

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

Report to the
Water Research Commission

by

J Cobbing, K Eales, J Gibson, K Lenkoe and T Rossouw

WRC Report No. 2158/1/14
ISBN 978-1-4312-0584-4

September 2014

Obtainable from

Water Research Commission

Private Bag X03

GEZINA, 0031

orders@wrc.org.za or download from www.wrc.org.za

DISCLAIMER

This report has been reviewed by the Water Research Commission (WRC) and approved for publication.

Approval does not signify that the contents necessarily reflect the views and policies of the WRC

nor does mention of trade names or commercial products constitute endorsement or

recommendation for use.

EXECUTIVE SUMMARY

This report is the sixth and final output of Water Research Commission Project K5/2158, aimed at producing research that will support Local Municipalities in developing groundwater resources for water supply, and at informing others in the field. It provides a background to the success or failure of water supply systems to South African households that goes 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 spare parts, a shortage of funds, and so on. Usually, they are not. Whilst shortage of one or other commodity may indeed be the immediate cause of many water supply failures, this is usually a “downstream” consequence of many other issues combined. Many of these issues can be grouped under the heading of “operation and maintenance” (O&M), and they can combine in ways that can be unexpected. The overlapping factors governing groundwater sustainability, and the way in which they extend beyond the traditional concerns of hydrogeologists, should be considered a “complex problem”.

Groundwater cannot usually be “seen” in the same way as a dam or river, and many misconceptions about the resource still persist, such as that groundwater flows in “underground rivers”, that it is mysterious and unreliable, or that water diviners are needed to locate it. In fact, groundwater can be understood and managed in much the same way as other natural resources but this does require specific techniques and expertise. Misconceptions about the physical resource are often amplified by poor choices of technology (e.g. unsuitable pumps) and a lack of appropriate operation and maintenance to result in unreliable groundwater schemes.

This study concentrated on the 119 local municipalities which together make up the 24 “priority” district municipalities (DMs) as defined by the Department of Water Affairs. 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.

Case studies of rural boreholes in Chris Hani District Municipality in the Eastern Cape Province and urban groundwater supplies in Mahikeng, North West Province, show that groundwater is reliable when managed appropriately, and that costs are comparable with surface water sources. On the other hand, poor understanding of the resource and a failure to translate groundwater data into management actions can result in groundwater sources failing and continuity of water supplies being put into doubt. The situation is often exacerbated by poor communication and misunderstanding between the various interlocking organisations tasked with water supply management.

It is argued that all domestic water supply installations using groundwater as a raw water resource need input from a qualified hydrogeologist (groundwater scientist). Even where the resource is easy to find and the quantities needed are small, there are many additional issues such as delineation of protection zones, O&M recommendations based on water quality and other factors, pump duty cycles and other

operating rules, the possibility of artificial recharge and so on which need expert assistance. Since O&M costs often exceed installation costs over the lifetime of a groundwater source, a professional approach to groundwater supply installation in the first place, including appropriate O&M recommendations, will save resources in the long term.

An examination of the various sources of funding for the provision of water supplies at municipal level found that shortage of funds was not normally a constraint on water-supply infrastructure provision. There are however discrepancies between the levels of funding aimed at capital projects, and the amounts allocated to ongoing operation and maintenance. The capacity of local government to absorb and allocate funding can have a bearing on the type and scale of water supply infrastructure chosen. New types of grants (such as MWIG) with greater involvement of the national sphere of government are gaining in importance. Detailed breakdowns of budget spend at local level, particularly with respect to spend on operation and maintenance of water supply systems, are either not available or are difficult to obtain.

Drawing on the finding that physical / hydrogeological factors are only a minor part of groundwater-scheme sustainability, a range of other factors was explored. In the end four main groups of factors were considered in an attempt to characterise and predict the difficulty of the task ahead of each of the priority 119 local municipalities in providing domestic water supplies, as follows:

1. Actual or existing water supply backlogs
2. Demographic indicators such as unemployment
3. Indicators of financial “health” for the relevant water service authority such as audit scores
4. Geographical factors such as community accessibility by road

A series of maps was prepared (see Appendix C of this report) showing relative rankings for a series of sub-factors which together are considered to make up each of the four groups of factors. For example, the geographical factors included road density, average distance to a town of reasonable size, fragmentation of communities in each LM, and so on. By combining the groups of factors into one main map / table, it is possible to arrive at a relative “ranking” for the 119 LMs, and to suggest the 20 “most challenged” LMs in terms of the task of providing domestic water supplies to households in the years that lie ahead. Weightings were not assigned to the various factors, and the many sources of error have been briefly discussed in this report. Nevertheless, the work is an attempt to explore and discuss what are considered to be the “real” factors underlying the success or failure of groundwater supply schemes for domestic water supplies in South Africa. According to this process, the 20 “most challenged” LMs are (in alphabetical order):

LM Code	LM Name	Province
LIM472	Elias Motsoaledi	Limpopo
EC137	Engcobo	Eastern Cape
LIM475	Greater Tubatse	Limpopo
KZN274	Hlabisa	KwaZulu-Natal
KZN233	Indaka	KwaZulu-Natal
EC135	Intsika Yethu	Eastern Cape
KZN272	Jozini	KwaZulu-Natal
LIM473	Makhuduthamaga	Limpopo
EC121	Mbhashe	Eastern Cape
EC443	Mbizana	Eastern Cape
EC156	Mhlontlo	Eastern Cape
EC122	Mnquma	Eastern Cape
EC153	Ngquza Hill	Eastern Cape
EC444	Ntabankulu	Eastern Cape
EC155	Nyandeni	Eastern Cape
EC154	Port St Johns	Eastern Cape
LIM343	Thulamela	Limpopo
KZN271	Umhlabyalingana	KwaZulu-Natal
KZN435	Umzimkhulu	KwaZulu-Natal
EC442	Umzimvubu	Eastern Cape

The LMs with the biggest water supply backlogs (and sanitation backlogs too, although this is not covered in this report) tend to be in the Eastern Cape, KwaZulu-Natal and Limpopo Provinces, and overwhelmingly in former “homeland” areas. Households without improved water supplies tend to be rural and impoverished, with high levels of unemployment, and lack of access to other types of infrastructure such as roads and health care facilities. An examination of available hydrogeological data at national scale for groundwater occurrence (the GRA2 data) shows that there is little or no correlation between regional groundwater occurrence (utilisable potential) and the proportion of households with access to improved water supplies.

This study argues that neither absolute shortage of groundwater nor shortage of funds is the cause of domestic water supply backlogs in South Africa, and that adequate and professional operation and maintenance (O&M) of water supply systems (including groundwater) is in fact the key to sustainable water supplies. There is a danger that failures to adequately operate and maintain groundwater supplies in South Africa will result in the resource being characterised as unreliable or undesirable, and that more expensive options such as desalination or long pipelines to bring surface water will be chosen instead. Alternatively, domestic water supply failures will continue to be characterised in terms of the “discourse of shortage” – South Africa is a dry country, and therefore it is no surprise that water supplies fail or are inadequate. Both of these outcomes have already happened in parts of South Africa, and there is an urgent need to shift away from a narrow focus on “technical” hydrogeological factors to a wider appreciation of the varied strands related to O&M that really determine whether domestic water supplies from groundwater are reliable or not.

Acknowledgements

Many people working for water-related and public-sector organisations across South Africa and beyond assisted with information and made their valuable time available for interviews and discussions. These interviewees are anonymous. Department of Water Affairs staff gave their advice, and provided data and reports – in particular Mr Ernst Bertram, Mr Fred van Zyl, and Mr Stephen Marais. Mr Ben Cobbing of CSS (Pty) Ltd worked on spatial data analysis for the project and contributed many useful insights. Dr Ricky Murray and Dr Kevin Pietersen advised the authors and shared data and experience. Discussions with Dr Nick Robins and Mr Jeff Davies of the British Geological Survey drew on their long experience of African groundwater. Dr Shafick Adams, as the WRC research group leader responsible for the project, maintained the project momentum and kept a tight ship. The project Reference Group provided project direction, review and much useful advice. Thank you.

This project also draws on previous research, in particular the National Groundwater Strategy and the Dolomites Project for the Department of Water Affairs, and Water Research Commission Projects K5/1839 “The impact of IWRM on the lives of women and the poor in South Africa”, K5/2048 “Development of a groundwater resource assessment methodology for South Africa: towards a holistic approach”, and K5/1763 “The delineation of high-yielding wellfield areas in Karoo Aquifers as future water supply options to local authorities”.

AN APPRAISAL OF DIVERSE FACTORS INFLUENCING LONG-TERM SUCCESS OF GROUNDWATER SCHEMES FOR DOMESTIC WATER SUPPLIES, FOCUSING ON PRIORITY AREAS IN SOUTH AFRICA.

CONTENTS

EXECUTIVE SUMMARY	I
1 INTRODUCTION	1
1.1 BACKGROUND TO THE PROJECT	1
1.2 WHO IS THIS REPORT FOR?	1
1.3 INTERVIEWS.....	2
1.4 ORGANISATIONAL LANDSCAPE OF WATER SUPPLY IN SOUTH AFRICA	4
1.4.1 CATCHMENT MANAGEMENT AUTHORITIES	4
1.4.2 WATER USER ASSOCIATIONS.....	4
1.5 THE PRIORITY DISTRICT MUNICIPALITIES.....	5
1.6 ACTUAL WATER SUPPLY BACKLOGS IN SOUTH AFRICA.....	7
2 BACKGROUND TO GROUNDWATER IN SOUTH AFRICA	12
2.1 WHY USE GROUNDWATER?.....	12
2.1.1 PROXIMAL RESOURCE AND RESISTANCE TO DROUGHT.....	13
2.1.2 GROUNDWATER QUALITY	13
2.1.3 INCREMENTAL DEVELOPMENT OF GROUNDWATER	13
2.1.4 AMBIVALENCE TOWARDS GROUNDWATER IN SOUTH AFRICA.....	14
2.2 EXISTING GROUNDWATER ASSESSMENT AND PLANNING TOOLS IN RSA	15
2.2.1 HOW MUCH GROUNDWATER DOES SOUTH AFRICA HAVE?.....	15
2.2.2 GROUNDWATER DATABASES (LATE 19 TH CENTURY TO PRESENT)	16
2.2.3 VEGTER'S GROUNDWATER REGIONS (LATE 1980S TO PRESENT).....	16
2.2.4 NATIONAL GROUNDWATER MAPS (1995)	17
2.2.5 GROUNDWATER RESOURCE ASSESSMENT PHASE 1 (GRA1) (LATE 1990S TO ABOUT 2003)	17
2.2.6 HARVEST POTENTIAL MAP (1998).....	17
2.2.7 NORAD TOOLKIT FOR WATER SERVICES (2004)	17
2.2.8 DWA GUIDELINE (2008).....	17
2.2.9 GROUNDWATER RESOURCE ASSESSMENT PHASE 2 (GRA2) (2005)	18
2.2.10 GRIP (2002 TO PRESENT)	18
2.2.11 SOUTH AFRICAN GROUNDWATER DECISION TOOL (SAGDT) (LATE 1990S ONWARDS)	18
2.2.12 NATIONAL GROUNDWATER STRATEGY (2010)	19
2.2.13 GW ASSESSMENT METHODOLOGY (K5/2048) (2013)	19
2.2.14 WRC K5/1763 (2012).....	19
2.3 DISCUSSION OF GROUNDWATER ASSESSMENT AND PLANNING TOOLS.....	19
2.4 DO WE HAVE ADEQUATE HYDROGEOLOGICAL PLANNING TOOLS IN RSA?.....	21
3 TECHNICAL, ENGINEERING AND O&M RELATED CONSIDERATIONS.....	22
3.1 INTRODUCTION.....	22
3.1.1 RELIABILITY AND 'REPAIRABILITY'	23
3.2 OPERATION AND MAINTENANCE OF GROUNDWATER SCHEMES.....	24
3.3 RESPONSIBILITY FOR O&M.....	25
3.4 SCALING UP / PROFESSIONALISATION	28
3.5 COMMUNITY INVOLVEMENT IN SOUTH AFRICAN RURAL WATER SUPPLY O&M.....	28
3.5.1 SELF-SUPPLY	29
3.5.2 O&M RESOURCES.....	29
4 GROUNDWATER MANAGEMENT	30
4.1 WHAT IS GROUNDWATER MANAGEMENT?	30
4.2 GROUNDWATER MANAGEMENT AND GROUNDWATER GOVERNANCE	31
4.3 DECENTRALISATION	33

4.4	GROUNDWATER DATA	35
5	INFRASTRUCTURE FUNDING SINCE 1994: IMPLICATIONS FOR INVESTMENT IN GROUNDWATER SERVICES.....	37
5.1	INTRODUCTION.....	37
5.1.1	CONTEXT.....	37
5.1.2	INVESTMENT IN WATER SECTOR INFRASTRUCTURE.....	38
5.1.3	SOURCES OF FUNDING FOR WATER SERVICES INFRASTRUCTURE.....	39
5.1.4	GOVERNMENT FUNDING TO MUNICIPALITIES FOR BASIC SERVICES.....	40
5.2	GROUNDWATER AND THE FLOW OF FUNDS FOR MUNICIPAL WATER SERVICES	42
5.2.1	THE CONTEXT OF MUNICIPAL INFRASTRUCTURE FUNDING	42
5.2.2	NATIONAL GRANT FUNDING PROGRAMMES CURRENTLY TARGETING MUNICIPAL WATER SERVICES	44
5.2.3	REGIONAL BULK INFRASTRUCTURE GRANT (RBIG).....	47
5.2.4	THE ACCELERATED COMMUNITY INFRASTRUCTURE PROGRAMME (ACIP).....	48
5.2.5	RURAL HOUSEHOLD INFRASTRUCTURE GRANT	48
5.2.6	URBAN SERVICES DEVELOPMENT GRANT.....	49
5.2.7	MUNICIPAL WATER INFRASTRUCTURE GRANT.....	49
5.2.8	SUMMARY OF GOVERNMENT GRANTS FOR INFRASTRUCTURE SPENDING	56
5.3	OPERATING SUBSIDIES	57
5.3.1	THE EQUITABLE SHARE	57
5.3.2	WATER SERVICES OPERATING GRANT.....	60
5.4	MONITORING AND EVALUATION	60
5.4.1	MIG MONITORING	61
5.4.2	RBIG AND MWIG MONITORING BY DWA	62
5.4.3	MONITORING PERFORMANCE IN ACHIEVING THE PRESIDENTIAL OUTCOMES.....	62
5.5	SOME IMPLICATIONS OF CURRENT WATER SECTOR GRANTS TO MUNICIPALITIES	63
5.5.1	GRANT DEPENDENCE AND MUNICIPAL ACCOUNTABILITY	63
5.5.2	SUSTAINABILITY OF INFRASTRUCTURE FUNDED THROUGH GRANTS	64
6	CASE STUDY OF CHRIS HANI DISTRICT MUNICIPALITY	66
6.1	INTRODUCTION.....	66
6.1.1	TRANSMISSIVITY VARIATION IN CHDM	69
6.1.2	CHDM COMMUNITY CATEGORIES	69
6.2	COSTS FOR O&M AT CHDM	72
6.2.1	DATA AND DISCUSSION.....	73
6.3	PRELIMINARY ANALYSIS OF COSTS	78
6.4	CHRIS HANI CASE STUDY DM CONCLUSIONS.....	81
7	CASE STUDY OF MAHIKENG	82
7.1	INTRODUCTION.....	82
7.2	URBAN GROUNDWATER SUPPLIES AT MAHIKENG.....	83
7.2.1	COMPARTMENTALISATION.....	83
7.3	PERI-URBAN AND RURAL SUPPLIES AROUND MAHIKENG.....	89
7.4	GROUNDWATER QUALITY	91
7.5	SURFACE WATER SUPPLY TO MAHIKENG	91
7.6	FUTURE WATER REQUIREMENTS FOR MAHIKENG.....	92
7.7	INSTITUTIONAL ISSUES FOR WATER SUPPLY IN MAHIKENG	92
7.7.1	BOTSEHO WATER BOARD	92
7.7.2	DIVISION OF RESPONSIBILITIES	93
7.7.3	IRRIGATION NEAR MAHIKENG.....	97
7.7.4	SURFACE WATER OPTIONS FOR MAHIKENG.....	98
7.8	MAHIKENG CASE STUDY CONCLUSIONS	99
8	FINAL EVALUATION.....	101
8.1	INTRODUCTION AND METHODOLOGY	101
8.2	ACTUAL WATER SUPPLY BACKLOGS	102

8.2.1	INTRODUCTION	102
8.2.2	ATLAS MAPS – WATER SUPPLY BACKLOGS.....	102
8.3	DEMOGRAPHIC INDICATORS.....	103
8.3.1	INTRODUCTION	103
8.3.2	DEMOGRAPHIC CORRELATIONS	103
8.3.3	POPULATION AND MIIF TYPE.....	108
8.3.4	ATLAS MAPS – DEMOGRAPHICS	109
8.4	FINANCIAL INDICATORS	110
8.4.1	INTRODUCTION	110
8.4.2	GREEN AND BLUE DROP SCORES.....	111
8.4.3	AUDIT OUTCOMES	111
8.4.4	EXPENDITURE	113
8.4.5	EMPLOYEE COSTS.....	113
8.4.6	REPAIRS AND MAINTENANCE.....	113
8.4.7	LOCAL MUNICIPALITIES UNDER ADMINISTRATION	113
8.4.8	ATLAS MAPS – FINANCIALS.....	114
8.5	GEOGRAPHICAL INDICATORS	114
8.5.1	INTRODUCTION	114
8.5.2	DATASETS USED	115
8.5.3	TOWN DENSITY	115
8.5.4	ROAD DENSITY	116
8.5.5	ROAD INTERSECTS.....	116
8.5.6	DISTANCE FROM TOWNS	116
8.5.7	FRAGMENTATION / EDGE DENSITY.....	116
8.5.8	TOTAL COMMUNITIES.....	117
8.5.9	COMPOSITE GEOGRAPHICAL SCORE.....	117
8.5.10	ATLAS MAPS – GEOGRAPHICAL INDICATORS.....	120
8.6	FINAL COMPOSITE SCORE	120
8.7	METHODOLOGY AND ATLAS MAPS	121
8.8	PRELIMINARY RESULTS.....	121
8.9	SOURCES OF ERROR	126
8.10	RESPONSE TO ERRORS.....	126
8.11	GROUNDWATER SUSTAINABILITY – A LAST LOOK AT GRA2	129
8.11.1	GIS DATASETS USED:	129
8.11.2	GIS PROCESS:.....	129
8.11.3	GIS RESULT:	131
8.11.4	GRA2 CONCLUSION	135
9	CONCLUSIONS	136
9.1	INTRODUCTION.....	136
9.2	TECHNICAL AND MANAGEMENT ASPECTS OF GROUNDWATER.....	136
9.3	INFRASTRUCTURE FUNDING AND INVESTMENT	137
9.4	CHRIS HANI DM CASE STUDY	138
9.5	MAHIKENG CASE STUDY.....	138
9.6	FINAL ANALYSIS.....	139
10	REFERENCES	141
11	APPENDIX ONE: SUGGESTED LIST OF O&M TASKS	149
12	APPENDIX TWO: THE DWA GENERAL MAP CLASSIFICATION SYSTEM	151
13	APPENDIX THREE: ATLAS OF MAPS.....	152

LIST OF FIGURES

FIGURE 1-1 PRIMARY INSTITUTIONAL RELATIONSHIPS BETWEEN WATER SECTOR ORGANISATIONS.....	5
FIGURE 1-2 THE 24 PRIORITY DISTRICT MUNICIPALITIES.....	6
FIGURE 1-3 ACCESS TO PIPED WATER CENSUS QUESTION.....	7
FIGURE 1-4 SOURCE OF WATER CENSUS QUESTION.....	8
FIGURE 1-5 ACTUAL BACKLOGS IN 2011	11
FIGURE 2-1 BASIC AQUIFER MANAGEMENT STEPS ENVISAGED IN THE DWA GUIDELINE (DWA, 2008).....	18
FIGURE 2-2 K7/1763 DETAIL AROUND ZITHULELE HOSPITAL, EASTERN CAPE SHOWING HIGHER TRANSMISSIVITY ZONES	21
FIGURE 3-1 BIG REGIONAL SCHEMES SUBSTITUTE TECHNICAL COMPLEXITY FOR SMALL SCHEMES' LOGISTICAL CHALLENGES (GIBSON, 2011).....	23
FIGURE 5-1 HIGHEST LEVEL OF QUALIFICATION ACHIEVED: MUNICIPAL TECHNICAL SERVICES MANAGERS, 2012.....	43
FIGURE 5-2 TRENDS IN WATER SUPPLY BACKLOGS IN MUNICIPAL CATEGORIES ACCORDING TO DWA DATA	45
FIGURE 5-3 MIG ALLOCATIONS 2006 TO 2012, SHOWING THE PROPORTION MUNICIPALITIES HAVE SPENT EACH YEAR	46
FIGURE 5-4 PERCENTAGE OF MWIG ALLOCATED TO GROUNDWATER-BASED SYSTEMS, 2013/14	55
FIGURE 5-5 GOVERNMENT GRANTS FOR WATER SERVICES INFRASTRUCTURE, 2003-2016.....	56
FIGURE 5-6 GRANT FUNDING AVAILABLE IN 2013/14 FOR WATER SERVICES INFRASTRUCTURE.....	57
FIGURE 5-7 EQUITABLE SHARE ALLOCATIONS PER MUNICIPALITY, 2012/13 AND 2013/14 COMPARED.....	58
FIGURE 5-8 EQUITABLE SHARE ALLOCATIONS TO LOCAL GOVERNMENT, 1999-2013.....	59
FIGURE 6-1 NGA AND GRIP BOREHOLES IN CHDM.....	66
FIGURE 6-2 CHDM WITH GRA1 DATA AND NGA/GRIP BOREHOLES	67
FIGURE 6-3 DETAIL OF CHDM WITH GRA1 DATA AND NGA/GRIP BOREHOLES.....	68
FIGURE 6-4 PORTION OF CHDM WITH TRANSMISSIVITY ZONES	69
FIGURE 6-5 PORTION OF CHDM WITH DWA CATEGORIES AND NGA/GRIP BOREHOLES	71
FIGURE 6-6 O&M COST BREAKDOWN FOR BOREHOLE SERVED VILLAGES.....	79
FIGURE 6-7 O&M COST BREAKDOWN FOR VILLAGES SERVED BY GRAVITY SUPPLIES.....	80
FIGURE 7-1 MOLOPO EYE (LEFT) AND A BOREHOLE AT GROOTFONTEIN (RIGHT).....	84
FIGURE 7-2 NW DOLOMITE GROUNDWATER MANAGEMENT AREAS (COMPARTMENT BOUNDARIES AFTER HOLLAND AND WIEGMANS, 2009).....	85
FIGURE 7-3 GROUNDWATER MANAGEMENT UNITS NEAR MAHIKENG (BOUNDARIES AFTER HOLLAND AND WIEGMANS, 2009)	86
FIGURE 7-4 MAHIKENG'S WATER SOURCES AND MONITORING BOREHOLES AT GROOTFONTEIN (COMPARTMENT BOUNDARIES AFTER HOLLAND AND WIEGMANS, 2009)	87
FIGURE 7-5 HYDROGRAPHS FOR THE GROOTFONTEIN GROUNDWATER COMPARTMENT	89
FIGURE 7-6 MUNICIPALITIES IN NW PROVINCE	95
FIGURE 7-7 RURAL AND PERI-URBAN BOREHOLES OPERATED BY BOTSHELO WATER WITH BASIC GEOLOGY	96
FIGURE 7-8 MAHIKENG WATER TREATMENT PLANT	99
FIGURE 8-1 RDP ACCESS VS EMPLOYMENT	104
FIGURE 8-2 RDP ACCESS VS TRIBAL / TRADITIONAL HOUSEHOLDS	105
FIGURE 8-3 RDP ACCESS VS LOW INCOME HOUSEHOLDS	105
FIGURE 8-4 RDP ACCESS VS NON-WORKING AGE PEOPLE	106
FIGURE 8-5 UNEMPLOYMENT RATE VS NON-WORKING AGE PEOPLE	106
FIGURE 8-6 UNEMPLOYMENT RATE VS LOW INCOME HOUSEHOLDS	107
FIGURE 8-7 UNEMPLOYMENT RATE VS TRIBAL / TRADITIONAL HOUSEHOLDS.....	107
FIGURE 8-8 MIIF CATEGORIES VS NO ACCESS TO RDP STANDARD WATER	109
FIGURE 8-9 COMBINED RANKINGS FOR ALL 119 PRIORITY LMS	128
FIGURE 8-10 LM AND QUAT INTERSECTS FOR PART OF NW PROVINCE.....	130
FIGURE 8-11 GROUNDWATER AVAILABILITY PER LM IN A DRY YEAR.....	133
FIGURE 8-12 GROUNDWATER AVAILABILITY PER LM IN A WET YEAR	134
FIGURE 13-1 ACCESS TO RDP STANDARD WATER IN 2001	153

FIGURE 13-2 ACCESS TO RDP STANDARD WATER IN 2011	154
FIGURE 13-3 IMPROVEMENT 2001 TO 2011	155
FIGURE 13-4 POPULATION PER PRIORITY LM	156
FIGURE 13-5 PROPORTION OF "TRIBAL OR TRADITIONAL" COMMUNITIES	157
FIGURE 13-6 UNEMPLOYMENT RATE PER PRIORITY LM.....	158
FIGURE 13-7 MIIF TYPE FOR EACH PRIORITY LM.....	159
FIGURE 13-8 EMPLOYEE COSTS AS % OF TOTAL EXPENDITURE.....	160
FIGURE 13-9 REPAIRS AND MAINTENANCE EXPENDITURE AS % OF TOTAL EXPENDITURE	161
FIGURE 13-10 AUDIT OUTCOMES	162
FIGURE 13-11 BLUE AND GREEN DROP SCORES	163
FIGURE 13-12 FRUITLESS AND WASTEFUL, UNAUTHORISED AND IRREGULAR EXPENDITURE AS % OF TOTAL EXPENDITURE	164
FIGURE 13-13 SUBSET OF TOWNS USED IN GEOGRAPHICAL ANALYSIS	165
FIGURE 13-14 SUBSET OF ROADS USED IN GEOGRAPHICAL ANALYSIS	166
FIGURE 13-15 TOWN DENSITY (RANK 1).....	167
FIGURE 13-16 TOTAL ROAD DISTANCE (RANK 2)	168
FIGURE 13-17 ROAD INTERSECTIONS (RANK 3).....	169
FIGURE 13-18 DISTANCE FROM TOWN (RANK 4).....	170
FIGURE 13-19 FRAGMENTATION INDEX (RANK 5)	171
FIGURE 13-20 RELATIVE NUMBER OF COMMUNITIES (RANK 6)	172
FIGURE 13-21 WATER SUPPLY BACKLOG INDICATORS COMBINED	173
FIGURE 13-22 DEMOGRAPHIC BACKLOG INDICATORS COMBINED	174
FIGURE 13-23 FINANCIAL BACKLOG INDICATORS COMBINED	175
FIGURE 13-24 GEOGRAPHICAL BACKLOG INDICATORS COMBINED	176
FIGURE 13-25 ALL INDICATORS COMBINED.....	177

LIST OF TABLES

TABLE 1-1 AIMS OF WRC PROJECT K5/2158	1
TABLE 1-2 LIST OF INTERVIEWEES	3
TABLE 1-3 THE 16 LMS WHICH ARE WSAS OUT OF THE 119 PRIORITY LMS	7
TABLE 1-4 RDP STANDARD ACCESS TO PIPED WATER SINCE 2001 FOR PRIORITY LMS.....	10
TABLE 5-1 SUMMARY OF NATIONAL GRANTS AND FUNDS FOR LOCAL GOVERNMENT TO SUPPORT PROVISION OF BASIC WATER SERVICES	41
TABLE 5-2 ALLOCATION OF RBIG FUNDS 2013-2016, BY TYPE.....	47
TABLE 5-3 ALLOCATIONS TO ACIP, 2014/15	48
TABLE 5-4 MWIG ALLOCATIONS PER CATEGORY 2013/14	50
TABLE 5-5 MWIG MTEF ALLOCATIONS 2013/14-2015/16.....	51
TABLE 5-6 THE EQUITABLE SHARE FORMULA 2014/15.....	58
TABLE 6-1 DWA CATEGORIES FOR PRIORITY DM COMMUNITIES	70
TABLE 6-2 EXAMPLE OF ENTRY IN THE MGSM DATASET ANALYSED FOR THIS STUDY.....	73
TABLE 6-3: SUMMARY OF ENTRIES ON BOREHOLES WITHIN THE NTSIKAYETHU (INTSIKA YETHU) VILLAGE	74
TABLE 6-4: SUMMARY OF ENTRIES ON BOREHOLES WITHIN THE SAKHISIZWE VILLAGE.....	75
TABLE 6-5: SUMMARY OF ENTRIES ON BOREHOLES WITHIN THE EMALAHLENI VILLAGE	76
TABLE 6-6: SUMMARY OF BOREHOLES BY POWER SOURCE TYPE	77
TABLE 6-7 SNAPSHOT OF O&M COSTS IN CHRIS HANI DISTRICT MUNICIPALITY	79
TABLE 6-8 COMPARISON OF MONTHLY COSTS	80
TABLE 7-1 BULK WATER TREATMENT WORKS AROUND MAHIKENG	90
TABLE 7-2 FUTURE WATER REQUIREMENTS FOR MAHIKENG.....	92
TABLE 8-1 DCOG / TREASURY MIIF CATEGORIES.....	108
TABLE 8-2 AVAILABLE MUNICIPAL AUDIT INFORMATION	111
TABLE 8-3 AUDIT OUTCOME SCORES	112
TABLE 8-4 LOCAL MUNICIPALITIES UNDER ADMINISTRATION	113
TABLE 8-5 COMPOSITE GEOGRAPHICAL SCORES	118
TABLE 8-6 RESULTS SORTED BY ALPHABETICAL ORDER OF LM NAME.....	121
TABLE 8-7 RESULTS IN ORDER OF COMBINED RANK, MOST CHALLENGED TO MOST FAVOURABLE.....	124
TABLE 8-8 GAMAGARA LM RESULT.....	131
TABLE 8-9 GAMAGARA LM WORKED RESULT WITH EQUATIONS.....	132
TABLE 9-1 LIST OF MOST CHALLENGED LMS	140
TABLE 12-1 DWA GRA1 DATA KEY	151

ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
ACIP	Accelerated Community Infrastructure Programme
BRICS	Brazil, Russia, India, China and South Africa
CHDM	Chris Hani District Municipality
CMA	Catchment Management Authority
CMC	Catchment Management Council
CoGTA	Department of Co-operative Governance and Traditional Affairs
DeCoG	Department of Co-operative Governance
DM	District Municipality
DORA	Division of Revenue Act
DPME	Department of Performance Monitoring and Evaluation
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry (former name of DWA)
ES	Equitable Share
FFC	Financial and Fiscal Commission
GDP	Gross Domestic Product
GRIP	Groundwater Resource Information Project
IDP	Integrated Development Plan
IIWSP	Interim Intermediate Water Supply Programme
KPI	Key Performance Indicator
L/s	Litres per second
LM	Local Municipality
M ³ /hr	Cubic metres per hour
MDG	Millennium Development Goal
MGSM	Maluti GSM Consulting Engineers
MIG	Municipal Infrastructure Grant
MIIF	Municipal Infrastructure Investment Framework
MISA	Municipal Infrastructure Support Agent
MTEF	Medium Term Expenditure Framework
MWIG	Municipal Water Infrastructure Grant
NGS	National Groundwater Strategy
NMMDM	Ngaka Modiri Molema District Municipality
NORAD	Norwegian Agency for Development Cooperation
NWRS	National Water Resource Strategy
NWRS2	National Water Resource Strategy (Second Edition)
O&M	Operation and Maintenance
PPC	Parliamentary Portfolio Committee
Quat	Quaternary Catchment
RBIG	Regional Bulk Infrastructure Grant
RDP	Reconstruction and Development Programme
RHIG	Rural Household Infrastructure Grant
RO	Reverse osmosis (alternatively Regional Office of Dept. Water Affairs)

TCTA	Trans-Caledon Tunnel Authority
UGEPE	Utilisable Groundwater Exploitation Potential
USDG	Urban Services Development Grant
VLOM	Village-level operation and maintenance
WASH	Water, sanitation and hygiene
WCWDM	Water Conservation and Water Demand Management
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

AN APPRAISAL OF DIVERSE FACTORS INFLUENCING LONG-TERM SUCCESS OF GROUNDWATER SCHEMES FOR DOMESTIC WATER SUPPLIES, FOCUSING ON PRIORITY AREAS IN SOUTH AFRICA.

1 INTRODUCTION

1.1 BACKGROUND TO THE PROJECT

This Water Research Commission Project is titled “Favourable Zone Identification for Groundwater Development: Options Analysis for Local Municipalities (K5/2158)”. It started in April 2012, and finished in April 2014. This report is the sixth and final deliverable, entitled “Knowledge Dissemination Report (Final Report)” according to the contract. It was renamed “An Appraisal of Diverse Factors Influencing Long-Term Success of Groundwater Schemes, Focusing on Priority Areas” by the Reference Group, and it summarises and draws together the work done over the project term.

The original aims of the project are shown in Table 1-1 below.

TABLE 1-1 AIMS OF WRC PROJECT K5/2158

Aim	Description
1	The main aim of this solicited proposal is to develop a methodology and atlas of favourable target zones for groundwater development for priority municipal areas.
2	Prioritise areas based on aquifer characteristics and socio-economic factors.
3	Develop indicators for groundwater options analysis.
4	Delineate and map the potential target zones [based on desktop analyses and fieldwork.
5	Prioritise the target zones based on aquifer yield, infrastructure costs and treatment costs.
6	Develop conceptual models for all the selected sites.
7	Develop protection zone strategies for the selected target zones.
8	Repackaging of existing management plans for local municipalities.
9	Identify new or improved research and educational opportunities.

Over the course of the research, the project focus has changed from the primary availability of the physical groundwater resource (i.e. the “technical” or theoretical groundwater availability for any given area), via the growing awareness of the primary importance of the operation and maintenance (O&M) of groundwater sources (subsequent to their installation), to an interest in the many organisational and institutional issues which govern how and why O&M is carried out.

1.2 WHO IS THIS REPORT FOR?

This report focuses mainly on water schemes that provide domestic drinking water supplies, rather than the management of the natural or physical resource in aquifers or rivers – although the two are of course related. This report is aimed at a much greater group of people than “technical” specialists such as hydrogeologists, engineers and rural water supply technicians. Many of the critical decisions governing final longevity or sustainability of a given water supply scheme are made by people who may not necessarily have specialist technical knowledge of the water supply systems that are utilised.

As a result, if a scheme fails it may seem natural to blame the source of the water (e.g. the groundwater “dried up”), or some engineering component for failure (“the pump broke”) – whereas in fact these issues are likely to be the “downstream” consequence of earlier decisions made regarding operation and maintenance (O&M). This report tries to provide 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 all bear on water scheme sustainability. At the same time, it will also be useful for technical specialists who may tend to take O&M for granted. The emphasis is on groundwater, since groundwater still 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 surface water schemes.

There is a danger than groundwater in South Africa is increasingly being seen as unreliable and problematic by municipal water planners. In a meeting with the Department of Water Affairs in 2012, mayors of the 24 priority district municipalities 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 operation and maintenance makes groundwater schemes unreliable or otherwise difficult to manage. Operation and maintenance in its widest sense is not a simple task because it encompasses a wide variety of issues including the allocation of responsibility and funding, the matching of technology to the situation and circumstances in which it will be used, the cooperation and collaboration of diverse groups of stakeholders, the deployment of suitable skills, the recovery of costs, and the necessary chains of accountability / responsibility.

1.3 INTERVIEWS

There is considerable data available on groundwater occurrence in South Africa, together with related physical datasets such as rainfall, evaporation, etc. Less information is available on the various ways in which people collaborate or organise to manage water sources – both the legal or official ways in which management is supposed to happen, and the real or “de facto” institutions that are so important to successful water scheme management. For this reason interviews were used as a major data-gathering technique during the course of this research. The list of interviewees is shown in Table 1-2 below. Interviews were supported by notes and / or a recording taken during the interview. Interviews were confidential / anonymous. The interviews were supported by many discussions between the authors, and with experienced hydrogeologists and planners.

TABLE 1-2 LIST OF INTERVIEWEES

No.	Province	Interviewee	Organisation	Main interest	Date
1	E Cape	Consultant engineer	Private consultancy	Water scheme operation	March 2013
2	E Cape	Consultant engineer	Private consultancy	Small-scale irrigation	March 2013
3	E Cape	Borehole maintenance technician	Private consultancy	O&M of small schemes	March 2013
4	E Cape	Municipal engineer	District Municipality	Water scheme operations	March 2013
5	E Cape	Consultant hydrogeologist	Private consultancy	General groundwater, water scheme data	March 2013
6	E Cape	Scientist	Dept. Water Affairs	Rural asset management	March 2013
7	E Cape	Engineer	Water Board	Water supply operations	March 2013
8	E Cape	Consultant hydrogeologist	Private consultancy	Small town water supplies	March 2013
9	Limpopo	Hydrogeologist	Government Department	Groundwater supply and management	March 2013
10	Limpopo	Hydrogeologist	Private Consultancy	Groundwater supply and management	March 2013
11	Gauteng*	Municipal officials	Municipalities	Water supplies	March 2013
12	NW	Consultant engineer	Private consultancy	Water supplies in urban and rural areas	June 2013
13	NW	Consultant engineer	Private consultancy	Water supplies in rural areas	June 2013
14	NW	Engineer	Water Board	Water supply operations	June 2013
15	NW	Municipal technician	Local Municipality	Urban groundwater supply	July 2013
16	Gauteng	Scientist	Dept. Water Affairs	Rural water supply backlogs	July 2013
17	NW	Technical manager	District Municipality	Water supply operations	July 2013
18	NW	O&M technical manager	Private consultancy, previously water board	Rural groundwater supplies	July 2013
19	Limpopo	Hydrological technician	Local Municipality	Rural groundwater supplies	July 2013
20	Gauteng	Economist	National Treasury	Infrastructure funding	August 2013
21	Gauteng	Soil scientist and farmer	University and Water User Association	Groundwater for irrigation, WUAs	August 2013
22	Gauteng	Hydrogeologists	Private consultancy	Groundwater supplies and technical evaluation	August 2013
23	Gauteng	Hydrogeologist	Private Consultancy	Groundwater supplies	August 2013
24	Gauteng	Water Manager	Dept. Water Affairs	Groundwater supplies	October 2013
25	Gauteng	Aid Manager	International Aid Agency	Water Organisations	October 2013
26	Gauteng	Hydrogeologist	Dept. Water Affairs	Groundwater supplies	November 2013
27	NW	Hydrogeologists	Dept. Water Affairs	Groundwater supplies to Mahikeng	March 2014
28	Gauteng	Hydrogeologist	University	Water Organisations	March 2014

**In Gauteng a short talk was given to officials attending a municipal water managers' forum in March 2013 on the subject of groundwater for rural water supplies, and notes were compiled from the questions asked by the audience at the end of the talk.*

1.4 ORGANISATIONAL LANDSCAPE OF WATER SUPPLY IN SOUTH AFRICA

Contemporary South African law provides for a number of interlocking organisations mandated to manage domestic water supplies and sanitation as well as the overall assessment and management of the national water resource. Some of these organisations are constituted, funded and effective, and some are not.

1.4.1 CATCHMENT MANAGEMENT AUTHORITIES

In some ways the “elephant in the room” of South African water / groundwater management is the absence of the Catchment Management Authorities (CMAs) which (amongst other things) are envisaged as the organisations with the authority to manage water resources on a regional scale (Riemann et al, 2012). Since the 1998 Water Act, only two CMAs have been established. There are presently plans to reduce the overall number of CMAs (DWA, 2013e). In the absence of the CMAs, the DWA regional offices are mandated to carry out the tasks that would otherwise fall to the CMA. In some areas this works relatively well, but in others (e.g. North West Province) communication between DWA and other stakeholders is perceived to be poor. Routine monitoring of dolomite groundwater resources in parts of South Africa is in decline (Pietersen, 2013). It is probably fair to say that establishment of the CMAs has not been a political priority over the last decade and a half – the problem is a complicated one, but the net effect on water management functions at local and regional level has been to reduce effectiveness.

1.4.2 WATER USER ASSOCIATIONS

An important form of cooperative local management of water resources provided for in the law is Water User Associations – cooperative bodies of local water users. A Water User Association (WUA) is “a co-operative association of individual water users who wish to undertake water-related activities for their mutual benefit.” (DWA, undated). WUAs allow better control of joint finances and equipment; simplify negotiation with regulators and other stakeholders; facilitate debate and collective decisions; and consolidate joint interests. Where over-abstraction is a problem and there is potential for conflict between different groups of water users (e.g. dolomite compartments), a WUA would help to resolve problems before they arose. However, a current problem with WUAs is the very considerable time and effort needed to set one up – they do not exist in many areas where they would be beneficial, such as around Mahikeng in NW Province.

A WUA is regarded in law as a body corporate, able to borrow money, open bank accounts and enter into legal proceedings. WUAs may represent one sector (e.g. irrigating farmers), or many sectors (e.g. farmers, miners and forestry workers). The Minister of Water Affairs must establish a WUA, once she is satisfied that it is in the public interest and that wide public consultation has taken place. WUAs are generally funded through charges to their members, although in certain circumstances the state may assist with funding. Former subterranean water control boards are required to become WUAs, and this

process must incorporate a measure of transformation in terms of management structure (DWA, 2004). The final powers and functions of a WUA, once established, are delegated by the Minister, who may also remove functions and even dissolve the WUA under certain circumstances.

Figure 1-1 below shows one possible interpretation of the main water sector organisations, and the relationships between them:

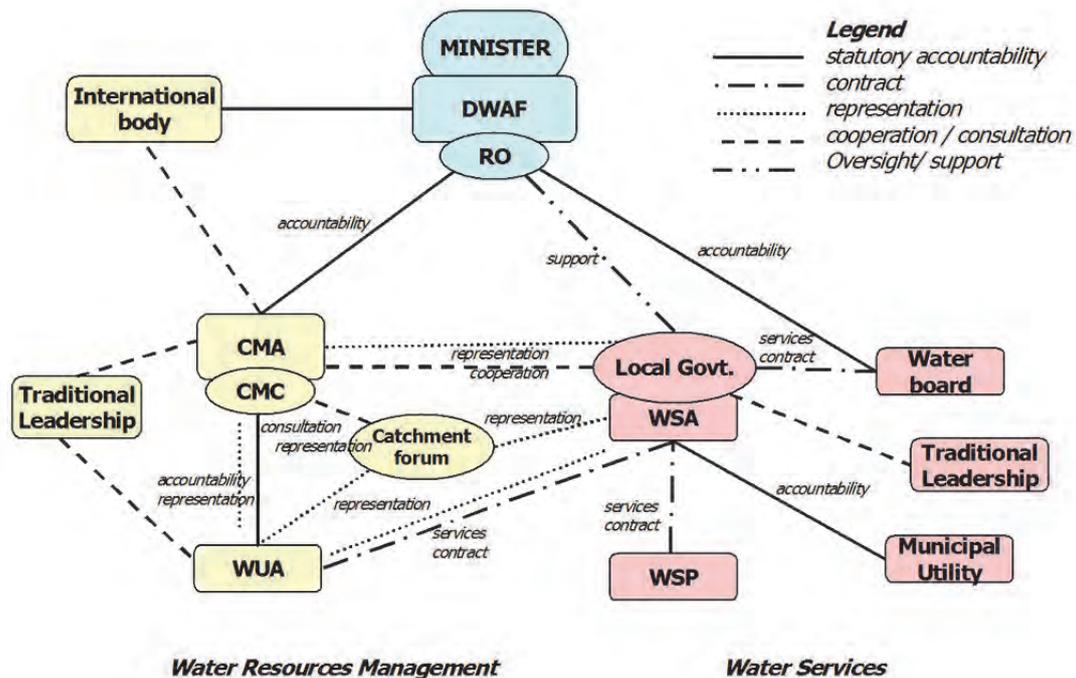


FIGURE 1-1 PRIMARY INSTITUTIONAL RELATIONSHIPS BETWEEN WATER SECTOR ORGANISATIONS

1.5 THE PRIORITY DISTRICT MUNICIPALITIES

The Department of Water Affairs (DWA) has identified 24 Priority District Municipalities for support in water and sanitation (DWA, 2013d). These 24 Priority DMs, broken down into their constituent 119 local municipalities, have been the focus of this study. The local municipality (LM) has been chosen as the “unit of study” since it is at this level (rather than at, say, quaternary catchment level) that many of the decisions are made that influence water supplies. Nevertheless, many other organisations covering different jurisdictional areas in geography as well as in mandate also have a major bearing on the delivery of safe water supplies at LM level – the focus on LMs should not detract from these. In particular, Water Services Authorities (WSAs) which are usually at DM level are responsible for domestic water supplies in their constituent LMs.

The physical availability of groundwater in priority areas in South Africa was examined in Deliverable 1 of this project, and is briefly revisited in this report – see the final chapter. Physical availability of groundwater is not thought to be the major determining factor on sustainable groundwater supplies, however, supported by the fact that many municipalities with the highest or most persistent domestic water supply backlogs are located in areas of relatively good groundwater potential.

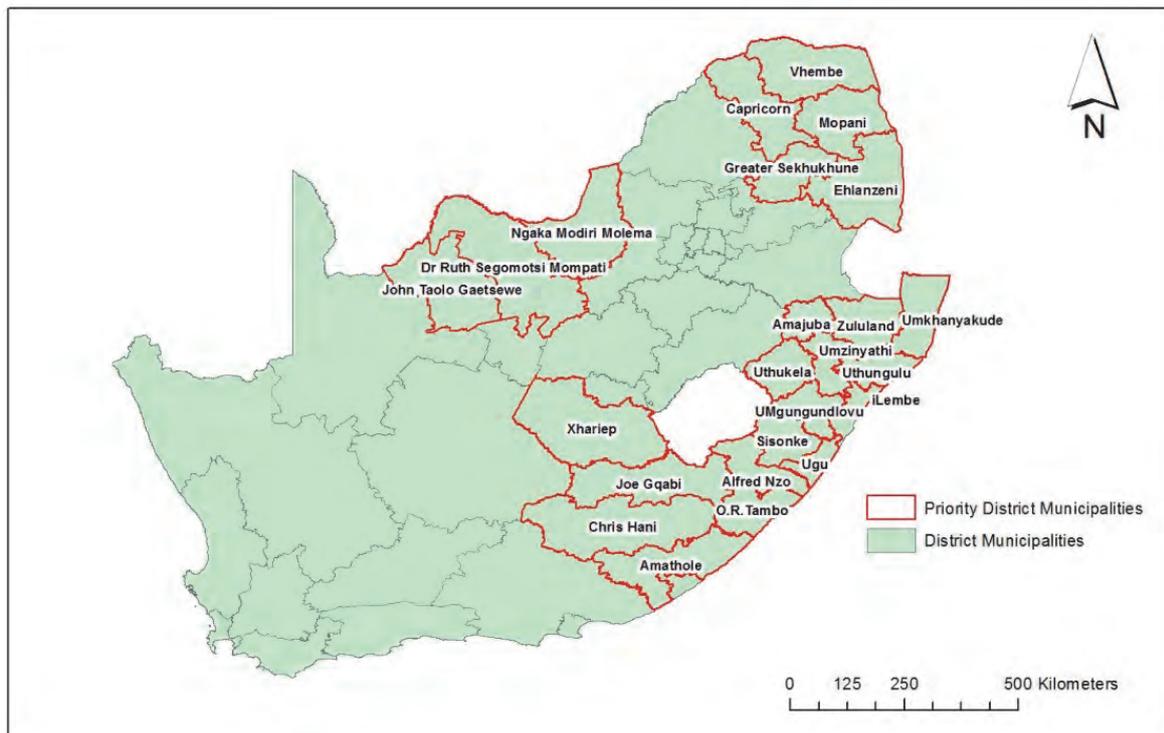


FIGURE 1-2 THE 24 PRIORITY DISTRICT MUNICIPALITIES

Of the 24 priority district municipalities as defined by DWA all but three have responsibility as a Water Services Authority (WSA) for at least one of the 119 priority LMs. 37 WSAs (21 DMs and 16 LMs) make up the total number of WSAs serving the 119 priority LMs. The 16 LMs that are also WSAs are shown in Table 1-3 on the next page:

TABLE 1-3 THE 16 LMS WHICH ARE WSAS OUT OF THE 119 PRIORITY LMS

LM Name	LM Code	MIIF	DM Name	DM Code
Newcastle	KZN252	B1	Amajuba	DC25
Polokwane	LIM354	B1	Capricorn	DC35
Bushbuckridge	MP325	B4	Ehlanzeni	DC32
Mbombela	MP322	B1	Ehlanzeni	DC32
Nkomazi	MP324	B4	Ehlanzeni	DC32
Thaba Chweu	MP321	B3	Ehlanzeni	DC32
Umjindi	MP323	B3	Ehlanzeni	DC32
Gamagara	NC453	B3	John Taolo Gaetsewe	DC45
Ga-Segonyana	NC452	B3	John Taolo Gaetsewe	DC45
Joe Morolong	NC451	B4	John Taolo Gaetsewe	DC45
The Msunduzi	KZN225	B1	UMgungundlovu	DC22
uMhlathuze	KZN282	B1	Uthungulu	DC28
Kopanong	FS162	B3	Xhariep	DC16
Letsemeng	FS161	B3	Xhariep	DC16
Mohokare	FS163	B3	Xhariep	DC16
Naledi	FS164	B3	Xhariep	DC16

1.6 ACTUAL WATER SUPPLY BACKLOGS IN SOUTH AFRICA

Information on access to a water supply in South Africa is derived mainly from data from the last census (2011) and from the census before that (2001). A Community Survey was conducted in 2007 to provide interim statistics, including on water supply. Both censuses asked South African households similar sets of questions regarding access to piped water and source of water, as follows (Stats SA, 2012):

H-07 ACCESS TO PIPED WATER

In which way does this household mainly get piped water for household use?

1 = Piped (tap) water inside the dwelling
 2 = Piped (tap) water inside the yard
 3 = Piped (tap) water on community stand: distance less than 200m from dwelling
 4 = Piped (tap) water on community stand: distance between 200m and 500m from dwelling
 5 = Piped (tap) water on community stand: distance between 500m and 1000m (1 km) from dwelling
 6 = Piped (tap) water on community stand: distance greater than 1000m (1 km) from dwelling
 7 = No access to piped water

Write the appropriate code in the box.

FIGURE 1-3 ACCESS TO PIPED WATER CENSUS QUESTION

H-08 SOURCE OF WATER

What is this household's MAIN source of WATER for household use?

1 = Regional/local water scheme (operated by municipality or other water services provider)
 2 = Borehole
 3 = Spring
 4 = Rain water tank
 5 = Dam/pool/stagnant water
 6 = River/stream
 7 = Water vendor
 8 = Water tanker
 9 = Other

Write the appropriate code in the box.

If 2-9, Go to H-10

FIGURE 1-4 SOURCE OF WATER CENSUS QUESTION

The census questions excluded water used for non-domestic purposes such as stock watering. Households were also asked questions about the reliability of their water supply (i.e. had the household had any interruptions in their piped water supply in the last twelve months, and also whether specific interruptions had lasted longer than two days.) Questions on alternative water sources for households experiencing interruptions in their primary source were also part of the census. The census data is available from a variety of sources including directly from Statistics South Africa, and is also available on-line at <http://interactive.statssa.gov.za/superweb/login.do>.

For the purposes of this Water Research Commission project, household access to piped water falling into the first three categories (Figure 1-3 above) was considered to be an “RDP standard” water supply, after the old Reconstruction and Development Programme minimum standard of an improved water supply within 200 m of a household. Other categories were considered to be not of “RDP standard”. Today an erf connection is regarded as the basic level of service but in many rural areas the RDP standard still needs to be achieved. Potable, improved water supplies from handpumps on boreholes or from protected springs (i.e. groundwater sources) MAY be seen by some households as not strictly “piped (tap)” water and therefore excluded from consideration. In other words access to a safe, RDP-standard water supply from a nearby borehole or protected spring may be considered “no access to piped water”. Since this project is more concerned with the relative positions of local municipalities regarding access to water, rather than absolute backlogs, this potential error was not considered significant for the purposes of the project. To repeat, “RDP standard” is no longer commonly used in South Africa (erf connections are preferred), but for the purposes of this study it is a convenient metric.

Table 1-4 below shows the results of the 2001 and 2011 censuses and the 2007 community survey in terms of the percent of households with access to piped water to “RDP standard” for the 119 Priority LMs. Note that populations have grown since 2001 and that just maintaining percentage household

access requires increasing coverage levels. Results for the 2007 community survey and the 2011 census were only available in the following years. The 2007 community survey results (based on a much smaller sample than the two censuses) show unfeasibly high levels of RDP-standard water-supply coverage for some LMs, for example up to 100% coverage for Great Kei, Inxuba Yethemba, Lekwa-Teemane and other local municipalities, and this was not confirmed by the 2011 census results. For this reason the 2007 community survey results have not been considered in more detail in this project.

Figure 1-5 below shows the actual backlogs in household water supply according to the 2011 census data. Local municipalities are ranked according to the percentage of households in each LM with access to water at RDP standard or better. “%RDP01” indicates the percentage of households in a particular LM with access to water at RDP standard or better according to data from the 2001 census, “%RDP07” indicates the percentage of households in a particular LM with access to water at RDP standard or better according to data from the 2007 household survey, and “%RDP11” indicates the percentage of households in a particular LM with access to water at RDP standard or better according to data from the 2011 census. In most LMs growth in the number of households between 2001 and 2011 implies that absolute numbers of households served to RDP level needs to rise just to keep the percentage of households served to RDP standard constant.

TABLE 1-4 RDP STANDARD ACCESS TO PIPED WATER SINCE 2001 FOR PRIORITY LMS

Code	LM Name	%RDP_01	%RDP_07	%RDP_12	Code	LM Name	%RDP_01	%RDP_07	%RDP_11
KZN263	Abaqulusi	51	82	78	MP322	Mbombela	67	85	72
LIM352	Aganang	58	82	86	KZN281	Mfolozi	22	81	75
EC124	Amahlathi	45	80	71	EC156	Mhlontlo	18	62	45
LIM334	Ba-Phalaborwa	76	100	91	KZN226	Mkhambathini	51	74	61
LIM351	Blouberg	51	79	66	EC122	Mnquma	25	81	44
MP325	Bushbuckridge	45	69	62	FS163	Mohokare	90	100	98
KZN254	Dannhauser	27	41	80	LIM353	Molemole	57	81	69
NW384	Ditsobotla	72	90	82	KZN223	Mpofana	71	96	81
KZN261	eDumbe	46	86	73	KZN244	Msinga	7	49	34
LIM472	Elias Motsoaledi	40	84	58	KZN285	Mthonjaneni	38	87	62
EC141	Elundini	19	75	38	KZN275	Mtubatuba	75	100	61
KZN253	Emadlangeni	41	82	49	LIM341	Musina	82	100	88
EC136	Emalahleni	34	87	75	LIM342	Mutale	45	100	63
KZN232	Emnambithi/Ladysmith	65	78	81	NW392	Naledi	93	100	92
KZN241	Endumeni	86	100	89	FS164	Naledi	87	99	97
EC137	Engcobo	11	69	43	KZN293	Ndwedwe	23	66	59
LIM471	Ephraim Mogale	52	92	79	KZN252	Newcastle	74	82	92
KZN215	Ezingoleni	17	54	56	EC126	Ngqushwa	41	91	71
LIM474	Fetakgomo	32	91	69	EC153	Ngquza Hill	12	88	20
NC453	Gamagara	97	100	99	KZN286	Nkandla	23	68	61
EC144	Gariep	90	100	97	MP324	Nkomazi	59	87	70
NC452	Ga-Segonyana	53	69	76	EC127	Nkonkobe	51	83	80
EC123	Great Kei	56	100	72	KZN265	Nongoma	13	82	37
LIM331	Greater Giyani	57	72	65	KZN242	Nqutu	31	58	63
KZN433	Greater Kokstad	87	99	92	EC444	Ntabankulu	10	75	35
LIM332	Greater Letaba	58	77	75	KZN283	Ntambanana	15	52	48
NW394	Greater Taung	48	59	71	EC128	Nxuba	78	100	94
LIM475	Greater Tubatse	32	75	57	EC155	Nyandeni	9	61	29
LIM333	Greater Tzaneen	50	69	63	KZN235	Okhahlamba	28	54	55
KZN216	Hibiscus Coast	51	68	83	LIM354	Polokwane	65	85	89
KZN274	Hlabisa	16	61	40	EC154	Port St Johns	10	69	24
KZN236	Imbabazane	22	46	50	NW385	Ramotshere Moiloa	70	96	79
KZN224	Impendle	65	88	74	NW381	Ratlou	33	79	61
KZN233	Indaka	52	72	63	KZN227	Richmond	37	81	74
KZN431	Ingwe	34	71	48	EC138	Sakhisizwe	52	95	77
EC133	Inkwanca	92	100	98	EC142	Senqu	41	67	67
EC135	Intsika Yethu	20	82	51	MP321	Thaba Chweu	85	100	91
EC131	Inxuba Yethemba	90	100	99	KZN273	The Big 5 False Bay	28	77	73
NC451	Joe Morolong	37	66	65	KZN225	The Msunduzi	80	86	92
KZN272	Jozini	23	62	46	LIM343	Thulamela	57	75	67
NW397	Kagisano/Molopo	47	68	70	EC132	Tsolwana	55	100	87
EC157	King Sabata Dalindyebo	30	68	52	NW382	Tswaing	72	97	78
FS162	Kopanong	91	99	98	KZN434	Ubuhlebezwe	20	73	47
KZN432	Kwa Sani	68	99	81	KZN266	Ulundi	30	86	62
KZN292	KwaDukuza	64	90	82	KZN212	Umdoni	60	89	85
NW396	Lekwa-Teemane	87	100	98	KZN271	Umhlabuyalingana	17	41	46
LIM355	Lepele-Nkumpi	46	64	68	KZN282	uMhlathuze	77	99	96
FS161	Letsemeng	87	100	94	MP323	Umjindi	73	100	87
EC134	Lukanji	77	95	91	KZN284	uMlalazi	24	72	61
NW383	Mafikeng	56	69	71	KZN222	uMngeni	85	99	91
LIM344	Makhado	60	74	70	KZN221	uMshwathi	56	75	76
LIM473	Makhuduthamaga	27	72	58	KZN234	Umtshezi	66	100	74
EC143	Maletswai	76	100	90	KZN214	UMuziwabantu	28	71	60
NW393	Mamusa	82	100	88	KZN245	Umvoti	37	73	53
KZN291	Mandeni	50	73	71	KZN435	Umzimkhulu	26	54	41
KZN294	Maphumulo	4	53	35	EC442	Umzimvubu	22	74	47
LIM335	Maruleng	65	100	68	KZN213	Umzumbe	11	41	37
EC441	Matatiele	92	70	57	KZN262	UPhongolo	47	81	64
EC121	Mbhashe	7	75	29	KZN211	Vulamehlo	15	65	43
EC443	Mbizana	8	73	10					

LM = Local Municipality

%RDP = percent of households with domestic water supply to RDP standard or better for the relevant census or household survey date and LM

2 BACKGROUND TO GROUNDWATER IN SOUTH AFRICA

2.1 WHY USE GROUNDWATER?

Groundwater can be called a “hidden resource”, since it cannot be seen and is difficult for the layperson to conceptualise. The only way in which hydrogeologists can directly “see” the resource and measure many of its characteristics is via boreholes or wells which penetrate the aquifer. Groundwater is effectively invisible, and in the eyes of policy makers can occasionally be “out of site and out of mind”. Groundwater is in fact much more important in South Africa and world-wide than is frequently realized (UNESCO, 2004). More than 98 % of the world's available fresh water is groundwater, and estimates of the total volume of fresh groundwater in storage range from 7 million km³ to as much as 60 million km³. Groundwater is also the world's most extracted raw material, with withdrawal rates in the region of 600 to 800 km³ a year (UNESCO 2004, Shah et al, 2000). The breakdown of that figure into percentages is distinctly different from that of surface water use, and is biased towards more valuable potable water as follows: drinking water (65%), irrigation and livestock (20%) and industry and mining (15%) (IAH, 2003). At world level – and in proportions that vary widely from one country to the next – 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). In countries such as Austria and Denmark groundwater supplies almost all drinking water. Around two-thirds of South Africa's population depends on groundwater for their domestic needs (Braune and Xu, 2006). Groundwater has been used in Southern Africa by humans for millennia, both “directly” from springs and “indirectly” via baseflow to rivers and lakes. Johannesburg's earliest safe water supply was groundwater, first from springs and then pumped from the dolomite aquifers to the south-west of the city. Both Pretoria and Johannesburg still rely on groundwater for a proportion of their water supply today (Dippenaar, 2013). Perhaps the most important role of groundwater is that it is critical to ecosystems and “environmental goods and services” – an area which has not received enough attention in the past. As Burke and Moench (2000) put it, “Groundwater is an often unnoticed and unacknowledged cornerstone in the foundation of many economic and environmental systems”. Groundwater has advantages over surface water which can make it particularly suitable for basic water supply, especially in rural areas where technical skills, funding and materials may be in short supply (Pietersen, 2005). These advantages are summarised as follows:

- Groundwater is a “proximal resource”, meaning it is usually 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 is still recommended
- Groundwater can be developed incrementally as funds and skills permit and as increasing demand dictates.

These advantages do not mean that groundwater is a “cheap option”, or that it requires lower levels of skills and planning compared with surface water supplies. Both surface water and groundwater have advantages and disadvantages and these need to be understood in the particular context of each scheme. Groundwater is nevertheless very important for domestic water supplies in South Africa, particularly in rural areas. As Hassan et al put it in their analysis for the World Bank, groundwater in South Africa “represents a key source of water supply especially in rural semi-arid areas and mainly for irrigation and domestic use” (2008:5).

2.1.1 PROXIMAL RESOURCE AND RESISTANCE TO DROUGHT

Groundwater is usually found close to where it is needed, particularly in the relatively small quantities required for basic water supply to households. This is in contrast to surface water, which can require extensive infrastructure such as dams, pumping stations and pipelines to bring water to where it is needed at an acceptable level of assurance. This is the main reason why groundwater is important as a basic resource over most of the developing world, and why it is usually favoured by planners and managers in developing rural areas. Groundwater usually takes much longer to deplete and replenish compared with surface water, and this longer timescale helps to make groundwater more resistant to the droughts which can afflict surface water supplies. The volumes of groundwater in storage are often much larger, in a given rural area, compared to volumes found in local rivers and dams.

2.1.2 GROUNDWATER QUALITY

Natural groundwater quality is frequently very good and it can often be drunk as is, in contrast with surface water which requires treatment (usually at least disinfection) before it is fit to drink. However, disinfection (e.g. chlorination) is often carried out at groundwater sources as a precaution. Some of the stages of a typical surface water treatment process such as flocculation and settling are not normally required for groundwater. This can be an advantage in those areas where lack of funds and expertise makes operating surface water treatment plants difficult. Groundwater can have natural quality problems however, and these can be different to those normally experienced by surface water managers (e.g. high fluoride, arsenic or iron concentrations, or simply high natural salinity). A significant difference between surface water and groundwater is that surface water virtually always has to be treated for microbiological contamination (e.g. bacteria or viruses) whereas groundwater may not require this (although it is often done anyway as a precaution), and it is this form of water contamination that causes most of the water-borne diseases in South Africa.

2.1.3 INCREMENTAL DEVELOPMENT OF GROUNDWATER

Groundwater development can be incremental, proceeding one borehole or spring-protection at a time, rather than needing one big initial infrastructure investment like a dam or large pumping station. In parallel with the dispersed nature of the groundwater resource, systems for abstracting groundwater can also stand alone – they do not depend on each other in the same way as a central treatment plant

or pumping station for surface water. If one borehole fails, others in the area should continue to operate. However, the dispersed nature of groundwater (many smaller, simpler schemes compared with one central but more complex system) does raise additional O&M issues and may in fact be more difficult logistically to manage (Figure 3-1).

2.1.4 AMBIVALENCE TOWARDS GROUNDWATER IN SOUTH AFRICA

In the 1970s Raymond Nace of the United States Geological Survey referred to the tendency amongst government officials and planners to generally ignore groundwater and to skew planning resources and expertise towards surface water as “hydroschizophrenia” (Llamas, 1985). This tendency was noted by the Spanish hydrogeologist MR Llamas, who wrote in 1985 that “until recently, groundwater was something of a mystery to most Spanish engineers and scientists, almost a kind of occult science, within the province of water diviners” (Llamas, 1985:161). The same can sometimes be said about South Africa. A practical outcome of hydroschizophrenia is the neglect of groundwater assessment and management at the planning level. Possible symptoms of this ailment include:

- A tendency to think of groundwater resources as limited and fragmented, and very difficult to assess accurately
- The view that groundwater is unreliable, and that boreholes “dry up” for no reason
- An understanding that groundwater exists in “underground rivers or lakes”
- The conviction that groundwater is unhealthy to drink, or backward and rural
- A perception that groundwater scientists are not needed, as water diviners can find and understand groundwater
- Arguments that boreholes are very difficult to manage

In South Africa the regulatory environment may have moved ahead of the technical and engineering community, who still tend to gravitate towards surface water solutions or surface water management approaches (geared to phenomena such as relatively rapid changes in response to rainfall). Some professionals in the technical and planning community in South Africa may still be suffering from hydroschizophrenia. This is partly because our old groundwater laws made regional management difficult, and partly because considerable attention has been paid in South Africa to large surface water schemes (e.g. Lesotho Highlands Water Project or the Vaal Dam), and surface water inter-basin transfers (which link surface water sources to large conurbations). There are also relatively few qualified hydrogeologists working in South Africa. It is worth remembering that our water planning unit – the catchment – reflects surface water flow, not necessarily groundwater.

There is also a resistance to the use of groundwater as a drinking water source by some rural communities and local municipal officials in South Africa. This is partly because groundwater in South Africa is often more mineralised than surface water, due to the nature of the aquifer rock and the rate of groundwater movement. This salinity (brackishness) means users may avoid drinking groundwater,

even where the groundwater quality is well within official standards for human health (and surface water may be microbiologically polluted). Groundwater may also contain concentrations of iron which, although not harmful, can stain clothes during washing. There is also evidence that groundwater sources are seen as less “sophisticated” than surface water sources, particularly where the groundwater source is a hand pump and surface water is delivered via a tap direct to a dwelling (Harvey and Reed, 2004). Reliance on groundwater in rural settlements is also still widely associated with the former ‘homelands’, where boreholes were the default rural water source in a context of severe under-development. Management and maintenance by the designated authorities was generally profoundly under-resourced, and reliable supply was often a function of local initiative rather than formal management.

Probably the greatest false reason for not wanting groundwater schemes in rural areas is the perception that “groundwater is unreliable”, when in fact it is basic infrastructure management (or O&M) that is to blame. Boreholes hardly ever “run dry”, particularly at the low pumping rates needed for rural supplies. In virtually every “failure” where the wider groundwater resource is blamed, it is in reality either pumps that have failed because of lack of maintenance, or pumping rates that have been set too high by unqualified people. In the latter case, the pumps suck air from the bottom of the boreholes although the surrounding aquifers are full, and all it takes to bring that water to the surface is to pump at a lower rate. When surface water infrastructure fails, it’s called a pipe burst; but when groundwater infrastructure fails, the groundwater resource is labelled unreliable! (Murray, pers.comm.)

2.2 EXISTING GROUNDWATER ASSESSMENT AND PLANNING TOOLS IN RSA

2.2.1 HOW MUCH GROUNDWATER DOES SOUTH AFRICA HAVE?

Groundwater in South Africa is in the same league, volumetrically, as our stored surface water resources: The total volume of available, renewable groundwater in South Africa is between 7.5 and 19 km³ per year, depending on how technical factors such as baseflow contribution, extractability and quality are considered (DWA, 2010a and Woodford et al, 2006). It is thought that we currently use about half of this available groundwater (DWA, 2010a). South Africa’s dams have a total capacity of about 32 km³ (DWA, 2004a) – although droughts can reduce this availability. The “assured yield” of South Africa’s surface water resources is about 12 km³ per year, but more than 80% of this total is already allocated (Middleton and Bailey, 2009). Although most large-volume water users rely on surface water, the majority of small water supplies, which are critical to livelihoods and health, depend on groundwater. In 2006 it was estimated that more than half of our population depended on groundwater for their domestic needs (Braune and Xu, 2006). Groundwater is also essential to the water supplies of many South African towns from Beaufort West to Pretoria. Groundwater is however

rarely available in the huge quantities that a dam can provide, being limited by the yield of boreholes or wellfields and the properties of the aquifers.

A lot of work has been done in the past twenty years or so to estimate groundwater availability at national, district and local levels, relating groundwater occurrence to aquifer type, to recharge, to natural groundwater quality, and to other hydrogeological or “technical” factors. Several of these efforts have also tackled the issue of “sustainability” – in other words, trying to quantify not only an expected borehole or aquifer yield, but whether than yield can be maintained indefinitely without negative consequences. Physical or hydrogeological groundwater “sustainability” is a study in its own right (e.g. Kalf and Woolley, 2005 or Sophocleous, 1997) and is more complex than it might appear. It is also important to distinguish between the physical sustainability of the resource (e.g. does the local recharge balance the abstractions) and issues of overall sustainability (sometimes called “assurance of supply”) linked to the engineering, administrative, social and even political dimensions of any given water supply. It is a primary contention of this project that some of the most important factors linked to overall sustainability or assurance of supply are complex and / or hidden.

What follows is a short summary of some of the major past efforts to quantify groundwater resource availability in South Africa, and in some cases to provide tools to decision makers in assessing the physical sustainability of groundwater as a supply in any particular area and in managing the supplies. Most of these resources are available free of charge, and in many cases can be downloaded from the web. The maps can be purchased as hard copies from the Department of Water Affairs.

2.2.2 GROUNDWATER DATABASES (LATE 19TH CENTURY TO PRESENT)

Much of the public borehole and related data collected by the Department of Water Affairs and its predecessors over many years is now consolidated into the on-line DWA National Groundwater Archive (NGA), although groundwater licensed abstraction data and groundwater quality data is held in databases such as WARMS and WMS. Also important are DWA’s Geohydrology (GH) series of groundwater reports, dating back to 1906, many of which are available on-line and free of charge from the DWA website (at: <http://www.dwaf.gov.za/ghreport/filter.aspx>). The NGA currently has around a quarter of a million borehole records. Considerable groundwater data and information is also held by the private sector (e.g. drillers, mines, groundwater consultants), which is often not accessible.

2.2.3 VEGTER’S GROUNDWATER REGIONS (LATE 1980S TO PRESENT)

A long-term project based on the division of South Africa into a series of “Groundwater Regions” was initiated and led by the renowned former Director of Geohydrology at DWA in the 1980s, JR Vegter (Vegter, 2001). These regions are based on the *occurrence* of groundwater (mainly type of opening – i.e. primary or secondary) as well as on lithostratigraphical, physiographical and climatic considerations (Vegter, 2001). Groundwater in a region is not necessarily part of the same hydraulic or hydrological unit. It is intended that each region will ultimately have a separate groundwater report

and map or maps, explaining and depicting groundwater occurrence and conditions in the region in detail. To date, full reports for 4 of the 64 Regions are complete and work is ongoing, coordinated by the Water Research Commission in Pretoria.

2.2.4 NATIONAL GROUNDWATER MAPS (1995)

The first comprehensive national estimates of how much groundwater is available in South Africa were provided by a series of national groundwater maps in 1995 (Vegter, 1995).

2.2.5 GROUNDWATER RESOURCE ASSESSMENT PHASE 1 (GRA1) (LATE 1990S TO ABOUT 2003)

A project led by the Department of Water Affairs led to the production of a set of twenty-one hydrogeological maps (sometimes known as the General Map Series or the “hydrogeological map series”) at a scale of 1:500 000 covering the country. Each map has an explanatory booklet (to date not all booklets are complete). The maps are based on the standard and internationally-accepted UNESCO hydrogeological map legend (UNESCO, 1983) and classify borehole yield and aquifer type using an alpha-numeric code (see Appendix 2).

2.2.6 HARVEST POTENTIAL MAP (1998)

Following comments that the General Map Series did not provide estimates of sustainability or long-term groundwater availability regarding abstractions, further work led to the development of a national “Harvest Potential Map” which estimates total groundwater availability (i.e. not just borehole yield) per unit area in South Africa (Baron et al, 1998).

2.2.7 NORAD TOOLKIT FOR WATER SERVICES (2004)

The Toolkit for Water Services was published by DWA in 2004 (DWA, 2004b), and was the outcome of a collaborative project supported by the Norwegian Agency for Development Cooperation (NORAD). The Toolkit consists of a series of documents, maps, computer programs and other outputs aimed at more appropriate use and management of groundwater in South Africa. The target audience for each output was not necessarily the same. The Toolkit is freely available on-line (e.g. at <http://intertest.dwaf.gov.za/groundwater/noradtoolkit.asp>)

2.2.8 DWA GUIDELINE (2008)

A Guideline for the Assessment, Planning and Management of Groundwater Resources in South Africa” was published by DWA in 2008 (DWA, 2008). The objectives of the guideline are to provide assistance and guidance to those involved with the assessment, planning and management of groundwater resources in South Africa, particularly with regard to the correct processes to follow (DWA, 2008). Assessment, Planning and Management of groundwater are related steps, each one of which has a bearing on the others in an iterative way.

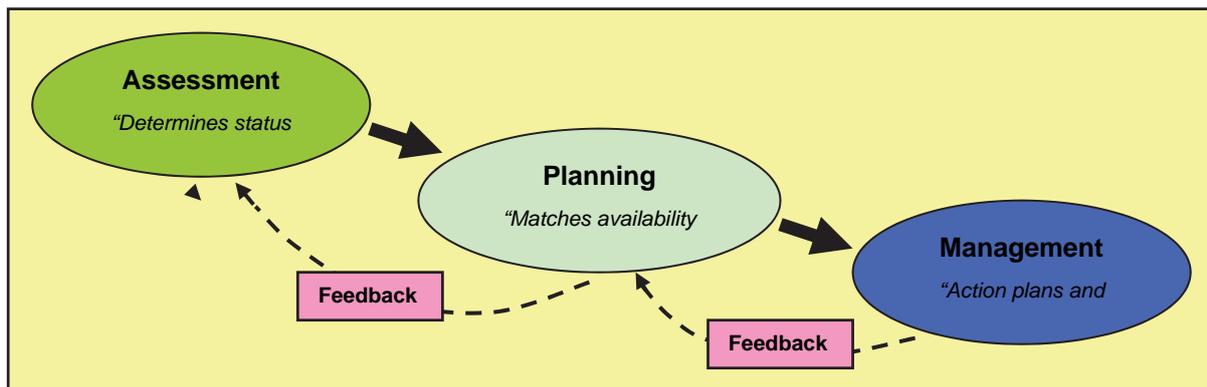


FIGURE 2-1 BASIC AQUIFER MANAGEMENT STEPS ENVISAGED IN THE DWA GUIDELINE (DWA, 2008)

2.2.9 GROUNDWATER RESOURCE ASSESSMENT PHASE 2 (GRA2) (2005)

The Groundwater Resources Assessment phase 2 (GRA2) process, which began in 2003, aimed to update the Harvest map (Baron et al, 1998) as well as producing a “planning potential” map, quantifying recharge and groundwater/surface water interaction, classifying aquifers, and making more accurate estimates of groundwater use. Estimates of groundwater availability, recharge, baseflow, and numerous other factors are given per quaternary catchment, having been aggregated up from a 1 km² grid developed from existing data. Doubts about this dataset for certain functions and / or in certain catchments has meant that it has not been “officially” released by DWA, but it is nevertheless still used in various ways as the best currently available dataset.

2.2.10 GRIP (2002 TO PRESENT)

The Groundwater Resource Information Project (GRIP) was originally conceived as a national project to improve data holdings by accessing unpublished or “private” data as well as “new” groundwater data collected by visiting boreholes in the field – particularly in priority areas. GRIP would also develop systems and procedures for the collection and verification of unpublished data. GRIP was originally started in the Eastern Cape and Limpopo Provinces, with later roll-out in KwaZulu-Natal and the Free State (Botha, 2005). All GRIP data would be entered into the DWAF national WARMS database, ensuring its accessibility. To date, GRIP has been most fully implemented in the Limpopo Province, where more than 2 500 villages have been visited.

2.2.11 SOUTH AFRICAN GROUNDWATER DECISION TOOL (SAGDT) (LATE 1990S ONWARDS)

The SAGDT is a set of software tools with a spatial (GIS) interface aimed at better assessment and management of groundwater resources in any given area in South Africa. “The South African Groundwater Decision Tool (SAGDT) is designed to provide methods/tools to assist groundwater professionals and regulators in making informed decisions concerning groundwater use, management and protection, while taking into account that groundwater forms part of an integrated water resource.”

(SAGDT website, at <http://www.usersupport.co.za/SAGDTabout.php>). The tool is freely available, and was rolled out in 2006 with a national road-show and training course for all interested parties, including DWA staff members.

2.2.12 NATIONAL GROUNDWATER STRATEGY (2010)

The output of this three-year project was a national strategy document produced by the Department of Water Affairs in 2010, following a process of consultation, and building on earlier strategy documents (DWA, 2010a). The National Groundwater Strategy contains recommendations for groundwater management and development in South Africa, an economic assessment of the cost of NOT implementing the strategy, and tables of actions, and was aligned with DWA's 2010-2013 strategic plan. It provided an important input document to the second edition of the National Water Resource Strategy, published in 2013.

2.2.13 GW ASSESSMENT METHODOLOGY (K5/2048) (2013)

This research project was funded by the Water Research Commission and was aimed at improving on the original GRA2 methodology. The project ended in 2013 and concentrated specifically on application of new methods for baseflow analysis and quantification in South Africa – one of the areas in which the original GRA2 dataset was thought to be weak. The deliverables are freely available from the Water Research Commission.

2.2.14 WRC K5/1763 (2012)

This project (The delineation of high-yielding wellfield areas in Karoo Aquifers as future water supply options to local authorities) focused on the Karoo geological basin and has established an aquifer yield model, a wellfield assessment model, costing algorithms for local authorities, and other tools designed to assist the hydrogeologist working at local municipality level (Baker and Dennis, 2012). The software and tools are all available free of charge from the Water Research Commission in Pretoria. See Figure 2-2 below.

2.3 DISCUSSION OF GROUNDWATER ASSESSMENT AND PLANNING TOOLS

It can be seen that the desktop data, reports and tools available to hydrogeologists and groundwater planners in South Africa is quite extensive and reflect decades of work by many scientists. At the same time, it is generally recognised that physically successful groundwater supplies will also require a field investigation, perhaps involving the geophysical siting of boreholes, trial drilling, pumping tests and other fieldwork. The tools outlined above were never intended to replace fieldwork, although they are very useful in focusing field investigations and in estimating broad costs and feasibilities. National planning tools such as these can sometimes be “hazardous” – for example they may easily underestimate the physical groundwater resources available at a particular location and lead to a

more expensive or complex alternative option (e.g. a desalination plant) being chosen – before proper local groundwater investigations have been carried out. All of the tools described above are based on field data and field measurements, and in some cases or areas this information is very patchy.

The following quote by Vegter (2001:xi) summarises the problem:

“The yield of a geohydrological unit can definitely not be determined or estimated prior to its development – at best it can only be guessed. It is only through exploratory drilling and testing that the hydraulic structure of a geohydrologic unit and its spatially variable hydraulic parameters may be determined. Even then, because the pattern of the permeable fractures in the hard rock formations (comprising 90 % of S.A.'s area) is generally unknown and does not necessarily conform to a simple regular system for which theoretical models have been developed, reliable evaluation of parameters (mostly double-porosity) may be very problematic. Numerical modelling on any such geohydrologic unit requires an inordinate amount of (borehole) data. If, in addition, the wide margin of uncertainty about recharge values is taken into account, prediction of long-term water level response to groundwater abstraction would appear to be highly questionable and a fruitless exercise.”

It is unlikely that planning or assessment tools, even when available at detailed scales, can ever replace basic fieldwork / hydrogeological field investigations (it is possible that this is a fundamental difference between surface water and groundwater!). The products discussed above should be seen as assisting and informing such investigations, not replacing them. Once established, groundwater schemes need to be monitored and the conceptual model updated, in line with the principle of adaptive management (see Seward et al 2006, and later in this report). Indeed it is argued that ANY groundwater supply established for domestic water supply purposes on behalf of a Water Service Authority (usually the LM, but sometimes the DM) needs to be informed by a hydrogeologist. Such a person needs to take into account not only the hydrogeological issues as shown in the example maps, but also consider the issues related to the O&M requirements of the source. There may be a danger in recommending more and more detailed hydrogeological products designed to assist local officials in siting and maintaining groundwater schemes (tied to the “discourse of shortage” – see later in this report – which blames water service failures on insufficient water, insufficient information or funds, etc.). It is possible that with the excellent outputs of WRC Project K7/1763 (Baker and Dennis, 2012) we have reached the limits of existing hydrogeological datasets. The final, detailed siting of boreholes, and the critical consideration of O&M requirements, should be carried out by hydrogeologists, or with the assistance of hydrogeologists. Figure 2-2 below shows Zithulele Hospital, in Mbashe LM in the Eastern Cape, with the transmissivity zones of Project K7/1763 overlaid. Whilst the T-zones provide very useful detail at regional or even local scale, it is apparent that final siting or wellfield design does require local fieldwork and local expert hydrogeological input.

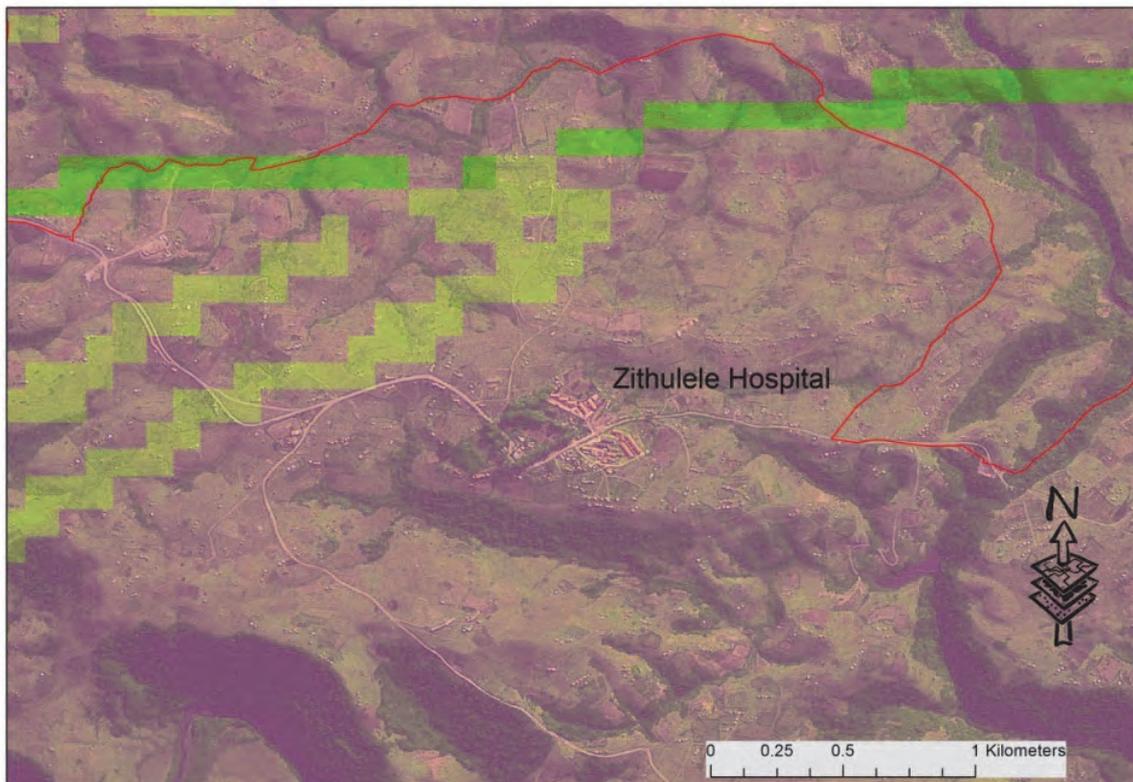


FIGURE 2-2 K7/1763 DETAIL AROUND ZITHULELE HOSPITAL, EASTERN CAPE SHOWING HIGHER TRANSMISSIVITY ZONES

2.4 DO WE HAVE ADEQUATE HYDROGEOLOGICAL PLANNING TOOLS IN RSA?

A large range of hydrogeological planning and assessment products and tools is available in South Africa (see above), mainly focused on the assessment of the physical groundwater resource, and on its management. South Africa probably has a range of such tools that is on a par with those available in most other countries, and arguably we are now reaching the limits of the available data in terms of what can be devised to guide hydrogeologists. Work has also been done to define the management framework applicable to groundwater at municipal level, including defining roles and responsibilities for the various organisations (Riemann et al, 2012). There is however much less information available on ancillary issues such as cost-recovery, day-to-day operation and maintenance, treatment technologies, etc. however, since presumably this is seen as a municipal responsibility that is one degree removed from hydrogeology. Tools that we DO have in South Africa covering day-to-day groundwater scheme operation include the NORAD toolkit (DWA, 2004b) and the draft guidelines prepared for the Northern Cape (Taljaard, 2008).

3 TECHNICAL, ENGINEERING AND O&M RELATED CONSIDERATIONS

3.1 INTRODUCTION

There is considerable wariness among municipalities and others in using groundwater, often because they under-estimate the basic operating and maintenance requirements needed to keep a groundwater system delivering water reliably, and then cite the inevitable failure 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 the merits of using groundwater as a municipal water resource is to understand their basic operating requirements.

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

One might assume that these simple requirements mean that small groundwater-based schemes are ideally suited to local authorities and service providers with limited capacity serving extensive rural settlements. However, as this section has already suggested, 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 seldom have just one or two settlements served by boreholes; they frequently have tens or hundreds, each of which needs attention and support on site. Duty-and-standby arrangements, common in surface water supplies, appear to be much less frequent in small groundwater systems.

Diesel pumps depend on regular and punctual delivery of fuel and this is a challenge in remote settlements located along poor roads, with a limited pool of functional delivery vehicles. Electrical pumps are less demanding logistically, but they presuppose 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. As mentioned, borehole electro-mechanical systems are seldom installed with a duty and standby arrangement, as is common for pumping systems for surface water systems – every breakdown affects perceptions of reliability.

3.1.1 RELIABILITY AND 'REPAIRABILITY'

Electrical pumps are generally more complex to repair than diesel-powered mechanical pumps (especially if complex electronic control systems are incorporated). Relative 'repairability' adds another dimension to considerations of sustainability: reliability matters, but how easy is it to fix a system when it fails? Diesel-powered boreholes lie at the 'simpler' end of the spectrum of repairability, and can often be repaired readily by a locally-based mechanic. Electrical pumps are more complex, and electricians close to remote settlements are rare.

These considerations may underlie the growing preference in many areas for big regional schemes where bulk water is sourced from large dams and pumped long distance, with centralized management of a complex network of pump stations, valves and reservoirs. Big regional schemes are generally perceived to be very reliable, yet detailed assessment by Gibson (2011) in a study of Eastern Cape schemes found no compelling evidence that regional schemes do in fact provide a more reliable service. In practice it can be difficult to achieve and sustain hydraulic balancing across widely differing elevations with numerous off-takes; and when the system fails, the impacts are experienced over a wide area. As Figure 3-1 below illustrates, big regional schemes substitute a technical complexity challenge for small schemes' logistical challenges. Neither is simple, and neither provides an assured reliability advantage.

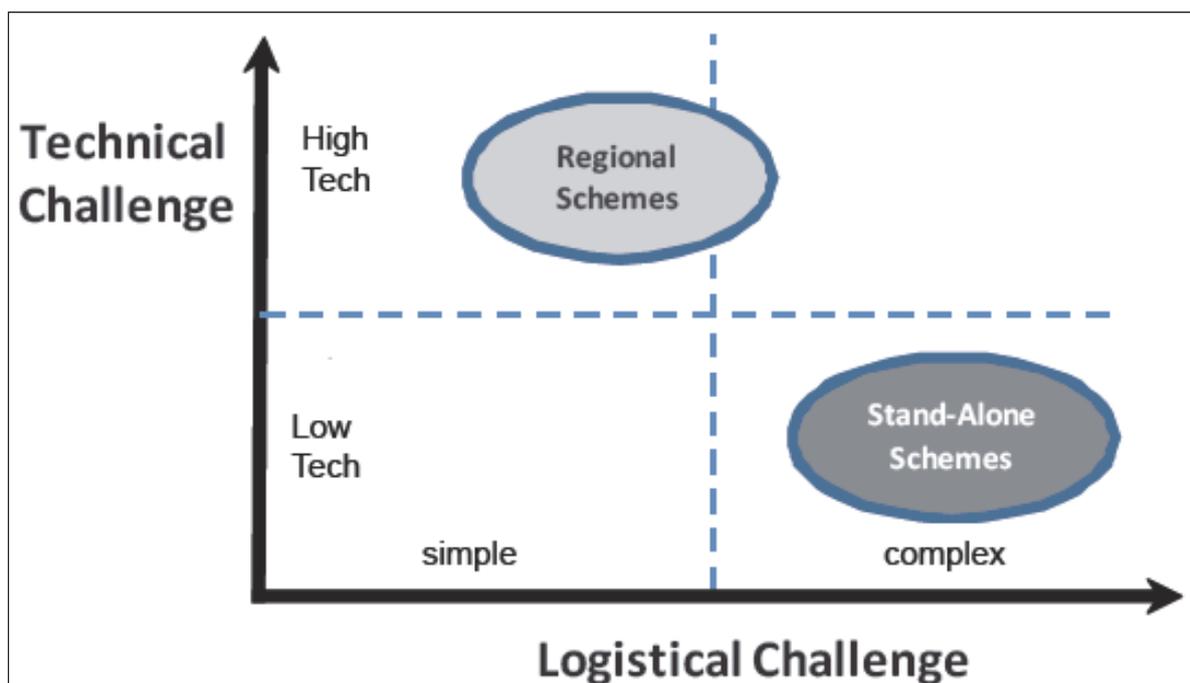


FIGURE 3-1 BIG REGIONAL SCHEMES SUBSTITUTE TECHNICAL COMPLEXITY FOR SMALL SCHEMES' LOGISTICAL CHALLENGES (GIBSON, 2011)

3.2 OPERATION AND MAINTENANCE OF GROUNDWATER SCHEMES

Operation and Maintenance (O&M) includes all of the routine tasks which need to be carried out to keep a groundwater source or well-field functional. A typical list of O&M tasks (after DWA, 2009) is included as an appendix in this report. Rogers et al (1998) define O&M costs as those costs needed for “running the system”, such as electricity, materials, and staff costs, as opposed to the capital costs needed to install or purchase the system. There is very high agreement that carrying out O&M on groundwater sources results in lower costs and higher reliability overall. A recent cost-benefit study of groundwater supplies 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 3 to 5 fold increase in net value is realized with the implementation of an operation and maintenance (O&M) program.

Neglecting O&M results in much more substantial loss of overall value than most people realise. As Taljaard (2008:42) state, “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 more generally (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 and so on) used to abstract the groundwater. It is common to hear that “the borehole dried up”, or “the groundwater ran out”. This is partly because groundwater is out of sight – it seems mysterious to most people in comparison with surface water. 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) that are related to a lack of monitoring. Unsuitable pumping regimes can cause infrastructure failure in several different ways. For example, a pumping regime which draws groundwater levels down excessively for short periods can introduce air into the aquifer and cause bacterial growth which leads to blockage (biofouling) of borehole screens. Precipitation of iron or manganese can also occur. High flow rates can mobilize silt or sand, leading to rapid pump wear or borehole screen damage, and pumps can also overheat and burn out if water levels drop below their intake shrouds.

In contrast with the relatively large number of publications on groundwater occurrence in South Africa (for example the General Hydrogeology Map series, the GRA2 database, GRIP, etc.) there are hardly any on O&M tasks or the correct approach to take once boreholes have been established. As far as is known, the only South African publication dedicated to groundwater O&M is the booklet “O&M of Groundwater Supply” developed in the Northern Cape Province (Taljaard, 2008). However several

publications (e.g. the NORAD documents, DWA 2008) do have sections on groundwater O&M. Further groundwater O&M manuals and other resources are available in the international literature (e.g. Gol 2013, USEPA 1988, or websites with downloadable resources such as www.operationandmaintance.net). Organisations such as DWA, the CSIR and the South African Bureau of Standards have specifications for borehole drilling and construction, groundwater monitoring and other tasks relevant to well-field O&M. As far as is known, there is no standard, agreed upon and widely respected list of O&M tasks for groundwater supplies that is used in South Africa. This may change as “asset management” becomes the subject of more attention at local government level in the coming years.

Most interview respondents during fieldwork in North West Province done for this project highlighted the strong requirement for adequate operation and maintenance of boreholes to achieve reliable supplies, and agreed that O&M failures were the primary cause of groundwater source failure. In other words, the main reason groundwater sources fail appears to be mechanical breakdowns or other issues related to operation and maintenance, rather than a failure of the groundwater resource itself. Adequate operation and maintenance in turn 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, etc.). In the opinion of Taljaard (2008:42): “There are many factors that determine the quality of O&M. The main ones are quality of staff, access to dedicated O&M funds, and the quality of records and analysis of information”.

A focus on O&M should not imply that groundwater source failure never occurs, or that an understanding of the primary resource is not needed. In some areas (particularly larger supplies, such as the Grootfontein wellfield supplying Mahikeng) groundwater is being used unsustainably and the resource itself is under stress. If O&M problems can be overcome, leading to boreholes yielding more water more reliably, then stress on the source will increase and source monitoring (and associated management measures like adaptive management) will become more important. Ironically, poor O&M “protects” the volumes in some aquifers to some extent at present because it reduces actual abstractions. On the other hand, poor O&M can harm groundwater quality – for example through leaking diesel tanks or cracked sanitary seals – and these issues can be more expensive and difficult to deal with than over-abstraction.

3.3 RESPONSIBILITY FOR O&M

O&M is usually seen as the responsibility of the applicable Water Services Authority (WSA) or Water Services Provider (WSP) – see Section 1 of this report. The relevant 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. These are linked to a clear acknowledgement of the importance of O&M at management level. 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 O&M functions may be carried out by different responsible authorities. For example, monitoring of groundwater in the Grootfontein compartment serving Mahikeng (see case study chapter later in this report) is carried out by DWA, meaning that close cooperation between DWA, the regional water board (currently Botshelo Water Board) and local government is required in order for smooth operation to take place. Falling water levels in the compartment need to be communicated early to the other partners, so that (for example) restrictions on use or other planning can be implemented. Conversely, if reduced amounts of water arrive at the Mahikeng water treatment plant, DWA would be notified by Botshelo Water Board of a possible leak or blockage in the pipeline. Successful O&M of larger groundwater resources therefore has the added complication of requiring close collaboration between different entities or organisations (Figure 1-1).

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 which have a great bearing on whether services are delivered and routine tasks accomplished, including groundwater management. One or more of these issues may be the key to better long-term groundwater operation and maintenance. One interviewee for this project stated that the lack of clarity over responsibility for various aspects of O&M for one of the district municipalities (DMs) in Limpopo Province had led to considerable waste and unnecessary breakdown of groundwater supplies – the debate appeared to be around whether the WSA (DM) or the WSP (appointed by the DM) had primary responsibility for O&M.

There is a school of thought that asserts that private sector contractors (“private service providers”) are in the best position to carry out O&M tasks for WSAs, since financial incentives and penalties can be used to improve or guarantee performance, and private sector firms are not normally involved in the day-to-day politics of local government. Contracts may even provide for straight-forward dismissal for poor performance. On the other hand, private service-providers may be perceived to be expensive,

more difficult to find in the remote rural areas where their services are most needed, and committing municipalities to medium- or long-term financial arrangements. The municipality must also maintain a monitoring function, ideally to a pre-agreed set of performance indicators. “Out-sourcing” of municipal functions is also resisted by many in local government as well as by trades unions.

It seems that there is not necessarily a “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 does seem to be 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 to month (Gibson, pers.comm.). This raises the need for adequate budgeting for O&M – regular and consistent budgets are needed long-term to carry out necessary preventive maintenance.

Unfortunately there is often greater pressure on municipalities to invest in capital items (e.g. new well-fields) 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. This does not fit well with the relatively short-term imperatives which elected municipal officials sometimes face – a newly elected official is under pressure to deliver on promises and to show short-term results which have more conspicuous benefits over a typical municipal term than investment in O&M. It may also be easier for municipalities to disburse funds in relatively large (capital) tranches, rather than take on the administration needed for longer term O&M. The need for consistent O&M is also not always fully recognised by non-experts, who more easily see the benefit of new capital acquisitions. Since engineering and groundwater skills are in short supply in municipalities, there may be few individuals within the organisations arguing for O&M from a position of personal experience. There are at present few “rules” governing what municipalities must spend budgets on (only guidelines), and no imperative to spend any proportion of funds on O&M of water supply systems.

As Taljaard (2008:39) argues: “It is often cheaper to maintain or rehabilitate a borehole than to replace it, once its performance has deteriorated significantly. Even when rehabilitation is more economical, as is often the case, money for rehabilitation is often more difficult to obtain than money for new projects. New projects are mostly grant funded, while O&M and rehabilitation are funded by municipal income. Since the water services income is not ring-fenced to cover necessary O&M costs related to delivering services, but used for other municipal expenses, this leads to less and less resources being allocated to O&M.”

It is also difficult to gauge what is being spent on O&M by any one municipality in South Africa, since figures for O&M are often combined with other expenditure (aggregated up) in financial reports. Expenditure on water is not ring-fenced (apart from special grants such as MWIG). So far it has been very difficult to decipher what is being spent on O&M of water sources, either as total expenditure, or

as a proportion of capital spend on water infrastructure. Nor is there any incentive for expenditure reporting to be any more detailed than what is required by law, since the more detail that is available the more closely costs and expenditure will be examined.

3.4 SCALING UP / PROFESSIONALIZATION

There is a growing acknowledgement in the international literature that operation and maintenance of groundwater supplies is one of the critical factors in success – if not THE main factor. See for example Lockwood and Smits (2011) or Schweitzer and Mihelcic (2011). This has led on to debate about the type of management approach that is best for rural water supply systems – for many years community-based management (or village-level operation and maintenance – “VLOM”) has been advocated for rural Africa, particularly where state institutions are unable or unwilling to operate or manage rural water supplies. There is now some acknowledgement that many communities either cannot (or simply do not) manage rural water supply systems in isolation, but do need support. Lockwood and Smits (2011:12) state that “A tipping point may now have been reached with more and more national governments and development partners beginning to recognise the scale of the problems associated with poor sustainability and the real threat this presents to achieving the WASH Millennium Development Goals.” Or as Carter (2009:2) puts it: “Moving from an unimproved to an engineered water supply actually increases dependence on external organisations to provide support. If the support does not follow, then systems fail.” Lockwood and Smits (2011) talk about “professionalising” community water supplies, and outline a “sustainable services at scale” or “Triple-S” approach that aims at much better sustainability. In a recent conference paper, Parsons discusses a small-town groundwater supply in South Africa and notes: “To harness the benefits of groundwater, groundwater schemes have to be based on proper exploration, good management and monitoring.” (Parsons, 2013:6). In general, a greater role for formal organisations (often local or regional government) is being recognised in the search for sustainable rural water supplies.

3.5 COMMUNITY INVOLVEMENT IN SOUTH AFRICAN RURAL WATER SUPPLY O&M

In South Africa the model of community-based water scheme operation and maintenance 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 Water Services Authorities and Water Services Providers and it is national policy to provide extensive funding to municipalities to undertake a rural water-supply function. Ironically, in South Africa we may have a distinctly different issue compared with the rest of the sub-continent in the sense that South African rural communities have too little involvement in water scheme provision, and O&M. Most agree that wide stakeholder involvement of some form is a necessary precondition for the elusive “sustainability”, but in parts of South Africa rural communities have precious little to do with the planning, operation or

maintenance of local water supply schemes. This is despite decentralisation and local government's close involvement in water supply provision. A balanced approach based on local circumstances (exactly what is hard to say!) is probably the answer, in which community involvement and support to local government water supply initiatives is encouraged or facilitated.

3.5.1 SELF-SUPPLY

"Self-supply" is an international term given to communities which must install and operate their own water supplies, usually communities in "difficult" or remote areas. As Lockwood and Smits (2011:4) say: "In many places, particularly in highly dispersed rural settlements, self-supply and household management is happening in a *de-facto* manner. However, more gains can be made if this is recognised as a Service Delivery Model and supported as such, as has been done, for example, in Thailand". Such an approach may never be politically acceptable in South Africa, but as the "last 5%" becomes the last 2% or even 1% some variation of this approach may well arise here, whether formally acknowledged or not.

3.5.2 O&M RESOURCES

At present there is only one dedicated O&M "manual" in South Africa (by Taljaard, 2008), and even this is not yet in its final finished form. Other O&M manuals exist in other parts of the world however, such as USEPA (1988), Government of India (2013) and Schneider (2012). As Taljaard writes in the manual (2008:10) "The main causes for the failure of groundwater extraction systems as sustainable sources for community water supply are poor assessments of groundwater potential, inadequate record keeping in previous exploration and development programmes, poor standards of workmanship and poor operations and maintenance practices." The Guideline for the Assessment, Planning and Management of Groundwater Resources in South Africa (DWA, 2008) and other documents (e.g. DWA's Sanitation Survey guidelines) also contain some O&M material.

To repeat the primary argument of this chapter: the main reason groundwater sources fail appears to be mechanical breakdowns or other issues related to operation and maintenance, rather than a failure of the groundwater resource itself.

4 GROUNDWATER MANAGEMENT

4.1 WHAT IS GROUNDWATER MANAGEMENT?

“By far the most serious groundwater challenge facing the world, then, is not in developing the resource but in its sustainable management” (Shah et al, 2000:8)

A hundred years ago borehole drilling and pumping technology was primitive and “management” of groundwater resources rarely entered anyone’s thoughts since only small amounts of groundwater were abstracted from shallow aquifers. In most places shallow wells were dug, springs were tapped, and people got on with their lives. But in the last fifty years a huge boom in global groundwater development has taken place, most of it for irrigation purposes (Mukherji and Shah, 2005). Konikow and Kendy (2005:317) state that “In the past half-century, ready access to pumped wells has ushered in a worldwide “explosion” of groundwater development for municipal, agricultural and industrial supplies”. In 2000 it was estimated that 750-800 km³ of groundwater was abstracted globally per annum (Shah et al, 2000) and today the figure is likely to be substantially larger. In South Africa it is thought that around 2-4 km³ is abstracted every year, roughly half of the sustainable total (DWA, 2010a). Nowadays over-abstraction, salinization and pollution of groundwater are serious problems in many parts of the world, leading to debate about how best to manage groundwater and giving rise to a growing literature on groundwater management or governance. Saline intrusion, land subsidence and ecological damage are other downsides to this “explosion”, but the benefits to people and societies have also been immense. Today most agree that groundwater management / effective governance (see next section for the difference) is needed to slow down or prevent deterioration of this “common pool” resource and that this is in everyone’s long-term interest. Growing populations and climate change complicate the picture. Often we are hampered by past approaches and legislation however, such as the “riparian principle” or “prior appropriation doctrine” which are still part of some legal systems and which see groundwater as essentially a “private” resource to be exploited by the owner of the overlying land (or senior rights holder). Even in South Africa, where groundwater is now legally part of the national water resource and cannot now be “owned” by anyone, many users still regard it as essentially private (e.g. signs saying “borehole water” on many suburban walls). It doesn’t help that groundwater can’t normally be seen – most people don’t have a sense of how it exists, how much is under the earth, or how it gets there in the first place. Many consider groundwater mysterious and unreliable, needing guidance by a water witch or diviner. These things complicate management because wide participation – and understanding – by all “stakeholders” is widely considered a necessary underpinning of all good groundwater management systems.

“Subterranean water resources pose particularly acute governance challenges. They require sophisticated technology and significant knowledge to be sustainably managed. By contrast, even

when surface water is not systematically measured it can, at a minimum, be visually monitored. As a result, groundwater resources are at heightened risk of unsustainable consumption, pollution, and uninformed perceptions with regard to quantity and quality of available resource.” (USAID, 2014)

Most agree also that whilst groundwater management must be anchored in a sound scientific understanding of the resource, a multi-disciplinary approach is needed to make sure that chosen management measures are effective, accepted and sustainable. Insights from other disciplines are vital since groundwater use cuts across many social, economic, political and geographical boundaries, at a variety of time-frames and geographical scales. Much of the work of hydrogeologists is aimed ultimately at better groundwater management, but to see groundwater management as essentially about hydrogeology and not also about the wider context in which groundwater is used is a shortcut to misunderstandings and frustration.

Writing about lack of access to a decent water supply, lack of participation, and associated material and spiritual poverty, Smith and Marin (2005) state: “Why is it critical to understand oppressive poverty, its consequences and the means for personal and social change? Professionals, decision makers and power brokers with political or economic authority often tend to underestimate, not understand, or choose to ignore these concepts and methodological choices. People impacted by daily problems or decisions that affect their well-being have the right to be involved in activities directed at those problems, and in fact, must be involved for any chance of success over the long term. If these statements are accepted, then the need for more support for participatory development of water programs becomes generally evident as does the very different knowledge and skill sets required, the shifting of financial priorities, the interdisciplinary collaboration urgently needed among hydrogeologists and social scientists, and the longer time frame necessary for successful development of water programs at the community level.” (Smith and Marin, 2005:348).

4.2 GROUNDWATER MANAGEMENT AND GROUNDWATER GOVERNANCE

A distinction is made between “management” and “governance”, with the former indicating a narrower range of issues including hydrogeological modelling and the application of laws and regulations, whilst the latter implies a broader range of issues at different levels with a bearing on all stakeholders (Mukherji and Shah, 2005). Mukherji and Shah (2005:339) state that a principle problem in groundwater is “the misallocation of roles and responsibilities assigned to various organisations that are in the business of governing groundwater. Thus, central and provincial governments are very often given responsibilities that are beyond their human and financial resources, while farmers and other stakeholders are asked to participate in aquifer management when their direct interests lie in non-participation”. Riemann et al (2012) identify four basic management function “building blocks” – planning, organising, leading/directing and controlling/monitoring.

The project “Groundwater Governance. A Global Framework for Action” is perhaps the flagship international programme investigating mechanisms for better groundwater governance at present in the world. It is funded by the World Bank’s global environment fund (GEF) and implemented by the Food and Agriculture Organization of the United Nations (FAO) together with UNESCO’s International Hydrological Programme (UNESCO-IHP), the International Association of Hydrologists (IAH) and the World Bank. The 4.5 M USD project, which started in June 2011 and runs until June 2014, is “designed to raise awareness of the importance of groundwater resources for many regions of the world, and identify and promote best practices in groundwater governance as a way to achieve the sustainable management of groundwater resources” (GWG, 2014). After a first project phase in which a review of the global situation with respect to groundwater governance was carried out, a second phase will lead to the main project outcome which is a “Global Framework for Action”. The first phase included case studies, thematic papers and five regional consultations. The second phase consists of a set of policy and institutional guidelines, recommendations and best practices aimed at various geographical levels. The five regional consultations done as part of the first phase were divided into Latin America and the Caribbean, sub-Saharan Africa, the Arab States, East and Southeast Asia and the Pacific, and the UNECE region. Resources and outcomes of the project are available at the project website (GWG, 2014).

Groundwater governance, as investigated by Groundwater Governance project members, shares with other water governance a need to be “accountable, transparent and participatory” (GWG, 2012a), but does have requirements that are particular to groundwater, based on the distinguishing characteristics of groundwater and aquifers. These include the common perception that groundwater is a private resource (ironically, groundwater is usually viewed as a classic “common pool” resource (e.g. Ostrom, 2005) in literature), the need for groundwater management to include consideration of baseflow to rivers, the susceptibility of groundwater to diffuse land-use practises, inherent long time-frames, and so on (GWG, 2012a). The general lack of resolution provided by existing groundwater data has led to management approaches that take uncertainty into account such as adaptive management (Seward et al, 2006) but which do not necessarily dovetail with management of other water resources. The Groundwater Governance project has distilled the following definition of groundwater governance, and quotes it in their synthesis paper (GWG, 2012a:14):

“Groundwater governance is the process by which groundwater is managed through the application of responsibility, participation, information availability, transparency, custom, and rule of law. It is the art of coordinating administrative actions and decision making between and among different jurisdictional levels – one of which may be global.”

The definition goes on to state that “Accordingly, ‘groundwater governance’ could be interpreted as the set of policies or decisions that moderates groundwater use and promotes aquifer protection. Governance can be distinguished from ‘government’ (who decides) and ‘management’ (what is done

to implement decisions)... Broadly, groundwater management is the set of actions to implement decisions that derive from the process of governance.” (GWG, 2012a:14). It is acknowledged that the definition does not capture “the wider context of political and power relations or social drivers that determine outcomes” (GWG, 2012b: 4). A set of groundwater governance principles are presented and discussed in the synthesis paper, as follows (GWG, 2014:26):

- Sustainability – more complex than it might first appear, and goes beyond the idea of “safe yield”. The time of aquifer response is a necessary consideration, for example.
- Transparency – especially important in the case of groundwater, which is mostly invisible and subject to various fallacies.
- Participation – considered necessary to reach agreement and implement management actions.
- Accountability – need to determine who is accountable for e.g. pollution, who benefits and who loses from groundwater abstractions, etc., and reach agreement on management response.
- Integration – groundwater management needs to be well integrated into other water sector governance, including consideration of long-term buffering and storage advantages.
- Precautionary Principle – especially around issues such as injection of pollutants.
- Knowledge Management Principle – the need to promote the use of groundwater knowledge more widely.

Natural aquifer systems are complex and difficult to characterise in detail. Good data collection greatly reduces uncertainty, but cannot normally allow the prediction of the long-term effects of groundwater pumping with 100% accuracy. There is always an element – hopefully small – of trial-and-error in aquifer management. A management approach whereby observations are fed back into the management system, and adjustments made if necessary, is called “Adaptive Management”. This approach helps to deal with the uncertainty about the regional status of groundwater resources due to poor monitoring, the limited knowledge of how groundwater parameters change with time and distance, and uncertainties about the impacts of groundwater use on surface water or the ecology. As Seward et al. (2006) put it: “Scenarios and goals are [therefore] regarded as hypotheses and estimates to be tested and challenged as the knowledge base grows”. A good groundwater manager is aware of uncertainty and knows that adaptive groundwater management is necessary from the beginning – she knows that the soundness of predictions and recommendations will grow as the knowledge base for groundwater expands with ongoing monitoring. (DWA, 2010a).

4.3 DECENTRALISATION

Decentralisation has become an important concept in the discourse of water governance globally, partly because it is seen to promote efficiency, transparency, democracy and accountability. There are

also historical, economic, religious and ideological roots to decentralisation which are less often explored in the water management literature. Decentralisation has been embraced by post-1980s free-market orthodoxy for example, which with Fukuyama's 1992 "The End of History" and the rejection of inefficient Soviet centralised bureaucratic planning in turn informs modern management theory. The economist Friedrich von Hayek warned of the dangers he perceived of the power of the state over the individual, and wrote in his influential book "The Road to Serfdom" (first published in 1944): "There would be no difficulty about efficient control or planning were conditions so simple that a single person or board could effectively survey all the relevant facts. It is only as the factors which have to be taken into account become so numerous that it is impossible to gain a synoptic view of them that decentralization becomes imperative." This has its echoes in current orthodox economic thinking urging governments to "cut red tape" or "get out of the way" of the economy. As Ronald Reagan once joked, "The nine most terrifying words in the English language are: *I'm from the government and I'm here to help.*" To be fair to Hayek, he did concede that the central state had a limited role to play in areas where the free market did not function well, such as in environmental legislation, and it could be argued that his work (and those of others) has been used in recent decades to justify ideological excesses which he did not contemplate. Nevertheless, it would be strange if the dominant economic ideologies of our time did not have some influence on thinking around planning and management in a variety of specialist fields, including hydrogeology. Water managers should probably remember the words of another great economist, JM Keynes, who once wrote "Practical men who believe themselves to be quite exempt from any intellectual influence, are usually the slaves of some defunct economist."

Decentralisation also has roots in the legal Principle of Subsidiarity which holds that issues should be decided upon or managed at the lowest or most devolved level practical. This is considered a founding principle of European Union law, and echoes a late 19th century Papal encyclical "Rerum novarum or Rights and Duties of Capital and Labour" which was concerned partly with "the enormous fortunes of some few individuals, and the utter poverty of the masses". According to the encyclical: "The limits [of the aid and authority of the law] must be determined by the nature of the occasion which calls for the law's interference – the principle being that the law must not undertake more, nor proceed further, than is required for the remedy of the evil or the removal of the mischief" (LEV, 2014).

The need to address water issues across multiple scales and a range of stakeholders is a cornerstone of Integrated Water Resource Management (IWRM) thinking (USACE, 2014). The recognition of the essentially local nature of much groundwater and the way in which local, private interests have shaped demand for groundwater (GWG, 2012b), have contributed to the widespread idea that the administration and governance of groundwater in particular should be as local or "decentralised" as possible. As GWG (2012b:20) put it "If an environment of good conduct is to be extended to fill the apparent groundwater governance gaps, the need for this to apply at the point of abstraction or the point of pollution will always implicate local institutions who have an interest in maintaining public

goods.” A local focus can of course have drawbacks too if it gives preference to a narrow set of local interests at the expense of broader interests, and this is acknowledged by some authors.

In South Africa decentralisation is important to water resource planners because it underpins our constitution as well as our water laws and policies. It was adopted with the intention of increasing public participation in local decision-making, and in promoting democracy and accountability more generally (Ntsebeza, 2002). It has also been extensively criticised as a system which *de facto* places the greatest administrative burdens on those least able to carry them, which can fail to separate the political from the administrative, and which draws on and reinforces right-of-centre policies and doctrines such as the New Public Management (Siddle and Koelbe, 2012). Manor (2001) maintained that three things are essential for decentralisation to deliver on its promises, and that serious doubts existed about all three in South Africa:

- Substantial resources (financial and other) must be available to local authorities
- Substantial powers must be devolved to local authorities
- Accountability mechanisms must exist which ensure that bureaucrats are accountable to elected representatives, and that elected representatives are accountable to voters.

Whilst it is acknowledged that much has been done since Manor was writing in 2001, all three of these things are still contentious today. As far back as the early 1980s, Rondinelli et al (1983) acknowledged that decentralisation in developing countries required careful planning and incremental institutional capacity building to be successful. Whilst decentralisation contributes to many of our current groundwater management challenges in South Africa – and is worth understanding as a result – a full discussion of it is not part of this project. Decentralisation of government / administration is a complex issue with many forms, with clear advantages and potential drawbacks. The devil lies in the details. Decentralisation is however a major reason why this study focuses on local municipalities and on the local sphere of government.

A frank appraisal of the successes and failures of decentralised or locally-managed water supply does appear to be leading to a more nuanced discussion, with partnerships between central and local levels being increasingly valued. The roll-out of new financial mechanisms (such as MWIG and RBIG, see later in this report) will explore this territory in years to come, as will the potentially growing role of Water Boards and other planned interventions.

4.4 GROUNDWATER DATA

Shah et al (2000) urge a global move towards better groundwater management, pointing to numerous examples of over-abstraction, pollution, salinization and other problems. One essential pillar of management is a physical understanding of the resource, however. “A major barrier that prevents transition from the groundwater development to management mode is lack of information. Many

countries with severe groundwater depletion problems do not have any idea of how much groundwater occurs and who withdraws how much groundwater and where.” (Shah et al, 2000:14)

The following recommendations or requirements were made with respect to improving monitoring of groundwater systems in South Africa in the GRA3 component of the work done towards the National Groundwater Strategy (DWA, 2010a):

- Recognition of lateral and vertical heterogeneity of aquifer systems, i.e. borehole clusters targeting different aquifers overlying each other, enabling differentiation of water level and quality data for each aquifer unit as well as the determination of leakage factors, i.e. the hydraulic interaction between these aquifers.
- A higher density of rainfall stations for important catchments is needed.
- Determination of specific yield/storativity values will require neighbouring boreholes within the same aquifer unit (vertical and horizontal).
- Monitoring boreholes drilled and equipped according to best practice (e.g. no-casing, steel, PVC or stainless steel casing, gravel packs, screening depth and prevention of hydraulic shortcuts between aquifers).
- Strategic review of existing monitoring borehole network (spatial distribution and sampling frequency) to increase efficiency of spatial coverage (i.e. some neighbouring BHs might be omitted while others should be drilled).
- Randomly drilled boreholes for unbiased estimates of aquifer properties.
- Usage of springs as integral monitoring point (discharge and quality) for upstream catchments (requires additional early warning boreholes).
- Long-term monitoring must continue (no model will ever replace measurements).

Whilst many of these recommendations and requirements are unlikely to be realised in the near future, they can be regarded as targets to be worked towards. Concentrating on areas where groundwater abstractions are critical (e.g. sole source aquifers or areas of high agricultural value due to groundwater irrigation), or where pollution is a known problem, is recommended. In many parts of South Africa monitoring of groundwater resources is in decline (see Mahikeng case study later in this report), but DWA are currently (early 2014) embarking on an ambitious plan to develop a strategy towards a new, integrated hydrological monitoring system that promises to reverse earlier setbacks. As mentioned before, the absence of the Catchment Management Agencies in South Africa has not helped the efficient collection and interpretation of hydrological data and its conversion into the information needed by managers.

5 INFRASTRUCTURE FUNDING SINCE 1994: IMPLICATIONS FOR INVESTMENT IN GROUNDWATER SERVICES

5.1 INTRODUCTION

5.1.1 CONTEXT

Since 1994, approximately 27 million people in South Africa have gained access to improved water supplies, bringing infrastructure coverage to over 95% of the population.¹ The number of additional people served with water supply infrastructure since 1994 is greater than the total population of Australia (23.2M), Mozambique (23.7M), North Korea (24.9M) or Afghanistan (25.5M).² This is a remarkable achievement by any measure, and indicates the quantum of public funding made available to drive infrastructure development. While many countries are struggling to meet their Millennium Development Goals because of inadequate funds for capital projects, South Africa met its MDG for expanding access to water in 2004. South Africa's challenge is sustain the benefit of massive public investment in water services infrastructure, with services that remain functional and meet people's needs.

Water services infrastructure development has outpaced institutional development and the systems required to keep new infrastructure functional. The 2011 census indicated that one in five households – 21% – with access to a tap is not always able to get water from a tap,³ and the Minister acknowledged recently in Parliament that '9 to 10%' of water services infrastructure is dysfunctional.⁴ Capital investment programmes tend to be more focused, more straightforward and better resourced than post-construction operation and management, and the number of technical and artisanal staff in municipalities with the skills required to manage the new service infrastructure lags far behind the proportional increase in infrastructure and service coverage. A range of indicators – municipal debt, qualified audits, water and wastewater quality, poor functionality of water supply systems, lapses in public accountability – indicate the extent to which government has under-estimated what it takes to convert massive investment in infrastructure for basic services into viable, sustainable and good quality services. But given the extent of gross inequality in the distribution of resources in South Africa, government has little option but to use its fiscal resources to drive rapid infrastructure development and hope that steadily its service challenges will be overcome; slowing the pace of delivery is not an option.

¹ Extrapolating backwards from the 1996 census, DWA estimates potable water supply coverage in 1994 at 59% of a population of 39.8-million. The 2011 census indicates 95.2% coverage out of a population of 51.77M, or roughly 49.2M people. The difference, in 2011, was 26.2M people. In October 2013, South Africa's population was estimated to be just over 53-million.

² http://en.wikipedia.org/wiki/List_of_countries_by_population

³ Census stats on functionality do not differentiate between those without for two days or several months.

⁴ Minister of Water Affairs, Budget Speech, May 2013.

5.1.2 INVESTMENT IN WATER SECTOR INFRASTRUCTURE

Government is investing on a colossal scale in water sector infrastructure. Its capital investments in economic and social infrastructure for water and sanitation aim to support improved economic growth and quality of life for all South Africans both directly, through improving supply, distribution, access and or quality, and indirectly, through creating jobs, developing markets and lowering transaction costs.

Expanding access to water requires investments all along the supply chain, and includes investments in new dams, bulk water supply schemes and wastewater infrastructure, as well as refurbishment of existing infrastructure.

- Mega-projects under consideration in the water sector total R131-bn in the period 2013-23, and includes major development like Phase 2 of the Lesotho Highlands Water Project to augment the Vaal River system.⁵ Yet this vast volume of project plans, procurement processes and funding flows represents just 3.6% of government's total R3 592-bn infrastructure spending programme; investments in electricity (55.7%) and transport (22.9%) dwarf those in the water sector, and highlight the extent to which government is looking to infrastructure spending to fuel economic growth and job creation (Treasury, 2013a).
- Government is currently building seven new dams, increasing the capacity of four and rehabilitating a further twenty-five.
- Large pipeline schemes to transfer water from dams to distribution centres are being financed and implemented by TCTA, and will serve a mix of industrial, commercial and municipal clients.
- Water boards have been investing in maintenance, refurbishment and expansion of treatment and distribution facilities, spending a combined total of R3.3-bn in the year to June 2013. The two largest, Rand Water and Umgeni Water, account for most of this spending.⁶
- National water and sanitation infrastructure development has been allocated R111.9-bn over the 2014 MTEF. From the 2013 MTEF, municipalities have been allocated R42.3-bn to improve reticulation, sanitation and sewage processing plants.⁷

⁵ Electricity has been allocated R2 002-billion, or 55.7%, and Transport, R823-billion or 22.9%. National Treasury *Budget Review 2013*.

⁶ The Minister noted that water boards could have accelerated their infrastructure investment programs if municipalities paid their current debt of R1.9-bn owed to water board.

Groundwater developments comprise a very small fraction of this total. Dams, bulk pipelines and large scale water treatment works do not usually target groundwater, and there are few groundwater developments in the list of mega-projects. At the level of municipal spending, it is difficult to identify projects and quantify spending on infrastructure associated with groundwater usage without detailed investigation of individual project descriptions, but even a generous estimate would struggle to assign more than a nominal percentage to groundwater development.

5.1.3 SOURCES OF FUNDING FOR WATER SERVICES INFRASTRUCTURE

Public funding for South Africa's infrastructure development comes from a mix of borrowing, tax revenue and tariffs. South Africa's Revenue Service has widened the tax base, reduced tax rates and become increasingly efficient at collecting the taxes due to it. The conservative US think-tank The Heritage Foundation estimates that tax revenue in South Africa as a proportion of GDP is about 26.9%; this is exactly the same as the United States, and precisely on the median of other BRICS nations.⁸ This fiscal income is supplemented by borrowing mainly through domestic bonds, purchased mainly by pension funds (29,1.% in 2013) and international investors (36,4%) (Treasury, 2014a). Net loan debt is projected to reach 54,8% of GDP in 2014/15, rising to 57,1% of GDP by March 2016 (Treasury, 2014a). Debt-service costs stood at at 2.9% of GDP in 2013.

In the 14 years since the first Division of Revenue Act was introduced in 1998, more than R165-bn in infrastructure grants was made available to municipalities or to national departments to spend on their behalf. Of this amount, just over R134-bn was allocated in the six years beginning 2007/08. The increase in allocation is accelerating. R131.6-billion has now been allocated for the three year MTEF period beginning 2014 (Treasury, 2014a). The water sector was a prominent spender in the 1990s and early 2000s, but spending in other sectors has increased steadily.

Government has committed itself to funding the social component of of infrastructure – i.e. infrastructure required to meet the basic needs of low income households. Funding required to support water services to non-poor or commercial customers is funded largely from loans and repaid from service tariffs.

⁷ National Treasury, *Budget Review 2013*

⁸ Brazil: 34.4%; Russia, 36.9%; India, 17.7%; China: 17%.

(http://en.wikipedia.org/wiki/List_of_countries_by_tax_revenue_as_percentage_of_GDP)

5.1.4 GOVERNMENT FUNDING TO MUNICIPALITIES FOR BASIC SERVICES

Government provides a wide arrange of funding support mechanisms to municipalities to support the provision of basic services to all. These are conditional and unconditional, direct and indirect, and focused on capital programmes or recurrent costs. The two most significant for municipal water services delivery are:

- MIG: the Municipal Infrastructure Grant, a conditional grant to fund infrastructure for basic services benefiting low income households
- The Equitable Share: an unconditional grant, but Treasury would like to see municipalities use it to fund the recurrent costs of basic services to low income households – notably for free basic services.

The Equitable Share was introduced in 1998 to give effect to the Constitutional requirement that provincial and local government should have an equitable share of national revenue, commensurate with their functions. It had three components, intended to support municipalities' *recurrent* costs – a basic services grant, to subsidise basic services for the poor; an institutional capacity-building grant to support individual municipalities that were unable to raise enough revenue to establish their core administrative infrastructure; and an intergovernmental grant allocation, based on a proportion of grants paid in previous years. From 2001, faced with evidence of low cost recovery in water services nationally – a combination of a low propensity to pay and difficulties faced by poor households in affording the cost of the new services being provided to them – the Equitable Share was significantly increased to accommodate the cost of the new Free Basic Water Policy of providing six free kilolitres of potable water monthly to every poor household. The policy was announced in September 2000 to ensure that no poor person should be denied access to a basic supply of water based on affordability. This represented a significant shift in government policy, with government now co-funding a portion of the operating costs of water services, as well as electricity, waste removal and sewage.

The MIG, conversely, provided *capital* funding to enable municipalities to invest in the infrastructure needed to provide basic services to the poor. Introduced from 2004, MIG consolidated several different national funding streams into a comprehensive grant, with the amount available per municipality over the next three years, published each year. For the first time, municipalities could plan multi-year programmes with reasonable certainty about their grant funding allocations for subsequent years. MIG was based on a formula that took into account the number of people still requiring basic infrastructure. Over half of the annual allocation was earmarked for new water and sanitation infrastructure. The funds were allocated per municipality and could be accessed directly from the Department of Provincial and Local Government, (now Department of Co-operative Governance, or DeCoG) rather than via the sectoral programmes of the different line departments.

The introduction of MIG also meant that from 2004, municipalities accounted to the Department of Provincial and Local Government, not DWAF, in how they spent capital grants for infrastructure in the water services sector. DWAF's role in relation to capital funding was limited to setting design standards and scrutinizing project technical reports during the preliminary design phase. This diminished DWAF's influence over how projects were conceived, implemented and monitored. As municipalities took up their new mandate, with increased funding and autonomy, project planning and implementation became increasingly technicist and driven by available grant funding, with less and less emphasis on the social capital and maintenance dimensions of sustainable services. MIG was introduced to consolidate and streamline a number of grants managed by different sector departments. Over the past decade, there has been a steady proliferation in the number of conditional and other grants; this increases the administrative burden of managing grant funding, particularly for municipalities having to assemble applications for conditional grants. Table 5-1 summarises government's main grants and funding supports for municipal water services; each is discussed in more detail in the next section.

TABLE 5-1 SUMMARY OF NATIONAL GRANTS AND FUNDS FOR LOCAL GOVERNMENT TO SUPPORT PROVISION OF BASIC WATER SERVICES

	Capital Funding	O&M Funding
Transferred Directly to municipalities	Municipal Infrastructure Grant (MIG) Municipal Water Infrastructure Grant (MWIG) Urban Services Development Grant (USDG) ⁹	Equitable Share (ES) Water Services Operating Subsidy Grant
Transferred Indirectly , via DWA	Regional Bulk Infrastructure Grant (RBIG) Accelerated Community Infrastructure Program (ACIP)	Water Services Operating Subsidy (indirect, through DWA)
Transferred indirectly , via Dept. Human Settlements	Rural Household Infrastructure Grant (RHIG) ¹⁰	
Transferred indirectly , via Dept.	Technical support for planning and implementing water and sanitation	

⁹ Targets the metros, and replaces MIG in those cities. It is mainly for funding service development in informal settlements.

¹⁰ In practice DHS targets RHIG exclusively at rural sanitation. From 2014/15 the grant will be transferred directly to municipalities, and their spending priorities may be different.

	Capital Funding	O&M Funding
of Co-operative Governance	programs, through the Municipal Infrastructure Support Agent (MISA)	

5.2 GROUNDWATER AND THE FLOW OF FUNDS FOR MUNICIPAL WATER SERVICES

Development and management of groundwater infrastructure for water services is not constrained by a shortage of public funds. On the contrary, the quantum 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 it effectively. For the financial year ending June 2013, municipalities 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 2013b). There is even evidence to suggest that the scale of ‘free money’ available to local authorities to develop water services provides strong incentives to consider *alternatives* to groundwater.

This section argues that the abundance of grant funding and transfers for capital developments and operational management removes the incentive for quantifying and weighing the costs and benefits of different sources of supply, and feeds an assumption that surface water can and should be provided wherever technically feasible.

5.2.1 THE CONTEXT OF MUNICIPAL INFRASTRUCTURE FUNDING

Infrastructure funding allocations to municipalities are based on the Municipal Infrastructure Investment Framework (MIIF), which is supported by an elaborate financial modelling tool whose assumptions and data sets are updated regularly. DeCoG is the custodian. A key financial modelling assumption underlying grant funding since the 1990s has been that all infrastructure backlogs would be eliminated by 2014 (PDG, 2008); the need for MIG was expected to fall away by this date (Hollingworth, 2011). Considerable emphasis has been given to programs to accelerate infrastructure delivery, through ever-greater capital grants and a widening program of technical and financial support to assist municipalities to withstand ‘cash-bombing’ by national government.¹¹ The latest iteration of the latter is the Municipal Infrastructure Support Agent (MISA), which is now institutionalizing the ad-hoc support and interventions, mainly to municipalities serving small towns and rural settlements, that were previously co-ordinated by the Development Bank’s Siyenza Manje program. MISA currently

¹¹ ‘Cash-bombing’ is a phrased coined by David Savage, a manager in National Treasury in the late 1990s.

provides a specialist Water and Sanitation support programme for 29 WSAs by MISA to assist them with planning, procurement and project management.

But institutional building takes longer than physical construction, and in many instances institutional capacity to manage new infrastructure sustainably has lagged behind delivery of new infrastructure. It is generally the youngest municipalities that have had the greatest infrastructure backlogs, and the greatest volume of new infrastructure development; they tend to have the least resources and readiness to maintain new and existing infrastructure.

Across municipalities, technical workloads have increased substantially, well beyond adjustments to staffing levels; the undersupply of key artisans like electricians, millwrights and plumbers is compromising many municipalities' ability to operate and maintain their own infrastructure. One consequence is that a substantial part of the value of recent investments has been compromised, with a widening infrastructure maintenance deficit.



Source: Municipal Demarcation Board Annual Skills Audit 2012 Findings

FIGURE 5-1 HIGHEST LEVEL OF QUALIFICATION ACHIEVED: MUNICIPAL TECHNICAL SERVICES MANAGERS, 2012

Whilst the academic qualifications of Municipal Managers and Chief Financial Officers are increasingly aligned better with their functional responsibilities, due to regulation, the overall academic qualifications and experience of municipal technical directors are frequently inadequate; their subordinates are often no better or less qualified. This often deepens their reliance on third party consultants or advisors, whose own interests may be short-term or at odds with the long term good of the municipality and the people living there.

Local Government legislation was amended in 2011 to require Section 56 managers (including technical services managers, who report to the Municipal Manager) to have ‘the required skills, expertise, competencies or qualifications’. Regulations are now being formulated to bring this amendment into effect from 2015. The amendment has obvious merit, but it will not make it any easier to fill key positions in rural municipalities far from the major cities – precisely where the service challenges are often the most acute.

5.2.2 NATIONAL GRANT FUNDING PROGRAMMES CURRENTLY TARGETING MUNICIPAL WATER SERVICES

Government transfers for funding water services infrastructure have increased tenfold over the past decade, from R1.1bn in 2003/04, to at least R11.8-bn in 2013/14. Since 2004, the bulk of the funds have been transferred directly to municipalities; municipalities have been able to determine their own priorities, and decide what infrastructure will best serve their service delivery objectives.

The next section outlines the main types of grants currently available to municipalities, and presents them in the order in which they have been introduced.

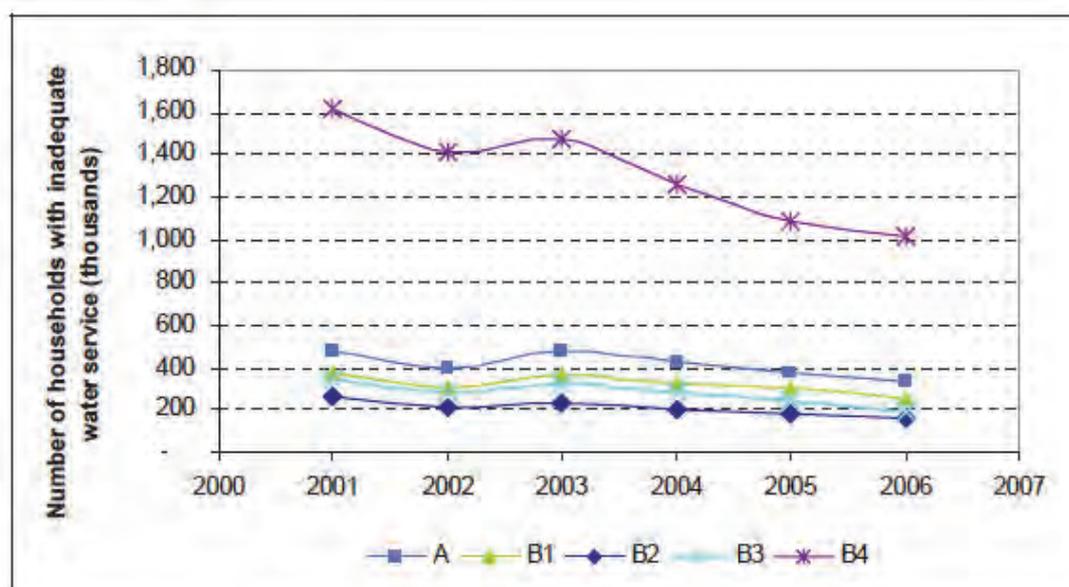
5.2.2.1 Municipal Infrastructure Grant (MIG)

The Municipal Infrastructure Grant is conditional grant financing for municipalities to cover the capital cost of basic infrastructure for the poor, and is the largest infrastructure grant by far as it consolidated a number of different funds into one stream. It funds basic services, roads and social infrastructure serving low income households in non-metropolitan areas, and is calculated according to a formula which takes account of poverty statistics, backlogs and municipal powers and functions. However poverty and institutional indicators are not necessarily a good proxy for the cost of providing basic infrastructure in a particular area, but Treasury does not currently have a better alternative.

Conditional allocations for basic services make up 75% of MIG. Water and sanitation comprise 72% of that 75%, and thus constitute 54% of the overall MIG grant per municipalities; roads are allocated 17.25% overall, and other services, 3.75% overall; electricity infrastructure is funded separately. Treasury allocated R14,684-billion to MIG for 2014/15; the 54% for water and sanitation comprised R7.262-billion. 54% of MIG targets water and sanitation. In practice, municipalities tend to allocate slightly more than this to water and sanitation, with water infrastructure getting the bulk of the funds overall.

The intention of Government has been to eliminate infrastructure backlogs by 2014, and funds are allocated in line with a financial modelling tool known as the Municipal Services Framework Model (MSFM) which calculates the necessary financial requirements at national and municipal level, the feasibility of removing backlogs and the long term sustainability of municipalities providing services.

The MSFM rests on a number of normative assumptions about the propensity of municipalities to convert funding inputs to viable service infrastructure outputs and delivery outcomes. A 2008 evaluation of MIG, for example, charted the rate of backlog reduction in water services infrastructure, and highlighted that the proportion of inadequately served people was barely changing across the different types of municipalities, even though the absolute number was declining; the gap between municipalities serving predominantly rural areas (B4s) and the rest persisted, despite massive spending; their infrastructure backlogs remained strikingly higher than metros and secondary cities.



Source: SPAID / PDG, 2008

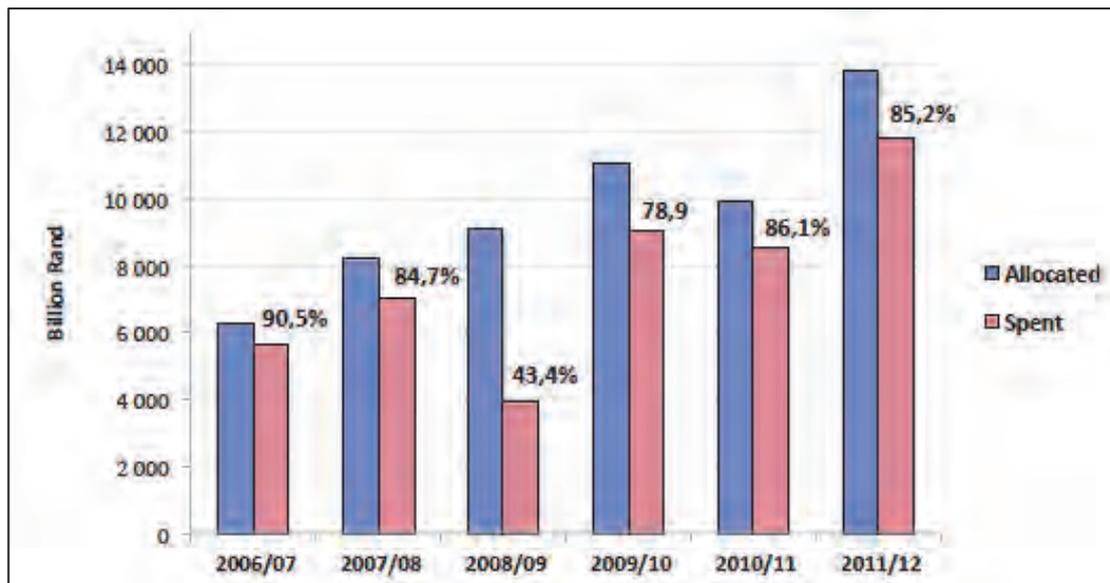
FIGURE 5-2 TRENDS IN WATER SUPPLY BACKLOGS IN MUNICIPAL CATEGORIES ACCORDING TO DWA DATA

Yet the authors of the report found this 'lack of change in the distribution of backlogs between municipal types' 'surprising'. There is now growing acknowledgement that there is more to eradicating infrastructure backlogs than the provision of funds; and the quantum of funds required varies widely, for reasons ranging from source options to topography to settlement density to design.

Hollingworth et al (2011) note that high capacity municipalities are able to supplement their MIG funding with other sources of finance, but the low capacity municipalities rely almost exclusively on MIG for capital funding; borrowing is not a significant source of funds for DMs. Analysis of municipal

financial data reported to Treasury shows that just 3 DMs targeted by MWIG borrowed any funds for capital expenditure in 2012/13,¹² and there is no evidence any of it was used to finance water infrastructure.

There has been substantial increase in the quantum of funds that local authorities are expected to absorb and use each year.



Source: Compiled from data published in the annual Budget Review.

FIGURE 5-3 MIG ALLOCATIONS 2006 TO 2012, SHOWING THE PROPORTION MUNICIPALITIES HAVE SPENT EACH YEAR

Note that the increase in the amount of MIG allocated to municipalities is far greater than represented here, because it excludes the metros from 2010.¹³

Spending of the total MIG allocated in 2012/13 declined to 79% (2014a). In a recent review, National Treasury attributed the under-spending to delays in project registration, absence of project management units, lack of capacity, delays with contractors, limited multi-year budgeting, and political interference in the capital procurement process (Treasury, 2013b).

¹² Ugu, R10M; Uthungulu, R16.6M; Ngaka Modiri Molema, R16.6M. (Treasury, 2013b.)

¹³ A separate MIG-Cities grant was introduced in 2010, and this subsequently morphed into an Urban Settlements Development Grant, which incorporates the MIG-Cities grant and combines it with a Human Settlements grant for upgrading informal settlements.

Data submitted by municipalities to National Treasury indicates that most DMs are spending their money. But there is little information about how effectively it is being spent – on what, through whom, and with what outcomes. More widely, MIG has been questioned for its value-for-money, lack of differentiation (particularly with respect to capacity) and poor linkages to sector-based capacity (see for example Hollingworth, 2011).

5.2.3 REGIONAL BULK INFRASTRUCTURE GRANT (RBIG)

MIG fuelled a substantial increase in the number of households with access to at least a basic level of water services; by the mid-2000s, bottlenecks in the supply of bulk water were being cited as a reason for slower-than-expected progress in eradicating service backlogs. Equally, large-scale wastewater treatment facilities were planned for some areas straddling a municipal boundary. The quantum of funds required was more than MIG's planners envisaged, and bulk supply infrastructure frequently straddled more than one municipality. DWAF lobbied successfully for a new funding mechanism for bulk water and wastewater infrastructure; it was highly conditional, and the benefits accrued to municipalities indirectly through DWAF: DWA builds bulk distribution infrastructure on behalf of municipalities. Under close DWA program management, spending of RBIG funds has been substantially higher – 96% in 2012/13 (Treasury 2014b) – than MIG and other grants managed by municipalities. R3,987 has been budgeted for 2014/15.

TABLE 5-2 ALLOCATION OF RBIG FUNDS 2013-2016, BY TYPE

Type	Definition	2013/14	2014/15	2015/16
Small infrastructure	Cost less than R90 million per annum and not totalling more than R250 million over the medium term	R1,452-bn	R1,946-bn	R2,146-bn
Large infrastructure	Cost between R90 and R 400 million per year totalling at least R250 million but less than R1 billion	R1,114-bn	R1,579-bn	R1,626-bn
Mega infrastructure	Cost over R400 million per year for a minimum of three years or totalling at least R 1 billion	R0,463-bn	R0,956-bn	R1,098-bn

Source: DWA, 2013b

DWA's Annual Report for 2011/12 noted that 'a huge backlog' had developed in regional bulk water and sanitation infrastructure belonging to municipalities – cross-boundary bulk supply pipelines and treatment works – and estimated that it would cost R110-bn to address this.

5.2.4 THE ACCELERATED COMMUNITY INFRASTRUCTURE PROGRAMME (ACIP)

ACIP uses funds pre-prioritised from DWA's budget to accelerate the achievement of universal access to water and sanitation services by 2014. Annual allocations since 2010/11 have averaged about R250-m, and have been aimed at three broad areas:

- Community infrastructure
- Water conservation and demand management
- Wastewater infrastructure refurbishment

Expanded access, combined with a lack of maintenance, has strained existing infrastructure, and a large proportion of ACIP has been allocated to rehabilitation. Wastewater infrastructure has been allocated the bulk of the funds, and been used largely to address problems identified through the Green Drop assessment process.

ACIP's budget has increased from R145,8-m in 2011/12 to R246,9M in 2014/15.

TABLE 5-3 ALLOCATIONS TO ACIP, 2014/15

Category	FY 2014	Percentages
Accelerated Community Water Supply	R60,8M	34,6%
Water Conservation and Demand Management	R93,7M	37,9%
Wastewater refurbishment	R90,7M	36,7%
Programme management and Contingencies	R1,6M	0,6%
Total:	R246,9M	

Source: DWA, 2014a

5.2.5 RURAL HOUSEHOLD INFRASTRUCTURE GRANT

MIG has mostly funded services in towns and cities, not rural areas. Consequently government introduced a Rural Household Infrastructure Grant (RHIG) in 2010/11 to support infrastructure development outside of small towns in the 23 priority districts; the emphasis was meant to be on providing basic water and sanitation services, and funds were managed by the national Department of Human Settlements. In practice, spending is focused exclusively on rural sanitation.

The benefits of the RHIG have been limited, and a large portion of the funds allocated have not been spent. In 2012/13, the allocation of R479.5M was reduced to R340.6M at the request of DHS; even so, final spending for the year was just R135M, or 39,6% of the reduced amount (Treasury, 2014b).

The allocation for 2013/14 was cut to R114M, and then restructured so that just R48M was transferred directly to municipalities, with the rest managed by DHS.

5.2.6 URBAN SERVICES DEVELOPMENT GRANT

The Urban Services Development Grant (USDG) funds informal settlement upgrading in metros, and includes provision of water and sanitation. It incorporates funds previously allocated through MIG, and subsequently allocated through a variant of MIG known as MIG Cities, which gave metros more latitude in how and when they spent MIG allocations over a three year period. There is no evidence of metros using any of it to develop groundwater sources. Tshwane is the only metro to make extensive use of groundwater for municipal water supply, and does not need the USDG to do so.

5.2.7 MUNICIPAL WATER INFRASTRUCTURE GRANT

Achieving the goal of eradicating service backlogs continues to elude government, despite the provision of substantial infrastructure funding. In 2012, DWA initiated a new Interim Intermediate Water Supply Programme (IIWSP). Acknowledging that some might still not have access to water under existing funded programmes in the short term, IIWSP aimed to provide water to unserved people in the interim, using intermediate technologies where these would accelerate access. A new conditional infrastructure grant, the Municipal Water Infrastructure Grant (MWIG), was introduced from 2013 to fund this programme.

According to StatsSA surveys and DWA assessments, most of the population without access to water supply live in rural settlements in Kwa-Zulu Natal, Limpopo and the Eastern Cape, and are located within 23 District Municipalities. Cabinet has now resolved to provide these 23 with priority support, and DWA has added one further, Zululand, to the list receiving MWIG support, 'because there is no good reason to exclude it'.¹⁴ They are all relatively young administrations, formed since 2000, and serve areas previously categorized as 'homelands'. Service improvements in those municipalities have had to start from a very low base of infrastructure and institutional development; they dominate the list of areas with water services backlogs. DWA estimates that addressing backlogs in the 24 DMs will take 78% of the R27-bn it estimates is needed. DWA breaks down the backlog as follows:

¹⁴ See Section 1.4 for a full list of the 24 District Municipalities and the local municipalities targeted within them.

TABLE 5-4 MWIG ALLOCATIONS PER CATEGORY 2013/14

MWIG identified needs per category	% of Cost
Communities having no formal water infrastructure	17.9%
Communities requiring extension to existing infrastructure	35.8%
Communities with access to infrastructure but no access to water because of functionality problems	28.2%
Communities with access to infrastructure but no access to water because of source problems	18.1%
	100%

Source: DWA, 2013b

According to this DWA data, less than 20% of the cost of addressing service backlogs needs to be targetted at providing infrastructure for the first time; most is needed to go back and address problems with the existing infrastructure (much of it developed in the past decade). The DWA data indicates that 18% of current service backlogs stem from problems with the source, but it is unclear what this means more specifically. It could suggest over-pumping or a collapsed borehole, rather than a problem with the water itself. However DWA informed the Standing Committee on Appropriations in March 2013 that these numbers, and the list of projects which MWIG will address, are based on questionable planning foundations. It described the master plans for more than 50% of all water services authorities as 'non-existent or useless' and 'terrible'.

Over a third (36%) of the total R4.3-bn MWIG budget over the 2013 MTEF was allocated to KwaZulu-Natal, where the greatest need is to develop new water infrastructure; Limpopo got the second highest allocation; notably, the bulk of funding in Limpopo is not needed for new infrastructure for unserved areas, like in KwaZulu-Natal, but to rehabilitate or extend existing infrastructure.

In 2013, MWIG funds were transferred directly to municipalities, despite DWA's request that it be authorised to manage the funds directly in the same way it manages RBIG disbursements to improve the effectiveness of spending. DWA introduced extensive conditions that municipalities must meet before it will approve spending through MWIG 'because the Department had experienced problems in the past with transferring money to municipalities'. Where municipalities have a poor track record in utilising MIG and other funds to tackle service backlogs, DWA has insisted that a water board be appointed to implement MWIG projects in a particular municipality; for example, Chris Hani DM implements MWIG projects itself, while OR Tambo DM does not.

Where a water board is appointed as an implementing agent, Treasury transfers MWIG project funds directly to the water board, not via the municipality. DWA has managed to persuade Umhlatuze Water,

Umgeni Water, Amatola Water, Bloem Water and Lepele Water to accept responsibility for implementing MWIG projects on behalf of DMs. As implementing agent (IA), the water board is also responsible for post-commissioning operation and maintenance; DWA initially stipulated a minimum two year contract period 'or until the municipality had capacity and resources to manage and operate effectively', but has had to accept a reduction to one year. It seems that DWA hoped that water boards would be appointed as water services providers to operate water supply schemes¹⁵, but this approach has not won support from municipalities, DeCoG or Treasury.

TABLE 5-5 MWIG MTEF ALLOCATIONS 2013/14-2015/16

Province	District	Local Municipality	Revised DM Total MTEF Allocation as at June 2013 (Rand Million)
Eastern Cape	Amathola	Amahlathi	130
	Chris Hani	Intsika Yethu	218,4
	Joe Gqabi	Elundini	60
		Senqu	
		Maletswai	
		Gariep	
	OR Tambo	Ngquza Hill	238,5
		Port St Johns	
		Nyandeni	
		Mhlonto	
		King Sabata Dalindyebo	
	Alfred Nzo	Matatiele	161
		Umzimvubu	
		Mbizana	
Ntabankulu			
Eastern Cape Total:			808
Free State	Xhariep	Letsemeng	160
		Kopanong	
		Mohokare	
		Naledi	
	Free State Total:		

¹⁵ 'The motive behind the involvement of the Water Boards was devised with the aim to change the existing paradigm and role of Water Boards and make them more directly involved in assisting WSA [sic] and municipalities in service delivery objectives.'

KwaZulu-Natal	Ugu	Vulamehlo	172,5
		uMuziwabantu	
		Hibiscus Coast	
	Umgungundlovu	uMshwati	193,4
		Msunduzi	
	uThukela	Emnambithi	84,5
		Indaka	
		Umtshezi	
		Okhahlmaba	
		Ombabazane	
	Umzinyathi	Endumeni	114
		Nqutu	
		Msinga	
		Umvoti	
	Amajuba	Newcastle	70
		Emadlangeni	
		Dannhauser	
	Zululand	eDumbe	149
		uPhongolo	
		Abaqulusi	
		Nongoma	
		ULundi	
	uMkhanyakude	Umhlabuyalingana	108
		Jozini	
		The Big 5 False Bay	
		Hlabisa	
		Mtubatuba	
uThungulu	Mfolozi	283,5	
	uMhlathuze		
	Ntambanana		
	Umlalazi		
	Mthonjaneni		
	Nkadla		
iLembe	Mandeni	312	
	KwaDukuza		
	Ndwedwe		
	Maphumelo		

	Sisonke	Ingwe	80	
		Kwa Sani		
		Greater Kokstad		
		Ubuhlebezwe		
		Umzimkhulu		
KwaZulu-Natal Total:			1574	
Limpopo	Mopani	Greater Giyani	162,4	
		Greater Letable		
		Greater Tzaneen		
		Ba-Phalaborwa		
		Maruleng		
	Vembe	Musina	324	
		Mutale		
		Thulamela		
		Makhado		
	Capricorn	Blouberg	88,4	
		Aganang		
		Molemole		
		Polokwane		
		Lepele-Nkumpi		
	Sekhukhune	Ephraim Mogale		266
		Elias Motsoaledi		
		Makhudathamaga		
		Fetakgomo		
		Greater Tubatse		
	Limpopo Total:			841
Mpumalanga	Ehlanzeni	Thaba Chweu	760	
		Mbombela		
		Umjindi		
		Nkomazi		
		Bushbuckridge		
	Mpumalanga Total:			760
Northern Cape	John T Gaetsewe	Joe Morolong	68	
		Ga-Segonyana		
Northern Cape Total:			68	

North West	Ngaka	Modiri	Ratlou	113
	Molema		Tswaing	
			Mahikeng	
			Ditsobotla	
			Ramotshere Moiloa	
	Dr Ruth Mompoti		Greater Taung	8,7
			North West Total:	121,6
National Total:				4333

Source: Division of Revenue Act, June 2013

MWIG is more than a ring-fenced portion of MIG for water services¹⁶; it represents an absolute increase in funding for water services, and is earmarked for projects to deliver benefits in the short-term, and possibly on an interim basis until greater improvements follow. It aimed to ensure that government honoured its commitment to eradicate all water services backlogs by 2014. Achievement of this goal is not achievable not least because the funds fall far short of what is needed; MWIG has been premised on an average allocation of R7 000 per household; but in KwaZulu-Natal, the average cost per household is currently R34 000, and in some small settlements, the unit cost can exceed R100 000 per household and more (DWA 2013b).

But municipalities were initially resistant to using MWIG for groundwater developments, and, according to DWA, 'more than 70% of WSAs do not want localised solutions and prefer regional schemes.' One reason is that water boards generally operate and manage the big regional schemes, and the municipalities can buy bulk potable water rather than having to abstract and treat it themselves.

A close analysis of MWIG projects itemized for 2013/14 indicates that municipalities allocated a relatively high proportion of MWIG to groundwater-based service improvements. Over a third – 34.2% – of 2013/14 projects focused on groundwater. This is remarkable, given that just 4% of an original wish-list of water services projects totalling R19.6-billion, submitted to DWA by the 24 District Municipalities in early 2013, were groundwater-based.

¹⁶ The comments of the Chair of the Parliamentary Standing Committee on Appropriations seem poorly informed: 'The chairperson said that this Committee appreciated that the Department of Water Affairs decided to take away its contribution to the Municipal Infrastructure Grant (MIG) because that grant was not performing and the money had been directed to a new Water Infrastructure Grant to ensure that people did receive water. This could well spell 'the end of the road' for MIG if all departments started to claim they could spend better elsewhere.' Minutes of the Standing Committee on Appropriations, 4 Jun 2013. www.pmg.org.za/report/20130604-department-cooperative-governance-traditional-affairs-201314-budget

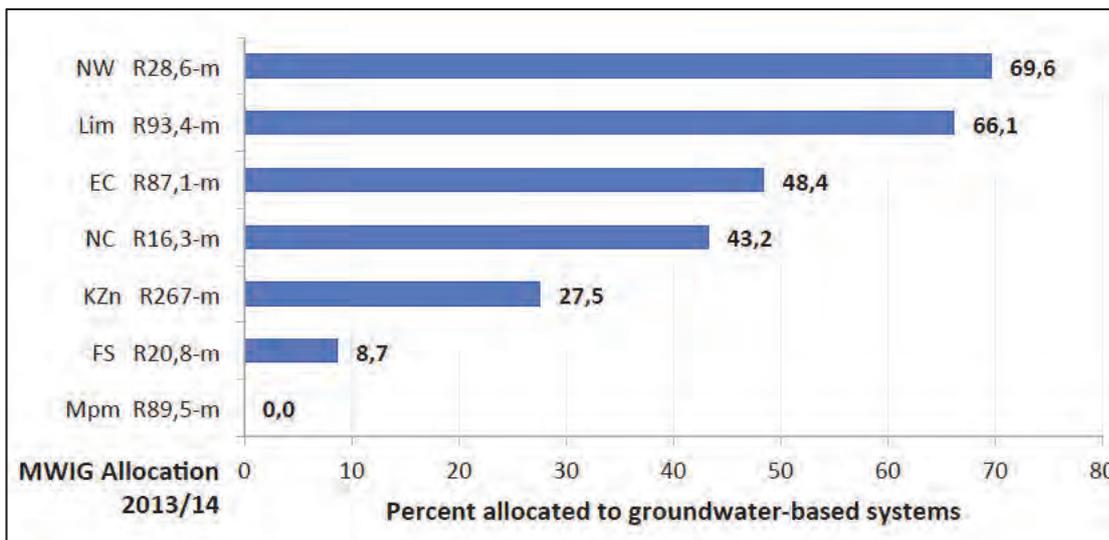


FIGURE 5-4 PERCENTAGE OF MWIG ALLOCATED TO GROUNDWATER-BASED SYSTEMS, 2013/14

By March 2014, seven borehole construction and refurbishment projects had been completed in Alfred Nzo DM, and groundwater projects were advancing well in Joe Morolong and Ga-Segonyana in the Northern Cape. This list of completed projects fell short of what DWA anticipated, but did vindicate its argument that groundwater projects could offer service improvements within short time frames.

By formulating the investment as interim and intermediate – not final and ‘forever’ – DWA hoped to nudge municipalities towards accepting more pragmatic service approaches than they might otherwise have done in the interest of delivering improved services sooner. However, in a report presented to the Parliamentary Portfolio Committee in February 2014, DWA officials described MWIG project progress and performance as ‘not satisfactory’. To date spending has been slow, some weak municipalities have resisted the appointment of water boards as implementing agents on their behalf, and there has been resistance to, or rejection of, unspecified ‘rudimentary localised solutions’. Some of the projects that have been implemented are consequently unsustainable and unaffordable, and overall costs are now substantially higher. Instead of the R4,3 billion allocated over three years to implement MWIG’s objective, DWA now estimates that over R20 billion will be needed (DWA 2014b).

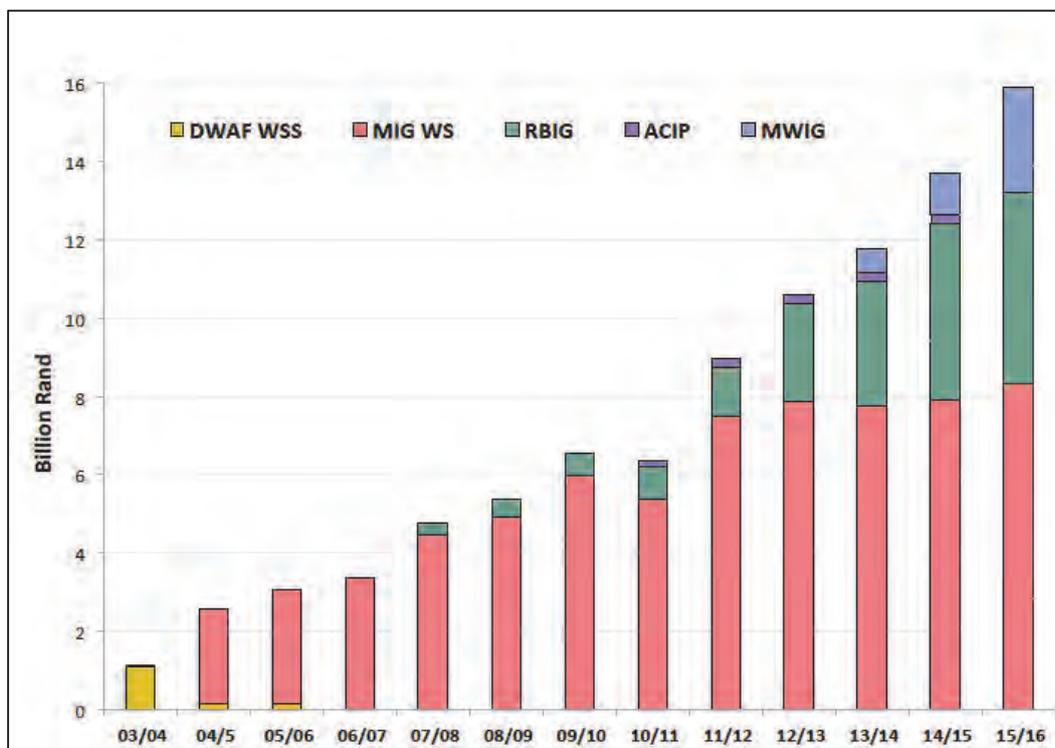
From 2014, DWA will have considerably greater control and authority over how MWIG funds are utilised. Treasury has agreed to designate half (R524M) of the R1 059M allocated for 2014/15 as a Schedule 6b grant; under-performing municipalities will sign a service level agreement with DWA, and DWA will drive implementation on their behalf.

It remains to be seen whether this revised approach will deliver the development and rehabilitation of groundwater-based schemes envisaged when MWIG was established, or whether some municipalities

will continue to resist 'rudimentary localised solutions'.

5.2.8 SUMMARY OF GOVERNMENT GRANTS FOR INFRASTRUCTURE SPENDING

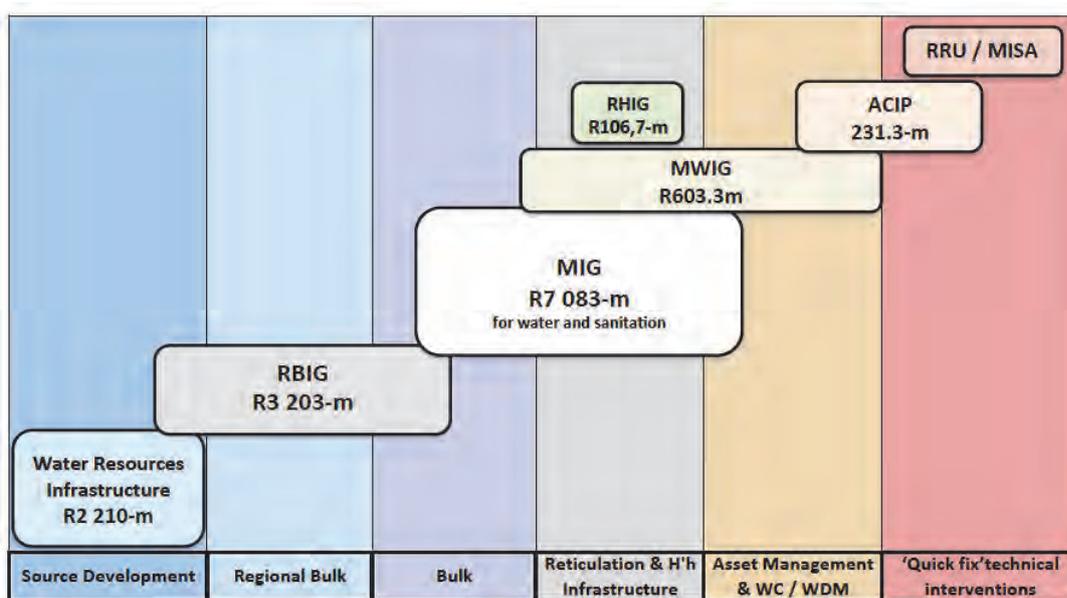
Figure 5-5 presents data which aggregates all water services grants to municipalities by year, starting in 2003 with funding for the last years of DWA's community water supply programme. It shows the extent of the increase in overall funding for water services infrastructure, and may shed light on why – with the notable exception of MWIG – such a small proportion of current spending goes to groundwater sources: there are substantial incentives to municipalities to find ways to absorb large tranches of grant funding each year, and the evidence suggests that surface water schemes may do this more effectively than smaller groundwater schemes.



SOURCE: COMPILED FROM DATA PUBLISHED IN THE ANNUAL DIVISION OF REVENUE ACT

FIGURE 5-5 GOVERNMENT GRANTS FOR WATER SERVICES INFRASTRUCTURE, 2003-2016

In 2013/14, national government allocated over R13.5-bn for water services infrastructure, including water resource developments.



Source: Adapted from DWA (2013b)

FIGURE 5-6 GRANT FUNDING AVAILABLE IN 2013/14 FOR WATER SERVICES INFRASTRUCTURE

5.3 OPERATING SUBSIDIES

5.3.1 THE EQUITABLE SHARE

Section 227 of the Constitution of South Africa entitles local government to an equitable share of nationally raised revenue to enable it to provide basic services and performs its allocated functions. The Equitable Share (ES) is an unconditional transfer that supplements the income that municipalities can raise from source of own revenue available to them, including property rates and service charges). It provides funding for the recurrent costs of providing free basic services and subsidises the cost of administration and other services.

The ES is calculated per municipality on the basis of R293,03 per month per household earning the equivalent of two state pensions per month or less, as quantified in the 2011 census (59% of the population); R169.09 is earmarked for water and sanitation.

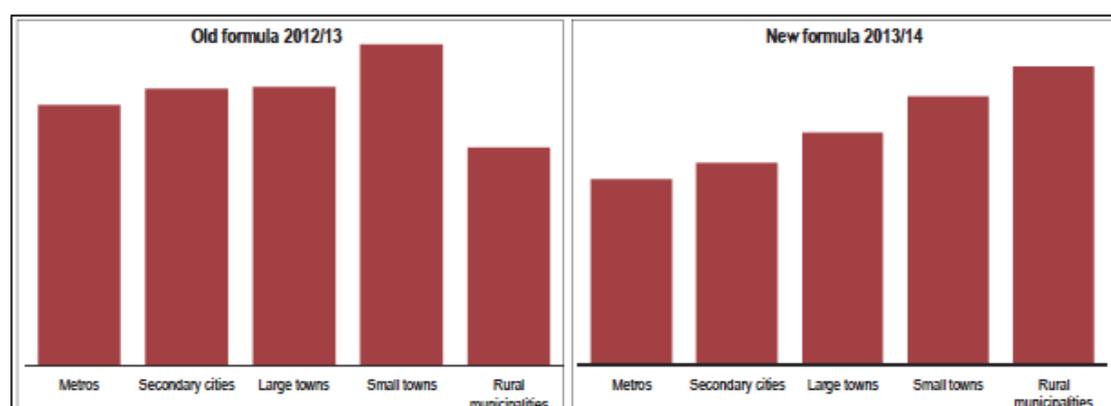
TABLE 5-6 THE EQUITABLE SHARE FORMULA 2014/15

	Allocation per households below affordability threshold			Total per service
	Operations	Maintenance	Total	
Energy	R54,20	R6,02	R60,22	R6 289 M
Water	R83,78	R9,31	R93,09	R9 722 M
Sanitation	R68,40	R7,60	R76,00	R7 937 M
Refuse	R57,34	R6,37	R63,71	R6 654 M
Total Basic Services	R263,72	R29,30	R293,03	R30 603 M

Source: Treasury 2014a

Treasury acknowledges that the cost of service provision varies widely across municipalities, but considers its allocation generous on average; the cost of supplying water in rural municipalities may be higher than in densely settled cities, but Treasury assumes that the greater cost will be offset by lower recurrent costs for sanitation.¹⁷

The local government equitable share was reviewed in 2012 and a new formula, based on 2011 Census data, is being phased in over 5 years from 2013/14. The revised formula allocates a greater share of funding to 'B4' municipalities serving predominantly rural areas. Municipalities serving small towns – the so-called B3s – are perhaps the most adversely affected



Source: National Treasury, Budget Review 2013

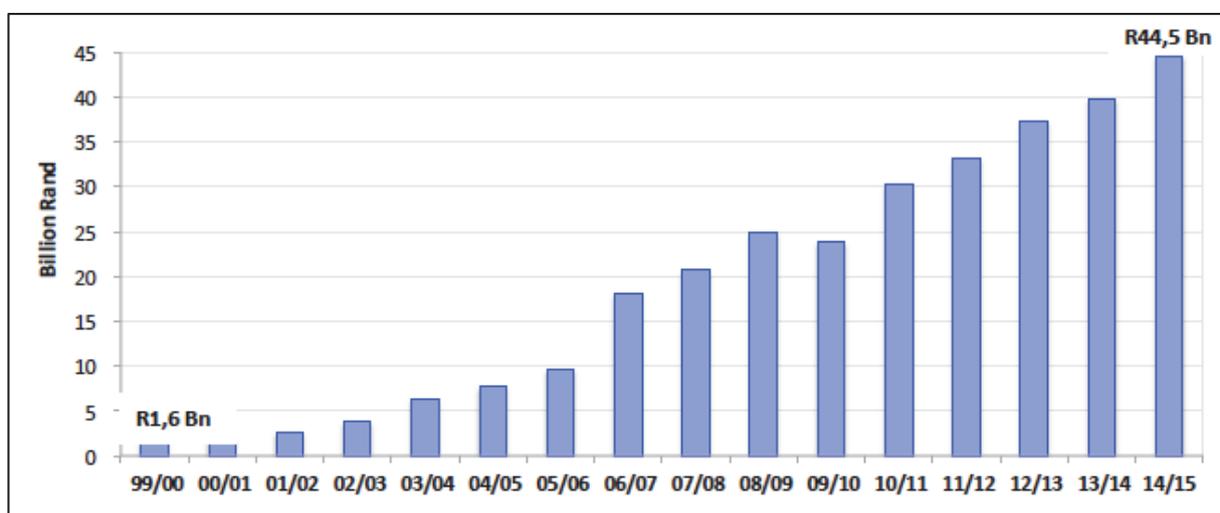
FIGURE 5-7 EQUITABLE SHARE ALLOCATIONS PER MUNICIPALITY, 2012/13 AND 2013/14 COMPARED

Treasury 'encourages' municipalities to use ES funds for the purpose for which they were allocated, but the ES is unconditional and it is the prerogative of municipalities to spend it as they wish. For

¹⁷ Steven Kenyon, Director: Local Government Budget Allocations, National Treasury. Interviewed, May 2013.

example, in most municipalities there is usually a significant gap between the theoretical income available to support water and sanitation provision and the budget actually allocated to water and sanitation services. Much of the Equitable Share is used to fund staff costs. Treasury hopes that the revised formula, which is more transparent, will facilitate greater oversight of municipalities. Government cannot require municipalities to report on how they use the ES, but they can track financial and service delivery performance, and then weigh performance there against the funds provided in the ES.¹⁸

The quantum of ES allocated each to municipalities has expanded exponentially since it was first introduced in 1999, as shown below in Figure 5-8.



Source: Data from annual Division of Revenue Acts.

FIGURE 5-8 EQUITABLE SHARE ALLOCATIONS TO LOCAL GOVERNMENT, 1999-2013

There can be little debate about the importance of the ES in enabling the provision of free basic services. However, the evidence suggests that the ES has weakened municipal revenue collection efforts for consumption beyond free basic amounts, compromised accountability to the recipients of basic services (particularly where municipalities rely heavily on the ES, not customers, for their operating income) and contributed to a sense of complacency among some municipal decision-makers about the adequacy of funds available for operating and maintaining water services. Municipal decision-makers do not necessarily assess the recurrent costs of new capital investments, particularly for water services, as rigorously as they should, and appear to assume that the ES can and will be used to support this additional cost – even where the cost is higher than the ES can

¹⁸ *ibid.*

support, and even where the municipality does not allocate any of the ES to support water services at all. The result is often a disconnect between infrastructure development and provision for ongoing operation and maintenance, with inadequate funds set aside to safeguard sustainability and functional services.

5.3.2 WATER SERVICES OPERATING GRANT

This grant was introduced in the early 2000s to subsidise and build operational capacity to run water schemes owned and or operated by DWA or other agencies on behalf of DWA. In 2014/15 Treasury made provision for a direct grant to targeted municipalities of R450M, and a further indirect grant of R142M via DWA.

To date close to 1 700 schemes have been transferred from DWA to municipalities, but the grant is still being paid to municipalities to ensure that the schemes remain functional. The bulk of the funds are paid to Limpopo municipalities. The grant was to have ended in the late 2000s but has been renewed and extended several times, in large part because of evidence that municipalities are not making provision to take on responsibility for the costs currently covered by the operating subsidy, with particular implications for maintenance. The subsidy will now continue until at least 2016/17.

5.4 MONITORING AND EVALUATION

This review has shown that government is transferring substantial funding to support provision of water services by municipalities. The amount of funding transferred is at times greater than the ability of the municipality to absorb it effectively, with the result that some spending decisions are poorly advised, poorly executed; this contributes to the development of new infrastructure that is poorly operated and maintained. The outcomes of massive investment in new water services infrastructure fall far short of what national government anticipated.

As the quantum of funds disbursed each year has climbed, the ability of public entities to absorb substantial funding allocations has become a prominent indicator of performance. Spending has become an end in itself – rather than a means to achieve defined objectives with indicators focused more on the outputs and outcomes achieved.

In March 2013 the Minister of Finance announced the start of a major review of the local government conditional grant framework, with a view to rationalising some grants and promoting greater accountability in the way they are used. The review is assessing whether the current local government infrastructure grant system is optimally structured to facilitate the efficient rollout of municipal infrastructure. It aims to assess whether the current system of infrastructure funding

responds effectively to government's policy goals, and evaluate how efficiently public funds are being used to meet these policy objectives. Its recommendations will address implementation changes to improve the functioning of the grant system. One option being explored is the introduction of performance-based grants, already being tested to some extent through the Integrated Cities Development Grant. The aim is to incentivise better performance, and allow for longer-term infrastructure planning (Treasury, 2013d).

The Financial and Fiscal Commission, for one, aims to play an active role in promoting debate on what mechanisms will best improve achievement of the desired outcomes of conditional grant funding. The FFC maintains that a rationalization of the local government grant system is necessary, and that monitoring and evaluation must focus on outcomes, rather than spending performance as the primary index.¹⁹

5.4.1 MIG MONITORING

Relatively little monitoring is done of how MIG funding is done, and there is even less evaluation. The last big evaluation of MIG was done in 2009, and focused more on project implementation than on project outcomes; the review of conditional grants announced in March 2013 will entail extensive evaluation of MIG's performance to date.

Government does not currently have the capacity to monitor the outcomes of MIG spending to the degree it should. MIG is administered by DeCoG, and primary responsibility for monitoring the outcomes of MIG spending lies with DeCoG. DWA, however, is better equipped than CoGTA to assess the outcome of MIG spending on water infrastructure, and DeCoG and DWA have been meeting sporadically literally for years to discuss ways of improving joint monitoring; progress has been limited.

Each year the Division of Revenue Act includes a detailed description of each grant and transfer, with an outline of past performance in spending and outcome. Thus the 2014/15 DORA reports that in 2012/13, 79% of allocated MIG funds were spent across all targeted infrastructure sectors, and that MIG funded new water connections to 151 300 households, and improved sanitation to 91 474 households, as well as roads and solid waste improvements. But this information is drawn primarily from documents outlining envisaged outcomes, and has not been verified in any way.

¹⁹ Financial and Fiscal Commission, 2013, 'Sustaining Local Government Finances: Report on the Financial and Fiscal Commission's review of the Local Government Fiscal Framework. Press release, 19 April 2013.

DWA staff acknowledge that there is virtually no follow-up once the initial technical appraisal has been done; there is no assessment of whether the output aligns with the approved plan, whether spending was in line with the approved budget, and whether the infrastructure is fit for purpose and able to support service delivery improvements to the number of people envisaged.

5.4.2 RBIG AND MWIG MONITORING BY DWA

DWA has secured strong leverage in overseeing how RBIG and MWIG are used. Both are conditional grants; RBIG is an indirect grant, administered by DWA, while MWIG is allocated directly to municipalities, but with DWA involved in all phases of planning, procurement and oversight of implementation. The results to date indicate a high rate of utilization of RBIG funds, with well-thought-through projects and implementation mechanisms, and comparatively good outcomes. A similar approach will now be applied to half the funds allocated to MWIG.

5.4.3 MONITORING PERFORMANCE IN ACHIEVING THE PRESIDENTIAL OUTCOMES

In January 2010, the Cabinet prioritized twelve performance outcomes to achieve government's development objectives in five priority areas: Rural Development, Basic Education, Health, Safety and Job Creation. Outcome 7, for example, called for vibrant, equitable and sustainable rural communities with food security for all. Outcome 10: Environmental assets and natural resources that are well protected and continually enhanced.

Ministers, government departments and municipalities were tasked with meeting a wide range of performance targets over the next three years to achieve these outcomes. One KPI under Outcome 10 aimed to diversify the mix of water resources in the interests of bolstering national water security, in part through tracking increased groundwater use. Under Sub-output 1.1: Water Demand, Indicator 1.1.3.(a) aimed to increase groundwater utilization from a baseline of 25% to 30% by 2014, through implementation a national groundwater strategy. But neither the Department of Performance Monitoring and Evaluation (DPME) or DWA regard groundwater as a core performance indicator in the Minister's Delivery Agreement at this stage, and no data has been released to quantify either a meaningful groundwater use baseline or any change in the use of groundwater sources. DPME is looking to see how DWA implements the second National Water Resource Strategy and monitors groundwater use within that.²⁰

More broadly, DPME has been working with the Department of Co-operative Governance and Treasury to develop a tool for monitoring and identifying management and service delivery problems

²⁰ Mohlago Mokgohloa, Outcome Facilitator 10: Environment, DPME. Pers. Comm, 24 October 2013.

in local government, and plans to start piloting municipal assessments in order to identify where to prioritise interventions. To date, there has been little practical progress towards implementation.

5.5 SOME IMPLICATIONS OF CURRENT WATER SECTOR GRANTS TO MUNICIPALITIES

5.5.1 GRANT DEPENDENCE AND MUNICIPAL ACCOUNTABILITY

Own revenues in the metropolitan budgets account, on average, for 81% of budgets (Treasury, 2013), but in the poorest municipalities, own revenues account for less than half of budgets. This is particularly acute in District Municipalities which are water services authorities; they cannot collect property rates income, as that is the prerogative of the local authority, and they do not sell electricity. Water services are their primary source of income – but the bulk of their funding comes from government grants and transfers, not service charges.

Alfred Nzo District Municipality provides an extreme illustration of dependence on grants and transfers. Its annual budget for the 2012/2013 financial year was just under R900M, of which R357M was for operating expenditure and R543M for capital projects. 95% of this expense was funded by grant income and equitable share; MIG contributes R308M, and the Equitable Share R265M. Service charges contribute 2% to total budgeted income, but the collection rate is low, so actual collection is only 0.5% of total revenue. But there is limited potential for generating a higher proportion of funds through own sources.

Detailed assessment of the income of Alfred Nzo residents, allowing an affordability threshold of not more than 3% of total monthly income for water services, indicates that the maximum possible amount that could potentially be collected from domestic customers for water services is about R24M per year. This caps the total income from residential consumers at a maximum of 3% of the total, and highlights the importance of improving collection from business and institutional users to nudge income from service charges towards 5% of the total budget. But even then the structural dependence on government grants and transfers remains entrenched; this has significant implications for the nature of local governance, as the administration and its political leadership accounts first and foremost to national and provincial government, not to local residents whose service bills contribute just a small fraction to municipal resources and hence to decision-making.

In a wide-ranging and sombre 2009 assessment, the *State of Local Government Report*, CoGTA quoted Section 152 of the Constitution, where the objectives of local government are set out; these include providing democratic and accountable government of local communities, and ensuring the provision of services to communities in a sustainable manner'. It flagged rising grant dependency in

municipalities, and reminded its readers of the close link between local accountability and local resource raising:

Transfers continue to weaken local democratic accountability. The growth in grant dependence and the prevalence of indirect transfers obscure the accountability of municipalities. The grant conditions often replace local oversight of municipal performance with complicated reporting requirements to national departments (Ibid, at 60).

One of the basic principles underlying Municipal Finances is the principle that Local Government is substantially financed by means of own resources. This is an important feature of any democratic local government system. It ensures that municipalities are directly accountable to local residents for the functions they perform and the services they provide (Ibid, at 63).

The report described a widespread 'culture of patronage and nepotism', and noted that 'the democratisation of the local sphere is now fraught with community frustration over poor institutionalisation of systems, poor service delivery and poor political governance.'

Meanwhile total debt owed to municipalities at the end of June 2013 has climbed to over R86,9-billion (Treasury, 2013c). This is a R36,5-billion above the figure which triggered alarm in 2009 and contributed to the development of a comprehensive Local Government Turnaround Strategy.²¹

5.5.2 SUSTAINABILITY OF INFRASTRUCTURE FUNDED THROUGH GRANTS

Considerable funds have been invested in water services infrastructure, but many installations are dysfunctional or perform poorly. Government aims to ensure that municipalities take responsibility for ensuring the sustainability and ongoing operation of their water schemes, but currently faces numerous challenges – not least because of perverse incentives which effectively reward municipalities for neglected maintenance and poor management through funding rehabilitation and rebuilding.

Hollingworth et al (2011) note that metros were the most concerned with the financial sustainability of capital projects, and cited concerns around the operating costs of new infrastructure as a reason for not always using their full MIG allocation. Most municipalities are less circumspect as substantial funding support from national government is assured. DeCoG and DWA require municipalities to submit detailed business plans indicating how they will safeguard the operational and financial sustainability of all new infrastructure developed with MIG and MWIG; in practice municipalities and

²¹ Presidential Outcomes Report, September 2013, p98

overseeing departments seem to give more emphasis to ensuring that available capital grants are used fully than on safeguarding long term financial sustainability, and it is this aspect that government gives most attention to.

In 2013, part of Treasury's rationale for making MWIG a direct grant, rather than a fund disbursed by DWA, was that it hoped this would compel municipalities to make O&M of schemes an integral part of its planning and design. The MWIG framework requires water services authorities to 'ensure ongoing effective and efficient operations and maintenance of the projects once completed', and requires them to address sustainability in the municipal IDP, WSDP and business plan for each project. It remains to be seen whether MWIG-funded developments will be managed and maintained any differently to those already in place.

6 CASE STUDY OF CHRIS HANI DISTRICT MUNICIPALITY

6.1 INTRODUCTION

Chris Hani District Municipality (CHDM) is one of the 24 Priority District Municipalities identified by DWA, 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 in the DM can be classified as “rural”, being predominantly in the east of the DM. Groundwater has good potential for addressing rural water supply backlogs in CHDM. The following figure (Figure 6-1) shows boreholes in the National Groundwater Archive (NGA) (2635 boreholes) and boreholes in the Eastern Cape GRIP database (a further 100 boreholes) which fall within CHDM:

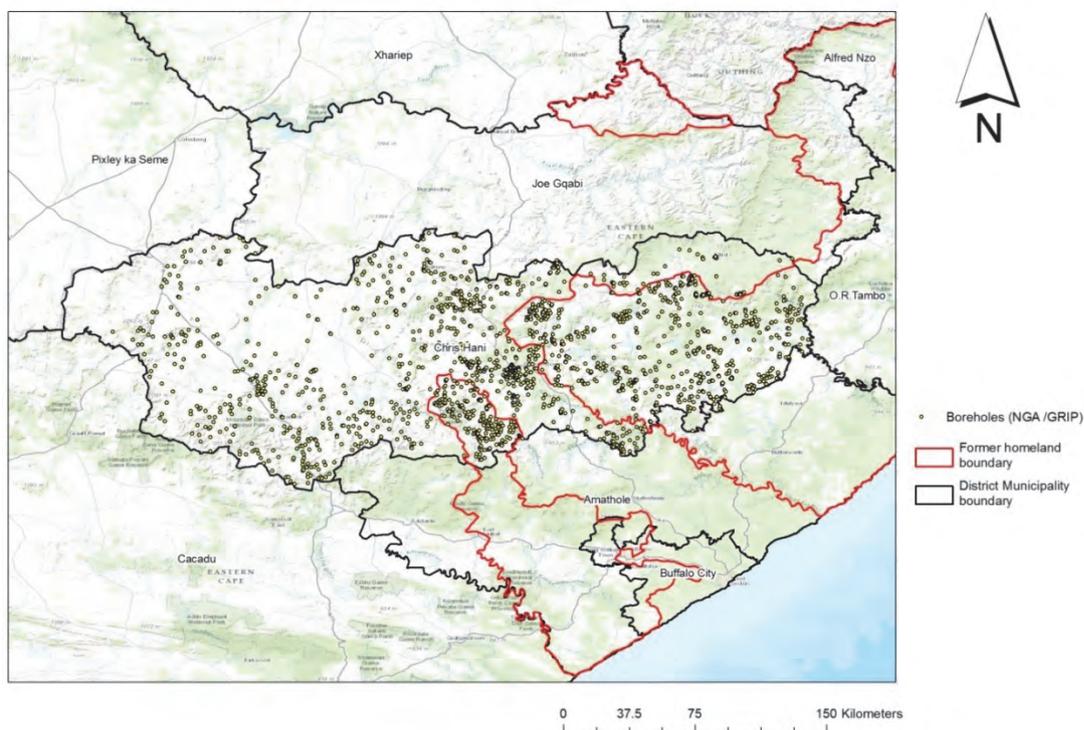


FIGURE 6-1 NGA AND GRIP BOREHOLES IN CHDM

Figure 6-2 below shows the aquifer types underlying CHDM according to the GRA1 database – note that almost all of the area of CHDM is underlain by either “B3” or “D3” aquifer type. (see Appendix 2 for the General Map classification system). At this scale it can be seen that the GRA1 data is not sufficient for siting boreholes at local level. Figure 6-3 shows the small western-most part of CHDM where the aquifer types are more varied, also with known (NGA and GRIP) boreholes plotted on it. It can be seen that the borehole locations do not necessarily follow the more productive GRA1 aquifer areas – suggesting that borehole siting is based on more local hydrogeological features (beyond the resolution of the GRA1 maps) or on other criteria such as settlement location – or (most likely) a combination of both.

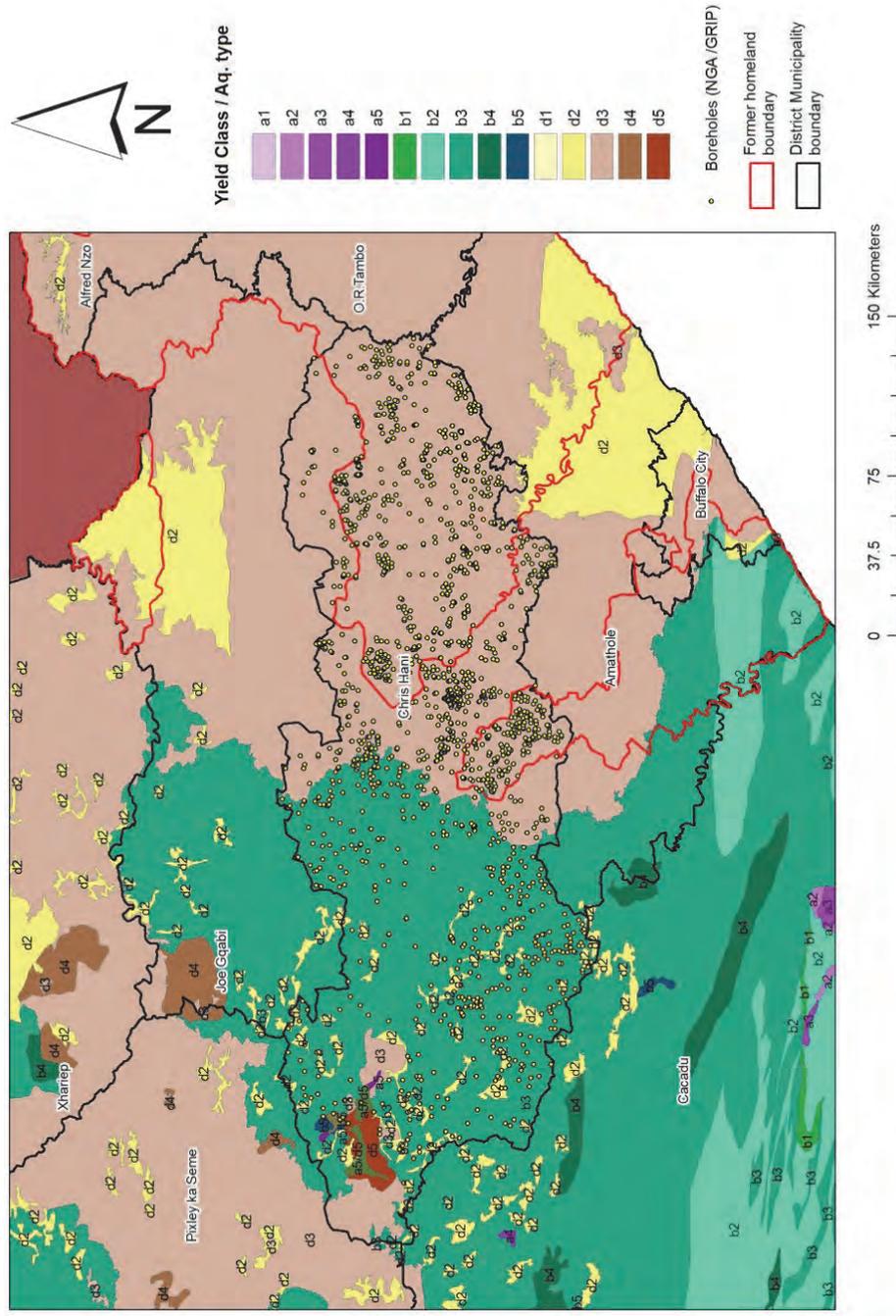


FIGURE 6-2 CHDM WITH GRA1 DATA AND NGA/GRIP BOREHOLES

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

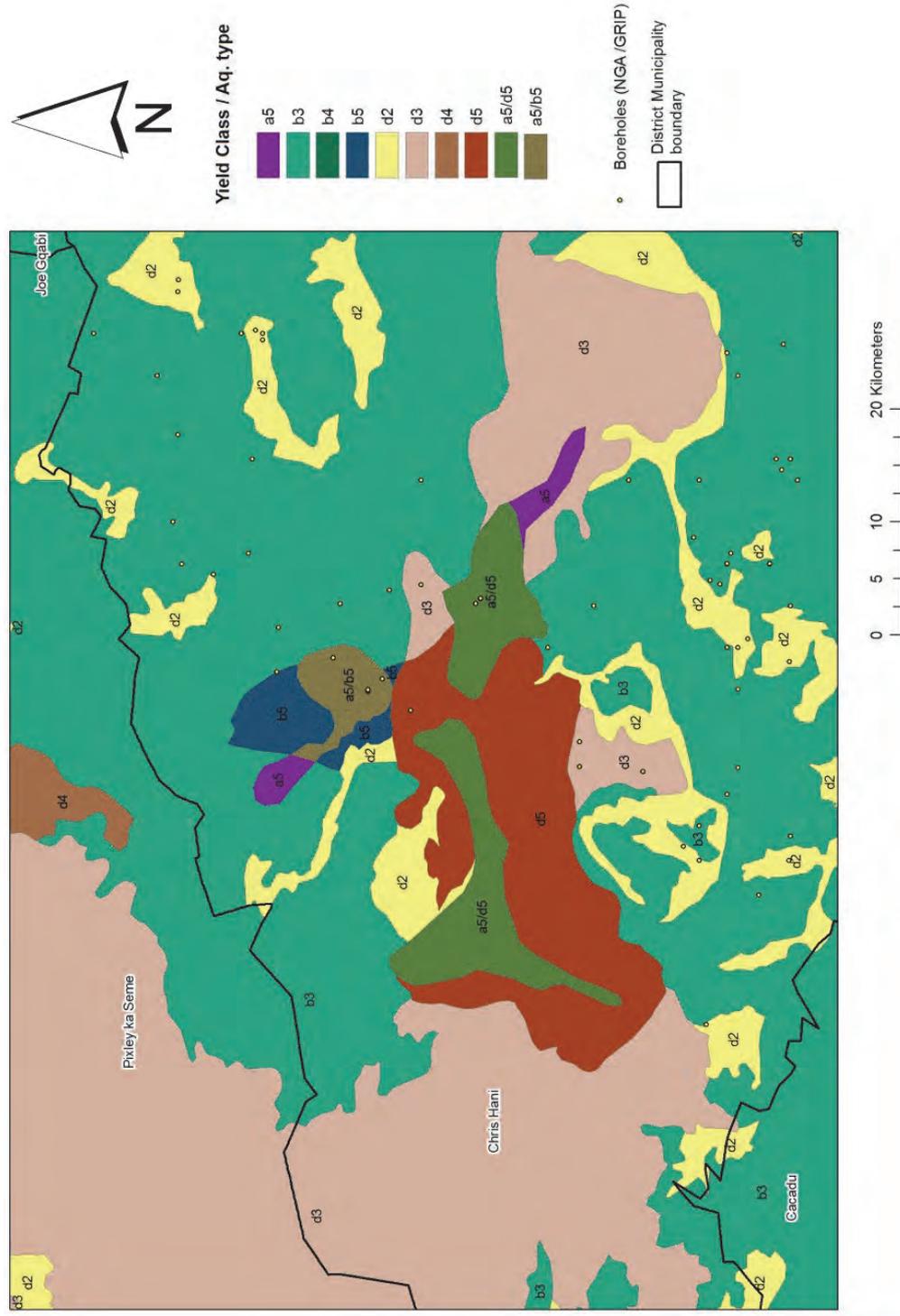


FIGURE 6-3 DETAIL OF CHDM WITH GRA1 DATA AND NGA/GRIP BOREHOLES

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

6.1.1 TRANSMISSIVITY VARIATION IN CHDM

The most detailed regional work on hydrogeological prospects in the Karoo Basin (including CHDM) to date has been WRC Project K5/1763 which has (amongst other things) delineated variations in transmissivity (T) based on known structures and other factors (Baker and Dennis, 2012). A portion of CHDM around the town of Queenstown has been shown in Figure 6-4 below, with the NGA/GRIP boreholes against a backdrop of the K5/1763 transmissivity variations (middle estimates of transmissivity). Just as with the GRA1 map, the borehole locations are not necessarily influenced by known T zones at this scale, but appear to be more random in their distribution.

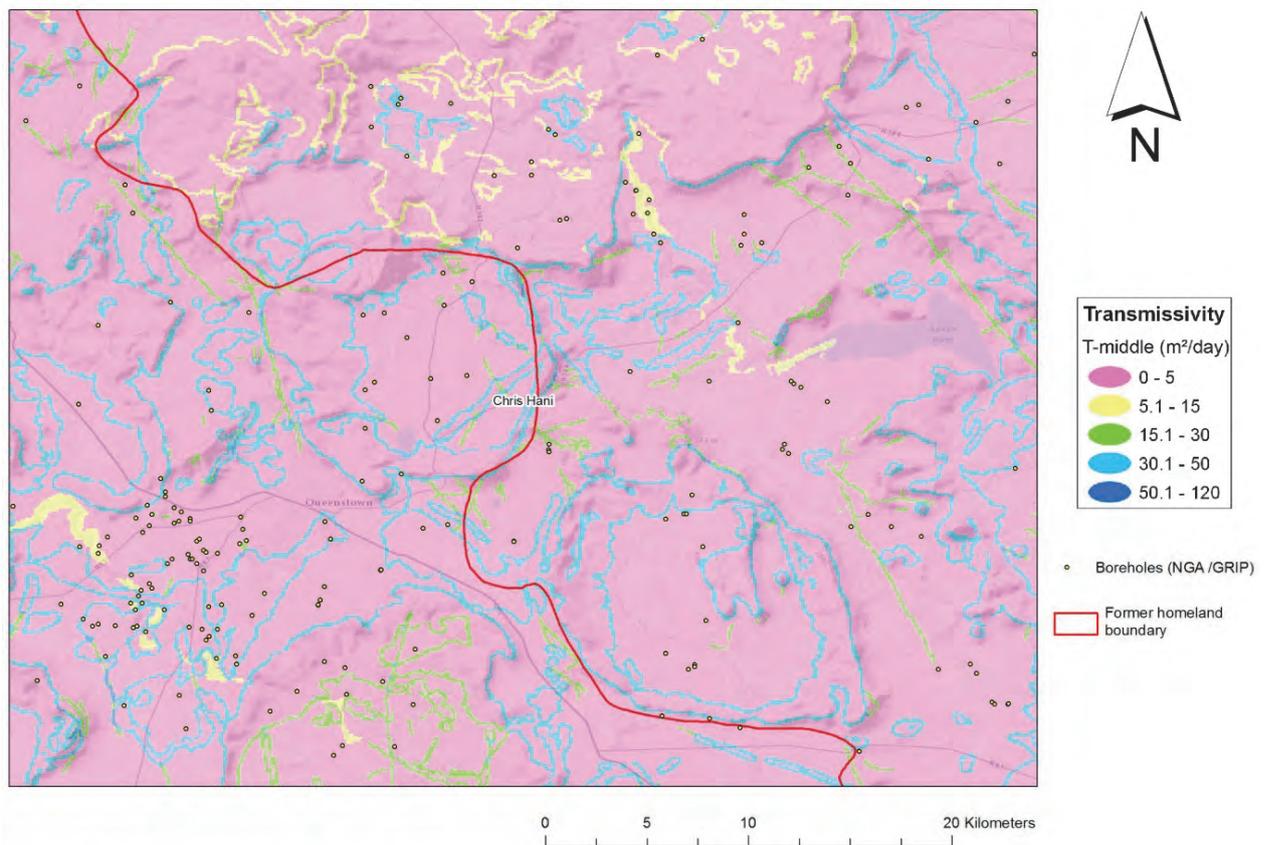


FIGURE 6-4 PORTION OF CHDM WITH TRANSMISSIVITY ZONES

6.1.2 CHDM COMMUNITY CATEGORIES

DWA have 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 follows (Table 6-1):

TABLE 6-1 DWA 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

Another smaller section of CHDM near Queenstown is shown in Figure 6-5 on the next page, with the settlements coloured according to the DWA Priority DM Category. The NGA/GRIP boreholes have also been plotted. Logically enough, boreholes appear to be sited near to communities in general – there is a correlation between borehole locations and community outlines. It is also clear that some communities (especially in the northern-most part of the map), despite having several boreholes nearby, are classified as Category 4 communities – i.e. communities that are experiencing problems with the water source. At least in some areas in CHDM, boreholes which 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 and not resource 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 as “unused”. The NGA borehole database unfortunately does not provide the status of the boreholes, but it is possible that a similar fraction of boreholes in use might be found.

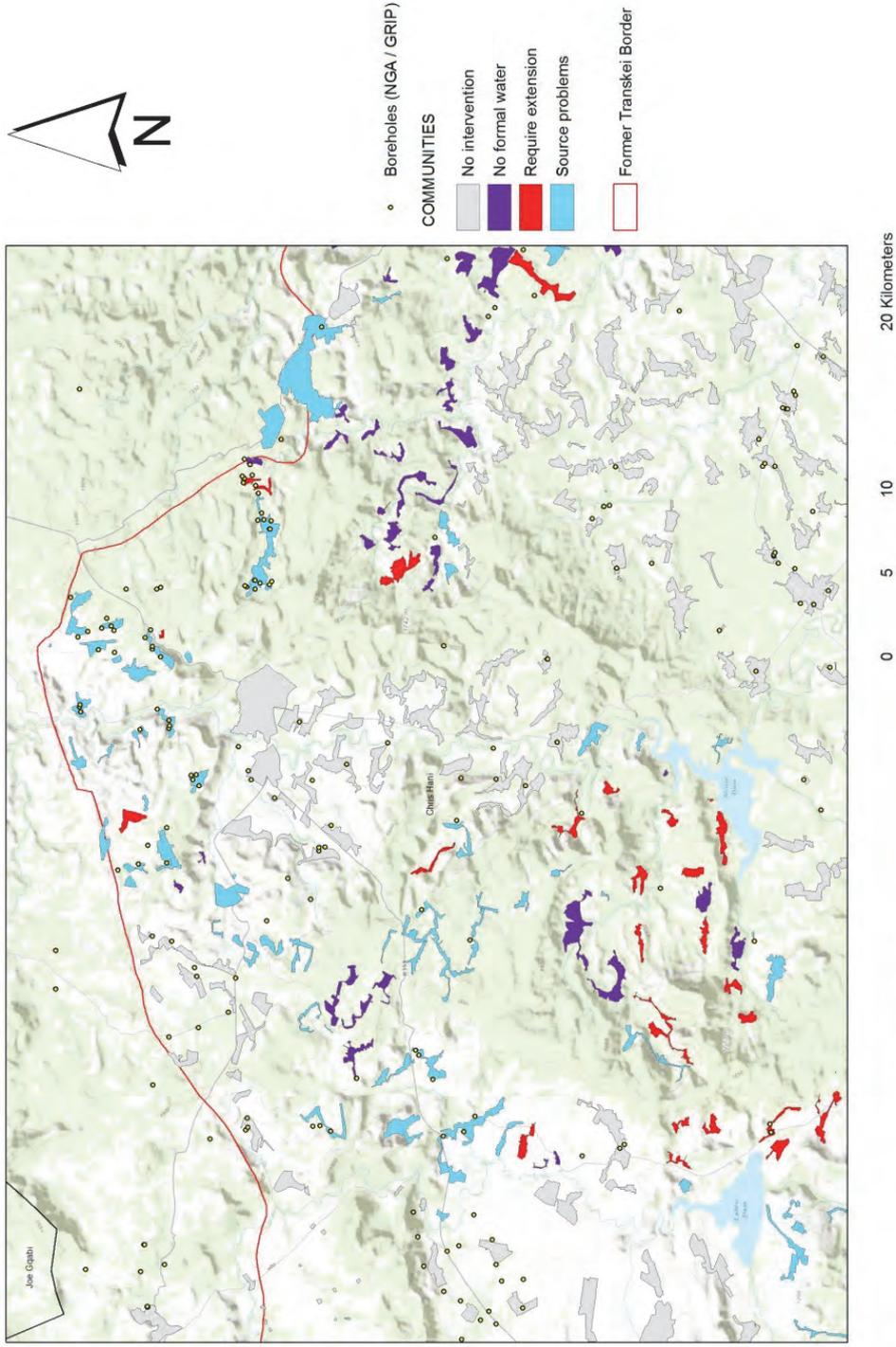


FIGURE 6-5 PORTION OF CHDM WITH DWA CATEGORIES AND NGA/GRIP BOREHOLES

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

The data presented for CHDM so far does seem to suggest that boreholes are not necessarily sited for hydrogeological reasons alone, or at least not for reasons which 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. In other words, existing national and regional data alone is unlikely to be sufficient on its own to site community water supply boreholes optimally. There is probably no substitute for local hydrogeological investigation by a qualified hydrogeologist. DWA 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 do have a bearing on future O&M requirements, and therefore on the long-term sustainability of the source.

6.2 COSTS FOR O&M AT CHDM

The costs for operation and maintenance of groundwater sources and supplies are usually difficult to obtain. Some municipalities do not keep disaggregated data on borehole O&M, and those that do are generally reluctant to make this data public. In many cases private contractors (“service providers”) carry out the 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. O&M budgets are also vulnerable to cuts and to appropriation for spending with more immediate and visible results.

Part of the water requirements of the Ntsikayethu, Sakhisizwe and Emalahleni villages of the Chris Hani District Municipality (CHDM) are met using groundwater supplied from a number of borehole schemes within the villages that have been operational for some time. These include manually powered (hand), wind-powered, electrically powered and Diesel/Petrol powered.

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, Instsika Yethu and Sakhisizwe. Maluti GSM (locally-based consulting engineers) were contracted to do this work in Insika yethu, Sakisizwe and parts of Emalahleni. Work included the maintenance of water infrastructure including these borehole schemes. For the duration that MGSM was contracted to undertake this oversight role, a record of each visit that MGSM 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 depending on what each visit entailed. MGSM took a decision that it

would aim for at least 75% of the boreholes to be visited each month with a 60-day period being the maximum length of time between visits for individual boreholes.

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

6.2.1 DATA AND DISCUSSION

For each visit undertaken by MGSM staff, the entry consisted of several columns capturing as much detail as possible. For this study, however, only the data under the columns shown Table 6-2 in below were considered.

TABLE 6-2 EXAMPLE OF ENTRY IN THE MGSM DATASET ANALYSED FOR THIS STUDY

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 categorise the visit and provide a description of what was done.

Firstly, for each borehole, the number of visits paid was determined. This was followed by determining for each borehole what number of these were repairs, inspections, maintenance or service. The results of these are presented in Table 6-3 to Table 6-5 below and summarised in Table 6-6 divided between the relevant villages. Owing to the differences in the number of times each borehole was visited, the number of repairs, inspections, etc. are presented as percentages of the total number of visits. This was done to facilitate some exploratory analysis.

Initially these results are presented based on the villages in which the respective boreholes are located. This is done to facilitate the analysis of the impact on attention received by the boreholes, of their geographic location. 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. It is apparent the geographic location of the boreholes did not impact significantly on the attention each borehole received as there is not much difference in the average number of times the boreholes in each village were visited.

TABLE 6-3: SUMMARY OF ENTRIES ON BOREHOLES WITHIN THE NTSIKAYETHU (INTSIKA YETHU) VILLAGE

Borehole	Number of entries	R (%)	I (%)	M (%)	S (%)
Emangweni	46	15.22%	21.74%	2.17%	60.87%
Emangweni 2	23	4.35%	0.00%	8.70%	86.96%
Hoita	58	10.34%	17.24%	12.07%	60.34%
Sentile	44	9.09%	11.36%	4.55%	75.00%
Ndulini	72	16.67%	4.17%	23.61%	55.56%
Zigudu Mission Gate	31	3.23%	96.77%	0.00%	0.00%
Zigudu Mission School	29	6.90%	93.10%	0.00%	0.00%
Lower Qutsa	39	7.69%	7.69%	5.13%	79.49%
Jojweni	28	0.00%	100.00%	0.00%	0.00%
Middle Qutsa	38	5.26%	10.53%	5.26%	78.95%
Zwelakhe	39	23.08%	10.26%	5.13%	61.54%
Ntlakwefolo	35	8.57%	34.29%	17.14%	40.00%
Mkhukwini	49	22.45%	24.49%	8.16%	44.90%
Mngqanga	28	7.14%	85.71%	7.14%	0.00%
No Gate	38	7.89%	89.47%	2.63%	0.00%
Zwelitsha Hand Pump	21	9.52%	90.48%	0.00%	0.00%
Zwelitsha	80	12.50%	#REF!	30.00%	30.00%
Bolotwa	7	28.57%	71.43%	0.00%	0.00%
Bolotwa Clinic	38	0.00%	42.11%	0.00%	57.89%
Dayimani	42	11.90%	14.29%	16.67%	57.14%
Dlakavu	61	1.64%	50.82%	3.28%	44.26%
Dudumashe	29	0.00%	100.00%	0.00%	0.00%
Esigxeni	33	3.03%	24.24%	0.00%	72.73%
Holi	39	12.82%	2.56%	7.69%	76.92%
Lalini	45	8.89%	2.22%	13.33%	75.56%
Lokishini	41	12.20%	36.59%	2.44%	48.78%
Lower Bilatye Hand Pump	22	22.73%	72.73%	0.00%	4.55%
Lower Bilatye	22	9.09%	13.64%	0.00%	77.27%
Mbinzana	59	27.12%	18.64%	10.17%	44.07%
Mkhonjana 1	42	7.14%	16.67%	7.14%	69.05%
Mkhonjana 2	17	11.76%	17.65%	0.00%	70.59%
Qineni	25	20.00%	8.00%	0.00%	72.00%
Qaqeni	41	7.32%	9.76%	2.44%	80.49%

Tshatshu	33	3.03%	15.15%	3.03%	78.79%
Upper Bilatye	25	28.00%	32.00%	0.00%	40.00%
Mzantsi	37	18.92%	67.57%	5.41%	8.11%
Singeni	13	0.00%	0.00%	0.00%	100.00%
Lower Woodhouse E	28	0.00%	64.29%	35.71%	0.00%
Lower Woodhouse W	43	9.30%	72.09%	18.60%	0.00%
Phukwana	20	0.00%	100.00%	0.00%	0.00%
Kwalumane	44	31.82%	61.36%	6.82%	0.00%
Kwanyoka	12	8.33%	0.00%	0.00%	91.67%
Mome	38	15.79%	7.89%	0.00%	76.32%
Ganya	16	6.25%	12.50%	6.25%	75.00%
kwaButshingi	26	7.69%	7.69%	19.23%	65.38%
Komkulu	29	13.79%	0.00%	27.59%	58.62%
Lower Qitsi	40	17.50%	0.00%	7.50%	75.00%
Ngcatharu	41	26.83%	24.39%	4.88%	43.90%
Luxeni	25	12.00%	4.00%	8.00%	76.00%
Mdibaniso	39	30.77%	0.00%	7.69%	61.54%
Maqomeni	22	0.00%	4.55%	9.09%	86.36%
Ndenxe	79	27.85%	22.78%	20.25%	29.11%
Gxojeni	21	0.00%	4.76%	9.52%	85.71%
Ngqwaru	56	28.57%	32.14%	17.86%	21.43%
Nobokwe A	54	22.22%	18.52%	3.70%	55.56%
Nobokwe B	43	6.98%	13.95%	6.98%	72.09%
Kolongqayi	8	25.00%	75.00%	0.00%	0.00%
Zingquthu	19	0.00%	5.26%	0.00%	94.74%

TABLE 6-4: SUMMARY OF ENTRIES ON BOREHOLES WITHIN THE SAKHISIZWE VILLAGE

Borehole	Number of entries	R (%)	I (%)	M (%)	S (%)
Aliba	78	28.21%	1.28%	26.92%	43.59%
Askeaton	7	42.86%	28.57%	28.57%	0.00%
Bilatye	2	50.00%	50.00%	0.00%	0.00%
Macangceni	83	34.94%	15.66%	22.89%	26.51%
Luxemi	28	7.14%	7.14%	7.14%	78.57%
Nkunzaneni	28	0.00%	3.57%	0.00%	96.43%
Xonya	51	9.80%	13.73%	19.61%	56.86%

Galili HP	13	0.00%	100.00%	0.00%	0.00%
Galili	38	15.79%	5.26%	13.16%	65.79%
New Rest	65	27.69%	12.31%	23.08%	36.92%
New Rest 2	56	51.79%	5.36%	17.86%	25.00%
Sidakeni	27	11.11%	0.00%	11.11%	77.78%
Tsengiwe	58	25.86%	6.90%	12.07%	55.17%
New Site	39	15.38%	7.69%	7.69%	69.23%
Emmangweni	43	37.21%	6.98%	11.63%	44.19%
Engxingweni	19	0.00%	89.47%	0.00%	10.53%
Upper Langanci	53	33.96%	7.55%	16.98%	41.51%
Barracks	36	0.00%	0.00%	8.33%	91.67%
Bumbane	22	18.18%	81.82%	0.00%	0.00%
Dutch	48	18.75%	10.42%	18.75%	52.08%
Voyizana	37	5.41%	8.11%	21.62%	64.86%

TABLE 6-5: SUMMARY OF ENTRIES ON BOREHOLES WITHIN THE EMALAHLENI VILLAGE

Borehole	Number of entries	R (%)	I (%)	M (%)	S (%)
Mhaga	21	4.76%	19.05%	0.00%	76.19%
Rwantswana-Mhaga	12	8.33%	8.33%	8.33%	75.00%
Mzantsi	36	19.44%	66.67%	5.56%	8.33%
Qumbu	34	0.00%	29.41%	0.00%	70.59%
Mpothulo	44	34.09%	4.55%	4.55%	56.82%
Ngxabani	55	20.00%	21.82%	10.91%	47.27%
Tshatshu	34	2.94%	11.76%	2.94%	82.35%
Tsolokazi	35	17.14%	5.71%	8.57%	68.57%
Lower Lanti	36	25.00%	8.33%	16.67%	50.00%

From the above tables it can be seen that there are no apparent trends/patterns that emerge beyond the fact that for all three villages, the visits classified as “Service” are the majority.

The next step involved the grouping of boreholes based on how they are powered. This resulted in three categories – the hand-powered and wind-powered category, the electrically powered category

and diesel and petrol engine category. Table 6-6 below shows the total number of boreholes powered by the different sources described above as well as the respective average number of visits.

TABLE 6-6: 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 (Table 6-3 to Table 6-5), the diesel and petrol engine powered boreholes seem 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 categorized 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. This view is supported by the proportion of "Service" entries versus "Inspection" entries. It is reasonable to suggest that the need for regular service by diesel/petrol engine powered installations led the technicians to make their inspections of boreholes coincide with Service visits. Subsequently these were entered into the record as "Service".

Extending that line of thought, electrically powered installations seem to be the most robust of all when (or rather, perhaps lend themselves least to preventive maintenance). The percentage number of entries categorised as "Repair" for electrically powered installations is generally lower than the corresponding percentage for the hand and wind powered installations. Although it can also be suggested that this lower level of repairs seems to have been achieved by a considerably higher number of "Maintenance" visits as opposed to the hand/wind powered installations.

Taking into account the average number of visits to the various categories of installations, the percentage number of entries marked as "Repair" as well as percentage number of entries for diesel/petrol engine powered installations, an inference can be to support the level/frequency of "Service" visits that these diesel/petrol engine powered installations received. The range of the percentage number of entries marked as "Repair" for the diesel/petrol engine powered installations is

a little higher than the corresponding range for electrically powered installation. It can be suggested that percentage number of "Repair" visits for diesel/petrol engine powered installations would likely have been higher if not for the higher number of visits on average made to these installations.

Note: While the records seem to suggest that electrically powered installations are the most robust (and as a result better suited), 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.

6.3 PRELIMINARY ANALYSIS OF COSTS

Work by MGSM in Chris Hani District Municipality on the operation and maintenance of water sources (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.

The following table (Table 6-7) shows the operation and maintenance 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 similar month-on-month (Gibson, pers.comm). All costs in South African Rands (ZAR).

TABLE 6-7 SNAPSHOT OF O&M COSTS IN CHRIS HANI DISTRICT MUNICIPALITY

	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
KI per household per month (estimated)	3	3	3
KI per village per month (estimated)	720	720	720
Cost per KI (ZAR)	8.89	10.28	8.06
Cost per household per month (ZAR)	27	31	24

The figures below show the breakdown of costs, both for all villages and for villages served by a borehole. (matl. = material, cbo = community based organisation).

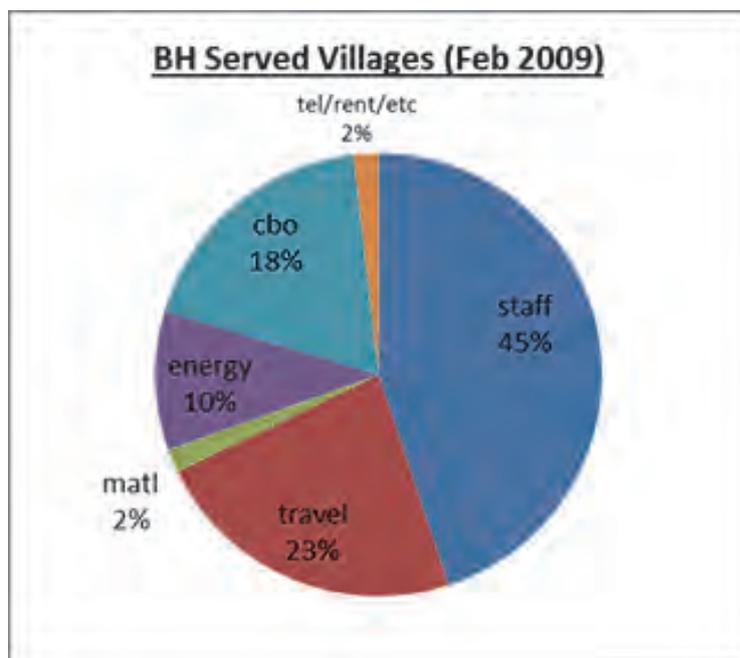


FIGURE 6-6 O&M COST BREAKDOWN FOR BOREHOLE SERVED VILLAGES

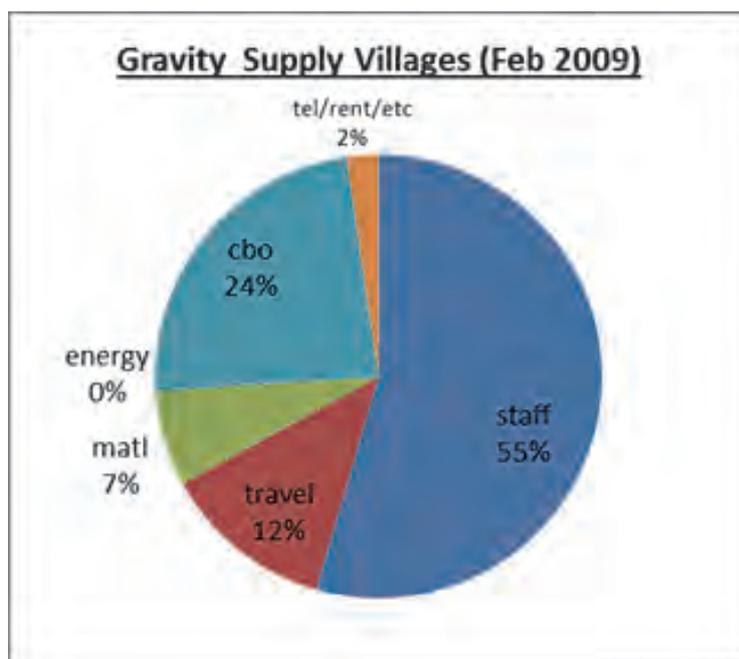


FIGURE 6-7 O&M COST BREAKDOWN FOR VILLAGES SERVED BY GRAVITY SUPPLIES

The biggest part of the cost was salaries and travel, which did not vary month on month. Therefore analysis of other months can be expected to yield similar results.

The electro-mech costs were for 120 installations (villages):-

- 89 of them were visited by an electro-mech technician in the month
- 37 inspections were carried out (mostly electrical systems)
- 50 services were conducted (diesel engines)
- 1 repair was made (major maintenance)
- 1 incident of minor maintenance was required.

The extract from Maluti's monthly report below illustrates the month in question (February 2009) and the preceding five months (Table 6-8):

TABLE 6-8 COMPARISON OF MONTHLY COSTS

150	114	122	130	117	120	installations
93%	70%	75%	80%	72%	74%	% visited
4	2	2	5	4	1	repairs done
59	30	32	47	24	37	inspections
35	55	49	53	57	50	services
3	5	5	1	2	1	maintenance
49	22	34	24	30	31	not visited
101	92	88	106	87	89	total visited

6.4 CHRIS HANI CASE STUDY DM CONCLUSIONS

Not surprisingly, boreholes in CHDM appear to be sited as much for proximity to communities or other reasons, as for regional hydrogeological properties. A competent hydrogeologist assisting with the installation of schemes would take into account the large number of different factors not immediately connected to the underlying hydrogeology (such as land access and land use) but which do have a bearing on overall O&M costs and therefore on sustainability. The O&M analysis shows that the cost per kilolitre delivered for both borehole schemes and gravity schemes in a rural part of Chris Hani DM are similar. Costs are similar month for month, and the largest part of the cost is salaries and travel costs. Whilst the different technologies for groundwater abstraction (e.g. diesel pumps vs electrical pumps) do show differences in cost, these need to be disaggregated from the economy of scope gained by visiting all types of scheme on the same “round” of visits. There are also likely to be additional costs associated with starting such a system of O&M, since the MGSM example shows a system that had been tried and tested and where early mistakes have been ironed out. These costs are important to consider since they begin to dwarf the costs of initial installation of infrastructure, and justify an increased focus on O&M.

7 CASE STUDY OF MAHIKENG

7.1 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. The town itself 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 a Water Services Authority under the Water Act (1998) and has responsibility for a range of water services planning, maintenance and operational duties. These include (NMMDM Annual Report 2012):

- Local Water Services Institutional Arrangements
- Section 78 Assessment
- Service Level Agreements with Water Services Providers
- Ensuring Access to Water Services
- Construction of Water Supply Facilities
- Construction of Sanitation Facilities
- Refurbishment of Water and Sanitation Infrastructure
- Water Services Planning
- Water Services Development Planning
- Water Services Master Planning
- Feasibility Studies, Technical Assessment and Approval of Designs
- Water Services Local Regulation
- Development of Water Services By-Laws and Policies
- Enforcing Water Services By-Laws and Policies
- Regulating local water services provision
- Water Services Provision
- Drinking Water Quality Management
- Water Resources Management (Surface and Ground Water Source)
- Operation and Maintenance of Water Supply Schemes
- Operation and Maintenance of Waste Water Treatment Works
- Customer Care

Mahikeng is mainly dependent on groundwater for the water supply to the urban centre and peri-urban surroundings (roughly 75% of the town's supply is from groundwater, whilst if the peri-urban areas are taken into account, roughly 90% of the population of NMMDM is reliant on groundwater). Rural areas in NMMDM are almost exclusively groundwater dependent, since perennial surface water is scarce.

7.2 URBAN GROUNDWATER SUPPLIES AT MAHIKENG

The town of Mahikeng (the main urban area, not the peri-urban and rural surrounds) 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 channelled to Mahikeng in a similar way to the Molopo Eye many years ago. Abstractions in the Grootfontein dolomite compartment led to the spring or eye disappearing as groundwater levels were drawn down below ground level and today only a hollow in the ground shows where the spring used to be. The Grootfontein wellfield used to yield about 20 ML/day (about 231 L/s) but other abstractions in the compartment (leading to falling water levels) and other factors such as pipeline breaks have reduced this. According to DWA (2010b), five of the nine pumping wells at Grootfontein have been lost due to falling water levels. Water from both the Molopo Eye and the Grootfontein wellfield (Figure 7-1 and Figure 7-4) are piped to the Mahikeng Water Treatment Plant about 5 km to the southeast of Mahikeng where the flows are combined and the water is chlorinated. Sand filters have been constructed at the water treatment plant but these are not normally used since the natural groundwater quality does not warrant filtration. The treatment plant has a capacity of 45 ML/day. The water is then pumped to Mahikeng for reticulation into supply (Figure 7-4).

7.2.1 COMPARTMENTALISATION

The dolomites in NW Province, including those supporting the Grootfontein Wellfield and the Molopo Eye, are divided into semi-autonomous groundwater units or “compartments” mainly by dolerite dykes, but occasionally also by faults and at contacts with adjacent rocks (Stephens and Bredenkamp, 2002, and Holland and Wiegman, 2009). These compartments are often used as the basis for hydrogeological characterisation and groundwater management. Compartment boundaries are rarely completely impermeable however, particularly in the upper weathered sections, but the extent of groundwater movement across compartment boundaries can be difficult to quantify. Compartment boundaries are normally marked by a distinct change in water levels, and in some cases force groundwater to the surface as springs or seeps. High yielding springs (e.g. Molopo Eye) found at geological/compartments boundaries or topographic lows are a feature of the dolomite aquifers. The water table or piezometric surface within a compartment may be relatively flat, reflecting the topography and relatively high permeability of the dolomites.

A Council for Geoscience study identified 37 compartments within the NW Dolomites study area, divided into 5 main units (Council for Geoscience, 2008). Work done by Holland and Wiegman in 2009 (Holland and Wiegman, 2009) distinguished between Groundwater Management Areas (GMAs) and Groundwater Management Units (GMUs) in the NW dolomites and elsewhere, as follows:

7.2.1.1 GMAs

GMAs generally coincide 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). (Holland and Wiegmans, 2009).

7.2.1.2 GMUs

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).

Holland and Wiegmans (2009) identified 33 GMUs together making up 10 GMAs in the NW Dolomites, as shown in Figure 7-2 and Figure 7-3. These distinctions were made using previous knowledge, analysis of aeromagnetic data to identify dykes, and analysis of water level changes across proposed compartment boundaries. It is possible that more work that needs to be done to further refine the number and exact extent of GMUs in the NW dolomites, as well as the “leakiness” of compartment boundaries – this is necessarily a work-in-progress.



FIGURE 7-1 MOLOPO EYE (LEFT) AND A BOREHOLE AT GROOTFONTEIN (RIGHT)

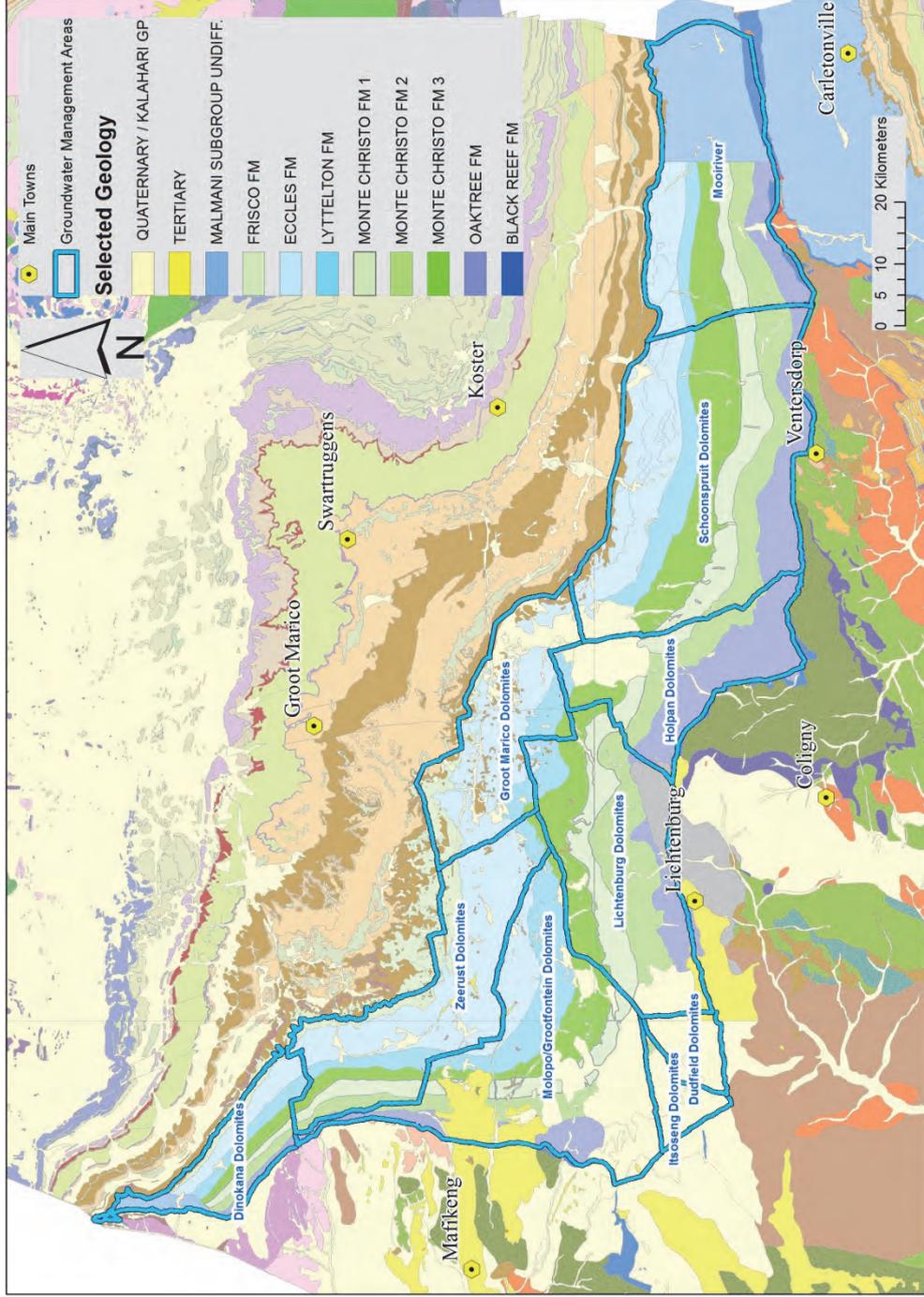


FIGURE 7-2 NW DOLOMITE GROUNDWATER MANAGEMENT AREAS (COMPARTMENT BOUNDARIES AFTER HOLLAND AND WIEGMANS, 2009)

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

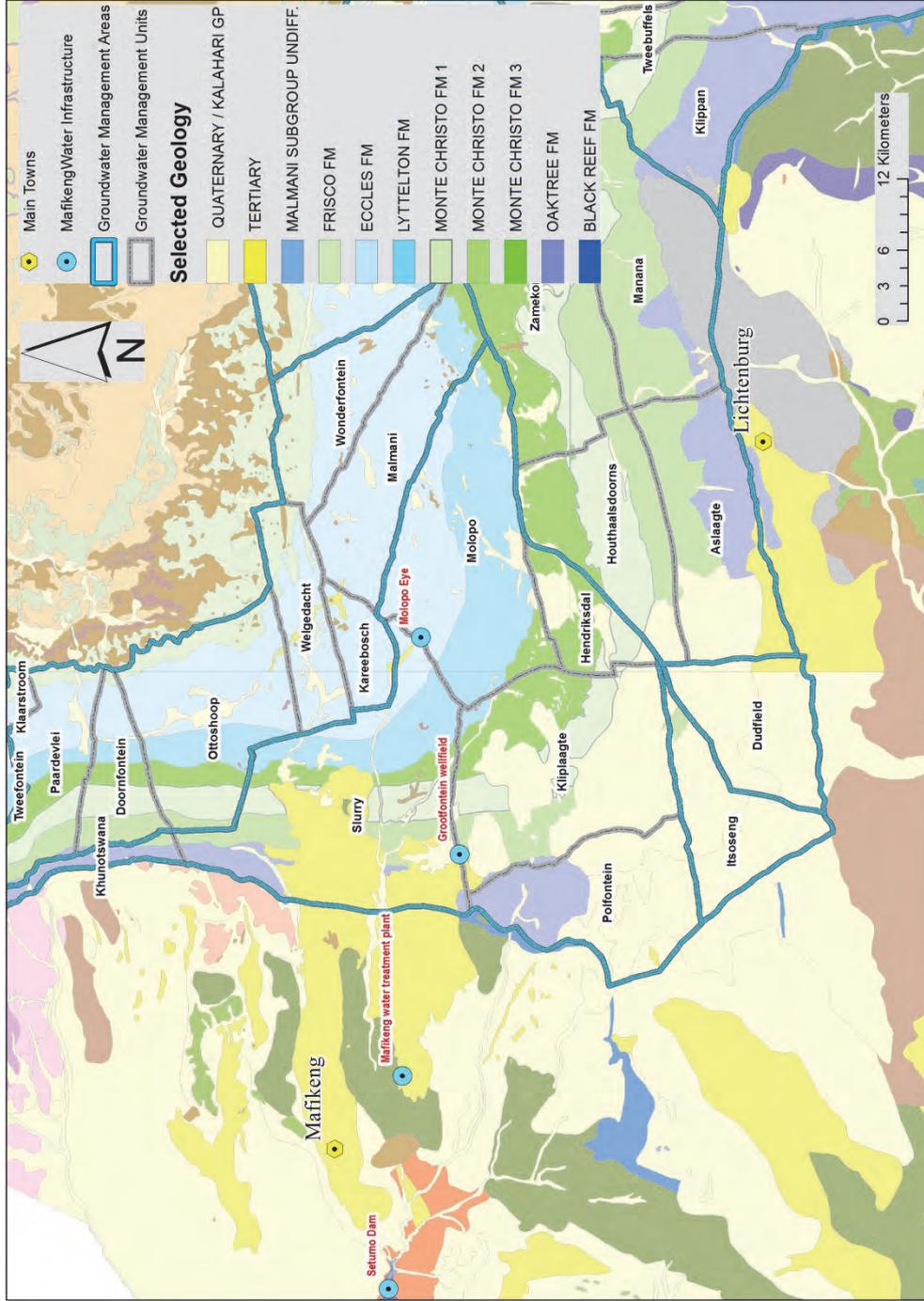


FIGURE 7-3 GROUNDWATER MANAGEMENT UNITS NEAR MAHIKENG (BOUNDARIES AFTER HOLLAND AND WIEGMANS, 2009)

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

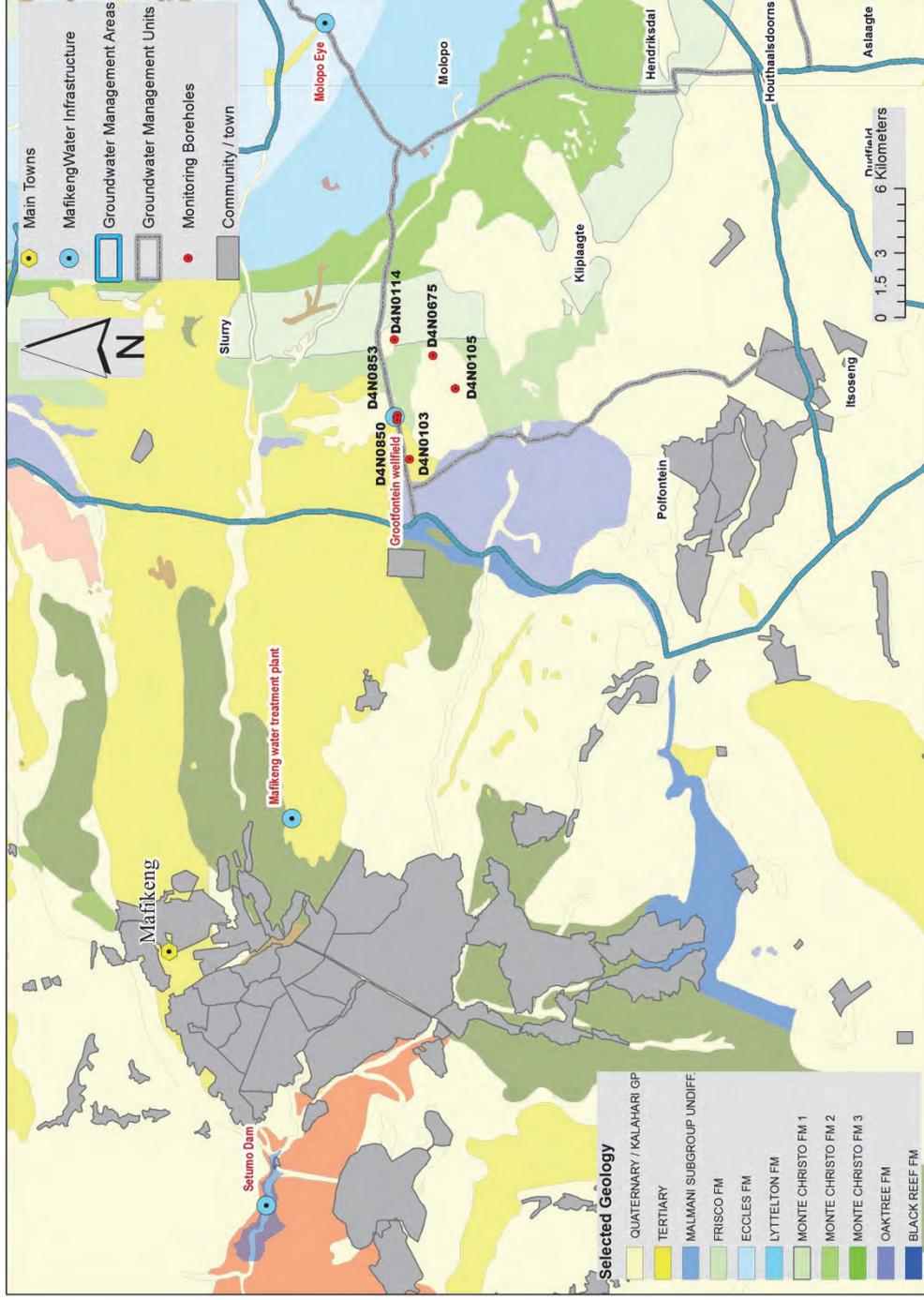


FIGURE 7-4 MAHIKENG'S WATER SOURCES AND MONITORING BOREHOLES AT GROOTFONTEIN (COMPARTMENT BOUNDARIES AFTER HOLLAND AND WIEGMANS, 2009)

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

The following charts (Figure 7-5) show hydrographs of groundwater monitoring boreholes the vicinity of the Grootfontein wellfield (see Figure 7-4 for locations of the boreholes), near Mahikeng. Data is from the National Groundwater Archive maintained by the Department of Water Affairs. It can be seen that water level records for a series of boreholes closest to the wellfield show unsustainable groundwater use over time. Of equal concern is the fact that only one of the monitoring boreholes (D4N0103) appears to still be operational – all of the others have ceased to operate.

At a time when groundwater abstractions for urban Mahikeng appear unsustainable the resolution of the monitoring array has worsened considerably. This situation does have potential to disrupt the security of the water supply to Mahikeng, since although Grootfontein only supplies a portion of the town's needs, there is very little room to spare (see Table 7-2).

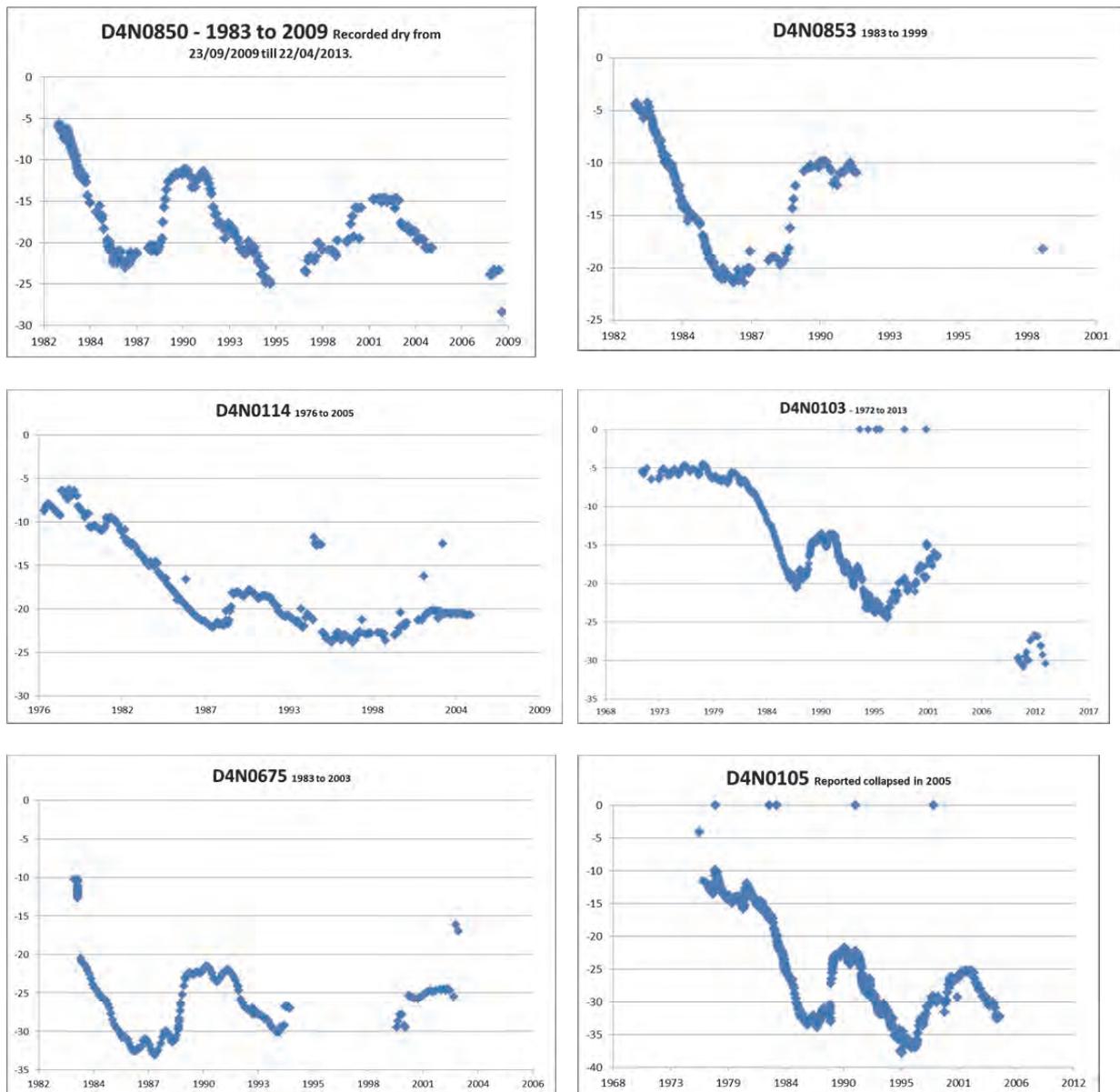


FIGURE 7-5 HYDROGRAPHS FOR THE GROOTFONTEIN GROUNDWATER COMPARTMENT

7.3 PERI-URBAN AND RURAL 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 operates and maintains a large number of these rural and peri-urban single-sources, including 358 boreholes in 30 villages in the NMMDM area and 97 boreholes in 46 villages in the Kagisano Molopo Local Municipality area (Botshelo Water website). According to a presentation to the Parliamentary Portfolio

Committee on Water and Environmental Affairs on 25th April 2012 (PPC 2012), Botshelo Water Board operates and maintains (but does not own) the following infrastructure on behalf of NMMDM and DrRSMDM:

- 95 Diesel Engines
- 56 Electric Pumps
- 88 Hand Pumps
- 119 Wind Pumps

The infrastructure is owned by the two District Municipalities, who are Water Services Authorities and Water Services Providers. Botshelo Water also operates other surface water and groundwater bulk sources for its supplies to peri-urban and rural areas (Table 7-1 below):

TABLE 7-1 BULK WATER TREATMENT WORKS AROUND MAHIKENG

Name	Source	Capacity	Average production	Communities served
Mmabatho Water Treatment Works	Setumo Dam to the west of Mahikeng	20 ML/day	10 ML/day	Mahikeng
Mahikeng Water Treatment Plant	Grootfontein boreholes and Molopo Eye	45 ML/day	28-36 ML/day	Mahikeng and peri-urban areas in NMMDM
Itsoseng Water Treatment Plant	Itsoseng boreholes about 40 km SE of Mahikeng	5 ML/day	4.4 ML/day	Local communities
Motswedi Water Treatment Plant	Sehujwane Dam about 20 km NW of Zeerust	2.2 ML/day	Not known	Local communities
Dinokana Water Treatment Plant	Dinokana Eye in Lehurutshe area about 30 km NW Zeerust	Depends on flow of eye	3.5 ML/day	Dinokana village of Ramotshere Moiloa Local Municipality

Figures from Botshelo Water (2013) and DWA (2010b)

In the 1990s when water meters were installed in rural areas it was found that most households used less than 6kL per month. With the transition to Free Basic Water in the early 2000s it was found that consumption did rise, but that most households still used less than the free basic amount. The scope for cost recovery in rural areas appears to be limited, since meters are problematic (can easily be bypassed, break down easily, etc.) and in any case the number of people using more than the free basic amount is relatively small. At the same time, operation and maintenance of scattered rural boreholes can be expensive and difficult to systematise. Another issue mentioned by more than one respondent was that domestic animals (goats, cows, donkeys, etc.) drink a significant proportion of the groundwater supplied to communities, yet this water use remains un-quantified. Without more data it

is difficult to estimate exactly how serious this problem may be. At present it is estimated that all rural residents receiving a water supply from NMMDM or its service providers receive Free Basic Water. According to the 2012 Annual Report, about 160 000 residents in 78 villages receive water supplied by tankers due to non-availability of other sources. NMMDM is working to reduce this number since tankering water is expensive.

7.4 GROUNDWATER 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. According to the NMMDM ISPD (NMMDM 2011:55) “More than 90 % of all consumer units in rural village settlements are reliant on inadequate pit latrines that are not conforming to the national standards of basic level of sanitation facility. As is the case in dense rural villages, the possible impact of the extensive use of pit latrines is vulnerability of underground water contamination, this necessitate careful monitoring of water quality in both rural dense and villages.” As far as is known, microbiological monitoring of rural groundwater supplies is erratic (and absent in some areas), and the implementation of standard protocols for siting boreholes to minimise contamination by pit latrines is needed (for example Lawrence et al, 2001).

7.5 SURFACE WATER SUPPLY TO MAHIKENG

The surface water component of Mahikeng's water supply is provided by the Setumo Dam to the west of the town centre (on the ephemeral 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). However, the actual yield of the dam may be less – according to the Reconciliation Strategy the 1 in 50 year firm historic yield determined for the Setumo dam is 3.03 million m³/a, or about 8.3 ML/day (DWA, 2010b). For much of the year the water flowing into the Setumo Dam is return flows from two wastewater treatments works (WWTWs) (Mahikeng WWTW and Mmabatho WWTW) and the quality of the dam water is poor (the dam is currently eutrophic). Essentially, the “surface water” is recycled waste water. 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 are being upgraded by a private contractor which should improve effluent quality in future. The upgrade or improvement of the Mmabatho Water Treatment Works is a recommendation of the Reconciliation Strategy for Mafikeng Cluster (DWA, 2010b).

7.6 FUTURE WATER REQUIREMENTS FOR MAHIKENG

According to the Reconciliation Strategy (DWA, 2010), Mahikeng's water requirements in the future (2020 and 2030) will be as follows (Table 7-2):

TABLE 7-2 FUTURE WATER REQUIREMENTS FOR MAHIKENG

Growth Scenario	2020 Requirement		2020 Shortfall		2030 Requirement		2030 Shortfall	
	(Mm ³ /a)	(ML/d)	(Mm ³ /a)	ML/d)	(Mm ³ /a)	(ML/d)	(Mm ³ /a)	(ML/d)
LOW GROWTH	16.961	46.47	2.361	6.47	17.851	48.91	3.251	8.91
HIGH GROWTH	17.612	48.25	3.012	8.25	19.093	52.31	4.493	12.31

The additional requirement of 12.31 ML/d under the "High Growth" scenario for 2030 could probably be met by a combination of the upgrade of the Mmabatho WWTW, increasing abstraction in the Grootfontein wellfield by controlling other groundwater uses in the area, and implementing water conservation and demand management (WCDM). Note that the Reconciliation Strategy (DWA, 2010b:13) considers that water sources are being used to their maximum capacity, stating "The cluster is currently utilising all its resources to their maximum available capacity given the limitations on treatment efficiency and the availability limitations on the Molopo and Grootfontein resources."

7.7 INSTITUTIONAL ISSUES FOR WATER SUPPLY IN MAHIKENG

7.7.1 BOTSHELO WATER BOARD

Botshelo Water Board is the bulk water supplier to Mahikeng, and it sources water almost exclusively from groundwater. Botshelo have battled with financial challenges in recent years, some of these linked to non-payment by municipal clients (below) and debt recovery generally. Botshelo Water Board also owes money to DWA. According to a presentation to the Parliamentary Portfolio Committee on Water and Environmental Affairs on 25th April 2012 (PPC 2012), Botshelo Water Board's activities can be summarised as follows (with income in brackets):

- Bulk Water Production (R 84 M)
- Operation and Maintenance of Municipal Infrastructure (R 62 M)
- Supply and billing to retail consumers on behalf of WSAs (R 8 M)

"Botshelo Water Board had received an audit disclaimer for 2010/11, due to lack of oversight by the accounting authority, failure to establish policies and procedures, non-adherence to regulations and a dysfunctional accounting system. It did not own any assets, so had not spent any Capex budget. It did secondary contractual work, like operation maintenance and installing rural infrastructure on behalf of the municipality. It was owed R79 million by municipalities, who paid only when threatened with cutting

of services. Municipalities also had not attended tariff meetings since 2009, although other stakeholders were represented. The water tariff had reduced as a result of the reduction of Eskom tariff increases. It was implementing a turnaround strategy to improve its financial performance, was trying to have assets transferred and to achieve more stability. Challenges included recovery of debt from all bulk and operational maintenance customers, lack of long term Service Level Agreements, and inadequate human, financial, infrastructure and management resources. It would focus on provision of water supply infrastructure services, stakeholder engagement, and business development in the 2012/13 year.” (PMG 2013)

According to the 2010/2011 Audit Report (see PPC, 2012), the root causes of some of these difficulties experienced by Botshelo Water Board were described as follows:

- Lack of oversight by accounting authority in terms of financial and performance reporting
- Ineffective HR management in terms of sufficient skilled resources
- Policies and procedures not established and communicated
- Inadequate development and monitoring of action plans to address internal control deficiencies
- Inadequate IT
- Dysfunctional accounting system
- Inadequate financial and performance management

7.7.2 DIVISION OF RESPONSIBILITIES

The Department of Water Affairs (NW Regional Office) is responsible for the operation of the Grootfontein boreholes and the monitoring of the resource in the dolomites. DWA is also responsible for the issuing and enforcement of licenses for irrigation abstractions in the dolomite compartments. The pipelines from the Grootfontein boreholes and the Molopo Eye as far as the Mahikeng Water Treatment Plant are also the responsibility of DWA – 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 water treatment plant it becomes the responsibility of Botshelo Water Board, who are bulk water suppliers to the municipalities, including NMMDM. Botshelo Water relies on payments by the municipalities for its operating costs. Botshelo Water Board is also responsible for a number of boreholes in the peri-urban and rural areas, and also for a number of bulk water treatment plants (Table 7-2). The major clients that Botshelo Water has contracts with are the Ngaka Modiri Molema District Municipality and Mahikeng and Ditsobotla Local Municipalities for bulk water provision, and Ngaka Modiri Molema and Dr Ruth Segomotsi Mompoti

District Municipalities for operation and maintenance of rural, urban and peri-urban water supply schemes (Botshelo Water, 2013).

Reticulation of drinking water, removal of waste water, billing of residents, maintenance of local water infrastructure and other functions are the responsibility of the relevant municipality. The waste water treatment plants serving Mahikeng are owned by the District Municipality (NMMDM) but operated by Mahikeng Local Municipality. Some peri-urban and rural boreholes still owned by the Department of Water Affairs are being transferred to the relevant municipalities, and others are owned or operated by other Water Service Providers (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 at a municipality) which need to maintain close collaboration.

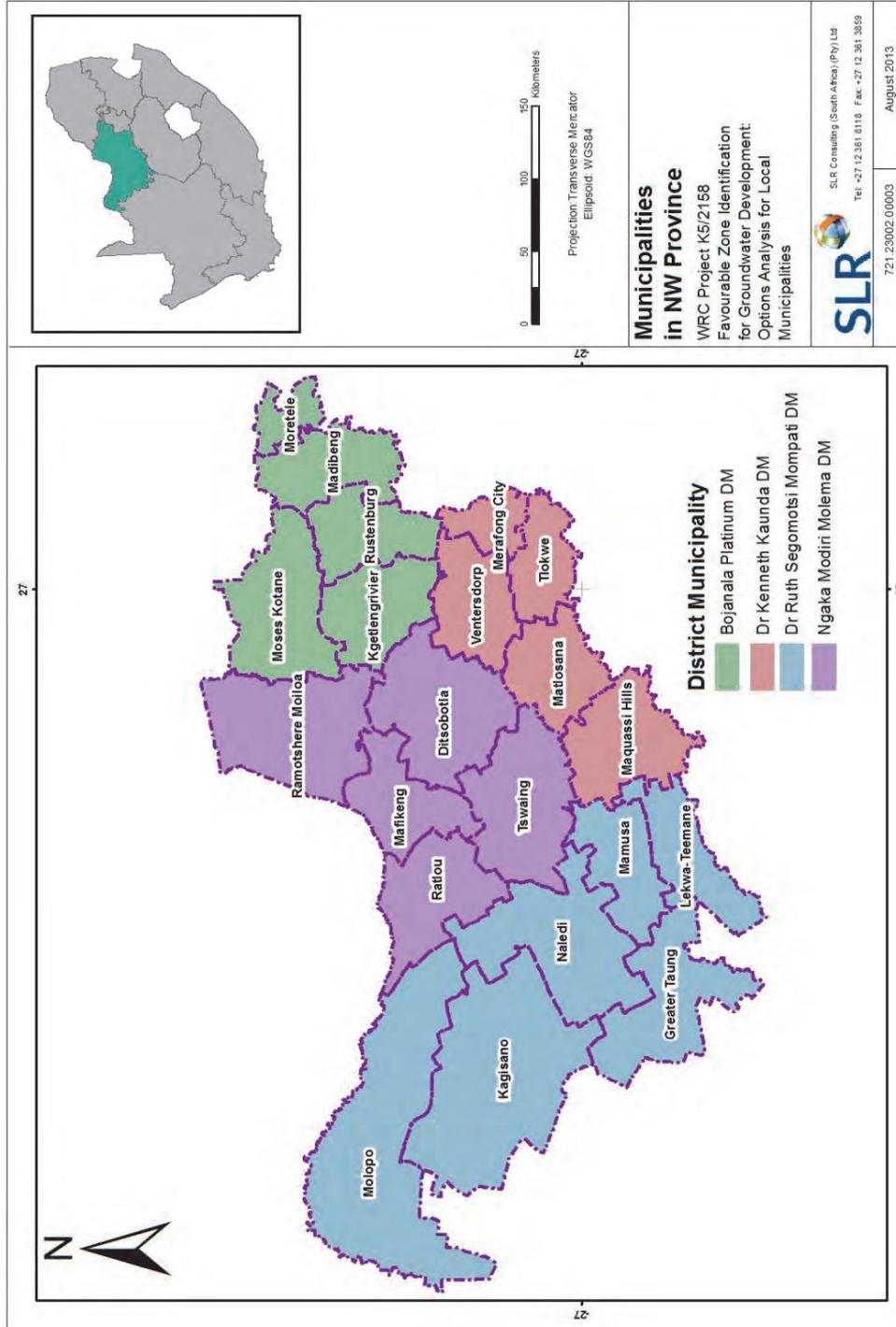


FIGURE 7-6 MUNICIPALITIES IN NW PROVINCE

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

Private contractors play an important role in Mahikeng and in the surrounding areas, acting as service providers to the various organisations and providing vital technical know-how. Private sector 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 (late 2013, early 2014) there is a dispute between Botshelo Water and NMMDM, with Botshelo Water claiming non-payment and NMMDM stating that Botshelo Water’s performance is inadequate (NMMDM Annual Report). The details of the financial arrangements between the Water Board and the Municipalities are beyond the scope of this study, but the problem is thought to have contributed to interruptions of water supply, including a complete failure of water supply between December 2012 and April 2013 in part of Mahikeng. Disputes also exist between these two organisations and DWA. 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.

In terms of the relationship between DWA and Water Boards generally, the Parliamentary Portfolio Committee on Water and Environmental Affairs (PPC, 2012) recorded the following: “The Chairperson also noted that, in general, the DWA was very weak in giving directives to the sector. It was failing to get quarterly reports from the Water Boards, entities were waiting endlessly for money from the Department and had ended up using consultants on how to get money elsewhere. The Department should intervene and lead the process. The better its leadership to the Water Boards, the easier for National Treasury to make allocations.”

The Reconciliation Strategy for Mahikeng has the following to say about the groundwater monitoring: “The actual available groundwater was estimated at a low confidence level since records for the monitoring system were not available from the municipality; communications with Botshelo Water implied that the system was not maintained due to insufficient capacity.” (DWA, 2010:3).

7.7.3 IRRIGATION NEAR MAHIKENG

More than one interview respondent mentioned the issue of dolomite groundwater being used for irrigation (usually centre pivot systems). This is seen to raise various issues – for example, there is perceived competition between irrigating farmers and water services providers (including DWA) for a finite resource. There also appears to be a lack of data as to exact amounts used for irrigation, whether these comply with licensed quantities, and what the implications of irrigation are for water levels. In cases where over-abstraction is taking place, it is not certain whether this is due to farmers exceeding licensed amounts, or the actual licensed amounts being inappropriately high. Greater

pressure on the groundwater resource in dolomite compartments implies a need for better monitoring, better enforcement of rules and agreements, and greater involvement of local organisations (particularly Water User Associations) in the management of the resource. At present all of these institutions appear to be weak. A large irrigation pivot was observed very close to the Grootfontein borehole abstractions in April 2013, and similar situations are thought to occur near Lichtenburg and Zeerust too. There is a need for better regulation and enforcement, in collaboration with irrigating farmers and Water User Associations, and in the absence of a Catchment Management Agency this will need to be coordinated by the Department of Water Affairs (DWA). Even if no unlicensed (“illegal”) irrigation is taking place, better enforcement and more transparent data would prevent the impression amongst some stakeholders that over-irrigation is taking place. As far as is known, a Water User Association for the Grootfontein groundwater compartment and surrounds does not yet exist.

According to the Reconciliation Strategy (DWA, 2010b) actual abstraction for irrigation purposes in the Grootfontein and Molopo areas is 21 Mm³/a (about 57.5 ML/d), whilst the Registered Use for irrigation is 16 Mm³/a (about 43.8 ML/d) based on WARMS data. This implies that groundwater abstraction for irrigation purposes exceeds licensed amounts. Although the state is empowered by the National Water Act to expropriate water supplies that are needed for domestic supplies, in practise this is difficult and expensive to do. A sensible strategy might be for the Water Board to purchase farms for the associated water rights, or negotiate long-term agreements with landowners for water supplies from groundwater. It is possible that the returns on water for supply for domestic purposes will be greater than those for irrigation of crops, and that this might be an attractive option for landowners. The Water Board, in turn, would gain access to a source of water that needs little or no treatment and has correspondingly lower costs. At the very least a WUA is needed to discuss these issues. According to the Water Services Development Plan of NMMDM, groundwater is purchased from private farms in the Coligny, Delareyville and Ottosdal areas, but no volumes are provided nor are the terms of the agreements known (NMMDM, 2009).

7.7.4 SURFACE WATER OPTIONS FOR MAHIKENG

Whilst most rural communities seem to be content with groundwater supplies, as long as the water keeps flowing, there does seem to be a preference at municipal management level for surface water. More than one interviewee spoke about wanting a pipeline from the Vaal River. In one case, the forthcoming Lesotho Highlands Water Project phase 2 has given the impression that relatively abundant surface water will soon be available in the Vaal River system. It is likely that the preference for surface water amongst some decision makers (not all) is due to the perceived difficulties in managing numerous disparate groundwater sources, on-going problems with groundwater quality (especially nitrate), and a perception that surface water is of generally superior quality to groundwater. Surface water is definitely seen as more reliable by some decision makers.

It is unlikely that a pipeline from the Vaal River will be economically feasible, but it is possible that Botshelo Water or the municipalities will increasingly opt for small groundwater bulk schemes relying

on a central well-field with reticulation to communities rather than scattered stand-alone boreholes. Such schemes may be more complex to run in terms of technical or engineering expertise, but O&M may be simpler to operationalize and administer (Gibson 2013, pers.comm, and Figure 3-1).



FIGURE 7-8 MAHIKENG WATER TREATMENT PLANT

7.8 MAHIKENG CASE STUDY CONCLUSIONS

The example of Mahikeng in NW Province has been used to illustrate some of the issues which together govern the functioning or “sustainability” of groundwater supplies for urban and peri-urban use. Mahikeng is mainly groundwater dependent (nearly entirely, if one considers that water from the Sehumo Dam is mainly return water from the town). The primary sources of groundwater for the town are the dolomite compartments to the east. These dolomite sources do have some problems with over-abstraction (especially at Grootfontein, where the available resource is thought to have recently collapsed due to failure to manage overabstraction) but in general the water shortages in Mahikeng have been caused by breakdowns in infrastructure or systems within the urban area itself. There is wide agreement that operation and maintenance (O&M) of groundwater sources and supplies is very important, and that lack of O&M is the primary reason for most failures of groundwater supply. The O&M issue is far from simple however, and raises in turn issues of responsibility, funding, authority, complexity and organisational functioning and interaction. The district and local municipalities ideally need to cooperate more closely with Botshelo Water Board and the Department of Water Affairs to ensure smooth operation of the various systems, but such cooperation has not always taken place (PPC, 2012). This has led in part to financial problems for some of the organisations involved, as well as a lack of cooperation on technical water matters. Coordination within organisations is also sometimes complex (e.g. between different departments or offices). The interactions between these organisations should be seen against a landscape in which other organisations envisaged in the National Water Act such as the Catchment Management Agencies and Water User Associations are not yet fully operational (Figure 1-1). Ngaka Modiri Molema District Municipality is one of the 24

“Priority District Municipalities” in which water supply backlogs have led to a variety of measures being taken, including the introduction of new types of funding (e.g. MWIG) which contain new provisions for project implementation and reporting. Greater engagement of the Water Boards, and support for the smaller Water Boards by the larger ones, is also envisaged.

The NWRS2 has the following to say about Mahikeng: “Growth in the area is primarily in and around Mahikeng which, although situated in the Molopo Catchment, is supplied from dolomitic aquifers in the Marico. The possibility of bringing water from the Vaal system to Mahikeng has been explored but does not appear promising due to the costs involved. Local sources (groundwater) and WCWDM are immediate options for Mahikeng.” (DWA, 2013: annexure 4). It may be that a crisis is needed before the groundwater resources supplying Mahikeng are given the management attention that they require.

8 FINAL EVALUATION

8.1 INTRODUCTION AND METHODOLOGY

One of the main findings of this project has been 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, operation and maintenance (O&M) of water supply systems, which in turn depend on a variety of subsidiary factors and/or institutions. These subsidiary factors are likely to include the financial competence or ability of the relevant Water Services Provider (WSP) municipality – since the logistics and procurement necessary for O&M requires a level of financial organisation and continuity. Past “Green Drop” and “Blue Drop” WSP performance is also likely to be relevant, as is the degree of improvement in providing RDP standard water supplies shown by comparing the 2001 and 2011 census datasets. 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 local municipality (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 which may require the most additional support.

It is acknowledged that “input factors” such as unemployment rates or geographical characteristics are being mixed together with “output factors” or monitoring tools such as percent access to an improved water supply or Blue Drop score. It is argued that “output factors” can also function as predictive tools in the same way as “input factors” in the sense that past performance is an indicator of future performance – for example a series of poor Blue Drop scores in the past implies poorer than average management of water quality, and makes poor Blue Drop scores in future more likely.

Four broad categories of indicators have been identified, all of which are thought to have some influence on the process of providing a reliable improved water supply to South African households:

1. Actual or existing water supply backlogs
2. Demographic indicators such as unemployment
3. Indicators of financial “health” for the relevant water service authority such as audit scores
4. Geographical factors such as community accessibility by road

Each of the 119 Priority LMs was scored relative to the other Priority LMs on a scale from 1 to 119 for each category. The score for each group ranged from 1 (best or most favourable) to 119 (worst or most challenging). The scores were then summed, and a new composite ranking from 1 to 119 was obtained from the result. Maps were produced for an Atlas (see Appendix 3) showing the following:

1. Composite rank or score (1 to 119) for actual water supply backlogs
2. Composite rank or score (1 to 119) for demographic indicators
3. Composite rank or score (1 to 119) for financial indicators
4. Composite rank or score (1 to 119) for geographic indicators
5. Final combined rank or score (1 to 119) for the four main groups together

Each of the four broad categories of indicators is discussed briefly in turn below. The various maps are shown in Appendix 3 of this report.

8.2 ACTUAL WATER SUPPLY BACKLOGS

8.2.1 INTRODUCTION

Information on access to a water supply in South Africa is derived from 2001 and 2011 census data and the 2007 Community Survey data as described in Chapter 1 of this report. The data is available on-line at <http://interactive.statssa.gov.za/superweb/login.do>. As described in Chapter 1, an “RDP standard” water supply has been defined, after the old Reconstruction and Development Programme minimum standard of an improved water supply within 200 m of a household. Today an erf connection is regarded as the basic level of service but in many rural areas the RDP standard still needs to be achieved and it is still a convenient description. See Table 1-4 in Chapter 1 for information on access to “RDP standard” household water supplies for each priority LM, for each of the applicable surveys.

8.2.2 ATLAS MAPS – WATER SUPPLY BACKLOGS

The following maps were produced for the accompanying Atlas to display actual water supply backlog information:

- Actual backlogs in 2001 – i.e. the percent of households lacking an improved water supply to RDP standard or better according to 2001 census data
- Actual backlogs in 2011 – i.e. the percent of households lacking an improved water supply to RDP standard or better according to 2011 census data
- Improvement in the decade 2001 to 2011 – i.e. the number of households served to RDP or better standard in 2012 expressed as a percentage of the number of households served to RDP or better standard in 2001.
- A combined Backlogs map which combines the relative ranks for the following indicators to give a “master backlog” rank:

- number of households not served to RDP standard in 2011
- the percentage of households not served to RDP standard in 2011
- the percentage of households not served to RDP standard in 2001
- percentage improvement between 2001 and 2011, i.e. the number of households served to RDP Standard or better in 2011 expressed as a percentage of the number of households served in 2001 (Census 01 and 111 Data)

Local municipalities were ranked from best (position 1) to worst (position 119), meaning that a lower number means a lesser task in providing water, a better organisational capacity, more favourable demographic or geographic circumstances, or similar.

8.3 DEMOGRAPHIC INDICATORS

8.3.1 INTRODUCTION

Demographic data (e.g. unemployment rate, age profiles, household income, percentage of households described as “tribal or traditional”, and population) was drawn from the Census 2011 data as described in the previous chapter. There are correlations between this demographic data and household access to water at “RDP standard” or better. Data for ALL local municipalities in South Africa was examined, with the aim of establishing correlations which might apply equally to the subset of 119 priority local municipalities. It is difficult to establish causal relationships between the data sets – in fact it is likely that the correlation between, for example, high unemployment and poor access to water is related to historical and economic factors not considered in depth by this project rather than an inherent relationship between the two. Nonetheless, it is argued that such correlations may assist in predicting the scale of the task ahead of individual priority local municipalities as they endeavour to provide water for all.

The 2011 census data distinguishes between three types of settlement or “geotypes” – urban areas, farming areas, and “tribal / traditional” areas. Some local municipalities have no settlements classified as tribal / traditional, whilst others have more than 90% of households living in such settlements.

8.3.2 DEMOGRAPHIC CORRELATIONS

For the total set of all 234 South African local and metropolitan municipalities, the following data derived from the 2011 census was compared:

- the unemployment rate (%)
- the proportion of people (%) younger than 19 and older than 60
- the proportion of households with an income of R2300 per month or less
- the proportion of settlements classified as tribal / traditional
- the proportion of households receiving water to RDP standard or better

Correlations can be seen between high proportions of households not receiving water to RDP standard or better and both unemployment rate and the proportion of people living in settlements classified as tribal / traditional. Interestingly, although correlations are apparent (and expected) between unemployment rate and the proportion of households with an income of R2300 per month or less, and between unemployment rate and the proportion of people (%) either younger than 19 or older than 60, there seems to be no correlation between access to water and either low household income, or high proportions of people not of working age.

This partly confirms observations made earlier in the project that the lack of access to an RDP standard water supply has its roots in the former “homelands” (i.e. high unemployment and high proportions of tribal / traditional settlements), but with the unexpected proviso that low household income and low numbers of working-age people don’t appear to be indicators of lack of RDP standard water supply. The figures below are shown with best-fit lines and correlation coefficients (R^2 values) for interest and comparison, not to imply correlations that do not in fact exist.

Lack of access to water at RDP standard or better does not correlate with rainfall, recharge, regional groundwater availability or other “natural” hydrological or hydrogeological factors. Many of the local municipalities with the largest backlogs are in fact in areas with relatively high natural or environmental water availability. See Deliverable 1 and later in this section for more information.

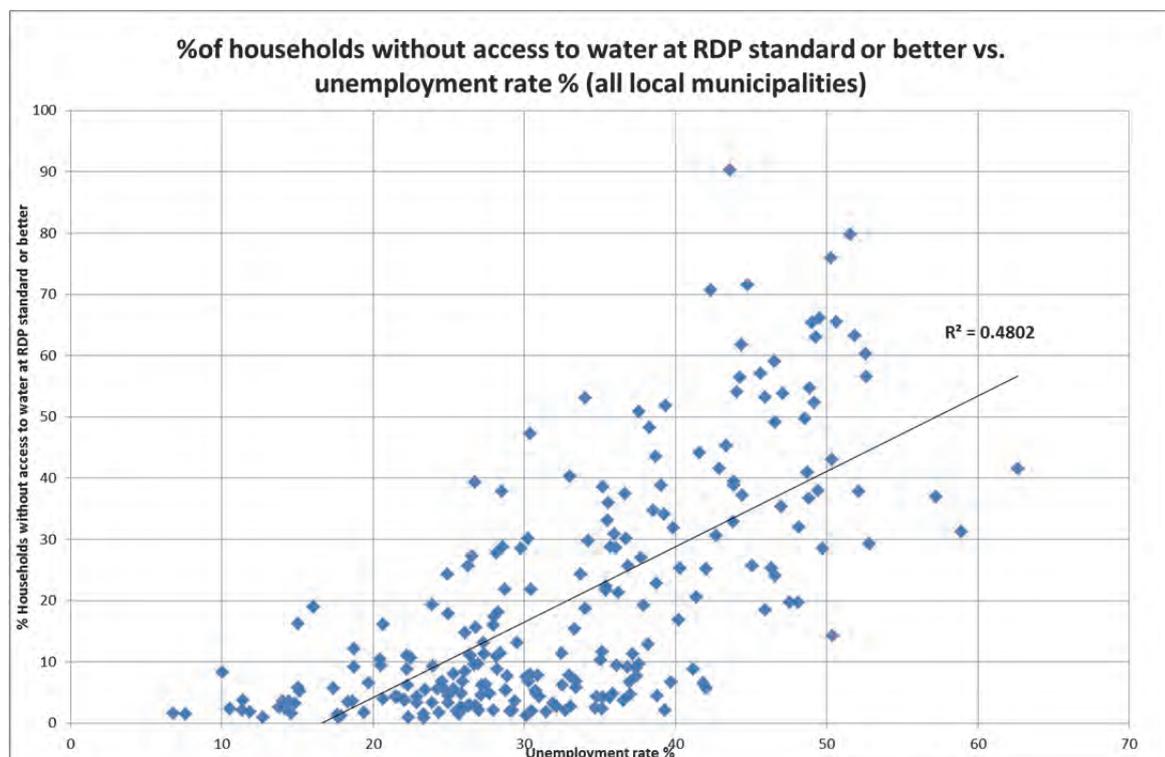


FIGURE 8-1 RDP ACCESS VS EMPLOYMENT

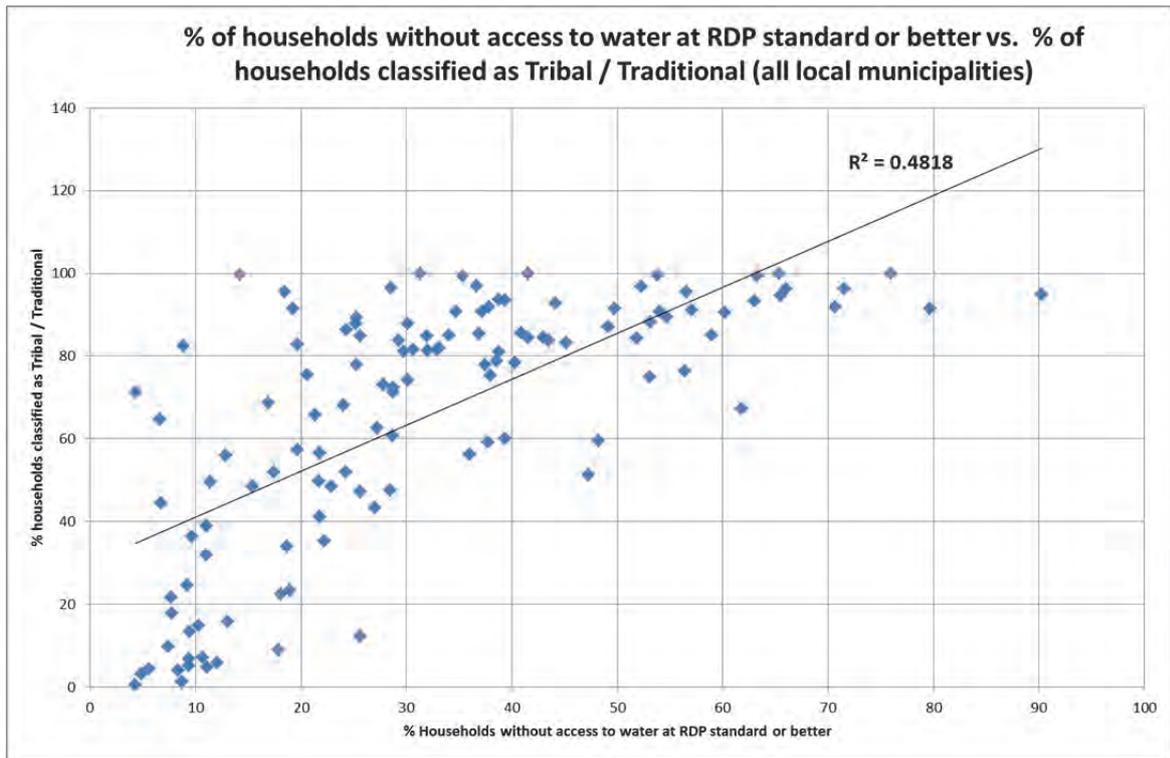


FIGURE 8-2 RDP ACCESS VS TRIBAL / TRADITIONAL HOUSEHOLDS

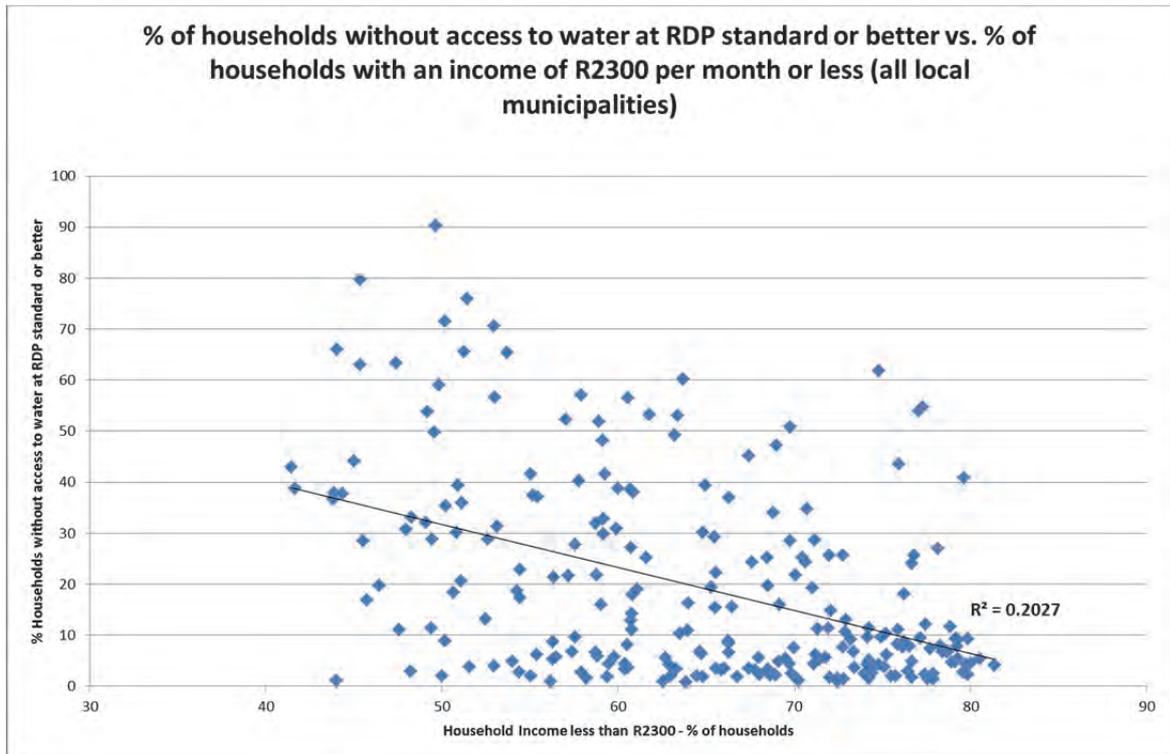


FIGURE 8-3 RDP ACCESS VS LOW INCOME HOUSEHOLDS

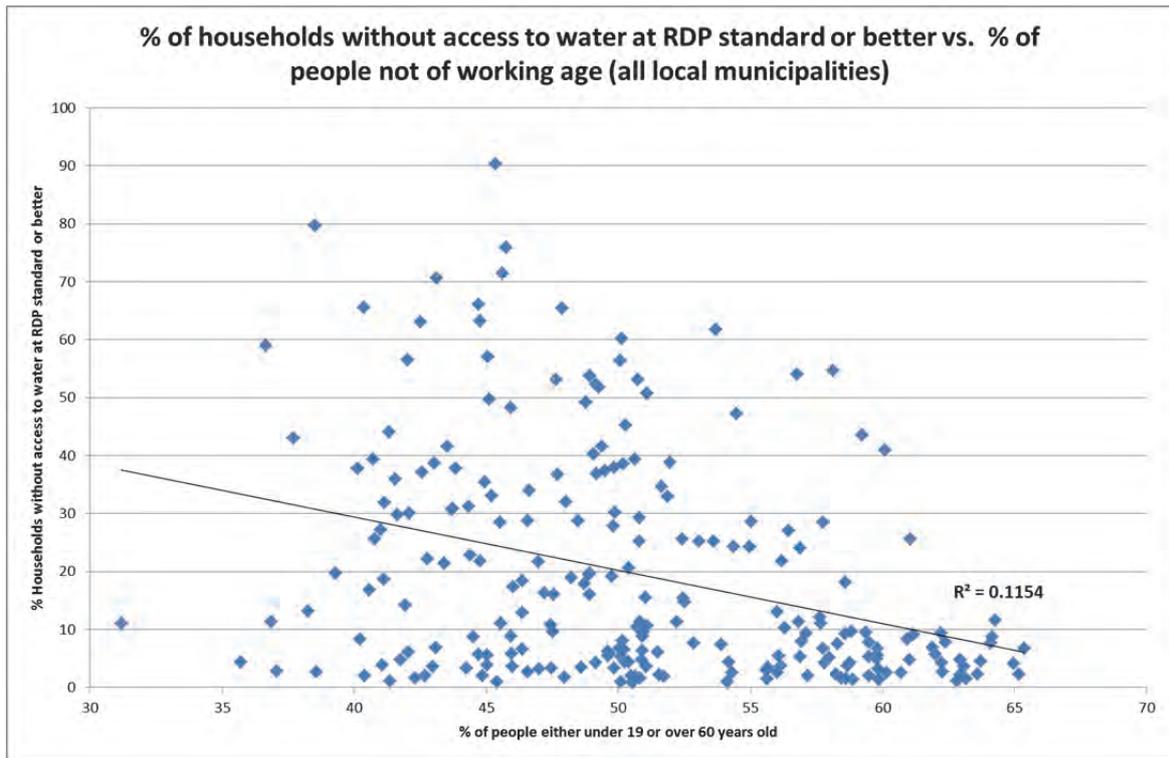


FIGURE 8-4 RDP ACCESS VS NON-WORKING AGE PEOPLE

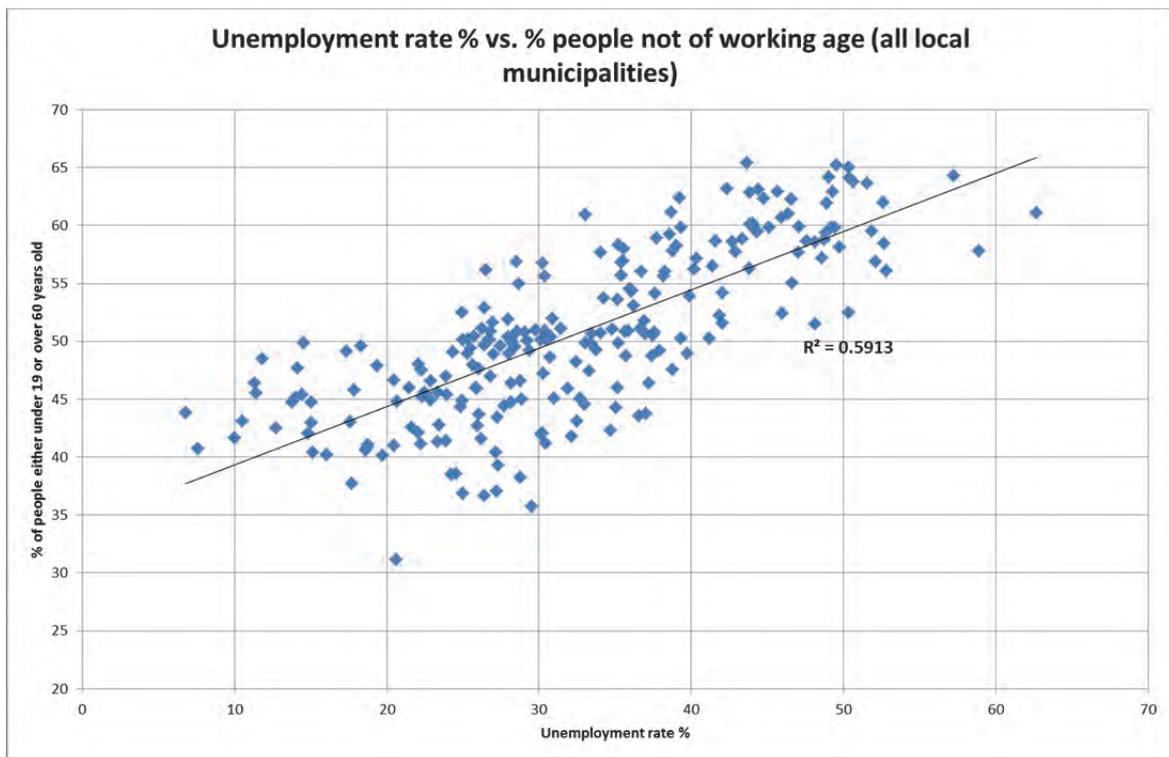


FIGURE 8-5 UNEMPLOYMENT RATE VS NON-WORKING AGE PEOPLE

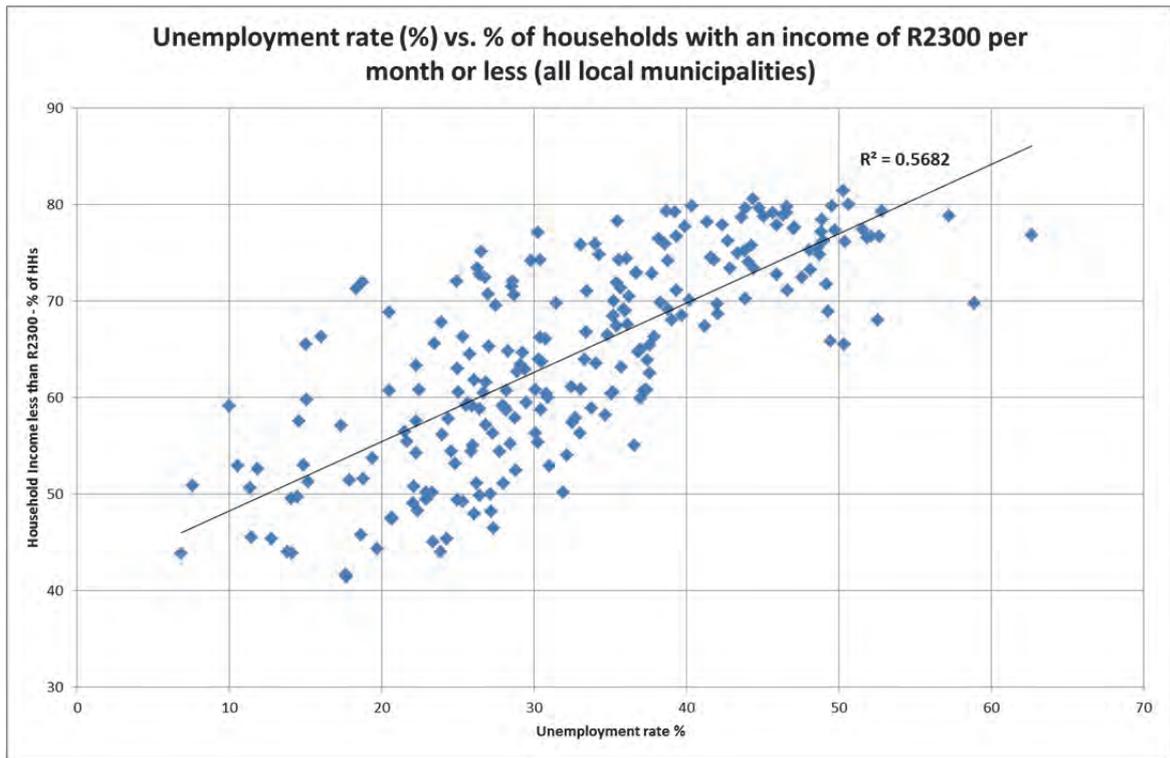


FIGURE 8-6 UNEMPLOYMENT RATE VS LOW INCOME HOUSEHOLDS

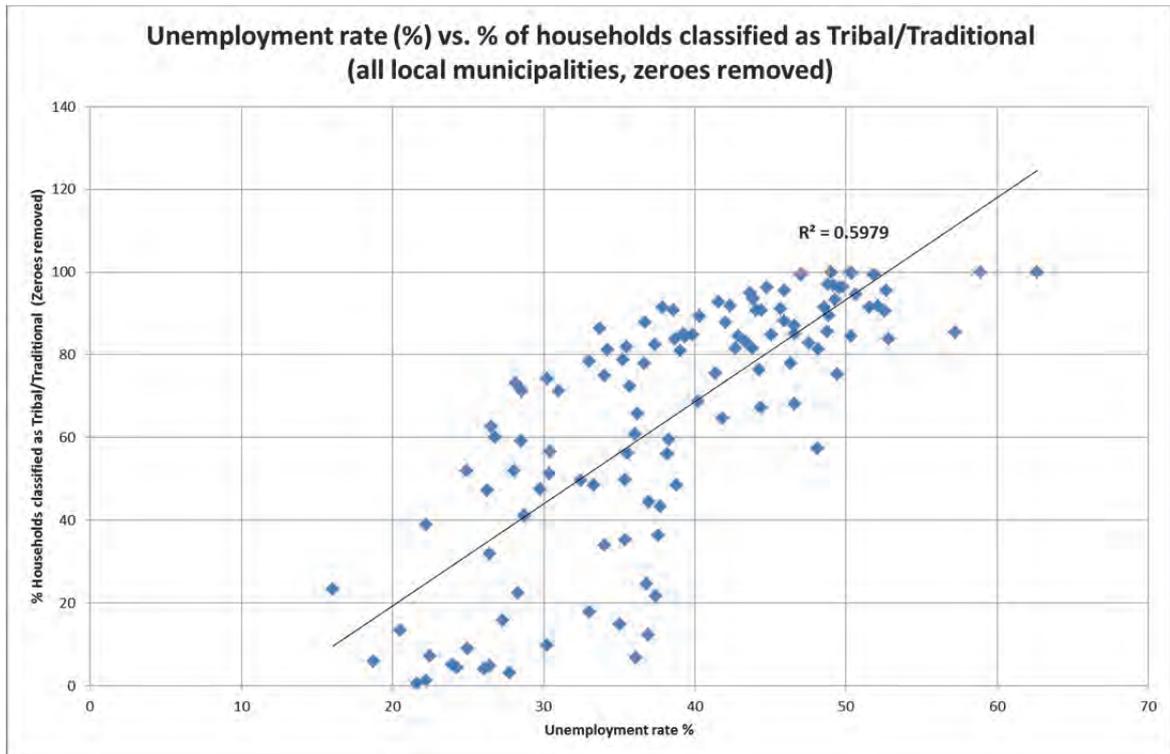


FIGURE 8-7 UNEMPLOYMENT RATE VS TRIBAL / TRADITIONAL HOUSEHOLDS

8.3.3 POPULATION AND MIIF TYPE

Another demographic factor that is thought to determine the scale of the task which a (rural) local municipality faces in supplying RDP standard water to all households is the population of the local municipality, particularly the population still to be served. Urban municipalities (e.g. metropolitan municipalities and municipalities with high proportions of people living in towns) are able to make use of economies of both scale and scope in supplying relatively large numbers of people with water in relatively small areas. Mainly rural municipalities face different engineering and logistical challenges, and must often install water schemes covering physically much larger areas (but possibly far fewer households).

The National Treasury and the Department of Co-operative Governance and Traditional Affairs (DCoG) have previously defined sub-categories of municipalities in South Africa based on geography, demographics and other factors. These sub-categories are sometimes known as Municipal Infrastructure Investment Framework (MIIF) categories based on National Treasury work on municipal finances (see for example Treasury, 2011). Water Service Authorities are spread across the various MIIF categories of municipality as follows (DWA 2011 and MDB 2011):

TABLE 8-1 DCOG / TREASURY MIIF CATEGORIES

Category	Description	Total Number	Number of WSAs
A	Metropolitan municipalities (metros)	8	8
B1	Secondary cities, local municipalities with the largest budgets	19	19
B2	Local municipalities with a large town as core	27	18
B3	Local municipalities with small towns, with relatively small population and significant proportion of urban population but with no large town as core	110	79
B4	Local municipalities which are mainly rural with communal tenure and with, at most, one or two small towns in their area	70	9
C1	District municipalities which are not water services authorities	22	0
C2	District municipalities which are water services authorities	22	22

Local municipalities falling into categories B3 and particularly B4, and in addition having large populations, are likely to find extending water supply coverage to all households, and operating and maintaining those supplies, logistically more difficult than other municipalities (Figure 8-8). The 119 priority local municipalities that are the focus of this report consist of 5 B1 municipalities, 9 B2 municipalities, 40 B3 municipalities and 65 B4 municipalities.

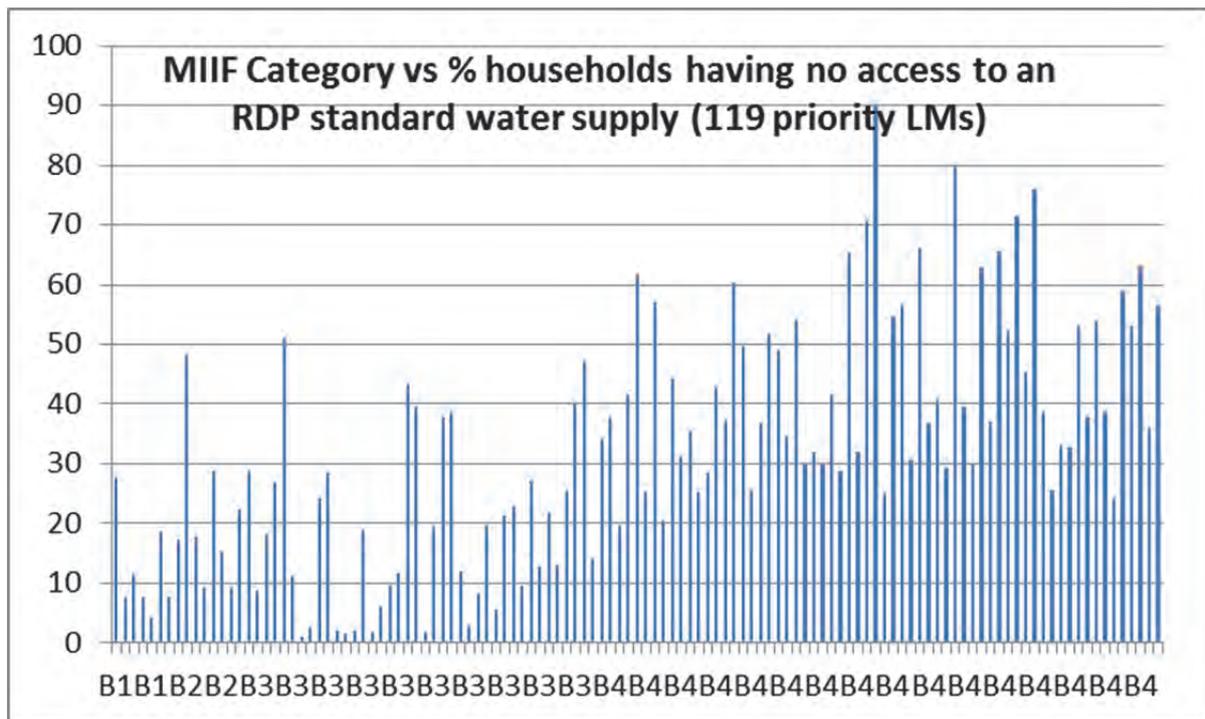


FIGURE 8-8 MIIF CATEGORIES VS NO ACCESS TO RDP STANDARD WATER

8.3.4 ATLAS MAPS – DEMOGRAPHICS

The following maps have been produced for the accompanying Atlas to display demographic information:

- A map showing the municipal infrastructure investment framework (MIIF) for each of the priority local municipalities (categories B1 to B4)
- A map showing the population of each priority local municipality
- A map showing the percentage of communities in each local municipality classified as “tribal or traditional” according to census 2011 geotype data
- A map showing the unemployment rate (%) for each priority local municipality
- A combined Demographics map which combines the relative ranks for the following indicators to give a “master demographic” rank:
 - The unemployment rate (%) for each priority LM
 - The percentage of households with an income of R2300 per month or less in each priority LM
 - The percentage of communities classified as “tribal or traditional” in each priority LM
 - The total population of each priority LM
 - The percentage of people not of working age (i.e. younger than 19 or older than 60) in each priority LM.

For the combined map, the priority local municipalities were ranked from best (position 1) to worst (position 119), meaning that a lower number means a lesser task in providing water, a better organisational capacity, more favourable demographic or geographic circumstances, or similar.

8.4 FINANCIAL INDICATORS

8.4.1 INTRODUCTION

It is likely that the financial capacity / financial sophistication of any particular municipality that is classified as a water services provider (WSA) has a bearing on the municipality's capacity to carry out routine water-related tasks such as operation and maintenance of water supplies. This is recognised in DWA's "Regulatory Performance Measurement System", which identifies KPIs and Benchmark Indicators for each municipality (DWA 2011). Only 16 of the priority 119 LMs are Water Services Authorities (this function is performed by the relevant DM for the other 103 LMs).

Financial information for the various WSAs (mostly district municipalities, but including the 16 local municipalities classified as WSAs) for this project was obtained from the website www.localgovernment.co.za (accessed December 2013 and January 2014). Information is available for both the 2010 and 2011 financial years, as follows (the example given in Table 8-2 below is for Alfred Nzo DM):

TABLE 8-2 AVAILABLE MUNICIPAL AUDIT INFORMATION

Alfred Nzo District Municipality (DC44)	Dec-11	Nov-10
AUDIT OUTCOME	Disclaimer of audit opinion	Disclaimer of audit opinion
Unauthorised Expenditure	389 195 305	13 141 422
Irregular Expenditure	247 386 611	29 146 096
Fruitless & Wasteful Expenditure	-	-
FINANCIAL POSITION		
Current Assets	228 240 345	80 603 409
Non-Current Assets	1 536 996 135	1 146 934 008
Total Assets	1 765 236 480	1 227 537 417
Current Liabilities	104 503 296	70 865 823
Non-Current Liabilities	31 201 055	22 869 385
Total Liabilities	135 704 351	93 735 208
Total Net Assets	1 629 532 129	1 133 802 209
FINANCIAL PERFORMANCE		
Total Revenue	1 147 532 437	350 702 081
Property Rates	-	-
Service Charges	15 412 754	14 217 269
Government Grants & Subsidies	1 115 489 186	325 875 068
Total Expenditure	-651 802 517	-220 002 299
Employee Costs	-92 233 206	-67 180 235
Councillor Remuneration	-6 004 373	-2 024 982
Debt Impairments	n/a	n/a
Repairs & Maintenance	-18 824 099	-17 861 497
Bulk Purchases	-2 268 002	-6 205 725
General Expenses	-64 309 945	-38 522 943
Surplus/Deficit for Year	495 729 919	130 699 782
CASH FLOW		
Net Cash Flows from Operating Activities	406 867 151	161 657 548
Cash & Cash Equivalents at End of Year	165 144 250	25 250 285

8.4.2 GREEN AND BLUE DROP SCORES

The Green and Blue Drop system of benchmarking is administered by the Department of Water Affairs and assesses the quality of wastewater discharges and potable water treatment respectively by means of a percentage score. The system is applied to Water Services Authorities only. Data available to this project included the Blue Drop Scores for 2010 and 2011 (2011 and 2012 reports respectively) and the Green Drop Score for 2010. An index score for each WSA was derived by adding these three percentage scores together to arrive at a relative ranking.

8.4.3 AUDIT OUTCOMES

Municipalities must be audited annually by law. The objective of an audit of financial statements is to express an opinion on whether the financial statements fairly represent the financial position of the auditee at financial year-end and the results of its operations for the financial year. According to www.localgovernment.co.za the Auditor-General can express one of the following audit opinions:

Clean audit outcome: The financial statements are free from material misstatements (in other words, a financially unqualified audit opinion) and there are no material findings on reporting on performance objectives or non-compliance with legislation.

Financially unqualified with findings: The financial statements contain no material misstatements. Unless the Auditor General expresses a clean audit outcome, findings have been raised on either reporting on predetermined objectives or non-compliance with legislation, or both these aspects.

Qualified audit opinion: The financial statements contain material misstatements in specific amounts, or there is insufficient evidence for the Auditor General to conclude that specific amounts included in the financial statements are not materially misstated.

Adverse audit opinion: The financial statements contain material misstatements that are not confined to specific amounts, or the misstatements represent a substantial portion of the financial statements.

Disclaimer of audit opinion: The auditee provided insufficient evidence in the form of documentation on which to base an audit opinion. The lack of sufficient evidence is not confined to specific amounts, or represents a substantial portion of the information contained in the financial statements.

A “score” was assigned to the 2010 and 2011 audit outcomes for each LM, according to the following table (Table 8-3):

TABLE 8-3 AUDIT OUTCOME SCORES

Audit outcome	Score
Clean audit outcome	5
Financially unqualified with findings	4
Qualified audit opinion	3
Adverse audit opinion	2
Disclaimer of audit opinion	1
Audit not finalised	1

These “audit scores” for 2010 and 2011 for each local municipality (reflecting the relevant WSA municipality) were added together to provide a single combined score for each local municipality, very roughly or broadly reflecting the relevant WSA audit compliance for the last two years for which data is available. The highest possible score is therefore $5 + 5 = 10$, for consecutive years of clean audits. The lowest possible score is 2.

8.4.4 EXPENDITURE

Unauthorised, fruitless and wasteful, and irregular expenditure were summed and expressed as a percentage of total expenditure for each of the two years of audit figures (2010 and 2011). An average value for the two sets of audit figures was then obtained for each relevant WSA. Results ranged from less than 5% to nearly 200%.

8.4.5 EMPLOYEE COSTS

Employee costs were expressed as a percentage of total expenditure for each audit year (2010 and 2011). An average value for the two sets of audit figures was then obtained for each relevant WSA. The Department of Water Affairs target / KPI for % Staff Costs of Total Costs is 35.5% (DWA, 2011). Note that total costs were not available as part of the audit information, and these may differ from total expenditure. Percentages ranged from less 10% to more than 35%.

8.4.6 REPAIRS AND MAINTENANCE

Expenditure on repairs and maintenance was expressed as a percentage of total expenditure for each audit year (2010 and 2011). Details of repairs and maintenance expenditure are not available (for example the proportion spent on water supply systems). An average value for the two sets of audit figures was then obtained for each relevant WSA. In theory the higher the spend on repairs and maintenance, the more reliable the applicable systems will be, all other things being equal. Percentage spends ranged from less than 1% to more than 8%. It may be more realistic to consider repairs and maintenance spend as a percentage of total asset value rather than total expenditure, but this would imply that high-value assets (such as dams) require correspondingly high spend on repairs and maintenance, which is not always the case. In addition, high-value and long-lasting assets may only require maintenance every few years, or from a special / dedicated fund, and this may not be captured by the audit information available.

8.4.7 LOCAL MUNICIPALITIES UNDER ADMINISTRATION

The following local municipalities (Table 8-4) were reported to be under financial administration in December 2013 in the Local Government Handbook (Local Government 2014). These have not been incorporated into the indicators in any way – in theory being under administration would be a financial advantage, since outside expertise and oversight is being brought to bear.

TABLE 8-4 LOCAL MUNICIPALITIES UNDER ADMINISTRATION

Local Municipality	Province
Mnquma LM	Eastern Cape
Mtubatuba LM	KwaZulu-Natal
Imbabazane LM	KwaZulu-Natal
Indaka LM	KwaZulu-Natal
AbaQulusi LM	KwaZulu-Natal

8.4.8 ATLAS MAPS – FINANCIALS

The following maps have been produced for the accompanying Atlas to display financial information for the applicable water services authority (WSA) corresponding to each of the 119 priority local municipalities:

- Combined green drop and blue drop score as described above
- Combined audit outcome score as described above
- Combined 2010 and 2011 fruitless and wasteful, unauthorised and irregular expenditure as described above
- Combined 2010 and 2011 employee costs expressed as a percentage of total costs, as described above
- Expenditure on repairs and maintenance averaged for the 2010 and 2011 years and provided as a percentage of total expenditure, as described above
- A combined Financials map which combines the relative ranks for the following indicators to give a “master financials” rank:
 - A rank or score for MIIF category – 30 for B1, 60 for B2, 90 for B3 and 120 for B4
 - A rank or score for the combined blue and green drop outcome
 - A rank or score for the combined audit results (2010 and 2011), ranging from 12 for a combined audit score of 9 to 96 for a combined audit score of 2
 - A rank or score for combined fruitless and wasteful, unauthorised and irregular expenditure expressed as a percentage of total expenditure
 - A rank or score for employee costs expressed as a percentage of total expenditure
 - A rank or score for expenditure on repairs and maintenance expressed as a percentage of total expenditure

Note that because several LMs may share the same District Municipality authorised as a WSA, the score or rank for groups of LMs may be the same. For the combined map, the priority local municipalities were ranked from best (position 1) to worst (position 119), meaning that a lower number means a lesser task in providing water, a better organisational capacity, more favourable demographic or geographic circumstances, or similar

8.5 GEOGRAPHICAL INDICATORS

8.5.1 INTRODUCTION

It is argued that geographical indicators or factors are likely to have a large influence on the ease with which a local municipality (or its proxy WSA) is able to carry out installation, operation and maintenance of water supply systems (including groundwater supplies), and therefore on the extent to which communities in the LM have access to a reliable improved water supply. These factors include

the total number of communities to be served, the distance from those communities to a town or hub, the total length of the road network in the LM, and the extent to which communities can be reached by roads. These factors are briefly discussed below. Whilst absolute values can be assigned to each of these factors, it is difficult to determine the objective extent to which each factor may control water supply installation and O&M. The 119 LMs have therefore been ranked according to their relative position in each factor, and a combined relative “geographical ranking” has been determined by combining the different factors.

8.5.2 DATASETS USED

- 1: A set of towns for the area of the 119 Priority LM coverage plus buffer (see below). The towns were classed by size into groups as: Small, LM Seat, Main and Provincial Capital.
- 2: A set of roads, derived from the CD NGI 1:50 000 vector dataset. The roads are classed by the standard CD NGI road classification structure.
- 3: A set of road buffers and village communities. The CD NGI roads were buffered to create the road buffers. The village communities are a data set obtained from the Department of Water Affairs and Forestry.
- 4: The main town data set buffered by circular (concentric) buffers (see below)
- 5: A “fragmentation index” (of sorts). The Relative Edge Density value, from the Patch analysis model for all village segments in all LMs (see below).
- 6: The centre of mass (correct centroid point) for total number of villages in each LM.

It is acknowledged that the geographical indicators depend partly on the accuracy / completeness of the original input GIS datasets used, and that errors may arise in this way. The indicators have been compiled as relative ranks as described above which to some extent may reduce such errors – assuming that errors are randomly distributed across the study area, of course.

All data was processed in Transverse Mercator, LO 27, WGS 84 Spheroid; this being the best central meridian for the greater study area.

8.5.3 TOWN DENSITY

A list of small South African towns in the 119 LMs was compiled, based on the (admittedly rather subjective criterion) that the towns had to offer reasonable facilities such as availability of diesel, basic welding, availability of groceries, etc. – in other words, towns where a satellite O&M facility might be located, or where repairs or basic spares might be commissioned. The list of towns included all of the LM seats. The density of such towns per unit area was then calculated for each LM, allowing a basic measurement of the availability of facilities to be made for each LM. The data was then sorted from low to high and ranked from 1 to 115 (115 only since there are some LMs with no main towns). This dataset is similar to the physical area of the LMs, with larger LMs having higher scores in general.

8.5.4 ROAD DENSITY

Since nearly all O&M activities will depend on transport by road – from inspection visits to delivery of new components – the total length of all roads in each LM was calculated, then divided by the area of each LM to arrive at a rough “road density” measurement. It is assumed that higher road densities will make O&M easier, all other things being equal.

8.5.5 ROAD INTERSECTS

A more sophisticated version of the road density measurement is to buffer each road, then determine what percentage of communities in each LM are intersected (fall within the buffer zone) of a road. It is assumed that the higher the percentage of communities intersected by a road, the easier the O&M task, all other things being equal. To some extent we are dealing with absolutes here – for example a village that is “just” outside the road buffer will be excluded. This distance could be 100 metres or less – causing a community to be “rejected” when still very close to a road. However a relative ranking has nevertheless been derived and such errors are assumed to partially cancel out across the dataset.

8.5.6 DISTANCE FROM TOWNS

Each town (as described above) was buffered by five concentric zones, and each community in each LM was classified according to which of the buffer zones it fell into. Buffer zones were within 10 km, 10 to 25 km, 25 to 50 km, 50 to 100 km, and greater than 100 km. The assumption here is that a community that is closer to a town is easier to serve than one that is further away. The percentage of communities falling into each zone was calculated, the percentages were then multiplied by a weighting factor (1 for zone 1, 2 for zone 2, etc.) and summed, allowing a “rank” to be derived for each LM. It is acknowledged that the buffer zones represent only “crow flies” or direct distances, and that the “real” distance needs to take account the actual distance by road, road surface, speed limits, topography, etc. However for the purposes of this project and the need to find a relative ranking it was assumed that such errors will at least partially cancel each other out across the dataset. The weighting factors are also subject to discussion, since for example it may be much easier to serve five communities in the first (10 km) buffer than one community that is 100 km from a town (although the two situations provide the same rank in this analysis). Other issues also apply – for example, LMs with high numbers of communities that are far from “towns” may also establish remote O&M bases to counter this problem and improve efficiency, or choose technologies that require fewer visits. Nonetheless, a relative ranking of the 119 LMs has been derived.

8.5.7 FRAGMENTATION / EDGE DENSITY

It is assumed that a large number of scattered communities is technically and logistically more difficult to service (and to provide O&M) compared with fewer, larger settlements with the same number of households. Another way of expressing this is to measure an “Edge Density” relative value – being

the amount of “edge” relative to the village area. This value was created by the Patch Analysis model software (plugin to ArcGIS10). An edge density (ED) value was created by using Patch Analyst Plugin, and then choosing the Spatial Analysis by Regions with the Analysis Level as Landscape and analysed on the LM name. The lower the score the better (i.e. a low score implies fewer “edges” per area of settlement). Data was sorted and ranked from low to high according to the ED value.

8.5.8 TOTAL COMMUNITIES

Finally, a measurement of the total number of communities or villages per LM was derived. The village polygons were converted to a centre of mass point using ArcGIS – and then intersected with the LMs to create an accurate number of villages within each LM. Using the centre of mass excludes the edge / sliver effects of village polygons that cross LM boundaries, meaning that only the community or village centre is counted as a village. The lower the score the better. Data was ranked from low to high.

8.5.9 COMPOSITE GEOGRAPHICAL SCORE

A composite geographical score was then derived for each LM based on the six geographical indicators or factors, by simply summing the individual scores. The lower the score, the better. The issue of weighting each score was discussed by project members (for example it may be much more of a disadvantage to have fewer road intersects than to have a large number of communities) but in the end the issues were assumed to be equivalent / linear in the absence of better data. The composite score essentially provides a relative indication of the geographical ease or difficulty of establishing a water supply and (crucially) carrying out O&M. The table below (Table 8-5) shows the composite geographical scores for each LM, in alphabetical order of LM name, and in ascending order of score. The lowest (best) score was for Naledi (Free State) LM, and the highest (worst) score was for Umhlabuyalingana LM in KZN.

TABLE 8-5 COMPOSITE GEOGRAPHICAL SCORES

CODE	LM NAME	Score	CODE	LM NAME	Score
KZN263	Abaqulusi	352	FS164	Naledi_FS	102
LIM352	Aganang	397	KZN212	Umdoni	117
EC124	Amahlathi	356	KZN292	KwaDukuza	121
LIM334	Ba-Phalaborwa	284	KZN282	uMhlathuze	125
LIM351	Blouberg	462	EC133	Inkwanca	154
MP325	Bushbuckridge	423	KZN225	The Msunduzi	164
KZN254	Dannhauser	255	NW396	Lekwa-Teemane	168
NW384	Ditsobotla	332	LIM353	Molemole	181
KZN261	eDumbe	368	EC128	Nxuba	182
LIM472	Elias Motsoaledi	380	EC143	Maletswai	185
EC141	Elundini	477	KZN241	Endumeni	187
KZN253	Emadlangeni	245	EC138	Sakhisizwe	190
EC136	Emalaheni	378	KZN234	Umtshezi	194
KZN232	Emnambithi/Ladysmith	340	KZN291	Mandeni	195
KZN241	Endumeni	187	MP322	Mbombela	195
EC137	Engcobo	510	MP323	Umjindi	200
LIM471	Ephraim Mogale	289	MP321	Thaba Chweu	211
KZN215	Ezingoleni	229	NW383	Mafikeng	216
LIM474	Fetakgomo	263	NW393	Mamusa	220
NC453	Gamagara	238	KZN216	Hibiscus Coast	225
EC144	Gariep	302	KZN215	Ezingoleni	229
NC452	Ga-Segonyana	233	KZN252	Newcastle	231
EC123	Great Kei	274	NC452	Ga-Segonyana	233
LIM331	Greater Giyani	365	KZN222	uMngeni	236
KZN433	Greater Kokstad	435	MP324	Nkomazi	237
LIM332	Greater Letaba	295	NC453	Gamagara	238
NW394	Greater Taung	461	KZN253	Emadlangeni	245
LIM475	Greater Tubatse	428	EC131	Inxuba Yethemba	246
LIM333	Greater Tzaneen	282	LIM341	Musina	249
KZN216	Hibiscus Coast	225	FS163	Mohokare	253
KZN274	Hlabisa	430	KZN254	Dannhauser	255
KZN236	Imbabazane	358	LIM354	Polokwane	255
KZN224	Impendle	340	KZN432	Kwa Sani	260
KZN233	Indaka	579	LIM474	Fetakgomo	263
KZN431	Ingwe	322	NW392	Naledi_NW	263
EC133	Inkwanca	154	EC123	Great Kei	274
EC135	Intsika Yethu	477	KZN223	Mpofana	275
EC131	Inxuba Yethemba	246	LIM333	Greater Tzaneen	282
NC451	Joe Morolong	607	FS162	Kopanong	283
KZN272	Jozini	540	LIM334	Ba-Phalaborwa	284
NW397	Kagisano/Molopo	545	LIM471	Ephraim Mogale	289
EC157	King Sabata Dalindyebo	435	LIM335	Maruleng	290
FS162	Kopanong	283	KZN293	Ndwedwe	291
KZN432	Kwa Sani	260	LIM332	Greater Letaba	295
KZN292	KwaDukuza	121	EC144	Gariep	302
NW396	Lekwa-Teemane	168	FS161	Letsemeng	315
LIM355	Lepele-Nkumpi	430	KZN281	Mfolozi	319
FS161	Letsemeng	315	KZN431	Ingwe	322
EC134	Lukanji	413	KZN294	Maphumulo	325
NW383	Mafikeng	216	NW384	Ditsobotla	332
LIM344	Makhado	449	KZN275	Mtubatuba	333
LIM473	Makhuduthamaga	345	KZN232	Emnambithi/Ladysmith	340
EC143	Maletswai	185	KZN224	Impendle	340
NW393	Mamusa	220	LIM473	Makhuduthamaga	345
KZN291	Mandeni	195	KZN226	Mkhambathini	348
KZN294	Maphumulo	325	KZN227	Richmond	351
LIM335	Maruleng	290	KZN263	Abaqulusi	352
EC441	Matatiele	556	KZN214	UMuziwabantu	352
EC121	Mbhashe	521	KZN221	uMshwathi	353
EC443	Mbizana	585	EC124	Amahlathi	356
MP322	Mbombela	195	KZN236	Imbabazane	358

KZN281	Mfolozi	319		KZN285	Mthonjaneni	359
EC156	Mhlontlo	438		KZN283	Ntambanana	361
KZN226	Mkhambathini	348		LIM331	Greater Giyani	365
EC122	Mnquma	504		NW382	Tswaing	365
FS163	Mohokare	253		EC142	Senqu	367
LIM353	Molemole	181		KZN261	eDumbe	368
KZN223	Mpofana	275		EC136	Emalahleni	378
KZN244	Msinga	527		LIM472	Elias Motsoaledi	380
KZN285	Mthonjaneni	359		LIM352	Aganang	397
KZN275	Mtubatuba	333		EC134	Lukanji	413
LIM341	Musina	249		EC126	Ngqushwa	414
LIM342	Mutale	467		KZN434	Ubuhlebezwe	417
FS164	Naledi_FS	102		EC127	Nkonkobe	420
NW392	Naledi_NW	263		MP325	Bushbuckridge	423
KZN293	Ndwedwe	291		KZN284	uMalazi	423
KZN252	Newcastle	231		LIM475	Greater Tubatse	428
EC126	Ngqushwa	414		KZN274	Hlabisa	430
EC153	Ngquza Hill	529		LIM355	Lepele-Nkumpi	430
KZN286	Nkandla	567		EC132	Tsolwana	433
MP324	Nkomazi	237		KZN433	Greater Kokstad	435
EC127	Nkonkobe	420		EC157	King Sabata Dalindyebo	435
KZN265	Nongoma	535		EC156	Mhlontlo	438
KZN242	Nqutu	583		NW381	Ratlou	438
EC444	Ntabankulu	464		NW385	Ramotshere Moiloa	439
KZN283	Ntambanana	361		LIM344	Makhado	449
EC128	Nxuba	182		EC154	Port St Johns	457
EC155	Nyandeni	479		NW394	Greater Taung	461
KZN235	Okhahlamba	483		LIM351	Blouberg	462
LIM354	Polokwane	255		EC444	Ntabankulu	464
EC154	Port St Johns	457		KZN262	UPhongolo	465
NW385	Ramotshere Moiloa	439		LIM342	Mutale	467
NW381	Ratlou	438		EC141	Elundini	477
KZN227	Richmond	351		EC135	Intsika Yethu	477
EC138	Sakhisizwe	190		EC155	Nyandeni	479
EC142	Senqu	367		KZN273	The Big 5 False Bay	481
MP321	Thaba Chweu	211		KZN211	Vulamehlo	482
KZN273	The Big 5 False Bay	481		KZN235	Okhahlamba	483
KZN225	The Msunduzi	164		KZN213	Umzumbe	490
LIM343	Thulamela	509		KZN245	Umvoti	496
EC132	Tsolwana	433		EC442	Umzimvubu	499
NW382	Tswaing	365		EC122	Mnquma	504
KZN434	Ubuhlebezwe	417		KZN435	Umzimkhulu	505
KZN266	Ulundi	592		LIM343	Thulamela	509
KZN212	Umdoni	117		EC137	Engcobo	510
KZN271	Umhlabayalingana	660		EC121	Mbhashe	521
KZN282	uMhlathuze	125		KZN244	Msinga	527
MP323	Umjindi	200		EC153	Ngquza Hill	529
KZN284	uMalazi	423		KZN265	Nongoma	535
KZN222	uMngeni	236		KZN272	Jozini	540
KZN221	uMshwathi	353		NW397	Kagisano/Molopo	545
KZN234	Umtshezi	194		EC441	Matatiele	556
KZN214	UMuziwabantu	352		KZN286	Nkandla	567
KZN245	Umvoti	496		KZN233	Indaka	579
KZN435	Umzimkhulu	505		KZN242	Nqutu	583
EC442	Umzimvubu	499		EC443	Mbizana	585
KZN213	Umzumbe	490		KZN266	Ulundi	592
KZN262	UPhongolo	465		NC451	Joe Morolong	607
KZN211	Vulamehlo	482		KZN271	Umhlabayalingana	660

8.5.10 ATLAS MAPS – GEOGRAPHICAL INDICATORS

The following maps have been produced for the accompanying Atlas to display the geographical information for each of the 119 priority local municipalities as described above:

- Rank 1 – town density relative score
- Rank 2 – road density relative score
- Rank 3 – road intersections relative score
- Rank 4 – distance from town relative score
- Rank 5 – fragmentation index
- Rank 6 – total communities within each LM
- Combined geographical score as described above

The priority local municipalities were ranked from best (position 1) to worst (position 119) for each rank/indicator as well as for the final combined ranking, meaning that a lower number means more favourable geographic circumstances, lesser distances between communities and towns, more towns per LM, etc.

8.6 FINAL COMPOSITE SCORE

One of the main findings of this project is 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 usually related to adequate installation, operation and maintenance (O&M) of water supply systems, which in turn depend on a variety of subsidiary factors. These subsidiary factors are likely to include the financial competence or ability of the relevant Water Services Provider (WSP) municipality – since the logistics and procurement necessary for O&M requires a reasonable level of financial organisation and continuity. Past “green drop” and “blue drop” WSP performance is also likely to be relevant, as is the degree of improvement in providing RDP standard water supplies shown by comparing the 2001 and 2011 census datasets. 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 as “tribal or traditional”, it is possible to compile an index showing the relative task that lies ahead of each priority local municipality (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 which may require the most additional support.

8.7 METHODOLOGY AND ATLAS MAPS

The composite scores for the four main groups of factors (demographic, geographic, financial and backlog) were derived as described in the relevant sections above. Score for each group ranged from 1 (“best” or most favourable) to 119 (“worst” or most challenging). The scores were then summed, and a new composite ranking from 1 to 119 was obtained from the result. Maps were produced for the Atlas showing the following:

- Composite rank or score (1 to 119) for water supply backlogs
- Composite rank or score (1 to 119) for demographic indicators
- Composite rank or score (1 to 119) for financial indicators
- Composite rank or score (1 to 119) for geographic indicators
- Final combined rank or score (1 to 119) for the four main groups together

8.8 PRELIMINARY RESULTS

The preliminary combined results are shown in Table 8-6 and Table 8-7 below:

TABLE 8-6 RESULTS SORTED BY ALPHABETICAL ORDER OF LM NAME

Code	Name	Geographic	Financial	Demographic	Backlog	SUM	COMP RANK
KZN263	Abaqulusi	57	9	44	51	161	34
LIM352	Aganang	70	87	108	33	298	79
EC124	Amahlathi	60	45	49	69	223	55
LIM334	Ba-Phalaborwa	40	23	47	17	127	22
LIM351	Blouberg	89	88	98	81	356	95
MP325	Bushbuckridge	75	50	113	103	341	92
KZN254	Dannhauser	31	70	61	27	189	44
NW384	Ditsobotla	50	83	29	46	208	49
KZN261	eDumbe	67	9	43	49	168	37
LIM472	Elias Motsoaledi	69	119	86	95	369	102
EC141	Elundini	93	49	84	110	336	90
KZN253	Emadlangeni	27	52	19	91	189	43
EC136	Emalahleni	68	103	85	44	300	80
KZN232	Emnambithi/Ladysmith	52	41	38	53	184	41
KZN241	Endumeni	11	18	9	21	59	1
EC137	Engcobo	105	112	105	97	419	113
LIM471	Ephraim Mogale	41	119	66	30	256	65
KZN215	Ezingoleni	21	47	59	58	185	42
LIM474	Fetakgomo	34	119	79	52	284	75
NC453	Gamagara	26	81	1	1	109	15
EC144	Gariep	45	36	10	8	99	11
NC452	Ga-Segonyana	23	38	34	29	124	20
EC123	Great Kei	36	45	26	56	163	35
LIM331	Greater Giyani	64	34	110	94	302	81
KZN433	Greater Kokstad	81	29	12	23	145	31
LIM332	Greater Letaba	44	34	99	64	241	61
NW394	Greater Taung	88	97	107	65	357	96
LIM475	Greater Tubatse	77	119	83	88	367	100
LIM333	Greater Tzaneen	38	34	73	100	245	64
KZN216	Hibiscus Coast	20	22	40	43	125	21
KZN274	Hlabisa	78	117	64	116	375	105
KZN236	Imbabazane	61	78	78	89	306	82
KZN224	Impendle	53	58	62	45	218	53
KZN233	Indaka	114	78	96	82	370	103
KZN431	Ingwe	48	54	67	105	274	73
EC133	Inkwanca	5	94	20	5	124	19

EC135	Intsika Yethu	94	112	103	98	407	110
EC131	Inxuba Yethemba	28	94	4	6	132	24
NC451	Joe Morolong	118	101	68	55	342	93
KZN272	Jozini	110	117	90	101	418	112
NW397	Kagisano/Molopo	111	97	54	62	324	84
EC157	King Sabata Dalindyebo	82	72	70	109	333	87
FS162	Kopanong	39	115	14	14	182	40
KZN432	Kwa Sani	33	40	2	38	113	16
KZN292	KwaDukuza	3	13	22	32	70	5
NW396	Lekwa-Teemane	7	76	16	3	102	12
LIM355	Lepele-Nkumpi	79	90	89	79	337	91
FS161	Letsemeng	46	67	3	22	138	27
EC134	Lukanji	71	69	36	26	202	48
NW383	Mafikeng	18	61	55	75	209	50
LIM344	Makhado	86	96	87	92	361	99
LIM473	Makhuduthamaga	54	119	119	93	385	106
EC143	Maletswai	10	36	7	16	69	4
NW393	Mamusa	19	76	21	18	134	25
KZN291	Mandeni	14	27	45	57	143	30
KZN294	Maphumulo	49	27	94	96	266	70
LIM335	Maruleng	42	34	60	61	197	46
EC441	Matatiele	112	79	100	37	328	85
EC121	Mbhashe	106	60	112	111	389	107
EC443	Mbizana	116	99	114	119	448	118
MP322	Mbombela	15	2	48	78	143	29
KZN281	Mfolozi	47	16	57	36	156	32
EC156	Mhlontlo	83	114	111	106	414	111
KZN226	Mkhambathini	55	43	25	74	197	47
EC122	Mnquma	102	60	92	115	369	101
FS163	Mohokare	30	85	18	7	140	28
LIM353	Molemole	8	92	72	70	242	62
KZN223	Mpofana	37	43	5	35	120	17
KZN244	Msinga	107	25	118	108	358	97
KZN285	Mthonjaneni	62	7	30	60	159	33
KZN275	Mtubatuba	51	108	63	39	261	69
LIM341	Musina	29	74	15	4	122	18
LIM342	Mutale	92	96	88	59	335	88
FS164	Naledi-FS	1	76	8	12	97	9
NW392	Naledi-NW	35	110	17	2	164	36
KZN293	Ndwedwe	43	27	82	73	225	56
KZN252	Newcastle	22	4	42	24	92	7
EC126	Ngqushwa	72	60	75	54	261	68
EC153	Ngquza Hill	108	114	116	117	455	119
KZN286	Nkandla	113	16	80	71	280	74
MP324	Nkomazi	25	105	77	80	287	76
EC127	Nkonkobe	74	45	58	41	218	54
KZN265	Nongoma	109	20	97	104	330	86
KZN242	Nqutu	115	25	91	63	294	77
EC444	Ntabankulu	90	99	109	102	400	109
KZN283	Ntambanana	63	16	69	68	216	52
EC128	Nxuba	9	45	24	20	98	10
EC155	Nyandeni	95	114	117	113	439	117
KZN235	Okhahlamba	98	78	74	86	336	89
LIM354	Polokwane	32	14	50	40	136	26
EC154	Port St Johns	87	114	115	112	428	116
NW385	Ramotshere Moiloa	85	83	51	50	269	72
NW381	Ratlou	84	106	93	67	350	94
KZN227	Richmond	56	58	28	31	173	38
EC138	Sakhisizwe	12	94	41	28	175	39
EC142	Senqu	66	49	71	72	258	66
MP321	Thaba Chweu	17	65	13	9	104	13
KZN273	The Big 5 False Bay	96	108	31	25	260	67
KZN225	The Msunduzi	6	11	35	42	94	8
LIM343	Thulamela	104	96	95	99	394	108
EC132	Tsolwana	80	94	37	15	226	57
NW382	Tswaing	65	83	33	48	229	58
KZN434	Ubuhlebezwe	73	54	53	87	267	71
KZN266	Ulundi	117	20	76	84	297	78

KZN212	Umdoni	2	22	23	13	60	2
KZN271	Umhlabuyalingana	119	117	101	90	427	115
KZN282	uMhlathuze	4	5	46	11	66	3
MP323	Umjindi	16	63	11	19	109	14
KZN284	uMlalazi	76	16	65	76	233	59
KZN222	uMngeni	24	31	6	10	71	6
KZN221	uMshwathi	59	58	32	47	196	45
KZN234	Umtshezi	13	56	27	34	130	23
KZN214	UMuziwabantu	58	32	56	66	212	51
KZN245	Umvoti	100	18	39	85	242	63
KZN435	Umzimkhulu	103	54	104	114	375	104
EC442	Umzimvubu	101	99	102	118	420	114
KZN213	Umzombe	99	47	106	107	359	98
KZN262	UPhongolo	91	20	52	77	240	60
KZN211	Vulamehlo	97	47	81	83	308	83

Geographic = combined ranking for geographic indicators

Financial = combined ranking for financial indicators

Demographic = combined ranking for demographic indicators

Backlog = combined ranking for water supply backlog indicators

COMBINED = four ranking types combined to provide final overall relative ranking

TABLE 8-7 RESULTS IN ORDER OF COMBINED RANK, MOST CHALLENGED TO MOST FAVOURABLE

Code	Name	Geographic	Financial	Demographic	Backlog	SUM	COMP RANK
EC153	Ngquza Hill	108	114	116	117	455	119
EC443	Mbizana	116	99	114	119	448	118
EC155	Nyandeni	95	114	117	113	439	117
EC154	Port St Johns	87	114	115	112	428	116
KZN271	Umhlabuyalingana	119	117	101	90	427	115
EC442	Umzimvubu	101	99	102	118	420	114
EC137	Engcobo	105	112	105	97	419	113
KZN272	Jozini	110	117	90	101	418	112
EC156	Mhlontlo	83	114	111	106	414	111
EC135	Intsika Yethu	94	112	103	98	407	110
EC444	Ntabankulu	90	99	109	102	400	109
LIM343	Thulamela	104	96	95	99	394	108
EC121	Mbhashe	106	60	112	111	389	107
LIM473	Makhuduthamaga	54	119	119	93	385	106
KZN274	Hlabisa	78	117	64	116	375	105
KZN435	Umzimkhulu	103	54	104	114	375	104
KZN233	Indaka	114	78	96	82	370	103
LIM472	Elias Motsoaledi	69	119	86	95	369	102
EC122	Mnquma	102	60	92	115	369	101
LIM475	Greater Tubatse	77	119	83	88	367	100
LIM344	Makhado	86	96	87	92	361	99
KZN213	Umzumbe	99	47	106	107	359	98
KZN244	Msinga	107	25	118	108	358	97
NW394	Greater Taung	88	97	107	65	357	96
LIM351	Blouberg	89	88	98	81	356	95
NW381	Ratlou	84	106	93	67	350	94
NC451	Joe Morolong	118	101	68	55	342	93
MP325	Bushbuckridge	75	50	113	103	341	92
LIM355	Lepele-Nkumpi	79	90	89	79	337	91
EC141	Elundini	93	49	84	110	336	90
KZN235	Okhahlamba	98	78	74	86	336	89
LIM342	Mutale	92	96	88	59	335	88
EC157	King Sabata Dalindyebo	82	72	70	109	333	87
KZN265	Nongoma	109	20	97	104	330	86
EC441	Matatiele	112	79	100	37	328	85
NW397	Kagisano/Molopo	111	97	54	62	324	84
KZN211	Vulamehlo	97	47	81	83	308	83
KZN236	Imbabazane	61	78	78	89	306	82
LIM331	Greater Giyani	64	34	110	94	302	81
EC136	Emalahleni	68	103	85	44	300	80
LIM352	Aganang	70	87	108	33	298	79
KZN266	Ulundi	117	20	76	84	297	78
KZN242	Nqutu	115	25	91	63	294	77
MP324	Nkomazi	25	105	77	80	287	76
LIM474	Fetakgomo	34	119	79	52	284	75
KZN286	Nkandla	113	16	80	71	280	74
KZN431	Ingwe	48	54	67	105	274	73
NW385	Ramotshere Moiloa	85	83	51	50	269	72
KZN434	Ubuhlebezwe	73	54	53	87	267	71
KZN294	Maphumulo	49	27	94	96	266	70
KZN275	Mtubatuba	51	108	63	39	261	69
EC126	Ngqushwa	72	60	75	54	261	68
KZN273	The Big 5 False Bay	96	108	31	25	260	67
EC142	Senqu	66	49	71	72	258	66
LIM471	Ephraim Mogale	41	119	66	30	256	65
LIM333	Greater Tzaneen	38	34	73	100	245	64
KZN245	Umvoti	100	18	39	85	242	63
LIM353	Molemole	8	92	72	70	242	62
LIM332	Greater Letaba	44	34	99	64	241	61
KZN262	UPhongolo	91	20	52	77	240	60
KZN284	uMlalazi	76	16	65	76	233	59
NW382	Tswaing	65	83	33	48	229	58
EC132	Tsolwana	80	94	37	15	226	57
KZN293	Ndwedwe	43	27	82	73	225	56

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

EC124	Amahlathi	60	45	49	69	223	55
EC127	Nkonkobe	74	45	58	41	218	54
KZN224	Impendle	53	58	62	45	218	53
KZN283	Ntambanana	63	16	69	68	216	52
KZN214	UMuziwabantu	58	32	56	66	212	51
NW383	Mafikeng	18	61	55	75	209	50
NW384	Ditsobotla	50	83	29	46	208	49
EC134	Lukanji	71	69	36	26	202	48
KZN226	Mkhambathini	55	43	25	74	197	47
LIM335	Maruleng	42	34	60	61	197	46
KZN221	uMshwathi	59	58	32	47	196	45
KZN254	Dannhauser	31	70	61	27	189	44
KZN253	Emadlangeni	27	52	19	91	189	43
KZN215	Ezingoleni	21	47	59	58	185	42
KZN232	Emnambithi/Ladysmith	52	41	38	53	184	41
FS162	Kopanong	39	115	14	14	182	40
EC138	Sakhisizwe	12	94	41	28	175	39
KZN227	Richmond	56	58	28	31	173	38
KZN261	eDumbe	67	9	43	49	168	37
NW392	Naledi-NW	35	110	17	2	164	36
EC123	Great Kei	36	45	26	56	163	35
KZN263	Abaqulusi	57	9	44	51	161	34
KZN285	Mthonjaneni	62	7	30	60	159	33
KZN281	Mfolozi	47	16	57	36	156	32
KZN433	Greater Kokstad	81	29	12	23	145	31
KZN291	Mandeni	14	27	45	57	143	30
MP322	Mbombela	15	2	48	78	143	29
FS163	Mohokare	30	85	18	7	140	28
FS161	Letsemeng	46	67	3	22	138	27
LIM354	Polokwane	32	14	50	40	136	26
NW393	Mamusa	19	76	21	18	134	25
EC131	Inxuba Yethemba	28	94	4	6	132	24
KZN234	Umtshezi	13	56	27	34	130	23
LIM334	Ba-Phalaborwa	40	23	47	17	127	22
KZN216	Hibiscus Coast	20	22	40	43	125	21
NC452	Ga-Segonyana	23	38	34	29	124	20
EC133	Inkwanca	5	94	20	5	124	19
LIM341	Musina	29	74	15	4	122	18
KZN223	Mpofana	37	43	5	35	120	17
KZN432	Kwa Sani	33	40	2	38	113	16
NC453	Gamagara	26	81	1	1	109	15
MP323	Umjindi	16	63	11	19	109	14
MP321	Thaba Chweu	17	65	13	9	104	13
NW396	Lekwa-Teemane	7	76	16	3	102	12
EC144	Gariep	45	36	10	8	99	11
EC128	Nxuba	9	45	24	20	98	10
FS164	Naledi-FS	1	76	8	12	97	9
KZN225	The Msunduzi	6	11	35	42	94	8
KZN252	Newcastle	22	4	42	24	92	7
KZN222	uMngeni	24	31	6	10	71	6
KZN292	KwaDukuza	3	13	22	32	70	5
EC143	Maletswai	10	36	7	16	69	4
KZN282	uMhlathuze	4	5	46	11	66	3
KZN212	Umdoni	2	22	23	13	60	2
KZN241	Endumeni	11	18	9	21	59	1

Geographic = combined ranking for geographic indicators

Financial = combined ranking for financial indicators

Demographic = combined ranking for demographic indicators

Backlog = combined ranking for water supply backlog indicators

COMBINED = four ranking types combined to provide final overall relative ranking

8.9 SOURCES OF ERROR

Sources of error are likely to include:

- Lack of resolution in the existing data – for example, a local municipality with very good figures for expenditure on maintenance may be spending very little of that total on water infrastructure. Performance over time in various indicators is also probably important, but the data is in some cases just a recent snapshot – for example, the last two audit outcomes only have been assessed, rather than the available recent history of audit performance.
- The lack of data on important indicators, such as availability / autonomy of skilled staff, willingness of communities to pay for services, expectations of community members and related cooperation with the WSA, etc. Some of these absent data sets can be guessed (but are difficult or impossible to obtain), whilst some cannot. As former US Defence Secretary Donald Rumsfeld once put it (quoting Clem Sunter): *“There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know.”* In the South African municipal water supply world there are probably many important “known unknowns” to be assessed, as well as “unknown unknowns” to be discovered.
- Severe non-linearity in the data – for example, the absolute distance from a “town” to a water supply facility in need of service is unlikely to imply a corresponding linear increase in cost – certain distances may necessitate special trips, overnight trips and so on, or even the establishment of satellite O&M facilities. It is possible that empirical work on the total dataset of South African municipalities, or even including other similar middle income countries, would allow reasonable weighting factors to be derived.
- The part played by sheer chance or happenstance can't be ignored – as Ecclesiastes 9:11 tells us *“I returned, and saw under the sun, that the race is not to the swift, nor the battle to the strong, neither yet bread to the wise, nor yet riches to men of understanding, nor yet favour to men of skill; but time and chance happeneth to them all.”* For example, a single breakdown, or unlucky combination of breakdowns, might have a disproportionately large negative effect on water supply in a particular LM – and vice versa – due to the characteristics of the particular systems used.

8.10 RESPONSE TO ERRORS

The authors have tried to overcome some of the errors inherent in the data and in the methodologies by applying the same algorithms consistently across all 119 backlog local municipalities, and by providing relative ranks (1 to 119) rather than absolute figures where appropriate. All indicators were considered to have an equal bearing on the final capacity to provide, install, operate and maintain

water supplies to an acceptable standard – in other words, no weightings for each rank were applied. This assumption of linearity is very unlikely to be correct, but has been made until better analysis can be done. Whilst many errors will be found with the method described above, it does at least introduce a variety of factors into the debate about domestic water supply sustainability from groundwater sources, which in the past has tended to focus mainly on “physical” or hydrogeological factors only.

The map shown below in Figure 8-9 below shows the four groups of factors combined into a single “score” for each of the priority LMs. The “most challenged” LMs are shown in Table 8-6 and Table 8-7 above. By comparing Figure 8-9 with Figure 8-11 and Figure 8-12 it can be seen that the biggest water supply backlogs often coincide with the greatest potential for groundwater development from a purely hydrogeological point of view. No causal relationship is inferred, just that this does support the argument that primary groundwater availability is only a minor factor in domestic household water security.

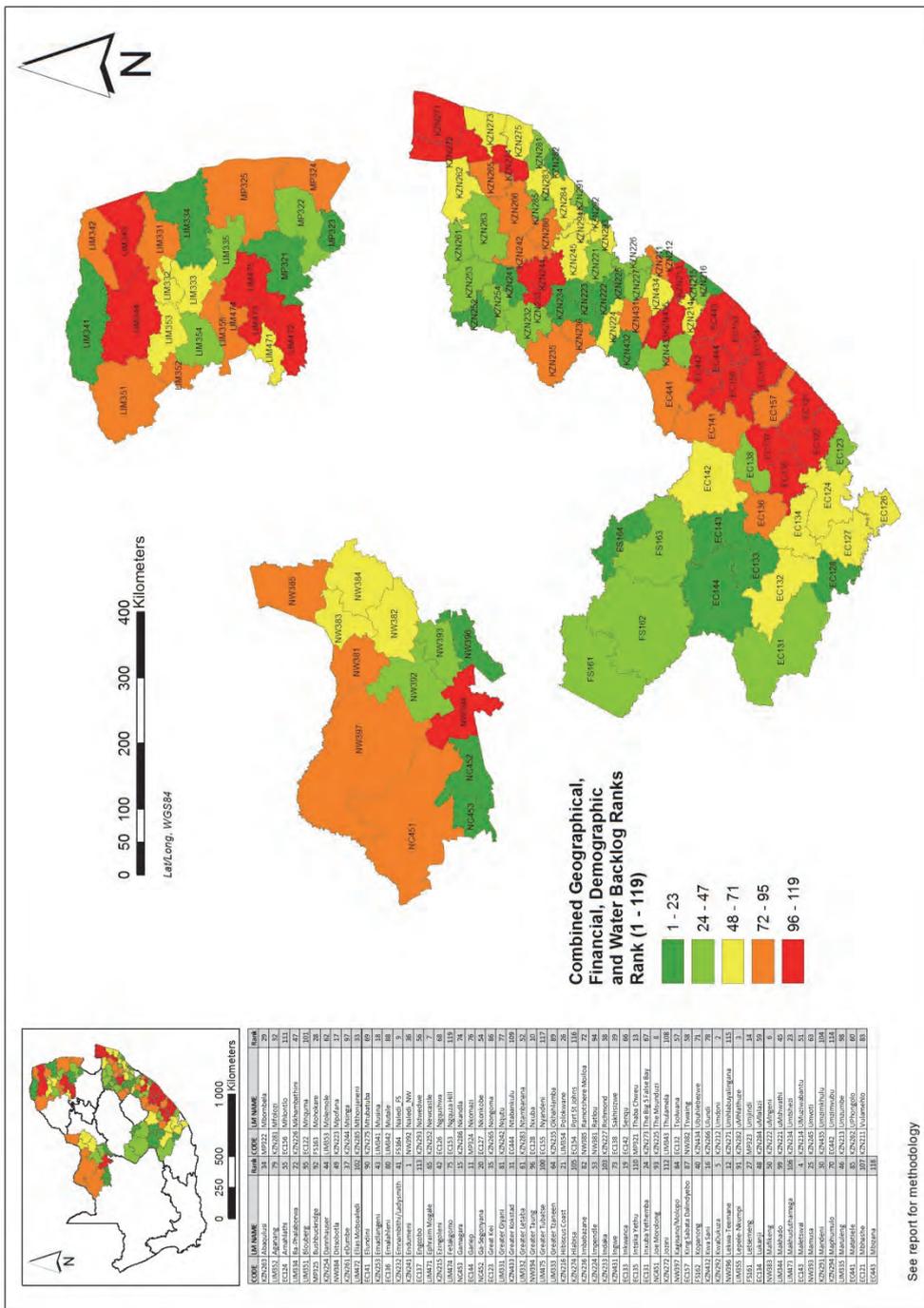


FIGURE 8-9 COMBINED RANKINGS FOR ALL 119 PRIORITY LMS

See report for methodology

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

8.11 GROUNDWATER SUSTAINABILITY – A LAST LOOK AT GRA2

Some might still argue that absolute availability of the physical resource of groundwater is still a determining factor. The GRA2 project (see above) estimated the utilisable groundwater exploitation potential for a wet year (UGEP WET) and the utilisable groundwater exploitation potential for a dry or drought year (UGEP DRY) for each of the 1948 quaternary hydrological catchments in South Africa. The UGEP takes into account groundwater levels, aquifer thickness, baseflow, known abstractions, groundwater quality, and other factors and can therefore be regarded as our best guess as to the remaining groundwater potential for any given quaternary catchment in South Africa. Since the GRA2 data is provided per quaternary catchment, and the “unit of analysis” of this project is the local municipality (LM), the following methodology using ArcGIS 10 software was used:

8.11.1 GIS DATASETS USED:

1. 119 Selected Local Municipal (LM) areas, being a shapefile of the 119 selected LMs in the study area making up the 24 “Priority DMs).
2. The selected quaternary catchment boundaries that intersect (or cross border) with the 119 LMs.
3. GRA2 All Phases data for each intersecting quaternary catchment. The relevant UGEP DRY and UGEP WET values were taken from this spreadsheet.

8.11.2 GIS PROCESS:

1. The area of the 119 LMs in hectares was calculated, using the correct projection, to get an accurate total area for each LM.
2. The area of the relevant quaternary catchments in hectares was calculated, using the correct projection to get an accurate total area of each quaternary catchment.
3. The quaternary catchment boundaries and the LM boundaries were intersected. Intersecting two datasets into each other allows one to summarise the result either by an LM value or a quaternary catchment value or a proportion value of both.

Figure 8-10 below shows the LM boundaries as dark black outlines, with the thinner quaternary catchment (“quat”) boundaries within and along the borders of the LM boundaries (part of NW Province is used as an example). The result of the intersect process provides a “many-to-one” result of quaternary catchments to LMs boundaries; the LM boundaries being larger than the quaternary catchment boundaries.

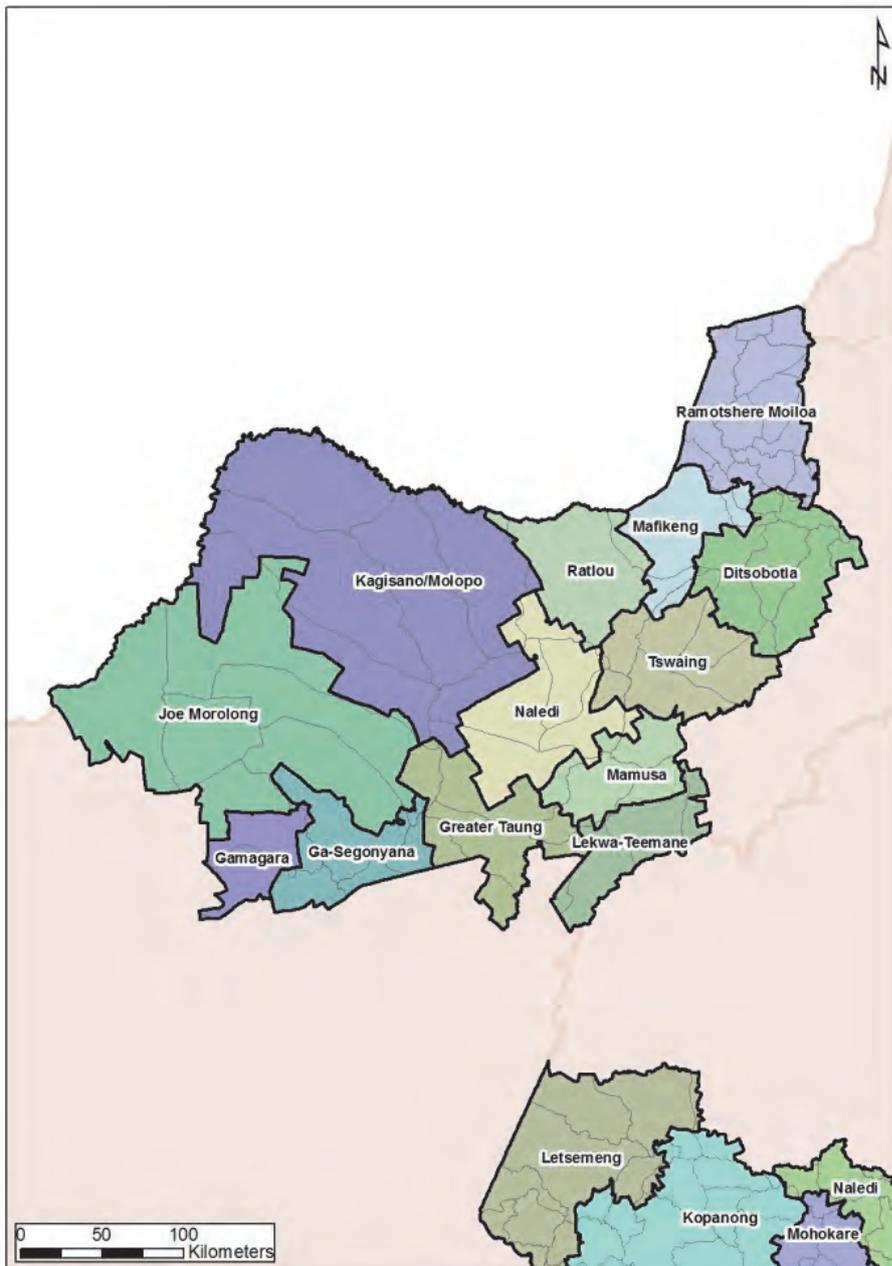


FIGURE 8-10 LM AND QUAT INTERSECTS FOR PART OF NW PROVINCE

4. Calculate each quaternary catchment segment area value in hectares. This value will be used to calculate the proportional UGEP scores per hectare.
5. Calculate the proportional UGEPDRY and UGEPWET values as:
 - a. The UGEPDRY and UGEPWET segment areas as a proportion of the total quaternary catchment area. This is required because of the quaternary catchment to LM in intersect process, where resulting in small portions of quaternary catchments making up the larger LM area.

- b. The UGEPDRY and UGPWET proportional area values (from A) as a proportion of the total LM area. This result normalises the UGEPDRY and UGEPWET value for each LM, since the LMs have different areas.
6. Summarise the (many-to-one) UGEPDRY and UGEPWET values for each quaternary for each LM. This final process provides a total proportional and normalised UGEPDRY and UGEPWET value for each LM.

8.11.3 GIS RESULT:

The GIS processes provide the following result: a proportional (catchment segment area / total catchment area in hectares) and normalised (proportional catchment result / total LM area in hectares) UGEPDRY and UGEPWET value for each LM. The example of Gamagara Local Municipality is shown in Table 8-7 below:

TABLE 8-8 GAMAGARA LM RESULT

Gamagara	UGEPDRY	UGEPWET
D41J	8.1	12.4
D41K	8.4	12.8
D41L	1.7	2.1
D73C	0.1	0.1
Total	18.2	27.4

The table on the next page (Table 8-9) shows the process required to get to the values in Table 8-8 (above).

TABLE 8-9 GAMAGARA LM WORKED RESULT WITH EQUATIONS

GIS data	GIS process	GIS data	GIS process	GRA 11 data	GRA 11 data	GRA 11 data	GRA 11 data	GIS process	Excel / GIS summary process	Excel / GIS summary process	Excel / GIS summary process		
A	B	C	D	E	F	G	H	I	J	K	L	M	N
		LM Area (ha.)	Quat Area (ha.)		UGEPWET	UGEPDRY	UGEPWETLS	UGEPDRYLS	Quat. segment area (ha.)	Proportional quat. area x UGEPDRY	Proportional quat. area x UGEPWET	(Proportional quat. area x UGEPDRY) / LM area	(Proportional quat. area x UGEPWET) / LM area
1	Name	26295											
2	Gama gara	3.8	D41J	38878	109035	708123	0.09	0.06	11650	2121892.3	3267236.5	8.1	12.4
3	Gama gara	26295	D41	42298	101600	667959	0.08	0.05	14031	2215812.8	3370365.3	8.4	12.8
4	Gama gara	26295	K	53909	569133	467078	0.34	0.28	5114.7	443141.5	539966.5	1.7	2.1
5	Gama gara	26295	D73	62505	114801	883005	0.06	0.05	1022.5	14444.5	18779.5	0.1	0.1
Equation										$J4/E4*G4$	$J4/E4*F4$	$K4/C4$	$L4/C4$

Where values for:

- Columns B and D are from the GIS LM and quaternary catchment datasets
- Columns F, G, H and I are from the “GRA2 All Phase” dataset
- Columns C, E and J are from GIS area calculations
- Columns K,L, M and N are the summary calculation results either done in MS Excel or GIS

The figures below (Figure 8-11 and Figure 8-12) show the GRA2 results for UGEP DRY and UGEP WET for each priority LM. The numbers on the map legends refer to cubic metres of groundwater per year, per hectare, averaged over each priority LM.

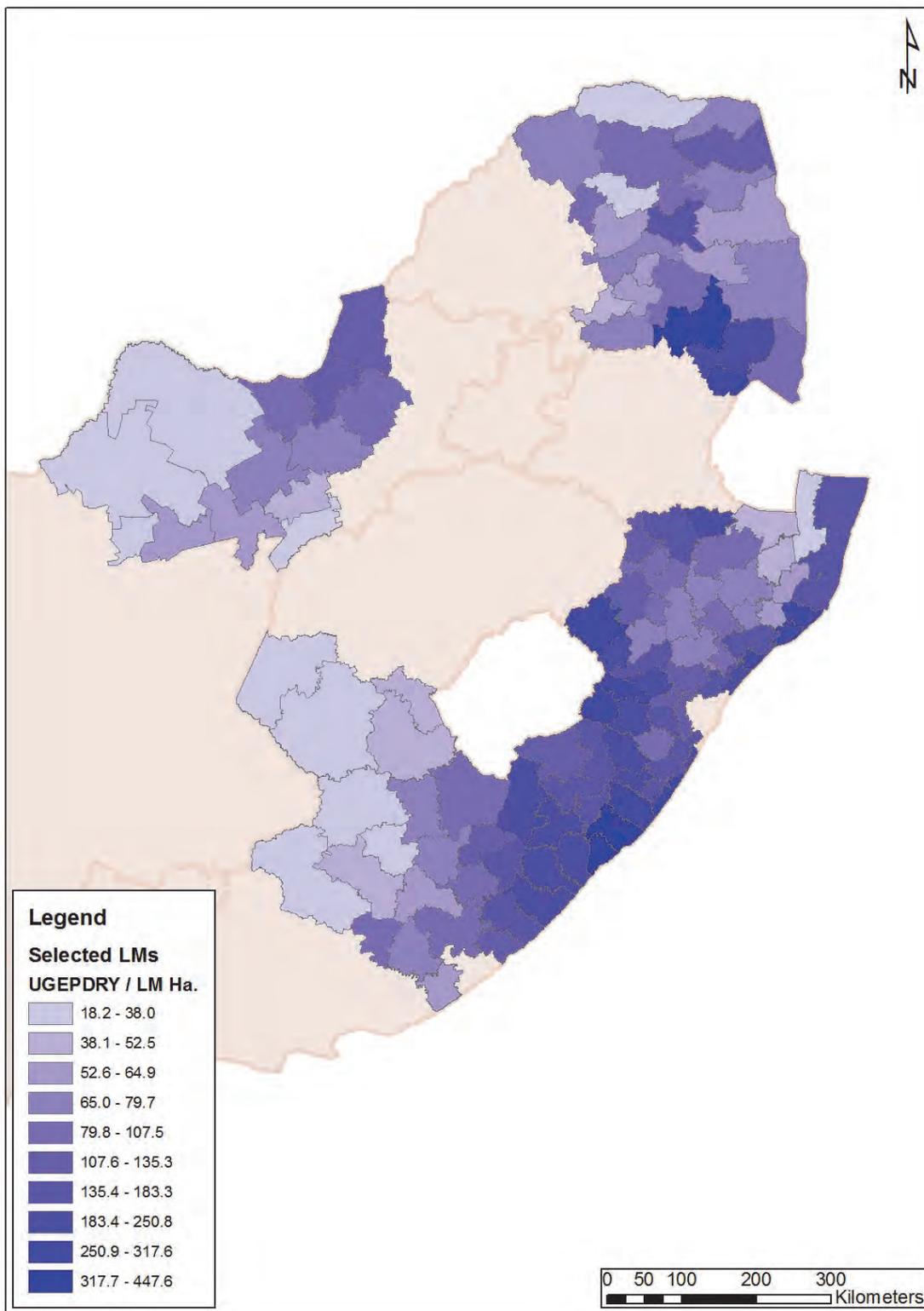


FIGURE 8-11 GROUNDWATER AVAILABILITY PER LM IN A DRY YEAR

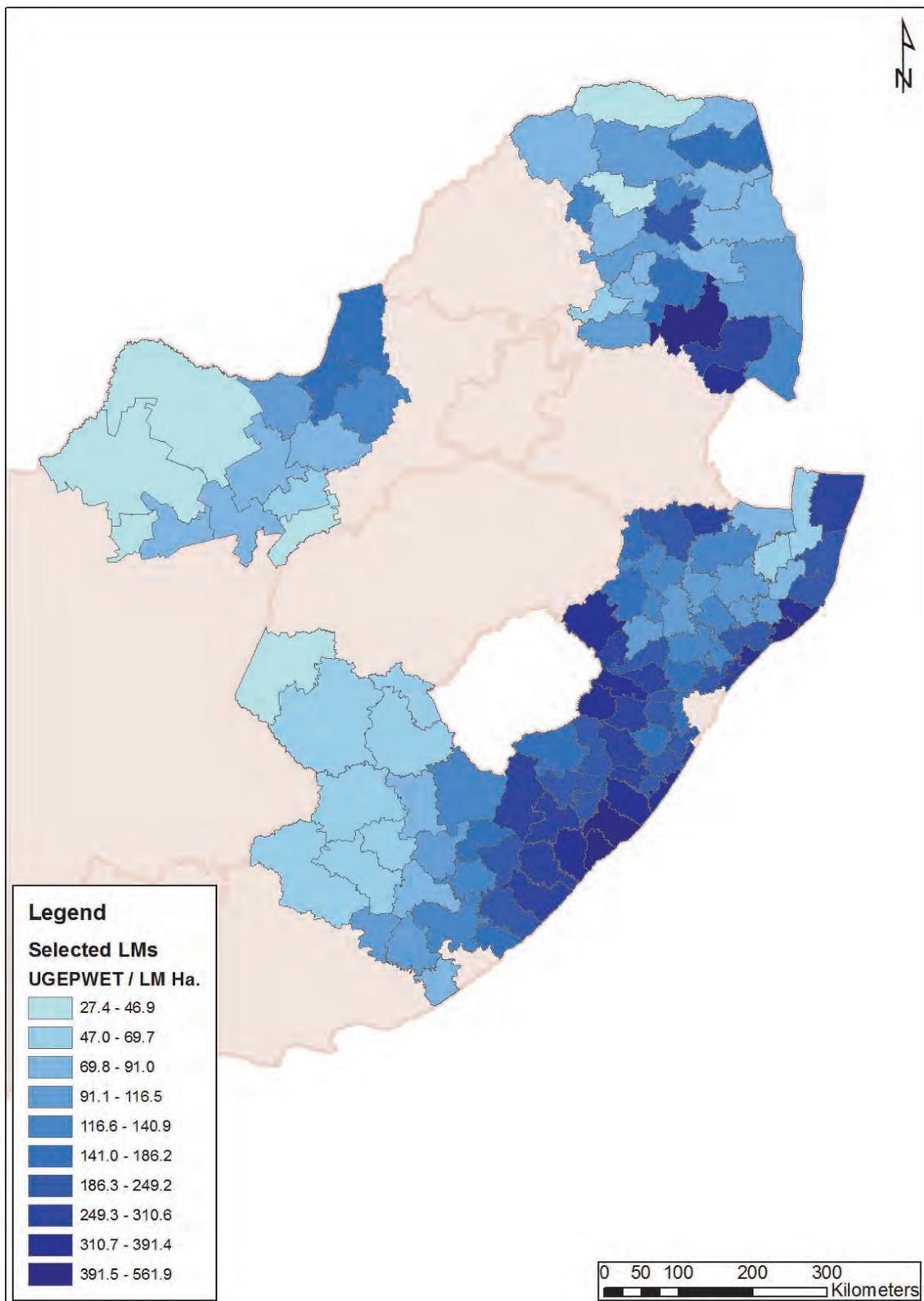


FIGURE 8-12 GROUNDWATER AVAILABILITY PER LM IN A WET YEAR

8.11.4 GRA2 CONCLUSION

The figures and methodology above strongly suggest that groundwater availability at LM scale is not a major factor behind lack of access to an improved water supply at local municipal level, for most local municipalities. The data shows that the wetter eastern parts of the country have more groundwater available per hectare than the drier north-western parts – as expected. Neither map correlates well with the maps showing the biggest water supply backlogs. Some of the most deprived local municipalities in terms of domestic water supplies have the highest groundwater exploitation potentials from a “physical” or hydrogeological point of view.

The maps and figures provided do NOT provide information that is detailed enough to use at local or village scale – specialist hydrogeological advice is recommended for the establishment of groundwater sources for domestic water supply.

9 CONCLUSIONS

9.1 INTRODUCTION

Hydrogeologists working in Africa have produced a wide variety of guides, maps, reports, toolkits, building-blocks, text-books, computer programs, user-manuals and other outputs all aimed at assisting managers, decision-makers and other non-hydrogeologists in establishing, operating and managing groundwater supplies. Hydrogeologists may even be unique amongst professionals for the effort and attention paid to producing and promoting simplified material to enable non-hydrogeologists to plan and implement groundwater schemes. A growing body of work is now acknowledging that sustainability, operation and maintenance, vulnerability to pollution, protection zoning, and other issues may require a more professional approach in those parts of the sub-continent that can afford them (including South Africa). The cost of failing groundwater systems is very high, not only in terms of replacing or repairing the sources themselves but also in terms of the externalised costs (e.g. poor health outcomes) and opportunity costs (e.g. time spent fetching water could be better spent) as well as the reputation of the resource amongst municipal planners and others (Whinnery, 2012). Specialist hydrogeological advice should be required for all domestic groundwater supply schemes at municipal level in South Africa – this saves costs and avoids problems in the long run.

9.2 TECHNICAL AND MANAGEMENT ASPECTS OF GROUNDWATER

Groundwater is often well suited to the relatively small quantities of water required in many rural parts of South Africa for domestic supply – when properly managed. The high failure rate of groundwater schemes is one factor behind what seems to be an increasing disinclination to use groundwater by WSAs in South Africa. Routine operation and maintenance demands for numerous small groundwater schemes may be more onerous (even if cheaper) compared with a surface water alternative. However, shortages of funds, unavailability of surface water and the technical difficulties in supplying “last 5%” scattered rural communities with centralised surface water schemes probably means that much greater use of groundwater is inevitable in backlog rural areas in South Africa. In this context the following recommendations are proposed:

1. Groundwater schemes must be planned and installed with advice from a qualified hydrogeologist. There is no way to get around this. Existing tools (e.g. NORAD, GMS, GRA1 and GRA2, etc.) are very useful in the feasibility study and these can in theory be used by the non-specialist (e.g. a local municipal 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, which takes into account land ownership, access, pollution sources, protection zone requirements and other factors as well as the basic groundwater conditions.

2. A plan for the on-going operation and maintenance of an installed groundwater scheme must be developed, and it must be financially and logistically sustainable. The O&M plan also benefits from professional groundwater advice, since the choice of technology can be matched not only to the existing resource but also to 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.

9.3 INFRASTRUCTURE FUNDING AND INVESTMENT

This report has outlined the extent of government's commitment to eradicating water services backlogs and subsidising the cost of basic provision to poor households. It has traced the extent of the growth in grants and transfers from national to local government to support municipal water services improvements and described the main grants and funding vehicles.

Evidently the development and management of groundwater infrastructure for water services is not constrained by a shortage of public funds. On the contrary, the quantum 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 it effectively. There is even evidence to suggest that the scale of 'free money' available to local authorities to develop water services may provide incentives to consider *alternatives* to groundwater; the pressure from DeCoG and Treasury to show utilisation of large annual grants may promote investment in more ambitious and complex projects than would be considered if funds depended on loans and local revenue for repayment; and because larger schemes may bundle more works together and reduce the administrative burden of procurement, as opposed to a number of small local developments each with their own procurement, design and project management demands.

The abundance of grant funding and transfers for capital developments and operational management remove the incentive for quantifying and weighing the costs of life-cycle management, and tend to drive an emphasis on building new infrastructure. For a range of reasons explored elsewhere in this study, this ties in closely with an assumption that surface water can and should be provided wherever technically feasible. Utilisation of capital funds confirms this.

A notable new development is MWIG. It is a highly conditional grant, with stringent oversight by DWA, that funds investment in water infrastructure for interim and intermediate water supply, with the aim of eradicating service backlogs by 2016. By formulating the investment as interim and intermediate – not final and 'forever' – DWA is trying to nudge municipalities towards accepting more pragmatic service approaches than they might otherwise. The result has been greater investment in developing and

rehabilitating groundwater-based systems, precisely because they enable improvements in the short term, 'until' more extensive developments are feasible.

Groundwater developments are often regarded as a 'poor man's resource', precisely because localised borehole developments or spring protection usually have a far lower capital cost than schemes that rely on the development of large surface water impoundments and conveyance systems with pipe networks and pumping systems. The popular wisdom is that groundwater schemes are simpler and cheaper to operate relative to big surface water developments. However, 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-alone groundwater systems are assessed. This evidence underlines the importance of rigorous assessment of the financial and technical feasibility of all water supply options; it is doubtful that existing infrastructure investment frameworks do this adequately. Perhaps there is scope to explore inputs to inform the review of conditional grants currently being undertaken by Treasury and its partners, with a view to supporting better use of national resources to develop sustainable and cost-effective water supply systems.

9.4 CHRIS HANI DM CASE STUDY

Groundwater is extensively used in Chris Hani District Municipality (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, and other factors. It is likely that only a local hydrogeological investigation can identify all of these factors (including local scale variations in aquifer properties which are not obvious even on the best regional-scale maps). 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 is similar to costs for comparable surface water sources, and that similar reliabilities can be obtained from both sources if timely O&M (including preventive maintenance) is carried out.

9.5 MAHIKENG CASE STUDY

The town of Mahikeng is almost entirely groundwater-dependent (supplies from the Setumo Dam are mainly derived from waste water return flows, originating in the groundwater sources), 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 (approx. Feb. 2014) the boreholes supplying the town from the Grootfontein compartment ran dry due to over-abstraction. (A relatively unusual reason for borehole failure!). At present there is no Water User Association consisting of the major abstractors in the compartment,

nor is there yet a Catchment Management Agency (Figure 1-1) – their tasks are performed by the Department of Water Affairs. Cooperation and even dialogue between the various organisations mandated to manage the domestic water supplies of Mahikeng from source to tap appears to be poor, and at the time of writing 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 a necessity. In Mahikeng some municipal officials (and others) 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 and the large distance to 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.

9.6 FINAL ANALYSIS

This report 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, operation and maintenance is a result of a larger range of inputs and parameters which cross many traditional disciplinary boundaries and are generally complex in the way they interact. One aim of this project is to assist in moving the debate away from the “discourse of shortage” and towards a more realistic appraisal of the problem. Shortages exist (and do cause problems), but it is argued that these shortages are usually a downstream consequence of existing institutional structures and decision-making processes. This has led to a vicious circle developing in which failure of groundwater supplies at municipal level is blamed on a shortage of “technical” or hydrogeological material and information, or a shortage of water more generally, leading to demands for more information and an increased focus on the “technical” or hydrogeological issues at the expense of the “real” or underlying issues which are clustered around operation and maintenance of groundwater sources.

This report argues that O&M – and by extension groundwater source sustainability – is in fact related to a range of demographic, financial, geographical and other factors, and that physical or hydrogeological availability of groundwater in fact has only a relatively minor role to play. This does not mean that there are no areas with genuine shortages of groundwater, just that on average most groundwater supply failures are due to poor O&M and not to an absolute shortage of water. An attempt has been made to depict the various factors related to O&M as a series of maps. It is acknowledged that errors exist in this methodology, and that many factors have most likely been overlooked. Nevertheless, an attempt has been made to break away from the “discourse of shortage”.

The preliminary list of the twenty “most challenged” local municipalities in South Africa in terms of providing sustainable improved water supplies is shown in Table 9-1 below, in alphabetical order (i.e.

not in order of absolute rank). It is predicted that these LMs will require the most support in years to come.

TABLE 9-1 LIST OF MOST CHALLENGED LMS

LM Code	LM Name	Province
LIM472	Elias Motsoaledi	Limpopo
EC137	Engcobo	Eastern Cape
LIM475	Greater Tubatse	Limpopo
KZN274	Hlabisa	Kwa-Zulu Natal
KZN233	Indaka	Kwa-Zulu Natal
EC135	Intsika Yethu	Eastern Cape
KZN272	Jozini	Kwa-Zulu Natal
LIM473	Makhuduthamaga	Limpopo
EC121	Mbhashe	Eastern Cape
EC443	Mbizana	Eastern Cape
EC156	Mhlontlo	Eastern Cape
EC122	Mnquma	Eastern Cape
EC153	Ngquza Hill	Eastern Cape
EC444	Ntabankulu	Eastern Cape
EC155	Nyandeni	Eastern Cape
EC154	Port St Johns	Eastern Cape
LIM343	Thulamela	Limpopo
KZN271	Umhlabuyalingana	Kwa-Zulu Natal
KZN435	Umzimkhulu	Kwa-Zulu Natal
EC442	Umzimvubu	Eastern Cape

Work done using the GRA2 dataset appears to support the contention that absolute (or environmental) shortages of water (including groundwater) is NOT to blame for domestic water supply backlogs in South Africa – and nor is shortage of funds. Operation and Maintenance (O&M) of water supply systems is however critical and the many issues linked to O&M, including chains of responsibility and the linkages between the various interlocking organisations (Figure 1-1), need to be given more attention.

10 REFERENCES

- Baker K and Dennis R 2012 Aquifer Firm Yield Model Manual. Water Research Commission Report No: 1763/1/11. Water Research Commission, Pretoria.
- Baron J, Seward P and Seymour A 1998 The Groundwater Harvest Potential Map of the Republic of South Africa. Technical Report GH 3917. Directorate Geohydrology, Department of Water Affairs, Pretoria.
- Botha F 2005 A Proposed Method to implement a Groundwater Resource Information Project (GRIP) in Rural Communities, South Africa. Unpublished PhD Thesis, University of the Free State, Bloemfontein.
- Botshelo Water 2013. Website of Botshelo Water Board. Accessed August 2013 at <http://botshelowater.co.za/botshelo/home.html>
- Braune E and Xu Y 2006 A South African perspective on the protection of groundwater resources, in: Y. Xu & B. Usher (Eds) Groundwater Pollution in Africa. London: Taylor and Francis.
- Carter RC 2009 Operation and maintenance of rural water supplies. Challenging the Community Based O&M Paradigm. Published as Perspectives No. 2 of the Rural Water Supply Network. St Gallen, Switzerland. Available at: <http://www.rural-water-supply.net/en/resources/details/207>. Downloaded in October 2013.
- Council for Geoscience 2008 North-West Dolomites – Coordination and Integration of Projects. Unpublished report prepared by the Council for Geoscience, Pretoria.
- Department of Co-operative Governance and Traditional Affairs (CoGTA) (2009) Local Government Turnaround Strategy.
- Dippenaar M 2013 Hydrogeological Heritage Overview: Pretoria's Fountains – Arteries of Life. Water Research Commission publication SP44/13, Pretoria.
- DWA (undated) Water Management Institutions Overview. Department of Water Affairs and Forestry, Pretoria.
- DWA 2004a National Water Resource Strategy. First Edition, September 2004. Department of Water Affairs, Pretoria.
- DWA 2004b Toolkit for Water Services. Norwegian Agency for Development Cooperation (NORAD) and Department of Water Affairs (DWA), Pretoria.
- DWA 2008 A Guideline for the Assessment, Planning and Management of Groundwater Resources in South Africa. (Final Draft, March 2008). Department of Water Affairs, Pretoria.

- DWA 2009 National Groundwater Strategy: Review of groundwater management examples in South Africa. National Groundwater Strategy DWA Project No. WP9390 Activity NGS02 Marketing and Communication. Unpublished report. Department of Water Affairs, Pretoria.
- DWA 2010a Groundwater Strategy 2010. Department of Water Affairs, Pretoria.
- DWA 2010b Development of a Reconciliation Strategy for All Towns in the Northern Region. Ngaka Modiri Molema District Municipality and Mafikeng Local Municipality. Prepared by SRK Consulting for the Department of Water Affairs, Pretoria.
- DWA 2011 Water Services Regulatory Comparative Analysis. Booklet published by the Department of Water Affairs, Pretoria.
- DWA 2013a MWIG Briefing to the Standing Committee on Appropriations, 5 March 2013.
- DWA 2013b 'Briefing to the Portfolio Committee on Water and Environment on the comprehensive investment programme for water infrastructure development', 13 March 2013
- DWA 2013c MWIG update to the Portfolio Committee on Water and Sanitation, 15 September 2013.
- DWA 2013d Priority District Municipality Implementation Plans for the 24 Priority DMs. Available at <http://www.dwa.gov.za/downloads/WS/24PriorityDMs/ImplementationPlans2013/> and accessed August 2013
- DWA 2013e National Water Resource Strategy Second Edition. Department of Water Affairs, Pretoria.
- Fukuyama F 1992 The End of History and the Last Man.
- Gibson pers. Comm. Personal Communication with Mr Jim Gibson. Maluti GSM, East London. July 2013.
- GoI 2013 Operation and Maintenance Manual for Rural Water Supplies. Government of India Ministry of Drinking Water and Sanitation. May 2013.
- GWG 2012a Groundwater Governance. Synthesis of Thematic Papers / Case Studies. Working draft for regional consultations, 30 April 2012. Available from the project website at www.groundwatergovernance.org
- GWG 2012b Trends in local groundwater management institutions. Thematic Paper No. 7. Available from the project website at www.groundwatergovernance.org
- GWG 2014 Website of the "Groundwater Governance. A Global Framework for Action" project at <http://www.groundwatergovernance.org/> and accessed March 2014
- Harvey P and Reed B 2004 Rural Water Supply in Africa. Building Blocks for Handpump Sustainability. WEDC, Loughborough University, UK.

- Hassan R Thurlow J Roe T Diao X Chumi S and Tsur Y 2008 Macro-Micro Feedback Links of Water Management in South Africa. CGE Analyses of Selected Policy Regimes. World Bank Policy Research Working Paper 4768. World Bank, Washington DC. Accessed March 2014 at: http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2008/11/04/000158349_20081104093521/Rendered/PDF/WPS4768.pdf
- Holland M and Wiegmans F 2009 Geohydrology Guideline Development: Activity 18&19 Desktop development of a Dolomite hydrogeological compartment map and explanation booklet (Report). Report prepared for the Department of Water Affairs by Water Geosciences Consulting as part of DWA Project Number: 14/14/5/2 Implementation of Dolomite Guideline. Department of Water Affairs, Pretoria.
- Hollingworth B, Koch P, Chimuti S and Malzbender D 2011 An investigation into the water infrastructure development financial allocation pathways in municipalities. WRC Report no TT476/10. Water Research Commission, Pretoria.
- IAH 2003 Groundwater: From Development to Management. Briefing paper prepared for the Third World Water Forum, Kyoto, Japan. International Association of Hydrogeologists. Goring, United Kingdom.
- Ive O 2002 Partnership approaches for public, private and NGO stakeholders for the implementation of community water service supply projects. Paper presented to the Bi-ennial WISA Conference, May 2002
- Konikow LF and Kendy E 2005 Groundwater depletion: A global Problem. Hydrogeology Journal (2005) 13:317-320
- Lawrence AR, MacDonald DMJ, Howard AG, Barrett MH, Pedley S, Ahmed KM and Nalubega M 2001 ARGOSS 2001 Guidelines for Assessing the Risk to Groundwater from On-Site Sanitation. British Geological Survey Commissioned Report CR/01/142. British Geological Survey, Keyworth, UK.
- LEV 2014 Rerum novarum. Papal encyclical given at St. Peter's in Rome, 15th May 1891. Libreria Editrice Vaticana. Official translation from the Latin accessed March 2014 at http://www.vatican.va/holy_father/leo_xiii/encyclicals/documents/hf_l-xiii_enc_15051891_rerum-novarum_en.html
- Llamas MR 1985 Spanish Water Resources Policy: The illogical influence of certain physical and administrative factors. In: Hydrogeology in the Service of Man, Mémoires of the 18th Congress of the International Association of Hydrogeologists, Cambridge, 1985.

- Local Government 2014 The Local Government Handbook. A complete guide to municipalities in South Africa. On-line publication and print publication published by Yes! Media, Cape Town, South Africa. Accessed January 2014 at <http://www.localgovernment.co.za/>
- Lockwood H and Smits S 2011 Supporting Rural Water Supply. Moving Towards a Service Delivery Approach. Practical Action Publishing Limited, Rugby. Available at <http://www.aguaconsult.co.uk/uploads/pdfs/Supporting%20Rural%20Water%20Supply.pdf> and accessed October 2013.
- MacDonald A, Davies J, Calow R and Chilton J 2005 Developing Groundwater, ITDG Publ, Warwickshire, UK.
- Manor J 2001 Local Government in South Africa: Potential Disaster despite Genuine Promise. SLSA Working Paper 8. Sustainable Livelihoods in Southern Africa. Research funded by the Overseas Development Institute, London.
- MDB 2011 Municipal Capacity Assessment 2011 – National Trends in Municipal Capacity. Report by the Municipal Demarcation Board. Downloaded January 2014 from: <http://www.demarcation.org.za/Webpage%20upload/Capacity%20Assessment%20%20Report%20All%20Provinces%202011/Final%20Municipal%20Capacity%20Assessment%20National%20Trends%20Report%2020121001.pdf>
- Middleton BJ and Bailey AK 2009 Water Resources of South Africa, 2005 Study (WR2005). WRC Report Number TT380/08. Water Research Commission, Pretoria.
- Moore M and Kenyon S 2013 Presentation to the Standing Committee on Appropriations on the Municipal Water Infrastructure Grant by National Treasury on 5 March 2013. Parliamentary Monitoring Group. Available at <http://www.pmg.org.za/report/20130305-dwa-cogta-salga-readiness-administer-new-municipal-water-infrastructure> and accessed August 2013.
- Mukherji A and Shah T 2005 Groundwater socio-ecology and governance: a review of institutions and policies in selected countries. Hydrogeology Journal (2005) 13:328-345
- Murray pers.comm. Personal communication with Dr Ricky Murray of Groundwater Africa in 2013, and many similar discussions in preceding years.
- National Treasury 2013 Budget Review 2013.
- NMMDM 2009 Water Services Development Plan for Ngaka Modiri Molema District Municipality. Prepared by Modipa Development Consultants in April 2009, Mahikeng. Accessed in August 2013 at <http://www.nmmdm.gov.za/nmm/?q=node/41>

- NMMDM 2011 Integrated Development Plan (IDP) of Ngaka Modiri Molema District Municipality. Accessed in August 2013 at <http://www.nmmdm.gov.za/nmm/sites/default/files/u1/Documents/2011-2012-IDP.pdf>
- Ntsebeza L 2002 Decentralisation and natural resource management in rural South Africa: Problems and prospects. Occasional Paper published by the Programme for Land and Agrarian Studies (PLAAS), University of the Western Cape, Cape Town.
- Ostrom E 2005 Understanding Institutional Diversity. Princeton University Press, New Jersey.
- Pietersen K 2013 Addressing illegal water use in the Vaal River System: Groundwater Options Report. Unpublished report to the Department of Water Affairs by SLR Consulting (South Africa) (Pty) Ltd. Department of Water Affairs, Pretoria.
- PMG 2013 Municipal Water Infrastructure Grant readiness: Department of Water Affairs, National Treasury and South African Local Government Association briefings. Meeting report information for meeting on 5th March 2013 published by the Parliamentary Monitoring Group, Parliament of South Africa. Records are available at www.pmg.org.za
- PMG 2013 Municipal Water Infrastructure Grant readiness: Department of Water Affairs, National Treasury and South African Local Government Association briefings. Meeting report information for meeting on 5th March 2013 published by the Parliamentary Monitoring Group, Parliament of South Africa. Records are available at www.pmg.org.za
- PPC 2012. Presentation to the Parliamentary Portfolio Committee on Water and Environmental Affairs on 25th April 2012 by Botshelo Water Board. Accessed August 2013 at http://d2zmx6mlqh7g3a.cloudfront.net/cdn/farfuture/0tGSv72TrdKriZrsZo1eaMSEN-N0yF1b83QJ_lr2Fso/mtime:1336036077/files/docs/120425Botshelo.pdf
- PPC 2012. Presentation to the Parliamentary Portfolio Committee on Water and Environmental Affairs on 25th April 2012 by Botshelo Water Board. Accessed August 2013 at http://d2zmx6mlqh7g3a.cloudfront.net/cdn/farfuture/0tGSv72TrdKriZrsZo1eaMSEN-N0yF1b83QJ_lr2Fso/mtime:1336036077/files/docs/120425Botshelo.pdf
- Riemann K, Chimboza N and Fubesi M 2012 A proposed groundwater management framework for municipalities in South Africa. Water SA Vol. 38 No. 3 pp 445-452
- Rogers P, Bhatia R and Huber A 1998. Water as a social and economic good: How to put the principle into practice. Global Water Partnership Technical Advisory Committee Background Paper No. 2. Accessed August 2013 at: http://info.worldbank.org/etools/docs/library/80637/IWRM4_TEC02-WaterAsSocialEconGood-Rogers.pdf.

- Rondinelli DA, Nellis JR and Shabir Cheema G 1983 Decentralisation in Developing Countries. A Review of Recent Experience. World Bank Staff Working Paper No. 581. World Bank, Washington.
- RSA 1998a Act No. 36 of 1998: National Water Act. Republic of South Africa Government Gazette 398 (19182) Cape Town, South Africa.
- RSA 1998b Act No. 107 of 1998: National Environmental Management Act. Republic of South Africa Government Gazette 401 (19519). Cape Town, South Africa.
- RSA 2002 Act No. 28 of 2002: Mineral and Petroleum Resources Development Act, 2002. Republic of South Africa Government Gazette 448 (23922) Cape Town, South Africa.
- Schneider S J 2012 Water Well Guidelines for use in Developing Countries. Second Edition.
- Schweitzer RW and Mihelcic JR 2011 Community Managed Rural Water Systems: What makes them Sustainable? Short paper presented at the 6th Rural Water Supply Network Forum 2011 Uganda Rural Water Supply in the 21st Century: Myths of the Past, Visions for the Future.
- Seward P, Xu Y and Brendonck L 2006 Sustainable groundwater use, the capture principle, and adaptive management. Water SA Vol. 32 No. 4 October 2006.
- Shah T, Molden D, Sakthivadivel R and Seckler D 2000 The Global Groundwater Situation: Overview of Opportunities and Challenges. International Water Management Institute (IWMI), Colombo.
- Siddle A and Koelbe TA 2012 The Failure of Decentralisation in South African Local Government. Complexity and Unanticipated Consequences. UCT Press, Cape Town.
- Smith SE and Marin LE 2005 Water and the rural poor in Latin America: The case of Tlamacazapa, Guerrero, Mexico. Hydrogeology Journal (2005) 13:346-349
- Sophocleous M 1997 Managing water resources systems: why "safe yield" is not sustainable. Ground Water 35(4): 561
- SPAID / PDG, 2008 Municipal Infrastructure Grant Baseline Study. Produced for Support Programme For Accelerated Infrastructure Development (SPAID)
- Stats SA 2012 Census 2011 Metadata. Report no. 03-01-47 published by Statistics South Africa, Pretoria.
- Stephens A and Bredenkamp DB 2002 Institutional arrangements for groundwater management in dolomitic terrains: situation analysis. WRC Report No KV140/02. Water Research Commission, Pretoria.

- Taljaard 2008 O&M of Groundwater Supply. O&M Handbook Water Supply Services. Department of Housing & Local Government, Northern Cape, and Department of Water Affairs & Forestry: Northern Cape Region.
- The Presidency Department of Performance Monitoring and Evaluation 2013 Progress towards the targets in the delivery agreements for the priority outcomes. September 2013
- Treasury 2011 2011 Local Government Budgets and Expenditure Review 2006/07-2012/13. Report published by the National Treasury of South Africa. Downloaded January 2014 from: <http://www.treasury.gov.za/publications/igfr/2011/lg/default.aspx>
- UNESCO 1983 International legend for hydrogeological maps. UNESCO, Paris. Available at <http://unesdoc.unesco.org/images/0015/001584/158459eo.pdf> and accessed March 2014.
- UNESCO 2004 Groundwater Resources of the World and their Use. IHP-VI Series on Groundwater No. 6. Zekster IS and Everett LG (eds.) United Nations Educational, Scientific and Cultural Organisation (UNESCO), Paris.
- USACE 2014 Building Strong Collaborative Relationships for a Sustainable Water Resources Future. Understanding Integrated Water Resources Management (IWRM). United States Army Corps of Engineers, Washington.
- USAID 2014 Water and Conflict. A toolkit for Programming. United States Agency for International Development, Washington. Accessed February 2014 at http://aquadoc.typepad.com/files/usaidthat_water_and_conflict_toolkit.pdf
- USEPA 1988 Operation and Maintenance Inspection Guide (RCRA Ground Water Monitoring Systems). RCRA Enforcement Division, United States Environmental Protection Agency.
- Van Dyk 2005 Managing the Impact of Irrigation on the Tosca-Molopo Groundwater Resource. Technical Report GH4023. Department of Water Affairs, Pretoria. Available from <http://www.dwa.gov.za/ghreport/default.aspx> and accessed August 2013.
- Vegter JR 1995 An explanation of a set of national groundwater maps. WRC Report No TT74/95. Water Research Commission, Pretoria.
- Vegter JR 2001 Groundwater development in South Africa and an introduction to the hydrogeology of groundwater regions. WRC Report No TT134/00. Water Research Commission, Pretoria.
- Von Hayek F 1944 The Road to Serfdom.
- Weaver JMC, Cave L and Talma AS 2007 Groundwater Sampling (Second Edition) A comprehensive guide for sampling methods. Water Research Commission Report No. TT303/07. Water Research Commission, Pretoria

Whinnery J 2012 A Well Construction Cost-Benefit Analysis: For Water Supply Well Guidelines for use in Developing Countries. Unpublished paper, Oregon State University, USA. Available at: <http://aquadoc.typepad.com/files/well-construction-cba-2012-10-05.pdf> and accessed August 2013.

Woodford A, Rosewarne P and Girman J 2006 'How much groundwater does South Africa have?' Internal discussion document. Accessed March 2014 at: http://www.srk.co.za/files/File/newsletters/groundwater/PDFs/1_A_Woodford.pdf

11 APPENDIX ONE: SUGGESTED LIST OF O&M TASKS

Below is a suggested list of O&M tasks for groundwater sources, after DWA (2009). This will need to be updated in the light of new information, and “tailored” for different environments and circumstances. The various tasks need to be costed, and “economies of scope” need to be examined.

Task	Description	Notes
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 with a dip meter needs a reliable, trained operator. See DWA (2004). Water level monitoring provides very early warning of future supply problems. Assessment, planning and management of the groundwater resource covered in detail in DWA (2008).
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.	Normally needs skilled personnel and samples usually need to be submitted to a laboratory. See DWA (2004). See Weaver et al (2007) for further details on groundwater sampling.
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.	Flow meter accuracy may need to be verified. See DWA (2004). Declining pumping rates can be early warning of pump failure, borehole fouling or other problems.
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.	When compared with water levels and pumping rates, gives information about borehole efficiency and possible problems such as clogging or biofouling. See DWA (2004).
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.	Important for establishing long-term and seasonal trends, and for planning upgrades to infrastructure. See DWA (2004).
Cleaning and maintaining above-ground infrastructure	Visual checks, partial dismantling, cleaning. As recommended by manufacturers. Protection from flooding also necessary.	Failure of pipe-work, valves, filters, etc. can disrupt supply and introduce contaminants.
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.	Borehole pump failure can severely disrupt supply. Large schemes often have “duty” and “standby” boreholes to prevent disruption – one borehole can be serviced or maintained while the other continues to pump.
Servicing of diesel engines	Where surface diesel engines are used for positive displacement pumps, these must be serviced and worn parts replaced.	Regular servicing of diesel engines allows other aspects of the pump operation to be inspected at the same time. Neglecting services leads to breakdown and higher ultimate costs.

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.	Clogging or fouling of screens can slowly reduce performance and increase electricity consumption. Removing and replacing pumps likely to require purging and disinfection of the borehole. The work is likely to require a specialist contractor.
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.).	Failure of treatment exposes consumers to risk. It is possible that the Delmas tragedy, in which people died following a typhoid outbreak related to contaminated groundwater, would not have happened had better management of chlorination systems existed.
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.	Storage reservoirs are often needed to buffer supply volumes or to provide pressure by gravity. Maintenance needs to be planned to avoid disruption.
Electrical systems	Visual checks and testing with specialized equipment.	Vital for both pumping and monitoring systems.
Security of installations	All installations should be secure and off-limits to unauthorized people. Valuable infrastructure should be located underground where possible. Repairs need to be done promptly to prevent further deterioration.	Vandalism, cable theft and other criminal activities can severely disrupt supply and incur great expense.
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.	Lack of a protection zone increases risk of groundwater contamination. It is usually much more difficult and expensive to remove contaminants from groundwater than it is to prevent the contamination. Existence of a protection zone adds to local awareness of the groundwater resource.
Reporting	Data from all the tasks listed above needs to be recorded, and passed to the relevant management organization or responsible person. In particular, ordering and budgeting for new parts is important.	The flow of information describing day-to-day operations to authorities responsible for management decisions is of critical importance.

12 APPENDIX TWO: THE DWA GENERAL MAP CLASSIFICATION SYSTEM

The GRA1 dataset is the basis for the Hydrogeological Map Series of the Republic of South Africa. This is a series of 22 hydrogeological maps at a scale of 1:500 000, plus accompanying brochures. South Africa can be divided into zones according to Aquifer Type and Borehole Yield Class (median expected borehole yield, excluding dry boreholes) (Table 12-1). The higher the number, the better the expected borehole yields in any particular area. The hydrogeological maps rely on colour to distinguish between aquifer type (e.g. purple for intergranular, green for karst), and intensity of colour to signify borehole yield class (e.g. dark green for a karst aquifer with median borehole yield of more than 5 L/s). Apart from colour and intensity, the hydrogeological maps are also ornamented (e.g. hatching or dots) to show the lithology (e.g. diagonal crosses indicate basic intrusive rocks such as dolerite). The maps also contain schematic cross sections, information on water quality and rainfall, and show known major groundwater abstractions.

TABLE 12-1 DWA GRA1 DATA KEY

Aquifer Type	Borehole Yield Class (L/s)				
	Class "1" 0-0.1	Class "2" 0.1-0.5	Class "3" 0.5-2.0	Class "4" 2.0-5.0	Class "5" >5.0
Type "a": Intergranular	a1	a2	a3	a4	a5
Type "b": Fractured	b1	b2	b3	b4	b5
Type "c": Karst	c1	c2	c3	c4	c5
Type "d": Inter-granular and fractured	d1	d2	d3	d4	d5

13 APPENDIX THREE: ATLAS OF MAPS

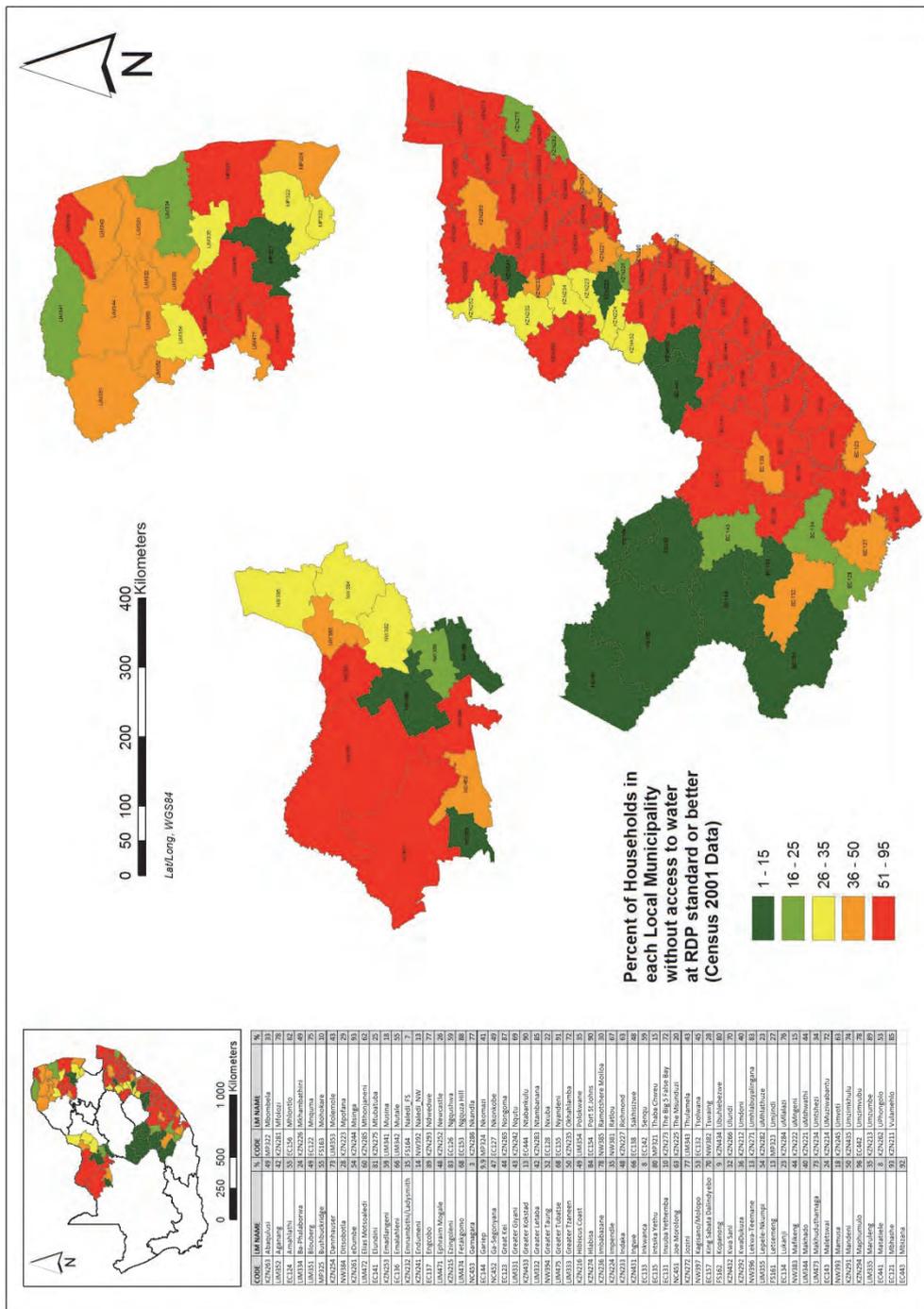


FIGURE 13-1 ACCESS TO RDP STANDARD WATER IN 2001

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

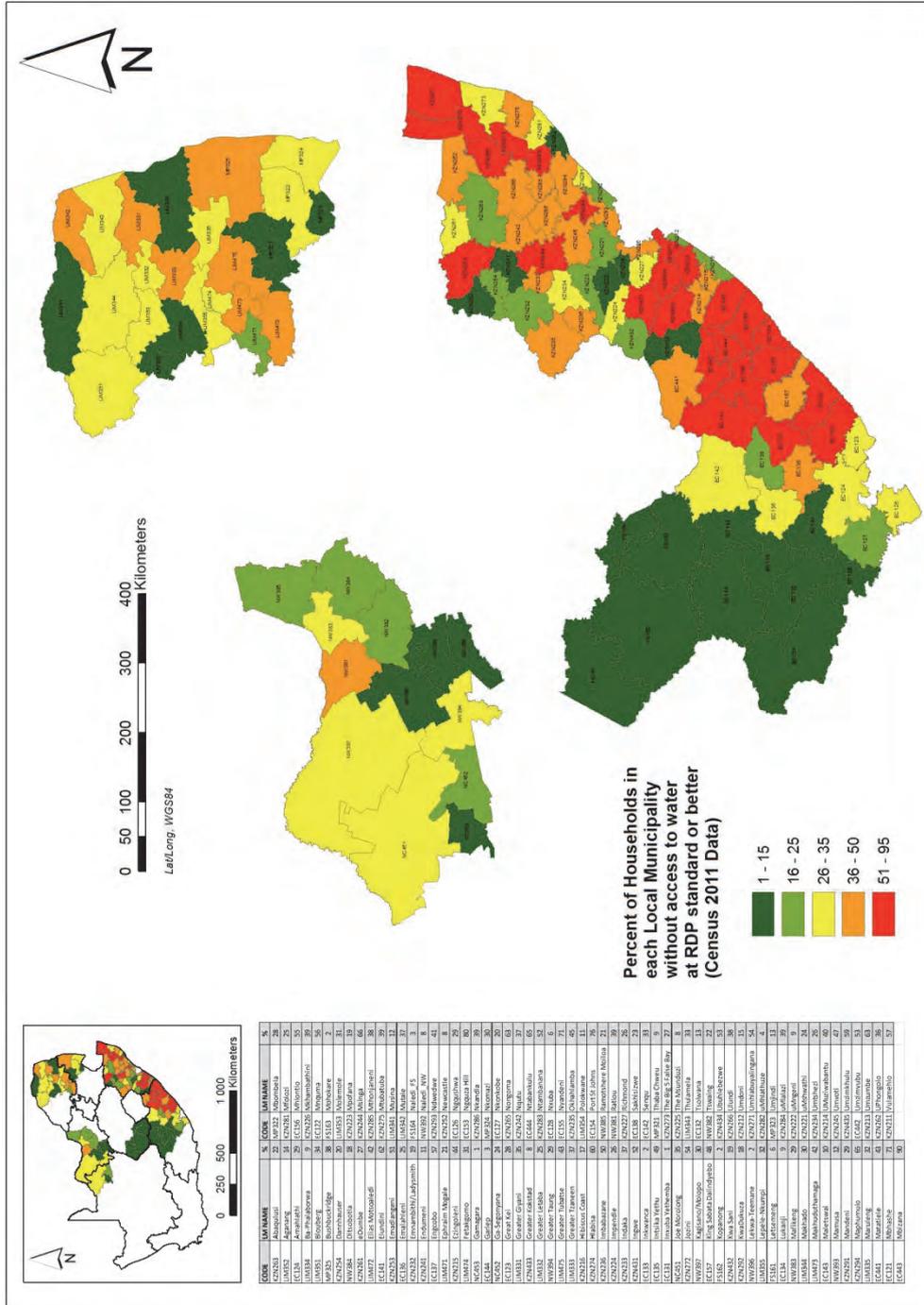


FIGURE 13-2 ACCESS TO RDP STANDARD WATER IN 2011

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

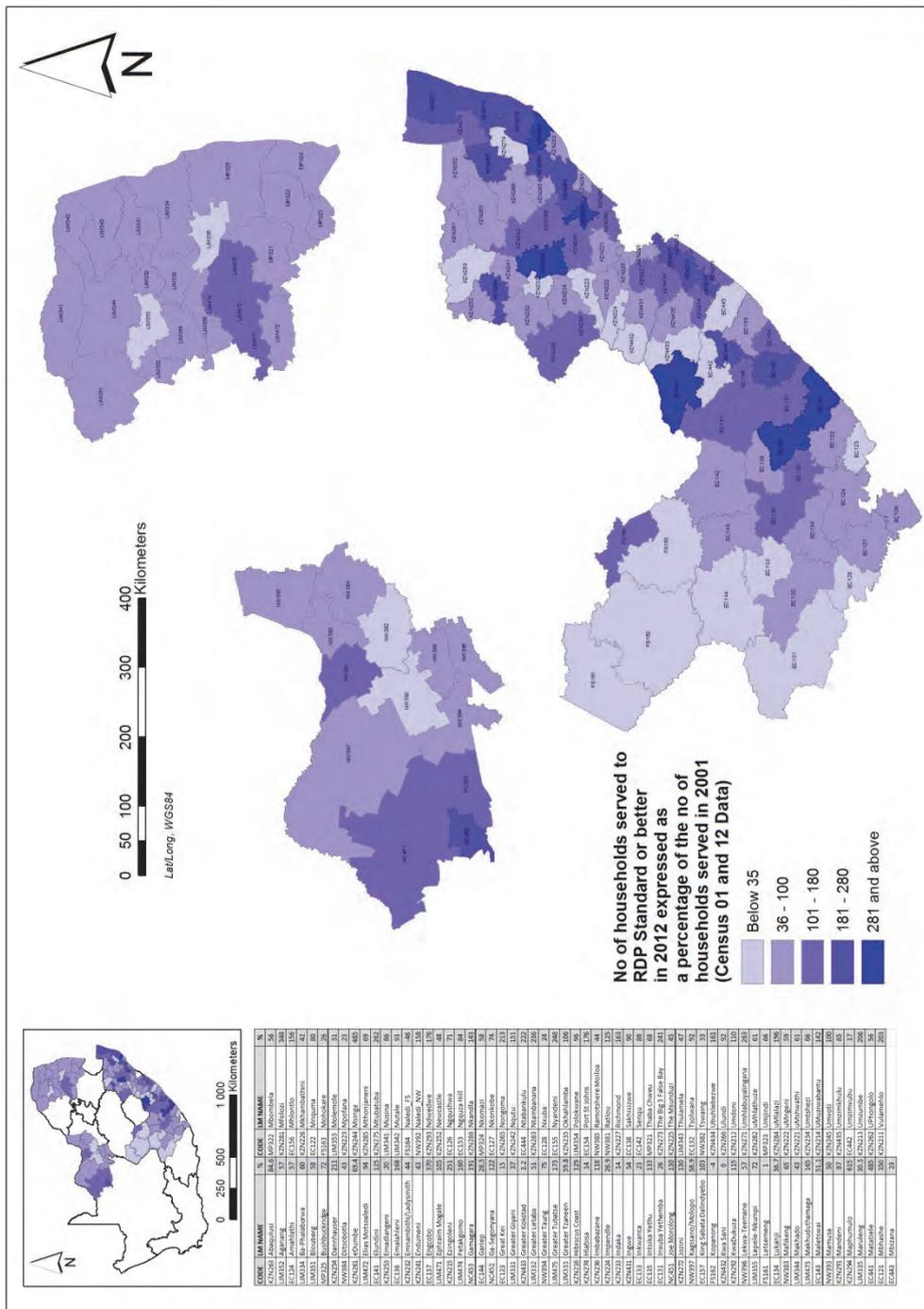


FIGURE 13-3 IMPROVEMENT 2001 TO 2011

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

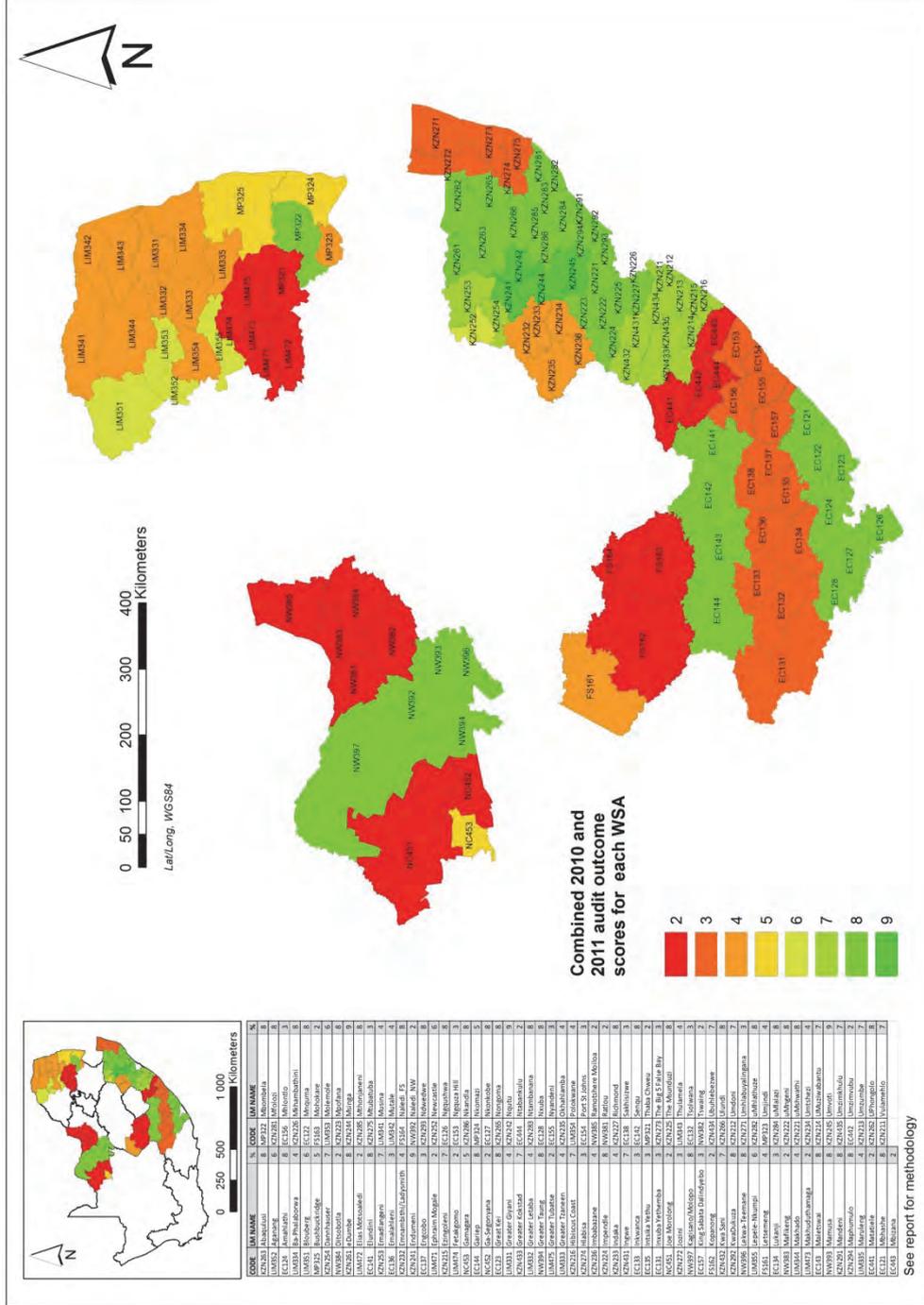


FIGURE 13-10 AUDIT OUTCOMES

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

See report for methodology

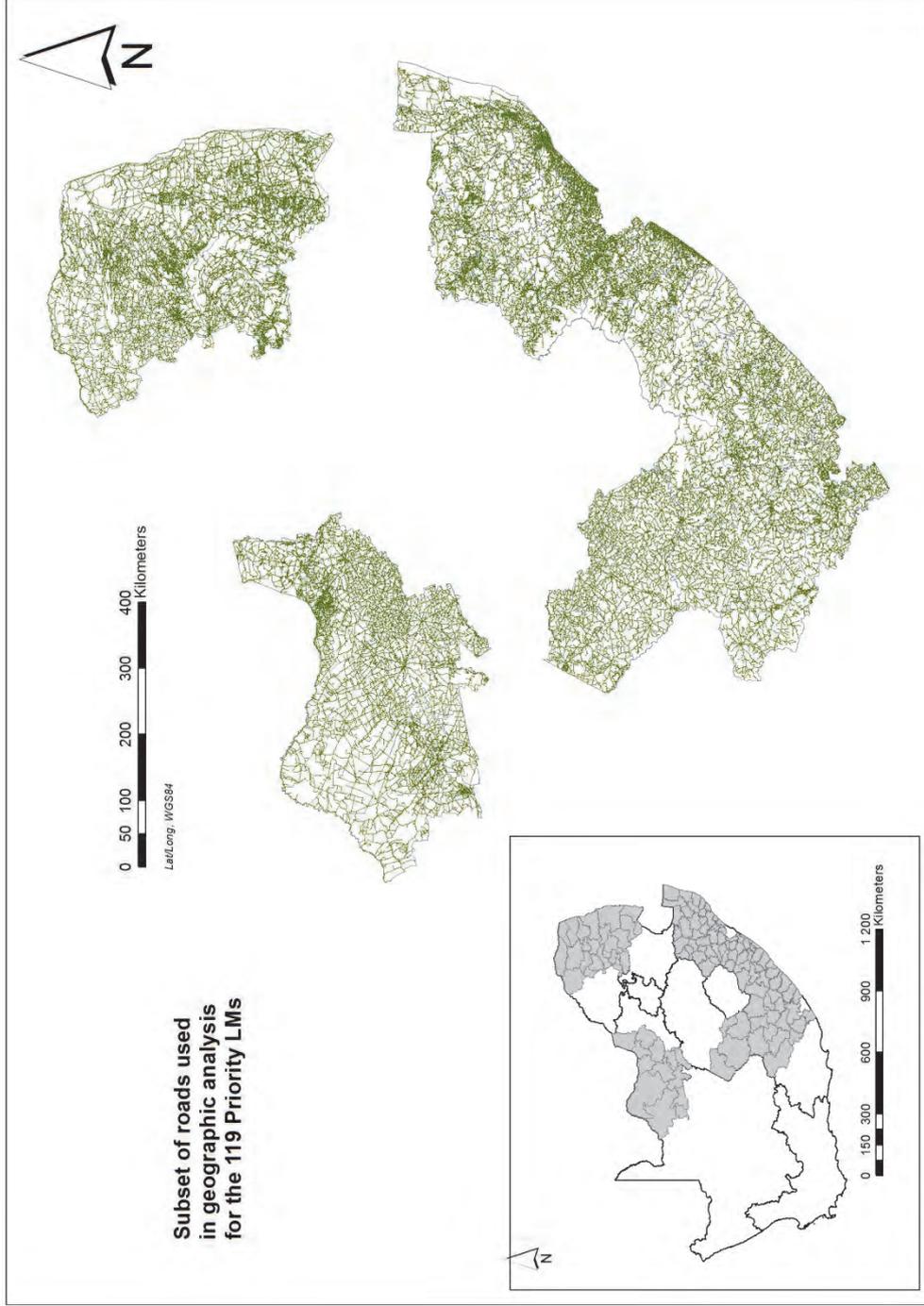


FIGURE 13-14 SUBSET OF ROADS USED IN GEOGRAPHICAL ANALYSIS

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

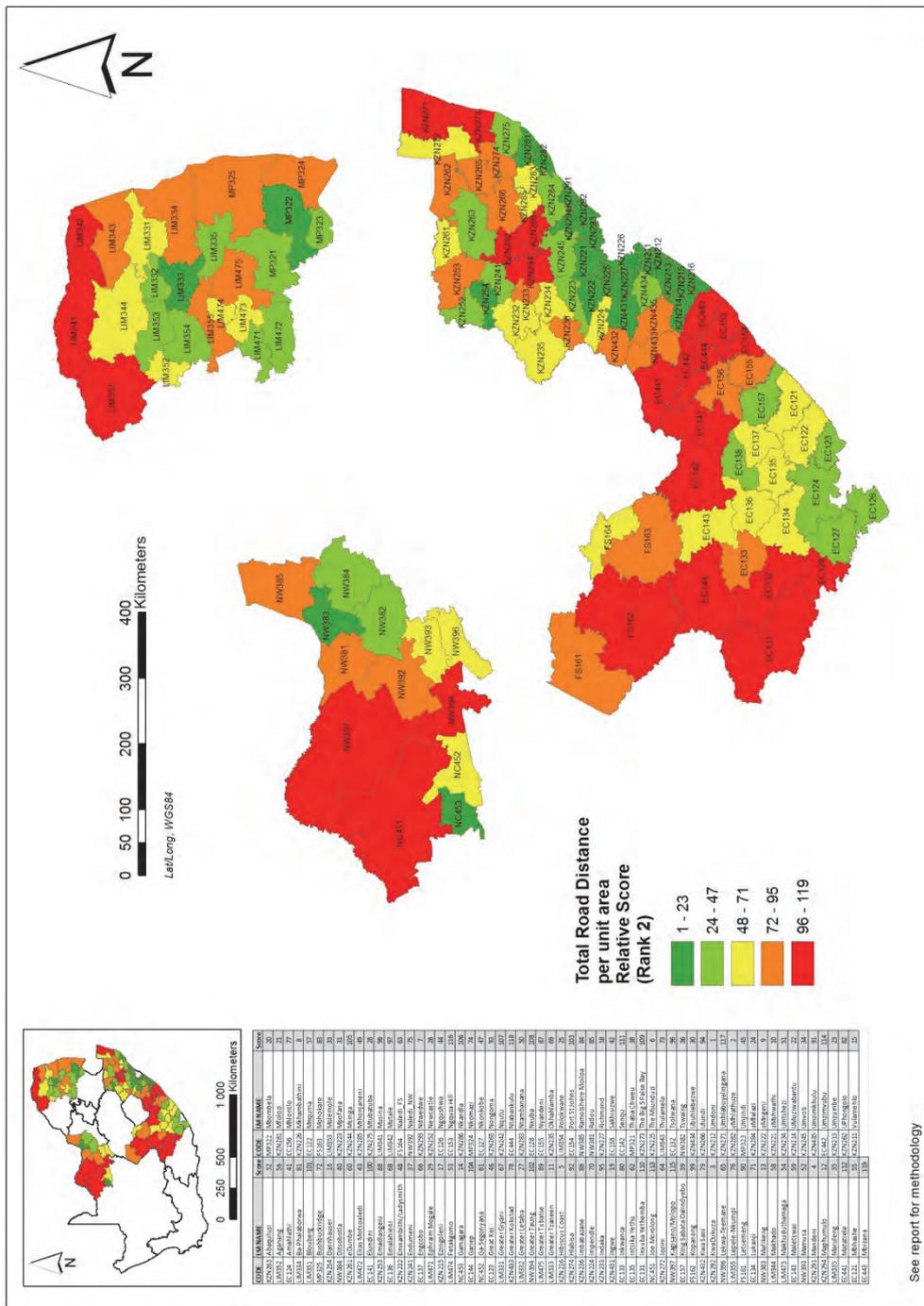


FIGURE 13-16 TOTAL ROAD DISTANCE (RANK 2)

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

See report for methodology

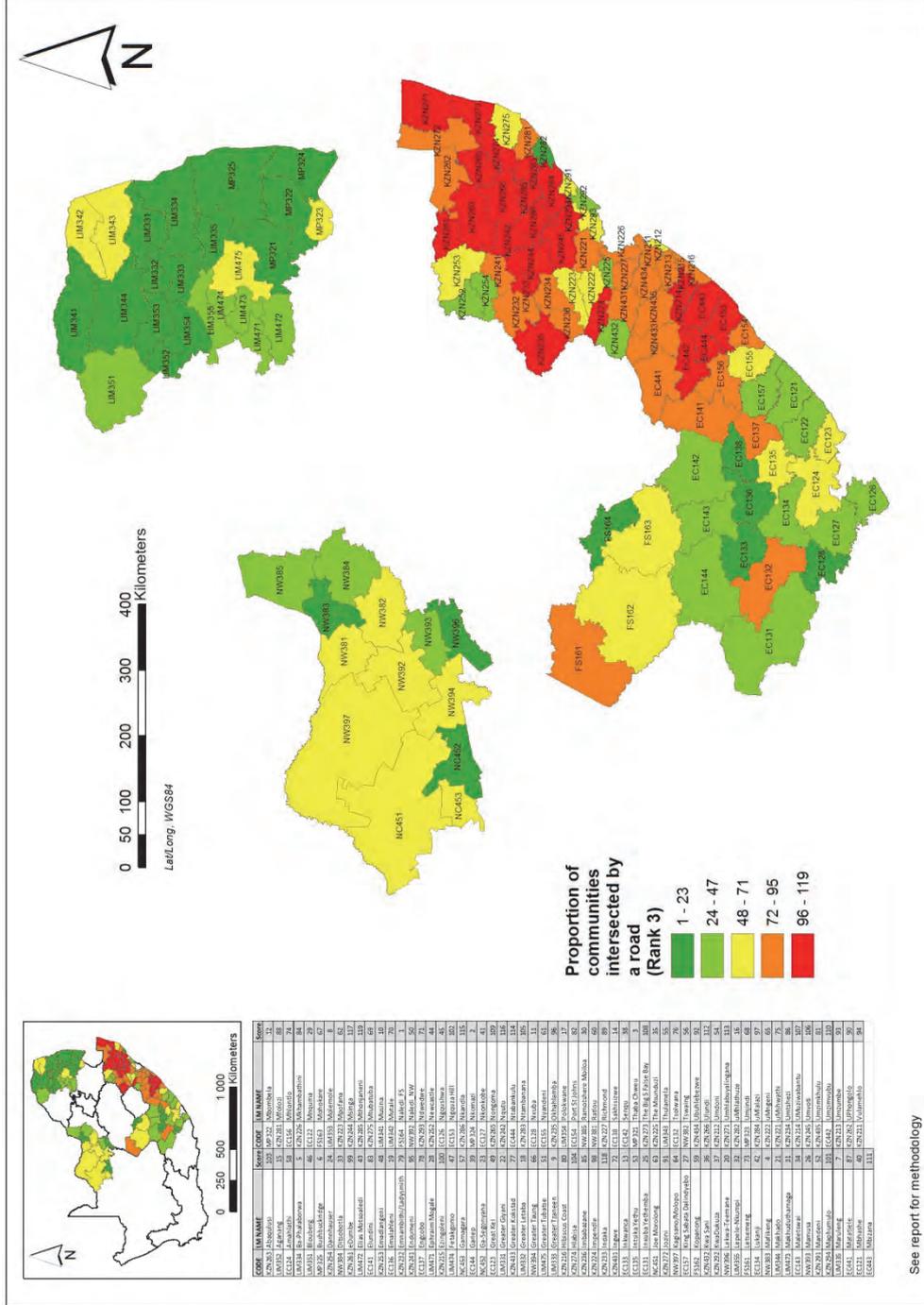


FIGURE 13-17 ROAD INTERSECTIONS (RANK 3)

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

See report for methodology

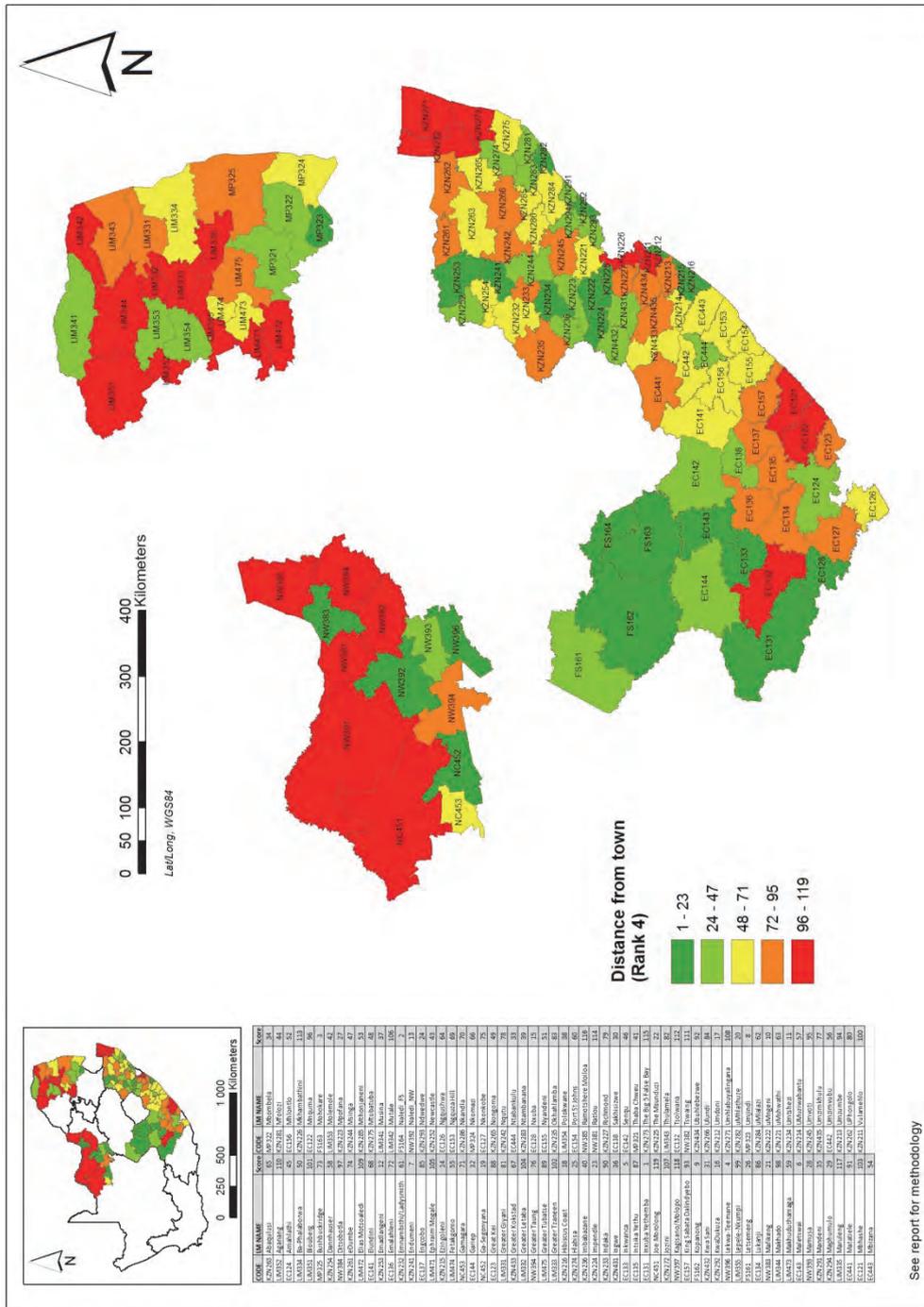
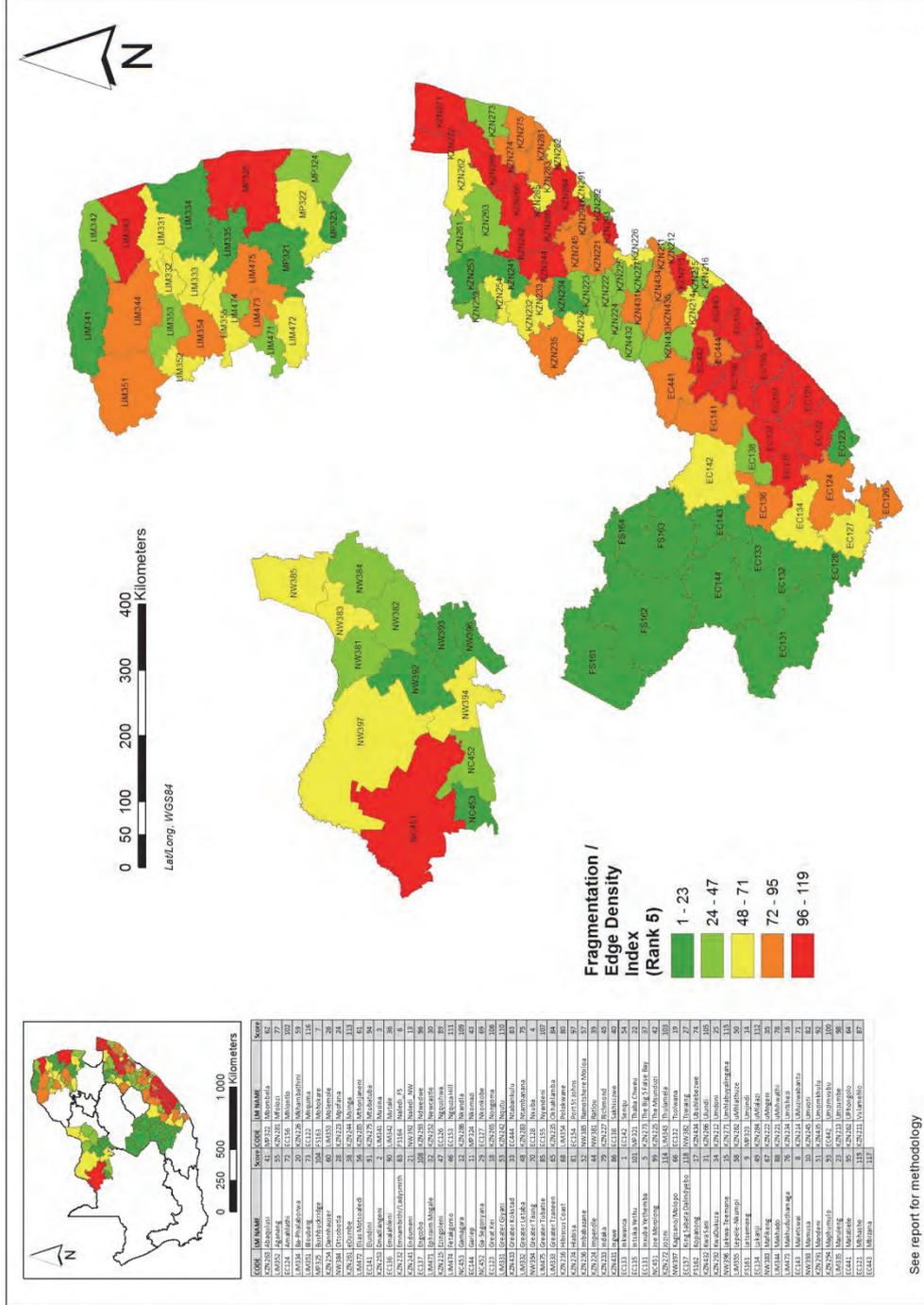


FIGURE 13-18 DISTANCE FROM TOWN (RANK 4)

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

See report for methodology



See report for methodology

FIGURE 13-19 FRAGMENTATION INDEX (RANK 5)

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

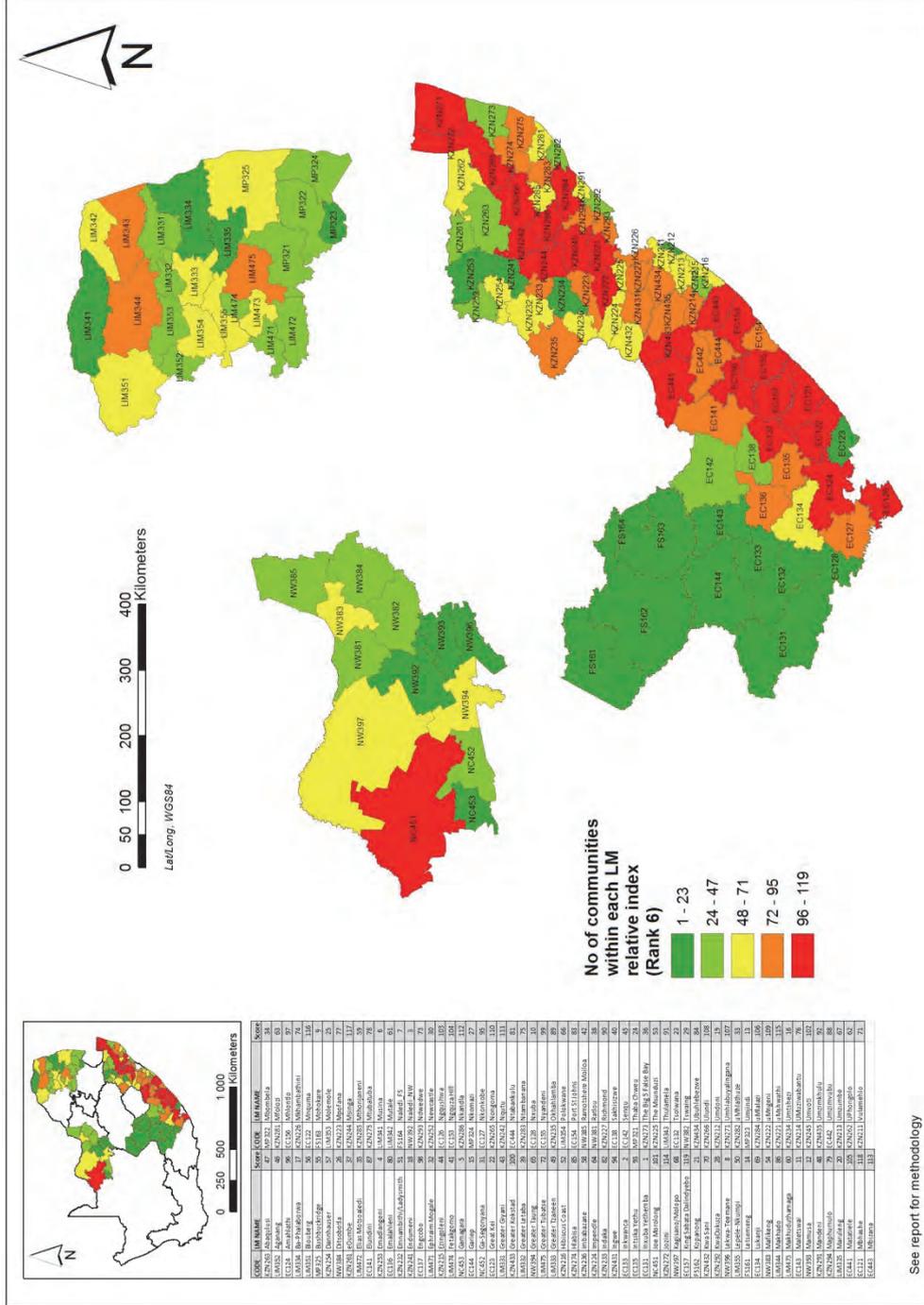


FIGURE 13-20 RELATIVE NUMBER OF COMMUNITIES (RANK 6)

See report for methodology

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

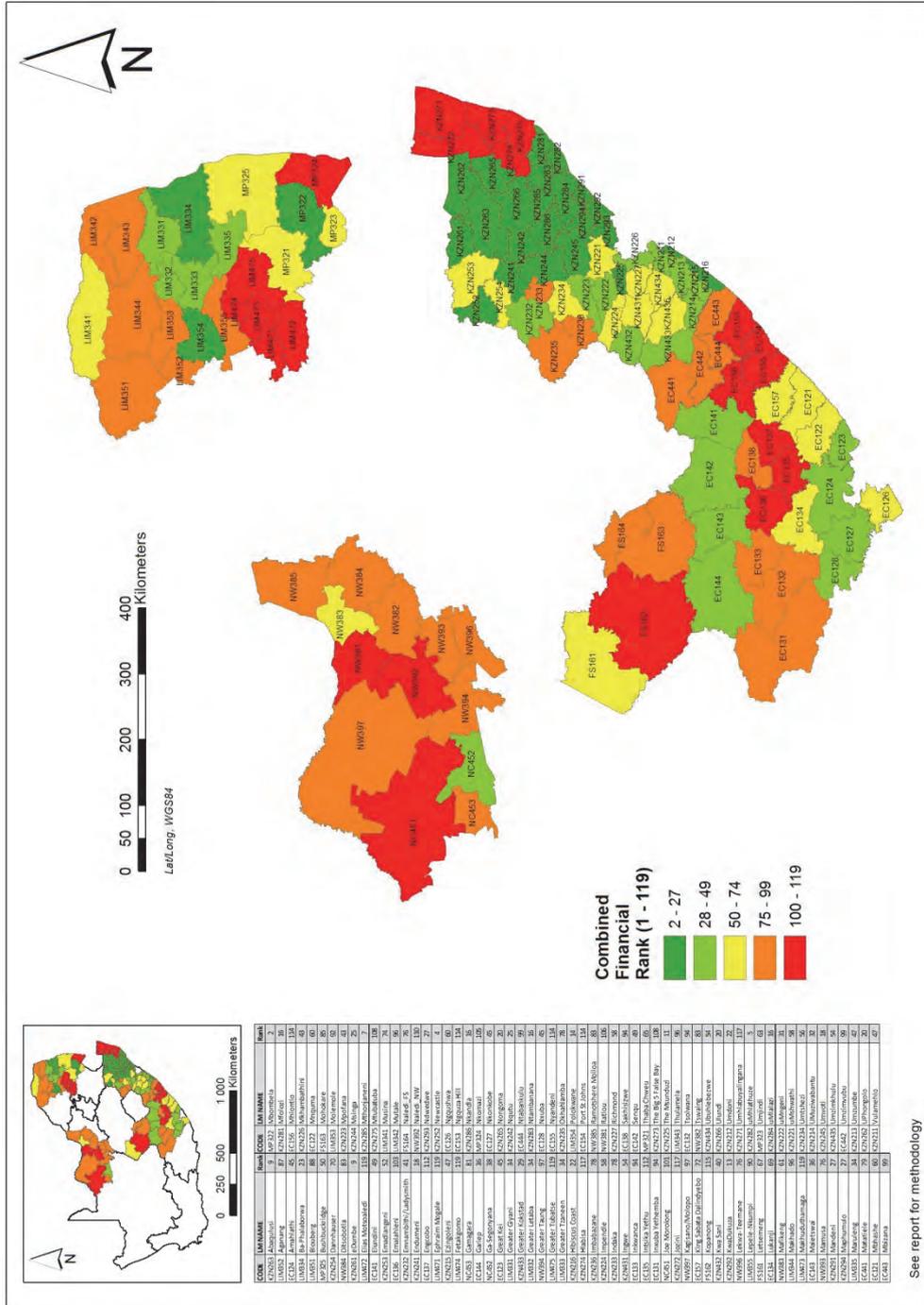


FIGURE 13-23 FINANCIAL BACKLOG INDICATORS COMBINED

See report for methodology

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

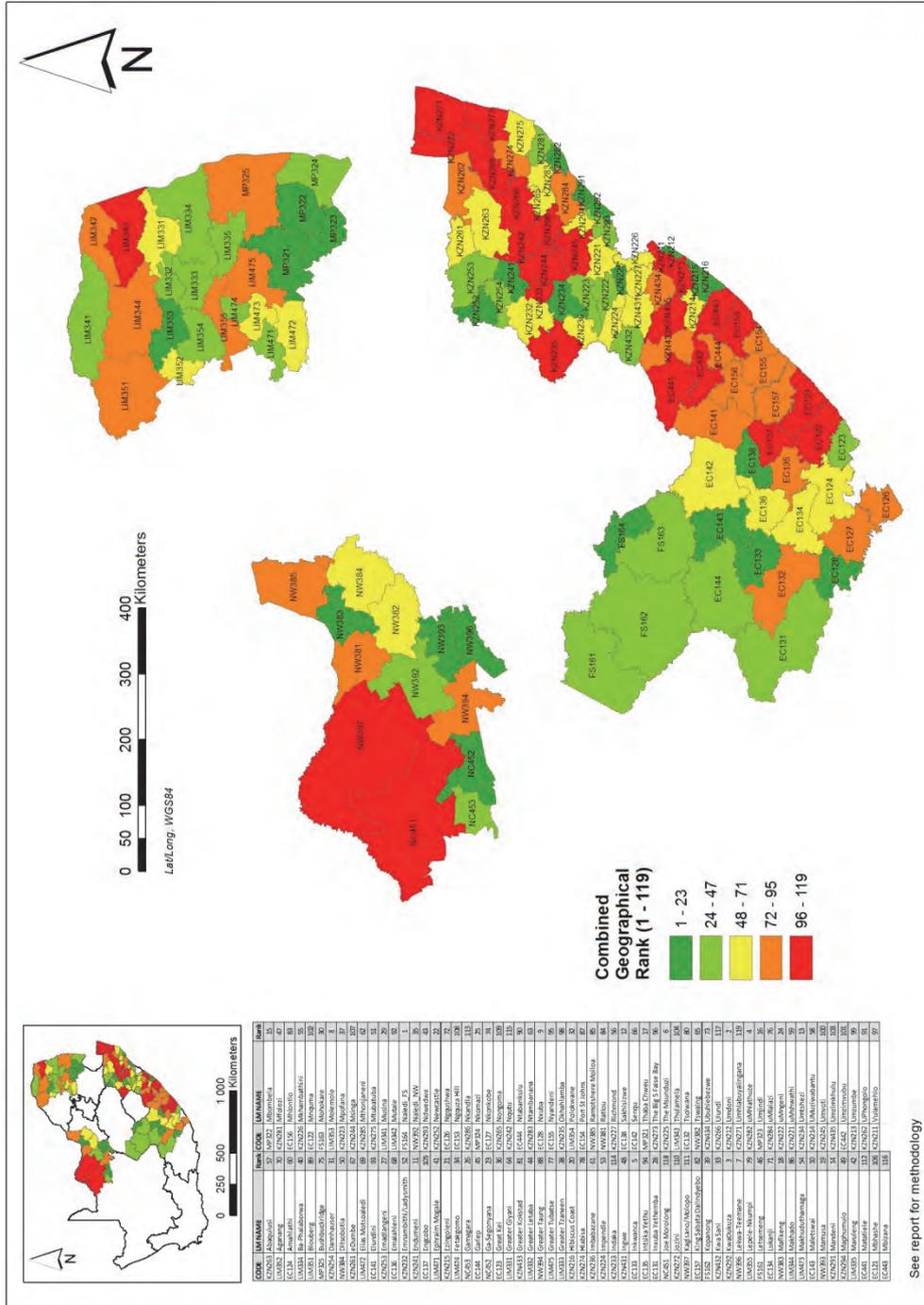


FIGURE 13-24 GEOGRAPHICAL BACKLOG INDICATORS COMBINED

See report for methodology

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.

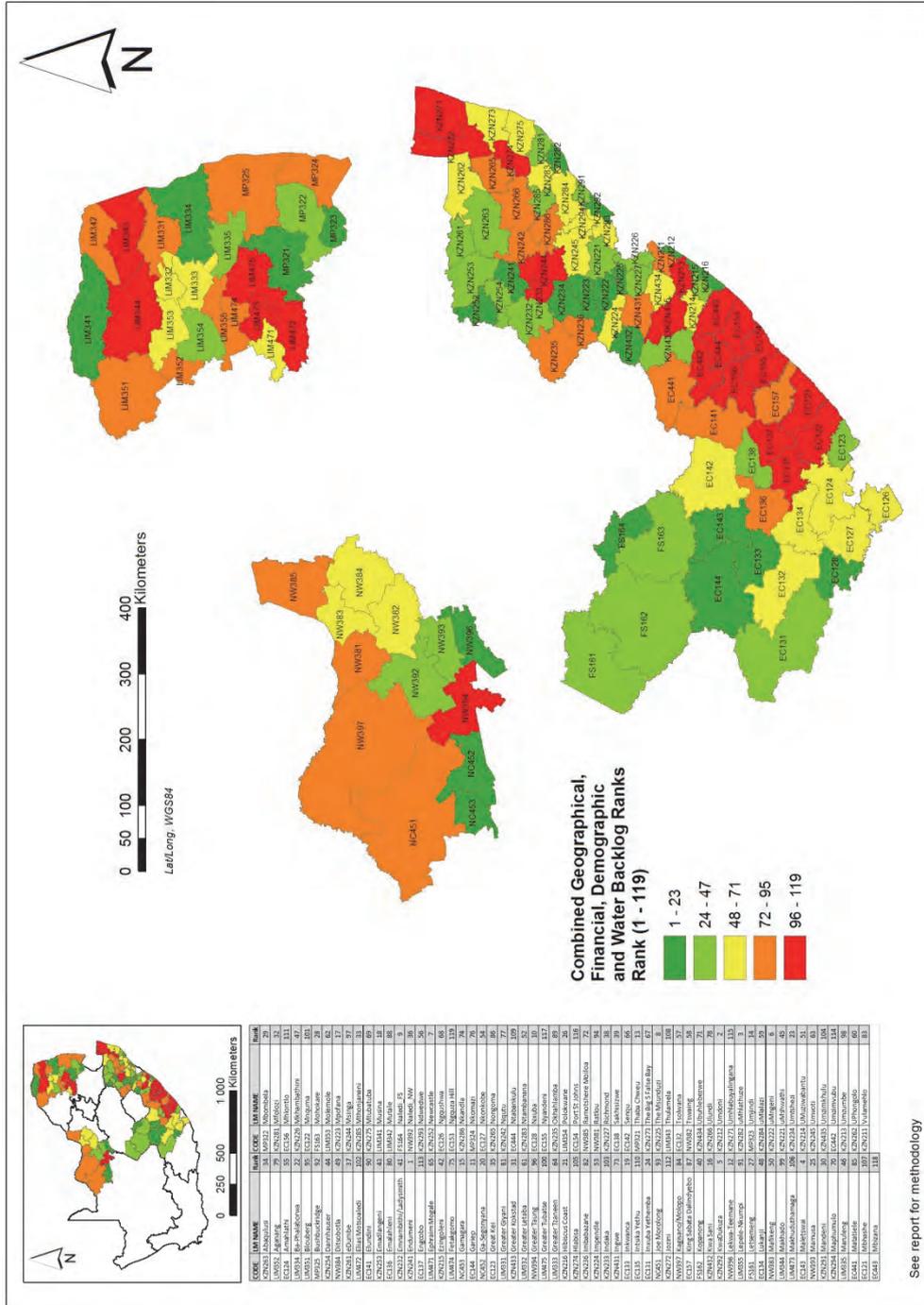


FIGURE 13-25 ALL INDICATORS COMBINED

See report for methodology

An appraisal of diverse factors influencing long-term success of groundwater schemes for domestic water supplies, focusing on priority areas in South Africa.