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GROUNDWATER FOR DOMESTIC WATER SUPPLY

Insights from Research and Municipal Case Studies

WATER RESEARCH COMMISSION

ABOUT THIS PUBLICATION

This publication is compiled from the Water Research Commission (WRC) Research Report entitled *An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa* (WRC Report No. 2158/1/14, September 2014) by J Cobbing, K Eales, J Gibson, K Lenkoe and T Rossouw.

It is written as much for decision makers who are accountable for critical decisions governing sustainability of water supply schemes as for technical specialists such as hydrogeologists, engineers and rural water supply technicians. It is aimed particularly at those who have existing groundwater schemes and / or groundwater potential within their municipal boundaries.

The document provides an holistic understanding of the complex issues involved in operation and maintenance (O&M) for groundwater schemes, and moves the reader from the traditional "discourse of shortage" – i.e. water supply failures in South Africa are due to a shortage of water, skills, funds, spare parts, etc. to an understanding of the centrality of O&M for successful groundwater use for domestic purposes.

To obtain the full WRC Report No. 2158/1/14 contact:
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CONTENTS

ACRONYMS

CHDM	Chris Hani District Municipality
CMA	Catchment Management Authority
DM	District Municipality
DrRSMDM	Dr Ruth Segomotsi Mompati District Municipality
DWA	Department of Water Affairs (now Department of Water and Sanitation)
DWS	Department of Water and Sanitation
GMA	Groundwater Management Area
GMU	Groundwater Management Unit
GRIP	Groundwater Resource Information Project
IDP	Integrated Development Plan
L/s	Litres per second
LM	Local Municipality
M^3/hr	Cubic metres per hour
Ml/day	Megalitre per day
MLM	Mahikeng Local Municipality
MWIG	Municipal Water Infrastructure Grant
NGA	National Groundwater Archive
NMMDM	Ngaka Modiri Molema District Municipality
O&M	Operation and Maintenance
PPC	Parliamentary Portfolio Committee
RDP	Reconstruction and Development Programme
WRC	Water Research Commission
WSA	Water Services Authority
WSDP	Water Services Development Plan
WSP	Water Service Provider
WUA	Water User Association
WWTW	Waste Water Treatment Works
ZAR	South African Rand (unit of money)

1 INTRODUCTION

1.1 The value of groundwater

Groundwater is often called a "hidden resource", since it cannot be seen. The only way in which hydrogeologists can "see" the resource and measure many of its characteristics is via boreholes or wells that penetrate an aquifer.

At world level groundwater exploitation covers approximately 50% of drinking water needs, 20% of the demand for irrigation water, and 40% of the needs of self-supplied industry (UNESCO 2004). Around two-thirds of South Africa's population depends on groundwater for their domestic needs (Braune and Xu, 2006). Johannesburg's earliest safe water supply was groundwater, first from springs and then pumped from the dolomite aquifers to the southwest of the city. Both Pretoria and Johannesburg still rely on groundwater for a proportion of their water supply today (Dippenaar, 2013).

Groundwater has advantages over surface water that can make it particularly suitable for basic water supply, especially in rural areas where technical skills, funding and materials may be in short supply. These advantages are summarised as follows:

- Groundwater is a "proximal resource", meaning it is found close to where it is needed.
- Groundwater is resistant to the effects of drought.
- The natural microbiological quality of groundwater is usually good – but precautionary treatment (e.g. chlorination) is still recommended.
- Groundwater can be developed incrementally as funds and skills permit, and as increasing demand dictates.

1.2 Perceptions of unreliability of groundwater

This document provides a context for decision-makers and commentators on South Africa's water supply schemes in which they can consider the many and varied factors that bear on water scheme sustainability. At the same time, it applies to technical specialists who may tend to take operation and maintenance (O&M) for granted. The emphasis is on **groundwater**, since groundwater has great potential for domestic water supplies in South Africa – and, in contrast, surface water resources may be limited or distant. However many of the observations about the relationship between O&M and scheme sustainability apply equally to groundwater and surface water schemes.

There is a danger that groundwater in South Africa is increasingly being seen as unreliable and problematic by municipal water planners. In a meeting with the Department of Water and Sanitation (DWS) in 2012, mayors of the 24 priority District Municipalities (DMs)[1] declared that "borehole water is not preferred and is not reliable" (PPC, 2012). This perceived unreliability, it is argued, is not because the physical resource is lacking, but because poor O&M makes groundwater schemes unreliable or difficult to manage. O&M is not a simple task because it encompasses a wide variety of issues including allocation of responsibility and funding,

1 The Department of Water and Sanitation (DWS) identified 24 Priority DMs for support in water and sanitation (DWA, 2013).

matching of technology to the situation and circumstances for use, cooperation and collaboration of diverse groups of stakeholders, deployment of suitable skills, recovery of costs, and necessary chains of accountability and responsibility.

1.3 The priority DMs and two case studies selected for the WRC research

As mentioned above, DWS identified 24 Priority DMs for support in water and sanitation. This WRC research concentrated on the 119 Local Municipalities (LMs) that together make up the 24 Priority DMs. These priority DMs include those areas of South Africa with the most severe water supply backlogs. Most of the findings are more widely applicable, however. Much of the information for the study was derived from a series of interviews, carried out in four provinces in South Africa with a range of respondents. Interview material was supplemented by existing hydrogeological data, census data, literature reviews, and other information.

The focus on the four provinces was supplemented by two case studies: one of the rural boreholes in Chris Hani District Municipality (CHDM) in the Eastern Cape Province, and the other of urban groundwater supplies in Mahikeng, North West Province.

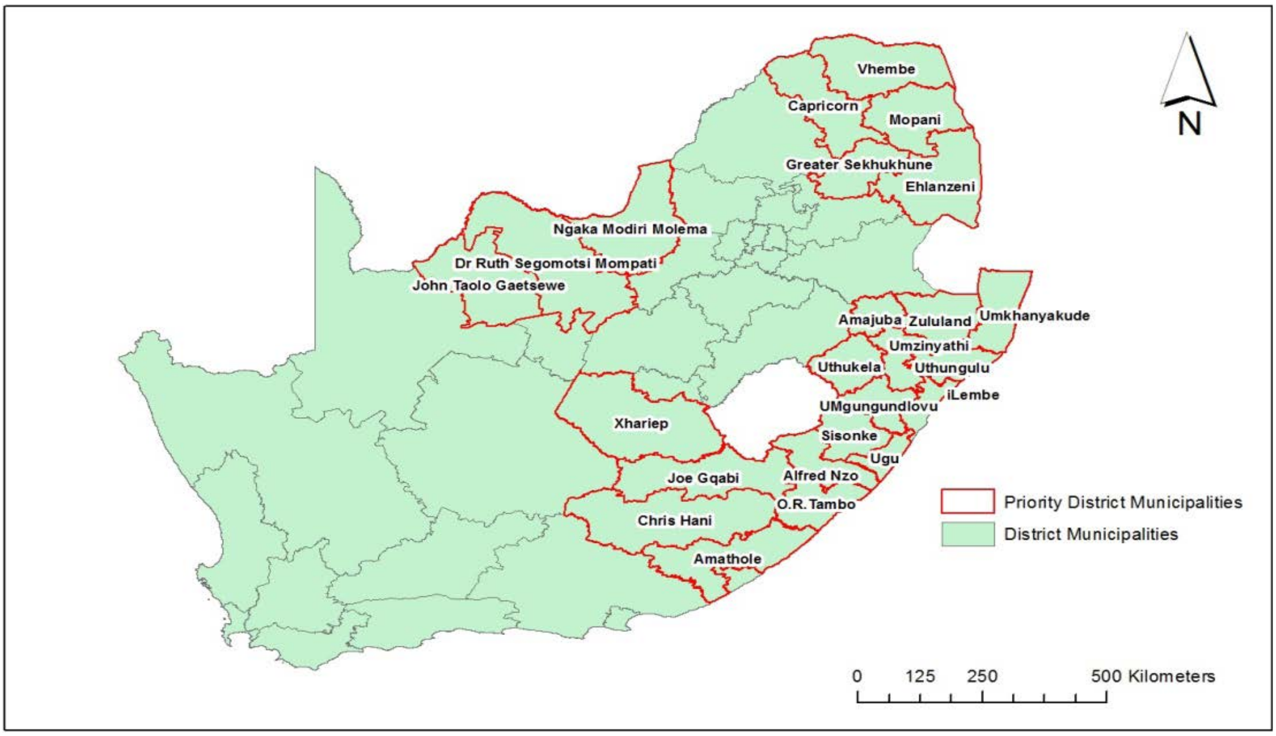

Figure 1: The 24 Priority DMs

2 TECHNICAL, ENGINEERING AND O&M CONSIDERATIONS

As mentioned, municipalities are wary to use groundwater, often because they under-estimate the basic O&M requirements needed to keep a groundwater system delivering water reliably. So when schemes fail it is used as proof that groundwater is unreliable. Groundwater systems offer considerable benefits, often outweighing surface water schemes, but they are not maintenance free. An important starting point for shifting perceptions about groundwater as a water resource is to understand the basic operating requirements.

The research found that the technology underlying small local groundwater schemes is quite simple. Springs require protection and a reservoir; boreholes require a hand pump, diesel pump or electric pump to raise water to ground level or an overhead storage tank; treatment requires little more than chlorination, because underground filtration removes the need for the large settling and flocculation systems to remove solids. Once the aquifer draw-down rate is known, electro-mechanical pumps can be sized correctly, and the pumping regime can be scheduled. From there on site operational management should be straightforward.

One might assume that these simple requirements mean that small groundwater-based schemes are best suited to local authorities and service providers with limited capacity serving extensive rural settlements. However, the real challenge is not technical but logistical. Small groundwater schemes do indeed have smaller pumps, fewer valves, shorter pipelines and simpler treatment requirements; but sound functioning relies primarily on attention to detail and rapid response times when things go wrong. And municipalities often have tens or hundreds of settlements served by boreholes, each of which needs attention and support on site. Duty-and-standby arrangements, common in surface water supplies, are as required in small groundwater systems.

Diesel pumps depend on regular and punctual delivery of fuel. This is a challenge in remote settlements along poor roads, with a limited pool of delivery vehicles. Electrical pumps are less demanding, but they require an electricity supply, and are vulnerable to power outages, power surges and cable theft. Any problem in sourcing spare parts or technical support will prolong the period during which taps stand dry. Electro-mechanical systems break down and fail; they need ready access to skilled personnel.

3 O&M OF GROUNDWATER SCHEMES

O&M includes all of the routine tasks that need to be carried out to keep a groundwater source or wellfield functional – see Table 1 below for a typical list of O&M tasks for groundwater sources. It needs to be tailored for specific circumstances. The various tasks must be costed. The Research Report contains this, along with notes, as Appendix One.

Table 1: A typical list of O&M tasks

Task	Description
Monitoring of water levels	Can be done using a dip meter, but may be more efficient and reliable to use automated loggers once initial trends have been established. Water level data needs to be entered into a database or report to provide the "bigger picture" of the groundwater resource. At some sources it is impossible to access the water level.
Monitoring of water quality	Ionic and microbiological parameters both need to be considered. Sampling protocols and methods of analysis need to be followed. Basic quality monitoring can be done by field personnel by measuring electrical conductivity of water.
Monitoring of pumping rates	Can be done using a flow meter fitted to each borehole, or by other methods such as electricity or diesel consumption. Information needs to be recorded in a database or report.
Monitoring of electricity consumption	Can be done using electricity meters on each borehole power supply, or even by monitoring electricity charges. Information needs to be recorded in a database or report.
Monitoring of water demand	Measuring or estimating consumption by various sectors (domestic, industrial, agricultural, etc.). Information needs to be recorded in a database or report.
Cleaning and maintaining above-ground infrastructure	Visual checks, partial dismantling, cleaning. As recommended by manufacturers. Protection from flooding also necessary.
Cleaning and maintaining submersible pumps	Involves lifting pump out of borehole using special equipment. Can be difficult and expensive. May only be necessary when pump performance declines. Exact schedule depends on hydro-geochemical conditions.
Servicing of diesel engines	Where surface diesel engines are used for positive displacement pumps, these must be serviced and worn parts replaced.
Cleaning and maintaining boreholes	Can be done by over-pumping, surging, acidification, jetting or other methods. May require pumps to be removed. May only be necessary when borehole performance declines. Exact schedule depends on hydro-geochemical conditions.
Cleaning and maintaining treatment facilities	Infrastructure commonly used to treat groundwater such as sand filters and chlorination systems are robust but not infallible. They need to be maintained and serviced in accordance with the manufacturer's recommendations (e.g. sand needs cleaning or changing in sand filters, chlorine supplies need to be restocked, etc.).
Cleaning and maintaining storage reservoirs	Checking for leaks should be a routine task. Removal of silt via a scour valve or even by draining and manual cleaning may be needed at times.
Electrical systems	Visual checks and testing with specialised equipment.
Security of installations	All installations should be secure and off-limits to unauthorised people. Valuable infrastructure should be located underground where possible. Repairs need to be done promptly to prevent further deterioration.
Groundwater protection zone security	If a protection zone has been established, encroachment by people or animals needs to be prevented (fences, etc. need maintaining). Negotiation with communities likely to be necessary. Status of the protection zone needs to be monitored, and some policy regarding enforcement needs to be in place.
Reporting	Data from all the tasks listed above needs to be recorded, and passed to the relevant management organisation or responsible person. In particular, ordering and budgeting for new parts is important.

Source: DWA, 2009

Rogers et al (1998) define O&M costs as those costs needed for "running the system", such as electricity, materials, and staff costs. There is agreement that carrying out O&M on groundwater sources results in lower costs and higher reliability overall. A recent cost-benefit study of groundwater for rural areas in developing countries (Whinnery, 2012) found that:

- Almost 40 times more benefit, than cost, is provided with a properly constructed, operated and maintained well system.
- A three to five times increase in net value is realised with the implementation of an O&M programme.

Neglecting O&M results in much more substantial loss of overall value than most people realise. As Taljaard (2008:42) states, "Basic first-line maintenance is an absolute necessity for sustainable operation of any borehole and plant, and should be conducted conscientiously." There is also the possibility of poor O&M leading to contamination of the aquifer (e.g. from a leaking diesel tank), implying still greater cost.

Failure of groundwater supply schemes is often blamed on the resource (i.e. the aquifer or the groundwater) rather than on the infrastructure (borehole, pump, pipes, valves, etc.) used to abstract the groundwater. It is common to hear that "the borehole dried up" or "the groundwater ran out". In fact, failure of groundwater supply schemes is almost always either due to failure of infrastructure (e.g. blocked borehole screen) or unsuitable pumping regimes (e.g. pumping at very high rates for short periods of time) related to a lack of monitoring. Unsuitable pumping regimes can cause infrastructure failure in several different ways.

Adequate O&M requires a surprisingly complex set of organisational functions and competencies (for example the right human skills, access to the right repair / lifting equipment, a good inventory of spare parts, adequate transport, a mechanism for reporting breakdowns, regular flow of funds, quality of records and analysis of information).

Finally, and in terms of O&M, it must be noted that in South Africa the model of community-based water scheme O&M has not taken root to the extent that it has in much of the rest of sub-Saharan Africa. Our legislation stipulates that local government is responsible for water supply and sanitation provision, through WSAs and Water Services Providers (WSPs), and it is national policy to provide extensive funding to municipalities to undertake the rural water-supply function. Rural communities have too little involvement in water scheme provision and O&M. It is generally accepted that wide stakeholder involvement of some form is a necessary precondition for sustainability. This is despite decentralisation and local government's close involvement in water supply provision. A balanced approach based on local circumstances is probably the answer, in which community involvement and support to local government water supply initiatives is encouraged or facilitated.

4 RESPONSILIBITY FOR O&M

O&M is usually seen as the responsibility of the applicable WSA or WSP. The municipality usually assumes one or both of these roles, but the situation can be more complex. Difficulties with cost-recovery can further complicate matters. Unfortunately, as soon as funds grow short, routine O&M functions are often the first to be cut from budgets. As roles and personnel change the final responsibility for planning and carrying out O&M may become difficult to establish. Tasks once considered routine become exceptional, and then rare. Trained personnel resign. Consultants, engaged to oversee the initial installation of the system, depart. In these circumstances a typical groundwater supply scheme is exposed to a greater risk of failure. Ensuring that O&M tasks are always carried out requires strong overall management, training of operators, and adequate funds. The input of specialist hydrogeologists is likely to be needed from time to time to interpret results and recommend solutions to problems. It is generally more difficult to ensure continuity of O&M than it is to carry out the tasks themselves, and it may even be more difficult and expensive to establish systems for O&M than it is to install the infrastructure in the first place.

In many cases different authorities carry out different O&M functions. Critical to successful O&M are more generic municipal or institutional functions and procedures such as budgeting, training and retention of staff, accountability frameworks, succession planning and other features that have an impact on delivery of services and undertaking routine tasks.

It seems there is no "one size fits all" O&M strategy, but that approaches to O&M need to take into account available skills, funding and other resources, the mix of organisations, as well as the physical constraints such as borehole types, distances, prevalence of theft, topography, etc. One common factor is the need for a consistent budget: once the number of boreholes being maintained rises above a certain level, and given fixed salary and other components, it seems that O&M costs can be remarkably consistent month on month. This raises the need for adequate budgeting for O&M – regular and consistent budgets are needed in the long-term to carry out necessary preventive maintenance. Unfortunately there is often great pressure to invest in capital items (e.g. new wellfields), and this can consume O&M budgets unexpectedly. Capital items bring short-term benefits, whereas investment in O&M may take years to prove its worth.

5 PUBLIC FUNDING FOR GROUNDWATER

Development and management of groundwater infrastructure for water services is not constrained by a shortage of public funds. On the contrary, the number of grants and transfers from national to local government to develop, operate, maintain and rehabilitate water services infrastructure has grown substantially, and well beyond the capacity of some municipalities to absorb and utilise effectively. For the financial year ending June 2013, municpalities spent only 76,9% of the R22,9-billion allocated to them through conditional capital grants; on the operational side, those receiving the Water Services Operating and Transfer Subsidy Grant spent just 49,7% of what they received (Treasury 2011).

In 2013, part of Treasury's rationale for making the Municipal Water Infrastructure Grant (MWIG) a direct grant, rather than a fund disbursed by DWS, was that it hoped this would compel municipalities to make O&M an integral part of its planning and design. The MWIG framework requires WSAs to ensure ongoing effective and efficient O&M of the projects once completed; and requires them to address sustainability in the municipal Integrated Development Plan (IDP), Water Services Development Plan (WSDP) and business plan for each project.

6 CASE STUDIES: CHRIS HANI DM AND MAHIKENG

These two case studies, which come directly from the Research Report, were chosen for the evidence they provide that groundwater is <u>reliable when managed properly</u>, and that the <u>costs are comparable with surface water sources</u>.

6.1 Chris Hani District Municipality (CHDM)

6.1.1 <u>Introduction</u>

Chris Hani District Municipality (CHDM) is one of the 24 Priority DMs identified by DWS, and incorporates some of the most deprived rural areas in South Africa. According to the DWA Priority DM report on CHDM, 98% of the settlements and 80% of the population are classified as "rural" (predominantly in the east). Groundwater has good potential for addressing rural water supply backlogs in CHDM. Figure 2 shows boreholes in the National Groundwater Archive (NGA) (2 635 boreholes) and boreholes in the Eastern Cape Groundwater Resource Information Project (GRIP) database (a further 100 boreholes) which fall within CHDM:

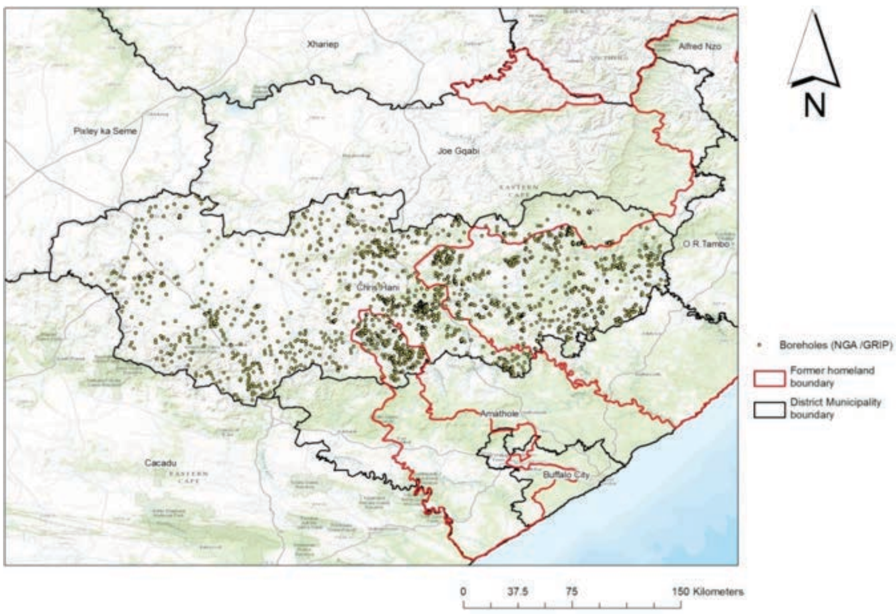

Figure 2: NGA and GRIP boreholes in CHDM

DWA has produced a series of reports for their 24 Priority DMs as part of their Water Services Acceleration Programme. The reports present detailed information regarding the water requirements of communities in each of the 24 Priority DMs. The reports divide the water requirements of each identified community into one of four categories, as set out in Table 2:

Table 2: DWS Categories for Priority DM Communities

CATEGORY	DESCRIPTION
1	Communities having **no formal** water infrastructure
2	Communities requiring **extension** to existing infrastructure
3	Communities with access to infrastructure but no access to water because of **functionality problems**
4	Communities with access to infrastructure but no access to water because of **source problems**

A smaller section of CHDM near Queenstown is shown in Figure 3 (below), with the settlements coloured according to the DWS Priority DM Category. The NGA/GRIP boreholes have also been plotted. Logically enough, boreholes appear to be sited near to communities in general. It is also clear that some communities, despite having several boreholes nearby, are classified as Category 4 communities i.e. communities experiencing problems with the water source. At least in some areas in CHDM, boreholes that are already present are classified as having problems. It is difficult to say what the problem with each borehole might be without visiting the area, but experience in other areas (e.g. North West Province) suggests that borehole failures are usually O&M related. Furthermore, of the 100 boreholes in the Eastern Cape Province GRIP database which fall within CHDM, only 24 are listed as "in use" – the others are either listed as "destroyed" or "unused". (The NGA borehole database unfortunately does not provide the status of the boreholes.)

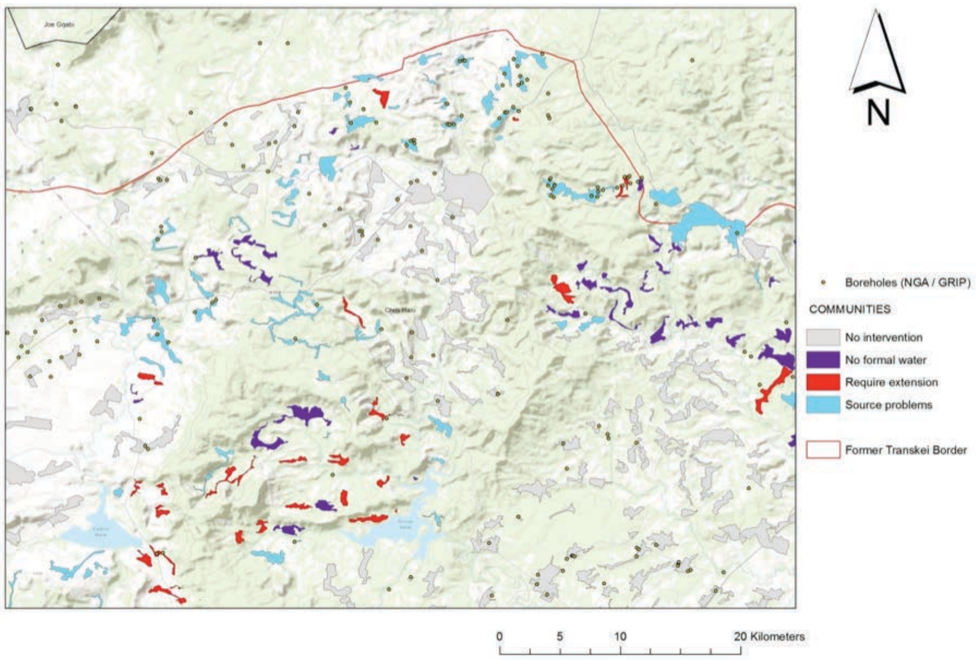

Figure 3: Portion of CHDM with DWS Categories and NGA/ GRIP Boreholes

The data presented for CHDM seems to suggest that boreholes are not necessarily sited for hydrogeological reasons alone, or at least not for reasons that can be shown on existing regional hydrogeological datasets. This implies that such datasets might not be sufficient for accurate local planning, and that local hydrogeological investigations are needed whenever a borehole is established for community / domestic water supply purposes. <u>There is probably no substitute for a local hydrogeological investigation by a qualified hydrogeologist.</u> DWS and others provide numerous guidelines for such investigations (e.g. DWA, 2008). Such locally-applied expertise would also be able to engage with a myriad of issues not directly related to the physical hydrogeology such as land-ownership or tenure problems, logistical issues with drilling rig access and pipeline / electricity services, potential pollution problems and other land-use issues, and the best way to ensure basic protection zones are implemented. All of these issues have a bearing on future O&M requirements and, therefore, on the long-term sustainability of the source.

6.1.2 <u>O&M costs</u>

6.1.2.1 Context

The costs for O&M of groundwater sources and supplies are usually difficult to obtain. Some municipalities do not keep disaggregated data on borehole O&M. In many cases private contractors carry out O&M, and there are not always clear requirements for the submission of data. Reporting of water supply costs by local government to national level (e.g. National Treasury) is aggregated at present, and does not allow comparisons of O&M costs to be made, or average costs per groundwater source to be estimated. O&M costs and the complexity of carrying out O&M is often underestimated.

During the period 2005-2009 CHDM made use of contracted Support Services Agents to work with local communities to ensure effective O&M of rural water supplies in the areas of Tsolwana, Lukhanji, Emalahleni, Intsika Yethu and Sakhisizwe. Maluti GSM (locally-based consulting engineers) were contracted to do this work in Intsika Yethu, Sakhisizwe and parts of Emalahleni. Work included the maintenance of water infrastructure, including the borehole schemes. For the duration that Maluti GSM undertook this oversight role, a record of each visit that artisans paid to each borehole was made (job cards). These were entered into the record as either **R**epair, **I**nspection, **M**aintenance or **S**ervice visits. Maluti GSM aimed to visit at least 75% of the boreholes each month, and a 60-day period as the maximum length of time between visits for individual boreholes.

Given the period over which these entries were made, the dataset generated is considerably extensive, and is being analysed further as part of a separate project (Gibson, pers.comm.). For the research project, a preliminary analysis of this dataset was undertaken with a view to identifying what trends were present in the record to either support the continued maintenance of the borehole schemes, or to support replacement with a more cost-effective option.

6.1.2.2 Data and discussion

For each visit undertaken by Maluti GSM staff, the entry consisted of several columns capturing as much detail as possible. For the WRC research, however, only the data under the columns shown in Table 3 below were considered.

Table 3: Example of entry in the Maluti GSM dataset analysed for the research

Scheme ID	Scheme	Village	Date of Service	Technician	Meter Reading	S/I/R.	Description
SCCH5165	Dayimane	Dayimane	05-Apr-06	Mbesi	617	S	Changed two filters and filled with oil.

The first three columns identify the specific borehole while the fourth and fifth columns contain the visit date and the technician who made the visit. The last two columns provide the category of the visit and a description of what was done.

For each borehole, the number of visits was determined. This was followed by determining for each borehole what number of these were repairs, inspections, maintenance or service. On average the boreholes in the Ntsikayethu (Intsika Yethu) village were visited about 36 times, those in Sakhisizwe village were visited about 40 times, while those in Emalahleni village were visited 34 times.

The next step involved grouping of boreholes based on how they are powered. This resulted in three categories – hand-powered and wind-powered, electrically powered, and diesel and petrol engine. Table 4 below shows the total number of boreholes powered by the different sources described above as well as the respective average number of visits.

Table 4: Summary of boreholes by power source type

Power Source	Number of boreholes	Average number of visits
Hand and wind-powered	13	25
Electrically powered	7	30
Diesel and petrol engine	63	40

As with the previous case, this was followed by the determination for each borehole of the number of repairs, inspections, and maintenance or service entries. Judging by the average number of visits, the diesel and petrol engine powered boreholes seemed to require more attention, followed closely by the electrically powered, with the hand and wind powered boreholes requiring the least amount of attention.

Diesel and petrol engine powered boreholes were serviced most frequently – mainly because they require servicing whilst electrical motors don't. Conversely, based on the percentage number of entries categorised as "Inspection", the diesel and petrol engine powered boreholes are lowest as opposed to the boreholes powered by electricity and wind/hand. It can be inferred from this that hand-powered, wind-powered and electric-powered installations may be more robust than the diesel/petrol powered installations. However, one would need to also take into consideration the unit cost of electric power as well as availability (proximity of power grid) to the water supply area, and the availability of skilled people to carry out repairs on technologically advanced items such as electrical control panels.

6.1.2.3 Analysis

Work by Maluti GSM in the CHDM on O&M (not just groundwater) in mainly rural areas has also allowed some interesting comparisons and costs to be made between gravity schemes and electro-mechanical schemes.

Table 5 shows the O&M costs for a random month (February 2009), including electro-mechanical costs for the source, and staff salaries and travel, but excluding any costs for maintaining reticulation networks. Costs are very simliar month on month (Gibson, pers.comm). All costs are in South African Rands (ZAR).

Table 5: Snapshot of O&M costs in CHDM

	Total	Electro-mechanical schemes	Gravity schemes
TOTAL COST (ZAR)	**1 627 616**	**703 365**	**924 251**
Villages	321	120	201
Cost per village per month (ZAR)	5 070	5 861	4 598
Escalation from Feb 2009	1.26	1.26	1.26
Cost per village per month in 2013 (ZAR)	6 401	7 400	5 805
Average households per village	240	240	240
Kl per household per month (estimated)	3	3	3
Kl per village per month (estimated)	720	720	720
Cost per Kl (ZAR)	**8.89**	**10.28**	**8.06**
Cost per household per month (ZAR)	**27**	**31**	**24**

Figure 4 below shows the breakdown of costs for villages and for villages served by a borehole (BH) (where matl. = material, cbo = community based organisation); and Figure 5 shows the breakdown of costs for villages served by gravity supply.

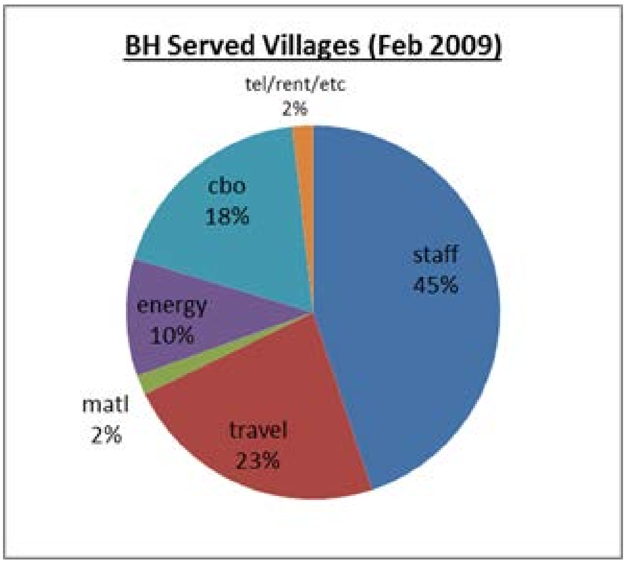

Figure 4: O&M cost breakdown for villages served by boreholes

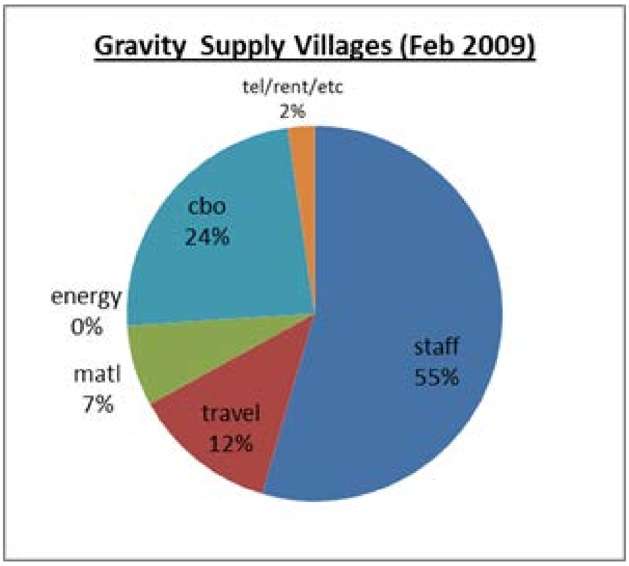

Figure 5: O&M cost breakdown for villages served by gravity supplies

The biggest part of the cost was salaries and travel, which did not vary month on month.

6.1.3 Conclusion

Groundwater is extensively used in the CHDM, particularly in rural areas. Proximity to communities appears to be more important in selecting borehole sites than information on regional hydrogeological properties provided by national-level tools. A viable borehole site must take into account not only the physical groundwater resource but also several other factors such as proximity to the point of use, available land, possible sources of pollution, access to power or road infrastructure. It is likely that only a local hydrogeological investigation can identify all of these factors. A comparison of costs based on data provided by a professional services provider working in parts of CHDM shows that O&M costs for groundwater sources are similar to costs for comparable surface water sources, and that similar reliabilities can be obtained from both sources if timely O&M is carried out.

6.2 Mahikeng and surrounds

6.2.1 Introduction

The town of Mahikeng (a.k.a. Mafikeng) is the provincial capital of North West Province, and is the seat of both Ngaka Modiri Molema District Municipality (NMMDM) and Mahikeng Local Municipality (MLM). The town has a population of about 70 000 people, and the peri-urban villages surrounding Mahikeng have a total population of about 230 000 people. NMMDM is the WSA with the responsibility for water services planning, O&M, etc. Mahikeng is mainly dependent on groundwater for the water supply to the urban centre and peri-urban surroundings (about 75% of the town's supply is from groundwater; and, including the peri-urban areas, about 90% of the population of NMMDM relies on groundwater). Rural areas in NMMDM are almost exclusively groundwater dependent.

6.2.2 Urban groundwater supplies at Mahikeng

The town of Mahikeng has two groundwater sources in the North West Dolomites aquifer, the Molopo Eye spring and the Grootfontein Wellfield at Rooigrond. The Molopo Eye flows naturally over a weir and into a pipeline. At present the Molopo Eye yields about 20 ML/day (about 231 L/s) and the Grootfontein Wellfield yields about 8 ML/day (about 93 L/s). The Grootfontein Wellfield replaced the Grootfontein Eye, a natural spring which used to be channeled to Mahikeng in a similar way many years ago. Abstractions in the Grootfontein dolomite compartment led to the spring disappearing as groundwater levels were drawn down below ground level. The Grootfontein Wellfield used to yield about 20 ML/day (about 231 L/s) but other abstractions in the compartment and other factors such as pipeline breaks have reduced this. According to DWA (2010), five of the nine pumping wells at Grootfontein have been lost due to falling water levels. Water from both the Molope Eye and the Grootfontein Wellfield are piped to the Mahikeng Water Treatment Plant about five km to the southeast of Mahikeng where the flows are combined and the water is chlorinated. The water is then pumped to Mahikeng for reticulation into supply.

Work done by Holland and Wiegmans in 2009 (Holland and Wiegmans, 2009) distinguished between Groundwater Management Areas (GMAs) and Groundwater Management Units (GMUs) in the North West dolomites:

What is a Groundwater Management Area (GMA)?

A GMA generally coincides with surface drainage boundaries (e.g. quaternary catchments). A GMA does not necessarily represent a dolomite compartment or unit (larger area comprising a number of GMUs and GRUs).

What is a Groundwater Management Unit (GMU)?

A GMU is an area of a catchment that requires consistent management actions to maintain the desired level of use or protection of groundwater. GMUs are based on surface water drainage and hydrogeological considerations, each of which represents a hydrogeologically homogeneous zone wherein boreholes tapping the shallow groundwater system will be, to some degree or other, in hydraulic connection.

Holland and Wiegmans (2009) identified 33 GMUs together making up 10 GMAs in the North West Dolomites, as shown in Figures 6 and 7.

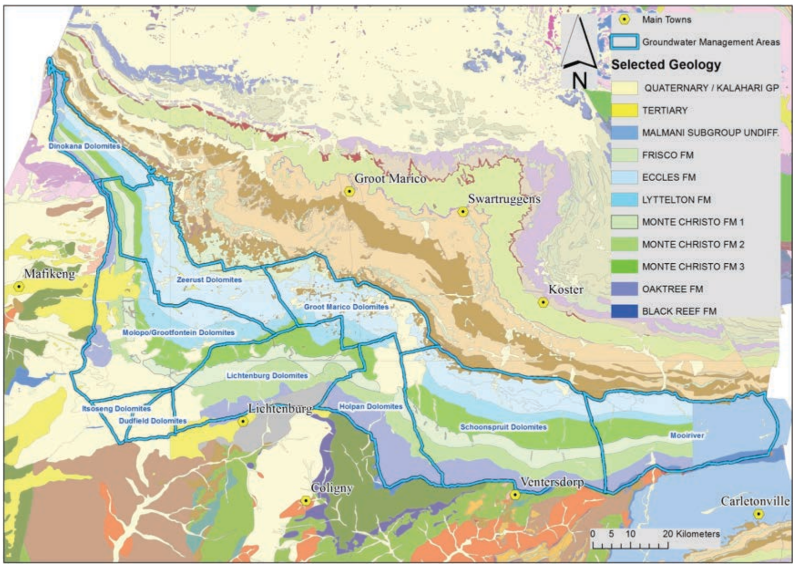

Figure 6: North West dolomite groundwater management areas (Compartment boundaries after Holland and Wiegmans, 2009)

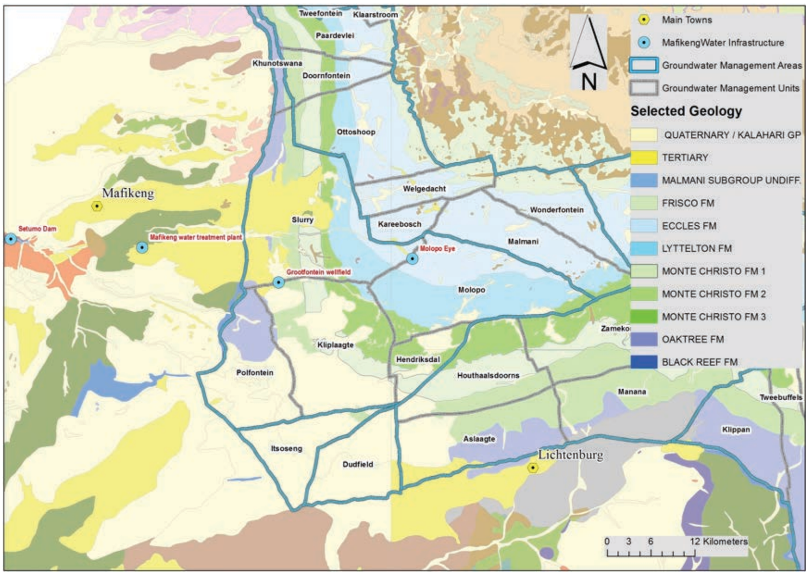

Figure 7: Groundwater management units near Mahikeng (Boundaries after Holland and Wiegmans, 2009)

6.2.3 Peri-urban and rural groundwater supplies around Mahikeng

Groundwater supplies in the peri-urban and rural parts of NMMDM are from boreholes drilled in a variety of lithologies and to a range of depths. They are equipped with electric submersible pumps, surface electric pumps, diesel pumps, wind pumps and other technologies. Botshelo Water Board operates and maintains a large number of these, including 358 boreholes in 30 villages in the NMMDM area and 97 boreholes in 46 villages in the Kagisano Molopo LM. Botshelo Water operates and maintains the following infrastructure on behalf of NMMDM and Dr Ruth Segomotsi Mompati DM (DrRSMDM): 95 diesel engines, 56 electric pumps, 88 hand pumps and 119 wind pumps. Botshelo Water also operates other surface water and groundwater bulk sources for its supplies to peri-urban and rural areas.

6.2.4 Groundwater and surface water quality

Groundwater quality from the dolomites (urban and some peri-urban areas) is reported to be good but hard, with scaling of pipes and fittings (e.g. geyser elements) being a problem. Groundwater quality in rural and peri-urban boreholes not in the dolomite appears to be variable, with high nitrates in some areas a particular concern. High levels of salinity, high hardness and microbiological problems are also recorded. The high nitrate problem is linked in some areas to the extensive use of on-site sanitation (pit latrines), although in other areas the nitrate is thought to be naturally occurring or due to concentrations of livestock. Shallow water tables appear to be well correlated with high anthropogenic nitrate contamination of groundwater and a simple risk map could be constructed using groundwater level information. The problem is an expensive one – treatment of nitrate is usually by blending with water that has lower concentrations of nitrate or, if this is not available, then reverse osmosis is needed with the associated high costs and maintenance requirements.

The surface water component of Mahikeng's water supply is provided by the Setumo Dam to the west of the town centre (on the Molopo River). This water is treated at the Mmabatho Water Treatment Works, about 14 km west of Mahikeng, with an average production of 10 ML/day but a capacity of double that (Botshelo Water, 2013). For much of the year the water flowing into the Setumo Dam is return flows from two wastewater treatments works (WWTW) (Mahikeng and Mmabatho), and the quality of the dam water is poor. The dam is currently eutrophic. Essentially, the "surface water" is recycled wastewater. This makes treatment of the surface water expensive, and further underlines the importance of the high-quality groundwater supplies available to the town. The WWTWs works are being upgraded to improve effluent quality in future.

6.2.5 Division of responsibilities between institutions

The DWS (North West Regional Office) is responsible for the operation of the Grootfontein boreholes and monitoring the resource in the dolomites. DWS is also responsible for the issuing and enforcement of licenses for irrigation abstractions in the dolomite compartments, as well as the pipelines from the Grootfontein boreholes and the Molopo Eye as far as the Mahikeng WWTW. Blockages by reeds and breakages have needed attention in recent years. Many of these functions would be transferred to the Catchment Management Agency (CMA) when this organisation is functional.

Once the groundwater from the dolomites reaches the Mahikeng WWTW it becomes the responsibility of Botshelo Water, who is the bulk water supplier to the municipalities, including NMMDM. Botshelo Water relies on payments by the municipalities for its operating costs. Botshelo Water is also responsible for a number of boreholes in the peri-urban and rural areas, and for a number of bulk water treatment plants.

Reticulation of drinking water, removal of wastewater, billing of residents, maintenance of local water infrastructure and other functions are the responsibility of the relevant municipality. The WWTWs serving Mahikeng are owned by the NMMDM but operated by the MLM. Some peri-urban and rural boreholes still owned by DWS are being transferred to the relevant municipalities, and others are owned or operated by other WSPs (i.e. not the municipalities). Further afield, Sedibeng Water Board operates small town and rural groundwater supplies. Within each entity, there may also be different departments (e.g. the Project Management Unit and the Technical Services Department), which need to maintain close collaboration.

Private contractors play an important role in Mahikeng and surrounding areas, acting as service providers to the various organisations and providing vital technical know-how. These contractors, however, are usually contracted to do a specific task, and are less often involved in high-level decision-making or long-term strategic planning. This can lead to a lack of continuity in some cases, for example where different private contractors are contracted to carry out different work packages, with the risk of insufficient coordination (lack of "economies of scope"). One study does not always build on the preceding one.

Strong cooperation is required between the different role players for water services to function smoothly. At the time of writing (early 2014) there was a dispute between Botshelo Water and NMMDM, with Botshelo Water claiming non-payment and NMMDM stating that Botshelo Water's performance was inadequate. The problem is thought to have contributed to interruptions of water supply, including a complete failure of supply between December 2012 and April 2013 in part of Mahikeng. Disputes also exist between these two organisations and DWS. In wealthier parts of the town many residents have their own borehole supplies (and reverse osmosis (RO) or similar filters for ensuring good drinking water), and so are insulated from supply interruptions to some extent.

6.2.6 <u>Conclusion</u>

The town of Mahikeng is almost entirely groundwater-dependent, and relies on groundwater in two dolomite compartments to the east of the town. One of these compartments, the Grootfontein Compartment, can potentially provide up to 25% of Mahikeng's water supply. However, in recent months (approximately February 2014) the boreholes supplying the town from the Grootfontein Compartment ran dry due to over-abstraction. At present there is no Water User Association (WUA) consisting of the major abstractors in the compartment, nor is there yet a CMA – so these tasks are undertaken by DWS. Cooperation between the various organisations mandated to manage the domestic water supplies of Mahikeng from source to tap appears to be poor, and the town is reliant on the Molope Eye groundwater source only. This source cannot meet projected future demand, meaning that (failing a pipeline carrying surface water from elsewhere) better management of groundwater will become necessary. In Mahikeng some municipal officials believe that a surface water source would solve many problems and is highly desirable – despite a high quality groundwater resource in close proximity to the town, as well as the large distance from the Vaal River. In contrast, the evidence points towards uncoordinated and often poor management (including O&M) of existing water infrastructure assets, due to underlying institutional issues.

7 CONCLUSION

One of the main findings of the research was that absolute / environmental lack of water (i.e. low rainfall, lack of rivers, etc.) does NOT appear to be the main reason for any particular South African community's lack of access to a safe / RDP / improved water supply. The main reasons for lack of access are linked to adequate installation and O&M of water supply systems, which in turn depend on a variety of subsidiary factors and/or institutions. These factors are likely to include the financial competence or ability of the relevant WSP municipality – since the logistics and procurement necessary for O&M requires a level of financial organisation and continuity. Geographical / physical factors such as the scattered nature of communities, the distance to communities, or the availability of roads to reach those communities are also likely to be important.

When these subsidiary factors are taken together with existing backlogs in water supply, and with demographic factors such as unemployment rate or the proportion of communities classified by the census as "tribal" or "traditional", it is possible to compile an index showing the relative task that may lie ahead of each Priority LM in providing a reliable, improved water supply to its communities. Those LMs with a relatively large task ahead are arguably also those that are likely to experience difficulties in future, and are those that may require the most additional support.

The research team made the following recommendations, among others:

1. <u>Groundwater schemes must be planned and installed with advice from a qualified hydrogeologist</u>. Existing tools are very useful in the feasibility study and these can in theory be used by the non-specialist (e.g. an LM technical manager) – but even at the feasibility stage professional advice is recommended as local variations in aquifer conditions or groundwater quality are common. Siting of boreholes cannot be done effectively without a site investigation that takes into account land ownership, access, pollution sources, protection zone requirements, groundwater conditions, etc..
2. <u>A plan for the on-going O&M of an installed groundwater scheme must be developed, and it must be financially and logistically sustainable</u>. The O&M plan also benefits from professional groundwater advice, since the choice of technology can be matched to the existing resource and the envisaged O&M regime. Existing resources or guidelines intended to support O&M are much less common than those aimed at understanding the potential of the physical groundwater resource. There is a need for better O&M resources and more standardisation of groundwater abstraction equipment and procedures to make groundwater supplies more robust.

3. Evidence suggests that the relative life cycle costs of most groundwater and surface water schemes might not be that different if the logistics of providing support to numerous small stand-along groundwater systems are assessed. This evidence underlines the importance of rigorous assessment of the financial and technical feasibility of all water supply options. Perhaps there is scope to explore inputs to inform the review of conditional grants currently being undertaken by Treasury and its partners (in 2014), with a view to supporting better use of national resources to develop sustainable and cost-effective water supply systems.

The research provides an explanation for the success or failure of water supply systems to South African households that attempts to go beyond the traditional "discourse of shortage" – i.e. water supply failures in South Africa are due to a shortage of water, a shortage of skills, a shortage of funds, a shortage of spare parts, and so on. Previous research has shown that successful water supply system installation, O&M is a result of a larger range of inputs and parameters that cross many traditional disciplinary boundaries and are generally complex in the way they interact.

To repeat the primary argument of the research: the main reason groundwater sources fail is because of mechanical breakdowns and other issues related to O&M, and not a failure of the groundwater resource itself. For this reason alone decision makers are urged to explore the groundwater potential in their areas, along with water conservation and demand management measures, to meet growing water demand throughout the country.

Repurposed for a municipal audience by

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