? see RCTrading BC

GROUNDWATER RESOURCE INFORMATION PROJECT
EASTERN CAPE PROVINCE

GROUNDWATER INFORMATION SOURCE REFERENCE SHEET

SOURCE REF NR:	SR 224	Own Archive		Copy attached	✓
		Sourced	✓	Copy at source	

A: SOURCE DESCRIPTION

District Municipality:	Amatole		Chris Hani		O R Tambo	
	Ukhahlamba		Cacadu		Alfred Nzo	✓
Local Municipality:	INGQUZA					
Institution where Information is held:	TOENS & PARTNERS					
Branch of Institution:	WYNBERG, CAPE TOWN					
Contact details: Contact person:	DES VISSER					
Contact Tel:	021-7625815					
Contact Email:	toens@mweb.co.za					

B: TYPE OF INFORMATION

Information format:	Hard copy	✓	Data Summary		Electronic Report	
	Specify Other:					
Report / Info Title:	DEVELOPMENT OF THE GROUNDWATER RESOURCES OF THE MFINIZWENI AREA, LUSIKISIKI DISTRICT					
Report Nr:	2001255		Date:	JULY 2001		
Author Details:	A WOODFORD					
Author's Qualification:	Hydrogeologist	✓	Govt Dept		Project Manager	
	Engineer		Technician		Other	
	Specify Other:					

Captured by: PS. Nel Date: 17/03/2004 Signed:

C: GEOHYDROLOGICAL CATEGORIZATION

Project Type	Source development	✓	Feasibility Study		Sanitation Study	
	Specify Other:					

Reference Co-ordinate:	Latitude	Longitude
	31° 15' 00"	29° 26' 00"

	Yes	No	Complete	Incomplete
Lithological & Construction Logs	✓		✓	
Hydrocensus Data	✓		✓	
Pump Testing Data	✓		✓	
Chemical Water Analysis Data	✓		✓	
Geohydrological Data	✓		✓	
Spring Data		✓		
Remote Sensing Data	✓		✓	
Map Data	✓		✓	

Comments:

Reviewed by: JU du Plooy Date: 17/03/2004 Signed:

TOENS & PARTNERS CC
HYDROGEOLOGICAL, GEOLOGICAL, CIVIL ENGINEERING & ENVIRONMENTAL CONSULTANTS CK1996/010713/23

7 Lester Road, WYNBERG, 7800
P O Box 18959, WYNBERG, 7824
Tel.: (021) 762-5815, Fax: (021) 762-5812
E-mail: toens@mweb.co.za

WILD COAST DISTRICT COUNCIL

DEVELOPMENT OF THE GROUNDWATER RESOURCES OF THE MFINIZWENI AREA, LUSIKISIKI DISTRICT

(T&P Report No. 2001255)
DRAFT VERSION 1.0

Compiler: AC Woodford

July 2001

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

In November 2000, Fongoqa Skade Toyi and Associates (FST) appointed Toens and Partners (T&P), on behalf of the Wild Coast District Council (WCDC), to conduct a geohydrological investigation of the Mfinizweni area as part of the Mfinizweni Bulk Water Supply (MBWS) project. The aim was to establish a number of production boreholes capable of meeting the total daily water requirement of the supply scheme, which is estimated at 284 m^3.

This report documents the geohydrological investigation that involved the siting and drilling of 10 exploration boreholes, as well as the pump-testing and yield assessment of 4 potential production boreholes.

2.0 LOCATION OF STUDY AREA

The Mfinizweni study area covers an area of 62.2 km^2 and is situated some 32 km northwest of Lusikisiki (**Figure 1**), and is 132 km by road from Umtata.

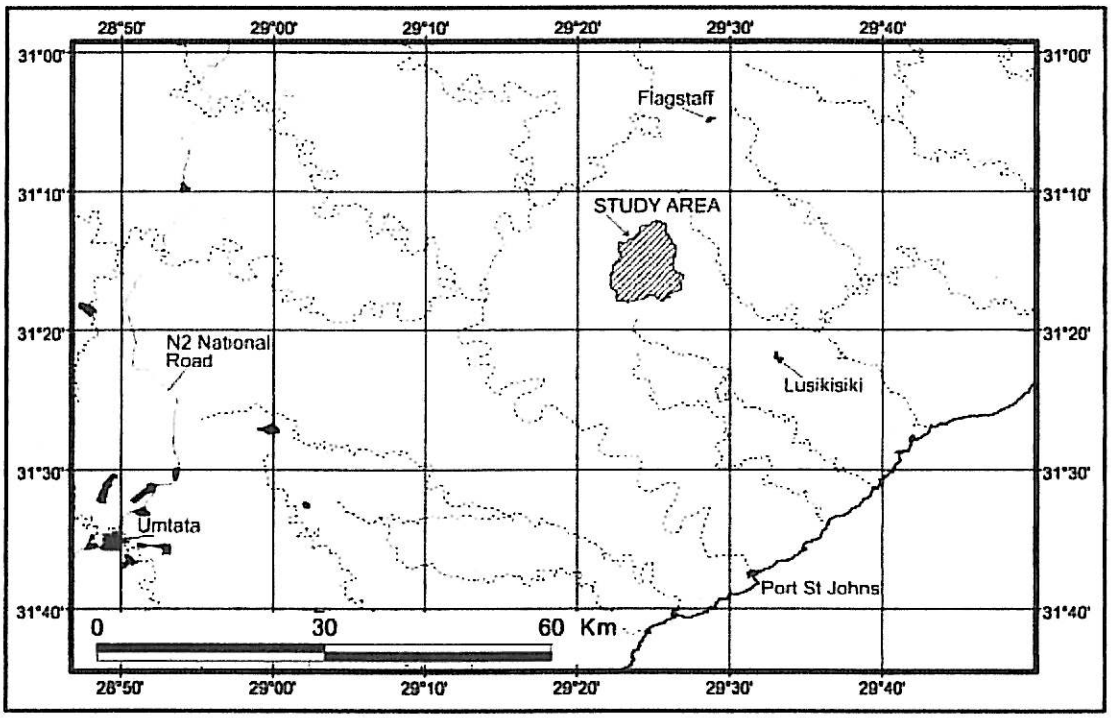

Figure 1: ***Location of the Mfinizweni Study Area***

3.0 TERMS OF REFERENCE

The Terms of Reference (TOR) stated that a geohydrological investigation was required to accomplish the following activities, namely:

- Preliminary siting of 4 boreholes.

- GPS fixing of the final borehole positions.
- Appointment and supervision of a drilling contractor.
- Pump-testing of the four boreholes.
- Water quality assessment.
- Recommendations and reporting.

The Mfinizweni area was subdivided into four supply zones (**Figure 2**) and it was requested that a single production borehole be developed within each of the four zones. The total daily water requirement of the supply scheme is estimated at 284 m^3 (i.e. 8 l/s assuming a 10hr daily pumping schedule) (**Table 1**).

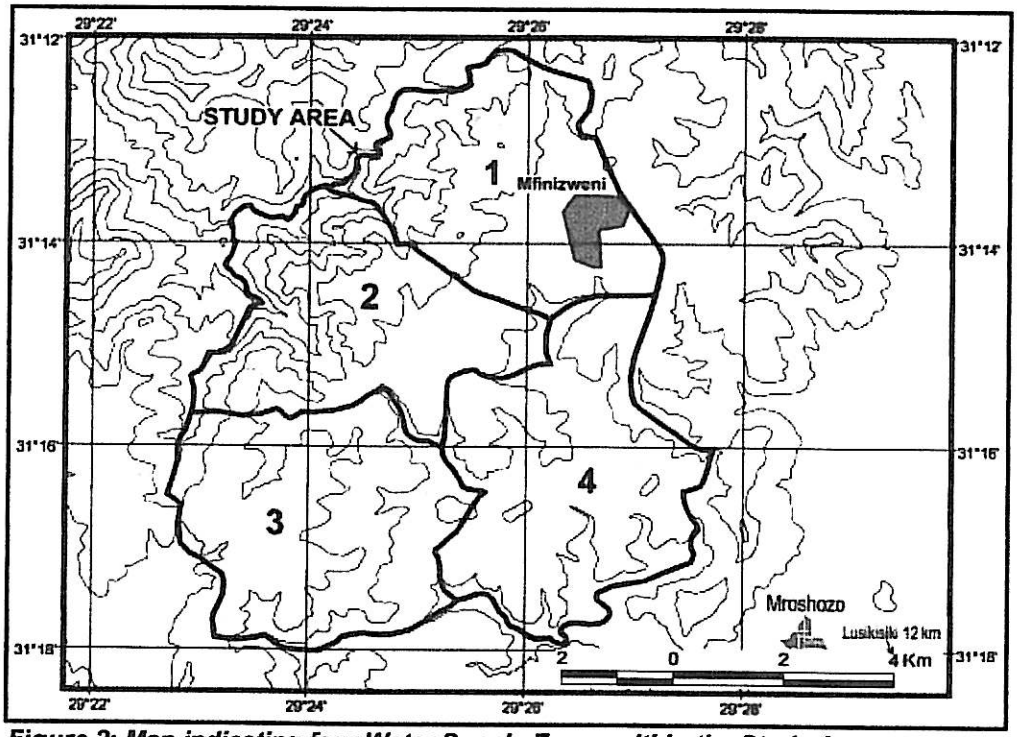

Figure 2: ***Map indicating four Water Supply Zones within the Study Area***

Table 1: ***Water Requirements per Supply Zone***

Supply Zone	Water Requirements		
	(m^3/day)	(m^3/month)	(l/s)
1	114.4	3 432	3.18
2	19.4	582	0.54
3	40.6	1 218	1.13
4	110.0	3 300	3.10
Total	284.4	8 532	7.95

Toens & Partners estimated that, given the local hydrogeological conditions, approximately seven (7) exploration boreholes would be required to meet the

anticipated average daily water requirements of the supply scheme (Letter TP1246/AW/02, dated 15th January 2001 to FST).

4.0 PHYSIOGRAPHY

The terrain is hilly and deeply dissected along the courses of the main rivers. The valley floors are often inaccessible to even 4x4 driven vehicles. Most of the inhabitants live along the top of the hills at an elevation of between 700 and 800 m.amsl.

The Mfinizweni study area lies mainly in the eastern portion of the T60F quaternary drainage region, although it also extends into the T32H and T36A catchments. The study area extends from the Mbhoyi River in the south to the Mavana River in the north, and is drained by the tributaries of the south-easterly flowing, perennial Xura River (**Figure 3**). The Mean Annual Precipitation (MAP) in this area is approximately 820mm (Schultze, 1977; Woodford, 1999).

5.0 GEOLOGY & HYDROGEOLOGY

The general geology of the study area is presented in **Figure 3**, and it was derived from the Geological Survey's 1/250 000 scale geological map (Umtata, mapsheet 3222).

The area is underlain by approximately 900m of rhythmically bedded shale and occasional sandy horizons of the Ecca Group. These rocks are conformably overlain by greenish-grey to greyish-red mudstone and subordinate grey, feldspathic sandstone of the Adelaide Subgroup (Beaufort Group). The total thickness of the Adelaide Group sediments is ±1 800m (SACS, 1980).

The rocks of Ecca and Beaufort Groups are heavily intruded by dolerite dykes, sills and inclined sheets. The proportion of dolerite to host rock is greatest in the Ecca Group (i.e. 40%) and thereafter progressively decreases upwards within the Beaufort Formations (Karpeta and Johnson, 1979). They state that the dykes generally vary in width between 3 and 10m and are commonly several kilometres long. The main dyke orientation in the study area is NW, with fewer ESE and E-W trending dykes. The thickness of dolerite sills is variable and often exceeds 100m.

Thin Quaternary alluvial deposits occur along the major river courses, such as the upper reaches of Xura River, near Mfinizweni, as well as along the southern boundary of the study area.

The Ecca and Beaufort sediments dip at low angles of between 1 and 3° towards the northwest, although localized steeper dips occur near dolerite intrusions.

The main aquifers in the area are associated with the weathered and fractured dolerite intrusives and associated host sediments. The target features to obtain relatively high-yielding boreholes are the more intensely fractured zones associated with the intrusive dykes and other linear structures (i.e. faults) of tectonic origin, as well as, but to a lesser extent the dolerite sills.

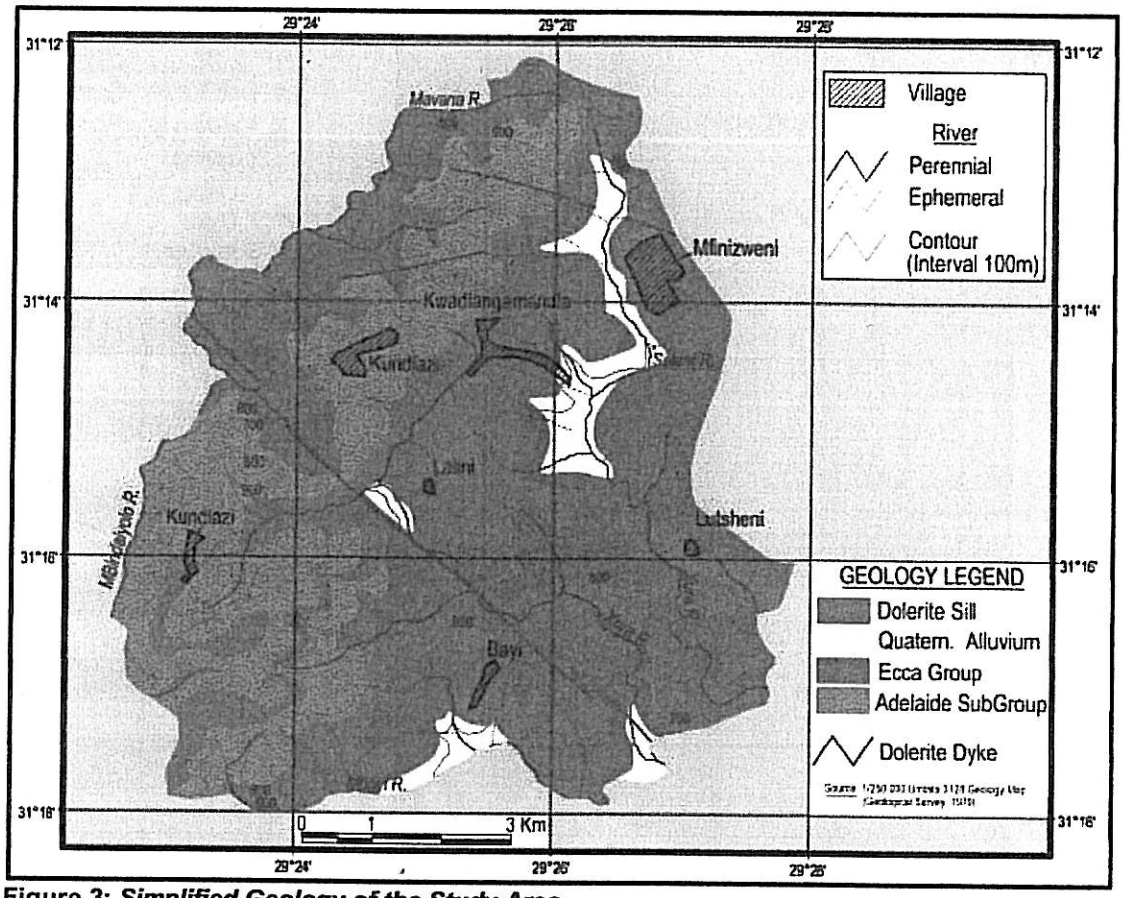

Figure 3: ***Simplified Geology of the Study Area***

6.0 LIMITED HYDROCENSUS

Mr. C. Esterhuyse of Toens & Partners conducted a limited hydrocensus of the existing waterpoints in the study area. The hydrocensus was carried out over the period 1st - 2nd June 2001. Five boreholes and a spring were located, two of the boreholes falling outside of the study area, i.e. at Hillside (**Figure 4**). During the survey all relevant data such as borehole depth, waterlevel, electrical conductivity (EC) etc. were recorded (**Table 2**).

Table 2: ***Summary of Hydrocensus Information***

Borehole Number	Latitude (d.d)	Longitude (d.d.)	Depth (m)	Waterlevel (m.bgl)	Main Water Strike (m.bgl)	EC (mS/m)	Source Type	Estimated Yield (l/s)	Remark
MFZ01	-31.24597	29.45233	81.0	12.49	81.00	-	Borehole	0.20	No equipment, unused.
MFZ02	-31.27169	29.38472	50.0	9.68	40.00	28.0	Borehole	0.40	Handpump, Domestic use.
MFZ03	-31.28503	29.47873	121. 0	10.13	79.00	-	Borehole	0.83	Equipped Mono Pump, Domestic use.
MFZ04	-31.27761	29.47259	176.0	-	dry	-	Borehole	0.00	Borehole sealed, 0-34m shale, 34-176m dolerite.
MFZ05	-31.24871	29.44886	0.0	0.00	-	33.0	Spring	2.00	
MFZ06	-31.24191	29.44581	30.0	1.96	-	-	Borehole	0.30	Handpump, out of order.

EC – Electrical Conductivity

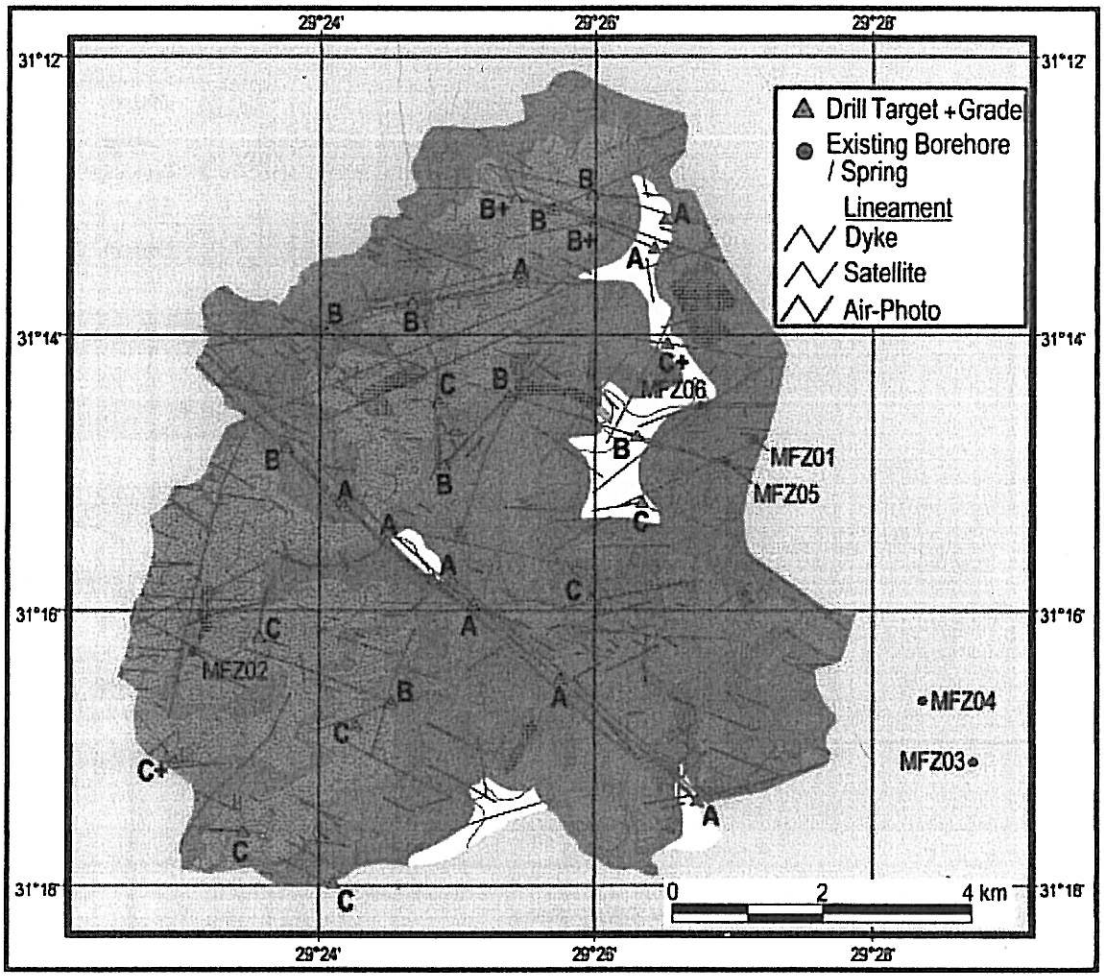

Figure 4: ***Waterpoints surveyed during the hydrocensus, exploration drill targets and mapped lineaments overlain on 1/250 0000 scale geological map***

The salinity of the groundwater in the study area is very low (i.e. Electrical Conductivity or EC of less than 50 mS/m). Borehole MFZ03, situated outside of the study area (**Figure 4**) is relatively high-yielding and is equipped with an engine-driven mono-pump. It is being pumped at a rate of 0.83 l/s and the water is used for drinking purposes.

The spring MFZ05 was flowing at 2.0 l/s (173 m^3/day) at the time of this investigation and with proper development/protection may represent a significant groundwater supply. It appears to daylight at the intersection of a WNW-trending dolerite dyke and a NE-trending satellite lineament. The long-term sustainable yield of the spring (MFZ05) should be ascertained by monitoring its flow through the dry season, along with the monthly rainfall.

7.0 REMOTE-SENSING, LINEAMENT MAPPING AND GIS ANALYSIS

The relevant 1/50 000 scale panchromatic aerial-photograph prints were scanned at 500dpi and geo-referenced using the 1/50 000 scale topocadastral mapsheets (3129AD and 3129AB), using ERDAS Imagine image-processing software. The Landsat Thematic Mapper (TM5) imagery (WRS No. 169-0-82) was similarly geo-referenced and digitally processed in ERDAS to enhance the visibility of geological lineaments. Lineaments were mapped onscreen from the digital air-photographs and satellite imagery using ESRI's Arcview GIS software (**Figure 5**).

The relevant geology from the 1/250 000 scale Umtata mapsheet was captured into the GIS (**Figure 3**).

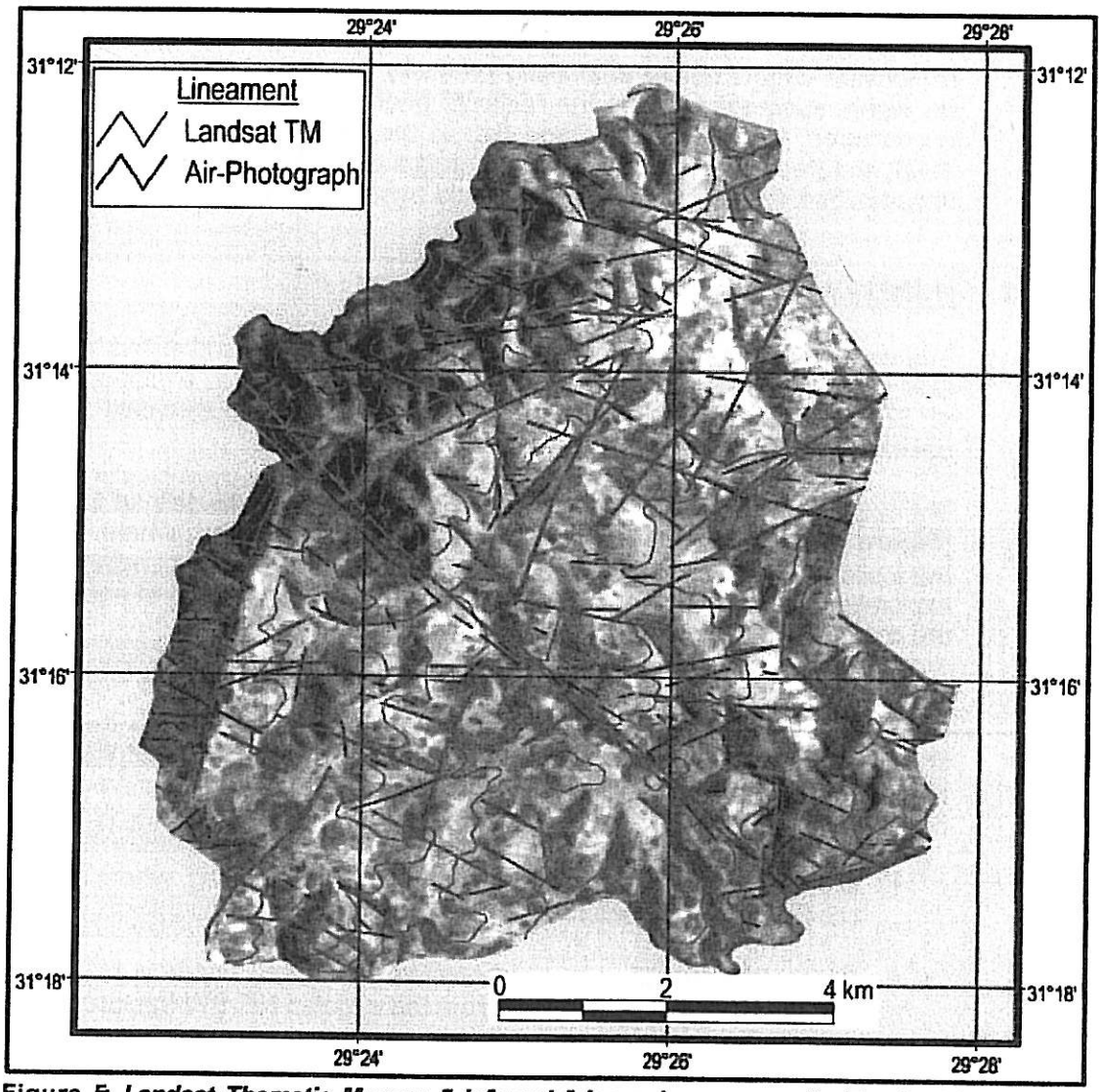

Figure 5: *Landsat Thematic Mapper 5 infrared false colour composite (Bands 4,5 and 7) of the Study Area, showing satellite air-photograph lineaments*

A large number of lineaments were mapped from the satellite and aerial-photographic imagery (**Figure 5**), the majority of which are WNW to NW trending and are thus probably dolerite dykes (**Chapter 5.0**).

Twenty-nine exploration drill-targets were identified in the study area (**Figure 4**), using GIS spatial analysis techniques and interpretation of the available geohydrological (existing boreholes, lithology, dykes and other lineaments) and topocadastral (rivers, elevation, settlements) information, as well as the digital imagery (satellite and aerial-photography). The exploration drill-sites were then ranked in terms of anticipated yield potential as follows:

- A – High
- B – Moderate
- C - Low

This integrated remote-sensing and GIS-based technique of locating favourable exploration targets before embarking on costly field investigations has proven to be highly successful under the 'difficult' geohydrological conditions commonly encountered in the Eastern Cape [i.e. in the districts Mqanduli, (Rasmussen, 1998) and Peddie (Rasmussen, 1997)]. It is a cost effective method as it reduces the amount of time spent on expensive field-based exploration surveys.

8.0 BOREHOLE SITING AND EXPLORATION DRILLING

Ten exploration boreholes were sited by Toens & Partners and drilled by Alderson Drilling over the period 2nd to the 17th June 2001, resulting in a total drilling depth of 979m. Mr. C. Esterhuyse of Toens and Partners supervised the drilling operations.

The exploration boreholes were mostly sited at various pre-defined target areas (**Figure 6**), using detailed field-mapping techniques and where necessary magnetic surveys. The geological description and target rating of each exploration site is presented in **Table 3**. The full geological logs of each borehole are contained in **Appendix A**.

Borehole TP01/01 had to be abandoned at a depth of 30m due to the drill-bit shearing off in the borehole and a replacement borehole TP01/02 was drilled at this site. The following exploration boreholes were not sited on predetermined drilling targets, namely:

- Borehole TP01/06 was sited based upon field mapping, where a 2m wide, NE-SW trending fracture zone was detected.
- Borehole TP01/07 was sited near to an existing borehole MFZ06, in an attempt to obtain higher yields from the targeted NE-SW fracture zone.

Table 3: ***Description of Drill Site and Exploration Drill Target Rating***

Target Rating	Borehole Number	Description of Structural Target
A	TP01/01	East-west dolerite dyke located by magnetic survey
A	TP01/02	East-west dolerite dyke located by magnetic survey
A	TP01/03	East-West dyke located by Magnetic survey
A	TP01/09	East-West dyke located by Magnetic survey -30m N of TP01/03 on another anomaly.
A	TP01/04	SE-NW trending dolerite dyke (outcrops in ditch & dips 81°S, ±10m wide - Sited 10m S of contact. NOTE: Terrain inaccessibility prevents optimum position along floor of valley.
A	TP01/05	Same dyke as TP01/04. Site moved 12m S of contact to intersect major fracture intersected in TP01/04 between 42-44m at greater depths. NOTE: Terrain inaccessibility prevents optimum position along floor of valley.
None	TP01/06	NE-SW fracture set 2m wide, dips 80 SE, 10m from centre of fracture in shale
None	TP01/07	NE-SW fracture set (1m wide), dipping 75° SE, sited 20m from 'hanging-wall' in mudstone. Attempt to optimize siting of existing borehole MFZ06.
B	TP01/08	E-W fracture set, ±3m wide in mudstone, dipping 78°S. Borehole sited 100m E of outcrop and 10m S of interpolated centre. NOTE: Terrain conditions prevent optimum siting on structure.
C+	TP01/10	2m wide NE-SW trending fracture-set outcropping in mudstone to the east of the drill-site, dips 78°SE. Borehole sited 12m SE of fracture zone center. Site selected due to proximity to proposed reservoir.

The technical and geohydrological results of the drilling programme are summarized in **Table 4** and indicate the following:

- Boreholes drilled on A-rated targets tend to yield better results than those drilled on lower rated targets (see A-rated boreholes TP01/02, /03, /09 and B-rated borehole TP01/08 compared to C+ rated borehole TP01/10 – also note that at borehole TP01/08 the optimal drill-site was inaccessible).

- Problems of gaining access to optimal A-rated drill targets, which are commonly located alongside the major drainage features, results in substantially lower borehole yields, especially when attempting to drill such targets on the more accessible but topographically elevated areas (see A-rated boreholes TP01/04 and TP01/05). In such rugged terrain, the cost effectiveness of constructing temporary roads to such drill targets should be considered given the greater probability of obtaining higher and more sustainable yielding boreholes.

- Structural features located in the field and not identified during the GIS analysis process often do not produce the desired results (i.e. boreholes TP01/06 and TP01/07), as these features are commonly not associated with the major tectonic structures in the area. This is because the major geological structures are often more easily detected on large-scale remotely-sensed imagery than in the field.

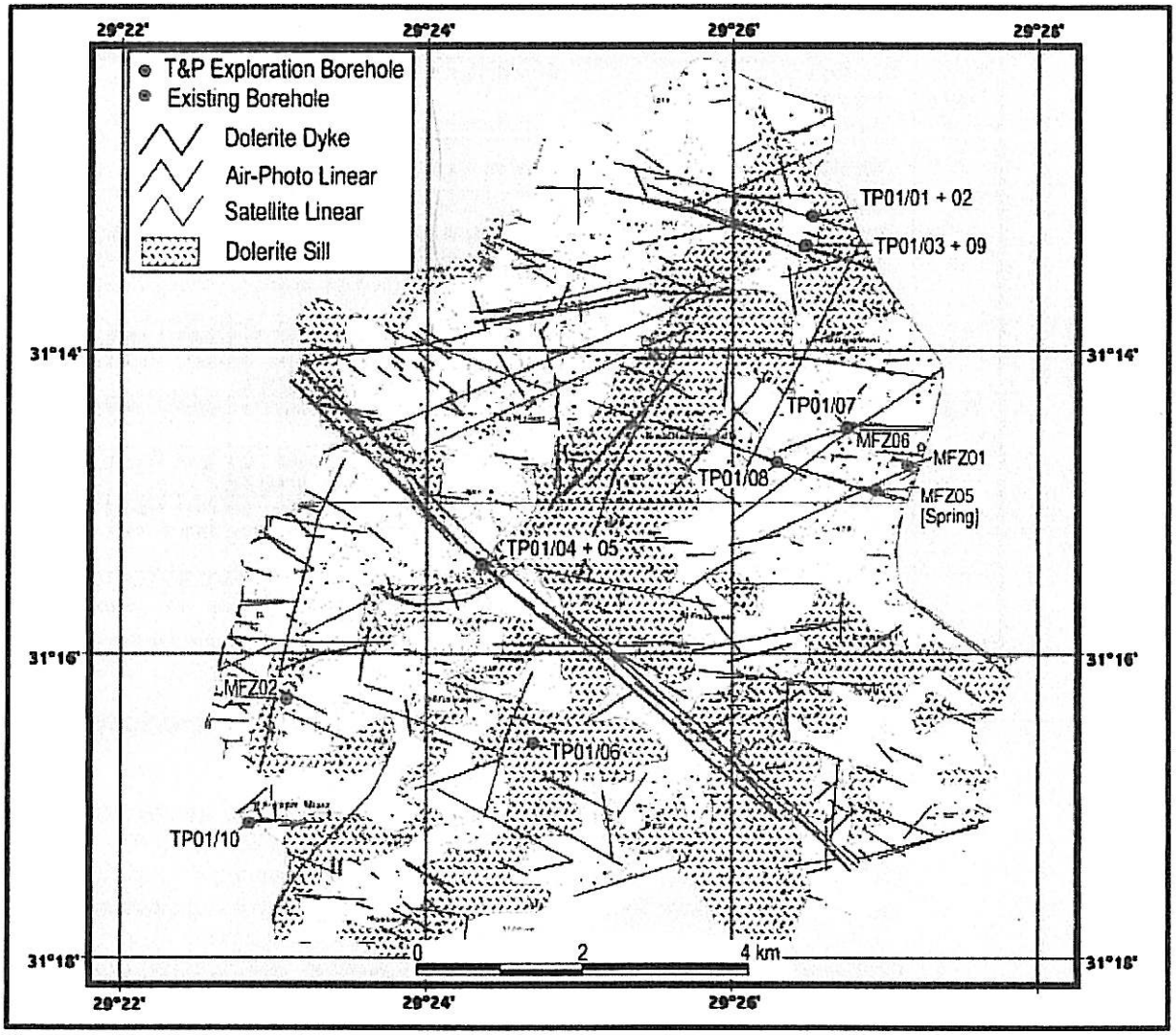

Figure 6: Map indicating T&P exploration and existing boreholes in the study area

Boreholes TP01/02, /03, /08 and TP01/09 yielded sufficient quantities of groundwater and were selected for pump-testing.

9.0 PUMP-TESTING

Caser Construction conducted step-drawdown and constant-discharge pump tests on four of the exploration boreholes, namely TP01/02, 03, 08 and TP01/09, over the period 5th to the 20th June 2001. The technical specifications of the step-drawdown and constant-discharge pumping-tests are summarized in **Tables 5** and **6**, respectively. The pump-test raw data is contained in **Appendix B**.

Table 4: Summary of the Geohydrological and Technical Results of the Drilling Programme

Borehole Number	Final Depth (m)	Water Strike (m. bgl)	Cumulative Yield (l/s)	Casing Depth (m)	Slotted Zone (m)	Water Level (m. bgl)	E.C. (mS/m)	Comments
TP01/01	30	25	0.50	-	-	-	25	Abandoned as drill-bit stuck in hole. Water intersected in fractured dolerite sill.
TP01/02	81	20-23	1.20	27 x 165mm	21-24	0.47	-	Blow-yield decreased to 1.0 l/s by 81m, replacement borehole for TP01/01.
TP01/03	101	11	0.25	20 x 203mm	14-20	1.00	-	Blow-yield decreased to 0.8 l/s at 46m. Dolerite intersected at 13m.
		13-16	0.80	22 x 165mm	10-22		30	
		20	12.00				32	
		47	1.00				34	
		53-56	2.30				35	
		60	3.15				37	
		69	4.20				34	
		76	5.60				35	
		89	8.00				39	
TP01/04	146	124	0.13	22 x 165mm	-	115.61	50	Correcting sited on dolerite dyke, but topographically high-lying area.
TP01/05	151	-	Dry	-	-	-	-	12m south of TP01/04 - destroyed
TP01/06	81	11-14	0.25	12 x 165mm	9-12	3.16	38	Borehole sited NE of optimum site due to lack of access.
		57	0.30				42	
TP01/07	121	9-10	0.20	12 x 165mm	9-12	2.76	27	
		84	0.30				28	
		104	0.35				28	
TP01/08	121	11	0.10	13 x 203mm	-	2.56		Water strike at 11m cased off. Borehole collapsed at 82m. Clay filled fractures and fault (82-91m) result in low yields.
		13-19	0.30	21 x 165mm	15-21		27	
		28	0.45				27	
		55	0.65				35	
TP01/09	71	11	0.85	21 x 203mm	12-21	1.35	26	
		16	2.60	27 x 165mm	12-27		37	
		21	6.50				37	
		22	8.00				37	
		26	9.80				37	
		30.5	10.60				37	
		33	12.00				37	
		35.5	12.65				37	
		40	14.00				37	
		46	16.00				37	
TP01/10	76	-	-	-	-	-	-	Dry - destroyed

Table 5: Step-Drawdown Pumping Tests - Technical Information

Borehole Number	Rest-Waterlevel (m.bgl) [Date - Time]	Step-Drawdown Test						
		No.	Time (min)	Yield (l/s)	Max. Drawdown (m.bgl)	Recovery		Depth Pump Inlet (m.bgl)
						Time (min)	Deficit	
TP01/02	0.87 [06/06/01 – 08h10]	1	60	0.60	12.10			57.5
		2	60	1.00	30.00			
		3	21	1.55	54.82	120	0.53	
TP01/03	1.00 [07/06/01 – 13h40]	1	60	1.70	1.42			87.5
		2	60	3.10	3.05			
		3	60	7.20	7.01			
		4	60	13.00	15.64	120	1.61	
TP01/08	2.13 [22/06/01 – 16h45]	1	60	0.28	5.11			32.8
		2	60	0.41	9.43			
		3	64	0.62	29.42	120	1.13	
TP01/09	1.83 [15/06/01 – 11h05]	1	60	3.04	2.61			52.0
		2	60	6.05	5.88			
		3	60	10.53	11.37			
		4	60	16.36	19.91	120	1.79	

Note:
- Deficit – Difference (m) between the pre-test rest-waterlevel and the final waterlevel measured at the end of the recovery period.

Table 6: Constant Discharge Pumping Tests - Technical Information

Borehole Number	Start Date and Time	Rest-Waterlevel (m.bgl)	Yield (l/s)	Depth Pump Inlet (m.bgl)	Drawdown		Recovery	
					Duration (min)	Max (m)	Duration (min)	Deficit (m)
TP01/02 [P]	06/06/01 13h15	0.47	0.73	57.5	1440	19.21	960	0.03
TP01/03 [P]	09/06/01 11h00	1.00	7.14	87.5	4320	41.26	2880	1.07
TP01/08 [P]	23/06/01 08h26	2.13	0.42	32.8	1440	16.45	1440	0.11
TP01/09 [P]	16/06/01 07h50	1.83	10.7	52.0	4320	16.10	2280	2.26
TP01/03 [O]		1.00	-	-	4320	5.00	2280	2.17

Note:
- [P] – Production Borehole, [O] – Observation Borehole.
- Deficit – Difference (m) between the pre-test rest-waterlevel and the final waterlevel measured at the end of the recovery period.
- Borehole TP01/09 is 25m from borehole TP01/03.

The waterlevel drawdown and recovery phases of the step-drawdown and constant-discharge tests were evaluated with the aim of assessing (i) the optimal borehole yield for design of pump equipment and (ii) the long-term sustainable yield of each borehole for management purposes. The recommended optimal pump rates and abstraction management strategy for the four proposed production boreholes are presented in **Table 7**.

It must be noted that borehole TP01/03 and TP01/09 are situated on the same structure and are 30m apart. It is estimated that boreholes TP03 and TP09 could be pumped simultaneously at a combined rate of 9.0 l/s for 8 hours per day - setting pumping rates of 3 and 5 l/s in boreholes TP03 and TP09, respectively. The combined maximum yield of these boreholes is estimated at 7 700 m^3/month or 257 m^3/day.

Table 7: Recommended Optimal Pump Rates and Abstraction Schedules for Proposed Production Boreholes

Borehole Number	Depth of Pump Inlet (m.bgl)	Recommended Pump-Rate[B] (l/s)	Recommended Daily Pumping Schedule (hrs/day)	Critical[A] Rest-Waterlevel (m.bgl)	Maximum Monthly Abstraction (m^3/month)
TP01/02	20.0	0.80	12.0	17.0	960
TP01/03	60.0	6.00	10.0	14.0	5 400
TP01/08	30.0	0.30	12.0	12.0	360
TP01/09	32.0	7.50	10.0	15.0	6 750

NOTE:
A - This is a "critical" **rest-waterlevel** at which the yield of the borehole will decline rapidly and possible physical damage (borehole collapse, screen encrustation etc.) may occur in the borehole with prolonged abstraction.
B - is the maximum immediate yield at which the borehole should be pumped, a lower yield may also be used.
Maximum Monthly Abstraction (m^3) ≅ "Safe Yield" of the borehole. The optimal yield and recommended pumping schedule (hrs/day) will not necessarily equate to the Maximum Monthly Abstraction - implying that the borehole will be pumped intermittently. **This monthly volume should never be exceeded.**

Analysis of the drilling and pumping-test information indicates that the combined long-term sustainable yield of these boreholes is **±9 020 m^3/month** or **301 m^3/day** (i.e. 3.5 l/s). This implies an excess capacity of 17 m^3/day.

The long-term sustainable yield of an aquifer is generally determined by balancing the inputs (recharge etc.) with the outputs (abstraction, evapotranspiration) from the system. Recharge from rainfall is the main input to such aquifer systems. The proposed production boreholes TP01/02, /03 and TP01/09 lie within the same groundwater unit (**Figure 7**) and are thus likely to influence one another with long-term abstraction. The groundwater unit has an areal extent of 2.23 km^2. Note that the groundwater unit was defined using the local geology and surface water catchment. In order to avoid over exploitation of the resource it is recommended that the abstraction from the groundwater unit does not exceed the Mean Annual Recharge (MAR). The groundwater unit receives a mean annual recharge of 133 000 m^3 or 364 m^3/day (from Woodford, 1999), whilst the combined maximum recommended abstraction from boreholes TP01/02, 03 and TP01/09 is 106 000 m^3 per annum (i.e. 27 000 m^3/annum below the MAR).

10.0 GROUNDWATER CHEMISTRY

The salinity of the groundwater in the study area is low, with an EC of less than 50 mS/m (**Tables 2** and **4**).

Three groundwater samples were drawn from boreholes TP01/02, /03 and TP01/08 during the pumping-tests, and submitted to the CSIR laboratories in Stellenbosch for selected macro-chemical analysis. The laboratory results are contained in **Appendix C**. All the tested chemical constituents fall within the maximum limits for domestic use with insignificant risk (SABS, 1984 - **Appendix D**). The bacteriological content of the groundwater must, however, be determined before it is incorporated into the supply scheme. The production boreholes should also be fenced-off to avoid livestock activity in the vicinity of the bores.

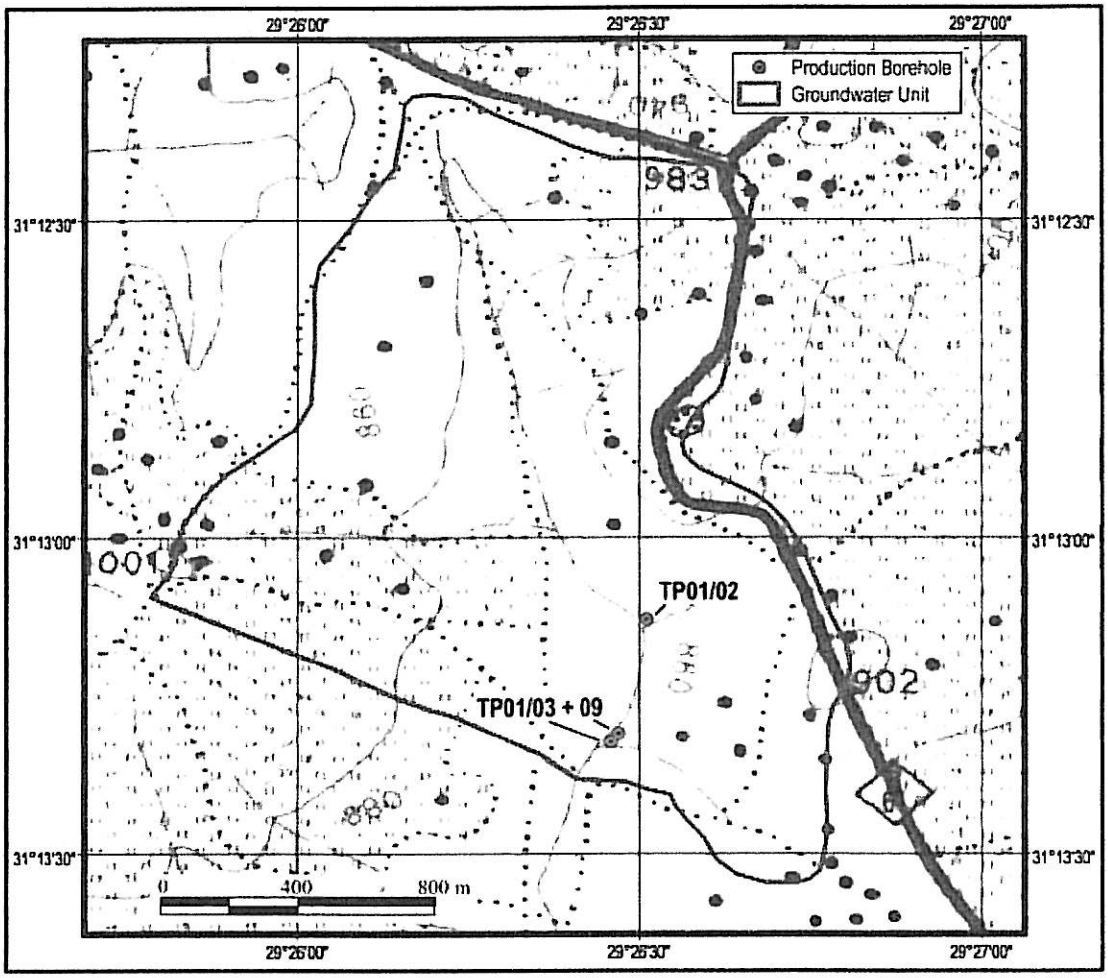

Figure 7: Outline of Groundwater Unit containing proposed Production Boreholes TP01/02, TP01/03 and TP01/09

11.0 CONCLUSIONS AND RECOMMENDATIONS

Toens and Partners sited and drilled ten exploration boreholes as part of the Mfinizweni Bulk Water Supply (MBWS) project on behalf of Fongoqa Skade Toyi and Associates. Pumping-tests were conducted on four of the exploration boreholes that were relatively high-yielding, namely TP01/02, /03, /08 and TP01/09. Analysis of the drilling and pumping-test information indicates that the combined long-term sustainable yield of these four boreholes is 108 240 m^3 per annum or 301 m^3/day. The salinity of the groundwater is low (electrical conductivity of less than 50 mS/m) and its macro-chemical constituents indicate that it is fit for domestic consumption.

In light of the above, it is recommended that:

1. Boreholes TP01/02, TP01/03 and TP01/09 should be equipped with pumps capable of delivering water at rates of 0.8, 3.0 and 5.0 l/s, respectively.

2. Borehole TP01/08 should be equipped with an engine (as per **Table 7**), to serve as an emergency standby production well, as well as to supplement the existing supply during peak water demand periods or during dry spells.

3. The bacteriological content of the groundwater from each source must be determined before it is incorporated into the supply scheme. However, to prevent any health risks it is strongly recommended that all water used for domestic purposes be adequately disinfected prior to usage.

4. All four of the proposed production boreholes fall within Supply Zone 1 (**Figure 2**) and it is therefore recommended that the groundwater be piped from this zone to the proposed reservoirs in the remaining three zones.

5. Alternatively, tempory roads could be constructed to the optimal drill sites and additional boreholes drilled at the three A-grade drill targets located on a NW trending dolerite dyke to the south of Lalini (**Figure 4**), along the boundary between Supply Zones 3 and 4.

6. The feasibility of developing the spring (MFZ05 in Supply Zone 4) as part of the water-supply scheme should be investigated. The long-term sustainable yield of the spring should be established by monitoring the monthly rate of flow and rainfall for at least 12 months.

7. It is extremely important that a groundwater monitoring system be established where:

   a. The waterlevels in the four production boreholes, as well as in TP01/01, are recorded on a monthly basis. The rest-waterlevel within a particular production borehole should not be allowed to drop below the critical-level indicated in **Table 7**.
   b. A flow-meter should be installed on the outlet of the main collector-reservoir in order to measure the total volumes of groundwater abstracted from the production boreholes on a monthly basis and to ensure that the total volumes abstracted do not exceed 9 020 m^3/month.
   c. The abstraction from the individual boreholes should be measured and recorded on at least a quarterly basis.
   d. The macro-chemistry and bacteriological content of the water should be determined on an annual basis (i.e. sampled from the main collector-reservoir).
   e. A rain-gauge should be installed at Mfinizweni village and the monthly rainfall (mm) recorded.
   f. A qualified hydrogeologist should assess this information after approximately 12 months of abstraction, where it will be possible to more accurately determine the long-term sustainable yield of the production boreholes.

REFERENCES

Karpeta, W.P. and Johnson, M.R., (1979): **The Geology of the Umtata Area - Explanation to Sheet 3222**, 1/250 000 scale geological map, Geological Survey, Department of Mines, Pretoria, 14p.

Rasmussen, J., (1997): **Peddie South Final Report**, Technical Report No. 970131b, Toens and Partners, Wynberg.

Rasmussen, J., (1998): **Mqanduli Rural Area - Groundwater Investigation – Phase 3**, Technical Report No. 980153, Toens and Partners, Wynberg.

Schultze, R.E., (1997): **South African Atlas of Agrohydrology and – Climatology**, Water Research Commission, Technical Report, T82/96, Pretoria

South African Committee for Stratigraphy (SACS), 1980. **Stratigraphy of South Africa.** Part 1 (Comp. L.E. Kent). Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia, and the Republics of Bophuthatswana, Transkei en Venda: Handb. Geol. Surv. S. Afr., No. 8.

Woodford, A.C., (1999): **Groundwater Resources of the T60 Drainage Region**, Technical Report No. 990200 for the Uhlmann Witthaus & Prins Consulting Engineers, Toens and Partners, Wynberg, 86p.

APPENDIX A

Geohydrological Logs of Exploration Boreholes

APPENDIX A

BOREHOLE NUMBER: TP01/01					
Depth Interval (m)	Geology	Water Strike (m)	Yield (l/s)	E.C. (mS/m)	Comments
0-1	Grey, clayey topsoil.				Borehole abandoned due to lost drill bit.
-10	Red clay.				
-22	Decomposed, yellow dolerite clay, with boulders.				
-28	Weathered grey dolerite.	25	0.50	25	
-30	Fresh grey dolerite.				

BOREHOLE NUMBER: TP01/02					
Depth Interval (m)	Geology	Water Strike (m)	Yield (l/s)	E.C. (mS/m)	Comments
0-1	Grey, clayey topsoil.				Replaces TP2001/01.
-6	Red clay.				
-23	Fractured grey dolerite with lots of iron staining.	12-23	1.20	25	Final blowyield 1.00 l/s.
-61	Fresh dark grey coarse-grained dolerite.				
-65	Well-jointed greenish olivine-rich dolerite.				
-71	Coarse-grained grey olive-rich dolerite.				
-81	Medium grained dark grey dolerite – solid.				
	10 m West of TP2001/01				

BOREHOLE NUMBER: TP01/03					
Depth Interval (m)	Geology	Water Strike (m)	Yield (l/s)	E.C. (mS/m)	Comments
0-1	Dark brown, clayey topsoil.	11	0.25	30	
-7.5	Yellow clay.	13-16	0.80	30	
-13	Weathered, grey dolerite.	19.5		32	
-21	Fractured shale, with iron staining - fragments 75mm	20	12.00	32	Decreased to 0.8 l/s at 46m
-24	Jointed, blue-grey mudstone.				
-29	Fresh medium grained grey dolerite				
-30	Light grey mudstone.				
-33	Purple, mudstone.				
-39	Light grey, mudstone.				
-46	Purple mudstone, with calcite veining.				
-47	Well-jointed mudstone, with lots of calcite.	47	1.00	34	
-51	Purple mudstone.				
-62	Purple mudstone, with calcite veining and pyrite.	53-56	2.30	35	
-67	Fresh light grey mudstone.	60	3.15	37	
-72	Jointed blue-grey mudstone, with staining and calcite.	69	4.20	34	
-76	Well-jointed mudstone, with lots of calcite.	76	5.60	35	
-87	Grey mudstone, with some calcite.				
-90	Well-jointed mudstone, with lots of calcite.	89	8.00	39	
-101	Grey mudstone, with some calcite.				

APPENDIX A

BOREHOLE NUMBER: TP01/04					
Depth Interval (m)	Geology	Water Strike (m)	Yield (l/s)	E.C. (mS/m)	Comments
0-1	Dark brown manganese rich topsoil				
-25	Yellow clayey weathered mudstone				
-33	Brown weathered dolerite				
-42	Dark grey medium grained dolerite				
-44	Fractured grey dolerite - fragments 50-70mm diameter.				
-58	Olivine-rich greenish dolerite				
-62	Well jointed grey dolerite with calcite veins				
-104	Fresh fine grained blue-grey dolerite				
-105	Coarse grained grey dolerite with calcite veins				
-123	Fresh fine grained blue-grey dolerite				
-127	Well jointed and stained medium grained dolerite	124	0.13	50	Waterlevel 115.61 m.bgl
-129	Fresh fine grained dark grey dolerite				
-132	Jointed and stained coarse grained dolerite				
-146	Fresh fine grained dark grey dolerite				

BOREHOLE NUMBER: TP01/05					
Depth Interval (m)	Geology	Water Strike (m)	Yield (l/s)	E.C. (mS/m)	Comments
0-17	Yellow clayey weathered mudstone				12m South of TP2001/04
-37	Very fine grained dark grey dolerite				Dry - Destroyed
-38	Well jointed fine grained dolerite with iron staining				
-43	Very fine grained dark grey dolerite - some joints				
-45	Fractured fine gr. dolerite - fragments 15mm max.				
-76	Very fine grained dark grey dolerite - some joints				
-77	Fractured fine gr. dolerite with iron staining (10mm)				
-84	Fresh fine grained blue-grey dolerite				
-98	Medium grained olivine rich dolerite				
-150	Fresh fine grained dark grey dolerite				

BOREHOLE NUMBER: TP01/06					
Depth Interval (m)	Geology	Water Strike (m)	Yield (l/s)	E.C. (mS/m)	Comments
0-2	Brown clayey topsoil.				
-4	Yellow clay.				
-11	Yellow clayey weathered shale.	11-14	0.25	38	
-14	Fractured dark grey dolerite.				
-55	Fresh fine-grained dark grey dolerite.				
-60	Well-jointed dark grey dolerite, with calcite veins.	57	0.30	42	
-81	Fresh fine-grained dark grey dolerite.				

BOREHOLE NUMBER: TP01/07					
Depth Interval (m)	Geology	Water Strike (m)	Yield (l/s)	E.C. (mS/m)	Comments
0-1	Brown clayey topsoil.				
-3	Yellow clayey weathered mudstone.				
-10	Weathered dolerite boulders with clay.	9-10	0.20	27	
-55	Fresh fine-grained dark grey dolerite.				
-56	Jointed fine-grained grey dolerite.				
-83	Fresh fine-grained dark grey dolerite.				
-84	Well-jointed dolerite with lots of calcite.	84	0.30	28	
-103	Fresh fine-grained grey dolerite - lighter color 101m+.				
-104	Well- jointed dolerite with lots of calcite.	104	0.35	28	
-121	Fresh very fine-grained grey dolerite.				

BOREHOLE NUMBER: TP01/08					
Depth Interval (m)	Geology	Water Strike (m)	Yield (l/s)	E.C. (mS/m)	Comments
0-1	Brown clayey topsoil.				
-2	Dolerite boulders with clay.				
-4	Yellow clay.				
-11	Highly weathered dolerite.	11	0.10		
-12	Yellow clay - weathered dolerite.				
-19	Grey weathered dolerite.	13-19	0.30	27	
-21	Jointed blue-grey dolerite.				
-23	Weathered dolerite with white clay.				
-26	Jointed blue-grey coarse-grained dolerite.				
-30	Weathered dolerite, with white clay.	28	0.45	27	
-34	Jointed grey dolerite.				
-35	Light grey coarse-grained dolerite.				
-41	Well-jointed light grey dolerite, with iron staining.				
-42	Fine-grained dark grey dolerite.				
-43	Well-jointed coarse-grained light grey dolerite.				
-52	Dark shale – well-jointed with lots of calcite (?).				
-56	Fractured shale with lots of white clay.	55	0.65	35	
-60	Well-jointed black shale - chloride staining.				
-63	Fresh black shale				
-65	Well-jointed black shale - chloride staining.				
-74	Fresh black shale.				
-75	Well-jointed black shale, with white clay.				
-82	Black shale, with some joints.				
-91	Fractured grey shale with lots of white kaolin clay.				Main fault zone - borehole collapses
-98	Grey shale with some joints.				
-100	Well-jointed grey shale, with white clay.				
-104	Grey shale, with some joints.				
-106	Well-jointed grey shale, with white clay and weathering.				
-118	Fresh grey shale.				
-121	Clayey jointed black shale.				

APPENDIX A

BOREHOLE NUMBER: TP01/09					
Depth Interval (m)	Geology	Water Strike (m)	Yield (l/s)	E.C. (mS/m)	Comments
0-1	Brown clayey topsoil.	11	0.85	26	
-2	Yellow clay.	16	2.60	37	
-4	Black clay.	21	6.50	37	
-23	Weathered dolerite.	22	8.00	37	
-26	Fractured dolerite.	26	9.80	37	
-30	Light grey coarse-grained dolerite.	30.5	10.60		
-33	Fractured dolerite.	33	12.00	37	
-35	Light grey coarse-grained dolerite.				
-36	Fractured dolerite.	35.5	12.65	37	
-38	Fresh light grey dolerite.				
-39	Jointed light grey dolerite, with calcite.				
-40	Fractured dolerite.	40	14.00	37	Max pump-test yield > 19 l/s
-45	Fresh light grey dolerite.				
-46	Fractured dolerite.				
-56	Fresh light grey fine-grained dolerite.				
-58	Well-jointed dolerite - partially weathered.				
-71	Fresh light grey fine-grained dolerite.				

BOREHOLE NUMBER: TP01/10					
Depth Interval (m)	Geology	Water Strike (m)	Yield (l/s)	E.C. (mS/m)	Comments
0-1	Reddish brown clayey topsoil.				Dry - Destroyed
-2	Black clay.				
-4	Jointed & weathered dolerite.				
-21	Fresh fine-grained grey dolerite.				
-22	Jointed grey dolerite with calcite veins.				
-34	Medium grained grey dolerite – fresh.				
-76	Dark grey dolerite - Very fine grained and hard.				

APPENDIX B

Pumping-Test Data

APPENDIX B

Borehole Number: TP01/02 **Rest Water Level (m):** 0.47

Date Started: 06/06/2001 **Time Started:** 08h10

Pump Inlet (m): 57.5 **STEP-DRAWDOWN TEST**

Pumping Time (min)	Step 1		Step 2		Step 3	
	Pump Yield (l/s)	Draw= down (m)	Pump Yield (l/s)	Draw= down (m)	Pump Yield (l/s)	Draw= down (m)
1		1.71		12.98		31.90
2		2.18		14.62		34.54
3		2.76	0.9	15.30	1.5	37.48
4		3.12		16.12		41.38
5		3.50	1.0	16.93	1.6	42.81
6		3.82		17.94		46.73
8	0.6	4.25		18.96	1.6	48.30
10		4.42	1.0	19.77		52.43
12	0.6	4.66		20.41	1.6	54.82
15		5.02		20.86	1.0	54.82
18	0.6	5.40	1.0	21.45	1.1	54.82
21		7.17		21.84	1.1	54.82
25	0.6	9.12	1.0	22.61		
30		10.74		23.43		
35	0.6	11.25	1.0	24.30		
40		11.60		25.07		
45	0.6	11.77	1.0	25.89		
50		11.91		26.96		
60	0.6	12.10	1.0	30.00		
70						
85						
100						
120						
140						
Average	**0.6**		**1.0**		**1.3**	

Borehole Number:	**TP01/02**	**Rest Water Level (m. b.collar):**	0.47
Date started:	07/06/2001	**Time started:**	13h15
Pump Intake (m):	57.5	**CONSTANT-DISCHARGE TEST**	

Pumping Time (min)	Draw= down (m)	Pump Yield (l/s)	E.C. (mS/m)	Remarks	Recovery (m)
1	3.12				14.74
2	4.94	0.7			12.65
3	6.3				10.99
5	8.27	0.7			7.48
7	11.08				6.97
10	13.05	0.7			5.36
15	14.85				3.74
20	15.98	0.7			2.78
30	16.82				1.81
40	17.04	0.7			1.45
60	17.24				1.09
90	17.87	0.7			0.86
120	17.91				0.73
150	17.98	0.7			0.65
180	18.02				0.59
210	18.04	0.7			0.54
240	18.06				0.49
300	18.07	0.7			0.43
360	18.09				0.38
420	18.11	0.7			0.33
480	18.12				0.27
540	18.16	0.7			0.24
600	18.21				0.18
720	18.36	0.7			0.12
840	18.42				0.07
960	18.64	0.7			0.03
1080	18.85				0
1200	18.95	0.7			
1320	19.11	0.7			
1440	19.21	0.7			
1800					
2280					
2880					
3480					
3900					
4320					
Average		**0.73**			

APPENDIX B

Borehole Number: TP01/03 **Rest Water Level (m):** 1.00

Date Started: 08/06/2001 **Time Started:** 13h40

Pump Inlet (m): 87.5 **STEP-DRAWDOWN TEST**

Pumping Time (min)	Step 1		Step 2		Step 3		Step 4		Recovery (m)
	Pump Yield (l/s)	Draw= down (m)	Pump Yield (l/s)	Draw= down (m)	Pump Yield (l/s)	Draw= down (m)	Pump Yield (l/s)	Draw= down (m)	
1		0.35		1.64		3.86		9.10	8.69
2		0.43		1.71		4.27		9.89	7.67
3	1.7	0.52	3.1	1.83		4.48		10.67	6.93
5		0.67		1.96	7.0	4.73		11.52	6.29
7	1.7	0.77	3.1	2.11	7.2	5.06	13.0	11.91	5.87
10		0.85		2.27		5.45		12.39	5.40
15	1.7	0.97	3.1	2.41	7.2	5.80	13.0	13.14	4.87
20		1.05		2.55		6.08		13.46	4.44
30	1.7	1.21	3.1	2.74	7.2	6.53	13.0	14.89	4.08
40		1.30		2.88		6.81		15.24	3.65
50	1.7	1.37	3.1	2.94	7.2	6.92	13.0	15.47	3.27
60	1.7	1.42	3.1	3.05	7.2	7.01	13.0	15.64	3.08
70									2.57
80									2.35
90									2.15
100									1.97
110									1.79
120									1.61
150									
180									
Average	**1.7**		**3.1**		**7.2**		**13.0**		

Borehole Number: TP01/03 **Rest Water Level (m. b.collar):** 1.00
Date started: 09/06/2001 **Time started:** 11h00
Pump Intake (m): 87.5 **CONSTANT-DISCHARGE TEST**

Pumping Time (min)	Draw=down (m)	Pump Yield (l/s)	E.C. (mS/m)	Remarks	Recovery (m)
1	1.03				21.86
2	1.21				19.34
3	1.34				18.40
5	2.06				15.72
7	2.96				15.30
10	3.95	6.99			14.96
15	5.05				14.71
20	5.62	7.98			14.10
30	6.47				14.00
40	7.08	7.02			13.47
60	8.04				13.00
90	8.64	7.01			12.19
120	8.82				11.73
150	8.92	7.02			11.07
180	8.98				10.87
210	9.27	7.03			10.45
240	9.50				10.04
300	9.82	7.10			9.38
360	10.15				9.04
420	10.25	7.12			8.67
480	10.57				8.11
540	10.89	7.10			7.78
600	11.10				7.02
720	11.44	7.11			6.56
840	11.83				5.74
960	12.17	7.12			5.26
1080	12.58				4.99
1200	12.79	7.10			4.74
1320	13.08				4.41
1440	13.32	7.13			4.11
1800	16.12				3.10
2280	18.28	7.12			2.09
2880	21.42				1.07
3480	28.94	7.13			
3900	35.67				
4320	41.26	7.08			
Average		7.14			

APPENDIX B

Borehole Number: TP01/08 **Rest Water Level (m):** 2.13

Date Started: 22/06/2001 **Time Started:** 11:45

Pump Inlet (m): 32.75 **STEP-DRAWDOWN TEST**

Pumping Time (min)	Step 1		Step 2		Step 3		Step 4		Recovery (m)
	Pump Yield (l/s)	Draw= down (m)	Pump Yield (l/s)	Draw= down (m)	Pump Yield (l/s)	Draw= down (m)	Pump Yield (l/s)	Draw= down (m)	
1		0.65		5.25		9.71	1.22	26.28	27.67
2		1.06	0.3	5.35	0.5	9.95	0.79	28.14	25.14
3		1.43		5.50		10.39	0.62	29.42	24.09
4		1.71	0.4	5.74	0.6	10.89	0.62	29.42	22.65
5	0.3	1.93		5.96		11.28			20.14
6		2.12	0.4	6.27	0.6	11.67			19.35
8	0.3	2.43		6.51		12.22			15.15
10		2.68	0.4	6.78	0.6	12.52			13.87
12	0.3	2.89		6.98		12.94			12.31
15		3.07	0.4	7.43	0.6	13.25			9.95
18	0.3	3.26		7.85		14.17			8.66
21		3.45	0.4	8.16	0.6	14.73			7.42
25	0.3	3.79		8.46		15.82			5.97
30		4.08	0.4	8.70	0.6	17.03			4.96
35	0.3	4.42		8.90		18.71			4.08
40	0.3	4.61	0.4	9.08	0.6	20.02			3.50
45		4.77		9.25		21.47			3.05
50	0.3	4.92	0.4	9.32	0.6	22.75			2.69
60		5.11		9.43		24.92			2.18
70									1.83
85									1.50
100									1.26
120									1.13
140									
Average	**0.28**		**0.39**		**0.60**		**0.81**		

Borehole Number:	**TP01/08**	**Rest Water Level (m b.collar):**	0.41
Date started:	23/06/2001	**Time started:**	8:26
Pump Intake (m):	32.75	**CONSTANT-DISCHARGE TEST**	

Pumping Time (min)	Draw=down (m)	Pump Yield (l/s)	E.C. (mS/m)	Remarks	Recovery (m)
1	1.94			Water turbidity cleared after 13h40	14.45
2	2.93				13.20
3	3.95	0.4			12.52
5	5.67				10.69
7	6.07	0.4			8.93
10	6.62				7.25
15	8.17	0.4			5.21
20	9.22				4.26
30	10.39	0.4			3.46
40	10.87				2.97
60	11.54	0.4			2.34
90	12.09				1.91
120	12.59	0.4			1.61
150	12.91				1.45
180	13.10	0.4			1.36
210	13.20				1.29
240	13.41	0.4			1.12
300	13.52				1.00
360	13.74	0.4			0.96
420	13.97				0.92
480	14.00	0.4			0.81
540	14.25				0.72
600	14.34	0.4			0.64
720	14.43				0.55
840	14.62				0.43
960	14.81				0.31
1080	15.78				0.22
1200	16.16				0.17
1320	16.24				0.11
1440	16.45				
1800					
2280					
2880					
3480					
3900					
4320					
	Average	**0.4**		**Volume Pumped (Kl) = 35.7**	

Borehole Number: TP01/09 **Rest Water Level (m):** 1.83
Date Started: 15/06/2001 **Time Started:** 11:05
Pump Inlet (m): 52 **STEP-DRAWDOWN TEST**

Pumping Time (min)	Step 1		Step 2		Step 3		Step 4		Recovery (m)
	Pump Yield (l/s)	Draw=down (m)	Pump Yield (l/s)	Draw=down (m)	Pump Yield (l/s)	Draw=down (m)	Pump Yield (l/s)	Draw=down (m)	
1		1.08		3.61		7.88		15.91	9.01
2		1.13		3.85	10.01	8.23	16.44	16.33	5.71
3	2.5	1.38	6.03	4.05	9.93	8.80	16.35	16.91	4.64
4	3.1	1.56		4.16	10.07	9.20		17.04	4.35
5		1.60	6.04	4.31		9.43	16.36	17.56	4.22
6	3.1	1.63		4.43	10.71	9.58		17.68	3.96
8		1.78	6.04	4.60		9.80	16.37	17.95	3.80
10	3.1	1.85		4.72	10.71	9.92		18.23	3.61
12		1.92	6.03	4.83		10.10	16.36	18.41	3.52
15	3.1	2.02		4.91	10.72	10.35		18.60	3.37
18		2.07	6.02	5.00		10.57	16.35	18.74	3.19
21	3.1	2.16		5.10	10.73	10.67		18.95	3.06
25		2.21	6.03	5.20		10.73	16.34	19.04	2.96
30	3.1	2.26		5.32	10.73	10.84		19.10	2.84
35		2.35	6.11	5.44		10.93	16.35	19.21	2.71
40	3.1	2.41		5.53	10.73	11.04		19.32	2.64
45		2.48	6.10	5.64		11.16	16.34	19.54	2.56
50		2.54		5.78	10.73	11.24		19.73	2.47
60	3.1	2.61	6.09	5.88	10.74	11.37	16.35	19.91	2.35
70									2.18
85									2.04
100									19.10
120									1.79
140									
Average	**3.04**		**6.05**		**10.53**		**16.36**		

PRODUCTION BOREHOLE

Borehole Number:	**TP01/09**	**Rest Water Level (m. b.collar):**	1.83
Date started:	16/06/2001	**Time started:**	7:50
Pump Intake (m):	52	CONSTANT-DISCHARGE	

Pumping Time (min)	Draw= down (m)	Pump Yield (l/s)	E.C. (mS/m)	Remarks	Recovery (m)
1	6.21				7.82
2	7.20	10.7			7.17
3	7.81				7.04
5	8.19	10.7			6.85
7	8.63				6.74
10	9.10	10.7			6.65
15	9.97				6.44
20	10.58	10.7			6.32
30	11.18				6.22
40	11.74	10.7			6.13
60	12.20				5.93
90	12.63	10.7			5.69
120	12.74				5.51
150	12.86	10.7			5.25
180	13.03				5.23
210	13.10	10.7			5.12
240	13.19				5.02
300	13.28	10.7			4.82
360	13.37				4.70
420	13.52	10.7			4.50
480	13.69				4.37
540	13.78	10.7			4.16
600	13.84				4.08
720	13.92	10.7			3.86
840	13.98				3.71
960	14.09	10.7			3.63
1080	14.18				3.52
1200	14.29	10.7			3.34
1320	14.41				3.19
1440	14.58	10.7			2.96
1800	14.91				2.47
2280	15.22	10.7			2.26
2880	15.50				1.07
3480	15.67	10.7			
3900	15.89				
4320	16.10	10.7			
	Average	**10.7**		**Volume Pumped (Kl) = 2765.2**	

APPENDIX B

OBSERVATION BOREHOLE:

Obs. Borehole Number:	**TP01/03**	**Rest Water Level (m .b.collar):**	1.83
Date started:	16/06/2001	**Time started:**	7:50
Radial Distance (m):	25	**CONSTANT-DISCHARGE TEST**	

Pumping Time (min)	Draw= down (m)	Remarks	Recovery (m)
1	0.13		
60	0.92		4.74
120	1.56		4.61
180	1.97		4.49
240	2.28		
300	2.32		4.30
360	2.54		4.15
420	2.72		4.05
480	2.83		3.95
540	2.95		3.88
600	3.07		3.71
720	3.11		3.63
840	3.17		3.56
960	3.21		3.41
1080	3.28		3.27
1200	3.32		3.00
1320	3.38		2.82
1440	3.42		2.60
1800	3.68		2.26
2280	3.87		2.17
2880	4.05		
3480	4.54		
3900	4.82		
4320	5.00		

APPENDIX C

Macro-Chemistry of Groundwater from selected Production Boreholes

Mfinizweni Geohydrological Investigation:

	Borehole Number		
	TP01/02	**TP01/03**	**TP01/08**
Sample Date	07/06/01	12/06/01	24/06/01
EC (mS/m) 25°C	22	28	26
TDS (mg/l)	141	179	166
pH (Lab)	7.8	7.6	7.8
Na (mg/l)	15	20	16
Ca (mg/l)	16	16	12
Mg (mg/l)	9	13	16
K (mg/l)	0.5	0.6	0.8
Cl (mg/l)	14	29	11
SO_4 (mg/l)	0.8	1.5	1.4
F (mg/l)	<0.1	<0.1	<0.1
Alkalinity $CaCO^3$ (mg/l)	87	84	113
$NO_2 + NO_3$ as N (mg/l)	0.7	3.0	0.6
Hardness $CaCO^3$ (mg/l)	77	93	96
SAR	0.7	0.9	0.7
Exceeds SA Water Quality Guidelines for Domestic Use Maximum Limit for Insignificant Risk (see Appendix D).			

APPENDIX D

South African Water Quality Guidelines, Volume 1, Domestic Use (SABS, 1984)

APPENDIX D

Water Quality Variable	Units	Guideline Limits		
		Maximum Limit for No risk	Maximum Limit for Insignificant risk	Maximum Limit for low risk
Physical & Organoleptic				
Colour	mg/l Pt	20	-	-
Conductivity	mS/m (20°C)	70	300	400
DOC	mg/l	5	10	20
Dissolved Oxygen	% saturation	70	30	10
Odour	TON	1	5	10
pH	pH units	6.0 – 9.0	5.5 – 9.5	> 4 or < 11
Taste	TTN	1	5	10
Temperature	°C	< 25	< 30	< 40
Turbidity	NTU	1	5	10
Macro-variables				
Aluminum	mg/l Al	0.15	0.5	1.0
Ammonia	mg/l N	1.0	2.0	4.0
Barium	mg/l Ba	0.5	1.0	2.0
Boron	mg/l B	0.5	2.0	4.0
Bromide	mg/l Br	1.0	3.0	6.0
Calcium	mg/l Ca	150	200	400
Cerium	mg/l Ce	1.0	2.0	4.0
Chloride	mg/l Cl	250	600	1 200
Copper	mg/l Cu	0.5	1.0	2.0
Fluoride	mg/l F	1.0	1.5	3.0
Hardness	mg/l $CaCO_3$	20 – 300	650	1 300
Iodide	mg/l I	0.5	1.0	2.0
Iron	mg/l Fe	0.1	1.0	2.0
Lithium	mg/l Li	2.5	5.0	10.0
Magnesium	mg/l Mg	70	100	200
Manganese	mg/l Mn	0.05	1.0	2.0
Nitrates	mg/l N	6.0	10.0	20.0
Potassium	mg/l K	200	400	800
Sodium	mg/l Na	100	400	800
Sulphate	mg/l SO_4	200	600	1 200
Uranium	mg/l U	1	4	8
Zinc	mg/l Zn	1	5	10
Micro-variables				
Antimony	µg/l Sb	50	100	200
Arsenic	µg/l As	100	300	600
Beryllium	µg/l Be	2	5	10
Bismuth	µg/l Bi	250	500	1 000
Cadmium	µg/l Cd	10	20	40
Chromium	µg/l Cr	100	200	400
Cyanide	µg/l CN^-	200	300	600
Gold	µg/l Au	2	5	10
Lead	µg/l Pb	50	100	200
Mercury	µg/l Hg	5	10	20
Molybdenum	µg/l Mo	50	100	200
Nickel	µg/l Ni	250	500	1 000
Selenium	µg/l Se	20	50	100
Silver	µg/l Ag	20	50	100
Tellurium	µg/l Te	2	5	10
Thallium	µg/l Tl	5	10	20
Tin	µg/l Sn	100	200	400
Titanium	µg/l Ti	100	500	1 000
Tungsten	µg/l W	100	500	1 000
Vandium	µg/l V	250	500	1 000

SOURCE: South African Water Quality Guidelines, Volume 1, Domestic Use (SABS, 1984)
mg/l = µg/l / 1000