VSA Leboa Consulting (Pty) Ltd

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GEOHYDROLOGICAL REPORT

Groundwater assessment study Blyde Local source.

For
BTW Consulting (Pty) Ltd.

Tubatse Municipality
Sekhukhune District
Limpopo Province

REPORT-VSALEB/PR09/134
September 2009

Author: C.J Sonnekus (Pr.Sci.Nat)

Gis prepared by: A.M. Cronje

VSA Group of Companies

EXECUTIVE SUMMARY

VSA Leboa Consulting was appointed by BTW Consulting (Pty) Ltd in July 2009 to give a **groundwater situation assessment** of the **Blyde local water source area** based on available data from the groundwater data base. The outlay of the report is based on fifteen points that were identified by the client for the assessment. The requested output format for the interpretation of results and recommendations was to be in terms of short, medium and long term use regarding groundwater as the primary source of potable water.

All available data sources were used for information. Available groundwater data for the Blyde local water source study area consisted of 79 entry points of which 6 are reservoirs or booster pumps. Pump test data used for evaluation was from 18 boreholes and chemical data for 11 boreholes. The scope of work did not include field work and the data dates back from 1997.

The villages were grouped under **11 supply clusters** due to existing information confirming the sharing of the same sources and reservoirs. The **"DWAF form D village name"** list was used in maps and tables. According to existing information the water demand should be met in 6 clusters if the pump tested boreholes listed in table 3 are equipped and working. In three clusters more existing boreholes must be pump tested as a short term solution to establish whether the demand is met before starting a development phase. The water demand of the last two clusters, Marareng and Marareng LCH, is not known. Some pump tested boreholes have no information on the chemical water quality and this should be determined.

Existing information indicates 11 boreholes with chemical results. **81% thereof is classified as ideal or good water quality**. The recommended abstraction yield for a 24hr/day pumping cycle, as determined from 18 pump testing data using the FC-method, varies from 0.04l/s (3.4m³/day) to 8l/s (691.2m³/day) with an **average of 1.3l/s (112.3m³/day).**

The **recharge** for the area was calculated as 9.7E+06m³/a, the current annual abstraction as 1.3E+06 m³/a using the information of the pump tested boreholes. For a total water balance other factors must also be considered such as baseflow, the ecological reserve, inflow and outflow over aquifer boundaries and evapotranspiration. This was not part of the scope of work and was therefore not calculated. The difference between recharge and abstraction was calculated as 8.4E+6m³/a **indicating that even with all the factors not taken in account there is still enough scope for source development.**

Management of groundwater sources and village sanitation is equally important. Delineation of borehole protection zones from certain microbial pollution sources is essential. An area, with a radius of 158m around every borehole, must be protected.

Monitoring the well field, water level, quality and abstraction must be implemented as it is an essential part of groundwater management. **Water conservation** can only be successfully implemented with a properly managed plan.

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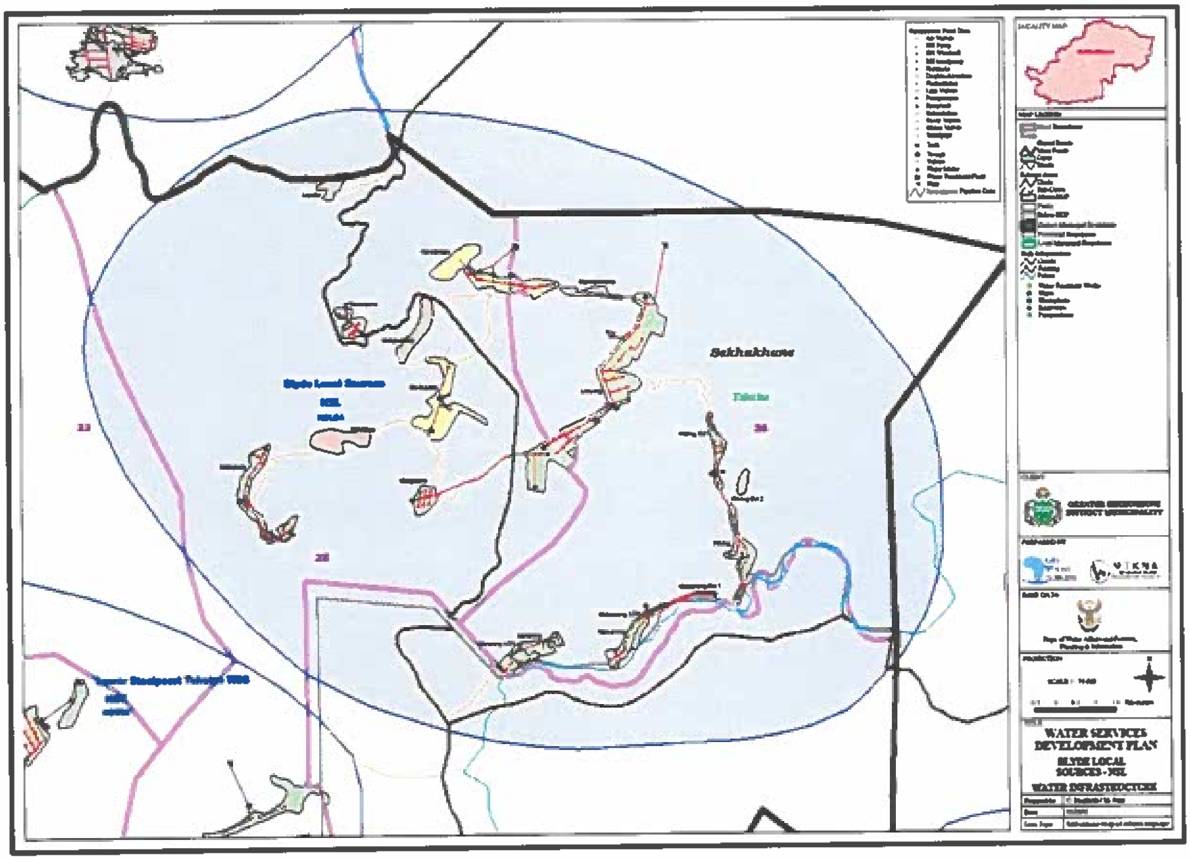
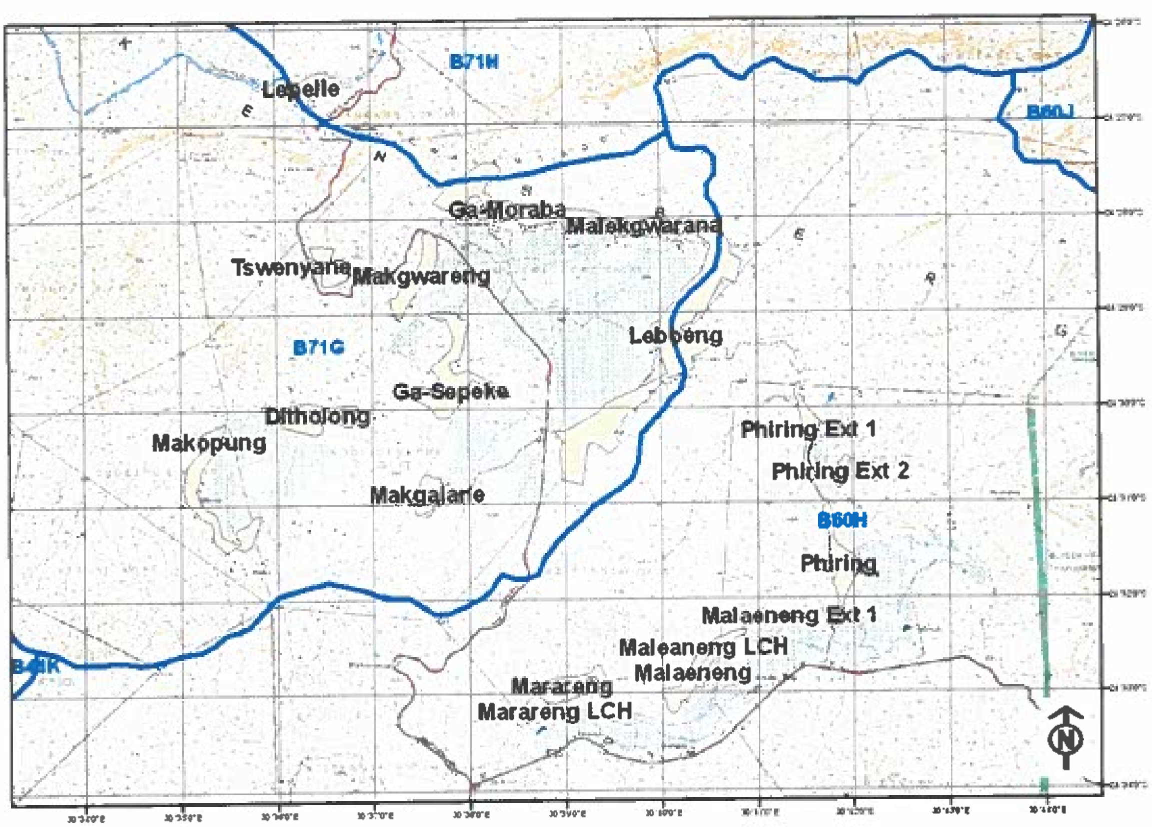


Map B: Topographical map with villages as from the DWAF form D



1 INTRODUCTION

1.1 Background:

VSA Leboa Consulting was appointed by BTW Consulting (Pty) Ltd in July 2009 to give a **groundwater situation assessment** of the **Blyde Local source area** based on available data from the groundwater data base. The outlay of the report is based on fifteen points that were identified by the client for the assessment. The requested output format for the interpretation of results and recommendations was to be in terms of short, medium and long term use regarding groundwater as the primary source of potable water.

All available data sources were used for information. Available groundwater data for the Blyde local source study area consisted of 79 entry points of which 6 are reservoirs or booster pumps. Testing data used for evaluation was from 18 boreholes and chemical data for 11 boreholes.

1.2 Scope of work:

The report outlay was pre-described by the client as discussed in the background. In addition to these, more points were included. To address the short, medium and long term use effectively, it was summarized under heading 18 'assessment of groundwater sources, short, medium ad long term'. Other additional points that were discussed are physiography with sub-headings topography and drainage, climate and rainfall, vegetation, sensitive habitats and the riparian vegetation. Under the pre-determined heading, identification of poor borehole sitting the correct approach to developing production boreholes was given. This was done as the existing borehole positions were not evaluated in the field to determine the proximity thereof relating to geological lineaments and possible pollution sources.

This report was kept as short as possible and does not include a full groundwater model for determining the reserve, or to give a water balance for the area. **No field work was done as it was not part of the scope of work.**

1.3 Location:

The southern boundary of the study area is the Bourke's Luck road and the Ohrigstad River, the western boundary is more or less the Phiring River and in the south the Drakensberg escarpment dividing the highveld and lowveld. The area is managed by the Sekhukhune District Municipality and falls on the 1:50 000 South African topographical map sheets 2430DA and 2430BC.

Table 1: Village co-ordinates:

Village Name as per DWAF form D village list	Approximate co-ordinates WGS 84		Alternative village name or spelling from information received
	Latitude	Longitude	
Ditholong	24° 30' 07.2"S	30° 36' 18.0"E	
Ga-Moraba	24° 27' 54.0"S	30° 38' 24.0"E	
Ga-Sepeke	24° 29' 42.0"S	30° 37' 44.4"E	
Leboeng	24° 29' 38.4"S	30° 40' 04.8"E	Rusteng, Ga-Komane
Makgalane	24° 30' 54.0"S	30° 37' 33.6"E	
Makgwareng	24° 28' 40.8"S	30° 37' 26.4"E	
Makopung	24° 30' 36.0"S	30° 35' 13.2"E	
Malaeneng	24° 32' 45.6"S	30° 40' 19.2"E	Matshekgweng
Malaeneng Ext1	24° 32' 13.7"S	30° 41' 20.4"E	Maleaneng
Malaeneng LCH	24° 32' 45.6"S	30° 40' 26.4"E	
Malekgwareng	24° 33' 25.2"S	30° 28' 51.6"E	Malekgwarana, Ga-Nkoana
Marareng	24° 32' 56.4"S	30° 38' 56.4"E	Mapareng
Marareng LCH	24° 33' 03.6"S	30° 38' 52.8"E	
Phiring	24° 31' 40.8"S	30° 41' 49.2"E	Mohlatsengwane
Phiring Ext1	24° 30' 18.0"S	30° 41' 31.2"E	Phiring
Phiring Ext2	24° 30' 43.2"S	30° 41' 52.8"E	Lekgwareng

1.4 Existing data sources and evaluation:

All available data sources were used for this study. This includes data from the data base maintained by VSA Leboa Consulting and from the Limpopo Aquabase data base that includes historical National Groundwater Data Base data and data from the Groundwater Resource Implementation Programme (GRIP). The Aquabase database is managed and continuously being up-dated by GPM Geo-consultants under the appointment of **The Department of Water and Environment Affairs.** Various role-players in the groundwater industry committed themselves to the upkeep of this data base and all new information is handed to GPM on a regular basis. The GRIP project was a major source of data. This project was done by geo-consultants under the appointment of the Department of Water Affairs and Forestry in the period 2000-2002 when all the boreholes in the former rural areas were visited, field marked, and the status quo investigated. The data obtained from this project was verified and linked with data from the National Groundwater Data Base. The GRIP project is still continuing on a smaller scale whereby boreholes are tested in areas with poor data coverage. It must be stated that in many areas the method of marking boreholes and forwarding data to DWAF was not enforced by municipalities after 2002. The result is that although a good ground basis of data exists but it must be verified again by a hydro census if up-to-date information is needed.

2 PHYSIOGRAPHY

2.1 Topography and drainage

On the **southern part** of the study area, drainage towards the east flowing Ohrigstad River, comes from numerous south and north flowing ephemeral streams. These streams act as conduits for water from the higher areas during raining periods. In this part of the study area the Ohrigstad River forms a broad (1km) valley within the mountainous area. On the eastern side of the study area the south flowing Phiring River joins the Ohrigstad River. The valley thins out from there and the Ohrigstad River flows into a narrow gorge further to the east.

The **topography in the south** is controlled by the river and the erosion of the underlying dolomitic formation. Elevation from the river towards the surrounding mountain increases from approximately 860mamsl to 1253maml within a 1.5-2km horizontal distance. In the southern part of the study area the main feature is the broad valley formed by the Ohrigstad River within the mountainous area. The topography appears layered especially along the Abel Erasmus pass where the geology is more visible. The rugged appearance of the area is linked to the solubility differences between the calcium magnesium rich dolomite and more silica rich dolomite which is very resistant to weathering.

In the **northern part** of the study area drainage is from numerous north-east and south-west ephemeral steams through narrow steep valleys, flowing down the higher lying areas towards a broad valley where it infiltrates into the underlying dolomitic rocks. Water draining from the dolomitic aquifers in lower lying areas is observed near the Strijdom Tunnel where it flows out. This over-flow consists of Tufaceous deposits formed over a very long period. This water as well as other surface water flows into the north flowing Tswenyane River to join the east flowing Olifants River at the base of the Drakensberg Mountain range.

The **topography in the northern** part is characterized by a very broad open valley within the mountainous area. The topography is related to the geology of the area that consists of dolomitic formations. The mountains in this area slope towards the north east at a slight gradient to end in the north-east as the escarpment dividing the highveld and lowveld. The escarpment is formed by the resistant Black Reef quartzitic formation. Various steep cutting gorges related to intrusive dykes cut through the area. These gorges are mostly in a north-east to south-western direction. The weathering of the area is rugged due to the difference in solubility between the calcium magnesium rich dolomite and the silica rich dolomite.

2.2 Climate and rainfall

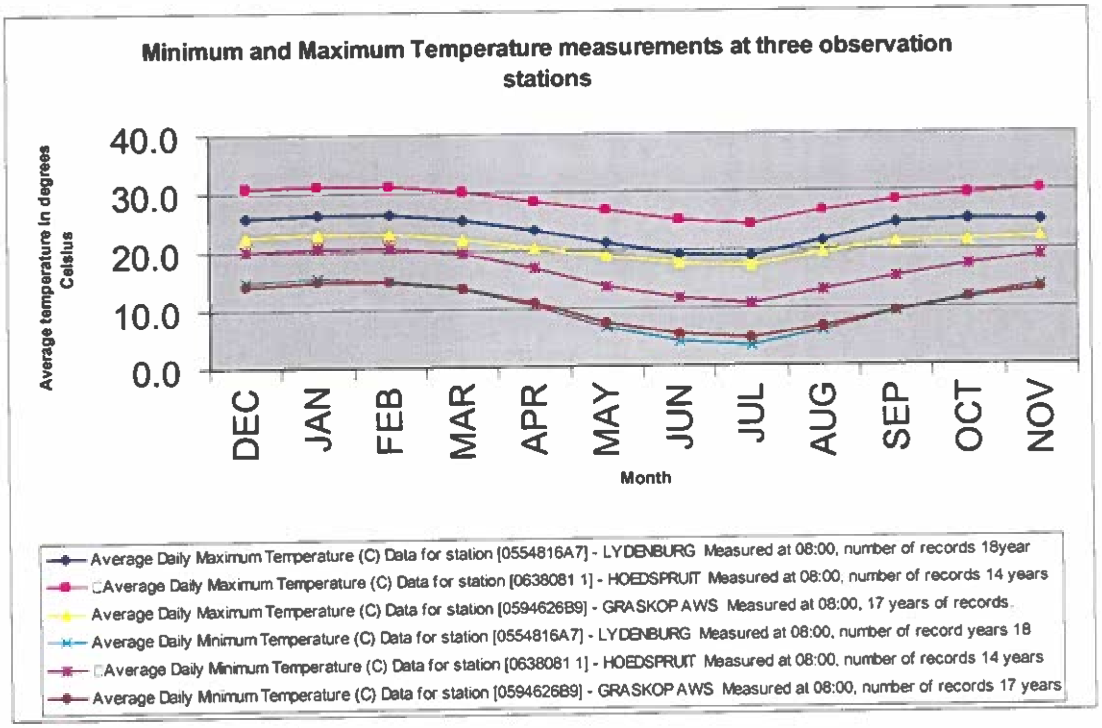


Figure 1: Minimum and Maximum Temperature measurements at three observation stations.

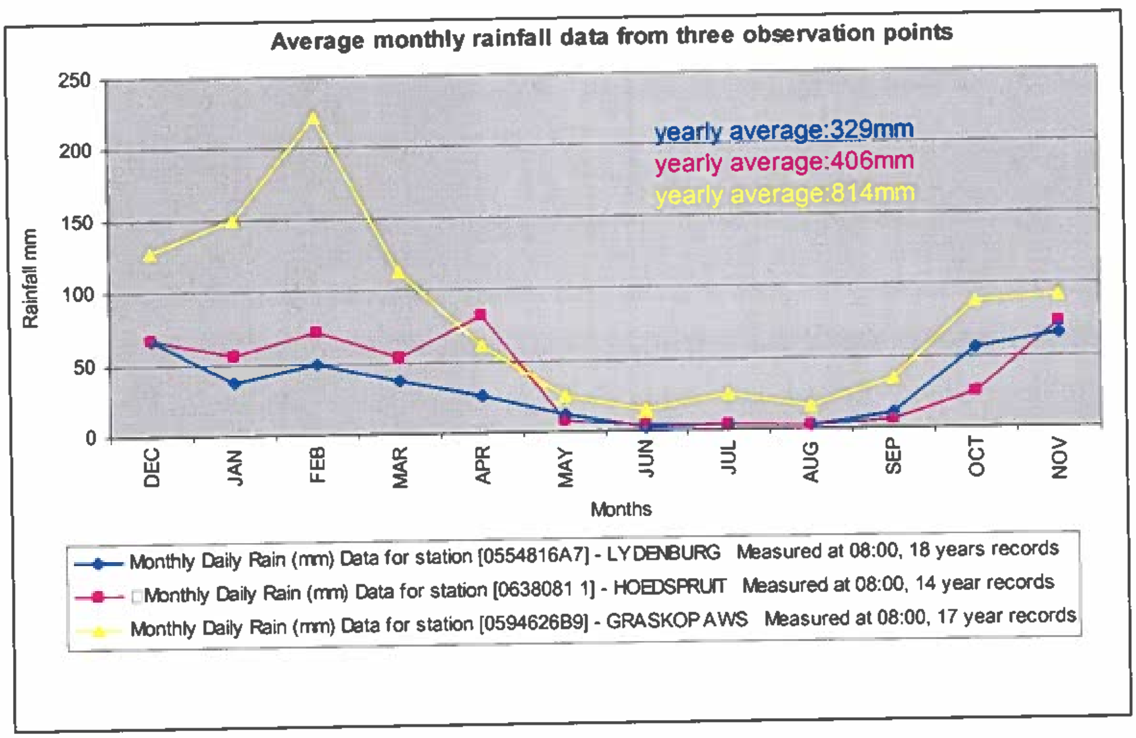


Figure 2: Average monthly rainfall data from three observation points.

Temperature data is available from three sources in the vicinity of the study area, Lydenburg, Hoedspruit and Graskop observation points. The temperature for the study area is more or less a comparison between data from Graskop and

Hoedspruit. The average summer temperature ranges from 14.5-31 degrees and the winter temperatures ranges between 5.6 and 25.2 degrees Celsius.

Rainfall data are from the same sources. These rainfall figures were compared to those indicated on the maps produced by (Vegter 1995). These maps have contoured rainfall data giving a figure of 710mm/annual in the southern part of the area up to 1372mm/a on the escarpment. **For the Blyde local area the lowest (710mm/annum) mean annual precipitation was accepted lowest, thus the most conservative according to Vegter's figures.**

2.3 Vegetation

The lower area is covered by the Sourish Mixed Bushveld vegetation unit, (vegetation type 19, Acocks 1988), forming part of the Tropical Bush and Savanna veld type. The higher lying area is covered by the North-eastern Mountain Sourveld vegetation unit, (vegetation type 8, Acocks 1988), forming part of the inland Tropical Forest veld.

2.4 Sensitive habitats

Preservation of plant species in this area, especially in the small valleys and mountainous areas, is crucial to the survival of numerous small animals and the preservation of biodiversity. These plants also prevent the degradation of the area by erosion. Another sensitive area is the well known area around the Strijdom Tunnel where some of the best preserved Tufaceous deposits in South Africa occurs. Acid rain or pollution in this area resulting in a change in pH will dissolve these deposits.

2.5 Riparian vegetation

The riparian zone comprises plant communities contiguous to and affected by surface and subsurface hydrological features of perennial or intermitted water bodies (rivers ad streams). Riparian areas have one or both of the following characteristics: 1) distinctly different vegetative species to adjacent areas, and 2) species similar to adjacent areas but exhibiting more rigorous or robust growth formation. The vegetation is dependent on the river for a number of functions including growth, temperature control, seed dispersal, seed germination and nutrient enrichment (Kemper, 2001). This vegetation comprises a distinct composition of species, often different from that of the surrounding terrestrial vegetation. Tree species are positioned according to their dependence or affinity for water, with the more water loving (mesic species) being located closest to the river channel, often with their roots in the water, and the less water loving terrestrial species further away from the river (Kemper, 2001).

Certain sections along the Ohrigstad River are more typical of the natural riparian vegetation, whilst others have been severely altered due to riparian zone degradation related to farming activities around the river and the invasion of alien plant species. The valley area surrounding the Tswenyane River is still pristine although some alien plant species occur in this valley.

3 OVERVIEW OF THE GEOLOGY OF THE AREA (REGIONAL GEOLOGY)

Information on the regional geology surrounding the study area was obtained from the 1:250 000 South African geological map series and explanatory booklet, map sheet 2430 Pilgrim's Rest, Council of Geoscience. The geological map in the report is a scanned copy of part of this map.

3.1 Pretoria group

The area is underlain by rocks of the Transvaal sequence and is mainly presented by rocks of the Chuniespoort group in the study area. The formations developed in the area include the Black Reef quartzite formation (Vbr) that occurs on the escarpment between the high-and lowveld. It is described as a fine-to medium-grained quartzite, gritty in places with pebble layers; basic lava, tuff, agglomerate and shale. This is overlain by rocks of the Malmani subgroup (Vmd) consisting of grey to greyish blue and pink, compact and poorly bedded dolomite and limestone with chert layers: lower transition zone of shale with thin, interlayered quartzite and dolomite.

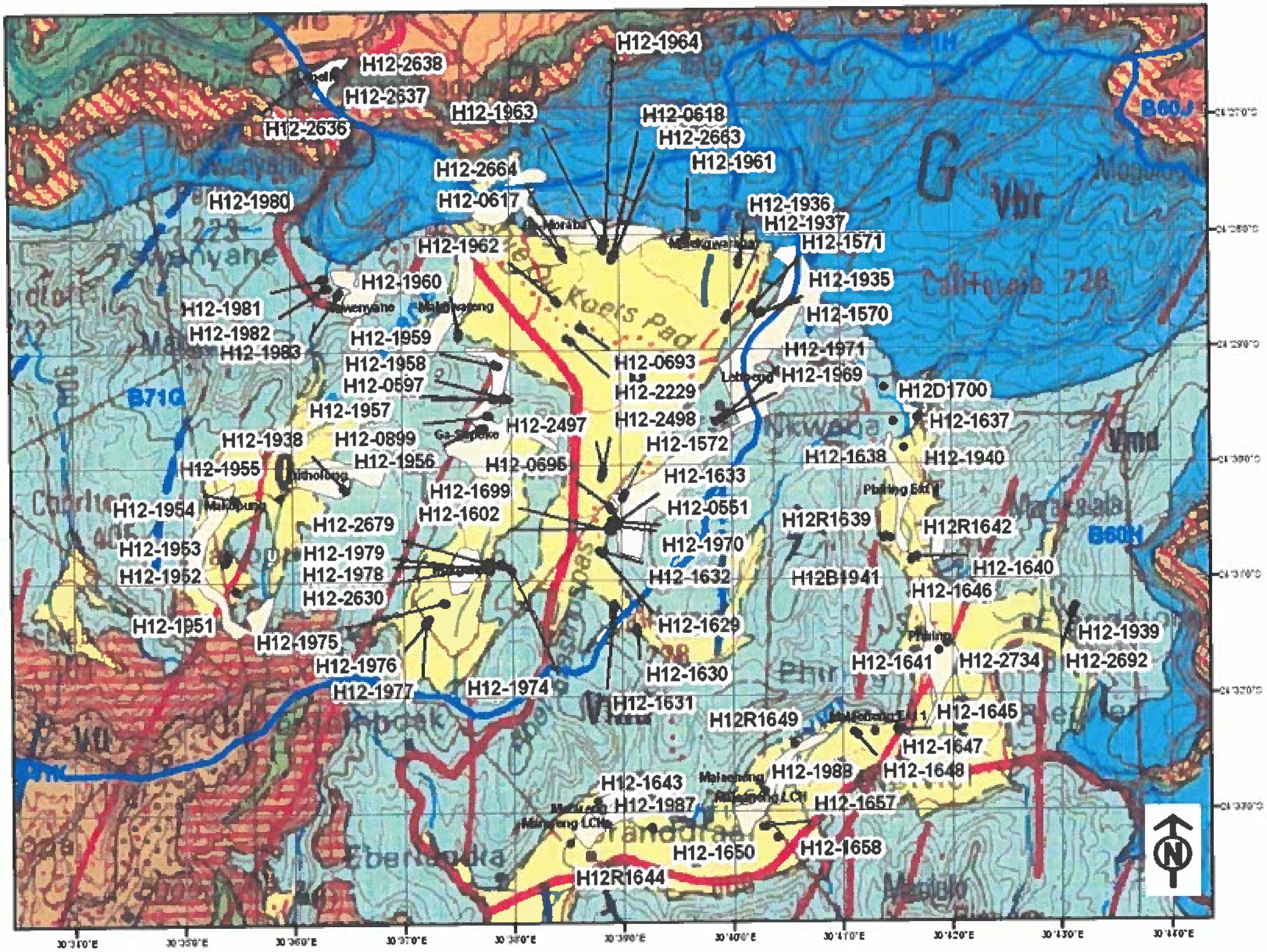
3.2 Quaternary deposits

The alluvium developed next to the Ohrigstad River and the Phiring River in the study area is recorded on drill logs to be up to 12 metres deep. It consists of clay, silt, sand, gravel and boulders. Due to the steep gradient, alluvium along the Tswenyane River consists mostly of boulders and huge rock fragments that rolled directly from the mountain side into the river bed. Quaternary deposits in the valley area in the northern part of the study area consists (from drilling logs) of a dark brown clayey soil up to 5 metres deep followed by sand and boulders to depths of up to 18metres.

3.3 Structural geology

Numerous lineaments inferred from aerial magnetic data or from field observations are plotted ton the geological map. Most prominent among these are the long continuous dykes trending slightly east of north. These dykes had an influence on the topography and drainage of this region most prominent near the escarpment where deep gorges have formed along the dyke trends. Field investigations identified these lineaments as diabase and dolerite dykes.

Map C: Regional geology and existing boreholes



DATABASE OF ABSTRACTION BOREHOLES

oreholes listed under this heading include boreholes with known yields, un-tested boreholes currently equipped and probably in use as production boreholes.

orehole lumber	Site Name	Co-ordinates WGS 84		Depth (m)	Static water level (m)	Depth to intake (m)	Pump rate (l/s)	Pump schedule (hr/day)	Abstraction (m³day)	last known equip	last known power	water quality	Comment
		Longitude	Latitude										
12-1955	Ditholong	30.598194	24.504472	48.52	27.20	30.00	0.50	24.00	43.20	N	N	Class 2	Tested
12-0617	Ga-Moraba	30.641527	24.469805	82.50	7.60	42.00	5.00	24.00	432.00	M	D	Class 0	Tested
12-2663	Ga-Moraba	30.648972	24.470277	0.00	0.00	0.00	0.00	0.00	0.00	M	D		To test
12-1571	Malekgwarana	30.669930	24.477350	44.00	29.06	39.00	0.40	24.00	34.56	M	E		Tested
12-1633	Leboeng	30.648346	24.508728	83.10	13.99	42.00	0.04	24.00	3.46	S	E	Class 1	Police station
12-1629	Leboeng	30.646680	24.512340	119.58	23.93	90.00	0.2	24.00	17.28	S	E	Class 1	Tested
12-1630	Leboeng	30.652333	24.523555	240.60	109.20	180.00	0.70	24.00	60.48	N	N	Class 0	Tested
12-2497	Leboeng	30.647444	24.501250	222.13	66.97	108.00	1.00	24.00	86.40	N	N	Class 1	Tested
12-1572	Leboeng	30.650086	24.505403	0.00	0.00	0.00	0.00	0.00	0.00	M	E		To test
12-1977	Makgalane	30.620083	24.522555	0.00	0.00	0.00	0.00	0.00	0.00	M	D		No access
12-1979	Makgalane	30.630250	24.514499	66.14	6.27	30.00	0.2	24.00	17.28	N	N		Tested
12-1960	Makgwareng / Ga Sepeke	30.625638	24.481361	41.42	27.20	36.00	2.00	24.00	172.80	H	H	Class 2	Tested
12-1951	Makopung	30.591310	24.517760	130.21	33.74	60.00	0.97	24.00	83.81	N	N		Tested
12-1658	Malaeneng	30.673348	24.553726	36.00	11.66	33.00	0.4	24.00	34.56	N	N	Class 0	Tested
12-1645	Malaeneng Ext 2	30.691682	24.538449	75.54	5.73	42.00	13.00	12.00	561.60	M	E	Class 1	Pump suction
12-1650	Mapareng	30.654458	24.552337	30.00	6.55	22.00	2.50	24.00	216.00	N	N	Class 1	Tested
12-1643	Mapareng	30.646125	24.548448	36.62	26.54	33.00	1.2	24.00	103.6	M	D	Class 1	Tested
12-1638	Phiring Ext 1	30.691404	24.494008	95.10	30.45	60.00	0.55	24.00	47.52	N	N		Tested
12-1637	Phiring Ext 1	30.695015	24.493452	59.20	18.90	54.00	0.40	24.00	34.56	M	D	Class 0	Tested
12-1640	Phiring Ext 2	30.694182	24.513729	42.04	10.56	30.00	8.00	24.00	518.40	M	E	Class 0	Tested
12-1646	Phiring Ext 2	30.693904	24.514006	60.00	10.52	24.00	4.2	24.00	518.40	N	N	Class 0	Tested
12-1980	Tswenyane	30.602890	24.467120	40.54	17.34	30.00	0.5	24.00	43.2	N	N		Tested

5 DATABASE OF MONITORING BOREHOLES

Boreholes listed under this heading form part of the Department of Water and Environmental Affairs monitoring network. A request to the Department came back with a reply that there are no boreholes within the area being monitored. Tested, low yielding boreholes can be considered for monitoring purposes.

6 AQUIFER PARAMETERS AND AQUIFER TEST DATA.

Pump testing of boreholes is the only method that provides simultaneous information on the hydraulic behaviour of the borehole, the reservoir (aquifer) and its boundaries. This information is essential for efficient aquifer and well field management. (Manual on pumping test analysis in fractured rock aquifers, 2001). Pump test data is used for two objectives, to determine the sustainable yield of a single point source and to determine aquifer parameters. For this study two aquifer parameters were reported the first is the Transmissivity (T) and the second is Storativity (S). The values for the second parameter are very small and when using analytical methods the value is affected by the distance between the observation and the pumped borehole. A numerical model is usually used to determine this value accurately and for this report an accepted default value was used.

6.1 Transmissivity (T) and Storativity (S):

Transmissivity is the product of the average hydraulic conductivity K and the saturated thickness of the aquifer D. Consequently, transmissivity is the rate of flow through a unit hydraulic gradient through a cross-section of unit width over the whole saturated thickness of the aquifer. Storativity or storage coefficient of a saturated confined aquifer of thickness D is the volume of water released from storage per unit surface area of the aquifer per unit decline in the component of hydraulic head normal to that surface. (Analysis and evaluation of pumping test data, 1994)

Table 2: Calculated aquifer parameters from available testing data using the FC method.

Blyde Local Sources			
Borehole nr.	Transmissivity $T(m^2/d)$	Storativity S	Sustainable abstraction 24hr/day pumping cycle _Q(l/s)
H12-0617	272.0	0.03	5
H12-1629	1.1	0.03	0.2
H12-1630	15.0	0.03	0.7
H12-1633	0.4	0.003	0.04
H12-1637	2.3	0.003	0.4
H12-1640	2260.0	0.03	8
H12-1643	38.0	0.003	1.2
H12-1646	1740.0	0.03	4.2
H12-1658	3.4	0.003	0.4
H12-1951	7.8	0.03	0.5
H12-1955	4.0	0.03	0.5
H12-1960	77.0	0.03	1.5
H12-1979	2.2	0.03	0.2
H12-1980	13.5	0.003	0.5
H12-2229	0.7	0.03	0.1
H12-2497	4.7	0.03	1
H12-2638	0.8	0.03	0.1
H12-2734	9.8	0.03	0.6
Geometric mean T =	10.8		Average:1.3

7 WATER CONSERVATION AND DEMAND

7.1 Water conservation

The Water Act considers groundwater as part of the larger hydrologic cycle and in a continual state of flux with surface water. Both should be seen as a linked source and managed in such a way. Sustainable development of groundwater resources refers to a holistic approach to **development, conservation and management** of these resources. Good sustainable yield estimates are the result of scientifically sound pumping test analysis. It must be noted that these quantities vary with time and location and can only be estimated, and thus may carry a degree of uncertainty. All sources of uncertainty need to be recognized and their impact on water **quality** or the **sustainability** of the aquifer must be evaluated.

Pump tests are important tools that provide information on the hydraulic behaviour of a borehole, the reservoir and the reservoir boundaries. All this information is essential for **efficient aquifer and well field management**. A further essential consideration in the development of an aquifer is the **chemical quality** of water produced, as the quality can limit its use. Groundwater movement induced by pumping may change the groundwater chemistry. The delineation of protection zones from certain microbial pollution sources are an essential part of the management plan.

Monitoring the well field, water level, quality and abstraction must be implemented, as it is an essential part of groundwater management. Water conservation can only be successfully implemented with a properly managed plan.

Table 3: Current water demand and available sources.

Village	Water demand m³/day		Recommended sources Borehole number (m³/day) and domestic chemical classification		Boreholes available for testing with potential	Comment on supply
	High	Low	Motorized	Hand pump or not equipped		
Ditholong	19.3	8.5		H12-1955 (43.2) Class 2	H12-1938	Demand is met; equip borehole
Tswenyane	48.2	21.3		H12-1980 (43.2) Class ?	H12-1981 H12-1982 H12-1983	Check chemistry; equip borehole test additional boreholes if demand is not met.
Ga-Maraba	108.4	47.8	H12-0617 (432) Class 0	H12-2229 (8.6) Class 2	H12-1962 H12-1964 H12-2663 H12-0693	Demand is met
Ga-Sepeke and Makgwareng	75.4 94.5	33.3 41.7	H12-1960 (172.8) Class 2		H12-0597	Demand is met
Leboeng or Ga-Komane or Rutseng	175.7 43.5 61.8	77.1 19.2 27.3	H12-1633 (10.3) Class 1 belongs to SAPS H12-1629 (17.2) Class 1	H12-1630 (60.4) Class 0 H12-2497 (86.4) Class 1	H12-0695 H12-1572 H12-0551 H12-1970 H12-2498 H12-1602 H12-1699	Demand in not met - need to test more boreholes
Makgalane	48.6	21.4		H12-1979 (17.2) Class ?	H12-1977 H12-1974 H12-2630	H12-1977 motorised diesel installation; to test borehole
Makopung	51	22.5		H12-1951 (83.8) Class ?	H12-1952 H12-1953 H12-1954	Check chemistry; equip borehole; demand is met.
Malaeneng and Malaeneng Ext1 and Malaeneng LCH	11.9	5.2	H12-1645 (561.6) Class 1	H12-1658 (34.5) Class 0	H12-1657 H12-1989	Demand is met

Table 2: Current water demand and available sources.

Village	Water demand m³/day		Recommended sources Borehole number (m³/day) and domestic chemical classification		Boreholes available for testing with potential	Comment on supply
	High	Low	Motorized	Hand pump or unequipped		
Malekgwareng or Ga-Nkoana	154.0	67.95	H12-1571 (34.5) Class ?		H12-1935 H12-1936 H12-1937 H12-1570	Check chemistry; test existing boreholes; Demand is not met
Marareng and Marareng LCH	?	?	H12-1643 (103.6) Class 1	H12-1650 (216) Class 1	H12-1987	Demand not known but believe that it is met
Phiring or Mohlatsengwane	54.0	23.8	H12-2734 (51.8) Class 1 belong to clinic	H12-2692 (0.7) Class ?		Information from GRIP indicates that these three villages are linked on the same supply system - demand is met
Phiring Ext1 or Phiring	43.5	19.2	H12-1637 (34.5) Class 0	H12-1638 (47.5) Class ?	H12-1940	
Phiring Ext2 or Lekwareng	15.3	6.7	H12-1640 (691.2) Class 0	H12-1646 (362.8) Class 0		
Total demand	**112.8**	**49.7**				

Note: Available abstraction calculated from the recommended 24hr/day pumping cycle.

- **Short term action**: Verify availability of borehole listed by a field survey.
- **Medium term action:** Check chemistry, rehabilitate and test boreholes where necessary, upgrade and install equipment
- **Long term action:** Drill new sources where necessary.

8 GROUNDWATER RECHARGE AND PROTECTION

8.1 Recharge

To calculate recharge the chloride method was used. The correct position to sample the chloride for these calculations is just under the water table for un-cased boreholes or just under the casing in steel cased boreholes. The values used in this calculation are from pump tests therefore they represent an average value. Eleven values from eleven different boreholes were used for the calculation of the harmonic mean. The harmonic mean was calculated to be 11mg/l.
The recharge method using the chloride concentration of the boreholes is presented by the equation:

$$RE_{av} = a.Rf_{av}$$

Where

a	= $Cl_{rainfall}/Cl_{groundwater}$ represents the recharge coefficient
RE_{av}	= average recharge
Cl	= chloride concentration
Rf_{av}	= average rainfall

Locality	Mean average rainfall (Rf) (mm/a)	$Cl_{rainfall}$ (mg/l)	$Cl_{groundwater}$ (mg/l) Harmonic mean 11 samples	Recharge Cl method % Rf	Average recharge mm/a calculated from available chemical data	Vegter (1995)
Blyde Local sources	710	1	11	9%	64.5mm/a	50-75mm/a

Table 4: Recharge values.

The rainfall in the area increases towards the escarpment from 709 to 1372.5mm/a. This information is from contoured rainfall data from the maps compiled by Vegter (1995). These maps gives contoured recharge data for the area from 25-37mm/a and 50-75mm/a. In this report it was decided to use a recharge of 64.5mm/a and an average rainfall of 710mm/a. The catchment surface area was calculated from the topographical maps and is estimated to be approximately 150km².

The recharge for the area was calculated as 9.7E+06m³/a and the current annual abstraction as 1.3E+06 m³/a based on the information from pump tested boreholes. For a total water balance other factors must also be considered such as baseflow, the ecological reserve, inflow and outflow over aquifer boundaries and evapo-transpiration. This was not part of the scope of work and was therefore not calculated.

The difference between recharge and abstraction was calculated as 8.4E+6m³/a indicating that even with all the factors not taken in account that there is still enough scope for source development.

8.2 Borehole Protection zones

Protection zone 1: Borehole construction, fencing, and infrastructure.

- For protection zone 1 (i.e. the immediate fenced area around the borehole), it is proposed that the distance of the fence around the borehole must be at least 5m. For a borehole that is supplying water in an area with a small population, (less than 20 people), a well-constructed sanitary seal (0.5-5mbgl is regarded as enough. Quality monitoring must still be done.
- The pump house and floor is also part of a protection zone 1.

In areas with a high density of pit latrines near to boreholes must be constructed correctly and fenced off. With a high number of people concentrated in such an area a risk of Nitrate pollution is possible in nearby boreholes. Pit latrines should be constructed taking local geological and geohydrological conditions in account. In practice it is usually the cheapest toilets that are installed.

Protection zone 2: Microbial (bacteria and viruses) and nitrate pollution.

- Studies have shown that bacteria usually die within 30days after being introduced into the soil. In some cases a minimum distance of 50m between a pit latrine and a borehole will be adequate as was proposed by Xu and Braune (1995).
- Boreholes located on lineaments should be treated with caution as the travel times can be fast in these fracture zones. The protection zone in these cases will not be round but stretched along the lineament strike.
- The FC method for pump test analysis makes provision for the calculation of a protection zone. The interpreter must take certain parameters into account such as the estimated clay content of the surface.

Because of the high clay content predominantly in the alluvial deposits on the Transvaal Sequence Rocks, the risk of microbial pollution in boreholes located in these areas is low.

Protection zone 3: Hazardous chemical elements.

- The FC programme can be used. The programme estimates the catchment area of the borehole by using the recharge and the abstraction rate.

To our knowledge no hazardous chemical elements are present in the study area.

Table 5: Estimated half length of main fracture and estimated protection zone using the FC method

Estimated protection zone around boreholes in the Blyde Local Sources Area			
Borehole number	**Transmissivity T(m^2/d)**	**Half length of fracture(m)**	**Protection Zone around borehole(m)**
H12-0617	180.0	126	252
H12-1629	1.1	30	60
H12-1630	15.0	118	236
H12-1633	0.4	25	50
H12-1637	2.3	26	52
H12-1640	2200.0	280	140
H12-1643	38.0	105	209
H12-1646	4.2	358	751
H12-1658	3.4	34	69
H12-1951	7.8	27	53
H12-1955	3.1	67	135
H12-1960	80.0	116	233
H12-1979	2.2	25	50
H12-1980	13.5	81	162
H12-2229	0.7	37	75
H12-2497	4.7	26	53
H12-2638	0.8	63	127
H12-2734	9.8	64	128
		Average	**158**

On average a production borehole must be 158m away from a pit latrine (protection zone)

9 GROUNDWATER USERS

The National Water Act prioritises water user groups according to importance. Decreasing in importance is basic human needs, ecological needs and then inessential uses such as economic development. The application for a water user's licence does not differentiate between users of surface or groundwater.

When using surface or groundwater for irrigation, mining, industrial or a feeding pen, the owner or appointed representative must apply for a Water User licence. Other usage that must be registered is as follows:

- Dumping of waste or water that contains waste.
- Storage of water (>than 10 000m^3) or if the full dam capacity surface area is bigger than one ha.
- Activities reducing stream flow such as forestry and power generation using water
- Irrigation using waste water and recharge of groundwater.

The National Water Act allows for relatively low water usage such as non-commercial small gardens, livestock watering (not feeding pens) if the use is not excessive in relation to the available source and needs of other users. If your water source is from local government or any other bulk supplier there is no need to register. The local government or any other bulk supplier must register.

Water users in the study area include the community for domestic and agriculture supply, clinics, schools, police stations and staff housing.

GROUNDWATER QUALITY

'ater quality of domestic water, utilized for human consumption and food preparation, must be safe to use if the consumers' health is to be protected. For this reason the *"Quality of omestic Water Supplies"* (Second edition, 1998)" was set forward by the Department of Water Affairs and Forestry, Department of Health and the Water Research Commission in)98. This document facilitates the evaluation of water on the basis of five water quality classes:

able 6: Available laboratory results on groundwater samples

orehole umber	Water class	Ph	EC	TDS	Total Hardness	P Alkalinity	Total M Alkalinity	Ion Balance Error	Major Cations (mg/l)							Major Anions (mg/l)					
									Ca	Fe	K	Mg	Mn	Na	Si	F	Cl	NO_2	NO_3 as N	PO_4 as P	SO_4
			(mS/m)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	%	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
12-0617	CLASS 0	7.39	7	66.0	17	0.6	19.9	7.88	3.0	0.05	2.2	2.3	0.05	3.9	7.5	0.1	4.44		0.49	0.8	2.39
12-1630	CLASS 0	8.79	59	348						0.05			0.05			0.1	11.4	0.2	3.4	0.8	4.8
12-1955	CLASS 2	8.26		392	425.7	0.6	327.44	11.75	74.2	0.05	0.594	58.4	0.05	17.2	14.8	0.25	9.17	0.2	3.56	0.8	13.63
12-1960	CLASS 2	8.01	82	538	426	0.6	455.4		72.2	0.05	0.5	59.7	0.05	10.0	13.4	0.25	18.05		9.42	0.8	17.35
12-2497	CLASS 1	8.73	83	534						0.3			0.07			0.3	49.5	0.2	3.3	0.8	41.6
12-2734	CLASS 1		44		255.6			0	48.3	0.05	1.44	32.8	0.05	11.9	6.4	0.19	14.78	0.2	0.84	0.8	5.5
12-1650	CLASS 1	8.5	71.2	585.48			330.86	2.56	68.05		0.44	41.48		28.61	11.33	0.26	22.94		1.77		12.33
12-1646	CLASS 0	8.16	14.5	117.49			60.29	-11.64	12.56		0.64	7.4		3.58	5.5	0.14	10		0.97		10.27
12-1640	CLASS 0	7.52	14.6	116.28			66.2	-9.59	12.64		0.56	8.1		3.19	6.54	0.13	10		0.86		4
12-1641	CLASS 1	8.32	53.6	458.04			272.14	-0.23	53.09		0.8	33.86		13.12	9.22	0.2	13.88		1.03		6.48
12-1633	CLASS 1	8.39	55.2	458.63			276.54	1.22	54.48		1.14	33.73		15.38	11.83	0.38	10		1.21		5.89

Iote: Water quality for domestic supplies: Blue- Class 0; Green- Class 1; Yellow-Class 2

Classification for domestic use;

- Hydro-chemical results of boreholes H12-0617, H12-1630, H12-1646 and H12-1640 are classified as a Class 0 for domestic use. (Ideal water quality. Suitable for lifetime use.)
- Hydro-chemical results of boreholes H12-2497, H12-2734, H12-1650, H12-1641 and H12-1633 are classified as a Class 1 for domestic use. (Good water quality. Suitable for use, rare instances of negative effects.)
- Hydro-chemical results of boreholes H12-1955 and H12-1960 are classified as a Class 2 for domestic use. (Marginal water quality-conditionally acceptable. Negative effects may occur in some sensitive groups.)

No other information is available on the chemical analysis of groundwater within the area. From the existing information it is clear that the groundwater in the area is of an ideal or good water quality. The two boreholes with poorer water quality are due to the calculated Total Hardness reported as $CaCO_3$.

11 DESCRIPTION OF GROUNDWATER MONITORING PROGRAMMES (QUALITY AND QUANTITY)

Groundwater monitoring is essential to prevent the unsustainable decline of the groundwater resource over the long term. **Useful markers for the detection thereof are groundwater level/piezometric surface and/or groundwater quality.**

Groundwater monitoring must be seen at two levels. The first is **regional monitoring** to evaluate rainfall and discharge in the catchment. The positioning of such observation points should be carefully considered taking in account geology, structural geology, existing well fields and social behaviour and future expansion of villages.

On a **local monitoring** scale part of the granting of a water user licence, landfill site or sewerage works to a municipality is a **monitoring and management plan** that the user must adhere to. Local monitoring boreholes, carefully chosen according to various parameters should be near the well field to observe the long term affect of pumping on the source. Abstraction in the well field must be monitored and adjustments can be made depending on the response of the static water table. Chemical changes must be observed in the production boreholes and the positioning of method of sanitation within the village must be controlled.

Petrol stations or bulk storage of non-aqueous phase liquids usually have a monitoring hole that must be monitored on a regular basis for leakage.

DESCRIPTION, COORDINATES AND LOCATION OF ALL POINTS

able 7: Description, co-ordinates and location of all points.

orehole Number	Site name	co-ordinates WGS 84		Depth (m)	Static water level (m)	Depth to intake (m)	Pump rate (l/s)	Pump schedule (hr/day)	Abstraction (m³day)	last known equip	last known power	water quality	Comment
		Longitude	Latitude										
12-1938	Ditholong	30.6080830	-24.5034717	0.00	0.00	0.00	0.00	0.00	0.00	H	H		No access
12-1955	Ditholong	30.5981940	-24.5044717	48.52	27.20	30.00	0.50	24.00	43.20	N	N	Class 2	Tested
12-1964	Ga-Moraba	30.6479440	-24.4680267	0.00	0.00	0.00	0.00	0.00	0.00	H	H		To test
12-2663	Ga-Moraba	30.6489720	-24.4702767	0.00	0.00	0.00	0.00	0.00	0.00	M	D		To test
12-0618	Ga-Moraba	30.6489440	-24.4701937	30.58	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1962	Ga-Moraba	30.6407000	-24.4765097	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1963	Ga-Moraba	30.6477220	-24.4690267	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-2664	Ga-Moraba	30.6414160	-24.4696377	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-2229	Ga-Moraba	30.6419400	-24.4816697	107.80	23.50	30.00	0.10	24.00	8.64	N	N	Class 2	Tested
12-0617	Ga-Moraba	30.6415270	-24.4698047	82.50	7.60	42.00	5.00	24.00	432.00	M	D	Class 0	Tested
12-0693	Ga-Moraga	30.6439500	-24.4800997	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-0597	Ga-Sepeke	30.6325000	-24.4903877	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-0899	Ga-Sepeke	30.6303050	-24.4928607	0.00	0.00	0.00	0.00	0.00	0.00	N	N		No access
12-1956	Ga-Sepeke	30.6293050	-24.4944437	0.00	0.00	0.00	0.00	0.00	0.00	N	N		Blocked
12-1957	Ga-Sepeke	30.6311666	-24.4904437	0.00	0.00	0.00	0.00	0.00	0.00	N	N		No access
12-1958	Ga-Sepeke	30.6330830	-24.4904437	0.00	0.00	0.00	0.00	0.00	0.00	N	N		Blocked
12-1959	Ga-Sepeke	30.6315550	-24.4855827	10.77	10.03	0.00	0.00	0.00	0.00	N	N		Blocked
12-0695	Leboeng	30.6486300	-24.5065297	90.00	0.00	0.00	0.00	0.00	0.00	H	H		To test
12-1572	Leboeng	30.6500862	-24.5054034	0.00	0.00	0.00	0.00	0.00	0.00	M	E		To test
12-0551	Leboeng	30.6485700	-24.5080097	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1631	Leboeng	30.6489025	-24.5201169	94.00	0.00	0.00	0.00	0.00	0.00	N	N		Dry-drill
12-1632	Leboeng	30.6466802	-24.5123396	64.00	0.00	0.00	0.00	0.00	0.00	N	N		Dry-drill
12-1969	Leboeng	30.6645830	-24.4938607	0.00	0.00	0.00	0.00	0.00	0.00	N	N		Blocked
12-1970	Leboeng	30.6487800	-24.5087297	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1971	Leboeng	30.6658610	-24.4929717	0.00	0.00	0.00	0.00	0.00	0.00	N	N		Blocked

able 4: Description, co-ordinates and location of all points.

orehole Number	Site name	co-ordinates WGS 84		Depth (m)	Static water level (m)	Depth to intake (m)	Pump rate (l/s)	Pump schedule (hr/day)	Abstraction (m^3day)	last known equip	last known power	water quality	Comment
		Longitude	Latitude										
12-2498	Leboeng	30.6469861	-24.5019507	250.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1602	Leboeng	30.6486100	-24.5091597	0.00	0.00	0.00	0.00	0.00	0.00	S	E	Class 2	To test
12-1699	Leboeng	30.6486247	-24.5095620	0.00	0.00	0.00	0.00	0.00	0.00	S	E		To test
12-1633	Leboeng	30.6483469	-24.5087288	83.10	13.99	42.00	0.04	24.00	3.46	S	E	Class 1	Tested
12-1571	Leboeng	30.6699300	-24.4773497	44.00	29.06	39.00	0.40	24.00	34.56	M	E		Tested
12-1629	Leboeng	30.6466802	-24.5123396	119.58	23.93	90.00	0.48	24.00	41.47	S	E	Class 1	Tested
12-1630	Leboeng	30.6523330	-24.5235547	240.60	109.20	180.00	0.70	24.00	60.48	N	N	Class 0	Tested
12-2497	Leboeng	30.6474440	-24.5012497	222.13	66.97	108.00	1.00	24.00	86.40	N	N	Class 1	Tested
12-1647	Malaeneng	30.6883481	-24.5387268	0.00	0.00	0.00	0.00	0.00	0.00	N	N		Blocked
12-1648	Malaeneng	30.6852925	-24.5387268	18.04	18.00	0.00	0.00	0.00	0.00	N	N		Blocked
12R1649	Malaeneng	30.6761253	-24.5403934	0.00	0.00	0.00	0.00	0.00	0.00	Z	Z		Reservoir
12-1977	Makgalane	30.6200830	-24.5225547	0.00	0.00	0.00	0.00	0.00	0.00	M	D		No access
12-1974	Makgalane	30.6329700	-24.5148097	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1975	Makgalane	30.6233330	-24.5198327	0.00	0.00	0.00	0.00	0.00	0.00	N	N		Blocked
12-1976	Makgalane	30.6207770	-24.5220827	0.00	0.00	0.00	0.00	0.00	0.00	N	N		Blocked
12-1978	Makgalane	30.6301110	-24.5150547	0.00	0.00	0.00	0.00	0.00	0.00	N	N		Blocked
12-2630	Makgalane	30.6319444	-24.5143053	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-2679	Makgalane	30.6301940	-24.5143327	0.00	0.00	0.00	0.00	0.00	0.00	N	N		Blocked
12-1979	Makgalane	30.6302500	-24.5144997	66.14	6.27	30.00	0.15	24.00	12.96	N	N		Tested
12-1960	Makgwareng	30.6256380	-24.4813607	41.42	27.20	36.00	2.00	24.00	172.80	H	H	Class 2	Tested
12-1954	Makopung	30.5915550	-24.5048047	0.00	0.00	0.00	0.00	0.00	0.00	H	H		To test
12-1952	Makopung	30.5898500	-24.5136397	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1953	Makopung	30.5899900	-24.5126197	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1951	Makopung	30.5913100	-24.5177597	130.21	33.74	60.00	0.97	24.00	83.81	N	N		Tested

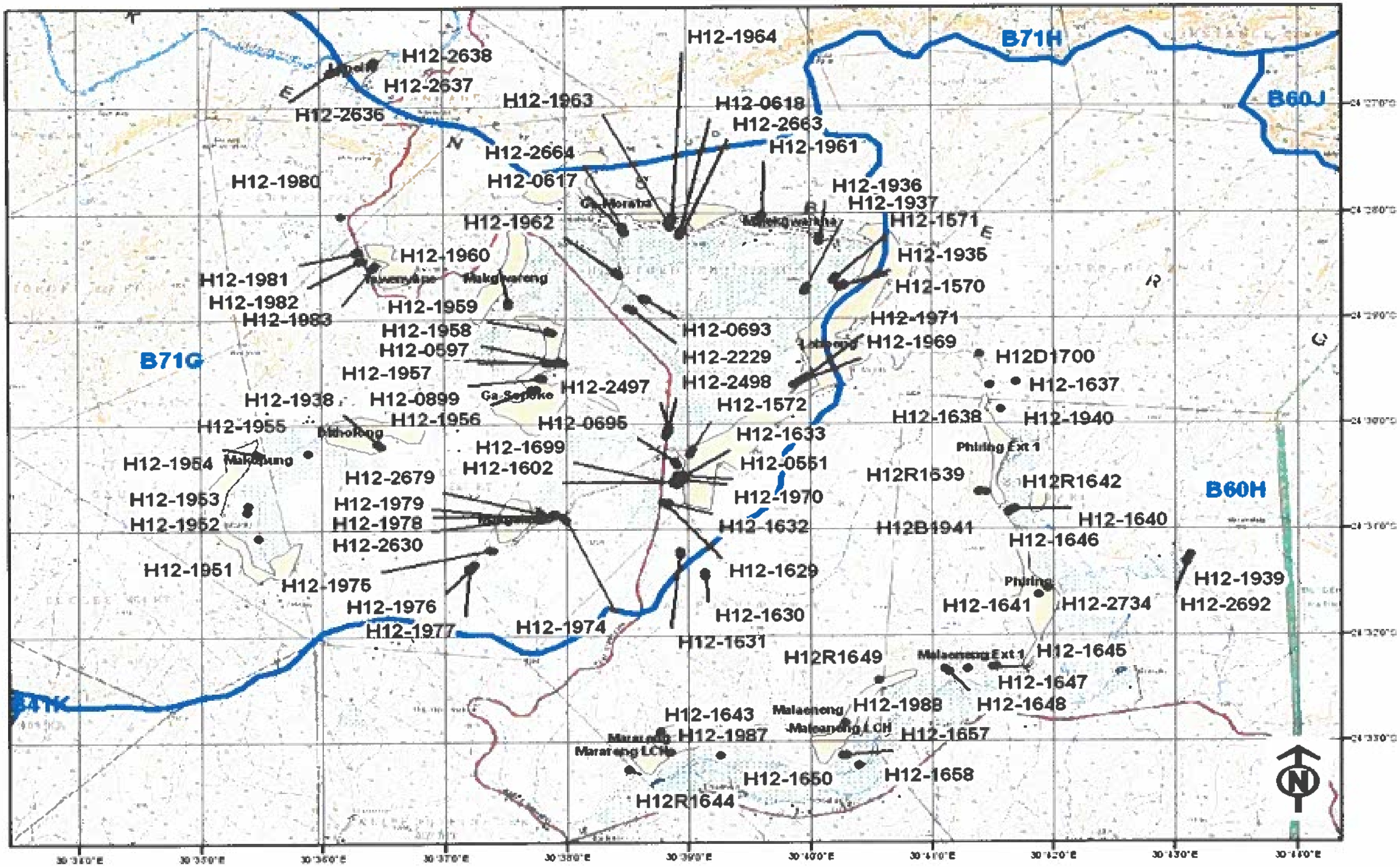
able 4: Description, coordinates and location of all points.

orehole umber	Site name	co-ordinates WGS 84		Depth (m)	Static water level (m)	Depth to intake (m)	Pump rate (l/s)	Pump schedule (hr/day)	Abstraction (m³day)	last known equip	last known power	water quality	Comment
		Longitude	Latitude										
12-1657	Malaeneng	30.6711253	-24.5523370	0.00	0.00	0.00	0.00	0.00	0.00	H	H		To test
12-1658	Malaeneng	30.6733476	-24.5537258	36.00	11.66	33.00	1.00	24.00	86.40	N	N	Class 0	Tested
12-1645	Malaeneng Ext 2	30.6916816	-24.5384491	75.54	5.73	42.00	13.00	12.00	561.60	M	E	Class 1	Pump suction
12-1570	Malekgwarana	30.6705168	-24.4789952	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1935	Malekgwarana	30.6708700	-24.4784197	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1936	Malekgwarana	30.6681200	-24.4711997	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1937	Malekgwarana	30.6657967	-24.4797152	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1961	Malekgwarana	30.6601380	-24.4676937	0.00	0.00	0.00	0.00	0.00	0.00	N	N		Blocked
12-1987	Mapareng	30.6474700	-24.5517397	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1650	Mapareng	30.6544579	-24.5523370	30.00	6.55	22.00	2.50	24.00	216.00	N	N	Class 1	Tested
12-1643	Mapareng	30.6461245	-24.5484483	36.62	26.54	33.00	3.80	24.00	328.32	M	D	Class 1	Tested
12R1644	Marareng	30.6419574	-24.5545590	0.00	0.00	0.00	0.00	0.00	0.00	Z	Z		Reservoir
12B1941	Phiring	30.6895973	-24.5115031	0.00	0.00	0.00	0.00	0.00	0.00	C	E		booster pump
12-1641	Phiring	30.6980707	-24.5270610	34.35	26.82	0.00	0.00	0.00	0.00	N	N	Class 1	Blocked
12-1939	Phiring	30.7189100	-24.5206497	23.17	13.00	0.00	0.00	0.00	0.00	N	N		Blocked
12-2692	Phiring	30.7184722	-24.5214164	64.90	17.71	60.00	0.10	2.00	0.72	N	N		Pump suction
12-2734	Phiring	30.6992500	-24.5261297	41.01	21.64	0.00	0.00	0.00	0.00	S	E	Class 1	Tested
12-1638	Phiring	30.6914035	-24.4940076	95.10	30.45	60.00	0.55	24.00	47.52	N	N		Tested
12-1637	Phiring	30.6950149	-24.4934521	59.20	18.90	54.00	0.90	24.00	77.76	M	D	Class 0	Tested
12-1640	Phiring	30.6941817	-24.5137285	42.04	10.56	30.00	6.00	24.00	518.40	M	E	Class 0	Tested
12-1646	Phiring	30.6939039	-24.5140063	60.00	10.52	24.00	6.00	24.00	518.40	N	N	Class 0	Tested
12-1940	Phiring Ext 1	30.6929900	-24.4977497	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1988	Phiring Ext 1	30.6716100	-24.5470997	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12D1700	Phiring Ext 1	30.6900150	-24.4890079	0.00	0.00	0.00	0.00	0.00	0.00	Z	Z		Reservoir
12R1639	Phiring Ext 1	30.6900000	-24.5105553	0.00	0.00	0.00	0.00	0.00	0.00	Z	Z		Reservoir

able 4: Description, coordinates and location of all points.

orehole Number	Site name	co-ordinates WGS 84		Depth (m)	Static water level (m)	Depth to intake (m)	Pump rate (l/s)	Pump schedule (hr/day)	Abstraction (m³day)	last known equip	last known power	water quality	Comment
		Longitude	Latitude										
12R1642	Phiring Ext 2	30.6906874	-24.5114531	0.00	0.00	0.00	0.00	0.00	0.00	Z	Z		Reservoir
12-1981	Tswenyane	30.6051500	-24.4727297	19.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1982	Tswenyane	30.6056500	-24.4740597	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1983	Tswenyane	30.6074100	-24.4748097	0.00	0.00	0.00	0.00	0.00	0.00	N	N		To test
12-1980	Tswenyane	30.6028900	-24.4671197	40.54	17.34	30.00	0.81	24.00	69.98	N	N		Tested

Map D: Topographic map indicating borehole and village positions in the Lower Blyde source area.



13 OVERVIEW OF GROUNDWATER QUANTITY AND QUALITY

The chemical composition of groundwater is the result of interaction between rainwater, soils and various rock types. Most of this interaction takes place in the unsaturated zone and later in the saturated zone along the groundwater flow path, where physical and geochemical properties of the rock types influence the type and character of the groundwater quality. In the area under discussion, water is mainly abstracted for stock watering and domestic purposes. **Eight boreholes with acceptable Ion balance errors were plotted on various diagrams. This is a representative plot of groundwater in the area.** Data plotted on these diagrams is used to identify the hydro-chemical water type, to describe the dominant ionic species, to visualize trends, to get a "fingerprint" of the water and to relate it to the geological setting and to classify the water for irrigation purposes.

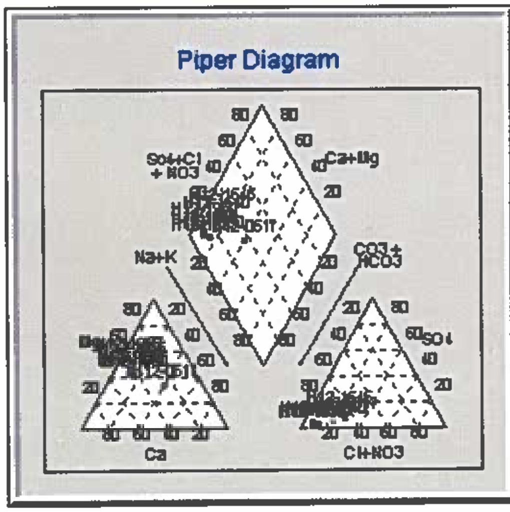


Diagram 1: Piper diagram H12-0867

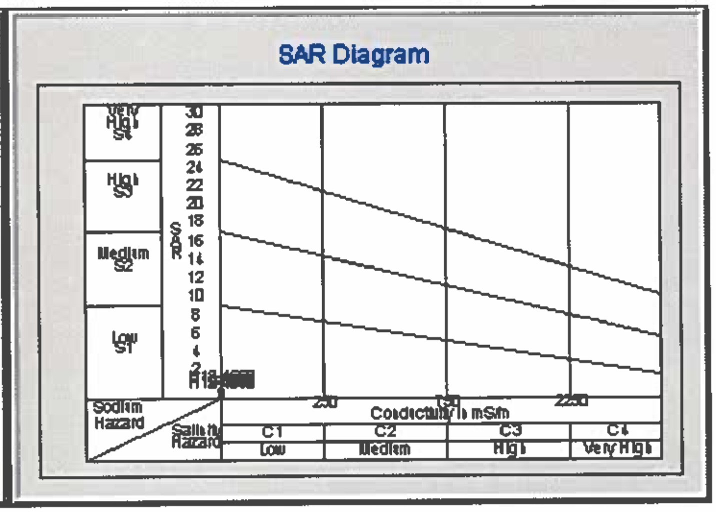


Diagram 2: SAR diagram H12-0867

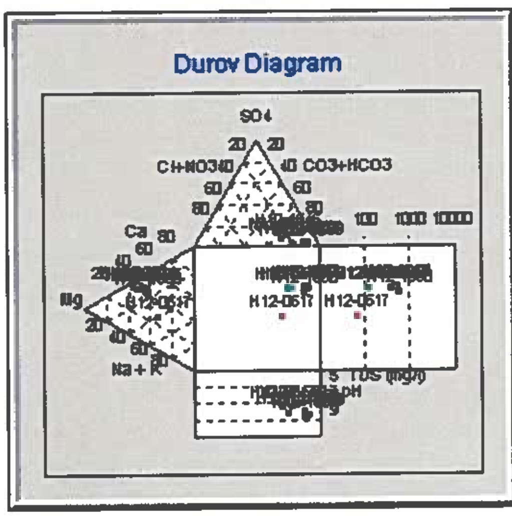


Diagram 3: Durov Diagram

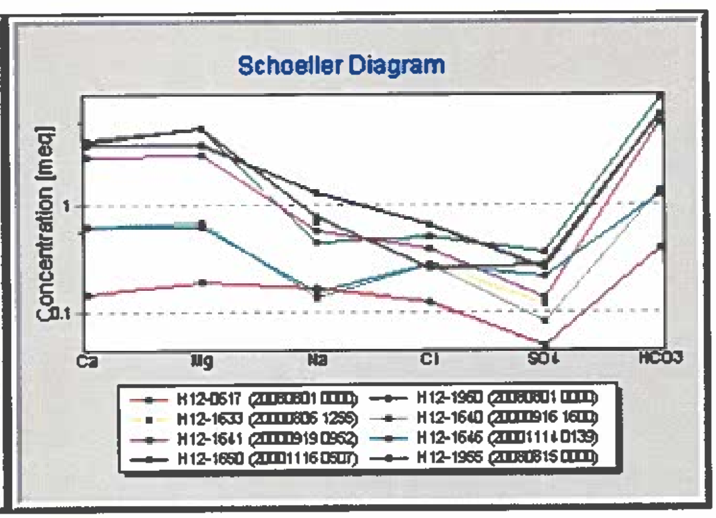


Diagram 4: Schoeller diagram.

13.1 Overview on groundwater quality.

- The hydro chemical water type is **TYPE B**. Dominant cations Mg^{2+} and Ca^{2+}. Dominant anions HCO_3^- . This water is associated with dolomitic aquifers.
- **Domestic water quality Class 0** in 36 % of the sampled boreholes.
- **Domestic water quality Class 1** in 45 % of the sampled boreholes due to the reported electrical conductivity (EC), the Total dissolved salts (TDS) and the calculated Total Hardness as CaCO3.
- **Domestic water quality Class 2** in 18% of the sampled boreholes due to the calculated Total Hardness as CaCO3.
- The water is class **C1S1 irrigation water.**
- **Low salinity water (C1)** can be used for irrigation on most crops in most soils with little likelihood that soil salinity will develop.
- **Low-sodium water (S1)** can be used for irrigation on almost all soils with little danger of developing harmful levels of sodium.
- The plotted parameters on the Schoeller diagram give a distinctive plot.

It is recommended that boreholes in this area of study must be, on average, 158m away from a pit latrine. Management of groundwater sources and village sanitation is equally important. Delineation of borehole protection zones from certain microbial pollution sources is essential. An area, with a radius of 158m around every borehole, must be protected.

13.2 Overview on groundwater quantity.

The recommended long term abstraction yield for a 24hr/day pumping cycle, (as determined from pump test data using the FC-method), varies from 0.041/s (3.4m³/day) to 8l/s (691.2m³/day) with an average of **1.3l/s (112.3m³/day).** Pump test data from 18 boreholes in the Lower Blyde supply area were evaluated.

14 INDENTIFICATION OF BOREHOLES OF CONCERN

- Boreholes of concern will include production boreholes situated in the same aquifer, threatening the resources of the aquifer.
- Production boreholes near obvious pollution sites especially down gradient from such site. These sites include landfills, sewerage works and smaller point sources such as pit latrines.
- Boreholes identified with construction problems, such as insufficient casing. This will result in high maintenance cost.
- Development of well fields without professional input.

15 INDENTIFICATION OF POOR BOREHOLE SITING REGADING POSITION AND SANITATION

The Minimum Standards and Guidelines for Groundwater Resource Development for the Community Water Supply and Sanitation Programme, a document by The Department of Water and Environment Affairs gives clear guidelines regarding the **positioning and development** of production boreholes for domestic supply.

A scientific approach for the development of groundwater sources must be followed utilizing existing technology such as satellite imagery interpretation, aerial photo interpretation, geophysical methods such as the electromagnetic, magnetic and DC resistivity profiling together with a sound understanding of the local geology and hydrogeological conditions of the study area. .

16 REHABILITATION / MITIGATION REQUIREMENTS.

In a **point source context** rehabilitation will refer to the actions that must be taken to rehabilitate a borehole. It includes removal of fallen equipment, instalment of new equipment etc. This project did not include a field phase to get an up-to-date status quo on the point sources. The data used is mostly dated from 2000 to 2002.

Rehabilitation of blocked boreholes and no access:
Boreholes listed are boreholes known to be blocked (information from the last survey) and boreholes with access problems (the problem is usually related to roads).

In an **aquifer context** the rehabilitation and mitigation requirements will refer to pollution control. The best way to deal with pollution sources such as landfills is to use strict design criteria and up-to-date management control. Pollution from the source needs to be minimized, as it is time consuming and very expensive to rehabilitate an aquifer.

Table 8: Rehabilitation of blocked boreholes or access roads.

Borehole Number	Site Name	co-ordinates WGS 84		last known equip	Last Known power	water quality	Comment
		Longitude	Latitude				
H12-1956	Ga-Sepeke	30.6293050	-24.4944437	N	N		Blocked
H12-1958	Ga-Sepeke	30.6330830	-24.4904437	N	N		Blocked
H12-1957	Ga-Sepeke	30.6311666	-24.4904437	N	N		No access
H12-1959	Ga-Sepeke	30.6315550	-24.4855827	N	N		Blocked
H12-1969	Leboeng	30.6645830	-24.4938607	N	N		Blocked
H12-1971	Leboeng	30.6658610	-24.4929717	N	N		Blocked
H12-1647	Maleaneng	30.6883481	-24.5387268	N	N		Blocked
H12-1648	Maleaneng	30.6852925	-24.5387268	N	N		Blocked
H12-1975	Makgalane	30.6233330	-24.5198327	N	N		Blocked
H12-1976	Makgalane	30.6207770	-24.5220827	N	N		Blocked
H12-1978	Makgalane	30.6301110	-24.5150547	N	N		Blocked
H12-2679	Makgalane	30.6301940	-24.5143327	N	N		Blocked
H12-1961	Malekgwarana	30.6601380	-24.4676937	N	N		Blocked
H12-1641	Phiring	30.6980707	-24.5270610	N	N	Class 1	Blocked
H12-1939	Phiring	30.7189100	-24.5206497	N	N		Blocked
H12-1938	Ditholong	30.6080830	-24.5034717	H	H		No access
H12-0899	Ga-Sepeke	30.6303050	-24.4928607	N	N		No access
H12-1957	Ga-Sepeke	30.6311666	-24.4904437	N	N		No access
H12-1977	Makgalane	30.6200830	-24.5225547	M	D		No access

Note: No more information is available on the above listed boreholes. A field visit should be performed to verify the status of these boreholes. If these boreholes are near production boreholes or no information is available to verify these holes to be strong, rehabilitation is recommended. Access roads are part of the maintenance of equipped sources.

UN-USABLE BOREHOLES

Borehole Number	Site name	co-ordinates WGS 84		Depth (m)	Static water level (m)	Depth to intake (m)	Pump rate (l/s)	Pump schedule (hr/day)	Abstraction (m³day)	last known equip	last known power	water quality	Comment
		Longitude	Latitude										
H12-1631	Leboeng	30.6489025	-24.5201169	94.00	0.00	0.00	0.00	0.00	0.00	N	N		Dry-drill
H12-1632	Leboeng	30.6466802	-24.5123396	64.00	0.00	0.00	0.00	0.00	0.00	N	N		Dry drill
H12-2734	Phiring	30.6992500	-24.5261297	41.01	21.64	0.00	0.00	0.00	0.00	S	E	Class 1	Tested
H12-1633	Leboeng	30.6483469	-24.5087288	83.10	13.99	42.00	0.04	24.00	3.46	S	E	Class 1	Tested
H12-2229	Ga-Moraba	30.6419400	-24.4816697	107.80	23.50	30.00	0.10	24.00	8.64	N	N	Class 2	Tested

Note: Boreholes listed as un-usable includes known dry borehole or boreholes that was tested and found to have un-economical yields. The last can be considered for monitoring boreholes. Before any action is taken on the tested boreholes they should be visited to confirm the status. It is known that H12-1633 belongs to the police station.

18 ASSESSMENT OF GROUNDWATER SOURCES – short, medium & long term.

Blyde Local water source area:

Short term:

- A field visit to the motorised and tested boreholes is recommended to confirm available information and to evaluate the current status thereof.
- Pump test the un-tested boreholes where necessary.
- Sample and evaluate the groundwater chemistry in boreholes that have not been chemically analysed.
- Equip and upgrade new and existing installations to the Department of Water Affairs and Forestry specifications.
- During this phase blocked boreholes can be visited and a final decision made regarding rehabilitation.
- Confirm the current water supply and demand in the villages.

Medium term:

- Electrification of installations.
- Implement the use of the long term recommended yield abstraction (FC method).
- The 24hr/day pumping schedule is recommended to minimize over pumping of boreholes and to minimize equipping cost. (Smaller pumps and head gear). The power supply in villages is not always suitable for big electrical motors.
- DWAF guidelines should be followed where new groundwater sources are developed.

Long term:

- Monitoring of abstraction volumes, water levels and quality of the well fields.
- Identification of possible pollution sites.
- Ensure the correct design and management control of water sources and possible pollution sources.
- Monitor population and expansion/development of the town to ensure reliable sources for the population.

19 CONCLUSIONS:

- This report does not include a full water balance determination or any field work. **All available data sources** were utilize for information with some information as old as 1997. Available groundwater data for the Blyde local source study area consisted of 79 entry points of which 6 are reservoirs or booster pumps. Testing data of 18 boreholes were evaluated and the chemical analyses of 11 boreholes were available.

- The villages were grouped under **11 supply clusters** due to existing information indicating the sharing of the same sources and reservoirs. The **DWAF form D village name** list was used. According to existing information the water demand should be met in 6 clusters if the tested boreholes listed in table 3 are equipped and in working order. In three clusters more existing boreholes must be tested as a short term solution to establish if the demand is met before starting a development phase. The water demand of the last cluster

Marareng and Marareng LCH is not known. Some tested boreholes have no information on the chemical water quality and this should be determined.

- The average **summer temperature ranges** from 14.5-31 degrees and the **winter temperatures** between 5.6 and 25.2 degrees Celsius.
- For the Blyde local area the **mean annual precipitation** was accepted as 710mm/annum that are the lowest thus the most conservative according to Vegter's figures.

- Existing information indicate **11 boreholes** with chemical results. From these 81% of the groundwater in the area is of an **ideal or good water quality**.
- The hydro-chemical water type is **TYPE B**. Dominant cations Mg^{2+} and Ca^{2+}. Dominant anions HCO_3^- . This water is associated with dolomitic aquifers.
- **Domestic water quality Class 0** in 36 % of the sampled boreholes.
- **Domestic water quality Class 1** in 45 % of the sampled boreholes due to the reported electrical conductivity (EC), the Total dissolved salts (TDS) and the calculated Total Hardness as CaCO3.
- **Domestic water quality Class 2** in 18% of the sampled boreholes due to the calculated Total Hardness as CaCo3.
- The water is class **C1S1 irrigation water.**

- The **recharge** for the area was calculated as 9.7E+06m³/a, and the current annual abstraction as 1.3E+06 m³/a using the long term recommended yields of the tested boreholes. For a total water balance other factors must also be considered such as baseflow, the ecological reserve, inflow and outflow over aquifer boundaries and evapotranspiration. This was not part of the scope of work and was therefore not calculated.

- The difference between **recharge and abstraction** was calculated as 8.4E+6m³/a indicating that even with all the factors considered, enough scope for source development still exists.
- The **recommended long term abstraction yields** (24hr/day pumping cycle using the FC-method) varies from 0.04l/s (3.4m³/day) to 8l/s (691.2m³/day) with an average of **1.3l/s (112.3m³/day)**. Pump test data from 18 boreholes in the Lower Blyde water supply area, were used.

- **Management** of groundwater sources and village sanitation is equally important. Delineation of borehole protection zones from certain microbial pollution sources is essential. An area, with a radius of 158m around every borehole, must be protected.

- **Monitoring** the well field, water level, quality and abstraction must be implemented as it is an essential part of groundwater management. Water conservation can only be successfully implemented with a properly managed plan.

- Recommendations were made for the **assessment of groundwater** use in the short, medium and long term.

- It is recommended that an extensive borehole census be carried out in this area to confirm and update all available borehole and related data.

20 REFERENCES

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VSA Leboa Consulting (Pty) Ltd

Reg No. 2000/002014/07

GEOHYDROLOGICAL REPORT

Groundwater assessment study Lower Steelpoort water supply zone.

For
BTW Consulting (Pty) Ltd.

Tubatse Municipality
Sekhukhune District
Limpopo Province

REPORT-VSALEB/PR09/134B
September 2009

Author: C.J Sonnekus (Pr.Sci.Nat)

Gis prepared by: A.M. Cronje

VSA Group of Companies

EXECUTIVE SUMMARY

VSA Leboa Consulting was appointed by BTW Consulting (Pty) Ltd July 2009 to give a **groundwater situation assessment** of the **Lower Steelpoort Tubatse** water supply zone from available data on the groundwater data base. The outlay of the report is based on fifteen points that were identified by the client for the assessment. The requested output format for the interpretation of results and recommendations was to be in terms of short, medium and long term use regarding groundwater as the primary source of potable water.

All available data sources were utilized for information. Available groundwater data for the Lower Steelpoort Tubatse water supply zone consisted of data for 88 groundwater sources. Pump test data used for evaluation was from 18 boreholes and chemical data for 15 boreholes. The scope of work did not include field work and data can be as old as 1997.

Nine villages fall under the supply zone and to our knowledge they are all connected and getting additional water from Strydfontein. It is not known if the water demand is met in each village. The **DWAF form D village name** list was used on all maps and tables.

Based on plotted chemical data diagrams the groundwater is identified as a hydro-chemical water **TYPE B** and as a Class **C1S1 irrigation water.** For domestic use approximately 93% of the groundwater in the area is of an **ideal to good water quality.** In 6% of the sampled boreholes the domestic classification is Class 2 due to the concentration of Manganese (Mn). Boreholes with water quality Class 2 can be equipped for domestic use.

The **recommended abstraction yields** for a 24hr/day pumping cycle as determined from pump test data using the FC-method varies from 0.1l/s (8.6m^3/day) to 1l/s (86.4m^3/day) in the mountainous area (14 tests) and from 0.4l/s (34.5m^3/day) to 5l/s (432m^3/day), information from 4 tests in the area near the Ohrigstad River.

The **recharge** for the area was calculated as 6.3E+06m^3/a and the current annual abstraction as 0.2E+06 m^3/a using the information of the tested boreholes. For a total water balance other factors must also be considered such as baseflow, the ecological reserve, inflow and outflow over aquifer boundaries and evapotranspiration. This was not part of the scope of work and was therefore not calculated. The difference between recharge and abstraction was calculated as 5.8E+6m^3/a indicating that even with the above factors not taken in account that there is still enough scope for source development .

Management of groundwater sources and village sanitation is equally important. Delineation of borehole protection zones from certain microbial pollution sources is essential. An area, with a radius of 150m around every borehole, must be protected for the boreholes near the river and 100m for boreholes in the mountainous areas.

Monitoring of the well field, water level, quality and abstraction must be implemented as it is an essential part of groundwater management. **Water conservation** can only be successfully implemented with a properly managed plan.

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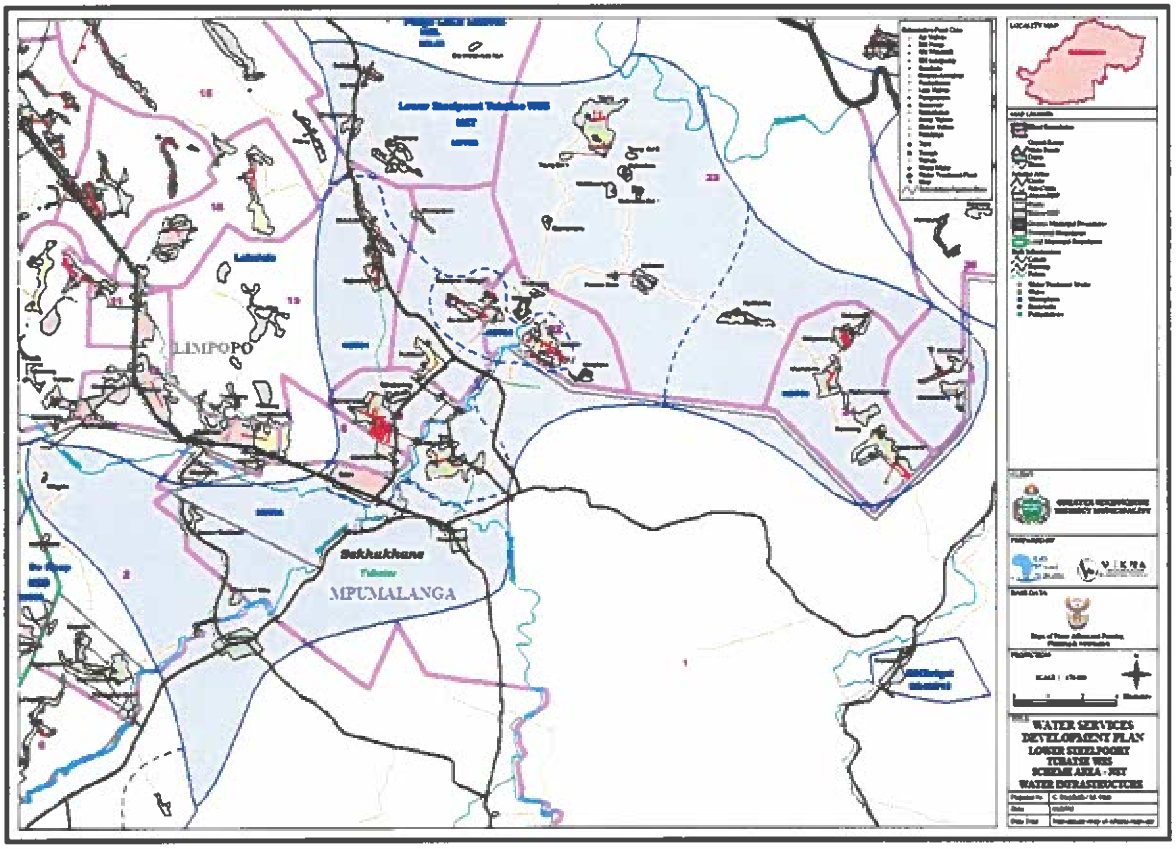
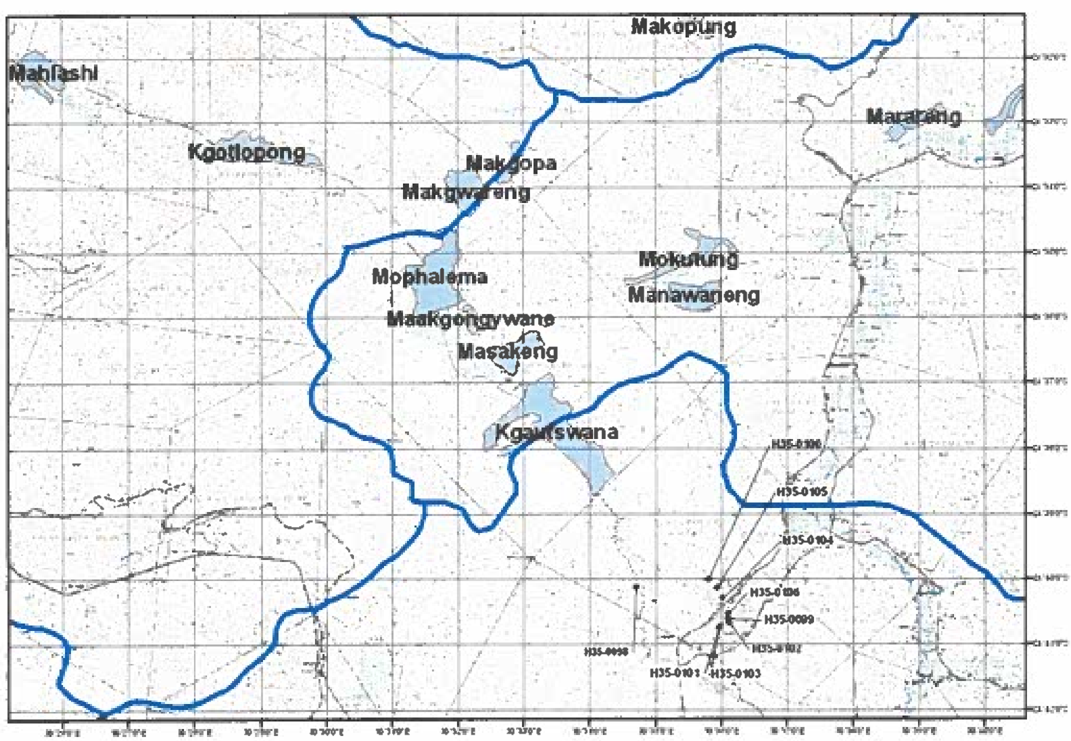


Map B: Villages falling under the Lower Steelpoort Tubatse water supply area.



1 INTRODUCTION

1.1 Background:

VSA Leboa Consulting was appointed by BTW Consulting (Pty) Ltd July 2009 to give a **groundwater situation assessment** of the **Lower Steelpoort Tubatse** water supply zone based on available data from the groundwater data base. The outlay of the report is based on fifteen points that were identified by the client for the assessment. The requested output format for the interpretation of results and recommendations was to be in terms of short, medium and long term use regarding groundwater as the primary source of potable water.

All **available data sources** were utilized for information. Available groundwater data for the Lower Steelpoort Tubatse water supply zone consisted of information on basic site information for a total of 88 borehole sources. Of these, 18 boreholes were tested and 15 have chemical results.

This area is supplied in bulk from boreholes within the villages as well as from boreholes located next to the Ohrigstad River on the farm Strydfontein. This farm was bought by the government for the community. This water scheme was designed and installed by MBB Consulting Engineers, Pretoria.

1.2 Scope of work:

The report outlay was pre-described by the client as discussed in the background. Additional information and recommendations are included in this report. To address the short, medium and long term use effectively it was summarized under heading 18 as 'assessment of groundwater sources, short, medium and long term'. Other additional points that were discussed are physiography with subheadings, topography and drainage, climate and rainfall, vegetation, sensitive habitats and the riparian vegetation.

This report does not include a full groundwater model for determining the reserve, or to give a water balance for the area. **No field work was done as it was not part of the scope of work.**

1.3 Location:

The Lower Steelpoort Tubatse area starts approximately 7km north of Ohrigstad on the farm Strydfontein 442KT (bought for the community by the government) The Ohrigstad River which flows through this farm is forming the south-eastern border. From the river the study area extends to the northwest in an approximate 5km wide zone to include topographical farms such as Rietfontein 440KT, Klipfontein 270KT and Fallowfield 403KT. The area is managed by the Sekhukhune District Municipality and falls on the 1:50 000 South African topographical map sheet 2430DA.

Table 1: Village co-ordinates:

Village	Approximate co-ordinates WGS 84		Alternative village name / spelling / comment from instructions received
	Latitude	Longitude	
Kgotlopong	24° 33' 25.2"S	30° 28' 51.6"E	Kgotiopong
Makgopa	24° 33' 39.6"S	30° 32' 49.2"E	
Makgawareng	24° 34' 04.8"S	30° 32' 13.2"E	
Mophalema	24° 35' 27.6"S	30° 31' 40.8"E	Matshiretsane, Ga-Molai
Maakgongywane	24° 36' 03.6"S	30° 32' 13.2"E	
Masakeng	24° 36' 36.0"S	30° 32' 45.6"E	Masakeng and Ga-Kgoedi grouped together
Kgautswana	24° 37' 48.0"S	30° 33' 32.4"E	North, South, includes Lebalelo and Paeng
Manawaneng	24° 35' 45.6"S	30° 35' 34.8"E	Mosola
Mokutung	24° 35' 06.0"S	30° 35' 38.4"E	Maketla

1.4 Existing data sources and evaluation:

All available data sources were utilized for this study. This includes data from the data base maintained by VSA Leboa Consulting and from the Limpopo Aquabase data base that includes historical National Groundwater Data Base data and data from the Groundwater Resource Implementation Project (GRIP). The Aquabase data base is managed and continuously being updated by GPM Geo-consultants under the appointment of **The Department of Water and Environment Affairs.** Various role-players in the groundwater industry committed themselves to the upkeep of this data base and all new information is handed to GPM on a regular basis. The GRIP project was a major source of data. This project was done by geo-consultants under the appointment of the Department of Water Affairs and Forestry in the period 2000-2002 when all the boreholes in the former rural areas were visited, field marked, and the status quo investigated. The data obtained from this project was verified and linked with data from the National Groundwater Data Base. The GRIP project is still continuing on a smaller scale whereby boreholes are tested in areas with poor data coverage. It must be stated that in many areas the method of marking boreholes and forwarding data to DWAF was not enforced by municipalities after 2002. The result is that a good basis of data exists but it must be verified again by a hydro-census if up-to-date information is required.

2 PHYSIOGRAPHY

2.1 Topography and drainage

Drainage from the major part of the study area is from a network of south-west to north-east striking narrow valleys that act as conduits for the water during raining periods. These valleys form a drainage pattern that is almost blocky to dendritical in appearance and drains water from the higher laying areas into south-east and east flowing ephemeral streams such as the Molapeng that continues for approximately 7km before joining the north flowing Ohrigstad River.

Drainage from the north western part of the study area has the same network of ephemeral streams. It joins to flow into a west flowing ephemeral stream that is in a narrow valley before turning north to join the north following Steelpoort River.

The topography is related to the regional geology which is a sedimentary succession. The dip of the succession is slightly to the south-west with poor soil cover on the higher slopes. On the northern and eastern side it forms escarpments that are layered in appearance, especially where the geology of the area is visible on the steep cliffs. Rubble from the higher areas, colluvium, occurs on the slopes and bases of the mountains. The lowest point in the study area is the elevation next to the Ohrigstad River at approximately 990mamsl. This increases steadily to a height of 1664mamsl, at Mawolo Hill, approximately 15km further to the north-west. From there the elevation decreases again to the border of the study area, approximately 5km further with the elevation between 900mamsl in the valleys and 1241mamsl on the mountains.

2.2 Climate and rainfall

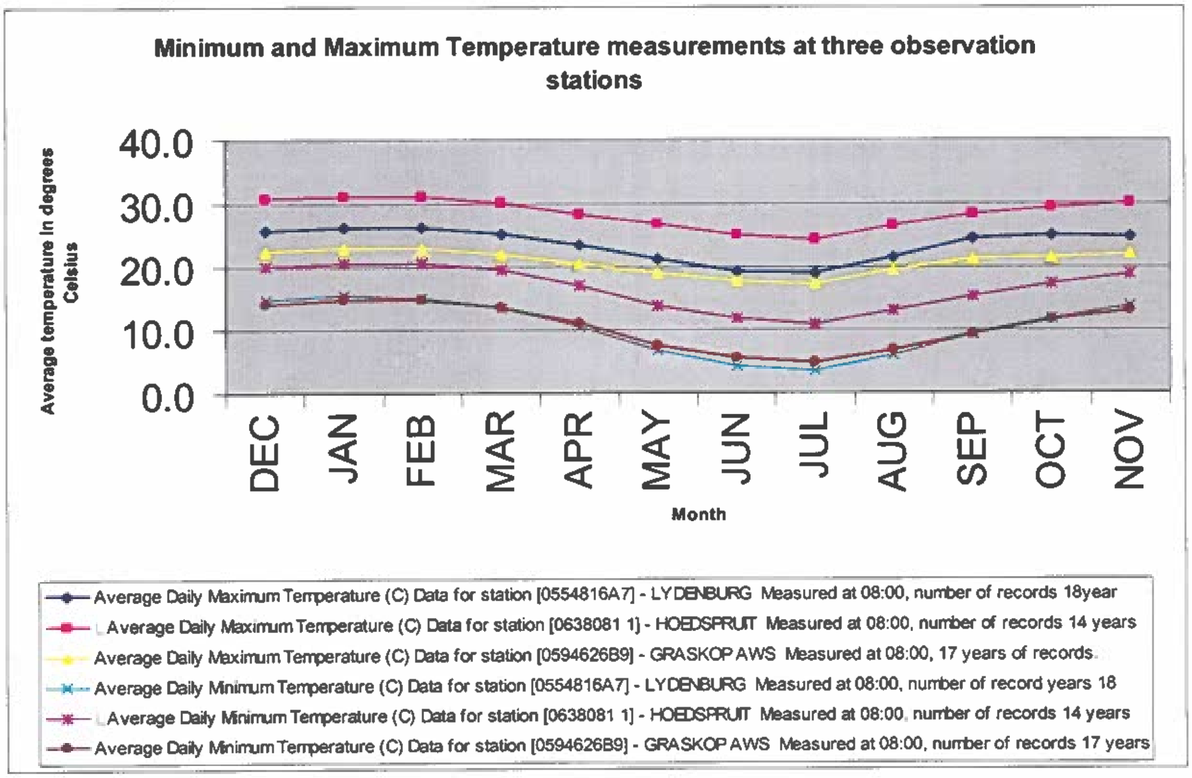


Figure 1: Minimum and Maximum Temperature measurements at three observation stations.

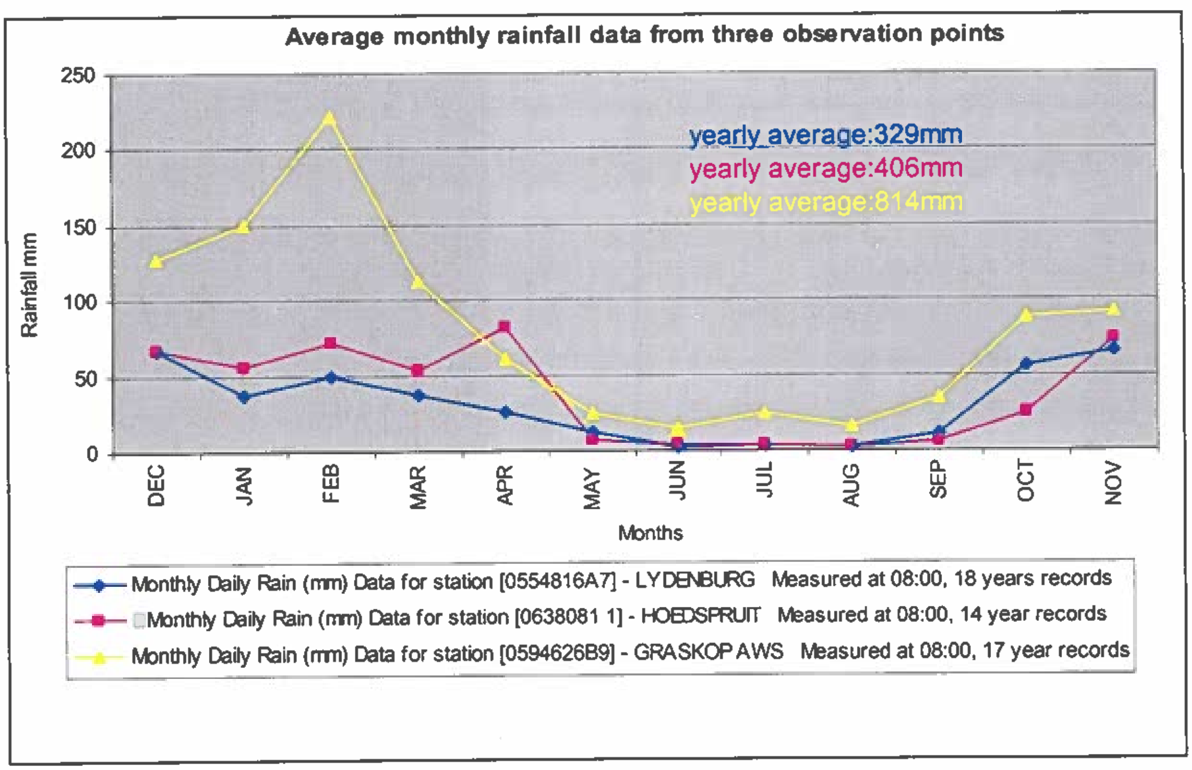


Figure 2: Average monthly rainfall data from three observation points.

Temperature data is available from three sources in the vicinity of the study area: Lydenburg, Hoedspruit and Graskop. The average summer temperature is between 14.5-31 degrees and the winter minimum temperatures are much colder, ranging between 4.7 to 25.2 degrees Celsius. The Lydenburg / Graskop data was used.

Rainfall data is from the same source. These rainfall figures were compared to those indicated on the maps produced by (Vegter 1995). These maps have contoured rainfall data giving a figure of 650mm/a in the south to 709mm/a in the northern part of the study area. **For the lower Steelpoort area the mean annual precipitation was accepted as 650mm/a.**

2.3 Vegetation

The lower lying areas are covered by the Sourish Mixed Bushveld vegetation unit, (vegetation type 19, Acocks 1988), forming part of the Tropical Bush and Savanna veld type. The higher laying areas are covered by the north-eastern Mountain Sourveld vegetation unit, (vegetation type 8, Acocks 1988), forming part of the inland Tropical Forest veld.

2.4 Sensitive habitats

Preservation of plant species in the Ohrigstad area, especially in the small valleys and mountainous areas are crucial to the survival of numerous small animals and the preservation of bio-diversity. These plants prevent the degradation of the area by erosion during rain storms, when water rushes down the slopes and valleys.

2.5 Riparian vegetation

The riparian zone comprises plant communities contiguous to and affected by surface and sub-surface hydrological features of perennial or intermittent water bodies, (rivers and streams). Riparian areas have one or both of the following characteristics: 1) distinctly different vegetative species to adjacent areas, and 2) species similar to adjacent areas but exhibiting more rigorous or robust growth formation. The vegetation is dependent on the river for a number of functions including growth, temperature control, seed dispersal, seed germination and nutrient enrichment (Kemper, 2001). This vegetation comprises a distinct composition of species, often different from that of the surrounding terrestrial vegetation. Tree species are positioned according to their dependence or affinity for water, with the more water loving, (mesic species), being located closest to the river channel, often with their roots in the water, and the less water loving terrestrial species further away from the river (Kemper, 2001).

Certain sections along the Ohrigstad River are more typical of the natural riparian vegetation, whilst others have been severely altered due to riparian zone degradation related to farming activities around the river and alien plant species.

3 OVERVIEW OF THE REGIONAL GEOLOGY OF THE AREA

Information on the regional geology surrounding the study area was obtained from the 1:250 000 South African geological map series and explanatory booklet. Map sheet 2430 Pilgrim's Rest.

3.1 Pretoria group

The area is underlain by rocks of the Transvaal sequence with mainly the rocks of the Pretoria group represented in the study area. The formations developed in the area include the Timeball Hill Formation, which is a dark-grey to black well-bedded shale with conglomerate, (Bevet's conglomerate sporadically developed at the base, flagstone and brownish to grey shale at the top (Vtl). This is overlain by fine to medium grained ripple marked quartzite, middle part argillaceous (Vtq). The upper part of this formation is presented by a red to grey, locally laminated shale, diamictite with occasional quartzite layers (Vtu). The Timeball Hill Formation is overlain by the Boshoek formation (Vb) represented in the area by a medium-grained quartzite, subgreywacke with conglomerate at base and siltstone at top). The main parts of these formations are considered to have formed in a tidal-shelf environment (Button 173b). The Timeball Hill Formation covers the major part of the study area.

Volcanic rocks in the Pretoria Group within the area, include fine-to medium-grained andesitic lava of the Hekpoort Andesite Formation (Vha). The middle part of the formation is amygdaloidal and it is brecciated at top. The lavas were extruded on land (Button 1973b). This formation forms part of the higher laying areas just south of the farm Rietfontein. On Klipfontein it covers the southern half of the farm.

The Dwaalheuwel (Vdw) and Strubenkop (Vst) formations are not well developed in the study area and rocks of the Daspoort formation (Vd) are mostly overlaying the Hekpoort formation. This formation consists of a medium-grained quartzite with gritty and conglomeratic layers and occasional shale layers.

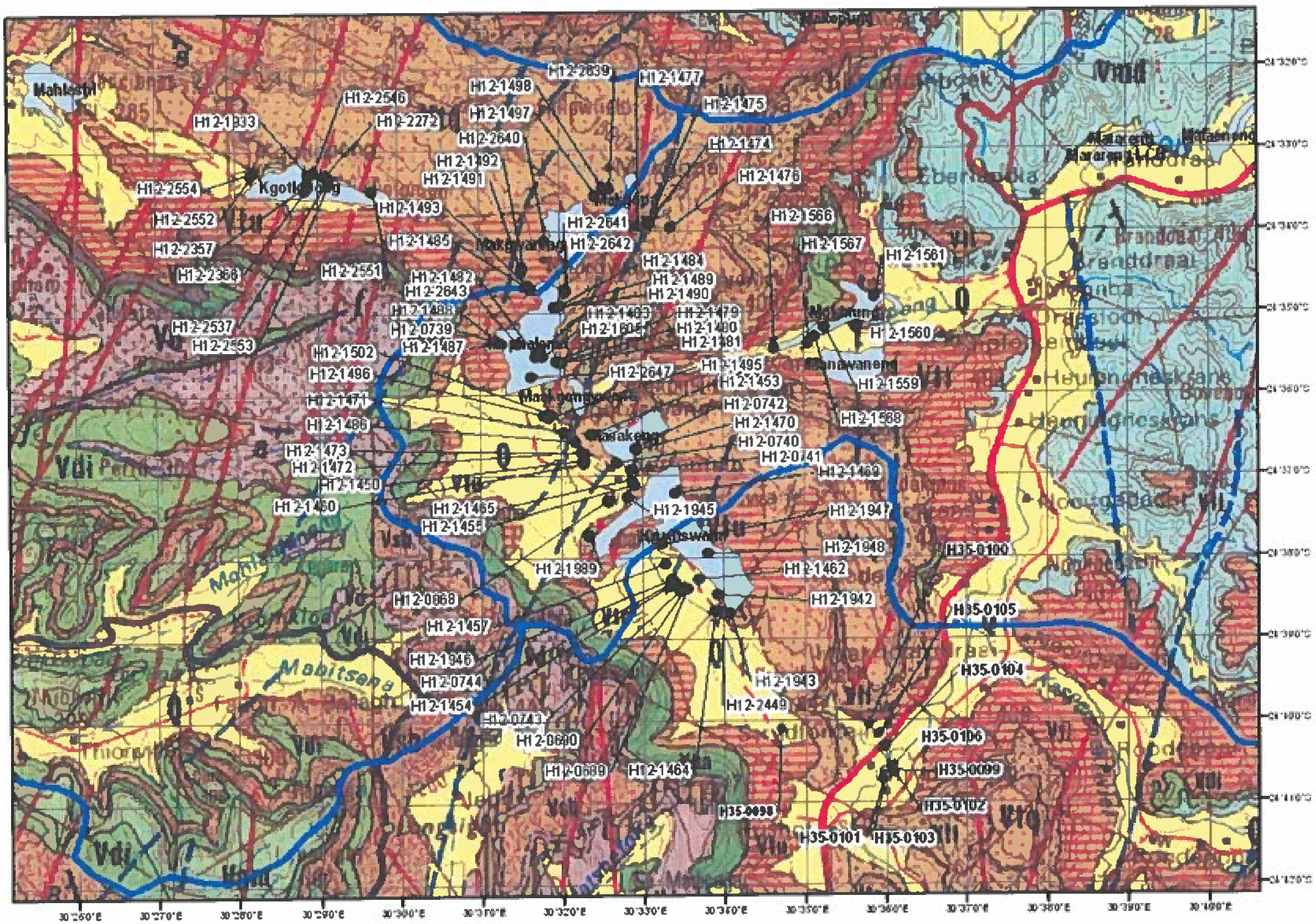
3.2 Quaternary deposits

Data from drilling logs in the area show that the alluvium next to the Ohrigstad River is poorly developed. The lower laying areas are covered with rubble, colluvium, from the mountains, also including quartzite dolerite and diabase boulders within a fine grained (weathered shale) matrix, which is almost weathered to clay.

3.3 Structural geology

Numerous lineaments inferred from aerial magnetic data or from field observations are plotted on the geological map. Most prominent among these are the long continuous dykes trending slightly east of north. These dykes had an influence on the topography and drainage of this region. It is most noticeable near the escarpment where deep gorges have formed along the dyke trends. Field investigations identified these lineaments as diabase and dolerite dykes. Thin vertical fracture and joint zones can also be seen especially along cliffs.

Map C: Regional geology and existing boreholes



DATABASE OF ABSTRACTION BOREHOLES

3oreholes listed under this heading include boreholes with known yields, untested boreholes currently equipped and probably in use as production boreholes. The short term actions ;hould include the inspection of the equipment and the upgrading thereof. Chemical analysis and pump testing of sources should be carried out where needed. Medium to long term ıctions will include development of new sources, training of pump operators, maintenance and management plans.

Table 2: Abstraction boreholes, tested boreholes or boreholes with the potential to be tested and equipped.

Borehole number	Site name	Co-ordinates WGS 4		Depth (m)	Static water level	Pump intake (m)	Discharge rate (l/s)	pumping period hr/day	Daily abstraction (m³/day)	last known equipment	last known power source	water quality	Comment last visit
		Longitude	Latitude										
H12-1464	Kgautswana	30.5649	24.6443	50.2	23.8	40.0	0.21	8	6.1	K	H	CLASS 2	Pump suction
H12-0689	Kgautswana	30.5592	24.6398	45.1	14.5	60.0	0.23	10	8.3	N	N		Pump suction
H12-2449	Kgautswana	30.5665	24.6444	47.1	18.4	30.0	0.08	24	6.9	S	E		Tested
H12-0867	Kgautswana	30.5431	24.6220	90.0	12.8	36.0	0.10	24	8.6	H	H	CLASS 1	Tested
H12-1945	Kgautswana	30.5469	24.6210	21.7	4.9	18.0	0.15	24	12.9	S	E		Tested
H12-1946	Kgautswana	30.5560	24.6379	45.1	21.6	30.0	0.34	24	29.4	N	N		Tested
H12-0868	Kgautswana	30.5429	24.6217	47.0	0.0	0.0	0.00	0	0.0	H	H		To test
H12-1942	Kgautswana	30.5653	24.6410	0.0	0.0	0.0	0.00	0	0.0	H	H		To test
H12-1947	Kgautswana	30.5538	24.6307	0.0	0.0	0.0	0.00	0	0.0	H	H		To test
H12-1948	Kgautswana	30.5633	24.6325	0.0	0.0	0.0	0.00	0	0.0	H	H		To test
H12-1457	Kgautswana	30.5547	24.6346	0.0	0.0	0.0	0.00	0	0.0	S	E		To test
H12-2272	Kgotlopong	30.4849	24.5552	37.3	4.5	18.0	0.10	24	8.6	N	N	CLASS 0	Tested
H12-2537	Kgotlopong	30.4859	24.5557	120.0	3.8	48.0	0.25	24	21.6	N	N	CLASS 2	Tested
H12-2551	Kgotlopong	30.4948	24.5583	49.0	-0.1	45.0	1.00	24	86.4	N	N	CLASS 0	Tested

Table 2: Abstraction boreholes, tested boreholes or boreholes with the potential to be tested and equipped.

Borehole number	Site name	Co-ordinates WGS 4		Depth (m)	Static water level	Pump intake (m)	Discharge rate (l/s)	pumping period hr/day	Daily abstraction (m^3/day)	last known equipment	last known power source	water quality	Comment last visit
		Longitude	Latitude										
H12-2552	Kgotlopong	30.4699	24.5550	114.0	26.9	60.0	0.11	24	9.5	N	N	CLASS 1	Tested
H12-1933	Kgotlopong	30.4816	24.5549	135.0	4.6	0.0	0.00	0	0.0	M	D		To test
H12-2366	Kgotlopong	30.4809	24.5581	30.0	5.9	0.0	0.00	0	0.0	S	E		To test
H12-2554	Kgotlopong	30.4705	24.5542	0.0	0.0	0.0	0.00	0	0.0	H	H		To test
H12-1502	Maakgongywane	30.5313	24.6041	59.5	12.4	30.0	0.30	24	25.9	S	E	CLASS 1	Tested
H12-1477	Makgopa	30.5495	24.5657	76.1	8.4	18.0	0.20	6	4.3	N	N	CLASS 0	Pump suction
H12-1498	Makgopa	30.5424	24.5579	66.6	8.4	48.0	0.10	12	4.3	N	N		Pump suction
H12-1497	Makgwareng	30.5408	24.5594	66.6	3.5	28.0	0.30	24	25.9	M	D		Tested
H12-1471	Masakeng	30.5341	24.6077	127.0	6.9	90.0	0.60	24	51.8	M	D	CLASS 0	Tested
H12-1486	Masakeng	30.5364	24.6097	139.8	1.7	36.0	0.60	24	51.8	M	D		Tested
H12-1495	Masakeng	30.5310	24.6047	68.8	9.7	24.0	1.00	24	86.4	M	D	CLASS 0	Tested
H12-1450	Masakeng	30.5383	24.6135	0.0	0.0	0.0	0.00	0	0.0	N	N		To test
H12-1472	Masakeng	30.5377	24.6119	51.0	4.9	0.0	0.00	0	0.0	N	N		To test
H12-1473	Masakeng	30.5384	24.6121	49.0	0.0	0.0	0.00	0	0.0	N	N		To test
H12-1561	Mokutung	30.5980	24.5802	23.6	12.4	18.0	0.06	24	5.2	H	H	CLASS 0	Tested
H12-1568	Mokutung	30.5857	24.5883	51.0	17.8	45.0	0.87	24	75.2	N	N		Tested
H12-1559	Mokutung	30.5875	24.5870	0.0	0.0	0.0	0.00	0	0.0	H	H		To test

Table 2: Abstraction boreholes, tested boreholes or boreholes with the potential to be tested and equipped.

Borehole number	Site name	Co-ordinates WGS 4 Longitude	Latitude	Depth (m)	Static water level	Pump intake (m)	Discharge rate (l/s)	pumping period hr/day	Daily abstraction (m³/day)	last known equipment	last known power source	water quality	Comment last visit
H12-1566	Mokutung	30.5770	24.5914	0.0	0.0	0.0	0.00	0	0.0	H	H		To test
H12-1567	Mokutung	30.5842	24.5905	0.0	0.0	0.0	0.00	0	0.0	N	N		To test
H12-1479	Mophalema	30.5326	24.5932	141.6	5.9	30.0	0.41	24	35.4	M	D	CLASS 0	Tested
H12-1490	Mophalema	30.5322	24.5822	120.0	28.7	72.0	0.20	24	17.3	N		CLASS 0	Tested
H12-1480	Mophalema	30.5331	24.5934	44.0	5.9	0.0	0.00	0	0.0	N	N		To test
H12-1488	Mophalema	30.5207	24.5894	0.0	0.0	0.0	0.00	0	0.0	S	E		To test
H12-1605	Mophalema	30.5297	24.5923	79.8	0.0	0.0	0.00	0	0.0	S	E		To test
H12-2642	Mophalema	30.5345	24.5789	0.0	0.0	0.0	0.00	0	0.0	N	N		To test
H12-2643	Mophalema	30.5245	24.5897	78.0	0.0	0.0	0.00	0	0.0	S	E		To test
H12-2647	Mophalema	30.5272	24.5963	0.0	0.0	0.0	0.00	0	0.0	S	E		To test
H35-0105	Strydfontein	30.5984	24.6697	109.0	11.9	37.0	0.10	2	0.7	S	E		Pump suction
H35-0100	Strydfontein	30.5965	24.6675	104.0	20.2	30.0	0.40	24	34.6	M	E	CLASS 0	Tested
H35-0103	Strydfontein	30.5996	24.6781	41.0	5.2	36.0	5.00	24	432.0	N	N	CLASS 1	Tested
H35-0104	Strydfontein	30.5998	24.6723	114.9	11.9	42.0	0.70	24	60.5	N	N	CLASS 0	Tested
H35-0106	Strydfontein	30.6013	24.6761	150.0	2.8	60.0	3.00	24	259.2	M	E	CLASS 1	Tested
H35-0099	Strydfontein	30.6012	24.6770						0.0	S	E		To test
H35-0102	Strydfontein	30.6015	24.6772			0.0	0.00	0	0.0	N	N		To test

5 DATABASE OF MONITORING BOREHOLES

Boreholes listed under this heading form part of the Department of Water and Environmental Affairs monitoring network. A query was sent to the Department and the reply was that there are no boreholes within the area being monitored. Pump tested low yielding boreholes can be considered for monitoring purposes if not belonging to schools etc and it is within the criteria for local monitoring sites.

6 AQUIFER PARAMETERS AND AQUIFER TEST DATA.

Pump testing of boreholes is the only method that provides simultaneous information on the hydraulic behaviour of the borehole, the reservoir (aquifer) and its boundaries. This information is essential for efficient aquifer and well field management. (Manual on pumping test analysis in fractured rock aquifers, 2001). Pump test data is used for two objectives, to determine the sustainable yield of a single point source and to determine aquifer parameters. For this study two aquifer parameters were reported the first is the Transmissivity (T) and the second is Storativity (S). The values for the second parameter are very small and when using analytical methods the value is affected by the distance between the observation and the pumped borehole. A numerical model is usually used to determine this value accurately and for this report an accepted default value was used.

6.1 Transmissivity (T) and Storativity (S):

Transmissivity is the product of the average hydraulic conductivity K and the saturated thickness of the aquifer D. Consequently, transmissivity is the rate of flow through a unit hydraulic gradient through a cross-section of unit width over the whole saturated thickness of the aquifer. Storativity or storage coefficient, of a saturated confined aquifer of thickness D, is the volume of water released from storage per unit surface area of the aquifer, per unit decline in the component of hydraulic head normal to that surface. (Analysis and evaluation of pumping test data, 1994)

Table 3: Aquifer parameters calculated from available pump test data in the area near the river on the farm Strydfontein using the FC method.

Borehole number	Transmissivity $T(m^2/d)$	Storativity S	Sustainable abstraction for a 24hr/day pumping schedul Q(l/s)
H35-0100	8.2	0.003	0.4
H35-0103	155.0	0.003	5
H35-0104	8.1	0.003	0.7
H35-0106	6.0	0.003	2.3
Geometric mean T =	15.8		Average: 2.1

Table 4: Aquifer parameters calculated from available pump test data in the mountainous area using the FC method

Lower Steelpoort Tubatse Water Scheme Area

Borehole number.	Transmissivity $T(m^2/d)$	Storativity S	Sustainable abstraction for a 24hr/day pumping schedule Q(l/s)
H12-0867	0.7	0.003	0.1
H12-1471	13.5	0.003	0.6
H12-1486	9.6	0.003	0.6
H12-1490	3.4	0.003	0.2
H12-1495	22.0	0.03	1
H12-1497	3.5	0.03	0.3
H12-1502	3.6	0.03	0.3
H12-1561	5.1	0.003	0.06
H12-1945	2.3	0.03	0.15
H12-2272	1.0	0.03	0.1
H12-2449	1.6	0.03	0.08
H12-2537	1.0	0.003	0.25
H12-2551	5.4	0.003	1
H12-2552	0.4	0.003	0.11
Geometric mean T =	2.9		Average:0.34

7 WATER CONSERVATION AND DEMAND

7.1 Water conservation

The Water Act considers groundwater as part of the larger hydrologic cycle and in a continual state of flux with surface water. Both should be seen as a linked source and managed in such a way. Sustainable development of groundwater resources refers to a holistic approach to **development, conservation and management** of these resources. Good sustainable yield estimates are the result of scientifically sound pumping test analysis. It must be noted that these quantities vary with time and location and can only be estimated, and thus may carry a degree of uncertainty. All sources of uncertainty need to be recognized and their impact on water **quality** or the **sustainability** of the aquifer must be evaluated.

Pump tests are important tools that provide information on the hydraulic behaviour of a borehole, the reservoir and the reservoir boundaries. All this information is essential for **efficient aquifer and well field management**. A further essential consideration in the development of an aquifer is the **chemical quality** of water produced, as the quality can limit its use. Groundwater movement induced by pumping may change the groundwater chemistry. The delineation of protection zones from certain microbial pollution sources are an essential part of the management plan.

Table 5: Current water demand and available sources.

Village	Water demand m³/day		Recommended sources m³/day		Boreholes available for testing with potential
	High	Low	motorized	hand pump or un-equipped	
Kgotlopong or Kgotiopong				H12-2272(8.6) Class 0, H12-2537(21.6), Class 2, H12-2551 (86.4) Class 0, H12-2552 (9.5) Class 1	H12-1933, H12-2366, H12-2554
Makgope	20.7	9.1		H12-1477 (4.3) Class 0, H12-1498 (4.3) Class ?	0
Makgwareng	94.5	41.7	H12-1497 (25.9) Class ?		
Mophalema or Matshiretsane or Ga Molai	? 10.5	? 4.6	H12-1479 (34.4) Class 0	H12-1490 (17.3) Class 0	H12-1490, H12-1480, H12-1488, H12-1605, H12-2642, H12-2643, H12-2647
Maakgongywane			H12-1502 (25.9) Class 1		
Masakeng or Ga -Kgoedi	51.6 69.7	22.8 30.7	H12-1471(51.8) Class 0, H12-1486 (51.8) Class ?, H12-1495 (86.4) Class 0		H12-1450, H12-1472, H12-1473
Kgautswana or North, South ,Lebalelo, Paeng	113.2 39.7 72.0 58.4	49.9 17.5 31.8 25.8	H12-1945 (12.9) Class ? H12-2449 (6.9) Class ?	H12-0689(8.3) Class ?, H12-1464(6.1) Class 2, H12-0867 (8.6) Class 1, H12-1946 (29.4) Class ?	H12-0868, H12-1942, H12-1947, H12-1948, H12-1457
Manawaneng or Mosola	23.1	10.2		No boreholes all in Mokutung	
Mokutung or Maketla	13.2 37.4	5.8 16.5		H12-1561 (5.2) Class 0, H12-1568 (75.2) Class ?	H12-1559, H12-1566, H12-1567
Strydfontein farm				H35-0100 (34.6) Class 0, H35-0103 (432) Class 1, H35-0104 (60.5) Class 0, H35-0106 (259.2) Class 1, H35-0105 (0.7) Class ?	H35-0099, H35-0102

Note: It is not known if the villages have water problems as they might be linked to the water sources from Strydfontein.

8 GROUNDWATER RECHARGE AND PROTECTION

8.1 Recharge

To calculate recharge the chloride method was used. The correct way to sample the chloride for these calculations is just under the water table for uncased holes or just under the casing in steel cased holes. The values used in this calculation are from pumping test therefore representing and average value. Fifteen values from fifteen different boreholes were used for the calculation of the harmonic mean. The harmonic mean was calculated to be 16.7mg/l.
The recharge method using the chloride concentration of the boreholes is presented by the equation:

$$RE_{av} = a.Rf_{av}$$

Where

a = $Cl_{rainfall}/Cl_{groundwater}$ represents the recharge coefficient
RE_{av} = average recharge
Cl = chloride concentration
Rf_{av} = average rainfall

Locality	Mean average rainfall (Rf) (mm/a)	$Cl_{rainfall}$ (mg/l)	$Cl_{groundwater}$ (mg/l) Harmonic mean 15 samples	Recharge Cl method % Rf	Average recharge mm/a calculated from available chemical data.	Vegter (1995)
Lower Steelpoort Tubatse	650	1	16.7	5.9%	38mm/a	32-45 mm/a

Table 6: Recharge values.

The rainfall in the area increases from the southeast to the northwest from 590 to 659mm/a. This data is from contoured rainfall data from the maps compiled by Vegter (1995). These maps give contoured recharge data for the area from 32-45mm/a. In this report it was decided to use a recharge of 38mm/a and an average rainfall of 650mm/a. The catchment surface area was calculated from the topographical maps and is estimated to be approximately 166km².

The recharge for the area was calculated as 6.3E+06m³/a and the current annual abstraction as 0.49E+05 m³/a using the information of the tested boreholes. For a total water balance other factors must also be considered such as baseflow, the ecological reserve, inflow and outflow over aquifer boundaries and evapo-transpiration. This was not part of the scope of work and was therefore not calculated.

The difference between recharge and abstraction was calculated as 5.8E+6m³/a, indicating that even with all the factors considered there is still enough scope for source development.

8.2 Borehole Protection zones

Protection zone 1: Borehole construction fencing, and infrastructure.

- For protection zone 1 (i.e. the immediate fenced area around the borehole), it is proposed that the distance of the fence around the borehole must be at least 5m. For a borehole that is supplying water in an area with a small population, (less than 20 people), a well-constructed sanitary seal, 0.5-5mbgl is regarded as sufficient. Quality monitoring must still be carried out
- The pump house and floor is also part of a protection zone 1.

In areas with a high density of pit latrines nearby boreholes should be constructed correctly and fenced off. With a high number of people concentrated in such an area, a risk of Nitrate pollution is possible in nearby boreholes. Pit latrines should be constructed taking local geological and geohydrological conditions in account. In practice it is usually the cheaper toilets that are installed.

Protection zone 2: Microbial (bacteria and viruses) and nitrate pollution.

- Studies have shown that bacteria usually die within 30days after being introduced into the soil. In some cases a minimum distance of 50m between a pit latrine and a borehole will be adequate, as was proposed by Xu and Braune (1995).
- Boreholes located on lineaments should be treated with caution, as the travel times can be fast in these fracture zones. The protection zone in these cases will not be round, but stretched along the lineament strike.
- The FC method for pump test analysis makes provision for the calculation of a protection zone. The interpreter must take certain parameters in account, such as the estimated clay content of the surface and the surrounding population.

Because of the high clay content predominantly in the alluvial deposits on the Transvaal Sequence Rocks, the risk of microbial pollution in boreholes located in these areas is low.

Protection zone 3: Hazardous chemical elements.

- ➢ The FC programme can be used. The programme estimates the catchment area of the borehole by using the recharge and the abstraction rate.

To our knowledge no hazardous chemical elements are present in the area.

Table 7: Estimated protection zone around boreholes in the Strydfontein area along the river, calculated using the FC method.

Borehole nr	T(m^2/d)	Half length of fracture(m)	Protection Zone around borehole(m)
H35-0100	6.0	46	92
H35-0103	155.0	158	315
H35-0104	8.1	68	135
H35-0106	8.2	34	69
		Average	153

On average a production borehole must be 153m away from a pit latrine (protection zone)

Table 8: Estimated protection zones around boreholes in the mountainous area calculated using the FC method.

Borehole number	Transmissivity $T(m^2/d)$	Half length of fracture (m)	Protection Zone around borehole (m)
H12-0867	0.7	29	58
H12-1471	13.5	35	70
H12-1486	9.6	89	178
H12-1490	3.4	139	277
H12-1495	22.0	46	91
H12-1497	3.5	44	88 (risk of microbial pollution high)
H12-1502	3.6	26	52
H12-1561	5.1	64	128
H12-1945	2.3	45	91
H12-2272	1.0	60	120
H12-2449	1.6	50	99
H12-2537	1.0	30	60
H12-2551	5.4	40	81 (Risk of microbial pollution very high)
H12-2552	0.4	19	38
		Average	105

On average a production borehole must be 105m away from a pit latrine (protection zone)

9 GROUNDWATER USERS

The National Water Act prioritises water user groups according to importance. Decreasing in importance is basic human needs, ecological needs and then inessential uses such as economic development. The application for a Water User's licence does not differentiate between users of surface or groundwater.

When using surface or groundwater for irrigation, mining, industrial or a feeding pen, the owner or appointed representative must apply for a Water User licence. Other usage that must be registered is as follows:

- Dumping of waste or water that contains waste.
- Storage of water (>than 10 000m³) or if the full dam capacity surface area is bigger than one ha.
- Activities reducing stream flow such as forestry.
- Irrigation using waste water.
- Power generation using water.
- Recharge of groundwater.

The National Water Act allows for relatively low water usage such as non-commercial small gardens, livestock watering, (not feeding pens), if the use is not excessive in relation to the available source and needs of other users. If your water source is from a local government or any other bulk supplier there is no need to register.

The local government or any other bulk supplier must register.

Water users in the study area include the communities, clinics and schools for domestic and agriculture supply. Along the Steelpoort valley fields are irrigated.

GROUNDWATER QUALITY

ble 9: Available chemical data

orehole number	Water class	Ph	EC (mS/m)	TDS (mg/l)	Total Hardness (mg/l)	P Alkalinity (mg/l)	Total M Alkalinity (mg/l)	Ion Balance Error	Major Cations (mg/l) Ca	Fe	K	Mg	Mn	Na	Si	Major Anions (mg/l) F	Cl	NO_2	NO_3 as N	PO_4 as P	SO_4
12-1495	0	8.3	59.3	449	206.87		226	-2.62	45		0.9	23		40	13	0.4	48		0.14		15
12-0741	0	6.1	7.1	49	15.71		11	-11.37	3		2.5	2		5	5	0.1	8		3		4
12-0867	1	7.69	64	258	208.46		204.24	-0.64	47.2	0.05	0.837	22	0.21	23.4	8.58	0.32	36.51	0.2	1.19	0.8	6.35
12-1454	1	8.7	77.2	576	252.12		249	-0.24	45		1	34		69	7.1	0.58	89		5.6		9
12-1464	1	7.68	74.6	450	280.94		229	**10.56**	58.2	0.01	1.49	33	0.15	54.1		0.25	52		2.9		10.2
12-1469	0	7.7	38.3	313	157.11			**75.22**	30		0.6	20		20	33.3	0.1	20		0.0		0
12-1471	0	7.8	50.5	377	185.43		196	-1.89	43		1.1	19		28	14.8	0.2	33		0.48		12
12-1477	0	7..3	24	188	95.14		112	-7.21	20		0.8	11		8	21.1	0.1	10		0.19		4
12-1479	0	6.7	9.2	72	29.8		39	-16.82	7		0.7	3		5	11.2	0.1	10		0.24		4
12-1490	0	7..5	35.2	292	161.03		173	-2.67	53		1.1	7		9	17.2	0.1	10		0.13		4
35-0100	0	8.1	25.4	210			114	-5.67	25		0.6	13		7	10.7	0.19	18		0.14		7
35-0101	2	7..3	47	262						0.05			0.43			0.5	23.7	0.2	0	0.8	16.7
H35-0103	1	8.6	39	218						0.14			0.1			0.6	13.8	0.2	0	0.8	1.1
H35-0104	0	8.3	24.4	185			103	-1.86	20		0.2	12		10	8.7	0.17	11		0.47		5
H35-0106	1	8..5	68	458						0.05			0.05			0.5	80.5	0.2	2.5	0.8	14.0

Water quality of domestic water, utilized for human consumption and food preparation, must be safe to use if the consumers' health is to be protected. For this reason the *"Quality of Domestic Water Supplies"* (Second edition, 1998)" was set forward by the Department of Water Affairs and Forestry, Department of Health and the Water Research Commission in 1998. This document facilitates the evaluation of water on the basis of five water quality classes:

Classification for domestic use;

- Hydro-chemical results of boreholes H12-1495, H12-0741, H12-1469, H12-1471, H12-1477, H12-1479, H12-1490, H35-0100, and H35-0104 are classified as a **Class 0** for domestic use. (Ideal water quality. Suitable for lifetime use.)
- Hydro-chemical results of H12-0867, H12-1454, H12-1464, H35-0103 and H35-0106 are classified as a **Class 1** for domestic use. (Good water quality. Suitable for use, rare instances of negative effects.)
- Hydro-chemical results of borehole H35-0101 are classified as a **Class 2** for domestic use. (Marginal water quality-conditionally acceptable. Negative effects may occur in some sensitive groups.)

No other information is available on the chemical analysis of groundwater within the area. From the existing chemical information, groundwater in the area is of an ideal and good water quality. The borehole with a poorer water quality is due to elevated concentrations of Manganese (Mn).

11 DESCRIPTION OF GROUNDWATER MONITORING PROGRAMMES (QUALITY AND QUANTITY)

Groundwater monitoring is essential to prevent the unsustainable decline of the groundwater resource over the long term. **Useful markers for the detection thereof are groundwater level/piezometric surface and/or groundwater quality.**

Groundwater monitoring must be seen at two levels. The first is **regional monitoring** to evaluate rainfall and discharge in the catchment area. The positioning of such observation points should be carefully considered taking in account geology, structural geology, existing well fields and social behaviour and future expansion of villages.

On a **local monitoring** scale part of the granting of a water user licence, landfill site or sewerage works to a municipality is a **monitoring and management plan** that the user must adhere to. Local monitoring boreholes, carefully chosen according to various parameters should be near the well field to observe the long term affect of pumping on the source. Abstraction in the well field must be monitored and adjustments can be made depending on the response of the static water table. Chemical changes must be observed in the production boreholes and the positioning of sanitation within the village must be controlled.

Petrol stations or bulk storage of non-aqueous phase liquids usually have a monitoring borehole that must be monitored on a regular basis for signs of leaks.

Mining areas should have monitoring boreholes as it is part of the mining licence. Slate is mined in the area.

DESCRIPTION, COORDINATES AND LOCATION OF ALL POINTS

able 10: Existing groundwater sources.

orehole umber	Site name	Co-ordinates WGS 84		Depth (m)	Static water level level	Pump intake (m)	Discharge rate (l/s)	pumping period hr/day	Daily abstraction (m³/day)	last known equip	last known power	water quality	Comment last visit
		Longitude	Latitude										
12-0689	Kgautswana	30.5592	24.6398	45.1	14.5	60.0	0.23	10	8.3	N	N		Pump suction
12-0690	Kgautswana	30.5586	24.6396	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
12-0743	Kgautswana	30.5575	24.6401	90.0	0.0	0.0	0.00	0	0.0	N	N		Dty-info
12-0744	Kgautswana	30.5567	24.6382	89.4	14.4	24.0	0.10	10	3.6	N	N		Pump suction
12-0867	Kgautswana	30.5431	24.6220	90.0	12.8	36.0	0.10	24	8.6	H	H	CLASS 1	Tested
12-0868	Kgautswana	30.5429	24.6217	47.0	0.0	0.0	0.00	0	0.0	H	H		To test
12-1454	Kgautswana	30.5556	24.6393	67.7	16.7	62.5	0.10	2	0.7	M	D	CLASS 1	Pump suction
12-1455	Kgautswana	30.5483	24.6184	33.1	17.2	30.0	0.10	8	2.9	N	N		Pump suction
12-1457	Kgautswana	30.5547	24.6346	0.0	0.0	0.0	0.00	0	0.0	S	E		To test
12-1462	Kgautswana	30.5614	24.6379	11.9	0.0	0.0	0.00	0	0.0	N	N		Blocked
12-1464	Kgautswana	30.5649	24.6443	50.2	23.8	40.0	0.21	8	6.1	K	H	CLASS 2	Pump suction
12-1465	Kgautswana	30.5480	24.6174	28.3	0.0	0.0	0.00	0	0.0	N	N		Blocked
12-1469	Kgautswana	30.5567	24.6201	78.0	7.8	27.0	0.06	6	1.3	N	N	CLASS 0	Pump suction
12-1942	Kgautswana	30.5653	24.6410	0.0	0.0	0.0	0.00	0	0.0	H	H		To test
12-1943	Kgautswana	30.5679	24.6449	41.1	24.3	40.0	0.15	8	4.3	K	H	CLASS 2	Pump suction
12-1945	Kgautswana	30.5469	24.6210	21.7	4.9	18.0	0.15	24	12.9	S	E		Tested
12-1946	Kgautswana	30.5560	24.6379	45.1	21.6	30.0	0.34	24	29.4	N	N		Tested
12-1947	Kgautswana	30.5538	24.6307	0.0	0.0	0.0	0.00	0	0.0	H	H		To test
12-1948	Kgautswana	30.5633	24.6325	0.0	0.0	0.0	0.00	0	0.0	H	H		To test
12-1989	Kgautswana	30.5390	24.6289	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked

ıble 10: Existing groundwater sources

ɔrehole umber	Site name	Co-ordinates WGS 84		Depth (m)	Static water level level	Pump intake (m)	Discharge rate (l/s)	pumping period hr/day	Daily abstraction (m³/day)	last known equip	last known power	water quality	Comment last visit
		Longitude	Latitude										
12-2449	Kgautswana	30.5665	24.6444	47.1	18.4	30.0	0.08	24	6.9	S	E		Tested
12-1933	Kgotlopong	30.4816	24.5549	135.0	4.6	0.0	0.00	0	0.0	M	D		To test
12-2272	Kgotlopong	30.4849	24.5552	37.3	4.5	18.0	0.10	24	8.6	N	N	CLASS 0	Tested
12-2357	Kgotlopong	30.4814	24.5567	0.0	0.0	0.0	0.00	0	0.0	N	N		Dry info
12-2366	Kgotlopong	30.4809	24.5581	30.0	5.9	0.0	0.00	0	0.0	S	E		To test
12-2537	Kgotlopong	30.4859	24.5557	120.0	3.8	48.0	0.25	24	21.6	N	N	CLASS 2	Tested
12-2546	Kgotlopong	30.4826	24.5544	100.0	0.0	0.0	0.00	0	0.0	N	N		Dry info
12-2551	Kgotlopong	30.4948	24.5583	49.0	-0.1	45.0	1.00	24	86.4	N	N	CLASS 0	Tested
12-2552	Kgotlopong	30.4699	24.5550	114.0	26.9	60.0	0.11	24	9.5	N	N	CLASS 1	Tested
12-2553	Kgotlopong	30.4859	24.5567	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
12-2554	Kgotlopong	30.4705	24.5542	0.0	0.0	0.0	0.00	0	0.0	H	H		To test
12-1496	Maakgongywane	30.5299	24.6043	57.8	12.8	43.0	0.10	2	0.7	N	N		Pump suction
12-1502	Maakgongywane	30.5313	24.6041	59.5	12.4	30.0	0.30	24	25.9	S	E	CLASS 1	Tested
12-1474	Makgopa	30.5519	24.5651	94.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
12-1475	Makgopa	30.5515	24.5651	135.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
12-1476	Makgopa	30.5561	24.5659	130.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
12-1477	Makgopa	30.5495	24.5657	76.1	8.4	18.0	0.20	6	4.3	N	N	CLASS 0	Pump suction
12-1498	Makgopa	30.5424	24.5579	66.6	8.4	48.0	0.10	12	4.3	N	N		Pump suction
12-2639	Makgopa	30.5436	24.5579	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
12-1497	Makgwareng	30.5408	24.5594	66.6	3.5	28.0	0.30	24	25.9	M	D		Tested
12-2640	Makgwareng	30.5303	24.5687	0.0	0.0	0.0	0.00	0	0.0	N	N		Destroyed

ıble 10: Existing groundwater sources

›rehole umber	Site name	Co-ordinates WGS 84		Depth (m)	Static water level level	Pump intake (m)	Discharge rate (l/s)	pumping period hr/day	Daily abstraction (m³/day)	last known equip	last known power	water quality	Comment last visit
		Longitude	Latitude										
12-0740	Masakeng	30.5447	24.6140	20.0	0.0	0.0	0.00	0	0.0	N	N		Dry-info
12-0741	Masakeng	30.5478	24.6154	10.4	7.6	0.0	0.00	0	0.0	H	H	CLASS 0	Blocked
12-0742	Masakeng	30.5486	24.6109	90.0	0.0	0.0	0.00	0	0.0	N	N		Dry-info
12-1450	Masakeng	30.5383	24.6135	0.0	0.0	0.0	0.00	0	0.0	N	N		To test
12-1453	Masakeng	30.5396	24.6082	9.3	7.3	0.0	0.00	0	0.0	N	N		Blocked
12-1460	Masakeng	30.5381	24.6141	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
12-1470	Masakeng	30.5489	24.6112	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
12-1471	Masakeng	30.5341	24.6077	127.0	6.9	90.0	0.60	24	51.8	M	D	CLASS 0	Tested
12-1472	Masakeng	30.5377	24.6119	51.0	4.9	0.0	0.00	0	0.0	N	N		To test
12-1473	Masakeng	30.5384	24.6121	49.0	0.0	0.0	0.00	0	0.0	N	N		To test
12-1486	Masakeng	30.5364	24.6097	139.8	1.7	36.0	0.60	24	51.8	M	D		Tested
12-1495	Masakeng	30.5310	24.6047	68.8	9.7	24.0	1.00	24	86.4	M	D	CLASS 0	Tested
12-1559	Mokutung	30.5875	24.5870	0.0	0.0	0.0	0.00	0	0.0	H	H		To test
12-1560	Mokutung	30.5945	24.5864	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
12-1561	Mokutung	30.5980	24.5802	23.6	12.4	18.0	0.06	24	5.2	H	H	CLASS 0	Tested
12-1566	Mokutung	30.5770	24.5914	0.0	0.0	0.0	0.00	0	0.0	H	H		To test
12-1567	Mokutung	30.5842	24.5905	0.0	0.0	0.0	0.00	0	0.0	N	N		To test
12-1568	Mokutung	30.5857	24.5883	51.0	17.8	45.0	0.87	24	75.2	N	N		Tested

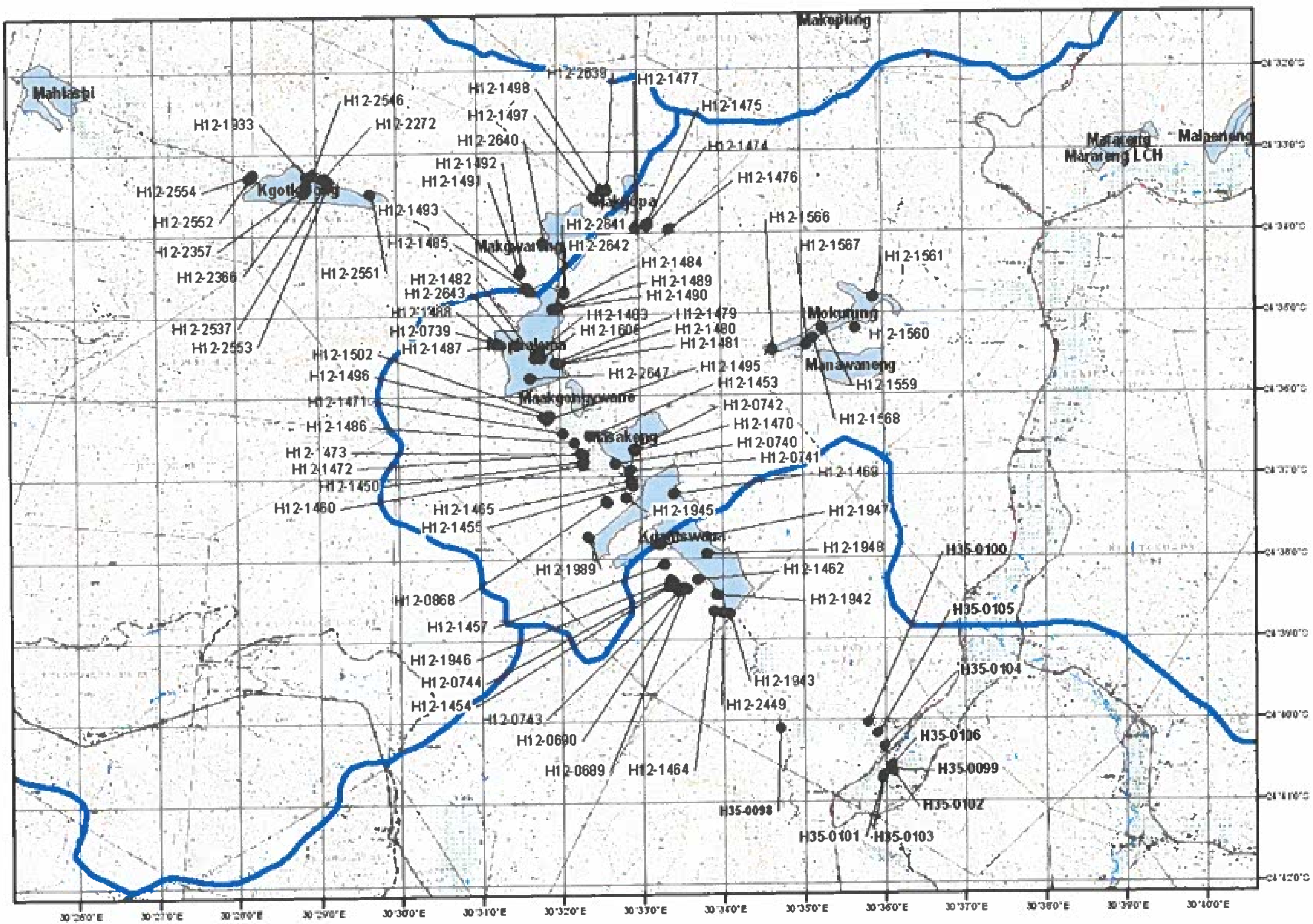
ıble 10: Existing groundwater sources

orehole umber	Site name	Co-ordinates WGS 84		Depth (m)	Static water level level	Pump intake (m)	Discharge rate (l/s)	pumping period hr/day	Daily abstraction (m³/day)	last known equip	last known power	water quality	Comment last visit
		Longitude	Latitude										
12-0739	Mophalema	30.5208	24.5894	100.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
12-1479	Mophalema	30.5326	24.5932	141.6	5.9	30.0	0.41	24	35.4	M	D	CLASS 0	Tested
12-1480	Mophalema	30.5331	24.5934	44.0	5.9	0.0	0.00	0	0.0	N	N		To test
12-1481	Mophalema	30.5332	24.5935	32.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
12-1482	Mophalema	30.5282	24.5921	54.1	0.0	0.0	0.00	0	0.0	N	N		Blocked
12-1483	Mophalema	30.5291	24.5907	45.3	17.1	39.0	0.10	2	0.7	H	H		Pump suction
12-1484	Mophalema	30.5332	24.5819	0.0	0.0	0.0	0.00	0	0.0	N	N		Dry-info
12-1485	Mophalema	30.5272	24.5786	67.0	0.0	0.0	0.00	0	0.0	N	N		Dry-info
12-1487	Mophalema	30.5208	24.5894	0.0	0.0	0.0	0.00	0	0.0	N	N		Dry-info
12-1488	Mophalema	30.5207	24.5894	0.0	0.0	0.0	0.00	0	0.0	S	E		To test
12-1489	Mophalema	30.5323	24.5822	48.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
12-1490	Mophalema	30.5322	24.5822	120.0	28.7	72.0	0.20	24	17.3	N		CLASS 0	Tested
12-1491	Mophalema	30.5252	24.5749	51.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
12-1492	Mophalema	30.5257	24.5741	101.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
12-1493	Mophalema	30.5267	24.5779	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
12-1605	Mophalema	30.5297	24.5923	79.8	0.0	0.0	0.00	0	0.0	S	E		To test
12-2641	Mophalema	30.5346	24.5788	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
12-2642	Mophalema	30.5345	24.5789	0.0	0.0	0.0	0.00	0	0.0	N	N		To test
12-2643	Mophalema	30.5245	24.5897	78.0	0.0	0.0	0.00	0	0.0	S	E		To test
12-2647	Mophalema	30.5272	24.5963	0.0	0.0	0.0	0.00	0	0.0	S	E		To test

ıble 10: Existing groundwater sources

ɔrehole umber	Site name	Co-ordinates WGS 84		Depth (m)	Static water level level	Pump intake (m)	Discharge rate (l/s)	pumping period hr/day	Daily abstraction (m³/day)	last known equip	last known power	water quality	Comment last visit
		Longitude	Latitude										
35-0098	Strydfontein	30.5783	24.6683	81.1	16.6	77.4	0.10	2	0.7	M	D		Pump suction
35-0099	Strydfontein	30.6012	24.6770						0.0	S	E		To test
35-0100	Strydfontein	30.5965	24.6675	104.0	20.2	30.0	0.40	24	34.6	M	E	CLASS 0	Tested
35-0101	Strydfontein	30.5994	24.6788	42.2	5.0	33.5	0.10	2	0.7	N	N	CLASS 2	Pump suction
35-0102	Strydfontein	30.6015	24.6772			0.0	0.00	0	0.0	N	N		To test
35-0103	Strydfontein	30.5996	24.6781	41.0	5.2	36.0	5.00	24	432.0	N	N	CLASS 1	Tested
35-0104	Strydfontein	30.5998	24.6723	114.9	11.9	42.0	0.70	24	60.5	N	N	CLASS 0	Tested
35-0105	Strydfontein	30.5984	24.6697	109.0	11.9	37.0	0.10	2	0.7	S	E		Pump suction
35-0106	Strydfontein	30.6013	24.6761	150.0	2.8	60.0	3.00	24	259.2	M	E	CLASS 1	Tested

Map D: Topographical map with positions of existing boreholes and quaternary catchment areas.



13 OVERVIEW OF GROUNDWATER QUANTITY AND QUALITY

The chemical composition of groundwater is the result of interaction between rainwater, soils and various rock types. Most of this interaction takes place in the unsaturated zone and later in the saturated zone along the groundwater flow path, where physical and geochemical properties of the rock types influence the type and character of the groundwater quality. In the area under discussion, water is mainly abstracted for livestock watering and domestic purposes. Along the river valley water is also used for irrigation. **H12-0867 is plotted on various diagrams. This is a representative plot of groundwater in the area.** Data plotted on these diagrams is used to identify the hydro-chemical water type, to describe the dominant ionic species, to visualize trends, to get a "fingerprint" of the water and to relate it to the geological setting and to classify the water for irrigation purposes.

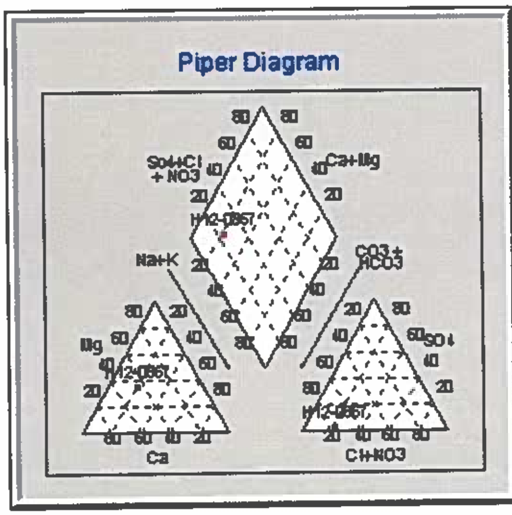


Diagram 1: Piper diagram H12-0867

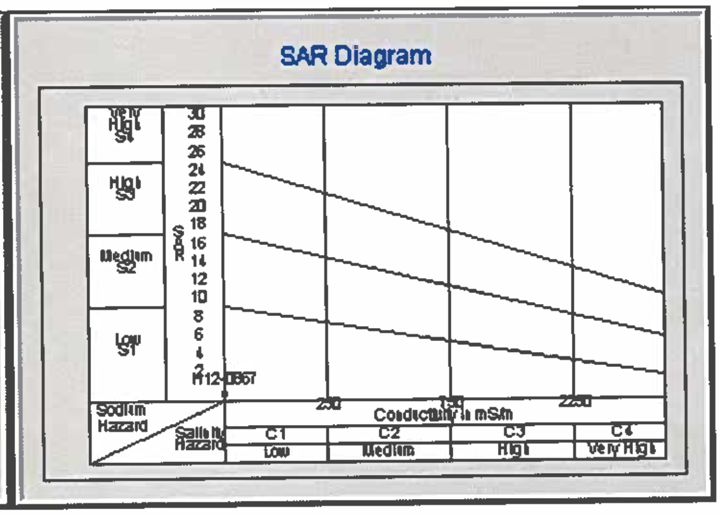


Diagram 2: SAR diagram H12-0867

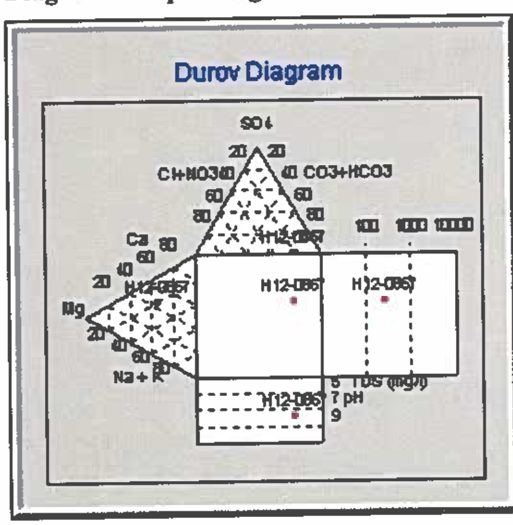


Diagram 3: Durov Diagram

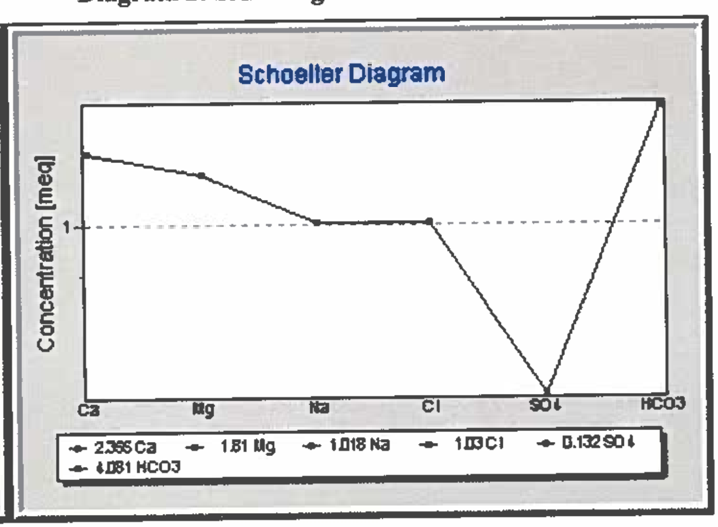


Diagram 4: Schoeller diagram.

13.1 Overview on groundwater quality.

- The hydro chemical water type is **TYPE B**. Dominant cations Mg^{2+} and Ca^{2+}. Dominant anions HCO_3^- .
- **Domestic water quality Class 0** in 60 % of the sampled boreholes.
- **Domestic water quality Class 1** in 33 % of the sampled boreholes due to the concentration of Manganese (Mn), the reported electrical conductivity (EC), the Total dissolved salts (TDS) and the calculated Total Harness as CaCO3.
- **Domestic water quality Class 2** in 6 % of the sampled boreholes due to the concentration of Manganese (Mn). Quality Class 2 water can be equipped for domestic use.
- The water is a Class **C1S1 irrigation water.**
- **Low salinity water (C1)** can be used for irrigation on most crops in most soils with little likelihood that soil salinity will develop.
- **Low-sodium water (S1)** can be used for irrigation on almost all soils with little danger of developing harmful levels of sodium.
- The plotted parameters on the Schoeller diagram give a distinctive plot. The Sulphate (SO_4) concentration of the groundwater shows a dip on the diagram.

It is recommended that boreholes in the mountainous part of the study area must be on average 105m away from pit latrines. The boreholes near the river should be 153m away from such sources. Management of groundwater sources and village sanitation is equally important. Delineation of borehole protection zones from certain microbial pollution sources is essential.

13.2 Overview of groundwater quantity.

The recommended abstraction yield for a 24hr/day pumping cycle, (determined from pump test data using the FC-method), varies from 0.1l/s (8.6m³/day) to 1l/s (86.4m³/day) in the mountainous area (14 tests evaluated). In the area close to Ohrigstad the yields ranges from 0.4l/s (34.5m³/day) to 5l/s (432m³/day). (4 tests evaluated).

14 INDENTIFICATION OF BOREHOLES OF CONCERN

- Boreholes of concern will include production boreholes situated in the same aquifer threatening the resources of the aquifer.
- Production boreholes near obvious pollution sites especially down gradient from such a site. These sites include landfills, sewerage works and smaller point sources such as pit latrines.
- Boreholes identified with construction problems, such as insufficient casing. This will result in high maintenance cost.
- Development of well fields without professional input.

15 INDENTIFICATION OF POOR BOREHOLE SITING REGADING POSITION AND SANITATION

The Minimum Standards and Guidelines for Groundwater Resource Development for the Community Water Supply and Sanitation Programme, a document by The Department of Water and Environment Affairs gives clear guidelines regarding the **positioning and development** of production boreholes for domestic supply.

This document explains the scientific approach for the development of groundwater sources that must be followed, utilizing existing technology such as satellite imagery interpretation, aerial photo interpretation, geophysical methods such as the electromagnetic, magnetic and DC resistivity profiling together with a sound understanding of the local geology and hydrogeological conditions of the study area.

Using the guideline document and competent people the development of production boreholes should not be in the vicinity of point pollution sources. Special cases will be schools or clinics where the available space is restricted and the borehole must be on the institution's property.

16 REHABILITATION/MITIGATION REQUIREMENTS.

In a **point source context** rehabilitation, will refer to the actions that must be taken to rehabilitate a borehole. It includes removal of fallen equipment, instalment of new equipment etc. This project did not include a field phase to get an up-to-date status quo on the point sources. The data used is mostly dated between 2000 and 2002.

Rehabilitation of blocked boreholes and no access:
Boreholes listed are boreholes known to be blocked (information from the last survey) and boreholes with access problems (the problem is usually related to roads).

In an **aquifer context** the rehabilitation and mitigation requirements will refer to pollution control. The best way to deal with pollution sources such as landfills is to use strict design criteria and up to date management control. Pollution from the source needs to be minimized, as it is time consuming and very expensive to rehabilitate an aquifer.

Table 11: Boreholes available for rehabilitation or monitoring.

Borehole number	Site name	Co-ordinates WGS 84		Depth (m)	Static water level	Pump intake (m)	Discharge rate (l/s)	pumping period hr/day	Daily abstraction (m³/day)	last known equip	last known power	water quality	Comment last visit
		Longitude	Latitude										
H12-1465	Kgautswana	30.5480	24.6174	28.3	0.0	0.0	0.00	0	0.0	N	N		Blocked
H12-1989	Kgautswana	30.5390	24.6289	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
H12-1462	Kgautswana	30.5614	24.6379	11.9	0.0	0.0	0.00	0	0.0	N	N		Blocked
H12-0690	Kgautswana	30.5586	24.6396	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
H12-1454	Kgautswana	30.5556	24.6393	67.7	16.7	62.5	0.10	2	0.7	M	D	CLASS 1	Pump suction
H12-1469	Kgautswana	30.5567	24.6201	78.0	7.8	27.0	0.06	6	1.3	N	N	CLASS 0	Pump suction
H12-1455	Kgautswana	30.5483	24.6184	33.1	17.2	30.0	0.10	8	2.9	N	N		Pump suction
H12-0744	Kgautswana	30.5567	24.6382	89.4	14.4	24.0	0.10	10	3.6	N	N		Pump suction
H12-1943	Kgautswana	30.5679	24.6449	41.1	24.3	40.0	0.15	8	4.3	K	H	CLASS 2	Pump suction
H12-2553	Kgotlopong	30.4859	24.5567	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
H12-1496	Maakgongywane	30.5299	24.6043	57.8	12.8	43.0	0.10	2	0.7	N	N		Pump suction
H12-1476	Makgopa	30.5561	24.5659	130.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
H12-2639	Makgopa	30.5436	24.5579	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked

Table 6: Boreholes available for rehabilitation or monitoring.

Borehole number	Site name	Co-ordinates WGS 84		Depth (m)	Static water level level	Pump intake (m)	Discharge rate (l/s)	pumping period hr/day	Daily abstraction (m³/day)	last known equip	last known power	water quality	Comment last visit
		Longitude	Latitude										
H12-0741	Masakeng	30.5478	24.6154	10.4	7.6	0.0	0.00	0	0.0	H	H	CLASS 0	Blocked
H12-1453	Masakeng	30.5396	24.6082	9.3	7.3	0.0	0.00	0	0.0	N	N		Blocked
H12-1460	Masakeng	30.5381	24.6141	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
H12-1470	Masakeng	30.5489	24.6112	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
H12-1560	Mokutung	30.5945	24.5864	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
H12-2641	Mophalema	30.5346	24.5788	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
H12-1482	Mophalema	30.5282	24.5921	54.1	0.0	0.0	0.00	0	0.0	N	N		Blocked
H12-1493	Mophalema	30.5267	24.5779	0.0	0.0	0.0	0.00	0	0.0	N	N		Blocked
H12-1483	Mophalema	30.5291	24.5907	45.3	17.1	39.0	0.10	2	0.7	H	H		Pump suction
H35-0098	Strydfontein	30.5783	24.6683	81.1	16.6	77.4	0.10	2	0.7	M	D		Pump suction
H35-0101	Strydfontein	30.5994	24.6788	42.2	5.0	33.5	0.10	2	0.7	N	N	CLASS 2	Pump suction

Note: No other information is available on the above listed boreholes. A field visit should be performed to verify the status of these boreholes. If these boreholes are near production boreholes or no information is available to verify these holes as being strong, rehabilitation is recommended. Access roads are part of the maintenance of equipped sources.

UN-USABLE BOREHOLES

oreholes listed as un-usable includes known dry boreholes or boreholes that were tested and found to have un-economical yields. The last can be considered for monitoring boreholes. efore any action is taken on the tested boreholes they should be visited to confirm their current status.

'able 12: Un-usable boreholes.

orehole number	Site name	Co-ordinates WGS 84		Depth (m)	Static water level level	Pump intake (m)	Discharge rate (l/s)	pumping period hr/day	Daily abstraction (m³/day)	last known equip	last known power	water quality	Comment last visit
		Longitude	Latitude										
I12-0743	Kgautswana	30.5575	24.6401	90.0	0.0	0.0	0.00	0	0.0	N	N		Dry-info
I12-2546	Kgotlopong	30.4826	24.5544	100.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
I12-2357	Kgotlopong	30.4814	24.5567	0.0	0.0	0.0	0.00	0	0.0	N	N		Dry-info
I12-1474	Makgopa	30.5519	24.5651	94.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
I12-1475	Makgopa	30.5515	24.5651	135.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
I12-2640	Makgwareng	30.5303	24.5687	0.0	0.0	0.0	0.00	0	0.0	N	N		Destroyed
I12-0740	Masakeng	30.5447	24.6140	20.0	0.0	0.0	0.00	0	0.0	N	N		Dry-info
I12-0742	Masakeng	30.5486	24.6109	90.0	0.0	0.0	0.00	0	0.0	N	N		Dry-info
I12-0739	Mophalema	30.5208	24.5894	100.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
I12-1481	Mophalema	30.5332	24.5935	32.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
I12-1489	Mophalema	30.5323	24.5822	48.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
I12-1491	Mophalema	30.5252	24.5749	51.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
I12-1492	Mophalema	30.5257	24.5741	101.0	0.0	0.0	0.00	0	0.0	N	N		Dry-drill
I12-1484	Mophalema	30.5332	24.5819	0.0	0.0	0.0	0.00	0	0.0	N	N		Dry-info
I12-1485	Mophalema	30.5272	24.5786	67.0	0.0	0.0	0.00	0	0.0	N	N		Dry-info
I12-1487	Mophalema	30.5208	24.5894	0.0	0.0	0.0	0.00	0	0.0	N	N		Dry-info

18 ASSESSMENT OF GROUNDWATER SOURCES, SHORT, MEDIUM AND LONG TERM.

Lower Steelpoort Tubatse water source area:

Short term:

- A field visit to the motorised and tested boreholes is recommended to confirm available information and to evaluate the current status thereof.
- Test the un-tested boreholes where needed.
- Sample and evaluate the groundwater chemistry in boreholes that haven't been chemically analysed.
- Equip and upgrade new and existing installations to the Department of Water Affairs and Forestry specifications.
- During this phase blocked boreholes can be visited and a final decision made regarding rehabilitation.
- Confirm the current water supply and demand in the villages.

Medium term:

- Electrification of installations.
- Implement the use of the long term recommended yield abstraction (FC method).
- The 24hr/day pumping schedule is recommended to minimize over pumping of boreholes and to minimize equipping cost. (Smaller pumps and head gear). The power supply in villages is not always suitable for big electrical motors.
- DWAF guidelines should be followed where new groundwater sources are developed.

Long term:

- Monitoring of abstraction volumes, water levels and quality of the well fields.
- Identification of possible pollution sites.
- Ensure the correct design and management control of water sources and possible pollution sources.
- Monitor population and expansion/development of the town to ensure reliable sources for the population.

19 CONCLUSIONS

- ➢ This report does not include a full water balance determination and the project did not include any field work. **All available data sources** were utilized for information with some information dating back to 1997. Available groundwater data for the Lower Steelpoort Tubatse water supply area consisted of basic site information on a total of 88 borehole sources. Testing data of 18 boreholes were evaluated and the chemical analyses of 15 boreholes were available.

- ➢ **Nine villages** fall under the supply zone and to our knowledge they are all connected and getting additional water from Strydfontein. It is not known if the demand is met.
- ➢ The **DWAF form D village names** list was used on all maps and tables.

- The average **summer temperatures** ranges between 14.5-31 degrees and the average winter temperatures are much colder ranging between 4.7 to 25.2 degrees Celsius. .
- For the Lower Steelpoort Tubatse water supply zone the **mean annual precipitation** was accepted as 650mm/annum as on Vegter's maps.

- The hydro-chemical water type is **TYPE B**. Dominant cations Mg^{2+} and Ca^{2+}. Dominant anions HCO_3^- .
- **Domestic water quality Class 0** in 60 % of the sampled boreholes.
- **Domestic water quality Class 1** in 33 % of the sampled boreholes due to the concentration of Manganese (Mn), the reported electrical conductivity (EC), the Total dissolved salts (TDS) and the calculated Total Harness as CaCO3.
- **Domestic water quality Class 2** in 6 % of the sampled boreholes due to the concentration of Manganese (Mn). Class 2 water quality boreholes can be equipped for domestic use.
- The water is classified as a Class **C1S1 irrigation water.**

- The **recharge** for the area was calculated as 6.3E+06m³/a and the current annual abstraction as 0.49E+05 m³/a using the long term recommended yields of the tested boreholes. For a total water balance other factors must also be considered such as baseflow, the ecological reserve, inflow and outflow over aquifer boundaries and evapotranspiration. This was not part of the scope of work and was therefore not calculated.
- The **difference between recharge and abstraction** was calculated as 5.8E+6m³/a indicating that even with all the factors considered, enough scope for source development still exists.

- The **recommended long term abstraction yields** (24hr/day pumping cycle using the FC-method) varies from 0.1l/s (8.6m³/day) to 1l/s (86.4m³/day) in the mountainous area (14 pumping tests evaluated) and from 0.4l/s (34.5m³/day) to 5l/s (432m³/day). (4 pumping tests evaluated) in the area near the Ohrigstad River.

- **Management** of groundwater sources and village sanitation is equally important. Delineation of borehole protection zones from certain microbial pollution sources is essential. An area, with a radius of 153m around every borehole, must be **protected** for the boreholes near the river and 105m for boreholes in the mountainous area's.

- Recommendations were made for the **assessment of groundwater** use in the short, medium and long term.

- It is recommended that an extensive borehole census be carried out in this area to confirm and update all available borehole and related data.

- **A Management plan, monitoring** the well field, water level, quality and abstraction, forms an essential part of water conservation.

20 REFERENCES

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VSA Leboa Consulting (Pty) Ltd

Reg No. 2000/002014/07

GEOHYDROLOGICAL REPORT

Groundwater assessment study Orighstad water supply zone.

For
BTW Consulting (Pty) Ltd.

Tubatse Municipality
Sekhukhune District
Limpopo Province

REPORT-VSALEB/PR09/134C
September 2009

Author: C.J Sonnekus (Pr.Sci.Nat)

Gis prepared by: A.M. Cronje

VSA Group of Companies

EXECUTIVE SUMMARY

VSA Leboa Consulting was appointed by BTW Consulting (Pty) Ltd July 2009 to give a **groundwater situation assessment of Orighstad and Maepa** based on data available on the Groundwater Data Base. The outlay of the report is based on fifteen points that should be addressed. These points were identified by the client for the assessment. The output for the interpretation of results and recommendations should be in terms of short, medium and long term use regarding groundwater as the primary source of potable water.

This report does not include a full water balance determination and the project did not include any field work. **All available data sources** were utilized, with some information dated 1997. Around **Orighstad, 8 known** boreholes are listed. No pump testing or water quality information is available. At **Maepa, 3 tested** boreholes are listed without any water quality information.

Available groundwater data for the nearby Lower Steelpoort Tubatse water supply area was also used for this study.

The town of Orighstad is currently supplied with water by a private farmer. No information regarding the daily usage could be obtained as the farmer was not available to supply the information. Existing boreholes are available in the town for pump testing if water is needed. Maepa have three pump tested boreholes. The chemistry is not known and the demand is not met. New sources should be developed and the water analysed.

The **groundwater quality** is expected to be a hydro-chemical water **TYPE B** and a Class **C1S1 irrigation water.** For domestic use approximately 93% of the groundwater in the area might be of an **ideal to good water quality.** It is recommended that boreholes in the mountainous part of the study area be on average, 105m away from pit latrines. The boreholes near the river should be 153m away from such sources.

In this report a recharge of 26mm/a, a surface area of 50.6km² and an average rainfall of 620mm/a was used to calculate recharge. The **recharge** for the area was calculated as 1.3E+06m³/a. The current annual abstraction is not known for Orighstad. For Maepa the demand is 0.3E+06 m³/a using the estimated peak requirement as supplied by the client.

Monitoring the well field, water level, quality and abstraction must be implemented as it is an essential part of groundwater management. Water conservation can only be successfully implemented with a properly managed plan.

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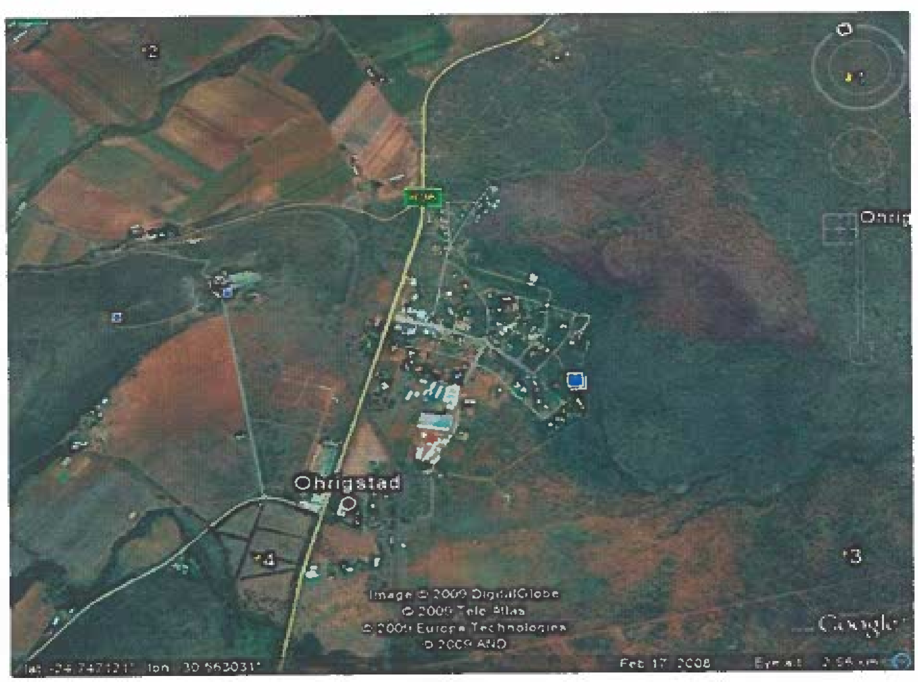
Map A: Locality Map Orighstad (Google image)



1 INTRODUCTION

1.1 Background:

VSA Leboa Consulting was appointed by BTW Consulting (Pty) Ltd July 2009 to give a **groundwater situation assessment of around Orighstad and Maepa** based on data available on the Groundwater data base. The outlay of the report is based on fifteen points that should be addressed. These points were identified by the client for the assessment. The output for the interpretation of results and recommendations should be in terms of short, medium and long term use regarding groundwater as the primary source of potable water.

Around Orighstad 8 known boreholes are listed. No pump testing or water quality information is available. The town is currently supplied by a private farmer. No information regarding the daily usage could be obtained as the farmer was not available. At Maepa, 3 tested boreholes are listed without any chemical data. Available groundwater data for the nearby Lower Steelpoort Tubatse water supply area was used for this study. It consisted of basic site information for a total of 88 boreholes. Of these, 18 boreholes were pump tested, and 15 had water quality results. Data from the farm Strydfontein will correspond to expected hydrological conditions next to the river at Orighstad. Data from the mountainous area of the lower Steelpoort Tubatse water source area will correspond to expected geohydrological conditions at Maepa.

1.2 Scope of work:

The report outlay was pre-described by the client as discussed in the background. Additionally to this, more points were included. To address the short, medium and long term use effectively, it was summarized under the heading 'Interpretation, Results and Recommendations for groundwater use in the short, medium and long term'. Other additional points that were discussed are physiography with subheadings topography and drainage, climate and rainfall, vegetation, sensitive habitats and the riparian vegetation. Under the pre-determined heading, "Identification of poor borehole sitting", the correct approach to developing production boreholes was given.

This report is a summary of the existing groundwater situation in this area and does not include a full groundwater model for determining the reserve, or to give a water balance for the area. **No field work was done as it was not part of the scope of work.**

1.3 Location:

Table 1: Village positions.

Village	Approximate co-ordinates WGS 84		Height mamsl		1:50 000 Topographical map reference	Approximate surface area km²
	Latitude	Longitude	Lowest	Highest		
Orighstad	24° 44' 30"	30° 33' 50"	1066	1451	2430DA & 2430DC	28.49

Maepa	24° 40' 50"	30° 31' 50"	1120	1512	2430DA	23.46

1.4 General comments on existing data sources and evaluation:

All available data sources were used for this study. This includes data from the data base maintained by VSA Leboa Consulting and from the Limpopo Aquabase data base that includes historical National Groundwater Data Base data and data from the Groundwater resource Information programme (GRIP). The Aquabase database is managed and continuously being updated by GPM Geo-consultants under appointment of **The Department of Water and Environment Affairs.** Various role-players in the groundwater industry committed themselves to the upkeep of this data base and all new information is handed to GPM on a regular basis. The GRIP project was a major source of data. This project was done by geo-consultants under the appointment of the Department of Water Affairs and Forestry in the period 2000-2002 when all the boreholes in the former rural areas were visited, field marked, and the status quo investigated. The data obtained from this project were verified and linked with data from the National Groundwater Data Base. The GRIP project is still continuing on a smaller scale whereby boreholes are tested in areas with poor data coverage. It must be stated that in many areas the method of marking boreholes and forwarding data to DWAF was not enforced by municipalities after 2002. The result is that a good ground basis of data exists but it must be verified again by a hydro census if up to date information are needed.

2 PHYSIOGRAPHY

2.1 Topography and drainage

The drainage pattern in the mountainous area is almost dendritically in appearance. Numerous ephemeral streams follow narrow steep valleys that are more or less east west or north south. These streams act as conduits for water from the mountains during rain periods, towards the north flowing Orighstad River. This river forms a broad 1km valley within the mountainous region. Less broad valleys (500m) were carved out by secondary rivers such as the Kaspersnek River that joins the Orighstad River 10km north of the town. The drainage patterns are related to the structural geology of the area, which is mostly near vertical intrusive diabase and dolerite dykes, thin fracture and jointed zones

The topography is related to the regional geology which is a sedimentary succession dipping slightly to the south west. This results in mountains having long flat slopes with a slight gradient, forming an escarpment in the north or north eastern side of the mountains. The cliffs have a layered appearance with rubble, colluvium, forming at the slope and base of the mountains. The lowest point in the study area is the elevation at approximately 1066mamsl, next to the Orighstad River. The elevation increases steadily to a height of 1451mamsl to the nearby mountains (1.5km) with an elevation of 1451mamsl. At Maepa, the elevation increases gently from approximately 1120mamsl to 1512mamsl to the Ramakgai koppie.

2.2 Climate and rainfall

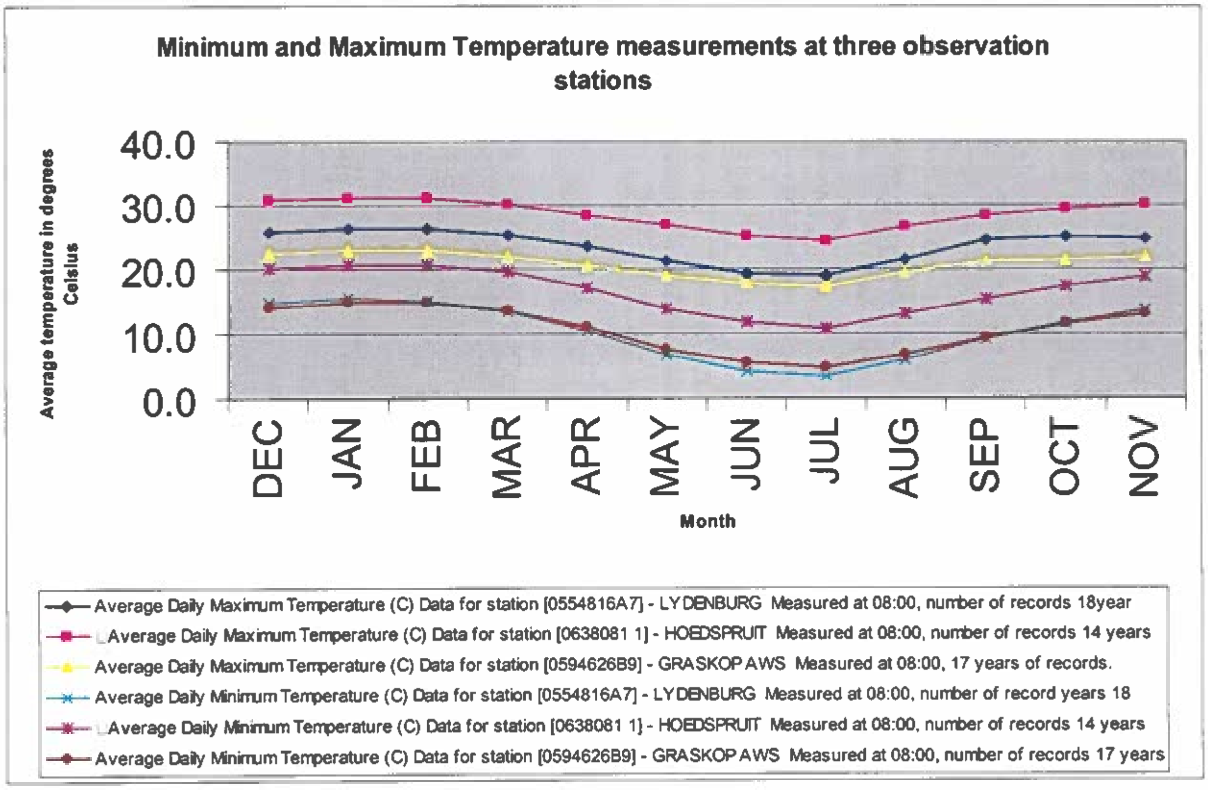


Figure 1: Minimum and Maximum Temperature measurements at three observation stations.

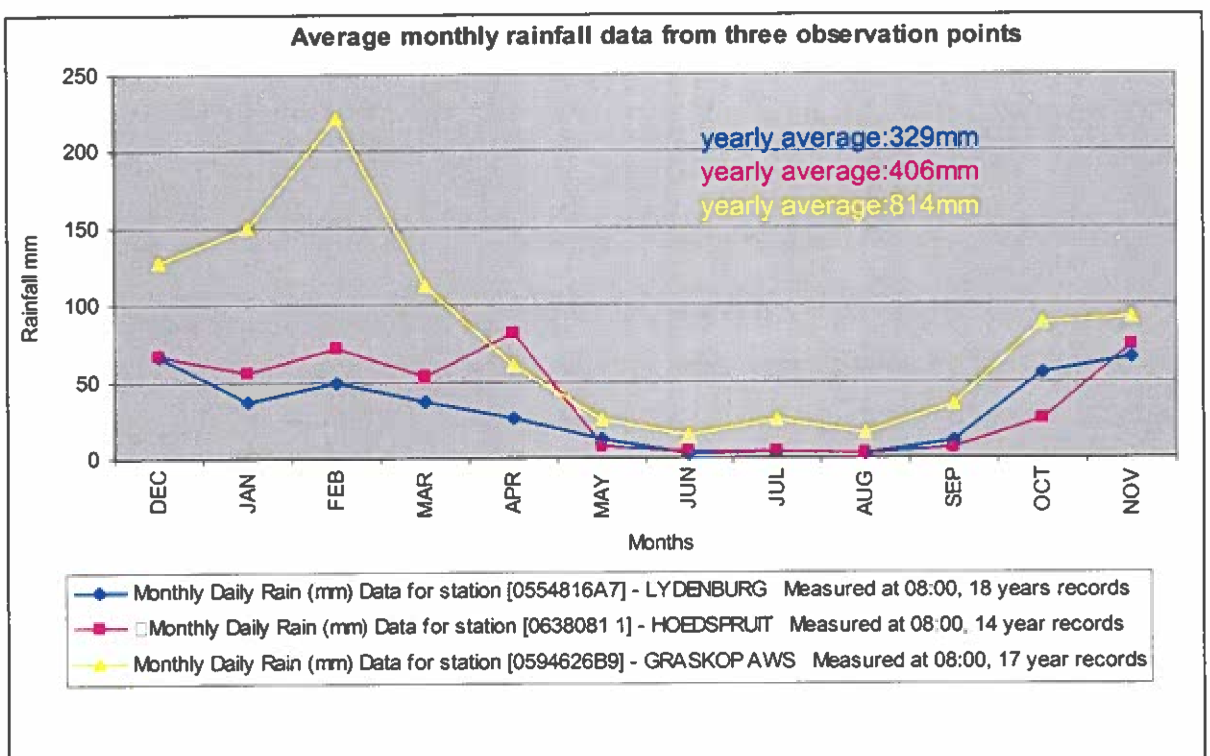


Figure 2: Average monthly rainfall data from three observation points.

Temperature data is available from three sources in the vicinity of the study area. (Lydenburg, Hoedspruit and Graskop). For this report the data from Lydenburg and Graskop was used. The average summer temperatures ranges from 14.5 to 26 degrees Celsius and the winter temperatures are much colder ranging from an average of 4.7 to 20 degrees Celsius.

Rainfall data is from the same source. These rainfall figures were compared to those indicated on the maps produced by Vegter 1995. These maps have contoured rainfall data indicating an average between 590mm/a and 650mm/a. **For Orighstad area the mean annual precipitation was accepted as 620mm/a**

2.3 Vegetation

The lower lying areas are covered by the Sourish Mixed Bushveld vegetation unit, (vegetation type 19, Acocks 1988) forming part of the Tropical Bush and Savanna veld type. The higher lying areas are covered by the North-eastern Mountain Sourveld vegetation unit, (vegetation type 8, Acocks 1988) forming part of the inland Tropical Forest veld.

2.4 Sensitive habitats

Preservation of plant species in the Orighstad area, especially in the small valleys and mountainous areas are crucial to the survival of numerous small animals and the preservation of biodiversity. These plants prevent the degradation of the area by erosion during rain storms, when water is rushing down the slopes and valleys.

2.5 Riparian vegetation

The riparian zone comprises plant communities contiguous to, and affected by surface and subsurface hydrological features of perennial or intermitted water bodies (rivers ad streams). Riparian areas have one or both of the following characteristics:

1) Distinctly different vegetative species to adjacent areas.

2) Species similar to adjacent areas, but exhibiting more rigorous or robust growth formation.

The vegetation is dependent on the river for a number of functions including growth, temperature control, seed dispersal, seed germination and nutrient enrichment (Kemper, 2001). This vegetation comprises a distinct composition of species, often different from that of the surrounding terrestrial vegetation. Tree species are positioned according to their dependency or affinity for water: the more water loving species, (mesic species) being located closest to the river channel, (often with their roots in the water), and the less water loving terrestrial species, further away from the river (Kemper, 2001).

Certain sections along the Orighstad River are more typical of the natural riparian vegetation. Others have been severely altered due to riparian zone degradation related to farming activities around the river and the introduction of alien plant species.

3 OVERVIEW OF THE GEOLOGY OF THE AREA (REGIONAL GEOLOGY)

Information on the regional geology surrounding the study area were obtained from the 1:250 000 South African geological map series and explanatory booklet. Map sheet 2430 Pilgrims Rest. The map included in the report is a scanned copy thereof.

3.1 Pretoria group

The area is underlain by rocks of the Transvaal sequence mainly presented by rocks of the Pretoria group in the study area. The formations developed in the area include the Timeball Hill Formation that is a dark-grey to black well-bedded shale with conglomerate. (Bevet's conglomerate sporadically developed at the base, flagstone and brownish to grey shale at the top (Vtl)) This is overlain by fine to medium grained ripple marked quartzite, middle part argillaceous (Vtq). The upper part of this formation is presented by a red to grey, locally laminated shale, diamictite with occasional quartzite layers (Vtu). The Timeball Hill Formation is overlain by the Boshoek formation (Vb) represented in the area by a medium-grained quartzite, subgreywacke with conglomerate at base and siltstone at top. The main parts of the formations are considered to have formed in a tidal-shelf environment (Button 173b)

Volcanic rocks in the Pretoria Group within the area include fine-to medium-grained andesitic lava of the Hekpoort Andesite Formation (Vha). The middle part of the formation is amygdaloidal and it is brecciated at the top. The lavas were extruded on land (Button 1973b). In the Orighstad area this formation forms part of the higher lying areas.

White-grey, medium-grained quartzite interlayered with shaly quarzite and shale of the Dwaalheuwel formation (Vdw) overlays the Hekpoort Andesite Formation. This forms the upper most parts of the mountains in the immediate vicinity of Orighstad and Maepa.

Further to the east the stratigraphically younger formation such as the Silverton Shale Formation (Vs) occurs, overlain in places by diabase sills (Vdi).

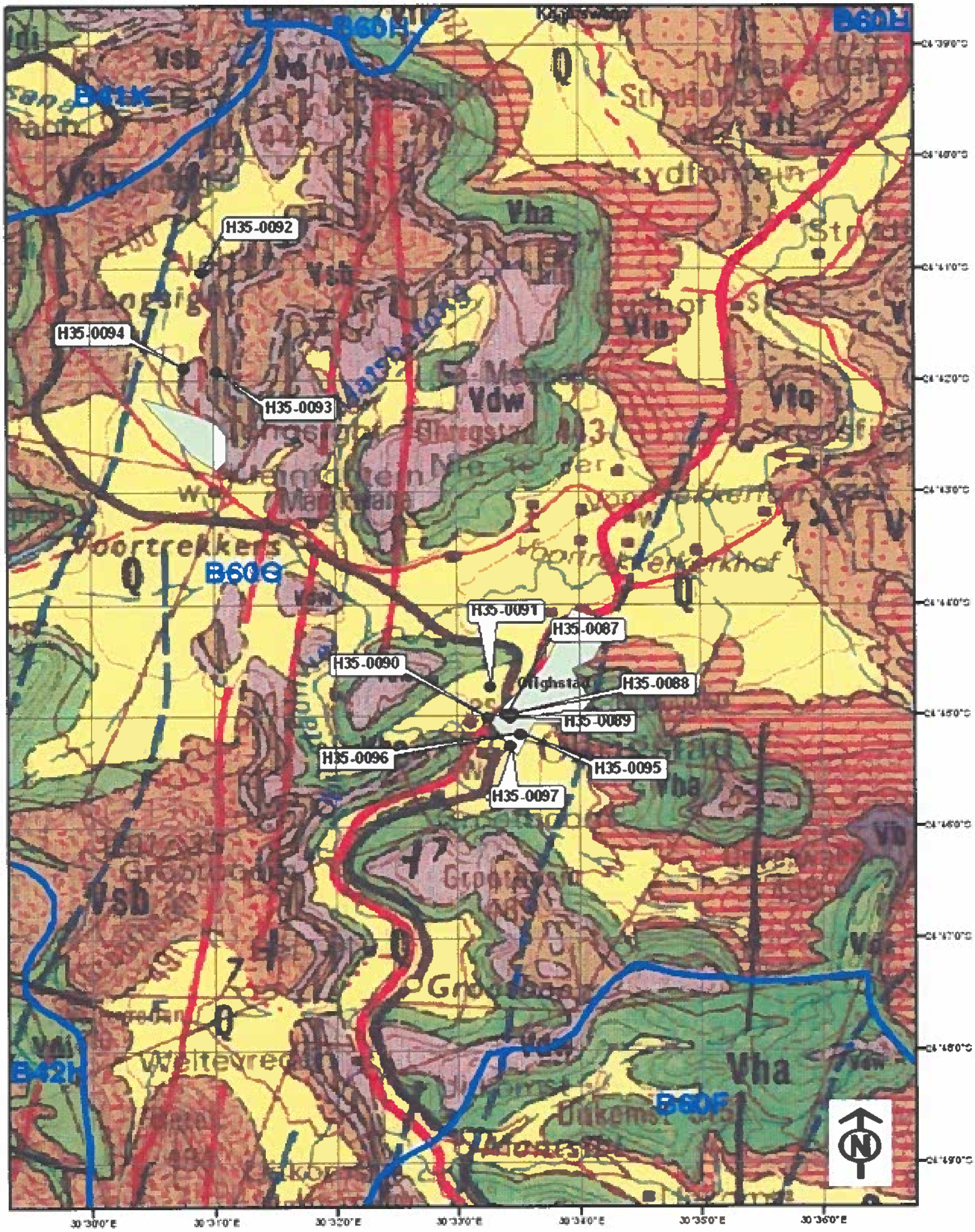
3.2 Quaternary deposits

From the information of drilling logs in the area, it is evident that the alluvium (river deposits) next to the river is poorly developed. The lower laying areas are covered with rubble (colluvium) from the mountains including quartzite, dolerite and diabase boulders, within a fine grained (weathered shale) matrix, which is almost weathered to clay.

3.3 Structural geology

Numerous lineaments inferred from aerial magnetic data, or from field observations, are plotted on the geological map. Most prominent among these, are the long continuous dykes trending slightly east of north. These dykes had an influence on the topography and drainage of this region. Most prominent near the escarpment where deep gorges have formed along the dyke trends. Field investigations identified these lineaments as diabase and dolerite dykes. Thin vertical fracture and joint zones can also be seen, especially along cliffs.

Map B: Regional geology and existing boreholes



4 DATABASE OF ABSTRACTION BOREHOLES

Boreholes listed under this heading include equipped boreholes (known and unknown yields)

Table 2: Existing equipped boreholes in and around Orighstad.

Borehole number	Co-ordinates WGS 84, decimal degree		Equipment as per last survey	POWER	QUALITY	Short to medium term action
	Longitude	Latitude				
H35-0088	30.5576660	-24.7496940	Submersible	Electrical	Unknown	To test
H35-0090	30.5542500	-24.7504160	Submersible	Electrical	Unknown	To test
H35-0091	30.5546660	-24.7456940	Submersible	Electrical	Unknown	To test
H35-0096	30.5587220	-24.7527500	Submersible	Electrical	Unknown	To test
H35-0097	30.5574440	-24.7545550	Submersible	Electrical	Unknown	To test

Note: This is the only data available for Orighstad.

Table 3: Existing equipped boreholes in and around Maepa village.

Borehole number	Co-ordinates WGS 84, decimal degree		Equipment as per last survey	POWER	QUALITY	Recommended Abstraction	Long term action
	Longitude	Latitude					
H35-0092	30.515200	-24.683970	Hand pump	hand	Unknown	0.3 x 24h/day (25.9m³/day)	If near a school or clinic it can be equipped
H35-0093	30.517240	-24.698580	Hand pump	hand	Unknown	0.2 x 24h/day (17.2m³/day)	If near a school or clinic it can be equipped
H35-0094	30.512800	-24.698200	Submersible	Electrical	Unknown	0.35 x 24h/day (30.2m³/day)	Manage and monitor

Note: These are the only boreholes listed under Maepa on the various data bases.

5 DATABASE OF MONITORING BOREHOLES

Boreholes listed under this heading form part of the Department of Water and Environmental Affairs monitoring network. A request for available information was sent to the Department: No boreholes are listed under the regional monitoring network.

6 AQUIFER PARAMETERS AND AQUIFER TEST DATA.

Pump testing of boreholes is the only method that provides simultaneous information on the hydraulic behaviour of the borehole, the reservoir (aquifer) and its boundaries. This information is essential for efficient aquifer and well field management. (Manual on pumping test analysis in fractured rock aquifers, 2001). Pump test data is used for two objectives, to determine the sustainable yield of a single point source and to determine aquifer parameters. For this study two aquifer parameters were reported, Transmissivity (T) and Storativity (S). The values for the second parameter are very small and when using analytical methods the value is affected by the distance between the observation and the pumped borehole. A numerical model is usually used to determine this value accurately and for this report an accepted default value was used.

6.1 Transmissivity (T) and Storativity (S):

Transmissivity is the product of the average hydraulic conductivity K and the saturated thickness of the aquifer D. Consequently, transmissivity is the rate of flow through a unit hydraulic gradient through a cross-section of unit width over the whole saturated thickness of the aquifer. Storativity or storage coefficient of a saturated confined aquifer of thickness D is the volume of water released from storage per unit surface area of the aquifer per unit decline in the component of hydraulic head normal to that surface. (Analysis and evaluation of pumping test data, 1994)

Table 4: Aquifer parameters calculated using the FC method from available pump test data for the Orighstad/Maepa area.

Borehole number	Transmissivity $T(m^2/d)$	Storativity S	Sustainable abstraction for a 24hr/day pumping cycle_ Q(l/s)
H35-0092	2.0	0.003	0.3
H35-0093	1.4	0.003	0.2
H35-0094	2.1	0.003	0.35
Geometric mean T =	1.8		

Table 5: Aquifer parameters calculated from available pump test data in the mountainous area using the FC method

Information from the Lower Steelpoort Tubatse water supply-mountain area

Borehole number.	Transmissivity $T(m^2/d)$	Storativity S	Sustainable abstraction for a 24hr/day pumping schedule _Q(l/s)
H12-0867	0.7	0.003	0.1
H12-1471	13.5	0.003	0.6
H12-1486	9.6	0.003	0.6
H12-1490	3.4	0.003	0.2
H12-1495	22.0	0.03	1
H12-1497	3.5	0.03	0.3
H12-1502	3.6	0.03	0.3
H12-1561	5.1	0.003	0.06
H12-1945	2.3	0.03	0.15
H12-2272	1.0	0.03	0.1
H12-2449	1.6	0.03	0.08
H12-2537	1.0	0.003	0.25
H12-2551	5.4	0.003	1
H12-2552	0.4	0.003	0.11
Geometric mean T =	2.9		

Table 6: Aquifer parameters calculated from available pump test data in the area near the river, on the farm Strydfontein using the FC method.

Information from the Lower Steelpoort Tubatse water supply--river area

Borehole number	Transmissivity $T(m^2/d)$	Storativity S	Sustainable abstraction for a 24hr/day pumping schedule _Q(l/s)
H35-0100	8.2	0.003	0.4
H35-0103	155.0	0.003	5
H35-0104	8.1	0.003	0.7
H35-0106	6.0	0.003	2.3
Geometric mean T =	15.8		

Limited available data for the Orighstad/Maepa area resulted in the use of nearby groundwater data. For the river area around Orighstad, the aquifer parameters can be used as obtained from information from the Lower Steelpoort Tubase water supply –river area. The geometric mean T-value for this area was calculated as 15.8m2/day.

For Maepa three boreholes were analysed. (H35-0092, H35-0093, H35-0094) The geometric mean T-value for these three boreholes was calculated as 1.8m2/day.

7 WATER CONSERVATION AND DEMAND

7.1 Water conservation

The Water Act considers groundwater as part of the larger hydrologic cycle and in a continual state of flux with surface water. Both should be seen as a linked source and managed in such a way. Sustainable development of groundwater resources refers to a holistic approach to **development, conservation and management** of these resources. Good sustainable yield estimates are the result of scientifically sound pumping test analysis. It must be noted that these quantities vary with time and location and can only be estimated, and thus may carry a degree of uncertainty. All sources of uncertainty need to be recognized and their impact on water **quality** or the **sustainability** of the aquifer must be evaluated.

Pump tests are important tools that provide information on the hydraulic behaviour of a borehole, the reservoir and the reservoir boundaries. All this information is essential for **efficient aquifer and well field management**. A further essential consideration in the development of an aquifer is the **chemical quality** of water produced, as the quality can limit its use. Groundwater movement induced by pumping may change the groundwater chemistry. The delineation of protection zones from certain microbial pollution sources are an essential part of the management plan.

Table 7: Current water demand and available sources.

Village	Water demand m^3/day		Recommended sources M^3/day		Boreholes available for testing with potential	Comment on supply
	High	Low	Motorized	Hand pump or unequipped		
Orighstad					5	Gets water from a farmer. It is not known if the demand is met.
Maepa	48.2	21.3	30.2 (1 hole)	43.1 (2 holes)	0	Demand is not met.

Note: Available abstraction calculated from the 24hr/day pumping cycle.

- **Short term action**: Verify availability of boreholes listed by a field survey.
- **Medium term action:** Check chemistry, rehabilitate and pump test boreholes where necessary, upgrade and install equipment.
- **Long term action:** Drill new sources if the demand is not met.

8 GROUNDWATER RECHARGE AND PROTECTION

8.1 Recharge

To calculate recharge the chloride method was used. The correct way to sample the chloride for these calculations is just under the water table for uncased holes or just under the casing in steel cased holes. The values used in this calculation are from pumping test therefore representing and average value. Fifteen values from fifteen different boreholes were used for the calculation of the harmonic mean. The harmonic mean was calculated to be 16.7mg/l.

The recharge method using the chloride concentration of the boreholes is presented by the equation:

$$RE_{av} = a.Rf_{av}$$

Where

a = $Cl_{rainfall}/Cl_{groundwater}$ represents the recharge coefficient

RE_{av} = average recharge

Cl = chloride concentration

Rf_{av} = average rainfall

Locality	Mean average rainfall (Rf) (mm/a)	$Cl_{rainfall}$ (mg/l)	$Cl_{groundwater}$ (mg/l) Harmonic mean 15 samples	Recharge Cl method % Rf	Average recharge mm/a calculated	Vegter (1995)
Orighstad/Maepa	620	1	16.7	5.9%	37mm/a	20-32 mm/a

Table 8: Recharge values.

The rainfall in the area increases from the southeast to the northwest from 590 to 650mm/a. This data is from contoured rainfall data from the maps compiled by Vegter (1995). These maps give contoured recharge data for the area from 20-32mm/a. In this report it was decided to use a recharge of 26mm/a and an average rainfall of 620mm/a. The catchment surface area was calculated from the topographical maps and is estimated to be approximately 50.6km².

The recharge for the area was calculated as 1.3E+06m³/a. The current annual abstraction is not known for Orighstad. For Maepa the demand is as 0.3E+06 m³/a using the estimated peak requirement as supplied by the client.

For a total water balance other factors must also be considered such as baseflow, the ecological reserve, inflow and outflow over aquifer boundaries and evapotranspiration. This was not part of the scope of work and was therefore not calculated.

8.2 Borehole Protection zones

Protection zone 1: Borehole construction fencing, and infrastructure.

- For protection zone I (i.e. the immediate fenced area around the borehole), it is proposed that the distance of the fence around the borehole must be at least 5m. For a borehole that is supplying water to less than say 20 people, a well-constructed sanitary seal (0.5-5mbgl) is regarded as enough. Quality monitoring is, however, very important.
- The pump house and floor is also part of a protection zone 1.

In areas with a high density of pit latrines, nearby boreholes should be constructed correctly and fenced off. With a high number of people concentrated in such an area a risk of Nitrate pollution is possible in nearby boreholes. Pit latrines should only be constructed taking local geological and geohydrological conditions in account

Protection zone 2: Microbial (bacteria and viruses) and nitrate pollution.

- Studies have shown that bacteria usually die within 30days after being introduced into the soil. In some cases a minimum distance of 50m between a pit latrine and a borehole will be adequate as was proposed by Xu and Braune (1995).
- Boreholes located on lineaments should be treated with caution as the travel times can be fast in these fracture zones. The protection zone in these cases will not be round but along the lineament strike.
- The FC method for pump test analysis makes provision for the calculation of a protection zone. The interpreter must take certain parameters in account such as the estimated clay content of the surface.

Because of the high clay content predominantly in the alluvial deposits on the Transvaal Sequence Rocks, the risk of microbial pollution in boreholes located in these areas is low.

Protection zone 3: Hazardous chemical elements.

- The estimation of the three protection zones was coded in the FC- programme. If persistent **hazardous elements** are present, the whole catchment area of the borehole must be protected.

No hazardous chemical elements are present in the study area.

Table 9: Calculated half length of main fracture and estimated protection zone of each borehole using the FC method.

Estimated protection zone around boreholes in the Maepa area

Borehole number	Transmissivity $T(m^2/d)$	Half length of fracture (m)	Protection Zone around borehole (m)
H35-0092	2.0	52	105
H35-0093	1.4	29	57
H35-0094	2.1	37	74
		Average	79

On average a production borehole must be 79m away from a pit latrine(protection zone)

It was recommended in the assessment report for the Lower Steelpoort Tubatse water supply area that boreholes in the mountainous areas should be 100m away from pit latrines. The boreholes near the river should be 150m away from such sources. **Due to limited data on the Orighstad / Maepa area these guideline distances should be used, as the geohydrological conditions are very similar.**

9 GROUNDWATER USERS

The National Water Act prioritises water user groups according to importance. Decreasing in importance is basic human needs, ecological needs and then inessential uses such as economic development. The application for a water user's licence does not differentiate between users of surface or groundwater.

When using surface or groundwater for irrigation, mining, industrial or a feeding pen, the owner or appointed representative must apply for a Water User licence. Other usage that must be registered

- Dumping of waste or water that contains waste.
- Storage of water (>10 000m^3), or if the full dam capacity surface area is bigger than one ha.
- Activities reducing stream flow, such as forestry.
- Activities such as irrigating with waste water, power generating with water and recharge of groundwater.

The National Water Act allows for relatively low water usage such as non-commercial small gardens, livestock watering (not feeding pens) if the use is not excessive in relation to the available source and needs of other users. If your water source is from local government or any other bulk supplier there is no need to register.

The local government or any other bulk supplier must register.

Water users in the study area include the community at Maepa and the town of Orighstad. The water is used for domestic, industrial and agriculture uses.

10 GROUNDWATER QUALITY

No chemistry data is available for Orighstad or for the sources at Maepa. For the study the same findings can be used as those found at the Lower Steelpoort Tubatse water supply area. In that area most of the water was of an ideal or good water quality.

11 DESCRIPTION OF GROUNDWATER MONITORING PROGRAMMES (QUALITY AND QUANTITY)

Groundwater monitoring is essential to prevent the unsustainable decline of the groundwater resource over the long term. **Useful markers for the detection thereof are groundwater level/piezometric surface and/or groundwater quality.**

Groundwater monitoring must be seen at two levels. The first is **regional monitoring** to evaluate rainfall and discharge in the catchment. The positioning of such observation points should be carefully considered taking in account geology, structural geology, existing well fields and social behaviour and future expansion of villages.

On a **local monitoring** scale part of the granting of a water user licence, landfill site or sewerage works to a municipality is a **monitoring and management plan** that the user must adhere to. Local monitoring boreholes, carefully chosen according to various parameters should be near the well field to observe the long term affect of pumping on the source. Abstraction in the well field must be monitored and adjustments can be made depending on the response of the static water table. Chemical changes must be observed in the production boreholes and the positioning of method of sanitation within the village must be controlled.

Petrol stations or bulk storage of non-aqueous phase liquids must be monitored on a regular basis for leaks. (monitoring borehole)

Storage sites with high volumes of possible pollutants and hazardous material such as pesticides and fertilizer must be monitored.

Mining areas should have monitoring boreholes as it is part of the mining licence. Slate is mined nearby the town.

If the Municipality owns and operates a landfill site with a daily dumped volume of between 25 and 150m^3/day, the licence requirement will include an observation borehole that must be monitored as per licence requirements.

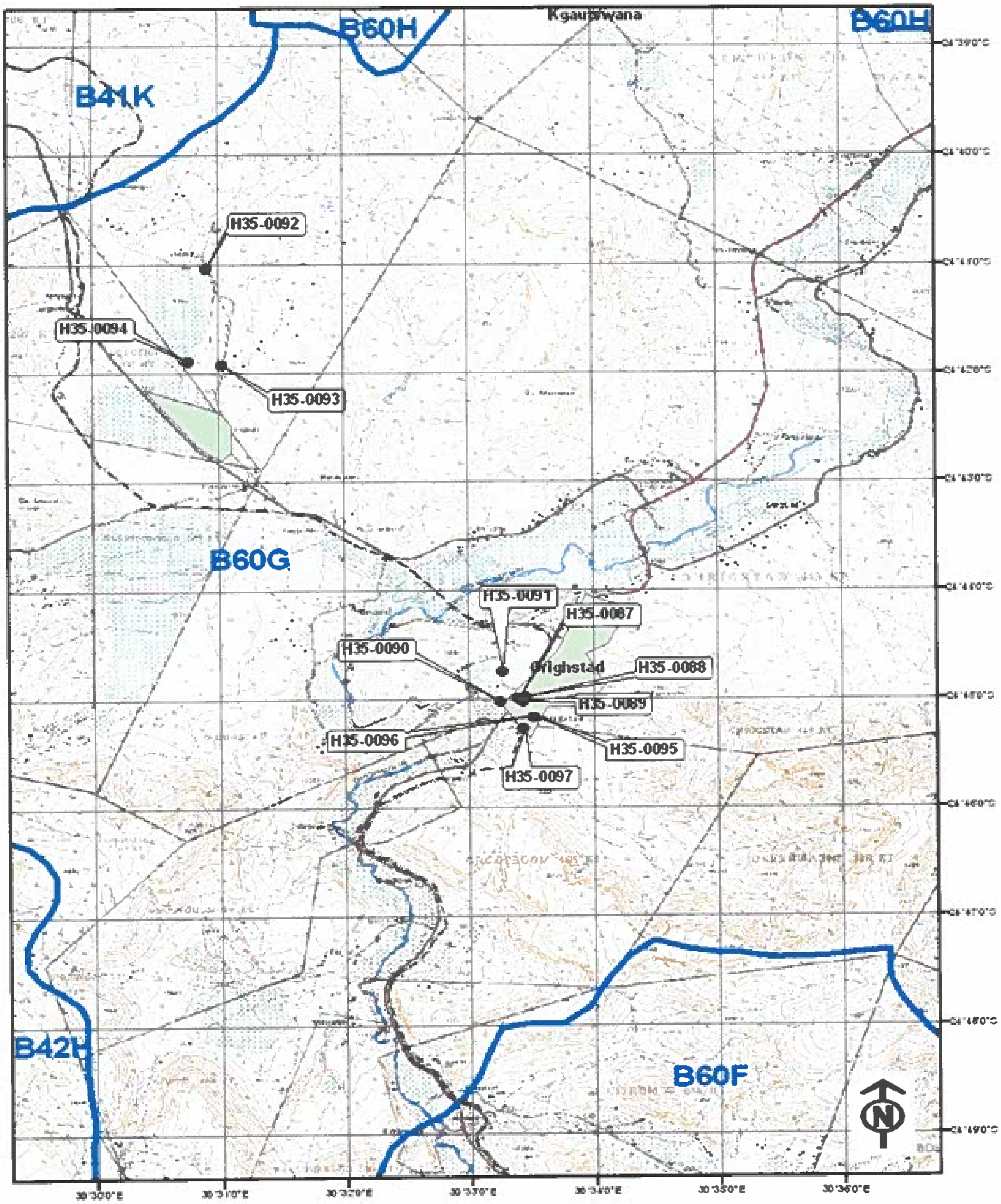
DESCRIPTION, COORDINATES AND LOCATION OF ALL POINTS

Table 10: Existing boreholes: information from all possible sources

Borehole Number	Site name	co-ordinates WGS 84		DEPTH (m)	Static water level (m)	Depth to intake (m)	Pump rate (l/s)	Pump schedule (hr/day)	Abstraction (m³day)	last known equip	last known power	water quality	Comment
		Longitude	Latitude										
H35-0087	Orighstad	30.5568	-24.7498	0.0	0.0		0.0	0.0	0.0	N	N		To test
H35-0088	Orighstad	30.5577	-24.7497	0.0	0.0		0.0	0.0	0.0	S	E		To test
H35-0089	Orighstad	30.5573	-24.7504	0.0	0.0		0.0	0.0	0.0	N	N		To test
H35-0090	Orighstad	30.5543	-24.7504	0.0	0.0		0.0	0.0	0.0	S	E		To test
H35-0091	Orighstad	30.5547	-24.7457	0.0	0.0		0.0	0.0	0.0	S	E		To test
H35-0095	Orighstad	30.5588	-24.7527	0.0	0.0		0.0	0.0	0.0	N	N		Blocked
H35-0096	Orighstad	30.5587	-24.7528	0.0	0.0		0.0	0.0	0.0	S	E		To test
H35-0097	Orighstad	30.5574	-24.7546	0.0	0.0		0.0	0.0	0.0	S	E		To test
H35-0092	Maepa	30.5152	-24.6840	80.6	24.1	42.0	0.3	24.0	25.9	H	H		Tested
H35-0093	Maepa	30.5172	-24.6986	119.9	45.3	68.0	0.2	24.0	17.3	H	H		Tested
H35-0094	Maepa	30.5128	-24.6982	100.8	19.3	48.0	0.35	24.0	30.2	S	E		Tested

No other data is available for the above boreholes

Map C: Topographical map with borehole positions Orighstad and Maepa

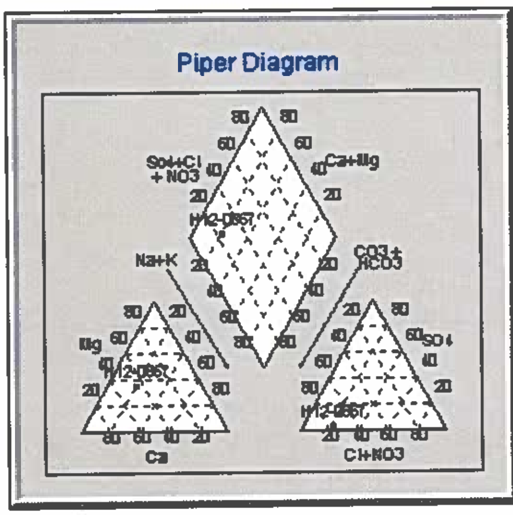


13 OVERVIEW OF GROUNDWATER QUANTITY AND QUALITY

The chemical composition of groundwater is the result of interaction between rainwater, soils and various rock types. Most of this interaction takes place in the unsaturated zone and later in the saturated zone along the groundwater flow path, where physical and geochemical properties of the rock types influence the type and character of the groundwater quality. In the area under discussion, water is mainly abstracted for livestock watering and domestic purposes. Along the river valley water is used for irrigation.

No water quality data is available for Orighstad or for the sources at Maepa. For this study findings from the Lower Steelpoort Tubatse water supply area were used, as the geohydrological conditions are similar.

Borehole H12-0867 is plotted on various diagrams. This is a representative plot of groundwater in the nearby Lower Steelpoort Tubatse water supply area. This area is within 5-15km from the Orighstad study area with similar geohydrological conditions. Data plotted on these diagrams is used to identify the hydro chemical water type, to describe the dominant ionic species, to visualize trends, to get a "fingerprint" of the water, and to relate it to the geological setting, and to classify the water for irrigation purposes.



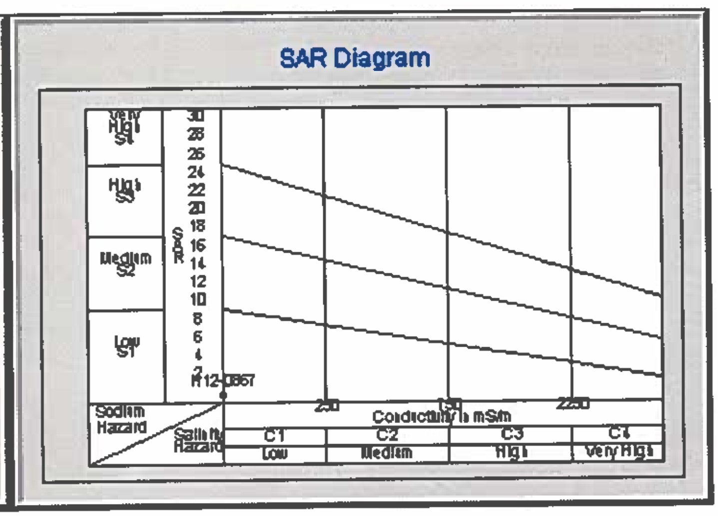
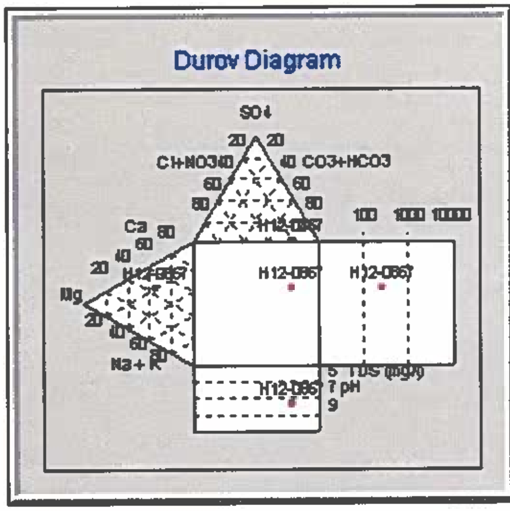


Diagram 1: Piper diagram H12-0867

Diagram 2: SAR diagram H12-0867



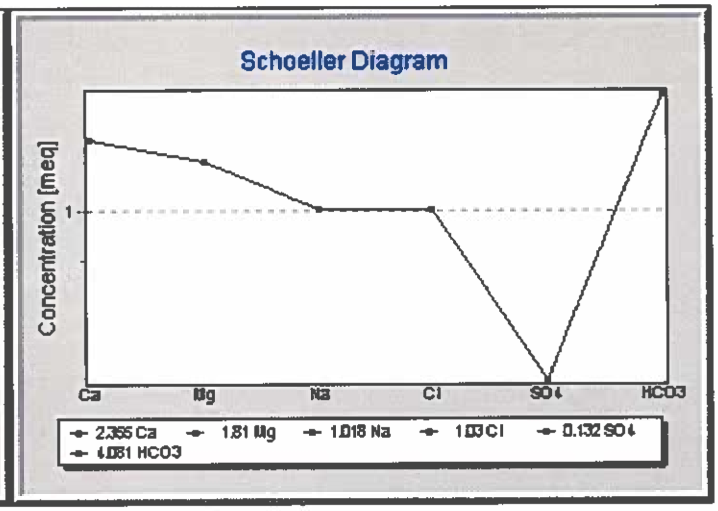


Diagram 3: Durov Diagram

Diagram 4: Schoeller diagram.

13.1 Overview on groundwater quality.

The overview is based on information from the Lower Steelpoort Tubatse water supply as no chemical data is available for Orighstad. The areas have similar geohydrological conditions.

- The hydro-chemical water type is **TYPE B**. Dominant cations Mg^{2+} and Ca^{2+}. Dominant anions HCO_3^- .
- **Domestic water quality Class** 0 in 60 % of the sampled boreholes.
- **Domestic water quality Class 1** in 33 % of the sampled boreholes due to the concentration of Manganese (Mn), the reported electrical conductivity (EC), the Total Dissolved Salts (TDS) and the calculated Total Hardness as CaCo3.
- **Domestic water quality Class 2** in 6 % of the sampled boreholes due to the concentration of Manganese (Mn). Quality Class 2 water can be equipped for domestic use.
- The water is classified as class **C1S1 irrigation water.**
- **Low salinity water (C1)** can be used for irrigation on most crops in most soils with little likelihood that soil salinity will develop.
- **Low-sodium water (S1)** can be used for irrigation on almost all soils with little danger of developing harmful levels of sodium.
- The plotted parameters on the Schoeller diagram give a distinctive plot. The Sulphate (SO_4) concentration of the groundwater shows a dip on the diagram.

It is recommended that boreholes in the mountainous part of the study area must be on average 100m away from pit latrines. The boreholes near the river should be 153m away from such sources. Management of groundwater sources and village sanitation is equally important. Delineation of borehole protection zones from certain microbial pollution sources is essential. .

13.2 Overview on groundwater quantity.

The overview on the quantity is based on information from the Lower Steelpoort Tubatse water supply area.

The recommended long term abstraction yields for a 24hr/day pumping cycle, (determined from pump test data using the FC-method), varies from 0.1l/s (8.6m³/day) to 1l/s (86.4m³/day) in the mountainous area (14 tests evaluated). In the area close to Orighstad the yields ranges from 0.4l/s (34.5m³/day) to 5l/s (432m³/day). (4 tests evaluated)

In Maepa, three boreholes were tested. The average recommended abstraction yield for a 24hr/day pumping cycle is 0.28l/s (24.1m³/day). This compare favourable with the average abstraction of the mountainous area in the **Lower Steelpoort Tubatse water supply area** of 0.34l/s (29.3m³/day)

14 IDENTIFICATION OF BOREHOLES OF CONCERN

- Boreholes of concern will include, production boreholes situated in the same aquifer threatening the resources of the aquifer.
- Production boreholes near obvious pollution sites especially down gradient from such site. These sites include landfills, sewerage works and smaller point sources such as pit latrines.
- Boreholes identified with construction problems, such as insufficient casing. This will result in high maintenance cost.
- Development of well fields without professional input.

15 IDENTIFICATION OF POOR BOREHOLE SITING REGADING POSITION AND SANITATION

The Minimum Standards and Guidelines for Groundwater Resource Development for the Community Water Supply and Sanitation Programme, a document by The Department of Water and Environment Affairs, gives clear guidelines regarding the **siting and development** of production boreholes for domestic supply.

This document explain the scientific approach for the development of groundwater sources that must be followed utilizing existing technology such as satellite imagery interpretation, aerial photo interpretation, geophysical methods such as the electromagnetic, magnetic and DC resistivity profiling together with a sound understanding of the local geology and hydrogeological conditions of the study area.

16 REHABILITATION/MITIGATION REQUIREMENTS.

A point source context rehabilitation, will refer to the actions that must be taken to rehabilitate a borehole It includes removal of fallen equipment, instalment of new equipment etc. This project did not include a field phase to get an up to date status quo on the point sources. The data used dates from the period 2000 to 2002.

Rehabilitation of blocked boreholes and no access:
Boreholes listed are boreholes known to be blocked (info from the last survey) and boreholes with access problems. (The problem could be related to roads).

In an **aquifer context** the rehabilitation and mitigation requirements will refer to pollution control. The best way to deal with pollution sources such as landfills is to use strict design criteria and up to date management control thereof to minimize pollution from the source as it is time consuming and very expensive to rehabilitate an aquifer.

17 UN-USABLE BOREHOLES

Un-usable boreholes will be boreholes that cannot be used for domestic water supply and for monitoring purposes. If old information indicates a good potential yield, they could be re-habilitated.

Table 11: Un-usable boreholes.

Borehole number	Un-usable for domestic supplies	Usable for monitoring	Comment:
H35-0095			Blocked

18 ASSESSMENT OF GROUNDWATER SOURCES, SHORT, MEDIUM AND LONG TERM.

Orighstad:

Short term:

- The current arrangement with the farmer supplying the town of Orighstad with water, needs to be evaluated
- If water supply is inadequate, development of new sources need to be planned.
- Testing of the existing municipal boreholes.

Medium term:

- The development of new sources using a scientific approach and according to the DWAF guideline. These actions can be on municipal ground or on areas that can be legally obtained by buying or by servitude arrangements.

Long term:

- Monitoring of abstraction yields, water levels and quality of the well fields.
- Identification of possible pollution sources.

- Ensure the correct design and management control of water sources and possible pollution sources.
- Monitor population and expansion/development of the town to ensure reliable sources for the population.

19 CONCLUSIONS

- This report does not include a full water balance determination and the project did not include any field work. **All available data sources** were utilized, with some information as old as 1997. Around Orighstad, 8 known boreholes are listed. No testing or chemical information is available. At Maepa, 3 pump tested boreholes are listed without any chemical data. **Available groundwater data for the nearby Lower Steelpoort Tubatse water supply area were used for this study.** It consisted of basic site information for a total of 88 borehole sources. Of these, 18 boreholes were tested, and 15 have chemical results. It is expected that data from the farm Strydfontein will correspond to hydrological conditions next to the river at Orighstad. Data from the mountainous area of the lower Steelpoort Tubatse water source area will correspond to geohydrological conditions at Maepa.
- The water supply to **Orighstad** is currently supplied by a private farmer. No information regarding the daily abstraction rates could be obtained, as the farmer was not available. Existing boreholes are available in the town for pump testing.
- **A total of 3 boreholes were sourced at Maepa**. No chemical analyses are available and the water demand is not met. It is recommended that new sources be developed.
- The **DWAF form D village names** were used on all maps and tables.
- The average summer temperatures ranges from 14.5 to 26 degrees Celsius and the winter temperatures is much colder, ranging from an average of 4.7 to 20 degrees Celsius.
- For the study area the **mean annual precipitation** was accepted as 620mm/annum, as was interpolated from Vegter's maps.
- The expected hydro chemical water type is **TYPE B.**
- The water is expected to be classified as a Class **C1S1 irrigation water.**
- The **domestic water quality** classification is expected to be **ideal to good.**
- Based on available information, a recharge of 26mm/annum, a surface area of 50.6km² and an average rainfall of 620mm/annum were used in calculations in this report.
- The recharge for the area was calculated as 1.3E+06m³/a. The current annual abstraction is not known for Orighstad. For Maepa the demand is as 0.3E+06 m³/a using the estimated peak requirement as supplied by the client.
- **Management** of groundwater sources and village sanitation is equally important. It is recommended that boreholes in the mountainous part of the study area must be on average 100m away from pit latrines. The boreholes near the river should be 150m away from such sources. Management of groundwater sources and village sanitation is equally important. Delineation of borehole protection zones from certain microbial pollution sources is essential.
- Recommendations were made for the **assessment of groundwater** use in the short, medium and long term.
- It is recommended that an extensive **borehole census** be carried out in this area to confirm and update all available borehole and related data
- **A Management plan, monitoring of** the well field, water level, quality and abstraction, forms an essential part of water conservation

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