.g. legislation)?

4. Governance provisions

- Does the organisation report to a higher authority? Who?
- Who are the stakeholders? How do they interact with the organisation? Is there a governing body (e.g. board, committees)? What is its/their role? Who is represented? What is their knowledge base regarding the management of water? Are they functional as a governance structure? How often do they meet? Where do they meet? How do they communicate? How do they contribute to the management/operations of the organisation? What are the challenges? What are the strengths?
- Is there a constitution? When was it adopted? How was it developed? Have there been amendments? Does it provide for a code of conduct? What are the challenges? What are the strengths?
- Are there policies and procedures? What do they cover (e.g. auditing, procurement, HR management, IT, etc.)? When were they adopted? How were they developed? Are they operational (e.g. how were they communicated? How are they implemented in the day to day operations of the organisation? Who is responsible for implementation? Who monitors and how?) Have there been amendments? What are the challenges? What are the strengths?

5. Functions and Activities

- What are the aims and objectives of the organisation?
- What are the activities that are carried out to implement/realise the aims and objectives?
- Who carries out these activities?

- Where do the activities get carried out (e.g. onsite or in the office)?
- What equipment is required?
- How often do the activities get carried out?
- Which areas benefit (i.e. what is the geographic spread)
- How are these activities monitored?
- Are the activities paid for by the beneficiaries? What is the charge rate/structure? What is the payment mechanism?
- What is the nature of your organisation's interaction with the groundwater resource?
- Is the nature of this interaction likely to change in the near future? If so, how?
- What are the challenges?
- What are the strengths?

6. Knowledge of groundwater system

- To what extent is the groundwater system understood within your organisation?
- Which members or sections of your organisation have the highest level of understanding of the groundwater system?
- Which aspects of the groundwater system are best understood by these members or sections of your organisation?
- Which members or sections of your organisation have the lowest level of understanding of the groundwater system?
- Which aspects of the groundwater system are least understood by these members or sections of your organisation?
- Is there a mechanism in place to communicate knowledge about the groundwater system to the rest of the organisation? If so, how is this achieved?
- Is there scope to improve the levels of knowledge of the groundwater system within your organisation? If so, how should this be achieved?

7. Institutional linkages

- What other institutions (concerned with the management of water resources) do you link/cooperate with?
- What are the areas of common interest between your organisation and these other organisations?
- How does your organisation contribute to the functioning of those organisations?
- What is the quality of your contribution?
- How do those institutions contribute to the nature of your organisation?
- What is the quality of their contribution?
- What are the points of contact (i.e. who in the organisation, which section of the organisation)?

- How does communication flow from these points of contact to the rest of the organisation?
- How does your organisation communicate with these institutions?
- In your opinion, has your organisation benefited from these institutional relationships?
- What are the challenges?
- What are the strengths?

8. Premises

- Does the organisation have premises to operate from?
- Does the organisation own or lease the premises?
- Where are they located?
- When were the premises acquired?
- How much space is available? Is this sufficient?
- What are the challenges?
- What are the strengths?

9. Equipment & communications

- What types of equipment are available to the organisation (e.g. cars, computers, printers, telephones-fax-internet, specialised machinery etc)
- Does the organisation own or lease the equipment?
- If there is a lease- what are its provisions?
- What maintenance provisions have been put in place?
- What is the equipment used for?
- What else is required?
- What is not required?
- What are the challenges?
- What are the strengths?

10. Human resources

- Is there staff or volunteers?
- How were they appointed?
- What is the demographic breakdown (race, gender, age, disability-?)
- What is the skills breakdown?
- Is there an HR management policy?
- Is there a training policy?
- How many vacancies are there? Where are they located?
- What are the challenges?
- What are the strengths?

11. Finances:

- Does the organisation operate a bank account?
- Is there a budget (proof!!)? Is it PFMA compliant?
- Are there audited statements (proof!!)?
- What is the income (breakdown according to categories- e.g. treasury transfers, service fees etc)?
- What is the expenditure (breakdown according to categories- e.g. salaries, communications, rent, equipment, debt servicing etc)?
- Is there a surplus?
- Is there overspending? Is there debt? What are the repayment provisions?
- What are the challenges?
- What are the strengths?

12. Future trajectory

- What changes are anticipated for the future (over 5 years, over 10 years)?
- What is the source of the anticipated changes?
- What are the skills challenges that are likely to arise?
- What are human resources challenges that are likely to arise?
- What are the equipment challenges that are likely to arise?
- What are the governance challenges that are likely to arise?
- What are the legislative challenges that are likely to arise?
- How is the organisation planning to adjust to the changes (i.e. the planning mechanisms that are being put in place)?

ANNEXURE C: Workshop report – marginal water users

Facilitated by Kabelo Reid

1. Introduction

The Water Research Commission is funding a study to investigate institutional arrangements for the management of the dolomitic aquifer in the Northwest. The purpose of the study is to investigate institutional options that will facilitate the management of the groundwater resource in an integrated manner. This investigation is also expected to provide suggestions on how the participation of the various stakeholder groups can be encouraged and sustained to ensure that the establishment of water management institutions has an element of on-going user participation and ownerships.

2. Workshop Schedule

In pursuit of the above stated outcome, three workshops that targeted marginal groundwater users were organised in the Northwest. Table 1 outlines the locality, date, venue and start time of each workshop.

Table 1: Workshop schedule

Place	Venue	Date
Lehurutshe	Lehurutshe civic centre	31 October 2003
Itsoseng	Itsoseng community hall	5 November 2003
Goedgevonden	Goedgevonden community hall	4 November 2003

3. Participants' Profile

For the purpose of organising the workshops, the term "marginal" was used to refer to the following water user groups (and their representatives):

- Users in rural settlements
- Domestic water users in urban areas
- Emerging farmers
- Ward councillors
- Water and/or development communities, and
- Traditional authorities.

The workshops were attended by a total of thirty three (33) people. This means that each workshop was attended by an average of eleven (11) people. All the participants in each workshop were Africans. The average gender profile in the workshops was fairly balanced- there were nineteen (19) women and fourteen (14) men in total.

Much effort was expended to ensure that the profile of participants in each workshop reflected the description of marginal water users as outlined above. However, owing to time constraints and our inability to reach all the desired categories of marginal water users, it was not possible to secure the attendance of the traditional authorities and the emerging farmers at any of the workshops.

4. Workshop Structure

The workshop structure was organised around five key topics or themes:

- Workshop expectations – The purpose of this theme was to get the participants to express what they expected to gain from the workshop through an activity that allowed them to indicate their expectations. The utility of this activity was that it provided an indication of issues of most concern to the participants. It also provided the facilitator with an opportunity to outline the parameters of what could be covered during the course of the workshop. We avoided alienating illiterate participants by allowing the people to make verbal contributions.
- Functioning of the aquifer – This topic focused on imparting basic knowledge regarding the characteristics and operation of the dolomitic aquifer. A major discussion point in this regard was an explanation of the geo-hydrological cycle.
- The need for sound water management practices – This topic focused on stimulating awareness of the need for sound water management practices. Key discussion points in this regard centred around exploring the utility of groundwater and highlighting the impact of human activity on groundwater resources.
- Participation in the management of water resources – The purpose of this topic was to highlight how people from marginalised communities can participate in the management of groundwater resources from the local to the regional levels.

The workshops were expected to run for six hours because it was assumed that participants representing marginal water users may require more time to engage properly with the issues. However, that assumption proved to be erroneous and the time taken to complete each workshop was usually sixty to ninety minutes shorter. The actual workshop agenda was as follows:

- Item 1: Opening, Introduction, Expectations
- Item 2: The functioning of the aquifer
- Item 3: The use and value of groundwater
- Item 4: How groundwater is managed.

5. Lehurutshe Workshop

5.1. Context

Lehurutshe is a former Bophuthatswana area near Zeerust. The area is made-up of a formal township as well as settlements on tribal communal lands. As a result, the area has urban as well peri-urban settlement patterns. The transition from Bophuthatswana to a democratic South Africa has resulted in mixed fortunes for the area. Lehurutshe, as the home of the only president Bophuthatswana ever had, benefited significantly from the spending patterns of the former homeland. A democratic South Africa has brought benefits such as an open society and poverty alleviation schemes such as free basic water, but it has also meant that Lehurutshe now has to compete for resources on an equal footing with other similar settlements in the Northwest.

5.2. Attendance

The workshop in Lehurutshe was attended by nine (9) people. There were two local government councillors among the participants. The rest of the attendants were active members of ward committees. Three (3) of the participants were men, while the other six (6) were women. A full list of participants is provided in Table 2:

Table 2: Lehurutshe workshop attendance list

Name	Representing
Abel Mokaiwa	Ward 14 (Committee Secretary)
Jacob Tsholo	Ward 12 (Councillor)
Damaria Pule	Ward 5 (Committee Secretary)
SS Moreki	Ward 13
D Ntthe	Ward 2
SM Moraka	Ward 10
TR Botlhoko	Ward 13
MG Mokgatihe	Ward 10 (Councillor)
Irene Boikanyo	Ward 5

5.3. Workshop Expectations

The workshop participants were requested to volunteer topics that they wished the workshop to address. This activity produced the following items/topics:

- Non-payment of water
- The provision of free basic water (6000 litres)
- The role of traditional authorities in the management of water
- The dependability of water services.

5.4. Workshop discussions

The workshop discussion was organised around the workshop topics and agenda items as listed in Item 4 of the report. The initial discussion point related to the nature of the aquifer. This discussion focused on outlining the size of the aquifer, the basic geological factors that contributed towards the formation of the aquifer, the hydrological cycle, recharge patterns, and the various compartments that characterise the aquifer. The participants indicated that they had a limited understanding of how the dolomitic aquifer works and thus had little contribute to this discussion. Most people indicated that they were under the impression that there is a network of underground streams that criss-crossed their area. The participants also indicated that they were fascinated to learn that their underground water resources emanated from a source that was significantly different from their preconceptions.

Most participants were aware of the source of water in their settlements. This was partly owing to the fact that everyone in attendance was actively involved in local government. However, a major concern that was express was the persistent problem of non-payment for water services. The participants highlighted the widely held notion that water is a natural and freely available resource that should not be paid for (a comparison was made to air). The issue of non-payment is already affecting the quality of infrastructure in the area. Repairs to pipes and generators are left unattended due to a shortage of funds.

A major source of groundwater in the area has traditionally been the Dinokana Eye. The eye is located on communal tribal lands. Under the former Bophuthatswana, traditional authorities were usually paid royalties for the use of water resources that are located within their tribal territory. This system does not apply in South Africa, as a result significant tensions have resulted between the local government authorities and the traditional authorities who regard the groundwater source as their tribal possession. Traditional authorities in the area are also reluctant to participate in the local government structures and processes. The local government structure in Zeerust makes provision for

the representation of traditional authorities. However, traditional authorities are yet to participate in the local government structures because they argue that their role in these structures is not clarified. This lack of cooperation has a major impact upon the ability of the local civic structures to manage groundwater resources in an integrated manner.

The flow of water from the Dinokana Eye is apparently not as reliable as it used to be due to a combination of infrastructural and over extraction challenges. Therefore competition around this resource is rising, and the residents of Dinokana (where the eye is located) are known to sabotage supplies to other areas. The lack of cooperation between traditional authorities and local government authorities is exacerbating the problem by resulting in the uncontrolled growth of settlements on tribal lands and the undermining of efforts to manage the groundwater resource in an integrated manner.

A Major concern among the participants related to issues of representation and community participation in the management of water. The participants indicated that they had little awareness of the current legislation governing water as well as the establishment of fora that will contribute to the formation of the Crocodile West-Marico Catchment Management Agency. The notion of Water User Associations was also a new concept to the participants (NB: the formation of the Zeerust Water User Association is currently stalled). The workshop was provided with an illustration of what happens when water management is not run in an integrated manner and communication between the various civic service agencies is poor: a local village had contractors laying underground telephone or electricity infrastructure in the area, they were not provided with diagrams indicating the location of water pipes which resulted in the contractors puncturing a number of the pipes that distribute water.

The participants thus listed a number of concerns that should be addressed before the integrated management of water resources can be achieved in their area:

- The cost of representation: most volunteers in the area are unemployed (the two councillors were the only people with a regular income among the participants) and wards in the area can be vast, therefore the cost of travelling to attend meetings can be unbearable to most people with an inclination to participate in water management (and other civic structures).
- The need for expert advice and organisational skills to get structures off the ground, this related to the stalled establishment of the Water User Association as well as to water management committees at the community level.
- The need to improve communication: the participants were eager to know who is representing them in various water management structures and how procedures can be established to ensure regular feedback.
- How payment for water services will be managed and enforced.
- How traditional authorities will be drawn into water management structures.
- The need for further education: the participants expressed gratitude with regards to the knowledge they had gained around water management institutions and the utility and functioning of the groundwater aquifer. However, they did not feel confident to impart the knowledge to other members of their communities. There was consensus around the need for similar workshops to be run with larger numbers of community members and activists.

6. Goedgevonden

6.1. Context

Goedgevonden is located about 20 kilometres from Ventersdorp. The community of Goedgevonden was forcibly removed from the locality in 1978 and relocated to Delareyville. These people started returning to their ancestral lands about seven years ago and are in the process of finalising their land restitution claim. The community is mostly Setswana speaking. Economic opportunities in the area are scarce (the only workshop participants with a regular income were not from Goedgevonden). Compared to Itsoseng and Lehurutshe, Goedgevonden is also characterised by highly organised civic structures.

6.2. Attendance

Table 3: Goedgevonden workshop attendance list

Name	Representing
Celia Lephoi	Councillor
Tabile Moalusi	
Thembile Menzi	Goedgevonden Management Committee (Secretary)
Plaatjie Dyantye	Goedgevonden Management Committee (Community Gardens)
Sannah Soya	Goedgevonden Management Committee (Community Gardens)
Nicholas Jacoby	Goedgevonden Management Committee (Water Coordinator)
Jacob Morei	Water Committee
Moses Morake	Water Committee
Linda Sepeng	Mvula Trust & Water Sanitation Forum
Kate Mcameni	Community Policing Forum
Baseline Mcameni	Livestock Committee
Mable Legobate	Goedgevonden Management Committee
Sarah Tekane	Community Property Association

The workshop in Goedgevonden was attended by thirteen (13) people- as indicated in Table 3. One of the participants was a councillor in the Ventersdorp Local Authority and a resident of a similar settlement close by. Another participant was a water sanitation development officer from Mvula Trust. The rest of the participants were residents of Goedgevonden and active in the various civic structures of the locality. The gender profile of the participants was seven women and six men. All participants were unemployed with the exception of the local government councillor and the development officer from Mvula Trust.

6.3. Workshop Expectations

The workshop participants were requested to volunteer topics that they wished the workshop to address. This activity produced the following items/topics:

- Non-payment of water
- The maintenance of infrastructure
- The quality and dependability of water resources
- The provision of free basic water (6000 litres)

- Water shortages

6.4. Workshop Discussions

The current community of Goedgevonden is still relatively new. The settlement is also surrounded by commercial farming operations. The only dependable source of water in the area is the groundwater resource. When the original Goedgevonden community was removed from the locality, the area was turned into an exclusive commercial agricultural haven. However, the re-establishment of the settlement has altered that scenario, and competition for groundwater between the surrounding farms and the community is fairly pronounced. The workshop participants indicated that local farmers often come to the community to complain about over-extraction. The participants were thus shocked to learn that commercial agricultural practices account for much higher volumes of groundwater consumption than domestic users.

The participants demonstrated a keen interest in understanding how the aquifer was formed and how it operates. The utility of groundwater in Goedgevonden was also acutely appreciated. The participants pointed out that access to dependable sources of groundwater had improved the lives of the community in the following ways:

- Various community projects (especially construction) depend on easily accessible sources of water,
- The community's life stock benefits from the water,
- The community operates gardening projects that contribute to the, alleviation of poverty and help with the nutrition of inhabitants, and
- The water has various domestic uses- hygiene, cooking, drinking etc.

The Goedgevonden settlement is entirely dependent upon groundwater. There are a number of boreholes in the area that pump water into two reservoirs which feed water to the whole settlement. The provision of water is currently not paid for. The Ventersdorp Local Authority has indicated that this situation is not sustainable and payments for water services should commence in 2004. The community is very concerned about this approach given the failure of previous attempts to get community members to pay for water services. The workshop participants were also concerned about how water usage (especially at boreholes) could be accurately determined so that user charges are fair.

The other concern among the attendants was the long term supply of water. Water shortages in the area are already common, and there is wide spread anxiety about the boreholes drying up.

The participants were particularly worried about the sustainability of integrated water management systems when non-payment was such a difficult challenge to overcome. A number of examples were given:

- The community is already struggling to maintain equipment due to the non-payment of water services,
- Community taps often disappear (they could be getting stolen for scrap metal), replacements are hard to effect due to the shortage of funds.

A popular solution was to encourage a greater sense ownership of water infrastructure within the community by placing taps inside each household's property. Although this option is likely to be costly, it was still favoured due to the belief that it will make the enforcement of payments easier.

The participants were also eager to get involved in integrated water management processes, but felt uneasy about the lack of communication regarding the new legislation governing the use of water and the institutional developments emanating from it. There was no knowledge of the evolving Ventersdorp Water User Association or the Lower Vaal Catchment Management Agency. However, the participants suggested a number of interventions that need to be implemented to ensure their participation in such structures:

- Training for the Water Committee: it was indicated that some of the system failures that have been experienced are in part related to the weakness of the Water Committee. It was suggested that the Water Committee's Management Committee is weak and policies and procedures do not exist.
- Training for the community was also called for so that the whole community should be adequately informed about groundwater and its management. The workshop participants felt that such an understanding at a community level would greatly improve the cooperation between the community and the people tasked with the management of the water resources.
- Communication with other institutions was also flagged as a major weakness. The workshop participants felt that their community was isolated from major institutional developments due to poor communication procedures.

7. Itsoseng

7.1. Context

Itsoseng is also a former Bophuthatswana settlement. It characterised by high levels of unemployment and the dilapidation of infrastructure. The closest town to Itsoseng is Lichtenburg, which is about 30 Kilometres from the settlement. Like Lehurutshe, Itsoseng has a formal township which is surrounded by villages and peri-urban settlements that are mostly under the authority of tribal authorities. Itsoseng experienced a violent and traumatic transition to the democratic dispensation which was characterised by a few days of extensive looting and damage to civic property as local and surrounding people vented against the collapsing Bophuthatswana government.

7.2. Attendance

Getting people to attend the workshop in Itsoseng was a challenging undertaking. The workshop was initially scheduled to be held on the 1st or the 3rd of November. However those dates had to be rescheduled due to the failure of local people to indicate their interest in participating in the workshop. The workshop date was finally rescheduled to the 5th of November.

Table 4: Itsoseng workshop attendance list (5 November 2003)

Name	Representing
Peterson Mkwanazi	United Christian Democratic Party; Ward 8
Thabo Ditse	Itsoseng, African National Congress
Lizza Kolwane	Itsoseng, African National Congress
Johanna Gaobotse	Verdwaal Ward 2
Letters Maluleka	Verdwaal Ward 2
Rebecca Phillipi	Itsoseng
Tello Mafojane	Verdwaal Ward 2

Solomon Phiri	Verdwaal Ward 2
Shimi Metswemere	Itsoseng; Ward 8
Molathegi Mokgaledisa	Itsoseng; Ward 8
Reginah Hitewa	Itsoseng; Ward 8

A total of eleven (11) people attended the workshop in Itsoseng. Most people who attended were unemployed community volunteers who worked mostly with the ward committees in and around Itsoseng. The gender profile of the participants constituted six (6) men and five (5) women.

7.3. Workshop Expectations

The workshop participants were requested to volunteer topics that they wished the workshop to address. This activity produced the following items/topics:

- Non-payment of water
- The provision of free basic water (6000 litres)
- Inconsistent water pressure in the area
- What the government is doing to address water shortages
- Use of groundwater to alleviate water shortages
- Services arrears.

7.4. Workshop Discussions

The workshop was attended by people from the formal township of Itsoseng and the neighbouring village of Verdwaal. The two settlements may differ in history and the infrastructure at their disposal. However, the workshop participants made it clear that they share very similar concerns with regard to the availability of water.

As in the other workshops, the participants were astonished to learn about how the groundwater aquifer functions and the new legislation and institutions that govern the use and management of groundwater resources. The participants were generally ignorant of these developments and lacked an understanding of how groundwater resources are intended to be managed. A major concern was voiced about the capacity of local people to participate in such process given the poor capacity of both individuals and organisations in the area. The participants stressed the need for organisational capacity building to help water committees to operate on a more sustainable basis and to educate community members on issues relating to the groundwater resource and its management.

A major capacity stumbling block that was identified related to the maintenance of infrastructure as well as the related problem of non-payment. The participants indicated that there were major infrastructural problems in the area:

- Infrastructure was often insufficient to cope with the water demands in the area, as a result Verdwaal and other villages in the area often needed water to be brought to them in mobile tanks. This meant that the community has a small window of opportunity to collect water for domestic use before the mobile tanks move on to another locality. Families without strong able bodied people to collect water are also disadvantaged because the collection of water in such instances becomes a major logistical undertaking.
- Where water is available the pressure is often very weak. As a result water often trickles out of taps at a frustratingly meagre rate. The parts of Verdwaal with access to piped water reported that their taps often produce little or no water

during the day time when usage in Itsoseng is high (therefore their taps only produce water in the evenings).

- The community of Verdwaal has a generator and pipes for reticulation (the equipment was donated to the village in 1999), however the infrastructure has not been installed despite promises by the local authority to do so. It is now feared that the equipment will soon become redundant or get stolen before the community can utilise it.
- Existing infrastructure is poorly maintained. The participants indicated that it was common to see water seeping to the surface from broken pipes.

The participants indicated that they were of the view that their problems were symptomatic of the bigger problems related to the civic culture and capacity in the area:

- The non-payment of services was rife. Most people have not paid for services since the transition to democracy. The Verdwaal community owed over R9000.00 in costs related to water. Some members of the community made contributions, however it was not clear what had happened to the collected money. The non-payment culture was also said to be compounded by the high levels of economic inactivity in the area.
- Civic organisations such as water committees were said to be in a poor state of organisation and rarely functioned.
- The capacity, effectiveness and groundwater related knowledge of elected officials was also raised as a stumbling block to progress. The example of poor surveying for the location of grave sites was cited to illustrate this point (whereby graves were sometimes located where they could easily contaminate drinking water).
- The community's generally poor level of knowledge of civic and local government processes was identified as another weakness in the area (in fact, even the participants were uncertain of the roles and responsibilities of councillors despite the fact that most of them were supposed to be members of ward committees).

As is in the other workshops, the participants expressed an interest in being accommodated in groundwater management strategies and institutions. However, unlike the other workshops, these participants were by far the most pessimistic about their ability to contribute meaningfully in such processes.

8. Conclusion and Recommendations

The communities in the three workshops had more points of similarity than differences. In all cases, the following issues were apparent:

- There were high levels of ignorance relating to how the aquifer worked,
- The participants were also ignorant of the new legislation and the institutional arrangements that it proposed,
- The participants were keenly interested in learning about the legislation, the institutions and the aquifer,
- The non-payment of water is a serious and recurring problem,
- Water shortages in the communities were already a serious problem (although responses differed- Goedgevonden actively worked towards solutions, Lehurutshe was fragmenting between tribal and urban interests and Itsoseng was generally trapped in a state of civic paralysis).

- The participants demonstrated a keen interest to participate in water management processes provided funding for travel and capacity building is provided.

It thus recommended that:

- Further capacity building for marginalised water users should be undertaken,
 - Such capacity building should target civic structures that are involved in water management to improve knowledge of legislation, the functioning of the aquifer and organisational development expertise,
 - Workshops for community members with a particular focus on the utility of groundwater and the need to contribute (financially) towards the management of water resources and infrastructure,
 - The Goedgevonden workshop recommended that initiatives that target school children should be made integral to any capacity building strategy since scholars have proved to be a good source of education and information for adults in their area,
- An outreach programme by the evolving Water User Associations and the Catchment Management Agencies and their affiliated fora should be undertaken to ensure the participation of these marginalised communities in the management of groundwater resources,
- Strategies to engender better communication between water services providers (i.e. local government) and the communities should be integral to any strategy to improve the institutional contact between marginalised communities and water management institutions, and
- Interim measures should be established to address water shortages and current conflicts around access to groundwater resources.

ANNEXURE D: Workshop report – dominant water users

Facilitated by Dana Grobler

1 Introduction

The Water Research Commission is funding a study to investigate institutional arrangements for the management of the dolomitic aquifer in the North West province. The purpose of the study is to investigate institutional options that will facilitate the management of the groundwater resource in an integrated manner. This investigation is also expected to provide suggestions on how the participation of the various stakeholder groups can be encouraged and sustained to ensure that the establishment of water management institutions has a strong element of on-going user participation and ownership.

2 Workshop Schedule

In pursuit of the above stated outcome, four workshops that targeted dominant groundwater users were organised in the North West province. Table 1 outlines the locality, venue and date of each workshop.

Table 1: Workshop schedule

Place	Venue	Date
1. Ventersdorp	Ventersdorp Municipal Boardroom	29 October 2003
2. Mafikeng	Botshelo Water Board	30 October 2003
3. Zeerust	Municipal Hall	31 October 2003
4. Lichtenburg	Diamond Hall	3 November 2003

3 Workshop Report

This report presents an overview of the proceedings of the aforementioned workshops. Although the aim of the workshops was to obtain input and comments on the proposed water management institutions, the users took the opportunity to voice a number of other water use management related matters within the respective areas. The comments and questions mostly covered water use registration, water use licensing and the collection and distribution of both technical and other information related to water resources management.

4 Workshop Objectives and Design

The purpose of the workshops was to encourage stakeholder participation in institutional arrangements study. This participation was facilitated by informing stakeholders on the key findings of the research project, with a specific reference to the geohydrological assessment, and as such Dr Dave Bredenkamp attended the workshops to supply further information or clarity where required. The key discussion points in the workshops were thus centred around the following issues:

- The dissemination of findings of WRC 1324 research process
- Enhancing the participants' knowledge of functioning of aquifer and how this impacts on its management
- To seek inputs relating to options for the aquifer's management, and thus challenging a dominant notion that WJAs alone can fulfill management functions.

Workshops ran for 3 to 4 hours according to the following agenda:

9am-9.15am	Welcome, introductions & Workshop expectations
9.15am-9.30am	Setting the context: Water Management in South Africa
9.30am-10am	Project overview
10am-10.15am	Tea-break
10.15-12.15pm	How should we be managing our aquifer?
12.15pm-12.30pm	WRAP-UP and WAY FORWARD

5 WORKSHOP ONE: VENTERSDORP

5.1 Participants

Name and Surname	Representing
Mr Zaid Bhabha	Ventersdorp Municipality
Mr Kobus (JJ) du Preez	Grootpan
Mr Johan van Graan	Schoonspruit Water Vereeniging
Mr James Mabo	Southern District Municipality
Mr Pierre (CP) Terblanche	Ventersdorp Municipality
Mr Bennie Yssel	Rietspruit Water Verbruikers Vereniging & Agri Noordwes

5.2 Summary of issues discussed in workshop

1. Water use registration, licensing and payment of catchment management charges

Users were concerned that the resource is not effectively and equitably managed, and the following were listed as reasons for these concerns:

- Illegal water use is not stopped and will lead to conflict amongst users and the proposed institutions. Some farmers have registered water use that was only exercised after the registration process had been completed and which should have been licensed.
- Users are unsure of the future allocation of water, given the fact that current use and availability of water is not clear. The way in which water use restrictions will be implemented is also unclear.
- Confusion exists in terms of the need to obtain approval for the drilling of boreholes and the replacement of existing boreholes. Participants indicated that water use was registered but did not refer to a specific borehole. Clarification is required on this issue.

- Control and monitoring of water use is not being done and this raises concerns, as there is the perception that DWAF only monitors sporadically, with the information never being provided to the users.
- License applications are often delayed and the framework for deciding on when to transfer water use and when to apply for a new license is unclear.
- Mining development is being delayed because mines are often told that they need to obtain water through a process of transferring water rights. This is causing delays in an area requiring economic development.
- DWAF indicated earlier that the catchment management charges were to be used to fund the activities of the WUA. In the absence of the WUA the distribution of CMC funds within a CMA was unclear to participants. The users proposed that the CMC's representation should be proportionally based and be calculated on the basis of monetary contributions from particular areas. The current CMC formats are unknown.

2. Current status of the water management institutions

2.1 Catchment management agencies, water user associations and water user forums

2.1.1 Establishment of the CMA

Nominations were made to the advisory committee for the establishment of the CMA.

2.1.2 Establishment of the water user association

The submission for the approval of the WUA was made to the DWAF and the users are awaiting approval by the Minister. In response to the question about adequate representativeness, the attendees suggested that all the issues with regarding this issue were adequately addressed in the process of compiling and establishing the constitution. They also believed that the fixed costs for the day-to-day management of the WUA should be funded from the catchment management charges (CMC). It is not the responsibility of the WUA to fund specific scientific and technical investigations.

The need to see progress with respect to the establishment of the WUA was critical for the initiation of all the other activities. The lengthy delay in the WUA's approval severely criticised.

2.2 Current institutional strengths and weaknesses

2.2.1 Current institutional weaknesses

The following institutional weaknesses were identified during the workshop:

- The delay in the establishment of the required institutions was allowing the formalisation of illegal uses and the potential over-utilisation of the resource, which could prove costly to rectify. The delay in the establishment of the CMA was also hampering the verification process, as this could not formally be discussed and planned.
- There was a perception that Land Affairs were initiating development in areas that could probably not be supplied with adequate water. As a result, the participants believed that the collaboration between the departments was not sufficient.

- The delay was also creating the perception that users are paying the CMC without getting anything back, and there was a strong opinion in favour of not paying the CMC until the WUA is established.
- The general increase in the awareness of water and the potential limitations was creating a culture of take (illegally) while you can, and the absence of appropriate institutions was fostering the situation.
- Technical information about the resources is not available in a format understandable by users. The way in which the data could be used in decision-making is also not understood. There is thus a need to package the technical information in a way that can be understood by the users.
- A lack of understanding of the resource and its behaviour under certain levels of utilisation.
- Collaboration between water users and the various proposed management institutions (including DWAF) is not formalised and is not adequately planned and implemented.

2.2.2 Current Institutional Strengths

The following institutional strengths were identified during the workshop:

- WUA could be a major rallying point- i.e. full institutional capacity would only be realised once the WUA was established.
- The willingness of the users to create and participate in the establishment of the WUA.
- Technical information was slowly becoming available.

3. Institutional recommendations

The following comments were made on the proposed creation of a dolomitic management structure:

- The proposed number of WUAs (i.e. five) seems to be logical because groupings would be representing the major sources of dolomitic water.
- The WUA should take responsibility for the monitoring, co-ordination and the collection and supply of data to the management institutions.
- The distribution of funds to undertake activities of the WUA was unknown and should be clarified.
- The international component is negligible, specifically in terms of the Ventersdorp WUA.
- Representativeness on the WUA governing boards should include a member from the donor dolomitic aquifer and a receiving WUA should be represented on the board of the donor dolomitic aquifer.
- The relationship between the proposed Dolomitic Aquifer Management Committee and its proposed sub-committees, in terms of the overall WMA, and the overall need for technical assistance in other areas of the entire CMA should be clarified.
- The proposed CMA should fit in between the DWAF and the dolomitic management committee.
- Everybody agreed on the need for a central committee for the co-ordination of the management of the entire business related to the dolomitic resources.
- Representation on the proposed dolomitic management committee should be clarified.

- The proposed Dolomitic Aquifer Management Committee should be specific to the dolomitic area of the North West Province, and should not cater for all dolomitic resources.
- The delegation of management powers to the WUA and other proposed management institutions should be clarified.
- Progress with the water use verification process (verification of registered water use and existing lawful use) was unknown and users would like to receive feedback on the progress.

5.3 Summary of evaluation questionnaire

A total of 4 assessment forms were received back, containing the following answers:

Questions	Answers			
	Participant 1	Participant 2	Participant 3	Participant 4
Do you have a better understanding of the research project under way?	Yes	Yes	Yes	Yes
Do you support the objectives of the study? Do you see a need for such a study?	Yes	Yes	Yes	Yes
What are your expectations of such a study?		To know more about the resource and to assist in the management of the resource	Improved knowledge on the resource and improving the management of the resource	The study must assist to move faster with implementation of the WUA
What are your greatest concerns about the management of the dolomitic aquifer?	The WUA must be formalised as soon as possible to ensure monitoring and management in the best possible way	It is taking too long to establish the WUA	It is a concern that the resource is not effectively and equitably managed!	Lack of control and measurement

WORKSHOP TWO: MAFIKENG

5.4 Participants

Name and Surname	Representing
Mr TJP du Plessis	Grootfontein Water Board
Mr Faan van Rensburg	Botshelo Water
Mr Mpho Mahura	Department Land Affairs – North West
Mr Enos Makhele	Botshelo Water
Mr S Mohapi	DOACE
Mr SP Seodisa	Botshelo Water
Ms Ellis Thebe	DWAF – North West

5.5 Summary of issues discussed in the workshop

1. Water use registration, licensing and payment of catchment management charges

The illegal use of water is most likely taking place in the area and the lack of legal action will allow the continuation of such practices. The licensing of new water uses takes too long and causes delays in much needed development.

The need and circumstances under which water use transfers should be applied to limit increases in demand is not clear. The users are unsure of the future allocation of water, given the fact that current use and availability of water is not known. The proposed water use restrictions are not clear either. Financial compensation for water that can be designated as water for primary use is not clear. The participants were also worried that government will be able to claim the water without compensation?

Control and monitoring of water use is not conducted, which raises concerns, there is a wide spread belief that DWAF only monitors sporadically and information is never provided to the users.

The utility of CMC, which are currently being paid, is unknown. The use of these funds should be clarified until such a time as the Minister formally approves the WUA. The distribution of funds to undertake activities of the WUA is unknown and should be clarified. The CMC is perceived to be expensive.

The communication between the DWAF and the users in terms of the establishment of the CMA and other water management related issues is not adequate and creates unnecessary misunderstandings and confusion. The dolomitic water resource is considered to be a strategic water resource, although the establishment of the Orange River forum is receiving increasing attention.

2. Current status of the water management institutions

2.1 Catchment management agencies, water user associations and water user forums

2.1.1 Establishment of the CMA

Nominations were made to the Minister for the approval of members of the advisory committee for the establishment of the Catchment Management Agency.

2.1.2 Establishment of the water user association

The constitution for the WUA was compiled and a formal request for the establishment of the WUA was submitted to the Minister. Representativeness was adequately addressed during the process of compiling the constitution and proposed composition of the WUA. In this area, only a limited number of farms are owned by historically disadvantaged individuals. Provision has been made for co-opting new members as the activities and responsibilities of the WUA unfold and the water user profiles change over time.

The proportional participation and voting rights in the various proposed management institutions (WUA and CMA) are not clear. There was a concern that the irrigation users (representing 70% of water use) will be sidelined by the many smaller water user groupings.

2.2 Current institutional strengths and weaknesses

2.2.1 Current institutional weaknesses

The following institutional weaknesses were identified during the workshop:

- The members of the proposed WUA are currently not paying the charges. They believe that the WUA is not in place and charges should not be levied against them, especially as they don't know how the money is being utilised.
- Representativeness on the advisory and ultimate CMA board is a concern, as this will not be done in proportion to the water use in the area being represented.
- Timeframes for the establishment and delegation of authority from DWAF to CMA and WUA is a problem. The delay in the establishment of the CMA is having a domino effect in terms of the establishment of the WUA and the acceptance of the management and self-regulatory functions.
- Concerns with regard to funding – funding was often cited as the reason for the slow progress of the establishment of water management organisations.
- Attendance of the forum meetings is not good.
- Illegal water use is not resolved. The Bala farm was bought with the specific aim of "reserving" water for the intended future primary use. Now farmers are using the water illegally, threatening the intended use, which is also an example of the inability of the current management institutions to resolve the problem.
- A licence application was made for 2000 ha irrigation in the Polfontein area (south of the Grootfontein area). The consideration and issuing of the licences is unknown. This situation could be resolved if the WUA and CMA are established.
- Proportional representation in the WUA was not a true reflection of the required composition, as irrigation farmers could dominate the WUA.

2.2.2 Current Institutional Strengths

The following institutional strengths were identified during the workshop:

- Water users groupings are well organised (specifically agriculture).
- Local municipalities are well organized.
- Botshelo Water is well established and suitably positioned to assist with the activities of the WUA.
- Knowledgeable (technical) people in all structures are currently involved in water management.
- Representation was adequately addressed in the process of the establishment of the proposed structure of the WUA. It should be recognised that the area has very few black farmers, thus the low numbers.

3. Institutional recommendations

The following recommendations and comments were made on the proposed creation of a Dolomitic Aquifer Management Committee:

The establishment of a proposed Dolomitic Aquifer Management Committee was supported by the users and they indicated that the dolomitic area feature prominently in the establishment of the CMA. The dolomitic area should be classified as a strategic resource, with the specific conditions and protection applicable to strategic resources. The dolomitic use might be smaller than the use in other areas of the CMA, but it is the only economically viable resource and should, therefore, be managed in a sustainable way. Everybody agreed on the need for a central committee for the co-ordination of the management of the entire dolomitic aquifer.

The establishment of five WUA, based on the major dolomitic compartments, was considered to be a logic way in organising the management of the dolomitic aquifer. The management of water use from an adjacent area (e.g. Bala farm) is not clear.

The current role of the regional office of DWAF, in terms of fulfilling the function of the proposed CMA, was unknown, as the functions of the CMA were not clear to the users.

The possible changes to the WMA boundaries were never formally discussed with the users, who would like to have the opportunity to examine the possible impact that such changes may have on their consumption. The possible expansion of the boundaries of the WUA (which previously constituted the water control area) to include the entire Grootfontein resource unit is a new concept to the users, but the users believed that this should not delay the establishment of the WUA, as provision is made for a regular review of the members and other related issues.

5.6 Summary of the evaluation questionnaire

A total of 5 assessment forms were received back, containing the following answers:

Questions	Answers				
	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Do you have a better understanding of the research	Yes	Yes	Yes	Yes	Yes

Questions	Answers				
	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
project underway?					
Do you support the objectives of the study? Do you see a need for such a study?	Yes	Yes –	Yes	Yes	Yes
What are your expectations of such a study?		To make recommendations that are practical to the current situation regarding groundwater management	To come up with good institutional proposals	Clear indications of the role to be played by stakeholders and also accelerate service delivery	Improvement of Service delivery. Clear understanding of the concepts
What are your greatest concerns about the management of the dolomitic aquifer?	How to integrate the various water users in terms of the institutional arrangements	From the proposed Instit Framework for groundwater management in dolomitic terrains, CDMs involvement was not clear.	Address the issue of primary use versus secondary use, especially the regulatory part	Payment of taxes and rates by emerging farmers	Monitoring system Implementation of a black farmer WJAs

WORKSHOP THREE: ZEERUST

5.7 Participants

Name and Surname	Representing
Mr. MB Garegae	DWAF Mmabatho
Mr. B Hlongwa	Central District Municipality
Mr. F Manyapelo	Ward Committee
Mr. K Moila	Ward Committee
Mr. BS Mokgojwa	Kgatelopele Vegetables
Ms. Phyllis Molatliwa	Central District Municipality
Mr. G Monoto	Ward Committee
Mr. G Motnana	Ward Committee, Ward 5
Mr. LB Ramesega	Zeerust Local Municipality
Mr. GD Rankae	Social Services
Mr. Alf Sephton	Marico Water Forum
Mr. Christie (CH) Swanepoel	Zeerust Boere Unie
Mr. Paul (P) Snyman	Zeerust Boere Vereniging

5.8 Summary of issues discussed during the workshop

1. Water use registration, licensing and payment of catchment management charges

The water users expressed the need to receive technical information with regards to the status of the water resources, licenses issued, the decisions taken by DWAF that affect them, and the activities of the WUA. The users required more information on the apparent discrepancy with relating to the calculation of water use tariffs for water users inside and outside the water schemes. The participants believed that users outside the schemes are paying substantially more due to the subsidisation of infrastructure for the schemes by the government. However the principle of paying for water was well accepted.

The management of the small springs and eyes, which flow north in the study area and are often the only source of water supply, is a concern. Users would like to receive more technical information and would like to understand why water levels are dropping. Farmers also want to know why they now need to drill deeper to get to the water in some places.

2. Current status of the water management institutions

2.1 Catchment management agencies, water user associations and water user forums

2.1.1 Establishment of the CMA

Nominations were made to the advisory committee for the establishment of the CMA.

2.1.2 Establishment of the Water User Association

The Marico Bosveld WUA (although the participants referred to this institution as WUA, that is in fact not the case) was initiated in 1998 and was recently established. The institutions proposed to be involved are listed in the constitution of the WUA. Two subcomponents (East and West of the Marico River) were created to make the logistical organisation of the WUA more practical.

The current Marico Bosveld WUA is organised into three main subcommittees, namely, water quality and quantity; control and management, and the community committee.

The current active members of the WUA mainly consist of people employed by government or members receiving a salary. This was also the reason why members of the WUA were getting involved in other water-related issues and losing their focus, which should be defined by the WUA. This possibly also explains why commercial farmers are not involved. The local municipality became involved for the first time this year and they are also the last organisation to be added, resulting in full representation on the proposed WUA.

2.1.3 Water user forums

One forum is active in the area. Two more water user forums are proposed, namely Supingstad and West Furrow. The management of the water user forums is encouraged to work through the WUA. With the exception of Molopo, the forums were not created

with the dolomites and the geographical areas delineated by the dolomitic aquifers in mind.

2.1.4 Rural communities

Rural communities are organised in water committees and they report to the ward councillors of the local municipality who, in turn, report to the district municipality. The involvement of the ward councillors was not formalised and they are, perhaps, not adequately represented.

2.3 Current institutional strengths and weaknesses

2.3.1 Current institutional weaknesses

The following institutional weaknesses were identified during the workshop:

- Lack of dissemination of technical and decision-making information to the WUA.
- Lack of distribution of information to the rural communities.
- Although more stakeholders are becoming involved, other members are losing interest in the activities of the WUA.
- The CMA accepted a "blanket" constitution, which was compiled by Mr Charles Fourie. Insufficient input was made to the constitution.
- Lack of focus of the WUA. The attendees said the proposed WUA and forums were becoming a vehicle for all sorts of other activities outside the scope of the forums and WUA.
- Self-regulation is not encouraged and the forum should assist in creating data collection and self-management in order to prevent over-utilisation of the resource.

2.3.2 Current Institutional Strengths

The following institutional strengths were identified during the workshop:

- The vision, mission, roles and responsibilities and an operational plan were compiled for the technical and community components.
- House rules (which supplement the WUA constitution) were compiled and are used to direct the activities.
- A starter pack was created to bring new stakeholders and elected members up to speed in terms of the activities of the forum.

3. Institutional recommendations

The following comments were made on the proposed creation of a Dolomitic Aquifer Management Committee:

- Dolomites must be viewed as a special case, because they were the only resource in the area. The Zeerust area is unique in the sense that it is a dry rural area without big water supply schemes. It thus requires a specific approach and supports the DAMC on that basis.
- The schematic diagram of the DAMC does not contain the links between local (third) level government- the link between the Water Services Authorities, Water Services Providers and Central District Municipality is not indicated. The delegation of authority is not clear from the diagram.
- The lines of communication are not clear and a way should be found to add these to the diagram.

- The NWA clearly makes provision for preference of primary water use. The institutional role of the WUA in determining and prioritising primary water use versus other uses is, however, not clear.
- The role and functions of the various levels of government (e.g. local and district municipalities) in the activities of the WUA is not clear and could create a big, clumsy institution without a specific focus. Attendees thought that Land Affairs should be represented on the forum.
- The water users would like to receive more information on the proposed institutions and how they would fit in with the management of the water resources.

5.9 Summary of the evaluation questionnaire

A total of 11 assessment forms were received back, containing the following answers:

Questions	Answers					
	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6
Do you have a better understanding of the research project under way?	Yes	Yes	Yes	No	Yes	Yes
Do you support the objectives of the study? Do you see a need for such a study?	Yes	Yes	Yes	Yes	Yes	Yes
What are your expectations of such a study?	To make sure that the underground water is not over-utilised.	I expect that ground water be protected from being over pumped.		To know more about the WRC and about the water management agency.	That the water users be helped.	To study how to manage water, and how to take care of it.
What are your greatest concerns about the management of the dolomitic aquifer?	Over-utilisation and the influence on the surrounding area.	I am concerned about the protection of our aquifers.	Will there be water for the future, will it be affordable and what will the quality be?	They should workshop more and more to let people have information about how to use water in their areas.	That if underground water is not properly managed/used it will be exhausted. So water above the ground should also be utilised by creation of dams.	My concern is that the management of the dolomitic aquifer should reach to the water committee so that all of them should be informed.

Questions	Answers				
	Participant 7	Participant 8	Participant 9	Participant 10	Participant 11
Do you have a better understanding of the research project under way?	Yes	Partly	Yes	Partly	Yes
Do you support the objectives of the study? Do you see a need for such a study?	Yes	Yes	Yes	Yes	Yes
What are your expectations of such a study?	I expect to go to the village and teach the people what I have learned.	Better provision of water to all communities	The study should assist our area to protect water especially after rainfall.	Percentages of polluted water also be done including how to manage the polluted water.	To increase knowledge
What are your greatest concerns about the management of the dolomitic aquifer?	My concern is that they inform the councillors, especially in rural areas about their meetings and workshops.		The community needs to be informed about that.	Lack of information, lack of involvement of the population and other stakeholders in the forum.	To get more information, Information to distribute to the communities

WORKSHOP FOUR: LICHTENBURG

5.10 Participants

Name and Surname	Representing
Mr A. Beyers	Agri North West
Mr A Borman	Lichtenburg
Mr PH Du Plessis	
Mr JJ Du Preez	Grootpan
Mr D. Lombard	Ditsobotla Local Municipality
Mr MM Moselane	Ditsobotla Local Municipality
Mr JH Nel	Agri Lichtenburg
Mr M. C Nkgwang	Ditsobotla Local Municipality
Mr AST Nxumalo	Ditsobotla Local Municipality
Mr A Olifant	Lichtenburg
Mr B Pretorius	Grootpan

5.11 Summary of issues discussed during the workshop

1. Water use registration, licensing and payment of catchment management charges

New water users are currently licensed but the basis on which this was done is not clear. It was initially understood that a quota system which would restrict users to very specific volumes would be implemented. Existing lawful use is not clear, as various users had registered volumes of water which included future use and for which a license was required. The continuation of illegal use is going to create major conflicts in the future. The users requested that this message should be communicated to the Department in order to prevent a Tosca (Northern Cape) situation.

Critical institutional requirements were identified as the collection of monitoring data, the interpretation of water use data and the response of the aquifer. The purpose and utilisation of catchment management charges is not clear and there is a perception that users are unlikely to continue paying if they are not informed about the use and allocation of the funds. This sentiment is further stoked by the continuing incidence of illegal use and the slow licensing process.

The calculation of water use tariffs (catchment management charges, water research commission levy, consumptive charges, etc) was being done in isolation by the Department and the users were not being informed as to the reasons for the way the calculations are made. Water users would like to receive more clarity on why other users in schemes were not being charged the same as they were. The users knew that the ring-fencing of catchment management charges was promised. But it is not clear on which basis this will take place, and whether it is currently being conducted.

2. Current status of the water management institutions

2.1 Catchment management agencies, water user associations and water user forums

2.1.1 Establishment of the CMA

The WUA has made nominations to the advisory committee for the establishment of the CMA. There is a perception that the Minister can veto nominations to the CMA and/or advisory committee for the establishment of a CMA, which worried the participants.

2.1.2 Establishment of the Water User Association

The application for the establishment of the WUA was submitted to the Minister for approval. The functions that should be fulfilled by the WUA and the link to the proposed CMA are not clear. The legal functions, mandate and jurisdiction of the WUA are not well understood.

Members felt strongly that the functions that would be fulfilled by the proposed WUA should be fulfilled by DWAF and only transferred once the WUA was formally established. Should the functions be delegated to them, they would take up the responsibility for them.

The establishment of a WUA for Grootpan was discussed but never formalised. It is unclear as to whether the water users in the Grootpan area should initiate the establishment of a WUA for their area.

2.2 Current institutional strengths and weaknesses

2.2.1 Current institutional weaknesses

The following institutional weaknesses were identified during the workshop:

- Although the NWA is recognised as a good law, its implementation of the NWA was poor and is creating negative ripple in the area.
- WUA is not legally established.
- Technical information about the extent, availability and sustainability of the dolomitic water resources is slowly becoming available – but it is still in a format that users cannot understand. Its utility in decision-making is also not understood.
- Communication between DWAF, the users and the proposed WUA is poor.
- The diamond diggers are not represented on the WUA, as they never responded to invitations to participate.

2.2.2 Current Institutional Strengths

The following institutional strengths were identified during the workshop:

- The willingness of the users to create and participate in the establishment of the WUA, and
- Technical information slowly becoming available.

But participants also stressed that institutional strengths will only be realised once the WUA and CMA are established.

3. Institutional recommendations

The following comments were made on the proposed creation of a Dolomitic Aquifer Management Committee:

- The participants were not aware of the possible changes in the WMA boundaries, and would like to be formally informed about the outcome of the study currently under way. Changes in the WMA boundaries will have a specific impact on the catchment management charges paid by users, if compared with the charges of neighbouring WMA.
- It was concluded that the dolomitic area should be viewed as a unique strategic resource, and a single tariff for the entire dolomitic area should be considered. The uniqueness of the dolomitic resource could also be used as a basis for creating management structures specifically for the dolomitic area.
- The water user association already provides representation for the local authorities and should not be duplicated in representation of the proposed Dolomitic Aquifer Management Committee.

5.12 Summary of the evaluation questionnaire

A total of 10 assessment forms were received back, containing the following answers:

Questions	Answers				
	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Do you have a better understanding of the research project under way?	Yes	Yes	Yes	Yes	Yes
Do you support the objectives of the study? Do you see a need for such a study?	Yes	Yes	Yes	Yes	Yes
What are your expectations of such a study?	That there will be sufficient water for the future.	That there will still be water available for years to come.	Good	It will help with the implementation of the NWA as well as the better management of the aquifer.	That it will be dependable.
What are your greatest concerns about the management of the dolomitic aquifer?	That the aquifer will be properly managed.	That the underground water will be properly managed.	That the whole dolomitic area should be under one management structure	Over-utilisation.	That it will not be managed and in the end dry out.

Questions	Answers				
	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10
Do you have a better understanding of the research project under way?	Yes	Yes		Yes	Yes.
Do you support the objectives of the study? Do you see a need for such a study?	Yes	Yes		Yes	Yes.
What are your expectations of such a study?	Good response and that identified problems should be attended to.	My expectations are that the water users union has legal rights to manage		It should produce comprehensive reference mentioned??	Informing us about where our water comes from, how economically we should

Questions	Answers				
	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10
		and to save the source.			use it, how do we deal with some water deficits in some areas.
What are your greatest concerns about the management of the dolomitic aquifer?	That all representatives of the WU must manage the source so that it won't dry out.	That the management of the source and the tax on the water not being well managed, also that there be a CWA just for the dolomitic area.	I think that the problem should be discussed with all the farmers in the area.	Sustainability and lack of alternatives sources	My biggest concern is communication and to whom are we paying the tariffs and how is it ploughed back by the national government in our area.

ANNEXURE E: Workshop report – DWAF Officials

Facilitated by Dana Grobler, with Anthea Stephens, David Bredekamp, Graham Hubert and Lutske Newton

1 Introduction

The Water Research Commission is funding a study to investigate institutional arrangements for the management of the dolomitic aquifer in the Northwest. The purpose of the study is to investigate institutional options that will facilitate the management of the groundwater resource in an integrated manner. This investigation is also expected to provide suggestions on how the participation of the various stakeholder groups and state institutions can be encouraged and sustained to ensure that the establishment of water management institutions has an element of on-going user participation and ownership. The realisation of such an end will require the active participation of DWAF as the primary custodian of water management responsibilities in the country. Furthermore, the integrated management of water resource will also require that such participation be coordinated to ensure institutional harmony.

In pursuit of the above stated outcome, a workshop for DWAF officials was organised to compliment similar undertaking with stakeholders in the North West. This workshop targeted officials who would be familiar with both groundwater management issues and the study area. As such, the participants were drawn from the following directorates in DWAF:

- Institutional Oversight
- Geohydrology
- Water Resources Planning Systems
- Gauteng Regional Office
- Northern Cape Regional Office
- Free State Regional Office, and
- North West Regional Office.

The workshop was held in Pretoria on 21 October 2003.

2 Workshop Objectives and Design

The objective of the workshop was to stimulate debate around optimal institutional arrangements for the management of the North West dolomitic aquifer. Such debate would need to take cognisance of issues such as:

- The existing legislative framework,
- Technical knowledge of the functioning of the aquifer, and
- The current institutional capacity available to the management of the aquifer.

To ensure the realisation of the workshop objective, the following workshop structure was observed:

Welcome, introduction and background of the research

- A presentation of the aims and objectives of the workshop

- A presentation and discussion of the conceptual geohydrological model of the aquifer
- A presentation and discussion of the key findings from the institutional assessment study, and
- A discussion on management challenges facing the aquifer:
 - Geohydrological aspects
 - Institutional aspects, and
 - Mainstreaming and integration of groundwater.

3 Workshop Report

The DWAF officials' workshop was attended by the following departmental officials:

Table 1: DWAF officials' workshop participants

Participants	DWAF Position	DWAF Office/Directorate
Rens Botha	Chief Engineer	DWAF Gauteng
Paul vd Merwe		DWAF North West
Ellis Thebe	Geohydrologist	DWAF North West
Johan vd Merwe	Deputy Director	DWAF Free State: Water Quality
Sonia Veltman	Geohydrologist	DWAF Free State
Gawie van Dyk	Assistant Director	DWAF Northern Cape: Geohydrology Directorate
Beyers Havenga	Deputy Director	DWAF HO: North Cluster: NWRP
Solly Mabunda	Director	DWAF HO: Option Analysis
Chris Moseki	Director	DWAF HO: Water Resource Planning Systems
Peter Viljoen	Deputy Director	DWAF HO: Water Quality Planning
Boniface Aleobua	Deputy Director	DWAF HO: Information Programmes
Eiman Karar	Director	DWAF HO: Water Management Institution Governance
Ndileka Mohapi	Assistant Director	DWAF HO: Water Management Institution Governance
Eberhard Braune	Director	DWAF HO: Information Programmes
Marlese Nel	Assistant Director	DWAF HO: Information Programmes
Neo Thulo	Consultant	DWAF NW and Gauteng: Stakeholder Liaison: Crocodile West-Marico
Phil Hobbs	Consultant	DWAF HO: RDM

The workshop participants worked in three discussions groups. The output of the discussion groups is as follows:

4 Geohydrological Aspects

The findings of this discussion group indicated that:

- The exact catchment boundary, based on the dolomitic aquifer, is still unknown. Further work is required to resolve this. In the interim, the following options should be considered:

- Schoonspruit - boundaries could be changed slightly and be used by management in the interim. A lot less damage would be done by acting now rather than waiting for 5 years. Nitrate pollution is a potential problem in Schoonspruit.
- Monitoring should continue in the interim. Monitoring stations needed to be added in some areas. This would add to the data required to resolve the questions around the boundaries.
- Management Constraints and challenges - The Free State regional representatives felt that the WUA is pivotal to the successful implementation of the management of the dolomitic aquifers.
- Roles and responsibilities - the WUA has a direct interest in the type, quality and frequency of the data that is collected and will influence the need for the collection of data and funding requirements.
- Illegal use need to be addressed immediately, thereafter the available resource can be determined and appropriately managed.
- Grootfontein can (should) decide on whether they would like to establish a water user forum.
- The role of public participation in decision-making was unknown. A uniform approach throughout the study area is of importance.
- Water allocation and demand management – farmers pay for what is allocated to them and not for actual consumption, therefore they are not motivated to use less water.
- Data collection should be a collaborative activity in which the data collection is done at a local level and the technical interpretation of the data and the generation of management information is conducted at a central (national) level.

5 Institutional Aspects

This discussion group generated the following points:

- Issues emerging from the institutional presentations:
 - All WMA and related CMAs are made-up of quaternary catchment areas, which imply that the boundary issue is not limited to the dolomitic area, and will require specific approaches to resolve problems around surface and groundwater boundaries.
 - The WUAs are multi-sectoral institutions and the approval of the applications from the WUA depends on their representativeness.
 - The NWA has legal provisions that make provision for the creation of the Dolomitic Area Management Committee.
 - The establishment of catchment management committees should follow after the establishment of the CMA. In most catchments the establishment of the CMA has not been initiated. Powers should not (and cannot) be delegated until the establishment of the CMA.
- Use of forums in the establishment of institutions
 - Water user forums are facilitate the creation of management structures in the absence of other structures. The NWA does not spell out what can be used for participation and Fora are sometimes not sustainable.
- Implementation of the DAMC in the absence of a CMA
 - The cluster can initiate and establish the DAMC as an interim measure.
 - The process of the establishment of the DAMC must take the process to establish the CMA into consideration.

- The Committee can be established in the cluster that deals with the management of the dolomitic aquifer.
- The Minister can establish a catchment management committee in the absence of the CMA, but the powers of such a structure will be limited.
- If a DAMC is established, it will be within the Central Cluster and the various forums and the proposed WUA will need to drive the process and activities.
- The co-ordination of the activities of the various interim institutions is the responsibility of the DWAF (Central Cluster) until formal approval and delegation of authorities have been completed. The economic viability of the institutions will determine their replicability. The timing of the implementation of the institutions will determine the success with which they can be implemented, as the CMA will emerge in a phased manner, which will also result in the proposed DAMC being established and given responsibilities in a phased manner.
- The role of the cluster manager in the proposed institutions and the way in which this role will change as the new institutions are created is not clear. The conclusion is that it will play an important role in terms of providing the managerial and logistical platform to perform activities in the interim until the CMA and WUAs are formally established.

6 Mainstreaming and Integration of Groundwater

The discussion in group three resulted in the following items:

- *The integration of groundwater into management activities will need to ensure that the following items are integrated:*
 - *Water quality and quantity management and monitoring.*
 - *The calculation of the water balance, which does not take the groundwater situation into consideration, and would result in more available water for allocation if it did.*
 - *Water availability is not quantified, limiting the integration of allocation, demand management and determination of sustainability.*
- Barriers/ obstacles to integrating groundwater (local, regional and national scale)- In this respect, groundwater is not considered a dependable water resource. This perception is held at all scales (national, regional and local). Therefore following actions have are underway to rectify the incorrect perceptions:
 - Groundwater strategy to address the incorrect perceptions.
 - Reconciliation strategy in the ISP to provide the framework for appropriate integration.
 - Capacity problems exist at all levels, but they are most pronounced at the local level. Studies are underway to inform the ISP process and improve the understanding of the resources. However, they will not necessarily address the capacity needs and the roles that the WUAs can play in the management and co-ordination at the local level.
- Awareness of the importance and management of groundwater resources-
- A very specific problem around awareness of the importance of management exists at local level.
- This problem is now being addressed groundwater practitioners are now being appointed in managerial positions. This should increase the profile and importance of groundwater resources.

- Tools and resources are also becoming available (1:500 000 maps) etc. to facilitate the management of groundwater resources.
- New structures are being established and there is a need to ensure that a balance is found in the composition and importance of the various aspects of groundwater management and monitoring.
- NWRS – Groundwater is mostly not adequately represented in the NWRS, and this situation should be reviewed with the next revision of the NWRS.
- Groundwater and surface water boundaries are often different. In the past, preference was given to surface water boundaries while ignoring the importance of groundwater delineations. This is evident in the way water services are planned. The boundary problem could easily be resolved, as it is often a mindset problem.
- The determination of the Reserve and the implementation thereof is supposed to assist in the integration of decision-making. It is not known how the groundwater Reserve should be implemented. Guidance is required.
- Understanding the impact of utilising groundwater in dolomitic areas – The exclusion of groundwater from the operation and maintenance (O&M) business plans in the region constitutes a specific barrier for the successful implementation and integration of groundwater into the management of groundwater resources.
- All drilling needs to be registered and data collection should take place. Local level control could address the problem.
- Groundwater monitoring programmes are not designed to address the management information needs, and do not provide a hierarchy of needs at the various levels (local, regional and national). Monitoring is often only done in crisis areas. Information is not available to the Resource Manager.
- Co-operative Governance was identified as a problem during the process of compiling the ISP documents. In some provinces committees are established but are not adequate.
- The National policies are good and innovative, but the lack of a formal IWRM policy development and implementation is a major barrier. The appointment of a departmental champion for IWRM should solve the problem.

7 CONCLUSION

The workshop was essentially an opportunity to introduce the department to the research project underway as well as a brainstorming opportunity. As a result, many issues were raised and very few real decisions were made. However, the workshop was very useful in highlighting the scope of challenges relating to the North West aquifer and the management of groundwater resources in general.

Other related WRC reports available:

Institutional arrangements for groundwater management in dolomitic terrains

Stephens A; Bredenkamp DB

The dolomitic groundwater in the North West province is a valuable natural resource, which provides a reliable supply of water to town, rural settlements, industries, agriculture and other activities in an area where surface water resources are negligible. Groundwater also sustains the flow of several springs, wetlands, and river channels, and is the lifeline of the ecology of these freshwater systems.

Water Management Areas (WMA5) have been demarcated largely according to surface water systems and seldom coincide with geohydrological boundaries, resulting in complex management problems and institutional arrangements. In the absence of an integrated approach, aquifer management is therefore seldom optimised, leading to neglect and the unsustainable use of groundwater

This project proposes institutional arrangements for the sustainable and equitable management of groundwater in the dolomitic terrains of the North West province, South Africa. The project has been divided into four phases:

- Phase 1: Situation Analysis (desk-top review)
- Phase 2: Situation Analysis (field research)
- Phase 3: Workshop Management Options and Approaches
- Phase 4: Preparation of Management Structure, institutional Principles, and Information System for Groundwater Management

Report Number: KV 140/02

ISBN No: 1 86845 940 3

TO ORDER: Contact Publications - Telephone No: 012 330 0340
Fax Number: 012 331 2565
E-mail: publications@wrc.org.za

Water Research Commission

Private Bag X03, Gezina, 0031, South Africa

Tel: +27 12 330 0340, Fax: +27 12 331 2565

Web: <http://www.wrc.org.za>

