The More Effective Management of the Gerhard Minnebron as Important Resource of Potable water for Potchefstroom

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Abstract

There is an ever-increasing demand for potable water in South Africa. The quality of surface and groundwater throughout many regions of South Africa has deteriorated over the past few years due to many forms of industrial and agricultural pollution. In order to comply with legislation and the basic human rights as set out in the Constitution of South Africa (RSA, 1996), the management and distribution of the potable water supply within South Africa needs to be addressed comprehensively (Nealer & Raga, 2008a:158).

As a resident of Potchefstroom, the researcher has a keen interest in the water services of the city of Potchefstroom, the origin of the potable water, how the potable water resources are managed, how the water is distributed and finally the destination of the grey water. In this study, the researcher focused on the management of one of the important resources of potable water for the Potchefstroom area, the Gerhard Minnebron (GMB). The GMB is the largest natural fountain in the Southern hemisphere; yielding 60-80 mega litres of water per day (see Figures 1, 2 and 4 for the locality of the fountain). This fountain flows out of a dolomitic groundwater compartment that is part of the larger Boskop-Turffontein dolomite compartment (Winde, 2006). The geology and geo-hydrology of the area where the fountain is situated and surrounding areas make the GMB a very vulnerable resource with regard to exploitation and pollution from upstream water users.

An empirical study was conducted with the relevant role-players in the current management of the GMB and stakeholders in the management of the GMB as important resource of potable water for the city of Potchefstroom and its residents. From this study, it was evident that knowledge concerning the GMB is limited, and the current management structures in place do not always function effectively so as to ensure the sustainable management and development of the GMB.

Legislation on water services management in South Africa has come a long way since the early 1990s, but its application, however, is not yet in place in all areas of South Africa.

From the research the researcher could arrive at some logical conclusions and make specific recommendations for the future management of the GMB that will assist in the efforts towards more effective management of the GMB as an important resource of potable water for Potchefstroom.

Opsomming

Die vraag na drinkbare water in Suid-Afrika groei teen ‘n enorme tempo. Desnieteenstaande het die kwaliteit van beide oppervlak- en grondwater in verskeie streke in Suid Afrika oor die afgelope twee dekades drasties verswak vanweë verskeie industriële en landbouaktiwiteite wat bygedra het tot die besoedeling van hierdie waterbronne. Om te voldoen aan wetgewing en basiese menseregte soos uiteengesit in die Grondwet van Suid-Afrika (RSA, 1996), moet die bestuur en verspreiding van drinkbare water in Suid Afrika aangespreek word (Nealer & Raga, 2008a:158).

Die Gerhard Minnebron (GMB), een van die primêre bronne van drinkbare water van Potchefstroom, is die grootste natuurlike fontein in die suidelike halfrond, en lewer meer as 60-80 megaliter water per dag. Hierdie fontein spruit uit ‘n dolomitiese grondwaterkompartement wat deel uitmaak van die groter Boskop-Turfloop-dolomietkompartement (Winde, 2006). Die geologie en geo-hidrologie van die omgewing rondom die GMB dra daartoe by dat dit kwesbaar is vir besoedeling deur watergebruikers stroomop met spesifieke verwysing na mynbouaktiwiteite en suurmynwaterbesoedeling. Hierdie studie fokus op die huidige bestuur van hierdie bron, hoe waterverspreiding plaasvind vanaf die GMB oorsprong, en wie verantwoordelik is vir die voorkoming van verdere agteruitgang van hierdie natuurlike hulpbron.

‘n Empiriese studie is onderneem om die relevante rolspelers in die bestuur van die GMB te identifiseer, en om hulle kennis rakende die aktiewe bestuur van hierdie bron te toets. Vanuit hierdie studie is dit duidelik dat kennis rakende die GMB beperk is, en dat die huidige bestuurstrukture in plek nie effektief funksioneer om te verseker dat hierdie bron volhoubaar ontwikkel en bestuur word nie. Wetgewing rakende die waterdienstebestuur in Suid Afrika het al ver gevorder sedert die 1990’s, maar die toepassing daarvan in die verskeie streke in Suid-Afrika geskied tans steeds nie.

Die navorser kan vanuit hierdie studie sekere kritiese afleidings en aanbevelings maak rakende die toekomstige bestuur van die GMB wat sal bydra tot die effektiewer bestuur van die GMB as ‘n belangrike bron van drinkbare water vir Potchefstroom.

Table of Contents

List of Figures

List of Tables

CHAPTER 1: ORIENTATION AND INTRODUCTION TO THE STUDY AREA

1.1. INTRODUCTION

There is an ever-increasing demand for potable water in South Africa. The quality of surface water and groundwater throughout many regions of South Africa has deteriorated over the past few years due to many forms of industrial and agricultural pollution. In order to comply with legislation and the basic human rights set out in the Constitution of South Africa (RSA, 1996), the management and distribution of the potable water supply within South Africa needs to be addressed comprehensively (Nealer & Raga, 2008a:158).

As a resident of Potchefstroom, the researcher has a keen interest in the water services of Potchefstroom, the origin of the potable water, how the potable water resources are managed, how the water is distributed and finally the destination of the grey water.

In this chapter, the orientation and methodology of the research study are discussed.

1.2. ORIENTATION AND PROBLEM STATEMENT

It could be said that the history of South Africa is imbedded in water. The first ships called at Table Bay harbour in search of fresh drinking water for their long journey to the East, and a halfway house for ships was established at the Cape in 1652 (Kleinhans, 1985:5). As people later started moving inland and settling across South Africa, the availability of water played an ever-increasing role.

The town of Potchefstroom was first founded in 1838 by a group of V*oortrekkers* under the leadership of Andries Hendrik Potgieter (Jenkins, 1971:7). It was the first town to be established in the then Transvaal Republic. The original location of the town was at Oudedorp, 11km north of its current position. Shortly after the establishment of the town, it was noted that the under-foot surface soil was very shallow and had a clay consistency due to the geologically underlying dolomite formations (Smit, 2010). Heavy rains during 1840 led to flooding of the Mooi River and the loss of many crops. On 26 November 1841 the decision was made to move the town down-stream off the muddy soils to its current position (off the dolomite).

During December 1841 a water canal was dug from the Mooi River for irrigation purposes (Badenhorst, 1939:12). The first water purification works was built in 1924 and had a purification capacity of 3.4 mega litres per day. Water was pumped from the irrigation canal next to the Mooi River. Since then, the purification works immediately west of the Potchefstroom Dam (Lakeside Dam) has been enlarged many times, to cope with the ever-increasing demand of the city of Potchefstroom for potable water.

Currently, according to the Tlokwe Local Municipality, the city is a medium-sized city with a population of approximately 250 000 (Tlokwe City Council, 2010). Since 1842, Potchefstroom has been reliant on the Mooi River as its sole source of raw water to the town (Van der Walt *et al*., 2002:109).

The Mooi River surface water catchment has three major tributaries, the Mooi River from the northern reach, the Wonderfontein Spruit from the north-eastern reach and the Loop Spruit from the eastern reach. Only the first two tributaries supply Potchefstroom with raw water. The Loop Spruit only joins this catchment downstream from Potchefstroom. Water from the Mooi River and the Wonderfontein Spruit join up just up-stream of the Gerhard Minnebron (GMB) fountain (see Figure 1).

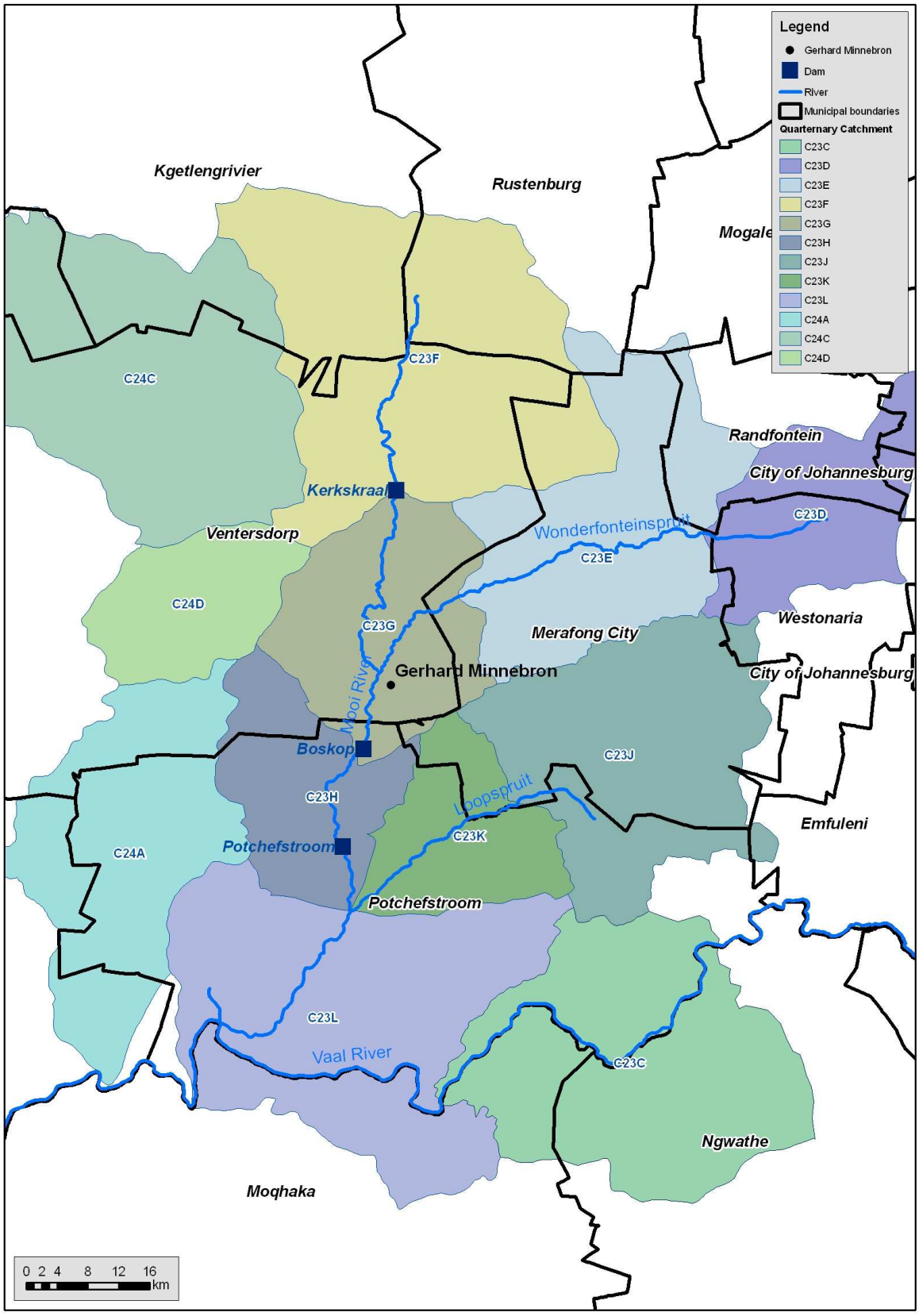


Figure 1: Mooi River Catchment and Tributaries with Municipal Boundaries (Potgieter, 2010)

The quality of the surface water from the Mooi River catchment has however been impacted over the past few years by polluted water from its main tributary, the Wonderfontein Spruit, along with water from the underground dolomite compartments polluted by gold mining activities that have been going on within this region for many years. These factors have negatively impacted the beneficial use of water within the Mooi River catchment (Le Roux, 2005:3). The Wonderfontein Spruit has recently made headlines in the media and presents an issue of great concern. This is a future threat that can have a devastating effect on the potable water supply of Potchefstroom's residents if not monitored and managed effectively.

The GMB is the largest natural fountain in the Southern hemisphere, yielding water at 60-80 mega litres per day (see Figure 1). The fountain is located outside the surface catchment of the Wonderfontein Spruit. It is however possibly linked to the Wonderfontein Spruit via a network of underground karst channels known as the Boskop-Turffontein dolomite compartment (Winde, 2006).

Figure 2: Photographs of Gerhard Minnebron Fountain (Researcher's personal library)

This fountain is a “national wonder” in this area. It is a natural fountain, yielding enough groundwater to meet the current needs of Potchefstroom, flowing from an underground dolomite compartment. The water is channelled in a cement canal for use by down-stream farmers as well as a natural flow into wetlands, the Mooi River and finally into the Boskop Dam. From the Dam the water is split between an Eastern Canal (agriculture), the natural flow of the Mooi River and the Western Canal (potable water supply of residents in Potchefstroom) (see Figure 4). In the past, this fountain attracted visitors and served as a popular picnic site for the residents of Potchefstroom. This site has the potential to serve as an opportunity to inform the broader public of the significance of natural springs, especially regarding its contribution to potable water in South Africa (Nealer, 2009a).

The GMB fountain is located outside the jurisdiction boundaries of the Tlokwe Local Municipality (see Figures 2 and 4). This means that the Tlokwe Local Municipality does not currently take responsibility for the site. It falls in the geographical responsibility area of the Ventersdorp Local Municipality. The city of Potchefstroom, however, is the only beneficiary of the GMB. Therefore the Ventersdorp Local Municipality, since it does not benefit from this surface water catchment area, does not necessarily feel a need to really take care of, conserve and manage the area in an effective, efficient and sustainable way.

In the context of environmental management and sustainable development, the issue of safe potable water supplied in and by the municipalities of the developing South Africa is very relevant at present. South Africa is a semi-arid country, its water resources are dwindling, and public concerns have been aroused regarding the environmental status of many areas within South Africa where water pollution, especially industrial pollution, has been occurring (Tempelhoff, 2008:5). Since the 1990s, water in South Africa and the history of water usage have received much more attention than in previous years; new legislation has been put in place to promote more sustainable usage of water and access of safe drinking water to all people (Tempelhoff, 2008:14-15). Linked to the problem of dwindling water

resources and unsustainable usage of these resources over many years, is the goal of effective, efficient, economic, equal, empathetically and environmentally friendly management of available resources.

Over the past 15 years, the nature of projects within the water sector has changed due to the institutional and legislative changes that have been made in South Africa. The focus has shifted from the international level to more local levels, especially regarding sustainability. As seen schematically in Figure 3 below, a typical water supply project started in 1994 at a high national level, followed by the Reconstruction and Development Programme (RDP) in 1995. In 1997 a more locally based approach was developed along with the introduction of the Consolidated Municipal Infrastructure Programme (CMIP) and the Build, Operate, Train and Transfer (BOTT) programme – in partnership with the private sector. Since 2003 capital works within the water industry have been dominated by the Municipal Infrastructure Grant (MIG) projects, focusing on support to institutional transformation and sustainable service delivery (Pretorius, 2009:54).

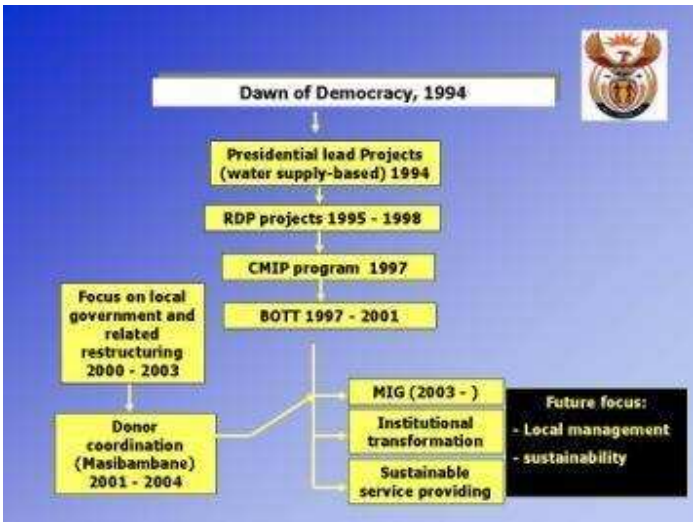


Figure 3: Project Development - Water Sector in South Africa (Pretorius, 2009)

The management of the GMB is a local matter that should be addressed more effectively by all the role-players (i.e. Department of Water Affairs, Tlokwe Local Municipality, Dr Kenneth Kaunda District Municipality, etc.) and stakeholders involved in the various combining efforts of optimum resource use and conservation in the municipal area.

The problem to be researched therefore arises as to who should take responsibility for this valuable resource and its more effective and sustainable management? It does not fall within the jurisdiction borders of the main beneficiary, the Tlokwe Local Municipality. Due to the location of the fountain and its source in the underground dolomitic compartments, there are many environmental risks and possible threats to the quality of water from this source if it is not managed effectively and preserved.

Figure 4 is a map indicating the GMB eye flowing into a canal used for agricultural purposes and also a wetlands that joins up with the Mooi River and then flows into the Boskop Dam.

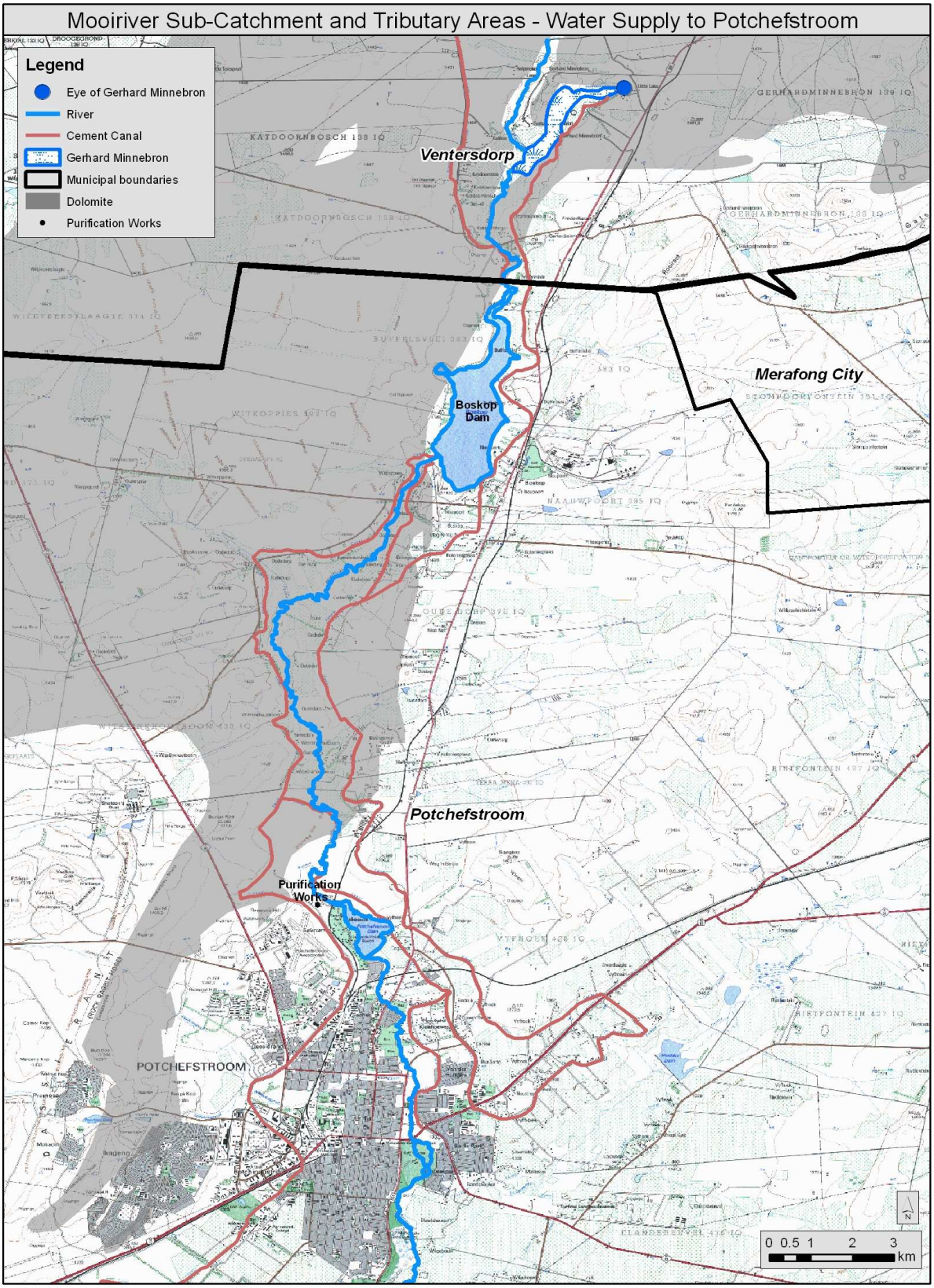


Figure 4: Eye of Gerhard Minnebron with canal and wetlands as part of the Mooi River Sub-catchment (Potgieter, 2010)

1.2.1. Research Questions

In light of the aforementioned the following research questions were identified:

(i) What is the overall nature and extent of the geology and geo-hydrology at the GMB site as an important resource supplying potable water to the city of Potchefstroom?
(ii) What does South Africa's water-related legislation state about the management and utilisation of groundwater resources in dolomite areas?
(iii) Who are the key role-players and stakeholders involved in the current management of the GMB as a major supplier of potable water to the Potchefstroom area?
(iv) What management processes are required for the more effective management of this valuable water resource?

1.2.2. Research Objectives

With reference to the identified research questions, the following research objectives were pursued in the research venture:

(i) Determining the overall nature and extent of the geology and geo-hydrology of the GMB as an important source of potable water for the city of Potchefstroom.
(ii) Current legislation with specific focus on the management and utilisation of groundwater resources in South Africa's dolomite areas was identified and analysed.
(iii) Key role-players and stakeholdes were identified in the endeavour to establish a more effective, efficient, economic, equal, empathetical and environmentally friendly management of the GMB – officials from the Department of Water Affairs (DWA), the Tlokwe Local Municipality, private landowners – and their current involvement and focuses with regard to this resource.

(iv) An analysis of the current management of the GMB and its effectiveness was made along with recommendations on adopting a more integrated water resource management approach.

1.2.3. Central Theoretical Statements

The GMB is a natural fountain that forms part of the Mooi River Catchment, a sub-catchment of the Upper Vaal Catchment. This fountain is a major tributary to the Boskop Dam, together with the Mooi River and the Wonderfontein Spruit (see Figure 1 for locality map). This natural fountain requires an integrated water resource management approach to ensure its sustainable usage and the monitoring of its water quality. There also are many uncertainties related to the water from the GMB, such as the possibility of pollution from upstream dolomitic aquifers polluted by the gold mines. Further uncertainty lies in the exact contribution the GMB makes to the Boskop Dam and therefore the potable water of Potchefstroom (Le Roux, 2010).

Currently there are very few role-players and stakeholders involved in the management and monitoring of the GMB, and the Tlokwe Local Municipality itself is not involved in any way (Le Roux, 2010).

1.2.4. Research Methodology

1.2.4.1. Literature review

A literature review is the exploration of a field of knowledge in order to provide definition and a framework for a piece of research. It has a number of purposes and enables one to (Anon, 2010):

- Define and limit the problem one is working on;
- Place one's study in a historical perspective;
- Avoid unnecessary duplication;

- Evaluate promising research methods; and
- Relate one's findings to previous knowledge and suggest further research.

A literature study was conducted in which primary and secondary literature such as books, periodicals, government reports and other documents were consulted. Information concerning the GMB and surrounding area was gathered and emphasis placed on the geology and geo-hydrology of the area and the significance of groundwater resources. The legislation of South Africa concerning management of water resources and specifically groundwater in a dolomitic area was consulted in detail and applied in the study.

Computer searches for relevant material have also been undertaken and the following databases have been consulted:

- Catalogue of Theses and Dissertations of South African Universities;
- Catalogue of Books: North-West University;
- Nexus;
- Sabinet – online; and
- Internet.

1.2.4.2. Research design and data collection

A combination of a qualitative and quantitative research approach was used for the purpose of this study in the form of a two-phased design where a quantitative study is followed by a qualitative study (Lee, 1999:19). The primary way of obtaining data for a qualitative study is by conducting interviews and using questionnaires. For the purpose of this study a Likert-scale type questionnaire was compiled and utilised for data collection together with unstructured interviews and the literature study. This type of questionnaire can be used for quantitative as well as qualitative research and combines the approaches in the analyses of the

data. These questionnaires and unstructured interviews were conducted with specific role-players during the data collection process in an effort to gain some clarity on issues surrounding the GMB and the current management structures in place for this resource from the role-players' perspective, be it the private landowner or the DWA official. The purpose of the questionnaire was to establish a basis regarding the knowledge of specific role-players on the GMB and specific facts concerning the GMB. Questionnaires were completed by 27 role-players in the following areas:

- Private land owners of the farm on which the GMB is situated and neighbouring farms;
- DWA officials of the Boskop Dam Hydrology Directorate;
- Engineers and Municipal Officials responsible for the potable water supply of Tlokwe Local Municipality;
- Disaster risk reduction practitioners in Potchefstroom;
- Geology, geo-hydrology and environmental specialists; and
- Relevant personnel at the North-West University with regard to environmental and municipal management.

All data obtained from questionnaires were taken into consideration and analysed.

Content analyses of documents and photographs of the specific area were also done during the research process. Site visits to the GMB were undertaken in an effort to gain more knowledge, with specific reference to the geo-hydrology of the area. Topographical and geological maps, along with orthophotos of the area, were consulted and utilised to gather specific information on the area's geo-hydrology and the location of the GMB with respect to other water resources contributing to the Boskop Dam. Geology and geo-hydrology specialists were also consulted to gain an understanding of the significance and implications of the geology and environment of the GMB. Information on the geology and specific location of the GMB is very significant due to controversial issues surrounding the

dolomitic area where the GMB is situated and its connection to the pollution of the Wonderfontein Spruit.

An empirical analysis was done to interpret collected data and logical conclusions were drawn relating to the research objectives.

Recommendations on the current management structure of the GMB and future possibilities were made. There are many factors to consider in the management of the GMB and these should be taken into account when planning for the future. Sustainability is the desired end result to be pursued.

1.2.5. Layout of the Mini-Dissertation

Chapter 1: Orientation and introduction to the study area

A general orientation to the locus and focus of this study is provided with emphasis on the specific problem. A short history of Potchefstroom with regard to its potable water supply and also the development of the area around the GMB, along with the problem statement and research objectives, is highlighted in this chapter. The specific research methodology used is outlined with a description of the procedures followed in the data collection process.

Chapter 2: Theoretical overview of the geology and geo-hydrology of the Gerhard Minnebron

This chapter contains a discussion and analysis of the relevant theory on the geology and geo-hydrology of the GMB and its immediate surroundings. The historical and cultural significance of the GMB is explored.

Chapter 3: Legislative aspects of water resource management with specific focus on groundwater

In this chapter an attempt is made to identify and analyse all current legislation with specific focus on the management and utilisation of groundwater resources in South Africa and the supply of potable water to towns. Focus is placed on the management of groundwater resources in dolomite areas in South Africa specifically and the implications thereof.

Chapter 4: Empirical findings

This chapter contains the empirical findings of the researcher with reference to the current management of the GMB and its effectiveness. It presents an analysis of the findings along with facts concerning the GMB.

Chapter 5: Summary, conclusions and recommendations

The final chapter is a summary and conclusion arising from all the findings and results of the research process. It summarises the current management structures affecting the GMB and contains recommendations for the improvement of the current management structure, leading towards the adoption of an integrated water resource management approach that involves all role-players, public and private.

1.3. SUMMARY

The GMB is a natural fountain flowing from an underground dolomitic compartment with the potential to supply the town of Potchefstroom with enough potable water to meet all its needs. This fact in itself makes this a resource of note that should be acknowledged as such.

The GMB should be developed, managed, used, protected, conserved and controlled (RSA, 1998) in such a manner as to ensure sustainability in terms of quality and quantity for future generations. There is an ever-increasing demand for potable water in South Africa. The quality of surface and groundwater throughout many regions of South Africa has deteriorated over the past few years due to

many forms of pollution. In order to comply with legislation and basic human rights as set out in the Constitution of South Africa, the management and distribution of the potable water supply within South Africa needs to be addressed in the best possible way (Nealer & Raga, 2008a:158).

The purpose of this study is to investigate and research the current management in place with regard to the GMB and identify who the key role-players are in this management process. It also focused on the sole beneficiaries of water from the GMB, Potchefstroom and the Tlokwe Local Municipality, and their role in the management of the GMB.

In the following chapter, the nature of the geology and geo-hydrology of the GMB and surrounding area will be discussed in more detail in an effort to further explore the significance of this resource and possible future threats to the quality and quantity of water from this resource due to its unique nature (geology and geo-hydrology).

CHAPTER 2: THEORETICAL OVERVIEW OF THE GEOLOGY AND GEO-HYDROLOGY OF THE GERHARD MINNEBRON

2.1. INTRODUCTION

In an effort to gain an understanding of the significance of the Gerhard Minnebron (GMB) as an important resource of potable water for Potchefstroom, it is important to consider the hydrological cycle and the effects of interactions of surface and groundwater. Part of the significance of this water resource is the nature of the geology of the GMB and surrounding area.

The GMB was declared a national asset in 1956 and the DWA have been involved in some manner with the management of this resource since then. The DWA built a weir in 1962 and have been measuring flow rate since 1967 (Culter, 2010).

2.2. HYDROLOGICAL WATER CYCLE

South Africa is generally classified as an arid to semi-arid country with an average rainfall of around 500mm per annum. This is lower than the world average of 860mm per annum. Further, rainfall within the country is very unevenly distributed and of the 'fallen rain' only 10% reaches the rivers which make-up the potable water resources of South Africa (Nealer & Raga, 2008b:158). These rivers and their catchments do not only serve to accumulate water, but there are also geo-hydrological interactions between the surface waters and groundwater. This is called the hydrological water cycle (see Figure 5) (DWA, 2008).

The hydrological water cycle from rainfall to water runoff is a complex system where several processes (infiltration, surface water runoff, recharge of underground water aquifers, seepage, re-infiltration, and moisture recycling)

are interconnected and interdependent with only one direction of flow: downstream (IUCN, 2005:22). As part of these interactions and the hydrological cycle, groundwater may eventually reach the surface via fountains, or flow into the rivers and sometimes flow from underground water compartments. The GMB is an example of such a groundwater resource.

Figure 5: Hydrological Water Cycle (DWA, 2010)

2.2.1. Surface Water and Groundwater

The main difference between surface water and groundwater is that surface water is collected on the ground surface - rivers, lakes or wetlands - while groundwater is any water found below the ground surface in aquifers, pore spaces of rocks, unconsolidated sediments, and soil moisture (Nealer & Raga, 2008c:303). The study and nature of surface water make up what is called hydrology while in respect of groundwater the term is geo-hydrology.

Contrary to what most people think, groundwater is not primarily found in underground rivers or lakes in caverns. It is found in the pore spaces of rocks and sediments and fills the cracks. It is found in unconsolidated sediments and soil moisture. In a way soil functions much like a sponge. An underground water aquifer does not only function as a storage reservoir, but is also a pathway for the underground movement of water. Groundwater is constantly moving, but moves at a very slow pace from the recharge area of the aquifer to the discharge area (natural springs and lakes) and may take a few days or hundreds of years to reach its natural discharge area. Groundwater often forms oases and swamps (Groundwater Foundation, 2010).

Groundwater can be accessed artificially by drilling boreholes or digging wells (Nealer & Raga, 2008c:303). Depending on the geology of any specific area, one may only have to drill a few metres to locate groundwater in one area while in another area one may have to drill several hundred metres before penetrating geological formations that will yield enough water for use (Groundwater Foundation, 2010).

The GMB is classified as a groundwater resource, although it has a surface catchment area at the origin of the eye. The GMB is a unique groundwater resource with regard to the geology and geo-hydrology of the area. It is part of a very complex catchment area due to the constant interaction between surface and groundwater and the operational measures undertaken in the area that influence the inflow of water into dolomitic compartments (Le Roux, 2005:16).

2.3. GEOLOGY OF THE GERHARD MINNEBRON

The GMB is located on dolomite (Figure 6) from the Malmani Subgroup in the Chuniespoort Group of the Transvaal Supergroup (Eriksson *et al*, 2006; Wilkinson, 1986). The Malmani dolomite (as it is also referred to) forms a stratigraphic succession of up to 1,600m thick in the Wonderfontein Spruit catchment area (Winde, 2010a) where the GMB is located.

Rocks from the Transvaal Supergroup overlie the rocks from the Ventersdorp Supergroup which consists mainly of different compositions of lava (commonly referred to as the Ventersdorp lava) together with subordinate sedimentary rocks (van der Westhuizen & de Bruiyn, 2006). The Ventersdorp lava in turn unconformably overlies rocks from the Witwatersrand Supergroup. The Witwatersrand Supergroup contains the gold bearing conglomerates (or 'reefs') that have been mined since the late 1800s, and has since come to be known as the greatest source of gold on earth (McCarthy, 2006). The world's biggest and deepest gold mines still mine gold today at depths approaching 4,000m. Some of these goldmines are located upstream and in close proximity to the GMB (Smit, 2010). In Figure 6 the nature of the dolomitic rock can be seen.

Figure 6: Dolomite outcrop at the GMB (Researcher's personal library)

2.3.1. Dolomite

The main characteristic of dolomite is its tendency to erode and form underground cavities, resulting in unstable situations with the risk of forming sinkholes. These underground cavities fill up with groundwater, thus forming

underground water reservoirs. Industrial or urban development on dolomite formations increases the risk of sinkholes. The natural surface drainage becomes interrupted and increased runoff and leakage from water-bearing utilities result in the concentrated ingress of water into the ground, causing erosion of the dolomite formations. Very specific precautions need to be taken in the event of development on these formations (Pretorius, 2009).

2.3.2. Dolerite

Dolerite is a different rock formation from dolomite, but forms part of the geology of this area. Dolerite is a solid rock formation that forms dykes within the dolomite, forming compartments within the underground cavities. Unlike dolomite, dolerite does not have the tendency to erode, but remains a solid rock formation. Little or no water exchange takes place within and through the dolerite dykes; therefore compartments formed by these dykes are completely separated from each other. Because of this quality, the water levels within the dolomite compartments often vary from one to another (Pretorius, 2009).

2.4. GEO-HYDROLOGY OF THE GERHARD MINNEBRON

2.4.1. Groundwater Occurrence

Dolomite is the most significant rock type when it comes to groundwater potential due to the nature of the groundwater occurrence in it. The dolomite from the Chuniespoort Group represents the most important aquifer in South Africa (Barnard, 2000). Although dolomite can be considered a sedimentary rock type (hence the layered nature of dolomite), it differs from other rock types of sedimentary origin in that it has a chemical nature. Whereas other sedimentary rocks were formed by the deposition of sedimentary clasts (termed ‘clastic’ sedimentary rocks) of sizes ranging from mud and silt-sized particles in mudstone and shale through sand-sized particles in sandstone to pebbles and even boulders in conglomerate, dolomite was formed by the deposition of precipitated carbonates out of water (Smit, 2010).

Dolomite is primarily very impervious due to the cemented nature of the rock, but is easily dissolved by acid in rain and other water. One of the ways that geologists use to test for dolomite is by dripping a bit of acid (like hydrochloric acid) onto the rock and observing whether any chemical reaction takes place where the dolomite is dissolved by the acid. In the geologic past, rainwater containing weak carbonic acid (H_2CO_3) from dissolved CO_2 in rainwater infiltrated through cracks in the dolomite caused by joints, faults and fractures and slowly dissolved the dolomite along these planes of weakness. This opened up cavities underground in the dolomite (called karsts) where groundwater can accumulate in large volumes (see Figure 7 for an example of dolomite with karst formations).

These cavities are often interlinked through open cracks and fissures to form extensive cave systems that serve as underground storage compartments for groundwater (Smit, 2010). The Malmani dolomite in the Wonderfontein Spruit area is host to the six longest caves measured in South Africa, some exceeding 14 km in length (Winde, 2010a). It is estimated that the total storage capacity created by the interlinked karsts exceeds that of the Vaal Dam several times (Winde, 2010b).

It often happens that linear geological dykes penetrate the dolomite and separate different underground cave systems from each other to form individual compartments. The dykes act as barriers to prevent water from flowing from one compartment to another (Smit, 2010). The compartments within the Chuniespoort Group dolomite have been identified and named and are indicated on Figure 8**Error! Reference source not found.**.

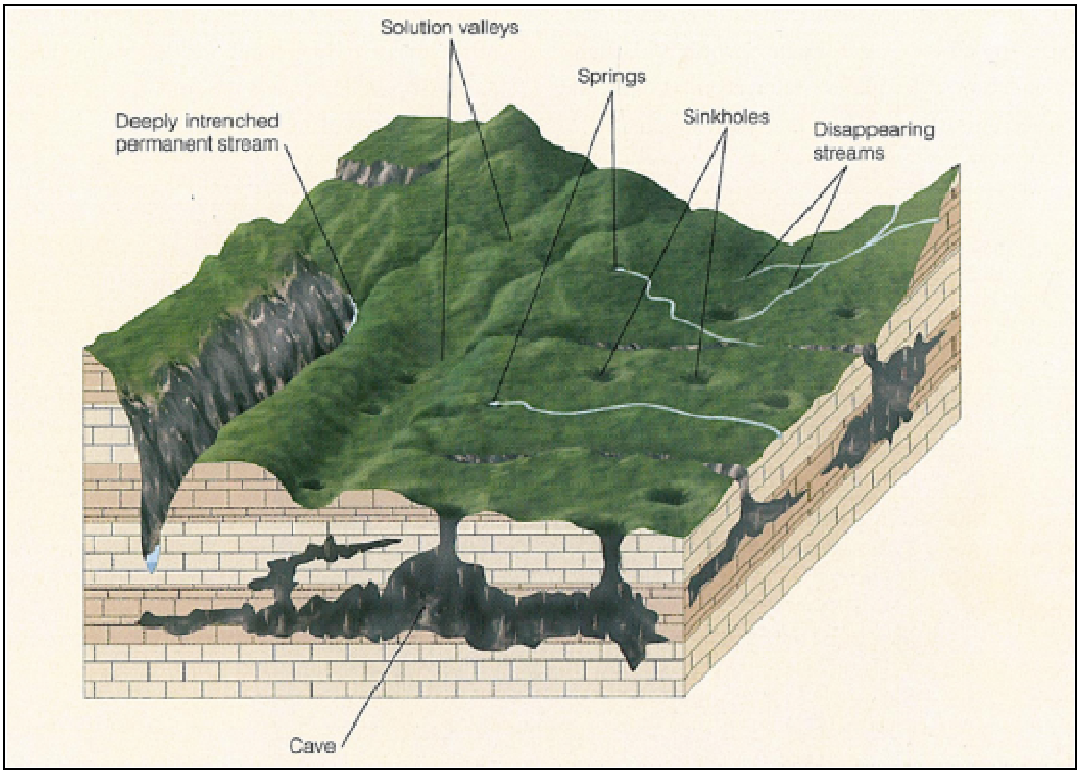


Figure 7: Karst formation through dissolution of dolomite (Monroe *et al.,* 2007)

Springs develop wherever the hydraulic head (or water level) in an underground water aquifer exceeds the topographic elevation and finds a way to seep or flow out onto the ground surface under normal gravimetric pressure. The same is true for karst-type aquifers. The hydraulic heads in different dolomitic compartments can differ, and each compartment can have its own spring(s) as indicated in Figure 8. The Malmani dolomite is also host to the three strongest karst springs in the southern hemisphere of which the GMB is the strongest at an average flow of 60 Mℓ/d (mega litres per day). The other two; the Oberholzer Eye (Eye of the Wonderfontein Spruit) and the Bank Eye both dried up in 1959 as a result of the dewatering of the Oberholzer and Bank compartments by mining activities (Winde, 2010a).

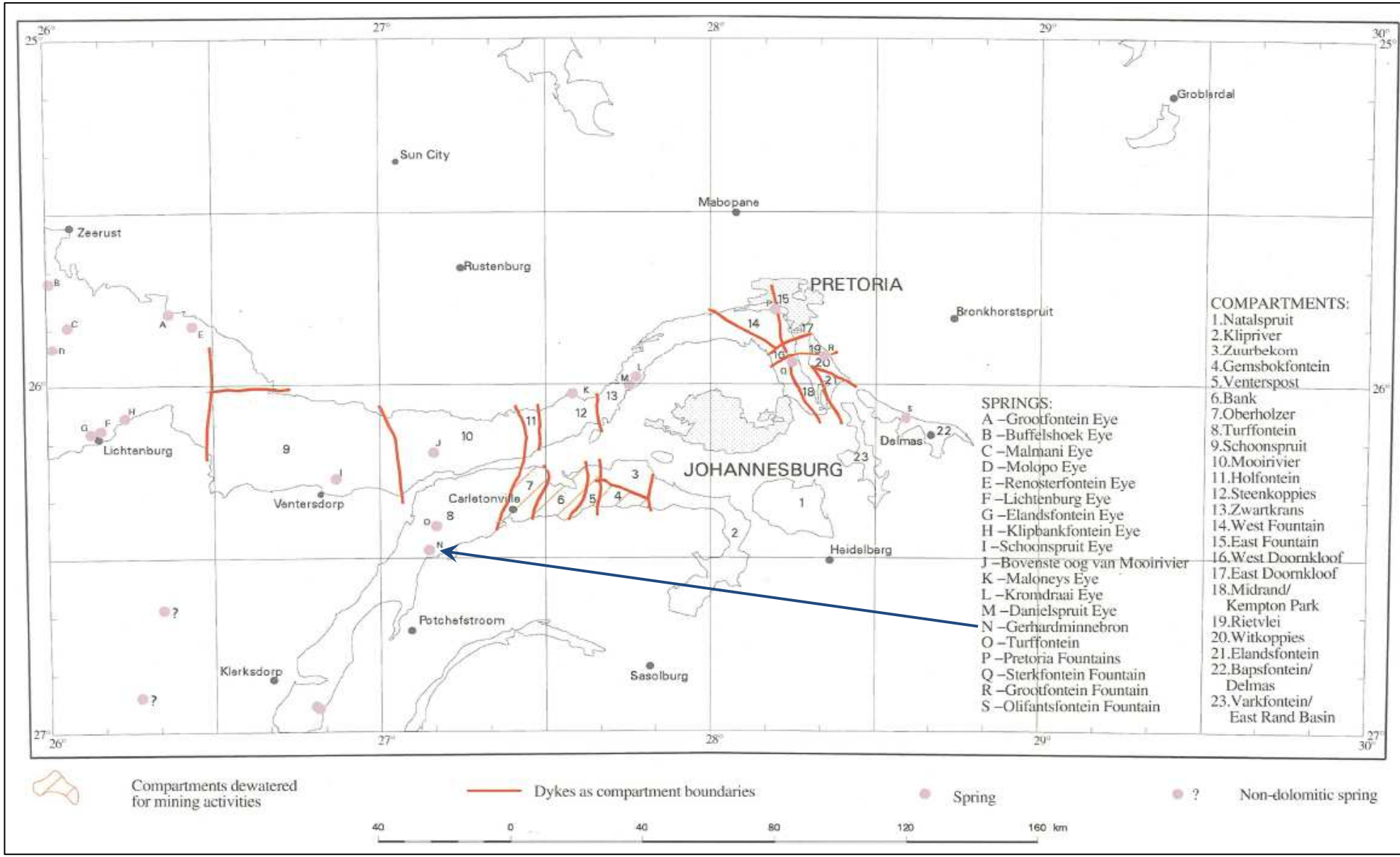


Figure 8: Map showing the different compartments in the Chuniespoort Group dolomite with associated springs (Barnard, 2000)

2.4.2. Impact of Mining on the Geohydrology

2.4.2.1. Current impact

Gold was discovered on the Witwatersrand in 1886. Shortly thereafter mining activities commenced in this area. Initial mining activities were performed using opencast methods, but as mines grew deeper the opencast methods were replaced by shafts. The sedimentary layers dip towards the south, and subsequently the gold mines started to target deeper elevations. This resulted in mines generally prospecting further to the south as they mined deeper. These deep level mines extended in a westerly direction along strikes to where they currently mine underneath the towns of Westonaria and Carletonville. The deepening of mines resulted in an increased ingress of water into the underground workings of the mines. This water needed to be pumped out in order to continue mining effectively in this area. The pumping out of water from these dykes resulted in an enormous mined-out void (Opperman, 2008:16).

One of the problems that deep level gold mines faced in the early years is the massive amounts of groundwater encountered in the Malmani dolomite overlying the Witwatersrand Supergroup. In order for the mines to penetrate the gold bearing strata of the Witwatersrand rocks, they had to negotiate their way through the overlying Malmani dolomite without causing the mine to flood with water from the surrounding cavities (Smit, 2010). A breakthrough was made in the 1930s whereby a shaft was sunk by the Venterspost Gold Mine through the Malmani dolomite where a process called ‘cementation’ was used to seal off the underground cavities and prevent water from flooding the shaft (Winde, 2010b). Unfortunately groundwater still managed to find its way through into the underground mine voids and the mines were faced with the problem of pumping water from the mine voids. This led to an idea proposed by some of the mines to dewater certain of the dolomite compartments in order to prevent groundwater from percolating into the mine voids. After obtaining permission from the South African Government in 1959, dewatering of the Venterspost, Oberholzer and Bank compartments commenced by gradually pumping out more water than what was received as natural recharge.

The water level decreased by up to 1,000 m which led to the drying up of boreholes and four springs with a flow totalling 135 Mℓ/d. This was anticipated by the four-year impact study preceding the dewatering of the compartments, but what was not foreseen was the development of sinkholes as a result of dewatering compartments close to the surface. Some sinkholes caused damage to infrastructure and even loss of lives. Several sinkholes formed in the flow path of the Wonderfontein Spruit, the river that was used to channel the abstracted groundwater away from the mining area. This defeated the purpose as large volumes of the abstracted groundwater, together with the original surface water from the Wonderfontein Spruit, were diverted back into the underground compartments. A 32 km long pipe line with a 1m diameter was then constructed to pipe the water downstream from the Wonderfontein Spruit over the dewatered area affected by sinkholes, onto the saturated Boskop-Turffontein (BTC) Compartment where the GMB is situated (Winde, 2010b).

It is estimated that the total volume of the three dewatered compartments of 3,500 Mm^3 exceed that of the Vaal Dam at full capacity (2,536 Mm^3) (Winde, 2010a). The total volume of groundwater that is currently being abstracted from the dewatered compartments and pumped back into the Wonderfontein Spruit is estimated at 140 Mℓ/d (Winde, 2010b).

The chemistry of the water is also being affected by mining activities. The conglomerates that are being mined for gold also contain sulphide minerals such as pyrite (FeS) and uranium oxides. Pyrite reacts with oxygen once it is exposed to the atmosphere to form sulphuric acid (H_2SO_4). This is the source of the controversial acid mine drainage (AMD) associated with gold and coal mines in South Africa (Smit, 2010). Uranium is brought to the surface and stored in waste dumps together with other harmful chemicals used in the gold extraction process that make their way into the groundwater through seepage.

2.4.2.2. Predicted future impact

Although the issue of mining-related radioactive pollution caused by uranium was raised as early as 1967, it is only during the past 4-5 years that the topic has received significant public and political attention. The issue of health risks posed to the densely populated area of the Wonderfontein Spruit Catchment by the extent of the uranium pollution is a controversial topic following an investigation report by the Water Research Commission in 2004 (Report No. 1214) that was being disputed by the National Nuclear Regulator in terms of the risk assessment used in the investigation (Winde, 2010b). Although the topic is still being debated, attention has been drawn to the current and future predicted extent of uranium pollution and other impacts caused by mining in the Wonderfontein Spruit area. Currently studies are underway to try and quantify the current extent of the uranium pollution in the Wonderfontein Spruit and predict post-closure impacts caused by the rewatering of the dewatered dolomite compartments once the mines stop pumping (Smit, 2010).

One of the theories is that three of the four dewatered dolomite compartments have been linked underground with the BTC by the piercing of the separating dykes by mining activities. This has the result that one big ‘mega-compartment’ has been formed, consisting of the BTC, the Oberholzer, Bank and Venterspost Compartments. Once the dewatering of the Oberholzer, Bank and Venterspost Compartments ceases after mine closure, the rewatering of these compartments would be limited by the lowest topographical outlet point of the mega-compartment which is the GMB Eye at 1395 metres above mean sea level (mamsl) followed by the lower and upper Turffontein Springs at 1410 and 1420 mamsl respectively not too far from the GMB Eye (Winde, 2010b). Theoretically it is therefore possible that the flow of the GMB (at an average of 60Mℓ/d) could increase by 135 Mℓ/d (which is the combined flow of the four springs that dried up on the dewatered compartments), depending on the manner in which the compartments are linked.

This has the potential that millions of litres of water that might be contaminated with uranium or other heavy metals could start flowing from the GMB and other springs into the Mooi River. According to a report on the radioactivity monitoring programme in the Mooi River and Wonderfontein Spruit Catchment by the Institute for Water Quality Studies of the Department of Water Affairs, delivered in 1999, the GMB had the lowest concentration of Uranium (^{238}U) of all of the sampling points monitored. The average uranium concentration measured in 1995 at the GMB Eye was 0.5 µg/L. This increased fourfold from 1998 to 2003 to an average of 2.3 µg/L (which includes a spike of 24 µg/L). Increases in uranium concentrations have also consistently been observed at Boskop Dam (fivefold) and Potchefstroom Dam (threefold) up to 2004 (Winde, 2010c).

2.5. SUMMARY

The GMB is a natural discharge area for underground water from the BTC. There is already evidence of mining-related water pollution impacting the water quality at the GMB with a fourfold increase in uranium concentrations measured between 1995 and 2003. Existing theories predict a possible increase of flow at the GMB as the three dewatered dolomite compartments east of the BTC are linked through mining voids to form a mega compartment with the GMB as the topographical lowest point of outflow on surface. This means that the GMB would be the first point of outflow of the new mega compartment, decanting contaminated mine water as the upstream dewatered compartments are allowed to refill and infiltrate or spill over into the BTC.

The need for immediate attention to the present and future management of the GMB is therefore evident to preserve the spring flow and water quality as far as is possible. The GMB is a natural gift that has the potential to supply the whole town of Potchefstroom with water. This natural fountain needs to be taken care of and specific action needs to be taken in order to ensure the effective management and conservation of this area.

In the next chapter, attention is given to the legislative aspects in place within South Africa with regard to the management of water resources and specifically groundwater resources. The role and responsibilities of the different government institutions for water resource management are set apart in an effort to work towards a more integrated approach where all role-players are identified and involved in the management process.

CHAPTER 3: LEGISLATIVE ASPECTS OF WATER RESOURCE MANAGEMENT WITH SPECIFIC FOCUS ON GROUNDWATER

3.1. INTRODUCTION

Over the past few years, the nature of legislation and structures with regard to water management and the provision of water services in South Africa have been transformed. This transformation started with the proclamation of the Constitution of the Republic of South Africa in 1996, followed by the Water Services Act 108 of 1997 and the National Water Act 36 of 1998. Focus has shifted towards an integrated water resource management (IWRM) structure with all role-players involved and specific emphasis on the responsibilities of local government. Through the Municipal Structures Act 117 of 1998 the role of a developmentally orientated local government sphere has been clearly defined for the first time (Nealer & Van Eeden, 2010:133).

This chapter is an overview of the important legislation on water resource management and specifically groundwater resource management in South Africa.

3.2. OVERVIEW OF LEGISLATION CONCERNING WATER MANAGEMENT IN SOUTH AFRICA AND THE ROLE OF LOCAL GOVERNMENT

In 1998, the Local Government: Municipal Demarcation Act 27 of 1998 established the 283 municipalities now functioning within South Africa covering the country from one end to the other. This brought about major changes and for the first time the place and role of local government was identified and established. Newly established municipalities are demarcated according to the topographical, environmental and physical characteristics of an area along with specific demographical and geographical aspects. However, some important aspects with regard to water management such as the surface water catchment areas and specific geology of the areas were not taken into account when demarcating these municipalities (Nealer & Van Eeden, 2010:134). Surface

water catchments are often shared between two or even more municipalities. This makes the management and involvement from local government in the IWRM process somewhat complex.

On a local level in order to manage water effectively, efficiently and economically a series of complex hydrological, geo-hydrological and public management functions is necessary within a regulated environment. It is therefore necessary for municipal managers and municipal officials to be equipped with knowledge of the physical environment they are managing and specific skills for the purpose of long term planning (Nealer & Raga, 2008c:295).

The following table is an outline of the important legislation and transformation of legislation on water management in South Africa. This process of reviewing all legislation on water management in South Africa was started by Prof Kader Asmal, the former Minister of the then Department of Water Affairs and Forestry.

Table 1: Important examples of legislation in South Africa since April 1994 as related to water and municipal governance (Nealer & Raga, 2008b:28-31)

Year:	Act:	Summarised purpose and / or goal:
1994 (Nov.)	White Paper on Water Supply and Sanitation Policy.	This document is dedicated to the millions of SA's citizens who struggle daily with the burden of not having the most basic of services (RSA 1994).
1995 (Nov.)	White Paper on the Transformation of Public Service.	To establish a policy framework to guide the introduction and implementation of new policies and legislation aimed at transforming the South African Public Service (RSA 1995).
1996 (Oct.)	Constitution of the Republic of South Africa, Act 108 of 1996.	This is the supreme law of the Republic, which embraces the human rights principles and sets forth the right of access to water as part of a lengthy list of social and economic rights (RSA 1996).
1996 (Apr.)	'Water Law Principles.'	A set of principles submitted by various role-players and stakeholders which guided DWAF in drafting a new water act.
1997 (Oct.)	White Paper on Transforming Public Service Delivery (*Batho*	This seeks to introduce a fresh approach to service delivery: an approach which puts pressure on systems, procedures, attitudes and behaviour within the Public Service and reorients

	Pele [people first] White Paper).	them in the customer's favour, an approach which puts the people first (RSA 1997a).
1997 (Dec.)	Water Services Act 108 of 1997.	To provide for, *inter alia*, the rights of access to basic water supply and basic sanitation, the setting of national standards and of norms and standards for tariffs, water services development plans, establishment of water boards, monitoring of water services, and financial assistance to water services institutions (RSA 1997b).
1998 (Jul.)	Local Government: Municipal Demarcation Act 27 of 1998.	To provide for criteria and procedures for the determination of municipal boundaries by an independent authority (RSA 1998a).
1998 (Aug.)	National Water Act 36 of 1998.	To recognise that water in SA is a scarce and unevenly distributed national resource which belongs to all its inhabitants and that the National Government is responsible for the nation's water resources and their use. This should be attained in a sustainable manner by means of, *inter alia*, integrated water catchment management of all aspects of water resources and, where appropriate, the delegation of management functions to a regional or catchment level so as to enable everyone to participate (RSA 1998b).
1998 (Nov.)	National Environmental Management Act 107 of 1998.	To provide for co-operative, environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for coordinating environmental functions exercised by organs of state (RSA 1998c).
1998 (Dec.)	Local Government: Municipal Structures Act 117 of 1998.	To provide for the definition and establishment of municipalities in accordance with the requirements relating to categories and types of municipalities and provide for an appropriate division of functions and powers between the categories of municipalities (RSA 1998d).
2000 (Nov.)	Local Government: Municipal Systems Act 32 of 2000.	To enable municipalities to move progressively towards the social and economic upliftment of local communities, and ensure universal access to essential services that are affordable to all (RSA 2000).
2001	IDP Guide Packs	Department of Provincial and Local Government has produced guide packs to assist municipalities with the integrated development planning process needed to produce IDPs
2002	Disaster Management Act 57 of 2002.	To provide for criteria and procedures with regards to disaster and risk management on national, provincial and local levels.

2003 (Sept.)	Strategic Framework for Water Services.	To map out a vision for how the water sector as a whole will work in providing water services.
2004 (Feb.)	Local Government: Municipal Finance Management Act 56 of 2003.	To secure sound and sustainable management of the financial affairs of municipalities and other institutions in the local sphere of government (RSA 2003).
2005 (Aug.)	Intergovernmental Relations Framework Act 13 of 2005	To establish a framework for the national government, provincial governments and local governments to promote and facilitate intergovernmental relations.

In the next section important legislation and protocols with regard to water services management in South Africa are discussed individually.

3.3. IMPORTANT LEGISLATION AND PROTOCOLS WITH REGARD TO WATER RESOURCE MANAGEMENT IN SOUTH AFRICA

3.3.1. Constitution of the Republic of South Africa (Act 108 of 1996)

Section 24 of the Constitution states that all citizens of South Africa have the right to an environment which is not harmful to their health and well-being, an environment which is protected and sustained by reasonable legislative criteria (RSA, 1996). These reasonable legislative criteria include measures that:

- Prevent pollution and ecological degradation;
- Promote conservation; and
- Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

These are all important factors in the management of water resources in such a manner as to prevent pollution, promote conservation and secure sustainability.

With regard to local government and their role and responsibilities, the Constitution states the following:

Chapter 7 of the Constitution recognises the autonomy of local government as similar to the other two spheres of government (National and Provincial). Local government has the right to manage their own affairs (Joubert, 2008:1).

The Constitution also mandates local government with regard to the following (Joubert, 2008:12):

- Provision of democratic and accountable government for local communities.
- Ensuring that services to communities are provided in a sustainable manner.
- Ensuring that social and economic development is promoted within communities.
- Promotion of a safe and healthy environment.
- Communities and organisations should be encouraged to be involved in the matters of local government.

It is important to consider these factors when looking at IWRM and the involvement of local government in the management of their water resources, ensuring the sustainable quality and quantity of the water and providing for a safe and healthy environment.

3.3.2. The Water Services Act (Act 108 of 1997)

This Act defines the role of water service authorities (municipalities, water service institutions, water boards) and minimum standards for basic water and sanitation services – giving expression to the principle of equity.

One of the main objects of the Act is to provide the right of access to basic sanitation and water supply along with an environment that is not harmful to human health or well-being. When taking this object into consideration, it is important for authorities to ensure the quality of water provided to the community is of such a nature as not to be harmful to human health or future well-being. This is to be taken into account in the management of the GMB and the potable water for Potchefstroom with regard to the pollution of the

Wonderfontein Spruit and possible impacts upon the water of pollution from upstream mining activities on surface and groundwater resources.

3.3.3. The National Water Act (NWA) (Act 36 of 1998)

This Act is implemented by the Department of Water Affairs (DWA) and gives a legislative framework to the way in which water resources are developed, managed, used, protected, conserved and controlled. Along with these aspects, there are other important factors such as geo-hydrological activities of identifying, surveying and mapping (demarcating) the nature and extent of a specific water resource, that need to be considered even before the water resource can be protected, used, developed, conserved, managed and controlled (Nealer & Raga, 2008b:40).

The aim of the NWA has been to introduce integrated water resource management to South Africa through a process that focuses on the meeting of basic human needs, equity in access, facilitating social and economic development, protection of the aquatic and associated ecosystem, reducing and preventing pollution and degradation and meeting international obligations (RSA, 1998b).

The process of integration has culminated in the notion of IWRM. According to DWA, the process of IWRM calls for co-ordinated planning and management of water, land and environmental resources, taking into account the amount of water available (surface water and groundwater), water use, water quality, environmental and social issues. The purpose of this process is to ensure sustainable, equitable and efficient use of water resources. Central in the process of IWRM is the participation and involvement of all role-players and stakeholders in public decision-making (Nealer & Raga, 2008b:41).

The Act has requirements that relate specifically to pollution control, protection of water resources (specifically for mines), dam safety and water use tariffs. In Chapter 4 of this Act, it is stipulated that water uses (abstraction, storage,

waste disposal, discharge removal of underground water and alteration to watercourses) must be licensed (Anon, 2009:131).

The DWA is the sole custodian of all South Africa's water resources. They have actively been establishing research and management procedures in order to protect the country's water resources. Through the NWA they attempt to ensure that surface water catchment areas, river basins and groundwater resources are managed in an integrated and sustainable way (Nealer & Raga, 2008a:158).

IWRM balances the ideas and goals of political groups and geographical regions for the purpose of managing the water while protecting water supplies for natural and ecological systems. Close cooperation between three main "sub-systems" within the water industry is needed for this process, these being the natural water resource system, the human activity system and the water resource management system (institutions and organisations managing water) (Pretorius, 2009a:36).

3.3.4. The National Environmental Management Act (Act 107 of 1998) (NEMA)

The Department of Environmental Affairs and Tourism (DEAT) regulates this Act along with relevant provincial Departments of the Environment. The Act lays down basic environmental principles and makes room for cooperative environmental governance through the establishment of principles for public decision-making on matters affecting the environment. Principles such as Duty of Care, Polluter Pays and Sustainability are promoted (Anon, 2009a:129).

In both the National Water Act (Act 36 of 1998) and the NEMA (Act 107 of 1998) pollution is defined as implying a human-induced change in environment that has an adverse effect on human health or well-being. In both these Acts, it is evident that pollution must be prevented as far as possible and in instances where it does occur, all possible measures must be taken to prevent such

pollution from continuing or returning. The NWA puts very specific regulatory measures in place and in section 24 specifically focuses on mines in order to prevent industrial pollution. Restrictions are placed on the locality of mining activities. Further prescribed measures to separate the disposal of clean and dirty water have been put in place. The NWA allows for the sustainable use of water resources, for various reasons as long as such use is authorised by the NWA (Liefferink, 2008).

3.3.5. Municipal Structures Act (Act 117 of 1998)

Chapter 5 of the Act provides a clear definition of the roles and functions of a specific municipality. The Act provides for a Category C (district) municipality to have the power and functions to administer the bulk supply of water that affects municipalities in the district (potable water supply systems, waste water and sewage disposal systems and solid waste disposal), whereas a Category B (local) municipality is only responsible for stormwater management systems in its own jurisdiction area. The Minister for Cooperative Governance and Traditional Affairs after consultation with the Minister of Water Affairs and the members of the Executive Council responsible for the local government in a specific province could authorise a Category B municipality to exercise power with regard to their potable water supply systems (Nealer & Van Eeden, 2010:139).

Considering the situation described above, a paradox seems to exist in the legislation and its implementation, specifically with regard to water services management in the local government sphere of South Africa. Currently, in most cases, the Category B municipalities have been taking responsibility for their own bulk water supply in terms of potable water and the management of their grey water in their jurisdiction areas. These municipalities are directly connected to the water consumers at a grass-roots level, but the Structures Act delegates the authority for water services management away from the Category B municipality and gives the authority to the Category C municipality in whose municipal management area the Category B municipality falls. The responsible

Category C municipalities are often located very far away and do not have the capacity, skills or experience to manage the water services in order to be in line with the Integrated Development Plan of their respective Category B municipalities. This leads to confusion and grey areas where the respective municipal responsibilities are concerned, which in turn results in poor municipal management of the water services (Nealer & Van Eeden, 2010: 139).

Tlokwe Local Municipality is a Category B municipality that has been exercising authority over the supply of potable water to the city of Potchefstroom. The municipality recently received a “Blue Drop” award for the quality of their water as well as the biomonitoring that are both up to standard (Nel, 2009). The Municipality however only becomes involved with the management of its potable water once the bulkwater enters the water purification plant in the town. A more effective strategy and management process will involve the Municipality in the management of the water resources supplying Boskop Dam and the source of potable water for Potchefstroom, such as the GMB.

3.3.6. Municipal Systems Act (Act 32 of 2000)

In combination with the Municipal Structures Amendment Act (33/2000b) and Local Government: Municipal Planning and Performance Regulations No. 7146 (2001), the Municipal Systems Act identifies a number of obligations for environmental management and sustainable development by local government that must be accommodated and reflected in the institutional framework and policies of a municipality (Pretorius, 2009a:53). This Act defines the main principles, processes and mechanisms that are necessary to enable municipalities to progressively move towards social and economic upliftment of their respective communities. In this Act, the integrated development plan of a municipality is defined (Joubert, 2008:4).

3.3.7. A Guideline for the Assessment, Planning and Management of Groundwater Resources within Dolomitic Areas in South Africa

The DWA compiled a guideline for the assessment, planning and management of groundwater resources within dolomitic areas in South Africa. This is an important guideline, due to the nature of dolomite. The physical characteristics of this host rock leave water resources in these areas particularly vulnerable to over-exploitation, pollution and unsustainable practices (Hubert *et al*., 2006).

In this guideline, the roles and responsibilities of institutions at various spheres of government and society are outlined with regard to the management of groundwater resources in dolomitic areas. Nationally, the DWA is responsible for the overall management of water resources in such a manner as to comply with the NWA (1998) - “protect, use, develop, conserve, manage and control water in a sustainable manner for the benefit of all”. The DEAT also has a role to play in the protection, conservation and maintenance of terrestrial and aquatic ecosystems and water resources (Hubert *et al.,* 2006:15).

On a regional level, the DWA regional offices have the delegated responsibility of managing water resources and acting as implementing agents of policies and strategies. Some challenges faced by these institutions in the execution of their tasks are the following:

- Limited geo-hydrological capacity and skills;
- Limited institutional capacity;
- A historic neglect of groundwater management overall; and
- Lack of a clear integrated management structure.

There are functions and responsibilities assigned to Catchment Management Agencies (CMAs) in this document, but in most areas no CMAs have been established, and the responsibility currently remains with the DWA.

On a site-specific level, roles and responsibilities are also assigned to District and Local Municipalities that fall in dolomitic areas. These responsibilities involve the planning and developing of water services and infrastructure, ensuring minimum levels of provision to their constituents.

The responsibilities also include the management of the local water source.
There are many challenges facing municipalities, and when it comes to the involvement and management of water resources and especially groundwater resources, they face specific challenges such as:

- A lack of capacity and skills, as well as financial resources; and
- A lack of clarity in terms of division of roles and responsibilities.

(Hubert *et al.,* 2006:15)

It is evident from this guideline, that municipalities do have a role to play in the management of their water resources. The challenges they face make it a difficult task especially when it comes to roles and responsibilities. DWA remains the custodian of the water while management tasks are not fully and effectively delegated so as to encourage IWRM involving relevant role-players and stakeholders.

3.4. SUMMARY

It is evident that legislation in South Africa, where water is concerned, has changed for the better over the past 14 years. In some cases however, a paradox exists where the management of water services on a local level is concerned, and this in turn creates confusion and leads to poor management of these services.

With reference to groundwater resources, a thorough and descriptive guideline has been compiled with regard to the management of groundwater resources on dolomite bedrock in South Africa. The GMB is one such groundwater resource in a dolomitic area of South Africa. It is currently under the management of the DWA, with no participation from the local municipality that benefits from its waters. The following chapter contains a discussion and analysis of acquired research data for this study along with the researcher's interpretations of the data.

CHAPTER 4: EMPIRICAL FINDINGS

4.1. INTRODUCTION

For the purpose of this study on the more effective management of the Gerhard Minnebron (GMB) as important resource of potable water for Potchefstroom, a 5-point Likert scale type questionnaire was compiled and utilised for data collection (see Appendix A).

The Likert-scale is a psychometric scale often used in questionnaires. When responding to a Likert-type question, respondents specify their level of agreement with a statement. The number at one end of the scale represents most agreement “fully agree” while at the other end of the scale is least agreement “fully disagree”.

Altogether 27 participants were chosen for the study out of specific working and living environments that are relevant to this study such as the Tlokwe Local Municipality, private landowners of the GMB and surrounding areas, Department of Water Affairs (DWA) Directorate of Hydrology at Boskop Dam, North-West University, local environmental and geology consulting specialists and long term residents of Potchefstroom. Table 2 presents a summary of the respective groups of respondents:

Table 2: Summary of respondents in the empirical study

Respondents in the study	
Tlokwe Local Municipality	5
Private landowners around the GMB	3
Department of Water Affairs	4
North-West University	4
Environmental and geology specialists	3
Long term residents of Potchefstroom	8

The purpose of the questionnaire was to establish the basis of knowledge surrounding certain facts concerning the GMB and also to establish what the general thoughts are regarding the overall questions of who is responsible for the management of the GMB and who is or is not currently involved.

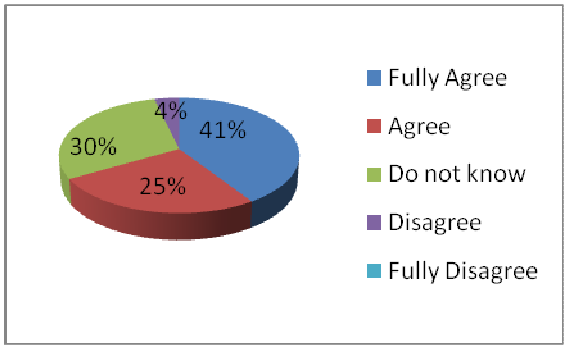
Respondents were furnished with the questionnaire consisting of twelve statements on which they had to mark whether they:

1) Fully Agree;
2) Agree;
3) Do not know;
4) Disagree; or
5) Fully disagree with the statement.

4.2. ANALYSIS OF QUESTIONNAIRE COLLECTED DATA

To statement No. 1 of the questionnaire, namely '**The Gerhard Minnebron is an important resource of potable water to Potchefstroom'**, the responses were the following:

Fully Agree	Agree	Do not know	Disagree	Fully Disagree
11	7	8	1	0
41%	25%	30%	4%	0%



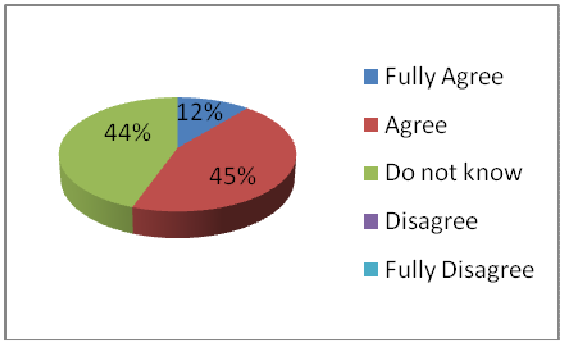
The majority (66%) of the respondents agreed/fully agreed that the GMB is indeed an important resourse of potable water to Potchefstroom. Some 30% answered that they 'do not know' and 4% disagreed with the statement.

There are three major tributaries to the Mooi River of which the GMB is one. The water from the Mooi River feeds into the Boskop Dam from where Potchefstroom's potable water comes. The specific contribution of water from

each tributary is unclear at present since there are no formal waterflow gauging stations measuring the individual flows (Le Roux, 2010). The GMB has had a constant water flow rate for the past few years (Le Roux, 2010) and therefore yields a constant amount of water to the Mooi River on a daily basis. This is important to note for the future, considering the current potable water situation in South Africa. Even though the majority of respondents agreed with the above statement, 30% were not so informed. This is a problem and one of the contributing factors why this research was undertaken. All role-players involved with the water resource management and supply of potable water to Potchefstroom should be aware of the fact that the GMB is an important resource of potable water to Potchefstroom.

Regarding statement No. 2 of the questionnaire '**The management of the Gerhard Minnebron is the responsibility of the Department of Water Affairs'**, the following responses were given:

Fully Agree	Agree	Do not know	Disagree	Fully Disagree
3	12	12	0	0
12%	44%	44%	0%	0%

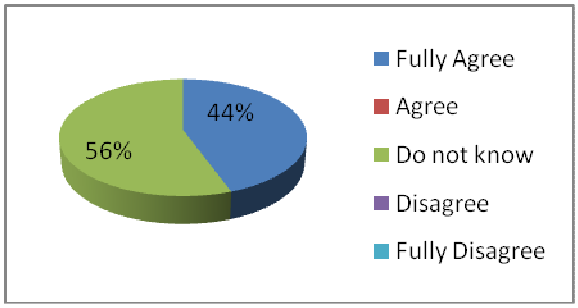


56% of the respondents agreed/fully agreed that the DWA is responsible for the management of the GMB. A large number of the respondents (44%), however, marked the 'do not know' option on the questionnaire. Considering that the majority of the respondents in this study are involved with the management and/or provision of potable water to Potchefstroom in some way or another, this high percentage of uninformed respondents is an alarming finding. How can effective management of the GMB take place in an integrated manner when the role-players do not know who is responsible for the management of the water resource to begin with?

The GMB is acknowledged as a national water resource by the DWA. The Department is the sole custodian of South Africa's water resources and is therefore primarily responsible for the management of the GMB at present. Within the National Water Act (NWA) provision is made for nineteen Catchment Management Agencies (CMA) that are to take responsibility for the management of water resources within a specific surface water catchment. Unfortunately up till now, only two CMAs have been established and the DWA still remains primarily responsible for the management of all water resources in the country. The DWA compiled a guideline for the assesment, planning and management of groundwater resources within dolomitic areas in South Africa. In this document, the roles and responsibilities of institutions on various levels of government are outlined. In the local government sphere of the developing South Africa, there are specific functions that a municipality should also fulfil which include the management of the local water resources (Hubert *et al.,* 2006:17).

Statement No. 3 in the questionnaire reads as follows '**The Gerhard Minnebron is a natural fountain flowing out of an underground dolomitic compartment 6km north of Boskop Dam'.**

Fully Agree	Agree	Do not know	Disagree	Fully Disagree
12	0	15	0	0
44%	0%	56%	0%	0%



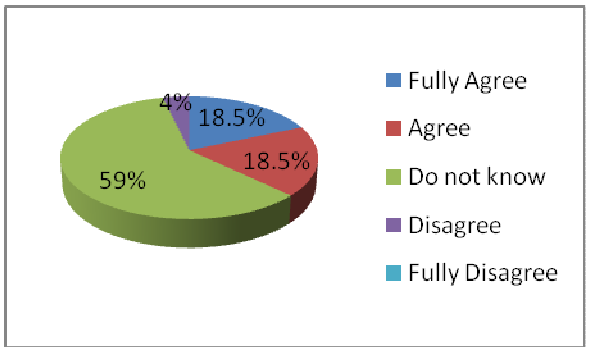
Some 44% of the respondents agreed/fully agreed with this statement concerning the GMB. A high 56% of the respondents marked the 'do not know' option which proves that the average resident of Potchefstroom is not well informed about the origin of the city's drinking water. The fact that the GMB is indeed a fountain flowing naturally from an underground dolomitic compartment, may be the most important fact about this water resource. The geology of this area makes it very significant, but at the same time very vulnerable to exploitation and pollution by upstream water users. It is therefore

vitally important that role-players and stakeholders in the management of this water resource be aware of its origin and the type of geology and geo-hydrology. All role-players along with the public who benefit from this groundwater should be made aware of the geo-hydrological and management facts concerning the GMB.

The GMB is situated immediately downstream of an area (Far West Rand) that has recently raised major concerns with regard to pollution by the gold mines and is possibly connected to the same underground compartment that is currently being contaminated (Winde, 2006). This geo-hydrologically sensitive and strategicaly important municipal area needs specific management structures and efforts in order to keep it sustainable and reliable for future use. All available knowledge and skills from different institutions and role-players should be applied in the management of the GMB to work towards a more effective and sustainable form of environmental development and management.

Statement No.4 on the questionnaire stated that '**The Gerhard Minnebron is the largest natural fountain in the Southern hemisphere flowing at an average yield of 2160 m³/hour (Winde, 2006)'.**

Fully Agree	Agree	Do not know	Disagree	Fully Disagree
5	5	16	1	0
18.5%	18.5%	59%	4%	0%



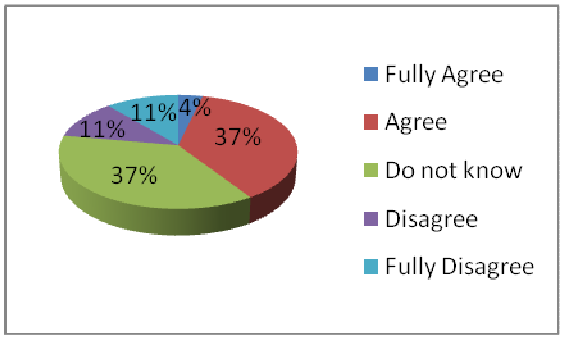
Altogether 37% of the respondents in this study responded they agree/fully agree with the above statement. But, an alarming 59% of the respondents indicated that they do not know.

The GMB with its unique nature, and vast potential when considering the average yield, is a natural wonder and a rare find. In order to develop, manage,

use, protect, conserve and control this resource as stated in the NWA (RSA, 1998), it is important for role-players and stakeholders in the municipal management to be aware of and acknowledge the significance and value of this potable water resource.

With reference to statement No. 5 that the '**Tlokwe Local Municipality is involved in the management of the resources of potable water to Potchefstroom',** 41% of the respondents either agreed/fully agreed with this statement.

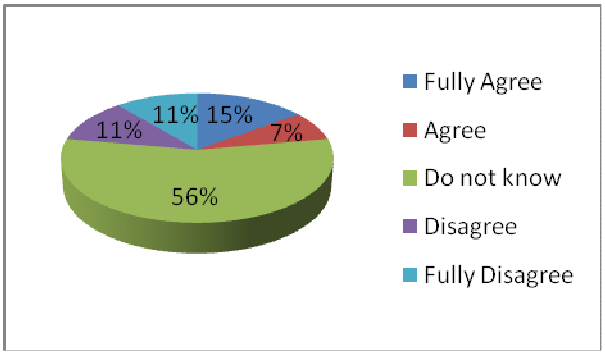
Fully Agree	Agree	Do not know	Disagree	Fully Disagree
1	10	10	3	3
4%	37%	37%	11%	11%



A big percentage (22%) of the respondents is actually of the opinion that they do not agree with this statement and the other 37% marked the 'do not know' option. Considering the above responses, the majority of respondents either do not know, or are under the wrong impression when it comes to the involvement of Tlokwe Local Municipality in the management of their water resources. Although this municipality recently received a Blue Drop Award for the quality of its potable water, it is not involved in the management of the specific resources of water that supply water to Boskop Dam from which Potchefstroom's potable water comes. They only become involved once the canal transported bulkwater from the Boskop Dam enters into the municipality's water purification plant at Lakeside dam (Le Roux, 2010). Currently the Boskop Dam office of the Hydrology Directorate of DWA is monitoring the flow rate of the GMB as well as the pH of the water (Le Roux, 2010).

In terms of statement No. 6, **'The Gerhard Minnebron falls within the jurisdiction boundaries of Tlokwe Local Municipality'**, the participant's answers ranged over the whole spectrum with almost equal distribution.

Fully Agree	Agree	Do not know	Disagree	Fully Disagree
4	2	15	3	3
15%	7%	56%	11%	11%



Some 22% of respondents either agreed/fully agreed with the statement, a very high 56% marked that they 'do not know' and another 22% disagreed/fully disagreed with the statement.

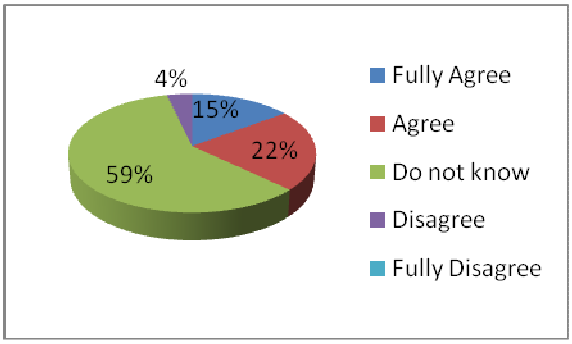
In actual effect, the GMB falls a few kilometres outside (north) of the jurisdiction boundary of Tlokwe Local Municipality and is situated within the Ventersdorp Local Municipality's jurisdiction boundaries (see Figure 1). The Ventersdorp Local Municipality, however, does not benefit from this water at all and therefore is not involved or very much concerned about the management of this valuable resource. The reason for this specific statement in the questionnaire is to raise concern that the GMB does not fall within the Tlokwe Local Municipality's boundaries, but that the said Municipality is the primary beneficiary of water from this resource. This is one of the factors that was not taken into account with the demarcation of the 283 municipalities currently functioning within South Africa (the water catchment area and specific geo-hydrology of an area) (Nealer & Van Eeden, 2010: 135). This makes the management of water catchment areas a challenging task.

All the respondents in this study were chosen from specific areas of importance related to the management of potable water for Potchefstroom. However, only 22% of the respondents knew that the GMB does not fall within the Tlokwe Local Municipality's municipal area boundaries. Although the management of the water resources remains primarily the responsibility of the DWA, it is necessary for the different institutions of state to work together, even across

municipal boundaries, in order to achieve effective management and sustainability.

To statement No. 7, **'The private landowners are responsible for the management of the natural environment of the Gerhard Minnebron and the surrounding area'**, the responses were the following:

Fully Agree	Agree	Do not know	Disagree	Fully Disagree
4	6	16	1	0
15%	22%	59%	4%	0%

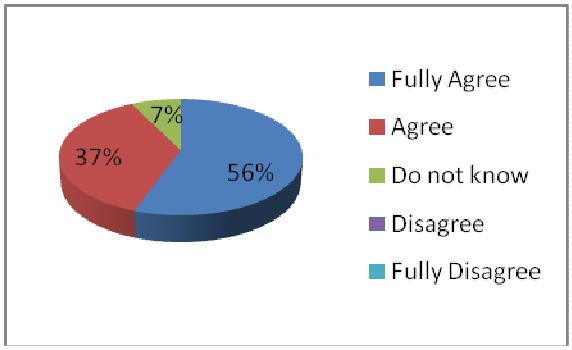


Some 37% of the respondents agreed/fully agreed with the statement, 59% of the respondents responded that they did not know and 4% disagreed.

Any private landowner is responsible for the upkeep and management of the environment on his land, and some of the respondents indicated in this manner, where 37% agreed that the private landowners are responsible for managing the natural environment and surroundings of the GMB. The GMB however is an acknowledged national water resource and therefore primarily the responsibility of the DWA even though it is situated on private land. The DWA has a shortage of man-power and capacity that often results in the neglect of the upkeep and maintenance of its water management infrastructure. An integrated and cooperative approach is the only way in which the GMB can be managed effectively and all involved parties can benefit. The private landowners already take responsibility for looking after the natural environment of the GMB and surrounding area. They need the support of a public-private-partnership in an integrated manner.

Statement 8 of the questionnaire stated that **'An effective public-private-partnership is essential to guarantee the more effective management of the Gerhard Minnebron'**.

Fully Agree	Agree	Do not know	Disagree	Fully Disagree
15	10	2	0	0
56%	37%	7%	0%	0%

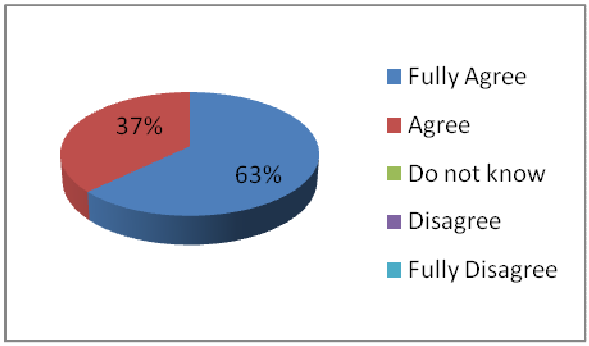


The majority of the respondents (93%) indicated that they agree/fully agree with the above statement. The other 7% responded that they 'do not know'. The capacity of the DWA is limited in terms of manpower and available resources. No Catchment Management Agency has been appointed within the Mooi River Catchment and therefore the water services management remains the responsibility of the DWA (of which the regional office is situated in Potchefstroom).

The only solution in order to ensure effective and sustainable management of this resource is a working public-private-partnership, making use of local resources such as environmental specialists and the North-West University. Respondents recognised that it is essential to pursue an effective public-private-partnership in the effort towards more effective management of the GMB. This resource requires specialised management and specific procedures due to its sensitive geo-hydrological nature. Acquiring input from environmental and geology specialists within the private and public sector is necessary to implement better strategies and procedures for the management of the GMB.

As the NWA identifies the need for an integrated water resource management (IWRM) approach, the following statement was included in the questionnaire, statement No. 9 '**An integrated water resource management approach involving all relevant role-players is necessary for the more effective management of the Gerhard Minnebron**'.

Fully Agree	Agree	Do not know	Disagree	Fully Disagree
17	10	0	0	0
63%	37%	0%	0%	0%



All of the respondents agreed/fully agreed with this statement. They recognised that IWRM is the only solution for the more effective management of the GMB. IWRM involves the management and development of water, land and other resources in a coordinated manner so as to maximise the socio-economic development in a sustainable end equitable manner (Braun & Xu, 2008:700). It involves three levels of integration:

- Integration within the physical processes – hydrological cycle;
- Spatial integration across catchment areas and aquifers; and
- Socio-economic integration.

(Braun & Xu, 2008:700).

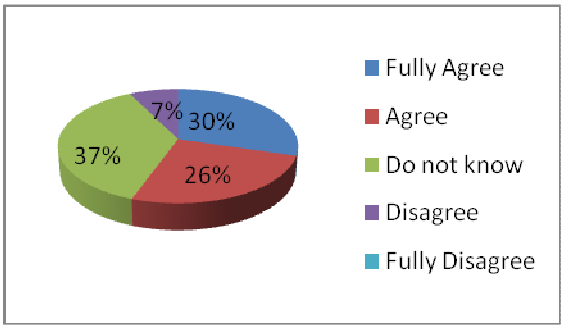
The GMB is located in a geo-hydrologically unique and complex area (dolomitic compartment). The area is also possibly threatened by pollution from gold mining activities that pose a great threat to the physical and man-changed environment and to human health. The only possibility of the more effective management of this resource is an IWRM approach where the environment and all the socio-economic development needs are taken into account. Correspondence and cooperation between the DWA, the local municipalities, private landowners, environmental specialists, academia and researchers are imperative to work towards a more effective IWRM.

The Wonderfontein Valley and Spruit were described as a 'natural jewel' by some adventurers during former years, with their lush water resources and mining potential (Swart *et al*., 2002: 635). Currently the Wonderfontein Spruit is a major focus area of environmental concern in South Africa. It is frequently

written about in the media and talked about in social conversations. It is considered as one of the most hazardous areas with its underground dolomitic compartments where sinkholes can form at any unexpected time while causing serious injuries and further water pollution (Van Eeden *et al.,* 2008:32). The possible contamination of the Wonderfontein Spruit is a result of the processing of gold-ore in this area, containing uranium (Prinsloo, 2008). The issue of health risks posed to the densely populated area of the Wonderfontein Spruit Catchment by the extent of the uranium pollution is a controversial topic following an investigation report by the Water Research Commission in 2004 (Report No. 1214) that was being disputed by the National Nuclear Regulator in terms of the risk assessment used in the investigation (Winde, 2010b). The Wonderfontein Spruit Catchment forms part of the Mooi River catchment system, of which the GMB is also part. This background sets the context of the next statement.

Statement 10: '**The Gerhard Minnebron is at risk of pollution from upstream mining activities in the Wonderfontein Spruit area (example Acid Mine Drainage)'**, elicited the following indications from the respondents:

Fully Agree	Agree	Do not know	Disagree	Fully Disagree
8	7	10	2	0
30%	26%	37%	7%	0%



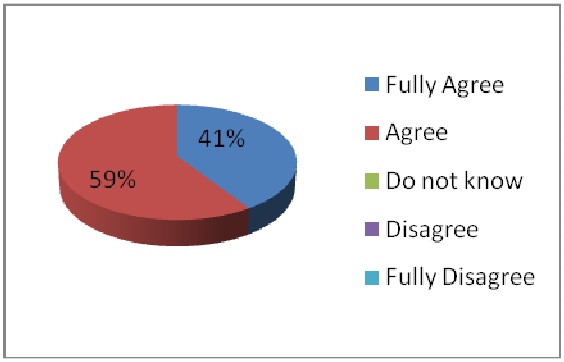
Altogether 56% of the respondents agreed/fully agreed with this statement. Some 37% of them indicated that they 'do not know' and 7% disagreed with the statement. Most of the respondents who agreed with this statement are involved in research or water management projects with regard to the GMB or private landowners who have done extensive research into the possible threats to the GMB. Those who do not know, are mostly long term residents of

Potchefstroom who are mostly unaware of the GMB's existence to begin with. Respondents who disagree with the above statement, might be ignoring and questioning the facts and evidence concerning the current status of the Wonderfontein Spruit and the impacts on the environment.

The above mentioned factors with regard to the Wonderfontein Spruit reveal that a possible threat to the waters of the GMB exists and specifically the threat of future contamination. This cannot be ignored or put on the back burner for future management to tackle. A proactive approach is needed where all possible actions are taken timeously to prevent the pollution of the GMB. Most of the respondents agreed that the possibility of future contamination of the GMB does exist. All the current evidence and factors point towards possible future problems. This should be kept in mind throughout the whole IWRM approach towards the effective management of the GMB.

Statement No.11 of the questionnaire reads as follows **'Awareness of the history and cultural heritage of the Gerhard Minnebron as important resource of potable water to Potchefstroom, should be promoted'**.

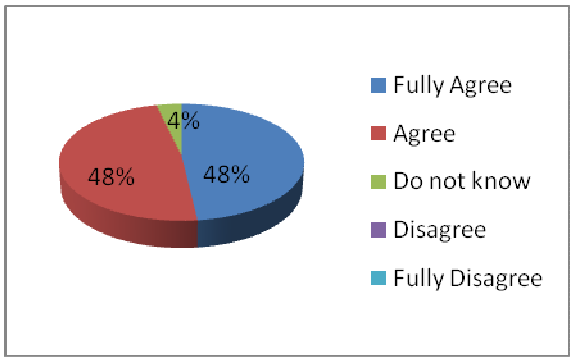
Fully Agree	Agree	Do not know	Disagree	Fully Disagree
11	16	0	0	0
41%	59%	0%	0%	0%



All of the respondents responded that they agree/fully agree with the statement. A natural fountain such as the GMB is not a common sight in South Africa. It is situated in a beautiful environment and has a cultural history dating back to before the Anglo Boer War that still needs to be explored (Culter, 2010). These are important factors to consider and respondents indicated accordingly.

The final statement in the questionnaire, No. 12, stated that **'The significance of the Gerhard Minnebron as a source of potable water to Potchefstroom should be investigated in more detail with regard to water quantity and quality'.**

Fully Agree	Agree	Do not know	Disagree	Fully Disagree
13	13	1	0	0
48%	48%	4%	0%	0%



The majority of the respondents (96%) indicated that they agree/fully agree with this statement and 4% responded that they 'do not know'. According to Le Roux (2010) from DWA, the specific flow contribution from the GMB towards the Mooi River is not being measured at present. The water quality with reference to the pH and electrical conductivity, however, are measured every 10 minutes. For future planning with regard to the water supply to the Boskop Dam, it is important to consider the contributions of each of the tributaries: the Mooi River, Wonderfontein Spruit and the GMB.

In future it might be necessary to investigate other alternatives like the diversion of the water from the Wonderfontein Spruit in an effort to improve the quality of potable water for Potchefstroom. In such a case it would be important to know if the contribution from the GMB along with the water from the Mooi River would provide enough water for the necessary usage. The flow rate of the GMB has remained constant over the years, but the rewatering of mines might change this in the future.

The concerns regarding the quality and future problems related to water pollution should also be taken into consideration and further investigation should be undertaken. Currently there is not sufficient monitoring taking place for the water of the GMB. A full range of analyses of the chemical aspects of

the water quality should be undertaken continuously in order to note any changes that can have a detrimental effect and create an environmental health risk for the downstream users and consumers in Potchefstroom.

In the questionnaire statements 1, 3 and 4 addressed strategically important facts and knowledge about the GMB regarding the contribution of potable water to Potchefstroom, the location and significance of the resource and the geo-hydrology. Considering the responses it is evident that there is a definite lack in knowledge where the GMB is concerned. The majority of the respondents to these statements indicated that they “do not know”. In order to manage this water resource and plan for the future management, knowledge and information concerning the GMB should be made available and presented to all involved role-players and stakeholders.

A further three statements in the questionnaire addressed specific issues concerning the current management of the GMB. These were statements 2, 5 and 7. Statement 2 was related to the current institution responsible for the management of the GMB, being the DWA. Statement 5 was related to Tlokwe Local Municipality which benefits from the waters of the GMB, while statement 7 concerned the private landowners of the GMB and surrounding areas. A very high percentage of the respondents chose the ‘do not know’ option for all three of these statements. This indicates that where the management of the water resources and GMB are concerned, perceptions are vague and unclear. The current management of the GMB is solely the responsibility of the DWA. The Tlokwe Local Municipality is not involved with the management of this water resource and the private landowners have taken some very limited responsibility for the physical environment of the GMB by wanting to take care of their private properties.

Three more statements addressed the future management of the GMB, being Nos 8, 9 and 12. Statements 8 and 9 specifically addressed the issues of IWRM and public-private-partnerships. All the respondents indicated that they agree with these statements and acknowledged that IWRM and public-private-

partnerships are the only way ahead where the management of the GMB is concerned. Currently, the idea is to work towards IWRM in the management of all water resources in South Africa. This can only be achieved by implementing effective public-private-partnerships. The DWA has a shortage of manpower and qualified, skilled personnel and cannot manage all water related services and the development and maintenance of them all alone. The only option is partnerships with the private and public sectors in order to build capacity and add skills. Statement 12 addresses the specific significance and value of the GMB as a resource of potable water for Potchefstroom and respondents agreed that this should be investigated in more detail. Currently the exact contribution of the GMB to the potable water of Potchefstroom is unclear.

Considering the above responses from the various respondents, it is evident that there are some gaps in specific knowledge of the GMB. In other cases disparities exist among respondents when issues such as the future impacts on the GMB are discussed.

4.3. SUMMARY

In this chapter the empirical findings of the research study on the more effective management of the GMB have been discussed and analysed. The data were acquired through the use of a 5-point Likert-scale type questionnaire. Altogether 27 respondents filled out the questionnaire.

All the statements in the questionnaire were based on certain facts and knowledge concerning the GMB and its management. Due to the unique nature of this water resource coming from a groundwater dolomitic aquifer and being the largest natural fountain in the Southern hemisphere (Winde, 2006), it is regarded as a significant water resource and should be managed accordingly. Knowledge concerning this resource is therefore imperative in order to manage it effectively.

It is certainly a problem when central role-players and stakeholders in the management of the potable water for Potchefstroom and the management of the GMB, such as the respondents in this study, do not possess even basic knowledge about an important resource such as the GMB. Awareness should be emphasised on the origin of a city's potable water as well as the destiny of its used water.

In the next chapter the logical conclusions and recommendations ensuing from the empirical study will be introduced.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. INTRODUCTION

Water is life, without it no living organism can survive. Looking at the relevant literature all over the world, it is evident that water resources are dwindling in many areas across the earth. There is a lot of speculation about the next world war being fought over water. This is quite possible considering all the hydropolitical situations we have all over where issues of transboundary river basins are involved. Linked to the problem of dwindling water resources and unsustainable usage of these resources over many years, is the management of available resources. Due to the developing nature of the world, with urbanisation and industrialisation, available water resources are exposed to many forms of exploitation and pollution. Having access to safe drinking water is definitely a basic need for people all over the world.

This research study focused on the management of one unique water resource in South Africa, the Gerhard Minnebron (GMB). The GMB is a groundwater resource in a dolomitic area of South Africa. It is the largest natural fountain in the Southern hemisphere and an important resource of potable water for the city of Potchefstroom.

The aim of this study was to determine the current management structure with regard to the GMB in order to work towards the more effective management of this valuable resource. Data were gathered by doing a thorough literature study along with a Likert-scale type questionnaire presented to specific role-players and stakeholders in the management of the GMB (see 4.2 above). The geology and geo-hydrology of the GMB were considered with regard to the specific management necessitated by the nature of the geology and geo-hydrology of the area (see 2.3 and 2.4 above). Furthermore, relevant legislation on the management of groundwater resources in South Africa, and

specifically in the local government sphere was considered and discussed (see 3.3 above).

In this chapter, the logical conclusions drawn from the empirical research study are presented, along with specific recommendations ensuing from these conclusions.

5.2. LOGICAL CONCLUSIONS

The following logical conclusions are drawn, based on the research questions asked in this study.

5.2.1. Geology and Geo-hydrology

The overall nature and extent of the geology and geo-hydrology of the GMB is extremely important in the analysis of the management of the GMB. The GMB is a natural fountain: a groundwater resource flowing naturally from a dolomitic compartment. This already confirms that this resource is vulnerable with regard to exploitation and pollution by upstream water users.

Dolomite is the most significant rock type when it comes to groundwater potential due to the nature of the groundwater occurrence in it. The dolomite from the Chuniespoort Group represents the most important underground water aquifer in South Africa (Barnard, 2000), and therefore makes the GMB a very significant water resource in South Africa.

From the research on the geology and geo-hydrology of the GMB and surrounding area, it is evident that there are various potential threats and future risks with regard to the water of the GMB. The GMB is a natural discharge area for underground water from the Boskop-Turffontein Compartment (BTC). There is already evidence of mining related water pollution impacting the water quality at the GMB with a fourfold increase in uranium concentrations measured between 1995 and 2003. Existing theories predict a possible increase of flow at

the GMB as the three dewatered dolomite compartments east of the BTC are linked through mining voids to form a mega compartment with the GMB as the topographical lowest point of outflow on the surface. This means that the GMB would be the first point of outflow of the new mega compartment, decanting contaminated mine water as the dewatered compartments are allowed to refill and infiltrate or spill over into the BTC.

The nature and extent of the geology and geo-hydrology of the GMB could put this resource at risk of pollution and contamination due to upstream water users and activities in view of all the facts regarding the specific area and current situation. The geology and geo-hydrology of the GMB also make this a very significant water resource with immense potential in the provision of potable water to Potchefstroom and surrounding area if it is developed, managed, used, protected, conserved and controlled in an effective and sustainable manner as stated in the NWA (RSA, 1998).

5.2.2. Legislation

Legislation in South Africa with regard to water services management has come a long way. The water-related legislation in South Africa has changed and evolved over the past few years with the focus shifting towards a more local level and specific guidelines set up for the management of groundwater resources in dolomitic areas of South Africa. The specific roles and responsibilities of the different institutions of state have been defined and structures have been put in place to move towards an integrated water resource management approach.

However, even though on paper all structures, plans and guidelines have been put in place, their actual implementation has not happened in an effective and efficient manner. The NWA makes provision for 22 catchment management agencies that are to take over some of the responsibilies and functions of the DWA in an effort to provide better management services for the nation's water resources. Of these 22 CMAs, only two have been established and therefore the DWA remains the sole custodian of most of the nation's water resources. In the

case of the GMB and Mooi River Catchment area, there is no CMA and the DWA is the custodian of the water resources.

Taking a look at further legislation with regard to municipal responsibilities in terms of the Municipal Structures Act, it is evident that a paradox exists where the responsibilities of the district and local municipalities are concerned (see 3.3.5 above).

The result of all of this is that confusion and grey areas exist regarding the roles and responsibilities of district and local municipalities especially in the case of water services, which most often leads to poor and ineffecient management of the water services in a specific area. Furthermore, the DWA does not have the capacity and necessary skills to manage the water resources on its own. This is the case with the GMB. The DWA has limited capacity and currently no support from local municipalities in the area with regard to the management of the water resources.

5.2.3. Role-players and Stakeholders

The key role-players identified in the management of the GMB, that are actively involved with the management of the GMB at present. are the DWA and the private landowners of the farm on which the GMB is situated and of the surrounding farms. There are some environmental and geology specialists involved in research concerning the GMB and the potential future impacts and threats to this water resource. The private landowners take minimal responsibility for the upkeep of the natural environment of the GMB and the DWA currently monitors the flow rate and the water quality in respect of the pH of the water.

It is evident that according to the legislation, where water services management is concerned in South Africa, the primary role-player is the DWA. In the NWA, provision is made for several other institutions such as CMAs, but in the case of the GMB none of these institutions have been established for the catchment

area. The Municipal Structures Act delegates some authority over bulkwater supply to the District and Local Municipalities. Their involvement however does not include the management of resources of potable water for towns. In the case of the GMB, this means that Tlokwe Local Municipality is not an active role-player in the management of this resource of potable water for the city of Potchefstroom even though it is the primary stakeholder with regard to the utilisation of this water. Not all role-players in the management of the GMB have been clearly defined so as to ensure effective and co-operative governance within the sphere of integrated water resource management (IWRM) in South Africa.

The Tlokwe Local Municipality, residents of Potchefstroom and the farm owners are the primary stakeholders in the GMB. It is clear from the empirical study that there is a definite lack in knowledge concerning the GMB on the part of the stakeholders involved. A very high percentage of the respondents indicated the 'do not know' option on statements concerning basic facts and information on the GMB and the management of the GMB. In order to manage this water resource and plan for the future management, the necessary knowledge and information concerning the GMB should be made available and presented to all involved role-players and stakeholders.

5.2.4. Management of the GMB

From the empirical study into the current management of the GMB, it is evident that perceptions are unclear and somewhat vague on who the responsible role-players are. As it stands at present, the current management of the GMB is solely the responsibility of the DWA. The Tlokwe Local Municipality is not involved with the management of this water resource and the private landowners have taken some very limited responsibility for the physical environment of the GMB by wanting to take care of their private properties.

For the planning of and future management of the GMB, all respondents in the empirical study agreed that an IWRM approach is necessary together with

public-private-partnerships to ensure the sustainable and effective management of this valuable water resource. Currently, the idea is to work towards IWRM regarding the management of all water resources in South Africa. The DWA has a shortage of manpower and qualified, skilled personnel and cannot manage all water related services and their development and maintenance all alone. The only option is partnerships with the private and public sectors in order to build capacity and add skills.

Sustainable development is a key term with regard to management within the legislation and policies of South Africa at present. Co-operative governance (COG) has been defined as a new way to facilitate sustainable development in the more effective management of natural resources. COG does not only involve the interactions and governance between different institutions of state, but it also has a broader focus that includes outside public and private groups of influential people (Nealer, 2009b). From the respondents in the study it is clear that this is the way to go for the future management of the GMB. This resource need to be managed so as to achieve sustainable development at the end of the day.

5.3. RECOMMENDATIONS

In an effort to work towards the more effective management of the GMB as an important resource of potable water for the city of Potchefstoom and its residents, , the following recommendations are made on the basis of the logical conclusions drawn from the study:

5.3.1. Geology and Geo-hydrology

- Waterflow rate monitors should be installed and monitored in order to measure the exact flow contribution of each of the three tributaries of potable water to Potchefstroom (the Mooi River, Wonderfontein Spruit and the GMB) so as to ensure the future sustainability and quality of the water.
- Considering the concerns with regard to the water quality of the Wonderfontein Spruit and the geological and geo-hydrological connections

with the GMB, a full range of analyses of the chemical aspects of the water quality of the GMB should be undertaken continuously in order to note any changes that can have a detrimental effect on and create an environmental health risk for the downstream users and consumers in Potchefstroom.

- Specific guidelines and procedures on the management of groundwater resources within dolomite areas of South Africa must be followed and implemented in the management of the GMB to ensure safe and economic development.

5.3.2. Legislation

- The roles and responsibilities of District and Local Municipalities with regard to water services management should be clearly defined in order to clear up confusion. A district municipality should delegate authority to its subordinate local municipalities with regard to their water services management.

5.3.3. Role-players and Stakeholders

- Tlokwe Local Municipality should take a more visible and active role and become an active role-player in the improved management of the GMB as it is a valuable resource of potable water for Potchefstroom. The DWA does not have the capacity to manage the resource and surrounding areas on its own. It needs the support and help of the surrounding local municipalities in order to ensure improved management of the Mooi River Catchment.

- All involved role-players and stakeholders in the management of the GMB should be informed about the nature and extent of the GMB with regard to its geology and geo-hydrology, water quality and water potential as an important resource of potable water for the city of Potchefstroom and all its residents.

- An active awareness campaign relating to the potable water resources of Potchefstroom, with emphasis on the GMB as the largest natural fountain in the Southern hemisphere and the sensitive geo-hydrology of the area, should be undertaken in an effort to inform the stakeholders and create awareness.

5.3.4. Management of the GMB

- Effective public-private-partnerships must be identified and pursued between the different institutions of state (the DWA and Tlokwe Local Municipality), local private institutions (geology and environmental specialists, private landowners) and public institutions (the North-West University) in an effort to work towards the more effective management of the GMB.

- Co-operative governance should be implemented as a vehicle towards sustainable development in the management of the GMB. This includes IWRM and public-private-partnerships.

5.4. FURTHER RESEARCH

In this study the primary focus has been on the management of the GMB as an important resource of potable water for Potchefstroom. The following valuable areas of research with reference to the GMB and its significance have been identified:

- Aspects such as the cultural heritage and history of the GMB could be researched and investigated together with possibilities for eco-tourism in an effort to stimulate awareness of the GMB and surrounding area.

- Research into the overall management and transportation of potable water resources for Potchefstroom and the possibility of closed pipelines as opposed to open-on-top cement canals could be undertaken.

- Ongoing research concerning the geological and geo-hydrological significance of the area along with the connections of underground dolomitic compartments and the impact of mining should be continued.

5.5. SUMMARY

In this research study, the management of the GMB as an important resource of potable water for Potchefstroom has been investigated, with a focus on specific aspects such as its geology and geo-hydrology, as well as legislative aspects of the management of groundwater resources in South Africa. Contrary to other areas in South Africa, where the demand for potable water far exceeds the available supply, the GMB is an exceptional natural phenomenon considering it is a natural fountain with a constant flow rate over the past years with the potential to supply the city of Potchefstroom with enough potable water to meet all its basic needs.

One of the most important factors established throughout this study is that the nature and extent of the geo-hydrology of the GMB plays a very important role in its significance as a resource of potable water for Potchefstroom. Furthermore, this sensitive nature places the GMB in a vulnerable position with regard to exploitation and pollution by upstream water users. These aspects were discussed in Chapter 2 of the mini-dissertation.

An overview of water related legislation in South Africa over the past few years was discussed in Chapter 3, with a specific focus on the management of groundwater resources in South Africa. Chapter 4 contains the analysed data of the empirical study conducted with relevant role-players and stakeholders in the management of the GMB through the use of a 5-point Likert-scale questionnaire.

In Chapter 5, logical conclusions have been drawn ensuing from the research study, followed by applicable recommendations. It is evident from this study that the current management structure in place for the management of the

GMB is not effective or efficient in nature. There are many risks involved with the GMB and threats to the future potential and water quality of the GMB. The DWA lack the capacity and necessary skills to manage this water resource on its own, and it requires the help of an integrated co-operative team through the use of public-private-partnerships in order to achieve the more effective management of the GMB.

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APPENDIX A:

More Effective Management of the Gerhard Minnebron as important resource of potable water to Potchefstroom

Questionnaire

Please fill out the following questionnaire by making a tick in the appropriate box.

	Fully Agree	1	Agree	2	Do not know	3	Disagree	4	Fully Disagree	5					
1	The Gerhard Minnebron is an important resource of potable water to Potchefstroom										1	2	3	4	5
2	The management of the Gerhard Minnebron is the responsibility of the Department of Water Affairs										1	2	3	4	5
3	The Gerhard Minnebron is a natural fountain flowing out of an underground dolomitic compartment 6km north of Boskop Dam										1	2	3	4	5
4	The Gerhard Minnebron is the largest natural fountain in the Southern hemisphere flowing at an average yield of 2160m³/hour.										1	2	3	4	5
5	Tlokwe Local Municipality is involved in the management of the resources of potable water to Potchefstroom										1	2	3	4	5
6	The Gerhard Minnebron falls within the jurisdiction boundaries of Tlokwe local Municipality										1	2	3	4	5
7	The private landowners are responsible for the management of the natural environment of the Gerhard Minnebron and the surrounding area.										1	2	3	4	5
8	An effective public-private-partnership is essential to guarantee the more effective management of the Gerhard Minnebron.										1	2	3	4	5
9	An integrated water resource management approach involving all relevant role-players is necessary for the more effective management of the Gerhard Minnebron										1	2	3	4	5
10	The Gerhard Minnebron is at risk of pollution from upstream mining activities in the Wonderfontein Spruit area (example Acid Mine Drainage).										1	2	3	4	5
11	Awareness of the history and cultural heritage of the Gerhard Minnebron as important resource of potable water to Potchefstroom, should be promoted										1	2	3	4	5
12	The Significance of the Gerhard Minnebron as a source of potable water to Potchefstroom should be investigated in more detail with regards to water quantity and quality.										1	2	3	4	5

Comments:	