BRANDVLEI GROUNDWATER (BWS)
(NCR016)

PHASE 3 : IMPLEMENTATION READINESS REPORT

FUNDED BY:	IMPLEMENTING AGENT:	PREPARED BY:
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SEPTEMBER 2013 **(Draft 1)**

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Executive Summary

Introduction

The overall purpose of the project is to provide the community of Brandvlei with drinking water for human consumption. The work discussed in this report is a result of the feasibility report completed by SRK Consulting (SRK) in May 2010, followed by further investigations performed by BVi Consulting Engineers. The recommendation following the SRK study was that the option of Desalination in Brandvlei using existing nearby boreholes for raw feed water supply, was deemed to be the most feasible.

However, most recent research and investigations indicate that high costs of minimum lining requirements for Brine storage ponds, result in very high Capital and Unit costs estimated at R 47.7 milj. and R 9.29 /kL for the RO Desalination option. Therefore, the option for upgrading of the existing Romanskolk pipeline needs to be relooked.

Description of the Project

Option 1 : The project aims to abstract groundwater from identified production boreholes BV1 and BV3 in the Sak River Aquifer close to Brandvlei. The following components will be discussed in the report with regard to installation and costs:

- RO Desalination Plant; Raw Water 0.5 ML Reservoir; Raw Water Supply Line (2,65 km Length); Borehole pump station; Brine Evaporation Ponds (52 000 m2 Surface Area); and High Voltage Electrical Supply Line

The feasibility of abovementioned components is dependent on (a) Current and Projected Water Use, (b) Water Demand versus Aquifer Capacity and (c) Water Quality.

Option 2 : The upgrade of Romanskolk existing water supply via replacement of existing 150 mm A/C line through installation of new 160 mm dia. uPVC pipeline along the existing 42 km route. The existing pipeline was constructed over 45 years ago on private property with no registered servitude or way leaves, which need to be addressed by municipality via agreement with land owners. This option shall include construction of a new gravity pipeline, 0.5 ML Storage reservoir, Power supply line, Pre-Treatment plant and Telemetry system.

Option 3 : The upgrade of Romanskolk existing water supply via replacement of existing 150 mm A/C line with a 200 mm dia. HDPE pipeline by means of Pipe-cracking along the existing 40.5 km route. This option shall also require for servitude or way leaves processes, which need to be addressed by municipality via agreement with land owners. This option shall also include construction of a new gravity pipeline, 0.5 ML Storage reservoir, Power supply line, Pre-Treatment plant and Telemetry system.

Option 4 : The upgrade of Romanskolk existing water supply via installation of a new 160 mm dia. uPVC pipeline along a alternative 52 km route. This option shall also require no servitude registration and the way-leave application was submitted to the Department of Roads and Public Works for final approval. This option shall include the construction of a new 52km gravity pipeline, 0.5 ML Storage reservoir, Power supply line, Pre-Treatment plant and Telemetry system.

Land Use

Option 1 : The final 2.65 km water supply line route falls within Municipal road reserves and no land use problems are foreseen.

Option 2 : The existing Romanskolk pipe line is running through privately owned farm property and no servitudes was registered during its installation in 1965, as farm owners at that stage agreed on good will. The process to register servitudes through consultation and agreements with land owners are problematic and a time consuming process. There are no existing routes to the pipeline to perform routine repair and maintenance work.

Option 3 : The Pipe-Cracking option can resolve the problems of servitude registration. However, the high Capital cost (***R 94 241 168.80)*** and Unit cost (***R 5.55/kL***) makes this option no longer feasible.

Option 4 : This option entails no problems with regard to Land use, as only final approval of the way-leave *application from DPW need to be obtained.*

Impact on the Environment and water related matters

Option 1 : Van Zyl Environmental Consultants was appointed to conduct the environmental impact assessment as per the environmental legal requirements. Consultations with DEA lead to decisive clarity from DWA National office on minimal requirements for lining of Brine effluent storage ponds, which stipulate the use of geo-synthetic clay layers, geo-drains and HDPE geo-membrane layers. The result being an increase in estimated cost for the Brine Evaporation Ponds from R 8.1 milj to R 20.7 milj.

Option 2 : The RBIG March 2013 outcome was that the Romanskolk option should be relooked, due to the high cost for Storage pond Lining system. The Romanskolk option shall require its own EIA process to be followed.

Option 3 : The Pipe-Cracking option shall require a EIA process to be followed, but this option was found to be no longer feasible due to the high Capital and O&M costs.

Option 3 : An EIA process is underway with Enviro Africa appointed to perform the assessment on the alternative 52 km route. The ROD and final approval from DEA is to be finalized during March 2014.

Geography

The topography of the study area is generally characterized by flat, open spaces interspersed with shallow depressions or "pans". The climate of the Northern Cape is typically that of desert and semi-desert with low and erratic rainfall. Summers are hot and dry and the winters cold and frosty. Summer temperatures usually range between 30°and 40°C while winter temperatures range from 3°C to 21°C.

Option 1 : The study area is situated outside of town on flat areas, with reservoir component and infrastructure on steep slopes and hard rock formations at the koppie to Northern boundary of town.

Option 2 & 3 : The existing Romanskolk pipeline stretches for some parts on its length across valleys and low mountain ranges consisting mostly out of hard rock. The pipeline also runs for about 7 km of its length through stretches of brackish pans.

Option 4 : The Romanskolk alternative pipeline route stretches whole of its length across valleys consisting mostly out of intermediate rock. The pipeline also runs for some parts of its length through stretches of brackish pans.

Design Standards

Option 1 : The project was designed taking into account all conventional design standards used in the civil engineering industry.

Option 2 & 4 : For this options conventional engineering design standards were used.

Option 3 : The method of "pipe cracking" is not commonly used and due to its high installation costs, this option was found not feasible with regard to affordability.

Possible problems that may arise as a result of the project

Option 1 : No technical problems were foreseen as a result of the project. Problems with regard to water quality, brine effluent containment and energy cost result in abnormal high unit cost of R9.29 /kL which is problematic in the case of end user affordability.

Option 2 : No technical problems were foreseen and unit cost of R 4.08 /kL relates to existing water tariffs of Hantam Municipality for Brandvlei.

Option 3 : No technical problems were foreseen and unit cost of R 5.55 /kL is higher than the existing water tariffs of Hantam Municipality for Brandvlei.

Option 4 : No technical problems were foreseen and unit cost of R 4.73 /kL relates to existing water tariffs of Hantam Municipality for Brandvlei.

Liaison with parties concerned

A full public participation process will form part of the EIA process which will involve all stakeholders such as government departments and agencies, landowners and other interested parties such as the Archaeological Society. Way-leaves shall be required on project implementation at various institutions.

Comparison of alternatives

The RBPAC outcome of March 2012 indicated that the existing Romanskolk boreholes and pipeline must be reinvestigated as a possible alternative option for water supply to Brandvlei.

The upgrading of the existing Romanskolk water supply pipeline was re-evaluated as possible alternative and compared against the alternative options. The option of Romanskolk water supply via an alternative 52km route is the most feasible option with regard to end user unit cost, as well as lower O&M costs for municipality.

Cost Estimate

The total project and O&M cost (incl. VAT) for this project is estimated to be as follows:

	Brandvlei Desalination	***Romanskolk via Alternative Route***	***Romanskolk via Pipe-Cracking***
Total Project Cost:	R 47 714 164.63	R 66 568 777.28	R 94 241 168.80
O&M Cost :	R 9.29 /kL (R 1 270 138.98/year)	**R 4.73 /kL** (R 570 895.04/year)	R 5.55 /kL (R 570 895.04/year)

The life cycle cost analysis performed on the two options using a population grow rate of 1.27% and annual escalation of 10% for O&M costs, indicate that the Romanskolk Alternative Route option will break even after **32 years** when it shall become more cost efficient than the Brandvlei Desalination option. The high capital cost and unit cost for the Romanskolk Pipe-Cracking option makes no longer feasible.

The unit cost of R 4.73 /kL is in line with the current water tariff in Brandvlei, but the council resolution on affordable water tariffs must be obtained from Hantam Municipality.

Social Component

The portion of the project that delivers water to the social component and taking network losses of 15% in to account is 85.97%, with **14.03% own funding**, as confirmed by indigent register provided by Hantam Municipality.

The breakup of funding contributions is as follow:

	Social Component	Brandvlei Desalination	Romanskolk via Alternative Route	Romanskolk via Pipe-Cracking
RBIG Funding	85.97%	R 41 019 867.33	R 57 229 177.82	R 81 019 132.82
Own Funding	14.03%	R 6 694 297.30	R 9 339 599.45	R 13 222 035.98
Tot Project Funding	**100.0%**	**R 47 714 164.63**	**R 66 568 777.28**	**R 94 241 168.80**

Recommendations

This document serves as a technical design report to convey to the client in broad terms what is suggested to ensure a long-term solution for the treatment and re-use of groundwater at Brandvlei within Hantam Local Municipality.

After investigating several options, the following is recommended:

- The high energy, O&M and unit costs together with latest cost estimations on storage pond linings makes the Brandvlei Desalination option unaffordable for the local community of Brandvlei.
- The high capital and unit cost for the Romanskolk Pipe-Cracking option makes it no longer feasible, with regard to affordability for the local community of Brandvlei and for the local municipality.
- The Romanskolk Alternative Route option is considered the most feasible option. The unit cost of **R4.73/kL** makes this option affordable for both end users and the local municipality. The alternative 52km route within the existing servitudes of the department of Roads and Public works shall simplify the EIA process and shall require only for way-leave application at the Department of Public Works and Roads.
- Should the Romanskolk Alternative Route option be agreed upon by all parties, the Evaluation Criteria for Implementation Readiness must be finalized and submitted to DWA.

All specific recommendations included in this report should be addressed as highlighted within the report.

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LIST OF ABBREVIATIONS

BVi	BVi Consulting Engineers (Northern Cape) Pty Ltd
DEADP	Department of Environmental Affairs and Development Planning
DEAT	Department of Environmental Affairs and Tourism
DPW	Department of Public Works
DTEC	Department of Tourism, Environment and Conservation (Northern Cape Province)
DWA	Department of Water Affairs (formerly the DWAF)
DWAF	Department of Water Affairs and Forestry
EC	Electrical Conductivity
ECA	Environment Conservation Act
EIA	Environmental Impact Assessment
GA	General Authorisation
IWRM	Integrated Water Resources Management
ℓ/s	Litres per second
L/p/d	Litres per person per day
m^2 /d	Square metres per day
m^3 /a	Cubic metres per annum
m^3 /d	Cubic metres per day
m^3 /hr	Cubic metres per hour
m^3 /m	Cubic metres per month
mamsl	Metres above mean sea level
MAP	Mean Annual Precipitation
mbgl	Metres below ground level
mg/ℓ	Milligrams per litre
mS/m	Milli-siemens per metre
ML	Mega Litre
NBRI	National Building Research Institute of the CSIR
NEMA	National Environment Management Act
NGDB	National Groundwater Database
NWA	National Water Act (Act No. 36 of 1998)
NWRS	National Water Resource Strategy
O & M	Operation and Maintenance
OD	Outer Diameter
RBIG	Regional Bulk Infrastructure Grant
ROD	Record of Decision
R/kL	Rand per kilo Litre
SAFCMA	South African Fibre-Cement Manufacturers Institute
SRK	SRK Consulting (SA) Pty Ltd
TDS	Total dissolved solids
WSA	Water Services Act

1. INTRODUCTION

1.1 Appointment

This report has been prepared for Hantam Municipality by BVi Consulting Engineers (BVi), under the appointment letter dated 7 July 2011. The appointment for implementation of the project and further investigations related to the project is funded under RBIG through the Department of Water Affairs (DWA).

1.2 Purpose of Project

The overall purpose of the project is to provide the community of Brandvlei with drinking water for human consumption. The work discussed in this report is a result of the feasibility report completed by SRK Consulting (SRK) in May 2010. The recommendation following the SRK study was that the option of Desalination in Brandvlei using existing nearby boreholes for raw feed water supply, was deemed to be the most feasible. It should be noted that at the time of the feasibility study the assumption was made that the saline borehole water had a TDS of about 25,000 mg/L, providing for 70% recovery after desalination on which the cost was estimated as R 8,586,889.00 (incl. VAT) by SRK Consulting.

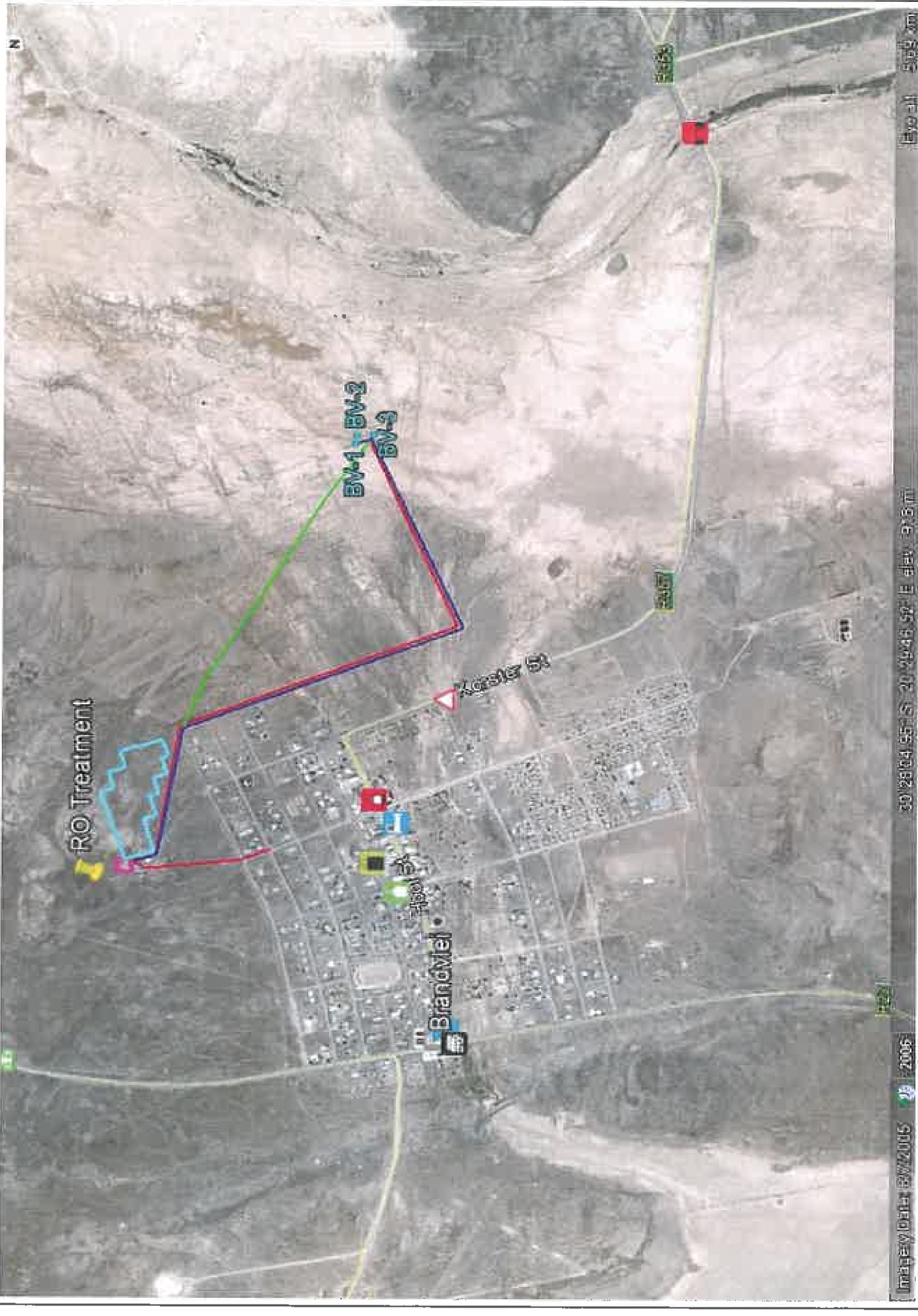
The advantages of this option were stipulated as follow:

- Favorable capital cost - Substantially lower than those of other two options which were investigated in the SRK Consulting (SRK), May 2010 report.
- The infrastructure is in close proximity of the town, which simplifies operation and maintenance thereof.
- From a health, aesthetic and operational perspective, the desalinated water is of superior quality than that from Romanskolk (Current source of supply).

During the investigation phase of this report, SRK Consulting was appointed for the Wellfield Development in order to determine the viability of the nearby boreholes with regards to pump tests and analysis on three nearby boles (BV1, BV2, and BV3). The pump analysis also provide for water sampling and testing to determine the water quality for each of the three boreholes. The water quality results is required in order to determine the extent of the desalination treatment works with regards to the magnitude and cost of the works and related infrastructure.

1.3 Project Location

The proposed desalination plant and related infrastructure is located adjacent to Brandvlei's Northern and Eastern borders, within the municipal town zoning area (**Figure 1.1**).


RO Treatment
BV-1 + BV-2
BV-3
Koster St
Brandvlei

The town of Brandvlei is located on the R27 road approximately 143 km South of Kenhardt or 150km North of Calvinia, which makes it accessible via major roads from distant city centres. The closest city centre being Cape Town from where specialized treatment plant materials and equipment will be imported and supplied is located 560 km to the south of Brandvlei.

1.4 Available Information

The available information that was used in this report was obtained from the Hantam Municipal Database, as well as from the reports done by SRK Consulting "Assessment of Groundwater Resource Potential & Options for Improving Brandvlei's Municipal Water Supply" (ref. **Appendix 5**) and "Wellfield Development for Feed Water Supply to Brandvlei's Proposed Desalination Plant" (ref. **Appendix 4**).

2. PROJECT DESCRIPTION

The current water use in Brandvlei, together with aquifer capacity and the water quality of the identified boreholes, was used in the preliminary design and investigation of the major components of the project. These three aspects are the major determining factors influencing the design and cost estimate of the desalination plant and its associated infrastructure and is further discussed under Determining Factors for Brandvlei's Water Supply.. The feasibility of whether the aquifer capacity is suitable to abstract the required water demand does not pose a problem, according to the Wellfield Development performed by SRK Consulting.

The projected water use figures combined with water quality results of the groundwater will determine the magnitude and size of the desalination plant with its associated infrastructure such as Brine Effluent Evaporation Ponds, Borehole Pump Stations, Raw Water Pump Line, Electrical Power Supply Line, etc. These components will be discussed further under Desalination Plant and Associated Infrastructure.

2.1 Determining Factors for Brandvlei's Water Supply

2.1.1 Current and Projected Water Use

The latest figures for the water use were obtained from the municipality's bulk water meter installed in 2009. The total and average monthly water use for 2010 and 2011 is summarized in **Table 2.1** and **Table 2.2** below.

Table 2.1 : Water Use Figures via Brandvlei Bulk Water Meter from 2010

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Q_{tot} (m^3/m)	11 739	9 851	12 419	10 659	8 755	9 403	9 430	10 750	10 706	10 670	10 826	11 988
Q_{avg} (m^3/d)	379	352	401	355.3	282	313	304	347	357	344	361	387

Note the following:

- *The average monthly water use for year 2010 is* ***Q avg = 348 m^3/d***
- *The maximum (peak) water use in March is* ***Q peak = 401 m^3/d***
- *The total water use in year 2010 is* ***Q tot = 127 196 m^3/a***

Table 2.2 : Water Use Figures via Brandvlei Bulk Water Meter from 2011

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Q_{tot} (m^3/m)	11 613	10 107	11 753	10 566	10 028	8 991	8 346	9 182	10 181	10 997	12 358	13 134
Q_{avg} (m^3/d)	375	361	379	352.2	323	300	269	296	339	355	412	424

Note the following:

- *The average monthly water use for year 2011 is* ***Q avg = 349 m^3/d***
- *The maximum (peak) water use in December is* ***Q peak = 424 m^3/d***
- *The total water use in year 2011 is* ***Q tot = 127 256 m^3/a***

When comparing the above values for the total water use in 2010 and 2011 with the value of 136 820 m^3/a for use in 2009 from *SRK Feasibility Study*, the losses in the Romanskolk pipeline is roughly 7,5 percent. This contradicts the general accepted belief that the Romanskolk pipeline is no more useable and should be discontinued. However, it should be mentioned that the accuracy of the meter readings at the boreholes is doubtful as the high fluoride content in the water has resulted in the malfunctioning of the water meters from time to time. The Romanskolk pipeline system is not be in a good condition with high fluoride content, but it is advisable to keep it in use as an additional backup water supply system.

The peak water use value of 424 m^3/d in 2011 corresponds to the 423 m^3/d from the *SRK Feasibility Study* and is the usage that must be designed for. However, assuming minimum losses of 10 % to 15 % in the Brandvlei network distribution, the design value for peak water use can be taken as either 385 m^3/d or 369 m^3/d.

The municipality's current population figure of 3012 inhabitants (pers. com. Mr. Thys Pieterse at Hantam municipality in Brandvlei), amount to 301 m^3/d for a water use of 100 L/p/d. The population according to the 2001 census is 2308 inhabitants for Brandvlei. The additional low cost houses constructed between 2001 and 2011 is 170 houses (pers. Com. Mr Bertie Leukes at Hantam Municipality in Calvinia). Assuming 5 persons per household the additional inhabitants of 850 persons will sum to a total of 3158 inhabitants. At 100 L/d per person, the water use is 316 m^3/d, that corresponds to the estimated water use of 301 m^3 per day for the current real figure population. The value of 100 L/c/d falls within the Moderate to High range for house connection according to the *"Guidelines for Human Settlement Planning & Design"* and corresponds to the 100 L/c/d water use value from the *SRK Groundwater Assessment Feasibility Study.* The town of Brandvlei consists of erven with no to very little gardening and lawns, thus assuming a conservative f_p = 1,4 peak flow factor, the real population water use of 301 m^3/d will lead to a peak water use of 421 m^3/d and taking into account 10% network losses the actual peak use will be 382 m3/d.

The 2001 census report through National Treasury indicated a negative population growth of -2.10 % for the Northern Cape. The most recent study on the Northern Cape's socio economic outlook (*Source: Global Insight 2011)* indicated that the Namakwa District Municipality recorded a growth rate of 1.27 % between 2007 and 2009, which will be used for the purpose of this report.

The final daily water use over a 20 year period is determined by applying 100 L/c/d to the current population figure, together with a peak flow factor of f_P = 1.4 and network losses of f_n = 10%. The projected increase in daily water use is shown in ***Table 2.3*** below.

Table 2.3: Projected Water Use over 20 Year Period

Year (i)	Population P i (persons)	Avg. Water Use Q i (m^3/d)	Peak Water Use Q i (m^3/d)	Design Water Use Q i (m^3/d)
0	3010	301	421	383
1	3048	305	427	388
2	3087	309	432	393
3	3126	313	438	398
4	3166	317	443	403
5	3206	321	449	408
6	3247	325	455	413
7	3288	329	460	418
8	3330	333	466	424
9	3372	337	472	429
10	**3415**	**341**	**478**	**435**
11	3458	346	484	440
12	3502	350	490	446
13	3547	355	497	451
14	3592	359	503	457
15	3637	364	509	463
16	3683	368	516	469
17	3730	373	522	475
18	3778	378	529	481
19	3826	383	536	487
20	**3874**	**387**	**542**	**493**

From the above table the projected design flows for year's ten (10) and twenty (20) are 435 m^3/d and 493 m^3/d respectively. The value of year ten (10) corresponds to the bulk flow meter value for peak water use (*ignoring network distribution losses*) of 424 m^3/d in December 2011.

However, due to the fact that during their life cycle all municipal internal water distribution networks encounters problems with calcification of flow meters, pipe breakage, etc. the effect of losses should be taken into account. The following should be noted:

- *The exact estimate on losses for the Brandvlei internal network can only be achieved by replacement of dysfunctional water meters and upgrading of the bulk internal water supply network through alternative MIG funding.*

2.1.2 Water Demand versus Aquifer Capacity

The capacity of the aquifer was investigated and summarized in detail in the *SRK Wellfield Development* report. This document forms part of this report and indicated that for a peak demand of 383 m^3/d, it is feasible to abstract the required feed water demand of 766 m^3/d from the two(2) identified production boreholes BV1 and BV3 situated within the aquifer. The water quality as discussed in this report allows for a 50 % recovery after desalination of the feed water. This means that each borehole should be pumped for 16 hrs/d at a delivery rate of 24 m^3/h, to supply this initial 766 m^3/d feed demand, which is double the peak water demand of 383 m^3/d due to the 50 % recovery.

Having a yield capacity of 1 210 m3/d, it is evident that after periods ten(10) and twenty(20) years the boreholes will be able deliver 870 m^3/d and 986 m^3/d respectively. The 24 m^3/h delivery rate will require 18 *hrs/d* and 20.5 *hrs/d* of operation time. It is however strongly suggested that:

- *Monitoring data obtained from boreholes to be reviewed on regular basis by SACNAS qualified hydrologist.*

2.1.3 Water Quality

The *SRK Groundwater Assessment Feasibility Study* indicated electrical conductivities (EC) measuring to 4 000 mS/m obtained from NGDB (DWAF) data collected in this area during 1996. This figure amounts to a TDS value of almost 25 000 mg/L for groundwater in and in close proximity of Brandvlei.

The latest water samples taken during the *SRK Wellfield Development* was sent for chemical analysis to determine the quality of the groundwater at the identified three (3) number of boreholes BV1,BV2 and BV3 situated 0.89 km to the East of Brandvlei. The test results obtained from SANAS approved Talbot Laboratories are summarized in **Table 2.4** below, indicating the chemistry of the water for the abovementioned three boreholes.

Table 2.4: Chemistry of the Water from the New Boreholes at Brandvlei

BH NO:	BV1	BV2	BV3
TALBOT & TALBOT LABORATORY NUMBER:	17303/11	17304/11	17305/11
SAMPLE DATE: Determinants (in mg/l unless stated otherwise)	3-Sep-11	3-Sep-11	30-Aug-11
Potassium as K	1.8	2.1	1.6
Sodium as Na	9 199	8 883	14 430
Calcium as Ca	717	851	627
Magnesium as Mg	1 762	1 703	1 787
Aluminium as Al	1.9	14	2.8
Sulphate as SO4	9 650	9 720	9 340
Sulphide as S2	<0.04	<0.04	<0.04
Chloride as Cl	24 143	23 593	23 343
Total Hardness	9 146	9 138	8 924
Total Alkalinity as CaCO3	336	371	339
Fluoride as F	9.70	8.80	10.00
Iron as Fe	0.15	0.87	0.19
Manganese as Mn	0.15	5.13	0.19
Conductivity mS/m (25°C)	5 270	5 240	5 210
pH (Lab) (25°C)	6.8	6.5	7.3
Total Dissolved Solids	37 244	37 208	37 872
Silicon, Si	13.88	13.42	13.32
Colour	<1	4	<1
Total phosphate as P	<1	<1	<1
Suspended solids	252	576	352
Turbidity NTU	19.1	207.0	0.8
Total Kjeldahl nitrogen as N	<1	<1	<1
Oil & Grease	6	4	6
Selected* constituents in µg/L (of health significance in drinking water)			
Antimony	0.14	0.85	0.20
Arsenic	5.8	11.0	8.2
Barium	14	54	17
Cadmium	0.38	0.98	0.60
Chromium	2.00	0.84	1.40
Copper	1.80	0.75	2.30
Lead	0.19	0.40	0.13
Mercury	1.40	0.92	1.80
Molybdenum	76	84	80
Nickel	1.7	17.0	2.3
Selenium	53	56	62
Uranium	211	198	197
*Only constituents of health significance in drinking water included			

The water from the alluvial aquifer is highly saline with and EC in excess of 5 200 mS/m and the TDS exceeding 37 000 mg/L. The TDS values is much higher than the original anticipated value of 25 000 mg/L. This will result in a much higher cost for the desalination process and for the brine effluent evaporation ponds, due to a reduction in recovery from 70 % to about 50 % after desalination.

The suspended solids of the water from both boreholes recommended for production purposes (BV1 and BV3) are high, whilst BV1 also has a high turbidity value of 19.1 mg/L. It is expected that the turbidity will be lower during production pumping as the recommended pumping rate is lower than the test rate during which the samples were collected. Turbidity should also be less as the boreholes only need to be pumped at 50% of their capacity to supply in the demand.

Trace element analysis results indicated relatively high levels of selenium, molybdenum and uranium. The desalination process should reduce these concentrations to acceptable limits. However, in view of the relative high uranium concentrations it is recommended that :

- *the radionuclide concentrations as well as gross alpha and beta radioactivity of the water is also determined. This will entail re-sampling the two proposed production boreholes and submitting the samples to the NECSA Radio Analysis laboratory in Pelindaba.*

The following should be noted:

- *NECSA is the only laboratory in the RSA that can do these analyses and it normally takes anything from 5 to 6 months to get results back.*
- *Turbidity of the water from BV2 is much higher, but this low yielding borehole is not recommended for production use.*
- *Due to the highly saline groundwater the corrosiveness on stainless steel pumping and piping equipment is very high and only highly durable Duplex Grade 904 steel must be used for piping and pumping equipment and accessories. Where specified, uPVC may be used for piping and other equipment.*

To solve the problem of suspended solids and turbidity, a type of pre-filtering will be required. The results show that the groundwater to be of a Sodium Chloride type. The high TDS values in combination with the high Chloride(Cl), Magnesium (Mg), Calsium (Ca) values is problematic in that it tends to form salt compounds which in turn crystallizes to precipitate on the RO membranes. This leads to the membranes clogging up and blocking.

2.2 Desalination Plant and Associated Infrastructure

2.2.1 Borehole Pump Stations

The groundwater resource for this project exists out of identified three (3) number of boreholes BV1, BV2, and BV3 of which BV2 is suitable only for monitoring purposes. The pump test investigation was carried out by SRK Consulting who appointed WellTek Services to develop the wellfields in September 2011.

The production boreholes BV1 and BV3 are more than capable to deliver the required water demand in Brandvlei (ref. par. 2.1.2), with good recovery results as indicated in the *SRK Wellfield Development* report. The borehole details are summarized in **Table 2.5** below.

Table 2.5: Summary of Brandvlei Borehole Information

Description	BV1	BV2	BV3
Latitude	30°27'49.18"S	30°27'49.32"S	30°27'51.26"S
Longitude	20°30'19.12"E	20°30'20.45"E	20°30'20.52"E
Datum	WGS84	WGS84	WGS84
Elevation[2] mamsl (Approximate)	915	916	917
Date Drilled	16-Aug-2011	17-Aug-2011	18-Aug-2011
Diameter Drilled m x mm	16.6 x 304	16.3 x 304	16.4 x 304
Final Depth m	16.6	16.3	16.4
304 mm x 5 mm wall Steel Casing standpipe m	3	3	3
194 mm OD 304 Stainless Steel x 0.5 mm slot free-flow screens and 0.6 – 1.5 mm filter sand mbgl	13 - 16	13 - 16	13 - 16
200 mm OD Cl12 uPVC casing mbgl	0 - 13	0 - 13	0 - 13
Collar Height magl	0.81	0.74	0.89
Water Strikes mbgl	13 – 14.5	13 - 14	12 - 14
Final Blow Yield m^3/hr	17	2	30
Water Level mbgl (Date measured))	5.86	5.92	6.11
Silt & Clay	0 - 10	0 - 4	0 - 3
Silty fine Sand	10 - 13	4 - 13	3 - 12
Pebbles mbgl	13 – 14.5	13-14	12 - 14
Shale mbgl	14.5 - 16.6	14 - 16.3	14 - 16.4
Hours Developed and Cleaned	2	4	2
Disinfected with chlorine granules	Yes	Yes	Yes
Sanitary seal and concrete collar	Yes	Yes	Yes
Lockable flange lid with padlock	Yes	Yes	Yes

-Note that special attention is drawn to the following with regards to the monitoring programme required on these boreholes:

- *A flow meter must be installed at each production borehole and the volume pumped recorded on a weekly basis.*
- *To measure the water level on a weekly basis with a dip-meter, each production borehole must be equipped with a conduit consisting of 35 mm HDP pipe inserted to just above the pump intake and strapped to the rising mains.*

The results of the pump analysis are included in the *SRK Wellfield Development* report. The recommended pumping rates and management details for the boreholes and pump system are summarized in **Table 2.6** as follow:

Table 2.6: Recommended Pumping Rates and Management for Brandvlei Boreholes

BH No.	Borehole Depth	Borehole Diameter	Pre-Pumping Water Level	Pump Intake	16hr/day Optimum Pumping Rate		Warning Pump Drawdown Level
	(m)	(mm)	(mbgl)	(mbgl)	(m^3/hr)	(m^3/d)	(mbgl)
BV1	16	175	5.7	14	23.94	383	11
BV3	16	175	5.1	14	23.94	383	11
Total					47.88	766	

The analysis results indicate that boreholes BV1 and BV3 can each yield 25.2 m^3/hr (7 L/s), or 605 m^3/d. Their combined yield is 50.4 m^3/hr, or 1 210 m^3/d.

The pump rates in the above table show that a rate of 383 m^3/d is required at each borehole, to ensure that the peak water demand of 766 m^3/d will be reached and the following should be noted:

- The number of two(2) Grundfos SP30/8/R borehole pumps(or similar) with 7.5 kW/ 380V electrical motors are required to deliver 6.67 L/s to the RO Desalination Plant.
- The optimum pumping rates allow for both boreholes being pumped simultaneously.
- Each pump is protected with a "dry-run" level sensor and when pump drawdown reaches the warning level of 11 mbgl, the pump must be switched off for at least 24 hr and the hydrologist consulted.
- Each pump is equipped with non-return valves to ensure one directional flow which will prevent feed water from running back into the boreholes in case of pump failure, etc.
- Water levels must preferably be monitored on a daily basis, or at least weekly.

- During final design of the pump houses the flood level must be taken into consideration so that the floor of the pump houses and other infrastructure will be elevated above the maximum flood level.
- Instead of equipping each pump with a dip-meter, alternatively a electronic level sensor in the form of pressure probes can be used to log data e.g. "recharge rate", "water level measurement", "drawdown rate", etc.
- Each pump intake will be installed at a depth of 14 mbgl within the boreholes with depth 16 mbgl, by lowering the pumps with 110 mm diameter HDPE 10 bar pipes into the boreholes via the platforms.
- The pump with all its mechanical components must consist of Duplex Grade 904 stainless steel, due to the high corrosive groundwater quality.
- The pumps are to be Multi-stage submersible pumps with a 3 Phase motor with sand shields, liquid-lubricated bearings and pressure equalizing diaphragm.

The preliminary design of the pumps concluded that the two(2) number of borehole pumps will each pump over a static head of H_{ST} =36 m. The head losses over the length of the pipeline for a delivery rate of 24 m^3/h (Q = 6.67 L/s) amounts to H_L = 21 m. The rise in total head over the pump is roughly H_M = 60 m depending on the final design and fabricate type of multi-stage submersible pumps to be specified.

*The total installation cost for the pump system, including all miscellaneous material and equipment (e.g. pumps, level sensors, valves, etc.) is estimated at **R 805 031.16 (incl. VAT & 10% Contingencies)***

2.2.2 Raw Water Pump Line

The pump system as indicated above for the two pumps, requires for a 125 mm diameter Class 9 uPVC pipe to be installed over the total distance of L = 2 650 m. The diameter of the pipe and the combined flow rate of 13.3 L/s for the multi-stage pumps running simultaneously in parallel, will ensure an adequate flow velocity V=1.18 m/s.

The pipeline is to be installed at a depth of 1.0 m below the natural ground level, measured from the top of the pipe. From the borehole pump station the pipeline runs 888 m to the West and form there 1 193 m in a Northern direction, alongside the municipal erf boundaries within the internal road reserve. The last 570 m of the pipeline runs within municipal commonage grounds up to the proposed new 0.5 ML saline raw water storage reservoir.

*Take note that the original route of the raw water pump line with a total length of 2 000 m is shown in **Figure 1.2**. This option was deemed not feasible due the fact that the pipeline passed through municipal erven situated at the East of the town, thus creating problems with regards to way leaves and tile deeds on privately owned municipal property.*

*The total installation cost for the raw water pumpline, including all miscellaneous material and equipment (e.g. bends, special fittings, valves, etc.) is estimated at **R 1 364 633.97 (incl. VAT & 10% Contingencies)***

2.2.3 Saline 0.5 ML Raw Water Storage Reservoir

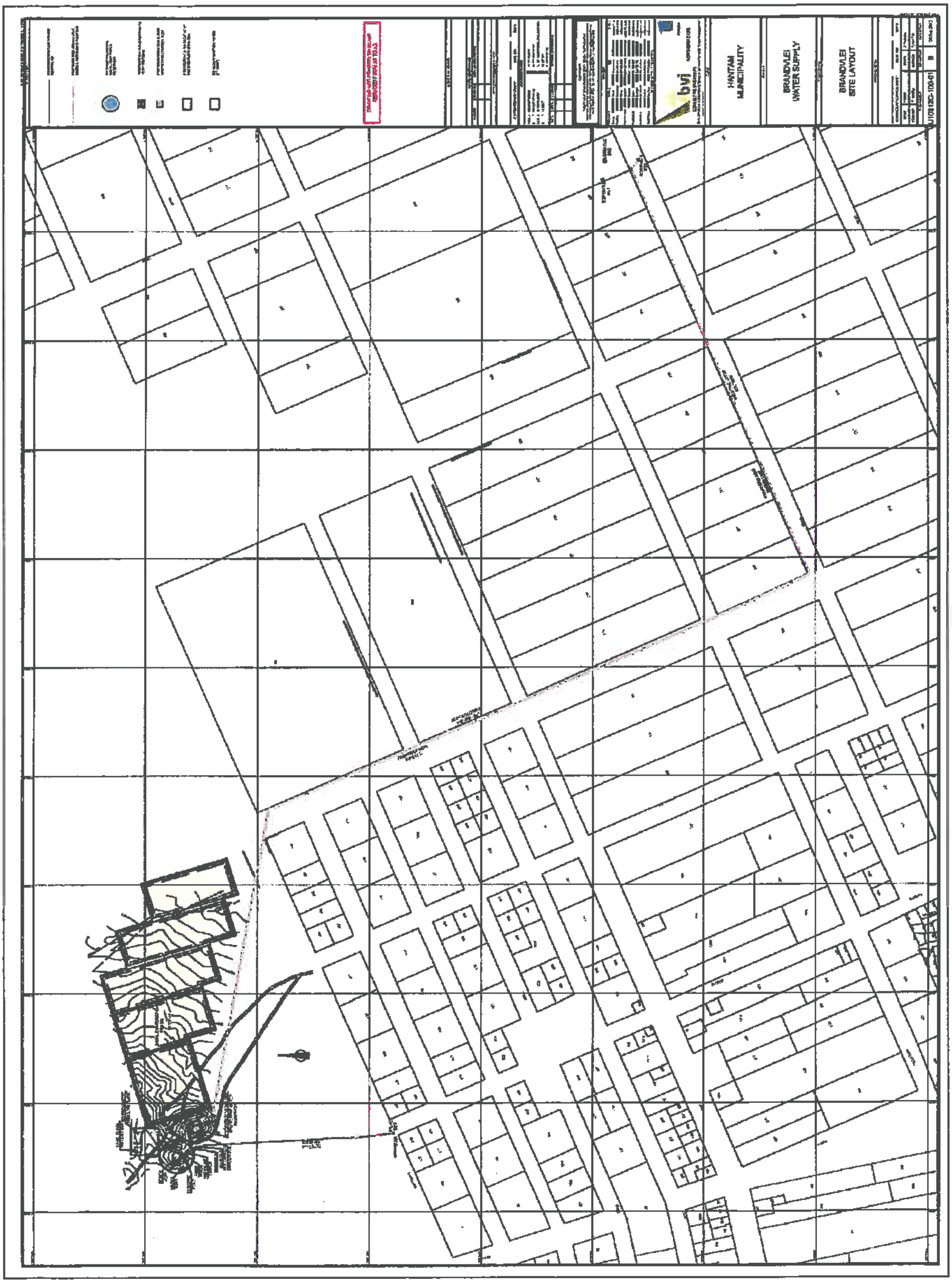
The existing 0.5 ML storage reservoir which currently is used for storing Fluoride rich water from Romanskolk, only makes provision for 20 h of backup storage with regards to the peak water demand of 384 m^3/d. The required water storage for a single water source according to the "Guidelines for Human Settle & Design", is 48h of peak demand which is equivalent to 768 m^3/d.

However, if the daily peak factor of 2.4 times the average daily demand is applied to 318 m^3/d obtained from the bulk water readings (10% network distribution losses included), the actual storage that must be provided for is 763 m^3/d. This implies that the current raw water storage in Brandvlei is not enough and that additional backup storage must be provide for to ensure that the town does not run into water shortages in case of emergency.

It is important to ensure that the water quality levels of feed water do not fluctuate, seeing that the desalination plant is specifically designed to treat saline water only, with a certain quality character. If the character of the water should by some reason deviate too much from the design water quality, problems may arise in the RO Plant due to the sensitive nature of the membranes and specialized inner workings of the plant which may result in plant failure and plant shut down.

The introduction of an additional new 0.5 ML reservoir, for storing the saline feed water will address the problem of back-up storage in Brandvlei and provide for the required 24 h retention back-up. This option will also ensure that the feed water with high salinity is kept separated from the Fluoride rich Romanskolk water being stored in the existing 0,5 ML storage reservoir. This will ensure that the feed water supply to the RO Treatment Plant is kept at consistent water quality levels with regards to the salinity of the water, which ensures proper working of the desalination plant.

The proposed new 0.5 ML storage reservoir is 16 m in diameter to a height of 3.5 m, consisting out of 200 mm thick reinforced concrete foundation, floor slab, walls and roof slab. The outfall of


HANTAM MUNICIPALITY
BRANDVLEI WATER SUPPLY
BRANDVLEI SITE LAYOUT

the saline raw water will be at full water level within the storage reservoir. The raw saline water runs through the outflow at reservoir floor level and fed to the RO treatment plant via a 125 mm diameter Class 6 uPVC pipe.

Provision must be made for the following:

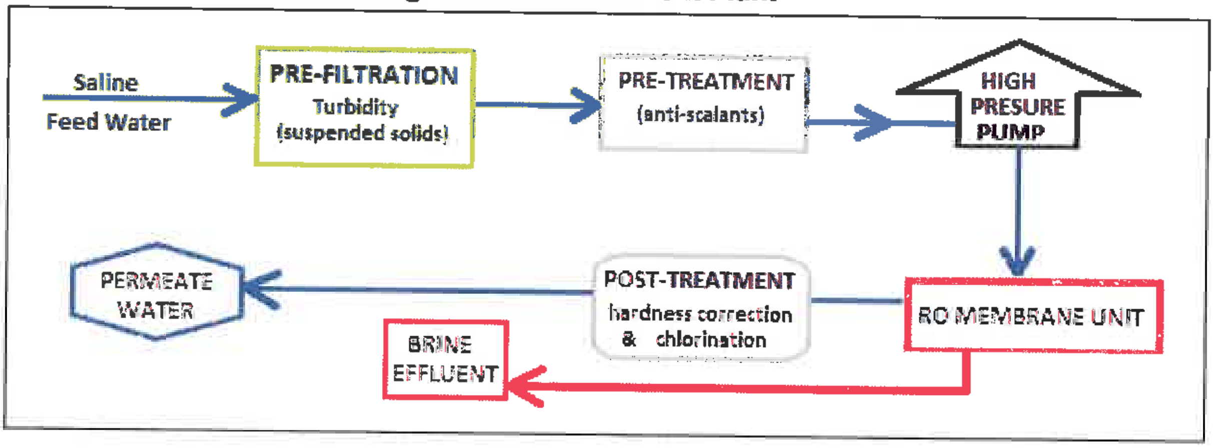
- A water level control censor and telemetry system to control the pump system start up and shutdown according to the water level in the storage reservoir.
- The installation of a cut-off valve at the reservoir's outflow will ensure that the water can be contained for a period of time during O & M procedures on both the reservoir and the RO plant.
- The installation of a scour valve at the reservoir's outflow to ensure that the reservoir can be emptied during routine O & M procedures.

The total installation cost for the saline raw water storage reservoir, including all miscellaneous material and equipment (e.g. bends, valves, etc.) is estimated at ***R 1 504 800.00*** *(incl. VAT & 10% Contingencies)*

2.2.4 Desalination Plant for RO Treatment

The desalination plant consists out of various specialized equipment and materials and purifies the highly saline feed water at a 50 % recovery rate to produce the permeate water and brine effluent. The flow diagram in **Figure 2.1** below indicates the different stages in the RO treatment process.

Figure 2.1 : Process Flow Diagram of RO Treatment Plant



The method of desalination through the reverse osmosis (RO) process as indicated in the above flow diagram consists out of the following major process phases:

a) **Saline Feed Water** with pre-determined flow rate and water quality determines the size and specific design of the plant to produce permeate water suitable for human consumption.
b) **Pre-Filtration** is required for the removal of suspended solids and other particles from the feed water, to protect the membranes from being damaged and from blockage. This can be achieved by using standard sand filters.
c) **Pre-Treatment** through the introduction of anti-scalants to promote the breaking down of high salt concentration which tends to precipitate onto filter membranes, causing blockage and ultimately prevents to membranes from functioning.
d) **High Pressure Pump** is required to force the pre-treated feed water through the membranes by producing in the order of 60 bar of pressure in front of the membranes, ensuring a recovery of almost 50 %.
e) **Post-treatment** by means of hardness correction and chlorination is necessary to bring the permeate water up to standard for human consumption and network distribution.
f) **Brine Effluent** is produced at a rate of 383 m^3/d and discharged into the evaporation ponds for safe storage.
g) **Permeate Water** is delivered to a 0.5 ML fresh water storage tank at 383 m^3/d from where it will be available for distribution into the municipal water network. This will help address the problem of back-up storage regarding the required 48 h backup storage capacity from one water supply and 24 h backup storage capacity required for two water supplies.

The desalination plant with all the specialized equipment and instruments are to be housed in a secure outbuilding of 6 x 12 m in size. This will ensure that the chemicals used are kept away from human contact; entrance to the plant is restricted with regards to vandalism and general public safety, as well as that ablution facilities are available for plant operators and personnel.

The highly sophisticated and specialized nature of the processes and operation of the plant calls for the following:

- The design and installation of the plant must be performed by a Desalination Treatment Plant Specialist Service Provider who has a good knowledge of RO treatment plants.
- The abovementioned specialist service provider must be a well established institution with a good track record in the field of RO treatment works.
- All the various aspects such as Mechanical, Electrical, Chemical, Project Management, Operation and Maintenance, etc. must be incorporated within a single entity RO Specialist Service Provider to ensure that all the above mentioned aspects of the plant will be operated and maintained by them for a period not less than a year.
- The plant must be operated by someone identified within the local municipality and this person must undergo onsite training from the specialist RO service provider for at least a

year (preferably three years), after which period the municipal plant operator will be solely responsible for the running of the plant in terms of operation and maintenance.

- Desalination Plant and associated infrastructure is designed for an initial peak flow of 383 m^3/d and upgrading of the plant is to take place after a period of ten(10) and twenty(20) years to accommodate for the projected peak water use of 435 m^3/d and 493 m^3/d respectively.

*The total installation cost for the desalination RO treatment plant, including all miscellaneous material and equipment (e.g. mechanical, electrical, pumps, valves, etc.) is estimated at **R 5 056 128.00 (incl. VAT & 10% Contingencies)***

2.2.5 Brine Evaporation Ponds

Using the peak water use of 383 m^3/d will result in an over estimation of the required evaporation pond surface area, in that the default assumption is made that brine effluent production will occur at peak water usage for all the months in a certain year. The average water use of 349 m^3/d (ref. par. 2.1.1 Table 2.2) together with a population growth rate of 1.27 %, was used for projecting the volume of brine effluent production per day. A water use correction factor was applied to these values according to seasonal water use patterns in Brandvlei, in order to determine the brine storage values (Bi) over time in the evaporation ponds.

The real gap-filled rainfall figures from gauging station D5E007 for the past twenty years (ref. **Appendix 1**), was used to determine the rainfall storage values (Ri) over time in the evaporation ponds. The gap-filled monthly mean evaporation obtained from the class S-pan evaporation gap-filled data of gauging station D5E007 (ref. **Appendix 2**), was used to determine the evaporation volume figures (Ei) from the ponds over time.

The cumulative real storage values (Si) are hence determined by summing the preceding Si-value of the previous month with Bi – and Ri – values and then subtracting Ei – values. Note that negative cumulative storage Si-values indicate that the ponds are empty and to be taken as nil. The last step in the dam balance exercise is to add extra surface area to the ponds of depth 1.5 m, in the case where the Si-value exceeds the dam storage capacity in any given month over a period of 20 years.

The surface area required for the evaporation ponds to handle the brine effluent of 349 m^3/d was determined at 52 000 m^2 for the first ten years. After a period of ten (10), years the projected increase in water demand will require an additional pond surface area of 10 000 m^2, hence the ponds must be expanded to 62 000 m^2. The calculations for the dam balance exercise are summarized in **Appendix 3** at the end of this report.

The following should be noted:

- Water license applications must be submitted to DWA for the storage of waste water effluent, as well as for abstraction of groundwater from a natural water source.
- The EIA process identified the disposal of the Brine effluent is a listed activity and consultation with DEA resulted in referral by them to DWA national office for minimum requirements on lining of the Storage Ponds.
- Decisive clarity from DWA National office (ref. Mr. Kelvin Legge) on minimal requirements for lining of Brine effluent storage ponds, stipulated the use of geo-synthetic clay layers (GCL), geo-drains and HDPE geo-membrane layers. The result being an increased estimated cost for the Brine Evaporation Ponds from R 8.1 milj to R 20.7 milj.

The total installation cost for the brine evaporation ponds, including all miscellaneous material and equipment (e.g. pipes, inlet structures, Geo-synthetic Clay Layers, Geo-drains & HDPE lining, etc.) is estimated at ***R 20 710 486.13 (incl. VAT & 10% Contingencies)***

2.2.6 High Voltage Power Supply

The electrical high voltage power supply will be provided from the municipal power grid, at a substation close to the entrance road to the site as indicated on the site layout. The power supply will also include the following:

- Installation of a 200 kVA power connection point for the RO Treatment Plant.
- Installation of a 50 kVA power connection point for the Borehole Pump Station.
- Installation of low voltage electrical supply cables from the transformers to the RO plant and the Borehole Pump station.
- Installation of all smaller materials.

The preliminary design indicates that the high voltage power supply line will be between 11 kV to 22 kV high voltage power and not more than 33 kV, hence no EIA is required on the power supply line of less than 33 kV high voltage. The power supply line is installed adjacent to the municipal main water distribution line, close to the entrance road and 3 m parallel to the 125 mm diameter raw water supply line.

*The total installation cost for the high voltage power supply, including all miscellaneous material and equipment (e.g. cables, poles, transformers, etc.) is estimated at **R 813 846.00 (incl. VAT & 10% Contingencies)***

3. LAND USE

The land use on the East of Brandvlei is currently made up of privately owned municipal plot erven, which was used in the past for irrigation purposes. The initial route installing the raw water supply pipeline over these erven, was thus considered not feasible due to way leave and servitude declaration constraints.

Option 1 : The high voltage power supply line, 125 mm diameter raw water supply line, desalination plant, 0.5 ML raw water storage reservoir and 52 000 m2 brine evaporation ponds falls with municipal road servitudes and municipal commonage. However, the production borehole BV1 and the monitoring borehole BV2 are both situated on municipal erf number. 305. The Hantam Local Municipality must communicate with and obtain permission from the private owner of this erf, with regards to registering a servitude on this property.

Option 2 : The existing Romanskolk pipe line is running through privately owned farm property and no servitudes was registered during its installation in 1965, as farm owners at that stage agreed on good will. The process to register servitudes and consult with the current farm owners shall have to be followed by Hantam Municipality. The process to register servitudes through consultation and agreements with land owners might be problematic and a time consuming process.

For this option further cost estimations are being performed for a "pipe cracking" method to be used, which might resolve the problems of servitude registration. An alternative route over 52 km falling within the Department of Public Works& Roads servitude, also could resolve the servitude registration issue by means of a way-leave application with the department.

4. IMPACT ON ENVIRONMENT AND WATER RELATED MATTERS

Government Notices R 543, R 544, R 545 and R 546, published in Government Gazette No 33306 (dated 18 June 2010) in terms of Chapter 5 of the National Environmental Management Act, Act No 107 of 1998 (as amended) are applicable. The thresholds defined in Regulations 544, 545 and 546 will be crossed by the proposed development and therefore an application for environmental authorization has to be submitted to the NC Department of Environment and Nature Conservation (DENC) and a scoping and environmental impact assessment process (full EIA) followed.

Option 1 : The EIA process must identify whether the disposal of the Brine effluent is a listed activity which are triggered according to NEMA. If the Brine disposal into the evaporation ponds be seen as a listed activity, provision must be made for HDPE lining of 1.5 mm thickness within the ponds. The minimum requirements obtained from DWA, stipulate the use of Geo-synthetic clay layers, Geo-drains and 2 mm thick HDPE Geo-membranes to be used for brine effluent storage.

Water Use Applications (WUA) in terms of the National Water Act, must be submitted to DWA for the following:

- Taking water from a water resource (DW760)
- Storing of water (DW 761)
- Disposing of waste in a manner which may detrimentally impact on a water resource (S 21 g) (DW767)
- Altering the bed, banks, course or characteristics of a watercourse (S21 i) (DW768 and/or 781)-floodplain
- Supplementary forms to be completed include Property where water use(s) occurs (DW901), S 21 e/g water uses (DW904) and S 21g water uses (DW905)
- Water Services Provider (DW757) must be confirmed seeing that Hantam Municipality may already be registered on the DWA database in terms of Romanskolk water supply.

The RBPAC scope and project approval of February 2012 indicated that the EIA process for Brandvlei desalination should proceed. Van Zyl Environmental Consultants is experiencing problems with EIA process, with regards to delays on Waste License application at DEA national office.

Option 2 : The RBIG March 2013 outcome was that the Romanskolk option should be relooked, due to the high cost for Storage pond Lining system. The Romanskolk option shall require its own EIA process to be followed. An EIA process is underway with Enviro Africa appointed to perform the assessment on the alternative 52 km route. No EIA process needs to be executed, should "pipe cracking" be considered as the alternative method to upgrade Romanskolk pipeline. As Romanskolk is an existing water source only to be upgraded, no water use applications shall be required.

5. GEOGRAPHY

5.1 Topography

Option 1 : *The study area is situated outside of town on flat areas, with reservoir component and infrastructure on steep slopes and hard rock formations at the koppie to Northern boundary of town.*

Option 2 : *The existing Romanskolk pipeline stretches for some parts on its length across valleys and low mountain ranges consisting mostly out of hard rock. The pipeline also runs for about 7 km of its length through stretches of brackish pans.*

5.2 Climate

The climate of the Northern Cape is typically that of desert and semi-desert with low and erratic rainfall. Summers are hot and dry and the winters cold and frosty. Summer temperatures usually range between 30°and 40°C while winter temperatures range from 3°C to 21°C. During the summer months, the rainy season with thunderstorms occur in the eastern areas whereas winter rainfalls occur mainly in the western region. Winters are generally typified by warm days and cold nights.

5.3 Hydrology

The study area is mainly drained by the northerly flowing Sak River and its tributaries. The majority of the study area falls within the D57C Quaternary catchment.

6. DESIGN STANDARDS

The following design standards were utilized for this project:

- Standard Specifications for Civil Engineering Construction: SABS 1200 series
- Guidelines for Human Settlement Planning and Design: CSIR 2000
- General Conditions of Contract for use in connection with Works of Civil Engineering Construction: SAICE 1990
- National Building Regulations: Act 29 of 1996
- Part 1: Unplasticized poly(vinyl chloride) (PVC-U) pressure pipe systems
- SANS 10112 / SABS 0112:2003 - The installation of polyethylene and poly(vinyl chloride)(PVC-U and PVC-M) pipes
- Specifications which were project specific

7. POSSIBLE PROBLEMS AS A RESULT OF THE PROJECT

With the physical project itself, no problems are foreseen at this stage with the exception of the funding to commence with the project.

8. LIAISON WITH PARTIES CONCERNED

Currently there is liaison with the following parties being stakeholders in the project:

- Department of Water Affairs
- Department of Environmental Affairs
- Department of Public Works
- Hantam Municipality

9. COMPARISON OF ALTERNATIVES

Comparisons are summarized for three different options in the SRK Feasibility Study report of 2010, with construction of the Brandvlei Desalination plant as the most feasible option.

The RBPAC outcome of March 2012 indicated that the existing Romanskolk boreholes and pipeline with layout shown in **Figure 9.1**, must be reinvestigated as a possible alternative water supply to Brandvlei. The abovementioned report "Assessment of the Groundwater Resource Potential and Options for Improving Brandvlei's Municipal Water Supply " must be referred to at all times and shall form part of this report.

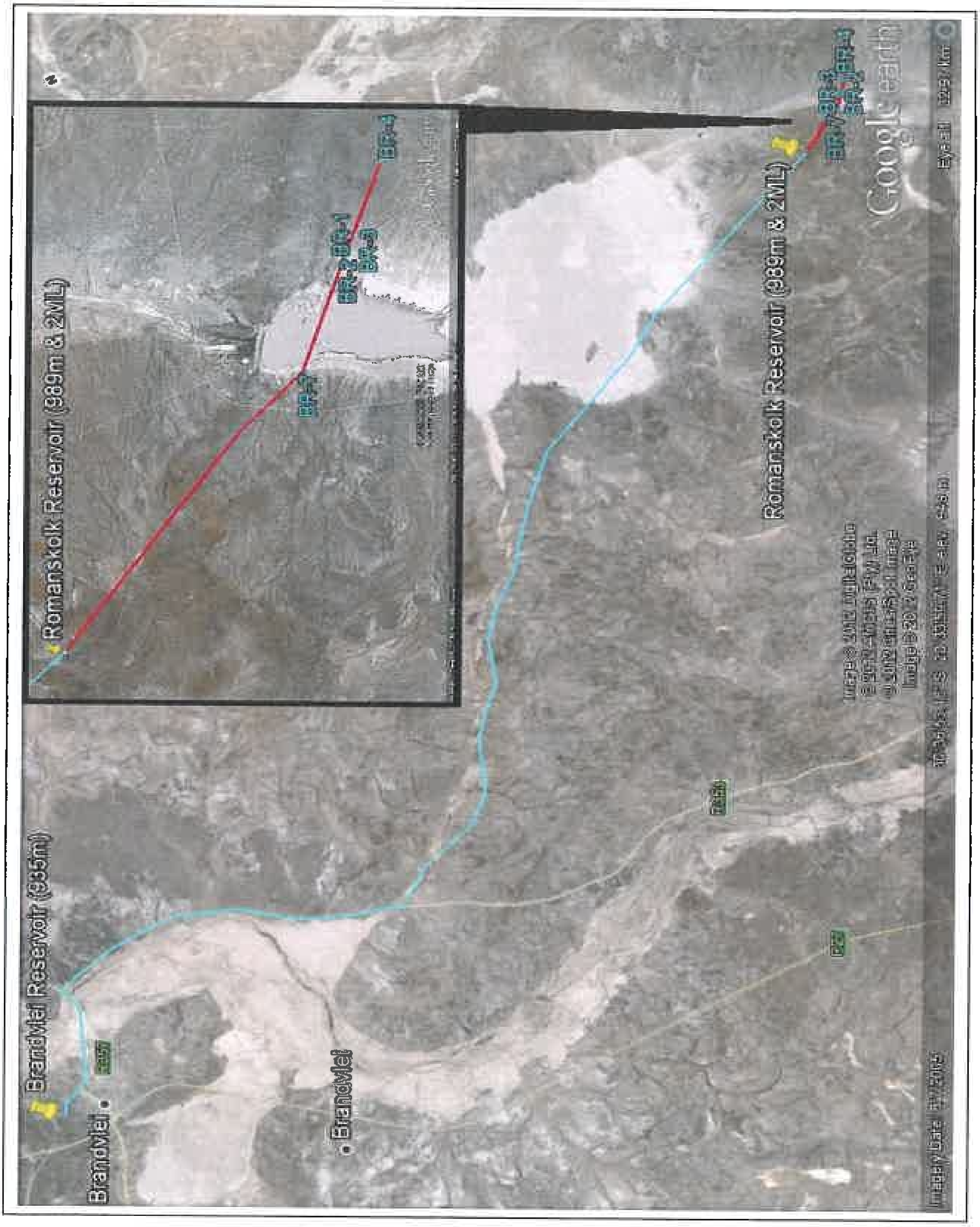
9.1 Romanskolk as Alternative Water Supply

9.1.1 Existing Groundwater Use at Romanskolk

The hydrocensus performed by SRK Consulting for Hantam Municipality as set out in their report (ref. **Appendix 5**), indicates that the existing number of five(5) production boreholes (BR1, BR2, BR3, BR4 and BR7) provides for an average estimated yield of 2.0 L/s, with the exclusion of borehole BR14 that was pumped dry and is no longer in use.

It should be noted that the pumping water level of borehole BR2 is only 1.3 m above the bottom of the 13.6 m deep borehole. Furthermore, the hydrocensus performed in 2010 reported an estimated "safe yield" of 150 000 m^3/a for the Romanskolk wellfields, indicating that the safe yield will be exceeded within the next few years. *However, The estimated safe yield of the SRK hydrocensus is based on the pump yields and the historic water level behaviour of the boreholes.*

These boreholes were never test pumped. According to SRK further exploration is possible at farms surrounding Romanskolk, as well as Romanskolk itself.



The quality of the water samples taken at these boreholes indicate that calcification is problematic, due to the hardness of the water and that pre-treatment must be provided for. (ref. **Appendix 5**). This is confirmed by the latest test results as shown in **Table 9.1**, from the water quality analysis performed by A.L. Abbott and Associates (Pty) Ltd.

Table 9.1: Chemistry of the Water from the Existing Boreholes at Romanskolk (April 2012)

Sample Marked :	Roman 3	Roman 4	Roman 7	Res. Dorp	Class I (Recomm. Operation al Limit)	Class II (Max. Allow. Limited Duration)	Class II Water Consump. Period,[a] max.
pH (at 25 °C)	7.60	7.42	7.38	7.67	5,0-9,5	4,0-10,0	No Limit [c]
Conductivity (mS/m, at 25 °C)	155	140	273	151	<150	150-370	7 years
Turbidity (NTU)	0.82	0.42	1.1	0.42	<1	1-5	No Limit [d]
Langelier Saturation Index	0.46	0.41	0.35	0.58	-	-	-
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Colour (as Pt)	<1	<1	<1	<1	<20	20-50	No Limit [b]
Total Alkalinity (as $CaCO_3$, [e])	364	476	316	400	-	-	-
Total Hardness ([e])	358	359	600	365	-	-	-
Calcium Hardness ([e])	220	220	395	223	-	-	-
Calcium (as Ca)	88.0	88.0	158	89.1	<150	150-300	7 years
Magnesium Hardness ([e])	138	139	205	142	-	-	-
Magnesium (as Mg)	33.7	34.0	50.1	34.7	<70	70-100	7 years
Sodium (as Na)	226	195	322	237	<200	200-600	7 years
Potassium (as K)	0.77	0.77	0.99	0.77	<50	50-100	7 years
Zinc (as Zn)	0.02	<0.01	0.04	<0.01	<5,0	5,0-10,0	1 year
Chloride (as Cl)	200	138	26.9	188	<200	200-600	7 years
Fluoride (as F)	0.78	0.94	1.3	1.1	<1,0	1,0-1,5	1 year
Sulphate (as SO4)	159	126	385	225	<400	400-600	7 years
Total Dissolved Solids	1160	1040	2050	1100	<1000	1000-2 400	7 years
Ammonia (as N)	<0.15	<0.15	<0.15	<0.15	<1,0	1,0-2,0	No Limit [d]
Nitrate & Nitrite (as N)	5.8	3.5	6.0	6.5	<10	10-20	7 years
Iron (as Fe) µg/l	<10	<10	120	<10	<200	200-2 000	7 years [b]
Manganese (as Mn) µg/l	<40	<40	<40	<40	<100	100-1 000	7 years
Aluminium (as Al) µg/l	80	800	60	<14	<300	300-500	1 year

a	The limits for the consumption of Class II water are based on the consumption of 2 litres of water per day by a person of mass 70 kg over a period of 70 years.
b	The limits given are based on aesthetic aspects.
c	No primary health effect – low pH values can result in structural problems in the distribution system.
d	These values can indicate process efficiency and risks associated with pathogens.
e	as $CaCO_3$

The test indicators for fluoride according to the laboratory results, indicates that the water is not suitable for long term human consumption with regard to the 1.5 mg/L Class 1 limit value as stated by SANS 241-2011. Provision must be made for de-fluorination of the Romanskolk water close to the Brandvlei reservoir in the town, where the fluoride was measured as 1.1 mg/L according to the laboratory test results performed in April 2012.

The total installation cost for the pre-treatment system for decalcification and defluorination, including all miscellaneous material and equipment is estimated at ***R 1 250 800.00 (incl. VAT & 10% Contingencies)***

9.1.2 Water Losses on Existing Romanskolk Water Supply Line

The water losses on Romanskolk were determined by means of a water balance as shown in **Table 9.2**, using the data provided by Hantam Municipality over a twelve month period.

Table 9.2: Water Balance for Romanskolk Bulk Water Supply to Brandvlei (2011/12)

	Jul '11-Total	Aug '11-Total	Sep '11-Total	Oct '11-Total	Nov '11-Total	Dec '11-Total
BG 1 borehole	4 756	3 122	0	1 344	3 222	4 096
BG 2 borehole		0	0	0	0	0
BG 3 borehole	4 931	3 438	0	1 825	3 736	4 731
BG 4 borehole	1 830	1 536	4 711	4 431	0	2 252
BG 7 borehole			5 761	5 948	3 055	0
BG 14 borehole		0	0	0	0	3 055
TOTAL SOURCE SUPPLY (m^3)	11 517	8 096	10 472	13 548	10 013	14 134
Brandvlei Reservoir (m^3)	8 346	9 182	10 181	10 987	12 259	13 134
Brandvlei Bulk Loss (%)	28%	-13%	3%	19%	-22%	7%
Difference Bulk Net Volume (m^3)	3 171	-1 086	291	2 561	-2 246	1 000
Brandvlei Billing (m^3)	5 092	4 879	6 434	6 453	6 846	7 243
Network Loss	39%	47%	37%	41%	44%	45%

	Jan '12-Total	Feb '12-Total	Mar '12-Total	Apr '12-Total	May '12-Total	Jun '12-Total	Grand Total
BG 1 borehole	3 869	2 807	5 126	4 450	5 015	4 135	41 942
BG 2 borehole	0	0	0	0	0	0	0
BG 3 borehole	5 559	5 209	5 029	3 495	3 433	2 510	43 896
BG 4 borehole	1 517	1 437	1 753	3 601	2 457	3 145	28 670
BG 7 borehole	6 341	3 466	2 283	0	1 214	0	28 067
BG 14 borehole	0	0	0	0	0	0	3 055
TOTAL SOURCE SUPPLY (m^3)	17 285	12 919	14 191	11 546	12 119	9 790	145 630
Brandvlei Reservoir (m^3)	12 891	11 533	12 533	9 913	9 780	9 015	129 753
Brandvlei Bulk Loss (%)	25%	11%	12%	14%	19%	8%	**
Difference Bulk Net Volume (m^3)	4 394	1 386	1 658	1 633	2 339	775	15 877
Brandvlei Billing (m^3)	10 232	7 811	8 214	7 169	6 300	6 363	83 036
Network Loss	21%	32%	34%	28%	36%	29%	

** Mean Bulk Water Losses over 12 Month Period = 11%

The pump volumes for each of the boreholes BR1, BR2, BR3, BR4, BR7 and BR14 was recorded on a monthly basis to determine the total amount of water pumped as 145 630 m^3/a from July 2011 to June 2012. The recorded monthly bulk water meter readings at the outflow of the Brandvlei's 0.5 ML reservoir was used to determine the total amount of water supplied to the town as 129 753 m^3/a over the same twelve month period from July 2011 to June 2012. The average losses on the existing 150 mm diameter A/C Romanskolk bulk water supply pipeline is calculated at 11% losses. By adding 4% losses on Brandvlei's internal distribution network to the 11% bulk water supply losses, total losses of 15% shall then be within internationally prescribed acceptable norm. It should be noted that there were months that the water usage in the town were more than the bulk water supplied from the boreholes. This confirms that the accuracy of the water meter readings is doubtful.

9.1.3 Pipe Breakage on Existing Romanskolk Water Supply Line

The recorded water loss of 11% on Romanskolk pipeline is not excessive and thus relatively normal. However, the approach of the Romanskolk Water Supply is also to be assessed with regard to the high number of breakages occurring on the asbestos-cement (A/C) 150 mm diameter gravity pipeline. A visual investigation performed on the pipe breakages that occurred all along the 42 km long pipe line, confirms the presence of distinct line breakage along the length of the existing pipe as shown in the photos below.

The CSIR (NBRI) report on behalf of SAFCMA relating to small diameter A/C pipes ranging from 20 mm up to 150 mm in diameter supplied prior to 1985, confirms that there is a definite problem with the behaviour of the hydraulic binder (OPC, Ordinary Portland Cement) used in A/C pipes manufactured before 1985 (ref **Appendix 6**). It was found that longitudinal cracking of small diameter asbestos-cement pipes occurred as a result of the combination of processes such as leaching of lime from the inside of the pipe, formation of expansive materials, differential distribution of water in the pipe wall, hydration of unhydrated clinker, etc. which is directly related to the behavior of the hydraulic binder phenomenon. The presence of longitudinal crack formation thus resulting in pipe instability and pipe breakages, as is the case with the existing 150 mm diameter asbestos-cement pipe line of Romanskolk.

Another critical factor contributing to the high number of pipe breakages on Romanskolk A/C pipe line is that the life span of the pipe is only about 30 years after which it must be replaced. The existing 150 mm A/C pipe line was installed at round about 1965 by the municipality at that time just after the 1961 floods that divided the town into two parts. Thus the existing A/C Romanskolk pipe line, which is currently 47 years in operation, is at this point in time 17 years over its useful life time and due for replacement.

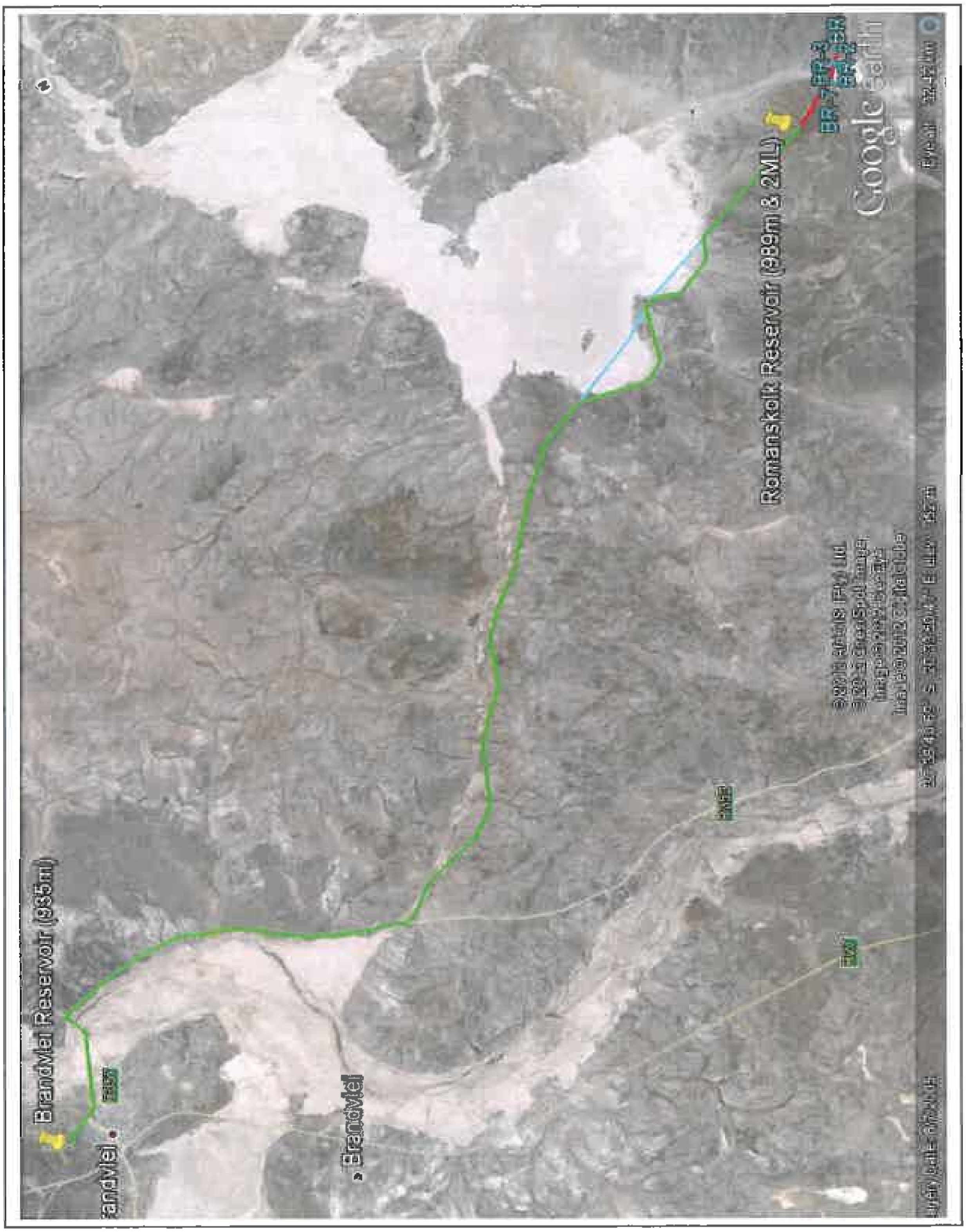
9.1.4 Design Capacity of Existing Romanskolk Water Supply Line

A design check was performed to determine whether the existing 150 mm constant inside diameter (CID) asbestos-cement pipe line, was still adequate with regards to existing capacity. The pipe line gravitating form the Romanskolk reservoir (979.38 mamsl) to the Brandvlei reservoir (933.10 mamsl). The assumed Hazen-Williams roughness coefficient of C = 90 was used in the design to compensate for the more than 30 year old pipe line. In order to overcome the maximum static head difference of 62.5 m and still obtaining an residual head of 0.7 m at Brandvlei's reservoir, the existing pipe line will only be able to provide for a flow rate of 4.65 L/s.

This flow rate equaling a supply of 401.76 m^3/d, indicates that the existing pipe line capacity is not sufficient to deliver the current summer peak water demand of 424 m^3/d during December 2011. In order to allow for the peak summer flow of 542 m3/d after 20 years from now (*ref. Tab 2.3 , pg.11*) the existing 150 mm CID A/C pipe shall have to be replaced.

The preliminary design performed requires installation of a 160 mm diameter Class 9 uPVC pipe, with length 42 km placed 1.0 m beneath natural ground, to provide a residual head of 4.63 m at Brandvlei's reservoir. The proposed pipe line route shall not pass over the pan, but will go around the pan as shown in **Figure 9.2** to ease operation and maintenance during rainfall seasons.

The total installation cost for the gravity pipe line, including all miscellaneous material and equipment (e.g. bends, special fittings, valves, etc.) is estimated at R 23 078 553.30 (incl. VAT & 10% Contingencies)



The option to perform a specialized "Pipe cracking" technique on the existing 150 mm dia A/C pipeline is being investigated.

The addition of a second 0.5ML storage reservoir next to the existing Brandvlei reservoir as mentioned in par. 2.2.3, must be incorporated to provide for 48 h hours of peak demand storage of 768 m3/d for a single water source.

*The total installation cost for the raw water storage reservoir, including all miscellaneous material and equipment (e.g. bends, valves, etc.) is estimated at **R 1 504 800.00** (incl. VAT & 10% Contingencies)*

9.1.5 Existing Pump System at Romanskolk

The existing Romanskolk pump system was upgraded in 1998 with regard to the submersible pumps and installation of a 110 mm diameter Class 9 uPVC rising main pump line. The rising main pipe line stretches over a length of 7.13 km from the existing boreholes BR1, BR2, BR3, BR4, BR7 and BR14 to the balancing 0.2 ML Romanskolk reservoir.

It should be noted that borehole BR14 is pumped dry and no longer in use. The existing electrical power supply to submersible borehole pumps provided by manually operated diesel driven machines are problematic with regard to high operation and maintenance cost. The very old machines are out dated and need to be dismantled and sent away for maintenance and repairs on a regular monthly basis (*per. com. Mr. Brian Meyer, Hantam Municipality*), thus alternative means of electrical power supply shall need to be looked at as confirmed by the SRK feasibility study of May 2010 (ref. **Appendix 5**).

*The total installation cost for the high voltage power supply, including all miscellaneous material and equipment (e.g. cables, poles, transformers, etc.) is estimated at **R 8 920 454.40 (incl. VAT & 10% Contingencies)***

Provision is to be made via a Telemetry system with automated level control on the Brandvlei storage reservoir and Romanskolk balance reservoir, to control the on- and off cycles of the existing submersible borehole pumps.

*The total installation cost for the Telemetry system, including all miscellaneous material and equipment (e.g. cables, transmitters, etc.) is estimated at **R 2 501 730.00 (incl. VAT & 10% Contingencies)***

9.1.6 Romanskolk Alternative Pipeline Route

The local municipality currently encounters problems with access on the existing 42 km pipeline route which effects routine repair and maintenance work. The option of an alternative 52 km route for the Romanskolk pipeline was investigated, with layout shown in **Figure 9.3**.

This option shall require for an EIA investigation, which is already in progress. The estimated time for ROD and approval from DEA is March 2014. The advantage of this option is that only a way-leave application needs to be submitted at the Department of Roads and Public Works, to construct the 200 mm diameter uPVC Class 9 pipeline within their already existing road servitude. The option of the alternative route shall imply that no time staking and problematic servitude registration processes need to be followed with private land owners. The written way-leave application was submitted to the Department of Roads and Public Works (Northern Cape; att. Mr. Jaco Roelofse) for their approval.

The alternative route has been surveyed in order to perform the preliminary design and cost estimations.

The total installation cost for the gravity pipe line, including all miscellaneous material and equipment (e.g. bends, special fittings, valves, etc.) is estimated at ***R 28 492 823.70 (incl. VAT & 10% Contingencies)***

The costs for Telemetry Level Control for this option is estimated at R 3 260 400.00 (incl. VAT & 10% Contingencies), as well as for the High Voltage power supply line at R 13 795 153.68 (incl. VAT & 10% Contingencies).

9.1.7 Pipe-Cracking on Existing Romanskolk Pipeline Route

The option of performing Pipe-cracking on the existing Romanskolk pipeline was investigated as a third alternative. This method entails the replacement of the existing 150 mm diameter CID A/C pipe with a 200 mm diameter OD PE100 PN8 HDPE pipe. The distance of manholes between butt-weld joint spacing varies from 100m to 200 m depending on the plant.

The total installation cost for the gravity pipe line via Pipe-Cracking, excluding miscellaneous material and equipment (e.g. bends, special fittings, valves, etc.) is estimated at ***R 39 069 004.32 (incl. VAT & 10% Contingencies)***

The costs for Telemetry Level Control for this option is estimated at R 2 501 730.00 (incl. VAT & 10% Contingencies), as well as for the High Voltage power supply line at R 10 882 111.68 (incl. VAT & 10% Contingencies).

It should be noted that this method is most commonly utilized in major city centres where the need for overcoming existing services and obstacles (e.g. streets, buildings, pipe- & sewer networks, storm water pipes and channels, parks and landfill sites etc.) is essential to limit construction cost.

The implementation of this construction method does not eliminate the process of servitude registration for routine repair and maintenance required on the 200mm HDPE pipeline route.

10. PROJECT COST ESTIMATE

10.1 Cost Estimate for Brandvlei Groundwater Desalination

The initial cost estimate for the Desalination option was done in April 2010 by SRK Consulting, Mr Des Visser. The initial costing included all the works as stipulated in this report with the exclusion of a Raw Water Storage 0.5 ML reservoir to a net cost of **R 8 586 889.00** (incl. VAT).

However, the costs of Evaporation Ponds of R 1 202 349.00 for a surface area of 30 417 m^2, was under estimated by almost R 4 272 711.00 (cost of similar projects in 2010 was R 180/ m^2 of surface area). The costs of the brine evaporation ponds have increase dramatically along with escalation increases , due to the increase in size of surface area for the Evaporation Ponds to 52 000 m^2 for a lower recovery of 50% on the Desalination Plant.

The stipulated minimum requirements on the Geo-membrane lining system for liquid contaminant waste containment (e.g. brine disposal) obtained from DWA (ref. Mr. Kelvin Legge) during March 2013, resulted in a further cost increase on the Evaporation Ponds estimated to R 20 710 486.13 in total (excl. VAT).

The information obtained from Mr. Legge was send to lining system specialists AQUATAN (Mr. Piet Meyer) whom provided detail of layer works on lining system accompanied by a prelim construction cost estimate of R 13 458 901.00 (excl. VAT and escalation). Please refer to **Appendix *8*** for typical layer work specifications and detail as provided via AQUATAN.

The price of electricity for this calculation was taken at R1.20 per kW.h for providing electricity in Brandvlei via the municipal power distribution network.

The following **Table 10.1** and **Table 10.2** provide a break-up of the costing for the various units as well as an estimate of the annual operational and maintenance costs.

Table 10.1: Project Costs for Brandvlei Groundwater Desalination (Estimated)

ITEM	DESCRIPTION	TOTAL
1	Preliminary and general	R 5 740 448.27
2	RO Desalination Plant	R 4 233 600.00
3	Raw Water 0.5 ML Reservoir	R 1 260 000.00
4	Raw Water Supply Line (2650 m Length)	R 1 142 636.10
5	Lifting Borehole pump station	R 674 069.15
6	Brine Evaporation Ponds (52 000 m^2 Surface Area)	R 20 710 486.13
7	High Voltage Electricity Supply Line	R 681 450.00
	Sub-Total	**R 34 442 689.65**
	10% Contingencies	R 3 444 268.96
	Total Construction Cost	**R 37 886 958.61**
	Professional fees	R 3 136 717.52
	Disbursements during Construction Phase	R 830 854.25
	Project Cost	**R 41 854 530.38**
	VAT	R 5 859 634.25
	Total Project Cost	***R 47 714 164.63***

Table 10.2: Summary of O&M Costs for Brandvlei Groundwater Desalination

ITEM	DESCRIPTION	O & M COST	Operation	Maintenance
1	**Maintenance Cost** (RO Treatment Plant Maintenance excluded)			
1.2	Proposed works			
1.2.1	4% on Pump station mechanical equipment (value R 350 344)	R 14 013.76		R 14 013.76
1.2.2	1% on Pipelines and Power lines (value of R 1 737 225)	R 17 372.25		R 17 372.25
1.2.3	0,5% on civil works to the value of R 9 613 952	R 106 067.72		R 106 067.72
2	**Operation Cost** (RO Treatment Plant Operation excluded)			
2.1	Borehole Pump station Electricity cost 0.38 kWh/kl @ 279 590 kl	R 105 120.00	R 105 120.00	
2.2	Salaries of operating staff required @R10 000/month (4 staff)	R 480 000.00	R 480 000.00	
2.3	Administrative costs @ R 3000 per month	R 36 000.00	R 36 000.00	
	Total annual cost	R 758 573.73	R 621 120.00	R 137 453.73
	Estimated water supply (kl/year)	279 590	279 590	279 590
3	Unit cost of water (R/kL)	R 2.71	R 2.22	R 0.49
4	O&M Cost for RO Desalination Plant (R/kL)	R 6.58	R 2.12	R 4.46
5	***Total Project O & M Costs (R/kL)***	***R 9.29***	***R 4.34***	***R 4.95***

10.2 Cost Estimate for Romanskolk Water Supply via Existing Route

The following **Table 10.3** and **Table 10.4** provide a break-up of the costing for the various units as well as an estimate of the annual operational and maintenance costs.

Table 10.3: Project Cost for Romanskolk Water Supply via Existing Route (Estimated)

ITEM	DESCRIPTION	TOTAL
1	Preliminary and general	R 5 103 510.00
2	Romanskolk Gravity Main (Pipe Trenches)	R 10 941 535.00
3	Romanskolk Gravity Main (Pipe Line)	R 9 302 810.00
4	Romanskolk ESKOM Power (Supply Line)	R 7 824 960.00
5	Raw Water 0.5 ML Reservoir	R 1 320 000.00
6	Calcification Pre Treatment	R 385 000.00
7	Telemetry Level Control	R 2 194 500.00
	Sub-Total	**R 37 072 315.00**
	10% Contingencies	R 3 707 231.50
	Total Construction Cost	**R 40 779 546.50**
	EIA (Romanskolk Upgrade)	R 260 000.00
	Professional fees	R 3 310 272.79
	Disbursements during Construction Phase	R 830 854.25
	Project Cost	**R 45 180 673.54**
	VAT	R 6 325 294.30
	Total Project Cost	***R 51 505 967.84***

Table 10.4: Summary of O&M Cost for Romanskolk Water Supply via Existing Route

ITEM	DESCRIPTION	O & M COST	Operation	Maintenance
1	**Maintenance Cost** (Romanskolk Maintenance excluded)			
1.2	Proposed works			
1.2.1	4% on Pump station mechanical equipment (value R 713 768)	R 28 550.72		R 28 550.72
1.2.2	1% on Pipelines and Power lines (value of R 30 876 235.50)	R 280 693.05		R 280 693.05
1.2.3	0,5% on civil works to the value of R 1 320 000	R 6 600.00		R 6 600.00
2	**Operation Cost** (Pre-Treatment Plant Operation excluded)			
2.1	Borehole Pump station Electricity cost 0.30 kWh/kl @ 139 795 kl	R 50 589.00	R 50 589.00	
2.2	Salaries of operating staff required @R10 000/month	R 120 000.00	R 120 000.00	
2.3	Administrative costs @ R 3000 per month	R 36 000.00	R 36 000.00	
	Total annual cost	R 522 432.77	R 206 589.00	R 315 843.77
	Estimated water supply (kl/year)	139 795.00	139 795.00	139 795.00
3	Unit cost of water (R/kL)	R 3.74	R 1.48	R 2.26
4	O&M Cost for Pre-Treatment Plant (R/kL)	R 0.35	R 0.01	R 0.34
5	***Total Project O & M Costs (R/kL)***	***R 4.08***	***R 1.49***	***R 2.59***

10.3 Cost Estimate for Romanskolk Water Supply via Alternative Route

The following **Table 10.5** and **Table 10.6** provide a break-up of the costing for the various units as well as an estimate of the annual operational and maintenance costs.

Table 10.5: Project Costs for Romanskolk Water Supply via Alternative Route (Estimated)

ITEM	DESCRIPTION	TOTAL
1	Preliminary and general	R 6 744 494.00
2	Romanskolk Gravity Main (Pipe Trenches)	R 13 532 695.00
3	Romanskolk Gravity Main (Pipe Line)	R 11 461 010.00
4	Romanskolk ESKOM Power (Supply Line)	R 12 101 012.00
5	Raw Water 0.5 ML Reservoir	R 1 320 000.00
6	Calcification Pre Treatment	R 385 000.00
7	Telemetry Level Control	R 2 860 000.00
	Sub-Total	**R 48 404 211.00**
	10% Contingencies	R 4 840 421.10
	Total Construction Cost	**R 53 244 632.10**
	EIA (Romanskolk Upgrade)	R 260 000.00
	Professional fees	R 4 058 177.93
	Disbursements during Construction Phase	R 830 854.25
	Project Cost	**R 58 393 664.28**
	VAT	R 8 175 113.00
	Total Project Cost	***R 66 568 777.28***

Table 10.6: Summary of O&M Costs for Romanskolk Water Supply via Alternative Route

ITEM	DESCRIPTION	O & M COST	Operation	Maintenance
1	**Maintenance Cost** (Romanskolk Maintenance excluded)			
1.2	Proposed works			
1.2.1	4% on Pumpstation mechanical equipment (value R 713 768)	R 28 550.72		R 28 550.72
1.2.2	1% on Pipelines and Powerlines (value of R 37 094 717)	R 370 947.17		R 370 947.17
1.2.3	0,5% on civil works to the value of R 1 320 000	R 6 600.00		R 6 600.00
2	**Operation Cost** (Pre-Treatment Plant Operation excluded)			
2.1	Borehole Pumpstation Electricity cost 0.30 kWh/kl @ 139 795 kl	R 50 589.00	R 50 589.00	
2.2	Salaries of operating staff required @R10 000/month	R 120 000.00	R 120 000.00	
2.3	Administrative costs @ R 3000 per month	R 36 000.00	R 36 000.00	
	Total annual cost	R 612 686.89	R 206 589.00	R 406 097.89
	Estimated water supply (kl/year)	139 795.00	139 795.00	139 795.00
3	Unit cost of water (R/kL)	R 4.38	R 1.48	R 2.90
4	O&M Cost for Pre-Treatment Plant (R/kL)	R 0.35	R 0.01	R 0.34
5	***Toatal Project O & M Costs (R/kL)***	***R 4.73***	***R 1.49***	***R 3.24***

10.4 Cost Estimate for Romanskolk Water Supply via Pipe Cracking

The following **Table 10.7** and **Table 10.7** provide a break-up of the costing for the various units as well as an estimate of the annual operational and maintenance costs.

Table 10.7: Project Costs for Romanskolk Water Supply via Pipe Cracking (Estimated)

ITEM	DESCRIPTION	TOTAL
1	Preliminary and general	R 16 708 200.22
2	Romanskolk Gravity Main (Pipe Cracking)	R 39 069 004.32
3	Romanskolk ESKOM Power (Supply Line)	R 9 545 712.00
4	Raw Water 0.5 ML Reservoir	R 1 320 000.00
5	Calcification Pre Treatment	R 385 000.00
6	Telemetry Level Control	R 2 194 500.00
	Sub-Total	**R 69 222 416.54**
	10% Contingencies	R 6 922 241.65
	Total Construction Cost	**R 76 144 658.19**
	EIA (Romanskolk Upgrade)	R 260 000.00
	Professional fees	R 5 432 179.49
	Disbursements during Construction Phase	R 830 854.25
	Project Cost	**R 82 667 691.93**
	VAT	R 11 573 476.87
	Total Project Cost	***R 94 241 168.80***

Table 10.8: Summary of O&M Costs for Romanskolk Water Supply via Pipe Cracking

ITEM	DESCRIPTION	O & M COST	Operation	Maintenance
1	**Maintenance Cost** (Romanskolk Maintenance excluded)			
1.2	Proposed works			
1.2.1	4% on Pumpstation mechanical equipment (value R 713 768)	R 28 550.72		R 28 550.72
1.2.2	1% on Pipelines and Powerlines (value of R 28 069 305)	R 486 147.16		R 486 147.16
1.2.3	0,5% on civil works to the value of R 1 320 000	R 6 600.00		R 6 600.00
2	**Operation Cost** (Pre-Treatment Plant Operation excluded)			
2.1	Borehole Pumstation Electricity cost 0.30 kWh/kl @ 139 795 kl	R 50 589.00	R 50 589.00	
2.2	Salaries of operating staff required @R10 000/month	R 120 000.00	R 120 000.00	
2.3	Administrative costs @ R 3000 per month	R 36 000.00	R 36 000.00	
	Total annual cost	R 727 886.88	R 206 589.00	R 521 297.88
	Estimated water supply (kl/year)	139 795.00	139 795.00	139 795.00
3	Unit cost of water (R/kL)	R 5.21	R 1.48	R 3.73
4	O&M Cost for Pre-Treatment Plant (R/kL)	R 0.35	R 0.01	R 0.34
5	*Total Project O & M Costs (R/kL)*	*R 5.55*	*R 1.49*	*R 4.06*

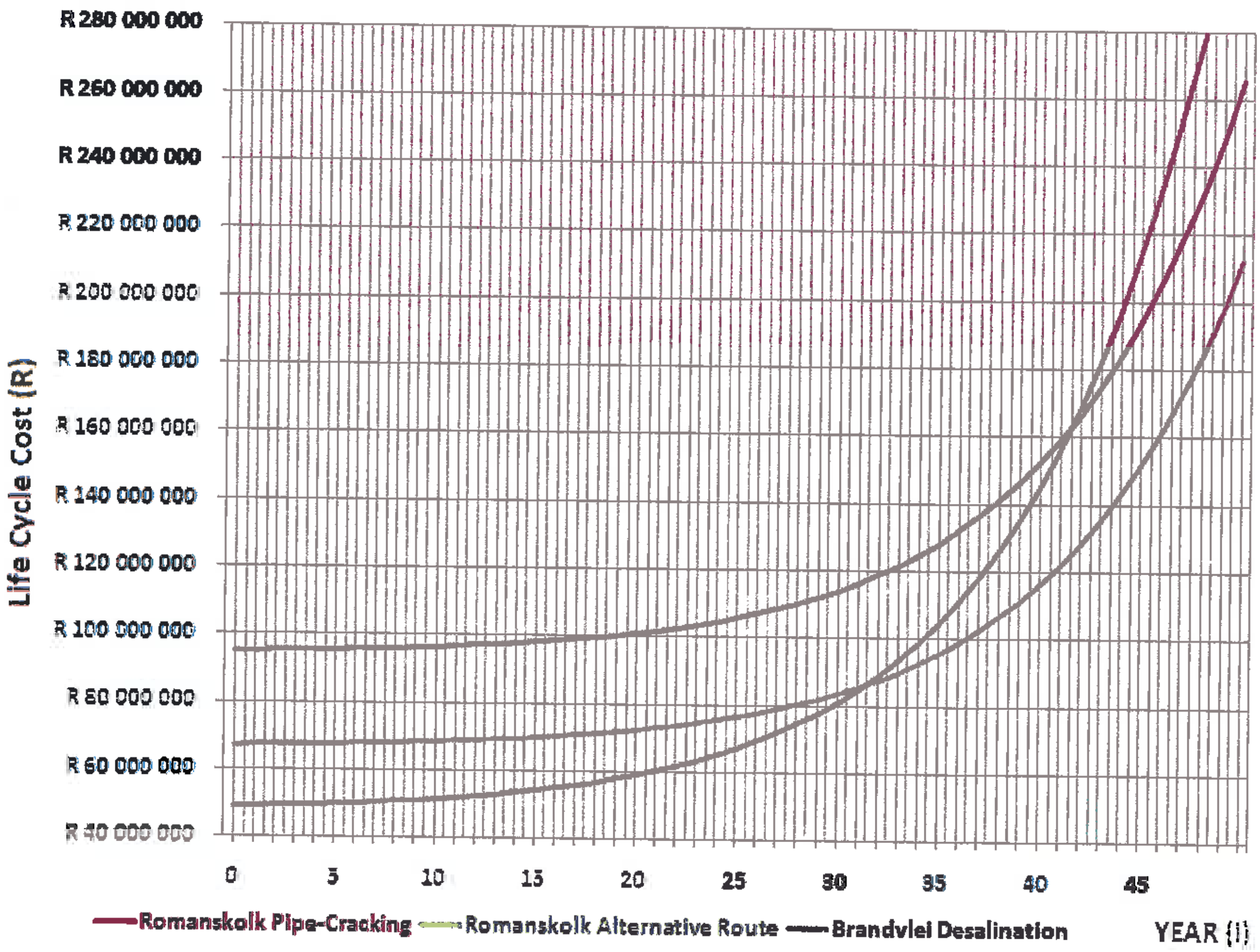
10.5 Life Cycle Cost Analysis

The option of upgrading Romanskolk pipeline via the existing route shall not form part of the life cycle cost analysis. This option shall no longer be considered as a feasible option due to the lack of servitude, as well as non-existing entrance routes for routine repair and maintenance work.

A population growth rate of 1.27% and 10% annual escalation in O&M costs was used to perform the life cycle cost analysis on the remaining three(3) options as shown in **Figure 10.1** below.

After 32 years the Brandvlei Desalination option shall break even with the Romanskolk Alternative Route option and become more expensive due to higher O&M unit costs. At year 42 the Brandvlei Desalination option will break even with the Romanskolk Pipe-Cracking option and become more expensive.

Figure 10.1 : Life Cycle Cost of Alternative Options



From the above cost analysis it is clear that the Romanskolk Pipe-Cracking option is not feasible with regard to life cycle cost. The figures indicate that over the long run the Brandvlei Desalination option is less feasible than the Romanskolk Alternative Route option. The high R9.29/KL unit cost for desalinated drinking water in Brandvlei shall also make this option unaffordable for the local community of Brandvlei and its indigents. Thus, the Romanskolk Alternative Route option (R4.73/KL unit cost) is the most feasible and affordable option.

11. SOCIAL COMPONENT

11.1 Social Component on Estimated Future Water Demand

The population of Brandvlei was assessed to have an positive growth potential according to the Reconciliation Strategy for Brandvlei Town, with anticipated population increase of 2804 (in 2008) to 3154 (in 2030) as indicated in **Table 11.1** below, taken from this report.

Table 11.1 : Historical and Projected Population for Brandvlei Town

Year	2008	2010	2015	2020	2025	2030
Population	2804	2785	2850	2942	3047	3153

It should be noted that the population growth rate was not positive as indicated in the above table taken from Reconciliation Strategy for Brandvlei Town report. However, the growth rate is shown to be negative from 2008 (2804) up to 2010 (2785). It should also be noted that to obtain a population growth of 2804 (in 2008) to 3153 (in 2030), a population growth rate of **0.535%** needs to be applied over the 22 year period.

The above growth rate is not in line with the most recent population growth rate of 1.16% obtained from a study performed by the Department of Social Development in 2007 (per. com. Me. Adeline Squires). For this reason the estimated growth rate of 1.27% as mentioned in par. 2.1.1 is taken as more representative with regard to projected future water demand.

The social component takes into account that the indigent population makes up 58.6% of the total population 3877 (in 2030), adding up to 2,272 indigents and 1,605 non-indigents in 2030. The figures obtained for associated users e.g. schools, crèche's, hospitals, clinics and community halls was double checked and confirmed with the figures from SETPLAN (per. com. Me. Adeline Squires). However, the indigent register obtained from Hantam Municipality indicates 494 households adding up to 1976 indigents for 2012 (ref. **Appendix 7**).

The estimated figure for indigents, using the growth rate of 1.27%, adds up to 2,480 indigents and 1,397 non-indigents in 2030. The prescribed water use for each water user type was used to calculate the water use per day in cubic metres. Thereafter the social component percentage was calculated with regard to the design water demand of 383 m^3/d into the network.

The social component as confirmed with Me. Adeline Squires from SETPLAN, is indicated in the **Table 11.2** below.

Table 11.2: Social Component on Estimated Future Water Demand

Indigents	Population 2030	Indigent population	Users 2030	Water use (L/day)	m3 / day	Supply in 2030 (m3/day)	% social component
Brandvlei	3,877	63.97%	2,480	80	198.4	383	51.80%
Non-indigents	1,397	100.00%	1,397	25	34.9	383	9.10%
Subtotal			***3,877***		***233.3***		***60.90%***
Associated users	**2011**	**Growth pa**	**Users 2030**				
Schools (day) learners	732	2.00%	1,066	20	21.33	383	5.60%
Schools (boarding)	56	2.00%	82	140	11.42	383	3.00%
Crèche learners	73	2.00%	107	20	2.13	383	0.60%
Hospital beds	6	0.50%	7	300	1.98	383	0.50%
Clinic outpatients			21,557	20	1.18	383	0.30%
Community hall seats			97	90	8.72	383	2.30%
Subtotal							**12.20%**
TOTAL social component							**73.10%**

Taking into account for network losses, with calculated network losses of 11 % on the Romanskolk pipeline and assuming a minimum of 4% network losses within Brandvlei, the social component with regard to 15% losses as confirmed with SETPLAN is indicated in the **Table 11.3** below.

Table 11.3: Social Component on Estimated Future Water Demand (with 15% losses)

Indigents	Population 2030	Indigent population	Users 2030	Water use (L/day)	m3 / day	Supply in 2030 (m3/day)	% social component
Brandvlei	3,877	63.97%	2,480	80	198.4	326	60.86%
Non-indigents	1,397	100.00%	1,397	25	34.9	326	10.71%
Subtotal			***3,877***		***233.3***		***71.57%***
Associated users	**2011**	**Growth pa**	**Users 2030**				
Schools (day) learners	**732**	2.00%	1,066	20	21.33	326	6.60%
Schools (boarding)	**56**	2.00%	82	140	11.42	326	3.50%
Crèche learners	**73**	2.00%	107	20	2.13	326	0.70%
Hospital beds	**6**	0.50%	7	300	1.98	326	0.60%
Clinic outpatients			21,557	20	1.18	326	0.40%
Community hall seats			97	90	8.72	326	2.70%
Subtotal							**14.40%**
TOTAL social component							**85.97%**

It should be noted that the actual internal network loss of 36% was measured over a twelve month period in Brandvlei. Of the 36% losses it can be assumed that a large percentage might be contributed to water use unaccounted for, due to calcified water meters which cannot be billed for.

The portion of the project that delivers water to the social component with no provision for any network losses is 73.10%. The portion of the project that delivers water to the social component and taking network losses in to account is **85.97%,** which can be applied to the total cost of the project as indicated in **Table 11.4** below.

Table 11.4: Social Component on RBIG vs Own Funding Portions

	Social Component	Brandvlei Desalination	Romanskolk via Alternative Route	Romanskolk via Pipe-Cracking
RBIG Funding	85.97%	R 41 019 867.33	R 57 229 177.82	R 81 019 132.82
Own Funding	14.03%	R 6 694 297.30	R 9 339 599.45	R 13 222 035.98
Tot Project Funding	100.0%	**R 47 714 164.63**	**R 66 568 777.28**	**R 94 241 168.80**

12. SUMMARY AND RECOMMENDATIONS

This document serves as a technical design report to convey to the client in broad terms what is suggested to ensure a long-term solution for the treatment and re-use of groundwater at Brandvlei within Hantam Local Municipality.

After investigating several options, the following is recommended:

- The high energy, O&M and unit costs together with latest cost estimations on storage pond linings makes the Brandvlei Desalination option unaffordable for the local community of Brandvlei.
- The high capital and unit cost for the Romanskolk Pipe-Cracking option makes it no longer feasible, with regard to affordability for the local community of Brandvlei and for the local municipality.
- The Romanskolk Alternative Route option is considered the most feasible option. The unit cost of **R4.73/kL** makes this option affordable for both end users and the local municipality. The alternative 52km route within the existing servitudes of the Department of Roads and Public Works shall simplify the EIA process and shall require only for way-leave application at the Department of Roads and Public Works.
- Should the Romanskolk Alternative Route option be agreed upon by all parties, the Evaluation Criteria for Implementation Readiness must be finalized and submitted to DWA (ref. **Appendix 9**).

All specific recommendations included in this report should be addressed as highlighted within the report.

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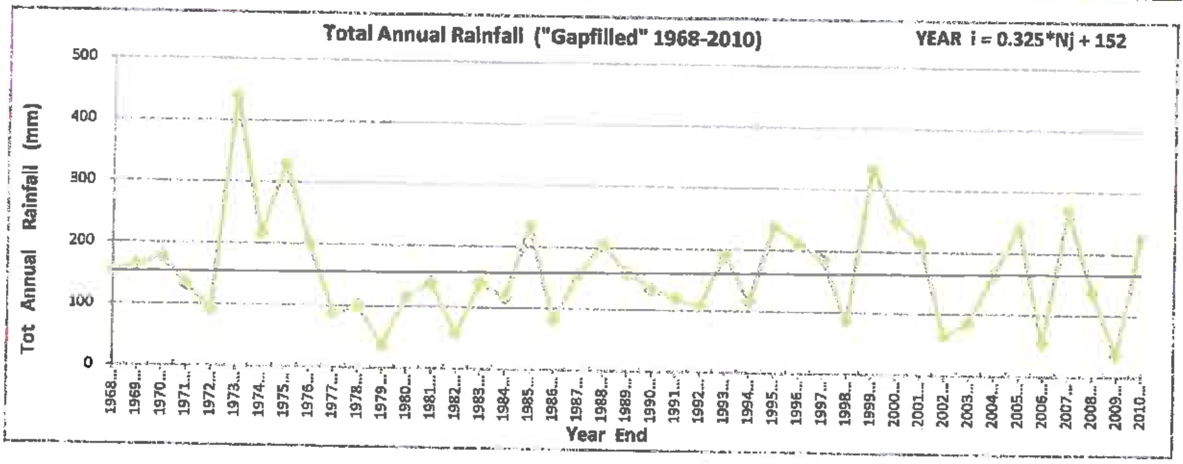
P. VAN DYK (BVi Consulting Engineers)

APPENDIX 1

Appendix 1 : Real Gap-filled Rainfall Data for Gauging station D5E007 (in mm)

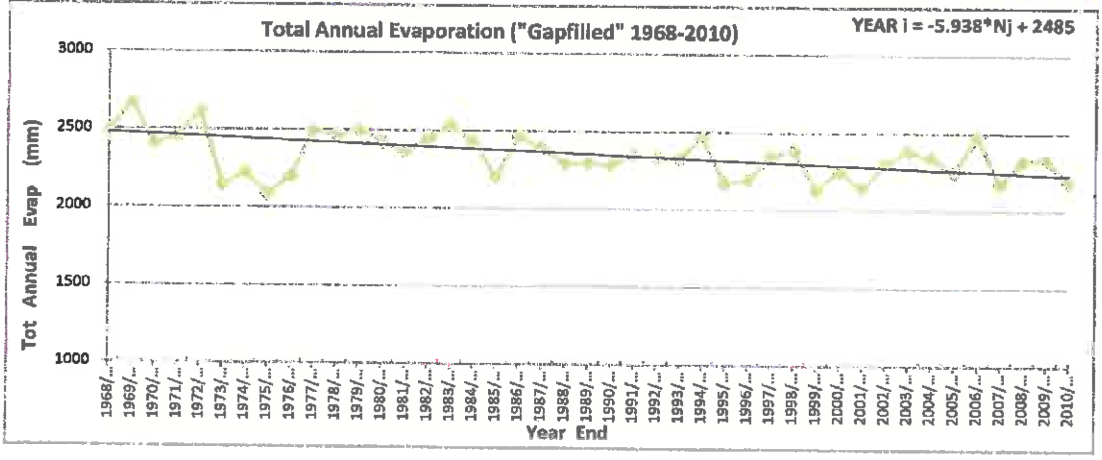
Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean Monthly	Annual Total
1968/69	32.1	4.2	0.0	2.8	75.8	16.4	5.9	14.5	0.0	0.0	0.0	0.4	12.7	152
1969/70	12.3	0.0	0.7	22.8	38.5	0.6	17.2	15.5	43.1	4.0	10.1	0.1	13.7	165
1970/71	2.1	17.7	0.8	24.5	33.5	34.8	10.3	13.3	1.0	28.9	10.8	0.0	14.8	178
1971/72	0.0	0.0	1.8	52.4	1.7	51.1	15.3	2.4	4.0	0.5	0.9	2.4	11.0	132
1972/73	0.0	0.0	0.0	1.1	31.4	23.9	21.4	0.1	2.3	10.6	1.3	0.7	7.7	93
1973/74	20.4	1.1	35.2	71.8	82.7	52.5	147.6	1.6	16.9	0.8	7.9	0.8	36.6	439
1974/75	1.1	17.8	3.1	20.0	12.1	101.8	25.1	15.5	7.8	12.8	0.0	0.2	18.1	217
1975/76	6.5	19.3	24.8	39.0	64.6	122.6	20.6	15.0	7.6	6.9	0.0	2.5	27.4	329
1976/77	75.0	1.3	0.0	1.2	34.2	19.2	29.3	19.3	8.7	4.1	2.7	6.7	16.8	202
1977/78	0.8	24.4	4.2	8.3	4.1	13.6	29.2	0.1	1.5	0.1	1.7	0.2	7.3	88
1978/79	5.3	7.6	0.8	24.9	33.9	0.0	0.0	0.2	6.0	15.3	7.0	0.1	8.4	101
1979/80	1.5	5.0	0.0	0.0	0.6	19.0	0.4	1.6	7.1	0.0	0.0	1.3	3.0	37
1980/81	0.0	0.0	11.5	0.0	8.8	39.5	0.0	4.2	0.0	1.2	32.8	18.6	9.7	117
1981/82	36.4	0.0	9.9	0.0	0.0	10.0	40.7	4.4	6.2	8.5	4.4	18.4	11.6	139
1982/83	21.1	0.0	0.3	2.3	0.0	4.4	6.1	5.5	1.9	0.9	0.0	14.1	4.7	57
1983/84	12.4	56.7	17.3	0.0	6.3	15.2	17.0	4.0	9.2	2.0	0.0	0.0	11.7	140
1984/85	6.0	8.8	0.0	22.5	53.0	10.2	4.0	11.4	0.0	0.3	0.0	1.6	9.8	118
1985/86	79.2	15.7	33.9	0.0	0.0	50.0	21.6	0.0	30.5	3.7	0.0	0.0	19.6	235
1986/87	33.4	0.0	0.0	0.0	6.4	4.4	18.3	4.3	5.3	1.5	4.4	3.8	6.8	82
1987/88	0.0	18.6	5.1	0.0	33.4	71.6	10.8	3.3	2.0	0.0	10.5	1.0	13.0	156
1988/89	0.0	22.0	66.0	14.4	40.0	5.4	41.9	8.4	1.6	3.8	0.0	2.6	17.2	206
1989/90	0.0	8.0	0.0	0.0	19.6	24.0	76.0	8.0	21.0	3.0	0.0	0.0	13.3	160
1990/91	0.0	1.0	39.0	4.0	0.0	44.0	6.0	0.0	15.0	1.0	0.0	23.0	11.1	133
1991/92	44.5	0.0	22.0	5.0	0.0	20.0	1.0	4.0	0.0	7.0	16.0	0.0	10.0	120
1992/93	0.0	0.0	0.0	0.0	10.0	33.0	29.0	9.0	11.0	1.0	13.0	0.0	8.8	106
1993/94	13.0	24.0	1.0	61.0	18.0	57.0	5.0	0.0	8.0	5.0	0.0	0.0	16.0	192
1994/95	0.0	0.0	2.0	33.0	12.0	38.0	0.0	4.0	3.0	0.0	11.0	14.0	9.8	117
1995/96	4.0	12.0	47.0	7.5	34.9	0.0	12.6	0.0	0.0	115.0	1.0	5.5	20.0	240
1996/97	9.8	47.0	0.0	3.0	36.8	79.0	5.0	17.5	12.5	0.0	0.0	0.0	17.6	211
1997/98	0.0	0.0	0.0	10.5	83.5	59.0	0.0	4.4	0.0	0.0	20.0	11.0	15.7	188
1998/99	7.0	10.0	4.0	11.0	3.0	20.0	9.0	15.0	5.0	0.0	0.0	3.0	7.3	87
1999/0	21.8	23.0	42.0	72.6	59.0	106.0	6.0	0.0	1.0	1.0	0.0	2.0	27.9	334
2000/1	0.0	0.0	0.0	0.0	9.0	49.0	150.0	4.0	0.0	27.0	0.0	10.0	20.8	249
2001/2	3.0	42.0	0.0	14.0	33.0	30.0	31.0	27.1	11.0	3.6	19.6	1.0	17.9	215
2002/3	0.0	0.0	34.0	0.0	9.0	4.0	0.8	2.0	0.0	0.0	13.0	1.2	5.3	64
2003/4	9.0	13.0	0.0	6.6	5.0	5.0	38.0	0.0	3.0	1.0	1.0	3.0	7.1	85
2004/5	27.0	5.0	5.0	12.0	49.0	34.4	13.5	14.0	5.0	0.0	0.0	0.0	13.7	165
2005/6	24.0	13.0	2.0	43.0	28.9	15.0	46.8	51.0	0.C	2.0	11.0	2.0	19.9	239
2006/7	0.0	0.0	0.0	1.0	3.0	11.0	16.6	1.0	13.0	5.0	2.0	1.0	4.5	54
2007/8	11.0	10.0	97.0	7.0	37.0	24.0	0.0	20.0	49.0	8.0	6.0	0.0	22.4	269
2008/9	4.0	4.5	0.0	9.0	62.0	6.0	25.0	6.0	15.0	3.0	3.0	0.0	11.5	138
2009/10	1.0	0.0	0.0	4.0	18.0	11.0	0.0	3.2	0.0	0.0	0.0	0.0	3.1	37
2010/11	0	0	61	15	72.4	24	22.7	8.0	8.0	4.9	5.0	3.6	18.9	227
Mean	12	10	13	15	27	32	23	8	8	7	5	4	14	163



APPENDIX 2

Appendix 2 : Mean Gap-filled S-Pan Evaporation Data for Gauging station D5E007 (in mm)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Mean Monthly	Annual Total
1968/69	224.7	305.3	343.0	368.8	276.4	207.1	150.2	113.3	68.5	94.5	149.8	183.8	207.1	2485
1969/70	260.9	344.5	405.0	402.2	335.9	260.0	164.9	104.9	72.4	74.7	101.0	150.9	223.1	2677
1970/71	230.2	301.5	350.1	337.9	271.2	227.3	146.3	113.2	87.1	76.2	95.1	168.3	200.4	2404
1971/72	233.0	283.5	342.5	329.9	284.3	220.9	152.4	112.2	86.8	101.2	122.4	188.0	204.8	2457
1972/73	262.8	335.2	374.4	382.9	256.0	228.2	164.5	113.9	99.3	95.7	128.4	175.5	218.1	2617
1973/74	237.9	302.3	309.9	294.5	206.7	190.3	126.8	89.2	67.3	85.6	94.5	135.8	178.4	2141
1974/75	216.8	267.0	331.9	337.1	248.0	193.9	145.3	77.0	69.8	71.2	98.2	166.4	185.2	2223
1975/76	221.2	296.6	289.4	268.5	229.0	166.0	135.0	90.2	58.8	72.7	106.2	152.5	173.8	2086
1976/77	207.4	258.8	328.3	329.4	238.9	200.0	129.9	94.0	70.6	79.9	116.7	143.4	183.1	2197
1977/78	253.3	314.8	344.7	323.9	290.3	243.1	147.2	111.1	88.7	101.8	110.0	166.8	208.0	2496
1978/79	242.1	302.8	351.8	346.6	274.8	240.4	176.3	113.9	79.3	69.7	104.3	163.8	205.5	2466
1979/80	227.3	310.9	343.2	344.6	296.2	233.5	165.5	115.3	81.9	102.6	123.2	156.8	208.4	2501
1980/81	263.0	270.0	340.5	348.0	274.8	228.5	170.0	116.2	82.0	92.2	95.4	148.2	202.4	2429
1981/82	229.4	295.0	330.9	334.0	285.0	219.0	126.7	106.4	89.2	75.5	118.4	154.4	197.0	2364
1982/83	224.1	285.0	339.3	360.8	281.0	245.4	169.1	104.5	72.9	86.9	123.0	154.1	203.8	2446
1983/84	260.4	257.6	335.3	367.0	324.3	241.2	161.0	111.0	87.2	85.0	128.0	177.0	211.3	2535
1984/85	231.0	311.8	351.5	339.5	243.0	218.2	159.0	112.4	78.0	90.3	127.0	165.6	202.3	2427
1985/86	248.2	256.7	268.9	319.0	256.0	203.0	134.6	115.0	67.2	72.7	97.0	164.0	183.5	2202
1986/87	217.4	285.0	380.0	351.0	267.4	249.4	156.3	114.8	77.3	87.5	126.4	148.8	205.1	2461
1987/88	248.0	298.6	346.1	359.0	259.4	186.6	137.8	115.3	72.0	86.0	117.5	169.0	199.6	2395
1988/89	232.0	280.0	312.0	310.4	235.0	245.4	139.9	104.4	64.6	81.8	120.0	163.6	190.8	2289
1989/90	236.0	277.0	344.0	338.0	250.6	228.0	124.0	91.0	66.0	61.0	115.0	165.0	191.3	2296
1990/91	236.0	277.0	289.0	319.5	277.0	195.5	171.0	128.0	67.0	79.0	111.0	132.0	190.2	2282
1991/92	183.5	271.0	316.0	350.0	279.0	224.0	160.0	113.0	78.0	95.0	119.0	161.0	195.8	2350
1992/93	209.0	268.0	349.0	348.0	248.0	232.0	132.0	93.0	83.0	92.0	119.9	160.1	194.5	2334
1993/94	251.0	284.0	320.0	300.0	230.0	203.0	149.0	118.0	77.0	82.0	121.0	194.0	194.1	2329
1994/95	248.0	303.0	353.0	337.0	275.0	225.0	172.0	109.0	85.0	90.0	120.5	151.0	205.7	2469
1995/96	205.0	258.0	268.0	310.5	258.9	227.0	156.6	105.0	78.0	66.5	94.8	141.5	180.8	2170
1996/97	183.8	223.0	294.0	327.0	271.8	222.0	139.0	94.5	58.0	81.0	116.0	176.0	182.2	2186
1997/98	261.0	276.0	312.0	310.5	265.3	210.5	164.0	104.4	84.0	80.0	127.1	148.5	195.3	2343
1998/99	231.0	265.0	338.0	328.0	274.0	217.0	153.0	88.0	87.0	138.0	116.8	150.0	198.8	2386
1999/00	227.8	262.5	248.0	276.6	249.0	192.4	151.0	93.0	71.0	85.0	121.0	152.0	177.4	2129
2000/01	237.0	265.0	347.0	319.0	253.0	231.0	124.0	96.0	70.0	72.0	103.0	134.0	187.6	2251
2001/02	218.0	225.0	309.0	310.0	239.0	202.0	145.0	99.2	62.0	76.6	90.6	161.0	178.1	2137
2002/03	221.0	272.0	301.0	328.7	262.0	222.0	154.8	108.0	79.0	93.0	103.0	153.2	191.5	2298
2003/04	221.0	272.0	319.0	315.6	285.0	244.0	148.0	133.0	85.0	83.0	115.0	164.0	198.7	2385
2004/05	229.0	297.0	328.0	324.0	259.0	214.4	127.5	102.0	69.0	98.0	111.0	185.0	195.3	2344
2005/06	235.0	274.0	339.0	289.0	259.9	230.0	129.8	75.0	75.0	87.0	93.6	164.0	187.6	2251
2006/07	242.0	312.0	341.0	339.0	271.0	238.0	180.6	124.0	76.0	83.0	113.0	159.0	206.6	2479
2007/08	218.0	253.0	275.0	309.0	259.0	208.0	160.0	90.0	71.0	82.0	93.0	151.5	180.8	2170
2008/09	235.0	278.5	350.0	328.0	225.0	231.0	155.0	101.0	64.0	80.0	111.0	162.0	193.4	2321
2009/10	224.0	279.0	324.0	301.0	239.0	231.0	155.0	106.2	82.0	98.0	131.5	161.5	194.4	2332
2010/11	224.0	285.0	299.0	271.5	202.9	211.0	150.2	105.2	75.9	85.4	113.1	160.1	181.9	2183
Mean	231	282	327	329	262	221	150	105	76	85	113	160	195	2342



APPENDIX 3

Appendix 3 : Dam Balance Exercice for Brine Evaporation Pond Area Determination

Avg. Water Use = 349 m^3/d
Depth of Ponds = 1.5 m
Initial Storage = 0.0 m^3

Initial Pond Area Y1 = **52 000** m^2
Additional Area Y 11 = 10 000 m^2
Population Growth = 1.27%

B = Brine Storage in Ponds
R = Rainfall Storage in Ponds
Ei = Evap Volume from Ponds
Si = Cummulative Pond Storage

Year (Y i)	Month	Days	S-Pan Evap (mm)	Rain-fall (mm)	Brine Effluent (m^3/d)	Water Use Corr.	Pond Area (m^2)	Storage Capacity (m^3)	B i (m^3/m)	R i (m^3/m)	E i (m^3/m)	S i (m^3/m)
1	Oct	31	231	45	349.0	1.00	**52 000**	78 000	10 819	2 314	12 029	1 104
	Nov	30	282	0	349.4	0.87	52 000	78 000	9 073	0	14 681	-4 504
	Dec	31	327	22	349.7	0.98	52 000	78 000	10 655	1 144	17 029	-5 230
	Jan	31	329	5	350.1	1.00	52 000	78 000	10 853	260	17 093	-5 980
	Feb	28	262	0	350.5	0.81	52 000	78 000	7 951	0	13 625	-5 674
	Mar	31	221	20	350.9	0.81	52 000	78 000	8 862	1 040	11 472	-1 570
	Apr	30	150	1	351.2	0.78	52 000	78 000	8 192	52	7 812	431
	May	31	105	4	351.6	0.76	52 000	78 000	8 252	208	5 472	3 419
	Jun	30	76	0	352.0	0.78	52 000	78 000	8 226	0	3 947	7 698
	Jul	31	85	7	352.3	0.80	52 000	78 000	8 763	364	4 440	12 386
	Aug	31	113	16	352.7	0.90	52 000	78 000	9 889	832	5 880	17 227
	Sep	30	160	0	353.1	1.00	52 000	78 000	10 585	0	8 324	19 488
2	Oct	31	231	0	353.5	1.00	52 000	78 000	10 957	0	12 029	18 417
	Nov	30	282	0	353.8	0.87	52 000	78 000	9 189	0	14 681	12 925
	Dec	31	327	0	354.2	0.98	52 000	78 000	10 791	0	17 029	6 687
	Jan	31	329	0	354.6	1.00	52 000	78 000	10 992	0	17 093	585
	Feb	28	262	10	355.0	0.81	52 000	78 000	8 052	520	13 625	-4 467
	Mar	31	221	33	355.3	0.81	52 000	78 000	8 975	1 716	11 472	-781
	Apr	30	150	29	355.7	0.78	52 000	78 000	8 296	1 508	7 812	1 992
	May	31	105	9	356.1	0.76	52 000	78 000	8 357	468	5 472	5 345
	Jun	30	76	11	356.5	0.78	52 000	78 000	8 331	572	3 947	10 301
	Jul	31	85	1	356.8	0.80	52 000	78 000	8 875	52	4 440	14 789
	Aug	31	113	13	357.2	0.90	52 000	78 000	10 016	676	5 880	19 601
	Sep	30	160	0	357.6	1.00	52 000	78 000	10 720	0	8 324	21 997
3	Oct	31	231	13	358.0	1.00	52 000	78 000	11 097	676	12 029	21 741
	Nov	30	282	24	358.4	0.87	52 000	78 000	9 306	1 248	14 681	17 615
	Dec	31	327	1	358.7	0.98	52 000	78 000	10 929	52	17 029	11 567
	Jan	31	329	61	359.1	1.00	52 000	78 000	11 132	3 172	17 093	8 778
	Feb	28	262	18	359.5	0.81	52 000	78 000	8 155	936	13 625	4 244
	Mar	31	221	57	359.9	0.81	52 000	78 000	9 089	2 964	11 472	4 825
	Apr	30	150	5	360.3	0.78	52 000	78 000	8 402	260	7 812	5 675
	May	31	105	0	360.6	0.76	52 000	78 000	8 464	0	5 472	8 667
	Jun	30	76	8	361.0	0.78	52 000	78 000	8 438	416	3 947	13 574
	Jul	31	85	5	361.4	0.80	52 000	78 000	8 989	260	4 440	18 383
	Aug	31	113	0	361.8	0.90	52 000	78 000	10 144	0	5 880	22 647
	Sep	30	160	0	362.2	1.00	52 000	78 000	10 857	0	8 324	25 180

4	Oct	31	231	0	362.5	1.00	52 000	78 000	11 239	0	12 029	24 390
	Nov	30	282	0	362.9	0.87	52 000	78 000	9 425	0	14 681	19 134
	Dec	31	327	2	363.3	0.98	52 000	78 000	11 068	104	17 029	13 278
	Jan	31	329	33	363.7	1.00	52 000	78 000	11 275	1 716	17 093	9 175
	Feb	28	262	12	364.1	0.81	52 000	78 000	8 260	624	13 625	4 433
	Mar	31	221	38	364.5	0.81	52 000	78 000	9 205	1 976	11 472	4 143
	Apr	30	150	0	364.9	0.78	52 000	78 000	8 510	0	7 812	4 840
	May	31	105	4	365.2	0.76	52 000	78 000	8 572	208	5 472	8 148
	Jun	30	76	3	365.6	0.78	52 000	78 000	8 545	156	3 947	12 903
	Jul	31	85	0	366.0	0.80	52 000	78 000	9 104	0	4 440	17 567
	Aug	31	113	11	366.4	0.90	52 000	78 000	10 273	572	5 880	22 532
	Sep	30	160	14	366.8	1.00	52 000	78 000	10 996	728	8 324	25 932
5	Oct	31	231	4	367.2	1.00	52 000	78 000	11 382	208	12 029	25 493
	Nov	30	282	12	367.6	0.87	52 000	78 000	9 546	624	14 681	20 982
	Dec	31	327	47	368.0	0.98	52 000	78 000	11 210	2 444	17 029	17 607
	Jan	31	329	8	368.3	1.00	52 000	78 000	11 419	390	17 093	12 322
	Feb	28	262	35	368.7	0.81	52 000	78 000	8 365	1 815	13 625	8 877
	Mar	31	221	0	369.1	0.81	52 000	78 000	9 323	0	11 472	6 728
	Apr	30	150	13	369.5	0.78	52 000	78 000	8 618	655	7 812	8 189
	May	31	105	0	369.9	0.76	52 000	78 000	8 681	0	5 472	11 399
	Jun	30	76	0	370.3	0.78	52 000	78 000	8 655	0	3 947	16 106
	Jul	31	85	115	370.7	0.80	52 000	78 000	9 220	5 980	4 440	26 867
	Aug	31	113	1	371.1	0.90	52 000	78 000	10 404	52	5 880	31 443
	Sep	30	160	6	371.5	1.00	52 000	78 000	11 136	286	8 324	34 541
6	Oct	31	231	10	371.9	1.00	52 000	78 000	11 528	510	12 029	34 550
	Nov	30	282	47	372.3	0.87	52 000	78 000	9 668	2 444	14 681	31 981
	Dec	31	327	0	372.7	0.98	52 000	78 000	11 353	0	17 029	26 305
	Jan	31	329	3	373.0	1.00	52 000	78 000	11 565	156	17 093	20 932
	Feb	28	262	37	373.4	0.81	52 000	78 000	8 472	1 914	13 625	17 692
	Mar	31	221	79	373.8	0.81	52 000	78 000	9 442	4 108	11 472	19 770
	Apr	30	150	5	374.2	0.78	52 000	78 000	8 728	260	7 812	20 946
	May	31	105	18	374.6	0.76	52 000	78 000	8 792	910	5 472	25 177
	Jun	30	76	13	375.0	0.78	52 000	78 000	8 765	650	3 947	30 645
	Jul	31	85	0	375.4	0.80	52 000	78 000	9 338	0	4 440	35 543
	Aug	31	113	0	375.8	0.90	52 000	78 000	10 537	0	5 880	40 200
	Sep	30	160	0	376.2	1.00	52 000	78 000	11 278	0	8 324	43 155
7	Oct	31	231	0	376.6	1.00	52 000	78 000	11 675	0	12 029	42 801
	Nov	30	282	0	377.0	0.87	52 000	78 000	9 791	0	14 681	37 911
	Dec	31	327	0	377.4	0.98	52 000	78 000	11 498	0	17 029	32 380
	Jan	31	329	11	377.8	1.00	52 000	78 000	11 712	546	17 093	27 545
	Feb	28	262	84	378.2	0.81	52 000	78 000	8 580	4 342	13 625	26 842
	Mar	31	221	59	378.6	0.81	52 000	78 000	9 563	3 068	11 472	28 001
	Apr	30	150	0	379.0	0.78	52 000	78 000	8 840	0	7 812	29 029
	May	31	105	4	379.4	0.76	52 000	78 000	8 905	229	5 472	32 690
	Jun	30	76	0	379.8	0.78	52 000	78 000	8 877	0	3 947	37 620
	Jul	31	85	0	380.2	0.80	52 000	78 000	9 457	0	4 440	42 638
	Aug	31	113	20	380.6	0.90	52 000	78 000	10 672	1 040	5 880	48 470
	Sep	30	160	11	381.0	1.00	52 000	78 000	11 422	572	8 324	52 140

8	Oct	31	231	7	381.4	1.00	52 000	78 000	11 824	364	12 029	52 300
	Nov	30	282	10	381.8	0.87	52 000	78 000	9 916	520	14 681	48 055
	Dec	31	327	4	382.2	0.98	52 000	78 000	11 645	208	17 029	42 879
	Jan	31	329	11	382.6	1.00	52 000	78 000	11 862	572	17 093	38 219
	Feb	28	262	3	383.0	0.81	52 000	78 000	8 690	156	13 625	33 440
	Mar	31	221	20	383.5	0.81	52 000	78 000	9 685	1 040	11 472	32 693
	Apr	30	150	9	383.9	0.78	52 000	78 000	8 953	468	7 812	34 301
	May	31	105	15	384.3	0.76	52 000	78 000	9 018	780	5 472	38 628
	Jun	30	76	5	384.7	0.78	52 000	78 000	8 991	260	3 947	43 932
	Jul	31	85	0	385.1	0.80	52 000	78 000	9 578	0	4 440	49 070
	Aug	31	113	0	385.5	0.90	52 000	78 000	10 808	0	5 880	53 998
	Sep	30	160	3	385.9	1.00	52 000	78 000	11 568	156	8 324	57 399
9	Oct	31	231	22	386.3	1.00	52 000	78 000	11 975	1 134	12 029	58 478
	Nov	30	282	23	386.7	0.87	52 000	78 000	10 043	1 196	14 681	55 036
	Dec	31	327	42	387.1	0.98	52 000	78 000	11 794	2 184	17 029	51 985
	Jan	31	329	73	387.5	1.00	52 000	78 000	12 013	3 775	17 093	50 680
	Feb	28	262	59	387.9	0.81	52 000	78 000	8 801	3 068	13 625	48 924
	Mar	31	221	106	388.4	0.81	52 000	78 000	9 809	5 512	11 472	52 773
	Apr	30	150	6	388.8	0.78	52 000	78 000	9 067	312	7 812	54 340
	May	31	105	0	389.2	0.76	52 000	78 000	9 133	0	5 472	58 001
	Jun	30	76	1	389.6	0.78	52 000	78 000	9 105	52	3 947	63 212
	Jul	31	85	1	390.0	0.80	52 000	78 000	9 700	52	4 440	68 524
	Aug	31	113	0	390.4	0.90	52 000	78 000	10 946	0	5 880	73 590
	Sep	30	160	2	390.8	1.00	52 000	78 000	11 716	104	8 324	77 087
10	Oct	31	231	0	391.2	1.00	52 000	78 000	12 128	0	12 029	77 186
	Nov	30	282	0	391.7	0.87	52 000	78 000	10 171	0	14 681	72 676
	Dec	31	327	0	392.1	0.98	52 000	78 000	11 944	0	17 029	67 592
	Jan	31	329	0	392.5	1.00	52 000	78 000	12 167	0	17 093	62 665
	Feb	28	262	9	392.9	0.81	52 000	78 000	8 913	468	13 625	58 421
	Mar	31	221	49	393.3	0.81	52 000	78 000	9 934	2 548	11 472	59 431
	Apr	30	150	150	393.7	0.78	52 000	78 000	9 183	7 800	7 812	68 602
	May	31	105	4	394.1	0.76	52 000	78 000	9 250	208	5 472	72 588
	Jun	30	76	0	394.6	0.78	52 000	78 000	9 222	0	3 947	77 863
	Jul	31	85	27	395.0	0.80	52 000	78 000	9 824	1 404	4 440	***84 651***
	Aug	31	113	0	395.4	0.90	52 000	78 000	11 086	0	5 880	***89 858***
	Sep	30	160	10	395.8	1.00	52 000	78 000	11 866	520	8 324	***93 920***
11	Oct	31	231	3	396.2	1.00	**62 000**	93 000	12 283	186	14 342	92 046
	Nov	30	282	42	396.7	0.87	62 000	93 000	10 301	2 604	17 504	87 448
	Dec	31	327	0	397.1	0.98	62 000	93 000	12 097	0	20 304	79 241
	Jan	31	329	14	397.5	1.00	62 000	93 000	12 322	868	20 381	72 050
	Feb	28	262	33	397.9	0.81	62 000	93 000	9 027	2 046	16 245	66 878
	Mar	31	221	30	398.3	0.81	62 000	93 000	10 061	1 860	13 678	65 121
	Apr	30	150	31	398.8	0.78	62 000	93 000	9 300	1 922	9 315	67 028
	May	31	105	27	399.2	0.76	62 000	93 000	9 368	1 680	6 524	71 553
	Jun	30	76	11	399.6	0.78	62 000	93 000	9 340	682	4 706	76 868
	Jul	31	85	4	400.0	0.80	62 000	93 000	9 950	223	5 293	81 748
	Aug	31	113	20	400.4	0.90	62 000	93 000	11 228	1 215	7 011	87 180
	Sep	30	160	1	400.9	1.00	62 000	93 000	12 017	62	9 924	89 335

12	Oct	31	231	0	401.3	1.00	62 000	93 000	12 440	0	14 342	87 433
	Nov	30	282	0	401.7	0.87	62 000	93 000	10 433	0	17 504	80 361
	Dec	31	327	34	402.1	0.98	62 000	93 000	12 251	2 108	20 304	74 417
	Jan	31	329	0	402.6	1.00	62 000	93 000	12 480	0	20 381	66 516
	Feb	28	262	9	403.0	0.81	62 000	93 000	9 142	558	16 245	59 971
	Mar	31	221	4	403.4	0.81	62 000	93 000	10 189	248	13 678	56 730
	Apr	30	150	1	403.9	0.78	62 000	93 000	9 419	50	9 315	56 884
	May	31	105	2	404.3	0.76	62 000	93 000	9 488	124	6 524	59 972
	Jun	30	76	0	404.7	0.78	62 000	93 000	9 459	0	4 706	64 725
	Jul	31	85	0	405.1	0.80	62 000	93 000	10 077	0	5 293	69 508
	Aug	31	113	13	405.6	0.90	62 000	93 000	11 371	806	7 011	74 675
	Sep	30	160	1	406.0	1.00	62 000	93 000	12 171	74	9 924	76 995
13	Oct	31	231	9	406.4	1.00	62 000	93 000	12 599	558	14 342	75 810
	Nov	30	282	13	406.9	0.87	62 000	93 000	10 566	806	17 504	69 678
	Dec	31	327	0	407.3	0.98	62 000	93 000	12 408	0	20 304	61 782
	Jan	31	329	7	407.7	1.00	62 000	93 000	12 639	409	20 381	54 450
	Feb	28	262	5	408.1	0.81	62 000	93 000	9 259	310	16 245	47 773
	Mar	31	221	5	408.6	0.81	62 000	93 000	10 320	310	13 678	44 725
	Apr	30	150	38	409.0	0.78	62 000	93 000	9 539	2 356	9 315	47 306
	May	31	105	0	409.4	0.76	62 000	93 000	9 609	0	6 524	50 391
	Jun	30	76	3	409.9	0.78	62 000	93 000	9 580	186	4 706	55 451
	Jul	31	85	1	410.3	0.80	62 000	93 000	10 205	62	5 293	60 425
	Aug	31	113	1	410.7	0.90	62 000	93 000	11 516	62	7 011	64 992
	Sep	30	160	3	411.2	1.00	62 000	93 000	12 326	186	9 924	67 580
14	Oct	31	231	27	411.6	1.00	62 000	93 000	12 760	1 674	14 342	67 672
	Nov	30	282	5	412.0	0.87	62 000	93 000	10 701	310	17 504	61 179
	Dec	31	327	5	412.5	0.98	62 000	93 000	12 566	310	20 304	53 751
	Jan	31	329	12	412.9	1.00	62 000	93 000	12 801	744	20 381	46 915
	Feb	28	262	49	413.4	0.81	62 000	93 000	9 377	3 038	16 245	43 085
	Mar	31	221	34	413.8	0.81	62 000	93 000	10 451	2 133	13 678	41 991
	Apr	30	150	14	414.2	0.78	62 000	93 000	9 661	837	9 315	43 175
	May	31	105	14	414.7	0.76	62 000	93 000	9 732	868	6 524	47 251
	Jun	30	76	5	415.1	0.78	62 000	93 000	9 702	310	4 706	52 557
	Jul	31	85	0	415.6	0.80	62 000	93 000	10 336	0	5 293	57 599
	Aug	31	113	0	416.0	0.90	62 000	93 000	11 664	0	7 011	62 252
	Sep	30	160	0	416.4	1.00	62 000	93 000	12 484	0	9 924	64 811
15	Oct	31	231	24	416.9	1.00	62 000	93 000	12 923	1 488	14 342	64 880
	Nov	30	282	13	417.3	0.87	62 000	93 000	10 838	806	17 504	59 020
	Dec	31	327	2	417.8	0.98	62 000	93 000	12 727	124	20 304	51 567
	Jan	31	329	43	418.2	1.00	62 000	93 000	12 964	2 666	20 381	46 816
	Feb	28	262	29	418.6	0.81	62 000	93 000	9 497	1 792	16 245	41 860
	Mar	31	221	15	419.1	0.81	62 000	93 000	10 585	930	13 678	39 697
	Apr	30	150	47	419.5	0.78	62 000	93 000	9 785	2 902	9 315	43 068
	May	31	105	51	420.0	0.76	62 000	93 000	9 856	3 162	6 524	49 562
	Jun	30	76	0	420.4	0.78	62 000	93 000	9 826	0	4 706	54 682
	Jul	31	85	2	420.9	0.80	62 000	93 000	10 468	124	5 293	59 981
	Aug	31	113	11	421.3	0.90	62 000	93 000	11 813	682	7 011	65 464
	Sep	30	160	2	421.8	1.00	62 000	93 000	12 643	124	9 924	68 307

16	Oct	31	231	0	422.2	1.00	62 000	93 000	13 088	0	14 342	67 053
	Nov	30	282	0	422.6	0.87	62 000	93 000	10 976	0	17 504	60 525
	Dec	31	327	0	423.1	0.98	62 000	93 000	12 889	0	20 304	53 111
	Jan	31	329	1	423.5	1.00	62 000	93 000	13 130	62	20 381	45 922
	Feb	28	262	3	424.0	0.81	62 000	93 000	9 618	186	16 245	39 481
	Mar	31	221	11	424.4	0.81	62 000	93 000	10 720	682	13 678	37 205
	Apr	30	150	17	424.9	0.78	62 000	93 000	9 910	1 029	9 315	38 829
	May	31	105	1	425.3	0.76	62 000	93 000	9 982	62	6 524	42 349
	Jun	30	76	13	425.8	0.78	62 000	93 000	9 951	806	4 706	48 401
	Jul	31	85	5	426.2	0.80	62 000	93 000	10 601	310	5 293	54 019
	Aug	31	113	2	426.7	0.90	62 000	93 000	11 963	124	7 011	59 095
	Sep	30	160	1	427.1	1.00	62 000	93 000	12 805	62	9 924	62 038
17	Oct	31	231	11	427.6	1.00	62 000	93 000	13 255	682	14 342	61 633
	Nov	30	282	10	428.0	0.87	62 000	93 000	11 116	620	17 504	55 865
	Dec	31	327	97	428.5	0.98	62 000	93 000	13 054	6 014	20 304	54 629
	Jan	31	329	7	428.9	1.00	62 000	93 000	13 297	434	20 381	47 980
	Feb	28	262	37	429.4	0.81	62 000	93 000	9 741	2 294	16 245	43 770
	Mar	31	221	24	429.9	0.81	62 000	93 000	10 857	1 488	13 678	42 437
	Apr	30	150	0	430.3	0.78	62 000	93 000	10 036	0	9 315	43 159
	May	31	105	20	430.8	0.76	62 000	93 000	10 110	1 240	6 524	47 984
	Jun	30	76	49	431.2	0.78	62 000	93 000	10 079	3 038	4 706	56 395
	Jul	31	85	8	431.7	0.80	62 000	93 000	10 737	496	5 293	62 334
	Aug	31	113	6	432.1	0.90	62 000	93 000	12 116	372	7 011	67 812
	Sep	30	160	0	432.6	1.00	62 000	93 000	12 968	0	9 924	70 856
18	Oct	31	231	4	433.1	1.00	62 000	93 000	13 425	248	14 342	70 186
	Nov	30	282	5	433.5	0.87	62 000	93 000	11 258	279	17 504	64 219
	Dec	31	327	0	434.0	0.98	62 000	93 000	13 221	0	20 304	57 136
	Jan	31	329	9	434.4	1.00	62 000	93 000	13 467	558	20 381	50 781
	Feb	28	262	62	434.9	0.81	62 000	93 000	9 866	3 844	16 245	48 245
	Mar	31	221	6	435.3	0.81	62 000	93 000	10 996	372	13 678	45 935
	Apr	30	150	25	435.8	0.78	62 000	93 000	10 164	1 550	9 315	48 335
	May	31	105	6	436.3	0.76	62 000	93 000	10 239	372	6 524	52 422
	Jun	30	76	15	436.7	0.78	62 000	93 000	10 207	930	4 706	58 853
	Jul	31	85	3	437.2	0.80	62 000	93 000	10 874	186	5 293	64 620
	Aug	31	113	3	437.7	0.90	62 000	93 000	12 271	186	7 011	70 066
	Sep	30	160	0	438.1	1.00	62 000	93 000	13 134	0	9 924	73 276
19	Oct	31	231	1	438.6	1.00	62 000	93 000	13 596	62	14 342	72 591
	Nov	30	282	0	439.0	0.87	62 000	93 000	11 402	0	17 504	66 489
	Dec	31	327	0	439.5	0.98	62 000	93 000	13 390	0	20 304	59 575
	Jan	31	329	4	440.0	1.00	62 000	93 000	13 639	248	20 381	53 082
	Feb	28	262	18	440.4	0.81	62 000	93 000	9 992	1 116	16 245	47 944
	Mar	31	221	11	440.9	0.81	62 000	93 000	11 136	682	13 678	46 085
	Apr	30	150	0	441.4	0.78	62 000	93 000	10 294	0	9 315	47 064
	May	31	105	3	441.8	0.76	62 000	93 000	10 370	198	6 524	51 108
	Jun	30	76	0	442.3	0.78	62 000	93 000	10 338	0	4 706	56 740
	Jul	31	85	0	442.8	0.80	62 000	93 000	11 013	0	5 293	62 460
	Aug	31	113	0	443.2	0.90	62 000	93 000	12 428	0	7 011	67 876
	Sep	30	160	0	443.7	1.00	62 000	93 000	13 302	0	9 924	71 254

20	Oct	31	231	0	444.2	1.00	62 000	93 000	13 770	0	14 342	70 681
	Nov	30	282	0	444.7	0.87	62 000	93 000	11 548	0	17 504	64 725
	Dec	31	327	61	445.1	0.98	62 000	93 000	13 561	3 782	20 304	61 764
	Jan	31	329	15	445.6	1.00	62 000	93 000	13 814	930	20 381	56 127
	Feb	28	262	72	446.1	0.81	62 000	93 000	10 119	4 489	16 245	54 490
	Mar	31	221	24	446.5	0.81	62 000	93 000	11 278	1 488	13 678	53 578
	Apr	30	150	23	447.0	0.78	62 000	93 000	10 426	1 408	9 315	56 098
	May	31	105	8	447.5	0.76	62 000	93 000	10 502	494	6 524	60 569
	Jun	30	76	8	448.0	0.78	62 000	93 000	10 470	495	4 706	66 828
	Jul	31	85	7	448.4	0.80	62 000	93 000	11 154	426	5 293	73 114
	Aug	31	113	5	448.9	0.90	62 000	93 000	12 587	311	7 011	79 001
	Sep	30	160	4	449.4	1.00	62 000	93 000	13 472	224	9 924	82 773

APPENDIX 4

Wellfield Development for Feed Water Supply to Brandvlei's Proposed Desalination Plant

Report Prepared for

BVi Consulting Engineers

Report Number 438301

Report Prepared by

srk consulting

November 2011

Wellfield Development for Feed Water Supply to Brandvlei's Proposed Desalination Plant

BVi Consulting Engineers - Northern Cape

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November 2011

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Disclaimer

The opinions expressed in this Report have been based on the information obtained by SRK Consulting (South Africa) (Pty) Ltd (SRK) from drilling and testing, as well as information obtained from the Department of Water Affairs, the Hantam Municipality, BVi in Upington and Veolia Water in Paarl. The opinions in this Report are provided in response to a specific request from BVi and the Hantam Municipality to do so. SRK has exercised all due care in reviewing the information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.

Glossary of Terms

Anisotrophic: Having some physical property that varies with direction.

Aquifer: A geological formation capable of supplying economic volumes of groundwater (*Also see Non-Aquifer*).

Aquifer system: A heterogeneous body of interlayered permeable and less permeable material that acts as a water-yielding hydraulic unit covering a region.

Borehole: Includes a well, excavation, or any other artificially constructed or improved groundwater cavity which can be used for the purpose of intercepting, collecting or storing water from an aquifer; observing or collecting data and information on water in an aquifer; or recharging an aquifer [from the National Water Act (Act No. 36 of 1998)].

Catchment: The area from which any rainfall will drain into the watercourse, contributing to the runoff at a particular point in a river system, synonymous with the term *river basin*.

Contamination: the introduction of pollutants (whether chemical substances, or energy such as noise, heat, or light) into the environment to such an extent that its effects become harmful to human health, other living organisms, or the environment.

Discharge area: An area in which subsurface water, including water in the unsaturated and saturated zones, is discharged at the land surface.

Electrical conductivity: A measurement of the ease with which water conducts electricity due to the presence of dissolved salts/ion in the water, i.e. distilled water - low EC, poor conductor of electricity, sea water - high EC and salt content indicate a good conductor of electricity.

Fault: A zone of displacement in rock formations resulting from forces of tension or compression in the earth's crust.

Formation: A general term used to describe a sequence of rock layers.

Fracture: Cracks, joints or breaks in the rock that can enhance water movement.

Geohydrology: The study of the properties, circulation and distribution of groundwater, in practise used interchangeably with hydrogeology; but in theory *hydrogeology* is the study of geology from the perspective of its role and influence in hydrology, while *geohydrology* is the study of hydrology from the perspective of the influence on geology.

Groundwater: Water found in the subsurface in the saturated zone below the water table or piezometric surface, i.e. the water table marks the upper surface of groundwater systems.

Groundwater flow: The movement of water through openings and pore spaces in rocks below the water table, i.e. in the saturated zone. Groundwater naturally drains from higher lying areas to low lying areas such as rivers, lakes and the oceans. The rate of flow depends on the slope of the water table and the transmissivity of the geological formations.

Groundwater resource: All groundwater available for beneficial use, including by man, aquatic ecosystems and the greater environment.

Hydraulic conductivity: Measure of the ease with which water will pass through porous material; defined as the rate of flow through a cross-section of one square meter under a unit hydraulic gradient at right angles to the direction of flow (in m/d).

Hydraulic gradient: Change in hydraulic head per unit of horizontal distance in a given direction, i.e. the difference in hydraulic head divided by the distance along the groundwater flow path. Groundwater flows from points of high elevation and pressure to points of low elevation and pressure.

Intergranular aquifer: Groundwater is contained and flows within the original interstices between constituent grains.

Lineaments: A major, linear, topographic feature of regional extent of structural or volcanic origin, most easily appreciated from remote sensing data, e.g. a fault system or dyke.

Porosity: The percentage of void space that a rock or sediment contains, which is an index of how much groundwater can be stored per volume when saturated. The effective porosity, also called the kinematic porosity, of a porous medium is defined as the ratio of the part of the pore volume where the water can circulate to the total volume of a representative sample of the medium.

Quaternary catchment: Fourth order catchment within a primary river basin catchment.

Recharge: The addition of water to the zone of saturation, either by the downward percolation of precipitation or surface water and / or the lateral migration of groundwater from adjacent aquifers.

Recharge area: An area over which recharge occurs.

Saturated zone: The subsurface zone below the water table where interstices are filled with water under pressure greater than that of the atmosphere.

Storativity: The ratio of the volume of water that drains by gravity to the total volume of rock.

Transmissivity: the rate at which a volume of water is transmitted through a unit width of aquifer under a unit hydraulic head (m^2/d); product of the thickness and average hydraulic conductivity of an aquifer.

Unsaturated zone: That part of the geological stratum above the water table where interstices and voids contain a combination of air and water; synonymous with the *zone of aeration* and *vadose zone*.

Water table: The upper surface of the saturated zone of an unconfined aquifer at which pore pressure is at atmospheric pressure, the depth to which may fluctuate seasonally.

Wellfield: An area containing more than one pumping borehole that provides water to a public water supply system or single owner (e.g. a municipality).

List of Abbreviations

DEADP	Department of Environmental Affairs and Development Planning
DTEC	Department of Tourism, Environment and Conservation (Northern Cape Province)
DEM	Digital Elevation Model
DWA	Department of Water Affairs (formerly the DWAF)
DWAF	Department of Water Affairs and Forestry
EC	Electrical Conductivity
ECA	Environment Conservation Act
EIA	Environmental Impact Assessment
GA	General Authorisation
GIS	Geographical Information System
GEP	Groundwater Exploitation Potential
GMU	Groundwater Management Unit
GRA	Groundwater Resource Area
GRP	Groundwater Resource Potential
IWRM	Integrated Water Resources Management
K	Hydraulic Conductivity
L/s	Litres per second
m	Metres
m^2/day	Square metres per day
m^3/a	Cubic metres per annum
m^3/d	Cubic metres per day
m^3/hr	Cubic metres per hour
m^3/month	Cubic metres per month
mamsl	Metres above mean sea level
MAP	Mean Annual Precipitation
mbgl	Metres below ground level
mg/L	Milligrams per litre
mS/m	Milli-Siemens per metre
NEMA	National Environment Management Act
NGA	National Groundwater Archive
NWA	National Water Act (Act No. 36 of 1998)
NWRS	National Water Resource Strategy
SRK	SRK Consulting (SA) Pty Ltd
T	Transmissivity
TDS	Total dissolved solids
WHO	World Health Organization

1 Introduction and Scope of Report

The work discussed in this report is a result of an investigation carried out by SRK in 2010 to assess the potential of groundwater resources in a 50 km radius of Brandvlei with the aim of improving the municipal water supply to Brandvlei (SRK, 2010). From this study it was concluded that water acceptable for long term human consumption is not available from the groundwater resources in the area and it was recommended that desalination of saline groundwater occurring close the town in the Sak River Alluvial Aquifer should be considered. The Hantam Municipality subsequently accepted this recommendation. After securing funds for the development of the desalination plant from the Regional Bulk Infrastructure Grants, SRK was subsequently appointed in July 2011 by BVi Consulting Engineers on behalf of the Hantam Municipality to establish and test a production wellfield for feed water supply to the desalination plant.

This report discusses the results of the wellfield development.

1.1 Terms of Reference

The terms of reference were to develop a wellfield close to Brandvlei in the Sak River Alluvial Aquifer to supply approximately 670 m^3/day of feed water to the proposed desalination plant.

1.2 Methodology

The following methodology was applied by SRK to establish the wellfield:

1. Geophysical surveys (electrical resistivity profiling) were carried out in the vicinity of the old Department of Water Affairs boreholes to determine sediment depth and to optimally site the new boreholes.
2. Three new production boreholes were subsequently drilled by using the mud-rotary method. The boreholes were equipped with corrosion resistant 194 mm OD 304 grade stainless steel screens and uPVC casing. Filter sand was inserted around the screens.
3. Each borehole was equipped with a:
    a. 3 m steel standpipe and lockable cap with padlock for protection;
    b. 2 m (from surface) sanitary seal consisting of Portland cement and bentonite; and
    c. concrete collar.
4. After completion of each borehole it was cleaned and developed by using compressed air.
5. Drilling operations were carried out under control of one of SRK's principal hydrogeologists, who logged the drill cuttings and recorded information on construction of the boreholes.
6. Once completed, each borehole was test pumped to determine its yield capacity and obtain representative water samples for chemical analysis at Talbot & Talbot, a SANAS accredited laboratory.
7. Pump testing of each borehole consisted of a step drawdown tests (SDT), i.e. 4 x 1 hr steps with each consecutive step at a higher pumping rate. After allowing the water level to recover, this was followed by a constant discharge test (CDT) of 72 hr duration. After pump shut down the water level recovery was recorded. During testing of the strongest borehole the other two boreholes were monitored.
8. The test data were analysed by means of the FC and other methods to determine the aquifer parameters, optimum yields and pumping schedules for boreholes.
9. Finally this report with recommendations on water quality, water treatment options and a production wellfield monitoring scheme was compiled.

2 Investigation Results

2.1 Geophysical Surveys

Two multi-electrode resistivity traverses were conducted during August 2011 approximately 1 km east of the town Brandvlei (**Figure 3**). The purpose of the investigation was to determine depth to bedrock and delineate possible palaeo-channels in the shale bedrock.

An Abem SAS 1000 Terrameter and ES 10-64 switching unit was used in the Brandvlei survey. Four multicore cables and stainless steel pegs were used with the **"roll-along"** survey method. Measurement of the resistivity of the ground is carried out by transmitting a controlled current (I) between two electrodes inserted in the ground, while measuring the potential (V) between two other electrodes. Direct current (DC) or a very low frequency alternating current is used; the method is often called DC-resistivity. The resistance (R) is calculated using Ohm's law.

The two multi-electrode resistivity traverses were conducted with the Schlumberger measuring protocol, at an electrode spacing of 10.0 m. This measuring protocol yields a maximum investigation depth of approximately 80 m. Traverse coordinates were obtained with a hand held GPS. Traverse positions with coordinates are shown in **Figure 3**.

The traverse coordinates are as follows:

Traverse-1:

0m: S30.466750° ; E20.504260°

600m: S30.461720° ; E20.506730°

Traverse-2:

0m: S30.461690° ; E20.504190°

400m: S30.464990° ; E20.506440°

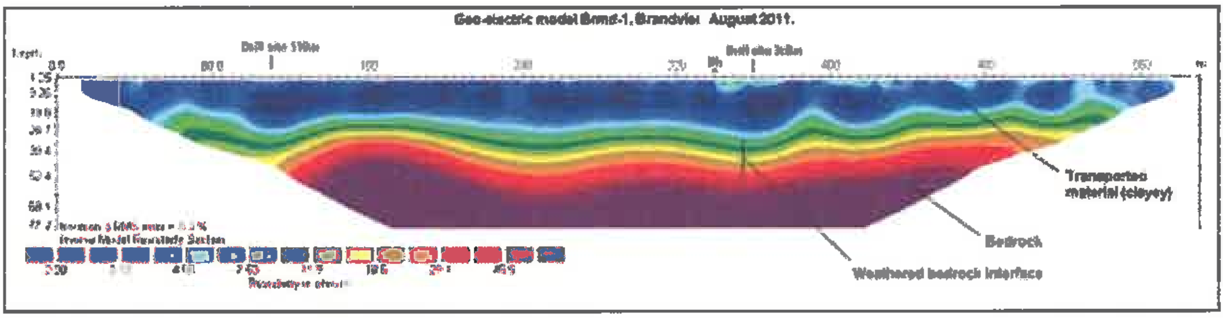

Figure 1: Geo-Electrical Model Traverse 1

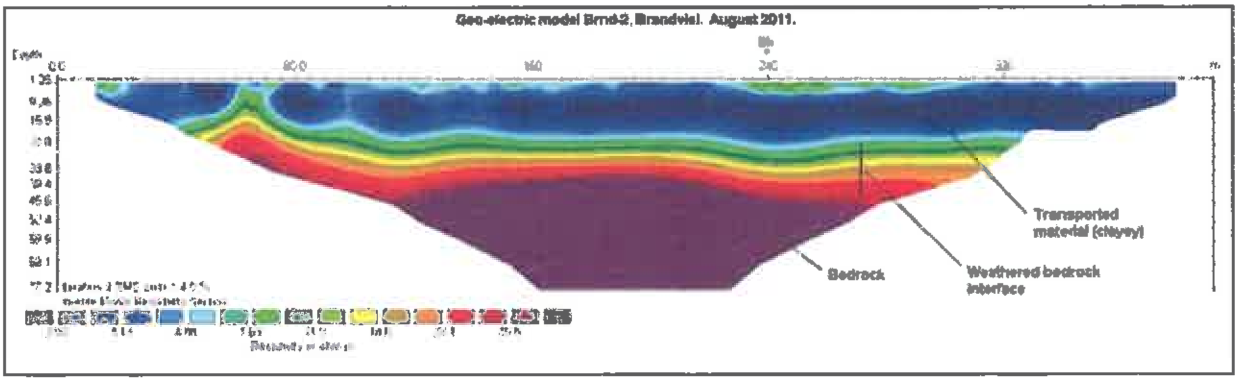

Figure 2: Geo-Electrical Model Traverse 2

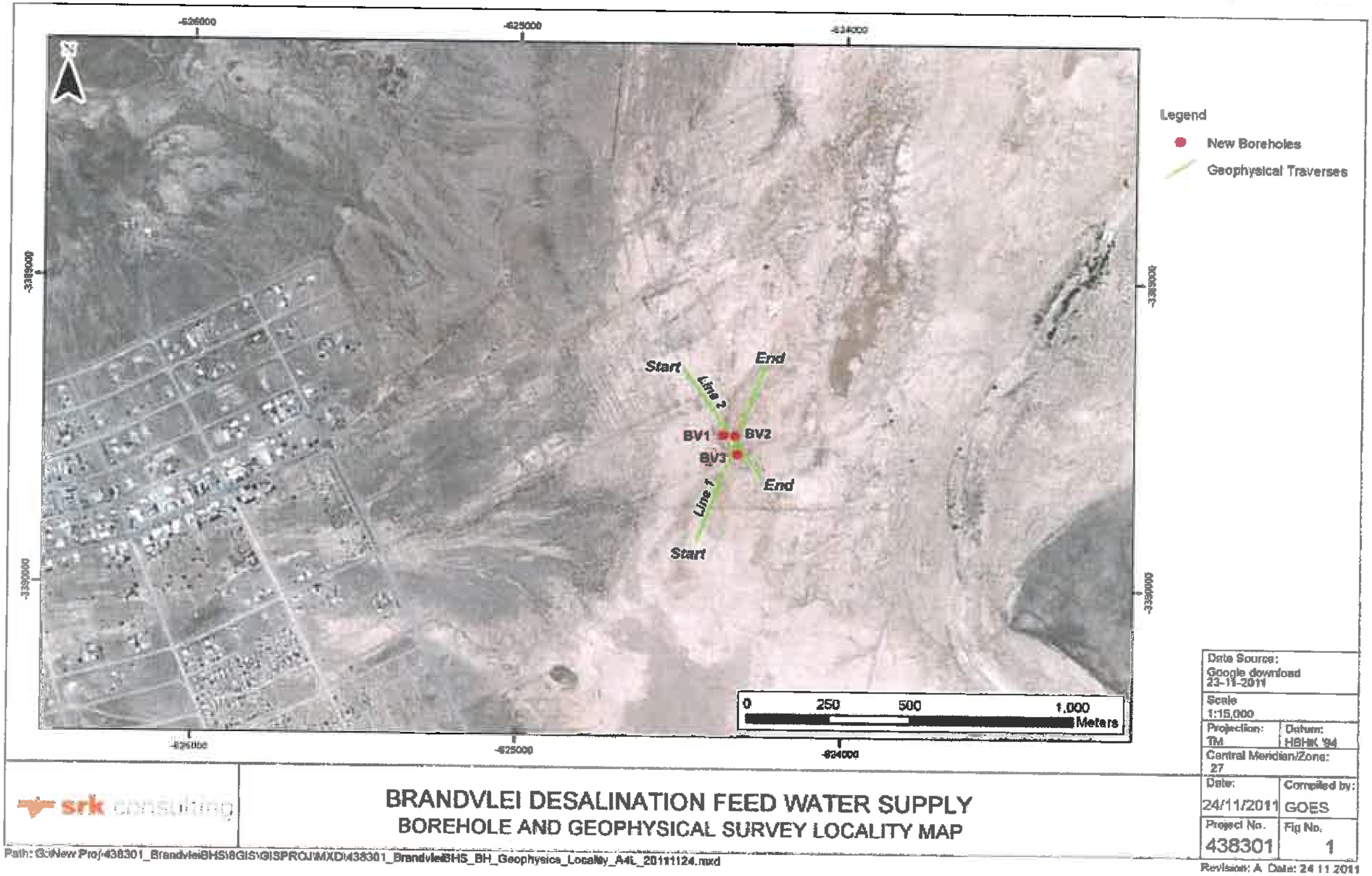

Figure 3: Locality Map Indicating Geophysical Survey Lines and Boreholes

Interpretation of the resistivity results entails relating different modelled ground resistivities with geology, e.g. lithological units, degree of weathering, bedrock and vertical/sub-vertical structures. The annotated geo-electric models above show the modelled ground resistivities of the substrate contoured on a logarithmic colour scale. *Note that the geo-electric models are contoured with the same logarithmic contour scale.* Standard deviation (difference between model response and measured data) below 8% encountered in the geo-electrical models is indicative of a noise free data set and consequently high integrity models.

Ground resistivity of the overlying sediments decreases to below 2 Ohm.m, which is indicative of a clayey material and/or saline saturated sediments. The fresh bedrock interface is estimated in the vicinity of the 20 Ohm.m contour at depth, i.e. a depth of approximately 14 to 15 mbgl. This was confirmed by the drilling logs. The sediment thickness seems to be fairly constant with no obvious palaeo-channels being evident.

2.2 Drilling

Drilling was carried out by Gerritsen Drilling SA and commenced on 15 August 2011 and was completed on 19 August 2011. Three boreholes, BV1, 2 and 3, were drilled. The borehole details are summarised in **Table 1** over page. All three boreholes intersected dark brown unconsolidated clay and silt down to approximately 12 – 13 mbgl followed by a 1 – 2 m thick pebble layer. Blow yield of the boreholes range from 0.6 L/s at BV2 to 4.7 L/s at BV1 and 8.3 L/s at BV3. The reason for the low yield of BV2 is a result of the thinner pebble layer here. It is also possible that the pebble layer here contains a matrix of silt or clay, which reduces the transmissivity and hence yield. It is not possible to determine the matrix material from the mud-rotary drill cuttings. Bedrock consisting of dark grey shale of the Prince Albert Formation of the Karoo Sequence was intersected below the pebble layer.

Table 1: Summary of Borehole Information

Description	BV1	BV2	BV3
Latitude	30°27'49.18"S	30°27'49.32"S	30°27'51.26"S
Longitude	20°30'19.12"E	20°30'20.45"E	20°30'20.52"E
Datum	WGS84	WGS84	WGS84
Elevation[2] mamsl (Approximate)	915	916	917
Date Drilled	16-Aug-2011	17-Aug-2011	18-Aug-2011
Diameter Drilled m x mm	16.6 x 304	16.3 x 304	16.4 x 304
Final Depth m	16.6	16.3	16.4
304 mm x 6 mm wall Steel Casing standpipe m	3	3	3
194 mm OD 304 Stainless Steel x 0.5 mm slot free-flow screens and 0.6 – 1.5 mm filter sand mbgl	13 - 16	13 - 16	13 - 16
200 mm OD Cl12 uPVC casing mbgl	0 - 13	0 - 13	0 - 13
Collar Height magl	0.81	0.74	0.89
Water Strikes mbgl	13 – 14.5	13 - 14	12 - 14
Final Blow Yield m^3/hr	17	2	30

Description	BV1	BV2	BV3
Water Level mbgl (Date measured))	5.86	5.92	6.11
Silt & Clay	0 - 10	0 - 4	0 - 3
Silty fine Sand	10 - 13	4 - 13	3 - 12
Pebbles mbgl	13 – 14.5	13-14	12 - 14
Shale mbgl	14.5 - 16.6	14 - 16.3	14 - 16.4
Hours Developed and Cleaned	2	4	2
Disinfected with chlorine granules	Yes	Yes	Yes
Sanitary seal and concrete collar	Yes	Yes	Yes
Lockable flange lid with padlock	Yes	Yes	Yes

2.3 Test Pumping

Test pumping of the boreholes was carried out by WellTek Services from 27 August 2011 to 3 September 2011. The two strong boreholes, BV1 and BV3, were each submitted to 4 x 1 hr step tests followed by a recovery test, then a 72 hr constant discharge test, which was followed by a recovery test. Borehole BV2 failed during the first step of the step test at a pumping rate of 1 L/s. The test results are summarised in **Table 2** (over page) and the data sheets are included in **Appendix 1**.

Both boreholes BV1 and BV3 produced very good yields with good recoveries after pump shutdown. Borehole BV2 has a very low yield (~0.5 L/s) and can be used for monitoring purposes.

Table 2: Summary of the Test Pumping Results

Borehole No.	BV1		BV2		BV3	
Aquifer	Alluvial		Alluvial		Alluvial	
BH Depth (m)	16.6		16.3		16.4	
Casing Diameter ID (mm)	176		176		176	
Depths of Screens (mbgl)	13 - 16		13 - 16		13 - 16	
Rest Water Level (mbgl)	5.73		5.66		5.12	
Date of RWL	31-Aug-11		3-Sep-11		26-Aug-11	
Pump Type	Orbit BP30		Orbit BP30		Orbit BP30	
Pump Intake Depth (mbgl)	14.3		14.3		14.3	
Available Drawdown before Cavitation (m)	8.6		8.6		9.1	
Step Drawdown Test (60 min)	Discharge (L/s)	Drawdown (m)	Discharge (L/s)	Drawdown (m)	Discharge (L/s)	Drawdown (m)
Step 1	2.52	0.87	1	8.7	2.53	0.28
Step 2	5.03	1.73			5.02	0.63
Step 3	7.51	2.84			7.51	1.30
Step 4	10.03	3.54			10.20	3.60
Constant Discharge Test	9.54	3.87			9.55	3.11
CDT Duration (hr)	72		0		72	

Borehole No.	BV1	BV2	BV3
CDT Recovery (Time in min)	150		240
Residual Drawdown at end of Recovery (m)	0.05		0.15
Drawdown in Observation BH at end of CDT (m)	BV3 – 0.53		BV1 – 0.64 BV3 – 0.21
Comments	Very good recovery	Pump suction occurred after 10 min in Step 1 Recovered to 0.23 m after 30 min.	Good recovery

To estimate optimum pumping rates, pumping schedules and aquifer parameters, the test pumping data were analysed by means of an Excel based software package developed by Van Tonder *et al* (2002). In the software package various methods such as the Flow Characteristic method (FC-method), porous aquifer solutions (Theis, Cooper-Jacob and Hantush methods), fractional pumping test analysis (Barkers Generalised Radial Flow Model) and step drawdown analysis were used to estimate risk-based sustainable yields for the boreholes as well as aquifer parameters such as transmissivity (T) and the storage coefficient (S). In the FC-Analysis the following aquifer input parameters were used:

- Average recharge of 2 mm per annum.
- Data were extrapolated for five years.

The boreholes affect each other during pumping. This was taken into consideration in the calculations of their "safe" pumping rates. The results of the analysis are included in **Appendix 2** and the recommended pumping rates and management details for the boreholes are summarised in **Table 3**.

Table 3: Recommended Pumping Rates and Management Details for the New Boreholes

BH No.	Borehole Depth	Borehole Diameter	Pre-Pumping Water Level	Pump Intake	24 hr/day Optimum Pumping Rate		Warning Pump Drawdown Level
	(m)	(mm)	(mbgl)	(mbgl)	(m^3/hr)	(m^3/d)	(mbgl)
BV1	**16**	**175**	**5.7**	**14**	**25.2**	**605**	**11**
BV3	**16**	**175**	**5.1**	**14**	**25.2**	**605**	**11**
Total					**50.4**	**1 210**	
Notes:	The optimum pumping rates allow for all boreholes being pumped simultaneously When pump drawdown reached the warning level, the pump must be switched off for at least 24 hr and the hydrogeologist consulted. Water levels must preferably be monitored on a daily basis, or at least weekly.						

The analysis results indicate that boreholes BV1 and BV3 can each yield 25.2 m^3/hr (7 L/s), or 605 m^3/d. Their combined yield is 50.4 m^3/hr, or 1 210 m^3/d.

The aquifer parameters calculated with the various porous aquifer solutions (Theis, Cooper-Jacob and Hantush methods) are summarised in **Table 4**. The average aquifer T is ~260 m^2/d whilst the specific yield is ~6%.

Table 4: Summary of Aquifer Parameters Derived From Porous Aquifer Solutions

Borehole	BV1	BV3	BV1	BV3
Method	T (m^2/d)		Specific Yield (%)	
Cooper-Jacob	242	260	9.1	8.4
Theis	239	266	9.6	8.8
Hantush	292	257	1.4	7.5
Neuman	248	278	1.0	1.0
Average BH	255	265	5.3	6.4
Average Aquifer	260		5.8	

2.4 Water Demand versus Aquifer Capacity

Feed water demand for the desalination plant was calculated as approximately 670 m^3/d to produce 330 m^3/d of fresh water (pers. com. Mr Abrie Wessels of Veolia Water in Paarl and Pieter van Dyk of BVi in Upington). Having a yield capacity of 1 210 m^3/d, it is evident that the two boreholes BV1 and BV3 can provide the required feed water demand. In fact the boreholes only need to be pumped for 13.5 hrs/day to supply the demand.

The volume (V) of water stored in the porous sediments of Sak River Alluvial Aquifer in an area of 1.5 x 5 km upstream of the new boreholes was calculated as follows:

V = W x L x T x Porosity , where

W = Width of the aquifer = 1 500 m;

L = Length of the aquifer = 5 000 m;

T = Saturation Thickness of the aquifer = 10 m; and

Porosity = 40%

Therefore V = 1 500 m x 5 000 m x 10 m x 0.4

= 30 million m^3

The aquifer will, however, not release all this water during abstraction. The fraction that will be released under gravity or pumping is called the specific yield (S_y) of the aquifer. An average S_y of 6% was derived from the pumping test analysis. By substituting S_y for porosity in the above formula a volume of 4.38 million m^3 was derived that could be available for abstraction. If there is no recharge, which is unlikely, this volume could provide feed water for an estimated 18 years.

Based on the flow-rates measured at the DWA gauging station on the bridge crossing the Sak River near Brandvlei (**Figure 4**), i.e. the road to Williston, the alluvial aquifer is likely to be recharged at least every five years when there is significant flow of $\geq$200 m^3/sec. This needs to be confirmed by monitoring of some of the observation boreholes in the aquifer, i.e. BV2 and G33758 (see **Figure 3** for positions).

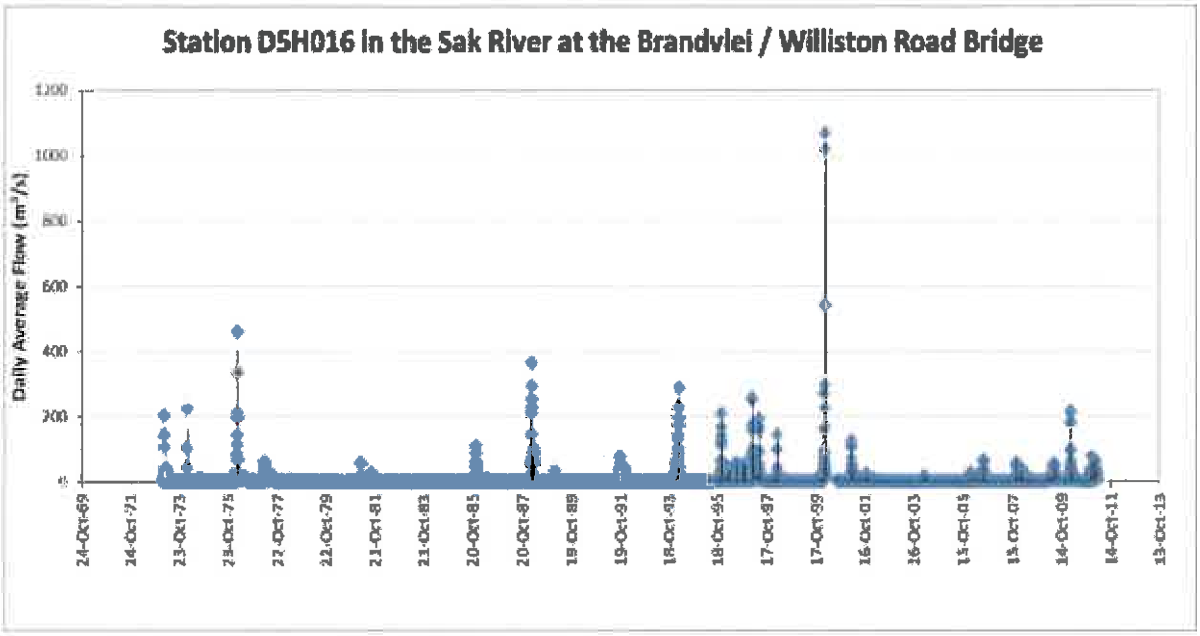

Figure 4: Average Daily Flow Rates for Gauging Station D5H016 near Brandvlei

The natural throughflow (q) across the aquifer was calculated as follows by using Darcy's law (Driscoll, 1995):

q = W x T x i, where

W = Width of the aquifer = 1 500 m;

T = Average transmissivity of the aquifer determined from test pumping as 260 m^2/d;

i = Natural water level gradient of the alluvial aquifer[1] = 0.0008

Therefore, q = 1 500 x 260 x 0.0008 = ~312 m^3/d.

Abstraction at the boreholes, however, will result in an area of water level depression radiating away from the boreholes, which in turn will artificially increase the water level gradient in an area around the boreholes. Assuming a 6 m drawdown at the boreholes an increased water level gradient of 0.0016 was calculated. Substituting this for the natural gradient in the above formula, a throughflow of approximately 620 m^3/d was calculated.

Based on the pumping test analysis results, the S_y of the aquifer, the surface flow records of the Sak River and the throughflow calculations, it can be concluded that it is feasible to abstract the required volume of water from the two new boreholes (BV1 and BV3). However, a monitoring programme should be implemented and the data so obtained should be reviewed by a SACNAS registered hydrogeologist on a six-monthly basis. Based on the results of the first two years of data reviewing the review schedule might eventually be reduced to annually.

The monitoring programme must comprise of the following:

- A flow meter must be installed at each production borehole and the volume pumped recorded on a weekly basis.

[1] Due to the lack of boreholes upstream in the aquifer the water level gradient in the alluvial aquifer was assumed to be the same as the surface elevation gradient.

- To measure the water level on a weekly basis with a dipmeter, each production borehole must be equipped with a conduit consisting of 35 mm class 6 HDP pipe inserted to just above the pump intake and strapped to the rising mains.
- The water levels must also be recorded on a weekly basis in observation boreholes BV2 and G33758.

During design of the pump houses the flood level must be taken into consideration so that the floor of the pump houses and other infrastructure are elevated above the maximum flood level.

2.5 Water Quality

The chemistry of the water from the three new boreholes are summarised in **Table 5**.

Table 5: Chemistry of the Water from the New Boreholes at Brandvlei

BH NO:	BV1	BV2	BV3
TALBOT & TALBOT LABORATORY NUMBER:	17303/11	17304/11	17305/11
SAMPLE DATE: Determinants (in mg/l unless stated otherwise)	3-Sep-11	3-Sep-11	30-Aug-11
Potassium as K	1.8	2.1	1.6
Sodium as Na	9 199	8 883	14 430
Calcium as Ca	717	851	627
Magnesium as Mg	1 762	1 703	1 787
Aluminium as Al	1.9	14	2.8
Sulphate as SO4	9 650	9 720	9 340
Sulphide as S2	<0.04	<0.04	<0.04
Chloride as Cl	24 143	23 593	23 343
Total Hardness	9 146	9 138	8 924
Total Alkalinity as CaCO3	336	371	339
Fluoride as F	9.70	8.80	10.00
Iron as Fe	0.15	0.87	0.19
Manganese as Mn	0.15	5.13	0.19
Conductivity mS/m (25°C)	5 270	5 240	5 210
pH (Lab) (25°C)	6.8	6.5	7.3
Total Dissolved Solids	37 244	37 208	37 872
Silicon, Si	13.88	13.42	13.32
Colour	<1	4	<1
Total phosphate as P	<1	<1	<1
Suspended solids	252	576	352
Turbidity NTU	19.1	207.0	0.8
Total Kjeldahl nitrogen as N	<1	<1	<1
Oil & Grease	6	4	6
Selected* constituents in µg/L (of health significance in drinking water)			
Antimony	0.14	0.85	0.20
Arsenic	5.8	11.0	8.2
Barium	14	54	17
Cadmium	0.38	0.98	0.60
Chromium	2.00	0.84	1.40
Copper	1.80	0.75	2.30
Lead	0.19	0.40	0.13
Mercury	1.40	0.92	1.80

BH NO:	BV1	BV2	BV3
TALBOT & TALBOT LABORATORY NUMBER:	17303/11	17304/11	17305/11
Molybdenum	76	84	80
Nickel	1.7	17.0	2.3
Selenium	53	56	62
Uranium	211	198	197
*Only constituents of health significance in drinking water included			

The water from the alluvial aquifer is highly saline with and EC in excess of 5 200 mS/m and the TDS exceeding 37 000 mg/L. In 1989 the then Department of Water Affairs reported ECs of 4 750 mS/m for the old boreholes drilled here.

The suspended solids of the water from both boreholes recommended for production purposes (BV1 and BV3) are high whilst BV1 also has a high turbidity. It is expected that the turbidity will be lower during production pumping as the recommended pumping rate is lower than the test rate during which the samples were collected. Turbidity should also be less as the boreholes only need to be pumped at 50% of their capacity to supply in the demand. Some sort of pre-filtering will likely be required. *Note: Turbidity of the water from BV2 is much higher, but this low yielding borehole is not recommended for production use.*

Plotting the chemistry data on a Piper diagram indicate the groundwater to be of a Sodium Chloride type (**Figure 5**).

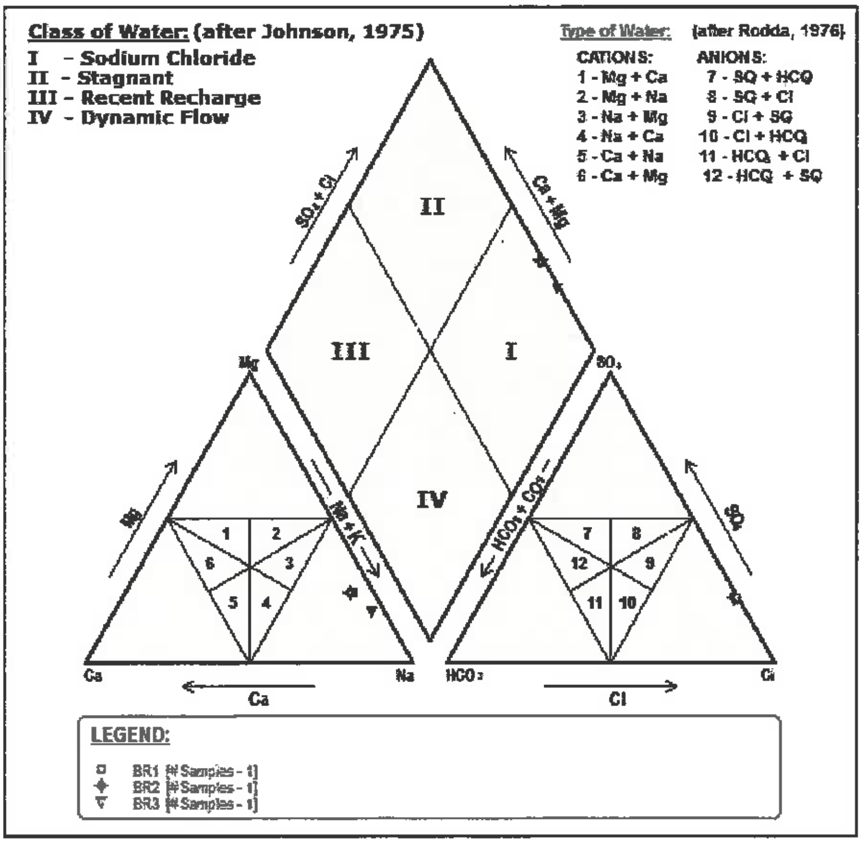

Figure 5: Piper Plot of the New Borehole Groundwater Chemistry

Trace element analysis results indicate relatively[2] high levels of selenium, molybdenum and uranium. The desalination process should reduce these concentrations to acceptable limits, however, in view of the relative high uranium concentrations, it is recommended that the radionuclide concentrations as well as gross alpha and beta radioactivity of the water is also determined. This will entail resampling the two proposed production boreholes and submitting the samples to the NECSA Radio Analysis laboratory in Pelindaba. *Note: NECSA is the only laboratory in the RSA that can do these analyses and it normally takes anything from 5 to 6 months to get results back.*

Due to the high TDS, the recovery of a reverse osmosis desalination plant will most likely be around 50%, which means larger waste water evaporation facilities than initially envisaged (SRK, Jul. 2010). This was confirmed per e-mail by Mr Abrie Wessels of Veolia Water.

[2] Relative to the World Health Organisation's guidelines for drinking water quality.

3 Conclusions

The following can be concluded for this investigation:

- Two of the three boreholes drilled have sufficiently high yields to supply the feed water demand of the proposed desalination plant.
- Pump test data analyses indicate that boreholes BV1 and BV3 can each be pumped at 25.2 m^3/hr for a 24 hr/day schedule to give a combined yield of 50.4 m^3/hr, or ~1 200 m^3/day, which is more than adequate to supply the ~670 m^3/d required for the desalination plant.
- The groundwater storage of the portion of the Sak River Aquifer in an area around and 5 km upstream of the boreholes was calculated as ~4.38 million m^3. The natural throughflow across the aquifer was calculated as 300 m^3/d and a pumping induced drawdown flow was calculated as approximately 600 m^3/day.
- Daily flow-rates measured at a nearby gauging station located on the Brandvlei / Williston road bridge indicate flow events exceeding 200 m^3/sec to occur on average at least every five years, thereby suggesting that aquifer recharge also occurs at similar intervals.
- The groundwater from the boreholes is very saline with an EC of just over 5 200 mS/m and TDS of between 37 200 and 37 800 mg/L. The fluoride is also high varying between ~8 to ~10 mg/L. The water from BV1 and BV2 is turbid and suspended solids are high with values of between ~250 and ~580 mg/L. *Note: BV2 is not recommended for abstraction.* Although the lower rates recommended for production pumping in all likelihood will reduce the turbidity, it is expected that some sort of pre-filtering will be required.
- Based on the pumping test analysis results, the specific yield of the aquifer, the surface flow records of the Sak River and the throughflow calculations, it can be concluded that it is feasible to abstract the required 670 m^3/d from the two new boreholes BV1 and BV3, provided that a monitoring programme is implemented and that the data are reviewed by a SACNAS registered hydrogeologist on at least a six-monthly basis.

4 Recommendations

The following is recommended:

1. Boreholes BV1 and BV3 can be equipped and utilised as summarised in the table below:

BH No.	Borehole Depth	Borehole Diameter	Pre-Pumping Water Level	Recommended Pump Intake	16 hr/day Optimum Pumping Rate		Warning Pump Drawdown Level
	(m)	(mm)	(mbgl)	(mbgl)	(m^3/hr)	(m^3/d)	(mbgl)
BV1	16	175	5.7	14	21	605	11
BV3	16	175	5.1	14	21	605	11
Total					42	670	

Notes:
The optimum pumping rates allow for all boreholes being pumped simultaneously
When pump drawdown reached the warning level, the pump must be switched off for at least 24 hrs and the hydrogeologist consulted.
Water levels must preferably be monitored on a daily basis, or at least weekly.

2. A monitoring scheme must be implemented to monitor the water levels and volumes abstracted in the two production boreholes on at least a weekly basis. For this purpose each borehole must be equipped with a volume meter and conduit pipe (35 mm ID class 6 HDP tied to the rising mains with cable ties) for lowering of the dipmeter probe without it getting stuck.
3. At the same time water levels must also be recorded in the observation boreholes BV2 and G33758 on at least a weekly basis.
4. Samples must be collected on a three-monthly basis at the production boreholes and submitted to a SANAS accredited laboratory for macro-chemical analysis for the first year of operation and thereafter on a six-monthly basis.
5. The monitoring data must be analysed and reported on by a SACNASP accredited hydrogeologist on a six monthly basis.

Prepared by

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Reviewed by

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Corporate Consultant

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

5 References

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Appendices

Appendix A: Pumping Test Data

Borehole number:	BV1	Type Pump	N/A
Operator:	DIFFERENCE	Installation Depth(mbgl)	N/A
Supervisor :	SAMUEL	Condition of Pump & Columns	N/A
Type of rig:	TOYOTA	Diesel / Electric	N/A
Rig number:	12	Pump house Condition	N/A

TESTING EQUIPMENT

Pump used	Depth installed (mbgl)	Starting time and date of step drawdown test	Ending time and date of step drawdown test
BP30	14.30	31/08/2011 07H00	31/08/2011 11H30

CALIBRATION AND OR STEPPED DRAWDOWN SUMMARY

STEP	DURATION [min]	RECOVERY [min]	YIELD [L/s]	Drawdown (m)	STEP	DURATION [min]	RECOVERY [min]	YIELD [L/s]	Drawdown (m)
1	60		2.52	0.87	5				
2	60		5.03	1.73	6				
3	60		7.51	2.84	7				
4	60	30	10.03	3.54	8				
Calibration:									
TOTAL:	240	30							
COMMENT:									

CONSTANT RATE DISCHARGE TEST SUMMARY

Pump used	Depth of pump intake [m]	Starting time and date	Ending time and date of constant discharge
BP30	14.30	31/08/2011 13H00	03/09/2011 15H30
Avg. yield [L/s]	Total drawdown [m]	Duration of CDT [m]	Duration of Recovery after CDT [min]
9.50	3.86	4320	150
COMMENT:			

MAINTENANCE

Total work time [hrs]:		Transport existing equip.. [Km]		Traveling [Km]	
List of parts replaced or repaired:					

OBSERVATION BOREHOLE INFORMATION

	Total draw down [m]	Duration [min]	Distance between holes [m]	Comments:
Observation Hole 1 BV3	0.52	4080	75	
Observation Hole 2				
Observation Hole 3				

ESTABLISHMENT

Establishment - date		Distance Travelled [km]		
Site Move From which		To which		
Village &	borehole	Village &	borehole	Traveling distance between boreholes [km]

BOREHOLE MEASUREMENTS BEFORE AND AFTER TEST

BEFORE TEST	Water level [mbgl]	5.73	Borehole depth [m]	16.25	Casing depth [m]	UPVC
AFTER TEST	Water level [mbgl]	5.78	Borehole depth [m]	16.25	Casing depth [m]	UPVC
Installed Test pump:			Reason:			
Was existing equipment re-installed:			If not where was it left:			
Remarks:						
Signed Contractor:			Signed Consultant:			

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STEPPED DISCHARGE TEST & RECOVERY

BOREHOLE NO: BV1	CO-ORDINATES:	PROVINCE:	NORTHERN CAPE
ALT BH NO: 0	LATITUDE [S]: 30.46366	DISTRICT:	BRANDVLEI
	LONGITUDE [E]: 20.50529	SITE NAME:	BRANDVLEI

BOREHOLE DEPTH [mbgl]:	16.25	DATUM LEVEL ABOVE CASING (m):	0.23	EXISTING PUMP:	N/A
WATER LEVEL [mbgl]:	5.73	CASING HEIGHT (magl):	0.39	CONTRACTOR:	WELLTEK SERVICES
DEPTH OF PUMP [m]:	14.30	DIAM OF CASING AT TOP (mm)	0	TEST PUMP TYPE:	BP30 MONO

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1			RPM		DISCHARGE RATE 2			RPM		DISCHARGE RATE 3			RPM	
DATE: 3108/2011		TIME: 07H00			DATE: 31/08/2011		TIME: 08H00			DATE: 31/08/2011		TIME: 09H00		
TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	0.10		1		1	0.99		1		1	1.99		1	
2	0.54		2		2	1.09	4.21	2		2	2.08	7.33	2	
3	0.62	2.53	3		3	1.12		3		3	2.11		3	
5	0.71		5		5	1.16		5		5	2.29	7.51	5	
7	0.73		7		7	1.18	5.08	7		7	2.38		7	
10	0.76	2.55	10		10	1.33		10		10	2.52		10	
15	0.80		15		15	1.47	5.08	15		15	2.60	7.52	15	
20	0.81	2.55	20		20	1.58		20		20	2.70		20	
30	0.84		30		30	1.60	5.06	30		30	2.73		30	
40	0.85	2.55	40		40	1.63		40		40	2.74	7.51	40	
50	0.86		50		50	1.69	5.03	50		50	2.77		50	
60	0.87	2.55	60		60	1.73		60		60	2.84	7.52	60	
70			70		70			70		70			70	
80			80		80			80		80			80	
90			90		90			90		90			90	
100			100		100			100		100			100	
110			110		110			110		110			110	
120			120		120			120		120			120	
			150					150					150	
			180					180					180	
			210					210					210	

DISCHARGE RATE 4			RPM		DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE: 31/08/2011		TIME: 10H00			DATE:		TIME:			DATE:		TIME:		
TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	3.14	9.20	1		1			1		1			1	0.96
2	3.20		2		2			2		2			2	0.39
3	3.27	10.06	3		3			3		3			3	0.18
5	3.30		5		5			5		5			5	0.15
7	3.30	10.05	7		7			7		7			7	0.13
10	3.33		10		10			10		10			10	0.09
15	3.35		15		15			15		15			15	0.07
20	3.37	10.04	20		20			20		20			20	0.06
30	3.38		30		30			30		30			30	0.05
40	3.45		40		40			40		40			40	
50	3.50	10.03	50		50			50		50			50	
60	3.54		60		60			60		60			60	
70			70		70			70		70			70	
80			80		80			80		80			80	
90			90		90			90		90			90	
100			100		100			100		100			100	
110			110		110			110		110			110	
120			120		120			120		120			120	
			150					150					150	
			180					180					180	
			210					210					210	
			240					240					240	
			300					300					300	
			360					360					360	

WAS SAND PUMPED ?	NO	WAS THE WATER CLEAN ?	YES
STATIC WATER LEVEL AFTER STEPPED DISCHARGE TEST?	5.78		

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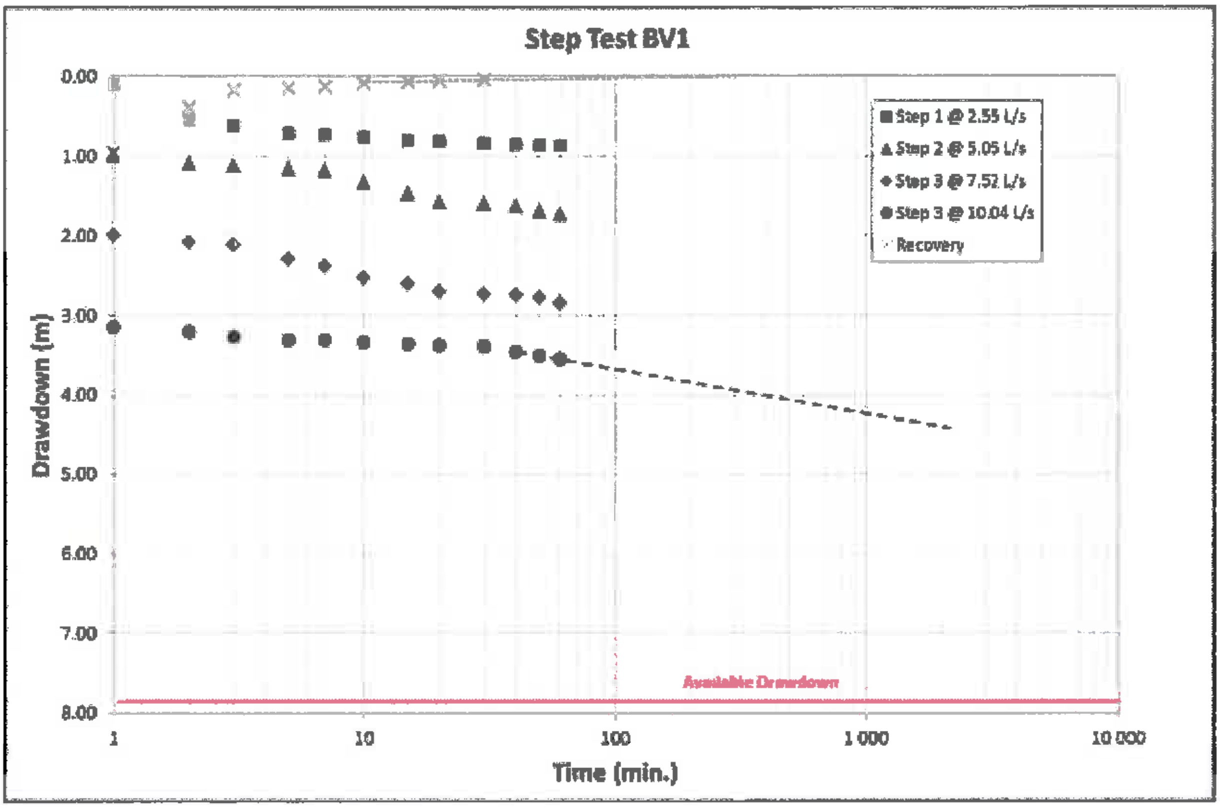
CONSTANT DISCHARGE TEST & RECOVERY

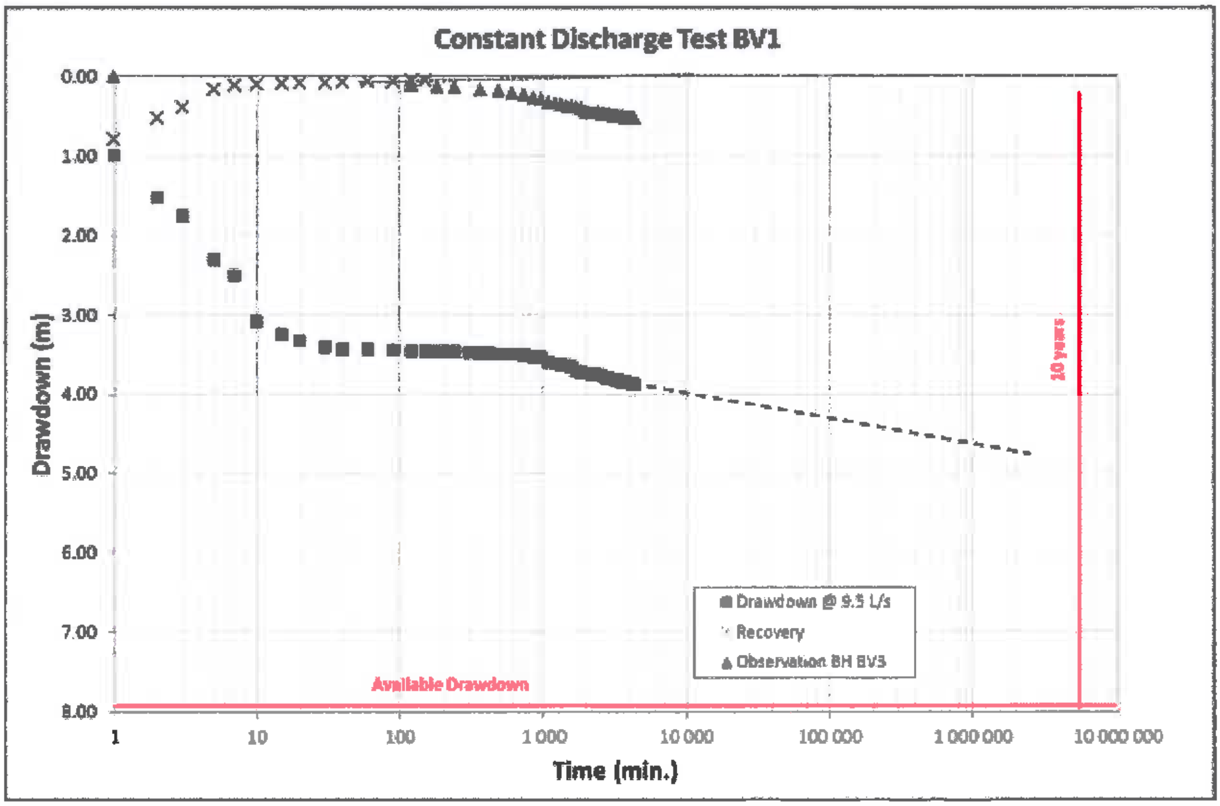
BOREHOLE NO:	BV1	CO-ORDINATES:		PROVINCE:	NORTHERN CAPE
		LATITUDE [S]: 30.46366		DISTRICT:	BRANDVLEI
ALT BH NO:	0	LONGITUDE [E]: 20.50529		SITE NAME:	BRANDVLEI
BOREHOLE DEPTH [mbgl]:	16.25	DATUM LEVEL ABOVE CASING (m):	0.23	EXISTING PUMP:	N/A
WATER LEVEL [mbgl]:	5.73	CASING HEIGHT (magl):	0.39	CONTRACTOR:	WELLTEK SERVICES
DEPTH OF PUMP [m]:	14.30	DIAM OF CASING AT TOP (mm)	0	TEST PUMP TYPE:	BP30 MONO

CONSTANT DISCHARGE TEST & RECOVERY

TEST STARTED				TEST COMPLETED			
DATE:	31.08.2011	TIME:	13H00	DATE:	03.09.2011	TIME:	13H00
TYPE OF PUMP:							

DISCHARGE BOREHOLE					OBSERVATION HOLE 1			OBSERVATION HOLE 2			OBSERVATION HOLE 3		
					NR:	BV3		NR:			NR:		
					Distance:	W/L 5.86		Distance:			Distance:		
TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME MIN	Recovery (m)	TIME: (min)	DRAWDOWN (M)	Recovery (m)	TIME: (min)	DRAWDOWN (M)	Recovery	TIME: (min)	DRAWDOWN (M)	Recovery (m)
1	0.99		1	0.79	1	0.00		1			1		
2	1.52		2	0.52	2			2			2		
3	1.75	9.55	3	0.39	3			3			3		
5	2.30		5	0.16	5			5			5		
7	2.50		7	0.11	7			7			7		
10	3.08	9.52	10	0.10	10			10			10		
15	3.24		15	0.09	15			15			15		
20	3.32	9.54	20	0.08	20			20			20		
30	3.40		30	0.08	30			30			30		
40	3.43	9.53	40	0.07	40			40			40		
60	3.43		60	0.06	60			60			60		
90	3.44	9.52	90	0.06	90			90			90		
120	3.45		120	0.05	120	0.11		120			120		
150	3.45	9.55	150	0.05	150			150			150		
180	3.46		180		180	0.13		180			180		
210	3.46	9.54	210		210			210			210		
240	3.46		240		240	0.14		240			240		
300	3.47	9.54	300		300			300			300		
360	3.48		360		360	0.17		360			360		
420	3.48	9.55	420		420			420			420		
480	3.49		480		480	0.18		480			480		
540	3.49	9.53	540		540			540			540		
600	3.49		600		600	0.21		600			600		
720	3.50	9.56	720		720	0.23		720			720		
840	3.52		840		840	0.27		840			840		
960	3.53	9.55	960		960	0.29		960			960		
1080	3.59		1080		1080	0.33		1080			1080		
1200	3.61	9.52	1200		1200	0.34		1200			1200		
1320	3.62		1320		1320	0.35		1320			1320		
1440	3.63	9.52	1440		1440	0.37		1440			1440		
1560	3.65		1560		1560	0.38		1560			1560		
1680	3.70		1680		1680	0.39		1680			1680		
1800	3.72	9.51	1800		1800	0.41		1800			1800		
1920	3.73		1920		1920	0.44		1920			1920		
2040	3.73		2040		2040	0.45		2040			2040		
2160	3.74	9.58	2160		2160	0.46		2160			2160		
2280	3.74		2280		2280	0.46		2280			2280		
2400	3.75	9.57	2400		2400	0.46		2400			2400		
2520	3.75		2520		2520	0.47		2520			2520		
2640	3.78	9.57	2640		2640	0.48		2640			2640		
2760	3.79		2760		2760	0.48		2760			2760		
2880	3.80	9.55	2880		2880	0.48		2880			2880		
3000	3.80		3000		3000	0.49		3000			3000		
3120	3.81	9.53	300		3120	0.49		3120			3120		
3240	3.81		3240		3240	0.50		3240			3240		
3360	3.83	9.52	3360		3360	0.51		3360			3360		
3480	3.84		3480		3480	0.51		3480			3480		
3600	3.84	9.50	3600		3600	0.51		3600			3600		
3720	3.84		3720		3720	0.52		3720			3720		
3840	3.85	9.51	3840		3840	0.52		3840			3840		
3960	3.85		3960		3960	0.52		3960			3960		
4080	3.86	9.50	4080		4080	0.52		4080			4080		
4200	3.86		4200		4200	0.53		4200			4200		
4320	3.87		4320		4320	0.53		4320			4320		
Total time pumped(min):				4320		W/L	5.86		W/L				
Average yield (l/s):				9.54									


Step Test BV1
Drawdown (m)
Time (min.)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
1
10
100
1 000
10 000
Step 1 @ 2.55 L/s
Step 2 @ 5.05 L/s
Step 3 @ 7.52 L/s
Step 3 @ 10.04 L/s
Recovery
Available Drawdown


Constant Discharge Test BV1
Drawdown (m)
Time (min.)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
1
10
100
1 000
10 000
100 000
1 000 000
10 000 000
10 years
Drawdown @ 9.5 L/s
Recovery
Observation BH BV3
Available Drawdown

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Borehole number:	BV2	Type Pump	N/A
Operator:	SAMUEL	Installation Depth(mbgl)	N/A
Supervisor :	HERMAN	Condition of Pump & Columns	N/A
Type of rig:	TOYOTA	Diesel / Electric	N/A
Rig number:	12	Pump house Condition	N/A

TESTING EQUIPMENT

Pump used	Depth installed (mbgl)	Starting time and date of step drawdown test	Ending time and date of step drawdown test
BP30	14.30	03/09/2011 15H00	03/09/2011 16H00

CALIBRATION AND OR STEPPED DRAWDOWN SUMMARY

STEP	DURATION [min]	RECOVERY [min]	YIELD [L/s]	Drawdown (m)	STEP	DURATION [min]	RECOVERY [min]	YIELD [L/s]	Drawdown (m)
1	10	30	1.00	8.70	5				
2					6				
3					7				
4					8				
Calibration:									
TOTAL:	10	30							
COMMENT:									

CONSTANT RATE DISCHARGE TEST SUMMARY

Pump used	Depth of pump intake [m]	Starting time and date	Ending time and date of constant discharge
Avg. yield [L/s]	Total drawdown [m]	Duration of CDT [m]	Duration of Recovery after CDT [min]
COMMENT:			

MAINTENANCE

Total work time [hrs]:		Transport existing equip.. [Km]		Traveling [Km]	
List of parts replaced or repaired:					

OBSERVATION BOREHOLE INFORMATION

	Total draw down [m]	Duration [min]	Distance between holes [m]	Comments:
Observation Hole 1				
Observation Hole 2				
Observation Hole 3				

ESTABLISHMENT

Establishment – date		Distance Travelled [km]		
Site Move From which		To which		
Village &	borehole	Village &	borehole	Traveling distance between boreholes [km]

BOREHOLE MEASUREMENTS BEFORE AND AFTER TEST

BEFORE TEST	Water level [mbgl]	5.66	Borehole depth [m]	15.98	Casing depth [m]	UPVC
AFTER TEST	Water level [mbgl]	5.72	Borehole depth [m]	15.98	Casing depth [m]	UPVC
Installed Test pump:			Reason:			
Was existing equipment re-installed:			If not where was it left:			
Remarks:						
Signed Contractor:			Signed Consultant:			

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borehole testing and associated projects

Department of Water Affairs National Standards and Guidelines FORM 3 BOREHOLE TEST RECORD SHEET

STEPPED DISCHARGE TEST & RECOVERY

BOREHOLE NO:	BV2	CO-ORDINATES:		PROVINCE:	NORTHERN CAPE
ALT BH NO:	0	LATITUDE [S]: 30.4637		DISTRICT:	BRANDVLEI
		LONGITUDE [E]: 20.50566		SITE NAME:	BRANDVLEI
BOREHOLE DEPTH [mbgl]:	15.98	DATUM LEVEL ABOVE CASING (m):	0.23	EXISTING PUMP:	N/A
WATER LEVEL [mbgl]:	5.66	CASING HEIGHT (magl):	0.38	CONTRACTOR:	WELLTEK SERVICES
DEPTH OF PUMP [m]:	14.30	DIAM OF CASING AT TOP (mm)	170	TEST PUMP TYPE:	BP30

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1 RPM

DATE: 03/09/2011 TIME: 15H00

TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	1.98		1	
2	3.06	1.00	2	
3	5.49		3	
5	6.99		5	
7	7.42	1.00	7	
10	8.70		10	
15	8.70	0.71	15	
16	8.70	0.55	20	
17	8.70	0.55	30	
18	8.70	0.49	40	
50			50	
60			60	
70			70	
80			80	
90			90	
100			100	
110			110	
120			120	
			150	
			180	
			210	

DISCHARGE RATE 2 RPM

DATE: TIME:

TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1			1	
2			2	
3			3	
5			5	
7			7	
10			10	
15			15	
20			20	
30			30	
40			40	
50			50	
60			60	
70			70	
80			80	
90			90	
100			100	
110			110	
120			120	
			150	
			180	
			210	

DISCHARGE RATE 3 RPM

DATE: TIME:

TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1			1	
2			2	
3			3	
5			5	
7			7	
10			10	
15			15	
20			20	
30			30	
40			40	
50			50	
60			60	
70			70	
80			80	
90			90	
100			100	
110			110	
120			120	
			150	
			180	
			210	

DISCHARGE RATE 4 RPM

DATE: TIME:

TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1			1	
2			2	
3			3	
5			5	
7			7	
10			10	
15			15	
20			20	
30			30	
40			40	
50			50	
60			60	
70			70	
80			80	
90			90	
100			100	
110			110	
120			120	
			150	
			180	
			210	
			240	
			300	
			360	

DISCHARGE RATE 5 RPM

DATE: TIME:

TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1			1	
2			2	
3			3	
5			5	
7			7	
10			10	
15			15	
20			20	
30			30	
40			40	
50			50	
60			60	
70			70	
80			80	
90			90	
100			100	
110			110	
120			120	
			150	
			180	
			210	
			240	
			300	
			360	

DISCHARGE RATE 6 RPM

DATE: TIME:

TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1			1	8.15
2			2	7.24
3			3	6.00
5			5	4.38
7			7	3.56
10			10	2.12
15			15	1.16
20			20	0.66
30			30	0.23
40			40	
50			50	
60			60	
70			70	
80			80	
90			90	
100			100	
110			110	
120			120	
			150	
			180	
			210	
			240	
			300	
			360	

WAS SAND PUMPED ? WAS THE WATER CLEAN ?

STATIC WATER LEVEL AFTER STEPPED DISCHARGE TEST?

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Borehole testing and associated projects

Borehole number:	BV3	Type Pump	N/A
Operator:	SAMUEL	Installation Depth(mbgl)	N/A
Supervisor :	HERMAN	Condition of Pump & Columns	N/A
Type of rig:	TOYOTA	Diesel / Electric	N/A
Rig number:	12	Pump house Condition	N/A

TESTING EQUIPMENT

Pump used	Depth installed (mbgl)	Starting time and date of step drawdown test	Ending time and date of step drawdown test
BP30	14.30	26/08/2011 13H00	26/08/2011 19H30

CALIBRATION AND OR STEPPED DRAWDOWN SUMMARY

STEP	DURATION [min]	RECOVERY [min]	YIELD [L/s]	Drawdown (m)	STEP	DURATION [min]	RECOVERY [min]	YIELD [L/s]	Drawdown (m)
1	60		2.53	0.28	5				
2	60		5.02	0.63	6				
3	60		7.51	1.30	7				
4	60	150	10.20	3.60	8				
Calibration:									
TOTAL:	240	150							
COMMENT:									

CONSTANT RATE DISCHARGE TEST SUMMARY

Pump used	Depth of pump intake [m]	Starting time and date	Ending time and date of constant discharge
BP30	14.30	27/08/2011 08H00	30/08/2011 10H00
Avg. yield [L/s]	Total drawdown [m]	Duration of CDT [m]	Duration of Recovery after CDT [min]
9.50	3.11	4320	120
COMMENT:			

MAINTENANCE

Total work time [hrs]:		Transport existing equip.. [Km]		Traveling [Km]	
List of parts replaced or repaired:					

OBSERVATION BOREHOLE INFORMATION

	Total draw down [m]	Duration [min]	Distance between holes [m]	Comments:
Observation Hole 1 BV2	0.21	4320	100M	
Observation Hole 2 BV1	0.64	4320	120M	
Observation Hole 3				

ESTABLISHMENT

Establishment - date		Distance Travelled [km]		
Site Move From which		CAPE TOWN	To which	BRANDVLEI
Village &	borehole	Village &	borehole	Traveling distance between boreholes [km]
	NP1	BRANDVLEI	BV3	592KM

BOREHOLE MEASUREMENTS BEFORE AND AFTER TEST

BEFORE TEST	Water level [mbgl]	5.12	Borehole depth [m]	15	Casing depth [m]	UPVC
AFTER TEST	Water level [mbgl]	5.96	Borehole depth [m]	15	Casing depth [m]	UPVC
Installed Test pump:			Reason:			
Was existing equipment re-installed:			If not where was it left:			
Remarks:						

welltek services

borehole testing and associated projects

STEPPED DISCHARGE TEST & RECOVERY

BOREHOLE NO:	BV3	CO-ORDINATES:		PROVINCE:	NORTHERN CAPE
ALT BH NO:	0	LATITUDE [S]: S 30.46424		DISTRICT:	BRANDVLEI
		LONGITUDE [E]: E 020.50570		SITE NAME:	BRANDVLEI
BOREHOLE DEPTH [mbgl]:	15.00	DATUM LEVEL ABOVE CASING (m):	0.23	EXISTING PUMP:	N/A
WATER LEVEL [mbgl]:	5.12	CASING HEIGHT (magl):	0.39	CONTRACTOR:	WELLTEK SERVICES
DEPTH OF PUMP [m]:	14.30	DIAM OF CASING AT TOP (mm)	170	TEST PUMP TYPE:	BP30

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1			RPM		DISCHARGE RATE 2			RPM		DISCHARGE RATE 3			RPM	
DATE: 26/08/2011		TIME: 13H00			DATE: 26/08/2011		TIME: 14H00			DATE: 26/08/2011		TIME: 15H00		
TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	0.09		1		1	0.33		1		1	0.70		1	
2	0.14		2		2	0.35	5.98	2		2	0.72		2	
3	0.19		3		3	0.38		3		3	0.79	6.89	3	
5	0.21	2.11	5		5	0.39	5.03	5		5	0.84		5	
7	0.24		7		7	0.50		7		7	1.05	7.51	7	
10	0.24	2.55	10		10	0.54	5.05	10		10	1.21		10	
15	0.26		15		15	0.56		15		15	1.28	7.54	15	
20	0.26	2.54	20		20	0.58		20		20	1.28		20	
30	0.27		30		30	0.60	5.03	30		30	1.29	7.53	30	
40	0.27	2.55	40		40	0.61		40		40	1.29		40	
50	0.28		50		50	0.63		50		50	1.30	7.51	50	
60	0.28	2.53	60		60	0.63	5.02	60		60			60	
70			70		70			70		70			70	
80			80		80			80		80			80	
90			90		90			90		90			90	
100			100		100			100		100			100	
110			110		110			110		110			110	
120			120		120			120		120			120	
			150					150					150	
			180					180					180	
			210					210					210	

DISCHARGE RATE 4			RPM		DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE: 26/08/2011		TIME: 16H00			DATE:		TIME:			DATE:		TIME:		
TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	1.61		1		1			1		1			1	0.40
2	1.69	9.08	2		2			2		2			2	0.26
3	1.71		3		3			3		3			3	0.20
5	2.08	10.21	5		5			5		5			5	0.16
7	2.17		7		7			7		7			7	0.14
10	2.29	10.22	10		10			10		10			10	0.13
15	2.60		15		15			15		15			15	0.13
20	2.80	10.23	20		20			20		20			20	0.12
30	3.20		30		30			30		30			30	0.10
40	3.30	10.21	40		40			40		40			40	0.09
50	3.48		50		50			50		50			50	0.06
60	3.60	10.20	60		60			60		60			60	0.06
70			70		70			70		70			70	0.05
80			80		80			80		80			80	0.05
90			90		90			90		90			90	0.04
100			100		100			100		100			100	0.04
110			110		110			110		110			110	0.03
120			120		120			120		120			120	0.03
			150					150					150	0.00
			180					180					180	
			210					210					210	
			240					240					240	
			300					300					300	
			360					360					360	

WAS SAND PUMPED ?	NO	WAS THE WATER CLEAN ?	YES
STATIC WATER LEVEL AFTER STEPPED DISCHARGE TEST?	5.12		

wellTek services

Borehole testing and associated projects

Department of Water Affairs Department of Water and Sanitation FORM 5 - BOREHOLE TEST RECORD SHEET

CONSTANT DISCHARGE TEST & RECOVERY

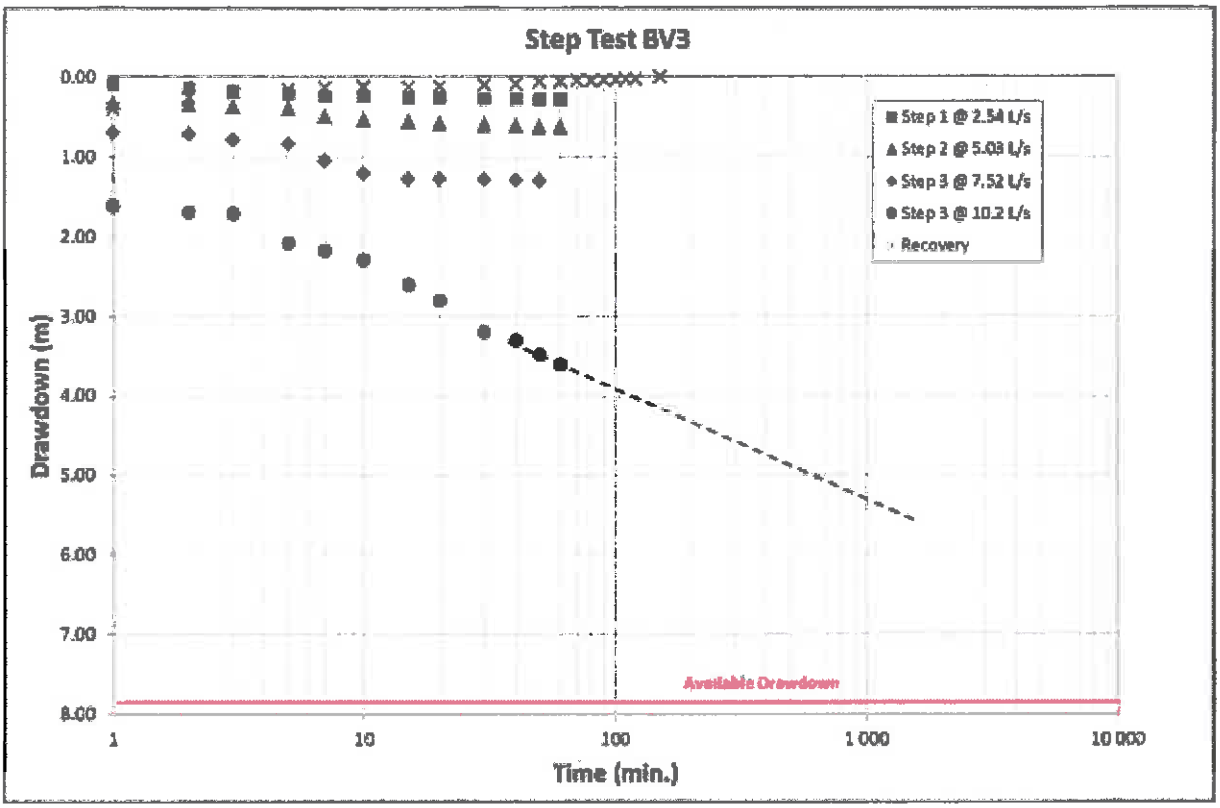
BOREHOLE NO: BV3	CO-ORDINATES:	PROVINCE:	NORTHERN CAPE
ALT BH NO: 0	LATITUDE [S]: S 30.46424	DISTRICT:	**BRANDVLEI**
	LONGITUDE [E]: E 020.50570	SITE NAME:	BRANDVLEI

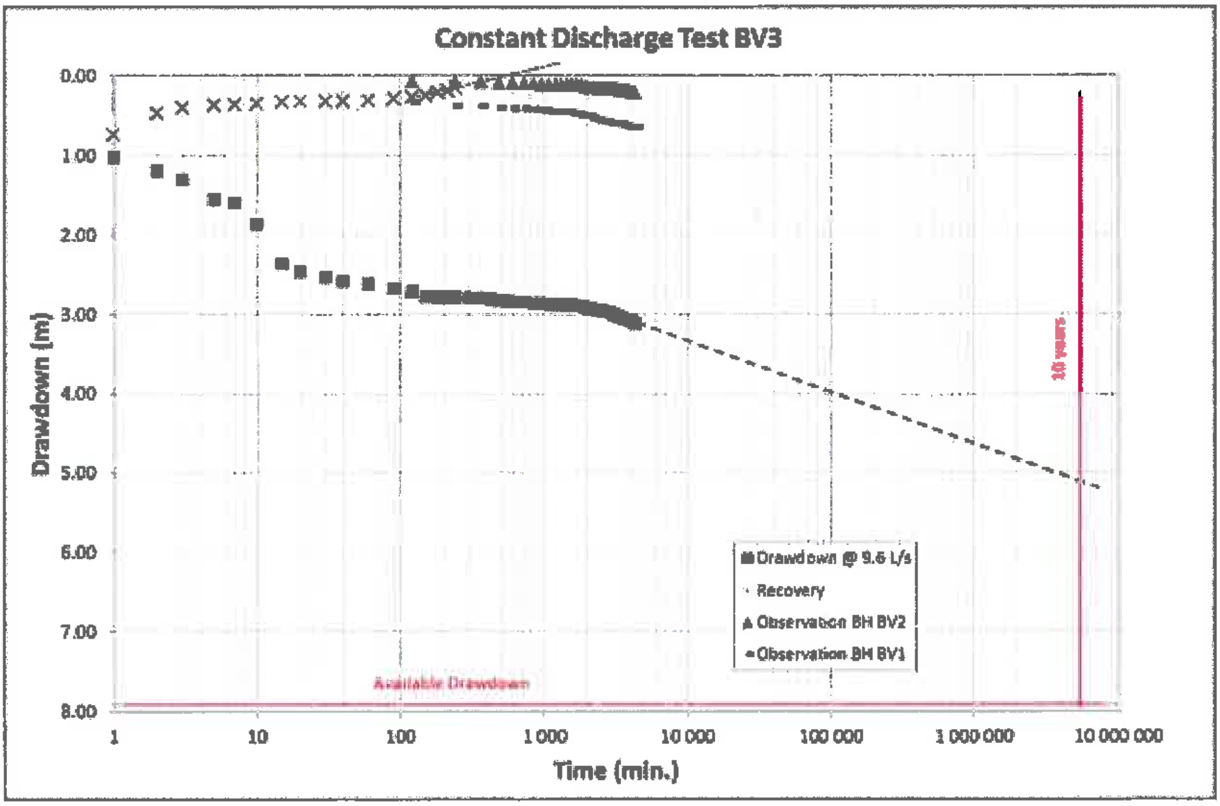
BOREHOLE DEPTH [mbgl]:	15.00	DATUM LEVEL ABOVE CASING (m):	0.23	EXISTING PUMP:	N/A
WATER LEVEL [mbgl]:	5.12	CASING HEIGHT (magl):	0.39	CONTRACTOR:	WELLTEK SERVICES
DEPTH OF PUMP [m]:	14.30	DIAM OF CASING AT TOP (mm)	170	TEST PUMP TYPE:	BP30

CONSTANT DISCHARGE TEST & RECOVERY

TEST STARTED				TEST COMPLETED					
DATE:	27/08/2011	TIME:	08H00	DATE:	31/08/2011	TIME:	12H00	TYPE OF PUMP:	BP 30 M

DISCHARGE BOREHOLE					OBSERVATION HOLE 1 NR: BV 2			OBSERVATION HOLE 2 NR: BV 1			OBSERVATION HOLE 3 NR:		
					Distance: 60			Distance: 75			Distance:		
TIME (MIN)	DRAWDOWN (M)	YIELD (L/S)	TIME MIN	Recovery (m)	TIME: (min)	DRAWDOWN (M)	Recovery (m)	TIME: (min)	DRAWDOWN (M)	Recovery (m)	TIME: (min)	DRAWDOWN (M)	Recovery (m)
1	1.02		1	0.74	1			1			1		
2	1.19		2	0.47	2			2			2		
3	1.30	8.51	3	0.40	3			3			3		
5	1.55		5	0.37	5			5			5		
7	1.59	9.52	7	0.36	7			7			7		
10	1.86		10	0.35	10			10			10		
15	2.36		15	0.33	15			15			15		
20	2.46	9.53	20	0.32	20			20			20		
30	2.53		30	0.32	30			30			30		
40	2.58	9.55	40	0.32	40			40			40		
60	2.62		60	0.31	60			60			60		
90	2.67		90	0.29	90			90			90		
120	2.71	9.54	120	0.27	120	0.07		120	0.33		120		
150	2.77		150	0.25	150			150			150		
180	2.78		180	0.21	180			180			180		
210	2.78	9.54	210	0.19	210			210			210		
240	2.78		240	0.15	240	0.08		240	0.37		240		
300	2.79	9.55	300		300			300			300		
360	2.79		360		360	0.08		360	0.38		360		
420	2.80	9.53	420		420			420			420		
480	2.82		480		480	0.09		480	0.40		480		
540	2.83	9.54	540		540			540			540		
600	2.84		600		600	0.09		600	0.41		600		
720	2.84		720		720	0.10		720	0.41		720		
840	2.86	9.55	840		840	0.10		840	0.42		840		
960	2.86		960		960	0.11		960	0.43		960		
1080	2.87		1080		1080	0.12		1080	0.44		1080		
1200	2.87	9.54	1200		1200	0.12		1200	0.45		1200		
1320	2.87		1320		1320	0.12		1320	0.45		1320		
1440	2.88		1440		1440	0.11		1440	0.45		1440		
1560	2.88	9.55	1560		1560	0.11		1560	0.46		1560		
1680	2.89		1680		1680	0.12		1680	0.47		1680		
1800	2.89		1800		1800	0.12		1800	0.49		1800		
1920	2.91	9.55	1920		1920	0.14		1920	0.50		1920		
2040	2.93		2040		2040	0.15		2040	0.50		2040		
2160	2.93	9.54	2160		2160	0.15		2160	0.53		2160		
2280	2.94		2280		2280	0.15		2280	0.54		2280		
2400	2.94		2400		2400	0.16		2400	0.56		2400		
2520	2.95	9.55	2520		2520	0.16		2520	0.56		2520		
2640	2.96		2640		2640	0.15		2640	0.57		2640		
2760	2.96	9.65	2760		2760	0.15		2760	0.58		2760		
2880	2.97		2880		2880	0.16		2880	0.59		2880		
3000	2.99		3000		3000	0.16		3000	0.59		3000		
3120	3.01	9.54	300		3120	0.16		3120	0.59		3120		
3240	3.02		3240		3240	0.17		3240	0.60		3240		
3360	3.03	9.56	3360		3360	0.18		3360	0.60		3360		
3480	3.04		3480		3480	0.18		3480	0.60		3480		
3600	3.05	9.55	3600		3600	0.18		3600	0.62		3600		
3720	3.06		3720		3720	0.19		3720	0.63		3720		
3840	3.06	9.55	3840		3840	0.19		3840	0.63		3840		
3960	3.07		3960		3960	0.20		3960	0.64		3960		
4080	3.07	9.54	4080		4080	0.20		4080	0.64		4080		
4200	3.10		4200		4200	0.21		4200	0.64		4200		
4320	3.11		4320		4320	0.21		4320	0.64		4320		
Total time pumped(min):				4320		W/L	5.15		W/L	5.16			
Average yield (l/s):				9.55									


Step Test BV3
Drawdown (m)
Time (min.)
Step 1 @ 2.54 L/s
Step 2 @ 5.03 L/s
Step 3 @ 7.52 L/s
Step 3 @ 10.2 L/s
Recovery
Available Drawdown


Constant Discharge Test BV3
Drawdown (m)
Time (min.)
Drawdown @ 9.6 L/s
Recovery
Observation BH BV2
Observation BH BV1
Available Drawdown
10 years

Appendix B: Pumping Test Analysis

FC-METHOD : Estimation of the sustainable yield of a borehole

BV1 — Main | Deriv | Inflection point method

Extrapolation time in years = (enter)	5	2628000	Extrapol.time in minutes
Effective borehole radius (r_e) = (enter)	1.37	1.37	Est. r_e / From r(e) sheet
Q (l/s) from pumping test =	9.55	2.21E-02	S-late / Change r_e
s_a (available draw down), sigma_s = (enter)	7.5	0.4	Sigma_s from risk / Down
Annual effective recharge (mm) =	2	7.12	s_available working draw down n(m)
t(end) and s(end) of pumping test =	4320	3.87	End time and draw down of test
Average maximum derivative = (enter)	0.8	0.8	Estimate of average of max deriv
Average second derivative = (enter)	0.0	0.0	Estimate of average second deriv
Derivative at radial flow period = (enter)	0.32	0.32	Read from derivative graph
	T-early[m^2/d] =	473.71	Aqui. thick (m) 8
T and S estimates from derivatives	T-late [m^2/d] =	192.79	Est. S-late = 4.40E-04
(To obtain correct S-value, use program RPTSOLV)	S-late =	8.80E-04	S-estimate could be wrong

BASIC SOLUTION

(Using derivatives + subjective information about boundaries) — Maximum influence of boundaries at long time

(No values of T and S are necessary)

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	6.05	8.23	10.41	16.95
Q_sust (l/s) =	11.24	8.26	6.53	4.01
	Best case	→		Worst case

Average Q_sust (l/s) = 7.02

with standard deviation= 3.04

(If no information exists about boundaries skip advanced solution and go to final recommendation)

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)

(Late T-and S-values a priori + distance to boundary)

T-late [m^2/d] = (enter) → 190.00

S-late = (enter) → 1.00E-01

1. BOUNDARY INFORMATION (choose a or b) — (Code =9999 = dummy value if not applicable)

(a) Barrier (no-flow) boundaries →	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
Bound. distance a[meter] : (enter)	9999	9999	9999	500
Bound. distance b[meter] : (enter)			9999	1500
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	1.02

(b) Fix head boundary + no-flow →	Closed Fix	Single Fix	90°Fix+no-flow	// Fix+no-flow
Bound. distance to fix head a[meter] : (enter)	9999	9999	9999	9999
Bound. distance to no-flow b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	0.00

2. INFLUENCE OF OTHER BOREHOLES →	Q (l/s)	r (m)	u_r	W(u,r)
BH1			0.00E+00	#NUM!
BH2			0.00E+00	#NUM!
s_(Influence of BH1,BH2) =	0.00	0.00	1.36E-07	15.24

SOLUTION INCLUDING BOUNDS AND BH's

Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9.62
Enter selected Q for risk analysis = (enter) →	9.62	Sigma_s =	0.218	Up / Risk

(Go to Risk sheet and perform risk analysis from which sigma_s will be estimated : only for barrier boundaries)

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	7.00
Total amount of water allowed to be abstracted per month (m^3) =	18144

COMMENTS

Q_sust with 68% safety =

Q_sust with 95% safety = 7 L/s

Cooper-Jacob method

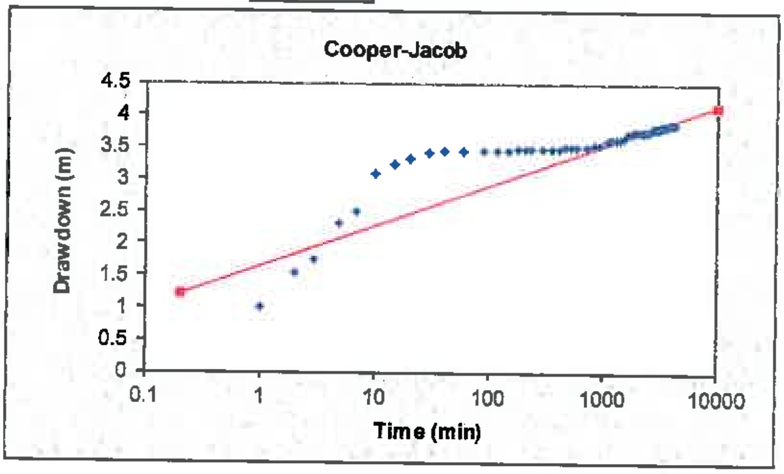
Main | Theis | Cooper-Jacob 2

BV1

$T(m^2/d)$ =	241.5
S =	9.12E-02

r_e (m)=	1.37	→ 0.10
Q (l/s) =	9.55	

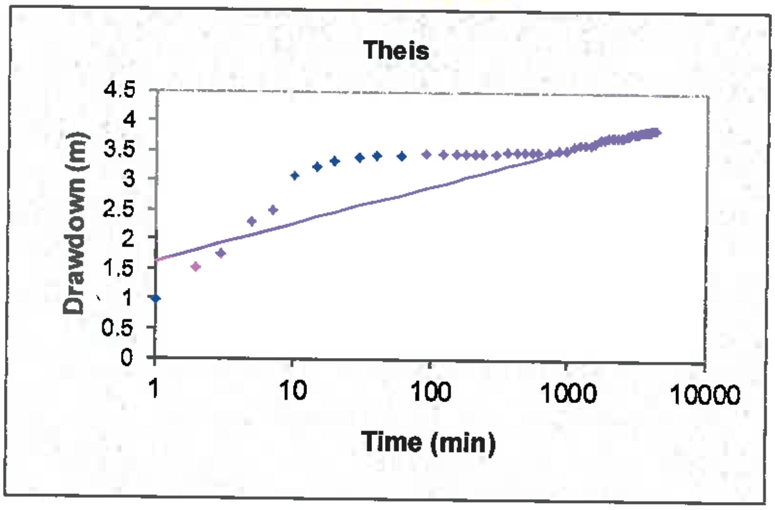
	No boundaries	1 no-flow	2 no-flow	Closed
Q_sust	16.93	8.46	5.59	4.23
Avg. Q_sust =	8.80	std. dev =	5.70	



Theis

T (m2/d)	S	r
239	9.60E-02	0.10

Top

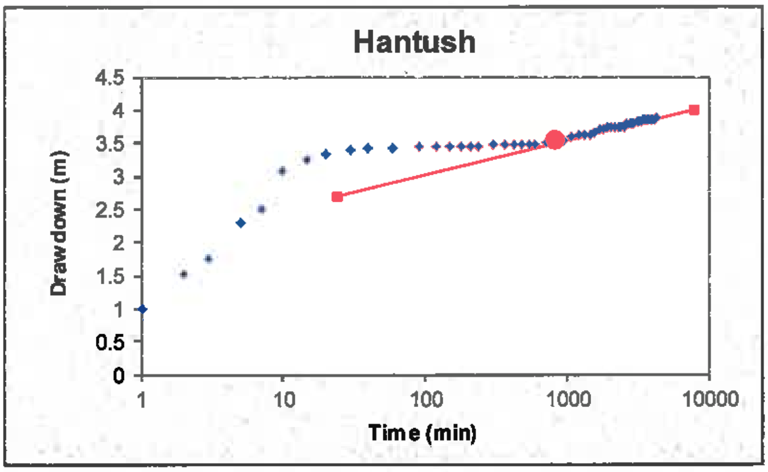


Leaky Aquifer: Hantush Method

Main | Water table

BV1

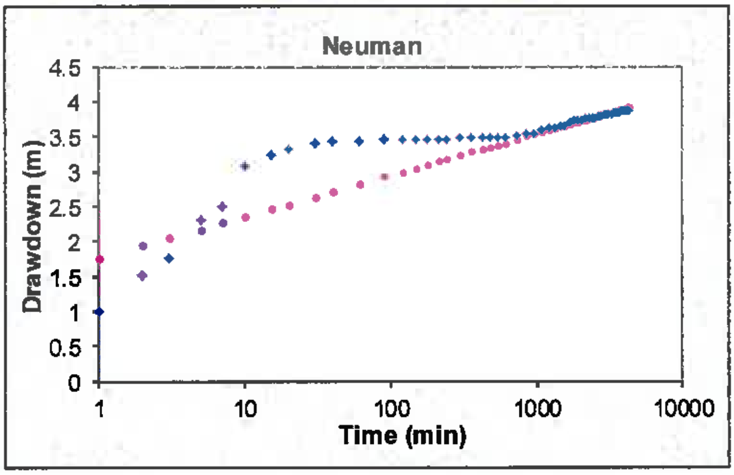
$T (m^2/d)$ =	292.2	r_e (m)=	1.37	→	0.2
S =	1.37E-02	Q (l/s) =	9.55		
L (m) =	53	C (d) =	10		



Watertable: Neuman method

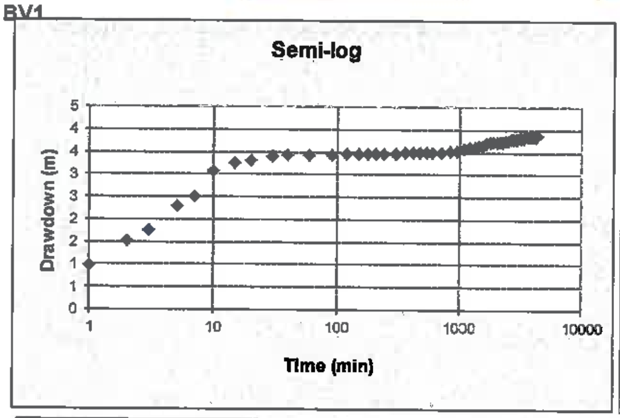
Top

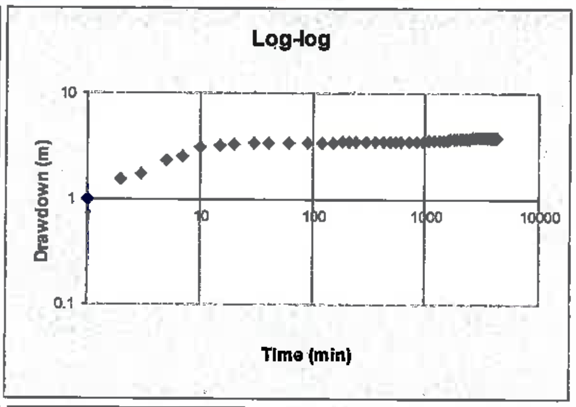
t	T	S	Sy	r
4444.4	248	1.00E-02	1	0.20

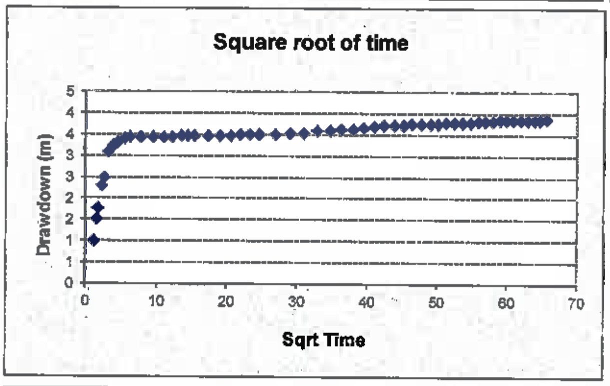


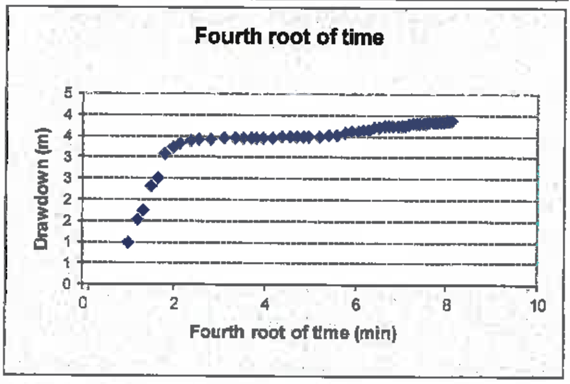
DIAGNOSTIC PLOTS | Main | Data

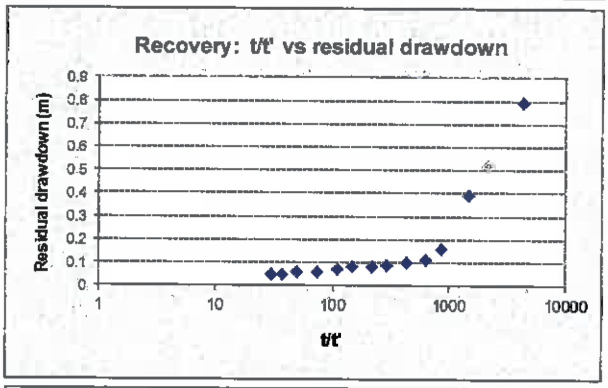
BV1

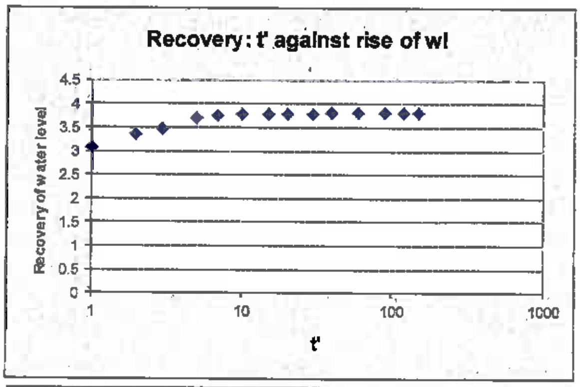


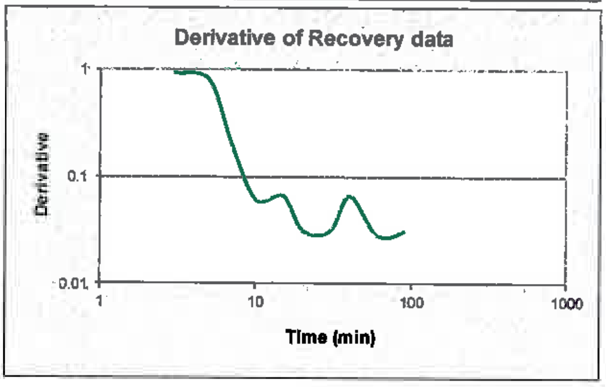


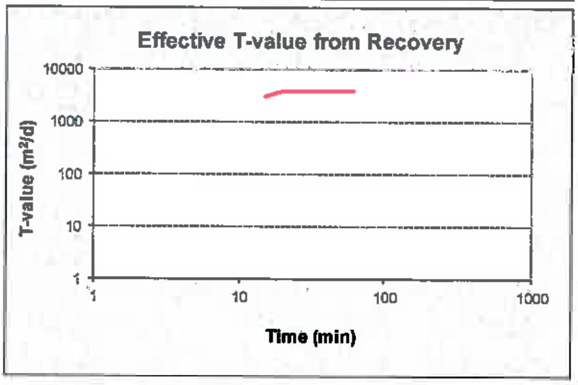












Summary	Main	BV1					
Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S	AD used
Basic FC	7.02	3.04	474	192.8	8.80E-04	7.5
Advanced FC	9.62		474	190.0	1.00E-01	7.5
FC Inflection point						
Cooper-Jacob	8.80	5.70		241.5	9.12E-02	7.5
FC Non-Linear						
Barker						
Average Q_sust (l/s)	8.48	1.33	b =	Fractal dimension n =		

Recommended abstraction rate (L/s)	7.00	for 24 hours per day
Hours per day of pumping		L/s for hours per day
Amount of water allowed to be abstracted per month	18144 m^3	604.8 m^3/d

FC-METHOD : Estimation of the sustainable yield of a borehole

BV3 — Main | Deriv | Inflection point method

Extrapolation time in years = (enter)	5	2628000	Extrapol.time in minutes
Effective borehole radius (r_e) = (enter)	3.68 ←	3.68	← Est. r_e — From r(e) sheet
Q (l/s) from pumping test =	9.55	1.67E-03	← S-late ← Change r_e
s_a (available drawdown), sigma_s = (enter)	7.5	0.9	← Sigma_s from risk — Down
Annual effective recharge (mm) =	2	6.62	s_available working drawdown(m)
t(end) and s(end) of pumping test =	4320	3.11	End time and drawdown of test
Average maximum derivative = (enter)	0.9 ←	0.9	Estimate of average of max deriv
Average second derivative = (enter)	0.1 ←	0.1	Estimate of average second deriv
Derivative at radial flow period = (enter)	0.57 ←	0.57	Read from derivative graph
T and S estimates from derivatives	T-early[m²/d] =	264.10	Aqui. thick (m) — 10
	T-late [m²/d] =	175.77	Est. S-late = 5.50E-04
(To obtain correct S-value, use program RPTSOLV)	S-late =	1.10E-03	S-estimate could be wrong

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)
(No values of T and S are necessary)

Maximum influence of boundaries at long time

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	5.87	8.26	10.65	17.83
Q_sust (l/s) =	10.78	7.65	5.94	3.55
	Best case	→	→	Worst case

Average Q_sust (l/s) = 6.46
with standard deviation= 3.04

(If no information exists about boundaries skip advanced solution and go to final recommendation)

ADVANCED SOLUTION

(Using derivatives + knowledge on boundaries and other boreholes)
(Late T-and S-values a priori + distance to boundary)

T-late [m²/d] = (enter) → 176.00
S-late = (enter) → 1.00E-01

1. BOUNDARY INFORMATION (choose a or b) — (Code =9999 = dummy value if not applicable)

(a) Barrier (no-flow) boundaries →	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
Bound. distance a[meter] : (enter)	9999	9999	9999	500
Bound. distance b[meter] : (enter)			9999	1500
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	1.04

(b) Fix head boundary + no-flow →	Closed Fix	Single Fix	90°Fix+no-flow	// Fix+no-flow
Bound. distance to fix head a[meter] : (enter)	9999	9999	9999	9999
Bound. distance to no-flow b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	0.00

2. INFLUENCE OF OTHER BOREHOLES →	Q (l/s)	r (m)	u_r	W(u,r)
BH1			0.00E+00	#NUM!
BH2			0.00E+00	#NUM!
s_(influence of BH1,BH2) =	0.00	0.00	1.05E-06	13.19

SOLUTION INCLUDING BOUNDS AND BH's

Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9.16
Enter selected Q for risk analysis = (enter) →	9.02	Sigma_s =	0.488	Up — Risk

(Go to Risk sheet and perform risk analysis from which sigma_s will be estimated : only for barrier boundaries)

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	7.00
Total amount of water allowed to be abstracted per month (m³) =	18144

COMMENTS

Q_sust with 68% safety =
Q_sust with 95% safety = 7 L/s

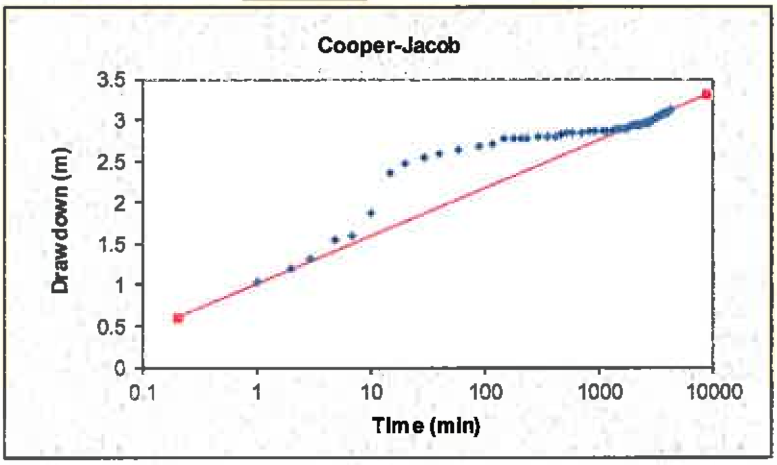
Cooper-Jacob method

Main | Theis | Cooper-Jacob 2

BV3

$T(m^2/d)$ =	260.4	r_e (m)=	3.68 → 0.30
S =	8.36E-02	Q (l/s) =	9.55

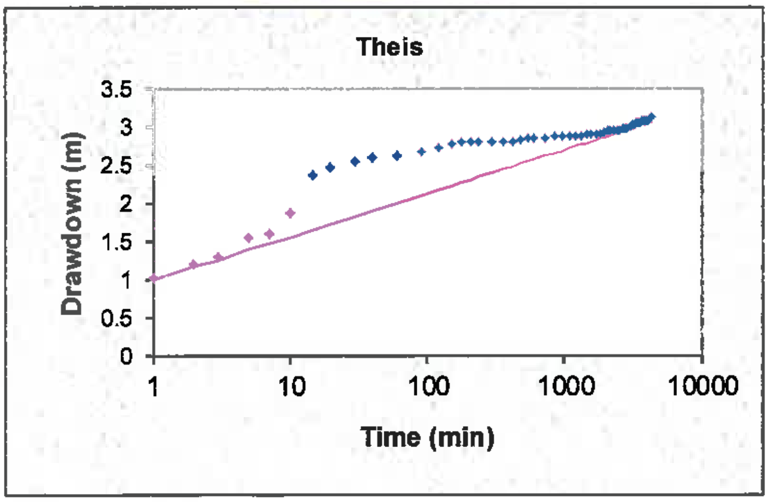
	No boundaries	1 no-flow	2 no-flow	Closed
Q_sust	20.66	10.33	6.82	5.16
Avg. Q_sust =	10.74	std. dev =	6.95	



Theis

T (m2/d)	S	r
266	8.80E-02	0.30

Top



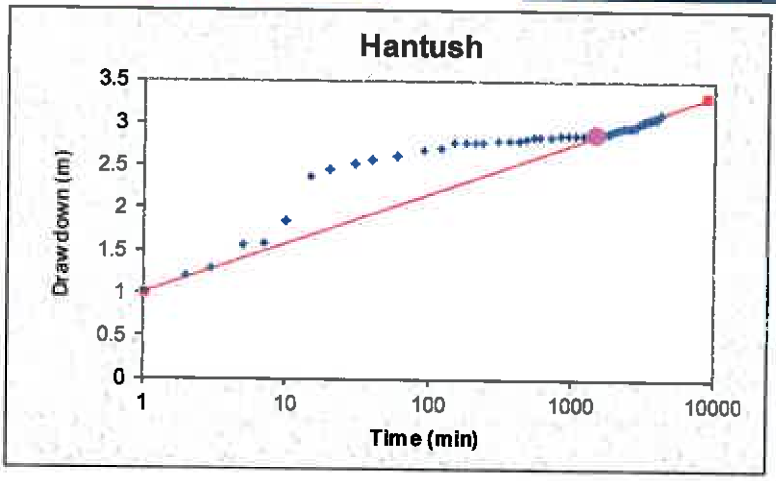
Leaky Aquifer: Hantush Method

Main | Water table

BV3

$T(m^2/d)$ =	257.3
S =	7.52E-02
L (m) =	53

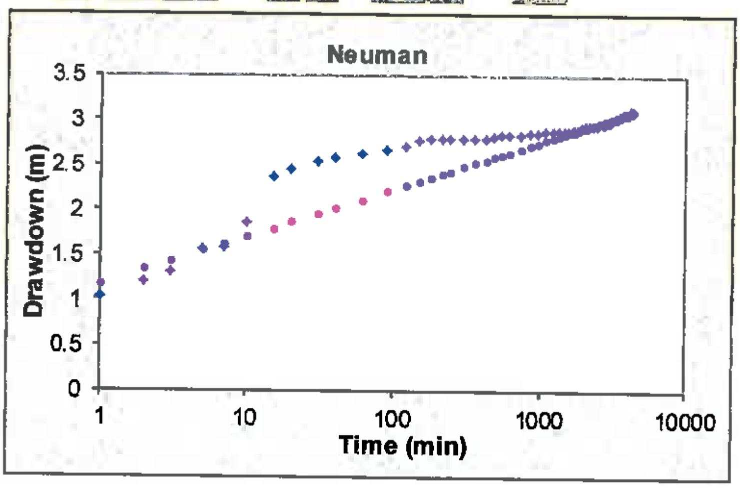
r_e (m)=	3.68	→ 0.5
Q (l/s) =	9.55	
C (d) =	11	

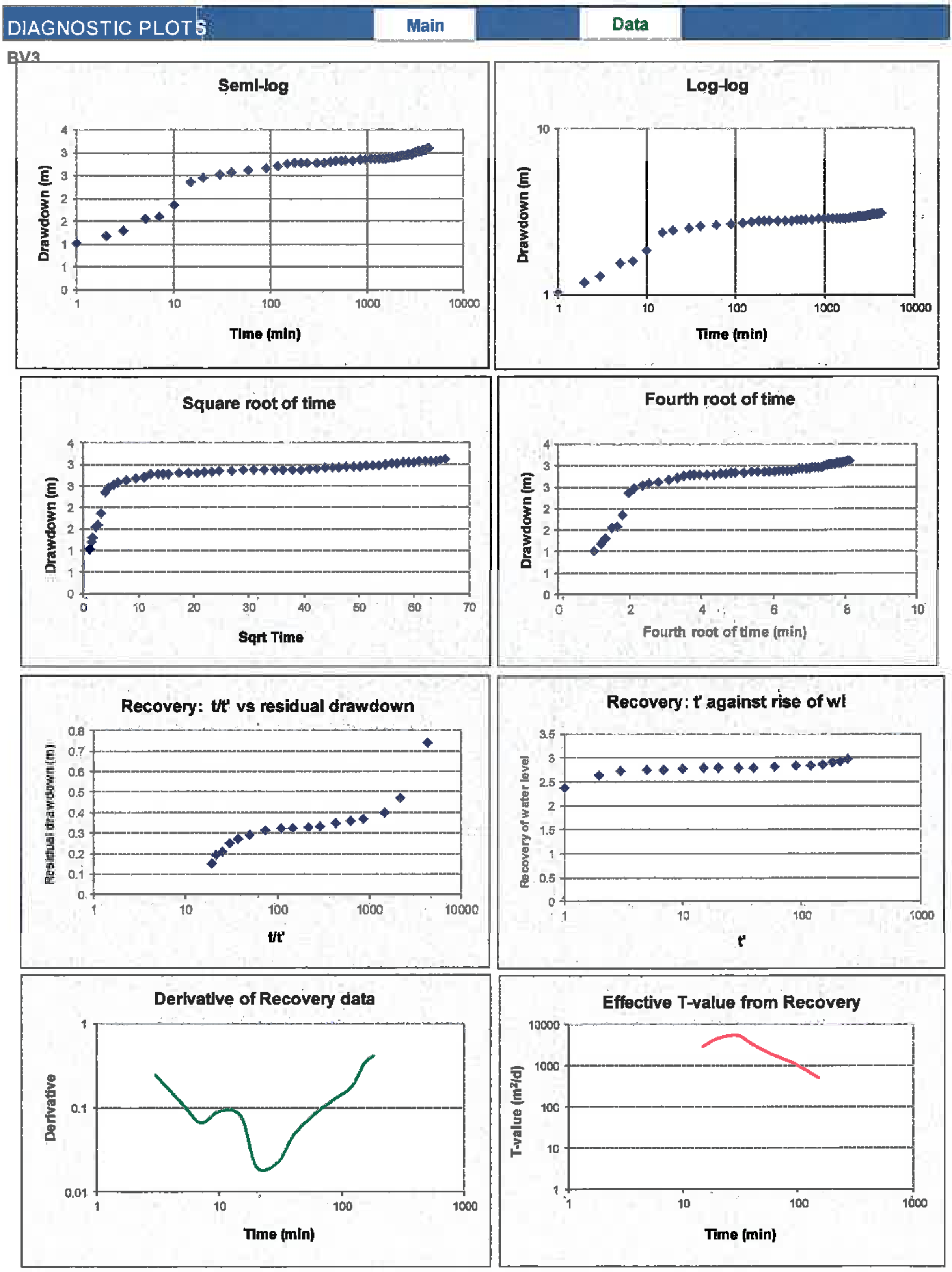


Watertable: Neuman method

Top

t	T	S	Sy	r
4956	278	1.00E-02	1	0.50





DIAGNOSTIC PLOTS
Main
Data
BV3
Semi-log
Drawdown (m)
Time (min)
Log-log
Drawdown (m)
Time (min)
Square root of time
Drawdown (m)
Sqrt Time
Fourth root of time
Drawdown (m)
Fourth root of time (min)
Recovery: t/t' vs residual drawdown
Residual drawdown (m)
t/t'
Recovery: t' against rise of wl
Recovery of water level
t'
Derivative of Recovery data
Derivative
Time (min)
Effective T-value from Recovery
T-value (m²/d)
Time (min)

Summary	Main	BV3					
Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S	AD used
☑	Basic FC	6.46	3.04	264	175.8	1.10E-03	7.5
☑	Advanced FC	9.16		264	176.0	1.00E-01	7.5
☐	FC Inflection point						
☑	Cooper-Jacob	11.41	7.39		260.4	1.88E-01	7.5
☐	FC Non-Linear						
☐	Barker						
	Average Q_sust (l/s)	9.01	2.48	b =	Fractal dimension n =		

Recommended abstraction rate (L/s)	7.00	for 24 hours per day
Hours per day of pumping		L/s for hours per day
Amount of water allowed to be abstracted per month	18144 m^3	604.8 m^3/d

Appendix C: Chemical Analysis Certificates

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sanas T0122 ISO/IEC 17025 Talbot LABORATORIES

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2011/11/30

ANALYTICAL REPORT

OUR REF:	WELLTEK 17303/11
COMPANY NAME:	WELLTEK
CONTACT ADDRESS:	18 HIGHFIELD ROAD, BEACON BAY, EAST LONDON
CONTACT PERSON:	HERMANN
SAMPLE TYPE:	EFFLUENT
DATE SUBMITTED:	2011/10/20

Determinand	Units	Method No	Results		
			17303/11	17304/11	17305/11
			BV1 05.09.2011	BV2 05.09.2011	BV3 05.09.2011
Chemical oxygen demand (total)	mg O_2/l	3	(423)	(628)	(564)
Chloride	mg Cl/l	16	24,143	23,593	23,343
Colour*	mg Pt-Co/l	48	<1	4	<1
Conductivity at 25°C	mS/m	2	5,270	5,240	5,210
Dissolved calcium	mg Ca/l	8A	717	851	627
Dissolved iron	mg Fe/l	20	0.15	0.87	0.19
Dissolved magnesium	mg Mg/l	9A	1,762	1,703	1,787
Dissolved manganese	mg Mn/l	19	0.15	5.13	0.19
Fluoride	µg F/l	18	9,700	8,800	10,000
Odour*	descriptive		nil	musty	nil
Oil & grease*	mg/l	52	6	4	6
pH at 25°C	pH units	1	6.8	6.5	7.3
Potassium	mg K/l	7A	1.8	2.1	1.6
Silicon*	mg Si/l		13.88	13.42	13.32
Sodium	mg Na/l	6A	9,199	8,883	14,430
Sulphate	mg SO_4/l	67	9,650	9,720	9,340
Sulphide*	mg S^{2-}/l		<0.04	<0.04	<0.04
Suspended solids at 105°C	mg/l	5	252	576	352
Total Alkalinity	mg $CaCO_3$/l	10	336	371	339
Total aluminium	mg Al/l		1.9**	14**	2.8**
Total dissolved solids at 180°C	mg/l	41	37,244	37,208	37,872
Total hardness	mg $CaCO_3$/l	calc	9,146	9,138	8,924
Total Kjeldahl nitrogen*	mg N/l		<1	<1	<1
Total organic carbon*	mg C/l				
Total phosphate*	µg P/l		<1,000**	<1,000**	<1,000**
Total solids at 105°C	mg/l	59	37,496	37,784	38,224
Turbidity	NTU	4	19.1	207	0.8

Talbot ENGINEERING Talbot GREEN ENERGY Talbot OPERATIONS

TALBOT *Laboratories*

ICP-MS (µg/l)	17303/11	17304/11	17305/11
DETERMINAND	BV1 05.09.2011	BV2 05.09.2011	BV3 05.09.2011
Lithium	428	482	451
Beryllium	0.01	0.05	0.08
Silicon	6283	7935	7585
Titanium	< 0.03	1.7	0.41
Vanadium	16	10	8.5
Chromium	2	0.84	1.4
Cobalt	0.31	52	1.5
Nickel	1.7	17	2.3
Copper	1.8	0.75	2.3
Zinc	48	53	1287
Gallium	0.02	0.16	< 0.01
Germanium	1.1	0.88	1.2
Arsenic	5.8	11	8.2
Selenium	53	56	62
Rubidium	0.08	0.05	0.17
Strontium	14963	14634	15448
Yttrium	0.86	1.2	0.7
Zirconium	0.23	0.34	0.1
Niobium	< 0.01	0.02	< 0.01
Molybdenum	76	84	80
Palladium	20	17	21
Silver	0.18	0.12	0.38
Cadmium	0.38	0.98	0.6
Tin	0.25	0.42	0.27
Antimony	0.14	0.85	0.2
Tellurium	0.85	0.3	0.62
Caesium	0.29	0.47	0.47
Barium	14	54	17
Lanthanum	0.23	0.49	0.23
Cerium	0.36	0.77	0.41
Praseodymium	0.04	0.07	0.03

TALBOT Laboratories

ICP-MS (µg/l)	17303/11	17304/11	17305/11
DETERMINAND	BV1 05.09.2011	BV2 05.09.2011	05.09.2011
Neodymium	0.16	0.31	0.13
Samarium	0.06	0.02	0.04
Europium	0.01	0.02	0.01
Gadolinium	0.23	0.13	0.02
Terbium	0.02	0.02	0.01
Dysprosium	0.06	0.1	0.03
Holmium	0.02	0.02	0
Erbium	0.06	0.09	0.02
Thulium	0.01	0.01	0
Ytterbium	0.05	0.06	0.01
Lutetium	0.01	0.01	0
Hafnium	0	0.02	0
Tantalum	0.05	0.03	0.04
Tungsten	0.07	0.49	0.17
Platinum	0.01	0.01	0
Gold	0.04	0.08	0.07
Mercury	1.4	0.92	1.8
Thallium	0.04	0.09	0.07
Lead	0.19	0.4	0.13
Bismuth	0.01	0.02	0.01
Thorium	0.05	0.09	0.01
Uranium	211	193	197

Belinda Talbot
LABORATORY MANAGER

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- Test marked * in this report are not SANAS accredited and are not included in the SANAS accreditation schedule for our laboratory.
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- Note: Estimates of Uncertainty of Measurement may be obtained from the laboratory.

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APPENDIX 5

Assessment of the Groundwater Resource Potential and Options for Improving Brandvlei's Municipal Water Supply

Report Prepared for

Hantam Municipality

Report No 412653/Draft V1

5 May 2010

SRK Consulting

Engineers and Scientists

Assessment of the Groundwater Resource Potential and Options for Improving Brandvlei's Municipal Water Supply

Hantam Municipality

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Reviewed by:

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Executive summary

Scope of work

This report has been compiled for the Hantam Local Municipality by SRK Consulting (SRK) to document the results of an assessment into the groundwater potential and possible options for improving Brandvlei's municipal water supply.

The town currently obtains all its municipal water supplies through an asbestos cement (AC) pipeline from a wellfield of five boreholes located ~40 km southeast of the town at Romanskolk. The AC pipeline is approximately 45 years old and is in a very bad condition resulting in numerous breakages and leakages. The municipality is especially concerned about the fact that the pipeline crosses a large pan that prevents detection of leakages and repairs from being undertaken when filled with water after good rains. This situation poses a high risk in that the town could be without water for an extended period.

Results

The geology of the area comprises mainly Tierberg shale of the Ecca Group with post-Karoo dolerite intrusions in the form of dykes and sills. Alluvium occurs in the main drainage channels but the vertical extent thereof is limited. Pan sediments consisting of clay, silt and alluvium occur in several pans throughout the study area. These sediments are generally less than 5 m thick.

The aquifer in the study area has been classed as a poor aquifer of low to medium vulnerability. Along the Sak River and the pans the vulnerability tends to be medium to high.

The average water level is 12 mbgl and groundwater flow is towards the Sak River and in a north westerly direction.

The Romanskolk Wellfield abstracts approximately 137 000 m^3/a for domestic, stock watering and irrigation purposes.

The groundwater quality is generally poor with few localised instances of good quality fit for human consumption. Fluoride is a major concern and very few boreholes yield groundwater with acceptable fluoride values. Therefore, the groundwater will likely at least have to be de-fluorinated. The only areas where potable groundwater may be located are the farms Groot Volstruisfontein, Kranskop and Kalkputs. Due to a fluoride concentration of ~1.8 mg/ℓ the water from Romanskolk is of unacceptable quality for human consumption. The water is also hard which causes operational problems such as calcification of the water meters, hot water cylinders and kettles.

Borehole yields vary between 0.1 and 25 ℓ/s with an average yield of 2.3 ℓ/s and a median yield of less than 0.85 ℓ/s.

Three Options have been identified to improve Brandvlei's water supply from groundwater resources, namely;

i. **Replacement of the Romanskolk pipeline and conversion of the borehole pumps to solar energy driven.**

ii. **Replacement of the Romanskolk pipeline and conversion of the borehole pumps to Eskom Power.**

iii. **Desalination in Brandvlei using existing nearby boreholes for raw water supply.**

The estimated costs (VAT Incl.) for implementation of these options are R12 651 468, R15 927 828 and R8 586 889, respectively. Operating costs are R2.33, R3.75 and R4.11 per m^3, whilst the unit costs, taken over a 20 year payback period at interest and capital repayment of 17,5% per annum, are R14.74, R19.38 and R12.53 per m^3, respectively.

It can be concluded that Option 3, i.e. desalination of water from existing boreholes at Brandvlei, is the least expensive. The advantages of implementing Option 3 are:

- Capital cost is substantially lower than those of the other two options.
- The infrastructure will be in or close proximity of the town, which will simplify operation and management thereof.
- From a health, aesthetic and operational perspective, the desalinated water will be of superior quality than that from Romanskolk.

Treatment of the Romanskolk water, which is unacceptable for human consumption due to an unacceptably high fluoride concentration, was not included in the cost estimates for Options 1 and 2. Should such treatment be included, their operational costs will almost certainly increase to at least equal and most likely beyond that of Option 3.

The following recommendations are made:

- Implementation of Option 3, i.e. desalination in Brandvlei with water abstracted from nearby existing boreholes.

- Some the high yielding existing DWA boreholes north east of Brandvlei town should be investigated by test pumping and down-hole video camera surveys to determine their suitability as possible production boreholes for supply of groundwater for desalination in the town. A well defined dolerite dyke is located ~500 m west of the town which also could be investigated if needed.

- If implementation of either Options 1 or 2 is preferred by Hantam Municipality, at least one additional production borehole should be drilled at Romanskolk on the main dolerite dyke and close to the Romanskolk Dam's overflow.

- All the production boreholes should be test pumped, their optimum pumping rates and schedules determined and the correct sized pumps installed. Production boreholes BR1 and BR7 must be put back in production. Therefore, the pumps and generator sets of these boreholes need to be repaired.

- The possibility of deepening the shallow production boreholes BR1, BR2 and BR3 to 50 mbgl must be investigated. If necessary, new deeper boreholes must be drilled close to these boreholes.

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Glossary of Terms

Anisotrophic: Having some physical property that varies with direction.

Aquifer: A geological formation capable of supplying economic volumes of groundwater (*Also see Non-Aquifer*).

Aquifer system: A heterogeneous body of interlayered permeable and less permeable material that acts as a water-yielding hydraulic unit covering a region.

Borehole: Includes a well, excavation, or any other artificially constructed or improved groundwater cavity which can be used for the purpose of intercepting, collecting or storing water from an aquifer; observing or collecting data and information on water in an aquifer; or recharging an aquifer [from the National Water Act (Act No. 36 of 1998)].

Catchment: The area from which any rainfall will drain into the watercourse, contributing to the runoff at a particular point in a river system, synonymous with the term *river basin*.

Contamination: the introduction of pollutants (whether chemical substances, or energy such as noise, heat, or light) into the environment to such an extent that its effects become harmful to human health, other living organisms, or the environment.

Discharge area: An area in which subsurface water, including water in the unsaturated and saturated zones, is discharged at the land surface.

Electrical conductivity: A measurement of the ease with which water conducts electricity due to the presence of dissolved salts/ion in the water, i.e. distilled water - low EC, poor conductor of electricity, sea water - high EC and salt content indicate a good conductor of electricity.

Fault: A zone of displacement in rock formations resulting from forces of tension or compression in the earth's crust.

Formation: A general term used to describe a sequence of rock layers.

Fracture: Cracks, joints or breaks in the rock that can enhance water movement.

Geohydrology: The study of the properties, circulation and distribution of groundwater, in practise used interchangeably with hydrogeology; but in theory *hydrogeology* is the study of geology from the perspective of its role and influence in hydrology, while *geohydrology* is the study of hydrology from the perspective of the influence on geology.

Groundwater: Water found in the subsurface in the saturated zone below the water table or piezometric surface, i.e. the water table marks the upper surface of groundwater systems.

Groundwater flow: The movement of water through openings and pore spaces in rocks below the water table, i.e. in the saturated zone. Groundwater naturally drains from higher lying areas to low lying areas such as rivers, lakes and the oceans. The rate of flow depends on the slope of the water table and the transmissivity of the geological formations.

Groundwater resource: All groundwater available for beneficial use, including by man, aquatic ecosystems and the greater environment.

Hydraulic conductivity: Measure of the ease with which water will pass through porous material; defined as the rate of flow through a cross-section of one square meter under a unit hydraulic gradient at right angles to the direction of flow (in m/d).

Hydraulic gradient: Change in hydraulic head per unit of horizontal distance in a given direction, i.e. the difference in hydraulic head divided by the distance along the groundwater flow path. Groundwater flows from points of high elevation and pressure to points of low elevation and pressure.

Intergranular aquifer: Groundwater is contained and flows within the original interstices between constituent grains.

Lineaments: A major, linear, topographic feature of regional extent of structural or volcanic origin, most easily appreciated from remote sensing data, e.g. a fault system or dyke.

Porosity: The percentage of void space that a rock or sediment contains, which is an index of how much groundwater can be stored per volume when saturated. The effective porosity, also called the kinematic porosity, of a porous medium is defined as the ratio of the part of the pore volume where the water can circulate to the total volume of a representative sample of the medium.

Quaternary catchment: Fourth order catchment within a primary river basin catchment.

Recharge: The addition of water to the zone of saturation, either by the downward percolation of precipitation or surface water and / or the lateral migration of groundwater from adjacent aquifers.

Recharge area: An area over which recharge occurs.

Saturated zone: The subsurface zone below the water table where interstices are filled with water under pressure greater than that of the atmosphere.

Storativity: The ratio of the volume of water that drains by gravity to the total volume of rock.

Transmissivity: the rate at which a volume of water is transmitted through a unit width of aquifer under a unit hydraulic head (m^2/d); product of the thickness and average hydraulic conductivity of an aquifer.

Unsaturated zone: That part of the geological stratum above the water table where interstices and voids contain a combination of air and water; synonymous with the *zone of aeration* and *vadose zone.*

Water table: The upper surface of the saturated zone of an unconfined aquifer at which pore pressure is at atmospheric pressure, the depth to which may fluctuate seasonally.

Wellfield: An area containing more than one pumping borehole that provides water to a public water supply system or single owner (e.g. a municipality).

List of Abbreviations

DEADP	Department of Environmental Affairs and Development Planning
DTEC	Department of Tourism, Environment and Conservation (Northern Cape Province)
DEM	Digital Elevation Model
DWA	Department of Water Affairs (formerly the DWAF)
DWAF	Department of Water Affairs and Forestry
EC	Electrical Conductivity
ECA	Environment Conservation Act
EIA	Environmental Impact Assessment
GA	General Authorisation
GIS	Geographical Information System
GEP	Groundwater Exploitation Potential
GMU	Groundwater Management Unit
GRA	Groundwater Resource Area
GRP	Groundwater Resource Potential
IWRM	Integrated Water Resources Management
K	Hydraulic Conductivity
ℓ/s	Litres per second
LANDSAT TM	LANDSAT Thematic Mapper
m^2/day	Square metres per day
m^3/a	Cubic metres per annum
m^3/d	Cubic metres per day
m^3/hr	Cubic metres per hour
m^3/month	Cubic metres per month
mamsl	Metres above mean sea level
MAP	Mean Annual Precipitation
mbgl	Metres below ground level
mg/ℓ	Milligrams per litre
MRDPA	Mineral and Petroleum Resources Development Act
mS/m	Milli-siemens per metre
NEMA	National Environment Management Act
NGDB	National Groundwater Database
NWA	National Water Act (Act No. 36 of 1998)
NWRS	National Water Resource Strategy
SRK	SRK Consulting (SA) Pty Ltd
T	Transmissivity
TDS	Total dissolved solids
UGEP	Utilisable Groundwater Exploitation Potential
WSA	Water Services Act

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4 May 2010

412653/Draft V1

Assessment of the Groundwater Resource Potential and Options for Improving Brandvlei's Municipal Water Supply

1 Introduction and Scope of Project

1.1 Background

This report has been prepared for the Hantam Local Municipality by SRK Consulting (SRK). It documents the results of an assessment into the groundwater potential and possible options for improving Brandvlei's municipal water supply undertaken by SRK at Brandvlei in the Northern Cape Province.

The town currently obtains all its municipal water supplies through an asbestos cement (AC) pipeline from a wellfield of five boreholes located ~40 km southeast of the town at Romanskolk. The AC pipeline is approximately 45 years old (pers. com. Mr Roelf Retief of the Hantam Municipality) and is in a very bad condition resulting in numerous breakages and leakages. Of specific concern to the municipality is the fact that the pipeline crosses a large pan that prevents detection of leakages and repairs from being undertaken when filled with water after good rains. This situation poses a high risk in that the town could be without water for an extended period (weeks if not months).

The study area is situated along the R27 Arterial Highway between Onderstedorings in the north and Bodam in the south, 20°E longitude in the west and 21°E longitude in the east (**Figure 1**).

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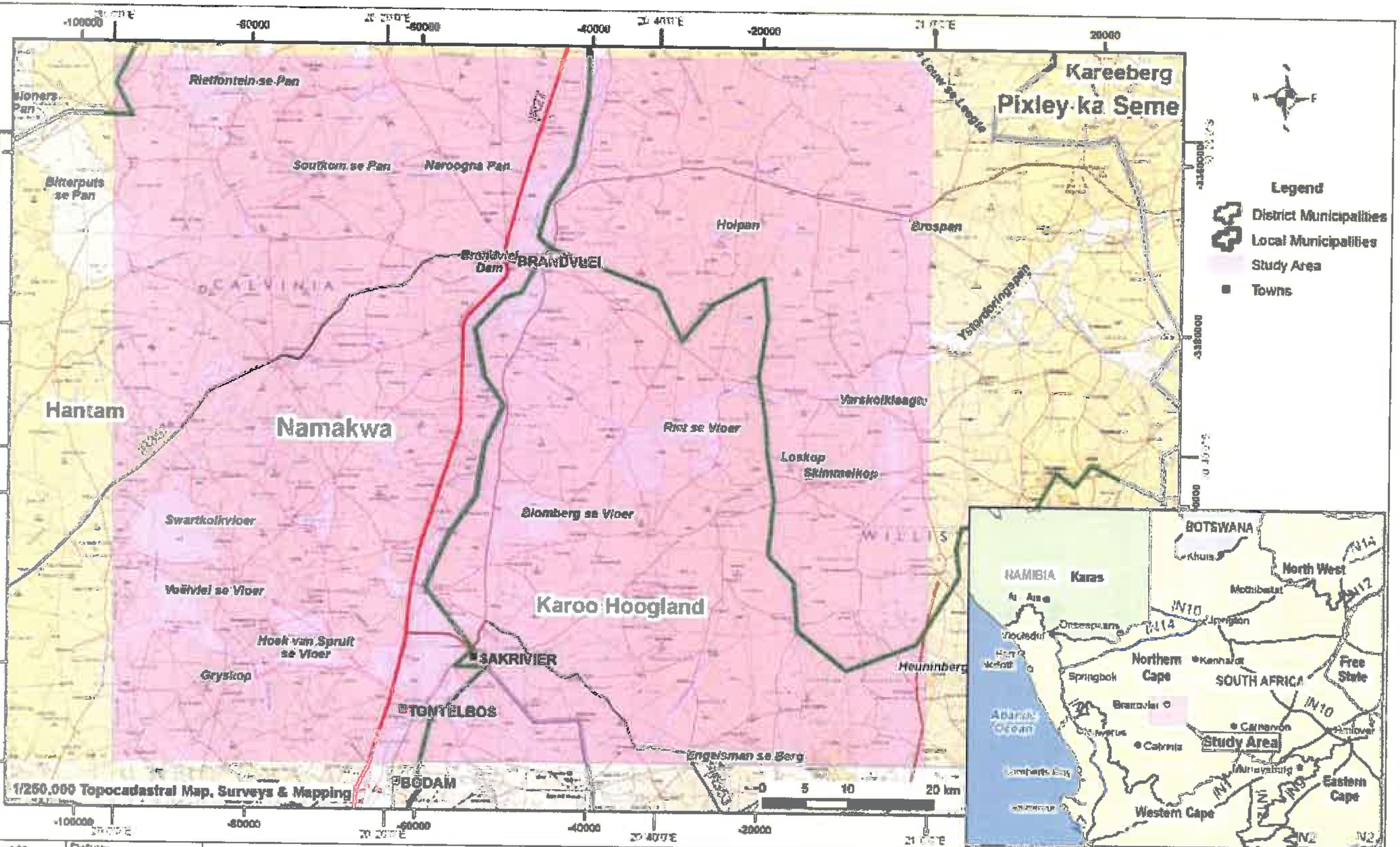

Project No	Datum: Hartebeeshoek '94
412653	Projection: Transverse Mercator
	Central Meridian/Zone: 21°

BRANDVLEI GROUNDWATER RESOURCE ASSESSMENT

LOCALITY MAP

Date: 12/01/2010	Scale 1:600,000
Compiled by: M. Goes	Fig No. 001
Revision: A	Date: 12/01/2010

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2 Scope of Work

2.1 Description of the Proposed Project

This study aims to assess the groundwater potential within a ~50 km radius sector south of Brandvlei with a view to augmenting the town's water supply from groundwater. Options to improve the water supply are also discussed and preliminary costs compared.

2.2 Study Objectives

The hydrogeological aspects of the project will include:

- Assessment of the groundwater resource exploitation potential, quality and usage in a ~50 km radius south of Brandvlei;
- Assessment of the *status quo* of the Municipality's existing boreholes, pumps and aquifers;
- Identification of areas with groundwater bearing structures yielding water of a quality acceptable for human consumption;
- Preliminary feasibility study of various water supply schemes for comparison of capital costs and unit costs of the water.

2.3 Investigative Methodology for Study

A three-phase approach to the groundwater studies and water supply augmentation scheme was proposed, namely:

- Phase 1: Desk study, hydrocensus, lineament mapping, assessing the groundwater exploitation potential and quality, determining the feasibility and costs of the various water supply options and for comparison and compilation of a progress report. Note: From our knowledge of the area we propose only assessing the area within a ~50 km radius south of the town as this is the most likely area where groundwater of acceptable quality is known to occur. Groundwater in the area north of the town is known to be of poor quality;
- Phase 2: Borehole siting, negotiation with land owners for servitudes, compilation of tenders for drilling and test pumping, tender evaluation and adjudication, drilling new boreholes, test pumping and chemical analysis, data analysis and final report compilation.
- Phase 3: Civil engineering design, compilation and calling for tenders, tender evaluation, and adjudication, appointment of contractor and construction of supplementary water supply scheme.

Phase 1

- There is a considerable amount of information available on the study area and the surrounding region. The first task is therefore to collate and review all the information and develop a conceptual hydrogeological model of the area. This includes DWAF's borehole data contained in the National Groundwater Database (NGDB) and reports that might be available as well as monitoring data collected by the Municipality.

- Spatial, quantative and qualitive analysis of rainfall, groundwater recharge, and aquifer yield potential and groundwater quality for the relevant Quaternary Catchment will be derived by means of ArcGIS from DWAF's GRA2 database.

- Potential groundwater bearing structures, formations and lineaments will be mapped on the satellite imagery and aerial photographs using ArcGIS desktop software. The structures and lineaments will then be overlain on the 1:50 000 scale digital topocadastral maps and any obvious "anthropogenic" lineaments will be removed. The geological data of the area will be digitised and attributed from the published geological and other relevant maps. The boreholes and other relevant groundwater information will be superimposed on GIS generated maps for analysis and inclusion in the report.

- As part of phase one, a detailed survey of existing boreholes and springs will be done within a 50 km radius south of the town. The field survey will check water levels, current abstraction, type of equipment, water usage, and basic chemistry based on field testing and any other information that can be obtained from the owners. The municipal boreholes will also be assessed and the water level and quality data compared to those collected previously.

- A conceptual hydrogeological model will be developed to help decide the optimum groundwater exploration and field testing programme for Phase 2.

- A preliminary civil engineering feasibility study of development of the various groundwater supply schemes will be carried out. Preliminary costs to develop these schemes will be determined and their unit reference values determined for comparison. This study will also include assessing the feasibility and costs for desalination of saline water from aquifers in close proximity to the town. The pros and cons of the various schemes will be discussed and recommendations made on the most feasible option.

- Finally a report will be compiled, including budgets for recommendations proposed for Phase 2

2.4 Limitations and Assumptions

This study was limited to fieldwork comprising a limited hydrocensus, water level data collection, groundwater chemistry and monitoring data, and a desk study review of aquifer and modelling data from previous hydrogeological work and reports. This data have been evaluated and based on SRK's hydrogeological knowledge and experience and knowledge of the study area, the data is considered a reasonable representation of the aquifer and study area conditions.

Options and costs for improving the water supply to Brandvlei are based on preliminary designs and tenders/quotations obtained for similar projects over the last two years.

2.5 Project Team

The project team was led by Des Visser, associate partner and principal hydrogeologist. Des has managed similar projects for 22 years.

Depending on the specific requirements through the project, the following comprised the core team for the Phase 1 evaluation stage of the project:

Des Visser	Principal hydrogeologist (22 years experience), project manager and technical input.
Peter Rosewarne	Principal hydrogeologist (34 years experience), internal review.
Millie Goes	Senior hydrogeologist/GIS specialist, GIS database & analysis and project hydrogeologist.
Chris Esterhuyse	Senior hydrogeologist (23 years experience), site hydrogeologist.
Tokkie van der Westhuizen	Principal civil engineer, preliminary engineering design and feasibility study.

2.6 Legislative and Policy Requirements

The administration of laws and regulations relating to groundwater exploration and abstraction is largely shared between the National Department of Water Affairs (DWA formerly the DWAF) and Northern Cape Province's Department of Tourism, Environment & Conservation (DTEC). The main legislation and applicable guidelines / quality standards covering the geohydrological issues applicable to this project are given below.

2.7 Policy Documents

The relevant documents are as follows:

- National Water Resource Strategy (NWRS 1st Edition, September 2004);
- Revision of General Authorisations in terms of Section 39 of the National Water Act, 1998 (Act No. 36 of 1998). Gazette No. 26187, Government Notice No. 399, DWAF, 26 March 2004;
- National Water Act (NWA) (Act No. 36 of 1998);
- Water Services Act (WSA) (Act No. 108 of 1997);
- National Water Policy White Paper, April 1997;
- National Environment Management Act (NEMA) (Act No. 107 of 1998); and
- National Environment Management: Waste Act (Act No. 59 of 2008).

The NWA is the principal legal instrument relating to water resource management in South Africa and contains comprehensive provisions for the protection, use, development, conservation, management and control of South Africa's water resources. In addition, the management of water as a renewable resource must be carried out within the framework of environmental legislation, i.e. NEMA. It declares the national government to be the public trustee of the nation's water resources – including water systems – and prioritises socio-economic and environmental needs.

A key aspect of the National Water Policy is Integrated Water Resources Management (IWRM). This recognises that water resources can only be successfully managed if the natural, social, economic and political environments in which water occurs and is used are taken into consideration. IWRM aims to strike a balance between the use of water resources for livelihoods and conservation of the resource whilst promoting social equity, environmental sustainability and economic growth and efficiency.

3 Available Information Reviewed

Existing reports, literature, maps and information that were reviewed are as follows:

Maps and photos

- Surveyor General's 1:250 000 scale topocadastral maps, sheets 3018, 3020, 3118 and 3120.
- Council for Geosciences' 1:250 000 scale geological map sheet 3020 Sak River.
- Department of Water Affairs and Forestry's (DWAF) 1:10 000 scale colour aerial photographs.
- Google Earth satellite image.
- DWAF's 1:500 000 scale geohydrological map, sheet 2920, Prieska and accompanying explanatory booklet (2001).

Other information

- DWAF's national groundwater database (NGDB) borehole information.
- DWAF's national Groundwater Resource Assessment Phase 2 (GRA-II) data sets.

4 Data Collation and Spatial/Quantitative Data Analysis

The relevant geohydrological data were captured into GIS (ArcGIS 9.3.1), the geological maps were georeferenced and the satellite coverage checked for geographical correctness for use in a GIS.

The Landsat TM7 coverage (1989) was processed and enhanced to map the potential groundwater-bearing structures such as faults and dolerite dykes, ring dykes and sills.

Detailed surface water drainage systems were defined using ESRI's Arc / InfoTM using a 20 x 20 m cell-sized Digital Elevation Model (DEM). The DEM was constructed using Arc/Info's GRID module from the relevant vector contour data of the 1:50 000 topocadastral map sheets.

5 Geography

5.1 Extent of the Study Area

The study area is located in the Northern Cape Province of South Africa, within the Hantam and Karoo Hoogland Local Municipalities of the Namakwa District Municipality (**Figure 1**). The study area measures approximately 7 972 km^2 in extent.

The town of Brandvlei is located along the R27 Arterial Route midway between Onderstedorings in the north and Bodam in the south, in the Northern Cape Province. In the southeast the study area is bounded by the Engelsman se Berg while the east is bounded by the Heuningberge. In the west the study area is bounded by the Drie Koppe near the town of Commissioners Pan. (**Figure 1**)

5.2 Topography

The topography of the study area is generally characterised by flat, open spaces interspersed with shallow depressions or "pans". The elevation ranges from 700 meters above mean sea level (mamsl) to values in excess of 1 300 mamsl in the southeast (**Figure 2**).

Several "koppies" are evident throughout the area.

5.3 Climate

The climate of the Northern Cape is typically that of desert and semi-desert with low and erractic rainfall. Summers are hot and dry and the winters cold and frosty. Summer temperatures usually range between 30°and 40°C while winter temperatures range from 3°C to 21°C.

During the summer months, the rainy season with thunderstorms occur in the eastern areas whereas winter rainfalls occur mainly in the western region. Winters are generally typified by warm days and cold nights.

5.4 Hydrology

The study area is mainly drained by the northerly flowing Sak River and its tributaries.

The majority of the study area falls within the D57A, -B, -C, -D and -E Quaternary catchments (**Figure 2**).

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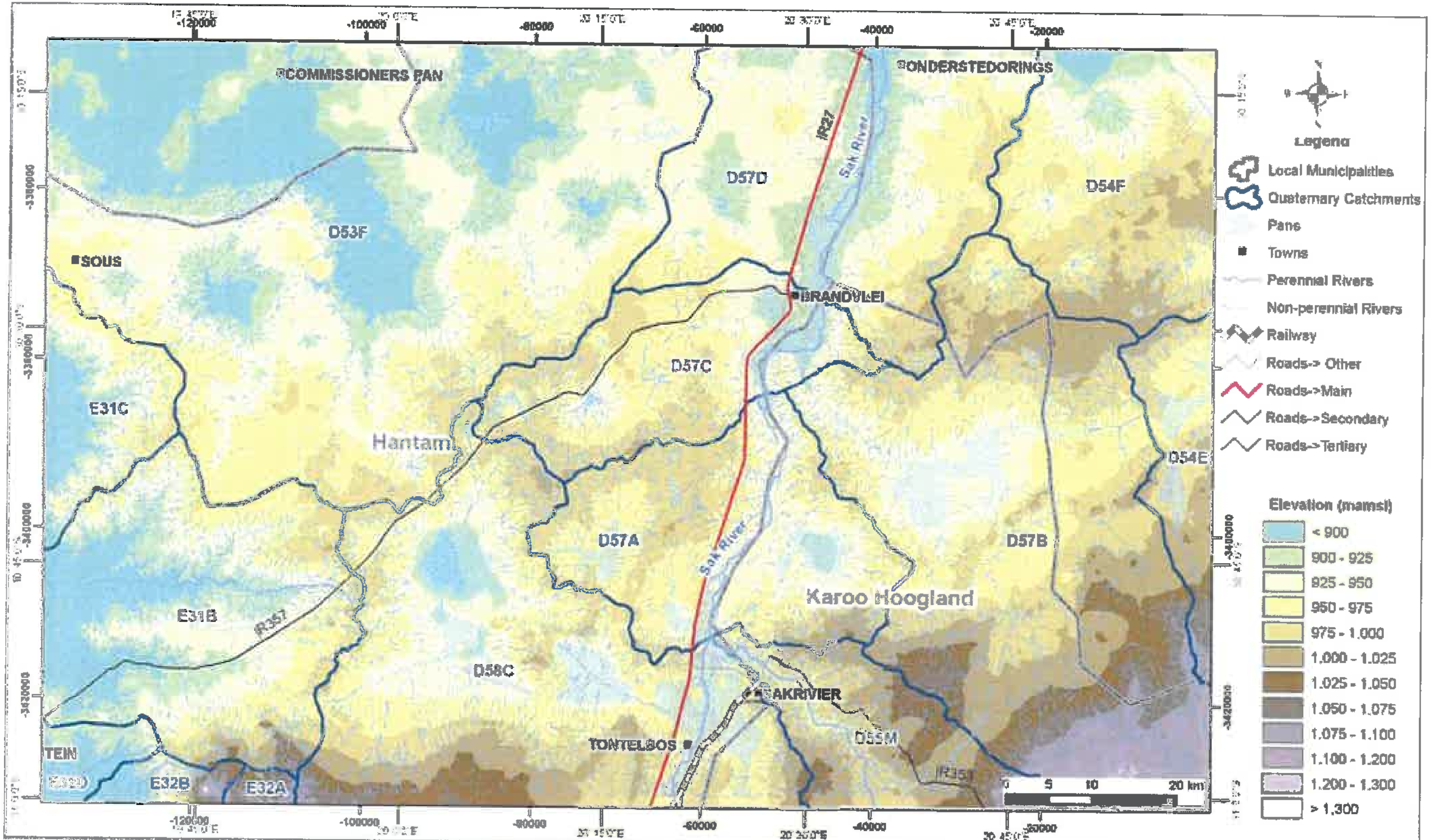

Project No.	Datum: Hartebeeshoek '94		Date:	Scale
412653	Projection: Transverse Mercator	**BRANDVLEI GROUNDWATER RESOURCE ASSESSMENT**	12/01/2010	1:600,000
	Central Meridian/Zone: 21°	PHYSIOGRAPHIC SETTING	Compiled by: M Goes	Fig No. 002

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Revision: A Date: 12/01/2010

6 Hydrocensus

Mr Chris Esterhuyse of SRK Consulting undertook a site visit from 8 to 12 February 2010. The first day was spent with Messrs Riaan van Wyk and Koos Nel of Hantam Municipality to obtain all relevant data in their possession. A hydrocensus of the municipal boreholes and surrounding farms at Romanskolk was conducted during the rest of the time.

Figure 7 indicates the localities of the 38 surveyed boreholes superimposed on the regional geological map of the area. During the hydrocensus all relevant and obtainable geohydrological data were collected. The hydrocensus concentrated on the area surrounding Romanskolk for two reasons, namely:

1. This area is known to have a better groundwater quality than the area further downstream.

2. These farms are relative close to the Romanskolk pipeline and will be most viable to explore from a financial point of view.

The aims of the hydrocensus were to collect groundwater-related information such as borehole positions and groundwater levels, quality and abstraction data.

Table 1 summarizes the hydrocensus results. Field measured Electrical Conductivities (ECs) varied between 120 and 530 mS/m with the better quality groundwater occurring in the higher lying areas and in association with dolerite intrusions.

The owners of the farms Kalkputs and Kranskop (Mr. CF Langner) and Groot Volstruisfontein (Mr. DWM Steenkamp) were not at home during the hydrocensus and boreholes on these farms were not surveyed. Mr. Brand du Toit of the farm Boomseputs (who knows the area well) reported that several "fresh" and high yielding boreholes occur on both these properties. However, it is known from previous negotiations between the municipality and Mr. Langner that he is not keen to have exploration boreholes drilled on his properties. Lengthy negotiations will be inevitable, should it be decided to explore groundwater on the two farms Kalkputs and Kranskop. During the hydrocensus Mr. Du Toit reported that Kranskop farm is known amongst the farmers in that area for its good groundwater potential, both qualitatively and quantatively.

The measured rest water levels of boreholes are generally <15 mbgl. Borehole BR14 which was previously utilized as a production borehole for Brandvlei, has been pumped dry and the pump was removed more than a year ago. The present water level is still >20 mbgl (initial water level after completion of the borehole ~6 mbgl), which indicates that the recharge to this borehole is extremely poor, despite the relative high immediate yield of 7 ℓ/s. The main water strikes of this borehole occurred from 45-48 mbgl in brecciated shale above a dolerite sill contact.

Several of the Romanskolk production boreholes are very shallow and the pumping water level of borehole BR2 is only 1.3 m above the (reported) bottom of the borehole. It is also clear that the pumping water levels of these production boreholes stabilize at between 12 and 12.6 mbgl with rest water levels of approximately 5 mbgl (measured in BR7 where the pump is out of order). The water level and abstraction monitoring data that could be obtained from the municipality are plotted in **Figure 3** to **Figure 6** over page.

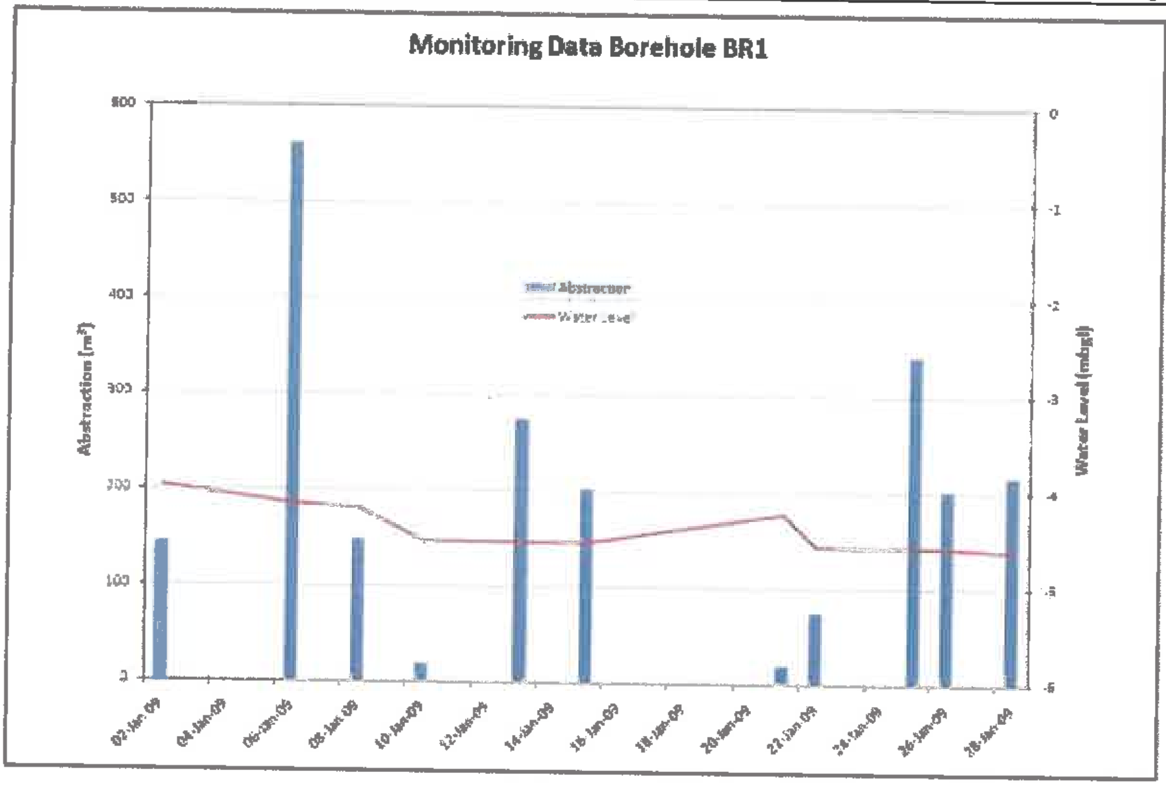

Figure 3: Graph showing water level versus abstraction in borehole BR1

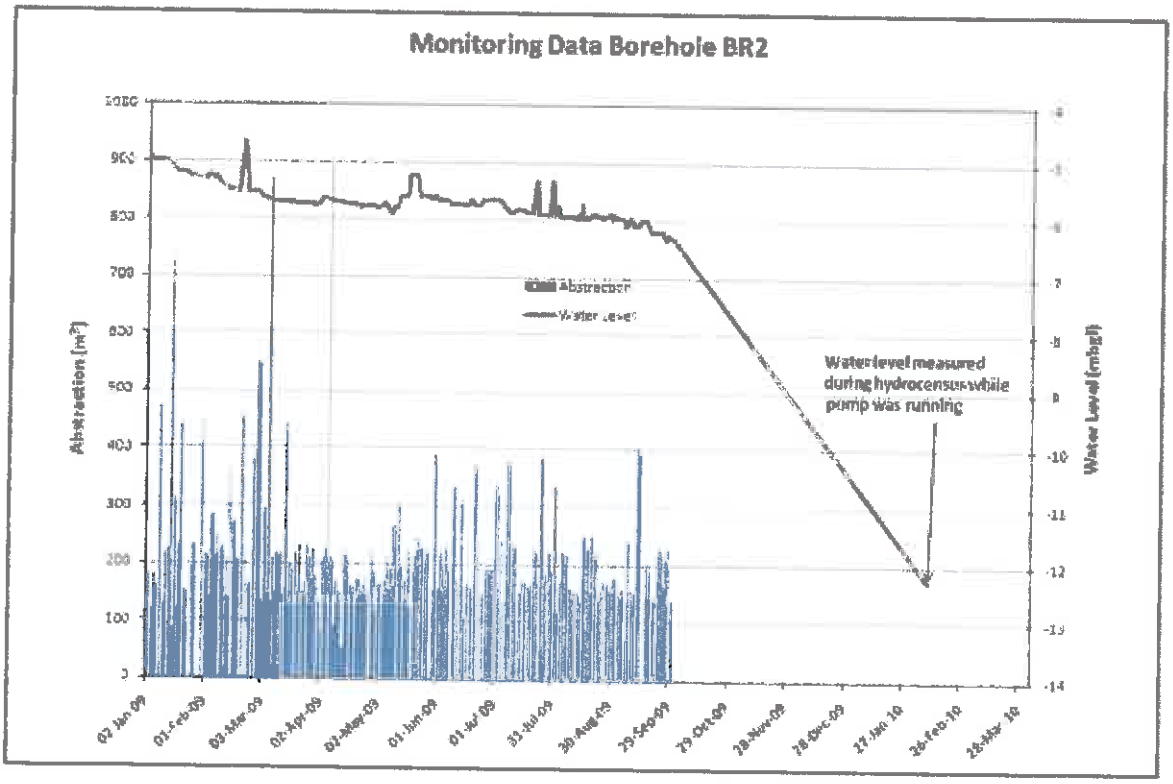

Figure 4: Graph showing water level versus abstraction in borehole BR2

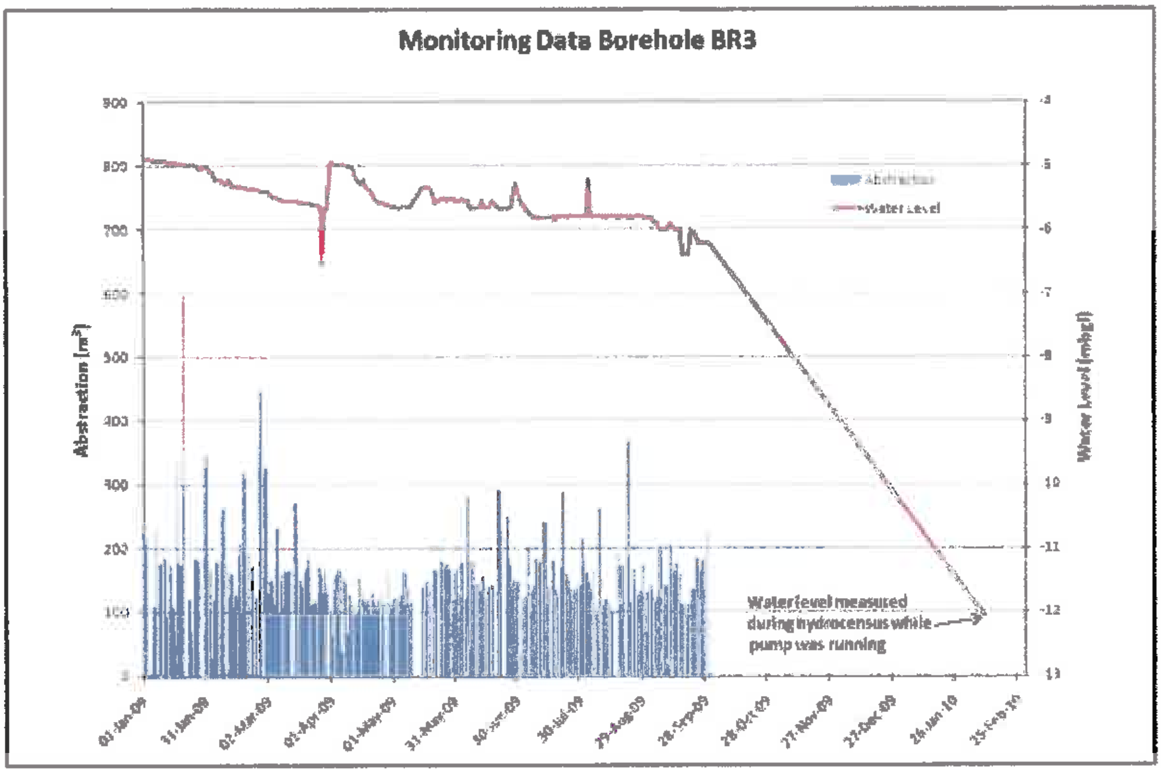

Figure 5: Graph showing water level versus abstraction in borehole BR3

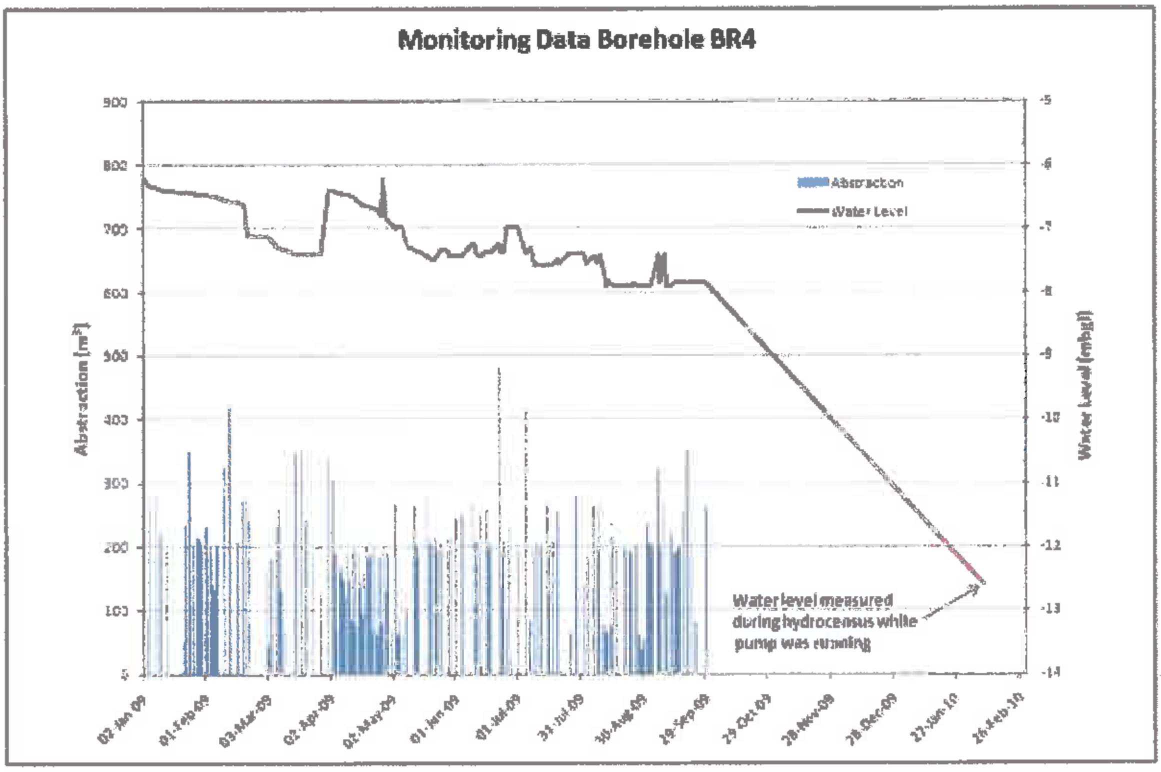

Figure 6: Graph showing water level versus abstraction in borehole BR4

The water levels shown up until September 2009 reflects rest water levels, which are similar to the water level (5.01 mbgl) measured in the nearby borehole, BR7, of which the pump is out of order. Based on the rest water level it can be concluded that the current rate of abstraction seems to be sustainable. Pump drawdown in some of the boreholes, however, seems excessive, e.g. BR2 where pump drawdown is to 12.27 mbgl and the borehole is only 13.6 m deep. To protect the pumps from getting damaged due to too large a drawdown, it is recommended that all the boreholes are test pumped to determine the optimum pumping rates and schedules. The correct sized pumps can then be installed and abstraction spread over all the existing boreholes. *Note: During the hydrocensus two of the production boreholes were out of order due to faulty pumps and/or generator sets.* Current annual abstraction from this well- field is approximately 137,000 m^3.

Boreholes with relatively high yields were located on the farm Leeuwkuilspoort. These boreholes are associated with dolerite dykes. They were previously utilized for irrigation purposes and have been pumped over an extended period of time. However, based on the field measured EC's of most of the boreholes here, which is >200 mS/m, the quality of the water from these boreholes is marginal (range 200 – 370 mS/m) and only suitable for short term human consumption (SANS 241 – 2006).

No groundwater samples were collected for this phase of the project. However, hydrochemistry analysis results obtained from the municipality are further discussed in **Section 8.4**.

6.1 Potential Areas for Future Groundwater Exploration

The hydrocensus results, geological map and Google Earth images were used to delineate areas where relative good quality groundwater and high yielding boreholes can be expected. These areas are indicated in **Figure 8**. (*Note: The area number does not represent its priority*). The farms Kranskop and Kalkputs were discarded due to foreseen problems to gain access to these properties.

The Romanskolk area (Area 2) is regarded as the first priority for further groundwater exploration in this area. Two prominent and parallel NW-SE striking dolerite dykes occur here. All the existing production boreholes are located along the smaller, south western dyke. No boreholes could be located along the north eastern dyke apart from an old dug well that has collapsed. This dyke and adjacent rocks are well exposed at the overflow of the Romanskolk Dam. Here the broad dolerite dyke (~20 m wide) is well brecciated and clearly dips steeply to the north east. This area is regarded as an excellent area to drill additional groundwater exploration borehole which can be used together with the other existing boreholes as it utilizes the "over flow" groundwater from the upstream compartment.

Areas 4 and 6 at the farm Groot Volstruisfontein are regarded as second priority. Good yielding boreholes with relative good quality groundwater can be expected in this area. It is anticipated that the groundwater will be fit for human consumption, except for the fluoride content which may be above the limit for long term use as drinking water (SANS 241-2006). As far as we could determine, Mr Steenkamp is open to negotiations regarding exploration drilling on his property. These areas are approximately 8 km upstream from Romanskolk. Several dolerites dykes and a dipping dolerite sill intersect the Romanskolk drainage channel on this property. There is also no irrigation on this farm which means no conflict of interests.

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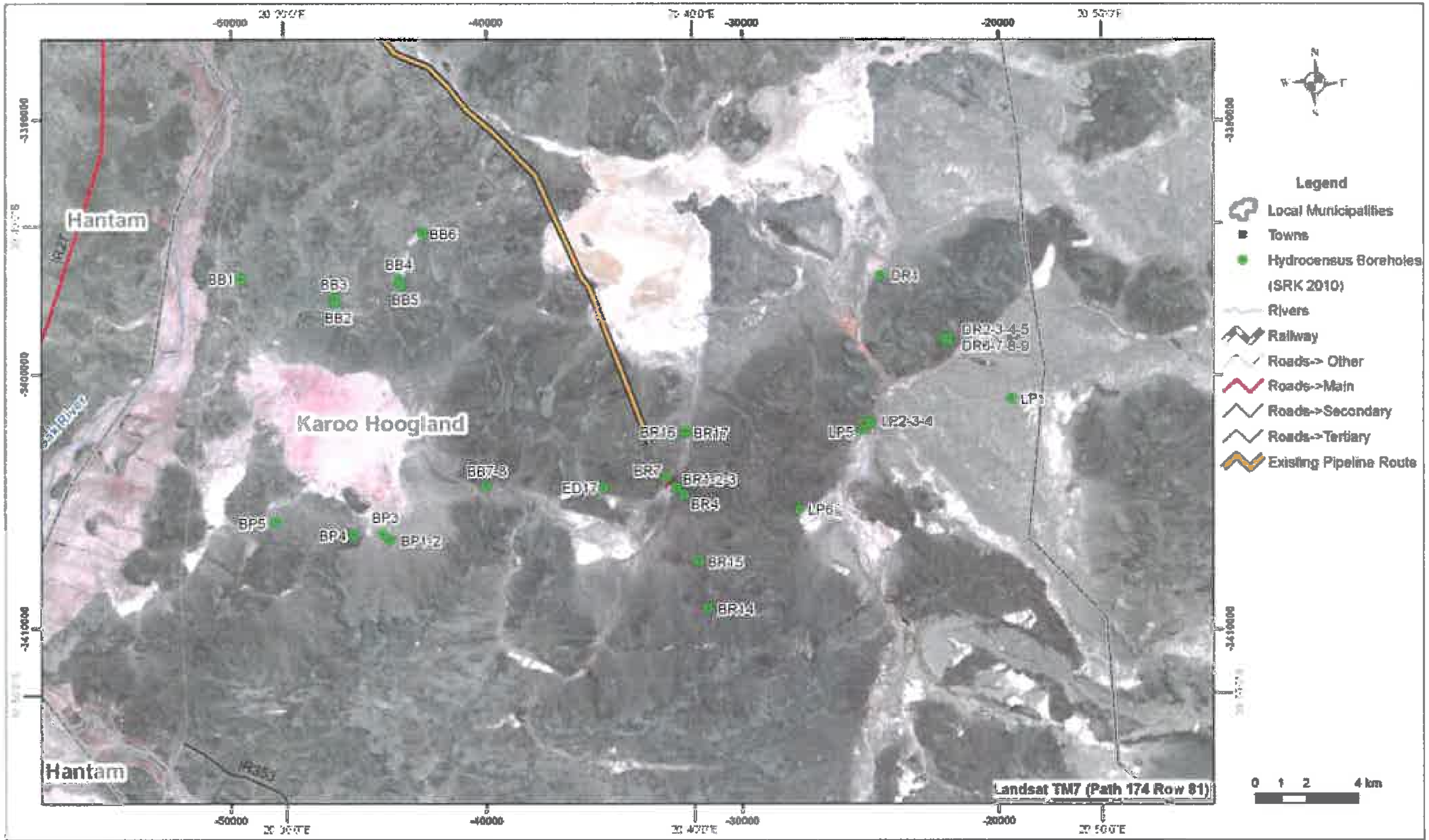

Project No	Datum: Hartebeeshoek '94	BRANDVLEI GROUNDWATER RESOURCE ASSESSMENT	Date: 12/01/2010	Scale 1:200,000
412653	Projection: Transverse Mercator	MAP SHOWING HYDROCENSUS BOREHOLES	Compiled by: M. Goes	Fig No. 007
	Central Meridian/Zone: 21°			

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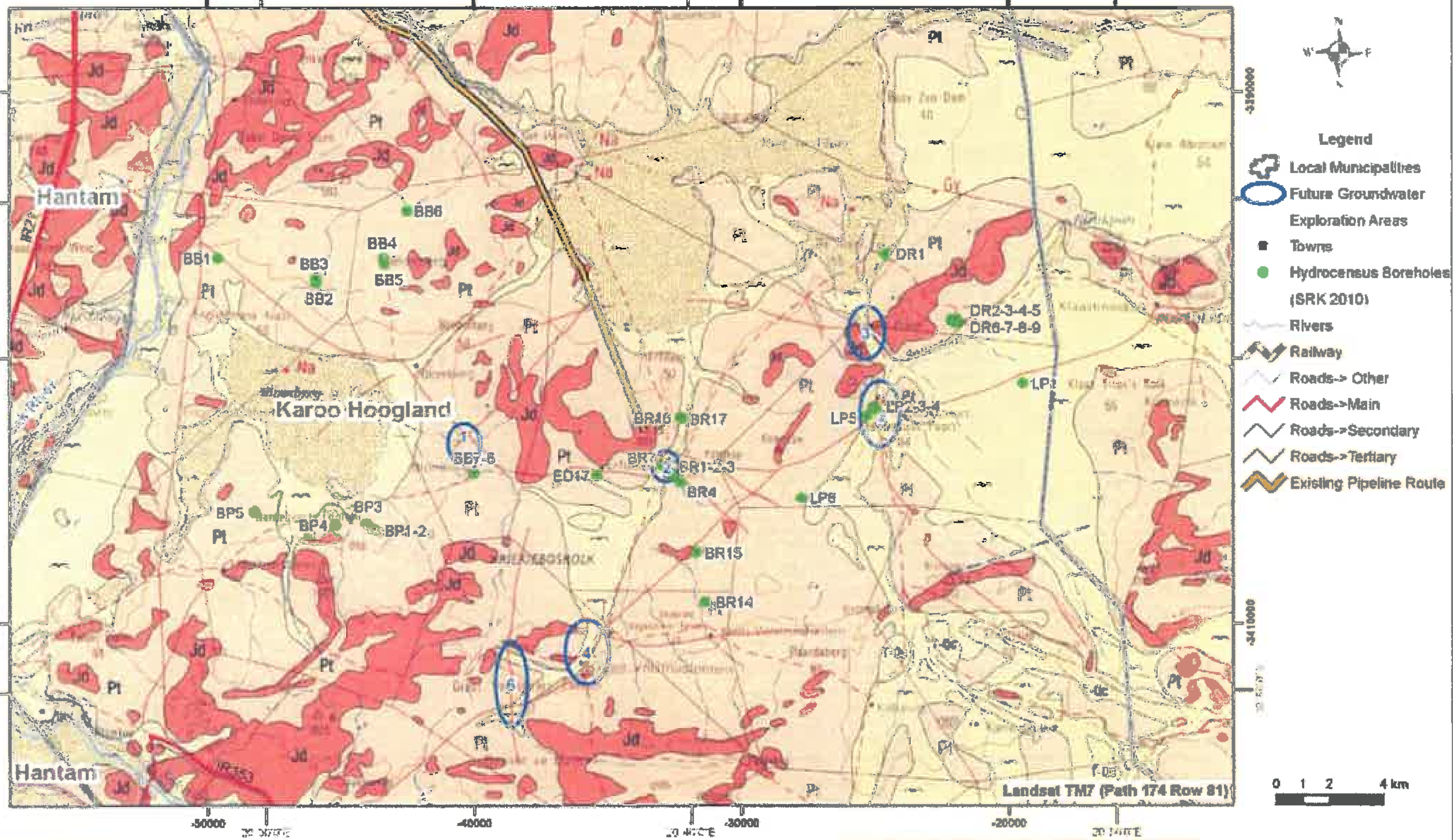
Revision: A Date: 12/01/2010

Table 1 Hydrocensus results of the Romanskolk area

Bh No	Date	Farm	Latitude	Longitude	Elevation (mamsl)	Depth (mbgl)	Equipment	Yield (ℓ/s)	Water Level (mbgl)	EC (mS/m)	pH	Use	Comments
BB1	11-Feb-10	Blomberg	-30.88333	20.48245	943		WP 50mm Cylinder		14.01	285	8.08	Stock	
BB2	11-Feb-10	Blomberg	-30.89410	20.52034	957		Plunger pump	0.7		216	7.50	Irrigation	Blocked at 12 mbgl - Pumping
BB3	11-Feb-10	Blomberg	-30.89282	20.52055	959		WP 80mm cylinder			280	7.50	Domestic	Baseplate closed
BB4	11-Feb-10	Blomberg	-30.88581	20.54716	971		WP 75mm Cylinder			402	8.03	Stock	Baseplate closed
BB5	11-Feb-10	Blomberg	-30.88771	20.54744	970		None		13.47			None	Was pumped at 2.5 ℓ/s. Yield decreased
BB6	11-Feb-10	Blomberg	-30.88977	20.55636	987		WP 80mm Cylinder			155	7.79	Stock	Baseplate closed
BB7	11-Feb-10	Blomberg	-30.75915	20.53224	950		WP 75mm Cylinder		5.45	530	7.35	Stock	
BB8	11-Feb-10	Blomberg	-30.75912	20.53215	950		WP 75mm Cylinder			420	7.20	Stock	Baseplate closed
BP1	10-Feb-10	Boomseputs	-30.77812	20.54284	940		WP 75mm Cylinder	1.3		239	7.55	Stock	Baseplate closed
BP2	10-Feb-10	Boomseputs	-30.77814	20.54206	937		None		7.37			None	
BP3	10-Feb-10	Boomseputs	-30.77627	[illegible]	933		Turbine 75mm					None	Out of order, baseplate closed. Old municipal production borehole, pumps dry
BP4	10-Feb-10	Boomseputs	-30.77660	20.52790	939		WP 80mm Cylinder		8.05	283	7.70	Stock	
BP5	10-Feb-10	Boomseputs	-30.77183	20.49619	935		WP 75mm Cylinder		5.07	120	8.34	Stock	
BR1	9-Feb-10	Romanskolk	-30.75961	20.65982	958	19	50mm Submersible					Domestic	Pump out of order - dipmeter stuck @ 2 mbgl
BR14	9-Feb-10	Swartkoppies	-30.80319	20.67256	938	80	None	7.0	20.23			None	No pumping for >1 year. No pump, borehole pumps dry
BR15	9-Feb-10	Romanskolk	-30.78637	20.66901	977		WP 75mm Cylinder					Stock	Out of order, baseplate closed
BR16	9-Feb-10	Romanskolk	-30.74040	20.66400	948	25	None		8.25			None	Old production borehole. Saline
BR17	9-Feb-10	Romanskolk	-30.74018	20.66325	946		WP 75mm Cylinder					Stock	Out of order, baseplate closed
BR2	9-Feb-10	Romanskolk	-30.75964	20.65992	959	13.6	50mm Submersible		12.27	212	8.07	Domestic	Pump water level. Pump yield = 1.7 ℓ/s
BR3	9-Feb-10	Romanskolk	-30.76015	20.65992	958	16.8	50mm Submersible		12.07	197	7.75	Domestic	Pump water level. Pump yield = 2.0 ℓ/s
BR4	9-Feb-10	Romanskolk	-30.76247	20.66315	962	38	50mm Submersible		12.80	137	7.84	Domestic	Pump water level. Pump yield = 2.5 ℓ/s
BR7	9-Feb-10	Romanskolk	-30.75644	20.65592	957	80	50mm Submersible		5.01			Domestic	Pump out of order
DR1	11-Feb-10	De Riet	-30.68501	20.74335	949		WP 80mm Cylinder					Stock	Out of order, baseplate closed
DR2	11-Feb-10	De Riet	-30.70752	20.76927	974		WP 75mm Cylinder			140	7.25	Stock	Baseplate closed
DR3	11-Feb-10	De Riet	-30.70741	20.76911	973		None	1.3	11.33			None	Previously equipped with mono pump
DR4	11-Feb-10	De Riet	-30.70730	20.76900	973		WP 75mm Cylinder			143	7.23	Stock	Baseplate closed
DR5	11-Feb-10	De Riet	-30.70784	20.76980	970		None		10.28			None	Low yield
DR6	11-Feb-10	De Riet	-30.70793	20.77010	968		None		9.42			None	Low yield
DR7	11-Feb-10	De Riet	-30.70806	20.77135	987		WP 80mm Cylinder			193	7.19	Stock	Baseplate closed
DR8	11-Feb-10	De Riet	-30.70711	20.77122	987	80	None		9.13			None	Dry
DR9	11-Feb-10	De Riet	-30.70729	20.77091	970		None					None	Dry. Blocked at 5 mbgl
ED17	9-Feb-10	Romanskolk	-30.75999	20.63016	987		WP 63mm Cylinder			218	7.30	Stock	Baseplate closed
LP1	10-Feb-10	Leeuwkuilspoort	-30.72888	20.79700	972		WP 75mm Cylinder			228	8.37	Stock	Baseplate closed
LP2	10-Feb-10	Leeuwkuilspoort	-30.73887	20.73832	985		WP 75mm Cylinder		5.24			Stock	Pump out of order
LP3	10-Feb-10	Leeuwkuilspoort	-30.73737	20.73943	983		WP 75mm Cylinder			261	7.70	Stock	Baseplate closed
LP4	10-Feb-10	Leeuwkuilspoort	-30.73757	20.73920	982		Plunger pump	4.0				None	Baseplate closed
LP5	10-Feb-10	Leeuwkuilspoort	-30.73969	20.73616	983		WP 100mm Cylinder	5.0		242	7.80	Stock	Baseplate closed
LP6	10-Feb-10	Leeuwkuilspoort	-30.76789	20.71013	970		WP 75mm Cylinder	1.5		133	7.85	Stock	Baseplate closed



Project No. 412653	Datum: Hartebeeshoek '94 Projection: Transverse Mercator Central Meridian/Zone: 21°	**BRANDVLEI GROUNDWATER RESOURCE ASSESSMENT** POSSIBLE GROUNDWATER EXPLORATION AREAS CLOSE TO ROMANSKOLK	Date: 12/01/2010 Compiled by: M. Goes Revision: A	Scale 1:200,000 Fig No 008 Date: 12/01/2010

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Areas 3 and 5 on the farm Leeuwkuilspoort (area 3 possibly partially covering De Riet farm) are regarded as a third priority. Field measured ECs at existing boreholes indicate that groundwater from Area 5 is only suitable for short term drinking (SANS 241 classification), but some individual elements, e.g. fluoride, may be above the SANS short term limit rendering the water unfit for human consumption. Mr Du Toit hires this farm from the owner Mr. Zandberg. According to Mr. Du Toit there can be negotiated regarding exploration drilling on this property. Two known high yielding boreholes exist close to the old homestead (boreholes LP4 and LP5). These are associated with two different dolerite dykes.

Area 3 is located further downstream where a prominent dolerite sill intersects the Soutsloot River. De Riet farm is owned by the Karoo Hoogland Municipality (Williston) and new upcoming farmers farm this property. This area was included as there should be no problem to explore the groundwater potential thereof. However, the groundwater quality is expected to be worse than that in Area 5.

A dolerite dyke intersects a significant drainage on the farm Blomberg (Area 1). Good yielding boreholes are expected in this area, but the groundwater quality will most likely be unfit for human consumption. This area was chosen as there is already a pipeline from borehole BP3 on the farm Boomseputs (also indicated as Blomberg on the map) to Brandvlei town (exact route of pipeline and condition thereof unknown). Area 1 is relative close to this pipeline and can keep the cost down of abstracting groundwater from this area.

7 Geology

The regional geology of the study area is presented in **Figure 9** and the various lithologies present are summarised in **Table 2**. The geology was derived from the 1/250 000 scale Council for Geoscience map sheet, 3020 Sak River.

The geology of the area comprises mainly sediments of the Ecca Group with post Karoo dolerite intrusions in the form of dykes and sills. Alluvium occurs in the main drainage channels but the vertical extent thereof is limited. Pan sediments consisting of clay, silt and alluvium occur in several pans throughout the study area. These sediments are generally less than 5 m thick.

The Ecca Group comprises the Prince Albert, Whitehill and Tierberg Formations (**Table 2**). The Prince Albert Formation mainly consists of shale and mudstone with layers of siltstone. The formation varies from 10 to 50 m in thickness. The colour of the sediments varies from olive-green to dark grey, and weathers to a light red to brownish colour.

The Whitehill Formation is approximately 11 to 14 m in thickness and comprises thick, white weathering, soft, dark grey to black shale.

The Tierberg Formation mainly comprises shale with subordinate siltstone and sandstone. The formation varies in thickness from 130 to 200 m. In an unweathered state the shale is dark grey weathering to green.

Dolerite occurs in the form of both sills and dykes in the study area and covers a large surface area. A dolerite sill is usually encountered on either the top or bottom contact of the Whitehill Formation. In the Tierberg Formation dolerite sills reach an approximate thickness of 60 m.

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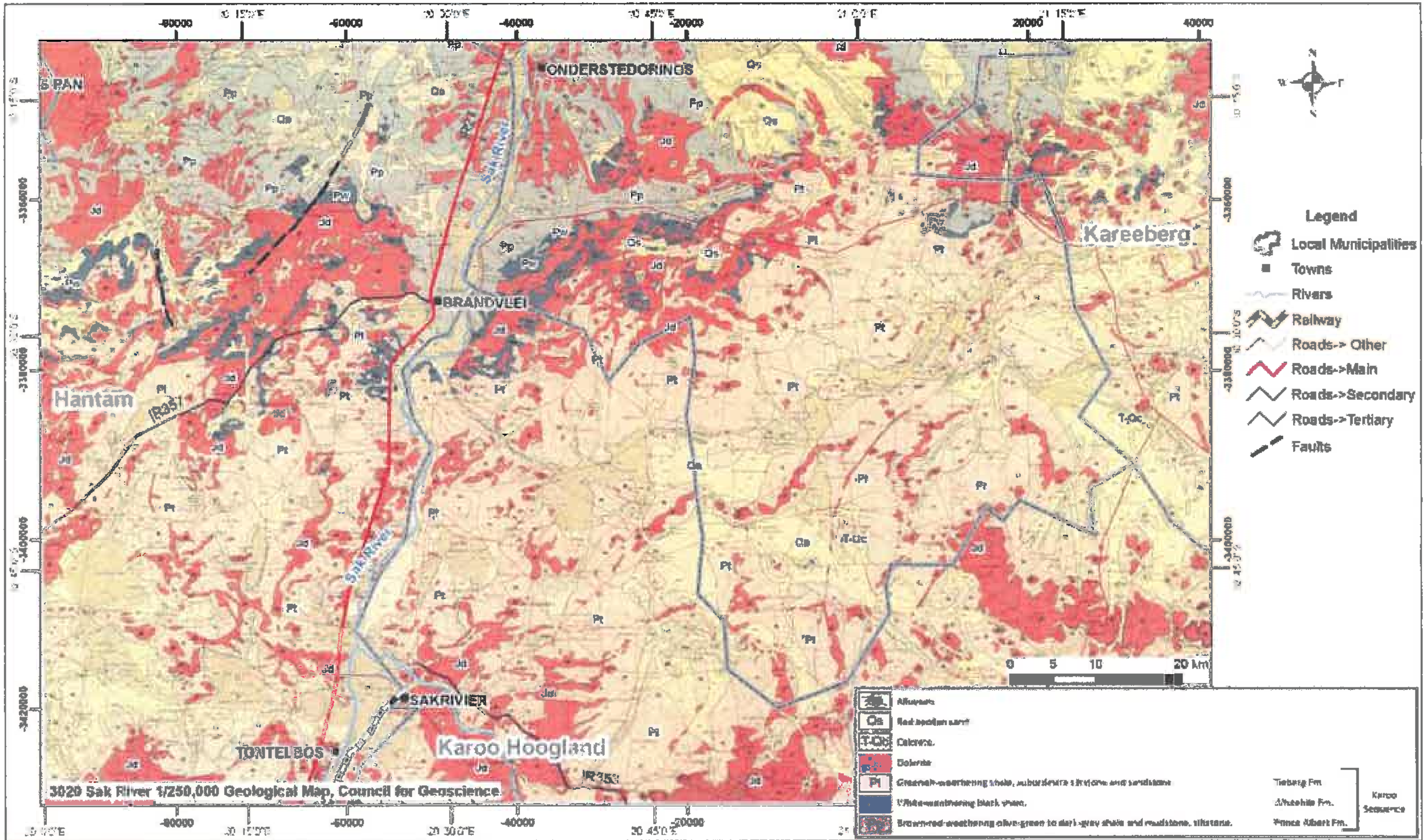

Project No.	Datum: Hartebeesthoek '94	BRANDVLEI GROUNDWATER RESOURCE ASSESSMENT	Date: 12/01/2010	Scale 1:600,000
412653	Projection: Transverse Mercator	GEOLOGY OF THE STUDY AREA AND SURROUNDS	Compiled by: M Goes	Fig No. 009
	Central Meridian/Zone: 21°		Revision: A	Date: 12/01/2010

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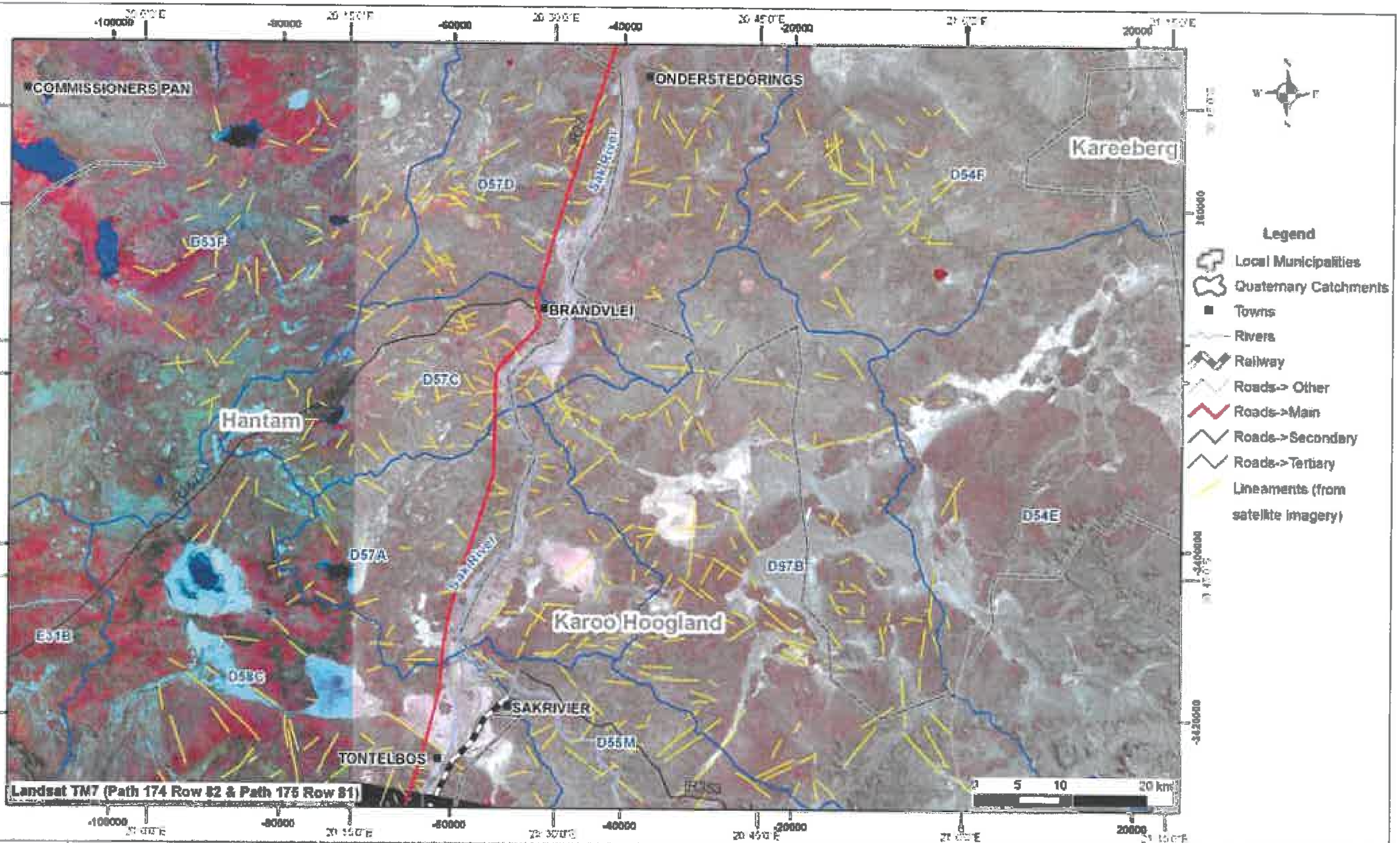

Project No	Datum: Hartebeeshoek '94	BRANDVLEI GROUNDWATER RESOURCE ASSESSMENT	Date: 12/01/2010	Scale 1:500,000
412653	Projection: Transverse Mercator	LINEAMENT INTERPRETATION FROM SATELLITE IMAGERY	Compiled by: M. Goes	Fig No. 010
	Central Meridian/Zone: 21°		Revision: A	Date: 12/01/2010

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Table 2 Summary of lithologies present in the study area

Code	Lithology	Formation	Group	Sequence
Qa	Alluvium.			
Qs	Red aeolian sand.			
T-Qc	Calcrete.			
Jd	Dolerite.			
Pt	Greenish-weathering shale, subordinate siltstone and sandstone.	Tieberg	Ecca	Karoo Sequence
Pw	White-weathering black shale.	Whitehill		
Pp	Brown-red-weathering olive-green to dark-grey shale and mudstone, siltstone.	Prince Albert		

Satellite imagery can reveal important groundwater-related information that is not clearly visible at ground level and remote sensing was therefore used to assist in identifying geological lineaments such as faults, fractures, joints and intrusions (dykes / sills). These structures potentially enhance or restrict groundwater flow and their identification is therefore of importance to this study. The results of the remote sensing interpretation are presented in **Figure 10**.

8 Hydrogeology

8.1 Aquifer Properties

8.1.1 Aquifer Types

Figure 9 and **Figure 11** shows that most of the study area is underlain by the fractured Ecca Group aquifer with intermittent occurrences of the intergranular and fractured dolorite aquifers. The weathered zone measures approximately 60 m in thickness while the fractured zone is approximately 110 m thick. The aquifer is thus approximately 170 m thick. (GRA-II Project, 2005)

8.1.2 Aquifer Classification and Vulnerability

According to Parsons and Conrad (2003) the study area is mostly classed as a minor aquifer while the southwest and north to northeast is classed as a poor aquifer (**Figure 12**).

Vulnerability is determined by evaluating seven parameters, namely:

- Depth to groundwater
- Recharge
- Aquifer media
- Soil media
- Topography
- Impact on vadose zone
- Hydraulic conductivity

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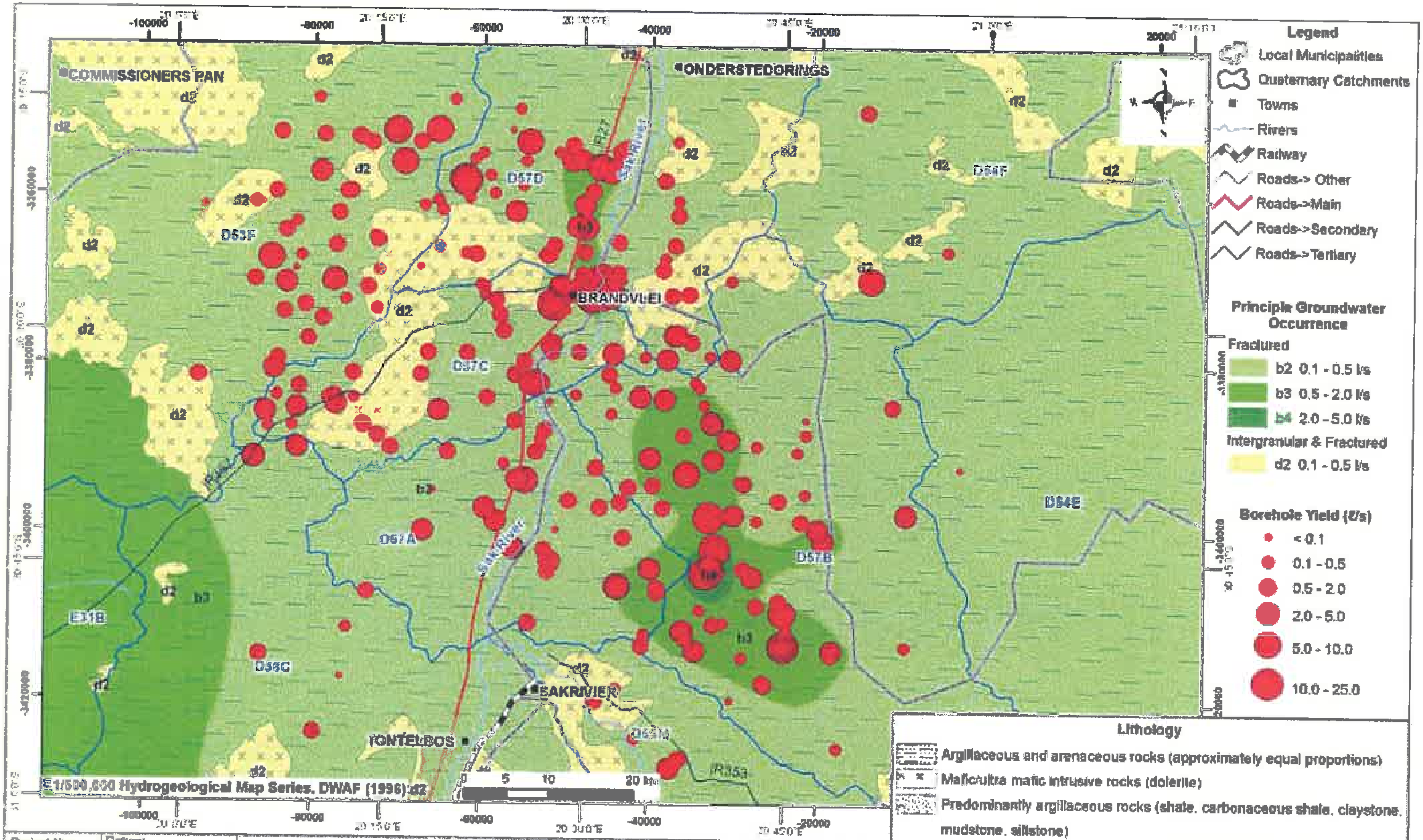

Project No.	Datum: Hartebeesthoek '94
412653	Projection: Transverse Mercator
	Central Meridian/Zone: 21°

BRANDVLEI GROUNDWATER RESOURCE ASSESSMENT

HYDROGEOLOGY

Date: 12/01/2010	Scale 1:600,000
Compiled by: M. Goes	Fig No 011
Revision: A	Date: 12/01/2010

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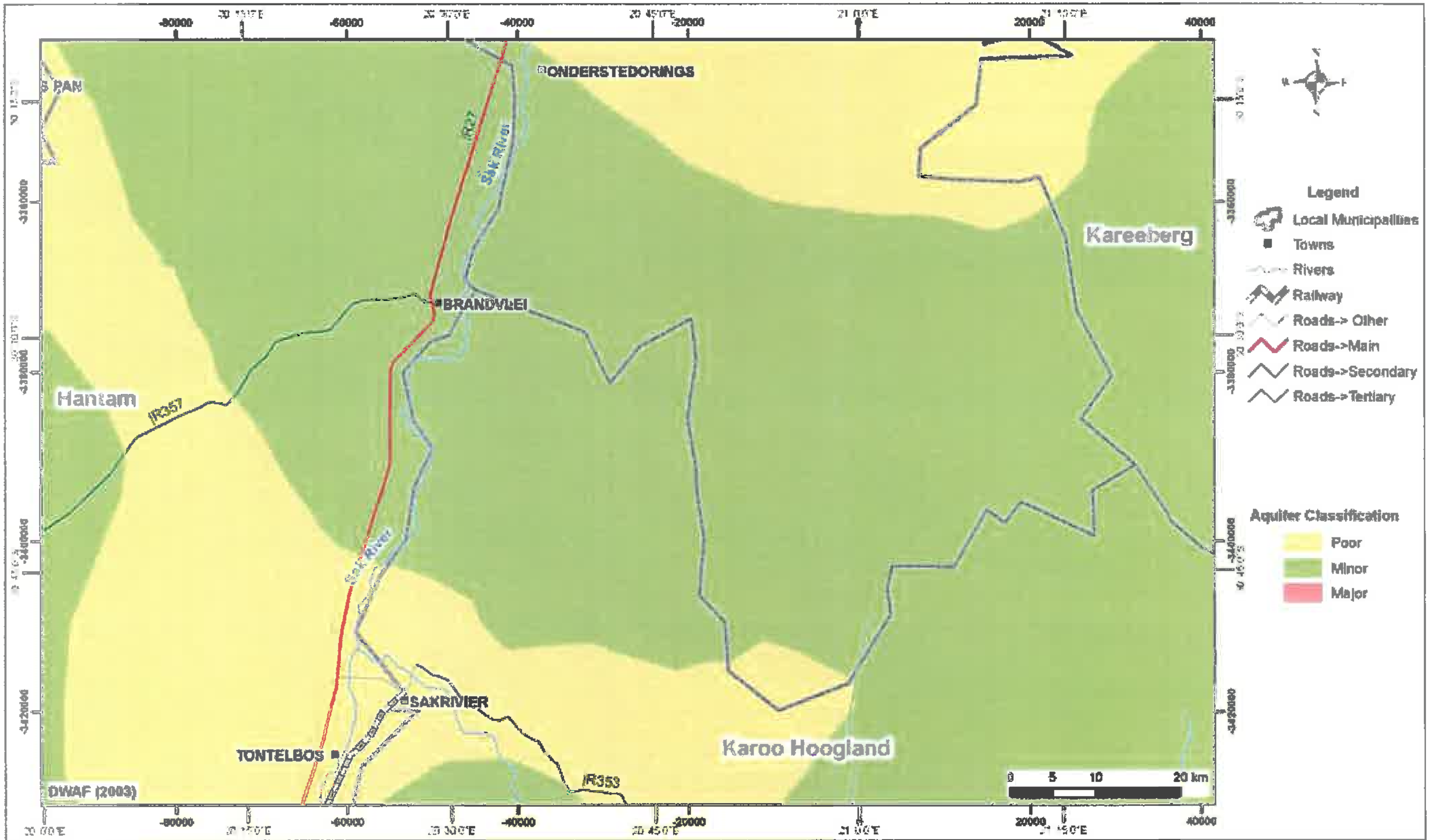

Project No.	Datum: Hartebeesthoek '94	BRANDVLEI GROUNDWATER RESOURCE ASSESSMENT	Date: 12/01/2010	Scale 1:600.000
412653	Projection: Transverse Mercator	AQUIFER CLASSIFICATION	Compiled by: M. Goes	Fig No. 012
	Central Meridian/Zone: 21°		Revision: A	Date: 12/01/2010

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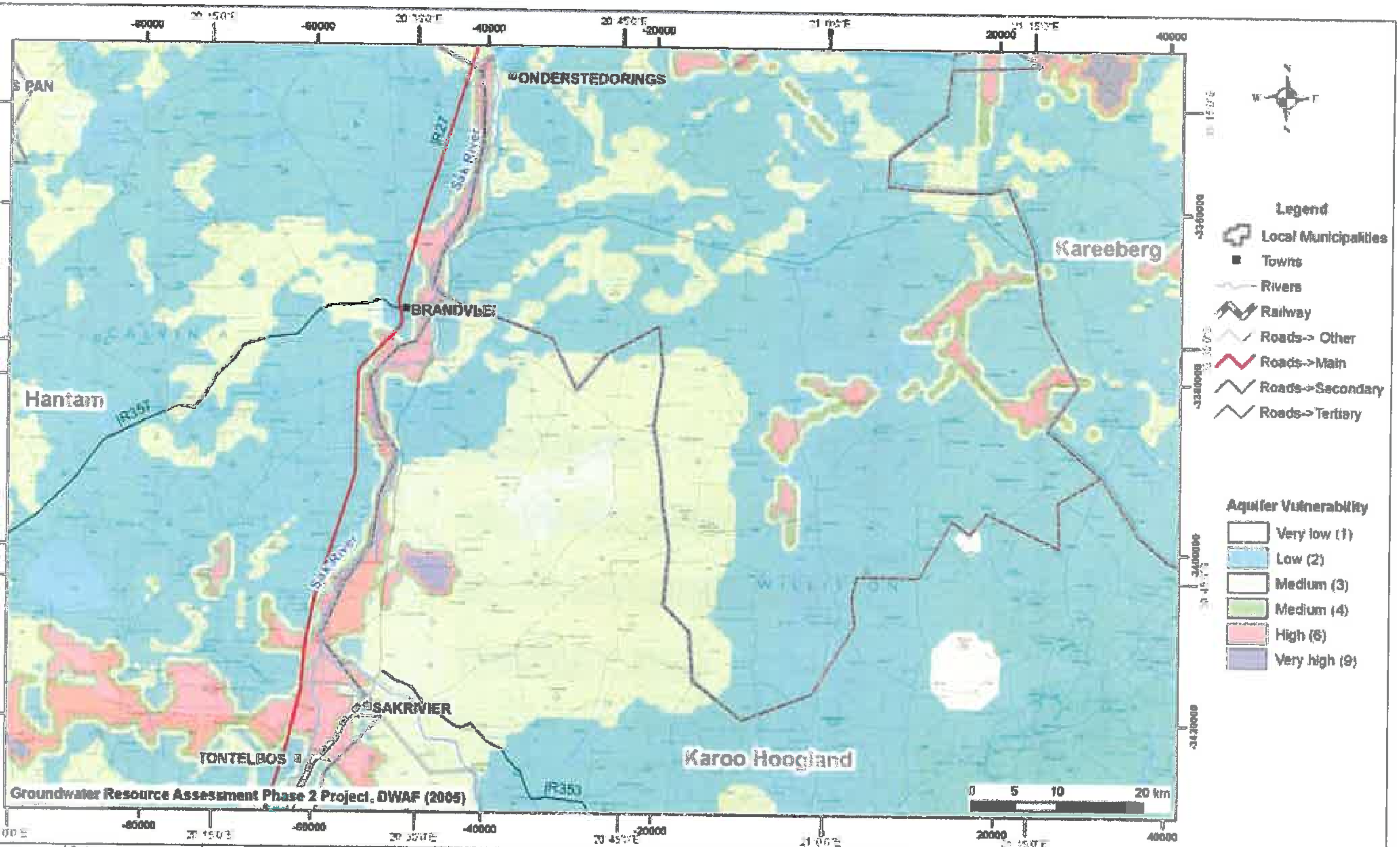

Project No. 412653	Datum: Hartebeeshoek '94 Projection: Transverse Mercator Central Meridian/Zone: 21°	**BRANDVLEI GROUNDWATER RESOURCE ASSESSMENT** AQUIFER VULNERABILITY	Date: 12/01/2010 Compiled by: M. Goes	Scale 1:500.000 Fig No. 013

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Revision: A Date: 12/01/2010

Aquifer vulnerability is defined as the likelihood for contamination to reach a specified position in the groundwater system after being introduced at some point above the uppermost aquifer. According to the findings of the GRA-II project (DWAF 2005) the study area is for the most part classified as being of low to medium vulnerability (**Figure 9**). Along the Sak River the vulnerability is classed as medium to high. In the east the area around Jacoblinks se Laagte and Ysterdoringspan is classed as being of medium to high vulnerability as well as the areas around Hoek van Spruit se Vloer and Voëlvlei se Vloer in the southwest. Blomberg se Vloer just east of the Sak River is of very high vulnerability.

8.2 Depth to Groundwater and Direction of Groundwater Flow

Data from the NGDB contained 540 boreholes with water level data. The water levels range between 0.08 and 54 mbgl with most being below 15 mbgl (**Figure 14**). The average water level for this area is 12 mbgl (NDGB).

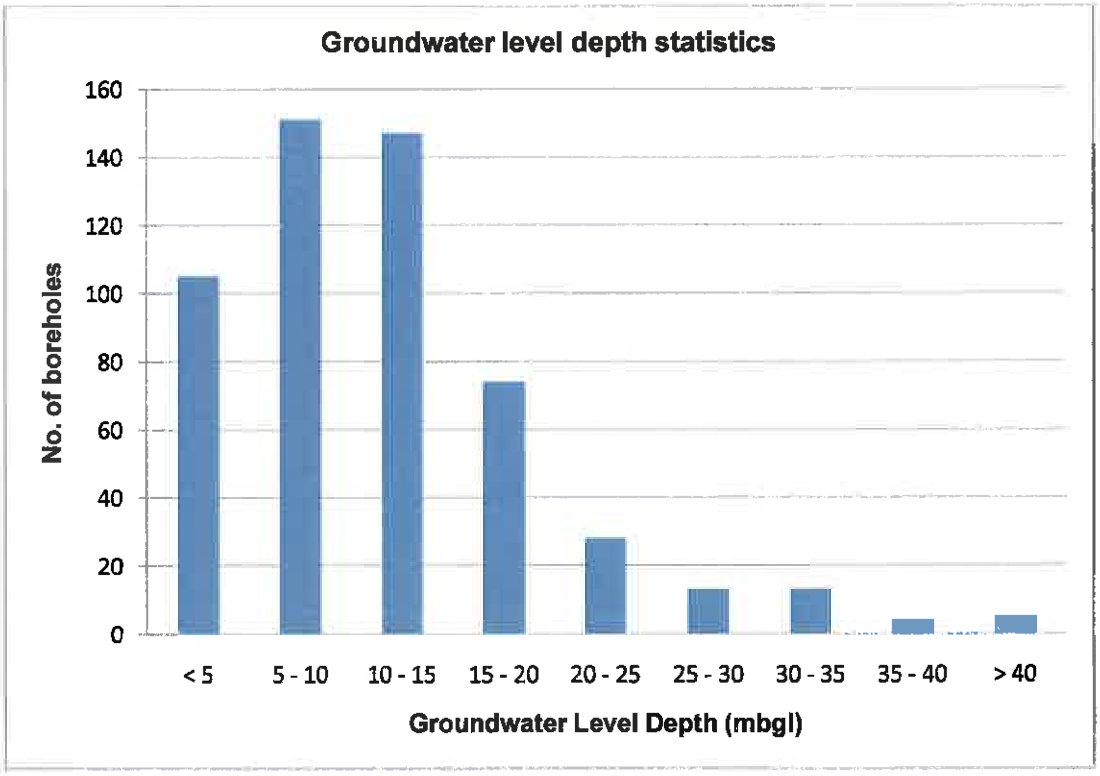

Figure 14: Water level depth statistics

Figure 15 presents a map showing groundwater elevations and inferred direction of groundwater flow. It is expected that groundwater flow in the superficial deposits will mimic the topography as they will represent unconfined conditions. The study area covers a vast area and traverses many water divides. It is however expected that groundwater would flow towards the Sak River and ultimately in a northerly direction.

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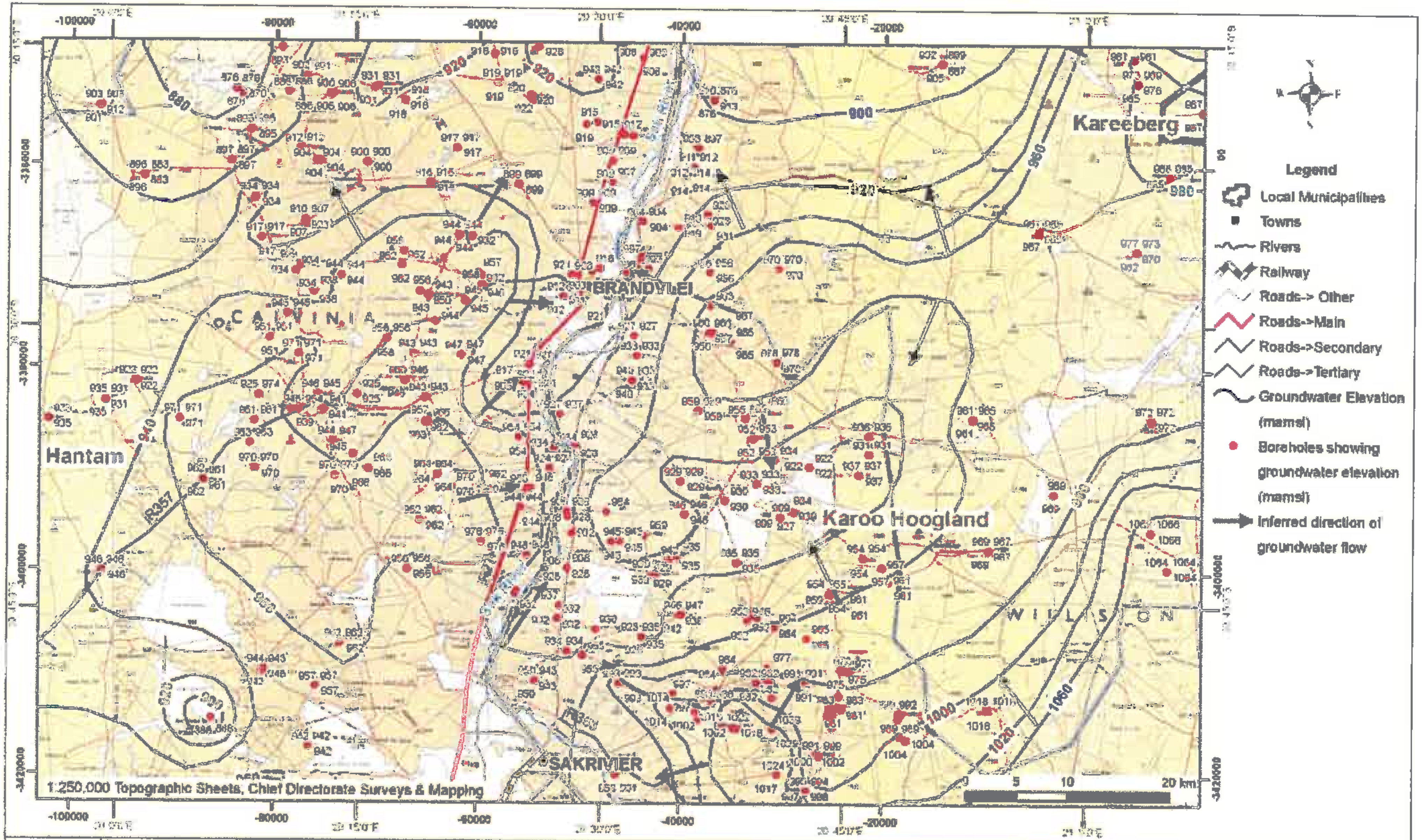

Project No.	Datum: Hartebeeshoek '94		Date: 12/01/2010	Scale 1:500,000
412653	Projection: Transverse Mercator	BRANDVLEI GROUNDWATER RESOURCE ASSESSMENT	Compiled by: M. Goes	Fig No. 015
	Central Meridian/Zone: 21°	GROUNDWATER ELEVATION AND INFERRED DIRECTION OF GROUNDWATER FLOW	Revision: A	Date: 12/01/2010

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Table 3: 2009 Abstraction figures for Romanskolk

Borehole No.	BH1	BH2	BH3	BH4	Total
Year 2009	m^3	m^3	m^3	m^3	m^3/month
Jan	2,407	4,193	3,240	2,764	12,605
Feb.	0	4,392	3,691	2,420	10,503
Mar.	0	6,367	4,511	2,247	13,124
Apr.	0	4,623	3,682	4,644	12,949
May	0	4,923	2,958	2,878	10,759
Jun.	0	3,718	3,727	3,267	10,711
Jul	0	4,548	3,877	2,749	11,173
Aug.	0	4,191	3,281	2,875	10,347
Sep	0	3,676	3,144	3,503	10,324
Oct					10,575
Nov.					11,250
Dec					12,500
Total					136,820
Maximum	2,407	6,367	4,511	4,644	13,124
Minimum	0	3,676	2,958	2,247	10,324
Average/month	267	4,515	3,568	3,038	11,402
Average/day	77.65	150.48	118.93	101.28	374.85
Average/hr (24 hr/day)	3.24	6.27	4.96	4.22	15.62
Average/hr (12 hr/day)	6.47	12.54	9.91	8.44	31.24
Average/hr (8 hr/day)	9.71	18.81	14.87	12.66	46.86
No abstraction for the individual boreholes were available from Oct to Dec 09					

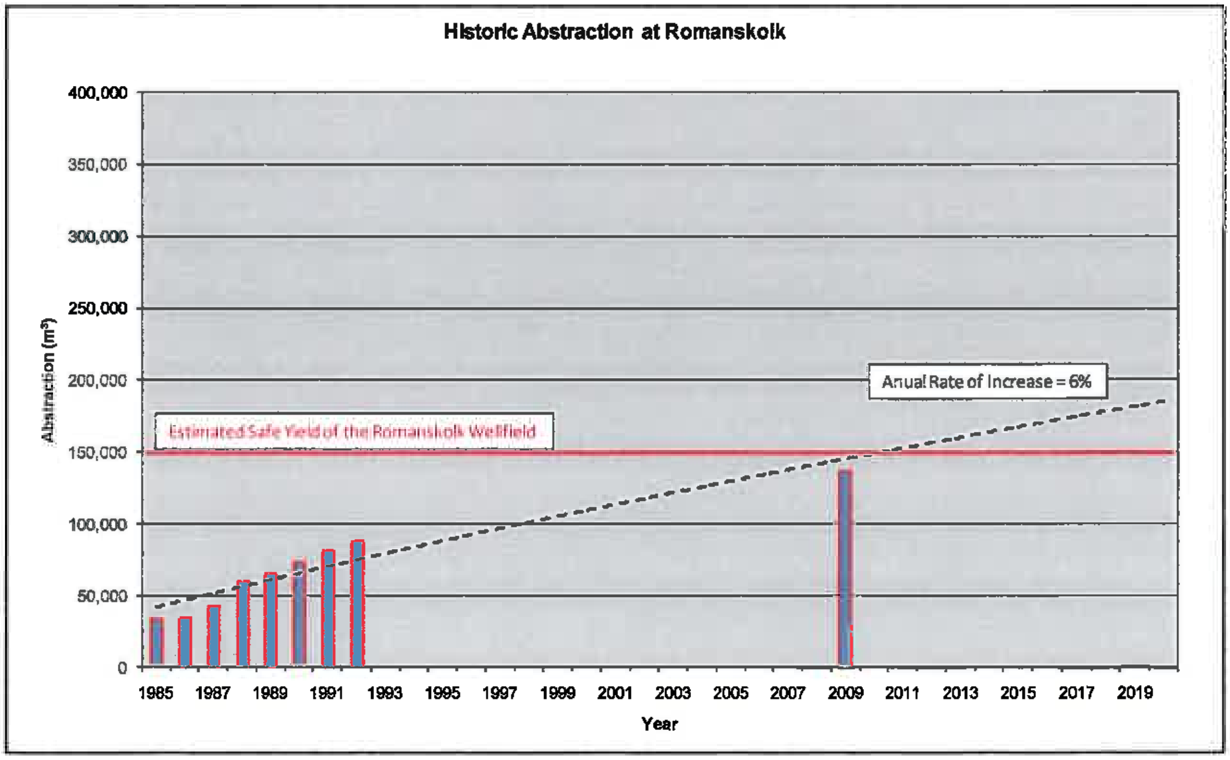

Figure 16: Graph showing historic abstraction rates for Romanskolk

8.3 Groundwater Use

Brandvlei has its production boreholes in the Romanskolk wellfield. Current annual abstraction from this well field is approximately 137,000 m^3 (**Table 3**). Borehole BR14 of this well field, which was previously utilized as a production borehole for Brandvlei, has pumped dry and the pump has been removed more than a year ago. During the hydrocensus two of the other production boreholes were out of order due to faulty pumps and/or generator sets.Romanskolk Wellfield's "safe yield" is estimated at 150 000 m^3/a. If the annual rate of increase in abstraction of 6% measured from 1985 should continue, the safe yield of the Wellfield will be exceeded within the next few years (**Figure 16**). *Note: The estimated safe yield is based on the pump yields and the historic water level behaviour of the boreholes. These boreholes were never test pumped.*

Boreholes associated with dolerite dykes and with relative high yields were located on the farm Leeuwkuilspoort. They were previously utilized for irrigation purposes and have been pumped over an extended period of time. However, based on the field measured EC's of most of the boreholes here, which is >200 mS/m, the quality of the water from these boreholes is marginal (range 200 – 370 mS/m) and only suitable for short term human consumption (SANS 241 – 2006).

The boreholes in this area are mostly used for stock watering and irrigation purposes and to a lesser extent domestic use at farmsteads due to the poor quality of the water.

8.4 Groundwater Quality

The northern extent of the study area is found to be of poor groundwater quality with electrical conductivities (EC) measuring in excess of 300 mS/m while the southern extent favours EC's between 70 and 300 mS/m (**Figure 17**) (DWAF, 1996). In and around the town of Brandvlei, EC's in excess of 4 000 mS/m having been measured. This is confirmed by the NGDB (DWAF) data collected for this area (**Figure 17**).

The chemical analysis obtained from the Municipality for the water abstracted from the Romanskolk boreholes is summarised and compared to the South African National Standards for Drinking Water (SANS 241 – 2006) in **Table 4**.

Table 4: Chemistry of the water abstracted at Romanskolk

LAB NUMBER:	6594	736	SANS (241 - 2006) Specifications for drinking water		
SAMPLE DATE:	11-Jun-97	13-Mar-98	Class 1 (Recom-mended limit)	Class 2 (Maximum Allowed)	Class 2 water Consumption Period, Max.[a]
Determinants (in mg/ℓ unless stated otherwise)	Wellfield Blend	Borehole BR14			
Calcium as Ca.	78	64	<150	150 – 300	7 years
Chloride as Cℓ	136	151	<200	200 – 400	7 years
Conductivity mS/m (25°C)	140	135	<150	150 – 370	7 years
Fluoride, F	?	**1.80**	<1.0	1.0 – 1.5	7 years
Magnesium as Mg	28	21	<70	70 – 100	7 years
Iron as Fe	-	0.1	<0.2	0.2 – 2.0	7 years
Alkalinity as $CaCO_3$	436	330	Not Specified - Not a health issue		
Nitrate as N	2.8	4.6	<10	10 – 20	7 years
pH (Lab)	7.0	7.7	5.0 – 9.5	4.0 - <5.0; >9.5 - 10.0	No health effect
Potassium as K	1.9	2.5	<50	50 – 100	7 years
Sodium as Na	200	200	<200	200 – 400	7 years
Sulphate as SO_4	100	120	<400	400 – 600	7 years
Total Dissolved Solids (TDS)	896	864	<1000	1000 - 2400	7 years
Total Alkalinity as $CaCO_3$	408		Not Specified - Not a health issue		
Total Hardness	308	246	Not Specified - Not a health issue		
Overall Classification	**?**	**3**			

[a] The limits for the consumption of class 2 water are based on the consumption of 2 l of water per day by a person of mass 70 kg over a period of 70 years.
? = Concentration not supplied.
Exceeding Limits for Human Consumption

8.5 Borehole Yields

Reported pumping rates for the 393 NGDB boreholes vary between 0.01 to 25 ℓ/s (**Figure 11**). The boreholes have an average yield is 2.3 ℓ/s and the median yield is 0.85 ℓ/s.

Table 5 Discharge rate statistics

Discharge Rate (L/s)	No. Of Boreholes
< 0.1	33
0.1 - 0.5	104
0.5 - 1.0	71
1.0 - 2.0	62
2.0 - 5.0	74
5.0 - 10.0	29
10.0 – 25.0	20

According to the DWAF 1:500 000 hydrogeological map, median borehole yields could vary between 0.1 and 5 ℓ/s (**Figure 11**). North of Brandvlei, along the R27, the fractured aquifer shows a median yield of between 0.5 and 2 ℓ/s. Southeast of Brandvlei the fractured aquifer has a median yield between 0.5 and 5 ℓ/s, while the intergranular and fractured aquifers have a median yield less than 0.5 ℓ/s.

Yields reported from the hydrocensus indicate average yields of 3 ℓ/s with a minimum of 0.7 ℓ/s and a maximum of 7 ℓ/s (**Table 1**).

Yields for the Romanskolk boreholes, BH2, 3 and 4 that were operational during the hydrocensus, were measured as 1.7, 2 and 2.5 ℓ/s, respectively.

Near Brandvlei there are a number of boreholes with reported yield ranging between 10 and 20 ℓ/s, especially some of the boreholes drilled in the Sak River northeast of town (Figure 19).

8.6 Recharge

Recharge data from the GRA-II project indicates recharge ranging between 0.2 and 2 mm/a (**Figure 18**) for the study area. Recharge data from the GRA-II project indicates a mean annual recharge for the study area of between 3 Mm^3/a during the dry season and 5 Mm^3/a during the wet season. However, when the exploitability and accessibility is taken into account these values decrease to give the groundwater exploitation potential of the catchment which varies between 0.65 and 0.8 Mm^3/a, depending on the season.

The low recharge indicated in the GRA-II project is evident in the Romanskolk Wellfield. The measured rest water levels of boreholes in the Romanskolk Wellfield are generally <15 mbgl. Borehole BR14 which was previously utilized as a production borehole for Brandvlei, has pumped dry and the pump has been removed more than a year ago. The present water level is still >20 mbgl (initial water level after completion of the borehole ~6 mbgl), which indicates that the recharge to this borehole is extremely poor, despite the relative high immediate yield of 7 ℓ/s.

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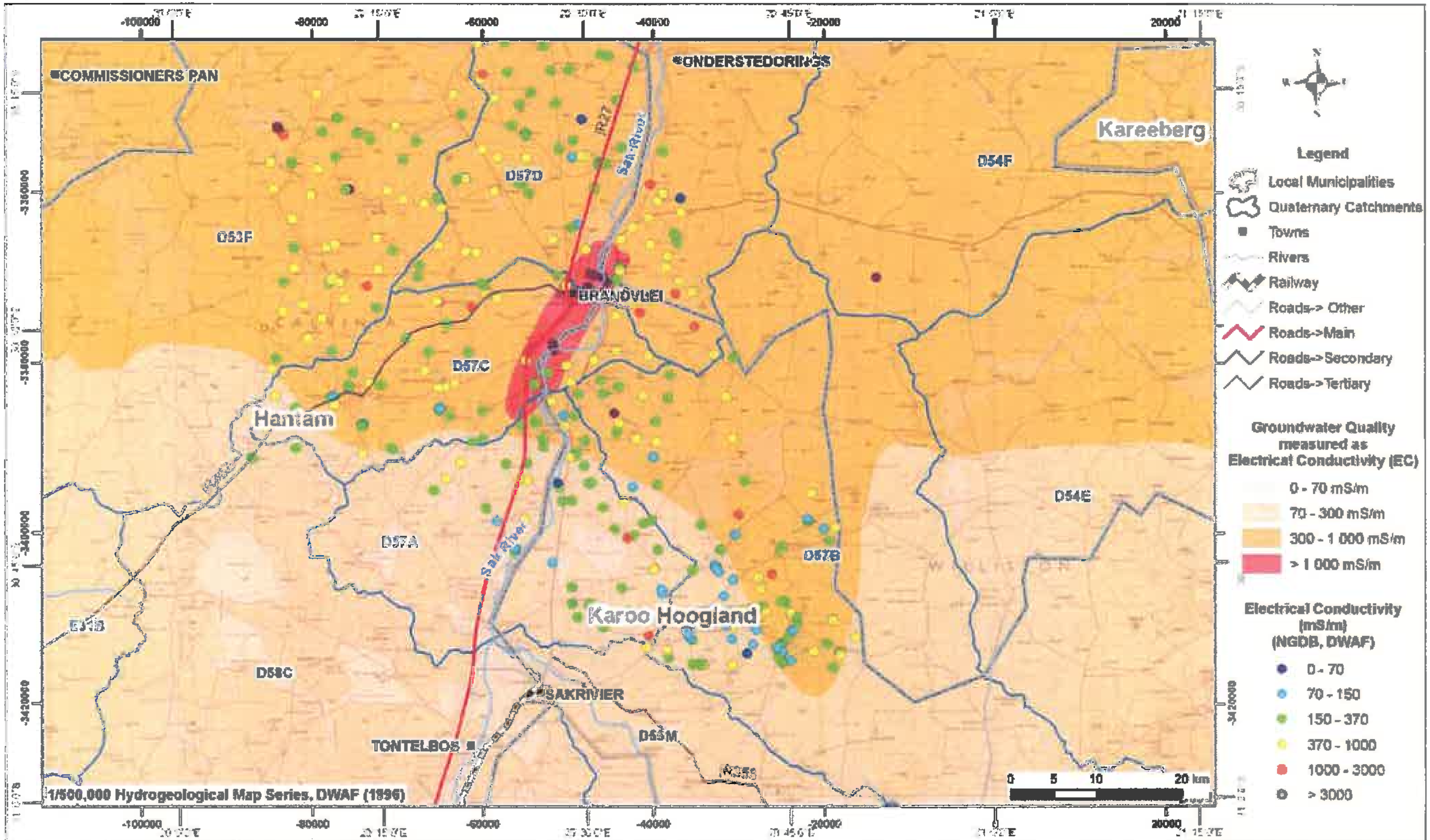

Project No.	Datum: Hartebeesthoek '94		Date:	Scale
412653	Projection: Transverse Mercator	**BRANDVLEI GROUNDWATER RESOURCE ASSESSMENT**	12/01/2010	1:600,000
	Central Meridian/Zone: 21°	GROUNDWATER QUALITY	Compiled by: M Goes	Fig No. 017

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Revision: A Date: 12/01/2010

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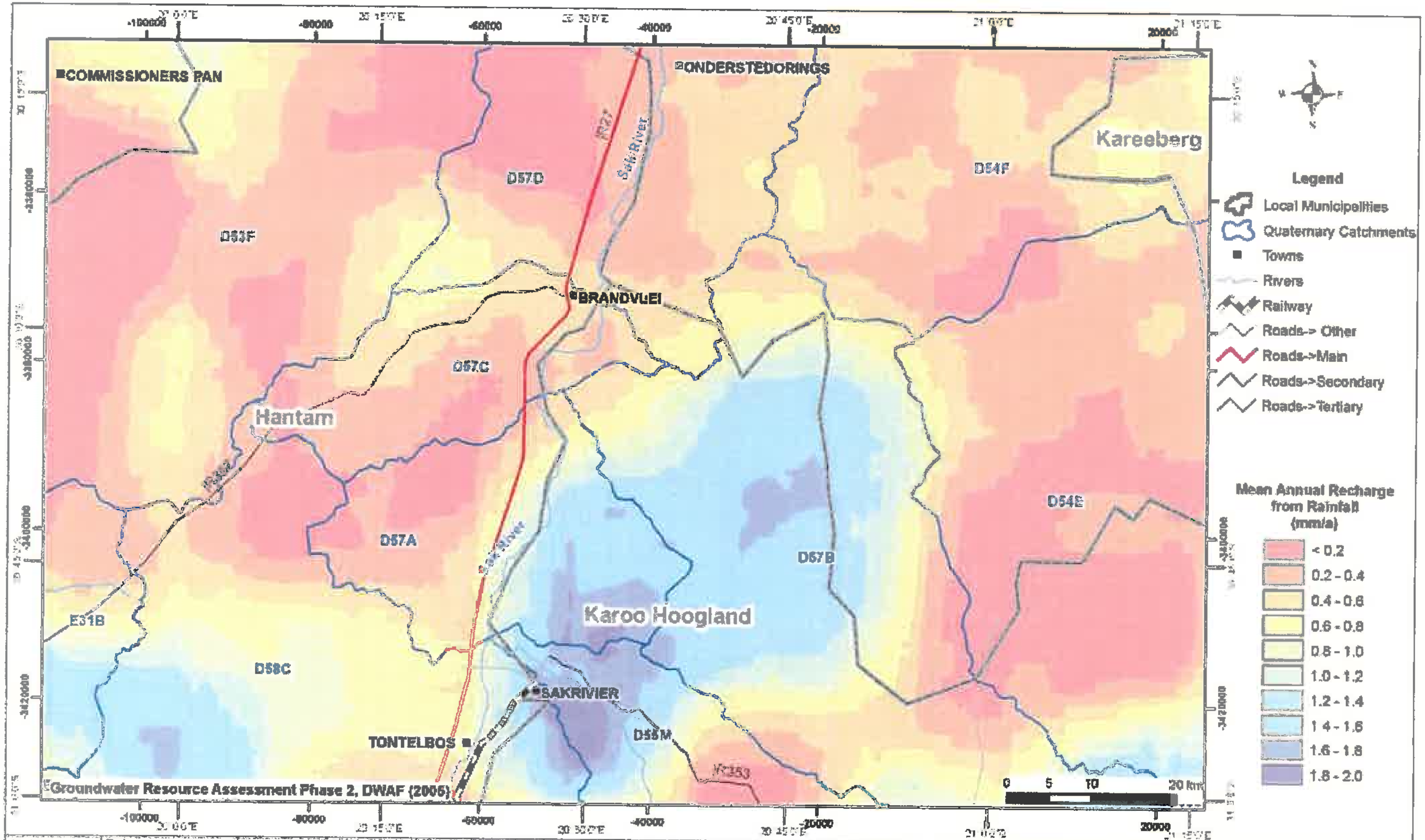

Project No.	Datum: Hartebeesthoek '94		Date:	Scale
412653	Projection Transverse Mercator	**BRANDVLEI GROUNDWATER RESOURCE ASSESSMENT**	12/01/2010	1:600.000
	Central Meridian/Zone: 21°	MEAN ANNUAL EFFECTIVE RECHARGE FROM RAINFALL (mm/a)	Compiled by: M. Goes	Fig No. 018

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9 Brandvlei's Water Demand

According to information obtained from the Hantam Municipality (**Table 3**) the amount of water abstracted at Romanskolk is ~137,000 m^3/a, or an average of ~11,400 m^3/month. Peak abstraction is 13 124 m^3/month (March 09) and lowest is 10 324 m^3/month (September 09).

Peak month abstraction is reportedly 14 000 m^3 (pers com Mr Koos Nel). According to Messrs. Nel and Retief large amounts of the groundwater abstracted are lost through leakages making accurate determination of actual consumption difficult. The situation is further exacerbated by inaccurate / faulty water meters caused by calcification due to the high $CaCO_3$ concentration in the water. Accurate water use figures are therefore not available and had to be estimated based on the current population figure of 2 300 persons supplied by the Municipality and by using generally accepted water use scenarios. These are as follows (**Table 6**):

Table 6: Current & Calculated Water Demand Scenarios for Brandvlei

Description	Unit	Average	Peak Month
Groundwater Abstraction at Romanskolk	(m^3/month)	11 400	14 000
	(m^3/day)	380	467
	(ℓ/p/d)	165	203
Peak month factor			1.23
Estimated Water Demand of the 2300 people (m^3/day)	@ 25 ℓ/p/d[A]	58	71
	@ 66 ℓ/p/d[B]	152	187
	@ 150 ℓ/p/d[C]	345	424
	@ 250 ℓ/p/d[D]	575	707

A – DWA's Basic Human Need.
B – Basic water supply criteria used for CMIP.
C – Average medium income use with flush toilets.
D – Average luxury use.

According to Mr Koos Nel the water sales in Brandvlei amounts to about 60% of the water abstracted at Romanskolk. If this is the case, the water consumption is approximately 228 m^3/day, or ~99 litres per person per day. This figure is most likely conservative as we were also informed that many problems are being experienced with faulty / inaccurate water meters due to the calcification of the moving parts. For purpose of this study the peak month abstraction was used in the preliminary designs and costing.

10 Options for Improving the Water Supply

The following options concerning improving the water supply to Brandvlei from groundwater resources have been considered and investigated:

(1) Replacement of the Romanskolk pipeline and conversion of the borehole pumps to solar energy driven.

(2) Replacement of the Romanskolk pipeline and conversion of the borehole pumps to Eskom Power.

(3) Desalination in Brandvlei using existing nearby boreholes for raw water supply.

Note: The option involving obtaining water from the Orange River has not been assessed as it is outside the scope of this report.

10.1 Romanskolk Boreholes and Pipeline

10.1.1 Status of the Existing Pipeline

Measurements and quantities have been taken from plans and drawings and may vary from surveyed dimensions. The existing 150 mm AC pipeline from Romanskolk to Brandvlei is about 45 years old and in very bad condition (**Figure 19**). This pipeline is approximately 40 km long and large water losses occur due to pipe breakages and leaking air valves (pers. com. Mr Retief). Taking cognisance of these factors cost estimates for the replacement of a section of the pipeline through the pan as well as the replacement of the whole pipeline have been prepared. *Note: According to Mr Roelf Retief of the Hantam Municipality there are no servitudes registered for the existing pipeline. Costs for surveying, compensation of the land owners and registration of the servitudes were not included in the cost estimates.*

10.1.2 Replacement of Existing Pipeline through the Pan

When the pan is inundated with water it is difficult to determine whether pipe breakages or leaks occur under the water level. Furthermore, it is also not possible to repair the breakages in the pan during inundation, which could result in Brandvlei being without any water for extended periods of time. To overcome this problem it is recommended that the existing pipeline be replace or that a duplicate 160 mm mPVC pipeline be laid adjacent to the existing pipeline across the pan, when dry.

The length of this 160 mm mPVC replacement will be 5 300 m and it will be possible to isolate this pipeline or the existing section by means of sluice valves placed outside the pan boundaries.

The cost for such a replacement is estimated at R1 198 000 (VAT Incl.)

10.1.3 Replacement of the Whole Romanskolk Pipeline

To minimize current water losses and reduce maintenance costs it is recommended that the existing AC pipeline from Romanskolk to Brandvlei be replaced with a new 160 mm mPVC pipeline.

The cost of replacing the existing pipeline is estimated at R8 588 000 (VAT Incl.).

Note: This cost estimate does not include servitude costs, if required.

10.1.4 Conversion of Boreholes at Romanskolk to Solar Energy or Eskom Power

There are currently five equipped production boreholes at Romanskolk of which two (BR1 and BR7) are out of order and three (BR2, BR3 and BR4) are in use. These boreholes are equipped with electrical pumps driven by diesel electricity generation sets. These boreholes are ~42 km from Brandvlei and have to be serviced from Brandvlei. The water from these boreholes is unfit for human consumption due to an unacceptably high fluoride concentration (see 0). The water is also hard, which poses operational problems such as calcification of hot water cylinders, kettles and volume meters. The most efficient way of treating water of this type to an acceptable standard for long term domestic use is by desalination. Treatment by defluorination and water softening will also improve the water to an acceptable quality, albeit the concentration of chemical elements other than fluoride will not be reduced.

In view of the long distance from the town and the high price of fuel, it should be considered to convert the current power generation here to solar energy and replace the existing pumps with suitable submersible pumps. The higher yielding boreholes can be equipped with two solar pumps per borehole.

The cost for conversion to solar power estimated at R2 674 000 (VAT Incl.).

An alternative option is to connect the Romanskolk Wellfield to Eskom's power supply, the nearest being at Brandvlei, a distance of ~42 km.

The cost for conversion to Eskom power is estimated at R5 951 000 (VAT Incl.).

Note: This cost estimate does not include costs for servitudes.

10.1.5 Desalination in Brandvlei

In view of the high costs involved in replacement and upgrading of the Romanskolk water supply works, it should be strongly considered to scrap the existing system and develop an alternative water supply system near the town.

Several high yielding boreholes are known to exist near the town in the Sakrivier area (**Figure 19**). The water from these boreholes, however, is saline and not fit for human consumption if untreated. The following treatment options should therefore be considered.

Desalination Plant

To utilise the saline ground water occurring in the near vicinity of Brandvlei for domestic use will require desalination. The most common method of desalination is the reverse osmosis (RO) process.

In the desalination process raw water is fed to the RO plant, which removes the salt particles by means of forcing the water through a membrane under very high pressures. The permeate (fresh water) is delivered into a fresh water tank while the effluent (brine or salt water) is discharged in an evaporation pond. The evaporation pond is designed so that no salt water can enter into the ground water.

In the desalination process approximately 70% of the raw water is recovered as fresh water while 30% is lost as brine.

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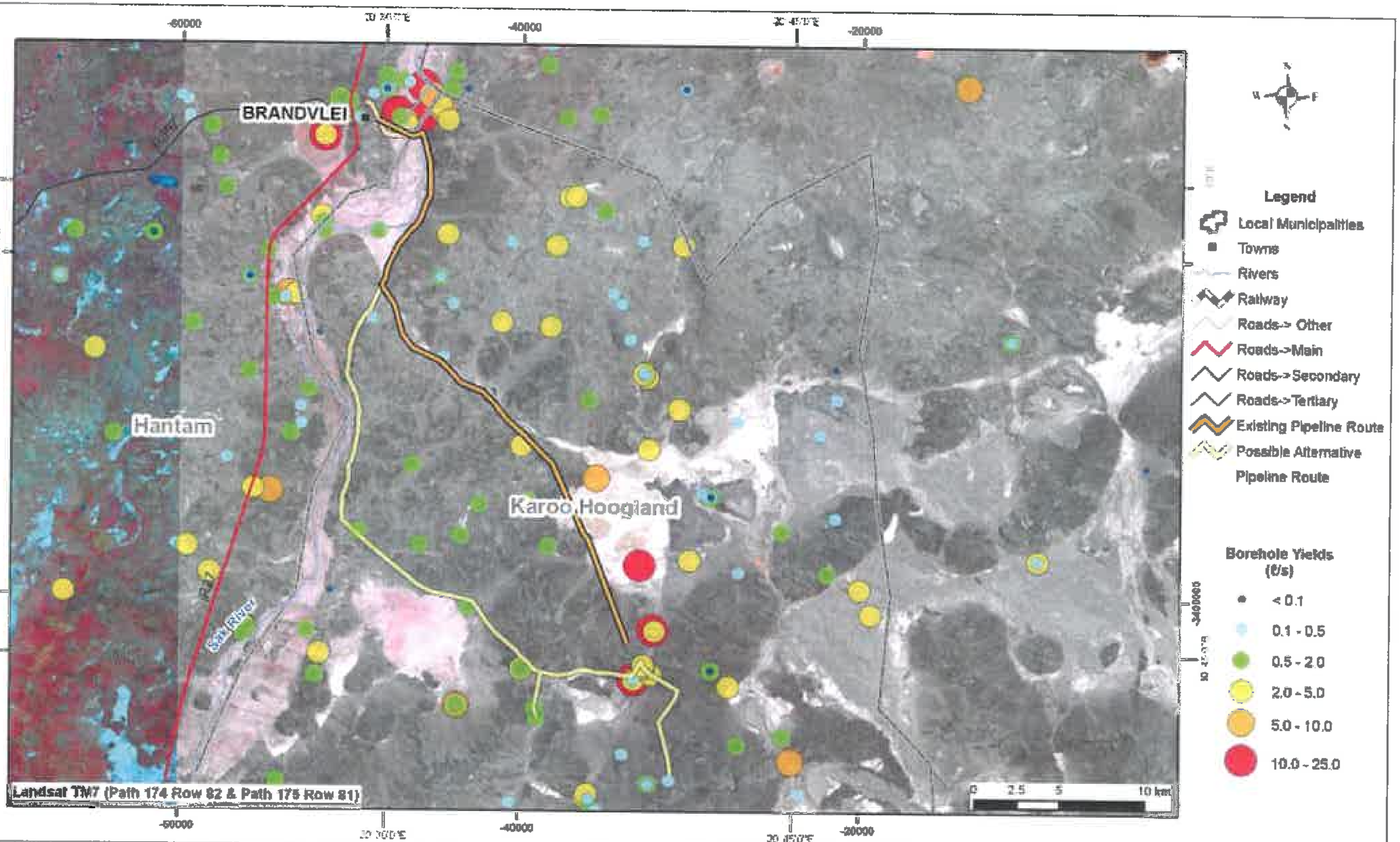

Project No	Datum: Hartebeeshoek '94		Date:	Scale
412653	Projection: Transverse Mercator	**BRANDVLEI GROUNDWATER RESOURCE ASSESSMENT**	12/01/2010	1:300,000
	Central Meridian/Zone: 21°	MAP SHOWING LOCATION OF EXISTING PIPELINE AND BOREHOLE YIELDS	Compiled by: M Goes	Fig No. 019

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Brandvlei's average water demand is 467 m^3 per day. The RO plant will therefore have to produce 467 m^3/d. Normally the RO plant will operate for 12 hr per day, therefore the capacity of the plant will have to be 38.9 m^3/h. The raw water fed into the RO plant will be 38.9/0.7 = ~55.6 m^3/h. This feed water can be abstracted from existing boreholes located near the town.

The cost of the installation of such a RO plant is estimated at R5 936 000 (VAT Incl.)
Note: This cost estimate includes the EIA for the whole of the desalination system, i.e. the RO plant, boreholes and evaporation pond.

Equipping of Existing Boreholes

To satisfy the town's average raw water demand will require two production boreholes each delivering 8 ℓ/s over a 12 hr day pumping schedule, i.e. 8 x 3 600 x 2 = 57.6 m^3/h. See **Figure 19** for localities of some existing boreholes that may be suitable for such production rates. *Note: The condition of these boreholes, which were drilled by the DWA, will have to be assessed and their optimum pumping rates and schedules determined by test pumping. Samples will also have to be taken for chemical analysis.*

The two production boreholes will be equipped with electrical submersible pumps and connected to the raw water reservoir. *Note: It has been assumed that on of the three existing reservoirs in the town can be used for raw water storage.* The envisaged equipment will include electrical submersible pumps, electricity supply from Eskom's power lines, pump houses, connecting pipelines and ancillary works.

The cost for testing and equipping the boreholes is estimated at R1 449 000 (VAT Incl.)

Brine Evaporation Pond

To prevent the brine from re-entering the groundwater and contaminating it, it will have to be discharged into a shallow evaporation pond. The pond will be sealed by means of a suitable engineering seal. The design of the pond will allow for evaporation of the water in accordance with the local evaporation factors and rainfall.

The cost of the evaporation pond is estimated at R1 202 000 (VAT Incl.).

10.2 Summary of Costs

The costs for the options described in the previous sections are summarised in **Table 7**. Also see **Appendix 2** for a breakdown of these costs. Please bear in mind that these costs are preliminary and based on tender prices for similar projects where we have been involved in over the last two years.

It can be concluded that Option 3, i.e. desalination of water from existing boreholes at Brandvlei, is the least expensive. The advantages of implementing Option 3 are:

- Capital cost is substantially lower than those of the other two options.
- The infrastructure will be in or close proximity of the town, which will simplify operation and management thereof.
- From a health, aesthetic and operational perspective, the desalinated water will be of superior quality than that from Romanskolk.

Treatment of the Romanskolk water, which is unacceptable for human consumption due to an unacceptably high fluoride concentration, was not included in the cost estimates for Options 1 and 2. Should such treatment be included in the costs for Option 1 and 2, their operational costs will almost certainly increase to at least equal and most likely beyond that of Option 3.

In view of these facts we recommend that Option 3 be implemented to provide Brandvlei with sufficient quantities of potable water.

Table 7: Summary of costs (in Rand) for options to improve Brandvlei's water supply

Option	Description	Estimated Cost		Operating Cost	Unit Cost
		VAT Excl.	VAT Incl.	R/m^3	R/m^3
1	REPLACE/UPGRADE ROMANSKOLK SYSTEM TO SOLAR ENERGY				
1.1	Install additional pipeline through the pan	1,050,607	1,197,692		
1.2	Replace whole of old pipeline	7,701,172	8,779,336		
1.3	Convert borehole system to solar electricity	2,346,000	2,674,440		
1.4	**TOTAL OPTION 1**	**11,097,779**	**12,651,468**	**2.33**	**14.74**
2	REPLACE/UPGRADE ROMANSKOLK SYSTEM TO ESKOM POWER				
2.1	Install additional pipeline through the pan	1,050,607	1,197,692		
2.2	Replace whole of old pipeline	7,701,172	8,779,336		
2.3	Connect boreholes to Eskom power	5,220,000	5,950,800		
2.4	**TOTAL OPTION 2**	**13,971,779**	**15,927,828**	**3.75**	**19.38**
3	DESALINATION IN BRANDVLEI				
3.1	RO plant	5,206,667	5,935,600		
3.2	Testing and equipping of existing boreholes	1,271,000	1,448,940		
3.3	Evaporation pond	1,054,692	1,202,349		
3.4	**TOTAL OPTION 3**	**7,532,359**	**8,586,889**	**4.11**	**12.53**

11 Conclusions

The following can be concluded for this investigation:

- The geology of the area comprises mainly Tierberg shale of the Ecca Group with post Karoo dolerite intrusions in the form of dykes and sills. Alluvium occurs in the main drainage channels but the vertical extent thereof is limited. Pan sediments consisting of clay, silt and alluvium occur in several pans throughout the study area. These sediments are generally less than 5 m thick.

- The aquifer in the study area has been classed as a poor aquifer of low to medium vulnerability. Along the Sak River and the pans the vulnerability tends to be medium to high.

- The average water level is 12 mbgl and groundwater flow is towards the Sak River and in a north westerly direction.
- The Romanskolk Wellfield abstracts approximately 137,000 m^3/a for domestic, stock watering and irrigation purposes.
- Based on the rest water level it can be concluded that the current rate of abstraction at Romanskolk seems to be sustainable. Pump drawdown in some of the boreholes, however, seems excessive, e.g. BR2 where pump drawdown is to 12.27 mbgl and the borehole is only 13.6 m deep. Excessive drawdown could cause pump suction occurring, which may damage the pumps.
- The hydrocensus results and previous discussion indicate that the changes of locating good yielding boreholes with acceptable quality of groundwater in this area are slim.
- The groundwater quality is generally poor with few localised instances of good quality for human consumption. Fluoride is a major concern and very few boreholes, if any, yield groundwater with acceptable fluoride values. Therefore the groundwater will likely at least have to be de-fluorinated.
- The only areas where potable groundwater may be located are the farms Groot Volstruisfontein, Kranskop and Kalkputs.
- Borehole yields vary between 0.1 and 25 ℓ/s with an average yield of 2.3 ℓ/s and a median yield of less than 0.85 ℓ/s.
- Due to a fluoride concentration of ~1.8 mg/ℓ the water from Romanskolk is of unacceptable quality for human consumption. The water is also hard which causes operational problems such as calcification of the water meters, hot water cylinders and kettles.
- The existing asbestos cement pipeline is approximately 45 years old and at the end of its operational life span. According to the Municipality large amounts of water is regularly lost through leakages and breaks in the pipeline. Maintenance costs are therefore high. Of special concern is the portion of the pipeline (~5 km) which crosses a pan. When filled with water after good rains leaks could not be detected here, nor can it be fixed until the pan has sufficiently dried out again. There is a high risk that the town might be without water for extended periods should the pipe break beneath the pan when it is inundated.

- Three options have been identified to improve Brandvlei's water supply from groundwater resources, namely;
    i. **Replacement of the Romanskolk pipeline and conversion of the borehole pumps to solar energy driven.**
    ii. **Replacement of the Romanskolk pipeline and conversion of the borehole pumps to Eskom Power.**
    iii. **Desalination in Brandvlei using existing nearby boreholes for raw water supply.**
- The capital costs for implementing these options are R11.098, R13.972 and R7.532 million, respectively. Unit costs of the water are R14.74, R19.38 and R12.53 per m^3, whilst operating costs are R2.33, R3.75 and R4.11 per m^3, respectively.

12 Recommendations

Based on the discussions and conclusions of this report the following is recommended to improve Brandvlei's water supply:

- Implementation of Option 3, i.e. desalination in Brandvlei with groundwater abstracted from nearby existing boreholes.
- Some the high yielding existing DWA boreholes north east of Brandvlei town can be investigated by test pumping and down-hole video camera surveys to determine their suitability as possible production boreholes for desalination in the town. A well defined dolerite dyke is located ~500 m west of the town which also could be investigated if needed.
- If implementation of either Options 1 or 2 is preferred by Hantam Municipality, at least one additional production borehole should be drilled at Romanskolk on the main dolerite dyke and close to the dam's overflow.
- All the production boreholes should be test pumped, their optimum pumping rates and schedules determined and the correct sized pumps installed. Production boreholes BR1 and BR7 must be put back in production. Therefore, the pumps and generator sets of these boreholes need to be repaired.
- The possibility to deepen the shallow production boreholes BR1, BR2 and BR3 to 50 mbgl must be investigated. If necessary new deeper boreholes must be drilled close to these boreholes.

13 Limitations

The statements, opinions, and conclusions contained in this report are based solely upon the services performed by SRK as described in this report, the scope of work as established for the report, and in accordance with our proposal. In performing these services and preparing the report, SRK relied upon the information provided by others, including public agencies, whose information is not guaranteed by SRK. No indications were found during our investigations that information contained in this report as provided to SRK was false.

This report is based on conditions encountered and the information reviewed at the time of the site investigations. SRK disclaims responsibility for any changes that may have occurred after this time or any error in the analytical results received from the laboratory. This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

SRK CONSULTING

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Principal Engineer

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Principal Hydrogeologist

14 References

Council for Geoscience (1990). *Geological Map Sheet 3020 Sak River, 1:250 000 scale.* Pretoria

Department of Water Affairs and Forestry (DWAF) (1996) Water Quality Guidelines for Domestic use: Irrigation. Volume 2.

Department of Water Affairs and Forestry (DWAF) (2000), 1:500 000 Hydrogeological Map Series, Sheet 2920 Prieska.

Department of Water Affairs and Forestry (DWAF) (2005). National Groundwater Resource Assessment Phase II. Unpublished Report to the DWAF, Pretoria.

National Groundwater Database (NGDB) Department of Water Affairs and Forestry.

Appendix 1: Chemical Analyses Certificates obtained from the Municipality

[illegible] ANALYTICAL SERVICES [illegible] P.01

Water, Environment and Forestry Technology [illegible]

Water, Environment and Forestry Technology

CSIR

Our ref: c:\let\bwm-2788

Report no 2788

11 June 1997

CERTIFICATE OF ANALYSIS

Brandvlei Municipality
P O Box [illegible]
BRANDVLEI
[illegible]

Attention Mr Vetter

CHEMICAL ANALYSIS

Water samples
Date Received: 11 June 1997
Analysis completed: 13 June 1997

LAB NUMBER:	[illegible]	9595	[illegible]
SAMPLE ID:	Kurman	Holpad	Sport Kom
Potassium as K mg/l	1,9	4,8	7,9
Sodium as Na mg/l	200	749	2481
Calcium as Ca mg/l	78	216	400
Magnesium as Mg mg/l	28	213	359
Sulphate as SO4 mg/l	[illegible]	1340	1597
Chloride as Cl mg/l	136	904	4350
Alkalinity as CaCO3 mg/l	336	339	400
Nitrate plus nitrite as N mg/l	2,8	6,5	11,8
Conductivity mS/m @25 °C	140	540	1450
pH (Lab)	7,0	7,0	7,3
Saturation pH (pHs) (20deg C)	7,1	6,8	6,5
Total Dissolved Solids (Calc) mg/l	696	3456	9280
Hardness as CaCO3 mg/l	308	1417	2416
% Difference	0,50	0,56	2,73
Anions meq/l	14,84	40,46	162,00

Mike [illegible]
ANALYTICAL SERVICES

Andrew Pascall
ANALYTICAL SERVICES

[illegible]

Borehole BR14 Analysis

MON, 16-MAR-98 9:25 ANALYTICAL SERVICES STELL 021 8882630 P.01

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Our ref\c\let\bvm-3464

Water, Environment and Forestry Technology

CSIR

Report No 3464

16 March 1998

CERTIFICATE OF ANALYSIS

Brandvlei Municipality
P O Box 12
BRANDVLEI
7020

Boorgat by J. Langner

Attention Mr Retief

CHEMICAL ANALYSIS

Water sample
Date Received: 13 March 1998
Analysis completed: 13 March 1998

SAMPLE No:	736
Potassium as K mg/L	2,5
Sodium as Na mg/L	200
Calcium as Ca mg/L	64
Magnesium as Mg mg/L	21
Sulphate as SO4 mg/L	120
Chloride as Cl mg/L	151
Alkalinity as CaCO3 mg/L	330
Nitrate plus nitrite as N mg/L	4,6
Iron as Fe mg/L	0,1
Fluoride as F mg/L	1,8
Conductivity mS/m @25 °C	135
pH (Lab)	7,7
Saturation pH (pHs) (20deg C)	7,3
Total Dissolved Solids (Calc) mg/L	864
Hardness as CaCO3 mg/L	246
% Difference	0,71
CATIONS meq/L	13,68
ANIONS meq/L	13,78

Mike Louw

Mike Louw
ANALYTICAL SERVICES
Page 1 of 1

Appendix 2: Breakdown of Costs

DESIGN CRITERIA		
DESCRIPTION	**UNIT**	**QUANT**
EXISTING PIPELINE		
Length of Pipeline Romanskolk to Brandvlei	m	39,000
Elevation at Reservoir	mamsl	982
Elevation at Brandvlei	mamsl	934
Difference in elevations	M	48
Water demand of Town	l/s	5.40
Average daily Water demand	L	466,667
Town population	P	2,300
Ave water demand	l/p/d	203
Friction loss/100m Pipeline	m	0.8205
Total Friction loss	kPa	320
Total Friction loss	m	32
Min. Dia of pipeline(AC)	mm	150
BOREHOLES		
Yield **BH2**/12 Hr day	l/h	6,600
	l/s	1.83
Yield **BH3**/12 Hr day	l/h	8,500
	l/s	2.36
Yield **BH4/1**2 Hr day	**l/h**	9,600
	l/s	2.67
Total Borehole yield/12 Hr day	**l/s**	**6.86**
	m^3/hr	**24.05**
	m^3/day	**577**
PIPE REPLACEMENT		
Length of Pipeline through pan	m	5,000
Dia of replacement pipe (mPVC)	mm	160
Use 160 mm mPVC class 6 Pipes	m	5,000

REPLACE PIPELINE THROUGH PAN				
DESCRIPTION	**UNIT**	**QUANT.**	**TARIFF**	**AMOUNT**
SECTION A:				
PRELIMINARY AND GENERAL				
SCHEDULED FIXED-CHARGE				
AND VALUE RELATED ITEMS				
Contractual Requirements	Sum	1	R 60,000.00	R 60,000.00
Establishment of Facilities on the Site				R 0.00
Facilities for the Engineer				R 0.00
(a) Furnished office	Sum	1	R 5,000.00	R 5,000.00
(b) Telephone	Not Req			R 0.00
(c) Name boards	No	1	R 5,000.00	R 5,000.00
Facilities for the Contractor				R 0.00
(a) Offices and Storage Sheds	Sum	1	R 3,500.00	R 3,500.00
(b) Workshops	Sum	1	R 3,500.00	R 3,500.00
(c) Laboratories	Not Req.			R 0.00
(d) Living accommodation	Sum	1	R 6,000.00	R 6,000.00
(e) Ablution and latrine facilities	Sum	1	R 12,000.00	R 12,000.00
(f) Tools and equipment	Sum	1	R 3,000.00	R 3,000.00
(g) Water supply, electric power				R 0.00
and communications	Sum	1	R 3,000.00	R 3,000.00
(h) Dealing with water	Sum	1	R 600.00	R 600.00
(i) Access	Sum	1	R 300.00	R 300.00
(j) Plant	Sum	1	R 300.00	R 300.00
Other Fixed-Charge Items	Sum	1	R 300.00	R 300.00
Removal of Site Establishment	Sum	1	R 1,800.00	R 1,800.00
SCHEDULED TIME-RELATED ITEMS				R 0.00
Contractual Requirements	Sum	1	R 30,000.00	R 30,000.00
Operation and Maintenance of Facilities on Site, for Duration of Construction, except where Otherwise Stated				
Facilities for the Engineer	Sum	1	R 3,500.00	R 3,500.00
(a) Furnished office	Sum	1	R 200.00	R 200.00
(b) Telephone	Not Req			R 0.00
(c) Name boards	Nr	1	R 150.00	R 150.00
Facilities for the Contractor				R 0.00
(a) Offices and Storage Sheds	Sum	1	R 200.00	R 200.00
(b) Workshops	Sum	1	R 200.00	R 200.00
(c) Laboratories	Not Req			R 0.00
(d) Living accommodation	Sum	1	R 200.00	R 200.00
(e) Ablution and latrine facilities	Sum	1	R 600.00	R 600.00
(f) Tools and equipment	Sum	1	R 300.00	R 300.00
(g) Water supply, electric power and communications	Sum	1	R 600.00	R 600.00
(h) Dealing with water	Sum	1	R 600.00	R 600.00
(i) Access	Sum	1	R 300.00	R 300.00
(j) Plant	Sum	1	R 300.00	R 300.00

REPLACE PIPELINE THROUGH PAN				
DESCRIPTION	**UNIT**	**QUANT.**	**TARIFF**	**AMOUNT**
Supervision For the Duration of The				R 0.00
Contract	Sum	1	R 30,000.00	R 30,000.00
Company Head Office Overhead				R 0.00
Costs for the duration				R 0.00
of the contract	Sum	1	R 10,000.00	R 10,000.00
SUMS STATED PROVISIONALLY BY THE ENGINEER				
(a) For work to be executed by the Contractor and valued in terms of the "valuation of variations" Clause In the Conditions of Contract	Sum	1	R 75,000.00	R 75,000.00
Existing Services				
(a) Excavate by hand in soft material to expose existing water mains	M^3	5	R 140.00	R 700.00
Setting Out in accordance with PSA5.1.1	Sum	1	R 5,000.00	R 5,000.00
SECTION B: PIPELINE				
SCHEDULED ITEMS: PROVISIONAL				
Clear site along pipeline route in terms of PSC5.1	M^2	7,950	R 1.50	R 11,925.00
Excavate in all materials for trenches, backfill, compact and dispose of surplus material in terms of PSD8.3.2 for				
(a) All pipes not exceeding 1.0 metre in depth	M	4,500	R 48.00	R 216,000.00
(b) All pipes exceeding 1.0 m but not exceeding 2.0 m in depth	M	800	R 50.00	R 40,000.00
Extra Over items 1.2.1,to 1.2.2 for excavation in intermediate material	M^3	500	R 20.00	R 10,000.00
Extra Over item 1.2.1, to 1.2.2 for excavation in hard rock.	M^3	100	R 380.00	R 38,000.00
Excavation Ancillaries (Provisional)				R 0.00
Imported backfill material from non-commercial sources.	M^3	50	R 28.00	R 1,400.00
Compaction in road reserves	M^3	0	R 26.00	R 0.00
Overhaul (Provisional)				R 0.00
(a) Short haul	M^3	30	R 18.00	R 540.00
(b) Truck haul	M^3	50	R 28.00	R 1,400.00
PIPELINE				
Supply, Deliver, lay, cut, join, bed, test and sterilise				
160mm dia. Class 6 mPVC pipe	M	5,300	R 36.00	R 190,800.00
Supply and fit 160mm dia. PVC fittings to suit mPVC pipe to withstand working pressure of 9 bar				
90^0 x 160 mm Elbows including one coupling each	No	2	R 204.00	R 408.00
160 x 160 x 160 Equal Tee pieces	No	2	R 335.00	R 670.00
Cut into existing AC pipe and fit 160 x 160x160 C.I. plain ended Tee piece	No	2	R 1,118.00	R 2,236.00
75 mm AC to PVC adaptor	No	0	R 120.00	R 0.00
110 x 75 PVC spigot and socket reducer	No	0	R 168.00	R 0.00
90^o x 75 mm PVC Bends	No	0	R 145.00	R 0.00
160 PVC to 150 mm AC adaptor	No	4	R 120.00	R 480.00
AIR RELEASE-VALVE UNITS				
Supply, Deliver, Drill, thread and fit the following items.				
160mm, PVC saddle, drilled and threaded for 25mm outlet. Unit shall withstand working pressure of 9 bar	No	1	R 60.00	R 60.00
50 mm Ditto	No	1	R 39.00	R 39.00
25mm Full bore ball cock isolators to withstand 9 bar working pressure	No	1	R 56.00	R 56.00
25mm barrel nipple, to withstand 9 bar working pressure	No	1	R 4.00	R 4.00

REPLACE PIPELINE THROUGH PAN				
DESCRIPTION	**UNIT**	**QUANT.**	**TARIFF**	**AMOUNT**
Model 025 RBX 2511 PN25 VENT-O-MAT air release valve	No	1	R 3,012.00	R 3,012.00
SCOUR-VALVE UNITS				
Supply, Deliver and Install the Following Items				
160mm X 75mm X 110mm, dia. unequal galvanized steel plain ended Tee, with 75mm flanged and drilled outlet.	No	1	R 1,500.00	R 1,500.00
80mm SABS Class 25 Waterworks Pattern Flanged Gate Valve with top cap for Spindle. Spindle to be left hand closing and non rising spindles and drilled Flanges	No	1	R 1,790.00	R 1,790.00
75mm Flanged adapter with flange drilled to Table SABS 1600/3	No	2	R 154.00	R 308.00
SPECIAL FITTINGS				
Flanged adapters for 150mm gate valve to 150mm AC plain ended pipe.	No	2	R 800.00	R 1,600.00
GATE/SLUICE VALVES				
Supply, Deliver and install 150 mm Class 25 DOWNRIGHT Flanged Gate valve with non-rising spindle and left hand closing mechanism to SABS 664	No	2	R 5,500.00	R 11,000.00
VALVE CHAMBERS				
Build Air Valve chamber, complete, with 50mm galv. vent pipe	No	1	R 6,817.00	R 6,817.00
Build Sluice Valve chamber	No	2	R 5,600.00	R 11,200.00
Build Check Valve chamber	No	0	R 3,433.00	R 0.00
Build Scour Valve chamber	No	1	R 3,600.00	R 3,600.00
Locking bars	No	3	R 383.00	R 1,149.00
Supply and deliver stainless steel padlock with 8 mm shank	No	3	R 102.00	R 306.00
PIPELINE MARKERS				
Supply and install pipeline markers	No	7	R 60.00	R 420.00
STEEL STRAPS				
Supply, fit and tighten firmly, mild steel straps, bolts and nuts	Sets	1	R 300.00	R 300.00
Clear up surplus material, and cart away from the site.	Sum	1	R 1,500.00	R 1,500.00
Level surplus soil from excavations on site, cart away surplus rock from excavations to spoil heaps and leave the site in a neat condition:	Sum	1	R 3,000.00	R 3,000.00
Cast concrete anchor blocks at Bends, Elbows, Tees etc	M^3	1	R 1,836.00	R 1,836.00
Sub Total A				**R 825,506.00**
Engineering design	%	10		R 82,550.60
Project management and supervision	%	10		R 82,550.60
EIA	Sum			R 60,000.00
Sub Total B				**R 1,050,607.20**
VAT	%	14		R 147,085.01
TOTAL				**R 1,197,692.21**

REPLACE PIPELINE FROM ROMANSKOLK TO BRANDVLEI				
DESCRIPTION	**UNIT**	**QUANT.**	**TARIFF**	**AMOUNT**
SECTION A:				
PRELIMINARY AND GENERAL				
SCHEDULED FIXED-CHARGE				
AND VALUE RELATED ITEMS				
Contractual Requirements	Sum	1	R 300,000.00	R 300,000.00
Establishment of Facilities on the Site				R 0.00
Facilities for the Engineer				R 0.00
(a) Furnished office	Sum	1	R 40,000.00	R 40,000.00
(b) Telephone	Not Req			R 0.00
(c) Name boards	No	1	R 25,000.00	R 25,000.00
Facilities for the Contractor				R 0.00
(a) Offices and Storage Sheds	Sum	1	R 16,000.00	R 16,000.00
(b) Workshops	Sum	1	R 16,000.00	R 16,000.00
(c) Laboratories	Not Req.			R 0.00
(d) Living accommodation	Sum	1	R 30,000.00	R 30,000.00
(e) Ablution and latrine facilities	Sum	1	R 40,000.00	R 40,000.00
(f) Tools and equipment	Sum	1	R 15,000.00	R 15,000.00
(g) Water supply, electric power				R 0.00
and communications	Sum	1	R 15,000.00	R 15,000.00
(h) Dealing with water	Sum	1	R 600.00	R 600.00
(i) Access	Sum	1	R 3,000.00	R 3,000.00
(j) Plant	Sum	1	R 3,000.00	R 3,000.00
Other Fixed-Charge Items	Sum	1	R 3,000.00	R 3,000.00
Removal of Site Establishment	Sum	1	R 1,800.00	R 1,800.00
SCHEDULED TIME-RELATED ITEMS				R 0.00
Contractual Requirements	Sum	1	R 150,000.00	R 150,000.00
Operation and Maintenance of Facilities on Site, for Duration of Construction, except where Otherwise Stated				
Facilities for the Engineer	Sum	1	R 16,000.00	R 16,000.00
(a) Furnished office	Sum	1	R 1,000.00	R 1,000.00
(b) Telephone	Not Req			R 0.00
(c) Name boards	Nr	1	R 600.00	R 600.00
Facilities for the Contractor				R 0.00
(a) Offices and Storage Sheds	Sum	1	R 600.00	R 600.00
(b) Workshops	Sum	1	R 600.00	R 600.00
(c) Laboratories	Not Req			R 0.00
(d) Living accommodation	Sum	1	R 600.00	R 600.00
(e) Ablution and latrine facilities	Sum	1	R 3,000.00	R 3,000.00
(f) Tools and equipment	Sum	1	R 1,500.00	R 1,500.00
(g) Water supply, electric power and communications	Sum	1	R 3,000.00	R 3,000.00
(h) Dealing with water	Sum	1	R 3,000.00	R 3,000.00
(i) Access	Sum	1	R 1,000.00	R 1,000.00
(j) Plant	Sum	1	R 1,000.00	R 1,000.00

REPLACE PIPELINE FROM ROMANSKOLK TO BRANDVLEI				
DESCRIPTION	**UNIT**	**QUANT.**	**TARIFF**	**AMOUNT**
Supervision For the Duration of The Contract	Sum	1	R 150,000.00	R 150,000.00
Company Head Office Overhead Costs for the duration of the contract	Sum	1	R 50,000.00	R 50,000.00
SUMS STATED PROVISIONALLY BY THE ENGINEER				
(a) For work to be executed by the Contractor and valued in terms of the "valuation of variations" Clause in the Conditions of Contract	Sum	1	R 550,000.00	R 550,000.00
Existing Services				
(a) Excavate by hand in soft material to expose existing water mains	M^3	20	R 140.00	R 2,800.00
Setting Out in accordance with PSA5.1.1	Sum	1	R 25,000.00	R 25,000.00
SECTION B: PIPELINE				
SCHEDULED ITEMS: PROVISIONAL				
Clear site along pipeline route in terms of PSC5.1	M^2	60,000	R 1.50	R 90,000.00
Excavate in all materials for trenches, backfill, compact and dispose of surplus material in terms of PSD8.3.2 for				
(a) All pipes not exceeding 1.0 metre in depth	M	35,000	R 48.00	R 1,680,000.00
(b) All pipes exceeding 1.0 m but not exceeding 2.0 m in depth	M	5000	R 50.00	R 250,000.00
Extra Over Items 1.2.1,to 1.2.2 for excavation in intermediate material	M^3	2500	R 20.00	R 50,000.00
Extra Over Item 1.2.1, to 1.2.2 for excavation in hard rock.	M^3	800	R 380.00	R 304,000.00
Excavation Ancillaries (Provisional)				
Imported backfill material from non-commercial sources.	M^3	500	R 28.00	R 14,000.00
Compaction in road reserves	M^3	50	R 26.00	R 1,300.00
Overhaul (Provisional)				
(a) Short haul	M^3	150	R 18.00	R 2,700.00
(b) Truck haul	M^3	150	R 28.00	R 4,200.00
PIPELINE				
Supply, Deliver, lay, cut, join, bed, test and sterilise				
160mm dia. Class 6 mPVC pipe	M	40,000	R 36.00	R 1,440,000.00
75mm dia Class 9 mPVC pipe	M	50	R 18.00	R 900.00
Supply and fit 160mm dia. PVC fittings to suit mPVC pipe to withstand working pressure of 9 bar				
90^0 x 160 mm Elbows including one coupling each	No	15	R 204.00	R 3,060.00
160 x 160 x 160 Equal Tee pieces	No	15	R 335.00	R 5,025.00
Cut into existing AC pipe and fit 160 x 160x160 C.I. plain ended Tee piece	No	15	R 1,118.00	R 16,770.00
75 mm AC to PVC adaptor	No	10	R 120.00	R 1,200.00
110 x 75 PVC spigot and socket reducer	No	10	R 168.00	R 1,680.00
90° x 75 mm PVC Bends	No	10	R 145.00	R 1,450.00
Special fittings	No	10	R 1,280.00	R 12,800.00
160 PVC to 150 mm AC adaptor	No	10	R 120.00	R 1,200.00
AIR RELEASE-VALVE UNITS				R 0.00
Supply, Deliver, Drill, thread and fit the following items.				
160mm, PVC saddle, drilled and threaded for 25mm outlet. Unit shall withstand working pressure of 9 bar	No	45	R 60.00	R 2,700.00
50 mm Ditto	No	45	R 39.00	R 1,755.00
25mm Full bore ball cock isolators, to withstand 9 bar working pressure	No	45	R 56.00	R 2,520.00

REPLACE PIPELINE FROM ROMANSKOLK TO BRANDVLEI				
DESCRIPTION	**UNIT**	**QUANT.**	**TARIFF**	**AMOUNT**
25mm barrel nipple, to withstand 9 bar working pressure	No	45	R 4.00	R 180.00
Model 025 RBX 2511 PN25 VENT-O-MAT air release valve	No	45	R 3,012.00	R 135,540.00
SCOUR-VALVE UNITS				
Supply, Deliver and Install the Following Items				
160mm X 75mm X 110mm, dia. unequal galvanized steel plain ended Tee, with 75mm flanged and drilled outlet.	No	40	R 1,500.00	R 60,000.00
80mm SABS Class 25 Waterworks Pattern Flanged Gate Valve with top cap for Spindle. Spindle to be left hand closing and non rising spindles and drilled Flanges	No	40	R 1,790.00	R 71,600.00
75mm Flanged adapter with flange drilled to Table SABS 1600/3	No	80	R 154.00	R 12,320.00
CHECK-VALVES				
Supply and fit, 100 mm SABS 144 Class 16 single door swing check valve, with flanged ends and door position indicators	No	3	R 1,412.00	R 4,236.00
SPECIAL FITTINGS				
Flanged adapters for 150mm gate valve to 150mm AC plain ended pipe.	No	25	R 800.00	R 20,000.00
Flanged adapters for 80 mm gate valve :				
to 75 mm class 9 mPVC plain ended pipe.	No	10	R 147.00	R 1,470.00
50 mm x 500 mm long galv. Flanged Spacer piece	No	10	R 335.00	R 3,350.00
75 mm x 150 mm long flanged Spacer pipe	No	10	R 325.00	R 3,250.00
50 mm X 75 mm galv. Flanged reducer	No	10	R 276.00	R 2,760.00
75 mm x 50 mm galv. reducing bush	No	10	R 26.00	R 260.00
50 mm x 200 mm long galv. Pipe threaded both ends	No	10	R 34.00	R 340.00
50 mm galv. Flange with pipe thread	No	10	R 64.00	R 640.00
50 mm x 75 mm galv. Flanged reducer	No	10	R 366.00	R 3,660.00
GATE/SLUICE VALVES				
Supply, Deliver and install 150 mm Class 25 DOWNRIGHT Flanged Gate valve with non-rising spindle and left hand closing mechanism to SABS 664	No	8	R 5,500.00	R 44,000.00
VALVE CHAMBERS				
Build Air Valve chamber, complete, with 50mm galv. vent pipe	No	45	R 6,817.00	R 306,765.00
Build Sluice Valve chamber	No	8	R 5,600.00	R 44,800.00
Build Check Valve chamber	No	3	R 3,433.00	R 10,299.00
Build Scour Valve chamber	No	40	R 3,600.00	R 144,000.00
Locking bars	No	104	R 383.00	R 39,832.00
Supply and deliver brass padlock with 8 mm shank	No	104	R 102.00	R 10,608.00
PIPELINE MARKERS				
Supply and install pipeline markers	No	100	R 60.00	R 6,000.00
STEEL STRAPS				R 0.00
Supply, fit and tighten firmly, mild steel straps, bolts and nuts	Sets	15	R 300.00	R 4,500.00
Clear up surplus material and cart away from the site.	Sum	1	R 6,000.00	R 6,000.00
Level surplus soil from excavations on site, cart away surplus rock from excavations to spoil heaps and leave the site in a neat condition:	Sum	1	R 15,000.00	R 15,000.00
Cast concrete anchor blocks at Bends, Elbows. Tees etc	M^3	15	R 1,836.00	R 27,540.00
Sub Total A				**R 6,334,310.00**

REPLACE PIPELINE FROM ROMANSKOLK TO BRANDVLEI				
DESCRIPTION	**UNIT**	**QUANT.**	**TARIFF**	**AMOUNT**
Engineering design	%	10		R 633,431.00
Project management and supervision	%	10		R 633,431.00
EIA	Sum			R 100,000.00
Sub Total B				**R 7,701,172.00**
VAT				R 886,803.40
TOTAL				**R 8,587,975.40**

CONVERT ROMANSKOLK WELLFIELD TO SOLAR ENERGY PUMPS				
DESCRIPTION	**UNIT**	**QUANT.**	**TARIFF**	**AMOUNT**
New Borehole pumps	No	10	R 38,000.00	R 380,000.00
Solar electricity supply	No	10	R 75,000.00	R 750,000.00
Pump houses	No	5	R 35,000.00	R 175,000.00
New Pipelines	M	1,000	R 250.00	R 250,000.00
Ancillary works	No	5	R 50,000.00	R 250,000.00
Loggers	No	5	R 30,000.00	R 150,000.00
Sub Total A				**R 1,955,000.00**
Engineering design	%	10		R 195,500.00
Project management and supervision	%	10		R 195,500.00
Sub Total B				**R 2,346,000.00**
VAT	%	14		R 328,440.00
Total				**R 2,674,440.00**

ESKOM ELECTRICITY SUPPLY TO BOREHOLES (THREE PHASE LINE)				
DESCRIPTION	**UNIT**	**QUANT.**	**TARIFF**	**AMOUNT**
Romanskolk three phase line including transformers	Km	42	R 100,000.00	R 4,200,000.00
Connections to boreholes	Km	1	R 100,000.00	R 100,000.00
Sub Total A				**R 4,300,000.00**
Engineering design	%	10		R 430,000.00
Project management and supervision	%	10		R 430,000.00
EIA	Sum			R 60,000.00
Sub Total B				**R 5,220,000.00**
VAT	%	14		R 730,800.00
TOTAL				**R 5,950,800.00**

DESALINATION IN BRANDVLEI				
DESCRIPTION	**UNIT**	**QUANT.**	**TARIFF**	**AMOUNT**
RO PLANT				
Average daily water demand of town	L	466,667		
Average water demand per hour	l/h	19,444		
Production of RO unit (12 hr day)	l/h	38,889		
	l/s	11		
Raw water required	l/h	55,556		
Raw water required	l/d	666,667		
Waste as brine	l/h	16,667		
Waste as brine	l/d	200,000		
Unit cost of plant	R/l/h	100		
Total cost of RO plant	No	1	R 3,888,888.89	R 3,888,888.89
Housing of Plant	No			R 250,000.00
Ancillary works	Sum			R 150,000.00
Sub Total 1A				**R 4,288,888.89**
Engineering design	%	10		R 428,888.89
Project management and supervision	%	10		R 428,888.89
EIA	Sum			R 60,000.00
Sub Total 1B				**R 5,206,666.67**
VAT	%	14		R 728,933.33
Total 1				**R 5,935,600.00**
EVAPORATION POND				
Daily brine disposal	m^3	200		
Evaporation Factor	mm/year	2,400		
Evaporation Factor	m/d	0.006575		
Area of pond	m^2	30,417		
Engineering seal	m^2	4,345		
Cost of seal	m^2		R 150.00	R 651,785.71
Excavation and trimmings	m^3	3,342	R 50.00	R 167,124.54
Contingencies	Sum	1	R 60,000.00	R 60,000.00
Sub Total 2A				**R 878,910.26**
Engineering design	%	10		R 87,891.03
Project management and supervision	%	10		R 87,891.03
Sub Total 2B				**R 1,054,692.31**
VAT	%	14		R 147,656.92
Total 2				**R 1,202,349.23**
EQUIPMENT OF BOREHOLES AND PIPELINES				
Borehole yield	l/s	8		
Cost of pump	No	2	R 90,000.00	R 180,000.00
Ancillary costs	No	2	R 60,000.00	R 120,000.00
Pipelines	m	1,000	R 250.00	R 250,000.00
Contingencies	Sum			R 50,000.00

DESALINATION IN BRANDVLEI				
DESCRIPTION	**UNIT**	**QUANT.**	**TARIFF**	**AMOUNT**
Pump Houses	No	2	R 35,000.00	R 70,000.00
Electricity supply	Sum			R 200,000.00
Data loggers	No	2	R 30,000.00	R 60,000.00
Sub Total 3A				**R 930,000.00**
Engineering design	%	10		R 93,000.00
Project management and supervision	%	10		R 93,000.00
Test pumping of three boreholes and down-hole camera surveys	BH	3	R 25,000.00	R 75,000.00
Geohydrological consultant	Sum	1	R 80,000.00	R 80,000.00
Sub Total 3B				**R 1,271,000.00**
VAT	%	14		R 177,940.00
Total 3				**R 1,448,940.00**
GRAND TOTAL DESALINATION				**R 8,586,889.23**

FEASIBILITY STUDY: BRANDVLEI WATER SUPPLY
PRELIMINARY COSTING

BRANDVLEI OPTION 1: UPGRADE/REPLACEMENT OF ROMANSKOLK SYSTEM WITH SOLAR ENERGY

COSTS IN MILLION RAND
SUPPLY IN MILLION CUBIC METERS PER YEAR

Components

Scheme yield 0.170 Mm^3/a

CAPITAL COST COMPONENTS	CIVIL	MECH	ELEC	TOTAL	COST FACTOR
PIPELINE PAN	0.16	0.89		1.05	1.00
REPLACE OLD PIPELINE	1.16	6.55		7.70	1.00
SOLAR ENERGY PUMPS	0.35	1.99		2.35	1.00
				0.00	1.00
				0.00	1.00
					1.00
					1.00
TOTAL COSTS	1.66	9.43	0.00	11.10	

ANNUAL COST COMPONENTS		TOTAL	COST FACTOR
MAINTENANCE			
(0.25% Civil)	0.004		
(4% Mech & Elec)	0.377	0.381	1.00
ELECTRICITY		0	
TREATMENT		0	
DISPOSE OF SLUDGE		0	
SALARIES		0.015	
		0.396	

CALEN YEAR	YEAR	WATER REQUIREMENTS Total Mcm	Increm. Mcm	SUPPLY	CAPITAL COSTS	Maint. Costs	Elec. Costs	Overhaul Costs	Treatment Costs	Sludge Costs	Salaries Costs
	0		0.00	0.00	3.70						
	1		0.00	0.00	3.70						
	2		0.00	0.00	3.70						
	3		0.43	0.17	0	0.381	0		0	0.00	0.015
	4		0.43	0.17	0	0.381	0		0	0.00	0.015
	5		0.43	0.17	0	0.381	0		0	0.00	0.015
	6		0.43	0.17	0	0.381	0		0	0.00	0.015
	7		0.43	0.17	0	0.381	0		0	0.00	0.015
	8		0.43	0.17	0	0.381	0		0	0.00	0.015
	9		0.43	0.17	0	0.381	0		0	0.00	0.015
	10		0.43	0.17	0	0.381	0		0	0.00	0.015
	11		0.43	0.17	0	0.381	0		0	0.00	0.015
	12		0.43	0.17	0	0.381	0		0	0.00	0.015
	13		0.43	0.17	0	0.381	0		0	0.00	0.015
	14		0.43	0.17	0	0.381	0		0	0.00	0.015
	15		0.43	0.17	0	0.381	0		0	0.00	0.015
	16		0.43	0.17	0	0.381	0		0	0.00	0.015
	17		0.43	0.17	0	0.381	0		0	0.00	0.015
	18		0.43	0.17	0	0.381	0		0	0.00	0.015
	19		0.43	0.17	0	0.381	0		0	0.00	0.015
	20		0.43	0.17	0	0.381	0		0	0.00	0.015

		SUPPLY	CAPITAL COSTS	Maint. Costs	Elec. Costs	Overhaul Costs	Treatment Costs	Sludge Costs	Salaries Costs
PRESENT VALUE @	**6.00%**	1.55	9.89	4.13	0.00	0.00	0.00	0.00	0.18
			UNIT REFERENCE VALUE =				**9.16**	(R/m^3)	
PRESENT VALUE @	3.00%	2.15	10.46	5.25	0.00	0.00	0.00	0.00	0.21
			UNIT REFERENCE VALUE =				7.42	(R/m^3)	
PRESENT VALUE @	9.00%	1.15	9.36	3.34	0.00	0.00	0.00	0.00	0.13
			UNIT REFERENCE VALUE =				11.14	(R/m^3)	

UNIT COST OF WATER

FIXED COST		
Interest and capital repayment @ 17.5% per annum :		
a) Civil Infrastructure - 20 year period		
(1.66)	0.303	
b) Mech./Elec equipment - 15 year period		
(9.4331)	1.812	2.115
OPERATING COST		
a) Maintenance :		
i. Civil works (0,25%)	0.004	
ii. Mech./Elec. (4%)	0.377	
b) Energy costs	0.015	0.396
TOTAL ANNUAL COST		2.512

UNIT COST OF WATER (R/m^3) : 14.74
OPERATING COST ONLY (R/m^3): 2.33

FEASIBILITY STUDY: BRANDVLEI WATER SUPPLY
PRELIMINARY COSTING

BRANDVLEI OPTION 2: UPGRADE/REPLACEMENT OF ROMANSKOLK SYSTEM WITH ESKOM POWER

COSTS IN MILLION RAND
SUPPLY IN MILLION CUBIC METERS PER YEAR

Components

Scheme yield 0.170 Mm3/a

CAPITAL COST COMPONENTS	CIVIL	MECH	ELEC	TOTAL	COST FACTOR
PIPELINE PAN	0.16	0.89		1.05	1.00
REPLACE OLD PIPELINE	1.16	6.55		7.70	1.00
ESKOM POWER LINE	0.78		4.44	5.22	1.00
				0.00	1.00
				0.00	1.00
					1.00
					1.00
TOTAL COSTS	2.10	7.44	4.44	13.97	

ANNUAL COST COMPONENTS			TOTAL	COST FACTOR
MAINTENANCE				
(0.25% Civil)		0.005		
(4% Mech & Elec)		0.475	0.480	1.00
ELECTRICITY	(R0.70/k?)		0.1193185	
TREATMENT			0	
DISPOSE OF SLUDGE			0	
SALARIES			0.04	
			0.640	

CALC YEAR	YEAR	WATER REQUIREMENTS Total Mcm	Increm. Mcm	SUPPLY	CAPITAL COSTS	Maint. Costs	Elec. Costs	Overhaul Costs	Treatment Costs	Sludge Costs	Salaries Costs
	0		0.00	0.00	4.66						
	1		0.00	0.00	4.66						
	2		0.00	0.00	4.66						
	3		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	4		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	5		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	6		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	7		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	8		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	9		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	10		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	11		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	12		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	13		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	14		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	15		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	16		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	17		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	18		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	19		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
	20		0.43	0.17	0	0.480	0.11932		0	0.00	0.040
PRESENT VALUE @		6.00%		1.55	12.45	5.20	1.29	0.00	0.00	0.00	0.43
					UNIT REFERENCE VALUE =				**12.60**	(R/m^3)	
PRESENT VALUE @		3.00%		2.15	13.17	6.61	1.64	0.00	0.00	0.00	0.55
					UNIT REFERENCE VALUE =				**10.24**	(R/m^3)	
PRESENT VALUE @		9.00%		1.15	11.79	4.21	1.04	0.00	0.00	0.00	0.35
					UNIT REFERENCE VALUE =				**15.09**	(R/m^3)	

UNIT COST OF WATER

FIXED COST		
Interest and capital repayment @ 17,5% per annum :		
a) Civil Infrastructure - 20 year period		
(2.10)	0.362	
b) Mech./Elec equipment - 15 year period		
(11.88)	2.281	2.663
OPERATING COST		
a) Maintenance :		
i. Civil works (0,25%)	0.005	
ii. Mech./Elec. (4%)	0.475	
b) Energy costs	0.159	0.640
TOTAL ANNUAL COST		3.303

UNIT COST OF WATER (R/m³) : 19.38

OPERATING COST ONLY (R/m³): 3.75

FEASIBILITY STUDY: BRANDVLEI WATER SUPPLY
PRELIMINARY COSTING

BRANDVLEI OPTION 3: DESALINATION IN BRANDVLEI

COSTS IN MILLION RAND
SUPPLY IN MILLION CUBIC METERS PER YEAR

Components

Scheme yield 0.170 Mm^3/a

CAPITAL COST COMPONENTS	CIVIL	MECH	ELEC	TOTAL	COST FACTOR
RO PLANT	0.76	4.43		1.05	1.00
BOREHOLES	0.19	1.08		7.70	1.00
EVAPORATION POND	0.16	0.90		2.35	1.00
				0.00	1.00
				0.00	1.00
					1.00
					1.00
TOTAL COSTS	1.13	6.40	0.00	11.10	

ANNUAL COST COMPONENTS			TOTAL	COST FACTOR
MAINTENANCE				
(0.25% Civil)		0.003		
(4% Mech & Elec)		0.256	0.259	1.00
ELECTRICITY	(R2.5/K?)		0.4261375	
TREATMENT			0	
DISPOSE OF SLUDGE			0	
SALARIES			0.015	
			0.700	

CALEN YEAR	YEAR	WATER REQUIREMENTS Total Mcm	Increm. Mcm	SUPPLY	CAPITAL COSTS	Maint. Costs	Elec. Costs	Overhaul Costs	Treatment Costs	Sludge Costs	Salaries Costs
	0		0.00	0.00	3.70						
	1		0.00	0.00	3.70						
	2		0.00	0.00	3.70						
	3		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	4		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	5		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	6		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	7		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	8		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	9		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	10		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	11		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	12		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	13		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	14		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	15		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	16		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	17		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	18		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	19		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
	20		0.43	0.17	0	0.259	0.426138		0	0.00	0.015
PRESENT VALUE @	6.00%			1.55	9.89	2.80	4.61	0.00	0.00	0.00	0.16
					UNIT REFERENCE VALUE =				**11.27**	(R/m^3)	
PRESENT VALUE @	3.00%			2.15	10.46	3.56	5.86	0.00	0.00	0.00	0.21
					UNIT REFERENCE VALUE =				**9.37**	(R/m^3)	
PRESENT VALUE @	9.00%			1.15	9.36	2.27	3.73	0.00	0.00	0.00	0.13
					UNIT REFERENCE VALUE =				**13.44**	(R/m^3)	

UNIT COST OF WATER

FIXED COST			
Interest and capital repayment @ 17,5% per annum :			
a) Civil infrastructure - 20 year period			
(1.13)	0.206		
b) Mech./Elec equipment - 15 year period			
(6.4025)	1.230	1.436	
OPERATING COST			
a) Maintenance :			
i. Civil works (0,25%)	0.003		
ii. Mech./Elec. (4%)	0.256		
b) Energy costs	0.441	0.700	
TOTAL ANNUAL COST		2.136	
		UNIT COST OF WATER (R/m^3) :	**12.53**
		OPERATING COST ONLY (R/m^3):	**4.11**

SRK Report Distribution Record

Report No. 412653/draft

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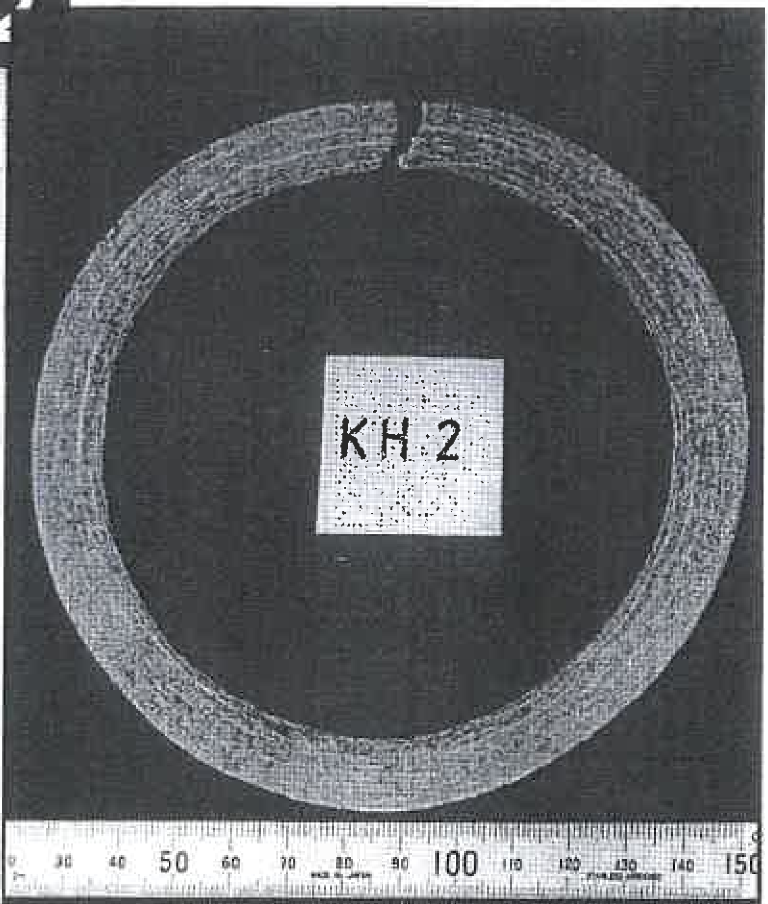
Approval Signature: ____________________

APPENDIX 6

Volume 2

AC UNDERGROUND



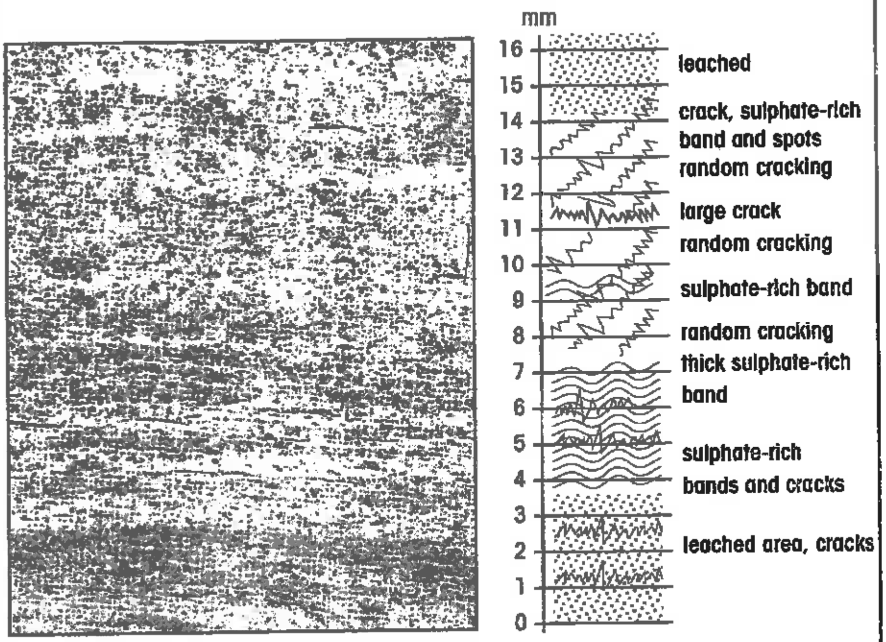
CROSS SECTION OF TYPICAL LONGITUDINAL CRACK
SHOWING HOOP STRESS

Contents:
An Update on the Influence of Slagment on Asbestos-cement pipes.

AC PIPES

Asbestos-cement pipes made with PBFC constantly meet the requirements of SABS 1223/85 and have sustained an outstanding performance over the past nine years in water reticulations countrywide. Pipes have the required strength for processing, transportation and handling during transit and installation, and are adequately matured by the time they leave the factory. The bitumen coating further enhances their durability.

Boutek and the industry are fully confident that asbestos-cement pipes made with PBFC, and in accordance with the modified process, will continue to perform satisfactorily and will be more durable than in the past.



PHOTOMICROGRAPH AND SEM EXAMINATION OF PIPE WALL

BACKGROUND LEADING UP TO THE N.B.R.I. REPORT & RECOMMENDATIONS

The asbestos-cement industry has manufactured and supplied building materials and pipes to the South African market and those of neighboring countries since the early 1940s. The Mazza manufacturing process, started in Europe in 1916, is used.

It is estimated that more than 4-million kilometres of asbestos-cement pressure pipes have been laid world-wide for conveying potable water, and over 2-million kilometres for conveying domestic sewage.

Asbestos-cement pipes for conveying potable water currently contain about 15% asbestos and 85% hydraulic binder, usually based on Portland cement, and are normally cured by immersion in water. The asbestos fibres, encapsulated in the cement, form and intrinsic part of the cement matrix and act as reinforcement.
A distinct advantage of asbestos-cement pipes is that they are made from inorganic materials, resulting in an end product with special properties, i.e. strengths with relatively low mass, and durability at low cost.

Asbestos-cement pipes have proven to be functionally reliable over many years; however, isolated cases of failure have occurred. In the case of water supply reticulations such failures have occurred after 20 to 30 years in small pipes, mainly 50, 75, 100 and 150mm diameter.

In the early 1980s this phenomenon was thoroughly investigated by the National Building Research Institute (NBRI) of the CSIR, on behalf of the South African Fibre-cement Manufacturers' Association (SAFCMA). This paper examines the findings and corrective action taken by the industry, and illustrates the success of the implementation, since 1985, of the NBRI recommendations.

COMBINATION OF TWO OR MORE PROCESSES CAUSES AC PIPE FAILURE

This investigation was very intensive, with information and samples collected from all over South Africa. The results are set out below.

Longitudinal cracking of small diameter asbestos-cement pipes occurs as a result of ***a combination of two or more*** of the following processes related to the behavior of the hydraulic binder (ordinary Portland cement, OPC), the chemical composition of the water conveyed, and the soil type:

- **Leaching of lime from the inside of the pipe.**
  The chemical stability and ultimately the durability of a Portland cement product is related to the free lime (calcium hydroxide) that is present in the product.

  Free lime, a by-product of the cement hydration process, gives stability to the hydrated calcium silicates (the cementitious compounds); if the free lime is leached out by soft or acid water, the cementitious components can decompose, resulting in weakened and unstable material, as well as reducing the pipe's effective wall thickness. Ultimately, this can lead to failure in pipes of all sizes.

- **Formation of expansive materials.**
  The breakdown of the hydrated cement compounds through the leaching process sets free sulphate ions. Some of the ions will be removed by the water being conveyed by the pipe, but others will penetrate deeper into the pipe wall towards the outside, where they will react with the hydrated cement compounds.

  The reaction of sulphate ions with calcium hydroxide and alumina between layers of asbestos-cement, forms calcium sulphate and ettringite. This causes radial expansion and places the outer circumference under hoop tension. This tension is one of the stress components which can lead to longitudinal cracking in small diameter pipes.

- **Differential distribution of water in the pipe wall.**
  Considerable stresses can result from the differential distribution of water in the pipe wall (wetter on the inside than on the outside), which can lead to differential dimensional changes.

- **Hydration of unhydrated clinker.**
  The hydration process in Portland cement does not stop after the normal factory curing of between 21 and 28 days, but can continue long afterwards in the presence of water. This results in expansion of the pipe wall which contributes to further stressing.

- **Carbonation of the outer surface layers of the pipe wall.**
  In certain well-aerated granular soils and in the presence of carbon dioxide (CO_2), carbonation of the outer surface layers can occur. Since carbonation results in shrinkage, this process can add tensile stresses to the outside surface layers.

It is highly unlikely that any one of the abovementioned processes on its own can cause a pipe failure. As indicated earlier, failure results from ***a combination of two or more processes***. It is furthermore important to realise that the number of pipe failures due to longitudinal cracking is limited.

The same phenomena may occur in large diameter pipes, but since wall thickness is directly related to diameter, the differential stresses are greatly reduced in large diameter pipes. Cracking therefore occurs mainly in small diameter pipes.

HOW ADDITION OF SLAGMENT LED TO DRAMATIC IMPROVEMENT IN PERFORMANCE OF AC PIPES

In an effort to solve the problem of longitudinal cracking, the NBRI made certain recommendations. These included modifying the composition of the hydraulic binder and adapting the manufacturing process. OPC as cementitious material was replaced by a mixture of Slagment and OPC (Portland blast-furnace cement, PBFC), in which at least 40% Slagment (ground, granulated blast-furnace slag), by mass, was used. These pipes distinguish themselves from OPC pipes in that, when they are cut through, the pipe walls have a distinct blue-green colour, as opposed to the grey colour of OPC pipes. This is due to the formation of complex iron and/or manganese sulphides. On exposure to air the sulphides oxidise rapidly, changing the colour of the wall surface to grey, similar to that of OPC pipes. The sulphides have no detrimental effect.

These modifications increase the stability of the pipe material, and reduce expansion and the likelihood of longitudinal cracking. The change in binder prevents ettringite expansion, which is the largest single contributory factor in longitudinal cracking. These solutions, as implemented by the industry since 1985, do not affect compliance with SABS specifications. The latest information on currently produced South African OPCs also indicates that they can be classed as sulphate-resisting, a factor which will further prevent stress development resulting from the formation of ettringite.

Bitumen dipping of pipes, which had been in practice in the industry before 1985, has continued in respect of all pipes installed in areas where the ground water is aggressive, or where the water being conveyed is soft. Since soft water attack can cause the development of chemical stress in asbestos-cement pipes, bitumen dipping minimises this stress component.

For pipes used in salt-bearing soils, double bitumen dipping is employed. This treatment deals effectively with damage that can be caused by salt crystallisation (not to be confused with sulphate attack). However, double dipping is unnecessary for pipes used in normal soils and those conveying potable waters in South Africa.

FURTHER APPRAISAL OF NEW GENERATION PIPES

Some 34 000 km of the new generation AC pipes of up to 150 mm diameter have been installed over the past nine years, all of which have performed exceptionally well in service. Furthermore, a 150 mm diameter new generation pipe which has been in service for 9 years, showed that the bitumen coating is still well intact and exhibited little or no hoop stress.

Despite the good performance over the past nine years of pipes made with PBFC, the industry nevertheless decided that it was in the interest of the customer as well as itself, as manufacturer and supplier of asbestos-cement pipes, to ensure that pipes manufactured in accordance with the new process do not have mechanical properties inferior to those of pipes previously manufactured. The industry therefore commissioned the CSIR's Division of Building Technology (Boutek) to:

a) establish the minimum factory maturing period that would produce asbestos-cement pipes of acceptable quality, and

b) determine the resistance to damage of PBFC pipes matured in accordance with the current maturing regime.

For this purpose Boutek determined the following properties in OPC and PBFC pipes, both types having been matured for different periods:

- bursting strength in accordance with SABS 1223/85
- crushing strength in accordance with SABS 1223/85 and recording the deformation under load during the crushing strength determinations
- unit flexural strength in accordance with SABS 1223/85
- impact resistance
- machineability and surface texture of machined surfaces
- degree of hydration
- drying shrinkage in an axial direction.

The results of the abovementioned investigation showed that, in comparision with OPC pipes, those made with PBFC have:

- higher bursting strength
- higher crushing strength
- higher flexural strength
- equal resistance to impact damage
- equal resistance to gradual point loading
- adequate machineability and are less brittle, and will therefore offer at least the same resistance to damage during processing, transportation, handling and installation as OPC pipes, which have proved to be entirely adequate for normal, accepted practice.

It was further shown that:

- pipes are already suitable for use after 10 days of maturing due to the improved curing process which involves eight days of water curing, part of which includes curing at a higher temperature
- pipes subjected to the latter maturing regime will be
  - adequately hydrated
  - adequately stable dimensionally.

The pipes fully comply with the requirements of SABS 1223/85: ***Standard Specification for Fibre-cement Pressure Pipes and Couplings.***

This paper was written by Dr. Japie Kruger and is based on the work done by the CSIR with whose permission this paper is published.

Dr. Kruger joined the National Building Research Institute (NBRI) of the CSIR in 1949 and obtained his DSc in 1976 from the University of Pretoria. He was head of the Inorganic Materials Division of the Institute from the beginning of 1981 until the end of 1987. Following the reorganisation of the CSIR he became a Project Leader/Consultant in the Building Materials Technology Programme of the Division of Building Technology which took over the functions of the NBRI. He retired in May 1994 and is since self employed as a Building Materials Science and Technology consultant.

Amongst other fields, Dr. Kruger has acknowledged experience in the use of slagment and also soft water attack of cement bonded products and helped to develop the current practice of using slagment in the production of asbestos-cement pipes.

APPENDIX 7

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210052400	858	12 Links E	U	A	2007/07/06	0	2009/06/30	105/06	200/000/00000524/00000/0000/0000
210052500	1216	12 Segels J	U	C	2012/08/24	0	2012/07/31	201107	200/000/00000525/00000/0000/0000
210052600	826	12 Julies D	U	A	2007/07/06	0	2009/06/30	105/06	200/000/00000526/00000/0000/0000
210052601	2128	12 KLAASTE A	E	C	2012/08/24	0	2012/07/31	R/B213/09	200/000/00000526/00000/0000/0000
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210052900	1482	12 Segels M	U	C	2012/08/24	0	2012/07/31	201107	200/000/00000529/00000/0000/0000
210053100	1316	12 Sass J	E	C	2011/07/20	0	2011/07/31	182/06	200/000/00000531/00000/0000/0000
210054701	1979	12 KOOPMAN JJ	E	C	2011/07/20	0	2011/07/31	200910	200/000/00000547/00000/0000/0000
210054901	2826	12 OUERS N	U	A	2012/11/28	0	2013/06/30	2012/07	200/000/00000549/00000/0000/0000
210055000	777	12 Loubser P	E	C	2010/09/28	0	2010/09/30	105/06	200/000/00000550/00000/0000/0000
210055100	781	12 Hendrikse J	U	C	2010/09/27	0	2010/09/30	105/06	200/000/00000551/00000/0000/0000

210055200	1903	12 Wiese L	P	A	2012/11/20	0	2013/06/30	2012/07	200/000/00000552/00000/0000/0000
210055301	2825	12 DE WEE M	U	A	2012/11/28	0	2013/06/30	2012/07	200/000/00000553/00000/0000/0000
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210055600	1502	12 Hesselman S	P	A	2012/11/20	0	2013/06/30	2012/07	200/000/00000556/00000/0000/0000
210056100	1521	12 Cloete J	U	A	2007/07/09	0	2009/06/30	90/07	200/000/00000561/00000/0000/0000
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210056700	2639	12 Beukes J	P	A	2012/11/20	0	2013/06/30	2012/07	200/000/00000567/00000/0000/0000
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210057310	1644	12 Olivier K	U	C	2012/08/24	0	2012/07/31	201107	200/000/00000573/00000/0000/0000
210057500	799	12 Whites M	E	C	2007/07/24	0	2007/07/31	105/06	200/000/00000575/00000/0000/0000
210108510	1645	12 Matthys P	E	C	2009/04/16	0	2009/04/30	90/07	200/000/00000575/00000/0000/0000
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210058500	1513	12 Claassen W	U	A	2007/07/09	0	2009/06/30	90/07	200/000/00000585/00000/0000/0000
210058510	1904	12 MOUTON G	P	C	2009/08/05	0	2012/07/31	2009/10	200/000/00000585/00000/0000/0000
210058900	1196	12 Verrooi J	U	A	2007/07/06	0	2009/06/30	149/06	200/000/00000589/00000/0000/0000
210059000	2879	12 Smit S	U	A	2013/01/18	0	2013/06/30	2012/07	200/000/00000590/00000/0000/0000
210059100	2792	12 Barends A	U	A	2012/08/20	0	2013/06/30	2012/07	200/000/00000591/00000/0000/0000

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2013/06/30	2012/07						
	200/000/00000596/00000/0000/0000						
210059800	819	12	Goeieman P	E	C	2011/07/20	0
2011/07/31	R/B213/09						
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210059900	1204	12	Plaatjies L	E	C	2011/07/20	0
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210060000	844	12	Goeieman K	P	A	2012/11/20	0
2013/06/30	2012/07						
	200/000/00000600/00000/0000/0000						
210060200	802	12	Syster R	U	A	2012/08/21	0
2013/06/30	2012/07						
	200/000/00000602/00000/0000/0000						
210060300	1184	12	Jase T	E	C	2011/07/20	0
2011/07/31	2009/10						
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210060400	1787	12	Bronn B	U	A	2012/08/21	0
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210060500        852                  12 Claassen N            U    C     2012/03/28     0
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210060800        850                  12 Beukes M              U    A     2007/07/06     0
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210061101        849                  12 Cloete C              U    C     2011/07/11     0
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210061300        856                  12 Wilson J              U    A     2007/07/06     0
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210061410        2646                  3 Okkies S              U    C     2012/03/28     0
2012/07/31   67/12
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210061600        1494                  0 Struis P              U    C     2007/07/24     0
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210061610        824                   0 Willemse A            U    A     2007/07/06     0
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210061700        816                  12 Syster H              U    C     2011/07/07     0
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210062000        758                  12 Januarie W            D    A     2007/07/06     0
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210062003        1905                 12 JANUARIE K            E    A     2012/08/21     0
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210062400	1224	12	Gous E	U	A	2012/08/21	0	2013/06/30	2012/07	200/000/00000624/00000/0000/0000
210062500	2117	12	Syster A	E	C	2011/07/20	0	2011/07/31	R/B213/09	200/000/00000625/00000/0000/0000
210062600	814	12	Klaaste M	U	C	2011/07/07	0	2012/07/31	201107	200/000/00000626/00000/0000/0000
210063100	846	12	Swart P	P	A	2012/11/20	0	2013/06/30	2012/07	200/000/00000631/00000/0000/0000
210063200	839	3	Van Staden J	P	A	2012/11/20	0	2013/06/30	2012/07	200/000/00000632/00000/0000/0000
210063300	859	3	Beukes SOPHIA	P	A	2012/11/20	0	2013/06/30	2012/07	200/000/00000633/00000/0000/0000
210063400	793	3	Sterkse W	P	A	2012/11/28	0	2013/06/30	2012/07	200/000/00000634/00000/0000/0000
210063500	761	12	Van Wyk J	P	A	2012/11/28	0	2013/06/30	2012/07	200/000/00000635/00000/0000/0000
210063600	2114	12	Mankapan P	U	C	2010/09/27	0	2011/06/30	2009/10	200/000/00000636/00000/0000/0000
210063700	1907	3	Isaks SAUL	P	C	2009/08/05	0	2012/07/31	2009/10	200/000/00000637/00000/0000/0000
210063710	2337	3	CLOETE M	P	A	2012/11/20	0	2013/06/30	2012/07	200/000/00000637/00000/0000/0000
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210064101	2013/06/30	1908	2012/07	3	STERKSE M	E	A	2012/08/21	0	200/000/00000641/00000/0000/0000
210064200	2013/06/30	1861	2012/07	12	Jantjies K	P	A	2012/11/28	0	200/000/00000642/00000/0000/0000
210064300	2011/07/31	815	2009/10	3	Segels H	E	C	2011/07/20	0	200/000/00000643/00000/0000/0000
210064301	2013/06/30	2824	2012/07	3	SEGELS J	P	A	2012/11/28	0	200/000/00000643/00000/0000/0000
210064600	2012/07/31	1909	2009/10	3	Gous K	U	C	2009/08/05	0	200/000/00000646/00000/0000/0000
210064700	2012/07/31	1910	R/B213/09	3	Blom S	E	C	2009/11/09	0	200/000/00000647/00000/0000/0000
210064800	2012/07/31	1205	201107	3	Snyers S E	U	C	2011/07/07	0	200/000/00000648/00000/0000/0000
210064900	2009/06/30	1522	90/07	12	Smit S	U	A	2007/07/09	0	200/000/00000649/00000/0000/0000
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210065411	2013/06/30	1862	2012/07	12	Strauss A	P	A	2012/11/21	0	200/000/00000654/00000/0000/0000
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210066700 1212 12 De Wee O U A 2007/07/06 0
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210070000	2012/07/31	845	105/06	200/000/00000700/00000/0000/0000	3 Januarie W	U	C	2009/08/05	0
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210071100	2012/07/31	843	67/12	200/000/00000711/00000/0000/0000	3 MALIQUA H	P	C	2012/03/28	0
210071200	2008/02/29	1523	90/07	200/000/00000712/00000/0000/0000	3 Van Rooy S	U	C	2008/02/26	0
210071201	2013/06/30	1784	2012/07	200/000/00000712/00000/0000/0000	3 KLAASEN F	P	A	2012/11/21	0

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210071301	1925		3 SMIT C	P	A	2012/11/21	0
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210071400	1191		12 Jansen H	E	C	2007/07/24	0
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210108010	1646		12 Scheffers W	E	A	2012/08/21	0
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210071500	789		12 Persens A	P	C	2012/04/11	0
2012/04/30	67/12	200/000/00000715/00000/0000/0000					
210071510	2648		12 PERSENS M	U	A	2012/11/21	0
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210071700	1486		3 Jaer G	U	C	2011/07/11	0
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210071800	834		12 Rosekrans S	P	A	2012/11/22	0
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210071910	2240		3 SPANGENBERG S	P	C	2010/10/25	0
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210072000	822		3 Barends J	U	C	2009/11/10	0
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30 January 2013         10:18:20
BP955                                      Indigent Report for Selected Data - Unit Seq
Page      30
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ACCOUNT-NUMBER   APPLICATION-NO   WARD SURNAME-AND-INITIALS      TYPE STATUS  STATUS-DATE
PERIOD  EXPIRY-DATE  COUNCIL-RES
                 UNIT-NO
NOTE-TYPE        USER-ID          NOTE-DATE
NOTE DESC
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TOTAL NUMBER OF DEBTORS ON REPORT =       494
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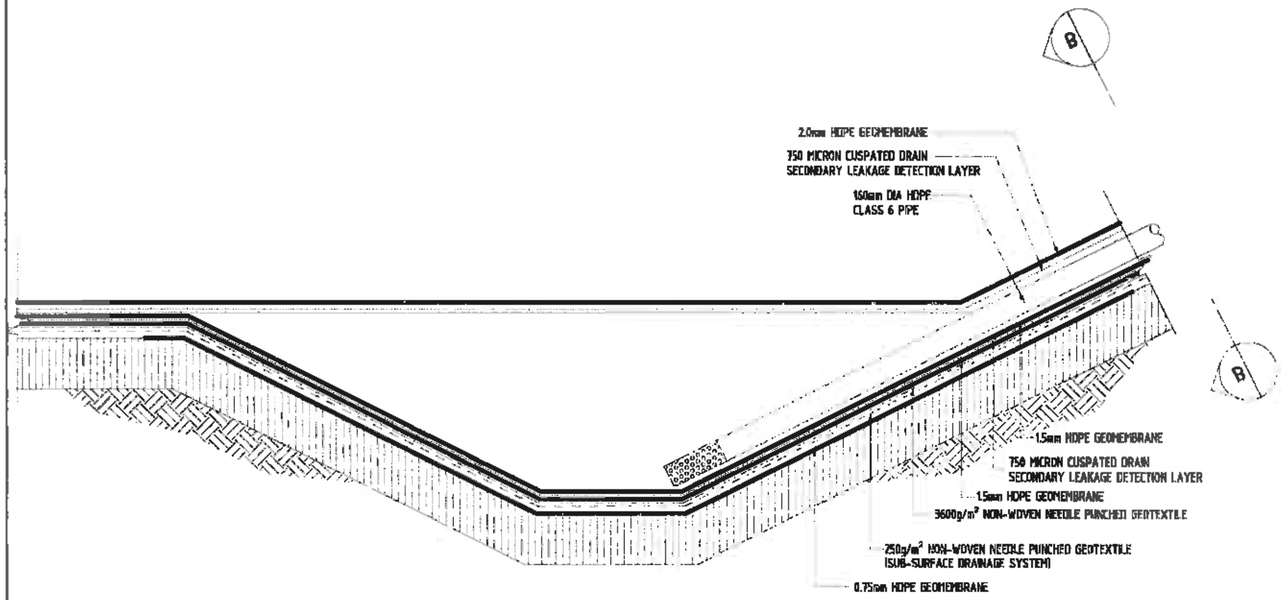
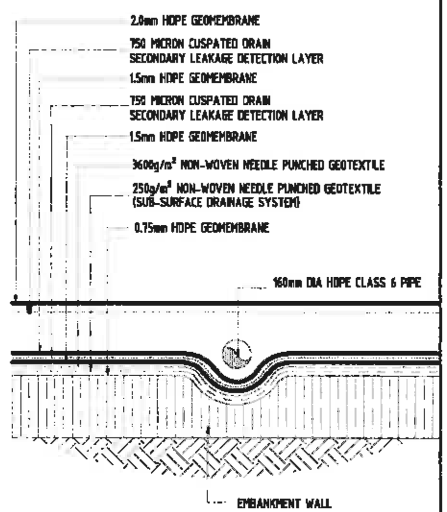
APPENDIX 8





SECTION B-B

REVISIONS		REV.
No.	DATE	BY

AQUATAN
LINING SYSTEMS

CLIENT	TITLE
-	MJ TI- IN R S.M ?) TAI S
	REF. DRG. -

DRAWN	DATE	SIGN
S. THOBALA	04/07/2008	-
CHECKED	DATE	SIGN
-	-	-
SCALE	NOT TO SCALE	-
PLEASE NOTE THAT DRAWING IS A GUIDELINE ONLY		
DWG. No.	STD 219a	

APPENDIX 9

Evaluation Criteria for Implementation Readiness Study: Brandvlei BWS

	CRITERIA	COMMENTS - 25/2/2013
1	**Strategic & Planning Issues**	
1.1	In line with Water Services Development Plan and Integrated Development Plan?	Not indicated
1.2	In line with Provincial Growth & Development Strategy?	Not indicated
1.3	Are other parts of the water / sanitation supply chain in place	Other parts of network is in place
1.4	Strategic importance	Augment source of supply
1.5	Do all parties agree to the need	Not indicated
1.6	Delivery targets	Not indicated
1.7	Economic growth requirements	
1.8	Water scarcity, etc.	Shortage of supplies from source over peak periods
1.9	Functional criticality of total scheme and specific components	Has to be completed in one phase
1.10	Extent of cost	R27,240,860.78 (incl Contingencies, Fees, VAT)
1.11	Available co-funding	Not indicated
2	**Social criteria:**	
2.1	number of households & people to be uplifted to basic and higher service levels	All on basic SL and above - improved supply
2.2	number of poor households to be served and the social cost (capital and operation)	2,480 persons
2.3	number of jobs to be created (temporary and permanent, by gender & age category)	Not indicated
2.4	affordability of proposed water tariffs (per service level and community)	Not indicated
2.5	contribution towards poverty eradication, social upliftment and health improvement	Improved water supply (quality & quantity)
2.6	number of associated services benefiting (e.g. schools, clinics, communal facilities)	Schools - 732 learners, boarding school/s - 56 learners, Creche - 73 learners, hospital - 6 beds, Clinic, community hall
2.7	socio-political support for the proposed development options (per development option)	Not indicated
3	**Economic criteria:**	
3.1	number of current businesses and industries to be served (by type and water use category)	Not indicated
3.2	expected economic value to be generated by the new businesses (GDP before & after) as aresult of the project	Not indicated
3.3	number of SMME's and BEE enterprises to benefit (by type & monetary value/benefit) during project and as an indirect result of the project	Not indicated
3.4	regional economic benefit from the proposed water users and their value chain integrated development objectives (socio-economic benefits, provincial growth & development objectives, IDPs and associated sector programmes like housing)	Not indicated
4	**Technical criteria:**	
4.1	Is the project part of the a Master Plan proposal	Not indicated
4.2	Appropriateness and acceptability of solution	Done
4.3	Appropriate water resource choice & adequate water allocation (confirmed / approved by DWAF WRM re choice, water license - volume, assurance & quality)	Done - licencing to be finalised
4.4	Compliance to water demand / water conservation objectives (acceptable water losses and appropriate plans to reduce / control water demand). Is a WDM / WC Strategy / Plan in place?	Not indicated
4.5	Optimal choice of bulk distribution networks (pipeline routes, pump stations and bulk storage) considering full life-cycle cost(capital, financing, operating & maintenance cost)	Provided
4.6	Proof of best suited technology (pro's and con's per option)	Not indicated
5	**Institutional criteria:**	
5.1	Do we know which institution will be the owner	Not indicated
5.2	Confidence in the capacity of the institution to implement	Not indicated
5.3	agreements on infrastructure ownership (per scheme component)	Not indicated
5.4	agreement on implementation responsibility (per scheme component)	Not indicated
5.5	proof of implementation capacity (e.g. capital expenditure over last 3 years)	Not indicated
5.6	history on past implementation quality & performance (e.g. functionality audits)	Not indicated
5.7	agreement on operating responsibilities (per scheme component)	Not indicated
5.8	proof of adequate staff numbers and skills levels (per scheme component)	Not indicated
5.9	history on water services interruptions (annual interruptions in household-days)	Not indicated
5.10	commitments for above by institutional leadership (e.g. municipal mayor and council)	Not indicated
5.11	cooperation agreements between key stakeholders	Not indicated
5.12	approval of institutional arrangements	Not indicated
5.13	cost recovery system (including policy on free basic water and non-payment)	Not indicated
5.14	water conservation and demand performance by institution	Not indicated
5.15	responsibilities & accountability	Not indicated
6	**Financial criteria:**	
6.1	available funding (grant, loan & investment)	Not indicated
6.2	funding conditions (repayment period, interest)	Not indicated
6.3	financial analysis of cost and income projections (cashflows)	Not indicated
6.4	proposed water & sanitation tariffs (R per kilolitre, per volume block, per user)	Not indicated
6.5	affordability of proposed water and sanitation tariffs (by user category)	Not indicated
6.6	financial viability and expected return on investment over expected useful life	Not indicated
6.7	financial status, performance and creditworthiness of municipality and implementing agents	Not indicated
7	**Legal criteria:**	
7.1	Has a water license with adequate allocation for all uses been approved	What is the status of the application/s
7.2	Has an environmental authorization been granted for the construction of the scheme (based on accepted environmental impact assessment and public participation process)	What is the status of the EIA
7.3	Have all land and property rights issues been addressed (land acquisition & servitudes)	Status?
8	**Sustainability criteria:** critical issues included under this criteria are	
8.1	Financial viability	Not indicated
8.2	Operating and management capacity, performance and commitment	Not indicated
8.3	Environmental and social acceptability and impact	Not indicated