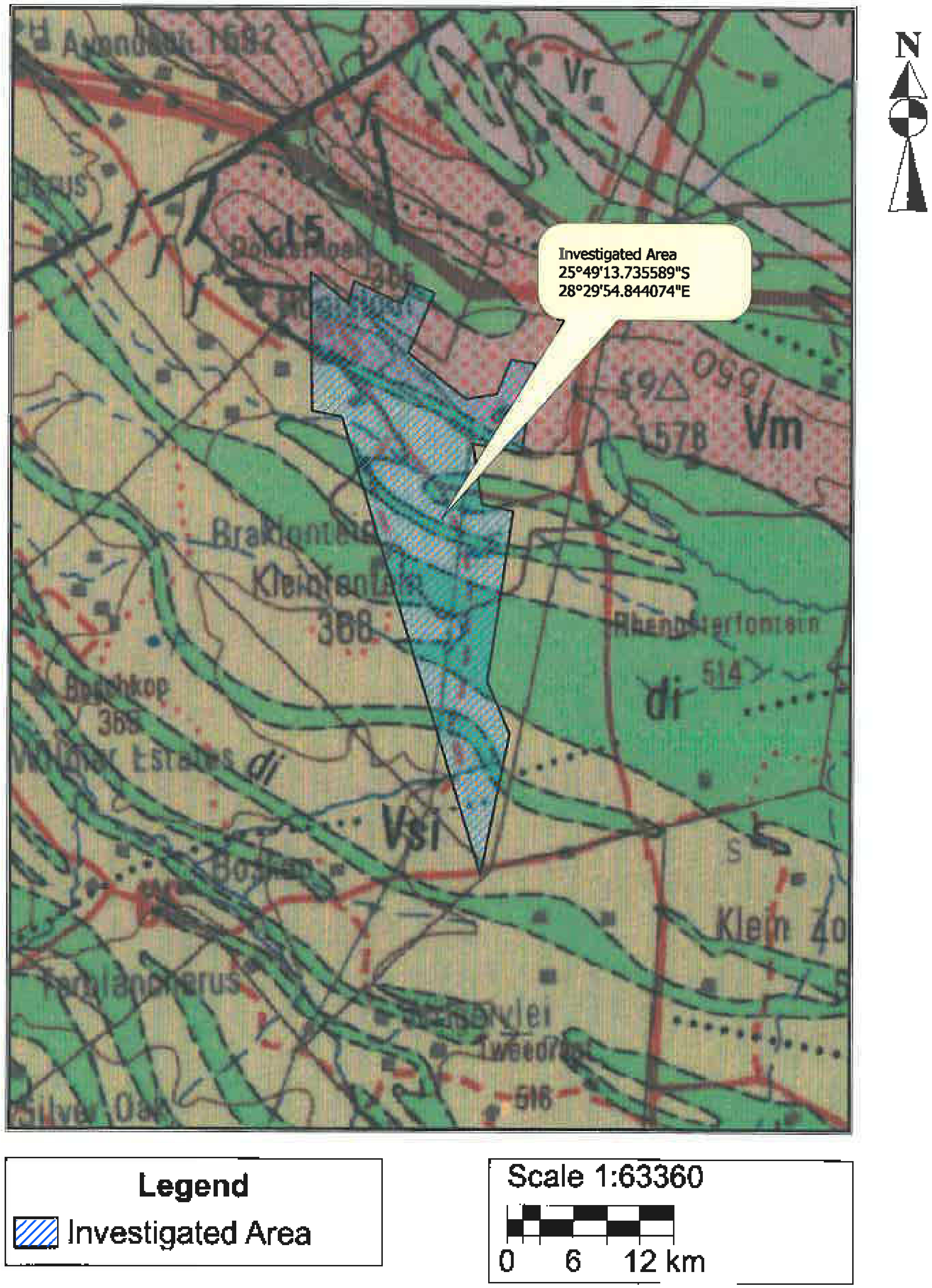
APPENDIX I

MAPS



HOLLAND-MUTER & ASSOCIATES CC; P.O. BOX 1450; FAERIE GLEN; 0043

FIGURE 2 : REGIONAL GEOLOGY MAP : KLEINFONTEIN SETTELMENT :
Located on Kleinfontein 368 JR : Portions 38,90,96 ,and the remaining extent and
Donkerhoek 365 JR : Portions 63,67,68 and the remaining extent of Portion 14.

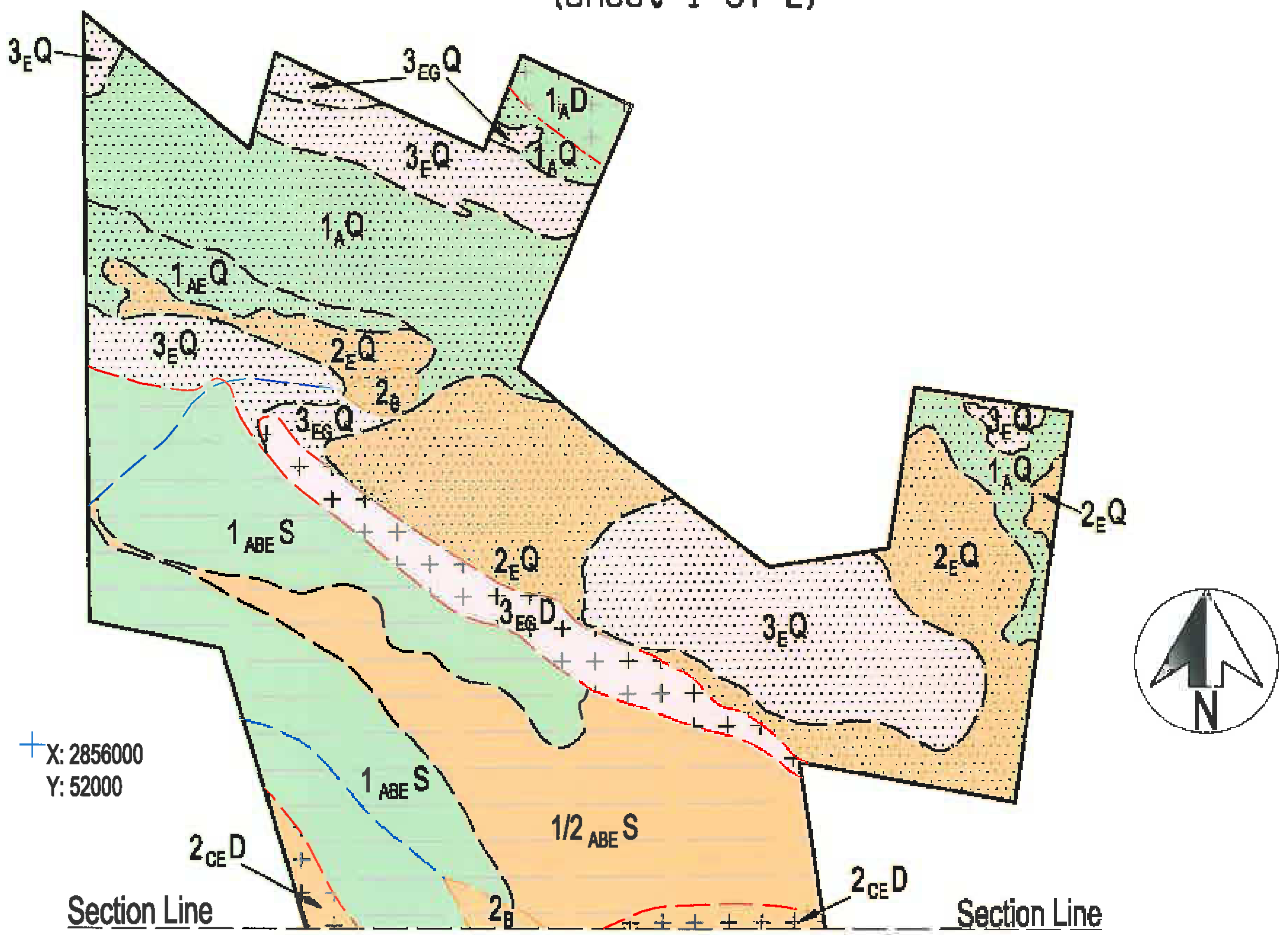
DATE: NOVEMBER 2011

DRAWING NR : 401

PORTIONS OF THE FARMS KLEINFONTEIN 368 JR & DONKERHOEK 365 JR, TSHWANE:

FIGURE 3: PHASE I (PLANNING) GEOTECHNICAL INVESTIGATION

(Sheet 1 of 2)



LEGEND	
	Site Boundary
	Inferred Geological Boundary
	Drainage Channels
	Gully Head
D	Diabase
Q	Magaliesberg Quartzite
S	Silverton Shale
	Mapping Unit
	Railway Line

PORTIONS OF THE FARMS KLEINFONTEIN 368 JR & DONKERHOEK 365 JR, TSHWANE

FIGURE 3 : PHASE I (PLANNING) GEOTECHNICAL INVESTIGATION (Sheet 1 of 2)

PROJECT: LNB19/11 FILE NO: 919

Holland-Muter & Associates CC

Engineering and Environmental Geologists

P.O. Box 1450 Faerie Glen 0043

Tel: (012) 991-2695 Fax: (012) 991-0796 Cell: 083 455-2610

e-mail: [illegible]

DATE:	SCALE:	DRAWING NUMBER:
NOV. 2011	1 : 15000	KLEI_201

DEFINITION OF GEOTECHNICAL CONSTRAINTS

Severity of constraint & cost increases from A-H

SUB-SCRIPT	GEOTECHNICAL PARAMETER	Most Favourable (1)	Intermediate (2)	Least Favourable (3)
A	Collapsible Soil	<750mm thick	>750mm thick	Any magnitude
B	Seepage	Perched water deeper than 1,5m	Perched water shallower than 1,5m	Swamps, marshes or drainage channel
C	Active Soil	Low heave	Moderate heave	High heave
D	Erodibility	Low	Intermediate	High
E	Difficulty of excavation to a depth of 1,5m	<10%	Between 10% - 50% Rock or hardpan pedocretes	>50% Rock or hardpan pedocretes
F	Instability in areas of soluble rock	Possibly unstable	Probably unstable	Known sinkholes
G	Steep slopes	Between 2° - 6°	Between 6° - 12°	>12°
H	Flooding	Does not exist	Adjacent to drainage channel	Areas in drainage channel

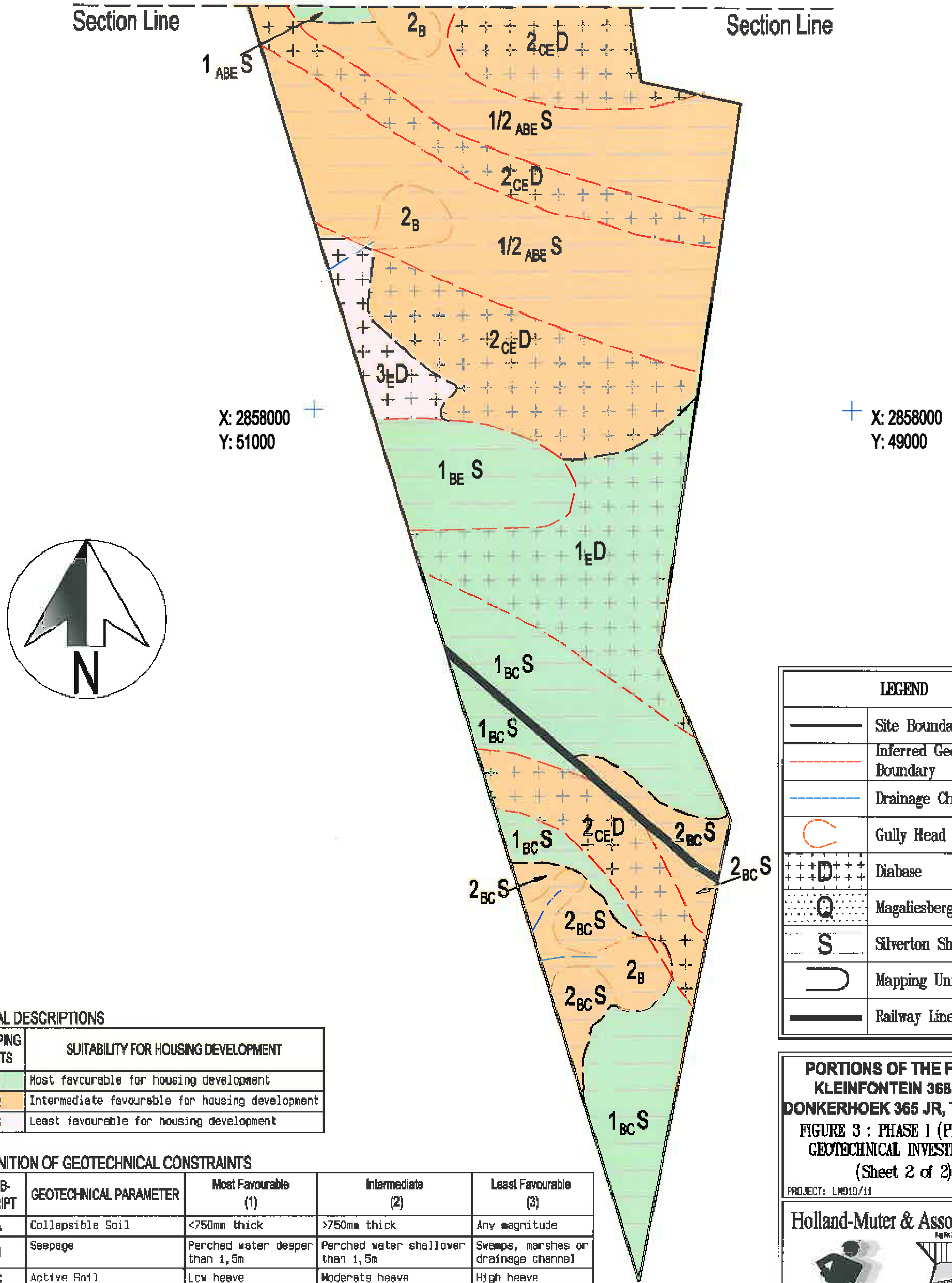
ZONAL DESCRIPTIONS

MAPPING UNITS	SUITABILITY FOR HOUSING DEVELOPMENT
1	Most favourable for housing development
2	Intermediate favourable for housing development
3	Least favourable for housing development

PORTIONS OF THE FARMS KLEINFONTEIN 368 JR & DONKERHOEK 365 JR, TSHWANE:

FIGURE 3: PHASE I (PLANNING) GEOTECHNICAL INVESTIGATION

(Sheet 2 of 2)



LEGEND	
	Site Boundary
	Inferred Geological Boundary
	Drainage Channels
	Gully Head
D	Diabase
Q	Magaliesberg Quartzite
S	Silverton Shale
	Mapping Unit
	Railway Line

ZONAL DESCRIPTIONS

MAPPING UNITS	SUITABILITY FOR HOUSING DEVELOPMENT
1	Most favourable for housing development
2	Intermediate favourable for housing development
3	Least favourable for housing development

DEFINITION OF GEOTECHNICAL CONSTRAINTS

SUB-SCRIPT	GEOTECHNICAL PARAMETER	Most Favourable (1)	Intermediate (2)	Least Favourable (3)
A	Collapsible Soil	<750mm thick	>750mm thick	Any magnitude
B	Seepage	Perched water deeper than 1,5m	Perched water shallower than 1,5m	Swamps, marshes or drainage channel
C	Active Soil	Low heave	Moderate heave	High heave
D	Erodibility	Low	Intermediate	High
E	Difficulty of excavation to a depth of 1,5m	<10%	Between 10% – 50% Rock or hardpan pedocretes	>50% Rock or hardpan pedocretes
F	Instability in areas of soluble rock	Possibly unstable	Probably unstable	Known sinkholes
G	Steep slopes	Between 2° – 6°	Between 6° – 12°	>12°
H	Flooding	Does not exist	Adjacent to drainage channel	Areas in drainage channel

Severity of constraint & cost increases from A-H

PORTIONS OF THE FARMS KLEINFONTEIN 368 JR & DONKERHOEK 365 JR, TSHWANE

FIGURE 3 : PHASE 1 (PLANNING) GEOTECHNICAL INVESTIGATION (Sheet 2 of 2)

PROJECT: LM010/11 FILE NO: 619

Holland-Muter & Associates CC

Engineering and Environmental Geologists

P.O. Box 1450 Faerie Glen 0043

Tel: (012) 991-2695 Fax: (012) 991-0796 Cell: 083 455-2610

e-mail: lhmuter@lantic.net

DATE:	SCALE:	DRAWING NUMBER:
NOV. 2011	1 : 15000	KLEI_202

Annexure G(ii)

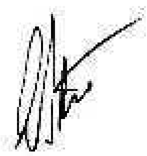
GEO-HYDROLOGY

GEOHYDROLOGICAL INVESTIGATION FOR THE KLEINFONTEIN TOWN DEVELOPMENT, GAUTENG PROVINCE

REPORT 106773-G2/2012

JULY 2012

Prepared for:	Kleinfontein Boerebelange Koöperatief Bpk P O Box 925 Rayton 1001
Contact person:	Mr Jan Groenewald Tel No: +27 12 802 1583
Prepared by:	Aurecon South Africa (Pty) Ltd P O Box 74381 LYNNWOOD RIDGE 0040
Contact person:	Dr M Levin Tel No: +27 12 427 3127

Report title	Geohydrological Investigation for the Kleinfontein Town Development, Gauteng Province	
Aurecon Report No.	106773-G2/2012	
Project team	Dr M Levin	Geohydrologist
	L Stroebel	Geohydrologist
	M Terblanche	Geotechnician
Co-ordinates (WGS84)	S 25.80043º	
	E 28.49512°	
Location	Tshwane, Gauteng Province	
Signed on behalf of Africon		
	L Stroebel	**Dr M Levin**
Date	July 2012	

GEOHYDROLOGICAL INVESTIGATION FOR THE KLEINFONTEIN TOWN DEVELOPMENT, GAUTENG PROVINCE

REPORT 106773-G2/2012 JULY 2012

CONTENTS PAGE

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS

DWA	**Department of Water Affairs**
GQM	**Groundwater Quality Management**
GRDM	**Groundwater Reserve Determination Measures**
KBK	**Kleinfontein Boerebelange Koöperatief Bpk**
SANS	**South African National Standards**
WULA	**Water Use License Application**

EXECUTIVE SUMMARY

Aurecon was appointed by Kleinfontein Boerebelange Koöperatief Bpk to provide the geohydrological report required as part of the Water Use License Application for **Phase 1** of the town development. The objective of the geohydrological investigation is to evaluate the groundwater resources available from the existing production boreholes and spring on the property. As part of the investigation a Rapid Reserve Determination was done to support a Water Use License Application (WULA) to the Department of Water Affairs.

The following conclusions were made:

- The groundwater, with exception of the borehole *NO,* is of excellent quality and complies with the SANS 241-1 Drinking Water Standards.
- The iron content in borehole *NO* exceeds the maximum allowable drinking water standard (Class II). The manganese concentration falls within Class II standards (suitable for short term use only). This water is not presently used.
- The combined sustainable yield calculated from the pump tests conducted on the selected production boreholes is 3.8 l/s.
- The sustainable yield calculated from the fountain flow is 1.55 l/s.
- The calculated annual recharge on the property is 438 795 l/day or 5.1 l/s.
- A Water Use License for abstraction of 257 600 l/day or 2.75 l/s can be applied for.
- This is 53% of the annual recharge on the property and therefore within 60-100% of the annual recharge on the property which places the water use license in Category B.
- The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification for the study area indicate that medium level groundwater protection may be required.
- Solid waste disposal site is not required as the solid waste is disposed at the licensed Rayton waste site.
- The Sanitation Protocol study shows medium overall risk to groundwater.
- Investigation into the complaints by neighbours showed that they are located outside the Kleinfontein catchment and is unlikely to be impacted by the groundwater abstraction on the Development.

Based on the above conclusions, the following recommendations are made:

- ➢ It is recommended that borehole *NO* be rehabilitated and tested before used for production.
- ➢ All the selected production boreholes need to be registered with the Department of Water Affairs for the WULA.
- ➢ Adherence to the sustainable yields of the boreholes is crucial to ensure long-term utilisation of the groundwater resource.
- ➢ Accurate monthly monitoring of the groundwater levels in the boreholes is recommended. If any significant fluctuation in water level occurs, immediate action needs to be taken.
- ➢ Groundwater quality and especially bacteriological analyses must be done on a regular basis.

- Reasonable and sound groundwater protection measures are recommended to ensure that no cumulative pollution affects the aquifer, even in the long term.
- It is recommended that a waterborne sewage system be installed for the development to treat the raw sewage water.

1 INTRODUCTION & SCOPE OF WORK

Aurecon was appointed by Kleinfontein Boerebelange Koöperatief Bpk to provide the geohydrological report required as part of the Water Use License Application for **Phase 1** of the town development. The objective of the geohydrological investigation is to evaluate the groundwater resources available from the existing production boreholes and spring on the property. As part of the investigation a Rapid Reserve Determination was done to support a Water Use License Application (WULA) to the Department of Water Affairs.

The scope of work consisted of the following:

- Describe the groundwater resources and usage
- Pump testing of existing production boreholes on-site to determine the sustainable yield of each borehole,
- Evaluate the quality of the groundwater,
- Determine the groundwater reserve and water available for abstraction through a "Rapid Reserve Determination" which will accompany the Water Use Licence application,
- Potential impacts of the development on the groundwater resources
- Conclusions and recommendations.

2 AVAILABLE INFORMATION

The following relevant information was available and consulted prior to the investigation:

- 1:50 000 scale topographical and geological maps 2528 CD Rietvleidam.
- 1:250 000 scale geological series map 2528 Pretoria
- 1:500 000 General Hydrogeological map (Johannesburg 2526)
- 1:3 000 000 Groundwater Harvest Potential Map of South Africa .
- DWA (2003) A Protocol to Manage the Potential of Groundwater Contamination from on-site sanitation. Technical Version. Edition 2, March 2003.
- Parsons R (1995) A South African Aquifer System Management Classification. Water Research Commission Report no KV 77/95
- Barnard H C (2000) An explanation of the 1:500 000 General Hydrogeological Map Johannesburg 2526. DWAF Report.
- Vegter J R (1995) Groundwater Resources of the Republic of South Africa.
- South African National Standard: Drinking Water, SANS 241:2006 Edition 6.1. Published by Standards South Africa.

- Berrington L (2006) ‘n Verslag betreffende die vasstelling van ‘n veilige langtermyn ontrekkingskedule vir die boorgat geleë op die Noordoos hoewe deur middel van ‘n konstante lewering pomptoets. Verslag No 2006-001. April 2006
- BK (2004) Kleinfontein Boerebelange Koöperatief Beperk Dienste Verslag. Julie 2004.

3 PHYSIOGRAPHY

3.1 SITE LOCATION

The locality of the development is next to the N4 Highway and on the farm Kleinfontein 368 JR. The extent of Phase 1 of the development on Kleinfontein 368 JR is shown on the map in Appendix A. The development is situated about 10 km south of Rayton as indicated on Figure 1. The town was established in 1988 and has informally developed according to recognized standards. Recently, the decision was taken to formalize the development.

3.2 TOPOGRAPHY & SITE CHARACTERISTICS

The topography is characterised by undulating hills and meadows. A ridge at an elevation of 1577 m above mean sea level runs from east to west through the site. The topography levels out towards the south of the study area. The higher lying Magaliesberg Quartzite in the northern part of the site forms a well-defined watershed. The main drainage from Phase 1 flows to the west as a tributary to the Edendalspruit which flows into the Roodeplaat Dam. The Kleinfontein Spring is located on the higher topography on the Quartzite ridge.

Figure 1: Locality of the Kleinfontein Site

The site is located in the sub-humid, warm climate zone and receives summer rainfall. The average rainfall measured in the quaternary catchment and recorded by DWA is 689 mm per annum.

The vegetation is described as Highveld grassland and varies across the site with grassland and scattered local and alien trees. Acacia trees occur on the iron rich diabase soils with grass cover on open fields.

3.3 GEOLOGY

The site is underlain by formations belonging to the Pretoria Group of the Transvaal Sequence. As shown in Figure 2 the southern part of the site is underlain by the Silverton Formation (Vsi) consisting of shale with inter-bedded quartzite, hornfels and limestone. The Silverton Formation is intruded by diabase dykes and sills (di) shown on Figure 2.
These diabase intrusions are very prevalent at certain stratigraphic levels below the Bushveld Igneous Complex in the Pretoria Group and the majority is found in the Silverton and Strubenkop Formations. As shown on Figure 2 the Silverton Formation is overlain by the Magaliesberg Formation (Vm) in the northern part of the site. The Magaliesberg Formation consists mainly of quartzite.

3.4 GEOHYDROLOGY

The aquifers present are classified as an intergranular and fractured aquifer according to the 1:500 000 geohydrological map (Johannesburg 2526). The groundwater occurrence is associated mainly with the weathered zones, as well as fault zones and dyke or sill contact zones. The groundwater yield potential in the sedimentary rocks is good and between 0.5 and 2 l/s.
According to Vegter (1995) the probability to drill a successful borehole (between 0.5 and 2l/s) is 40% to 60%. The probability of drilling a borehole yielding more than 2 l/s is between 30% and 40%.

According to Barnard (2000) the groundwater yield potential is classed as good on the basis that 40% of the boreholes on record produce more than 2 l/s and 22% produce more than 5 l/s. Higher yielding boreholes according to Barnard occur more often in association with the surface water drainage system of the broad valley bottoms. Boreholes were drilled on the property but unfortunately no geological logs are available as only the yield and quality are recorded.

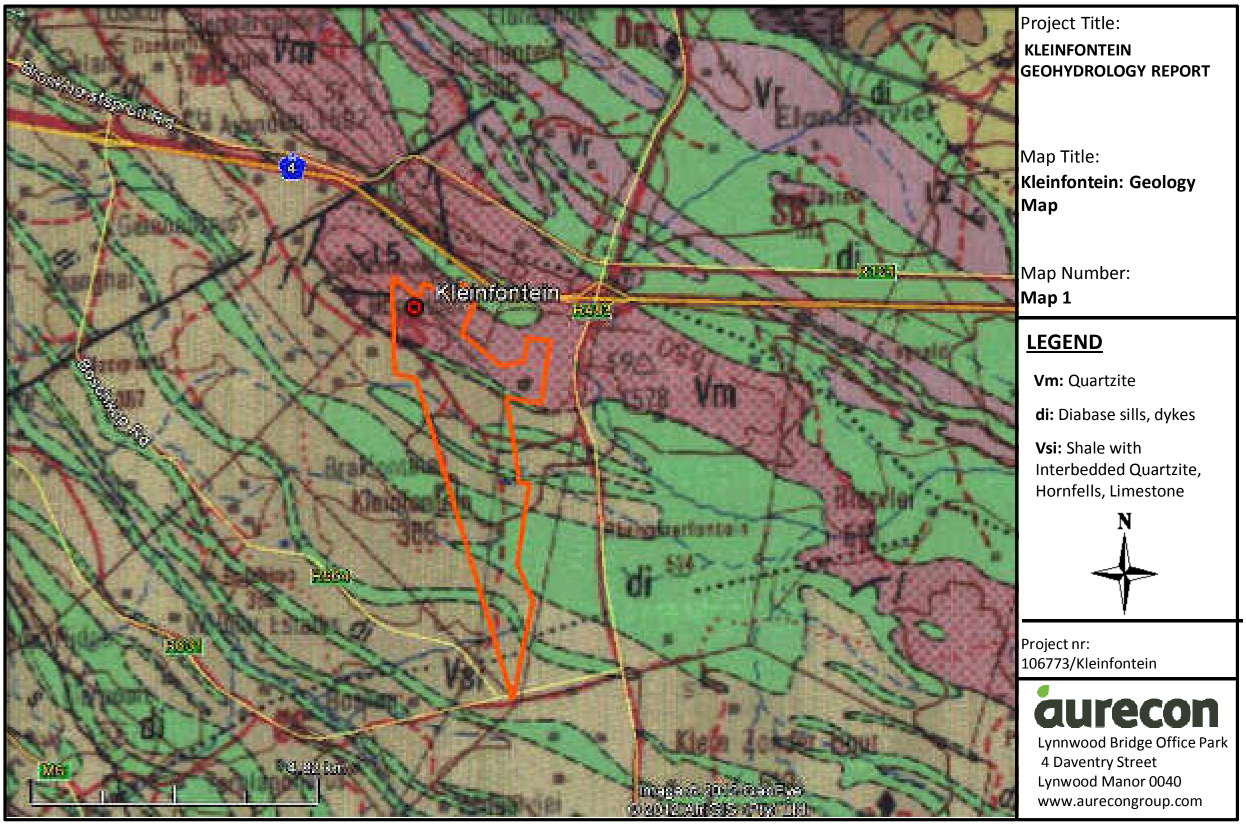


Figure 2: Geology of the Kleinfontein area as shown on the 1:50 000 2528 CD

4 WATER RESOURCES

Water supply for the Kleinfontein Development (Phase 1) consists of a fountain (natural spring) on the property and six boreholes. The coordinates as well as the sustainable yield of the boreholes and fountain are shown in Table 1.

Table 1: Coordinates and yields of the boreholes and fountain

Borehole No	WGS84 Y	WGS84 X	Sustainable Yield (l/s) 24 hrs	Depth (m)
T1	51223	55874	1.0	58
T2	51284	55919	0.8	35
T3a	51386	55874	0.8	19
T4	51431	55721	0.5	40
T5	51280	55979	0.4	21
NO	50387	54384	0.3	60
Fountain	51253	55106	2.0	~

4.1 FOUNTAIN

The fountain is located on a contact of the quartzite and diabase formations. The water originates from the quartzite aquifer, as was confirmed by the water quality. In 2005, a 90 degree V-notch weir was erected upstream of a slow sand filter installed in the flow path of the fountain, and approximately 200m downstream of the eye of the fountain. The water gravitates naturally from the eye down and through the vlei area to the sand filter. The flow of the fountain depends on the seasonal rainfall and the variation in flow is shown in the flow diagram in Appendix B. A maximum flow rate of close to 16 000 l/h during the high rainfall period in 2009 and a minimum of about 1 000l/h in 2007 during the low rainfall season was observed. The average flow calculated is approximately 9 000l/h. The water use registered at the DWA in 2001 is 49 000 kl/a on property T67550/1995 as per document No 26021581. This is approximately 1.55 l/s which correlates to the present average flow of 5 500l/h. However, at present the use is 0.75l/s or half of the average flow rate.

Production from the fountain is increased in the rainy season when flow from the fountain increased in order to reduce the production from the boreholes.

4.2 BOREHOLES

Six boreholes at Kleinfontein were test pumped by *Waterman* according to the DWA guidelines for pump testing. A stepped discharge test followed by a 24 hour constant discharge test with recovery monitoring was performed on the boreholes. The location of the boreholes is presented in the locality map in Appendix A and borehole test records giving testing and construction details of each borehole is presented in Appendix C.

The sustainable yields determined from the pump testing will be used in the WULA.

4.2.1 Description of a pumptest

The efficient operation and utilisation of a borehole requires insight into and an awareness of its productivity and that of the groundwater resource from which it draws water. This activity, which is also known as test pumping, provides a means of identifying potential constraints on the performance of a borehole and on the exploitation of the groundwater resource. It also provides data to calculate aquifer parameters such as Transmissivity (T) values.

4.2.2 Constant Discharge Test

A constant discharge test is performed to assess the productivity of the aquifer according to its response to the abstraction of water. This test entails pumping the borehole at a single pumping rate which is kept constant for an extended period of time. In this instance the boreholes were pumped for 24 hours.

4.2.3 Recovery Monitoring

This test provides an indication of the ability of a borehole and groundwater system to recover from the stress of abstraction. This ability can again be analysed to provide information with regards to the hydraulic properties of the groundwater system and arrive at an optimum yield for the medium to long term utilisation of the borehole.

4.2.4 Results & Data Processing

The data recorded during the pump tests were processed and the sustainable yield of the boreholes were calculated using the Flow Characterization Method (FC-Method) developed by the Institute for Groundwater Studies (University of the Free State). The FC Solution for the boreholes is presented in Appendix C. The calculated sustainable yield for the boreholes is presented in Table 2. Field forms used by the pump test contractor are presented in Appendix D.

4.2.5 Sustainable Yield

The FC-Method calculates the sustainable yield of a borehole by using derivatives, boundary information and error propagation. Data used for input into the software was obtained from the pumping test conducted on the boreholes. As described above a pump test basically entails continuous monitoring of the water level over a given time while pumping water from the borehole at a constant pre-determined yield.

After the pump has been switched off, continuous measuring of the recovering water level takes place. The aquifer was then modelled to obtain a sustainable pumping yield. The available drawdown is a critical parameter during this exercise and after calculating the sustainable yield, the water level should never drop beyond this level.

From Table 2, it can be concluded that a total volume of 327.69 m^3/day or 3.8 l/s (119 607 m^3/annum) can be abstracted from the existing boreholes pump tested.

It must be mentioned that borehole *NO* was drilled to 60m with the water strike at 53 m. The borehole has slowly filled with debris and is only 50m deep at present. The water strike is thus constraint and was tested at 0.5 l/s. This borehole was previously tested (72 hour test) by Berrington (2006) and the FC yield was calculated at 2.1l/s. Because of the formation stability problem it is recommended that this borehole be rehabilitated and re-tested.

Table 2: Calculated Sustainable Yield for the tested boreholes

BH nr.	Coordinates (WGS84)	Depth (m)	Static water level (mbgl)*	Sustainable Yield (l/s) Pumping 24 h/d	Volume available per day (m^3)
T1	X 51223 Y 55874	58	17.03	1.0	86.4
T2	X 51284 Y 55919	35	10.90	0.8	69.12
T3a	X 51386 Y 55874	19	9.40	0.8	69.12
T4	X 51431 Y 55721	40	11.20	0.5	43.2
T5	X 51280 Y 55979	21	9.0	0.4	34.56
NO	X 51223 Y 55874	60	9.50	0.3	25.29
			Total volume available from boreholes (m^3/day)		**327.69**

*meters below ground level

4.3 WATER USAGE

The following figures are available from the test results and the production figures were supplied by KBK.

Total available volume of water from the resources is as follows:

Source description	Yield (l/s)	Yield (m^3/day)
Fountain	1.55	133.92
6 Boreholes	3.80	328.32
Total available	**5.35**	**462.24**

Production capability at KBK:

Source description	Yield (l/s)	Yield (m^3/day)
Fountain	0.75	64.8
Boreholes	2.0	172.8
Total production capacity	**2.75**	**237.6**

The total usage for the period of 18 months from January 2011 to June 2012 is recorded as 62.930 Ml or 3496 m^3/month. **Total recorded usage is 116.537 m^3/day**

The total recorded usage of 116.537m^3/day is approximately 50% of potential production or 25% of available supply.

5 WATER QUALITY

Water samples were collected from each of the 6 boreholes at the end of the pumping tests. A sample was also collected at the fountain where it flow through the V-notch weir. The samples were submitted to an accredited laboratory (Aquatico Scientific Laboratories in Pretoria) for major inorganic analysis. The laboratory reports are presented in Appendix E.

The inorganic results were compared to the SABS drinking water standards (SANS 241:2006, edition 6.1). Water is classified according to their suitability for human consumption (**Error! Reference source not found.**):

- Class I: Recommended operational limit.
- Class 2: The maximum allowable concentration for short term use only.

From **Error! Reference source not found.**, it can be concluded that all the samples except the borehole *NO* comply with the Class I standard and is of excellent drinking water quality. Borehole *NO* was not in use for production before the pump test and shows manganese concentrations above Class I standards and high iron content exceeding the Class II standards. This borehole will be rehabilitated and water from the borehole will need aeration before storage to precipitate the iron. It is recommended that a chemical analysis be done once the borehole is rehabilitated.

No bacteriological tests were done at this stage. It is recommended that samples for microbiological analysis on the water be taken at the water reticulation system. Should microbial contamination occur, the water needs to be treated accordingly.

Table 3: Chemical parameters compared to SANS 241:2006 (edition 6.1) drinking water standards.

Sample Nr.	NO	T1	T2	T3A	T4	T5	FOUNTAIN	Class I	Class II
Ca	2.76	4.59	2.47	2.86	4.54	2.73	0.64	150	300
Mg	3.61	2.47	3.11	4.25	5.42	3.53	0.49	70	100
Na	1.65	2.58	3.67	4.13	3.94	4.10	0.64	200	400
K	1.35	0.51	1.42	1.33	1.99	1.43	0.34	50	100
Mn	0.22	0.00	0	0	0	0	0	0.1	1
Fe	3.655	-0.006	0	0.058	0	0	0	0.2	2
F	0.84	0.20	0	0	0	0.20	0.18	1	1.5
NO_3-N	0	1	0.36	0.108	0.721	0.106	0.060	10	20
NH_4-N	0.021	0.024	0.02	0	0.083	0.023	0.124	0.94	1.87
Cl	3.00	4.00	3.70	4.6	5.3	3.5	3.4	200	600
SO_4	3.67	2.79	0.73	0	0	0	0	400	600
TDS	32	30	29	34	42	31	6	1000	2400
pH	6.86	7.57	6.55	6.65	6.34	6.87	6.66	5.0 - 9.5	4.0 - 10.0
EC	7.19	6.48	5.69	7.84	9.76	7.19	1.48	150	370

Notes
Yellow = Class I
Tan = Class II
Exceeds maximum allowable drinking water standard
0 = below detection limit of analytical technique

EC values measured in mS/m, all other values measured as mg/l.

6 RAPID RESERVE DETERMINATION

6.1 INTRODUCTION

Definition of Reserve: *"The quantity and quality of water required to supply basic needs of people to be supplied with water from that resource and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of water resources".*

To be able to quantify the groundwater component of the Reserve, the following relationship has to be solved:

$$GW_{allocate} = (Re + GW_{in} - GW_{out}) - BHN - GW_{Bf}$$

where:
$GW_{allocate}$ = groundwater allocation
Re = recharge
GW_{in} = groundwater inflow
GW_{out} = groundwater outflow
BHN = basic human needs
GW_{Bf} = groundwater contribution to baseflow

Under the National Water Act (Act No. 36 of 1998) the water use at the Kleinfontein Development must be authorised. The water will be abstracted from boreholes and used as potable water in a residential development. Under these circumstances, the following (ground) water use is recognised as being relevant to the licence application:

- Section 21 (a) – taking water from a resource.

6.2 APPROACH

The assessment was done on a “rapid” level using the software GRDM version 4.0.0.0. The data used for the calculation was derived from the WRC90 dataset contained in the “GRDM” software driven by the Resource Directed Measures from the Department of Water Affairs. The local catchment falls within quaternary catchment A23A as shown on the map in Appendix F. The default values were used in the assessment in order to develop some guidance on the potential impact of the proposed abstraction on the overall groundwater use in the catchment.

6.3 DESCRIPTION OF THE STUDY AREA

The property referred to as Kleinfontein development Phase 1 has a total area of 286 ha and falls within 3 quaternary catchments namely, A23A, B20D and B31A. Groundwater abstraction however occurs only within catchment A23A. The quaternary catchment A23A has a total area of 684 km^2 of which 13 km^2 is protected (Magaliesberg, Roodeplaat and Bronberg areas), leaving an effective area of 671 km^2. The study area falls in the Crocodile (West) and Marico Water Management Area.

The dominant vegetation type is rocky Highveld grassland. The area has a sloping topography and is drained by surface runoff to the Edendalspruit, which flows alongside the southern boundary of the property from south-east to north-west.

6.4 PRESENT WATER DEMAND

A conservative projection of the planned water demand at the end of the project is 7 128 m^3/month or 85 536 m^3/annum. DWA categorises the water use licence applications in 3 categories based on the amount of recharge that is used by the applicant in relation to the specified property:

- Category A: Small scale abstractions (<60% recharge on property)
- Category B: Medium scale abstractions (60-100% recharge on property)
- Category C: Small scale abstractions (>100% recharge on property)

6.5 RDM ASSESSMENT

The following table summarises the most salient parameters relevant to this catchment (A23A):

Table 4: Most salient parameters relevant to catchment A23A.

Area km^2	Population	General Authorisation (m^3/ha/a)	Rainfall (mm/a)	Current use (Mm^3/a)
682	391615	NA	698	31.65

It is assumed that General Authorisation as a possible route can be excluded.

6.5.1 Classification

Groundwater classification is currently based on a Stress Index which relates water use to recharge. The study area is classified as category A, which indicates unstressed or low levels of stress in terms of abstraction/recharge. The resource is still being used sustainable. At this stage Classification is not directly linked to potential abstraction, but is only indicative of the current situation. A category C classification still implies that ~4.3 (Mm³/a) can still be abstracted from the quaternary catchment before very detailed studies will be required.

6.5.2 Reserve

The following table summarizes the Reserve for the catchment.

Table 5: A summary of the Reserve for the catchment.

Quantification of Reserve: A23A	
Human Need:	
Population	391615
Basic human need [l/d/p]	25
Basic human need total [Mm³/a]	3.57
Recharge:	
Recharge [Mm³/a]	38.25
Baseflow:	
Baseflow [Mm³/a]	14.00
☑ Maint. low flow [Mm³/a]	14.00
☐ EWR [Mm³/a]	0.00
Flow:	
Net Flow [Mm³/a]	0.00
Reserve:	
Reserve as % recharge	45.9
Groundwater allocation [Mm³/a]	20.68
Current abstraction [Mm³/a]	31.64

The allocatable portion is still relatively high (>50% of the recharge), with the greatest impact coming from current abstraction & base flow.

If this calculation is done based on the actual area of the property within the affected quaternary catchment, the following emerges:

Table 6: Recharge to Kleinfontein

Catchment	Actual area (ha) of property	Recharge in Quartenary Catchment (mm/a)	Recharge on property	
A23A	286	56	160160	m^3/a
Total	*286*		*160160*	m^3/a
			0.160	Mm^3/a
			438795	l/day
			5.1	l/second

From Table 6 it is evident that local recharge (160 160 m^3/annum) will supply in the allocatable portion (20.68 Mm^3/annum) for the quaternary catchment A23A. **The local recharge on the property will allow for abstraction of ~ 160 160 m^3/annum.** There will be applied for an abstraction of 85 536 m^3/annum (53%) from the total registered property of Phase 1 of the Kleinfontein Development. The recharge calculations (abstraction being 60-100% of the local recharge) places the property in Category B (medium scale abstraction – 60-100% abstraction of the recharge on the property) (see section 6.4).

6.5.3 Resource Quality Objectives

Maintain regional groundwater table to:

- Ensure that schedule 1 water users adjacent to the site have adequate water supply to sustain basic human need.
- Ensure that adequate water is available to maintain base flow in the Edendalspruit River.

Monitoring:

- The flow monitoring at the fountain must be done regularly to ensure that production does not exceed the flow rate in the dry season.
- Bacteriological monitoring must be done at least weekly to ensure clean healthy water.
- Inorganic analysis need to be done monthly. The iron and manganese content in borehole *NO* must be monitored.

7 AQUIFER CLASSIFICATION

The aquifer(s) underlying the subject area were classified in accordance *with "A South African Aquifer System Management Classification, December 1995"* by Parsons. Classification has been done in accordance with the following definitions for Aquifer System Management Classes:

- Sole Aquifer System: An aquifer which is used to supply 50% or more of domestic water for a given area, and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.

- Major Aquifer System: Highly permeable formations, usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (Electrical Conductivity of less than 150 mS/m).

- Minor Aquifer System: These can be fractured or potentially fractured rocks which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important for local supplies and in supplying base flow for rivers.

- Non-Aquifer System: These are formations with negligible permeability that are regarded as not containing groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, groundwater flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.

Table 7. Ratings for the Aquifer System Management and Second Variable Classifications:

Aquifer System Management Classification		
Class	Points	Study area
Sole Source Aquifer System:	6	6
Major Aquifer System:	4	
Minor Aquifer System:	2	
Non-Aquifer System:	0	
Special Aquifer System:	0 – 6	
Second Variable Classification (Weathering/Fracturing)		
Class	Points	Study area
High:	3	
Medium:	2	2
Low:	1	

Based on information collected during the hydrocensus it can be concluded that aquifer system in the study area can be classified as a “Sole Aquifer System”. The local population and farms make use of groundwater as a source of potable water to supplement surface water use. Borehole yields and water quality are generally excellent. In order to achieve the Groundwater Quality Management Index a points scoring system as presented in Table 7 and Table 8 was used.

The occurring aquifer(s), in terms of the above definitions, is classified as a sole aquifer system.

The vulnerability, or the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer, in terms of the above, is classified as **medium**. A moderately deep water table (9<17 mbgl) and rocks with slight weathering underlie the site. The level of groundwater protection based on the Groundwater Quality Management Classification:

Table 8. Ratings for the Groundwater Quality Management (GQM) Classification System:

Aquifer System Management Classification		
Class	Points	Study area
Sole Source Aquifer System:	6	6
Major Aquifer System:	4	
Minor Aquifer System:	2	
Non-Aquifer System:	0	
Special Aquifer System:	0 - 6	
Aquifer Vulnerability Classification		
Class	Points	Study area
High:	3	
Medium:	2	2
Low:	1	

GQM Index = Aquifer System Management x Aquifer Vulnerability
= 6 X 2 = 12

Table 9. GQM index for the study area

GQM Index	Level of Protection	Study Area
<1	Limited	
1 - 3	Low Level	
3 - 6	Medium Level	
6 - 10	High Level	
>10	Strictly Non-Degradation	12

7.1 AQUIFER SUSCEPTIBILITY

Aquifer susceptibility, a qualitative measure of the relative ease with which a groundwater body can be potentially contaminated by anthropogenic activities and which includes both aquifer vulnerability and the relative importance of the aquifer in terms of its classification, in terms of the above, is classified as **medium**.

7.2 AQUIFER PROTECTION CLASSIFICATION

The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a Groundwater Quality Management Index of 12 for the study area, indicating that **"strictly non-degradation protection"** will be required.

Due to the "strictly non-degradation" GQM index calculated for this area, a high level of protection is needed to adhere to the Department of Water Affair's (DWA) water quality objectives. Reasonable and sound groundwater protection measures are recommended to ensure that no cumulative pollution affects the aquifer, even in the long term.

In terms of DWAF's overarching water quality management objectives which is (1) protection of human health and (2) the protection of the environment, the significance of this aquifer classification is that if any potential risk exist, measures must be triggered to limit the risk to the environment, which in this case is the (1) protection of the Secondary Underlying Aquifer, (2) the Edendalspruit and its tributaries which drains the subject area and (3) the external users of groundwater in the area.

8 WASTE HANDLING

8.1 Solid waste

There is no solid waste disposal site as all solid waste is collected and transported to the Rayton Landfill site for disposal.

8.2 Sanitary Systems

All stands are presently served by septic tank systems. The septic tanks conform to the SANS and CSIR standards. According to the Services Report (2004) provided by KBK, infiltration tests were done on the various soil types to ensure that the soil can accommodate the sanitary systems adequately. Application at the Department of Water Affairs to build a Waste Water Treatment Facility at Kleinfontein is planned for the near future. The site selected is shown on the map in Appendix G.

The site is located in an area away from existing boreholes and surface water resources. Monitoring boreholes will be required for the permitting of the site by DWA.

Hydrological Assessment

The hydrogeological assessment as prescribed by the Sanitation Protocol comprises an assessment of the geological formations, the major and minor groundwater aquifers, water-bearing faults and fractures, and the major surface water resources. Issues such as the thickness of the unsaturated zone, the depth to the water table the permeability of the unsaturated zone, the location of production boreholes and the impact of abstracting groundwater, are important in the assessment.

The unsaturated zone underlying the Kleinfontein development area consists mainly of a shallow to deep weathered zone. Solid rock occurs at approximately 5 to 10 m on the quartzite. The occurrence of solid rock is deeper than 15m in the shale horizons. The aquifers present in the area are mainly fractured, faulted and contact zones in the fresh un-weathered rock. The depth to the water table varies between 10 and 25 m below ground level depending on the topography.

The area has an average rainfall of about 698 mm per annum and the recharge according the Groundwater Harvest Potential Map of South Africa is in the order of 10 000 to 15 000 cubic metres per square kilometre per annum that can be abstracted. Groundwater in the area is used mainly for domestic and game or cattle supply. Groundwater protection management against contamination is therefore of utmost importance.

Surface water conditions are important as impact occurs through run-off during rain events. Surface pollution sources should be managed in such a way that run-off is not contaminated by them. Contamination introduced into the unsaturated zone will migrate into the groundwater during high rainfall events.

Assessment of risk of Contamination

Variable drainage conditions can be expected with coefficient of permeability of between 10^{-1} and 10^{-8} m/sec determined across the development during the geotechnical investigations (pers. comm. Holland-Muter) . Permeability's of between 10^{-3} and 10^{-4} cm/sec are considered to be acceptable for installation of septic tanks. As stated before the aquifer at Kleinfontein development can be regarded as a major aquifer, which requires high protection. We further need to look at the contamination as the soil indicates variable percolation into the soil and runoff to surface water during the rainy season.

Unsaturated conditions:

The following is an assessment of the reduction of contaminants in the unsaturated zone according to the DWAF Protocol:

Table 10: Assessment of the reduction of contaminants in the unsaturated zone

Description	Rate
Rate of flow in the unsaturated zone:	**Slow to medium: 1-10 m/d**
Capacity of media to absorb contaminants:	**Medium**
Capacity to create an effective barrier to contaminants:	**Medium**
Reduction of bacteria and viruses	**High**
Reduction of nitrates and phosphates	**Minimal**
Reduction of chlorides	**Minimal**

From Table 10, it can be concluded the unsaturated zone is a **fair barrier** to the movements of **biological contaminants, but with little reduction in chemical contaminants.**

With the high density development and the variable thickness of the unsaturated zone in the Kleinfontein development area, the aquifer vulnerability is considered medium for the contaminant load that can be expected from septic tanks that are installed. A **medium overall risk** to the groundwater is estimated if precautionary measures are not taken due to the retention and overflow that may occur in septic tank pits.

It is recommended that a water borne sewage treatment system (such as the *activated sequential batch reactor* proposed), be utilised for the development to treat raw sewage. The treated effluent must be of the required DWA quality standard for release into the drainage system or for irrigation use.

8.3 Cemetery Site

There are two cemetery sites on the property located in the game park as shown in Appendix G. One site is historical and dates back to 1860 with graves of the original inhabitants as well as graves from the Anglo-Boer War in 1902. The cemetery presently in use is located adjacent to the historical cemetery and houses 25 graves of the Kleinfontein community. A record is kept of all funerals and the cemetery is well maintained and is in line with the standards of the National Cemetery Association (INCA). The cemetery is approximately 575 m upstream from the nearest borehole and no impact on the groundwater is envisaged.

9 POTENTIAL IMPACT ON OTHER USERS

The management of water resources at Kleinfontein focuses on protecting the resources and the environment. Homeowners are requested to use water efficiently and reduce water use during the rainy season. The production system is set to increase production from the fountain in the rainy season and reduce the production from the boreholes. During the pump testing the drawdown was monitored on observation boreholes in the vicinity but no impacts were recorded. This means that the drawdown in 24 hours testing did not impact on surrounding boreholes. It must be noted that the boreholes are shallow and available drawdown is restricted.

A number of complaints regarding reduction in water resources were received from neighbours. Details regarding their names and property localities are shown in Table 11. The complaints were concerning the reduction in their groundwater resources. Their usage as a percentage of the annual recharge on their properties was not considered but could be confirmed. It must be understood that groundwater is recharged by annual rainfall which fluctuates and therefore a reduction in resources is experienced by all users.

In order to investigate the potential impact on these properties the locality with respect to the boreholes pumped were plotted and are shown in Appendix H. Based on the localities the topographic profiles that exist between the localities were evaluated. The profiles are included in Appendix H with Profile A-A' showing the topography between borehole *NO* tested and the Donkerhoek localities. Profile B-B' shows the topography between the remaining 5 boreholes tested and the Donkerhoek localities. Both profiles show a watershed between the sites and it is therefore unlikely that the boreholes at Kleinfontein can impact on the properties in Table 11. Both the reduction in rainfall as well as other potential impacts on their groundwater should be investigated.

Table 11: Details of neighbours from which complaints were received.

Neighbour	Donkerhoek 365JR	Lattitude (WGS84)	Longitude (WGS84)
Adrian Roslee	Plot 13	na	na
Erik Pretorius	Plot 23 & 24	na	na
Jakkie Pieterse	Plot 69	25° 46' 58.88"	28° 27' 55.00 "
Lex Middelberg	na	25° 47' 10.25 "	28° 28' 16.76 "
Johan Thom	Plot 124	na	na

10 CONCLUSIONS AND RECOMMENDATIONS

Based on all the available information, test pumping data, analytical results and reserve determination, the following can be concluded:

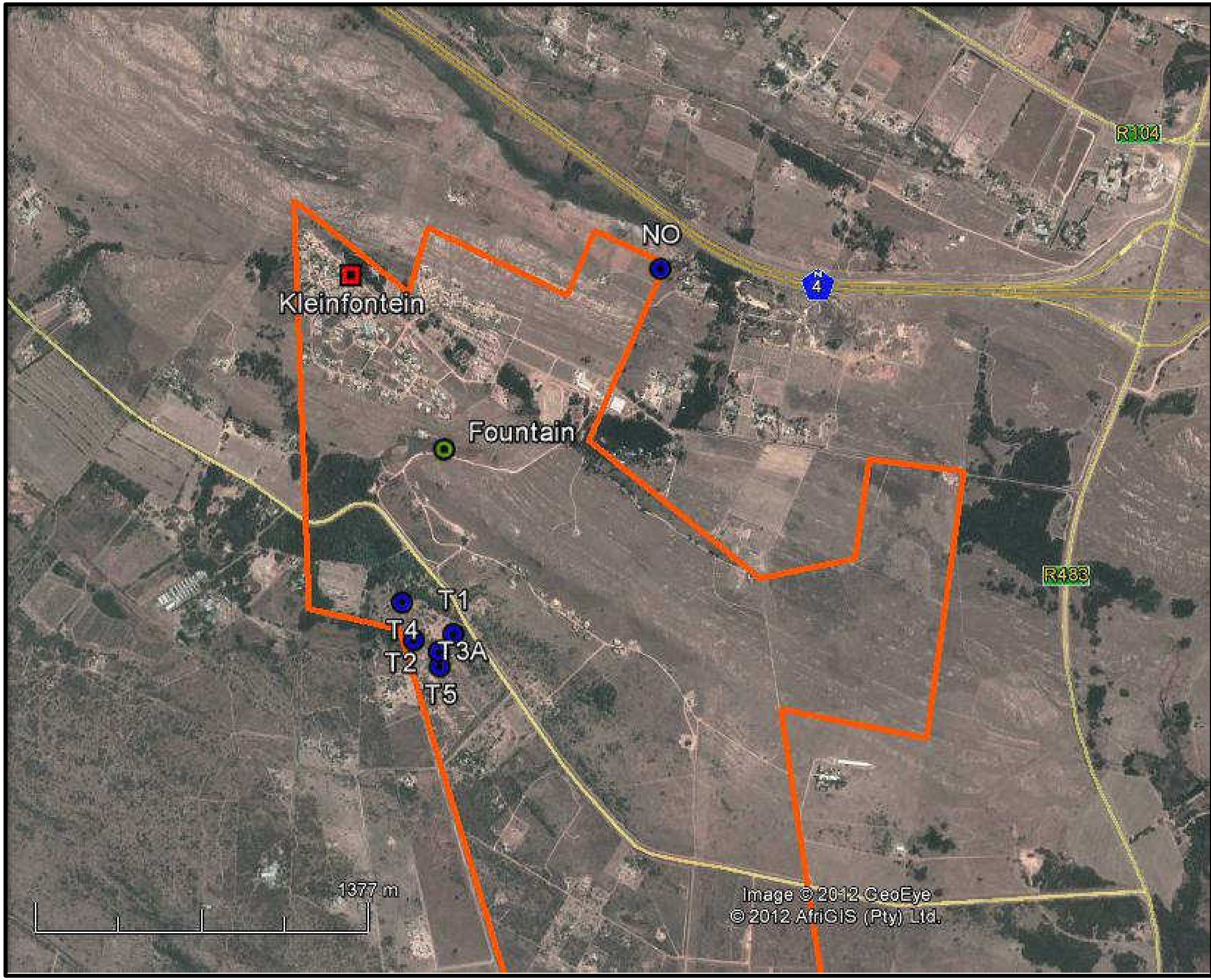
- The groundwater, with exception of the borehole *NO,* is of excellent quality and complies with the SANS 241-1 Drinking Water Standards.
- The iron content in borehole *NO* exceeds the maximum allowable drinking water standard (Class II). The manganese concentration falls within Class II standards (suitable for short term use only). This water is not presently used.
- The combined sustainable yield calculated from the pump tests conducted on the selected production boreholes is 3.8 l/s.
- The sustainable yield calculated from the fountain flow is 1.55 l/s.
- The calculated annual recharge on the property is 438 795 l/day or 5.1 l/s.
- A Water Use License for abstraction of 257 600 l/day or 2.75 l/s can be applied for.
- This is 53% of the annual recharge on the property and therefore within 60-100% of the annual recharge on the property which places the water use license in Category B.
- The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification for the study area indicate that medium level groundwater protection may be required.
- Solid waste disposal site is not required as the solid waste is disposed at the licensed Rayton waste site.
- The Sanitation Protocol study shows medium overall risk to groundwater.
- Investigation into the complaints by neighbours showed that they are located outside the Kleinfontein catchment and is unlikely to be impacted by the groundwater abstraction on the Development.

Based on the above conclusions, the following recommendations are made:

- ➢ It is recommended that borehole *NO* be rehabilitated and tested before used for production.
- ➢ All the selected production boreholes need to be registered with the Department of Water Affairs for the WULA.
- ➢ Adherence to the sustainable yields of the boreholes is crucial to ensure long-term utilisation of the groundwater resource.
- ➢ Accurate monthly monitoring of the groundwater levels in the boreholes is recommended. If any significant fluctuation in water level occurs, immediate action needs to be taken.
- ➢ Groundwater quality and especially bacteriological analyses must be done on a regular basis.
- ➢ Reasonable and sound groundwater protection measures are recommended to ensure that no cumulative pollution affects the aquifer, even in the long term.
- ➢ It is recommended that a waterborne sewage system be installed for the development to treat the raw sewage water.

Appendix A

Borehole Locality Map



Project Title:
KLEINFONTEIN GEOHYDROLOGY REPORT

Map Title:
Kleinfontein: BH Locations

Map Number:
Map 1

LEGEND

Boreholes

Fountain

Kleinfontein Town

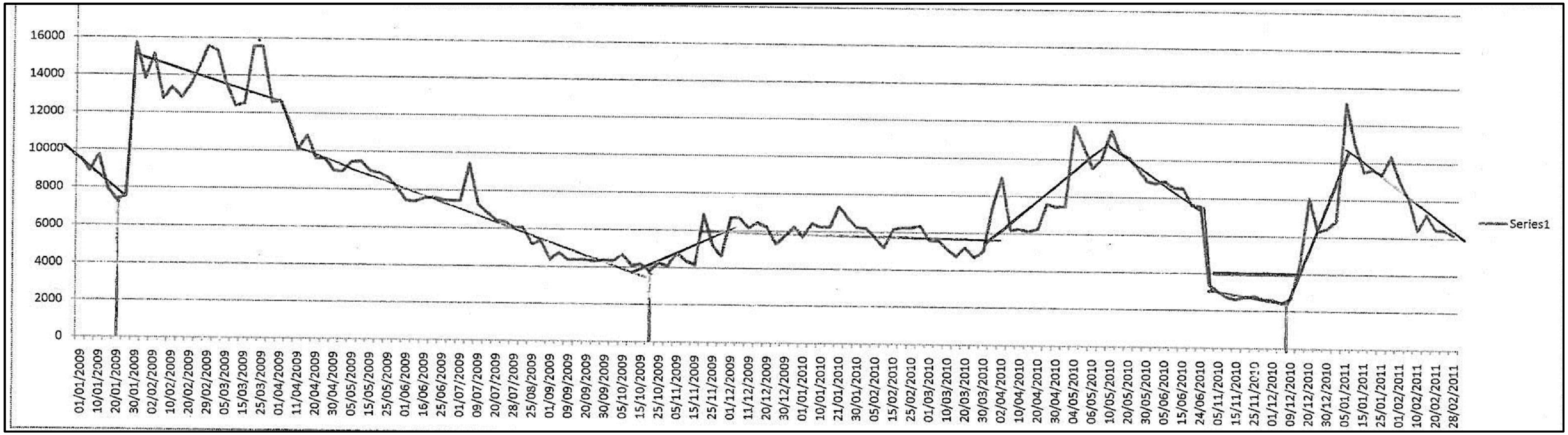
N

Project nr:
106773/Kleinfontein

aurecon
Lynnwood Bridge Office Park
4 Daventry Street
Lynnwood Manor 0040
www.aurecongroup.com

Appendix B

Fountain flow record


16000
14000
12000
10000
8000
6000
4000
2000
0
Series1
01/01/2009
10/01/2009
20/01/2009
30/01/2009
02/02/2009
10/02/2009
20/02/2009
29/02/2009
05/03/2009
15/03/2009
25/03/2009
01/04/2009
11/04/2009
20/04/2009
30/04/2009
05/05/2009
15/05/2009
25/05/2009
01/06/2009
16/06/2009
25/06/2009
01/07/2009
09/07/2009
20/07/2009
28/07/2009
25/08/2009
01/09/2009
09/09/2009
20/09/2009
30/09/2009
05/10/2009
15/10/2009
25/10/2009
05/11/2009
15/11/2009
25/11/2009
01/12/2009
11/12/2009
20/12/2009
30/12/2009
01/01/2010
10/01/2010
21/01/2010
30/01/2010
05/02/2010
15/02/2010
25/02/2010
01/03/2010
10/03/2010
20/03/2010
30/03/2010
02/04/2010
10/04/2010
20/04/2010
30/04/2010
04/05/2010
06/05/2010
10/05/2010
20/05/2010
30/05/2010
05/06/2010
15/06/2010
24/06/2010
05/11/2010
15/11/2010
25/11/2010
01/12/2010
09/12/2010
20/12/2010
30/12/2010
05/01/2011
15/01/2011
25/01/2011
01/02/2011
10/02/2011
20/02/2011
28/02/2011

Appendix C

FC-Method Solution

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

T1

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	#NUM! ←	#NUM! ←	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	1	0.00E+00 ←	S-late ←	Change r_e
s_a (available drawdown), sigma_s = (enter)	5.0	←	Sigma_s from risk	
Annual effective recharge (mm) =	20	9.00	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	6.17	End time and drawdown of test	
Average maximum derivative = (enter)	0.2 ←	0.2	Estimate of average of max deriv	
Average second derivative = (enter)	0.0 ←	0.0	Estimate of average second deriv	
Derivative at radial flow period = (enter)	#NUM! ←	#NUM!	Read from derivative graph	
	T-early[m^2/d] =	#NUM!	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	70.16	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	5.00E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

Maximum influence of boundaries at long time

(No values of T and S are necessary)	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	6.72	7.36	8.01	9.94
Q_sust (l/s) =	1.34	1.22	1.12	0.91
	Best case	→	→	**Worst case**
Average Q_sust (l/s) =	**1.14**	WARNING!! Est. Q_sust > Q during pumping test		
with standard deviation=	0.18	Suggestion:check available drawdown and rech		

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

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)

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

T-late [m^2/d] = (enter) →	70.16			
S-late = (enter) →	5.00E-03			
1. BOUNDARY INFORMATION (choose a or b)	(Code =9999 = dummy value if not applicable)			
(a) Barrier (no-flow) boundaries →	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
Bound. distance a[meter] : (enter)	9999	9999	9999	9999
Bound. distance b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	0.00
(b) Fix head boundary + no-flow →	Closed Fix	Single Fix	90°Fix+no-flow	// Fix+no-flow
Bound. distance to fix head a[meter] : (enter)	9999	9999	9999	9999
Bound. distance to no-flow b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	0.00
2. INFLUENCE OF OTHER BOREHOLES →	Q (l/s)	r (m)	u_r	W(u,r)
BH1			0.00E+00	#NUM!
BH2			0.00E+00	#NUM!
s_(influence of BH1,BH2) =	0.00	0.00	#NUM!	#NUM!
SOLUTION INCLUDING BOUNDS AND BH's				
Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
Enter selected Q for risk analysis = (enter) →		Sigma_s =	0.000	

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

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	1.00
Total amount of water allowed to be abstracted per month (m^3) =	2592

COMMENTS

Q_sust with 68% safety =

Q_sust with 95% safety =

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

T2

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	#NUM! ←	#NUM! ←	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	0.8	0.00E+00 ←	S-late ←	Change r_e
s_a (available drawdown), sigma_s = (enter)	12.0	23 ←	Sigma_s from risk	
Annual effective recharge (mm) =	20	16.00	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	6.36	End time and drawdown of test	
Average maximum derivative = (enter)	2.4 ←	2.4	Estimate of average of max deriv	
Average second derivative = (enter)	0.0 ←	0.0	Estimate of average second deriv	
Derivative at radial flow period = (enter)	#NUM! ←	#NUM!	Read from derivative graph	
	T-early[m^2/d] =	#NUM!	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	5.26	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	5.00E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

(No values of T and S are necessary)

Maximum influence of boundaries at long time

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	13.25	20.14	27.03	47.70
Q_sust (l/s) =	0.97	0.64	0.47	0.27
	Best case	→	→	**Worst case**

Average Q_sust (l/s) =	**0.53**
with standard deviation=	0.29

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

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)

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

T-late [m^2/d] = (enter) →	5.26
S-late = (enter) →	5.00E-03

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

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

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

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

SOLUTION INCLUDING BOUNDS AND BH's

Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
Enter selected Q for risk analysis = (enter) →		Sigma_s =	0.000	

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

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	0.80
Total amount of water allowed to be abstracted per month (m^3) =	2074

COMMENTS

Q_sust with 68% safety =

Q_sust with 95% safety =

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

T3A

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	#NUM!	#NUM!	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	1.2	0.00E+00	S-late	Change r_e
s_a (available drawdown), sigma_s = (enter)	10.0	0	Sigma_s from risk	
Annual effective recharge (mm) =	20	14.00	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	5.3	End time and drawdown of test	
Average maximum derivative = (enter)	5.4	5.4	Estimate of average of max deriv	
Average second derivative = (enter)	0.0	0.0	Estimate of average second deriv	
Derivative at radial flow period = (enter)	#NUM!	#NUM!	Read from derivative graph	
	T-early[m^2/d] =	#NUM!	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	3.52	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	5.00E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

(No values of T and S are necessary)

Maximum influence of boundaries at long time

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	20.93	36.37	51.81	98.13
Q_sust (l/s) =	0.80	0.46	0.32	0.17
	Best case			**Worst case**

Average Q_sust (l/s) =	**0.38**
with standard deviation=	0.27

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

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)

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

T-late [m^2/d] = (enter)	3.52
S-late = (enter)	5.00E-03

1. BOUNDARY INFORMATION (choose a or b)

(Code =9999 = dummy value if not applicable)

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

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

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

SOLUTION INCLUDING BOUNDS AND BH's

Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
Enter selected Q for risk analysis = (enter)		Sigma_s =	0.000	

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

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	0.80
Total amount of water allowed to be abstracted per month (m^3) =	2074

COMMENTS

Q_sust with 68% safety =

Q_sust with 95% safety =

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

T4

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	#NUM! ←	#NUM! ←	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	0.7	0.00E+00 ←	S-late ←	Change r_e
s_a (available drawdown), sigma_s = (enter)	6.0	0 ←	Sigma_s from risk	
Annual effective recharge (mm) =	20	10.00	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	2.68	End time and drawdown of test	
Average maximum derivative = (enter)	1.1 ←	1.1	Estimate of average of max deriv	
Average second derivative = (enter)	0.0 ←	0.0	Estimate of average second deriv	
Derivative at radial flow period = (enter)	#NUM! ←	#NUM!	Read from derivative graph	
	T-early[m^2/d] =	#NUM!	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	10.10	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	5.00E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

(No values of T and S are necessary)

Maximum influence of boundaries at long time

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	5.88	9.02	12.15	21.57
Q_sust (l/s) =	1.19	0.78	0.58	0.32
	Best case →			**Worst case**

Average Q_sust (l/s) =	**0.64**
with standard deviation=	0.37

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

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)

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

T-late [m^2/d] = (enter) →	10.10			
S-late = (enter) →	5.00E-03			
1. BOUNDARY INFORMATION (choose a or b)	(Code =9999 = dummy value if not applicable)			
(a) Barrier (no-flow) boundaries →	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
Bound. distance a[meter] : (enter)	9999	9999	9999	9999
Bound. distance b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	#NUM!
(b) Fix head boundary + no-flow →	Closed Fix	Single Fix	90°Fix+no-flow	// Fix+no-flow
Bound. distance to fix head a[meter] : (enter)	9999	9999	9999	9999
Bound. distance to no-flow b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	0.00
2. INFLUENCE OF OTHER BOREHOLES →	Q (l/s)	r (m)	u_r	W(u,r)
BH1			0.00E+00	#NUM!
BH2			0.00E+00	#NUM!
s_(influence of BH1,BH2) =	0.00	0.00	#NUM!	#NUM!
SOLUTION INCLUDING BOUNDS AND BH's				
Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
Enter selected Q for risk analysis = (enter) →		Sigma_s =	0.000	

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

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	0.50
Total amount of water allowed to be abstracted per month (m^3) =	1296

COMMENTS

Q_sust with 68% safety =

Q_sust with 95% safety =

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

T5

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	#NUM! ←	#NUM! ←	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	1	0.00E+00 ←	S-late ←	Change r_e
s_a (available drawdown), sigma_s = (enter)	10.0	0 ←	Sigma_s from risk	
Annual effective recharge (mm) =	20	14.00	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	7.6	End time and drawdown of test	
Average maximum derivative = (enter)	10.3 ←	10.3	Estimate of average of max deriv	
Average second derivative = (enter)	0.1 ←	0.1	Estimate of average second deriv	
Derivative at radial flow period = (enter)	#NUM! ←	#NUM!	Read from derivative graph	
	T-early[m^2/d] =	#NUM!	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	1.54	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	5.00E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

(No values of T and S are necessary)

Maximum influence of boundaries at long time

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	37.26	66.61	95.97	184.02
Q_sust (l/s) =	0.38	0.21	0.15	0.08
	Best case	→	→	**Worst case**

Average Q_sust (l/s) = **0.17**

with standard deviation= 0.13

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

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)

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

T-late [m^2/d] = (enter) → 1.54

S-late = (enter) → 5.00E-03

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

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

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

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

SOLUTION INCLUDING BOUNDS AND BH's

Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
Enter selected Q for risk analysis = (enter) →		Sigma_s =	0.000	

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

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	0.40
Total amount of water allowed to be abstracted per month (m^3) =	1037

COMMENTS

Q_sust with 68% safety =

Q_sust with 95% safety =

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

NO

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	26.52	26.52	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	0.5	1.38E-06	S-late	Change r_e
s_a (available drawdown), sigma_s = (enter)	31.7		Sigma_s from risk	
Annual effective recharge (mm) =	20	35.66	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	31.33	End time and drawdown of test	
Average maximum derivative = (enter)	4.7	4.7	Estimate of average of max deriv	
Average second derivative = (enter)	0.0	0.0	Estimate of average second deriv	
Derivative at radial flow period = (enter)	6.95	6.95	Read from derivative graph	
	T-early[m^2/d] =	1.14	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	1.69	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	5.00E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

(No values of T and S are necessary)

Maximum influence of boundaries at long time

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	44.75	58.16	71.58	111.83
Q_sust (l/s) =	0.40	0.31	0.25	0.16
	Best case			**Worst case**

Average Q_sust (l/s) = **0.26**

with standard deviation= 0.10

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

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)

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

T-late [m^2/d] = (enter)	1.69			
S-late = (enter)	5.00E-03			
1. BOUNDARY INFORMATION (choose a or b)	(Code =9999 = dummy value if not applicable)			
(a) Barrier (no-flow) boundaries	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
Bound. distance a[meter] : (enter)	9999	9999	9999	9999
Bound. distance b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	#NUM!	0.00	#NUM!	#NUM!
(b) Fix head boundary + no-flow	Closed Fix	Single Fix	90°Fix+no-flow	// Fix+no-flow
Bound. distance to fix head a[meter] : (enter)	9999	9999	9999	9999
Bound. distance to no-flow b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	#NUM!	0.00	#NUM!	#NUM!
2. INFLUENCE OF OTHER BOREHOLES	Q (l/s)	r (m)	u_r	W(u,r)
BH1			0.00E+00	#NUM!
BH2			0.00E+00	#NUM!
s_(influence of BH1,BH2) =	0.00	0.00	7.14E-04	6.67

SOLUTION INCLUDING BOUNDS AND BH's

Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
Enter selected Q for risk analysis = (enter)		Sigma_s =	0.000	

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

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	0.30
Total amount of water allowed to be abstracted per month (m^3) =	778

COMMENTS

Q_sust with 68% safety =

Q_sust with 95% safety =

Appendix D

Field Testing Records

WATER SOURCE EVALUATION REPORT

BH Number	NO

Project No:	
Province	
District	
Municipality	
Farm name & No.	
Village/Site name	

Map Ref Number	WGS84
Lat	50387
Long	54384
Altitude (mamsl)	1540
Drainage Region	
BH Diameter (mm)	165
Collar height (m)	0
BH Depth (m)	51.2

Status	
No info	
Destroyed	
In use	x
Unused	

Consumer	
No info	
Water disposed	
Farm	x
No urban	
Urban	

Toposetting	
Alluvial Fan	
Dry river bed	
Dunes	
Ephemeral stream	
Flat surface, plain	
In or along sinkhole	
Irrigated field	
Along dam, lake or swamp	
On mountain or hill	
At or in opencast mine	
In or along pan	
In or along river	
Hillside (slope)	
Terrace	
Valley	x
At or in waste disposal	

Purpose	
Drainage	
Exploration	
Mine drainage	
Observation	
Production (water supply)	x
Recharge	
Standby	
Waste disposal	
Other	

Equipment installed	
Airlift	
Centrifugal pump	
Gravity suction	
Handpump	
Jet	
Mono-type pump	
No equipment	
Observation tube	
Piston pump	
Powerhead	
Recorder	
Submersible pump	x
Turbine	
Windpump	
Windpump with powerhead	
Other:	

Site Type	
Stormwater	
Borehole	x
Canal or trench	
Dug well	
Effluent	
Fountain/Spring	
Gauging weir	
Sinkhole	
Drainage well	
Cattle dip	
Sewage	
Pit latrine, VIP, UDP	
Multiple borehole	
Meteorological Station	
Seepage from opencast mine	
Pan, dam, lake	
River or stream	
Seepage pond	
Tunnel, shaft or drain	
Flow from underground mine	
Rainwater harvesting station	
Wellpoint	
Reservoir	
Graveyard	
Other:	

Application	
No info	
Agriculture & domestic	x
Agriculture - irrigation only	
Agriculture - stock watering only	
Domestic - all purposes	
Domestic - garden only	
Nature conservation	
Public	
Industrial - commercial	
Industrial & mining - evaporate	
Industrial - industrial	
Industrial - mining	
Industrial - power generation	

TEST RECORD:

Date Started:	16/06/2012	**Test pump used:**	SP8-30	**Logger depth (m):**		**CD Date started:**	16/06/2012
Time Started:	08H00	**Pump depth (m):**	45.4	**SWL (mbgl):**	9.50	**CD Time started:**	10:30
						Waterlevel before constant started (m):	13.7

STEP TEST & RECOVERY

ep 1	RPM:			Step 2	RPM:		
Time (min)	**Drawdown (m)**	**Yield (L/s)**	**Recovery (m)**	**Time (min)**	**Drawdown (m)**	**Yield (L/s)**	**Recovery (m)**
1	16.42	0.38		1	31.97	0.9	
2	17.38			2	33.15		
3	18.34	0.38		3	34.18	0.85	
5	19.30			5	36.44		
7	20.10			7	38.00		
10	20.56	0.37		10	40.12	0.83	
15	21.50			15	42.12		
20	22.42	0.38		20	45.12	0.81	
30	22.96			30	PI	0.57	
40	23.80	0.37		40			
50	25.64			50			
60	26.48	0.37		60			
70				70			
80				80			
90				90			
100				100			
110				110			
120				120			

Step 3	RPM:			Step 4	RPM:		
Time (min)	**Drawdown (m)**	**Yield (L/s)**	**Recovery (m)**	**Time (min)**	**Drawdown (m)**	**Yield (L/s)**	**Recovery (m)**
1				1			
2				2			
3				3			
5				5			
7				7			
10				10			
15				15			
20				20			
30				30			
40				40			
50				50			
60				60			
70				70			
80				80			
90				90			
100				100			
110				110			
120				120			

Recovery	
Time (min)	**Waterlevel (m)**
1	41.16
2	39.45
3	37.9
5	35.46
7	33.09
10	30.06
15	25.29
20	22.74
30	17.9
40	13.77
60	
90	
120	
150	
180	
210	
240	
300	
360	
420	
480	
540	
600	
720	
840	
960	
1080	
1200	
1320	
1440	
2280	
2880	
3480	
3900	
4320	
4920	
5760	

CONSTANT DISCHARGE TEST

Constant Discharge Test		RPM:		
Time (min)	**Drawdown (m)**	**Yield (L/s)**	**Rec Time (min)**	**Recovery (m)**
1	20.64	0.56	1	
2	20.9		2	
3	21.5		3	
5	22.3	0.55	5	
7	23.4		7	
10	24.19		10	
15	25.8		15	
20	28.32		20	
30	30.74	0.55	30	
40	32.27		40	
60	36.63	0.55	60	
90	37.75		90	
120	38.4	0.53	120	
150	38.68	0.52	150	
180	38.76	0.52	180	
210	38.78		210	
240	38.8	0.51	240	
300	38.78	0.52	300	
360	38.89	0.52	360	
420	39.08	0.52	420	
480	39.08		480	
540	39.18	0.51	540	
600	39.25		600	
720	39.59	0.51	720	
840	39.6		840	
960	39.69	0.5	960	
1080	39.92	0.5	1080	
1200	40.21	0.51	1200	
1320	40.47	0.52	1320	
1440	40.83	0.52	1440	
2280			2280	
2880			2880	
3480			3480	
3900			3900	
4320			4320	
4920			4920	
5760			5760	

Observation BH		
BH no:		
Distance:		
Waterlevel:		
Lat:		
Long:		
	Drawdown	Recovery
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
60		
90		
120		
150		
180		
210		
240		
300		
360		
420		
480		
540		
600		
720		
840		
960		
1080		
1200		
1320		
1440		
2280		
2880		
3480		
3900		
4320		

WATER SOURCE EVALUATION REPORT

BH Number	T1

Project No:	
Province	
District	
Municipality	
Farm name & No.	
Village/Site name	

Map Ref Number	WGS84
Lat	51284
Long	55919
Altitude (mamsl)	1514
Drainage Region	
BH Diameter (mm)	165
Collar height (m)	0.12
BH Depth (m)	58

Status

No info	
Destroyed	
In use	x
Unused	

Consumer

No info	
Water disposed	
Farm	x
No urban	
Urban	

Toposetting

Alluvial Fan	
Dry river bed	
Dunes	
Ephemeral stream	
Flat surface, plain	
In or along sinkhole	
Irrigated field	
Along dam, lake or swamp	
On mountain or hill	
At or in opencast mine	
In or along pan	
In or along river	
Hillside (slope)	
Terrace	
Valley	x
At or in waste disposal	

Purpose

Drainage	
Exploration	
Mine drainage	
Observation	
Production (water supply)	x
Recharge	
Standby	
Waste disposal	
Other	

Equipment installed

Airlift	
Centrifugal pump	
Gravity suction	
Handpump	
Jet	
Mono-type pump	
No equipment	
Observation tube	
Piston pump	
Powerhead	
Recorder	
Submersible pump	x
Turbine	
Windpump	
Windpump with powerhead	
Other:	

Site Type

Stormwater	
Borehole	x
Canal or trench	
Dug well	
Effluent	
Fountain/Spring	
Gauging weir	
Sinkhole	
Drainage well	
Cattle dip	
Sewage	
Pit latrine, VIP, UDP	
Multiple borehole	
Meteorological Station	
Seepage from opencast mine	
Pan, dam, lake	
River or stream	
Seepage pond	
Tunnel, shaft or drain	
Flow from underground mine	
Rainwater harvesting station	
Wellpoint	
Reservoir	
Graveyard	
Other:	

Application

No info	
Agriculture & domestic	x
Agriculture - irrigation only	
Agriculture - stock watering only	
Domestic - all purposes	
Domestic - garden only	
Nature conservation	
Public	
Industrial - commercial	
Industrial & mining - evaporate	
Industrial - industrial	
Industrial - mining	
Industrial - power generation	

TEST RECORD:

Date Started:	14/06/2012	**Test pump used:**	SP8-30	**Logger depth (m):**		**CD Date started:**	14/06/2012
Time Started:	08:04	**Pump depth (m):**	36.26	**SWL (mbgl):**	17.00	**CD Time started:**	13:02:00 AM
						Waterlevel before constant started (m):	17.8

STEP TEST & RECOVERY

ep 1 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	18.30		
2	18.40	0.31	
3	18.30		
5	18.28		
7	18.27	0.31	
10	18.25		
15	18.28		
20	18.27	0.37	
30	18.85	0.4	
40	18.85	0.4	
50	18.95		
60	18.97	0.4	
70			
80			
90			
100			
110			
120			

Step 2 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	21.00		
2	20.37	0.77	
3	20.42		
5	20.54		
7	20.53		
10	20.55		
15	20.42	0.77	
20	20.40		
30	20.49		
40	20.53	0.75	
50	20.53		
60	20.52	0.75	
70			
80			
90			
100			
110			
120			

Step 3 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	22.12	1.06	
2	22.04		
3	22.04		
5	22.12	1.06	
7	22.30		
10	22.27	1.03	
15	22.24		
20	22.28	1.02	
30	22.36	1.02	
40	22.42		
50	22.47	1.02	
60	22.44		
70			
80			
90			
100			
110			
120			

Step 4 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	25.15	1.75	
2	25.26		
3	25.65		
5	26		
7	26.27	1.75	
10	26.73		
15	27.62		
20	28.34		
30	30.8	1.69	
40	32.94		
50	35.21		
60	36.12	1.69	
70	PI	1.02	
80			
90			
100			
110			
120			

Recovery

Time (min)	Waterlevel (m)
1	25.6
2	22.5
3	20.8
5	20.07
7	19
10	18.25
15	17.8
20	
30	
40	
60	
90	
120	
150	
180	
210	
240	
300	
360	
420	
480	
540	
600	
720	
840	
960	
1080	
1200	
1320	
1440	
2280	
2880	
3480	
3900	
4320	
4920	
5760	

CONSTANT DISCHARGE TEST

Constant Discharge Test RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Rec Time (min)	Recovery (m)
1	22.86	0.97	1	
2	22.9		2	
3	22.93		3	
5	22.95	0.97	5	
7	22.97		7	
10	22.98		10	
15	23	0.97	15	
20	23.02		20	
30	23.04		30	
40	23.05	0.97	40	
60	23.06		60	
90	23.06	0.97	90	
120	23.08	0.98	120	
150	23.11		150	
180	23.13	0.98	180	
210	23.15		210	
240	23.15	0.98	240	
300	23.15		300	
360	23.15		360	
420	23.17		420	
480	23.13		480	
540	23.09		540	
600	23.12		600	
720	23.09	0.95	720	
840	23.08		840	
960	23.08		960	
1080	23	0.95	1080	
1200	23.06		1200	
1320	23.1	0.97	1320	
1440	23.11	0.97	1440	
2280			2280	
2880			2880	
3480			3480	
3900			3900	
4320			4320	
4920			4920	
5760			5760	

Observation BH

BH no:
Distance:
Waterlevel:
Lat:
Long:

	Drawdown	Recovery
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
60		
90		
120		
150		
180		
210		
240		
300		
360		
420		
480		
540		
600		
720		
840		
960		
1080		
1200		
1320		
1440		
2280		
2880		
3480		
3900		
4320		

WATER SOURCE EVALUATION REPORT

BH Number	T2
Project No:	
Province	
District	
Municipality	
Farm name & No.	
Village/Site name	

Map Ref Number	WGS84
Lat	51284
Long	55919
Altitude (mamsl)	1512
Drainage Region	
BH Diameter (mm)	165
Collar height (m)	0.12
BH Depth (m)	37

Status	
No info	
Destroyed	
In use	x
Unused	

Consumer	
No info	
Water disposed	
Farm	x
No urban	
Urban	

Toposetting	
Alluvial Fan	
Dry river bed	
Dunes	
Ephemeral stream	
Flat surface, plain	
In or along sinkhole	
Irrigated field	
Along dam, lake or swamp	
On mountain or hill	
At or in opencast mine	
In or along pan	
In or along river	
Hillside (slope)	
Terrace	
Valley	x
At or in waste disposal	

Purpose	
Drainage	
Exploration	
Mine drainage	
Observation	
Production (water supply)	x
Recharge	
Standby	
Waste disposal	
Other	

Equipment installed	
Airlift	
Centrifugal pump	
Gravity suction	
Handpump	
Jet	
Mono-type pump	
No equipment	
Observation tube	
Piston pump	
Powerhead	
Recorder	
Submersible pump	x
Turbine	
Windpump	
Windpump with powerhead	
Other:	

Site Type	
Stormwater	
Borehole	x
Canal or trench	
Dug well	
Effluent	
Fountain/Spring	
Gauging weir	
Sinkhole	
Drainage well	
Cattle dip	
Sewage	
Pit latrine, VIP, UDP	
Multiple borehole	
Meteorological Station	
Seepage from opencast mine	
Pan, dam, lake	
River or stream	
Seepage pond	
Tunnel, shaft or drain	
Flow from underground mine	
Rainwater harvesting station	
Wellpoint	
Reservoir	
Graveyard	
Other:	

Application	
No info	
Agriculture & domestic	x
Agriculture - irrigation only	
Agriculture - stock watering only	
Domestic - all purposes	
Domestic - garden only	
Nature conservation	
Public	
Industrial - commercial	
Industrial & mining - evaporate	
Industrial - industrial	
Industrial - mining	
Industrial - power generation	

TEST RECORD:

Date Started:	19/06/2012	**Test pump used:**		**Logger depth (m):**		**CD Date started:**	19/06/2012
Time Started:	08:15	**Pump depth (m):**	34.8	**SWL (mbgl):**	11	**CD Time started:**	11:02
						Waterlevel before constant started (m):	

STEP TEST & RECOVERY

ep 1 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	12.80	0.45	
2	12.80	0.45	
3	12.73	0.45	
5	12.70		
7	12.67	0.43	
10	12.69		
15	12.67	0.44	
20	12.66		
30	12.70		
40	12.72	0.45	
50	12.73	0.44	
60	12.70		
70			
80			
90			
100			
110			
120			

Step 2 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	13.85	0.72	
2	14.57		
3	15.35		
5	15.73	0.8	
7	15.05		
10	14.95	0.79	
15	15.00		
20	15.03		
30	15.10	0.8	
40	15.23		
50	15.23		
60	15.47		
70			
80			
90			
100			
110			
120			

Recovery

Time (min)	Waterlevel (m)
1	34.65
2	29.13
3	23.7
5	19.68
7	14.1
10	13.4
15	
20	
30	
40	
60	
90	
120	
150	
180	
210	
240	
300	
360	
420	
480	
540	
600	
720	
840	
960	
1080	
1200	
1320	
1440	
2280	
2880	
3480	
3900	
4320	
4920	
5760	

Step 3 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	17.85	1.09	
2	18.30		
3	18.93	1.1	
5	20.07		
7	20.87	1.1	
10	21.00		
15	27.21		
20	30.50	1.09	
30	33.96		
40	PI	0.82	
50			
60			
70			
80			
90			
100			
110			
120			

Step 4 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1			
2			
3			
5			
7			
10			
15			
20			
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			

CONSTANT DISCHARGE TEST

Constant Discharge Test RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Rec Time (min)	Recovery (m)
1	15.59	0.76	1	
2	15.89		2	
3	17.02		3	
5	17.1	0.8	5	
7	16.86		7	
10	16.7		10	
15	16.7		15	
20	16.99	0.75	20	
30	16.95		30	
40	16.99		40	
60	17.05		60	
90	17.09	0.74	90	
120	17.1		120	
150	17.08	0.75	150	
180	17.06		180	
210	16.88	0.73	210	
240	16.85		240	
300	16.78		300	
360	16.8	0.76	360	
420	16.71		420	
480	17.28	0.76	480	
540	16.71		540	
600	16.78		600	
720	16.72	0.74	720	
840	17.31		840	
960	17.29		960	
1080	17.36	0.75	1080	
1200	17.27	0.76	1200	
1320	17.31	0.77	1320	
1440	17.35	0.77	1440	
2280			2280	
2880			2880	
3480			3480	
3900			3900	
4320			4320	
4920			4920	
5760			5760	

Observation BH

BH no:

Distance:

Waterlevel:

Lat:

Long:

	Drawdown	Recovery
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
60		
90		
120		
150		
180		
210		
240		
300		
360		
420		
480		
540		
600		
720		
840		
960		
1080		
1200		
1320		
1440		
2280		
2880		
3480		
3900		
4320		

WATER SOURCE EVALUATION REPORT

BH Number	T3A

Project No:	
Province	
District	
Municipality	
Farm name & No.	
Village/Site name	

Map Ref Number	WGS84
Lat	51386
Long	55874
Altitude (mamsl)	
Drainage Region	
BH Diameter (mm)	165
Collar height (m)	0.12
BH Depth (m)	19

Status

No info	Destroyed	In use	Unused
		x	

Consumer

No info	Water disposed	Farm	No urban	Urban
		x		

Toposetting

Alluvial Fan	Dry river bed	Dunes	Ephemeral stream	Flat surface, plain	In or along sinkhole	Irrigated field	Along dam, lake or swamp	On mountain or hill	At or in opencast mine	In or along pan	In or along river	Hillside (slope)	Terrace	Valley	At or in waste disposal
														x	

Purpose

Drainage	Exploration	Mine drainage	Observation	Production (water supply)	Recharge	Standby	Waste disposal	Other
				x				

Equipment installed

Airlift	Centrifugal pump	Gravity suction	Handpump	Jet	Mono-type pump	No equipment	Observation tube	Piston pump	Powerhead	Recorder	Submersible pump	Turbine	Windpump	Windpump with powerhead	Other:
											x				

Site Type

Stormwater	Borehole	Canal or trench	Dug well	Effluent	Fountain/Spring	Gauging weir	Sinkhole	Drainage well	Cattle dip	Sewage	Pit latrine, VIP, UDP	Multiple borehole	Meteorological Station	Seepage from opencast mine	Pan, dam, lake	River or stream	Seepage pond	Tunnel, shaft or drain	Flow from underground mine	Rainwater harvesting station	Wellpoint	Reservoir	Graveyard	Other:
	x																							

Application

No info	Agriculture & domestic	Agriculture - irrigation only	Agriculture - stock watering only	Domestic - all purposes	Domestic - garden only	Nature conservation	Public	Industrial - commercial	Industrial & mining - evaporate	Industrial - industrial	Industrial - mining	Industrial - power generation
	x											

TEST RECORD:

Date Started:	27/06/2012	**Test pump used:**		**Logger depth (m):**		**CD Date started:**	27/06/2012
Time Started:	08:30	**Pump depth (m):**	18.5	**SWL (mbgl):**	9.4	**CD Time started:**	14:20:00 AM
						Waterlevel before constant started (m):	10.42

STEP TEST & RECOVERY

ep 1 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	9.81	0.38	
2	9.75		
3	9.65		
5	9.70	0.38	
7	9.69		
10	9.68		
15	9.67	0.39	
20	9.67		
30	9.70		
40	9.73	0.37	
50	9.71		
60	9.73	0.37	
70			
80			
90			
100			
110			
120			

Step 2 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	9.90	0.6	
2	9.92		
3	9.94		
5	9.96	0.59	
7	9.97		
10	9.99		
15	9.99	0.55	
20	9.99		
30	9.98	0.56	
40	10.00	0.56	
50	10.03		
60	10.05		
70			
80			
90			
100			
110			
120			

Step 3 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	10.35	0.85	
2	10.33		
3	10.35		
5	10.38	0.83	
7	10.40		
10	10.43		
15	10.49	0.83	
20	10.48		
30	10.46	0.84	
40	10.5		
50	10.53		
60	10.57	0.83	
70			
80			
90			
100			
110			
120			

Step 4 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	10.94	1.7	
2	11.15		
3	11.43	1.7	
5	11.57		
7	11.64		
10	11.77	1.68	
15	11.96		
20	12.35		
30	13.89	1.67	
40	14.1		
50	14.16		
60	14.42	1.67	
70			
80			
90			
100			
110			
120			

Recovery

Time (min)	Waterlevel (m)
1	15.8
2	13.3
3	12.95
5	11.99
7	11.9
10	11.74
15	11.49
20	11.2
30	10.42
40	10.16
60	
90	
120	
150	
180	
210	
240	
300	
360	
420	
480	
540	
600	
720	
840	
960	
1080	
1200	
1320	
1440	
2280	
2880	
3480	
3900	
4320	
4920	
5760	

CONSTANT DISCHARGE TEST

Constant Discharge Test RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Rec Time (min)	Recovery (m)
1	11	1.18	1	12.06
2	11.15		2	11.97
3	11.23		3	11.96
5	11.4	1.15	5	11.95
7	11.67		7	11.83
10	11.9		10	11.67
15	12.09	1.14	15	11.46
20	12.6		20	11.23
30	12.57		30	10.59
40	12.57		40	10.35
60	12.73		60	9.99
90	12.8	1.14	90	
120	12.78	1.15	120	
150	12.99		150	
180	12.79		180	
210	12.74	1.14	210	
240	12.69		240	
300	12.68	1.13	300	
360	12.74		360	
420	12.81	1.14	420	
480	13.02		480	
540	13.45	1.13	540	
600	13.6		600	
720	14.7	1.13	720	
840	13.78		840	
960	13.76	1.14	960	
1080	13.75		1080	
1200	13.65	1.14	1200	
1320	13.66	1.14	1320	
1440	13.59	1.13	1440	
2280			2280	
2880			2880	
3480			3480	
3900			3900	
4320			4320	
4920			4920	
5760			5760	

Observation BH

BH no:
Distance:
Waterlevel:
Lat:
Long:

	Drawdown	Recovery
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
60		
90		
120		
150		
180		
210		
240		
300		
360		
420		
480		
540		
600		
720		
840		
960		
1080		
1200		
1320		
1440		
2280		
2880		
3480		
3900		
4320		

WATER SOURCE EVALUATION REPORT

BH Number	T4
Project No:	
Province	
District	
Municipality	
Farm name & No.	
Village/Site name	

Map Ref Number	WGS84
Lat	51431
Long	55721
Altitude (mamsl)	1512
Drainage Region	
BH Diameter (mm)	165
Collar height (m)	0.12
BH Depth (m)	39.4

Status

No info	
Destroyed	
In use	x
Unused	

Consumer

No info	
Water disposed	
Farm	x
No urban	
Urban	

Toposetting

Alluvial Fan	
Dry river bed	
Dunes	
Ephemeral stream	
Flat surface, plain	
In or along sinkhole	
Irrigated field	
Along dam, lake or swamp	
On mountain or hill	
At or in opencast mine	
In or along pan	
In or along river	
Hillside (slope)	
Terrace	
Valley	x
At or in waste disposal	

Purpose

Drainage	
Exploration	
Mine drainage	
Observation	
Production (water supply)	x
Recharge	
Standby	
Waste disposal	
Other	

Equipment installed

Airlift	
Centrifugal pump	
Gravity suction	
Handpump	
Jet	
Mono-type pump	
No equipment	
Observation tube	
Piston pump	
Powerhead	
Recorder	
Submersible pump	x
Turbine	
Windpump	
Windpump with powerhead	
Other:	

Site Type

Stormwater	
Borehole	x
Canal or trench	
Dug well	
Effluent	
Fountain/Spring	
Gauging weir	
Sinkhole	
Drainage well	
Cattle dip	
Sewage	
Pit latrine, VIP, UDP	
Multiple borehole	
Meteorological Station	
Seepage from opencast mine	
Pan, dam, lake	
River or stream	
Seepage pond	
Tunnel, shaft or drain	
Flow from underground mine	
Rainwater harvesting station	
Wellpoint	
Reservoir	
Graveyard	
Other:	

Application

No info	
Agriculture & domestic	x
Agriculture - irrigation only	
Agriculture - stock watering only	
Domestic - all purposes	
Domestic - garden only	
Nature conservation	
Public	
Industrial - commercial	
Industrial & mining - evaporate	
Industrial - industrial	
Industrial - mining	
Industrial - power generation	

TEST RECORD:

Date Started:	2001/07/12	**Test pump used:**		**Logger depth (m):**		**CD Date started:**	01/07/2012
Time Started:	08:25	**Pump depth (m):**	17.5	**SWL (mbgl):**	11.2	**CD Time started:**	13:00
						Waterlevel before constant started (m):	12.22

STEP TEST & RECOVERY

ep 1 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	11.90	0.13	
2	11.90		
3	11.89	0.13	
5	11.91		
7	11.89	0.14	
10	11.88		
15	11.89	0.13	
20	11.89		
30	11.88	0.13	
40	11.89		
50	11.91	0.13	
60	11.90		
70			
80			
90			
100			
110			
120			

Step 2 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	12.01	0.28	
2	12.11		
3	12.14	0.28	
5	12.16		
7	12.16	0.27	
10	12.15		
15	12.16	0.28	
20	12.18		
30	12.20	0.27	
40	12.19		
50	12.20	0.28	
60	12.22		
70			
80			
90			
100			
110			
120			

Step 3 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	12.47	0.53	
2	12.60		
3	12.57	0.53	
5	12.60		
7	12.63	0.51	
10	12.67	0.51	
15	12.67		
20	12.72		
30	12.76	0.52	
40	12.79		
50	12.8	0.51	
60	12.82		
70			
80			
90			
100			
110			
120			

Step 4 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	12.99	1.16	
2	13.14		
3	13.32	1.15	
5	13.55		
7	13.7	1.14	
10	13.86		
15	14.52		
20	14.8	1.16	
30	15.07		
40	15.15	1.15	
50	15.65		
60	16	1.16	
70			
80			
90			
100			
110			
120			

Recovery

Time (min)	Waterlevel (m)
1	14.72
2	14.04
3	13.83
5	13.09
7	12.98
10	12.85
15	12.6
20	12.37
30	12.24
40	12.15
60	11.96
90	
120	
150	
180	
210	
240	
300	
360	
420	
480	
540	
600	
720	
840	
960	
1080	
1200	
1320	
1440	
2280	
2880	
3480	
3900	
4320	
4920	
5760	

CONSTANT DISCHARGE TEST

Constant Discharge Test RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Rec Time (min)	Recovery (m)
1	12.73	0.66	1	12.88
2	12.92		2	12.84
3	12.99		3	12.8
5	13.08	0.67	5	12.74
7	13.11		7	12.67
10	13.14	0.64	10	12.57
15	13.27		15	12.4
20	13.34	0.64	20	12.31
30	13.38		30	12.23
40	13.52		40	12.2
60	13.51		60	12.12
90	13.52		90	12.02
120	13.55		120	
150	13.6		150	
180	13.6	0.65	180	
210	13.62		210	
240	13.63		240	
300	13.62		300	
360	13.7	0.65	360	
420	13.74		420	
480	13.73		480	
540	13.75	0.66	540	
600	13.61		600	
720	13.72		720	
840	13.64	0.66	840	
960	13.66		960	
1080	13.84		1080	
1200	13.86		1200	
1320	13.88	0.64	1320	
1440	13.84	0.64	1440	
2280			2280	
2880			2880	
3480			3480	
3900			3900	
4320			4320	
4920			4920	
5760			5760	

Observation BH

BH no:
Distance:
Waterlevel:
Lat:
Long:

	Drawdown	Recovery
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
60		
90		
120		
150		
180		
210		
240		
300		
360		
420		
480		
540		
600		
720		
840		
960		
1080		
1200		
1320		
1440		
2280		
2880		
3480		
3900		
4320		

WATER SOURCE EVALUATION REPORT

BH Number	T5

Project No:	
Province	
District	
Municipality	
Farm name & No.	
Village/Site name	

Map Ref Number	WGS84
Lat	51280
Long	55979
Altitude (mamsl)	
Drainage Region	
BH Diameter (mm)	165
Collar height (m)	0.25
BH Depth (m)	21

Status	
No info	
Destroyed	
In use	X
Unused	

Consumer	
No info	
Water disposed	
Farm	X
No urban	
Urban	

Toposetting	
Alluvial Fan	
Dry river bed	
Dunes	
Ephemeral stream	
Flat surface, plain	
In or along sinkhole	
Irrigated field	
Along dam, lake or swamp	
On mountain or hill	
At or in opencast mine	
In or along pan	
In or along river	
Hillside (slope)	
Terrace	
Valley	X
At or in waste disposal	

Purpose	
Drainage	
Exploration	
Mine drainage	
Observation	
Production (water supply)	X
Recharge	
Standby	
Waste disposal	
Other	

Equipment installed	
Airlift	
Centrifugal pump	
Gravity suction	
Handpump	
Jet	
Mono-type pump	
No equipment	
Observation tube	
Piston pump	
Powerhead	
Recorder	
Submersible pump	X
Turbine	
Windpump	
Windpump with powerhead	
Other:	

Site Type	
Stormwater	
Borehole	X
Canal or trench	
Dug well	
Effluent	
Fountain/Spring	
Gauging weir	
Sinkhole	
Drainage well	
Cattle dip	
Sewage	
Pit latrine, VIP, UDP	
Multiple borehole	
Meteorological Station	
Seepage from opencast mine	
Pan, dam, lake	
River or stream	
Seepage pond	
Tunnel, shaft or drain	
Flow from underground mine	
Rainwater harvesting station	
Wellpoint	
Reservoir	
Graveyard	
Other:	

Application	
No info	
Agriculture & domestic	X
Agriculture - irrigation only	
Agriculture - stock watering only	
Domestic - all purposes	
Domestic - garden only	
Nature conservation	
Public	
Industrial - commercial	
Industrial & mining - evaporate	
Industrial - industrial	
Industrial - mining	
Industrial - power generation	

TEST RECORD:

Date Started:	23/06/2012	**Test pump used:**		**Logger depth (m):**		**CD Date started:**	23/06/2012
Time Started:	07:45	**Pump depth (m):**	19	**SWL (mbgl):**	9	**CD Time started:**	12:00
						Waterlevel before constant started (m):	10.05

STEP TEST & RECOVERY

ep 1 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	9.50	0.59	
2	9.46		
3	9.43	0.58	
5	9.43		
7	9.45	0.58	
10	9.46		
15	9.47	0.57	
20	9.50		
30	9.51	5.7	
40	9.52		
50	9.55	0.57	
60	9.57		
70			
80			
90			
100			
110			
120			

Step 2 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	9.61	1.18	
2	9.64		
3	9.63	1.18	
5	9.67		
7	9.68	1.19	
10	9.70		
15	9.75	1.24	
20	9.76		
30	9.82	1.25	
40	9.90		
50	9.91	1.25	
60	9.97		
70			
80			
90			
100			
110			
120			

Step 3 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	10.10	1.78	
2	10.09		
3	10.10	1.81	
5	10.10		
7	10.15	1.81	
10	10.20		
15	10.26	1.8	
20	10.47		
30	10.50	1.79	
40	10.62		
50	10.81	1.8	
60	10.92		
70			
80			
90			
100			
110			
120			

Step 4 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	11.3	2.72	
2	11.49		
3	11.84	2.63	
5	12.23		
7	13.14	2.54	
10	14.97		
15	17.25	2.36	
20	PI	1.04	
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			

Recovery

Time (min)	Waterlevel (m)
1	13.25
2	12.2
3	11.65
5	11.2
7	10.91
10	10.63
15	10.42
20	10.32
30	10.1
40	10.05
60	
90	
120	
150	
180	
210	
240	
300	
360	
420	
480	
540	
600	
720	
840	
960	
1080	
1200	
1320	
1440	
2280	
2880	
3480	
3900	
4320	
4920	
5760	

CONSTANT DISCHARGE TEST

Constant Discharge Test RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Rec Time (min)	Recovery (m)
1	10.33	1	1	11.07
2	10.42		2	10.98
3	10.52		3	10.88
5	10.86	1	5	10.75
7	11.23		7	10.64
10	11.63		10	10.52
15	11.99	0.99	15	10.34
20	12.21		20	10.29
30	12.44		30	10.16
40	12.68	1	40	10.07
60	13.71		60	9.94
90	12.79		90	9.81
120	12.85	0.98	120	9.7
150	12.89		150	
180	12.97		180	
210	13.03	0.97	210	
240	13.1		240	
300	13.13		300	
360	13.14	0.98	360	
420	14.06		420	
480	14.7		480	
540	14.67		540	
600	16.6	0.97	600	
720	15.6		720	
840	15.8		840	
960	14.68		960	
1080	13.9		1080	
1200	12.23	0.96	1200	
1320	11.67	0.97	1320	
1440	11.49	0.97	1440	
2280			2280	
2880			2880	
3480			3480	
3900			3900	
4320			4320	
4920			4920	
5760			5760	

Observation BH

BH no:
Distance:
Waterlevel:
Lat:
Long:

	Drawdown	Recovery
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
60		
90		
120		
150		
180		
210		
240		
300		
360		
420		
480		
540		
600		
720		
840		
960		
1080		
1200		
1320		
1440		
2280		
2880		
3480		
3900		
4320		

Appendix E

Laboratory Reports

CLEAN STREAM
Scientific Services (Pty.) Ltd.

469 Jacqueline Drive, Garsfontein, Pretoria, 0042
P.O. Box 905008, Garsfontein, 0042
Tel (012) 348 2813/4, Fax 012 348 8575

Specialists in environmental monitoring

Test Report

Client: Aurecon
Address: 1040 Burnett Street, Hatfield, 0083
Report No: 8551 **Project:** Aurecon

Date of certificate: 26 Jun 2012
Date accepted: 20 Jun 2012
Date completed: 26 Jun 2012

	Lab no:		91849	91850	91851
	Date sampled:		20 Jun 2012	20 Jun 2012	20 Jun 2012
	Sample type:		Water	Water	Water
	Locality description		T1	NO	T2
	Analyses:	**Method**			
A	pH	CSM 20	7.57	6.86	6.55
A	Electrical conductivity (EC) mS/m	CSM 20	6.48	7.19	5.69
A	Total dissolved solids (TDS) mg/l	CSM 26	30	32	29
A	Total alkalinity mg/l	CSM 01	20.7	26.6	21.9
A	Chloride (Cl) mg/l	CSM 02	4.0	3.0	3.7
A	Sulphate (SO4) mg/l	CSM 03	2.79	3.67	0.73
A	Nitrate (NO3) mg/l as N	CSM 06	0.596	<0.057	0.361
A	Ammonium(NH4) mg/l as N	CSM 05	0.024	0.021	0.023
A	Orthophosphate (PO4) mg/l as P	CSM 04	0.078	0.060	<0.025
A	Fluoride (F) mg/l	CSM 08	0.198	0.844	<0.183
A	Calcium (Ca) mg/l	CSM 30	4.587	2.757	2.472
A	Magnesium (Mg) mg/l	CSM 30	2.465	3.613	3.105
A	Sodium (Na) mg/l	CSM 30	2.58	1.65	3.67
A	Potassium (K) mg/l	CSM 30	0.509	1.350	1.420
A	Aluminium (Al) mg/l	CSM 31	<0.006	<0.006	0.052
A	Iron (Fe) mg/l	CSM 31	<0.006	3.655	<0.006
A	Manganese (Mn) mg/l	CSM 31	<0.001	0.220	<0.001
A	Total hardness mg/l	CSM 26	22	22	19

A = Accredited (Included in the SANAS Schedule of Accreditation); N = Not accredited (Excluded from the SANAS Schedule of Accreditation)
OSD = Outsourced; S = Sub-contracted; NR = Not requested; RTF = Results to follow; TNTC = To numerous to count; ND = Not detected
NATD = Not able to determine

Clean Stream Scientific Services does not accept responsibility for any matters arising from the further use of these results. This certificate shall not be reproduced without written approval by the Managing Director. Measurement of uncertainty available on request for all methods included in the SANAS Schedule of Accreditation. This report only relates to the above samples and variables analysed.

sanas Testing laboratory
T0374

Report checked by: H. Holtzhausen (Laboratory Manager) HHausen

aquatico Laboratories (Pty) Ltd.
469 Jacqueline Drive, Garsfontein, Pretoria, 0042
P.O. Box 905008, Garsfontein, 0042
Tel (012) 348 2813/4, Fax 012 348 8575

Specialists in environmental monitoring

Test Report

Client: Aurecon
Address: 1040 Burnett Street, Hatfield, 0083
Report No: 8622 **Project:** Aurecon

Date of certificate: 04 Jul 2012
Date accepted: 29 Jun 2012
Date completed: 03 Jul 2012

Lab no:			92509	92510
Date sampled:			28 Jun 2012	28 Jun 2012
Sample type:			Water	Water
Locality description			T3A	T5
Analyses:		**Method**		
A	pH	CSM 20	6.65	6.87
A	Electrical conductivity (EC) mS/m	CSM 20	7.84	7.19
A	Total dissolved solids (TDS) mg/l	CSM 26	34	31
A	Total alkalinity mg/l	CSM 01	28.0	25.2
A	Chloride (Cl) mg/l	CSM 02	4.6	3.5
A	Sulphate (SO4) mg/l	CSM 03	<0.132	<0.132
A	Nitrate (NO3) mg/l as N	CSM 06	0.108	0.106
A	Ammonium(NH4) mg/l as N	CSM 05	<0.015	0.023
A	Orthophosphate (PO4) mg/l as P	CSM 04	<0.025	<0.025
A	Fluoride (F) mg/l	CSM 08	<0.183	0.196
A	Calcium (Ca) mg/l	CSM 30	2.857	2.726
A	Magnesium (Mg) mg/l	CSM 30	4.246	3.533
A	Sodium (Na) mg/l	CSM 30	4.13	4.10
A	Potassium (K) mg/l	CSM 30	1.333	1.426
A	Aluminium (Al) mg/l	CSM 31	0.494	0.102
A	Iron (Fe) mg/l	CSM 31	0.058	<0.006
A	Manganese (Mn) mg/l	CSM 31	<0.001	<0.001
A	Total hardness mg/l	CSM 26	25	21

A = Accredited (Included in the SANAS Schedule of Accreditation); N = Not accredited (Excluded from the SANAS Schedule of Accreditation); OSD = Outsourced; S = Sub-contracted; NR = Not requested; RTF = Results to follow; TNTC = To numerous to count; ND = Not detected; NATD = Not able to determine

Aquatico Laboratories does not accept responsibility for any matters arising from the further use of these results.
Measurement of uncertainty available on request. This report only relates to the above samples and variables analysed.

sanas Testing laboratory
T0374

Report checked by: H. Holtzhausen (Laboratory Manager) HHausen

aquatico Laboratories (Pty) Ltd.

489 Jacqueline Drive, Garsfontein, Pretoria, 0042
P.O. Box 905008, Garsfontein, 0042
Tel (012) 348 2813/4, Fax 012 348 8575

Specialists in environmental monitoring

Test Report

Client: **Aurecon**
Address: 1040 Burnett Street, Hatfield, 0083
Report No: 8634 **Project:** Aurecon

Date of certificate: 06 Jul 2012
Date accepted: 02 Jul 2012
Date completed: 05 Jul 2012

Lab no:			92578
Date sampled:			02 Jul 2012
Sample type:			Water
Locality description			T4
Analyses:		**Method**	
A	pH	CSM 20	6.34
A	Electrical conductivity (EC) mS/m	CSM 20	9.76
A	Total dissolved solids (TDS) mg/l	CSM 26	42
A	Total alkalinity mg/l	CSM 01	34.0
A	Chloride (Cl) mg/l	CSM 02	5.3
A	Sulphate (SO4) mg/l	CSM 03	<0.132
A	Nitrate (NO3) mg/l as N	CSM 06	0.721
A	Ammonium(NH4) mg/l as N	CSM 05	0.083
A	Orthophosphate (PO4) mg/l as P	CSM 04	<0.025
A	Fluoride (F) mg/l	CSM 08	<0.183
A	Calcium (Ca) mg/l	CSM 30	4.535
A	Magnesium (Mg) mg/l	CSM 30	5.419
A	Sodium (Na) mg/l	CSM 30	3.94
A	Potassium (K) mg/l	CSM 30	1.987
A	Aluminium (Al) mg/l	CSM 31	<0.006
A	Iron (Fe) mg/l	CSM 31	<0.006
A	Manganese (Mn) mg/l	CSM 31	<0.001
A	Total hardness mg/l	CSM 26	34

A = Accredited (Included in the SANAS Schedule of Accreditation); N = Not accredited (Excluded from the SANAS Schedule of Accreditation); OSD = Outsourced; S = Sub-contracted; NR = Not requested; RTF = Results to follow; TNTC = To numerous to count; ND = Not detected; NATD = Not able to determine

Aquatico Laboratories does not accept responsibility for any matters arising from the further use of these results.
Measurement of uncertainty available on request. This report only relates to the above samples and variables analysed.

Report checked by: H. Holtzhausen (Laboratory Manager) HHausen

sanas Testing laboratory
T0374

aquatico Laboratories (Pty). Ltd.

Test Report

Client: Aurecon
Address: 1040 Burnett Street, Hatfield, 0083
Report no: 8783
Project: Aurecon

Date of certificate: 17 July 2012
Date accepted: 12 July 2012
Date completed: 17 July 2012
Revision: 0

Lab no:				93951
Date sampled:				12-Jul-12
Sample type:				Water
Locality description:				Fountain
	Analyses	**Unit**	**Method**	
A	pH	pH	CSM 20	6.66
A	Electrical conductivity (EC)	mS/m	CSM 20	1.48
A	Total dissolved solids (TDS)	mg/l	CSM 26	6
A	Total alkalinity	mg/l	CSM 01	<8.26
A	Chloride (Cl)	mg/l	CSM 02	3.35
A	Sulphate (SO_4)	mg/l	CSM 03	<0.13
A	Fluoride (F)	mg/l	CSM 08	<0.18
A	Orthophosphate (PO_4) as P	mg/l	CSM 04	<0.03
A	Ammonium (NH4) as N	mg/l	CSM 05	0.124
A	Nitrate (NO3) as N	mg/l	CSM 06	<0.057
A	Calcium (Ca)	mg/l	CSM 30	0.64
A	Magnesium (Mg)	mg/l	CSM 30	0.49
A	Sodium (Na)	mg/l	CSM 30	0.64
A	Potassium (K)	mg/l	CSM 30	0.34
A	Aluminium (Al)	mg/l	CSM 31	0.01
A	Iron (Fe)	mg/l	CSM 31	<0.01
A	Manganese (Mn)	mg/l	CSM 31	<0.001
A	Total hardness	mg/l	CSM 26	4

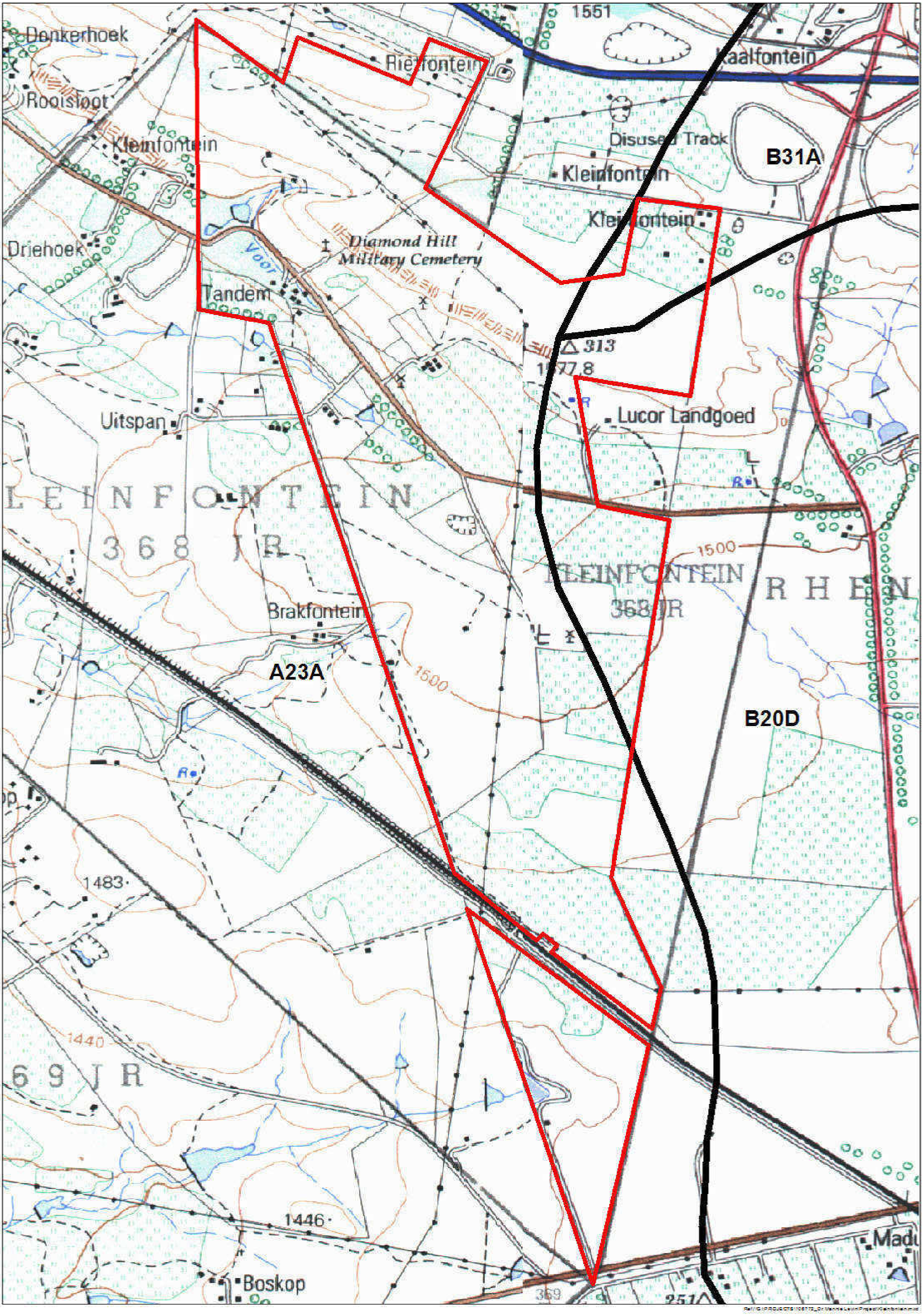
A = Accredited N= Not accredited O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine
Results marked 'Not SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory.
This test report shall not be reproduced except in full, without written approval of the laboratory.
Measurement of uncertainty available on request for all methods included in the SANAS Schedule of Accreditation.
Results reported against the limit of quantification.

HHausen

Laboratory Manager: H. Holtzhausen

Appendix F

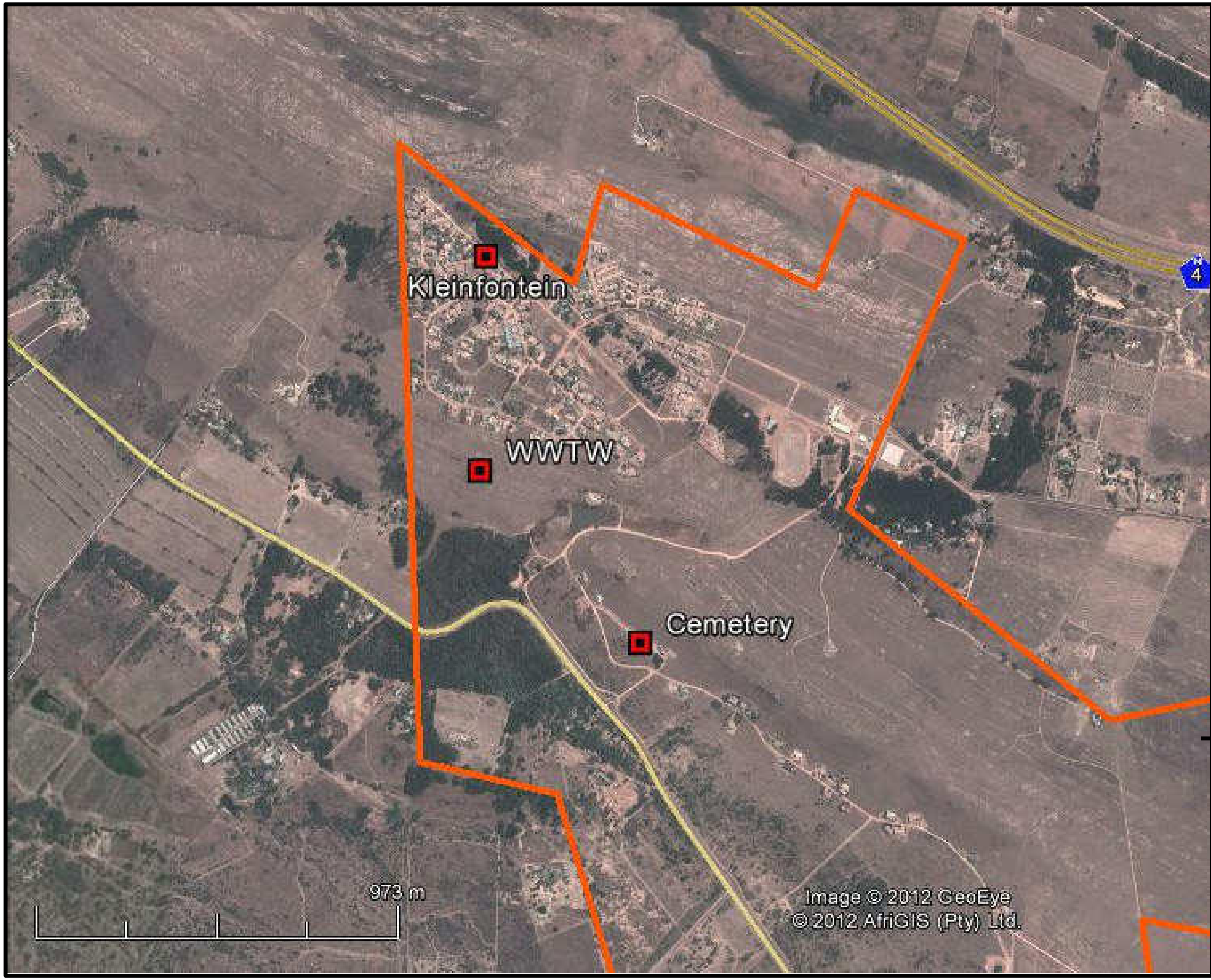
Catchment Map



Donkerhoek
Rooisloot
Kleinfontein
Driehoek
Riefontein
1551
Kaalfontein
Disused Track
B31A
Kleinfontein
Kleinfontein
Diamond Hill
Military Cemetery
Tandem
Voor
313
1577.8
Lucor Landgoed
Uitspan
KLEINFONTEIN
368 JR
KLEINFONTEIN
368 JR
1500
RHEN
Brakfontein
A23A
1500
B20D
1483
1440
69 JR
1446
Boskop
369
251
Madu

Appendix G

Location of Cemetery and Planned Waste Water Plant Sites



Project Title:
KLEINFONTEIN GEOHYDROLOGY REPORT

Map Title:
Kleinfontein: Locality Map

Map Number:
Map 4

LEGEND

N

Project nr:
106773/Kleinfontein

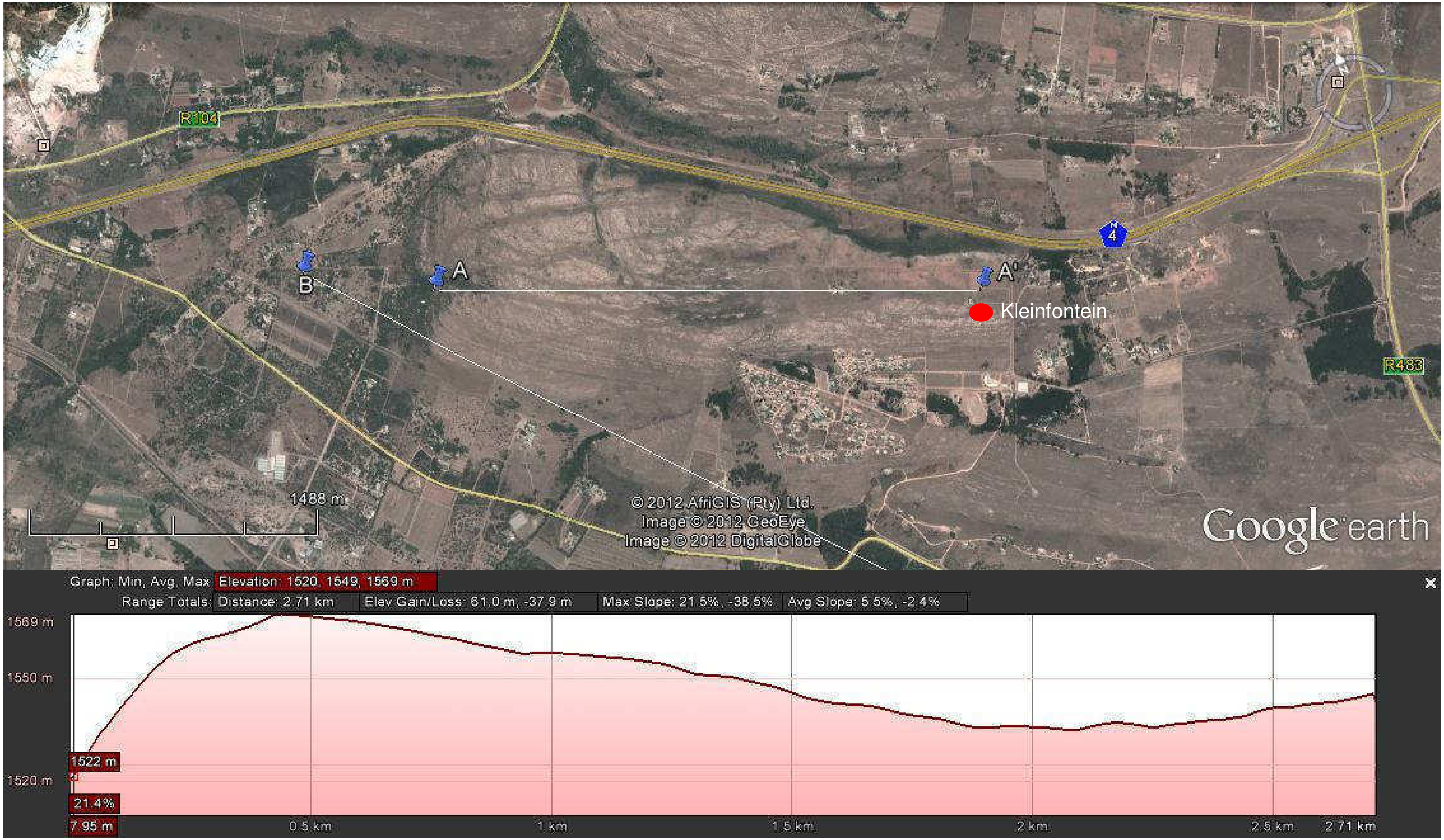
aurecon

Lynnwood Bridge Office Park
4 Daventry Street
Lynnwood Manor 0040
www.aurecongroup.com

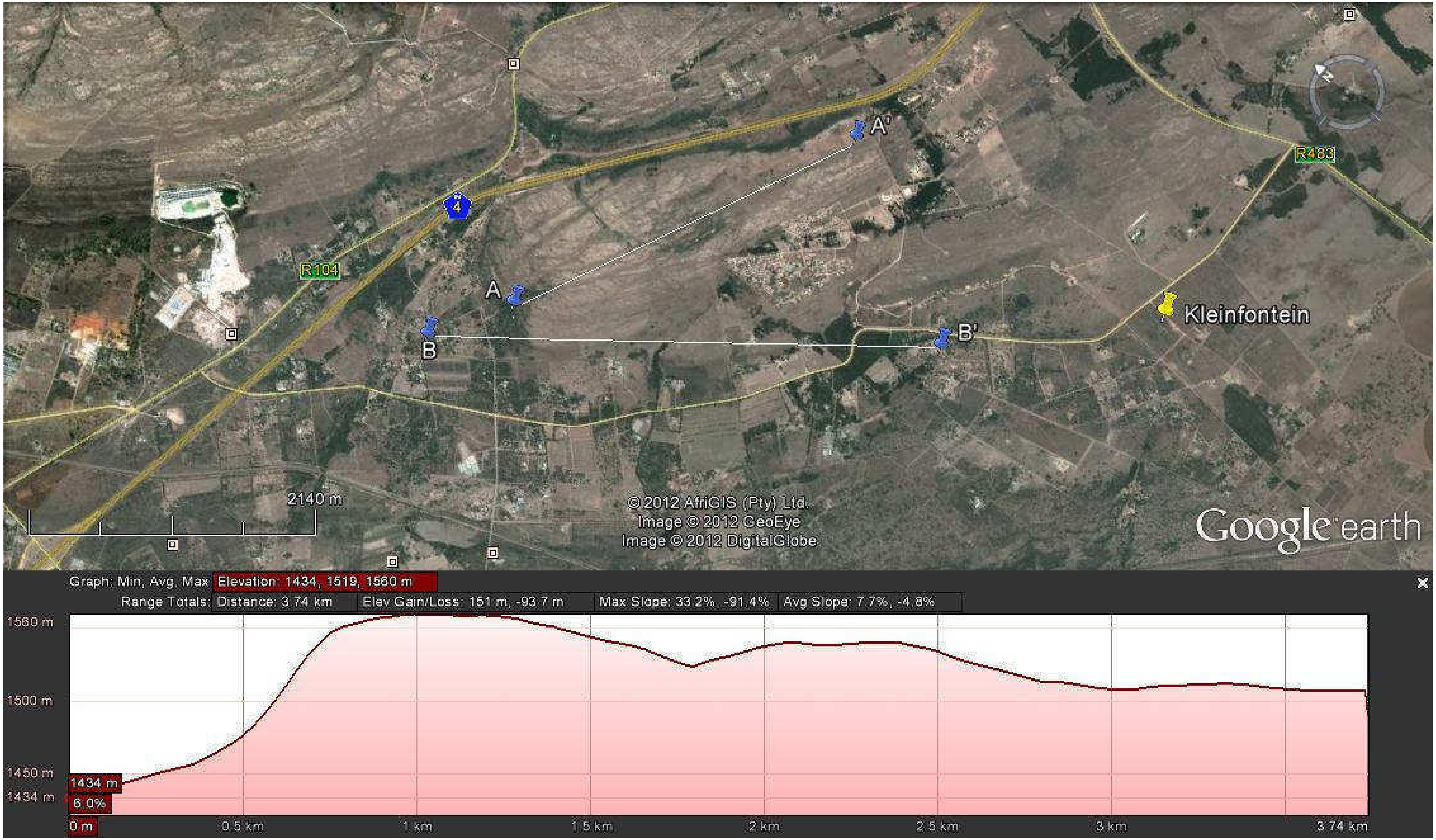
Appendix H

Profiles between Kleinfontein and Neighbours

Profile A-A'


R104
A
A'
B
Kleinfontein
4
R483
1488 m
© 2012 AfriGIS (Pty) Ltd.
Image © 2012 GeoEye
Image © 2012 DigitalGlobe
Google earth
Graph: Min, Avg, Max Elevation: 1520, 1549, 1569 m
Range Totals: Distance: 2.71 km
Elev Gain/Loss: 61.0 m, -37.9 m
Max Slope: 21.5%, -38.5%
Avg Slope: 5.5%, -2.4%
1569 m
1550 m
1520 m
1522 m
21.4%
7.95 m
0.5 km
1 km
1.5 km
2 km
2.5 km
2.71 km

Profile B-B’



A'
A
B
B'
R104
R483
Kleinfontein
2140 m
© 2012 AfriGIS (Pty) Ltd.
Image © 2012 GeoEye
Image © 2012 DigitalGlobe
Google earth
Graph: Min, Avg, Max Elevation: 1434, 1519, 1560 m
Range Totals: Distance: 3.74 km Elev Gain/Loss: 151 m, -93.7 m Max Slope: 33.2%, -91.4% Avg Slope: 7.7%, -4.8%
1560 m
1500 m
1450 m
1434 m
1434 m
6.0%
0 m
0.5 km
1 km
1.5 km
2 km
2.5 km
3 km
3.74 km

Annexure G(iii)

WETLAND DELINEATION

THE PROPOSED DEVELOPMENT ON PORTIONS OF THE FARM KLEINFONTEIN 368 JR, GAUTENG

Wetland Delineation and Functional Assessment Report
August 2011

Drafted by Antoinette Bootsma
(Pr Sci Nat Hons Botany)
Limosella Consulting
P.O. Box 32733, Waverley
Pretoria, 0135
Email: antoinette@limosella.co.za
Cell: +27 83 4545 454

Drafted for Bokamoso Landscape Architects
& Environmental Consultants
Tel: (012) 346 3810
Fax: 086 570 5659
Email: lizelleg@mweb.co.za

Declaration of Independence

I, **Antoinette Bootsma**, in my capacity as a specialist consultant, hereby declare that I -

- Act as an independent consultant;
- Do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- Undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- As a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member; and
- Based on information provided to me by the project proponent, and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional judgement.

2011.08.25

Antoinette Bootsma (PrSciNat)

Ecologist/Botanist

SACNASP Reg. No. 400222-09

Date

EXECUTIVE SUMMARY

Limosella Consulting was appointed by Bokamoso Environmental Consultants and Landscape Architects to undertake an independent assessment of potential wetland conditions that could potentially be affected by the proposed development on the portions of the farm Kleinfontein 368 JR, Gauteng.

Five wetland areas were identified during the current assessment. One large wetland system was recorded on the northern part of the site and includes two dams. This valley bottom wetland is found at the bottom of two steep ridges and is fed by water runoff from the ridges. Three wetland areas were identified on the southern section of the site. A low laying pan was found to the north of the southern section with *Typha capensis* (Bullrushes) and a variety of different sedges. At the eastern boundary a small valley bottom wetland was found dominated by *Imperata cylindrica* (Cottonwool Grass), a third wetland area was found on the southernmost portion of the site. This area was fenced and access could not be gained for soil samples. A visual inspection was conducted and the delineation was consequently based on vegetation gradients visible on aerial imagery. The southernmost section of the site has a low level of impact as can be seen by the absence of *Seriphuim plumosum* (Bankrotbossie), although in some areas the presence of *Tagetes minuta* (Khakiweed) was recorded. The relative importance of wetland habitat to bird and animal species should be verified by suitable qualified avifauna, herpetofauna and fauna specialists.

An artificial seepage wetland was recorded adjacent to a road. This wetland is not sensitive in a local or regional context, and although all wetlands are protected by various aspects of legislation, the current study finds that the contribution to local biodiversity and hydrological function can be mitigated by a variety of interventions, including for example bioswales that trap runoff from the road. The remaining four wetlands should be demarcated and (together with their associated 50m buffer zones) retained as natural open spaces in the development. The cumulative loss of habitat by increased urbanisation enhances the value of remaining areas of natural vegetation as refuges to many species. Apart from the generic mitigation measures that control the degradation of wetlands through alien vegetation encroachment, sedimentation, erosion and pollution, it is important to ensure that a continuum of natural open spaces should be included in the development layout that allows for linkages between wetland areas and smaller, intervening patches of surviving habitat that can also serve as "stepping stones" that link fragmented ecosystems by ensuring that primary ecological processes are maintained within and between groups of habitat fragments.

The approximate size of the wetland areas identified on site together with their associated 50m buffer zone is 33.44 Ha, (4.09% of the site).

Table of Contents

Figures

Tables

1 INTRODUCTION

Limosella Consulting was appointed by Bokamoso Environmental Consultants and Landscape Architects to undertake an independent assessment of potential wetland conditions that could potentially be affected by the proposed development on the portions of the farm Kleinfontein 368 JR, Gauteng. Fieldwork was conducted on the 17th of August 2011.

1.1 Locality of the Study Site

The study site is located south of Cullinan, just south of the N4 and west of the R515 in the Kungwini Municipality. The study area is divided into two sections, the northern living area and the southern small holding area. A gravel road divides these two areas. The northern part of the site is home to various wild game such as Zebra, Wildebeest and other antelope. Steep rocky outcrops and areas of ecological importance characterize the area. Approximate central coordinates are 25°48'54.52"and 28°29'43.97" (Figure 1).

1.2 Terms of Reference

The terms of reference for the current study were as follows:

- Conclusively identify the presence or absence of wetland conditions as prescribed by the DWAF (2005) delineation guideline;
- Identify the outer edge of the wetland temporary zone, or edge of the riparian zone;
- Classify the wetland or riparian areas according to the system proposed in the national wetlands inventory if relevant,
- Indicate the relative functional importance of the wetland or riparian areas;
- Discuss wetland buffer zones;
- Indicate possible impacts on the wetland or riparian areas; and
- Recommend mitigation measures in order to limit the impact of the proposed development on the wetland or riparian areas.

1.3 Assumptions and Limitations

The GPSmap 76CSx used for wetland delineations is accurate to within five meters. Therefore, the wetland delineation plotted digitally may be offset by at least five meters to either side. Furthermore, it is important to note that, during the course of converting spatial data to final drawings, several steps in the process may affect the accuracy of areas delineated in the current report. It is therefore suggested that the no-go areas identified in the current report be pegged in the field in collaboration with the surveyor for precise boundaries.

The site visit was conducted before the onset of the growing season. Although vegetation was suitably visible to provide clear wetland indicators, a full contingent of the species composition could not be provided. A Red Data scan, fauna and flora assessments were not included in the current study.

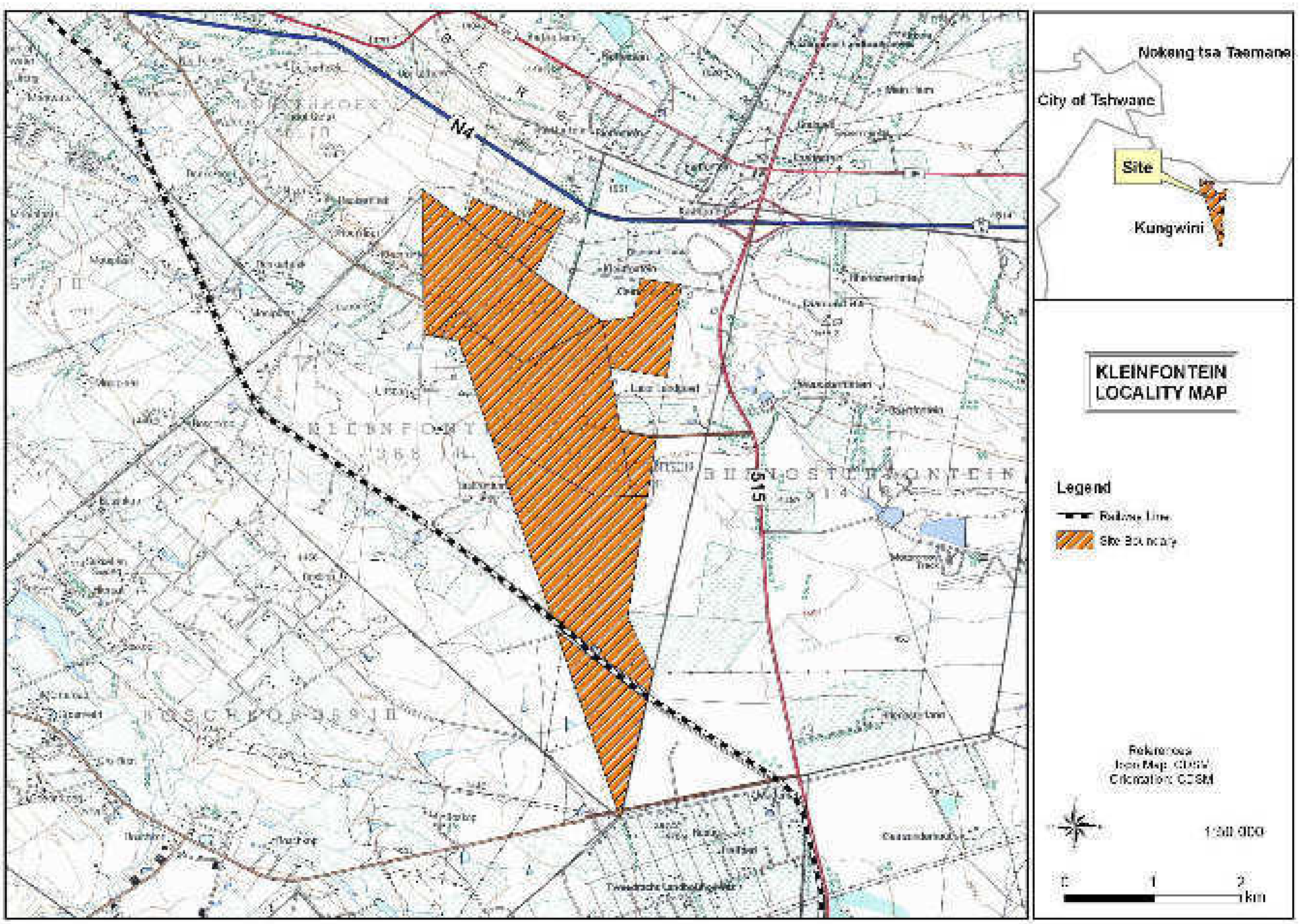


Figure 1: Location of the study site

1.4 Definitions and Legal Framework

In a South African legal context, the term watercourse is often used rather than the terms wetland, or river. The National Water Act (NWA) (1998) includes wetlands and rivers into the definition of the term watercourse in the following definition.

Watercourse means:

a) A river or spring;
b) A natural channel in which water flows regularly or intermittently;
c) A wetland, lake or dam into which, or from which, water flows, and
d) Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

Riparian habitat is the accepted indicator used to delineate the extent of a river's footprint (DWAF, 2005). The National Water Act, 1998 (Act No. 36 of 1998), defines a riparian habitat as follows: "Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse, which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.”.

In contrast, the National Water Act, 1998 (Act 36 of 1998) defines a wetland as “land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.”

Authoritative legislation that lists impacts and activities on wetlands and riparian areas that requires authorisation includes (Armstrong, 2009):

- Conservation of Agriculture Resources Act, 1983 (Act 43 of 1983);
- Environment Conservation Act, 1989 (Act 73 of 1989);
- National Water Act, 1998 (Act 36 of 1998);
- National Forests Act, 1998 (Act 84 of 1998);
- National Environmental Management Act, 1998 (Act No. 107 of 1998);
- National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004).
- GNR 1182 and 1183 of 5 September 1997, as amended (ECA);
- GNR 385, 386 and 387 of 21 April 2006 (NEMA);
- GNR 392, 393, 394 and 396 of 4 May 2007 (NEMA);
- GNR 398 of 24 March 2004 (NEMA); and
- GNR 544, 545 and 546 of 18 June 2010 (NEMA).

1.5 Description of the Receiving Environment

A review of literature and spatial data formed the basis of a characterisation of the biophysical environment in its theoretically undisturbed state and consequently an analysis of the degree of impact to the ecology of the study site in its current state. The northern part of the study area falls into two regional vegetation units *sensu* Mucina and Rutherford (2006) namely; Rand Highveld Grassland and Gold Reef Mountain Bushveld. The northern section of the site is home to various game such as Zebra, Wildebeest and other antelope. Steep rocky outcrops and areas of ecological importance characterize the area. Common invader species of this area include *Acacia mearnsii* (Black wattle), *Tagetes minuta* (Blackjack) and *Seriphium plumosum* (Bankrotbossie). The southern smallholding area of the site falls within the Rand Highveld Grassland vegetation unit. This area is used on a small scale for grazing. *Acacia caffra* (Common hookthorn) and *Acacia karroo* (Sweet Thorn) dominate this landscape. Common grasses of this area are *Themeda triandra, Heteropogon contortus,* and *Elionurus muticus*.

A surface water spatial layer reflected the presence of several non-perennial rivers associated with the site, although only two watercourses appear to cross onto the site boundary (CDSM, 1996) (Figure 2).

Avalon and Mispah soil forms are associated with the wetland areas identified in the current report (GDACE, 2002). Mispah soil is a relatively young shallow soil underlain by hard rock or silcrete. Penetration of roots and water is typically non-uniform and restricted to spaces between fragments of rock or saprolite (Fey, 2005). This soil form is not a recognized wetland soil (DWAF, 2005), however, particularly where anthropogenic disturbances such as agricultural practices have altered the landscape, the relative impermeable quality of the substrate together with the shallow soils layer may result in water being retained in the landscape to form wetland conditions.

Avalon soils are recognised as potential seasonal or temporary wetland soils (DWAF, 2005). Avalon soils are associated with hard or soft plinthic horizons which dam water within the lower part of the section. The strongest expression occurs in middle to lower slope positions in the landscape. Manganese is associated with iron in some plinthic materials in this soil form (Fey, 2005).

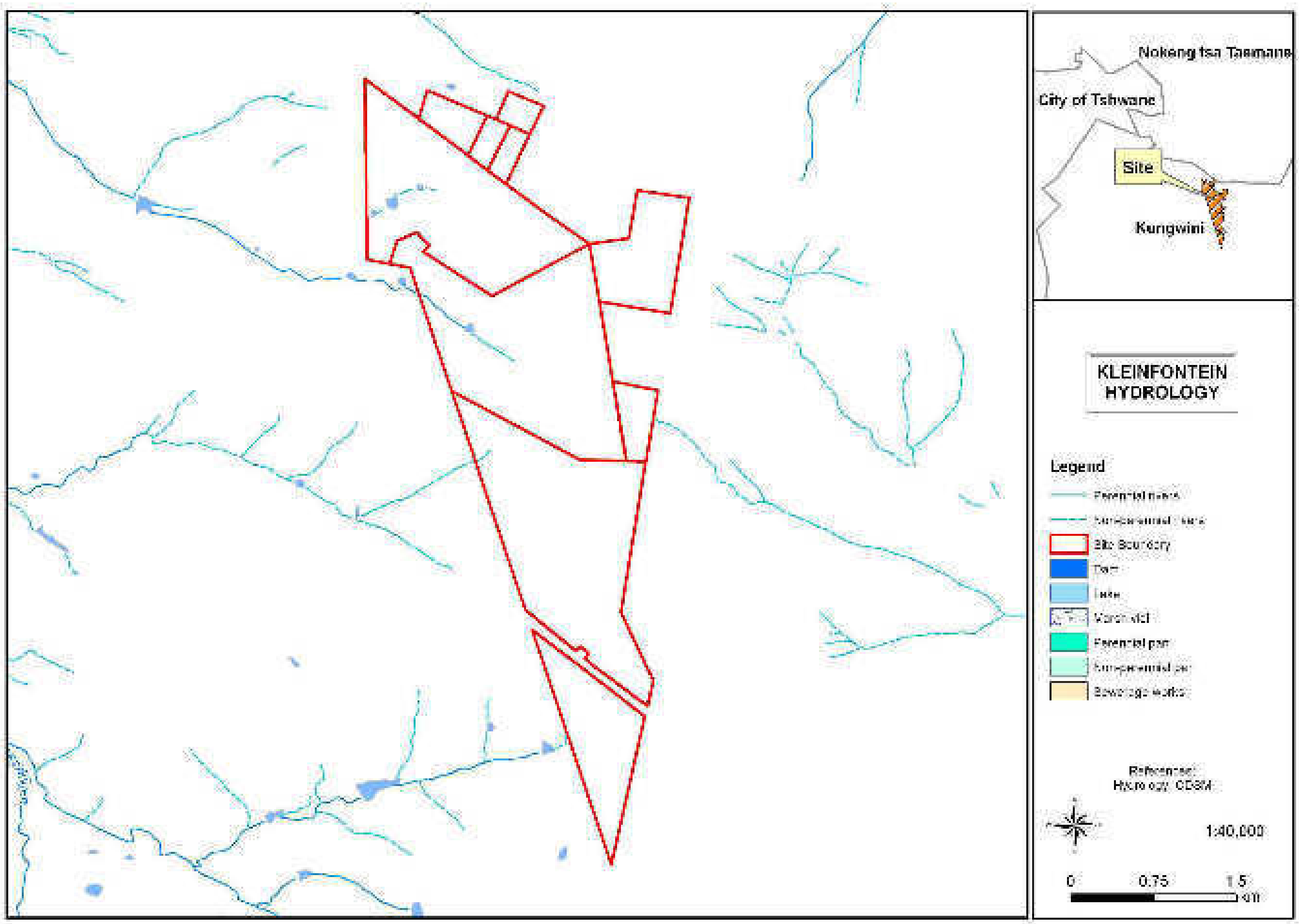


Figure 2: Hydrology of the region

2 RESULTS

2.1 Wetland Delineation

Wetlands are identified based on the following characteristic attributes (DWAF, 2005):

- The presence of plants adapted to or tolerant of saturated soils (hydrophytes);
- Wetland (hydromorphic) soils that display characteristics resulting from prolonged saturation; and
- A high water table that results in saturation at or near the surface, leading to anaerobic conditions developing within 50cm of the soil surface.

Thirty (30) points were sampled during the course of the field investigation to determine compliance with the definition of wetland and riparian conditions. One large wetland system was recorded on the northern part of the site and includes two dams. This valley bottom wetland is found at the bottom of two steep ridges and is fed by water runoff from the ridges. Two artificial structures were found in this system, including a 10m high dam wall. At the bottom of the system the water forms a small stream, which runs through a riparian area characterized by *Eucyluptus* sp. trees (Bluegums). The stream ends in a dam surrounded by the latter trees. Various bird species were found nesting in *Typha capensis* (Bullrushes) patches, animal tracks were also found in the muddy areas near the wetland edge.

Although some wetland indicators were found next to the gravel roads, soil samples proved negative for conclusive wetland conditions. A single seepage wetland associated by road runoff was delineated and is included in the wetland map below (Figure 3). Three wetland areas were identified on the southern section of the site. A low laying pan was found to the north of the southern section with *Typha capensis* (Bullrushes) and an array of different sedges. At the eastern boundary a small valley bottom wetland was found dominated by *Imperata cylindrica* (Cottonwool Grass). A third wetland area was found on the southernmost portion of the site. This area was fenced and access could not be gained for soil samples. A visual inspection was conducted and the delineation was consequently based on vegetation gradients visible on aerial imagery. The southernmost section of the site has a low level of impact as can be reflected by the absence of *Seriphium plumosum* (Bankrotbossie), although in some areas the presence of *Tagetes minuta* (Khakiweed) was recorded. The approximate sizes of the wetlands are provided in Table 1.

Table 1: Approximate sizes of the wetlands recorded on site

Wetland Number	Size (Ha)	Size as a percentage of the site (%)
1	3.37	0.42
2	0.04	0.01
3	0.74	0.09
4	0.09	0.01
5	4.10	0.52
Total size of the site	793.13	100.00

The higher laying areas were mostly dominated by shallow shale, while the lower laying areas were mostly dominated by dark organic soils.

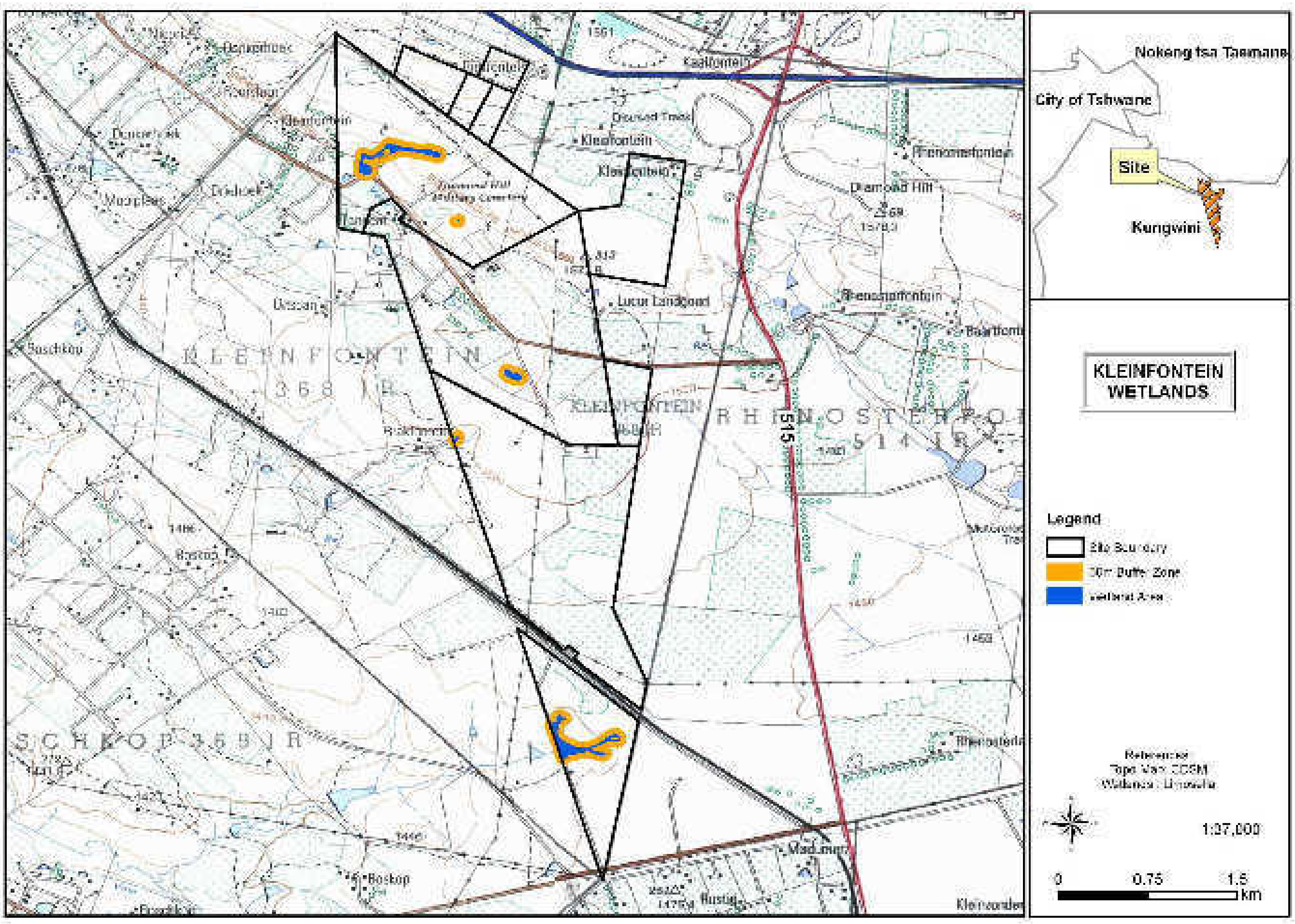


Figure 3: An overview of wetland areas recorded on the study site

Details of plant and soil characteristics recorded are discussed below and are presented in Appendix A. Five wetland areas were identified. A summary of their dominant characteristics is presented in Table 2 and Figures 4 to 6 below.

Table 2: Summary of dominant characteristics of the wetlands identified on site

Wetland Number	Approximate central coordinate	Dominant vegetation	Soil description and notes	Figure
1	25°48'10.64"S and 28°29'14.93"E	• *Eucalyptus* sp. • *Typha capensis* • *Zantedeschia aethiopica* • *Typha capensis* • *Verbena bonariensis* • *Plantago lanceolata*	The soil profile of this area is mostly orange sandy to clay soils with shallow shale. Slow moving water forms a small stream that moves into a riparian area Iron oxidation is visible on the water surface	Figure 4

2	25°48'30.23"S and 28°29'32.65"E	• *Typha capensis* • *Amaranthus hybridus* • *Pennesitum clandestinum* • *Tagetes minuta* • *Verbena bonariensis*	Small area of wetland vegetation formed by surface runoff from adjacent road	Figure 4
3	25°49'12.51"S and 28°29'47.62"E	• *Typha capensis* • *Imperata cylindrica* • Sedge species	Pan with shallow shale	Figure 5
4	25°49'29.78"S and 28°29'32.24"E	• *Imperata cylindrica* • *Verbena bonariensis*	Bottom of a valley where soils are dark, organic and damp	Figure 5
5	25°50'52.93"S and 28°30'0.39"E	Grass and sedge dominated wetland	This wetland was not accessible for sampling	Figure 6

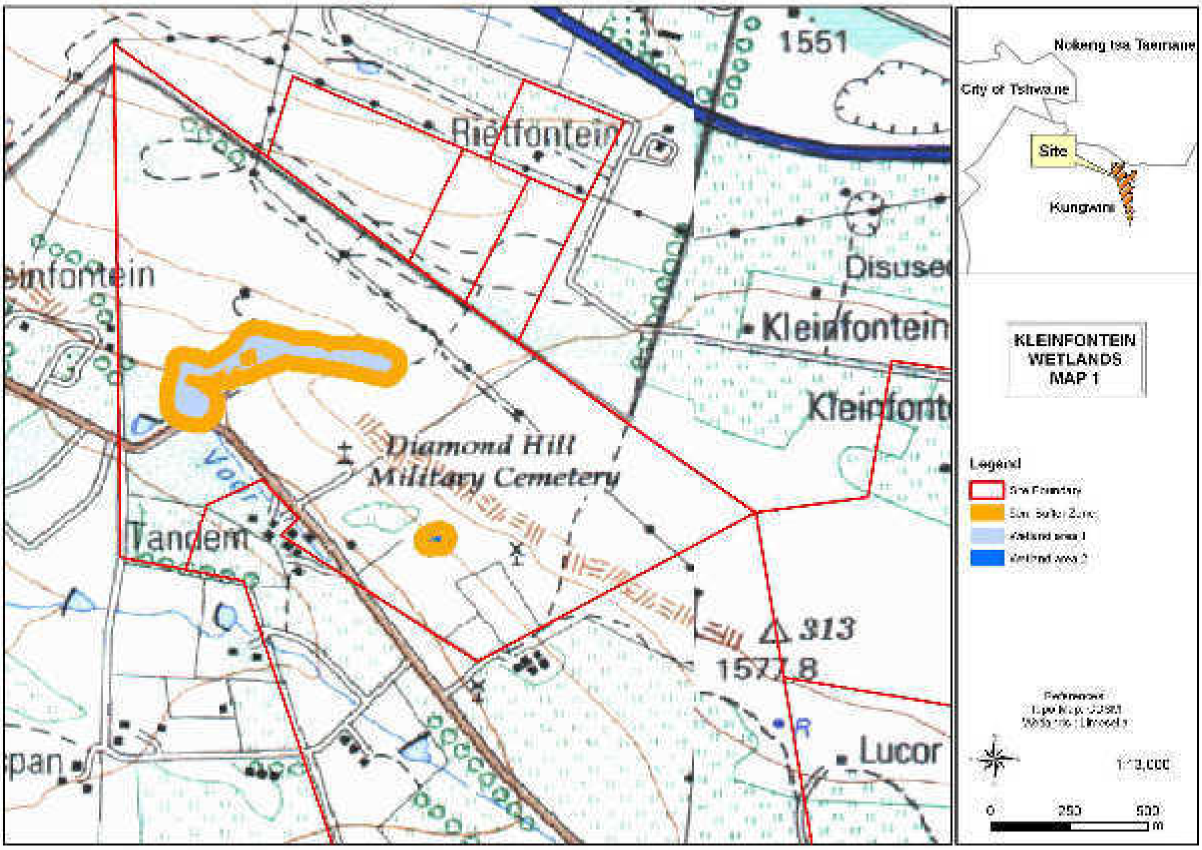


Figure 4: Wetlands one and two

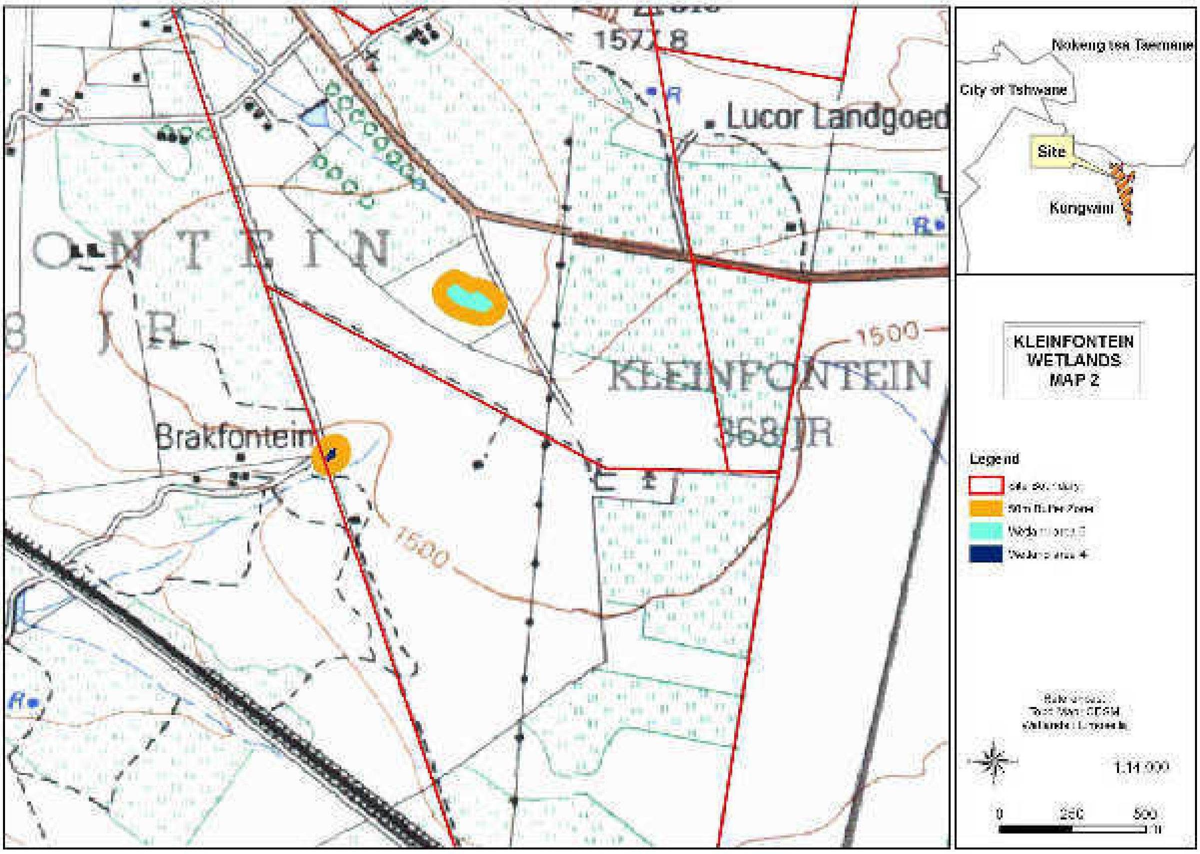


Figure 5: Wetlands three and four

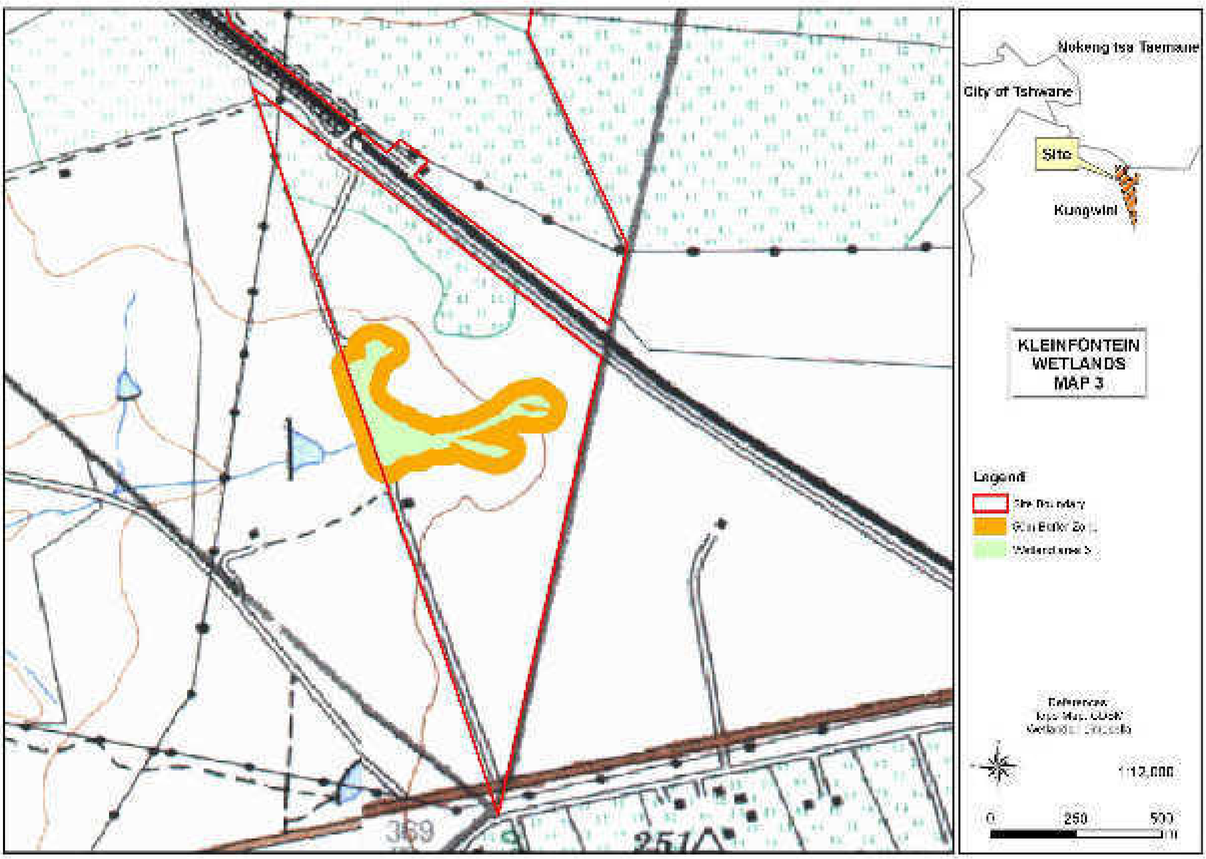


Figure 6: Wetland five

2.2 Classification

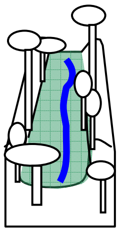
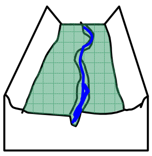
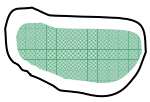
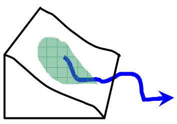
Differential weathering of geological formations may create steep slopes with shallow soils. In this instance, water is expected to flow in well defined channels at a high velocity. These conditions are conducive to the deposition of alluvial soils and the formation of channelled valley bottom wetlands and rivers. Where gentle slopes allow sediments to be accumulated and vegetation attenuates water flow velocity, waterlogging may occur. This in turn, leads to the formation of anaerobic conditions in the soil and unchannelled wetlands and floodplains are often the result. The reasoning follows that wetlands (particularly valley bottom wetlands) are most likely to occur at the lowest point of gravity in the landscape.

The classification system developed for the National Wetlands Inventory is based on the principles of the hydro-geomorphic (HGM) approach to wetland classification (Ewart-Smith *et al*, 2006). The current wetland study follows the same approach by classifying wetlands in terms of a functional unit in line with a level three category recognised in the classification system proposed in Ewart-Smith et al (2006). HGM units take into consideration factors that determine the nature of water movement into, through and out of the wetland system. HGM units encompass three key elements (Kotze *et al*, 2005):

a) Geomorphic setting - This refers to the landform, its position in the landscape and how it evolved (e.g. through the deposition of river borne sediment);
b) Water source - There are usually several sources, although their relative contributions will vary amongst wetlands, including precipitation, groundwater flow, stream flow, etc.; and
c) Hydrodynamics - This refers to how water moves through the wetland.

The northernmost wetland on site is classified as a valley bottom wetland with a riparian component which is probably of a secondary nature. Wetland two is formed by surface water runoff and is therefore also considered as an artificial wetland consistent with the characteristics of a seepage wetland as defined below. Wetland three (located below the gravel road dividing the northern and southern sections of the site) is classified as an inward draining pan wetland possibly formed by trampling of animals or wind erosion. Wetlands four and five are classified as valley bottom wetlands (Table 3).

Table 3: Classification of wetland and riparian areas (adapted from Brinson, 1993; Kotze, 1999, Marneweck and Batchelor, 2002 and DWAF, 2005). The highlighted section refers to the classification of the wetland on the study site

Hydro-geomorphic types	Description
Riparian habitat 	Riparian areas commonly reflect the high energy conditions associated with water flowing in a channel. Wetlands generally display more diffuse flows and are low energy environments. Due to water availability and rich alluvial soils, riparian areas are usually very productive. Tree growth is high and the vegetation under the trees is usually lush.
Valley bottom with a channel 	*Valley bottom areas with a well defined stream channel lack characteristic floodplain features. The may be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterized by the net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.*
Depression (includes Pans) 	A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. it is inward draining). It may also receive sub-surface water. An outlet is usually absent.
Hillslope seepage 	Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well defined stream channel connecting the area directly to a watercourse. Where seepage wetlands are not associated with a stream, water inputs mainly from sub-surface flow and outflow is either very limited or through diffuse sub-surface and/or surface flow

2.3 Buffer Zones

A buffer zone is defined as a strip of land surrounding a wetland or riparian area in which activities are controlled or restricted (DWAF, 2005). A development has several impacts on the surrounding environment and on a wetland or riparian area. The development changes habitats, the ecological environment, infiltration rate, amount of runoff and runoff intensity of the site, and therefore the water regime of the entire site.

Buffer zones have been shown to perform a wide range of functions and have therefore been widely proposed as a standard measure to protect water resources and their associated biodiversity. These include (i) maintaining basic hydrological processes; (ii) reducing impacts on water resources from upstream activities and adjoining landuses; (iii) providing habitat for various aspects of biodiversity. A brief description of each of the functions and associated services is outlined in Table 4 below.

Table 4: Generic functions of buffer zones relevant to the study site (adapted from Macfarlane *et al*, 2010)

Primary Role	Buffer Functions
Maintaining basic aquatic processes, services and values.	• Groundwater recharge: Seasonal flooding into wetland areas allows infiltration to the water table and replenishment of groundwater. This groundwater will often discharge during the dry season providing the base flow for streams, rivers, and wetlands. • Flood attenuation: Wetland vegetation increases the roughness of stream margins, slowing down flood-flows. This may therefore reduce flood damage in downstream areas. Vegetated buffers have therefore been promoted as providing cost-effective alternatives to highly engineered structures to reduce erosion and control flooding, particularly in urban settings.
Reducing impacts from upstream activities and adjoining landuses	• Storm water attenuation: Flooding into the buffer zone increases the area and reduces the velocity of storm flow. Roots, braches and leaves of plants provide direct resistance to water flowing through the buffer, decreasing its velocity and thereby reducing its erosion potential. More water is exchanged in this area with soil moisture and groundwater, rather than simply transferring out of the area via overland flow. • Sediment removal: Surface roughness provided by vegetation, or litter, reduces the velocity of overland flow, enhancing settling of particles. Buffer zones can therefore act as effective sediment traps, removing sediment from runoff water from adjoining lands thus reducing the sediment load of surface waters. • Removal of toxics: Buffer zones can remove toxic pollutants, such hydrocarbons that would otherwise affect the quality of water resources and thus their suitability for aquatic biota and for human use. • Nutrient removal: Wetland vegetation and vegetation in terrestrial buffer zones may significantly reduce the amount of nutrients (N & P), entering a water body reducing the potential for excessive outbreaks of microalgae that can have an adverse effect on both freshwater and estuarine environments. • Removal of pathogens: By slowing water contaminated with faecal material, buffer zones encourage deposition of pathogens, which soon die when exposed to the elements.

Despite limitations, buffer zones are well suited to perform functions such as sediment trapping, erosion control and nutrient retention which can significantly reduce the impact of activities taking place adjacent to water resources. Buffer zones are therefore proposed as a standard mitigation measure to reduce impacts of landuses / activities planned adjacent to water resources. These must however be considered in conjunction with other mitigation measures.

Local government policies require that protective wetland buffer zones be calculated from the outer edge of the temporary zone of a wetland and river buffer zones be calculated from the outer edge of the riparian zone (KZN DAEA, 2002; CoCT, 2008; CoJ, 2008b; GDACE, 2009). Although research is underway to provide further guidance on appropriate defensible buffer zones, there is no current standard other than the generic recommendation of 100m for rivers, and 50m for wetlands outside the urban edge.

2.4 Wetland Functionality, Status and Sensitivity

Wetland functionality is defined as a measure of the deviation of wetland structure and function from its natural reference condition. The hydrological, geomorphological and vegetation integrity was assessed for each wetland unit associated with the study site to provide a Present Ecological Status (PES) score (Macfarlane *et al*, 2007) and an Environmental Importance and Sensitivity category (EIS) (DWAF, 1999) and summarised in the tables below. The ecosystem services are also discussed in broad terms below.

2.4.1 Provision of Goods and Services - WET-Ecoservices

Hydro-geomorphic units are per definition characterised by physical and hydrological features that allow them to perform specific ecosystem services (Table 5). The degree of disturbance and modification of wetlands results in a decrease in the ability to which they are able to perform these ecosystem services. The ecosystem services provided by each wetland unit is summarised in Table 6.

Table 5: Preliminary rating of the hydrological benefits likely to be provided by a channelled valley bottom wetland given its particular hydro-geomorphic type (Kotze *et al*, 2005)

WETLAND HYDRO-GEOMORPHIC TYPE	GENERIC HYDROLOGICAL BENEFITS PROVIDED BY THE WETLAND							
	Flood attenuation		Stream flow regulation	Erosion control	Enhancement of water quality			
	Early wet season	Late wet season			Sediment trapping	Phosphates	Nitrates	Toxicants[1]
Valley bottom - channelled	+	0	0	+	+	+	+	+
Hillslope seepage not feeding a stream	+	0	0	++	0	0	++	+
Pan/ Depression	+	+	0	0	0	0	+	+

Note: [1]Toxicants are taken to include heavy metals and biocides

Rating:
- 0 Benefit unlikely to be provided to any significant extent
- \+ Benefit likely to be present at least to some degree
- ++ Benefit very likely to be present (and often supplied to a high level)

Table 6: A summary of ecosystem services provided by the wetlands on site

Wetland Number	Classification	Ecosystem Service (Kotze *et al,* 2005)
1	Valley bottom wetland with a channel, with riparian element	This wetland contributes to regional flood attenuation and sediment trapping to a certain extent especially from surface water flowing from adjacent ridges. The dams in the system further assist with sediment trapping. Some nitrate and toxicant removal potential is expected, particularly from the water delivered from the adjacent hillslopes. The habitat provided by the open water sections (dams) and riparian element is expected to be utilised by various bird and animal species. The relative importance of this habitat should be verified by suitable qualified avifauna, herpetofauna and fauna specialists.
2	Seepage wetland not linked to the stream channel	This small artificial wetland primarily functions to trap toxicants from the road. Since this is a small and seldom used road the amount of toxicants that are input into the wetland are not expected to be significant.
3	Inward draining pan	The pan is expected to contribute to trapping nitrates and phosphates from the surrounding agricultural areas. It may provide an important habitat to various bird and animal species. The relative importance of this habitat should be verified by suitable qualified avifauna, herpetofauna and fauna specialists.
4	Valley bottom wetland	This wetland is a small section of a larger system that is largely cut off by a dirt road. It contributes to regional flood attenuation early in the wet season and trapping of sediments and erosion control. The wetland traps nitrates and phosphates from the surrounding agricultural areas although this does not appear to be a significant land-use.
5	Valley bottom wetland	This wetland also forms a small section of a larger system that is cut off by a road. However, it's larger size, and the relative undisturbed adjacent grassland elevate its ability to provide ecosystem services such as flood attenuation, sediment trapping and erosion control. The biodiversity element of this wetland is expected to be significant and should be verified by

		suitable qualified avifauna, herpetofauna and fauna specialists.

2.4.2 Present Ecological Status (PES) – WET-Health

Table 7 provides an overview of the descriptions of the various PES categories to give a context for the scores obtained for each wetland presented in Table 8. As expected, wetland five scored the highest PES score although it remained in class C which describes moderately modified wetlands. No score could be obtained for the artificial seepage wetland as the fact that it presents wetland conditions is a derived condition. Wetland 4 obtained the lowest PES score, primarily due to its small size and the presence of the road which removes it to a large degree from the wetland system adjacent to the study site.

Table 7: Health categories used by WET-Health for describing the integrity of wetlands (Macfarlane *et al*, 2007)

DESCRIPTION	PES SCORE
Unmodified, natural.	A
Largely natural with few modifications. A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place.	B
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	C
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	D
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	E
Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	F

Table 8: A summary of the components of the PES scores obtained for each wetland on the site

Wetland Number	Hydrology	Geomorphology	Vegetation	Final PES Score
1	Alien vegetation abstracts water from the wetland diminishing the extent of seasonal and temporary zones. Changes to natural hydrology has been effected by the dams built in the wetland although water abstraction is not expected to be very large. Water distribution and retention patterns in the wetland have been largely altered by the dams and canalisation and the impact of the adjacent road. The impact of the modifications is clearly detrimental to the hydrological integrity. The PES score of this component of wetland integrity is 5, equivalent to class D	Stream straitening has occurred in the system of which this wetland area is part. A large degree of infilling and compaction was caused by the road constructed adjacent to, and across the wetland. The residential area in the wetland's catchment has changed runoff characteristics and therefore patterns of floodpeaks. Dirt roads and a borrow pit contribute to sediment input. The geomorphology has been moderately modified. That is to say that a moderate change in geomorphic processes has taken place but the system remains predominantly intact. The PES score of this component of wetland integrity is 3.2, equivalent to a class C	Deep flooding excludes emergent vegetation, dense patches of alien plants exclude natural wetland habitat. Vegetation composition has been substantially altered but some characteristic species remain, although the vegetation consists mainly of introduced, alien and/or ruderal species. This aspect of wetland integrity is likely to deteriorate with time if no steps are taken to actively rehabilitate the wetland. The PES score for this component of wetland integrity is 7.5, equivalent to class E	5.2 Class D

2	Since this wetland is predominantly artificial, no PES score can be derived for it as this involves the degree of change from a hypothetical natural reference condition			
3	Little modification to the hydrological component of the pan is evident although alien trees in the catchment contribute to a loss of water available to the wetland. This is also an inherent feature of a closed hydrological system that does not have upstream or downstream components. The PES score of this component of wetland integrity is 1.6, equivalent to class B	A large contribution to sediment input is provided by the numerous roads and tracks around the pan. A low degree of vegetation roughness in the catchment further contributes to sedimentation and ultimately deterioration of the geomorphological component of the wetland. The PES score of this component of wetland integrity is 3.4, equivalent to class C	Vegetation in and around the pan is largely natural although no sensitive or rare species were recorded. The PES score of this component of wetland integrity is 3.4, equivalent to class C	2.8 Class C
4	Clumps of alien trees abstract water from the wetland diminishing the extent of seasonal and temporary zones. Water distribution and retention patterns in the wetland have been largely altered by the road that bisects the wetland. The PES score of this component of wetland integrity is 5.9, equivalent to class D	Infilling and compaction of wetland soils has occurred due to the road constructed adjacent to, and across the wetland. The dirt road and tracks contribute to sediment input. The PES score of this component of wetland integrity is 6.2, equivalent to class E	Vegetation composition has been substantially altered but some characteristic species remain, although the vegetation consists mainly of introduced, alien and/or ruderal species. This aspect of wetland integrity is likely to deteriorate with time if no steps are taken to actively rehabilitate the wetland. The PES score of this component of wetland integrity is 7.1, equivalent to class E	6.4 Class E
5	Changes to natural hydrology has been effected by the dam resulting from the road built through the wetland. The PES score of this component of wetland integrity is 2.1, equivalent to class C	Infilling and compaction of wetland soils has occurred due to the road constructed adjacent to, and across the wetland. The dirt road and tracks contribute to sediment input. The low degree of alteration of the natural vegetation surrounding the wetland provides some mitigation by trapping sediments. The PES score of this component of wetland integrity is 2.4, equivalent to class C	Largely unmodified, vegetation roughness of the wetland and its catchment is impacted to some degree by grazing. Deep flooding by the dam has resulted in the loss of some emergent species and temporary and seasonal zonation. The PES score of this component of wetland integrity is 1.8, equivalent to class B	2.1 Class C

2.4.3 Ecological Importance and Sensitivity (EIS)

Ecological importance is an expression of a wetland's importance to the maintenance of ecological diversity and functioning on local and wider spatial scales. Ecological sensitivity refers to the system's ability to tolerate disturbance and its capacity to recover from disturbance once it has occurred (DWAF, 1999). This classification of water resources allows for an appropriate management class to be allocated to the water resource and includes the following:

- Ecological Importance in terms of ecosystems and biodiversity;
- Ecological functions; and
- Basic human needs.

The EIS scores for the five wetlands all fall within class C or D. Wetland 5 is the least impacted and scores the highest sensitivity although it also falls in class C (Table 9) The reason for the relatively low scores is primarily the relatively small sizes of the wetlands and the presence of the road that intersects most of them. Table 10 provides an overview of the EIS rating scale used with an explanation of the relative status of wetlands in each category.

Table 9: EIS scores obtained for the western section of the wetland (DWAF, 1999)

WETLAND IMPORTANCE AND SENSITIVITY	Importance Score Wetland 1	Importance Score Wetland 2	Importance Score Wetland 3	Importance Score Wetland 4	Importance Score Wetland 5
Ecological importance & sensitivity	2.7	0.6	1.6	1.0	2.8
Hydro-functional importance	1.3	0.4	0.6	0.9	2.0
Direct human benefits	0.5	0	0.7	0.5	0.5
Overall score	**1.5**	**0.3**	**1.0**	**0.8**	1.8
Class	**C**	**D**	**C**	**D**	C

Table 10: Environmental Importance and Sensitivity rating scale used for calculation of EIS scores (DWAF, 1999)

Ecological Importance and Sensitivity Categories	Rating	Recommended Ecological Management Class
Very High Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water in major rivers	>3 and <=4	A
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers	>2 and <=3	B
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water in major rivers	>1 and <=2	C
Low/Marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers	>0 and <=1	D

2.5 Impacts and Mitigation

Activities associated with the proposed development may have an impact on the wetland and their buffer zones unless measures are put in place to prevent this. A first line of defence is to demarcate the wetland and buffer zone areas and prevent access of construction vehicles and crew. Ideally a rehabilitation plan should be put into place that will address any erosion, alien vegetation encroachment or pollution of the wetlands resulting from the proposed activities. Prevention of sedimentation, pollution from crew camps or input of hydrocarbons from construction vehicles should be prioritised during the construction phase of the development. Following completion of the construction activities, trapping of oils and pollutants from parking areas and roads can be achieved by vegetated buffers and swales that direct polluted water into appropriate settling areas before release into the system.

In order to minimize artificially generated surface stormwater runoff, total sealing of paved areas such as parking lots, driveways, pavements and walkways should not be permitted. Permeable material should rather be utilized for these purposes (GDACE, 2008). An ecologically-sensitive stormwater management plan should be implemented that includes not allowing stormwater to be discharged directly into the identified buffer zone of the wetland areas. A continuum of natural open spaces should be included in the development layout that allows for linkages between wetland areas and smaller, intervening patches of natural habitat can also serve as "stepping stones" that link fragmented ecosystems by ensuring that certain ecological processes are maintained within and between groups of habitat fragments. Palisade fencing should be used to allow for the continued natural movement of fauna.

Although the wetland habitat recorded on the study site is in a relatively impacted condition, it remains a functional component within the ecological landscape. Vegetation clearing associated with the proposed activities are likely to result in the encroachment of alien invasive plant species. Revegetation of cleared areas with suitable indigenous species as soon as possible after the disturbance, together with an alien species monitoring and eradication program should prevent encroachment of these problem plants. Details regarding the identification and legislation associated with alien invasive species can be obtained from http://www.agis.agric.za.

3 CONCLUSION

Five wetland areas were identified during the current assessment. An artificial seepage wetland was recorded adjacent to a road. This wetland is not sensitive in a local or regional context, and although all wetlands are protected by various aspects of legislation, the current study finds that the contribution to local biodiversity and hydrological function can be mitigated by a variety of interventions, including for example bioswales that trap runoff from the road. The remaining four wetlands should be demarcated and (together with their associated 50m buffer zones) retained as natural open spaces in the development. The cumulative loss of habitat by increased urbanisation enhances the value of remaining areas of natural vegetation as refuges to many species. Apart from the generic mitigation measures that prohibit the degradation of wetlands through alien vegetation encroachment, sedimentation, erosion and pollution, it is important to ensure that a continuum of natural open spaces should be included in the development layout that allows for linkages between wetland areas and smaller, intervening patches of natural habitat that can also serve as "stepping stones" that link fragmented ecosystems by ensuring that primary ecological processes are maintained within and between groups of habitat fragments.

4 METHODOLOGY

The delineation method documented by the Department of Water affairs and Forestry in their document "A practical field procedure for identification and delineation of wetlands and riparian areas" (DWAF, 2005), and the Minimum Requirements for Biodiversity Assessments (GDACE, 2009) was followed throughout the field survey. These guidelines describe the use of indicators to determine the outer edge of the wetland and riparian areas such as soil and vegetation forms as well as the terrain unit indicator.

A hand held GPSmap 76CSx was used to capture GPS co-ordinates in the field. 1:50 000 cadastral maps and available GIS data were used as reference material for the mapping of the preliminary wetland boundaries. These were converted to digital image backdrops and delineation lines and boundaries were imposed accordingly after the field survey.

5 REFERENCES

Armstrong A. (2009). WET-Legal:Wetland rehabilitation and the law in South Africa. WRC Report TT 338/09. Water research Comission, Pretoria

Brinson, M. (1993). A hydrogeomorphic classification for wetlands. Prepared for US Army Corps of Engineers. 101pp. Wetlands Research Programme Technical Report WRP-DE-4

Bromilow C. (2001). Problem Plants of South Africa. Briza Publications CC

Chief Directorate: Surveys & Mapping. 1996: Hydrology. Cape Town: CDSM.

City of Cape Town (2008). Floodplain Management Policy, version 2.0 (draft for comment) City of Cape Town

Department of Development Planning & Local Government (2002) Geotechnical suitability study of vacant land in Gauteng Province. Johannesburg: DDPLG.

Department of Water Affairs and Forestry (2005). A practical field procedure for identification and delineation of wetlands and riparian areas. Department of Water affairs and Forestry. Pretoria. South Africa

Department of Water Affairs and Forestry (2007). Manual for the assessment of a Wetland Index of Habitat Integrity for South African floodplain and channelled valley bottom wetland types by M. Rountree (ed); C.P Todd, C. J. Kleynhans, A. L. Batchelor, M. D. Louw, D. Kotze, D. Walters, S. Schroeder, P. Illgner, M. Uys. and G.C. Marneweck. Report no. N/0000/00/WEI/0407. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa

Ewart-Smith J., Ollis D., Day J. and Malan H. (2006). National Wetland Inventory: Development of a Wetland Classification System for South Africa. Water Research Council project number K8/652

Fey M. (2005). Soils of South Africa: Systematics and environmental significance. Lombardi Trust. Draft submitted for comment

Gauteng Department of Agriculture Conservation & Environment (2002). Gauteng Agricultural Potential Atlas. Johannesburg

Gauteng Department of Agriculture, Conservation & Environment (2009) GDACE Minimum Requirements for Biodiversity Assessments Version 2. Directorate Nature Conservation, Johannesburg.

Kotze D C, 1999. A system for supporting wetland management decisions. Ph.D. thesis. School of Applied Environmental Sciences, University of Natal, Pietermaritzburg.

Kotze D.C., Marneweck, G.C., Batchelor, A.L., Lindley, D.S. and Collins, N.B. (2005). WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands

Macfarlane D.M., Kotze D.C., Ellery W.N., Walters D, Koopman V, Goodman P and Goge C. (2007). WET-Health: A technique for rapidly assessing wetland health. Water Research Commission, Pretoria

Macfarlane D.M., Teixeira-Leite A., Goodman P., Bate G and Colvin C. (2010) Draft Report on the Development of a Method and Model for Buffer Zone Determination. Water Research Commission project K5/1789. The Institute of Natural Resources and its Associates

Marneweck G C, and Batchelor A L, (2002). Wetland classification, mapping and inventory. In: PALMER R W, TURPIE J, MARNEWECK G C, and BATCHELOR A L. Ecological and economic evaluation of wetlands in the upper Olifants River Catchment, South Africa. WRC Report No. 1162/1/02. Water Research Commission, Pretoria

Mucina L., & Rutherford M. C. (2006). Vegetation Map of South Africa, Lesotho and Swaziland, 1:1 000 000 scale sheet maps. South African National Biodiversity Institute., Pretoria

Appendix A: Survey Data

Table 11: Survey Data

Survey point	Coordinates	Notes and important plant species	Area description
1	25°48'3.80"S and 28°29'31.80"E	• *Acacia mearnsii* wood	Invader species occurring in grasslands, open plains, next to roads and waterways.
2	25°47'55.90"S and 28°29'14.20"E	• *Aristida congesta* subsp. *Congesta* • Sandy soils • Rocky layer at 10cm	Disturbed area
3	25°47'50.60"S and 28°29'28.20"E	• *Themeda triandra* • *Elionurus muticus* • High mountainous area with rocky outcrops	Mountainous area
4	25°48'13.00"S and 28°29'32.20"E	• Low laying area sloped towards dam • Rocky • Sandy soil	Mountainous area
5	25°48'13.10"S and 28°29'27.50"E	• *Hypparhenia hirta* • *Verbena bonariensis* • *Eragrostis lehmeniana* • *Seriphium plumosum* • *Sedges* • Iron coloured clay soils • Various animal prints	Permanent to seasonal wetland area
6	25°48'12.90"S and 28°29'28.20"E	• High number of bird species • Dark clay soils	Edge of temporary zone
7	25°48'12.00"S and 28°29'28.00"E	• *Seriphuim plumosus* • Sedges	Edge of temporary zone
8	25°48'12.00"S and 28°29'26.80"E	• +- 3 meter high ridge with wetland conditions on both sides • *Verbena bonariensis* • *Amaranthus hybridus*	Ridge
9	25°48'11.30"S and 28°29'27.10"E	• *Imperata cylindrical* • *Sporobolus fimbriantus* • *Seriphium plumosum* • Beginning of stream that leads to dam	Temporary to permanent wet zone
10	25°48'12.40"S and 28°29'23.40"E	• Wetland from next to road	Temporary to permanent wet zone
11	25°48'11.00"S and 28°29'19.20"E	• *Zantedeschia aethiopica* • *Typha capensis* • *Verbena bonariensis* • *Plantago lanceolata*	Stream
12	25°48'10.90"S and 28°29'20.40"E	• Water channelled away, with excess water flowing into dam • *Plantago lanceolata*	Area of water channelling

13	25°48'12.20"S and 28°29'14.90"E	• *Amaranthus hybridus* • *Imperata cylindrica* • *Typha capensis*	Edge of dam
14	25°48'10.70"S and 28°29'14.40"E	• Dam wall covered in short grass • Edge of dam, with water flowing over to form a valley bottom wetland +-10m below • *Zantedeschia aethiopica*	Dam wall, with valley bottom wetland next to it.
15	25°48'12.30"S and 28°29'10.60"E	• Slow moving water that forms a small river that moves into a riparian area surrounded by *Eucyluptus* trees • Iron oxidation on water surface • *Typha capensis*	Valley bottom wetland and beginning of riparian area
16	25°48'16.30"S and 28°29'9.40"E	• Dug out area next to dam area, where previously mentioned stream leads into • Clay soils with shale • Dam surrounded by *Acacia mearnsii,* and *Eucyluptus* trees	Disturbed area next to dam
17	25°48'24.10"S and 28°29'23.20"E	• *Heteropogon contortus* • Sloped area	Shrubby grassland
18	25°48'30.40"S and 28°29'32.40"E	• Small area of wetland vegetation due to surface run off from adjacent road • *Typha capensis* • *Amaranthus hybridus* • *Pennesitum clandestinum* • *Tagetes minuta* • *Verbena bonariensis*	Temporary wet zone
19	25°48'39.00"S and 28°29'50.90"E	• Large number of *Seriphium plumosum* • *Hypparhenia hirta* • *Tagetes minuta*	Grassland
20	25°48'55.00"S and 28°29'40.60"E	• *Acacia karroo* • *Heteropogon contortus* • *Cymbopogon excuvatus* • Dry rocky soils •	*Acacia karroo* shrubland
21	25°48'19.00"S and 28°29'25.60"E	• Mountainous area with associated mountain vegetation • Rocky, with large boulders • *Eragrostis plana*	Top of mountain
22	25°49'36.20"S and 28°30'8.10"E	• Grassland dominated by tall grasses such as *Heteropogon contortus, Cymbopogon excavatus,* and *Hypparhenia hirta* • A small amount of trees can be observed, but is mostly limited to the western area near the boundary • Small animals such as hares and mongoose was observed	Smallholding area, mostly grassland.
23	25°49'39.60"S and 28°30'7.50"E	• Some wetland vegetation observed next to road but soil samples prove negative for evidence of wetland conditions • *Imperata cylindrica*	Road

24	25°50'26.10"S and 28°30'19.40"E	• Grassland next to agricultural land • *Heteropogon contortus*	Grazing grassland
25	25°50'33.20"S and 28°30'8.80"E	• Typical grassland area	Grassland
26	25°49'29.30"S and 28°29'53.70"E	• *Hypparhenia hirta* grassland with *Acacia* trees	Savannah area
27	25°49'12.30"S and 28°29'45.20"E	• Large pan dominated by large sedges and *Typha capensis* • Pan +-3,5m deep • Shale prevalent on surface	Pan wetland
28	25°49'13.90"S and 28°29'48.70"E	• Wetland edge • *Typha capensis* • *Imperata cylindrica* • Sedges	Edge of wetland
29	25°48'53.10"S and 28°29'36.30"E	• Low laying area • *Seriphium plumosum* • *Hypparhenia hirta*	Grassland
30	25°49'30.10"S and 28°29'31.80"E	• Bottom of a valley • Soils organic and damp • *Imperata cylindrica* • *Verbena bonariensis*	Temporary to seasonal wet zone

Appendix B: Glossary of Terms

Anaerobic	not having molecular oxygen (O_2) present
Buffer	A strip of land surrounding a wetland or riparian area in which activities are controlled or restricted, in order to reduce the impact of adjacent land uses on the wetland or riparian area
Gley	soil material that has developed under anaerobic conditions as a result of prolonged saturation with water. Grey and sometimes blue or green colours predominate but mottles (yellow, red, brown and black) may be present and indicate localised areas of better aeration
Hydrophyte	any plant that grows in water or on a substratum that is at least periodically deficient in oxygen as a result of soil saturation or flooding; plants typically found in wet habitats
Hydromorphic soil	soil that in its undrained condition is saturated or flooded long enough during the growing season to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils)
Mottles	soils with variegated colour patters are described as being mottled, with the "background colour" referred to as the matrix and the spots or blotches of colour referred to as mottles
Seepage	A type of wetland occurring on slopes, usually characterised by diffuse (i.e. unchannelled, and often subsurface) flows
Perched water table	the upper limit of a zone of saturation in soil, separated by a relatively impermeable unsaturated zone from the main body of groundwater
Permanently wet soil	soil which is flooded or waterlogged to the soil surface throughout the year, in most years
Sedges	Grass-like plants belonging to the family Cyperaceae, sometimes referred to as nutgrasses. Papyrus is a member of this family.
Soil horizons	layers of soil that have fairly uniform characteristics and have developed through pedogenic processes; they are bound by air, hard rock or other horizons (i.e. soil material that has different characteristics).
Soil profile	the vertically sectioned sample through the soil mantle, usually consisting of two or three horizons (Soil Classification Working Group, 1991)
Soil saturation	the soil is considered saturated if the water table or capillary fringe reaches the soil surface
Temporarily	The soil close to the soil surface (i.e. within 50 cm) is wet for periods > 2 weeks

wet soil	during the wet season in most years. However, it is seldom flooded or saturated at the surface for longer than a month.
Temporary zone of wetness	the outer zone of a wetland characterised by saturation within 50cm of the soil surface for less than three months in a year
Wetland:	"*land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil*." (National Water Act; Act 36 of 1998).
Wetland delineation	the determination and marking of the boundary of a wetland on a map using the DWAF (2005) methodology. This assessment includes identification of suggested buffer zones and is usually done in conjunction with a wetland functional assessment. The impact of the proposed development, together with appropriate mitigation measures are included in impact assessment tables

Appendix C: Abridged Curriculum Vitae of the Specialist

Name:	**ANTOINETTE BOOTSMA nee van Wyk**
Name of Company:	Limosella Consulting
Position:	Wetland Specialist
SACNASP Status:	Professional Natural Scientist # 400222-09

EDUCATIONAL QUALIFICATIONS

- B. Sc (Botany & Zoology), University of South Africa (1997 - 2001)
- B. Sc (Hons) Botany, University of Pretoria (2003-2005)
- Short course in wetland delineation, legislation and rehabilitation, University of Pretoria (2007)
- Short course in Wetland Soils, Terrasoil Science, (2009)
- MSc (Ecology), University of South Africa (2010 – ongoing)

KEY QUALIFICATIONS

- **Principal Specialist**

This entailed the management of wetland vegetation and rehabilitation related projects in terms of developing proposals, project management, technical investigation (delineation and functional assessment of wetlands and riparian areas in order to advise proposed development layouts) and quality control through the following:

- More than 90 fine scale wetland and ecological assessments in Gauteng, Mpumalanga, KwaZulu Natal, Limpopo and the Western Cape and Eastern Cape. Liaison with clients, and all facets of project management. April 2007, ongoing.
- Reviewing of specialist reports, including faunal and floral assessments, aquatic, wetland and rehabilitation reports;
- An assessment of wetlands in Tatu, Kenya in order to inform the proposed development of a residential estate. August 2009
- Riparian Management Plan for Mixed-Use developments in Kagiso, Gauteng. August 2009;
- Rehabilitation Plan for the wetland associated with Heroes Bridge in Soweto. Technical investigation as well as management of a team of specialist, integration of information into a final report. The technical investigation for this project also included an investigation into the occurrence of Red Data vegetation. June 2009;

- Input into the wetland component of the Green Star SA rating system. April 2009;
- Strategic analysis of wetlands in Thohyandou in conjunction with a strategic vegetation assessment of the area, March 2009;
- Strategic analysis of wetlands in Gauteng for the GDACE Regional Management Framework, August 2008;
- Successful completion of an audit of the wetlands in the City of Johannesburg. Specialist studies as well as project management and integration of independent datasets into a final report. July 2008.
- An assessment of wetlands in southern Mozambique. This involved a detailed analysis of the vegetation composition and sensitivity associated with wetlands and swamp forest in order to inform the development layout of a proposed resort. May 2008.
- An assessment of three wetlands in the Highlands of Lesotho. This involved a detailed assessment of the value of the study sites in terms of functionality and rehabilitation opportunities. Integration of the specialist reports socio economic, aquatic, terrestrial and wetland ecology studies into a final synthesis. May 2007.
- Ecological investigation on a strategic scale to inform an Environmental Management Framework for the Emakazeni Municipality and an Integrated Environmental Management Program for the Emalahleni Municipality. May and June 2007

Conservation ecology

The implementation and management of projects related to long and short term studies on impacts and rehabilitation in a mining environment.

- Principal investigator. Species assemblages in the woody vegetation communities of coastal dune forests between the Umfolozi and Umlalazi rivers. This relates to colonisation trends across disturbance and rehabilitation age gradients, including aspects such as seed ecology and phenology. 2006/7
- Principal investigator. Biodiversity of the coastal dune forests and associated habitats in Richards Bay, particularly on the epiphytic orchids and ferns found on the mineral lease area of Richards Bay Minerals. 2006
- Technical assistant. Biodiversity of the coastal dune forests and associated habitats in Richards Bay, particularly on the herpetofauna found on the mineral lease area of Richards Bay Minerals. 2006
- Principal investigator. Baseline vegetation, and topsoil maps for Richards Bay Minerals' Zulti South lease area. 2005/6
- Technical assistant. A species list of woody and herbaceous plants of the Sekhukhune area. 2005

Phytosociology

A technical investigation as part of academic research

- Principal investigator. A phytosociological study of vegetation associated with the wetlands of Lake Chrissie, Mpumalanga. 2004

Annexure G(iv)

Fauna and Flora Report

A.

GALAGO ENVIRONMENTAL

Fauna and Flora Specialists
638 Turf Street
Wingate Park, 0181
Tel: 012-345 4891
Fax: 086 675 6136
Email: Vanessam@lantic.net

Flora Assessment

of

PORTION 31 AND 38 AND THE REMAINDER OF KLEINFONTEIN 368 JR AND PORTION 14, 63 AND 68 OF DONKERHOEK 365 JR

February 2012

Report author: Mrs. P. Lemmer (Cert. Sci. Nat: B.Sc.)
Report verified/reviewed by: Dr. L.A. Coetzer (D.Sc., Prof. Nat. Sci.)

VERIFICATION STATEMENT

Petro Lemmer is a Certified Natural Scientist with the S.A. Council for Natural Scientific Professions. This communication serves to verify that the flora report compiled by Petro Lemmer has been prepared under my supervision, and I have verified the contents thereof.

Declaration of Independence: I, Dr. L.A. Coetzer (421009 5029 089) declare that I:

- am committed to biodiversity conservation but concomitantly recognize the need for economic development. Whereas I appreciate the opportunity to also learn through the processes of constructive criticism and debate, I reserve the right to form and hold my own opinions and therefore will not willingly submit to the interests of other parties or change my statements to appease them
- abide by the Code of Ethics of the S.A. Council for Natural Scientific Professions
- act as an independent specialist consultant in the field of botany
- am subcontracted as specialist consultant by Galago Environmental CC for the proposed Kleinfontein & Donkerhoek development project described in this report
- have no financial interest in the proposed development other than remuneration for work performed
- have or will not have any vested or conflicting interests in the proposed development
- undertake to disclose to the Galago Environmental CC and its client as well as the competent authority any material information that have or may have the potential to influence the decision of the competent authority required in terms of the Environmental Impact Assessment Regulations, 2006.

L.A. Coetzer

Dr. L.A. Coetzer

Declaration of Independence:

I, Petro Lemmer (440129 0025 085) declare that I:

- am committed to biodiversity conservation but concomitantly recognize the need for economic development. Whereas I appreciate the opportunity to also learn through the processes of constructive criticism and debate, I reserve the right to form and hold my own opinions and therefore will not willingly submit to the interests of other parties or change my statements to appease them

- abide by the Code of Ethics of the S.A. Council for Natural Scientific Professions

- act as an independent specialist consultant in the field of botany

- am subcontracted as specialist consultant by Galago Environmental CC for the proposed Kleinfontein & Donkerhoek project described in this report

- have no financial interest in the proposed development other than remuneration for work performed

- have or will not have any vested or conflicting interests in the proposed development

- undertake to disclose to the Galago Environmental CC and its client as well as the competent authority any material information that have or may have the potential to influence the decision of the competent authority required in terms of the Environmental Impact Assessment Regulations, 2006.

Petro Lemmer

TABLE OF CONTENTS

FIGURES:

TABLES:

1. INTRODUCTION

Galago Environmental was appointed to conduct a vegetation survey on Portions 31 and 38 and the Remainder of the farm Kleinfontein 368-JR and Portions 14, 63, 67 and 68 of the farm Donkerhoek 365-JR, scheduled for development into an eco estate with residents, open spaces, gape park areas etc. The objective was to determine which species might still occur on the site. Special attention had to be given to the habitat requirements of all the Red List species that may occur in the area. This survey focuses on the current status of threatened plant species occurring, or which are likely to occur on the study site, and a description of the available and sensitive habitats on the site and within 200 meters of the boundary of the site.

2. OBJECTIVES OF THE STUDY

- To assess the current status of the habitat component and current general conservation status of the area;
- To list the perceptible flora of the site and to recommend steps to be taken should endangered, vulnerable or rare species be found;
- To highlight potential impacts of the development on the flora of the proposed site; and
- To provide management recommendations to mitigate negative and enhance positive impacts should the proposed development be approved.

3. SCOPE OF STUDY

This report:

- Lists the more noticeable trees, shrubs, herbs, geophytes and grasses observed during the study and offers recommendations about the preservation of the sensitive areas on the site;
- Indicates medicinal plants recorded and lists alien species;
- Comments on connectivity with natural vegetation on adjacent sites;
- Comments on ecological sensitive areas;
- Evaluates the conservation importance and significance of the site with special emphasis on the current status of resident threatened species; and
- Offers recommendations to reduce or minimise impacts, should the proposed development be approved

4. STUDY AREA

4.1 Regional Vegetation

The study site lies in the quarter degree grid cells 2528CD (Rietvlei dam) and 2528DC (Bronkhorstspruit). According to Mucina and Rutherford (2006) the site falls within the two vegetation units Gold Reef Mountain Bushveld and Rand Highveld Grassland with the large Marikana Thornveld vegetation unit, with open *Acacia karroo* woodland and dense shrubs and climbers in places, immediately west of the site.

The authors described the Gold Reef Mountain Bushveld as featuring rocky hills and ridges often west-east trending with more dense woody vegetation often on the south-facing slopes associated with distinct floristic differences (e.g. preponderance of *Acacia caffra* on the southern slopes). Tree cover elsewhere is variable. Tree and shrub layers are often continuous and the herbaceous layer is dominated by grasses. It consists predominantly of quartzites, conglomerates and some shale horizons of the Magaliesberg, Daspoort and Silverton Formations and the Hospital Hill, Turffontein and Government subgroups. Soils are shallow, gravel lithosols.

The Rand Highveld Grassland is, according to Mucina and Rutherford, a highly variable landscape with extensive sloping plains and a series of slightly elevated ridges. The vegetation is species-rich, wiry, sour grassland, characterized by *Themeda, Eragrostis, Heteropogon* and *Elionurus*, alternating with low sour scrubland on rocky outcrops and steeper slopes. Typical herbs mostly belong to the Asteraceae and rocky ridges carry sparse woodlands with *Acacia caffra* and *Celtis africana* accompanied by a rich suite of shrubs with the genus *Searsia* most prominent. The area comprises quartzite ridges supporting shallow soils on rocky ridges and soils of various qualities elsewhere.

Both units fall within a summer-rainfall region with very dry winters and frequent winter frosts, less common on the ridges and hills.

The Gold Reef Mountain Bushveld is considered least threatened. Its conservation target is 24%. Some 22% is conserved in statutory reserves such as Magaliesberg Nature Area and the Rustenburg, Wonderboom and Suikerbosrand Nature Reserves. About 15% is transformed, mainly by cultivation and urbanization.

The Rand Highveld Grassland is considered endangered. Its conservation target is 24%. Poorly conserved (only 1%) in statutory reserves and a few private nature reserves. Almost 50% of the unit is already been transformed by cultivation, plantations, urbanization and dam-building.

4.2 The study site

The wedge-shaped 808 ha study site lies in the southwestern quadrant of the crossing of the N4 highway with Road R151, straddling Road D1342. The narrow southern tip of the site abuts Road D631 (Boschkop Road) just east of Road D964 and the northern boundary line runs just south of the N4 highway along the crest of the Magaliesberg. The Sentra Rand railway line runs through the lower quarter of the site.

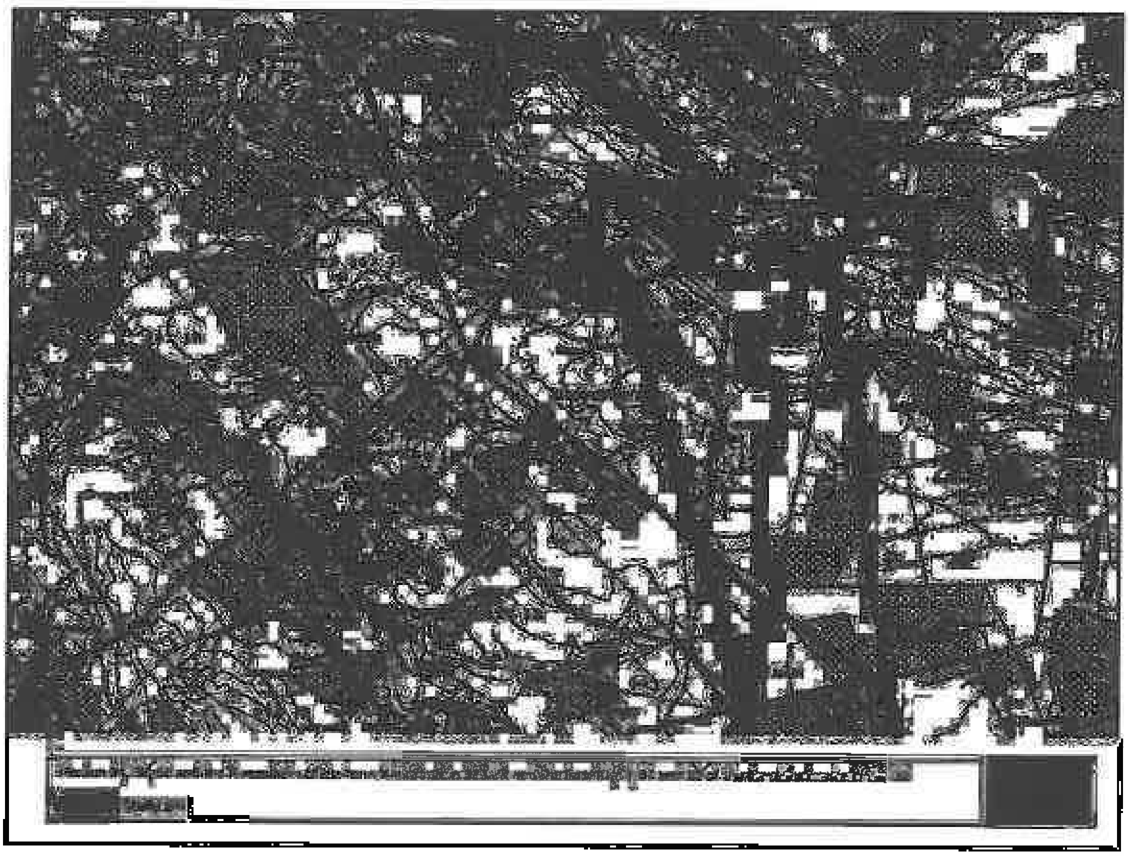


Figure 1: Locality map of the study area

5. METHOD

Information about the Red List and Orange List plant species that occur in the area was obtained from GDARD (GDACE). The Guidelines issued by GDARD (GDACE) to plant specialists as well as various publications (see Section 11) were consulted about the habitat preferences of the Red- and Orange List species concerned.

The SANBI lists of plants recorded in the 2528CD and 2528DC quarter degree grid cells were obtained and consulted to verify the record of occurrence of the plant species seen on the site. The vegetation map published in Mucina and Rutherford (2006) was consulted about the composition of Rand Highveld Grassland and Gold Reef Mountain Bushveld. A desktop study of the habitats of the Red List and Orange List species known to occur in the area was done before the site visit.

The study site was visited on 26, 29 and 31 March 2011 to determine whether suitable habitat for the Red List species known to occur in the quarter degree grid cells existed and to survey the flora present on the site. The areas where the habitat was suitable for the Red List species *Argyrolobium campicola* were revisited on 17 February 2012, which was within the flowering time of this species.

The various study units were identified (see Figure 2) and one or more plots, depending on the size and composition of the study unit, were selected at random from each study unit for detailed study. Each plot, which measured about 10m x 10m, was surveyed in a random crisscross fashion and the plants recorded. Areas where the habitat was suitable for the Red List species known to occur in the quarter degree grid cell were examined in detail.

Suitable habitat for Red List species on the neighbouring properties, where accessible, was examined to a distance of 200 m from the boundaries of the site for the presence of Red List plant species.

6. RESULTS

6.1 Vegetation Study units

Twelve vegetation study units were identified:

- *Tristachya – Digitaria* ridge vegetation;
- *Aristida – Seriphium* plateau grassland;
- *Eragrostis – Protea welwitschii* grassland;
- *Acacia – Celtis* disturbed savanna;
- *Hyparrhenia – Richardia* veld;
- Alien thicket;
- Wetland vegetation;
- *Hyparrhenia – Helichrysum* veld;
- *Hyparrhenia – Eragrostis* grassland;
- Moist *Eragrostis* grassland;
- Mixed alien and indigenous vegetation; and
- Cultivated fields.

Tables 3 to 13 list the trees, shrubs, geophytes, herbs and grasses actually found on each of the surveyed areas of the site.

Figure 2: Vegetation Study units

6.2 Medicinal plants

The names of known medicinal plants are marked with numbers to footnotes in Tables 3 to 13 and the footnotes themselves appear at the end of the last table. Of the 412 plant species recorded on the site, 55 species with medicinal properties were found. Their distribution in the various study units is as follows:

Table 1: Number of medicinal species in the various study units

STUDY UNIT	TOTAL NO OF SPECIES IN STUDY UNIT	NO OF MEDICINAL SPECIES IN STUDY UNIT
Tristachya – *Digitaria* ridge vegetation	221	32
Aristida – *Seriphium* plateau grassland	136	15
Eragrostis – *Protea welwitschii* grassland	112	12
Acacia – *Celtis* disturbed savanna	87	18
Hyparrhenia – *Richardia* veld	80	12
Alien thicket	12	0
Wetland vegetation	49	4
Hyparrhenia – *Helichrysum* veld	47	13
Hyparrhenia – *Eragrostis* grassland	38	10
Moist *Eragrostis* grassland	63	11
Mixed alien and indigenous vegetation	Not surveyed	
Cultivated fields	42	4

6.3 Alien plants

Alien plants are not listed separately, but are included in the lists as they form part of each particular study unit. Their names are marked with an asterisk in Tables 3 to 13. Forty-five alien plant species, of which seven species were Category 1 Declared weeds, five were Category 2 Declared invaders and three were Category 3 Declared invaders, were recorded on the site. The number of alien species in each study unit is reflected in table 2.

Table 2: Number of Alien species in each study unit

STUDY UNIT	NO. OF ALIEN SPECIES	CAT 1	CAT 2	CAT 3	NOT DECLARED
Tristachya – Digitaria ridge vegetation	11	1	1	1	8
Aristida – Seriphium plateau grassland	17	4	1	0	12
Eragrostis – Protea welwitschii grassland	1	0	0	0	1
Acacia – Celtis disturbed savanna	24	5	4	3	12
Hyparrhenia – Richardia veld	9	2	2	0	
Alien thicket	4	0	4	0	0
Wetland vegetation	7	0	1	0	6
Hyparrhenia – Helichrysum veld	5	1	0	0	4
Hyparrhenia – Eragrostis grassland	5	1	0	0	4
Moist *Eragrostis* grassland	8	1	0	0	7
Mixed alien and indigenous vegetation	Not surveyed				
Cultivated fields	14	0	0	0	14

The alien plant names printed in **bold** in the plant tables are those of Category 1 Declared Weeds and the removal of these plants is ***compulsory*** in terms of the regulations formulated under "The Conservation of Agricultural Resources Act" (Act No. 43 of 1983), as amended.

In terms of these regulations, Category 2 Declared invaders may not occur on any land other than a demarcated area and should likewise be removed.

Although the regulations under the above Act require that Category 3 Declared invader plants may not occur on any land or inland water surface other than in a biological control reserve, these provisions shall not apply in respect of category 3 plants already in existence at the time of the commencement of said regulations. If this is the case, a land user must take all reasonable steps to curtail the spreading of propagating material of Category 3 plants.

6.4 Orange List species

The habitat was suitable for four of the seven Orange List plant species known to occur in the 2528CD and 2528DC quarter degree grid cells. One of these species, *Hypoxis hemerocallidea* (African potato) was found sparsely scattered in the *Hyparrhenia – Helichrysum* veld and in the Moist *Eragrostis* grassland. (See Annexure A for a list of the Orange- and Red List species known to occur in the quarter degree grid cells).

6.5 Red List species

Fifteen Red List plant species are known to occur in the 2528CD and 2528DC quarter degree grid cells. The habitat was suitable for four of the Red List species known to occur in the two quarter-degree grid cells. Two of these species and a third species for which the habitat was not suitable, are known to occur within 5 km of the site. One of them, *Adromischus umbraticola* subsp *umbraticola* was found in abundance in the *Tristachya – Digitaria* ridge vegetation study unit.

The *Eragrostis – Protea welwitschii* grassland and the Moist *Eragrostis* grassland were examined dring the flowering time of the Red List species *Argyrolobium campicola*, but none was found. Although *Trachyandra erythrorrhiza* flowers from September to November, the plant and its spent inflorescence can be seen without difficulty outside its flowering time. None was found in the Wetland vegetation during any of the surveys.

6.6 *Tristachya – Digitaria* ridge vegetation

6.6.1 Compositional aspects and Connectivity

This study unit comprised natural primary vegetation on the crest of that part of the Magaliesberg that lies south of the N4 highway. The species divorsity of this study unit was very high. Connectivity with natural grassland existed to the northwest and the southeast but is limited by the N4 highway and Road R515. Of the 412 plant species recorded on the site 221 were recorded in the *Tristachya – Digitaria* ridgo vegetation. Of these, 210 were indigenous species. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	104
Tree species	14
Shrubs and dwarf shrubs	23
Grasses	29
Geophytes	32
Sedges	5
Succulents	14
Total No of species	221

6.6.2 Red- and Orange List species

The habitat of the *Tristachya – Digitaria* ridge vegetation was suitable for the Red List species *Ceropegia decidua subsp pretoriensis* and for *Adromischus umbraticola* subsp *umbraticola*. The latter species was found in abundance in this study unit (see Annexure B). The habitat was suitable for the Orange List species *Boophane disticha* (Cape poison bulb/Seeroogblom) and *Callilepis leptophylla* (Wild daisy/Bergbitterbossie), but none were found.

Figure 3: Map showing the red listed species found on site together with the 400m buffer

6.6.3 Medicinal and alien species

Thirty-two of the 55 medicinal species recorded on the site and 11 of the 45 alien species recorded on the site were found in this study unit. Of the alien species, one was a Category 1 Declared weed, one was a Category 2 Declared invader and one was a Category 3 Declared Invader.

6.6.4 Sensitivity

Owing to the high species diversity, the locality of the study unit on the crest of the Magaliesberg ridge and the presence of the Red List species, the *Tristachya – Digitaria* ridge vegetation study unit was considered sensitive.

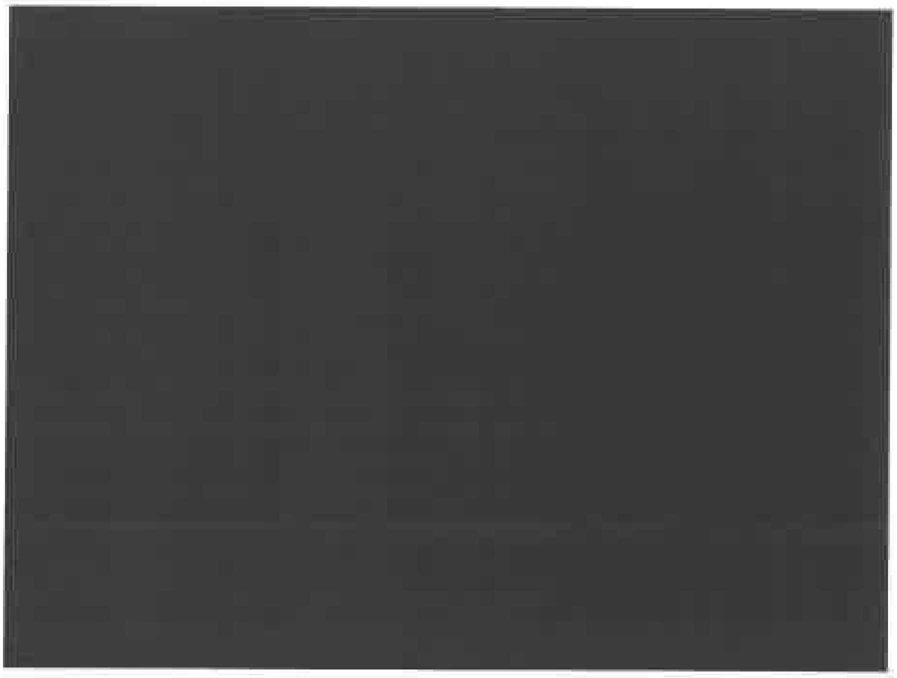


Figure 4: The *Tristachya – Digitaria* ridge vegetation

Table 3: Plants recorded in the *Tristachya – Digitaria* ridge vegetation

SCIENTIFIC NAME	INV CAT	COMMON NAMES
Acacia caffra		Common hook thorn / Gewone haakdoring
*Acacia decurrens**	2	Green wattle / Groenwattel
Acacia karroo[1,2]		Sweet thorn / Soetdoring
Acalypha angustata		Copper leaf / Katpisbossie
*Acanthospermum australe**		Prostrate starbur / Kruipsterklits
Acrotome hispida		White cat's paws
Adromischus umbraticola subsp umbraticola		
Aeollanthus buchnerianus		
Afrocanthium gilfillanii		Velvet rock alder / Fluweelklipels
Aloe greatheadii var davyana[1,2]		Kleinaalwyn
Aloe marlothii subsp marlothii[1,2,4]		Mountain aloe / Bergaalwyn
Aloe pretoriensis		
Aloe verecunda		Grass aloe
Aloe zebrina		
*Amaranthus deflexus**		Perennial pigweed / Meerjarige misbredie
Anacampseros subnuda subsp subnuda		Hasieskos
Ancylobotrys capensis		Wild apricot / Wilde appelkoos
Andropogon schirensis		Stab grass / Tweevingergras
Anthospermum rigidum subsp rigidum		

SCIENTIFIC NAME	INV CAT	COMMON NAMES
Aristida adscensionis subsp adscenscionis		Annual threeawn / Eenjarige steekgras
Aristida aequiglumis		Curly-leaved three-awned grass
Aristida junciformis subsp galpinii		Ngongoni three-awn / Ngongoni steekgras
Asparagus flavicaulis subsp flavicaulis		
Asparagus suaveolens		Wild asparagus / Katdoring
Asplenium cordatum		Rusty-back fern
Athrixia elata		Wild tea / Bostee
Babiana bainsii		Bobbejaanuintjie
Becium obovatum subsp obovatum var obovatum[2,3]		Cat's whiskers / Katsnor
*Bidens pilosa**		Blackjack / knapsekêrel
Brachiaria serrata		Velvet grass / Fluweelgras
Bulbostylis burchellii		Biesie
Burkea africana		Wild syringa / Wildesering
Celtis africana		White stinkwood / Witstinkhout
Chaenostoma leve		Ruikbossie
Chaetacanthus setiger		
Chaetacanthus sp.		
Chamaecrista comosa var capricornia		
Cheilanthes hirta var hirta[1,2]		Hairy lip fern / Harige lipvaring
Cheilanthes viridis var viridis		Cliff brake / Kransruigtevaring
Chlorophytum recurvifolium		
Chortolirion angolense		
Cleome maculata		
Cleome monophylla		
Cleome rubella		Pretty lady / Mooinooientjie
Clutia pulchella var pulchella[4]		Common lightning bush / Gewone bliksembos
Coleochloa setifera		
Commelina africana var krebsiana		
Commelina africana var lancispatha		
Commelina livingstonii		
Commelina modesta		
*Conyza albida**		Tall fleabane / Vaalskraalhans
Cotyledon orbiculata var oblonga[1,2]		
Crassula capitella subsp nodulosa		
Crassula setulosa var setulosa forma setulosa		
Cryptolepis oblongifolia		Red-stemmed milk rope / Rooistam bokhoring
Cucumis zeyheri		Wild cucumber / Wilde agurkie
Cyanotis speciosa		Doll's powder puff / Bloupoeierkwassie
Cyathula cf uncinulata		
Cymbopogon nardus		Giant turpentine grass / Reuse terpentyngras
Cyperus obtusiflorus var obtusiflorus		Witbiesie
Cyperus sp 1		
Dianthus mooiensis subsp mooiensis var mooiensis[2,3]		Wild pink / Wilde angelier
Dicoma anomala subsp anomala[1,2,3]		Maagbitterwortel
Digitaria diagonalis var diagonalis		Brown-seed finger grass / Bruinsaadvingergras
Digitaria monodactyla		One-finger grass / Eenvingergras
Diheteropogon amplectens var. amplectens		Broadleaved bluestem / Breëblaar blougras
Diospyros lycioides subsp guerkei		Bushveld bluebush / Bosveldbloubos
Dipcadi viride		Slymuintjie
Dipcadi sp		
Drimia depressa		
Drimia multisetosa		

SCIENTIFIC NAME	INV CAT	COMMON NAMES
Elephantorrhiza elephantina[1,4,3]		Elephant's root / Olifantswortel
Elionurus muticus		Wire grass / Draadgras
Englerophytum magalismontanum[4]		Stem fruit / Stamvrug
Eragrostis chloromelas		Curly leaf / Krulblaar
Eragrostis nindensis		Wether love grass / Hamelgras
Eragrostis racemosa		Narrow heart love grass / Smalhartjiesgras
Eragrostis sclerantha subsp sclerantha		
Eriosema cordatum		
Eriospermum flagelliforme		
Eriospermum porphyrovalve		
Euclea crispa subsp crispa[4]		Blue guarri / Bloughwarrie
Eulophia sp		Ground orchid / Grondorgidee
Eulophia welwitschii		Ground orchid / Grondorgidee
Euphorbia davyi		
Fadogia homblei		Wilde dadel
Felicia muricata subsp *muricata*[3]		White felicia / Blouheuning karooblom
Fimbristylis sp		
Geigeria burkei subsp burkei var burkei		Vermeersiektebossie
Gerbera viridifolia		Griekwateebossie
Gisekia phamacioides var pharnacioides		
Gladiolus crassifolius		
Gladiolus dalenii subsp dalenii[3]		Wild gladiolus / Wildeswaardlelie
Gladiolus permeabilis subsp edulis		Kleinaandblom
Gladiolus vinosomaculatus		
Gnidia capitata[1,2]		Kerrieblom
Gnidia sericocephala		
Gomphocarpus fruticosus subsp fruticosus[1,2]		Milkweed / melkbos
Gomphocarpus tomentosus subsp tomentosus		
Gymnosporia buxifolia[2]		Spikethorn / pendoring
Gymnosporia tenuispina		Bell spike thorn / Klokkiespendoring
Helichrysum dasymallum		
Helichrysum kraussii		
Helichrysum nudifolium var nudifolium[1,2]		Hottentot's tea / Hottentotstee
Helichrysum paronychioides		
Helichrysum setosum		Yellow everlasting / Geelsowejaartjie
Huernia stapelioides		
Hyparrhenia hirta		Common thatching grass / Dekgras
Hypoestis forskaolii		White ribbon bush
Hypoxis acuminata		
Hypoxis iridifolia		
Hypoxis multiceps		
Hypoxis obtusa		
Hypoxis rigidula var rigidula		Silver-leaved star flower / Wilde tulp
Indigastrum burkeanum		
Indigofera hedyantha		Aambeibossie
Indigofera melanadenia		
Ipomoea ommaneyi[2]		Beespatat
Justicia anagalloides		
Kalanchoe thyrsiflora		White lady / Geel plakkie
Kohautia virgata		
Lapeirousia sandersonii		Blou-angelier
Ledebouria inquinata		
Ledebouria luteola		
Ledebouria marginata		
Ledebouria ovatifolia		
Leonotis randii		Wild dagga / Wildedagga
Leonotis schinzii		Rock dagga / Klipdagga
Lippia javanica[1,2,3]		Fever tea / Koorsbossie
Lopholaena coriifolia		Small-leaved fluff bush / Kleinblaar

SCIENTIFIC NAME	INV CAT	COMMON NAMES
		pluisbossie
Lotononis eriantha		
Lotononis foliosa		
Loudetia simplex		Russet grass / Stingelgras
*Melia azedarach**	3	Syringa / sering
Melinis nerviglumis		Bristle leaf red top / Steekblaarblinkgras
Melinis repens subsp repens		Red top grass
Monocymbium ceresiiforme		Boat grass / Bootjiegras
Nerine rehmannii		
Nidorella hottentotica		
Nuxia congesta		Wild elder / Wildevlier
Oldenlandia herbacea var herbacea		
Opuntia ficus-indica*	**1**	**Sweet prickly pear / Boereturksvy**
Oxalis obliquifolia		Sorrel / suring
Oxygonum dregeanum subsp canescens var lineerifolium		Starstalk
Panicum natalense		Natal panicum / Suurbuffelsgras
Parinari capensis subsp capensis		Dwarf mobola / Grysappeltjie
Pavetta gardeniifolia var gardeniifolia		Common bride's bush / Gewone bruidsbos
Pavetta zeyheri subsp. zeyheri		Small-leaved bride's bush / Fynblaarbruidsbos
Pearsonia cajanifolia subsp cajanifolia		
Pearsonia sessilifolia subsp *sessilifolia*		Silwerertjietee
Pechuel-Loeschia leubnitziae		Stinkbush / stinkbitterbos
Pellaea calomelanos var calomelanos [1,2]		Black cliff brake / Swart kransruigtevaring
Pentarrhinum insipidum		Donkieperske
Phyllanthus parvulus var parvulus		Dye bush / Kleurbossie
*Phytolacca octandra**		Ink berry / Inkbessie
*Polycarpaea corymbosa var corymbosa**		
Polygala rehmannii		
Pseudognaphalium oligandrum		
Pygmaeothamnus chamaedendrum var setulosus		Sand applogoorappel
Pygmaeothamnus zeyheri var zeyheri		Sand apple / Goorappel
Raphionacme galpinii		
Raphionacme hirsuta [2]		Khadi root / Khadiwortel
Rhynchosia minima var prostrata		
Rhynchosia monophylla		
Rhynchosia sp		
Rhynchosia totta var totta		Yellow carpet bean / Tottabossie
*Richardia brasiliensis**		Tropical richardia / Tropiese richardia
Rotheca hirsuta		Small violet bush
Rothmannia capensis [4]		Mock gardenia / Valskatjiepiering
Scabiosa columbaria [1,2,3]		Wild scabiosa / Bitterbos
Schizachyrium sanguineum		Red autumn grass / Rooi herfsgras
Searsia leptodictya forma leptodictya		Mountain karee / Bergkaree
Searsia magalismontana subsp megalismonta		Rock currant / Klip-taaibos
Searsia pyroides var pyroides [4]		Common wild currant / Taaibos
Searsia zeyheri [2]		Blue currant / Blou taaibos
Selaginella dregei		Drege's spike moss / Drege se stekelmos
Selaginella mittenii		Spike moss / Stekelmos
Senecio affinis		
Senecio coronatus		Sybossie
Senecio erubescens var crepidifolius		
Senecio oxyriifolius subsp. oxyriifolius [2]		False nasturtium / Kappertjieblaar
Senecio venosus		Besembossie
Seriphium plumosum		Bankrupt bush / Bankrotbos
Setaria sphacelata var sphacelata		Small creeping foxtail / Kleinkruipmannagras
Sida dregei		Spider-leg

SCIENTIFIC NAME	INV CAT	COMMON NAMES
Silene burchellii var. angustifolia		
Sisyranthus cf randii		
Solanum lichtensteinii		Giant bitter apple / Bitterappel
Solanum panduriforme		Poison apple / Gifappel
Sonchus dregeanus		
Sonchus wilmsii		Milk thistle / Melkdissel
Sphenostylis angustifolia		Wild swetpea bush / Wilde ertjie
Sporobolus pectinatus		Fringed dropseed / Kammetjiesgras
Sporobolus stapfianus		Fibrous dropseed / Veselfynsaadgras
Striga gesnerioides		
Syncolostemon canescens		
Syncolostemon pretoriae		Dwarf sage bush
*Tagetes minuta**		Tall khaki weed / Lang kakiebos
Tephrosia elongata var elongata		
Tephrosia longipes subsp longipes var longipes		
Tephrosia semiglabra		
Themeda triandra		Red grass / Rooigras
Thesium sp 2		
Thesium sp 3		
Thesium utile		Besembossie
Trachypogon spicatus		Giant spear grass / Bokbaardgras
Tristachya biseriata		Trident grass / Drieblomgras
Tristachya rehmannii		Broom trident grass / Besem drieblomgras
Tritonia nelsonii		
Urelytrum agropyroides		Quinine grass / Varkstertgras
Vangueria infausta subsp infausta[2]		Wild medlar / Wildemispel
Vernonia galpinii		Kwasbossie
Vernonia natalensis[1,2]		Silver vernonia / Silwervernonia
Vernonia oligocephala[1,2]		Cape vernonia / Blounaaldetee bossie
Vernonia poskeana subsp botswanica		
Vernonia staehelinoides		
Wahlenbergia denticulata var transvaalensis		
Xerophyta retinervis[1,2]		Monkey's tail / Bobbejaanstert
Zanthoxylum capense[1,2]		Small knobwood / Klein perdepram
Zehneria marlothii		
Zornia linearis		

6.7 *Aristida – Seriphium plateau* grassland

6.7.1 Compositional aspects and Connectivity

This study unit was situated on the plateau of the Magaliesberg. Part of the study unit was used as grazing for game. The vegetation of this study unit was degraded as a result of overgrazing over a long period. *Seriphium plumosum* was present in large numbers, especially in the area east and northeast of the game fence, where it has become the dominant species. Small pockets of moist to wet montane grassland occurred in places as evidenced by the presence of the sedge *Fimbristylis* sp. Connectivity with natural grassland existed along the ridge of the mountain. Of the 412 plant species recorded on the site 136 were recorded in the *Aristida – Seriphium* plateau grassland study unit. Of these, 119 were indigenous species. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	70
Tree species	5
Shrubs and dwarf shrubs	11
Grasses	23
Geophytes	13
Sedges	8
Succulents	6
Total No of species	136

6.7.2 Red– and Orange List species

The habitat of this study unit was not suitable for any of the Red List species or Orange List species known to occur in the two quarter-degree grid cells.

6.7.3 Medicinal and alien species

Fifteen of the 55 medicinal species recorded on the site and 17 of the 45 alien species recorded on the site were found in this study unit. Of the alien species, four were Category 1 Declared weeds and one was a Category 2 Declared invader.

6.7.4 Sensitivity

The vegetation of this study unit was not considered sensitive.

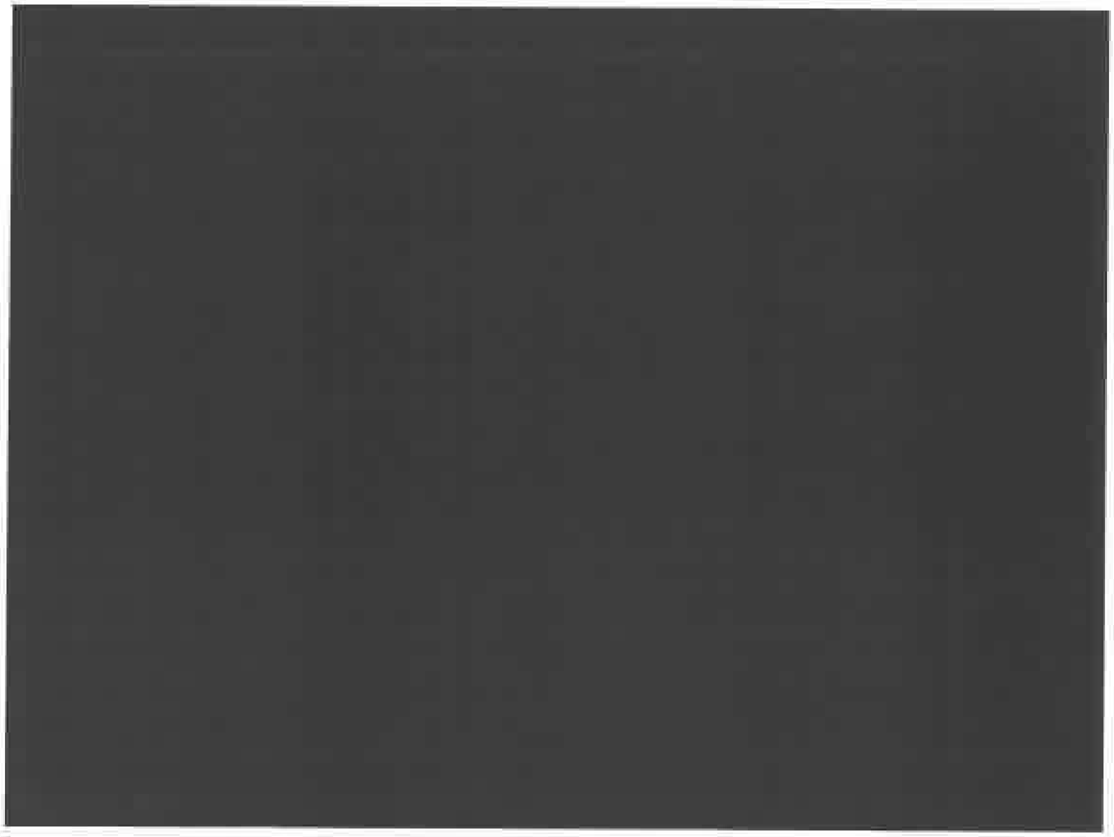


Figure 5: Part of the plateau where game was kept.

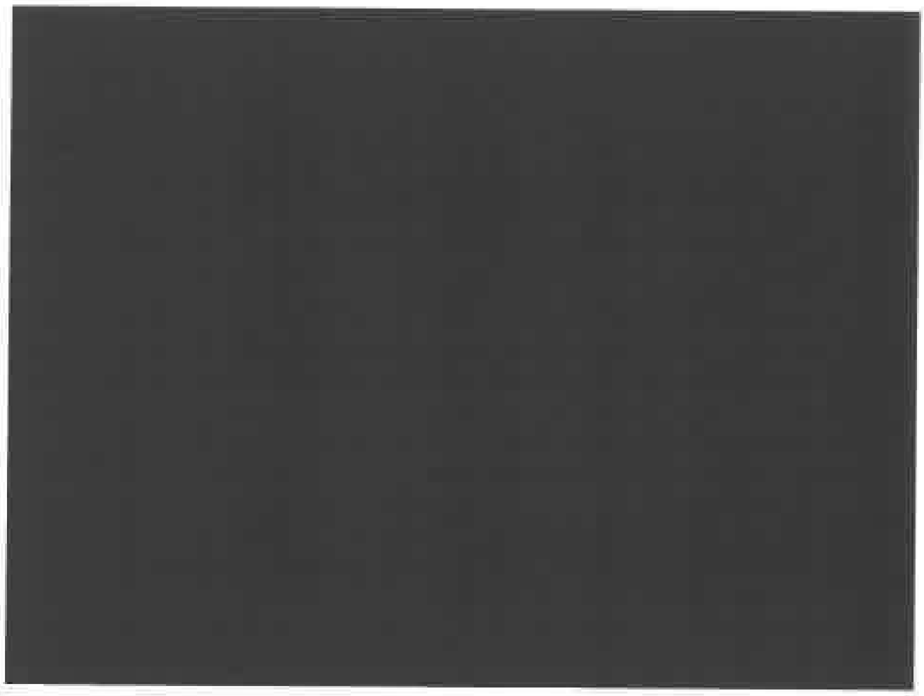


Figure 6: Severe *Seriphium plumosum* (Bankrupt bush) invasion on the plateau.

Table 4: Plants recorded in the *Aristida – Seriphium* plateau grassland

SCIENTIFIC NAME	INV CAT	COMMON NAMES
*Acacia decurrens**	2	Green wattle / Groenwattel
Acalypha angustata		Copper leaf / Katpisbossie
*Acanthospermum australe**		Prostrate starbur / Kruipsterklits
Achyranthus aspera var aspera*	**1**	**Chaff flower / Langklits**
Aeollanthus buchnerianus		
Aloe greatheadii var davyana[1,2]		Kleinaalwyn
Anacampseros subnuda subsp subnuda		Hasieskos
Anthospermum rigidum subsp rigidum		
Aristida adscensionis subsp adscenscionis		Annual threeawn / Eenjarige steekgras
Aristida aequiglumis		Curly-leaved three-awned grass
Aristida junciformis subsp galpinii		Ngongoni three-awn / Ngongoni steekgras
Asparagus suaveolens		Wild asparagus / Katdoring
Aspidoglossum cf glabrescens		
Babiana bainsii		Bobbejaanuintjie
Becium obovatum subsp obovatum var obovatum[2,3]		Cat's whiskers / Katsnor
*Bidens pilosa**		Blackjack / knapsekêrel
Brachiaria serrata		Velvet grass / Fluweelgras
Bulbostylis burchellii		Biesie
Bulbostylis contexta		
Burkea africana		Wild syringa / Wildesering
Campuloclinium macrocephalum*	**1**	**Pom pom weed / Pompombossie**
Chamaecrista capensis var capensis		
Chamaecrista comosa var capricornia		
Chamaecrista mimosoides		
Cheilanthes viridis var glauca		Blue cliff brake / Blou kransruigtevaring
*Chenopodium ambrosiodes**		
Cleome maculata		
Cleome rubella		Pretty lady / Mooinooientjie
Commelina africana var krebsiana		
*Commelina benghalensis**		Wandering jew / Wandelende jood
*Conyza albida**		Tall fleabane / Vaalskraalhans
*Cosmos bipinnatus**		Cosmos / kosmos

SCIENTIFIC NAME	INV CAT	COMMON NAMES
Crassula lanceolata subsp transvaalensis		
Crinum graminicola		Graslelie
Cucumis zeyheri		Wild cucumber / Wilde agurkie
Cyanotis speciosa		Doll's powder puff / Bloupoeierkwassie
Cyathula cf uncinulata		
Cynodon dactylon		Couch grass / Kweek
Cyperus esculentus var esculentus		Yellow nutsedge / Geeluintjie
Cyperus obtusiflorus var obtusiflorus		Witbiesie
Cyperus semitrifidus		
Cyperus sp 1		
Dicoma anomala subsp anomala [1,2,3]		Maagbitterwortel
Digitaria diagonalis var diagonalis		Brown-seed finger grass / Bruinsaadvingergras
Digitaria monodactyla		One-finger grass / Eenvingergras
Diospyros lycioides subsp guerkei		Bushveld bluebush / Bosveldbloubos
Dipcadi viride		Slymuintjie
Elephantorrhiza elephantina[1,2,3]		Elephant's root / Olifantswortel
Elionurus muticus		Wire grass / Draadgras
Englerophytum magalismontanum[4]		Stem fruit / Stamvrug
Eragrostis chloromelas		Curly leaf / Krulblaar
Eragrostis curvula		Weeping love grass / Oulandsgras
Eragrostis gummiflua		Gum grass / Gomgras
Eragrostis nindensis		Wether love grass / Hamelgras
Eragrostis racemosa		Narrow heart love grass / Smalhartjiesgras
Eragrostis sclerantha subsp sclerantha		
Euphorbia davyi		
Felicia muricata subsp *muricata*[3]		White felicia / Blouheuning karooblom
Fimbristylis complanata		
Fimbristylis sp		
Geigeria burkei subsp burkei var burkei		Vermeersiektebossie
Gisekia pharnacioides var pharnacioides		
Gladiolus vinosomaculatus		
Gnidia capitata[1,2]		Kerrieblom
Gomphocarpus fruticosus subsp fruticosus[1,2]		Milkweed / melkbos
Helichrysum caespititium		Speelwonderboom
Helichrysum callicomum		
*Hypochaeris radicata**		Hairy wild lettuce / Harige skaapslaai
Hypoxis iridifolia		
Hypoxis obtusa		
Indigastrum burkeanum		
Indigofera comosa		
Indigofera egens		
Indigofera hedyantha		Aambeibossie
Ipomoea ommaneyi[2]		Beespatat
Justicia anagalloides		
Kohautia virgata		
Lapeirousia sandersonii		Blou-angelier
Ledebouria ovatifolia		
Ledebouria revoluta[3]		Common ledebouria
Lippia javanica[1,2,3]		Fever tea / Koorsbossie
Lopholaena coriifolia		Small-leaved fluff bush / Kleinblaar pluisbossie
Lotononis calycina		Hairy lotononis
Loudetia simplex		Russet grass / Stingelgras
Melinis nerviglumis		Bristle leaf red top / Steekblaarblinkgras
Monocymbium ceresiiforme		Boat grass / Bootjiegras
Nerine rehmannii		
Nidorella hottentotica		

SCIENTIFIC NAME	INV CAT	COMMON NAMES
Oldenlandia herbacea var herbacea		
Opuntia ficus-indica*	1	**Sweet prickly pear / Boereturksvy**
*Oxalis corniculata**		Sorrel / steenboksuring
Panicum natalense		Natal panicum / Suurbuffelsgras
Parinari capensis subsp capensis		Dwarf mobola / Grysappeltjie
Pechuel-Loeschia leubnitziae		Stinkbush / stinkbitterbos
Pellaea calomelanos var calomelanos [1,2]		Black cliff brake / Swart kransruigtevaring
Pentarrhinum insipidum		Donkieperske
Perotis patens		Cat's tail / Katstertgras
Phyllanthus parvulus var parvulus		Dye bush / Kleurbossie
Pollichia campestris		Waxberry / teesuikerbossie
*Polycarpaea corymbosa var corymbosa**		
Polygala sp		
Portulaca quadrifida		Purslane / porslein
Protea caffra subsp caffra [1,2,4]		Common sugarbush / Gewone suikerbos
Pseudognaphalium oligandrum		
Pygmaeothamnus chamaedendrum var setulosus		Sand applegoorappel
Pygmaeothamnus zeyheri var zeyheri		Sand apple / Goorappel
Rhynchosia monophylla		
*Richardia brasiliensis**		Tropical richardia / Tropiese richardia
Scabiosa columbaria [1,2,3]		Wild scabiosa / Bitterbos
Searsia magalismontana subsp magalismonta		Rock currant / Klip-taaibos
Selaginella dregei		Drege's spike moss / Drege se stekelmos
Selago densiflora		Koningstapyt
Senecio affinis		
Senecio lydenburgensis		
Senecio venosus		Besembossie
Senecio sp		
Seriphium plumosum		Bankrupt bush / Bankrotbos
Setaria sphacelata var sphacelata		Small creeping foxtail / Kleinkruipmannagras
Solanum lichtensteinii		Giant bitter apple / Bitterappel
Solanum mauritianum*	1	**Bugweed / luisboom**
*Solanum nigrum**		Nastergal
Solanum rubetorum		/ Wildelemoentjie
Sphenostylis angustifolia		Wild swetpea bush / Wilde ertjie
Sporobolus pectinatus		Fringed dropseed / Kammetjiesgras
Syncolostemon pretoriae		Dwarf sage bush
*Tagetes minuta**		Tall khaki weed / Lang kakiebos
Tephrosia elongata var elongata		
Tephrosia longipes subsp longipes var longipes		
Tephrosia semiglabra		
Themeda triandra		Red grass / Rooigras
Trachyandra saltii var saltii		
Tristachya rehmannii		Broom trident grass / Besem drieblomgras
Ursinia nana subsp leptophylla		Magriet
Vernonia poskeana subsp botswanica		
Xerophyta retinervis [1,2]		Monkey's tail / Bobbejaanstert
Zornia linearis		

6.8 *Eragrostis – Protea welwitschii* grassland

6.8.1 Compositional aspects and Connectivity

The *Eragrostis – Protea welwitschii* grassland comprised natural primary grassland on the plateau and slopes of the Magaliesberg. Sheet rock of Magaliesberg quartzite was evident throughout the study unit. Small pockets of moist to wet montane grassland occurred in places as evidenced by the presence of the sedge *Fimbristylis* sp. Connectivity with natural grassland existed along the ridge of the Magaliesberg. Of the 412 plant species recorded on the site 112 were recorded in the *Eragrostis – Protea welwitschii* grassland. Of these, 111 were indigenous species. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	50
Shrubs and dwarf shrubs	8
Grasses	29
Geophytes	20
Sedges	4
Succulents	1
Total No of species	111

6.8.2 Red– and Orange List species

The habitat of the *Eragrostis – Protea welwitschii* grassland was suitable for the Red List species *Argyrolobium campicola*, but none was observed during the surveys.

The habitat was suitable for the Orange List species *Boophane disticha* (Cape poison bulb/Seeroogblom), but none was found.

6.8.3 Medicinal and alien species

Twelve of the 55 medicinal species recorded on the site were found in this study unit. One non-declared alien species, *Tagetes minuta* (Tall khaki weed) was found in very small numbers this study unit.

6.8.4 Sensitivity

Owing to its pristine condition, the vegetation of this study unit was considered sensitive.

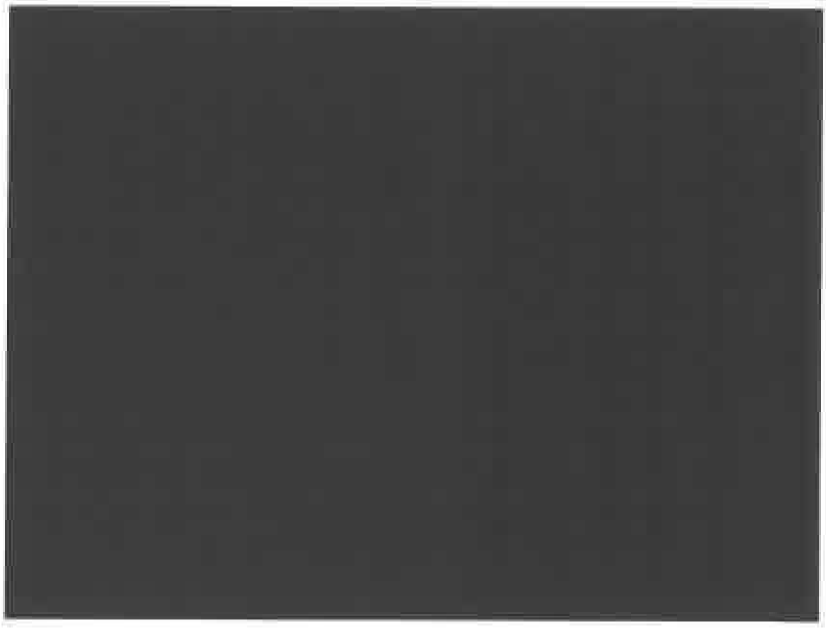


Figure 7: *Eragrostis – Protea welwitschii* grassland on the slope of the Magaliesberg.

Table 5: Plants recorded in the *Eragrostis – Protea welwitschii* grassland

SCIENTIFIC NAME	COMMON NAMES
Acalypha angustata	Copper leaf / Katpisbossie
Afrosciadium megalismontanum[2]	Wild parsley / Wildepietersielie
Alysicarpus rugosus subsp perennirufus	Pioneer fodder plant
Ancylobotrys capensis	Wild apricot / Wilde appelkoos
Andropogon chinensis	Hairy blue grass / Harige blougras
Anthospermum rigidum subsp rigidum	
Aristida aequiglumis	Curly-leaved three-awned grass
Aristida junciformis subsp galpinii	Ngongoni three-awn / Ngongoni steekgras
Asparagus flavicaulis subsp flavicaulis	
Babiana bainsii	Bobbejaanuintjie
Blepharis innocua	
Brachiaria serrata	Velvet grass / Fluweelgras
Bulbostylis burchellii	Biesie
Bulbostylis cf oritrephes	
Chaetacanthus setiger	
Chamaecrista comosa var capricornia	
Chamaecrista mimosoides	
Cleome maculata	
Cleome rubella	Pretty lady / Mooinooientjie
Commelina africana var lancispatha	
Commelina livingstonii	
Crassula lanceolata subsp transvaalensis	
Cucumis zeyheri	Wild cucumber / Wilde agurkie
Cyanotis speciosa	Doll's powder puff / Bloupoeierkwassie
Cycnium adonense	Ink plant / Inkblom
Cyperus obtusiflorus var obtusiflorus	Witbiesie
Dianthus mooiensis subsp mooiensis var mooiensis[2,3]	Wild pink / Wilde angelier
Digitaria diagonalis var diagonalis	Brown-seed finger grass / Bruinsaadvingergras
Digitaria monodactyla	One-finger grass / Eenvingergras
Diheteropogon amplectens var. amplectens	Broadleaved bluestem / Breëblaar blougras
Drimia depressa	
Drimia multisetosa	
Elephantorrhiza elephantina[1,2,3]	Elephant's root / Olifantswortel
Elionurus muticus	Wire grass / Draadgras
Eragrostis chloromelas	Curly leaf / Krulblaar

SCIENTIFIC NAME	COMMON NAMES
Eragrostis curvula	Weeping love grass / Oulandsgras
Eragrostis gummiflua	Gum grass / Gomgras
Eragrostis nindensis	Wether love grass / Hamelgras
Eragrostis racemosa	Narrow heart love grass / Smalhartjiesgras
Eragrostis trichophora	Hairy love grass / Harige-pluimgras
Eriosema burkei var burkei	
Eulophia sp	Ground orchid / Grondorgidee
Felicia muricata subsp *muricata*[3]	White felicia / Blouheuning karooblom
Fimbristylis complanata	
Gerbera viridifolia	Griekwateebossie
Gladiolus sp	
Gladiolus permeabilis subsp edulis	Kleinaandblom
Gladiolus vinosomaculatus	
Harpochloa falx	Caterpillar grass / Ruspergras
Helichrysum caespititium	Speelwonderboom
Helichrysum dregeanum	
Helichrysum nudifolium var nudifolium[1,2]	Hottentot's tea / Hottentotstee
Helichrysum paronychioides	
Helichrysum setosum	Yellow everlasting / Geelsewejaartjie
Hibiscus microcarpus	
Hyparrhenia hirta	Common thatching grass / Dekgras
Hypoxis acuminata	
Hypoxis iridifolia	
Hypoxis rigidula var *rigidula*	Silver-leaved star flower / Wilde tulp
Indigastrum burkeanum	
Indigofera egens	
Indigofera oxalidea	
Lapeirousia sandersonii	Blou-angelier
Ledebouria inquinata	
Ledebouria marginata	
Ledebouria revoluta[3]	Common ledebouria
Leonotis randii	Wild dagga / Wildedagga
Lotononis calycina	Hairy lotononis
Lotononis foliosa	
Loudetia simplex	Russet grass / Stingelgras
Melinis nerviglumis	Bristle leaf red top / Steekblaarblinkgras
Microchloa caffra	Pincushion grass / Elsgras
Monocymbium ceresiiforme	Boat grass / Bootjiegras
Neorautanenia ficifolia	
Nidorella hottentotica	
Panicum natalense	Natal panicum / Suurbuffelsgras
Parinari capensis subsp capensis	Dwarf mobola / Grysappeltjie
Pavetta zeyheri subsp. zeyheri	Small-leaved bride's bush / Fynblaarbruidsbos
Pearsonia cajanifolia subsp cajanifolia	
Pogonarthria squarrosa	Herring bone grass / Sekelgras
Polygala hottentotta[2,3]	Small purple broom
Protea welwitschii	Honeyscented protea / Vaalsuikerbos
Raphionacme galpinii	
Rotheca hirsuta	Small violet bush
Scabiosa columbaria[1,2,3]	Wild scabiosa / Bitterbos
Schizachyrium sanguineum	Red autumn grass / Rooi herfsgras
Selaginella dregei	Drege's spike moss / Drege se stekelmos
Selago densiflora	Koningstapyt
Senecio coronatus	Sybossie
Senecio lydenburgensis	
Seriphium plumosum	Bankrupt bush / Bankrotbos
Setaria sphacelata var sphacelata	Small creeping foxtail / Kleinkruipmannagras
Silene burchellii var. angustifolia	
Solanum panduriforme	Poison apple / Gifappel
Sporobolus stapfianus	Fibrous dropseed / Veselfynsaadgras

SCIENTIFIC NAME	COMMON NAMES
Syncolostemon pretoriae	Dwarf sage bush
*Tagetes minuta**	Tall khaki weed / Lang kakiebos
Talinum caffrum[2]	Porcupine root / Ystervarkwortel
Tephrosia elongata var elongata	
Themeda triandra	Red grass / Rooigras
Thesium sp 3	
Thesium utile	Besembossie
Tricholaena monachne	Blue seed grass / Blousaadgras
Trichoneura grandiglumis var grandiglumis	Small rolling grass / Klein rolgras
Tristachya rehmannii	Broom trident grass / Besem drieblomgras
Vernonia galpinii	Kwasbossie
Vernonia natalensis[1,2]	Silver vernonia / Silwervernonia
Vernonia oligocephala[1,2]	Cape vernonia / Blounaaldetee bossie
Vernonia staehelinoides	
Xerophyta retinervis[1,2]	Monkey's tail / Bobbejaanstert
Zaluzienskya elongata	
Zornia linearis	

6.9 Acacia – Celtis *disturbed savanna*

6.9.1 Compositional aspects and Connectivity

The *Acacia – Celtis* disturbed savanna contained many elements of the neighbouring Marikana Thornveld (Mucina and Rutherford 2006) and was by far the largest study unit on the site. It was very disturbed by the presence of alien species. Connectivity with natural vegetation existed to the west. In comparison with the other study units that showed a high species diversity, the species diversity of the *Acacia – Celtis* disturbed savanna study unit was relatively low. Of the 412 plant species recorded on the site 87 were recorded in this study unit. Of these, 63 were indigenous species. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	41
Tree species	21
Shrubs and dwarf shrubs	9
Grasses	12
Geophytes	3
Succulents	1
Total No of species	87

6.9.2 Red– and Orange List species

The habitat of this study unit was not suitable for any of the Red List species or Orange List species known to occur in the two quarter-degree grid cells.

6.9.3 Medicinal and alien species

Eighteen of the 55 medicinal species recorded on the site and 24 of the 45 alien species recorded on the site were found in the *Acacia – Celtis* disturbed savanna study unit. Of the alien species, five were Category 1 Declared weeds, four were Category 2 Declared invaders and three were Category 3 Declared invaders.

6.9.4 Sensitivity

The vegetation of this study unit was not considered sensitive.

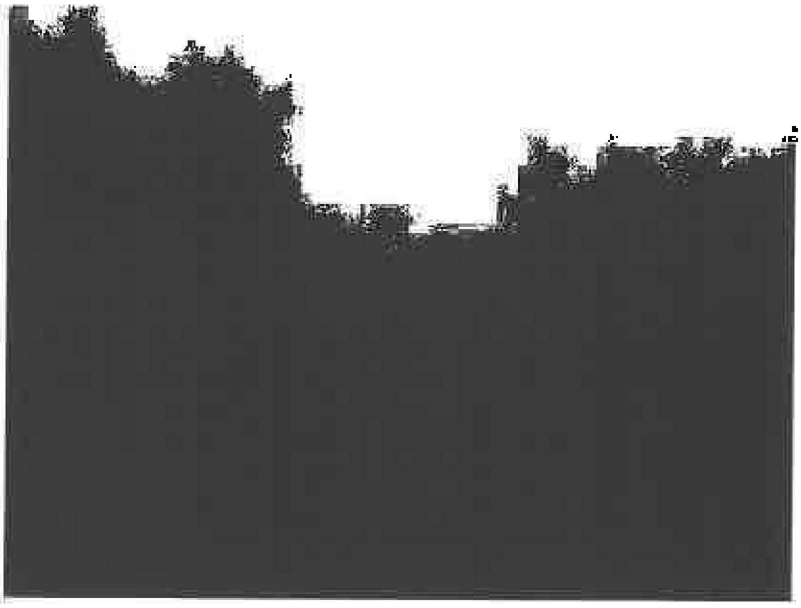


Figure 8: Dense vegetation in the *Acacia – Celtis* disturbed savanna.

Table 6: Plants recorded in the *Acacia – Celtis* disturbed savanna

SCIENTIFIC NAME	INV CAT	COMMON NAMES
Acacia caffra		Common hook thorn / Gewone haakdoring
*Acacia decurrens**	2	Green wattle / Groenwattel
Acacia karroo[1,2]		Sweet thorn / Soetdoring
*Acacia melanoxylon**	2	Australian blackwood / Australiese swarthout
Acacia nilotica subsp kraussiana		Scented pod / Lekkerruikpeul
Acacia sieberiana var woodii		Paper-bark thorn / Papierbasdoring
Achyranthus aspera var aspera*	**1**	**Chaff flower / Langklits**
Afrocanthium gilfillanii		Velvet rock alder / Fluweelklipels
Afrocanthium mundianum		Rock alder / Klipels
Aloe marlothii subsp marlothii[1,2,4]		Mountain aloe / Bergaalwyn
Araujia sericifera*	**1**	**Moth catcher / Motvanger**
Aristida congesta subsp *barbicollis*		Spreading threeawn grass / Witsteekgras
Asparagus suaveolens		Wild asparagus / Katdoring
*Bidens bipinnata**		Spanish blackjack / Spaanse knapsekêrel
*Bidens pilosa**		Blackjack / knapsekêrel
Bonatea antennifera		Terrestrial orchid / Grondorgidie
Campuloclinium macrocephalum*	**1**	**Pom pom weed / Pompombossie**
Celtis africana		White stinkwood / Witstinkhout
Cheilanthes involuta var obscura[1,2]		Involuted lip fern / Lipvaring
Chlorophytum bowkeri		
Cirsium vulgare*	**1**	**Scotch thistle / Skotse dissel**
Clematis brachiata[2]		Traveler's joy / Klimop
Cleome monophylla		
Commelina africana var lancispatha		
*Commelina benghalensis**		Wandering jew / Wandelende jood
Convolvulus sagittatus		
Conyza podocephala		
*Cosmos bipinnatus**		Cosmos / kosmos
Cyathula cf uncinulata		
Cynoglossum hispidum		Hound's tongue / Ossetongblaar
Digitaria diagonalis var diagonalis		Brown-seed finger grass / Bruinsaadvingergras
Diospyros lycioides subsp guerkei		Bushveld bluebush / Bosveldbloubos
Dovyalis zeyheri		Wild apricot / Wilde appelkoos
Ehretia rigida subsp nervifolia[2,4]		Puzzle bush / Deurmekaarbos
Eleusine coracana subsp africana		Goose grass / Osgras

SCIENTIFIC NAME	INV CAT	COMMON NAMES
Eragrostis chloromelas		Curly leaf / Krulblaar
Eragrostis curvula		Weeping love grass / Oulandsgras
_Eucalyptus sp_*	2	Gum tree / Bloekom
Euclea crispa subsp crispa[4]		Blue guarri / Bloughwarrie
Felicia muricata subsp _muricata_[3]		White felicia / Blouheuning karooblom
Gladiolus crassifolius		
_Gleditsia triacanthos_*	2	Honey locust / Driedoring
Gomphocarpus fruticosus subsp fruticosus[1,2]		Milkweed / melkbos
Gymnosporia buxifolia[2]		Spikethorn / pendoring
Helichrysum dasymallum		
Helichrysum rugulosum[2,3]		
Hyparrhenia hirta		Common thatching grass / Dekgras
Hyparrhenia tamba		Blue thatching grass / Blou tamboekiegras
Ipomoea obscura var obscura		Wild petunia / Wilde patat
_Jacaranda mimosifolia_*	3	Jakaranda
Lantana rugosa[2,3]		Bird's brandy / Voëlbrandewyn
Leucas martinicensis		Bobbin weed / Kleintolbossie
Lippia javanica[1,2,3]		Fever tea / Koorsbossie
_Melia azedarach_*	3	Syringa / sering
Melinis repens subsp repens		Red top grass
_Morus alba_*	3	Common mulberry / Gewone moerbei
Oxalis obliquifolia		Sorrel / suring
Pavonia burchellii		
Pelargonium luridum[1,2]		Stalkflowered pelonium / Wildemalva
_Pennisetum clandestinum_*		Kikuyu / kikoejoe
Pentarrhinum insipidum		Donkieperske
_Physalis angulata_*		Wild gooseberry / Wilde appeliefie
Pollichia campestris		Waxberry / teesuikerbossie
_Prunus persica_*		Peach / perske
Pseudognaphalium oligandrum		
_Richardia brasiliensis_*		Tropical richardia / Tropiese richardia
_Salvia tiliifolia_*		
Searsia discolor		Gwarrie
Searsia lancea		Karee / karee
Searsia leptodictya forma leptodictya		Mountain karee / Bergkaree
Searsia zeyheri[2]		Blue currant / Blou taaibos
Senecio erubescens var crepidifolius		
Setaria sphacelata var sphacelata		Small creeping foxtail / Kleinkruipmannagras
Sida dregei		Spider-leg
Sida rhombifolia subsp rhombifolia		Arrow leaf Sida / Taaiman
_Solanum mauritianum_*	1	**Bugweed / luisboom**
Sporobolus africanus		Rat's tail dropseed / Taaipol
_Tagetes minuta_*		Tall khaki weed / Lang kakiebos
Teucrium trifidum		Koorsbossie
Tragus berteronianus		Common carrot-seed grass / Gewone wortelsaadgras
Tripteris aghillana var aghillana		Bietou
_Verbena bonariensis_*		Purple top / Blouwaterbossie
Vernonia oligocephala[1,2]		Cape vernonia / Blounaaldetee bossie
Vigna vexillata var vexillata[3]		Narrow-leaved wild pea / Wilde-ertjie
Withania somnifera[1,2]		Winter cherry / Geneesblaarbossie
_Zinnia peruviana_*		Redstar zinnia / Wildejakobregop
Ziziphus mucronata subsp mucronata[1,2]		Buffalothorn / Blinkblaar-wag-'n-bietjie

6.10 *Hyparrhenia – Richardia* veld

6.10.1 Compositional aspects and Connectivity

Like the Old cultivated field study unit at the southernmost tip of the study site, the *Hyparrhenia – Richardia* veld appeared to be old cultivated fields, but differing in species composition and numbers. As the title of this study unit suggests, *Richardia brasiliensis* was one of the dominant species and formed large patches in the study unit. Of the 412 plant species recorded on the site 80 were recorded in the *Hyparrhenia – Richardia* veld study unit. Of these, 71 were indigenous species. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	47
Tree species	3
Shrubs and dwarf shrubs	6
Grasses	17
Geophytes	5
Sedges	1
Succulents	1
Total No of species	80

6.10.2 Red– and Orange List species

The habitat of this study unit was not suitable for any of the Red List species or Orange List species known to occur in the two quarter-degree grid cells.

6.10.3 Medicinal and alien species

Twelve of the 55 medicinal species recorded on the site and nine of the 45 alien species recorded on the site were found in this study unit. Of the alien species, two were Category 1 Declared weeds and two were Category 2 Declared invaders.

6.10.4 Sensitivity

The vegetation of this study unit was tot considered sensitive.

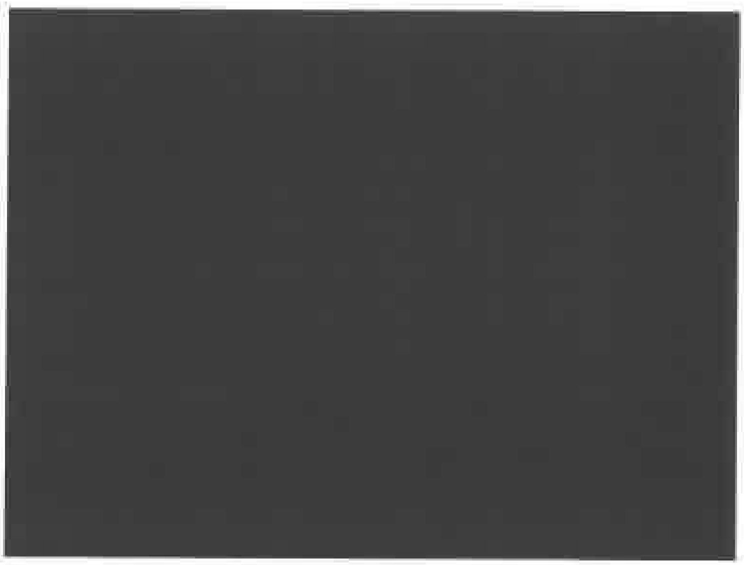


Figure 9: Dense patches of *Richardia brasiliensis* in the *Hyparrhenia – Richardia* veld

Table 7: Plants recorded in the *Hyparrhenia* – *Richardia* veld

SCIENTIFIC NAME	INV CAT	COMMON NAMES
*Acacia decurrens**	2	Green wattle / Groenwattel
Acacia karroo[1,2]		Sweet thorn / Soetdoring
*Acanthospermum australe**		Prostrate starbur / Kruipsterklits
Aloe greatheadii var davyana[1,2]		Kleinaalwyn
Aristida congesta subsp *congesta*		Tassle threeawn grass / Katstertstoekgras
Athrixia elata		Wild tea / Bostee
Campuloclinium macrocephalum*	**1**	**Pom pom weed / Pompombossie**
Chamaecrista mimosoides		
Cleome maculata		
Cleome monophylla		
Cleome rubella		Pretty lady / Mooinooientjie
Commelina africana var africana		
Commelina africana var krebsiana		
*Conyza albida**		Tall fleabane / Vaalskraalhans
Crinum graminicola		Graslelie
Cucumis zeyheri		Wild cucumber / Wilde agurkie
Cynodon dactylon		Couch grass / Kweek
Cyperus esculentus var esculentus		Yellow nutsedge / Geeluintjie
Dichilus lebeckioides		
Dicoma anomala subsp anomala[1,2,3]		Maagbitterwortel
Dicoma macrocephala		
Digitaria diagonalis var diagonalis		Brown-seed finger grass / Bruinsaadvingergras
Eragrostis chloromelas		Curly leaf / Krulblaar
Eragrostis gummiflua		Gum grass / Gomgras
Eragrostis racemosa		Narrow heart love grass / Smalhartjiesgras
Eriosema burkei var burkei		
Eucalyptus sp*	2	Gum tree / Bloekom
Felicia muricata subsp *muricata*[3]		White felicia / Blouheuning karooblom
Gisekia pharnacioides var pharnacioides		
Gladiolus permeabilis subsp edulis		Kleinaandblom
Gomphocarpus fruticosus subsp fruticosus[1,2]		Milkweed / melkbos
*Gomphrena celosioides**		Bachelor's button / Mierbossie
Helichrysum caespititium		Speelwonderboom
Helichrysum callicomum		
Helichrysum rugulosum[2,3]		
Heteropogon contortus		Spear grass / Assegaaigras
Hyparrhenia hirta		Common thatching grass / Dekgras
Hyparrhenia tamba		Blue thatching grass / Blou tamboekiegras
Hypoxis acuminata		
Hypoxis rigidula var rigidula		Silver-leaved star flower / Wilde tulp
Indigofera comosa		
Indigofera oxalidea		
Ipomoea ommaneyi[2]		Beespatat
Kohautia virgata		
Lantana rugosa[2,3]		Bird's brandy / Voëlbrandewyn
Lippia javanica[1,2,3]		Fever tea / Koorsbossie
Lotononis calycina		Hairy lotononis
Melinis repens subsp repens		Red top grass
Monsonia angustifolia		Crane's bill / Angelbossie
Nemesia fruticans		Wilde leeubekkie
Nidorella hottentotica		
Panicum natalense		Natal panicum / Suurbuffelsgras
Pelargonium dolomiticum		
Pelargonium luridum[1,2]		Stalkflowered pelonium / Wildemalva
Pentarrhinum insipidum		Donkieperske
Perotis patens		Cat's tail / Katstertgras
Phyllanthus parvulus var parvulus		Dye bush / Kleurbossie
Pogonarthria squarrosa		Herring bone grass / Sekelgras

SCIENTIFIC NAME	INV CAT	COMMON NAMES
Pollichia campestris		Waxberry / teesuikerbossie
Polygala hottentotta[2,3]		Small purple broom
Pseudognaphalium oligandrum		
Pteris vittata		Narrow-leaved brake / Smalblaar ruigtevaring
Rhynchosia monophylla		
*Richardia brasiliensis**		Tropical richardia / Tropiese richardia
Scabiosa columbaria[1,2,3]		Wild scabiosa / Bitterbos
Schizachyrium sanguineum		Red autumn grass / Rooi herfsgras
Selago densiflora		Koningstapyt
Senecio erubescens var crepidifolius		
Senecio inaequidens		Canary weed / Geelopslag
Seriphium plumosum		Bankrupt bush / Bankrotbos
Setaria sphacelata var sphacelata		Small creeping foxtail / Kleinkruipmannagras
Sida dregei		Spider-leg
Solanum lichtensteinii		Giant bitter apple / Bitterappel
Solanum rubetorum		/ Wildelemoentjie
Solanum sisymbriifolium*	**1**	**Wild tomato / Doringbitterappel**
Sporobolus africanus		Rat's tail dropseed / Taaipol
Trichoneura grandiglumis var grandiglumis		Small rolling grass / Klein rolgras
*Verbena bonariensis**		Purple top / Blouwaterbossie
Vernonia poskeana subsp botswanica		
Wahlenbergia sp		

6.11 Alien thicket

6.11.1 Compositional aspects and Connectivity

This study unit comprised thickets of trees that were dominated by one or two alien woody species. One such thicket of mainly *Populus alba* occurred in the *Hyparrhenia – Helichrysum* veld. This thicket may conceal a pan, which will be discussed under Wetland vegetation. Another, comprising *Eucalyptus* sp, occurred in the *Acacia – Celtis* disturbed savanna northeast of Road D1342. Large numbers of *Acacia decurrens* grew at the western boundary of the study site on both sides of Road D1342 and thickets of this species also meanders through the township near the northern boundary of the site. Of the 412 plant species recorded on the site 12 were recorded in this study unit. Of these, 8 were indigenous species, of which most were grasses. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	2
Tree species	4
Grasses	5
Geophytes	1
Total No of species	12

6.11.2 Red– and Orange List species

The habitat of this study unit was not suitable for any of the Red List species or Orange List species known to occur in the two quarter-degree grid cells.

6.11.3 Medicinal and alien species

Four alien tree species, all Category 2 Declared Invaders, were recorded in this study unit. No medicinal species were recorded in the Alien thicket study unit.

6.11.4 Sensitivity

The vegetation of this study unit was not considered sensitive.

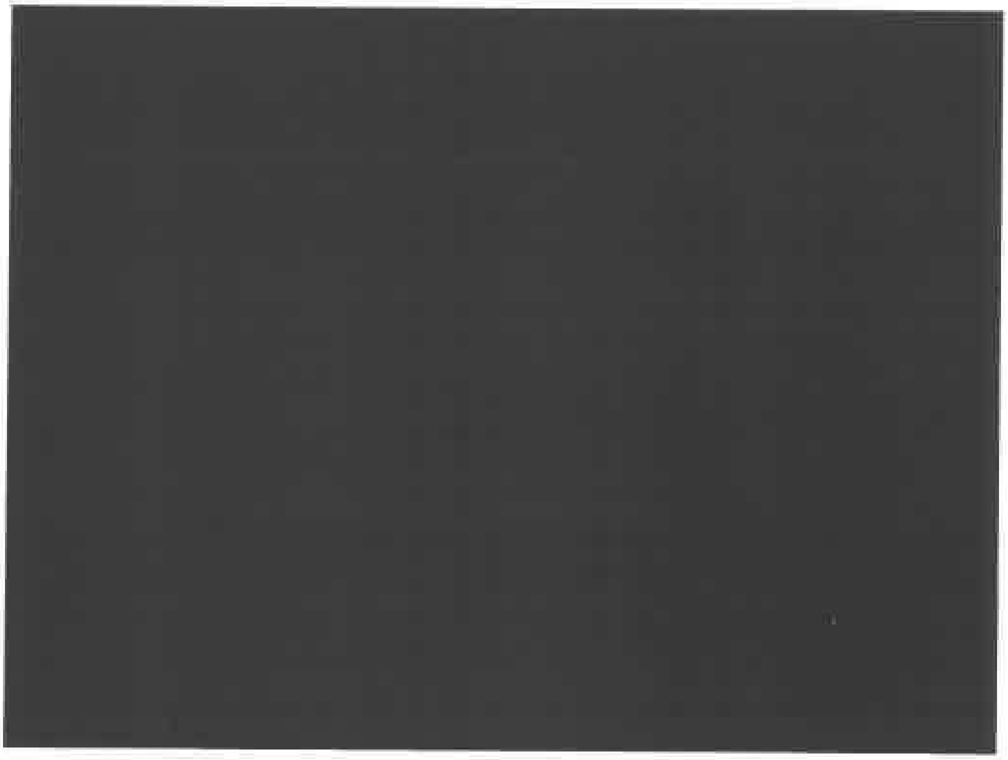


Figure 10: A *Eucalyptus* thicket in the *Acacia – Celtis* disturbed savanna.

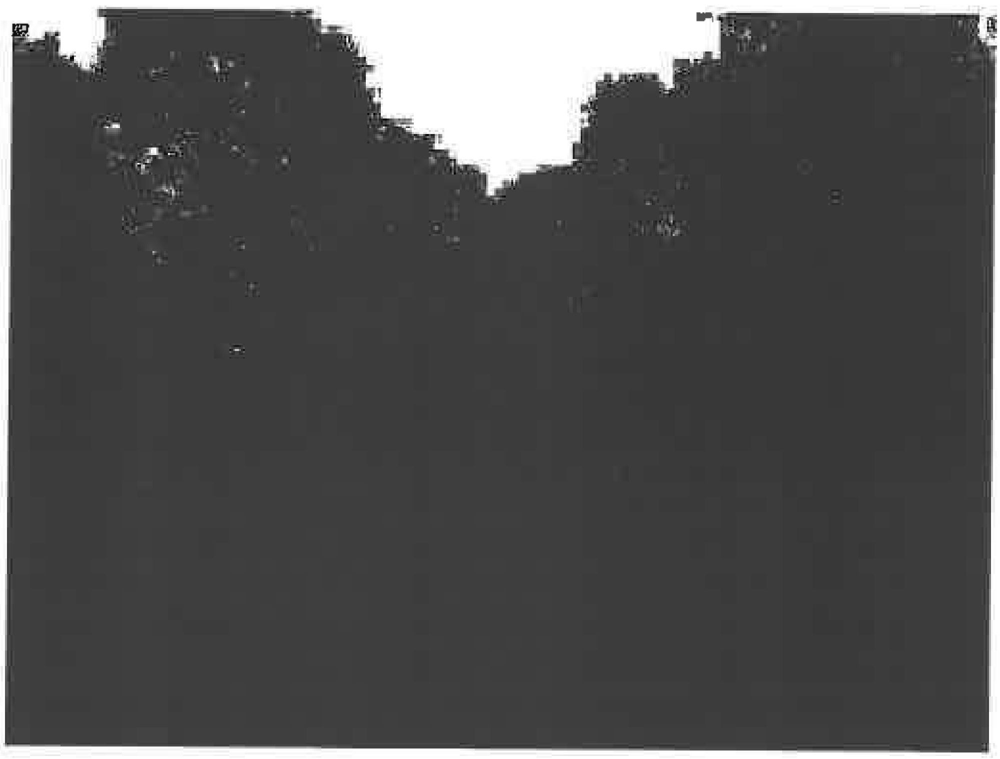


Figure 11: Eucalyptus and Wattle thicket surrounding the earthen dam at the end of the drainage line.

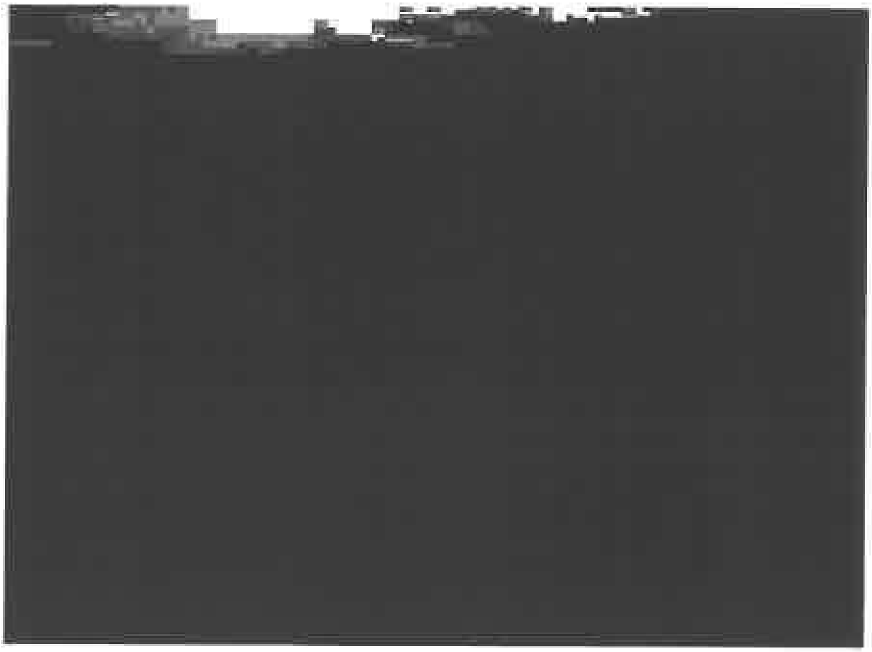


Figure 12: *Populus alba* thicket that might conceal a wetland in the *Hyparrhenia – Helichrysum* veld

Table 8: Plants recorded in the Alien thicket

SCIENTIFIC NAME	INV CAT	COMMON NAMES
*Acacia decurrens**	2	Green wattle / Groenwattel
*Acacia melanoxylon**	2	Australian blackwood / Australiese swarthout
Acalypha angustata		Copper leaf / Katpisbossie
Aristida congesta subsp *barbicollis*		Spreading threeawn grass / Witsteekgras
Cynodon dactylon		Couch grass / Kweek
Eragrostis chloromelas		Curly leaf / Krulblaar
Eragrostis curvula		Weeping love grass / Oulandsgras
Eragrostis plana		Tough love grass / Taaipoleragrostis
Eucalyptus sp*	2	Gum tree / Bloekom
Gladiolus crassifolius		
*Populus alba**	2	White poplar / Witpopulier
Tephrosia semiglabra		

6.12 Wetland vegetation

6.12.1 Compositional aspects and Connectivity

Three, and possibly four, wetland areas occurred on the study site and one within 200 meters of the northern boundary of the site. The drainage line that runs through the *Trachyandra – Digitaria* ridge vegetation south of the township was very disturbed by the presence of alien species, particularly Kikuyu grass (*Pennisetum clandestinum*). The drainage line flows into an earthen dam completely surrounded by *Eucalyptus* sp and *Acacia decurrens* thickets. Connectivity of this drainage line with other wetland vegetation did not exist.

The second wetland is a pan southwest of Road D1342 in the *Acacia – Celtis* disturbed savanna. This wetland was likewise disturbed with some of the alien species that have invaded the *Acacia – Celtis* disturbed savanna also occurring in that wetland. Connectivity of this pan with other wetland vegetation did not exist.

A thicket of *Populus alba*, which may conceal a small pan, occurred in the *Hyparrhenia – Helichrysum* veld.
In contrast, the wetland in the Moist *Eragrostis* grassland near the southern tip of the study site was almost unspoilt. Although the wetland outside, but within 200 meters of, the northern boundary of the site was not surveyed, it appeared to be unspoilt except for the presence of *Verbena bonariensis* in rather large numbers.

Of the 412 plant species recorded on the site 49 were recorded in the Wetland vegetation study unit. Of these, 42 were indigenous species. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	22
Tree species	1
Shrubs and dwarf shrubs	2
Grasses	11
Geophytes	2
Sedges	11
Total No of species	49

6.12.2 Red– and Orange List species

The habitat of the Wetland vegetation was suitable for the Red List species *Trachyandra erythrorrhiza*, which flowers from September to November. The plant and its spent inflorescence can be seen without difficulty outside its flowering time. None was found in the Wetland vegetation during any of the surveys.

The habitat was not suitable for any of the Orange List species known to occur in the two quarter-degree grid cells.

6.12.3 Medicinal and alien species

Four medicinal species were recorded in this study unit. Seven of the 45 alien species recorded on the site were found in this study unit. Of these, one was a Category 2 Declared invader.

6.12.4 Sensitivity

As wetlands form biological filters and drainage lines form corridors for the movement of species, which include pollinators of plant species, all the parts of this study unit were considered sensitive and should be excluded from development. A wetland specialist should determine the extent of the three wetland areas on the site and also whether the *Populus alba* thicket that occurred in the *Hyparrhenia – Helichrysum* veld concealed a wetland and if it does, what the extant of the wetland was.

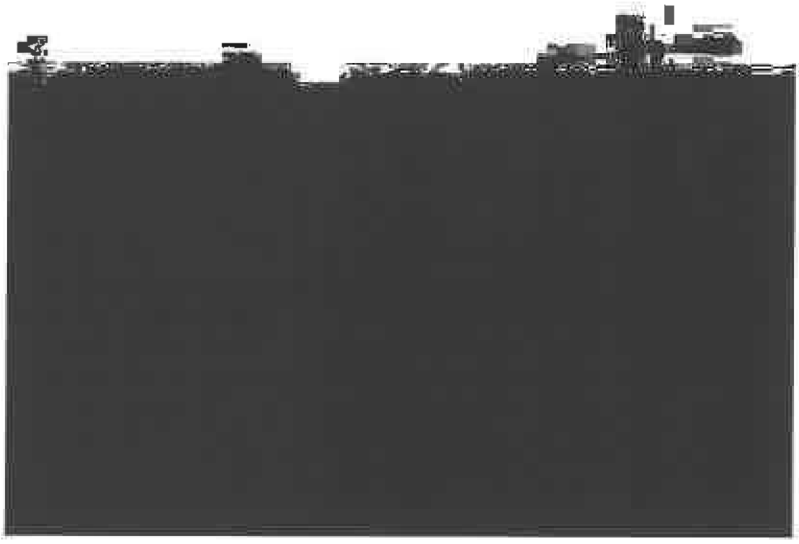


Figure 13: Drainage line and wetland below the township.

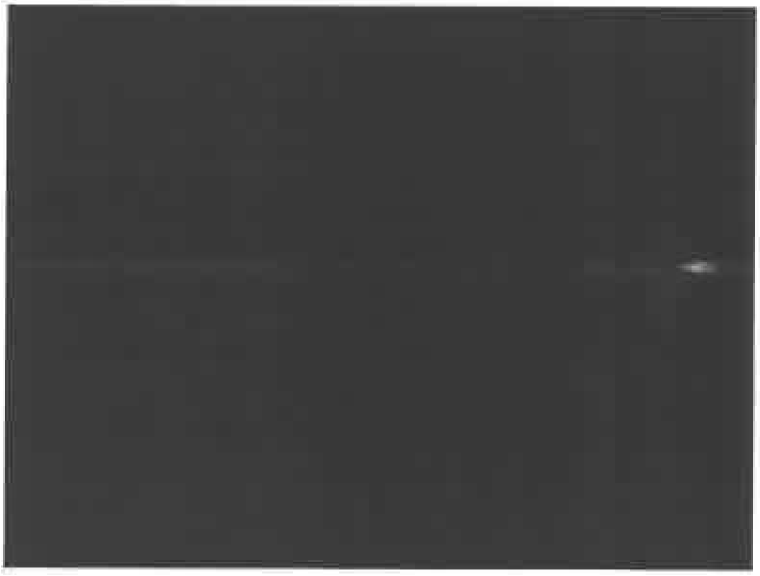


Figure 14: Earthen dam in the Moist *Eragrostis* grassland.

Table 9: Plants recorded in the Wetland vegetation

SCIENTIFIC NAME	INV CAT	COMMON NAMES
Andropogon chinensis		Hairy blue grass / Harige blougras
Andropogon eucomus		Old man's beard / Klein wilbaardgras
Berkheya radula		Boesmanrietjie
Calamagrostis epigeios var capensis		
Chironia palustris subsp transvaalensis		
Ciclospermum leptophyllum		Wild celery / Wildeseldery
Cladium mariscus subsp jamaicense		
Commelina africana var africana		
Cynodon dactylon		Couch grass / Kweek
Cyperus sp 1		
Cyperus sp 2		
Dryopteris athamantica		Buckler fern / Regop skildvaring
Eragrostis gummiflua		Gum grass / Gomgras
Erica drakensbergensis		

SCIENTIFIC NAME	INV CAT	COMMON NAMES
Eucalyptus sp*	2	Gum tree / Bloekom
Fimbristylis complanata		
Fuirena pubescens var. pubescens		
Gladiolus sp		
Gnidia microcephala		Besembossie
Helichrysum aureonitens[2]		Golden everlasting / Goue sewejaartjie
Helichrysum difficile		Everlasting / sewejaartjie
Helichrysum dregeanum		
Hypericum lalandii		Spindly hypericum / Laland se sintjanskruid
Imperata cylindrica		Cottonwool grass / Donsgras
Jamesbrittenia aurantiaca		Cape saffron / Saffraanbossie
Juncus lomatophyllus		
Juncus sp		
Kyllinga erecta var erecta		Green button sedge / Groenknoop biesie
Leersia hexandra		Wild rice grass / Wilderysgras
Monopsis decipiens		Butterfly lobelia / Skoenlapperplant
Morella serrata[4]		Lance leaved waxberry / Smalblaarwasbessie
*Paspalum dilatatum**		Common paspalum / Gewone paspalum
Pelargonium luridum[1,2]		Stalkflowered pelonium / Wildemalva
*Pennisetum clandestinum**		Kikuyu / kikoejoe
Persicaria attenuata subsp africana		Bristly snake root / Slangwortel
*Persicaria lapathifolia**		Spotted knotweed / Hanekam
Pycnostachys reticulata		
Pycreus sp		
*Ranunculus multifidus**		Common buttercup / Geelbotterblom
Rhynchospora brownii		
Rorippa nudiuscula		
Schoenoplectus corymbosis		
Senecio consanguineus		Starvation seneci / Hongerbos senecio
Seriphium plumosum		Bankrupt bush / Bankrotbos
Setaria incrassata		Vlei bristle grass / Vleimannagras
Setaria pumila		Garden bristle grass / Tuin mannagras
Typha capensis[1,2]		Bulrush / papkuil
*Verbena bonariensis**		Purple top / Blouwaterbossie
Verbena sp*		

6.13 *Hyparrhenia – Helichrysum* veld

6.13.1 Compositional aspects and Connectivity

This study unit comprised disturbed grassland that had not been burned for some time. The canopy cover was thick with grass and other dried herbaceous plants, particularly *Helichrysum rugulosum*. A thicket of *Populus alba*, which may conceal a small pan, occurred in the *Hyparrhenia – Helichrysum* veld. A wetland specialist should determine whether the *Populus alba* thicket concealed a wetland and if it does, what the extent of the wetland was. Of the 412 plant species recorded on the site 47 were recorded in this study unit. Of these, 42 were indigenous species. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	27
Tree species	4
Shrubs and dwarf shrubs	5
Grasses	4
Geophytes	7
Total No of species	47

6.13.2 Red– and Orange List species

The habitat of this study unit was not suitable for any of the Red List species, but was suitable for the Orange List *Hypoxis hemerocallidea* (African potato), which was found sparsely scattered in the *Hyparrhenia – Helichrysum* veld.

6.13.3 Medicinal and alien species

Thirteen of the 55 medicinal species recorded on the site and five of the 45 alien species recorded on the site were found in the *Hyparrhenia – Helichrysum* veld study unit. Of the alien species, one was a Category 1 Declared weed.

6.13.4 Sensitivity

The vegetation of this study unit was not considered sensitive.

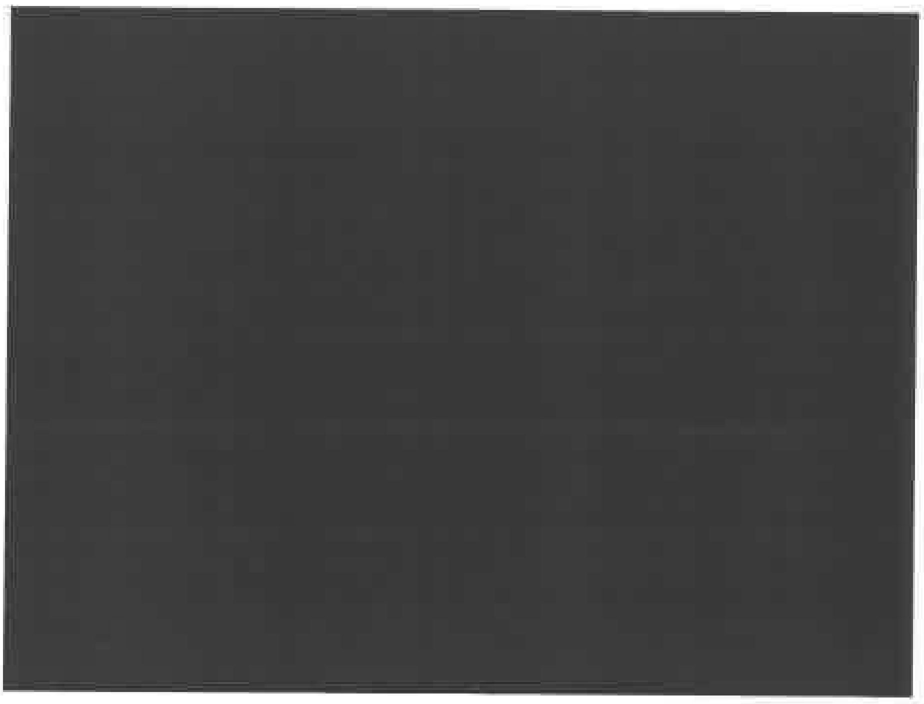


Figure 15: Dense grass cover in the *Hyparrhenia – Helichrysum* veld.

Table 10: Plants recorded in the *Hyparrhenia – Helichrysum* veld

SCIENTIFIC NAME	INV CAT	COMMON NAMES
Acacia caffra		Common hook thorn / Gewone haakdoring
Acacia karroo[1,2]		Sweet thorn / Soetdoring
Alysicarpus rugosus subsp perennirufus		Pioneer fodder plant
Campuloclinium macrocephalum*	**1**	**Pom pom weed / Pompombossie**
Chamaecrista mimosoides		
Cheilanthes viridis var glauca		Blue cliff brake / Blou kransruigtevaring
Clematis brachiata[2]		Traveler's joy / Klimop
*Conyza albida**		Tall fleabane / Vaalskraalhans
Crotalaria brachycarpa		Jaagsiektebossie
Cucumis zeyheri		Wild cucumber / Wilde agurkie
Cycnium adonense		Ink plant / Inkblom
Ehretia rigida subsp nervifolia[2,4]		Puzzle bush / Deurmekaarbos
Elephantorrhiza elephantina[1,2,3]		Elephant's root / Olifantswortel
Eragrostis chloromelas		Curly leaf / Krulblaar

SCIENTIFIC NAME	INV CA T	COMMON NAMES
Eragrostis curvula		Weeping love grass / Oulandsgras
Eriosema burkei var burkei		
Eriosema cordatum		
Eulophia sp		Ground orchid / Grondorgidee
Gladiolus crassifolius		
Gladiolus dalenii subsp dalenii[3]		Wild gladiolus / Wildeswaardlelie
Helichrysum nudifolium var nudifolium[1,2]		Hottentot's tea / Hottentotstee
Helichrysum rugulosum[2,3]		
Hermannia depressa[2,3]		Creeping red Hermannia / Rooiopslag
Hibiscus microcarpus		
Hyparrhenia hirta		Common thatching grass / Dekgras
Hyparrhenia tamba		Blue thatching grass / Blou tamboekiegras
Hypoxis hemerocallidea[1,2,3]		African potato / Gifbol
Hypoxis cf longifolia		
Hypoxis rigidula var rigidula		Silver-leaved star flower / Wilde tulp
Indigofera oxalidea		
Ipomoea oblongata[2]		
Lippia javanica[1,2,3]		Fever tea / Koorsbossie
Lotononis calycina		Hairy lotononis
*Oenothera tetraptera**		White evening primrose / Witaandblom
Plectranthus madagascariensis var ramosior		
*Prunus persica**		Peach / perske
Secamone sp		
Senecio affinis		
Senecio erubescens var crepidifolius		
Seriphium plumosum		Bankrupt bush / Bankrotbos
Sonchus dregeanus		
Tephrosia semiglabra		
Teucrium trifidum		Koorsbossie
*Verbena bonariensis**		Purple top / Blouwaterbossie
Vernonia oligocephala[1,2]		Cape vernonia / Blounaaldetee bossie
Vigna unguiculata subsp stenophylla		
Vigna vexillata var vexillata[3]		Narrow-leaved wild pea / Wilde-ertjie

6.14 Hyparrhenia – Eragrostis grassland

6.14.1 Compositional aspects and Connectivity

The species diversity of this study unit was low, suggesting that it might be an old cultivated field that have in the past been planted with pasture grasses, specifically *Eragrostis chloromelas* and *Eragrostis curvula* as was apparently done on the neighbouring property to the east where cattle grazed in planted pasture between circular maize fields. Shrubs occurred sparsely in this study unit. Connectivity with neighbouring natural grassland did not exist. Of the 412 plant species recorded on the site 38 were recorded in the *Hyparrhenia – Eragrostis* grassland study unit. Of these, 33 were indigenous species. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	29
Shrubs and dwarf shrubs	3
Grasses	3
Geophytes	3
Total No of species	38

6.14.2 Red– and Orange List species

The habitat of this study unit was not suitable for any of the Red List species, but was suitable for the Orange List species *Eucomis autumnalis* (Pineapple flower) known to occur in the quarter degree grid cells. None was, however, found.

6.14.3 Medicinal and alien species

Ten of the 55 medicinal species recorded on the site and five of the 45 alien species recorded on the site were found in this study unit. Of the alien species, one was a Category 1 Declared weed.

6.14.4 Sensitivity

The vegetation of this study unit was not considered sensitive.

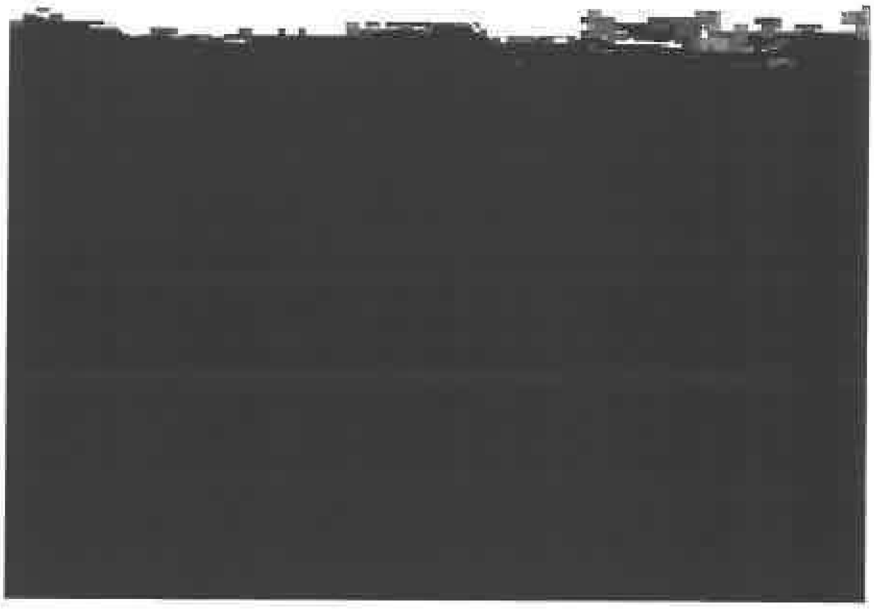


Figure 16: *Hyparrhenia – Eragrostis* grassland.

Table 11: Plants recorded in the *Hyparrhenia – Eragrostis* grassland

SCIENTIFIC NAME	COMMON NAMES
Achyranthus aspera var aspera*	**Chaff flower / Langklits**
Afrosciadium magalismontanum[2]	Wild parsley / Wildepietersielie
Anthospermum rigidum subsp rigidum	
Chamaecrista mimosoides	
*Conyza albida**	Tall fleabane / Vaalskraalhans
Conyza pinnata	
Corchorus confusus	
*Cosmos bipinnatus**	Cosmos / kosmos
Diospyros lycioides subsp guerkei	Bushveld bluebush / Bosveldbloubos
Eragrostis chloromelas	Curly leaf / Krulblaar
Eragrostis curvula	Weeping love grass / Oulandsgras
Gladiolus crassifolius	
Helichrysum nudifolium var nudifolium[1,2]	Hottentot's tea / Hottentotstee
Helichrysum rugulosum[2,3]	
Hermannia depressa[2,3]	Creeping red Hermannia / Rooiopslag
Hyparrhenia hirta	Common thatching grass / Dekgras
Hypoxis iridifolia	

SCIENTIFIC NAME	COMMON NAMES
Hypoxis rigidula var rigidula	Silver-leaved star flower / Wilde tulp
Ipomoea crassipes var crassipes[2,3]	Leafy-flowered Ipomoea / Wildewinde
Kohautia amatymbica[2]	Tremble tops
Kohautia virgata	
Leucas martinicensis	Bobbin weed / Kleintolbossie
Lippia javanica[1,2,3]	Fever tea / Koorsbossie
Monsonia angustifolia	Crane's bill / Angelbossie
Pentarrhinum insipidum	Donkieperske
Polygala sp	
Rhynchosia totta var totta	Yellow carpet bean / Tottabossie
*Salvia tiliifolia**	
Scabiosa columbaria[1,2,3]	Wild scabiosa / Bitterbos
Senecio affinis	
Sida spinosa var spinosa	
Solanum panduriforme	Poison apple / Gifappel
Sonchus wilmsii	Milk thistle / Melkdissel
Tephrosia semiglabra	
Thesium sp 1	
*Verbena bonariensis**	Purple top / Blouwaterbossie
Vernonia oligocephala[1,2]	Cape vernonia / Blounaaldetee bossie
Vigna vexillata var vexillata[3]	Narrow-leaved wild pea / Wilde-ertjie

6.15 Moist *Eragrostis* grassland

6.15.1 Compositional aspects and Connectivity

This study unit comprised natural moist grassland with a wetland on its western boundary. Its percentage of herbaceous plant was remarkably high. Connectivity with natural grassland existed to the west. Of the 412 plant species recorded on the site 63 were recorded in the Moist *Eragrostis* grassland. Of these, 55 were indigenous species. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	42
Shrubs and dwarf shrubs	5
Grasses	9
Geophytes	7
Total No of species	63

6.15.2 Red– and Orange List species

The habitat of the Moist *Eragrostis* grassland was suitable for the Red List species *Argyrolobium campicola*, but none was observed during the surveys.

The habitat of this study unit was suitable for the Orange List species *Eucomis autumnalis* (Pineapple flower) and *Hypoxis hemerocallidea* (African potato), the latter of which was found sparsely scattered in the Moist *Eragrostis* grassland.

6.15.3 Medicinal and alien species

Eleven of the 55 medicinal species recorded on the site and eight of the 45 alien species recorded on the site were found in this study unit. Of the alien species one was a Category 1 Declared weed.

6.15.4 Sensitivity

The vegetation of this study unit was not considered sensitive, but because the wetland vegetation encroaches into this study unit, a wetland specialist should determine the extent of the wetland.

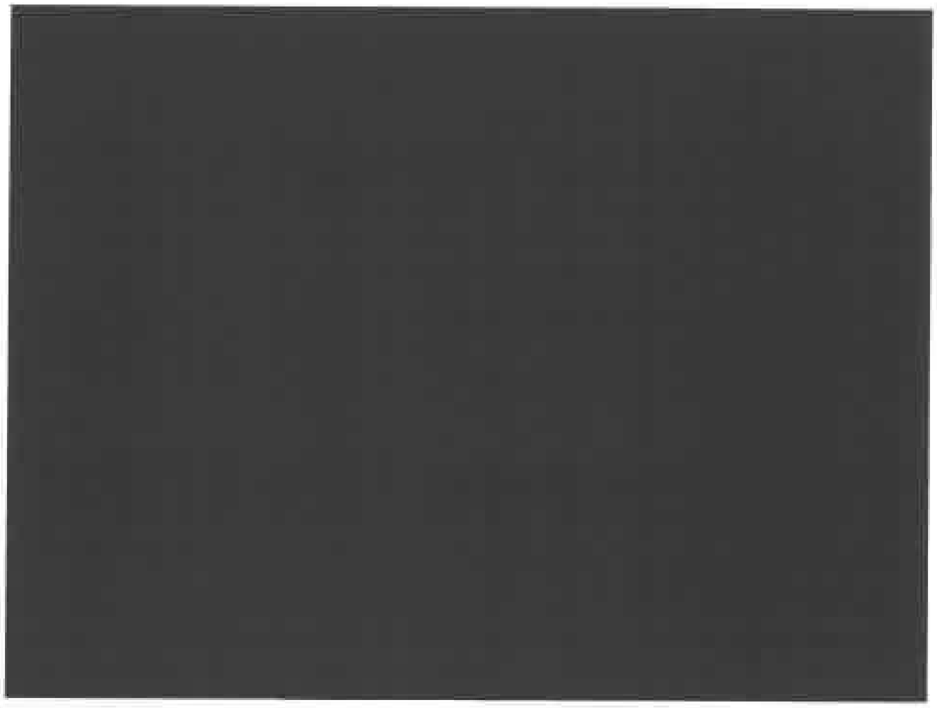


Figure 17: Moist *Eragrostis* grassland.

Table 12: Plants recorded in the Moist *Eragrostis* grassland

SCIENTIFIC NAME	COMMON NAMES
Afrosciadium magalismontanum[2]	Wild parsley / Wildepietersielie
Alysicarpus rugosus subsp perennirufus	Pioneer fodder plant
Anthospermum rigidum subsp rigidum	
Aristea torulosa	
Aristida bipartita	Rolling grass / Grootrolgras
Asclepias sp	
Brachiaria eruciformis	Sweet signal grass / Litjies-sinjaalgras
Campuloclinium macrocephalum*	**Pom pom weed / Pompombossie**
Chamaecrista mimosoides	
Ciclospermum leptophyllum	Wild celery / Wildeseldery
Colchicum melanthioides var melanthioides	Pajama flower / Patrysbom
Conyza podocephala	
Corchorus confusus	
Crabbea hirsuta[2,3]	Prickle head
Crotalaria brachycarpa	Jaagsiektebossie
Cucumis myriocarpus subsp myriocarpus	
Diospyros lycioides subsp guerkei	Bushveld bluebush / Bosveldbloubos
Dipcadi viride	Slymuintjie
Drimia depressa	
Eragrostis chloromelas	Curly leaf / Krulblaar
Eragrostis gummiflua	Gum grass / Gomgras
Eragrostis plana	Tough love grass / Taaipoleragrostis
Eragrostis trichophora	Hairy love grass / Harige-pluimgras
Eriosema salignum	Narrow-leaved Eriosema / Smalblaar Eriosema
Geigeria burkei subsp burkei var burkei	Vermaersiektebossie
Gladiolus crassifolius	

SCIENTIFIC NAME	COMMON NAMES
Gladiolus sp	
Gomphocarpus fruticosus subsp fruticosus[1,2]	Milkweed / melkbos
Haplocarpha scaposa	False gerbera / Tonteldoosbossie
Helichrysum dregeanum	
Helichrysum nudifolium var nudifolium[1,2]	Hottentot's tea / Hottentotstee
Helichrysum rugulosum[2,3]	
Hermannia coccocarpa	
Hermannia depressa[2,3]	Creeping red Hermannia / Rooiopslag
Heteropogon contortus	Spear grass / Assegaaigras
*Hibiscus trionum**	Bladder hibiscus / Terblansbossie
Hyparrhenia hirta	Common thatching grass / Dekgras
*Hypochaeris radicata**	Hairy wild lettuce / Harige skaapslaai
Hypoxis hemerocallidea[1,2,3]	African potato / Gifbol
Indigofera oxalidea	
Ipomoea bathycolpos	Veldsambreeltjies
Ipomoea crassipes var crassipes[2,3]	Leafy-flowered Ipomoea / Wildewinde
Jamesbrittenia aurantiaca	Cape saffron / Saffraanbossie
Kohautia amatymbica[2]	Tremble tops
Lotononis foliosa	
Mimulus gracilis	Wild monkey flower
Nesaea schinzii	
Nidorella anomala	
*Oenothera rosea**	Pink evening primrose / Pienk aandblom
*Oenothera tetraptera**	White evening primrose / Witaandblom
*Paspalum dilatatum**	Common paspalum / Gewone paspalum
Polygala hottentotta[2,3]	Small purple broom
*Ranunculus multifidus**	Common buttercup / Geelbotterblom
Salvia runcinata	Wildesalie
Selago tenuifolia	
Senecio erubescens var crepidifolius	
Seriphium plumosum	Bankrupt bush / Bankrotbos
*Sesbania bispinosa var bispinosa**	
Sida dregei	Spider-leg
Solanum panduriforme	Poison apple / Gifappel
Sonchus wilmsii	Milk thistle / Melkdissel
Vernonia oligocephala[1,2]	Cape vernonia / Blounaaldetee bossie
Wahlenbergia denticulata var transvaalensis	

6.16 Mixed alien and indigenous vegetation

6.16.1 Compositional aspects

This study unit comprised natural vegetation and ornamental plants in the gardens of the township and around the residences on the rest of the study site. A survey of the gardens was not deemed necessary.

6.16.2 Red– and Orange List species

The habitat of this study unit was not suitable for any of the Red List species or Orange List species known to occur in the two quarter-degree grid cells.

6.16.3 Sensitivity

The vegetation of this study unit was not considered sensitive.

6.17 Cultivated fields

6.17.1 Compositional aspects and Connectivity

The high proportion of grasses, the presence of many annual species and the absence of perennial plants such as geophytes and woody species suggest that this study unit might have been a cultivated field in the past. The species diversity of this study unit was low. Of the 412 plant species recorded on the site 42 were recorded in this study unit. Of these, 28 were indigenous species. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	29
Shrubs and dwarf shrubs	1
Grasses	11
Sedges	1
Total No of species	42

6.17.2 Red– and Orange List species

The habitat of this study unit was not suitable for any of the Red List species or Orange List species known to occur in the two quarter-degree grid cells.

6.17.3 Medicinal and alien species

Four medicinal species were recorded in this study unit. Fourteen of the 45 alien species recorded on the site were found in this study unit. None of these species were declared invader plants.

6.17.4 Sensitivity

The vegetation of this study unit was not considered sensitive.

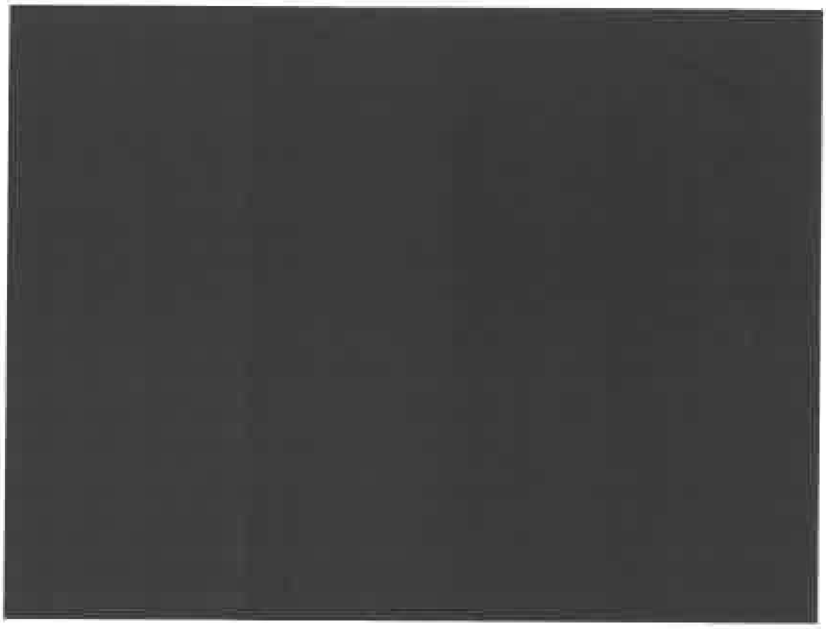


Figure 18: Old cultivated field in the southern tip of the study site.

Table 13: Plants recorded in the Cultivated fields

SCIENTIFIC NAME	COMMON NAMES
*Acanthospermum australe**	Prostrate starbur / Kruipsterklits
*Amaranthus deflexus**	Perennial pigweed / Meerjarige misbredie
Aristida adscensionis subsp adscenscionis	Annual threeawn / Eenjarige steekgras
Aristida congesta subsp *barbicollis*	Spreading threeawn grass / Witsteekgras
*Bidens bipinnata**	Spanish blackjack / Spaanse knapsekêrel
*Bidens pilosa**	Blackjack / knapsekêrel
Cleome monophylla	
Commelina africana var africana	
*Conyza albida**	Tall fleabane / Vaalskraalhans
Conyza podocephala	
*Cosmos bipinnatus**	Cosmos / kosmos
Crotalaria brachycarpa	Jaagsiektebossie
Cymbopogon nardus	Giant turpentine grass / Reuse terpentyngras
Cynodon dactylon	Couch grass / Kweek
Cyperus esculentus var esculentus	Yellow nutsedge / Geeluintjie
Eragrostis chloromelas	Curly leaf / Krulblaar
Eragrostis plana	Tough love grass / Taaipoleragrostis
Felicia muricata subsp *muricata*[3]	White felicia / Blouheuning karooblom
Gisekia pharnacioides var pharnacioides	
Gomphocarpus fruticosus subsp fruticosus[1,2]	Milkweed / melkbos
*Gomphrena celosioides**	Bachelor's button / Mierbossie
Helichrysum nudifolium var nudifolium[1,2]	Hottentot's tea / Hottentotstee
Helichrysum rugulosum[2,3]	
*Hibiscus trionum**	Bladder hibiscus / Terblansbossie
Hyparrhenia hirta	Common thatching grass / Dekgras
Hyparrhenia tamba	Blue thatching grass / Blou tamboekiegras
*Hypochaeris radicata**	Hairy wild lettuce / Harige skaapslaai
Melinis repens subsp repens	Red top grass
Monsonia angustifolia	Crane's bill / Angelbossie
Nemesia fruticans	Wilde leeubekkie
Nidorella hottentotica	
*Paspalum dilatatum**	Common paspalum / Gewone paspalum
*Richardia brasiliensis**	Tropical richardia / Tropiese richardia
Salvia runcinata	Wildesalie
Selago densiflora	Koningstapyt
Senecio consanguineus	Starvation seneci / Hongerbos senecio
*Sesbania bispinosa var bispinosa**	
Sonchus wilmsii	Milk thistle / Melkdissel
Sporobolus africanus	Rat's tail dropseed / Taaipol
*Tagetes minuta**	Tall khaki weed / Lang kakiebos
Ursinia nana subsp leptophylla	Magriet
*Verbena bonariensis**	Purple top / Blouwaterbossie

[1] Van Wyk, B-E., Van Oudtshoorn, B. & Gericke, N. 2002.
[2] Watt, J.M. & Breyer-Brandwijk, M.G. 1962.
[3] Pooley, E. 1998.
[4] Van Wyk, B. & Van Wyk P. 1997.

7. FINDINGS AND POTENTIAL IMPLICATIONS

The typography of this study site resulted in very varied vegetation types: from mountainous terrain with montane type flora to flat plains with thornveld and grassland. Twelve study units were identified. The habitat of the various study units was suitable for four Red List species, one of which was found in large numbers in the *Trachyandra – Digitaria* ridge vegetation on the crest of the Magaliesberg.

The vegetation on the crest of the Magaliesberg, except the *Aristida – Seriphium* plateau grassland, was considered sensitive and the apparent uncontrolled use of the open space by persons with off-road motorbikes was deemed detrimental to the flora in general and the Red List species in particular and may lead to the eradication of some of the plants.

8. LIMITATIONS, ASSUMPTIONS AND GAPS IN KNOWLEDGE

The site was visited at the end of summer when plants were becoming dormant and some grasses were starting to loose their inflorescences (e.g. *Elionurus muticus*).

Although the survey was done during the flowering time of the very elusive Red List *Ceropegia decidua* subsp *pretoriensis*, the habitat was very suitable for this species and it must be assumed that they also occur in the *Trachyandra* – *Digitaria* ridge vegetation.

9. RECOMMENDED MITIGATION MEASURES

The following mitigation measures are proposed by the specialist:

- Where possible, trees naturally growing on the site should be retained as part of the landscaping. Measures to ensure that these trees survive the physical disturbance from the development should be implemented. A tree surgeon should be consulted in this regard.
- Garden refuse should be collected and dumped at a central dumping site where it can be composted. Dumping of any garden refuse, including Kikuyu grass cuttings, at any other place, e.g. in the veld, should be strictly prohibited.

The following mitigation measures were developed by GDARD (Directorate of Nature Conservation, GDACE, 2008 and 2009) and are applicable to the study site. Where appropriate, Galago Environmental's specific elaborations are given in brackets.

- An appropriate management authority (e.g. the body corporate) that must be contractually bound to implement the Environmental Management Plan (EMP) and Record of Decision (ROD) during the operational phase of the development should be identified and informed of their responsibilities in terms of the EMP and ROD.
- All areas designated as sensitive in a sensitivity mapping exercise should be incorporated into an open space system. Development should be located on the areas of lowest sensitivity.
- Development structures should be clustered as close as possible to existing development.
- The open space system should be managed in accordance with an Ecological Management Plan that complies with the *Minimum Requirements for Ecological Management Plans* and forms part of the EMP.
- The Ecological Management Plan should:
    - Include a fire management programme to ensure persistence of grassland
    - include an ongoing monitoring and eradication programme for all non-indigenous species, with specific emphasis on invasive and weedy species
    - include a comprehensive surface runoff and storm water management plan, indicating how all surface runoff generated as a result of the development (during both the construction and operational phases) will be managed (e.g. artificial wetlands / storm water and flood retention ponds) prior to entering any natural drainage system or wetland and how surface runoff will be retained outside of any demarcated buffer/flood zones and subsequently released to simulate natural hydrological conditions
    - ensure the persistence of all Red and Orange List species
    - include a monitoring programme for all Red and Orange List species
    - facilitate/augment natural ecological processes
    - provide for the habitat and life history needs of important pollinators

- minimize artificial edge effects (e.g. water runoff from developed areas & application of chemicals)
  - include a comprehensive plan for limited recreational development (trails, bird hides etc.) within the open space syste
  - include management recommendations for neighbouring land, especially where correct management on adjacent land is crucial for the long-term persistence of sensitive species present on the development site
  - result in a report back to the Directorate of Nature Conservation on an annual basis
  - investigate and advise on appropriate legislative tools (e.g. the NEMA: Protected Areas Act 57 of 2003) for formally protecting the area (as well as adjacent land where it is crucial for the long-term persistence of sensitive species present on the development site)
- The open space system should be fenced off prior to construction commencing (including site clearing and pegging). All construction-related impacts (including service roads, temporary housing, temporary ablution, disturbance of natural habitat, storing of equipment/building materials/vehicles or any other activity) should be excluded from the open space system. Access of vehicles to the open space system should be prevented and access of people should be controlled, both during the construction and operational phases. Movement of indigenous fauna should however be allowed (i.e. no solid walls, e.g. through the erection of palisade fencing).
- Information boards should be erected within the development to inform residents of the presence of Red / Orange List species, their identification, conservation status and importance, biology, habitat requirements and management requirements.
- Only indigenous plant species, preferably species that are indigenous to the natural vegetation of the area, should be used for landscaping in communal areas. As far as possible, plants naturally growing on the development site, but would otherwise be destroyed during clearing for development purposes, should be incorporated into landscaped areas. Forage and host plants required by pollinators should also be planted in landscaped areas.
- In order to minimize artificially generated surface stormwater runoff, total sealing of paved areas such as parking lots, driveways, pavements and walkways should be avoided. Permeable material should rather be utilized for these purposes.
- The crossing of natural drainage systems should be minimized and only constructed at the shortest possible route, perpendicular to the natural drainage system. Where possible, bridge crossings should span the entire stretch of the buffer zone (see *Sensitivity Mapping Rules for Biodiversity Assessments* for buffer zone requirements).
- Rehabilitation of natural vegetation should proceed in accordance with a rehabilitation plan compiled by a specialist registered in terms of the Natural Scientific Professions Act (No. 27 of 2003) in the field of Ecological Science.

10. CONCLUSION

To lessen the impact of the development on the vegetation of the site, great care should be taken to group residences on smaller lots in certain areas, rather than spreading them out over large areas. Roads, footpaths, services etc should be constructed with great care.

The vegetation of the *Trachyandra – Digitaria* ridge vegetation, the *Eragrostis – Protea welwitschii* grassland and the Wetland is deemed sensitive and should be excluded from the development and where possible, these areas must be connected to other natural grassland areas on the neighbouring properties to facilitate connectivity. Dumping of builders' rubble and garden and other waste in the areas earmarked for exclusion must be prevented, through fencing or other management measures. These areas must be properly managed throughout the lifespan of the project in terms of fire, eradication of exotics etc. to ensure continuous biodiversity.

All Category 1 Declared Weeds and Category 2 and 3 Declared Invader species must be removed from the site.

Figure 19: Vegetation sensitivity map

11. LITERATURE SOURCES

Botha C. 2001. *Common weeds of crops and gardens in southern Africa.* ARC – Grain Crops Institute, Agricultural Research Council, Pretoria.

Bothalia. 1962. Volume 7 part 4 (South African species of *Anthericum, Chlorophytum* and *Trachyandra*). Botanical Research Institute, Department of Agricultural Technical Services, Pretoria.

Bothalia. 1962. Volume 8, part 1 (The Cucurbitaceae of Southern African). Botanical Research Institute, Department of Agricultural Technical Services, Pretoria.

Bromilow, C. 2001. *Problem plants of South Africa.* Briza Publications, Pretoria

Burrows, J. (ed.) 2002. *Trees and shrubs of Mpumalanga and Kruger National Park.* Jacana, Johannesburg.

Burrows, J.E. 1990. *Southern African ferns and fern allies.* Frandsen Publishers, Sandton.

Chippendall, L.K.A. *et. al.* 1955. *The grasses and pastures of South Africa.* Central News Agency, Cape Times Limited, Parow.

Coates Palgrave, M. (3rd ed) 2002. *Keith Coates Palgrave: Trees of southern Africa.* Struik Publishers, Johannesburg.

Eardley, C. 2002. *Pollinators for Africa.* ARC – Plant Protection Research Institute, Department of Agriculture, Pretoria.

Eardley, C.; Roth, D.; Clarke, J.; Buchmann, S. and Gemmill, B. 2006. *Pollinators and pollination: a resource book for policy and practice.* African Pollinator Initiative (API)

Fabian, A. & Germishuizen, G. 1997. *Wild flowers of northern South Africa.* Fernwood Press, Cape Town.

Flora of Southern Africa. 1980. Vol. 27,4 (Asclepiadaceae: *Brachystelma, Ceropegia*, Riocreuxia). Botanical Research Institute, Department of Agricultural Technical Services, Pretoria

Flora of Southern Africa. 1985. Vol. 28,4 (Lamiaceae). Botanical Research Institute, Department of Agriculture & Water Supply, Pretoria

Flora of Southern Africa. 2000. Vol. 5,1: Fascicle 1: Aloaceae (First part): *Aloe*. National Botanical Institute, Pretoria

Flowering plants of Africa. 1993. Vol. 52: Plate 2073 (*Ceropegia decidua* subsp *pretoriensis*). National Botanical Institute, Pretoria.

Germishuizen, G. & Clarke, B. 2003. *Illustruated guide to the Wildflowers of northern South Africa*. Briza Publications, Pretoria.

Germishuizen, G. & Meyer, N.L. (eds) 2003. *Plants of southern Africa: an annotated checklist. Strelitzia 14*, National Botanical Institute, Pretoria.

Gibbs Russell. G.E. *et. al.* 1990. *Grasses of southern Africa. Memoirs of the Botanical survey of South Africa* No. 58. National Botanic Gardens/Botanical Research Institute, South Africa.

Goldblatt, P. & Manning, J. 1998. *Gladiolus in southern Africa.* Fernwood Press, Cape Town.

Gordon-Gray, K.D. 1995. *Cyperaceae in Natal. Stelitzia 2.* National Botanical Institute, Pretoria.

Hartman, H.E.K. 2001. Aloe Vol 39,3&4. 2002. (*The genus* Delosperma *in Gauteng*, part III, species with yellow flowers.) Succulent Society of South Africa, Pretoria.

Henderson, L. 2001. *Alien weeds and invasive plants*. Plant Protection Research Institute, Agricultural Research Council, Pretoria.

Jacobsen, W.B.G. 1983. *The ferns and fern allies of southern Africa*. Butterworths, Durban.

Leathart, S. 1977. *Trees of the world.* The Hamlyn Publishing Group, Limited, London.

Linder, H.P. & Kurzweil, H. 1999. *Orchids of Southern Africa*. A.A. Balkema, Rotterdam.

Mucina, L. & Rutherford, M.C. 2006. *The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19.* South African National Biodiversity Institute, Pretoria.

Onderstall, J. 1984. *Transvaal lowveld and escarpment including the Kruger National Park.*
Pfab, M. 2001. *Red Data Plant Policy for Environmental Impact Evaluations*. Final Draft. Directorate of Nature Conservation, Department of Agriculture, Conservation, Environment and Land Affairs.

Pfab, M. 2009. *GDACE Requirements for Biodiversity assessments. Version 2.* Directorate of Nature Conservation, Department of Agriculture, Conservation and Environment.

Pfab, M.F. & Victor, J.E. 2002. Threatened plants of Gauteng, South Africa. South African Journal of Botany, Vol 68: 370 – 375.

Pfab, M.F. 2002. *Priority ranking scheme for Red Data plants in Gauteng, South Africa*. South African Journal of Botany, Vol 68: 299 – 303.

Pooley, E. 1998. *A field guide to the wild flowers of Kwazulu-Natal and the eastern region*. Natal Flora Publications Trust, Durban.

Raimondo, D., Von Staden. L., Foden, W., Victor, J.E., Helme, N.A., Turner R.C., Kamundi, D.A. & Manyama, P.A. (eds) 2009. *Red list of South African Plants 2009.* Strelitzia 25. South African National Biodiversity Institute, Pretoria.

Retief, E. & Herman, P.P.J. 1997. *Plants of the northern provinces of South Africa: keys and diagnostic characters. Strelitzia 6: 1-681*, National Botanical Institute, Pretoria.

Reynolds, G.W. 1982. *The aloes of South Africa.* Balkema, Cape Town.

Smith, C.A. 1966. *Common names of South African plants*. Botanical Research Institute, Department of Agricultural Technical Services, Pretoria.

Stewart, J. *et. al.* 1982. *Wild orchids of southern Africa*. Macmillan South Africa, Johannesburg.

Van Oudshoorn, F.P. 2002. *Guide to grasses of southern Africa.* Briza Publications, Pretoria.

Van Wyk, B. & Malan, S. 1998. *Field guide to the wild flowers of the Highveld.* Struik, Cape Town.

Van Wyk, B. & Van Wyk P. 1997. *Field guide to trees of southern Africa*. Struik Publishers, Cape Town.

Van Wyk, B-E., & Smith, G.F. 2008. *Guide to the Aloes of South Africa,* Briza Publications, Pretoria.

Van Wyk, B-E., Van Oudtshoorn, B. & Gericke, N. 2002. *Medicinal plants of South Africa*. Briza Publications, Pretoria.

Watt, J.M. & Breyer-Brandwijk, M.G. 1962. *The medicinal and poisonous plants of southern and eastern Africa.* 2nd edition. Livingstone, London.

ANNEXURE A: Red– and Orange List* plants of the 2528CD & DC q.d.g.c.

Annexure A and B are confidential and may not be made available to the public

Species	Flower season	Suitable habitat	Priority grouping	Conserv status	PRESENCE ON SITE
▲ *Adromischus umbraticola* subsp *umbraticola*	Sep-Jan	Rock crevices on rocky ridges, usually south-facing, or in shallow gravel on top of rocks, but often in shade of other vegetation.	A2	Near threatened[1]	**FOUND**
▲ *Argyrolobium campicola*	Nov-Feb	Highveld grassland	A3	Near threatened[1]	**Habitat suitable**
Boophane disticha	Oct-Jan	Dry grassland and rocky areas.	N/A	Declining[2]	**Habitat suitable**
Bowiea volubilis subsp volubilis	Sep-Apr	Shady places, steep rocky slopes and in open woodland, under large boulders in bush or low forest.	B	Vulnerable[2]	Habitat not suitable
Brachycorythis conica subsp transvaalensis	Jan-Mrt	Short grassland, hillsides,on sandy gravel overlying dolomite, sometimes also on quartzites, occasionally open woodland, 1000 – 1705m	A3	Vulnerable[1]	Habitat not suitable
Callilepis leptophylla	Aug-Jan & May	Grassland or open woodland, often on rocky outcrops or rocky hillslopes.	N/A	Declining[2]	**Habitat suitable**
Ceropegia decidua subsp. pretoriensis	Nov-Apr	Direct sunshine or shaded situations, rocky outcrops of the quartzitic Magaliesberg mountain series, in pockets of soil among rocks, in shade of shrubs and low trees, can be seen twining around grass spikes.	A1	Vulnerable[1]	**Habitat suitable**
Cheilanthes deltoidea subsp nov Gauteng form	Nov-Jun	Southwest-facing soil pockets and rock crevices in chert rocks.	A2	Vulnerable[1]	Habitat not suitable
Crinum macowanii	Oct-Jan	Grassland along rivers in gravely soil or on sandy flats	N/A	Declining[2]	Habitat not suitable
Delosperma gautengense	Nov-Apr	Among rocks on hillslopes of Magaliesberg and associated ridge systems on south-facing slopes.	A1	Vulnerable[1]	Habitat not suitable
▲ *Delosperma leendertziae*	Oct-Apr	Rocky ridges; on rather steep south facing slopes of quartzite in mountain grassveld.	A2	Near Threatened[1]	Habitat not suitable
Eucomis autumnalis	Nov-Apr	Damp open grassland and sheltered places.	N/A	Declining[2]	**Habitat suitable**
Eulophia coddii	Early Dec	Steep hillsides on soil derived from sandstone, grassland or mixed bush.	A2	Vulnerable[1]	Habitat not suitable
Gunnera perpensa	Oct-Mar	In cold or cool continually moist localities, mainly along upland streambanks.	N/A	Declining[2]	Habitat not suitable
Habenaria barbertonii	Feb-Mar	In grassland on rocky hillsides.	A2	Near threatened[1]	Habitat not suitable
Habenaria bicolor	Jan-Apr	Well-drained grassland, at about 1500m.	B	Near Threatened[2]	Habitat not suitable
Habenaria kraenzliniana	Feb-Apr	Terrestrial in stony, grassy hillsides, recorded from 1000 to 1400m.	A3	Near Threatened[1]	Habitat not suitable
Habenaria mossii	Mar-Apr	Open grassland on dolomite or in black sandy soil.	A1	Endangered[1]	Habitat not suitable
Hypoxis hemerocallidea	Sep-Mar	Occurs in a wide range of habitats. Appears to be drought and fire tolerant. Grassland and mixed woodland.	N/A	Declining[2]	**FOUND**
Ilex mitis var mitis	Oct-Dec	River banks, stream beds, evergreen forests.	N/A	Declining[2]	Habitat not suitable

Species	Flower season	Suitable habitat	Priority grouping	Conserv status	PRESENCE ON SITE
Stenostelma umbelluliferum	Sep-Mar	Deep black turf in open woodland mainly in the vicinity of drainage lines.	A3	Near threatened[1]	Habitat not suitable
Trachyandra erythrorrhiza	Sep-Nov	Marshy areas, grassland, usually in black turf marshes.	A3	Near Threatened 1	Habitat suitable

[1] global status
[2] national status
* Orange listed plants have no priority grouping and are designated 'N/A'
▲ Has been recorded from the farm on which the study site is situated / within 5km of the study site. Should suitable habitat be present, it is highly likely that this species occur on the study site.

ANNEXURE B

CONFIDENTIAL

Coordinates of the Red List species *Adromischus umbraticola* subsp *umbraticola*

S 25° 48' 16,4" / E 28° 29' 28,6"
S 25° 48' 15,1" / E 28° 29' 25,8"
S 25° 48' 11,5" / E 28° 29' 12,2"
S 25° 48' 11,1" / E 28° 29' 30,0"
S 25° 48' 20,9" / E 28° 29' 26,7"
S 25° 48' 20,9" / E 28° 29' 27,9"
S 25° 48' 21,0" / E 28° 29' 28,6"
S 25° 48' 22,3" / E 28° 29' 29,5"
S 25° 48' 22,7" / E 28° 29' 30,8"
S 25° 48' 24,2" / E 28° 29' 32,7"
S 25° 48' 25,4" / E 28° 29' 34,0"
S 25° 48' 26,7" / E 28° 29' 35,9"
S 25° 48' 28,8" / E 28° 29' 40,8"
S 25° 48' 29,9" / E 28° 29' 42,8"
S 25° 48' 31,8" / E 28° 29' 47,4"
S 25° 48' 31,2" / E 28° 29' 48,1"
S 25° 48' 33,0" / E 28° 29' 50,5"
S 25° 48' 37,3" / E 28° 29' 58,3"
S 25° 48' 39,1" / E 28° 30' 01,0"
S 25° 48' 36,1" / E 28° 30' 03,5"
S 25° 48' 34,4" / E 28° 29' 58,6"

GALAGO
ENVIRONMENTAL

Fauna and Flora Specialists
638 Turf Street
Wingate Park, 0181
Tel: 012-345 4891
Fax: 086 675 6136
Email: Vanessam@lantic.net

Mammal Habitat Survey

of

PORTION 31 AND 38 AND THE REMAINDER OF KLEINFONTEIN 368 JR AND PORTION 14, 63 AND 68 OF DONKERHOEK 365 JR

November 2011

Report author: I.L. Rautenbach Pr.Sci.Nat., Ph.D, T.H.E.D.

TABLE OF CONTENTS

FIGURES:

TABLES:

Declaration of Independence:

I, Ignatius Lourens Rautenbach (421201 5012 00 5) declare that I:

- am committed to biodiversity conservation but concomitantly recognize the need for economic development. Whereas I appreciate the opportunity to also learn through the processes of constructive criticism and debate, I reserve the right to form and hold my own opinions and therefore will not willingly submit to the interests of other parties or change my statements to appease them
- abide by the Code of Ethics of the S.A. Council for Natural Scientific Professions
- act as an independent specialist consultant in the field of zoology
- am subcontracted as specialist consultant by Galago Environmental CC for the proposed development of Portions of the farms Kleinfontein 368 JR & Donkerhoek 365 JR" described in this report
- have no financial interest in the proposed development other than remuneration for work performed
- have or will not have any vested or conflicting interests in the proposed development
- undertake to disclose to the Galago Environmental CC and its client as well as the competent authority any material information that have or may have the potential to influence the decision of the competent authority required in terms of the Environmental Impact Assessment Regulations 2006

Dr. I.L. Rautenbach

1. INTRODUCTION

Galago Environmental CC. was appointed by Bokamosa CC on behalf of the Kleinfontein Boerebelange Koöperatief Bpk to undertake a mammal habitat and species diversity assessment for Portions 31 and 38 and the Remainder of the farm Kleinfontein 368-JR and Portions 14, 63, 67 and 68 of the farm Donkerhoek 365-JR, scheduled for development into an estate with residential properties, open spaces, game park etc. The 880 ha cooperative property is being developed as an environmental and cultural conservation asset, but which incorporates restricted residential opportunities.

This report focuses on the reigning status of threatened and sensitive mammals likely to occur on the proposed development site. Special attention was paid to the qualitative and quantitative habitat conditions for Red Data species deemed present on the site, and mitigation measures to ameliorate the effect of the development is suggested. The secondary objective of the investigation was to gauge which mammals might still reside on the site and compile a complete list of mammal diversity of the study area.

2. SCOPE AND OBJECTIVES OF THE STUDY

- To qualitatively and quantitatively estimate the significance of the mammal habitat components and current general conservation status of the property;
- Comments on ecological sensitive areas;
- Comments on connectivity with natural vegetation and habitats on adjacent sites;
- To provide a list of mammals which occur or might occur, and to identify species of conservation importance;
- To highlight potential impacts of the proposed development on the mammals of the study site, and
- To provide management recommendations to mitigate negative and enhance positive impacts should the proposed development be approved.

3. STUDY AREA

The study site (2528CD) is located east of Pretoria and abuts the N4 towards the north and is a short distance west of the R515. Collectively it is managed as the Kleinfontein Bavaria under the auspices of the Kleinfontein Boerebelange Koöperatief Bpk. It is in a rural setting and surrounded by agricultural properties with a variety of foci.

The study site comprises a number of adjoining properties. Activities range from the 190 ha game camp, open areas, smallholdings and individual residential properties.

The topography of the site is that of typical Highveld Grassland undulating plains. Floristically it falls in the Rand Highveld Grassland and Gold Reef Mountain Bushveld veld types as defined by Mucina and Rutherford (2006).

The site is bisected by a railway line to the south, and the Rhenosterfontein Road towards the north. The northernmost portion of the study site is the main focus of the development and has a high-density housing complex to the north-west (333 building plots set aside). The latter is located on a modest quartzite plateau. At the southern base of the plateau is a drainage line fed by perennial fountains and with three manmade dams. A number of freestanding residences were constructed on some of the 50 erven set aside along the foot of the slope. The plain between the base of the escarpment and the Rhenosterfontein Road consists of savannah veld. This entire area is enclosed by a game fence.

A number of smallholdings to the south of the Rhenosterfontein Road form the middle portion of the study site. Individual properties are fenced with normal agricultural wire fences.

There are no bat caves on the site, but presumably there are ample roosting sites in structures of civilization for the bats listed in Table 1.

The following GPS coordinates spatially define the site:
25º 48.605'S; 28º 29.724'E at the base of the escarpment
25º 49.150'S; 28º 30.305'S on the Rhenosterfontein Road at the eastern border
25º 48.335'S; 28º 28.981'E on the Rhenosterfontein Road south the built-up section
25º 50.801'S; 28º 30.433'E where the railway bisects the southern border of the site
25º 51.401'S; 28º 30.490'W at the westernmost point of the site

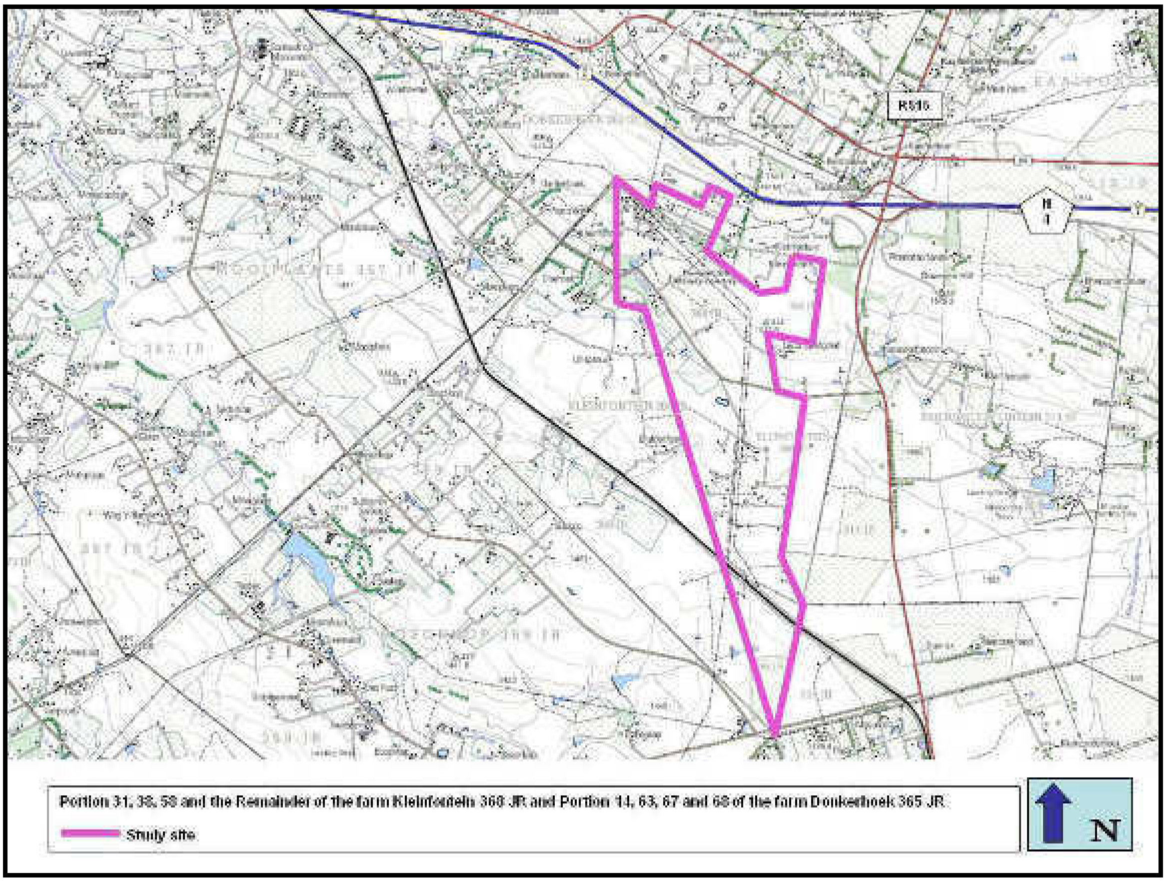


Figure 1: Locality map of the study area

4. METHODS

An eight hour site visit was conducted on 26 March 2011 and again on 23 April 2011. During these visits the observed and derived presence of mammals associated with the recognized habitat types of the study site, were recorded. This was done with due regard to the well recorded global distributions of Southern African mammals, coupled to the qualitative and quantitative nature of recognized habitats.

The 500 meters of adjoining properties was scanned for important fauna habitats.

4.1 Field Surveys

During the site visit mammals were identified by visual sightings through random transect walks. No trapping or mist netting was conducted, as the terms of reference did not require such intensive work, although in terms of Anonymous (January 2009) this may be required later. In addition, mammals were also identified by means of spoor, droppings, burrows or roosting sites. Locals were interviewed to confirm occurrences or absences of species.

Three criteria were used to gauge the probability of occurrence of mammals on the study site. These include known distribution range, habitat preference and the qualitative and quantitative presence of suitable habitat.

4.2 Desktop Surveys

As the majority of mammals are secretive, nocturnal, hibernators and/or seasonal, distributional ranges and the presence of suitable habitats were used to deduce the presence or absence of these species based on authoritative tomes, scientific literature, field guides, atlases and databases. This can be done with a high level of confidence irrespective of season. During the field work phase of the project, this derived list of occurrences is audited.

The probability of occurrences of **mammal** species was based on their respective geographical distributional ranges and the suitability of on-site habitat. In other words, *high* probability would be applicable to a species with a distributional range overlying the study site as well as the presence of prime habitat occurring on the study site. Another consideration for inclusion in this category is the inclination of a species to be common (= robust), i.e. normally occurring at high population densities.

Medium probability pertains to a mammal species with its distributional range peripherally overlapping the study site, or required habitat on the site being sub-optimal. The size of the site as it relates to its likelihood to sustain a viable breeding population, as well as its geographical isolation is also taken into consideration. Species categorised as *medium* normally do not occur at high population numbers, but cannot be deemed as rare.

A *low* probability of occurrence will mean that the species' distributional range is peripheral to the study site <u>and</u> habitat is sub-optimal. Furthermore, some mammals categorised as *low* are generally deemed rare.

4.3 Specific Requirements

During the visit the site was surveyed and assessed for the potential occurrence of Red Data and/or ridge and wetland-associated sensitive species such as:

Juliana's golden mole (*Neamblosomus juliana*), Highveld golden mole (*Amblysomus septentrionalis*), Rough-haired golden mole (*Chrysospalax villosus*), African marsh rat (*Dasymys incomtus*), Angoni vlei rat (*Otomys angoniensis*), Vlei rat (*Otomys irroratus*), White-tailed rat (*Mystromys albicaudatus*), a number of shrews such as the Forest shrew (*Myosorex varius*), Southern African hedgehog *(Atelerix frontalis), a number of bats such as the* Short-eared trident bat (*Cloeotis percivali*), African clawless otter (*Aonyx capensis*), Spotted-necked otter (*Lutra maculicollis*), Marsh mongoose (*Atilax paludinosus*), Brown hyena (*Parahyaena brunnea*), etc.

5. RESULTS

Global mammal distributions correlate well with biomes as defined by Acocks (1953), Low and Rebelo (1998), Knobel and Bredenkamp (2005) as well as Mucina and Rutherford (2006). However, the local occurrences of mammals are more closely dependent on broadly defined habitat types, in particular terrestrial, arboreal (tree-living), rupiculous (rock-dwelling) and wetland-associated vegetation cover. It is thus possible to deduce the presence or absence of mammal species by evaluating the habitat types within the context of global distribution ranges. Sight records and information from residents or knowledgeable locals audit such deductions.

Mammal Habitat Assessment

All four major mammal habitats are present on the site.

The terrestrial habitat is by far the largest. It is prevalent on the grassland plateau towards the N4 and the section south of the railway line and the lush stand of grass offer excellent habitat for small terrestrial mammals. Terrestrial habitat in fact also extends to the ground storey of the arboreal habitat, but is inclined to have a sparser stand of grass as result of the shade effect of the tree canopy. Termitaria were recorded; this is significant since some vertebrates use moribund termitaria as refuges, such as dwarf shrews and pygmy mice.

The arboreal habitat is common on the lower-lying valleys at the base of the escarpment and the smallholdings south of the Rhenosterspruit Road. *Acacia* trees, karee and white stinkwood trees predominate. Although this habitat type cannot be regarded as ideal for *Thallomys* (tree rat) species, they are assumed to be present in the extensive range of the arboreal habitat on the site. Species such as SA galagos and savannah dormice are also likely occupants. The stand of trees is rather dense, which could be indicative of a low incidence of veld fires (which is conducive for terrestrial habitat offering refuge and nourishment on a more sustained basis). However, the exotic invaders such as wattles, seringa and *Eucalyptus* are not deemed part of the arboreal habitat since mammals avoid these (with the occasional exception of galagos). The proteas along the slopes of the escarpment do not contribute significantly to the requirements of arboreal mammals. Unfortunately Kikuyu escaped and is rampant inside the fence along the Rhenosterfontein Road. Although Kikuyu is excellent habitat for small mammals, this situation constitutes an environmental management challenge.

The rupiculous habitat is well developed on the plateau and escarpment slopes on the northern section of the site. Ample nooks and crannies are available for Namaqua rock rats, rock dormice and rock elephant shrews. However, it would appear that this habitat type of the site is not suitable for dassies.

The wetland habitat is restricted to the drainage line, also located on the northern section of the site. The drainage line is fed by rainwater, but also by fountains (Anonomous, 2009). Three dams were constructed in the drainage line to stabilize availability of water. The wetland vegetation along the banks of the drainage line and especially the dams form good habitat for moisture-reliant species such as vlei rats and shrews.

There are no bat caves, but some of the buildings on the site are likely to harbour colonies of the species listed in Table 1.

The 500 meters of adjoining properties reflect the conditions described for the site, although not in a similar state of improving conservation.

The conservation status of the site is in good condition, and given the progressive range management objectives for the site, is steadily improving.

Figure 2: A northerly view over the slope of the plateau, with a residence built on the base of the slope.

Figure 3: A view of the savannah inside the fence along the Rhenosterspruit Road. Note the Kikuyu in and along the shoulder of the road.

Figure 4: Another view of the savannah within the northern section of the site. Note the basal cover for terrestrial small mammals.

Figure 5: The drainage line and one of the dams in the northern portion of the site. Note the lush semi-aquatic vegetation ideal for moisture-reliant small mammals.

Figure 6: The grassland on the plateau, situated between the residential development and the N4. Quartzite rock protrusions are abundant.

Expected and Observed Mammal Species Richness

Large mammals and some medium-sized mammals have over the decades been extirpated to favour agriculture and stock-raising. Since the founding of the Bavaria, this trend has been reversed by the re-introduction of nyala (accidentally), black wildebeest, red hartebeest, blesbok, southern reedbuck and impala. The re-introduction of springbok is anticipated. The conservation sentiment of the Bavaria now furthermore nurtures the persistence / immigration of mammals such as white-tailed mongooses, marsh mongooses, black-backed jackals, brown hyenas, leopard, caracal, steenbok and duiker.

Of the 59 mammal species recorded or expected to occur on the study site (Table 1), 18 were confirmed during the site visit, or reported by the inhabitants (Table 2). It should be noted that potential occurrences is interpreted as to be possible over a period of time as result of expansion and contractions of population densities and ranges which stimulate migration. All feral mammal species expected to occur on the study site (e.g. house mice, house rats, dogs and cats) were omitted from the assessment since these species normally associate with human settlements.

Most of the species of the resident diversity (Table 2) are common and widespread. However, eight Red Data species were identified to be likely residents. These are species with discerning habitat requirements, and are discussed below.

Common species include four-striped rock elephant shrews, field mice, multimammate mice, Tete veld rats, Namaqua rock mice, Highveld gerbils, climbing mice, lesser red musk shrew, reddish-grey musk shrews, genets and mongooses. Moribund termitaria are indicative of the occurrence of dwarf shrews and pygmy mice; these have a penchant for these structures as refuges.

The six species of bats are likely to prey on insect swarms rising over the wetland system during summer sunsets. The Mauritian tomb bat is a seasonal migrator and small family units often roost during summer on the walls under the eaves of roofs. Flat-headed free-tailed bats are fairly widespread and have a predilection to roost in very narrow rock crevices with > 1 meter free-fall airspace to become airborne, such as under roofs or in cliff faces. The site has ample opportunities for both species. Colonies of Egyptian free-tailed bats, Cape serotine bats, African yellow house bats and greenish yellow house bats are al widespread and common. They are certain to have found roosting opportunities in buildings somewhere on the Bavaria.

The two genet species and the mongooses are very resilient species and are commonly found in rural settings close to human habitation conditional to sustainable prey sources.

The mammal diversity is relatively high and can be ascribed due to wide habitat diversity, the extensive size of the site and of the adjoining areas, and good conservation aiming to progressively improve habitat by means of a scientifically derived management plan.

Threatened and Red Listed Mammal Species

It is amazing how many local mammals have never been studied in nature. As result, the conservation status of species such as the rock dormouse, the forest shrew, the greater dwarf shrew, the lesser red musk shrew and the reddish-grey musk shrew are unknown entities and are forced to be ranked as “Data Deficient” as a precautionary measure. Based on 40 years of field observations and museum collecting, this specialist does not deem any of these as Red Data species, but has no experience of the African weasel and accepts its conservation ranking of “Data Deficient”.

Hedgehogs “Near Threatened” are capable to withstand predation with their passive defence mechanisms. They became endangered directly as result of predation by humans and their pets, which is a consideration in this instance. Considering the undisturbed and extensive nature of the site, its continued presence is most likely *sans* predation by humans and domesticated carnivore pets.

The brown hyenas is an extremely secretive scavenger and its presence is often overlooked or population densities under-estimated. Records of occurrence are to this date still accrued in the rural areas outside Pretoria.

Although not Red Listed, vlei rats are deemed 'sensitive' given their reliance on a moist and rank habitat close to water.

No other Red Data or sensitive species are deemed present on the site, either since the site is too disturbed, falls outside the distributional ranges of some species, or does not offer suitable habitat(s).

Table 1: The mammals which were observed or deduced to occupy the site
(Systematics and taxonomy as proposed by Bronner et.al [2003] and Skinner and Chimimba [2005])

	SCIENTIFIC NAME	ENGLISH NAME
*	*Elephantulus myurus*	Eastern rock elephant shrew
√	*Lepus saxatilis*	Scrub hare
?	*Pronolagus randensis*	Jameson's red rock rabbit
√	*Cryptomys hottentotus*	African mole rat
*	*Hystrix africaeaustralis*	Cape porcupine
DD*	*Graphiurus platyops*	Rock dormouse
*	*Graphiurus murinus*	Woodland dormouse
*	*Rhabdomys pumilio*	Four-striped grass mouse
*	*Mus minutoides*	Pygmy mouse
*	*Mastomys natalensis*	Natal multimammate mouse
*	*Mastomys coucha*	Southern multimammate mouse
?	*Thallomys paedulcus*	Acacia rat
?	*Thallomys nigricauda*	Black-tailed tree rat
*	*Aethomys ineptus*	Tete veld rat
*	*Aethomys namaquensis*	Namaqua rock mouse
*	*Otomys angoniensis*	Angoni vlei rat
*	*Otomys irroratus*	Vlei rat
*	*Gerbilliscus brantsii*	Highveld gerbil
*	*Saccostomus campestris*	Pouched mouse
*	*Dendromus melanotis*	Grey pygmy climbing mouse
*	*Dendromus mesomelas*	Brants' climbing mouse
*	*Dendromus mystacalis*	Chestnut climbing mouse
?	*Galago moholi*	South African galago
*	*Cercopithecus pygerythrus*	Vervet monkey
DD*	*Myosorex varius*	Forest shrew
DD?	*Suncus lixus*	Greater dwarf shrew
DD*	*Crocidura cyanea*	Reddish-grey musk shrew
DD*	*Crocidura hirta*	Lesser red musk shrew
NT√	*Atelerix frontalis*	Southern African hedgehog
?	*Taphozous mauritianus*	Mauritian tomb bat
?	*Sauromys petrophilus*	Flat-headed free-tailed bat
*	*Tadarida aegyptiaca*	Egyptian free-tailed bat
√	*Neoromicia capensis*	Cape serotine bat
√	*Scotophilus dinganii*	African yellow house bat
√	*Scotophilus viridis*	Greenish yellow house bat
√	*Proteles cristatus*	Aardwolf
NT√	*Parahyaena brunnea*	Brown hyena
?	*Panthera pardus*	Leopard
?	*Caracal caracal*	Caracal

	SCIENTIFIC NAME	ENGLISH NAME
*	*Felis silvestris*	African wild cat
*	*Genetta genetta*	Small-spotted genet
*	*Genetta tigrina*	SA large-spotted genet
*	*Cynictis penicillata*	Yellow mongoose
√	*Galerella sanguinea*	Slender mongoose
√	*Ichneumia albicauda*	White-tailed mongoose
?	*Atilax paludinosus*	Marsh mongoose
√	*Canis mesomelas*	Black-backed jackal
DD?	*Poecilogale albinucha*	African weasel
*	*Ictonyx striatus*	Striped polecat
√	*Equus quagga*	Plains zebra
√	*Tragelaphus strepsiceros*	Kudu
√	*Tragelaphus angasii*	Nyala
√	*Connochaetes gnou*	Black wildebeest
√	*Alcelaphus buselaphus*	Red hartebeest
√	*Damaliscus pygargus phillipsi*	Blesbok
√	*Sylvicapra grimmia*	Common duiker
√	*Redunca arundinum*	Southern reedbuck
√	*Raphicerus campestris*	Steenbok
√	*Aepyceros melampus*	Impala

√ Definitely there or have a *high* probability to occur;
***** *Medium* probability to occur based on ecological and distributional parameters;
? *Low* probability to occur based on ecological and distributional parameters.

Red Data species rankings as defined in Friedmann and Daly's S.A. Red Data Book / IUCN (World Conservation Union) (2004) are indicated in the first column: CR= Critically Endangered, En = Endangered, Vu = Vulnerable, LR/cd = Lower risk conservation dependent, LR/nt = Lower Risk near threatened, DD = Data Deficient. All other species are deemed of Least Concern.

Table 2: Mammal species positively confirmed from the study site, observed indicators and habitat.

SCIENTIFIC NAME	ENGLISH NAME	OBSERVATION INDICATOR	HABITAT
L. saxatilis	Scrub hare	Faecal pellets	Short grassveld
C. hottentotus	African mole rat	Tunnel system	Universal
A. frontalis	SA hedgehog	Corporate records	Grassveld
P. cristatus	Aardwolf	Corporate records	Open terrain
P. brunnea	Brown hyena	Corporate records	Universal
G. sanguinea	Slender mongoose	Corporate records	Universal
I. albicauda	White-tailed mongoose	Corporate records	Close to streams
C. mesomelas	Black-backed jackal	Corporate records	Universal
E. quagga	Plains zebra	Corporate records	Grassveld
T. strepsiceros	Kudu	Corporate records	Savannah
T. angasii	Nyala	Corporate records	Moist savannah
C. gnou	Black wildebeest	Corporate records	Grassveld
A. buselaphus	Red hartebeest	Corporate records	Grassveld
D. p. phillipsi	Blesbok	Corporate records	Grassveld
S. grimmia	Common duiker	Corporate records	Grassveld
R. arundinum	Southern reedbuck	Corporate records	Moist grassveld
R. campestris	Steenbok	Deduction	Grassveld
A. melampus	Impala	Corporate records	Savannah

Scrub hares, mole rats, slender and white-tailed mongooses, common duiker and steenbok are widespread and common. They are reticent in habits or unique in habitat selection and are therefore seldom observed. They frequently co-exist with human settlements in peri-urban settings.

Considering the size of the site and the rural nature of the district, coupled to the prevailing conservation sentiments of the Bavaria, it comes of no surprise that hedgehogs, aardwolfs, black-backed jackals, brown hyenas and kudus persist, if not on a permanent basis then at least as vagrants.

Zebra, nyala, black wildebeest, red hartebeest, blesbok, southern reedbuck and impala have been re-introduced.

6. FINDINGS AND POTENTIAL IMPLICATIONS

This report has adopted a conservative approach by listing species as residents at least on the basis of reasonable likelihood. This renders the conclusions and proposed mitigation measures as robust. Fifty-nine mammal species are listed (Table 1) as resident or likely residents, of which the presence of 18 has been confirmed. Eight species are ranked as Red Data species (Friedmann and Daly, 2004); the conservation sentiments of the Bavaria will undoubtedly serve to stabilize their on-site existence.

Within the ambit of the Management Plan (Anonymous, 2009) the development has not and will not result in a loss of ecological sensitive and important habitat units, ecosystem function (e.g. reduction in water quality, soil pollution), significant loss of mammal habitat, nor of loss/displacement of threatened or protected species.

This Management Plan (Anonymous, 2009) report deals with a truly unique situation, namely a conservation-orientated development which strives to restore the natural and endemic bio-diversity of the site. It can be argued that the development actually contributes to nature conservation on a national level, since <1% of the Rand Highveld Grassland (Mucina and Rutherford, 2006) overlying the site enjoys any form of formal conservation.

The Kleinfontein Project develops nature conservation and regulated residential development in tandem. Land-use practices are clearly defined, as are present and future remedial actions. It does so by means of a well-argued and researched document (Anonomous, 2009) under the control of elected governance structures. Derived management plans are flexible and allows for future land additions to the presently 880 ha Bavaria.

It is not clear whether keeping dogs and cats are allowed on the study site; none were observed during the site visits. They are carnivores and will undoubtedly account for a measure of predation on indigenous animals. Therefore, allowing pets on the Bavaria should not be endorsed.

The drainage line fed by fountains and dammed in three localities, are deemed as ecologically sensitive. This system not only provide valuable habitat for moisture-reliant mammals, but serve as a dispersal corridor for migration. Although dealing with the sensitivity of this system is not evident in the Management Plan, the site visits reiterate that its sanctity is honoured but should *post haste* be formalised in the Management Plan.

GDARD's Ridges Policy prohibits development on ridges, slopes > 5º and a buffer zone of 200 meters along the foot of ridges are proposed. Unfortunately some residences have already been constructed on erven at the base of the plateau slope within the 200 meters 'no-go' zone. From a mammal perspective this is of little consequence since the habitat displaced by the buildings is 'ecotonal' in nature and thus suboptimal for rupiculous, terrestrial and arboreal mammals. It is however recommended that, in the view of the overall objectives of the Bavaria, future developments be located 200 meters away from the base of the plateau base into the small savannah area.

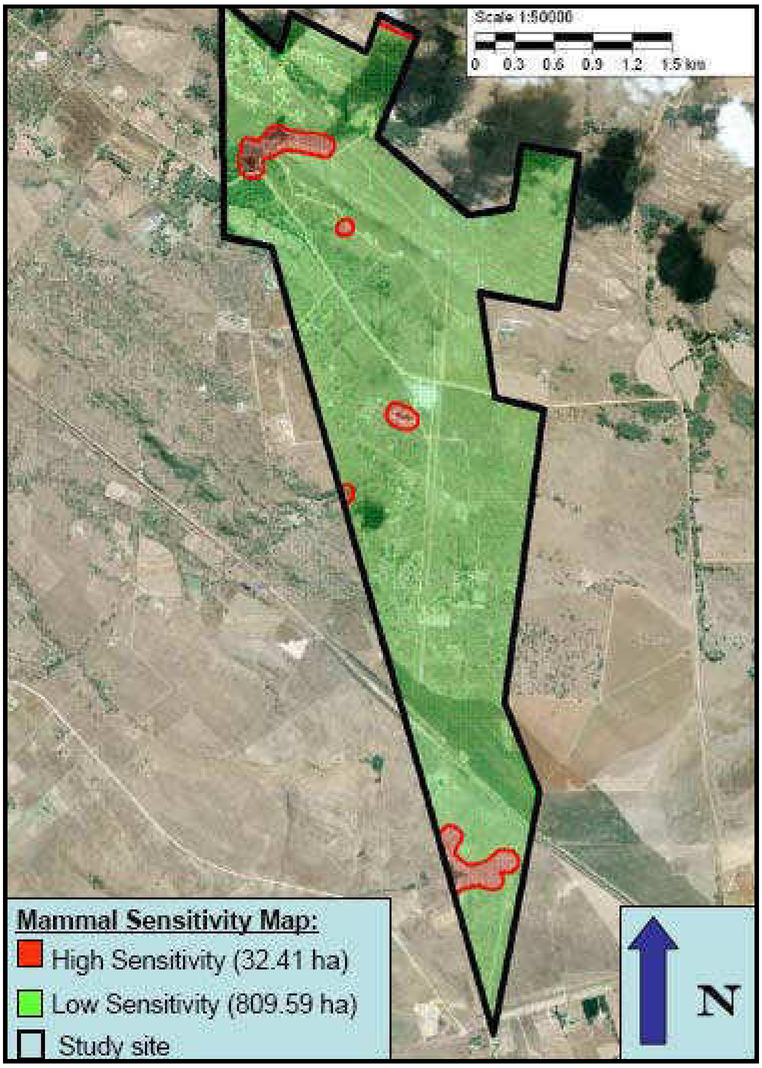


Figure 7: Mammal habitat map

7. LIMITATIONS, ASSUMPTIONS AND GAPS IN INFORMATION

The Galago Environmental personnel are amply experienced to derive reasonably accurate species lists of a location such as this site. Specialists have access to ample data bases and information resources, and have earlier conducted numerous intensive field surveys which allow the extrapolation of habitat diversity and quality into species richness. In this instance an intensive mammal survey is deemed an expensive and fruitless experience with little chance of radically altering our conclusions.

Even though every care is taken to ensure the accuracy of this report, environmental assessment studies are limited in scope, time and budget. Discussions and proposed mitigations are to some extent made on reasonable and informed assumptions built on *bone fide* information sources, as well as deductive reasoning. Deriving a 100% factual report based on field collecting and observations can only be done over several years and seasons to account for fluctuating environmental conditions and migrations. Since environmental impact studies deal with dynamic natural systems additional information may come to light at a later stage. Galago Environmental can thus not accept responsibility for conclusions and mitigation measures made in good faith based on own databases or on the information provided at the time of the directive. This report should therefore be viewed and acted upon with these limitations in mind.

8. RECOMMENDED MITIGATION MEASURES

The following mitigation measures were developed by GDARD (GDACE) (Directorate of Nature Conservation, GDACE, 2008 and 2009). It is submitted that they are applicable to the study site. Assuming that the GDARD mitigation measures will contribute to the management plan of the Bavaria, the entire document is included here. **Where appropriate, Galago Environmental's specific elaborations are given in italics and in brackets.**

- An appropriate management authority (e.g. the body corporate) that must be contractually bound to implement the Environmental Management Plan (EMP) and Record of Decision (ROD) during the operational phase of the development should be identified and informed of their responsibilities in terms of the EMP and ROD.
- All areas designated as sensitive in a sensitivity mapping exercise should be incorporated into an open space system (*viz. drainage line, dams and associated wetland; plateau and escarpment ridge*). Development should be located on the areas of lowest sensitivity (*viz. high density residential zone*).
- Development structures should be clustered as close as possible to existing development.
- The open space system should be managed in accordance with an Ecological Management Plan that complies with the *Minimum Requirements for Ecological Management Plans* and forms part of the EMP.
- The Ecological Management Plan should:
    - include a fire management programme to ensure persistence of grassland
    - include an ongoing monitoring and eradication programme for all non-indigenous species, with specific emphasis on invasive and weedy species (*wattles, pom-poms and Kikuyu should be targeted on a priority basis*)
    - include a comprehensive surface runoff and storm water management plan, indicating how all surface runoff generated as a result of the development (during both the construction and operational phases) will be managed (e.g. artificial wetlands / storm water and flood retention ponds) prior to entering any natural drainage system or wetland and how surface runoff will be retained outside of any demarcated buffer/flood zones and subsequently released to simulate natural hydrological conditions
    - ensure the persistence of all Red and Orange List species
    - include a monitoring programme for all Red and Orange List species

- facilitate/augment natural ecological processes
  - provide for the habitat and life history needs of important pollinators
  - minimize artificial edge effects (e.g. water runoff from developed areas & application of chemicals)
  - include a comprehensive plan for limited recreational development (trails, bird hides etc.) within the open space system
  - include management recommendations for neighbouring land, especially where correct management on adjacent land is crucial for the long-term persistence of sensitive species present on the development site
  - result in a report back to the Directorate of Nature Conservation on an annual basis
  - investigate and advise on appropriate legislative tools (e.g. the NEMA: Protected Areas Act 57 of 2003) for formally protecting the area (as well as adjacent land where it is crucial for the long-term persistence of sensitive species present on the development site)
- The open space system should be fenced off prior to construction commencing (including site clearing and pegging). All construction-related impacts (including service roads, temporary housing, temporary ablution, disturbance of natural habitat, storing of equipment/building materials/vehicles or any other activity) should be excluded from the open space system. Access of vehicles to the open space system should be prevented and access of people should be controlled, both during the construction and operational phases. Movement of indigenous fauna should however be allowed (i.e. no solid walls, e.g. through the erection of palisade fencing).
- Information boards should be erected within the development to inform residents of the presence of Red / Orange List species, their identification, conservation status and importance, biology, habitat requirements and management requirements.

Reference: Directorate of Nature Conservation, GDACE. 2008 and revised on February 2009. GDACE Requirements for Biodiversity Assessments, Version 2. Gauteng Provincial Government.

9. CONCLUSIONS

The ideals of the Kleinfontein Bavaria are laudable and progress to date impressive. Minor errors crept into the execution of the project ideals. The drainage lines and wetlands on the site are deemed sensitive in terms of mammals.

10. ACKNOWLEDGEMENTS

Mr 'Lampies" Lampbrechts (resident) greatly assisted in compiling the list of occurrences (Table 1), particularly in terms of reintroduced herbivores and sight records of naturally occurring herbivores and carnivores. These records are therefore marked as definite occurrences in Table 1 and listed in Table 2.

11. LITERATURE SOURCES

Anonymous. (January 2009). Beleids- en Bestuursriglyne vir die Kleinfontein Bewaria. Kleinfontein Boerebelange Koöperatief Bpk Internal Report.

Acocks, J.P.H. 1988. Veld types of South Africa, 3rd ed. *Memoirs of the Botanical Survey of South Africa.*

Bredenkamp, G.J. & Brown, L.R. 2001. Vegetation – A reliable ecological basis for environmental planning. *Urban Greenfile* Nov-Dec 2001: 38-39.

Bronner, G.N., Hoffmann, M., Taylor, P.J., Chimimba, C.T., Best, P.B., Mathee, C.A. & Robinson, T.J. 2003. A revised systematic checklist of the extant mammals of the southern African subregion. Durban Museum Novitates 28:56-103.

Department of Environmental Affairs and Tourism. 2007. National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004): Publication of Lists of Critically Endangered, Endangered, Vulnerable and Protected Species. Government Notices.

Directorate of Nature Conservation, GDACE. 2009. GDACE Requirements for Biodiversity Assessments, Version 2. Gauteng Provincial Government.

Friedman, Y. and Daly, B. (editors). 2004. *Red Data Book of the Mammals of South Africa: A Conservation Assessment*: CBSG Southern Africa, Conservation Breeding Specialist Group (SSC/IUCN), Endangered Wildlife Trust. South Africa.

Knobel, J. & Bredenkamp, G. 2005. *The magnificent natural heritage of South Africa.* Roggebaai, Sunbird Publishers.

Low, A.B. & Rebelo, A.G. 1996. 'Vegetation Map of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism, Pretoria.

Low, A.E. & Rebelo, A.G. (eds). 1998. *Vegetation of South Africa, Lesotho and Swaziland*. A companion to the Vegetation Map of South Africa, Lesotho and Swaziland. Department of Environmental Affairs & Tourism, Pretoria.

Meester, J.A.J., Rautenbach, I.L., Dippenaar, N.J. & Baker, C.M. 1986. *Classification of Southern African Mammals*. Transvaal Museum Monograph No. 5. Transvaal Museum, Pretoria, RSA.

Mills, G. & Hes, L. 1997. The complete book of Southern African Mammals. Struik Winchester, Cape Town, RSA.

Mucina, L. & Rutherford, M.C. 2006. *The vegetation of South Africa, Lesotho and Swaziland.* Strelitzia 19. South African National Biodiversity Institute, Pretoria.

Rautenbach, I.L. 1978. A numerical re-appraisal of the southern African biotic zones. Bulletin of the Carnegie Museum of Natural History 6:175-187.

Rautenbach, I.L. 1982. Mammals of the Transvaal. Ecoplan Monograph No. 1. Pretoria, RSA.

Russel, P.J., Wolfe, S.L., Hertz, P.E., Starr, C., Fenton, M.B., Addy, H., Maxwell, D., Haffie, T. and Davey, K. 2010. *Biology: Exploring the Diversity of Life.* First Canadian Edition. Nelson Education, Toronto. 1256pp.

Skinner, J.D. & Chimimba, T.C. 2005. *The Mammals of the Southern African Subregion*. 3rd edition. Cambridge University Press.

Skinner, J.D. & Smithers, R.H.N. 1990. *The Mammals of the Southern African Subregion*. 2nd edition. Pretoria: University of Pretoria.

Smithers,R.H.N. 1983. *The Mammals of the Southern African Subregion.* Pretoria: University of Pretoria.

Taylor, P.J. 1998. *The Smaller Mammals of KwaZulu-Natal*. University of Natal Press: Pietermaritzburg.

Taylor, P.J. 2000. *Bats of Southern Africa. University of Natal Press*: Pietermaritzburg.

The Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983)

The Environmental Conservation Act, 1989 (Act No. 73 of 1989)
The National Environment Management Act, 1998 (Act No. 107 of 1998)
The National Environmental Management Biodiversity Act, 2004. (Act 10 0f 2004). Government Gazette RSA Vol. 467, 26436, Cape Town, June 2004.
The National Environmental Management Biodiversity Act, 2004. (Act 10 of 2004). Draft List of Threatened Ecosystems. Government Gazette RSA Vol. 1477, 32689, Cape Town, 6 Nov 2009.
The National Forests Act, 2006 (Act 84 of 1998 as amended). Government Gazette RSA Vol. 897, 29062, Cape Town, 8 Sept 2006.
The Natural Scientific Professions Act (Act 27 of 2003).

GALAGO ENVIRONMENTAL

C.

Fauna and Flora Specialists
638 Turf Street
Wingate Park, 0181
Tel: 012-345 4891
Fax: 086 675 6136
Email: Vanessam@lantic.net

Avifauna Assessment

of

PORTION 31 AND 38 AND THE REMAINDER OF KLEINFONTEIN 368 JR AND PORTION 14, 63 AND 68 OF DONKERHOEK 365 JR

February 2012

Report author: Mr. R.F. Geyser
Report verified/reviewed by: Dr. A.C. Kemp (Ph.D., Pr.Sci. Nat. (Zoology & Ecology))

VERIFICATION STATEMENT

Mr R. Geyser is not registered as a Professional Natural Scientist with the S.A. Council for Natural Scientific Professions. This communication serves to verify that the bird report compiled by Mr R.F. Geyser has been prepared under my supervision, and I have verified the contents thereof.

Declaration of Independence: I, Alan Charles Kemp (4405075033081), declare that I:

- am committed to biodiversity conservation but concomitantly recognize the need for economic development. Whereas I appreciate the opportunity to also learn through the processes of constructive criticism and debate, I reserve the right to form and hold my own opinions and therefore will not willingly submit to the interests of other parties or change my statements to appease them
- abide by the Code of Ethics of the S.A. Council for Natural Scientific Professions
- act as an independent specialist consultant in the field of zoology
- am subcontracted as specialist consultant by Galago Environmental CC for the proposed development of Portion 31, 38 and the remainder of Kleinfontein 365 JR and Portion 14, 63, 67 and 68 of the farm Donkerhoek 365 JR described in this report
- have no financial interest in the proposed development other than remuneration for work performed
- neither have nor will have any vested or conflicting interests in the proposed development
- undertake to disclose to Galago Environmental CC and its client, and the competent authority, any material information that has or may have the potential to influence decisions by the competent authority as required in terms of the Environmental Impact Assessment Regulations 2006

Dr A.C. Kemp

DECLARATION OF INDEPENDENCE:

I, Rihann F. Geyser (690304 5248 084), declare that I:

- am committed to biodiversity conservation but concomitantly recognize the need for economic development. Whereas I appreciate the opportunity to also learn through the processes of constructive criticism and debate, I reserve the right to form and hold my own opinions and therefore will not willingly submit to the interests of other parties or change my statements to appease them
- act as an independent specialist consultant in the field of zoology
- am subcontracted as specialist consultant by Galago Environmental CC for the proposed Kleinfontein & Donkerhoek project described in this report
- have no financial interest in the proposed development other than remuneration for work performed
- neither have nor will have any vested or conflicting interests in the proposed development
- undertake to disclose to Galago Environmental CC and its client, and the competent authority, any material information that has or may have the potential to influence decisions by the competent authority as required in terms of the Environmental Impact Assessment Regulations 2006

Rihann F. Geyser

TABLE OF CONTENTS

FIGURES:

TABLES:

1. INTRODUCTION

Galago Environmental CC. was appointed to undertake an avifaunal habitat survey/scan for Portions 31, 38 and the remainder of Kleinfontein 365 JR and Portions 14, 63, 67 and 68 of the farm Donkerhoek 365 JR (hereafter referred to as the study site), which is scheduled for development into an eco estate with residents, open spaces, gape park areas etc. This is in accordance with the 2010 EIA Regulations (No. R. 543-546, Department of Environmental Affairs and Tourism, 18 June 2010) emanating from Chapter 5 of the National Environmental Management Act, 1998 (Act No. 107 of 1998).

The primary objective was to determine the presence of Red Data avifaunal species and to identify suitable habitat for these species. Direct observations and published data apart, qualitative and quantitative habitat assessments were used to derive the presence / absence of Red Data avifaunal species. A list of avifaunal species likely to be affected by the new development is compiled.

2. SCOPE AND OBJECTIVES OF THE STUDY

- To qualitatively and quantitatively assess the significance of the avifaunal habitat components, and current general conservation status of the property;
- To comment on ecologically sensitive areas;
- To comment on connectivity with natural vegetation and habitats on adjacent sites;
- To provide a list of avifauna that occur or that are likely to occur, and to identify species of conservation importance;
- To highlight potential impacts of the proposed development on the avifauna of the study site, and
- To provide management recommendations to mitigate negative and enhance positive impacts should the proposed development be approved.

3. STUDY AREA

The study site, 508 ha in extent, is situated within the 2528CD quarter degree grid cell (q.d.g.c.; SABAP1 protocol) and 2545_2825 pentad (SABAP2 protocol) south west of the N4/R515 intersection within the Gauteng Province (25°48'01.4" S 28°29'41.5" E)

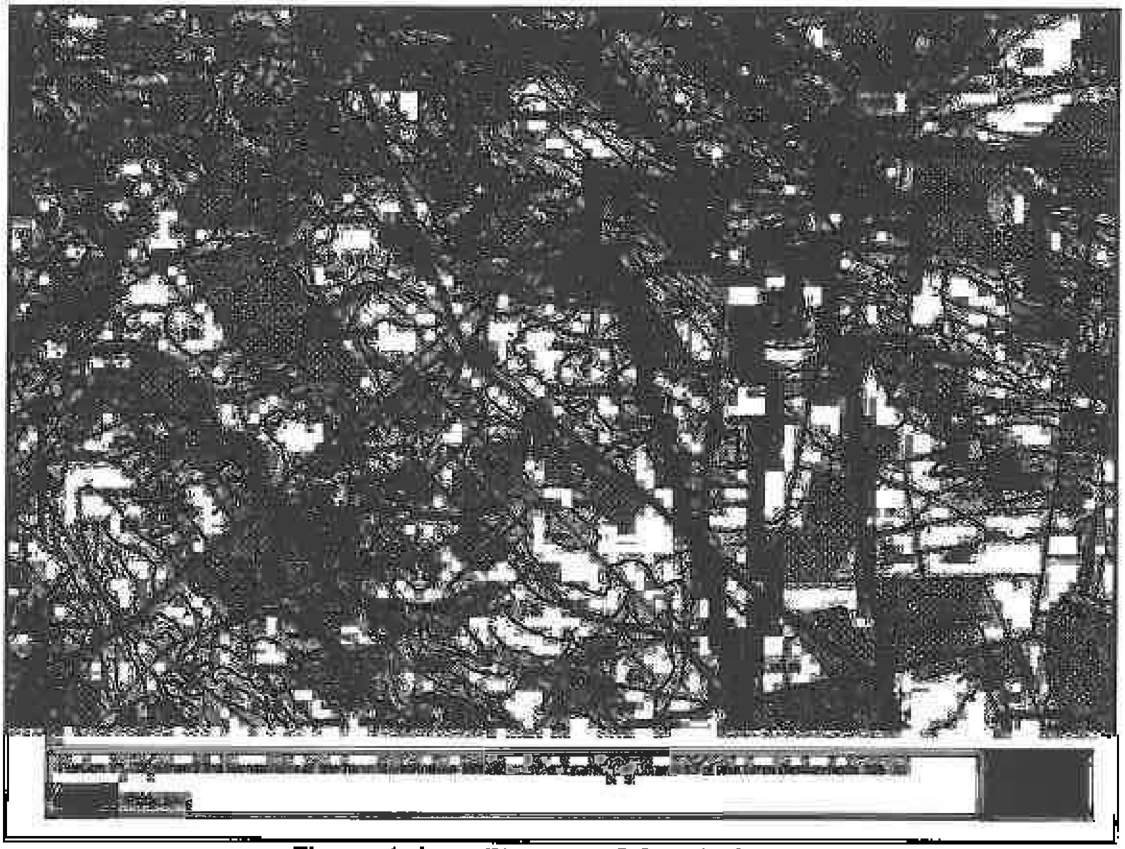


Figure 1: Locality map of the study area

4. METHODS

Site visits were conducted on two full days, 26 March 2011 and 23 April 2011 to record the presence of bird species associated with the habitat systems on the study site and to identify possible sensitive areas. During this visit the observed and derived presence of avifaunal species associated with the recognized habitat types of the study site, were recorded. This was done with due regard to the well recorded global distributions of Southern African avifauna, coupled to the qualitative and quantitative nature of recognized habitats.

4.1 Field Surveys

During the site visit, birds were identified by visual sightings using a 10X42 Bushnell Legend binoculars and a 20X-60X Pentax spotting scope or aural records along random transect walks and where necessary were verified from Sasol Birds of Southern Africa (Sinclair *et al.*, 2005) and Southern African Bird Sounds (Gibbon, 1991).

The 500 m of adjoining properties was scanned for important animal species and avifaunal habitats.

No trapping or mist netting was conducted, since the terms of reference did not require such intensive work. In addition, birds were also identified by means of feathers, nests, signs, droppings, burrows or roosting sites. Locals were interviewed to confirm occurrences or absences of species.

4.2 Desktop Surveys

The presence of suitable habitats was used to deduce the likelihood of presence or absence of avifaunal species, based on authoritative tomes, scientific literature, field guides, atlases and databases. This can be done irrespective of season.

The likely occurrence of key avifaunal species was verified according to distribution records obtained during the Southern African Bird Atlas Project 1 (SABAP1) period from 1981 to 1993 (Harrison *et al.* 1997). Earlier records of only Red Data avifaunal species were obtained from the period between 1974 and 1987 according to Tarboton *et al.* (1987). The most recent avifaunal distribution data were obtained from the current SABAP2 data which commenced on 1 July 2007.

The occurrence and historic distribution of likely avifaunal species, especially all Red Data avifaunal species recorded for the q.d.g.c. 2528CD, were verified from SABAP1 (southern Africa Bird Atlas Project 1) data (Harrison *et al.* 1997), Tarboton *et al.* (1987) and the current SABAP2 project (SABAP2 data for the 2528CD q.d.g.c and for the 2545_2825 pentad). The reporting rate for each avifaunal species likely to occur on the study site, based on Harrison *et al.* (1997), was scored between 0 – 100% and was calculated as follows: Total number of cards on which a species was reported during the Southern African Bird Atlas SABAP1 and, Red Data species only, the current SABAP2 project period X 100 ÷ total number of cards for the particular q.d.g.c. (Harrison *et al.*, 1997) and pentad(s) (SABAP2). It is important to note that a q.d.g.c. (SABAP1 Protocol) covers a large area: for example, q.d.g.c. 2528CD covers an area of ±27 X 25 km (±693 km^2) (15 minutes of latitude by 15 minutes of longitude, 15' x 15') and a pentad (SABAP2 Protocol) and area of ±8 X 7.6 km (5 minutes of latitude by 5 minutes of longitude, 5' x 5') and it is possible that suitable habitat will exist for a certain Red Data avifaunal species within this wider area surrounding the study site. However, the specific habitat(s) found on site may not suit the particular Red Data species, even though it has been recorded for the q.d.g.c or pentad. For example, the Cape Vulture occurs along the Magaliesberg but will not favour the habitat found within the Pretoria CBD, both of which are in the same q.d.g.c. Red Data bird species were selected and categorised according to Barnes (2000).

An avifaunal diversity index, that gives an indication of which habitat system on the study site will hold the richest bird diversity, was calculated as the sum of the probability of occurrence of bird species within a specific habitat system on site. For each species and habitat, the probability of occurrence was ranked as: 5 = present on site, 4 = not observed on site but has a high probability of occurring there, 3 = medium probability, 2 = low probability, 1 = very low probability and 0 = not likely to occur.

4.3 Specific Requirements

During the site visit, the study site was surveyed visually and its habitats assessed for the potential occurrence of priority Red Data avifauna, according to GDACE's requirement for Biodiversity Assessments, Version 2 (2009), as well as for any other Red Data bird species: The priority Red Data bird species for Gauteng are (in Roberts VII order and nomenclature, Hockey *et al.* 2005):

- Half-collared Kingfisher (*Alcedo semitorquata*)
- African Grass-Owl (*Tyto capensis*)
- White-bellied Korhaan (*Eupodotis senegalensis*)
- Blue Crane (*Anthropoides paradiseus*)
- African Finfoot (*Podica senegalensis*)

- Cape Vulture (*Gyps coprotheres*)
- African Marsh-Harrier (*Circus ranivorus*)
- Martial Eagle (*Polemaetus bellicosus*)
- Secretarybird (*Sagittarius serpentarius*)
- Lesser Kestrel (*Falco naumanni*)
- Greater Flamingo (*Phoenicopterus ruber*)
- Lesser Flamingo (*Phoenicopterus minor*)
- White-backed Night-Heron (*Gorsachius leuconotus*)
- Black Stork (*Ciconia nigra*)

Particular reference was made to the occurrence of White-bellied Korhaan (*Eupodotis senegalensis*) as per GDARD minimum requirements.

5. RESULTS

Avifaunal Habitat Assessment:
Figure 2 illustrates the major habitat systems identified as likely to be used by bird species expected to occur on the study site.

Five major avifaunal habitat systems were identified. A short description of each habitat type follows, ranked from most to least important (refer to figure 2):

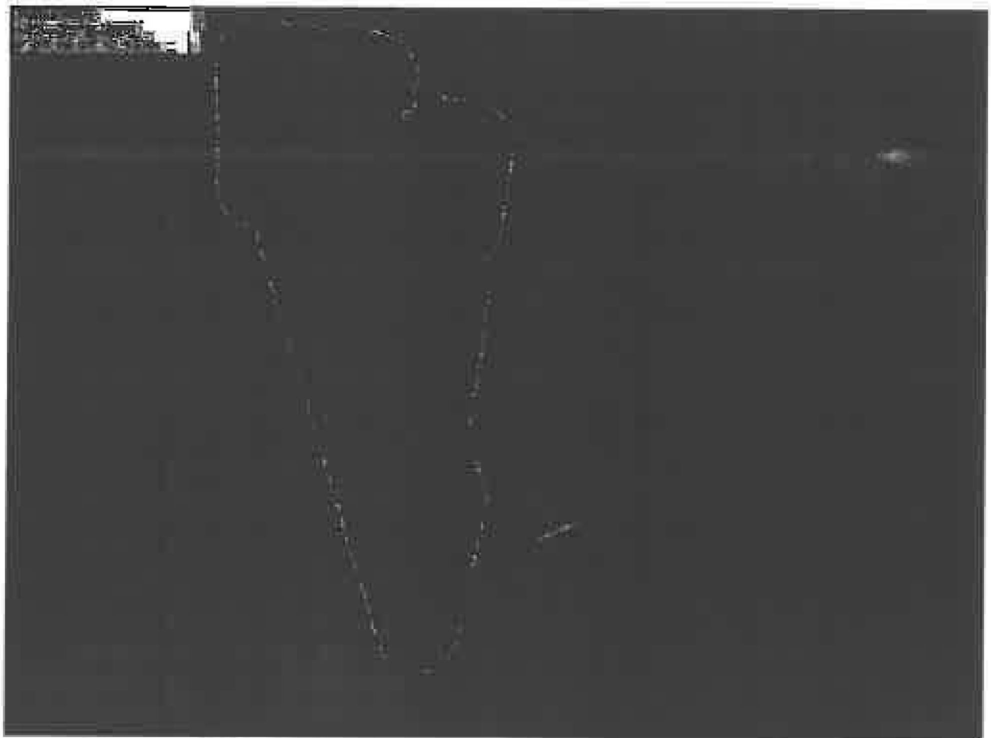


Figure 2: Bird habitat systems identified from the study site.

Open grassland, rocky ridges and fallow fields:
A southern portion of the study site is situated within the Mesic Highveld Grassland Bioregion of the Grassland Biome and more specifically within the Rand Highveld Grassland vegetation type according to Mucina and Rutherford (2006).

The grassland areas consist of natural grassland in the flatter areas on the study site and more disturbed grassland areas and fallow fields in the southern portion of the study site.

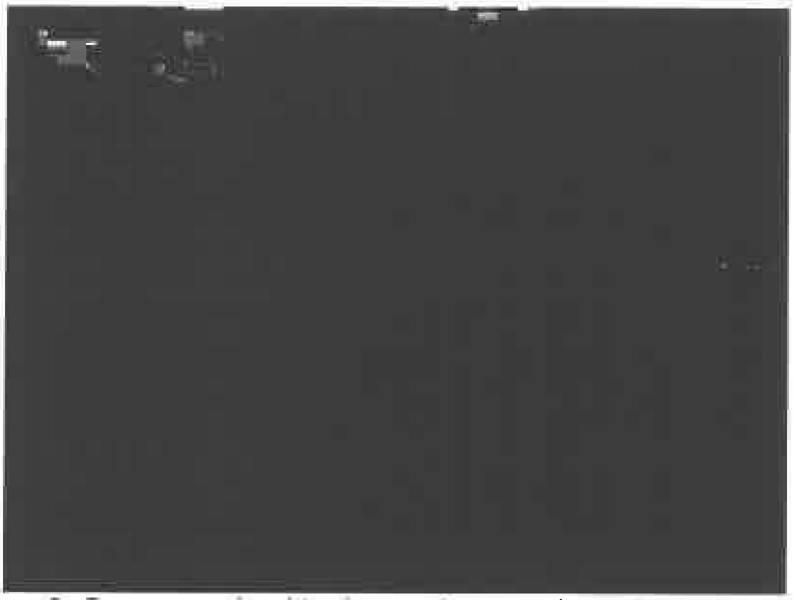


Figure 3: Open grassland in the northern portion of the study site.

The presence and abundance of bird species in this habitat will vary from season to season - lush and green in summer after summer rains and dry, brown, frosted or burnt during winter. The habitat favours ground-living bird species, such as lapwings, francolins, pipits, longclaws, larks and chats. These birds hunt for insects and/or breed on the ground, in burrows in the ground, or between the grasses. Weavers and widowbirds make use of such habitat for feeding on ripe seeds during late summer and early winter when the grass is not burnt, and widowbirds and cisticolas will also breed in the tall grass during summer. Species such as weavers and bishops that breed in the wetland habitat during summer will also make use of the open grassland habitat for feeding during winter after the grasses have seeded. Aerial feeding birds such as martins, swifts and swallows will also hunt for insects over the grasslands.

There is also a rocky ridge that runs through the northern portion of the property and the vegetation is known as Gold Reef Mountain Bushveld (Mucina and Rutherford, 2006), that provides the typical impression of rocky highveld grassland, protecting some low woody plants from fire. The rocky ridge, although small in area, might favour species such as Wailing Cisticola *(Cisticola lais)*, chats and Bokmakierie *(Telophorus zeylonus)*. The outcrops will favour birds associated with rocky habitats such as chats, wheaears, rock thrushes, buntings and cisticolas that will favour the rocky nature of the area for breeding and to perch on when hunting for insects and to scan the surroundings for predators. The trees and shrubs growing between these rocks will also provide food in the form of seeds and fruits to various bird species, and shelter and nesting sites for many birds, especially passerines.

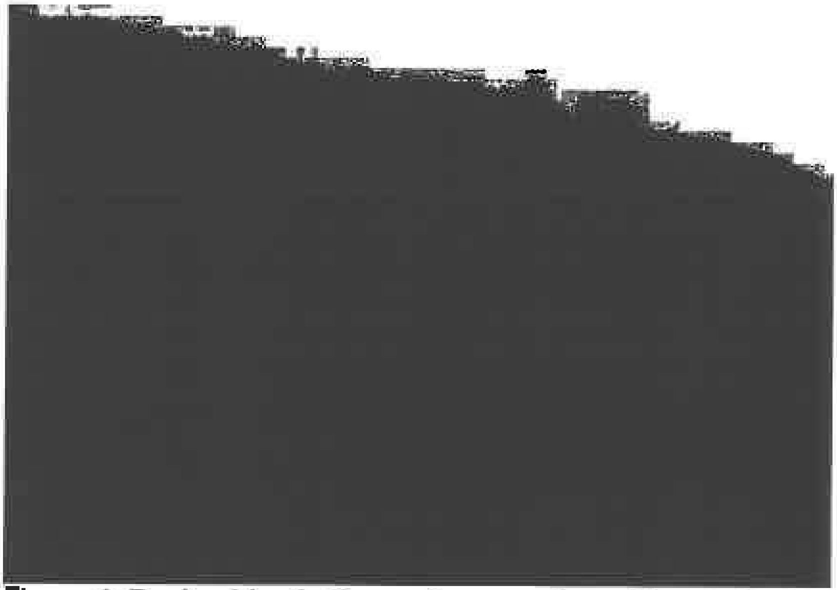


Figure 4: Rocky ridge in the northern portion of the study site.

Wetlands:

The wetland system on the study site is limited to a small and narrow stream that cuts through the ridge with a series of dammed up areas constructed within this stream in the north-western portion of the property (figure 5).

Figure 5: Narrow stream with dammed up areas.

This habitat system consists of fast-flowing water covered with wetland vegetation such as rushes and reeds bordered with sedges and wetland grasses. The banks of the stream is steep offering few marshy areas. This habitat is ideal for birds such as warblers, crakes and moorhen that hunt and feed in the undergrowth at water level. Bishops and weavers, that use the rushes for roosting and breeding, and birds such as snipes and some duck species, that use the short march grass on the edge of the wetland for feeding and breeding, also prefer this habitat. This is a mainly a permanent wetland area and probably never dies up completely except in times of drought. During the winter the water flow is limited to a shallow and narrow stream that meanders through the wetland area but during summer, during high rainfall, the stream becomes broader with faster water flow. In winter the aquatic and semi-aquatic vegetation becomes dry and brown due to limited water or due to cold and frost or burnt down completely and during summer the vegetation becomes lush and green especially after good rains. Some swallows and martins make use of this wetland habitat for roosting or forages over the wetland area or drink water in flight from the surface of the dams. Aquatic fauna that lives within the water such as fish, frogs and their tadpoles will attract birds that feed on them such as kingfishers and cormorants. The open water of the dams will favour open water avifaunal species such as ducks and grebes.

***Acacia* savannah and mixed exotic and indigenous woodland and vegetation:**
Acacia savannah woodland grows in areas, especially in the southern portion of the study site as well as within the isolated areas within the southern most smallholdings. These woodlands, dominated by *Acacia karoo* and *Acacia caffra* (Barnes 1998), vary in density from place to place. These trees are hardy and able to withstand extremely cold and dry weather conditions. Mixed exotic and indigenous vegetation dominates the southern portion of the study site.

Figure 6: Acacia dominated woodland

This habitat will favour species typically associated with a woodland habitat and more specifically mixed *Acacia* savanna woodland. This area generally include a great variety of arboreal passerines such as drongos, warblers, flycatchers, shrikes, sunbirds, waxbills and weavers and arboreal non-passerines such as doves, cuckoos, woodpeckers. Many of these species make use of the thorny nature of these trees to build their nests. *Acacia* trees generally attract many insects and in turn attract a good diversity of typical "Bushveld" bird species.

Suburban, rural gardens smallholdings and transformed areas:
Other areas are mainly disturbed by past and present human activities and consists of small built up areas or smallholding with mixed exotic and indigenous vegetation.

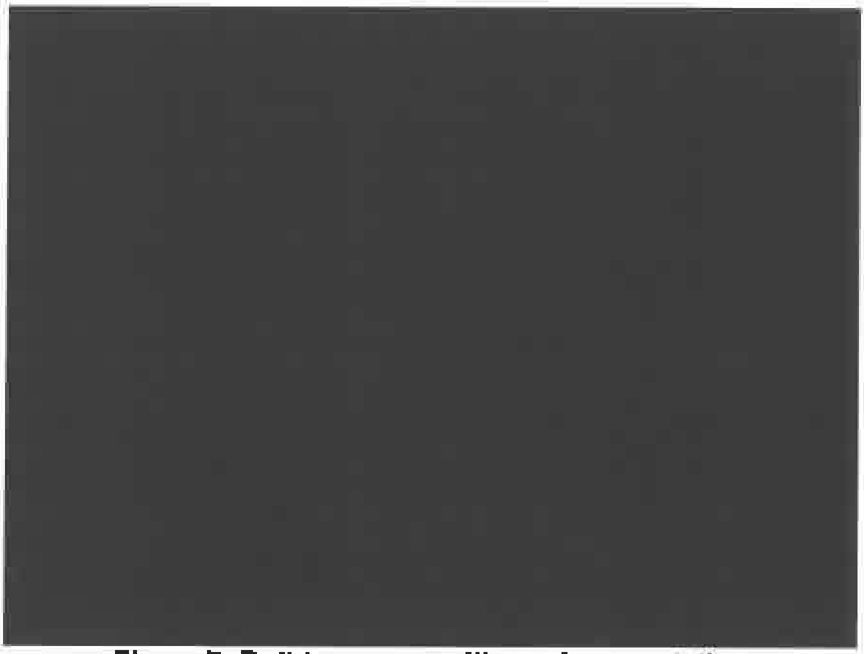


Figure 7: Build up areas with garden vegetation

Rural and suburban gardens have created an evergreen habitat for many bird species, where birds can hide, breed and forage for food. Natural predators such as snakes and smaller wild-cat species, which largely are persecuted by man, have been driven out of these areas, making it a relatively safe environment for birds apart from domestic cats and dogs. Many bird species have adapted to human-altered areas and these species are mainly the more common bird species found within southern Africa.

The ranges of some species have also increased and species not previously known to occur within Gauteng suburbs are now common, e.g. Grey Go-away-bird and Thick-billed Weaver. Some species, which are mainly alien species, are dependant on humans for survival such as the House Sparrow and Common Myna.

Large gardens, parks, sport fields and golf courses with open lawns also create ideal habitat for ground-feeding birds. These lawns are usually well watered and the ground soft, making it easy for birds that probe in the ground with their beaks in search of worms and other ground-living insects. There is usually water present, in the form of irrigation systems, ponds, man made dams such as at golf courses, water features and/or swimming pools. The interest in birds among the public has grown and bird feeders are today a normal feature in most gardens. Certain exotic trees reach considerable heights in gardens, which allows birds to nest in them and thereby be protected from predators.

Fruit-bearing trees are also an important food supply for many bird species. Most of these bird species are not habitat specific and, due to their high level of adaptability, are also not threatened.

Exotic vegetation:
There are several areas on the study site that are overgrown by exotic invasive vegetation such as wattle and *Eucalyptus*.

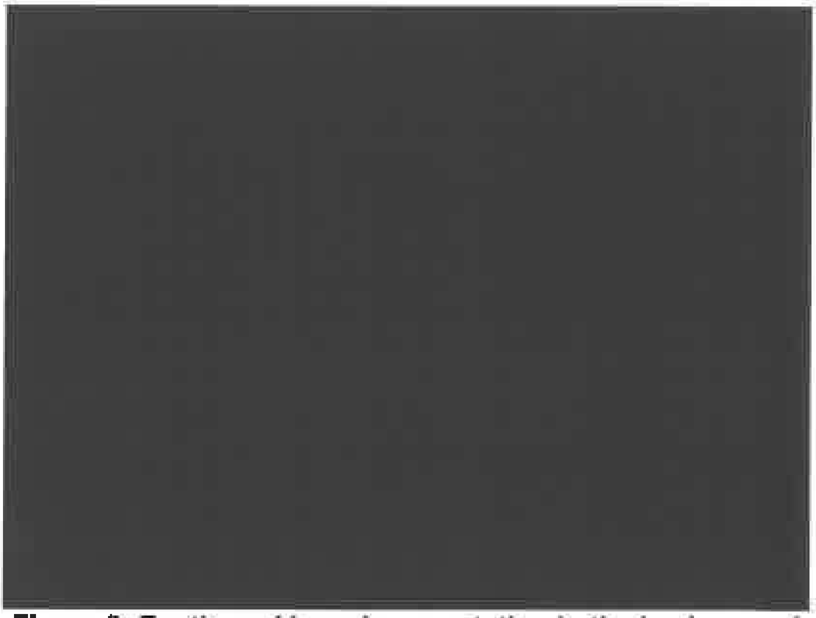


Figure 8: Exotic and invasive vegetation in the background

Exotic plantations usually do not offer a large variation in plant communities and these trees are mostly unpalatable in their live stage for insect and game species. As a result, few insect-eating bird species will occur within these plantations. A number of nectar feeding species, such as white-eyes and sunbirds, will feed on the nectar produced by the flowers of these trees, and some birds also make nests in these trees.

A few species of bird of prey, which require tall trees for nest building, have increased their ranges due to the presence of these trees. These include Black and Ovambo Sparrowhawks, and Bat Hawks have also benefited from large *Eucalyptus* (blue gum) trees but do not occur regularly within the Gauteng region.

No or little grass growth takes place on the ground where these trees grow and seed-eating bird species are few. The roots of these trees are known to extract large volumes of water daily and the surrounding ground is normally hard and dry.

The growth of black wattle on site varies from single standing trees to dense wattle bush clumps. In general, black wattle trees create a sterile environment and are not utilised by many bird species. Some of the most common species have however adapted to black wattle plantations, such as Cape White-eye, White-bellied Sunbird, Southern Boubou, Neddicky, Black-crowned Tchagra and Cape Robin. These birds either make use of the flowers for nectar-feeding or the trees for nest building or shelter. None of the Red Data bird species are known to make use of black wattle trees.

Observed and Expected Species Richness

Of the 341 bird species recorded for the 2528CC q.d.g.c. according to the SABAP1 data (Hockey *et al*, 2005), 205 (60.1 %) are likely to occur on the study site and 74 (36 %) of these bird species were actually observed on site.

The avifaunal diversity index indicates that the largest bird species diversity is likely to occur within the Acacia savannah and mixed exotic and indigenous vegetation habitat system on site, with a diversity index (BI) of 525, followed by the open grassland, rocky outcrop, and fallow fields (BI 444), wetland (BI 367), gardens, smallholdings (build up area) and transformed area (BI 360) and exotic and alien trees (BI 317).

The bird species listed in Table 1 are in the species order according to *Roberts - Birds of Southern Africa* VIIth edition (Hockey *et al*, 2005). These comprise the 207 species actually observed on site (**in bold**) or likely to occur within the specific habitat systems found on and surrounding the study site. This does not include overflying birds or rare vagrants. The reporting rate for each species is the percentage for the q.d.g.c. according to the SABAP 1 atlas (Harrison *et al.* 1997) and is represented by colour codes as follows: Yellow = Very Low, Light Orange = Low, Dark Orange = Medium and Red = High. The habitat preference scores for each species are shown under the recognised habitat types on site: **GR = open Grassland, Rocky ridges and fallow fields, WT = Wetland, AW = Acacia savannah and mixed exotic and indigenous vegetation, ST = Suburban gardens and smallholdings and Transformed areas, and EX = Exotic Trees and Plantations,** with their possibility of occurrence in these specific habitats rated as 5 = present, 4 = High, 3 = Medium, 2 = Low, 1 = Very low, and 0 = Not likely to occur.

Table 1: Bird species observed and that are likely to occur on the study site.

SCIENTIFIC NAMES	ENGLISH NAMES	R rate (%)*	HABITAT PREFERENCE				
		2528CD	GR	WT	AW	ST	EX
Peliperdix coqui	Coqui Francolin		4	2	2	0	0
Dendroperdix sephaena	Crested Francolin		1	0	2	0	0
Scleroptila levaillantii	Red-winged Francolin		2	1	0	0	0
Pternistis swainsonii	**Swainson's Spurfowl**		5	4	4	2	1
Coturnix coturnix	Common Quail		3	1	1	0	0
Numida meleagris	**Helmeted Guineafowl**		5	4	5	4	4
Dendrocygna viduata	White-faced Duck		0	3	0	0	0
Alopochen aegyptiaca	Egyptian Goose		0	3	0	0	0
Anas sparsa	African Black Duck		0	4	0	0	0
Anas undulata	Yellow-billed Duck		0	4	0	0	0
Anas smithii	Cape Shoveler		0	2	0	0	0
Anas erythrorhyncha	Red-billed Teal		0	3	0	0	0
Indicator indicator	Greater Honeyguide		2	0	2	1	3
Indicator minor	Lesser Honeyguide		2	2	4	2	4
Prodotiscus regulus	Brown-backed Honeybird		3	1	2	0	0
Jynx ruficollis	**Red-throated Wryneck**		4	3	5	3	5
Campethera abingoni	Golden-tailed Woodpecker		0	0	4	2	1
Dendropicos fuscescens	Cardinal Woodpecker		0	0	4	4	3
Dendropicos namaquus	Bearded Woodpecker		0	0	2	1	1
Pogoniulus chrysoconus	Yellow-fronted Tinkerbird		0	0	2	0	0
Tricholaema leucomelas	Acacia Pied Barbet		2	1	2	1	1
Lybius torquatus	**Black-collared Barbet**		3	0	5	4	4
Trachyphonus vaillantii	**Crested Barbet**		3	0	5	5	4
Tockus nasutus	African Grey Hornbill		3	0	4	3	4
Upupa africana	**African Hoopoe**		3	0	4	4	0
Phoeniculus purpureus	Green Wood-Hoopoe		0	0	4	4	4
Rhinopomastus cyanomelas	**Common Scimitarbill**		0	0	5	1	2
Alcedo cristata	Malachite Kingfisher		0	3	0	0	0
Halcyon senegalensis	Woodland Kingfisher		0	1	2	1	2
Halcyon albiventris	**Brown-hooded Kingfisher**		2	3	5	4	4
Ceryle rudis	Pied Kingfisher		0	4	0	0	0
Merops bullockoides	**White-fronted Bee-eater**		3	4	4	1	2
Merops pusillus	Little Bee-eater		0	0	2	0	0
Merops apiaster	European Bee-eater		4	4	4	2	3
Colius striatus	**Speckled Mousebird**		2	2	4	5	3
Urocolius indicus	**Red-faced Mousebird**		4	2	5	4	4
Clamator jacobinus	Jacobin Cuckoo		0	0	2	0	1
Cuculus solitarius	Red-chested Cuckoo		0	0	4	2	4
Cuculus clamosus	Black Cuckoo		0	0	4	1	4

SCIENTIFIC NAMES	ENGLISH NAMES	R rate (%)*	HABITAT PREFERENCE				
		2528CD	GR	WT	AW	ST	EX
Chrysococcyx klaas	Klaas's Cuckoo	[redacted]	2	0	2	1	2
Chrysococcyx caprius	**Diderick Cuckoo**	[redacted]	4	5	5	3	4
Centropus burchellii	Burchell's Coucal	[redacted]	0	4	3	2	1
Cypsiurus parvus	**African Palm-Swift**	[redacted]	5	5	5	4	2
Apus barbatus	African Black Swift	[redacted]	2	2	2	0	0
Apus affinis	Little Swift	[redacted]	4	4	4	4	2
Apus caffer	**White-rumped Swift**	[redacted]	5	5	4	4	2
Corythaixoides concolor	**Grey Go-away-bird**	[redacted]	2	0	5	4	3
Tyto alba	Barn Owl	[redacted]	4	2	4	3	3
Bubo africanus	Spotted Eagle-Owl	[redacted]	4	2	4	4	4
Glaucidium perlatum	Pearl-spotted Owlet	[redacted]	0	0	3	0	0
Caprimulgus pectoralis	Fiery-necked Nightjar	[redacted]	3	0	1	0	0
Caprimulgus tristigma	Freckled Nightjar	[redacted]	2	0	0	0	0
Caprimulgus rufigena	Rufous-cheeked Nightjar	[redacted]	3	0	3	0	0
Columba livia	Rock Dove	[redacted]	2	2	1	4	2
Columba guinea	**Speckled Pigeon**	[redacted]	4	2	3	5	2
Columba arquatrix	African Olive-Pigeon	[redacted]	0	0	1	1	1
Streptopelia senegalensis	**Laughing Dove**	[redacted]	4	4	5	5	4
Streptopelia capicola	**Cape Turtle-Dove**	[redacted]	4	4	5	4	5
Streptopelia semitorquata	**Red-eyed Dove**	[redacted]	4	5	5	4	5
Turtur chalcospilos	Emerald-spotted Wood-Dove	[redacted]	0	0	2	0	0
Treron calvus	African Green-Pigeon	[redacted]	0	0	2	2	0
Afrotis afraoides	Northern Black Korhaan	[redacted]	2	0	0	0	0
Amaurornis flavirostris	Black Crake	[redacted]	0	3	0	0	0
Gallinula chloropus	Common Moorhen	[redacted]	0	4	0	0	0
Fulica cristata	Red-knobbed Coot	[redacted]	0	4	0	0	0
Tringa glareola	Wood Sandpiper	[redacted]	0	3	0	0	0
Actitis hypoleucos	Common Sandpiper	[redacted]	0	3	0	0	0
Burhinus capensis	**Spotted Thick-knee**	[redacted]	4	0	4	5	1
Charadrius tricollaris	Three-banded Plover	[redacted]	2	4	0	0	0
Vanellus armatus	**Blacksmith Lapwing**	[redacted]	2	5	2	4	0
Vanellus senegallus	**African Wattled Lapwing**	[redacted]	5	5	3	2	0
Vanellus coronatus	**Crowned Lapwing**	[redacted]	5	0	4	5	1
Elanus caeruleus	**Black-shouldered Kite**	[redacted]	5	4	4	2	3
Milvus migrans	Black Kite	[redacted]	2	2	2	0	1
Circaetus pectoralis	Black-chested Snake-Eagle	[redacted]	2	0	0	0	1
Circaetus cinereus	**Brown Snake-Eagle**	[redacted]	5	0	0	0	1
Polyboroides typus	African Harrier-Hawk	[redacted]	2	0	2	0	1
Accipiter minullus	Little Sparrowhawk	[redacted]	0	0	4	3	4
Accipiter ovampensis	Ovambo Sparrowhawk	[redacted]	2	0	2	0	4
Accipiter melanoleucus	Black Sparrowhawk	[redacted]	2	0	2	0	3
Buteo vulpinus	Steppe Buzzard	[redacted]	4	0	4	0	4
Falco naumanni	Lesser Kestrel (VU)	[redacted]	1	0	0	0	1
Falco amurensis	Amur Falcon	[redacted]	3	0	1	0	1
Tachybaptus ruficollis	Little Grebe	[redacted]	0	4	0	0	0
Anhinga rufa	African Darter	[redacted]	0	3	0	0	0
Phalacrocorax africanus	Reed Cormorant	[redacted]	0	4	0	0	0
Egretta garzetta	Little Egret	[redacted]	0	3	0	0	0
Ardea cinerea	Grey Heron	[redacted]	3	0	0	0	0
Ardea melanocephala	Black-headed Heron	[redacted]	4	3	3	0	0
Ardea purpurea	Purple Heron	[redacted]	0	2	0	0	0
Bubulcus ibis	Cattle Egret	[redacted]	4	4	4	3	2
Butorides striata	Green-backed Heron	[redacted]	0	2	0	0	0
Nycticorax nycticorax	Black-crowned Night-Heron	[redacted]	0	2	0	0	0
Scopus umbretta	Hamerkop	[redacted]	0	4	0	0	0

SCIENTIFIC NAMES	ENGLISH NAMES	R rate (%)*	HABITAT PREFERENCE				
		2528CD	GR	WT	AW	ST	EX
Bostrychia hagedash	**Hadeda Ibis**	[redacted]	1	5	4	4	5
Threskiornis aethiopicus	African Sacred Ibis	[redacted]	0	2	0	0	0
Ciconia ciconia	White Stork	[redacted]	2	0	0	0	0
Oriolus larvatus	**Black-headed Oriole**	[redacted]	1	0	4	3	5
Dicrurus adsimilis	Fork-tailed Drongo	[redacted]	0	0	4	2	3
Terpsiphone viridis	**African Paradise-Flycatcher**	[redacted]	0	0	4	5	4
Dryoscopus cubla	**Black-backed Puffback**	[redacted]	0	0	5	3	2
Tchagra senegalus	Black-crowned Tchagra	[redacted]	4	0	3	0	3
Tchagra australis	**Brown-crowned Tchagra**	[redacted]	2	0	5	0	2
Laniarius ferrugineus	**Southern Boubou**	[redacted]	0	0	5	3	4
Laniarius atrococcineus	**Crimson-breasted Shrike**	[redacted]	0	0	5	1	3
Telophorus zeylonus	Bokmakierie	[redacted]	4	0	3	3	2
Malaconotus blanchoti	Grey-headed Bush-Shrike	[redacted]	0	0	3	1	2
Batis molitor	**Chinspot Batis**	[redacted]	0	0	5	0	1
Corvus albus	Pied Crow	[redacted]	4	0	4	3	4
Lanius collurio	Red-backed Shrike	[redacted]	3	0	4	0	1
Lanius minor	Lesser Grey Shrike	[redacted]	2	0	3	0	1
Lanius collaris	**Common Fiscal**	[redacted]	5	3	5	4	3
Parus niger	Southern Black Tit	[redacted]	0	0	4	0	0
Riparia paludicola	Brown-throated Martin	[redacted]	1	4	0	0	0
Riparia cincta	Banded Martin	[redacted]	4	2	1	0	0
Hirundo rustica	**Barn Swallow**	[redacted]	5	5	4	3	2
Hirundo albigularis	**White-throated Swallow**	[redacted]	4	5	4	4	0
Hirundo dimidiata	Pearl-breasted Swallow	[redacted]	3	3	3	0	0
Hirundo cucullata	**Greater Striped Swallow**	[redacted]	5	5	4	5	2
Hirundo abyssinica	Lesser Striped Swallow	[redacted]	4	4	4	4	2
Hirundo semirufa	Red-breasted Swallow	[redacted]	2	1	2	0	0
Hirundo spilodera	**South African Cliff-Swallow**	[redacted]	4	5	2	0	0
Hirundo fuligula	**Rock Martin**	[redacted]	5	4	4	4	0
Delichon urbicum	Common House-Martin	[redacted]	3	3	2	1	0
Pycnonotus tricolor	**Dark-capped Bulbul**	[redacted]	4	4	5	5	4
Stenostira scita	Fairy Flycatcher	[redacted]	0	0	4	0	1
Sphenoeacus afer	**Cape Grassbird**	[redacted]	2	5	0	0	0
Sylvietta rufescens	Long-billed Crombec	[redacted]	0	0	4	0	0
Acrocephalus arundinaceus	Great Reed-Warbler	[redacted]	0	2	2	1	1
Acrocephalus gracilirostris	Lesser Swamp-Warbler	[redacted]	0	4	0	0	0
Phylloscopus trochilus	**Willow Warbler**	[redacted]	0	1	4	4	5
Turdoides jardineii	Arrow-marked Babbler	[redacted]	0	0	4	3	4
Parisoma subcaeruleum	Chestnut-vented Tit-Babbler	[redacted]	0	0	4	0	0
Zosterops virens	Cape White-eye	[redacted]	2	0	4	4	4
Cisticola aberrans	**Lazy Cisticola**	[redacted]	5	0	0	0	0
Cisticola chiniana	Rattling Cisticola	[redacted]	0	0	3	0	1
Cisticola lais	**Wailing Cisticola**	[redacted]	5	0	0	0	0
Cisticola tinniens	**Levaillant's Cisticola**	[redacted]	2	5	0	0	0
Cisticola fulvicapilla	**Neddicky**	[redacted]	4	3	5	2	5
Cisticola juncidis	**Zitting Cisticola**	[redacted]	5	4	3	0	0
Cisticola aridulus	**Desert Cisticola**	[redacted]	5	0	0	0	0
Cisticola textrix	Cloud Cisticola	[redacted]	3	0	0	0	0
Prinia subflava	**Tawny-flanked Prinia**	[redacted]	4	5	4	3	4
Prinia flavicans	**Black-chested Prinia**	[redacted]	5	2	4	1	3
Mirafra africana	Rufous-naped Lark	[redacted]	5	0	4	0	0
Calendulauda sabota	Sabota Lark	[redacted]	0	0	2	0	0
Chersomanes albofasciata	Spike-heeled Lark	[redacted]	3	0	0	0	0
Calandrella cinerea	Red-capped Lark	[redacted]	2	0	0	0	0
Monticola rupestris	Cape Rock-Thrush	[redacted]	2	0	0	0	0
Psophocichla litsitsirupa	**Groundscraper Thrush**	[redacted]	2	0	5	5	2

SCIENTIFIC NAMES	ENGLISH NAMES	R rate (%)*	HABITAT PREFERENCE				
		2528CD	GR	WT	AW	ST	EX
Turdus libonyanus	Kurrichane Thrush	[redacted]	0	0	4	4	4
Turdus smithi	Karoo Thrush		1	2	4	4	4
Melaenornis pammelaina	Southern Black Flycatcher		0	0	2	1	2
Sigelus silens	Fiscal Flycatcher		3	0	4	4	4
Muscicapa striata	**Spotted Flycatcher**		4	3	5	4	5
Cossypha caffra	**Cape Robin-Chat**		2	3	5	4	5
Cercotrichas leucophrys	**White-browed Scrub-Robin**		0	0	5	0	2
Saxicola torquatus	**African Stonechat**		4	5	3	0	0
Oenanthe monticola	**Mountain Wheatear**		4	0	0	5	0
Oenanthe pileata	Capped Wheatear		3	0	0	0	0
Cercomela familiaris	**Familiar Chat**		5	0	3	5	0
Thamnolaea cinnamomeiventris	**Mocking Cliff-Chat**		4	0	0	5	0
Onychognathus morio	Red-winged Starling		4	0	3	4	0
Lamprotornis nitens	Cape Glossy Starling		4	0	4	4	3
Cinnyricinclus leucogaster	Violet-backed Starling		2	0	3	3	1
Spreo bicolor	Pied Starling		2	0	0	2	0
Creatophora cinerea	Wattled Starling		1	0	2	2	0
Acridotheres tristis	**Common Myna (INT)**		2	2	3	5	4
Chalcomitra amethystina	**Amethyst Sunbird**		2	1	5	4	5
Cinnyris talatala	**White-bellied Sunbird**		3	1	5	5	5
Ploceus capensis	Cape Weaver		2	3	2	2	1
Ploceus velatus	**Southern Masked-Weaver**		5	5	5	5	5
Ploceus cucullatus	Village Weaver		0	2	1	1	0
Quelea quelea	Red-billed Quelea		3	4	4	3	2
Euplectes afer	Yellow-crowned Bishop		2	4	0	0	0
Euplectes orix	**Southern Red Bishop**		4	5	4	4	3
Euplectes albonotatus	White-winged Widowbird		3	4	3	2	0
Euplectes ardens	**Red-collared Widowbird**		4	5	3	0	0
Euplectes progne	Long-tailed Widowbird		4	4	2	0	0
Amblyospiza albifrons	Thick-billed Weaver		2	4	3	2	1
Sporaeginthus subflavus	Orange-breasted Waxbill		2	4	0	0	0
Ortygospiza atricollis	**African Quailfinch**		5	5	1	0	0
Amadina erythrocephala	Red-headed Finch		3	0	3	4	1
Estrilda astrild	**Common Waxbill**		2	5	3	2	0
Uraeginthus angolensis	Blue Waxbill		0	0	4	3	2
Pytilia melba	Green-winged Pytilia		0	0	3	0	1
Lagonosticta senegala	Red-billed Firefinch		0	0	2	0	1
Lagonosticta rhodopareia	Jameson's Firefinch		0	3	4	0	2
Spermestes cucullatus	Bronze Mannikin		4	4	4	4	4
Vidua macroura	**Pin-tailed Whydah**		4	5	4	4	3
Vidua paradisaea	Long-tailed Paradise-Whydah		0	0	2	1	0
Passer domesticus	House Sparrow		0	0	0	4	3
Passer melanurus	**Cape Sparrow**		4	4	4	5	4
Passer diffusus	**Southern Grey-headed Sparrow**		4	4	5	5	4
Motacilla capensis	Cape Wagtail		2	4	1	4	0
Macronyx capensis	**Cape Longclaw**		5	4	2	0	0
Anthus lineiventris	Striped Pipit		2	0	0	1	0
Anthus cinnamomeus	African Pipit		4	0	2	4	0
Anthus similis	Long-billed Pipit		2	0	0	0	0
Crithagra mozambicus	**Yellow-fronted Canary**		2	3	5	4	4
Crithagra atrogularis	**Black-throated Canary**		4	4	4	5	5
Crithagra gularis	**Streaky-headed Seedeater**		4	0	5	4	4
Emberiza tahapisi	**Cinnamon-breasted Bunting**		5	0	2	2	3
Emberiza capensis	Cape Bunting		2	0	0	0	0
Emberiza flaviventris	Golden-breasted Bunting		0	0	3	0	0
	Avifaunal diversity index:		444	367	525	360	317

*The reporting rate is calculated as follows: Total number of cards on which a species was reported X 100 ÷ total number of cards for a particular quarter degree grid cell. **INT** = Introduced or alien birds species to Southern Africa.

Red Data Species Categories for the birds (Barnes, 2000)
RE = Regionally extinct, **CR** = Critically Endangered **EN** = Endangered, **VU** = Vulnerable, **NT** = Near-threatened.

The biodiversity index gives an indication of which habitat will hold the richest bird diversity on site. The colour codes for each species are represented as follows: The colour codes for each species are represented as follows: Yellow = Very Low, Light Orange = Low, Dark Orange = Medium and Red = High. The likelihood of occurrence of each species in the specific habitat systems on the study site are as follow: 5 = present, 4 = High, 3 = Medium, 2 = Low, 1 = very low, and 0 = Not likely to occur.

Threatened and Red Listed Bird Species

The following Red Data bird species were recorded for the 2528CD q.d.g.c according to Harrison *et al.* (1997) and Tarboton *et al* (1987) (Table 2).

Table 2: Red Data bird species recorded for the 2528CD q.d.g.c.

SCIENTIFIC NAMES	ENGLISH NAMES	REPORTING RATE (%)* SABAP1/SABAP2/2545_2825
Alcedo semitorquata	Half-collared Kingfisher (NT)	<1 / 0 / 0 (T)
Tyto capensis	African Grass-Owl (VU)	1 / 0.9 / 0 (Tb)
Neotis denhami	Denham's Bustard (VU)	0 / 0 / 0 (T)
Eupodotis caerulescens	Blue Korhaan (NT)	<1 / 0 / 0 (T)
Eupodotis senegalensis	White-bellied Korhaan (VU)	<1 / 0.9 / 0 (T)
Anthropoides paradiseus	Blue Crane (VU)	3 / 0.1 / 0 (Tb)
Podica senegalensis	African Finfoot (VU)	0 / 0 / 0 (T)
Crex crex	Corn Crake (VU)	<1 / 0 / 0
Rostratula benghalensis	Greater Painted-snipe (NT)	<1 / 0 / 0
Glareola nordmanni	Black-winged Pratincole (NT)	<1 / 0 / 0 (T)
Sterna caspia	Caspian Tern (NT)	<1 / 0 / 0
Gyps coprotheres	Cape Vulture (VU)	0 / 0 / 0 (T)
Aegypius tracheliotus	Lappet-faced Vulture (VU)	0 / 0 / 0 (T)
Terathopius ecaudatus	Bateleur (VU)	0 / 0 / 0 (T)
Circus ranivorus	African Marsh-Harrier (VU)	0 / 0 / 0 (T)
Aquila rapax	Tawny Eagle (VU)	<1 / 0 / 0
Aquila ayresii	Ayres's Hawk-Eagle (NT)	<1 / 0.1 / 7.7
Polemaetus bellicosus	Martial Eagle (VU)	0 / 0 / 0 (Tb)
Sagittarius serpentarius	Secretarybird (NT)	2 / 3.2 / 0 (T)
Falco naumanni	Lesser Kestrel (VU)	1 / 0.7 / 0 (T)
Falco biarmicus	Lanner Falcon (NT)	1 / 1.5 / 0 (Tb)
Falco peregrinus	Peregrine Falcon (NT)	<1 / 0.7 / 0
Phoenicopterus ruber	Greater Flamingo (NT)	<1 / 0 / 0 (T)
Mycteria ibis	Yellow-billed Stork (NT)	0 / 0.1 / 0 (T)
Ciconia nigra	Black Stork (NT)	<1 / 0 / 0
Mirafra cheniana	Melodious Lark (NT)	0 / 1.2 / 7.7 (Tb)
	Tarboton *et al* (1987) :	**19**
	SABAP1 2528CD q.d.g.c.:	**17**
	SABAP2 2528CD q.d.g.c.:	**10**
	SABAP2 2545_2825 Pentad:	**2**

*The reporting rate is calculated as follows: Total number of cards on which a species was reported X 100 ÷ total number of cards for a particular quarter degree grid cell. T = Bird species recorded as present (light blue) and Tb = bird species recording as breeding (dark blue) for the q.d.g.c. according to Tarboton *et al* (1987). Bird species with both reporting rates and T or Tb were recorded for the q.d.g.c. according to both Harrison *et al.* (1997) and Tarboton *et al.* (1987).

Red Data Species Categories for the birds (Barnes, 2000)
RE = Regionally extinct, **CR** = Critically Endangered **EN** = Endangered, **VU** = Vulnerable, **NT** = Near-threatened.

A total of 26 Red Data avifaunal species have been recorded within the 2528CD q.d.g.c. Nine of these species appear to have disappeared from the area or were not subsequently recorded for this q.d.g.c. during the time of the southern African Bird Atlas project (SABAP1). It is unlikely that they will ever recur in this region again except maybe on rare occasions or in protected areas. Five of these species used to breed within the said q.d.g.c. (Tarboton et al., 1987) and only one, the African Grass-Owl, has been recorded as a breeding species for the q.d.g.c. during the period of SABAP1. This decline in breeding species is probably due to the large extent of development that took place during a short space of time. Blue Cranes and Secretary birds indicate a low reporting rate, although they occurred on the site up to the 1970s (Kemp, A. C., pers. comm.) while all the rest of the Red Data avifaunal species indicate a very low reporting rate. Ten of the seventeen Red Data avifaunal species recorded for SABAP1 was recorded for the same q.d.g.c. according to the SABAP2 data. This is probably due to the occurrence of these species within the Rietvlei Nature Reserve which is situated within the same q.d.g.c. and where suitable habitat can be found for these species. Only two Red Data avifaunal species were recorded for the 2545_2825 pentad and none were recorded during the survey on the study site (Table 5).

Summary of the Red Data bird species

Table 3 provides a list of the Red Data bird species recorded for the 2528CD q.d.g.c. according to Harrison *et al.* (1997) and an indication of their likelihood of occurrence on the study site based on habitat and food availability.

Table 3: Red Data bird species assessment for the 2528CD q.d.g.c.

SCIENTIFIC NAME	PRESENCE OF SUITABLE HABITAT AND HABITAT REQUIREMENTS	LIKELIHOOD OF OCCURRENCE ON STUDY SITE
*Alcedo semitorquata** (Half-collared Kingfisher) **(NT)**	None on site: Requires fast-flowing streams, rivers and estuaries, usually with dense marginal vegetation (Maclean, 1993), especially perennial streams and smaller rivers with overhanging riparian vegetation on their banks. Nests in sand/earth banks (Tarboton *et al.* 1987) and requires riverbanks in which to excavate nest tunnels (Harrison *et al.* 1997a). Most typically occurs along fast-flowing streams with clear water and well-wooded riparian growth, often near rapids. It most frequently favours broken escarpment terrain and requires at least 1 km up and down stream of undisturbed river and riparian vegetation while breeding. It occurs from sea-level to 2000 m.a.s.l. in southern Africa. Usually perches low down on the banks of rivers and streams, often on exposed roots, as well as exposed rock and low overhanging tree branches.	Highly unlikely Due to a lack of suitable breeding, foraging and roosting habitat.
*Tyto capensis** (African Grass-Owl) **(VU)**	None on site: Occurs predominately in rank grass, typically but not always at fairly high altitudes. Breeds mainly in permanent and seasonal vleis, which it vacates while hunting or during post-breeding although it will sometimes breed in any area of long grass, sedges or even weeds (Van Rooyen, pers comm.) and not necessarily associated with wetlands (Tarboton *et al.* 1987) although this is more the exception than the rule. Foraging mainly confined to tall grassland next to their wetland vegetation and rarely hunts in short grassland, wetlands or croplands nearby (Barnes, 2000). Mainly restricted to wet areas (marshes and vleis) where tall dense grass and/or sedges occur.	Highly unlikely No suitable breeding, roosting and foraging habitat were identified on and surrounding the study site

SCIENTIFIC NAME	PRESENCE OF SUITABLE HABITAT AND HABITAT REQUIREMENTS	LIKELIHOOD OF OCCURRENCE ON STUDY SITE
	Prefers permanent or seasonal vleis and vacates the latter when these dried up or are burnt. Roosts and breeds in vleis but often hunt elsewhere e.g. old lands and disturbed grassland although this is suboptimal habitat conditions (Tarboton *et al.* 1987). May rarely occur in sparse *Acacia* woodland where patches of dense grass cover are present (Harrison *et al.* 1997a).	
*Eupodotis senegalensis** (White-bellied Korhaan) (VU)	None on site: Occurs in fairly tall, dense grassland, especially sour and mixed grassland, in open or lightly wooded, undulating to hilly country. In winter, occasionally on modified pastures and burnt ground (Harrison *et al.* 1997a).	Highly unlikely Due to high human presence on site and disturbance surrounding the study site. Scarce in Gauteng and secretive resident; widespread (Marais & Peacock, 2008)
*Anthropoides paradiseus** (Blue Crane) (VU)	None on site: Midlands and highland grassland, edge of karoo, cultivated land and edges of vleis (Maclean, 1993). Nests in both moist situations in vleis which have short grass cover and in dry sites far from water, usually exposed places such as on hillsides; forages in grassland and cultivated and fallow lands; roosts communally in the shallow water of pans and dams (Tarboton *et al.* 1987). Short dry grassland, being more abundant and evenly disturbed in the eastern "sour" grassland, where natural grazing of livestock is the predominant land use. Prefers to nest in areas of open grassland (Barnes, 2000) In the fynbos biome it inhabit cereal croplands and cultivated pastures and avoids natural vegetation. By contrast, it is found in natural vegetation in the Karoo and grassland biomes, but it also feeds in crop fields (Harrison *et al.* 1997a).	Highly unlikely Due to the small extent of the grassland, disturbance surrounding the study site and high human presence on the study site. Localised but common in the south-eastern Gauteng (Marais & Peacock, 2008)
Crex crex (Corn Crake) (VU)	None on site: Rank grassland and savanna, dry grassland bordering marshes and streams, including long grass areas of seasonally flooded grassland and, occasionally, wet clay patches and soft mud fringing ponds. In Acacia savanna, occurs mostly where trees are small and scattered, and grass dense often tussocky, 0.7 – 1.5 m tall (Hockey *et al.* 2005).	Highly unlikely Due to a lack of suitable foraging habitat Rare summer visitor. Widespread but elusive (Marais & Peacock, 2008).
Rostratula benghalensis (Greater Painted-snipe) (NT)	None on site: Dams, pans and marshy river flood plains. Favours waterside habitat with substantial cover and receding water levels with exposed mud among vegetation, departing when water recedes beyond the fringes of vegetation. Rare in seasonally flooded grassland and palm savanna (Hockey *et al.* 2005).	Highly unlikely Due to a lack of suitable foraging habitat. Uncommon visitor and resident (Marais & Peacock, 2008)
Glareola nordmanni (Black-winged Pratincole) (NT)	None on site: A non-breeding overland migrant to southern Africa. In southern Africa winter quarters, prefers open grassland, edges of pans and cultivated fields, but most common in seasonally wet	Highly unlikely Might only pass through the area on rare occasions.

SCIENTIFIC NAME	PRESENCE OF SUITABLE HABITAT AND HABITAT REQUIREMENTS	LIKELIHOOD OF OCCURRENCE ON STUDY SITE
	grasslands and pan systems. Attracted to damp ground after rains, also to agricultural activities, including mowing and ploughing, and to newly flooded grassland (Hockey *et al.* 2005).	Erratic summer migrant sometimes in large flocks (Marais & Peacock, 2008)
Sterna caspia (Caspian Tern) **(NT)**	None on site: Occurs along coast, mostly in sheltered bays and estuaries. Inland, at large water bodies, both natural and man-made, with preference for saline pans and large impoundments. Coastal breeding habitat primarily offshore islands, but with increasing use of sandy beaches and islands in saltworks, where protection is offered. Inland, breeds on small, low islets in pans and dams (Hockey *et al.* 2005).	Highly unlikely Due to a lack of suitable foraging and breeding habitat. Non-breeding winter visitor to large water bodies in Gauteng (Marais & Peacock, 2008)
Aquila rapax (Tawney Eagle) **(VU)**	None on site: Occurs in lightly wooded savanna; absent from dense forests and highlands. Able to colonise Nama Karoo and treeless grasslands by breeding on pylons and alien trees (Hockey *et al.* 2005).	Highly unlikely There are no suitable foraging, breeding or roosting habitat for this species on the study site. Uncommon. NW & NE Gauteng (Marais & Peacock, 2008)
Aquila ayresii (Ayres's Hawk-Eagle) **(NT)**	None on site: Non-breeding summer visitor to South Africa, favouring dense woodland and forest edge, often in hilly country. Regular in larger northern cities and towns (Johannesburg, Pretoria, Mokopane/Pietersburg), where it often roosts in *Eucalyptus* stands or other tall trees within its prime distribution range (Hockey *et al.* 2005).	Highly unlikely Might on rare occasions move through the area but unlikely to make use of the habitat systems on the study site on a permanent basis. Rare in Gauteng (Marais & Peacock, 2008)
*Sagittarius serpentarius** (Secretarybird) **(NT)**	None on site: Open grassland with scattered trees, shrubland, open *Acacia* and *Combretum* savanna (Hockey *et al.* 2005). Restricted to large conservation areas in the region. Avoids densely wooded areas, rocky hills and mountainous areas (Hockey *et al.* 2005 & Barnes, 2000). Requires small to medium-sized trees with a flat crown for nesting, and often roosts in similar locations. Nesting density only about 150 km^2/pair (n = 4, Kemp, 1995), part of which used to include the site.	Highly unlikely Due to the small extent of the study site, lack of suitable habitat and the disturbance surrounding it. Uncommon in open areas within Gauteng (Marais & Peacock, 2008)
*Falco naumanni** (Lesser Kestrel) **(VU)**	Yes: Non-breeding Palaearctic migrant. Forages preferentially in pristine open grassland but also hunts in converted grassland such as small scale pastures provided the conversion is not as total as in plantation forestry or in areas of consolidated agricultural monoculture (Barnes, 2000; Hockey *et al.* 2005) such as maize, sorghum, peanuts, wheat, beans and other crops (Tarboton & Allan 1984) where they hunt for large insects and small rodents, but avoid wooded areas except on migration. They	Unlikely Will only move through the area a rare occasions during their northern or southern migration but unlikely to make use of the habitat systems on site on a permanent basis.

SCIENTIFIC NAME	PRESENCE OF SUITABLE HABITAT AND HABITAT REQUIREMENTS	LIKELIHOOD OF OCCURRENCE ON STUDY SITE
	roost communally in tall trees, mainly *Eucalyptus*, in urban areas (Barnes, 2000), often in towns or villages, but also in farm lands (pers. obs). Favour a warm, dry, open or lightly wooded environment, and are concentrated in the grassy Karoo, western fringes of the grassland biome and southeast Kalahari. Generally avoids foraging in transformed habitats but occurs in some agricultural areas, including croplands, in fynbos and renosterveld of the Western Cape (Hockey *et al.* 2005). Large numbers congregate in sweet and mixed grasslands of the highveld regions.	Localised summer migrant (Marais & Peacock, 2008)
*Falco biarmicus** (Lanner Falcon) (**NT**)	None on site: Most frequent in open grassland, open or cleared woodland, and agricultural areas. Breeding pairs generally favour habitats where cliffs are available as nest and roost sites, but will use alternative sites such as trees, electricity pylons and building ledges if cliffs are absent (Hockey *et al.* 2005). Mountains or open country, from semi desert to woodland and agricultural land, also cities (Maclean, 1993), even on forest-grassland ecotones. Generally a cliff nesting species and its wider distribution is closely associated with mountains with suitable cliffs. Able to breed on lower rock faces than Peregrine Falcon *Falco peregrinus* and also utilises the disused nests of other species, such as crows, other raptors and storks, on cliffs, in trees and on power pylons, and also quarry walls (Tarboton *et al.* 1987). Generally prefers open habitats e.g. alpine grassland and the Kalahari, but exploits a wide range of habitats – grassland, open savanna, agricultural lands, suburban and urban areas, rural settlements – in both flat and hilly or mountainous country. Also breeds in wooded and forested areas where cliffs occur (Harrison *et al.* 1997a).	<u>Unlikely</u> Due to a lack of suitable breeding habitat. Uncommon resident in open areas in Gauteng (Marais & Peacock, 2008), although used to breed on and around this site until ~1985 (Kemp, 1993)
Falco peregrinus (Peregrine Falcon) (**NT**)	None on site: Resident *F. p. minor* mostly restricted to mountainous riparian or coastal habitats, where high cliffs provides breeding and roosting sites. Breeding pairs prefer habitats that favour specialised, high speed, aerial hunting, e.g. high cliffs overhanging vegetation with raised and/or discontinuous canopy (eg forest, fynbos, woodland), or expanses of open water. Also uses quarries and dam walls, and frequents city centres, e.g. Cape Town, where tall buildings substitute for rock faces. Migrant *F. p. calidus* in more open country, often coastal, even roosting on ground on almost unvegetated salt flats.	<u>Highly unlikely</u> Due to a lack of suitable breeding habitat. Could move through the area on rare occasions. Uncommon resident and summer migrant in Gauteng (Marais & Peacock, 2008)
*Phoenicopterus ruber** (Greater Flamingo) (**NT**)	None on site: Breeds at recently flooded, large, eutrophic wetlands (favoured foraging habitat), shallow salt pans; at other times, at coastal mudflats, inland dams, sewage treatments works, small ephemeral pans and river mouths (Hockey *et al.* 2005). Usually breeds colonially on mudflats in large pans (Harrison *et al.* 1997a). Shallow pans, especially saline pans when they have water; also occasionally on other bodies of shallow water such as dams and vleis (Tarboton *et al.* 1987). Large	<u>Highly unlikely</u> Due to a lack of suitable foraging and breeding habitat. Mainly restricted to the south-eastern Gauteng (Marais & Peacock, 2008)

SCIENTIFIC NAME	PRESENCE OF SUITABLE HABITAT AND HABITAT REQUIREMENTS	LIKELIHOOD OF OCCURRENCE ON STUDY SITE
	bodies of shallow water, both inland and coastal; prefers saline and brackish water (Maclean 1993). Occasionally forages along sandy coasts.	
*Ciconia nigra** (Black Stork) (**NT**)	None on site: Dams, pans, flood plains, shallows of rivers, pools in dry riverbeds, estuaries and sometimes on marshland and flooded grassland; uncommon at seasonal pans lacking fish. Associated with mountainous regions (Hockey *et al.*, 2005) where they nest (Maclean, 1993) on cliffs (Harrison *et al.* 1997a). Feeds in shallow water, but occasionally on dry land, in streams and rivers, marshes, floodplains, coastal estuaries and large and small dams; it is typically seen at pools in large rivers.	<u>Highly unlikely</u> Due to a lack of suitable breeding and foraging habitat
Mirafra cheniana (Melodious Lark) (**NT**)	None on site: Occurs in grassland dominated by *Themeda triandra* grass in South Africa. Occasionally in planted pastures of *Eragrostis curvula* and *E. tef.* Avoids wet lowlands, favouring fairly short grassland (< 0.5 m), with open spaces between tussocks, at 550 – 1 750 m.a.s.l. with annual rainfall of between 400 – 800 mm p/a (Hockey *et al.*, 2005).	<u>Unlikely</u> Due to a lack of suitable habitat Localised resident in Gauteng (Marais & Peacock, 2008) where suitable habitat occur

*Priority Red Data bird species according to GDACE.

6. FINDINGS AND POTENTIAL IMPLICATIONS

The habitat systems on site will not favour any of the mentioned Red Data avifaunal species due to a lack of suitable breeding, roosting and/or foraging habitat on and surrounding the study site. The bird species observed on or that are likely to occur on the study site are the more common bird species associated with the various habitat systems and species that are able to adapt to areas transformed by man. The rocky ridge on the study site can be described as sensitive and avifaunal species that are habitat specific with reference to the rocky ridge will be affected by development in this area. These species are unable to adapt to and survive in other habitat systems due to their specific breeding, roosting and foraging requirements.

The rest of the area within 500 m surrounding the study is unsuitable for any Red Data avifaunal species due to high human density and human presence and the area being transformed by man to make place for roads, residential, business and agricultural purposes.

Particular reference was made to the occurrence of White-bellied Korhaan (*Eupodotis senegalensis*) as per GDARD requirements.

White-bellied Korhaan (*Eupodotis senegalensis*):

<u>Criteria for IUCN threatened category:</u> A1c: A2c; C1. Status: Vulnerable
<u>Habitat:</u> According to Barnes (2000) it inhabits relatively tall vegetation, typically fairly dense grassland in either open or lightly wooded regions. It seems to be most abundant in hilly areas at the interface between the grassland and savanna biomes (Tarboton *et al.* 1987). They occur in low abundance in severely grazed and recently burnt sites (Barnes 2000).
<u>Threats:</u> Within Gauteng habitat loss through crop farming, overgrazing, burning and high human densities are the main reasons for the population decline of this species.

Even where suitable habitat exits, it is often modified by inappropriate fire regimes and grazing practices (Barnes 2000). The genetic integrity of this species may be threatened as a result of severely fragmented distribution (Barnes 2000).
On site conclusion: It is unlikely that the White-bellied Korhaan will make use of the open grassland habitat due to the small extent of suitable grassland and the disturbance surrounding the study site, even though at least two pairs lived in the general area until ~1985 (Kemp, A. C., pers.comm.).

7. LIMITATIONS, ASSUMPTIONS AND GAPS IN KNOWLEDGE

The Galago Environmental team has appropriate training and registration, as well as extensive practical experience and access to wide-ranging data bases to consider the derived species lists with high limits of accuracy. In this instance the biodiversity of all Alignments has to a greater or lesser extent been jeopardized, which renders the need for field surveys unnecessary. In instances where uncertainty exists regarding the presence of a species it is listed as a potential occupant, which renders the suggested mitigation measures and conclusions more robust.

Even though every care is taken to ensure the accuracy of this report, environmental assessment studies are limited in scope, time and budget. Discussions and proposed mitigations are to some extent made on reasonable and informed assumptions built on *bone fide* information sources, as well as deductive reasoning. Deriving a 100% factual report based on field collecting and observations can only be done over several years and seasons to account for fluctuating environmental conditions and migrations. Since environmental impact studies deal with dynamic natural systems additional information may come to light at a later stage. Galago Environmental can thus not accept responsibility for conclusions and mitigation measures made in good faith based on own databases or on the information provided at the time of the directive. This report should therefore be viewed and acted upon with these limitations in mind.

The general assessment of species rests mainly on the 1987 atlas for birds of the then-Transvaal (Tarboton *et al.* 1987) and comparison with the 1997 SABAP atlas (Harrison et al. 1997), so any limitations in either of those studies will by implication also affect this survey and conclusions.

8. RECOMMENDED MITIGATION MEASURES

The following mitigation measures are proposed by the specialist:

- No further development should be allow within the natural grassland area on the on the ridge.
- Limited housing development can be planned for the area that consists of *Acacia* savannah woodland.
- Proper veld management practises should be implemented with respect to grazing, burning and control of woody invasions.
- Where possible, **work should be restricted to one area at a time**, as this will give the smaller birds, mammals and reptiles a chance to weather the disturbance in an undisturbed zone close to their natural territories.
- **No vehicles should be allowed to move in or across the wet areas or drainage lines and possibly get stuck.** This leaves visible scars and destroys habitat, and it is important to conserve areas where there are tall reeds or grass, or areas were there is short grass and mud.

- With proper cultivation of specific indigenous plant species, the bird numbers and species in the area could even increase. Indigenous plant species that attract birds to gardens or that are natural to the area could be obtained from the local nurseries surrounding the area. The area must however be kept as natural as possible.
- It is important to note that birds inhabiting one of the named microhabitats on site will not move, in most cases, into a different habitat. In other words, birds found in the open woodland will not now, with the development, move into the grassland areas or the wetland area. If the objective is to keep these species on site, suitable open woodland must be kept for these species.
- The contractor must ensure that no fauna is disturbed, trapped, hunted or killed during the construction phase. Conservation-orientated clauses should be built into contracts for construction personnel, complete with penalty clauses for non-compliance.
- It is suggested that where work is to be done close to the drainage lines, these areas **be fenced off during construction**, to prevent heavy machines and trucks from trampling the plants, compacting the soil and dumping in the system.
- During the construction phase, noise must be kept to a minimum to reduce the impact of the development on the fauna residing on the site.
- Alien and invasive plants must be removed.

The following mitigation measures were developed by GDARD (Directorate of Nature Conservation, GDACE, 2008 and 2009) and are applicable to the study site:

- An appropriate management authority (e.g. the body corporate) that must be contractually bound to implement the Environmental Management Plan (EMP) and Record of Decision (ROD) during the operational phase of the development should be identified and informed of their responsibilities in terms of the EMP and ROD.
- All areas designated as sensitive in a sensitivity mapping exercise should be incorporated into an open space system. Development should be located on the areas of lowest sensitivity.
- Development structures should be clustered as close as possible to existing development.
- The open space system should be managed in accordance with an Ecological Management Plan that complies with the *Minimum Requirements for Ecological Management Plans* and forms part of the EMP.
- The Ecological Management Plan should:
    - Include a fire management programme to ensure persistence of grassland
    - include an ongoing monitoring and eradication programme for all non-indigenous species, with specific emphasis on invasive and weedy species
    - include a comprehensive surface runoff and storm water management plan, indicating how all surface runoff generated as a result of the development (during both the construction and operational phases) will be managed (e.g. artificial wetlands/storm water and flood retention ponds) prior to entering any natural drainage system or wetland and how surface runoff will be retained outside of any demarcated buffer/flood zones and subsequently released to simulate natural hydrological conditions
    - ensure the persistence of all Red and Orange List species
    - include a monitoring programme for all Red and Orange List species
    - facilitate/augment natural ecological processes

- provide for the habitat and life history needs of important pollinators
- minimize artificial edge effects (e.g. water runoff from developed areas and application of chemicals)
- include a comprehensive plan for limited recreational development (trails, bird hides, etc.) within the open space system
- include management recommendations for neighbouring land, especially where correct management on adjacent land is crucial for the long-term persistence of sensitive species present on the development site
- result in a report back to the Directorate of Nature Conservation on an annual basis
- investigate and advise on appropriate legislative tools (e.g. the NEMA: Protected Areas Act 57 of 2003) for formally protecting the area (as well as adjacent land where it is crucial for the long-term persistence of sensitive species present on the development site)

* The open space system should be fenced off prior to construction commencing (including site clearing and pegging). All construction-related impacts (including service roads, temporary housing, temporary ablutions, disturbance of natural habitat, storing of equipment/building materials/vehicles or any other activity) should be excluded from the open space system. Access of vehicles to the open space system should be prevented and access of people should be controlled, during both the construction and operational phases. Movement of indigenous fauna should however be allowed (i.e. no solid walls, e.g. through the erection of palisade fencing).
* The crossing of natural drainage systems should be minimized and only constructed at the shortest possible route, perpendicular to the natural drainage system. Where possible, bridge crossings should span the entire stretch of the buffer zone (see *Sensitivity Mapping Rules for Biodiversity Assessments* for buffer zone requirements).

9. CONCLUSIONS

The habitat systems will not favour any of the Red Data avifaunal species due to the small extent or lack of suitable breeding, roosting or foraging habitat. Some might only move through the area on rare occasions but it is unlikely that they will make use of the habitat systems on a permanent basis. The open grassland habitat will not favour White-bellied Korhaan due to the small and fragmented state of the grassland on the study site and the disturbance surrounding the grassland areas. Lesser Kestrel might on rare occasions move through the area during migration.

In terms of avifaunal biodiversity it is important that natural habitat systems be kept undisturbed and in a natural state as far as possible to ensure future biodiversity on and surrounding the study site. The rocky ridges in particular can be deemed as sensitive since avifaunal species that occur there are habitat specific and will not move into other habitat systems due to their own unique breeding, roosting and foraging requirements.

No further development should be allowed within this sensitive area and any proposed development should take place in areas that has already been disturbed by past and present human activities or areas overgrown by alien invasive plant species.

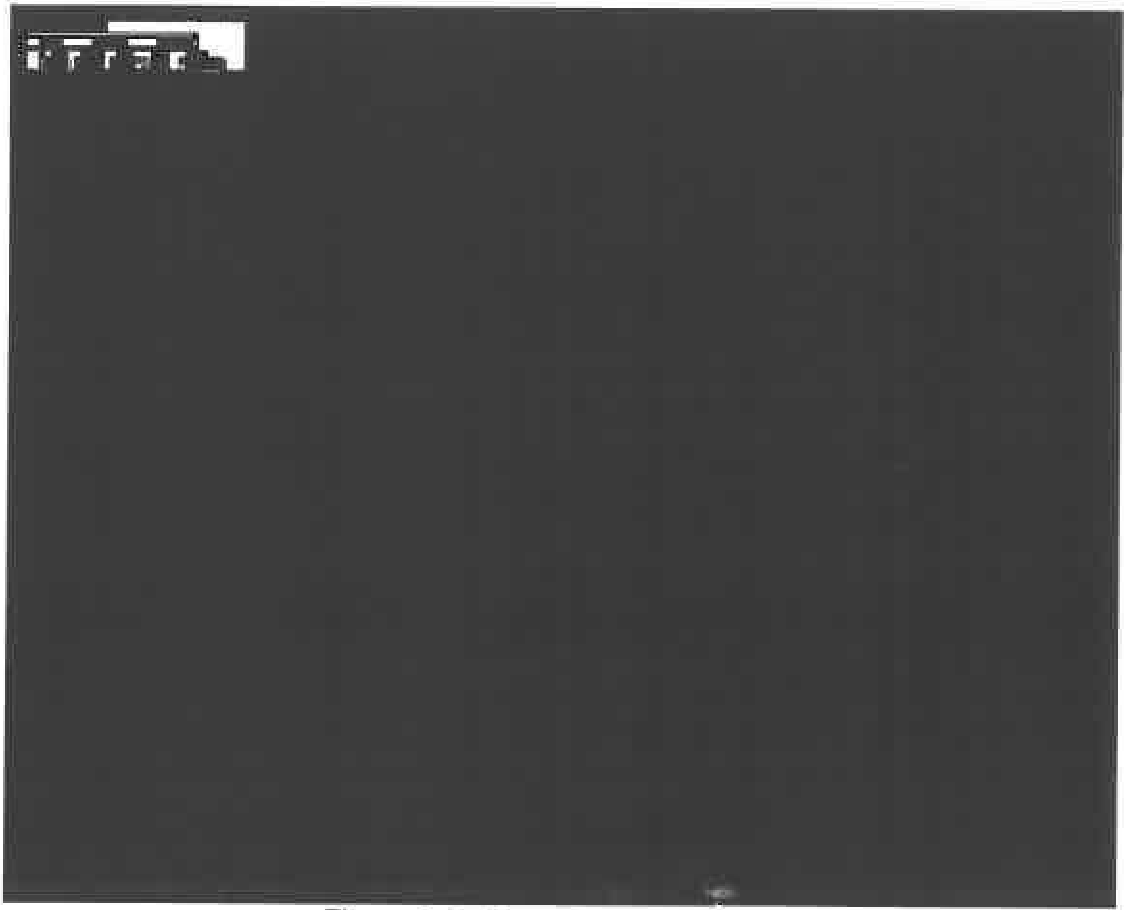


Figure 9: Avifaunal sensitivity map

10. LITERATURE SOURCES

Barnes, K.N. (ed.). 1998. *The Important Bird Areas of southern Africa.* Johannesburg: BirdLife South Africa.

Barnes, K.N. (ed.). 2000. *The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland.* BirdLife South Africa, Johannesburg.

Chittenden, H. 2007. *Roberts Bird Guide*. John Voelcker Bird Book Fund, Cape Town.

Harrison, J.A., Allan, D.G., Underhill, L.G., Herremans, M., Tree, A.J., Parker, V. & Brown, C.J. (eds.). 1997. *The Atlas of Southern African Birds.* Vol. 1 & 2. BirdLife South Africa, Johannesburg.

Hockey, P.A.R., Dean, W.R.J. & Ryan, P.G. 2005. *Roberts Birds of Southern Africa VII th Edition*, The Trustees of the John Voelcker Bird Book Fund, Cape Town.

Keith, S., Urban, E.K. & Fry, C.H. 1992. *The Birds of Africa.* Vol. 4. Academic Press, London.

Kemp, A. C. 1993. Breeding biology of Lanner Falcons near Pretoria, South Africa. Ostrich 64: 26-31.

Maclean, G.L., 1990. *Ornithology for Africa.* University of Natal Press, Pietermaritzburg.

Maclean, G.L., 1993. *Roberts' Birds of Southern Africa.* John Voelcker Bird Book Fund, Cape Town.

Marais, M. & Peacock, F., 2008. *The Chamberlain guide to Birding Gauteng*, Mirafra Publishing, CTP Book Printers, Cape Town

Mucina, L. & Rutherford, M.C. (eds) 2006. *The vegetation of South Africa, Lesotho and Swaziland.* Strelitzia 19. South African National Biodiversity Institute, Pretoria.

Peacock, F., 2006. Pipits of Southern Africa – a complete guide to Africa's ultimate LBJ's, Published by the author, Pretoria; www.pipits.co.za.

Percy, W., & Pitman C.R.S., 1963 *Further notes on the African Finfoot, Podica senegalensis* (Viellot). Bull. Br. Ornithol. Club 83:127-132 .

Sinclair, I., Hockey, P. & Tarboton W. 2002. *Sasol Birds of Southern Africa*. Struik, Cape Town.

Sinclair I., & Hockey P. 2005. *The Larger Illustrated Guide to Birds of Southern Africa*. Struik, Cape Town.

Steyn, P. 1982. *Birds of prey of southern Africa*. Claremont, Cape Town: David Philip.

Tarboton, W.R., Kemp, M.I., & Kemp, A.C. 1987. *Birds of the Transvaal*. Transvaal Museum, Pretoria.

Tarboton, W., 2001. *A Guide to the Nests and Eggs of Southern African Birds*. Struik, Cape Town.

Urban, E.K., Fry, C.H., & Keith, S., 1986. *Birds of Africa*. Vol. 2. Academic Press, London.

GALAGO ENVIRONMENTAL

Fauna and Flora Specialists

638 Turf Street
Wingate Park, 0181
Tel: 012-345 4891
Fax: 086 675 6136
Email: Vanessam@lantic.net

Herpetofaunal Habitat Assessment

of

PORTION 31 AND 38 AND THE REMAINDER OF KLEINFONTEIN 368 JR AND PORTION 14, 63 AND 68 OF DONKERHOEK 365 JR

February 2012

Report author: Mr. **W.D. Haacke** (Pri. Sci. Nat: M.Sc)

Declaration of Independence:

I, **Wulf D. Haacke** (361215 5016 081) declare that I:

- am committed to biodiversity conservation but concomitantly recognize the need for economic development. Whereas I appreciate the opportunity to also learn through the processes of constructive criticism and debate, I reserve the right to form and hold my own opinions and therefore will not willingly submit to the interests of other parties or change my statements to appease them

- abide by the Code of Ethics of the S.A. Council for Natural Scientific Professions

- act as an independent specialist consultant in the field of herpetology

- am subcontracted as specialist consultant by Galago Environmental CC for the proposed Kleinfontein & Donkerhoek development project described in this report

- have no financial interest in the proposed development other than remuneration for work performed

- have or will not have any vested or conflicting interests in the proposed development

- undertake to disclose to the Galago Environmental CC and its client as well as the competent authority any material information that have or may have the potential to influence the decision of the competent authority required in terms of the Environmental Impact Assessment Regulations, 2006.

Wulf D Haacke

TABLE OF CONTENTS

FIGURES:

TABLES:

1. INTRODUCTION

Galago Environmental CC was appointed to undertake a reptile and amphibian habitat survey on Portions 31 and 38 and the Remainder of the farm Kleinfontein 368-JR and Portions 14, 63, 67 and 68 of the farm Donkerhoek 365-JR (hereafter referred to as the study site), scheduled for development into an eco estate with residential areas, open spaces, gape park areas etc.

The objective was to determine which species might still occur on the site. Special attention had to be given to the habitat requirements of all the Red Data species which may occur in the area. This survey focuses on the current status of threatened herpetofaunal species occurring, or which are likely to occur, on the proposed development site, and a description of the available and sensitive habitats on the site.

2. OBJECTIVES OF THE HABITAT STUDY

- To assess the current status of the habitat component and current general conservation status of the property;
- To provide lists of reptiles and amphibians which occur or might occur and to identify species of conservation importance;
- To highlight potential impacts of the development on the herpetofauna of the study site; and
- To provide management recommendations to mitigate negative and enhance positive impacts should the proposed development be approved.

3. SCOPE OF STUDY

This report:

- is a reptile and amphibian survey based on sightings and literature, with comments on preferred habitats;
- comments on ecologically sensitive areas;
- evaluates the conservation importance and significance of the site, with special emphasis on the current status of resident threatened species;
- offers recommendations to reduce or minimise impacts, should the proposed development be approved.

4. STUDY AREA

This site of 808 ha lies southeast of Pretoria in the quarter degree grid cells 2528CD and 2528DC, in the Cullinan district south of the N4 Highway and the Donkerhoek Pass. A narrow southern section extends across the railway line to Sentrarand. Due to the fact that it consists of a conglomerate of eight portions of two farms it has an irregular shape which extends from the southern slope of the Magaliesberg southwards with a sharply pointed extension into the undulating lowland. It is a rural community with the majority of the houses unfenced and some released antelope wander around freely. The study site lies in Rand Highveld Grassland and Gold Reef Mountain Bushveld (Mucina *et al*, 2006). The site is extremely invaded by exotics, such as agricultural weeds, gumtrees and extensive stands of Black Wattle.

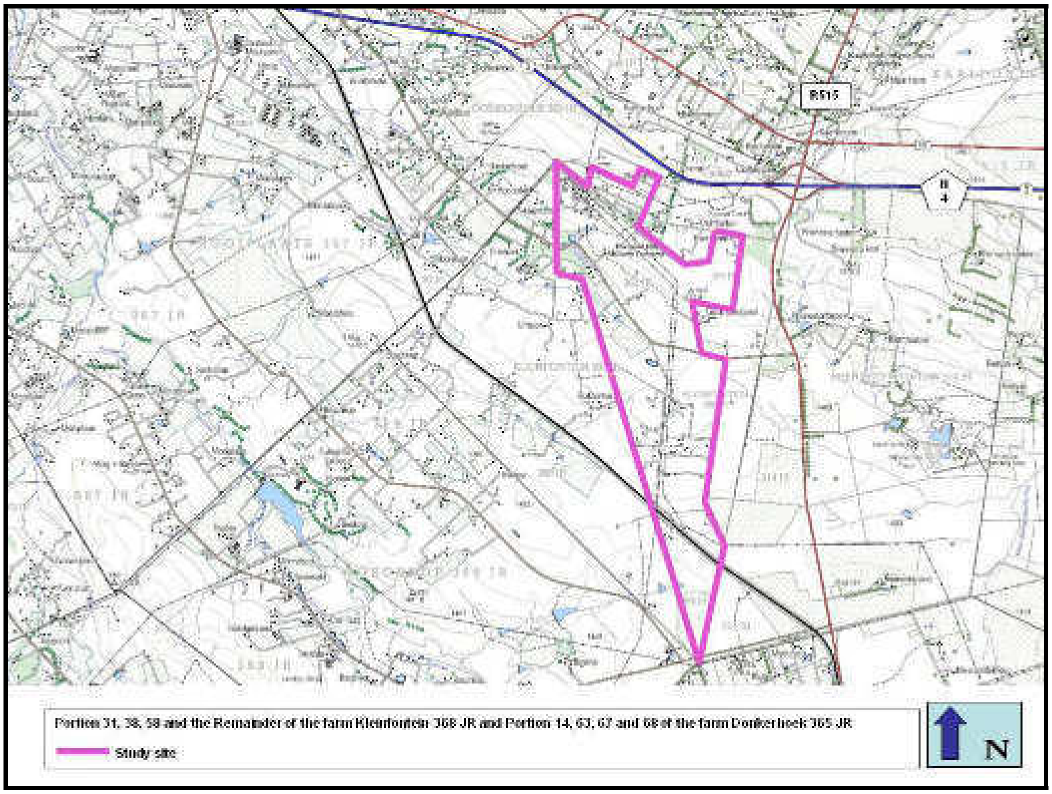


Figure 1: Locality map of the study area

Figure 2: House on lower slope of Magaliesberg, in natural grassveld.

Figure 3: View southeastwards across grassveld with a stand of gumtrees around ruins of a former farmhouse.

Figure 4: View southwards on rocky top of the ridge towards the community hall and Black Wattle thickets.

Figure 5: View northeastwards from near the main drainage line near the western border of the site through mountain bushveld towards the Magaliesberg ridge past the Diamond Hill military cemetery.

Figure 6: View northwards across grassveld of the southern tip of the site south of the railway line.

Figure 7: View of entrance to property in woodland in the southern section.

Figure 8: View northwards from southern section across grassveld to mountain bushveld.

5. METHOD

A site visit was conducted on 26 March 2011 and again on the 9 April 2011 in the company of other specialists of the Galago Environmental team. During these visits the habitat types of the study site were recorded in order to deduct which herpetofaunal species might possibly be associated with them. This was done with due regard to the known distributions of Southern African herpetofauna (Minter *et al,* 2004. SARCA Reptile Survey, 2006 – 9).

The following GPS coordinates spatially define the site:

- Diamond Hill Military Cemetery, along a row of houses with the uphill slope and the ridge (25°48’37” S, 28°29’43” E.1534m) (Figures 1 + 2).
- The upper dam in the drainage line (25°48’11” S, 28°29’19” E. 1501m).
- Open grassveld on the rocky top of the ridge (Figure 3).
- Eastern edge (25°49’09” S,28°30’18,2” E.1522m).
- Drainage line (25°48’54” S, 28°29’33” E. 1498m)
- Railway line crossing (25°50’45,4” S, 28°30’29,6” E)

The 500 meters of adjoining properties were scanned for important faunal habitats. The slope and the ridge of the Magaliesberg have rocky substrate with some extended dense stands of Black Wattles. Lower down, still on rocky substrate, Gold Reef Mountain Bushveld takes over. The undeveloped sections of this area appear to show that they are unsuitable for ploughing. On the eastern side of the southern extension of the site are some irrigation spillpoints in the Rand Highveld Grassland. No important herpetofaunal habitats were noticed beyond the border of the site.

5.1 Field Surveys

During the site visits it was attempted to identify reptiles and amphibians visually during random transect walks. Possible burrows or other reptile retreats (stumps or rocks) were inspected for any inhabitants. Amphibians may also be identified by their calls but none were vocalising.

5.2 Desktop Surveys

As the majority of reptiles and amphibians are secretive, nocturnal and/or poikilothermic or seasonal, distributional ranges and the presence of suitable habitats were used to deduce the presence or absence of these species based on authoritative tomes, scientific literature, field guides, atlases and databases. This can be done irrespective of season.

The probability of occurrences of herpetofaunal species was based on their respective geographical distributional ranges and the suitability of on-site habitat. In other words, *high* probability would be applicable to a species with a distributional range overlying the study site as well as the presence of prime habitat occurring on the study site. Another consideration for inclusion in this category is the inclination of a species to be common, i.e. normally occurring at high population densities.

Medium probability pertains to a herpetofaunal species with its distributional range peripherally overlapping the study site, or required habitat on the site being sub-optimal. The size of the site as it relates to its likelihood to sustain a viable breeding population, as well as its geographical isolation is also taken into consideration. Species categorised as *medium* normally do not occur at high population numbers, but cannot be deemed as rare. A *low* probability of occurrence will mean that the species' distributional range is peripheral to the study site and habitat is sub-optimal. Furthermore, some herpetofauna categorised as *low* are generally deemed rare.

Based on the impressions gathered during this visit and records in the Transvaal Museum, the documentation of the herpetofauna of the then Transvaal by Dr N. H. G. Jacobsen (Unpublished Ph.D. thesis, University of Pretoria, 1989) and his internal report for the Gauteng Province (1995), the "Atlas and Red Data Book of the Frogs of South Africa, Lesotho and Swaziland" (Minter, *et al*, 2004) and the SARCA reptile survey (2006 – 9), the following list of species which may occur on this site was compiled. The vegetation type was analysed according to the standard handbook by Mucina and Rutherford (eds) (2006).

5.3 Specific Requirements

During the visits the sites were surveyed and assessed for the potential occurrence of Red Data species such as:

- Giant Bullfrogs (*Pyxicephalus adspersus*); only recorded from 2528Dc.
- Striped Harlequin Snake (*Homoroselaps dorsalis*); not recorded and no termitaria seen.
- Southern African Python (*Python natalensis*); Beyond range and not recorded.

6. RESULTS

Amphibians:
This site is only partially suitable for Bullfrogs. The rocky slope and ridge of the Magaliesberg is not suitable at all. The extension into the lowlands, probably the area south of the road crossing the site, appears flat enough for the formation of shallow breeding ponds. In patches, the substrate there appears suitable as dipersal area, in which these frogs may feed and burrow to aestivate and hibernate. Existing records indicate that this frog has been recorded in the eastern quarter degree grid cell 2528DC, which suggests a possible marginal presence in the eastern section of the southern extension of the site. This frog would potentially have more suitable conditions in the area adjacent to the east of the site and the central area of this grid cell, both currently have very little development. At present no actual sightings with GPS readings are available, although a local resident confirmed that bullfrogs have been seen on the site. The other listed amphibians may benefit from the earthen dams, small wetlands and the drainage line across the centre of the site.

Reptiles:
No targeted Red Data species have been recorded in the two quarter degree grid cells of the site. The known range of the python does not extend as far as the site. The Striped Harlequin Snake is unlikely to occur here as no termitaria, which in moribund form usually provide ideal retreats, were noticed.

The requirements for reptiles differ from those of amphibians and cannot be defined as feeding, dispersal and breeding areas. All southern African reptiles, except for terrestrial tortoises, are predators. The available habitats on the site should provide an adequate variety of prey species for the listed reptiles, which are mainly grassland generalists.

Table 1: **List of amphibians and reptiles which may still occur on this site:-**

SCIENTIFIC NAMES	COMMON NAMES	PROBABILITY OF OCCURRENCE
CLASS: AMPHIBIA	**AMPHIBIANS**	
Order: ANURA	**FROGS**	
Family: Bufonidae	**Toads**	
Amietophrynus gutturalis	Guttural Toad	Medium
Amietophrynus rangeri	Raucous Toad	Medium
Schismaderma careens	Red Toad	Medium
Family: Pipidae	**Platannas**	
Xenopus laevis	Common Platanna	Low
Family: Microhylidae	**Rubber and Rain Frogs**	
Breviceps adspersus	Bushveld Rain Frog	Medium
Family: Pyxicephalidae	**Common Frogs**	
Amieta angolensis	Common River Frog	High
Phrynobatrachus natalensis	Snoring Puddle Frog	High
Kassina senegalensis	Bubbling Kassina	High
Tomopterna cryptotis	Tremolo Sand Frog	Medium
Tomopterna natalensis	Natal Sand Frog	Low
Cacosternum boettgeri	Common Caco	High
CLASS: REPTILIA	**REPTILES**	
Order: SQUAMATA	**SCALE-BEARING REPTILES**	
Suborder: LACERTILIA	**LIZARDS**	
Family: Gekkonidae	**Geckos**	
Pachydactylus capensis	Cape Thick-toed Gecko	Low
Pachydactylus affinis	Transvaal Thick-toed Gecko	Medium
Family: Chamaeleonidae	**Chameleons**	
Chamaeleo dilepis	Flap-necked Chameleon	Low
Family: Agamidae	**Agamas**	
Agama atra	Rock Agama	Low
Agama distanti	Distant's Ground Agama	Low
Family: Scincidae	**Skinks**	
Trachylepis punctatissima	Speckled Skink	Medium
Trachylepis capensis	Cape Skink	Low
Afroblepharus wahlbergii	Wahlberg's Snake-eyed Skink	Medium
Mochlus sundevallii	Sundevall's Writhing Skink Low	Low
Family: Lacertidae	**Lacertids**	
Pedioplanis lineoocellata	Spotted Sand Lizard	Low
Nucras holubi	Holub's Sand Lizard	Low
Nucras ornata	Ornate Sand Lizard	Low
Family: Gerrhosauridae	**Plated Lizards**	
Gerrhosaurus flavigularis	Yellow-throated Plated Lizard	Low
Family: Cordylidae	**Girdled Lizards**	

SCIENTIFIC NAMES	COMMON NAMES	PROBABILITY OF OCCURRENCE
Chamaesaura aenea	Coppery Grass Lizard	Low
Chamaesaura anguina	Cape Grass Lizard	Low
Cordylus jonesii	Jones' Girdled Lizard	Low
Cordylus vittifer	Common Girdled Lizard	Low
Family: Varanidae	**Monitor lizards**	
Varanus albigularis	Rock Monitor	Low
Suborder: SERPENTES	**SNAKES**	
Family: Typhlopidae	**Blind Snakes**	
Typhlops bibronii	Bibron's Blind Snake	Low
Family: Leptotyphlopidae	**Thread Snakes**	
Leptotyphlops s.scutifrons	Peters' Thread Snake	Medium
Family: Atractaspididae	**African Burrowing Snakes**	
Atractaspis bibronii	Bibron's Stiletto Snake	Low
Apparalactus capensis	Cape Centipede-eater	Medium
Family: Colubridae	**Typical Snakes**	
Lamprophis capensis	Brown House Snake	Medium
Lycodonomorphus rufulus	Brown Water Snake	Low
Lycophidion capense	Cape Wolf Snake	Medium
Pseudaspis cana	Mole Snake	Low
Psammophis brevirostris	Shortsnouted Sand Snake	Low
Psammophris crucifer	Cross-marked Sand Snake	Low
Psammophis trinasalis	Fork-marked Sand Snake	Low
Psammophylax rhombeatus	Rhombic Skaapsteker	Medium
Psammophylax tritaeniatus	Striped Skaapsteker	Low
Telescopus semivariegatus	Eastern Tiger Snake	Low
Dispholidus typus	Boomslang	High
Dasypeltis scabra	Rhombic Egg-eater	High
Family: Elapidae	**Cobras, Mambas, other Elapids**	
Naja annulifera	Snouted Cobra	Medium
Naja mossambica	Mozambique Spitting Cobra	Low
Hemachatus haemachatus	Rinkhals	Low
Elapsoidea s. media	Highveld Garter Snake	Low
Family: Viperidae	**Adders**	
Bitis arietans	Puff Adder	High
Causus rhombeatus	Rhombic Night Adder	Low
Order: CHELONIA	**TORTOISES**	
Suborder: PLEURODIRA	**SIDE-NECKED TERRAPINS**	
Family: Pelomedusidae	**Side-necked Terrapins**	
Pelomedusa subrufa	Helmeted Terrapin	Low

7. FINDINGS AND POTENTIAL IMPLICATIONS

This site has a variety of habitats, due to a combination of substrate and vegetation types, drainage lines and earthen dams.

This variety of available habitat types provides suitable situations for habitat-specific reptiles and some frogs. The rocky outcrops on the slope and the crest of the ridge provide a habitat for the rock agama, the common girdled lizard and some skinks.

Further downhill the herpetofauna consists of grassveld generalists. As several taxa have only been recorded from one of the two quarter degree grid cells which cover this site, this indicates that the resident populations of these reptiles and amphibians tend to be small and disrupted.

As this site lies in a contact zone between Highveld Grassveld and the Savannah Bushveld, there is a potential overlap between some of the typical marker species, such as the northern cobras of tropical savannah, with the Rinkhals representing the southern Highveld species.

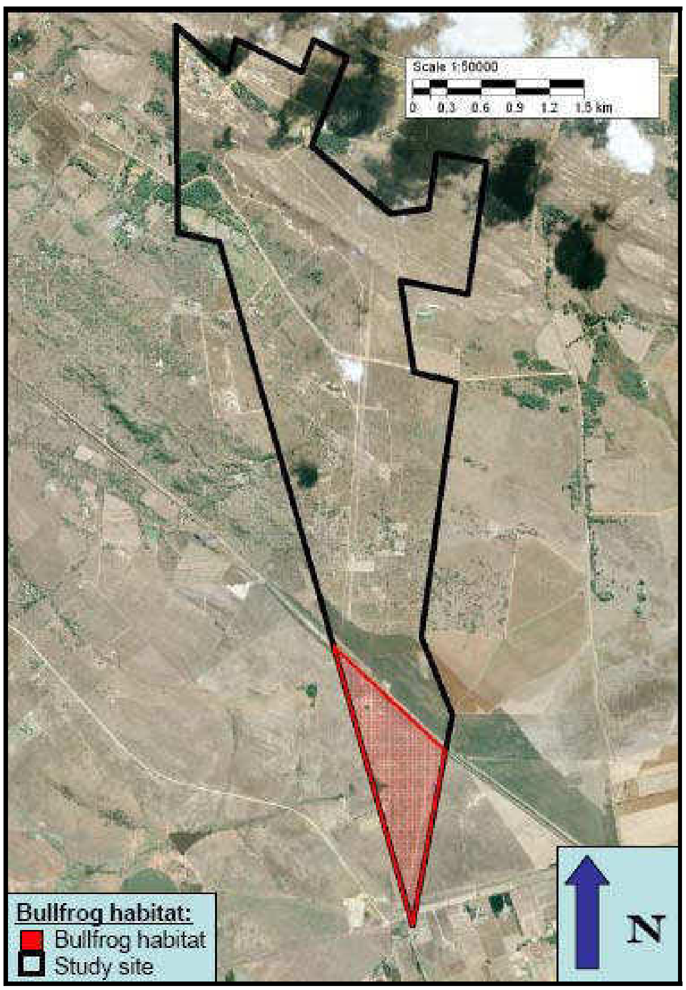


Figure 9: Bullfrog Habitat map

8. LIMITATIONS, ASSUMPTIONS AND GAPS IN KNOWLEDGE

This site in the two adjacent quarter degree grid cells has been residentially occupied for some time and a fairly high density housing complexes developed. Some areas have been taken over by dense stands of exotic plants, such as black wattles and gumtrees, and earthen dams have been built, therefore the original indigenous herpetofauna may have been affected.

9. RECOMMENDED MITIGATION MEASURES

Mitigation measures proposed by the specialist:

- It is important to note that the trenches for the water pipeline and even those for sewage lines do not need to be wide, which means that the environmental damage caused by the actual digging can be reduced to a minimum. However, while they are open their presence will mean that wildlife of any size may fall into them, from where it will be difficult to escape and death may be caused by drowning, excessive exposure to the sun or by being buried alive during the final construction work.
- Environmental damage caused by these trenches may be kept to a minimum by good forward planning and thereby reducing the actual length of time that they are open. Possible damage to wildlife is in direct proportion to the time that these trenches are open and may destroy amphibian and reptilian species.
- The design of the stormwater lines is not known. If large diameter cement pipes are used and the trenches are closed again, potential danger become reduced by filling in the trenches. Open stormwater channels are dangerous, as they will continuously contribute to wildlife destruction.

The following mitigation measures were developed by GDACE (Directorate of Nature Conservation, GDACE, 2009) and are applicable to the study site.

- When Giant Bullfrogs / Giant Bullfrog habitat will be retained in an open space system of a development situated within the urban edge, Giant Bullfrogs should be prevented from leaving the site and entering unsuitable habitat through the erection of an impermeable wall or appropriately designed fence prior to construction commencing. The wall/fence should be solid (i.e. without openings) below ground to the level of the foundations and for at least 20cm above ground.
- The crossing of natural drainage systems should be minimized and only constructed at the shortest possible route, perpendicular to the natural drainage system. Where possible, bridge crossings should span the entire stretch of the buffer zone.
- Disturbance to any wetlands during construction should be minimized. A plan for the immediate rehabilitation of damage caused to wetlands should be compiled by a specialist registered in accordance with the Natural Scientific Professions Act (No. 27 of 2003) in the field of Ecological Science. This rehabilitation plan should form part of the EMP and a record book should be maintained on site to monitor and report on the implementation of the plan.
- All storm water structures should be designed so as to block amphibian and

reptile access to the road surface.

- A comprehensive surface runoff and storm water management plan should be compiled, indicating how all surface runoff generated as a result of the road development (during both the construction and operational phases) will be managed (e.g. artificial wetlands / storm water and flood retention ponds) prior to entering any natural drainage system or wetland and how surface runoff will be retained outside of any demarcated buffer/flood zones and subsequently released to simulate natural hydrological conditions. This plan should form part of the EMP.
- Where roads are routed past expected or confirmed Giant Bullfrog breeding areas, road signs warning motorists to slow down on account of Giant Bullfrogs should be erected (in accordance with applicable legislation).

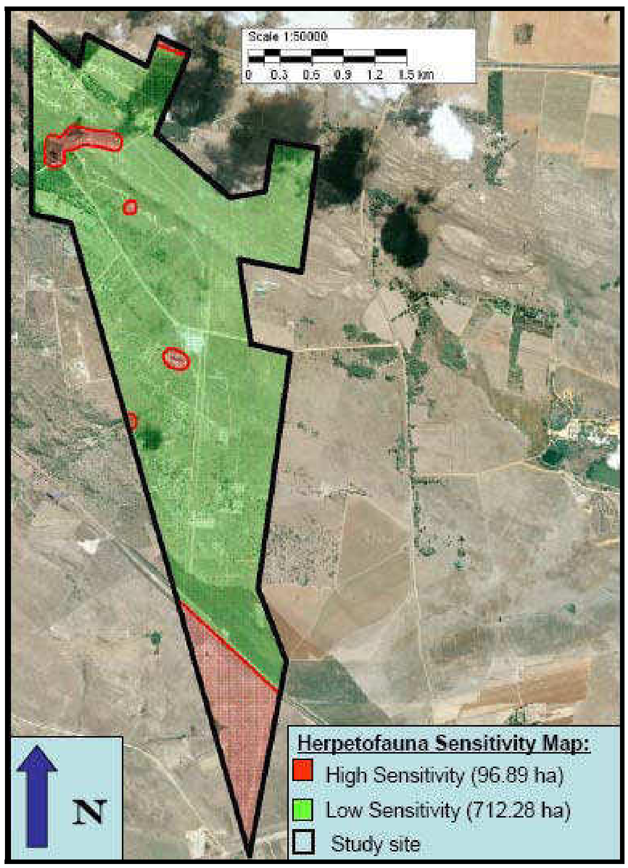


Figure 10: Herpetofaunal sensitivity map

10. CONCLUSION

This site has been occupied for some time and the northwestern corner is densely covered by houses. In parts it has been seriously disturbed by introduced exotic plants such as Black Wattle and Eucalyptus trees, which occur in thick stands on and around the site. The eastern section of the rocky ridge is relatively undisturbed. The entire site is run as a communal project and houses may have some gardens surrounding them but no walls or fences are allowed. Some antelopes have been introduced and these move freely on the site. As this system does not allow walls, bullfrogs would be able to move freely, mainly in the area near the southeastern border, where this frog has been recorded. The middle of this narrow site appears to have been subdivided into small plots for residential purposes. Some cattle were seen and some ploughing has been done. The long grassveld south of the railway line appears undisturbed.

The Giant Bullfrog occurs in the eastern quarter degree grid cell on this site. The wetlands and an adjacent open area should remain undeveloped for this frog. The rest of the listed species should be fairly well distributed, although in low densities. The proposed further development on this site will not have any seriously detrimental effects on the herpetofauna. Some commensal species, such as Speckled Skinks, which are able to live in association with human activities and structures, may benefit from this development.

11. LITERATURE SOURCES

Branch, W.R. 1998. *'Field Guide to the Snakes and other Reptiles of Southern Africa*'. 3rd edition. Struik Publishers, Cape Town. 399 pp., maps, 112 plates.

Branch, W.R. 2002. '*The Conservation Status of South Africa's threatened Reptiles'*: 89 – 103. In:- G.H.Verdoorn & J. le Roux (editors), '*The State of Southern Africa's Species',* Proceedings of a conference held at the Rosebank Hotel, 4 – 7 September 2001. World Wildlife Fund.

Department of Environmental Affairs and Tourism. 2007. National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004): Publication of Lists of Critically Endangered, Endangered, Vulnerable and Protected Species. Government Notices.

Directorate of Nature Conservation, GDACE. 2008 and revised on February 2009. GDACE Requirements for Biodiversity Assessments, Version 2. Gauteng Provincial Government.

Du Preez, L. & V. Carruthers, 2009. *'A complete Guide to the Frogs of Southern Africa'.* Struik Nature, Cape Town, 488 pp., illustr., maps

Jacobsen, N.H.G. Dec.1989. '*A herpetological survey of the Transvaal'*. 3 Vols, 1621 pp., 266maps. (Unpublished Ph.D. Thesis).

Jacobsen, N.H.G. 1995. '*The Herpetology of the Gauteng Province,* - localities and distribution maps'. Pages not numbered. Internal Report, Chief Directorate of Nature and Environmental Conservation, Gauteng Province.

Minter, L.R., M.Burger, J.A.Harrison, H.H.Braack, P.J.Bishop and D.Kloepfer, eds. 2004. '*Atlas and Red Data Book of the Frogs of South Africa, Lesotho and Swaziland'*. SI/MAB Series #9. Smithsonian Institution, Washington, DC.

Mucina, L. & Rutherford, M.C. 2006. '*The vegetation of South Africa, Lesotho and Swaziland*'. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

SARCA reptile survey (ongoing). Animal Demography Unit 2009 Department of Zoology - University of Cape Town.

Yetman, C. A., J. W. H. Ferguson, 2011. 'Spawning and non-breeding activity of adult giant bullfrogs (Pyxicephalus adspersus)'. African Journal of Herpetology. 60: 1, 13 – 29.

GALAGO ENVIRONMENTAL

Fauna and Flora Specialists

638 Turf Street
Wingate Park, 0181
Tel: 012-345 4891
Fax: 086 675 6136
Email: Vanessam@lantic.net
VAT No: 4080227657

Invertebrate Fauna Habitat Survey

PORTION 31 AND 38 AND THE REMAINDER OF KLEINFONTEIN 368 JR AND PORTION 14, 63 AND 68 OF DONKERHOEK 365 JR

February 2012

Report author: Reinier Terblanche (M.Sc, Pr.Sci.Nat)

TABLE OF CONTENTS

FIGURES:

TABLES:

1. INTRODUCTION

A habitat survey of invertebrates, of known high conservation priority, was required for Portion 31 and 38 and the remainder of Kleinfontein 368 JR and Portions 14, 63, 67 and 68 of Donkerhoek 365 JR. The survey focused on the possibility that invertebrate species of conservation concern, known to occur in the Gauteng Province are likely to occur within the proposed development site (with its alternatives) or not. Species of conservation concern include Threatened species (Critically Endangered, Endangered, Vulnerable), Near Threatened species, Critically Rare species or Rare species.

1.1 Objectives of the habitat study

The objectives of the habitat study are to provide:

- A detailed butterfly habitat survey;
- A detailed habitat survey of possible threatened or localized chafer beetles, mygalomorph spiders and rock scorpions;
- Evaluate the conservation importance and significance of the site with special emphasis on the current status of threatened invertebrate species;
- Recording of possible host plants of the larvae of butterfly species;
- Literature investigation of possible species that may occur on site;
- Identification of potential ecological impacts on invertebrates that could occur as a result of the development; and
- Make recommendations to reduce or minimise impacts, should the development be approved.

1.2 Scope of study

- Four site visits at the specific site of key elements of habitats on the site, relevant to invertebrate conservation.
- Recording of any sightings and/or evidence of existing butterflies and selected fruit chafers, mygalomorph spiders and rock scorpions.
- An evaluation of the conservation importance and significance of the site with special emphasis on the current status of threatened species.
- Recording of possible host plants of the larvae of butterfly species.
- Literature investigation of possible species that might occur on site.
- Integration of the literature investigation and field observations to identify potential ecological impacts that could occur as a result of the development.
- Integration of literature investigation and field observations to make recommendations to reduce or minimise impacts, should the development be approved.

2. STUDY AREA

The study site is situated at the intersection of the Savanna - and Grassland Biomes (Mucina & Rutherford 2006). Landscape at the site could be divided into a west-east directed rocky ridge and flatter areas with very few rocks on gentle slopes. The vegetation type at the rocky ridge is Gold Reef Mountain Bushveld but with a relatively low cover of indigenous trees. Grassland at the flats is represented by Rand Highveld Grassland (Mucina & Rutherford 2006). The site is part of the summer-rainfall region with dry winters. Frost is frequent in the winter, but less common on the ridges and hills (Mucina & Rutherford, 2006). Mean annual precipitation varies from 600 – 750mm a year. The ridge at the site is surrounded by thornveld, grassland at the flats, some cultivated fields, wetland vegetation along streambeds and built-up areas. A highway (N4) cuts between the northern section of the ridge at the site and other ridges further to the north. A smaller tar road exists between the ridge at the site and a chain of ridges to the east.

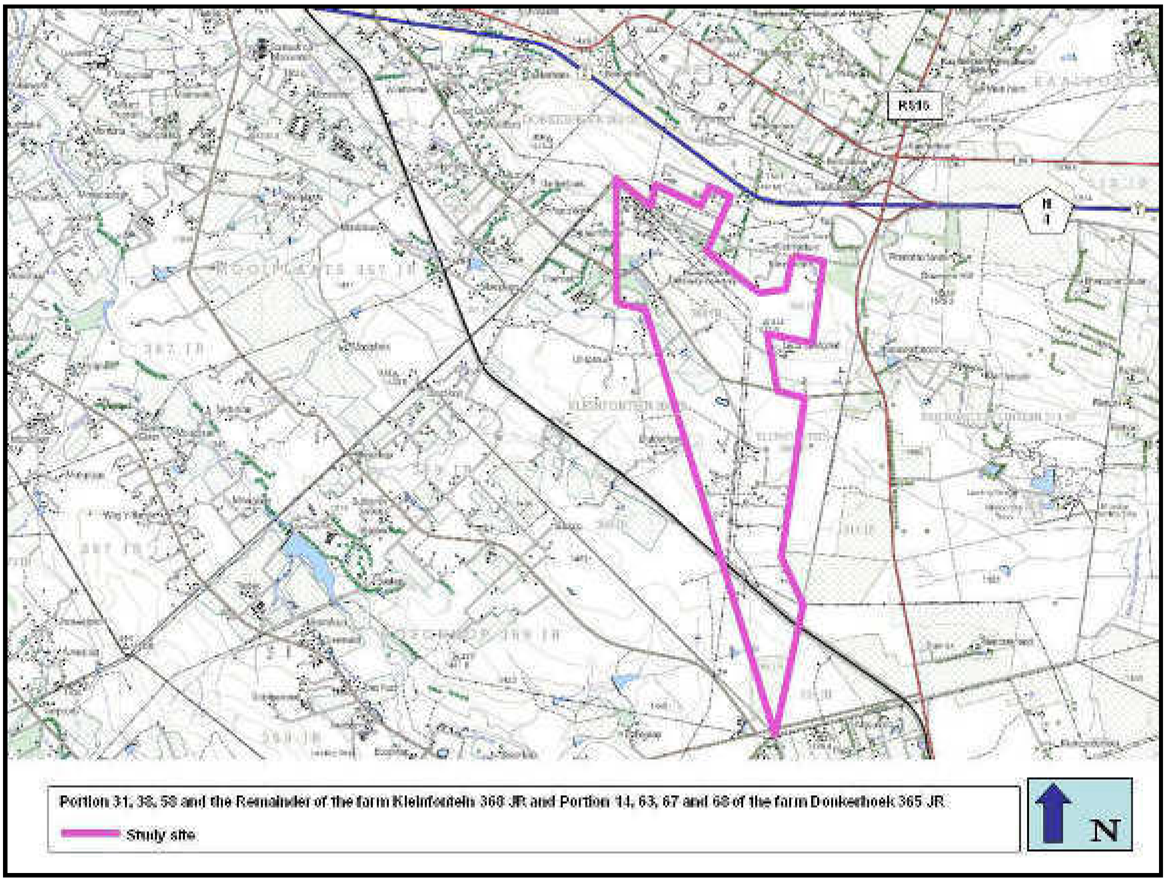


Figure 1: Locality map of the study area

3. METHODS

Surveys were conducted on 31 March 2011, 29 April 2011, 15 May 2011 and 12 September 2011.

3.1 Habitat characteristics and vegetation

The habitat was investigated by noting habitat structure (rockiness, slope, plant structure/physiognymy) as well as floristic composition. Voucher specimens of plant species were only taken where the taxonomy was in doubt and where the plant specimens were of significant relevance for invertebrate conservation. Field guides such as those by Van Oudtshoorn (1999), Van Wyk & Malan (1998) and Van Wyk & Van Wyk (1997) were used to confirm the taxonomy of the species. In this case no plant specimens were needed to be collected as voucher specimens or to be sent to a herbarium for identification.

3.2 Butterflies

Butterflies were noted as sight records or voucher specimens. Voucher specimens are mostly taken of those species of which the taxa warrant collecting due to taxonomic difficulties or in the cases where species can look similar in the veldt.

Many butterflies use only one species or a limited number of plant species as host plants for their larvae. Myrmecophilous (ant-loving) butterflies such as the *Aloeides*, *Chrysoritis*, *Erikssonia, Lepidochrysops* and *Orachrysops* species (Lepidoptera: Lycaenidae), which live in association with a specific ant species, require a unique ecosystem for their survival (Deutschländer & Bredenkamp, 1999; Terblanche, Morgenthal & Cilliers, 2003; Edge, Cilliers & Terblanche, 2008; Gardiner & Terblanche, 2010). Known food plants of butterflies were therefore also recorded. After the visits to the site and the identification of the butterflies found there, a list was also compiled of butterflies that will most probably be found in the area in all the other seasons because of suitable habitat. The emphasis is on a habitat survey.

3.3 Fruit chafer beetles

Different habitat types in the areas were explored for any sensitive or special fruit chafer species. Selection of methods to find fruit chafers depends on the different types of habitat present and the species that may be present. Fruit bait traps would probably not be successful for capturing *Ichnestoma* species in a grassland patch (Holm & Marais 1992). Possible chafer beetles of high conservation priority were noted as sight records accompanied by the collecting of voucher specimens with grass nets or containers. Voucher specimens are taken where the relevant species belongs to taxa that warrant collecting due to taxonomic difficulties or possible confusion of identity in the veldt.

3.4 Mygalomorph spiders and rock scorpions

Relatively homogenous habitat / vegetation areas were identified and explored to identify any sensitive or special species. Selected stones that were lifted to search for Arachnids were put back very carefully resulting in the least disturbance possible. The area was searched for possible signs of trap door spiders or other mygalomorph spiders (for example traces of wafer-lids, cork-lids or silk-lined burrows). Investigations by brushing the soil surface with a small broom/paint brush, scraping or digging into the soil with a spade, were made. All the above actions were accompanied by the least disturbance possible.

3.5. Limitations

It should be emphasized that the survey is by no means an exhaustive list of the butterflies or other invertebrates present on the site, because of the time constraint. The on site butterfly and invertebrate survey was conducted during March 2011, April 2011, May 2011 and September 2011 which is an optimal time series of the year to find sensitive butterflies as well as other invertebrates of high conservation priority. Weather conditions during the visits were favourable for recording butterflies and invertebrates. However, the focus remains the habitat survey that focused on the probability of threatened species being present at the site.

4. RESULTS

4.1. Habitat and vegetation characteristics

Table 1: Outline of the main habitat and vegetation characteristics of the proposed site.

HABITAT FEATURE	DESCRIPTION
Topography	The site comprises a rocky ridge section with an upper plateau at the northern parts of the site and a flat area that covers the central and southern parts of the site.
Rockiness	Rocky ridges are found in the northern part of the site which include a plateau that contain rocky outcrops and sheet rock.
Presence of wetlands	A wetland and dam are present at the southern slope of the rocky ridges.
Vegetation in general	Vegetation at the site is a mosaic of different areas depending on the land use. Cultivated fields, gardens with exotic and indigenous plant species, patches of exotic trees are found in and around present developed areas. Remnants of grassland or *Acacia karroo* woodland are found in the valley bottom with its gentle slopes (flat area). Rocky ridge vegetation that contains pristine patches of rocky ridge vegetation is found in the northern parts of the site at a conservation area. Wetland patches of which most have been invaded or surrounded by exotic trees (*Eucalyptus,* exotic *Acacia, Populus*) are found at the site. One wetland is also partly invaded by kikuyu (*Pennisetum clandestinum*). Extensive patches of exotic invasive tree species are present at the site. Patches of the exotic *Eucalyptus camaldulensis* (red river gum, "bloekom") trees are present. Extensive patches of exotic invasive *Acacia decurrens* (green wattle) are present. Grassland at the rocky ridge contain a variety of indigenous grass species including *Loudetia simplex*, *Tristachya rehmannii*, *Aristida junciformis* subsp. *galpinii*, *Aristida transvaalensis*, *Digitaria monodactyla*, *Digitaria diagonalis* var. *diagonalis*, *Schizachyrium sanguineum*, *Panicum natalense* and *Monocymbium ceresiiforme*. A number of succulents including *Adromischus umbraticola*, *Euphorbia davyi* and *Aloe pretoriensis* are found in the rocky ridge vegetation. In addition shrubs such as *Clutia pulchella* (lightning bush), *Parinari capensis* (dwarf mobola), *Searsia magalismontana*, *Xerophyta retinervis* (monkey's tail) and *Protea welwitschii* are also recorded. Patches or clumps of indigenous trees are also found.
Signs of disturbances	The residential environment is obviously modified (containing roads, built up areas, fences) whilst vegetation in residential areas contain many exotic plant species. Patches of exotic *Eucalyptus* trees and exotic *Acacia decurrens* (green wattle) are present. High frequencies of *Seriphium plumosum* (bankrupt bush) in some parts suggest possible overgrazing.
Characteristics of surrounding areas (with a view to buffer zones, corridors and connectivity of habitats with more natural vegetation)	The rocky ridge area could be very important as stepping stones in a conservation corridor. Remnant patches of indigenous grassland and woodland could also be important stepping stones of natural corridors in an increasingly urbanised area.

Photo 1: View of the quartzite ridge. Vegetation consists of grassland with trees that are only found in favourable secluded areas.
Photo: September 2011, R.F. Terblanche

Photo 2: An example of *Stygionympha wichgrafi*, a butterfly that exclusively favours rocky ridges.
Photo: R.F. Terblanche.

Photo 3: Rocks, grasses and *Clutia pulchella* (lightning bush).
Photo: September 2011, R.F. Terblanche.

Photo 4: *Crematogaster* species at the rocky ridges where the host plant of *Chrysoritis aureus* (Heidelberg Copper butterfly), *Clutia pulchella* is present at the site.
Photo: September 2011, R.F. Terblanche.

4.2. Threatened invertebrate species

4.2.1. Butterflies

Table 2: Butterfly species in the Gauteng Province that appear in the present revised red data book of butterfly species in South Africa (Henning, Terblanche & Ball, 2009).
Invertebrates such as threatened butterfly species are normally very habitat specific and residential status imply a unique ecosystem that is at stake. No = 0; Yes = 1.

SPECIES	COMMON NAMES	GLOBAL CONSERVATION STATUS	RESIDENT AT SITE	NOT FOUND/ UNLIKELY TO OCCUR AT SITE
Chrysoritis aureus	**Golden Copper/ Heidelberg Copper**	Vulnerable	0	1
Aloeides dentatis dentatis	**Roodepoort Copper**	Vulnerable	0	1
Lepidochrysops praeterita	**Highveld Blue**	Endangered	0	1
*Metisella meninx**	**Marsh Sylph**	Vulnerable	0	1
*Platylesches dolomitica***	**Hilltop Hopper**	Vulnerable	?	?
*Orachrysops mijburghi****	**Mijburgh's Blue**	Vulnerable	0	1

* *Metisella meninx* is no longer treated as a threatened species based on valid new information on its distribution and abundance. *Metisella meninx* is at present regarded as a species of conservation concern in the Rare category (which is not a formal IUCN category): rare habitat specialist. Mecenero, S. et al. *In prep.* South African butterfly atlas. Part of SABCA: South African Butterfly Conservation Assessment: A joint project of the Animal Demography Unit (ADU) of the University of Cape Town, the South African National Biodiversity Institute (SANBI) and the Lepidopterist's Society of Africa (LepSoc). http://sabca.adu.org.za.

** *Platylesches dolomitica* is no longer treated as a threatened species based on valid new information on its distribution. Mecenero, S. et al. *In prep.* South African butterfly atlas. Part of SABCA: South African Butterfly Conservation Assessment: A joint project of the Animal Demography Unit (ADU) of the University of Cape Town, the South African National Biodiversity Institute (SANBI) and the Lepidopterist's Society of Africa (LepSoc). http://sabca.adu.org.za.

*** This entity may prove to be a different taxon of which only one or possibly two localities in Gauteng are known up to date. At present it is recognised as the Suikerbosrand population of *Orachrysops mijburghi* (Terblanche & Edge 2007).

4.3. Invertebrate species of high/special conservation significance

4.3.1. Butterflies

Table 3: Butterfly species of high conservation priority in the Gauteng Province due to localized distribution and habitat specificities.

The conservation priority of these butterflies is largely based on the unpublished Gauteng butterfly atlas work (G.A. Henning, P. Roos, M. Forsyth) and own records and analyses. No = 0; Yes = 1.

SPECIES	TRIVIAL NAME	RESIDENT AT SITE	NOT FOUND/ UNLIKELY TO OCCUR AT SITE
Lepidochrysops letsea	Free State Blue	0	1
Lepidochrysops tantalus	King Blue	0	1
Thestor basutus basutus	Basutu Skolly	0	1
Gegenis hottentota	Marsh Hottentot Skipper	0	1
Lepidochrysops procera	Potchefstroom Blue	0	1
Lepidochrysops ketsi ketsi	Ketsi Blue	0	1
Lepidochrysops ignota	Zulu Blue	0	1
Kedestes nerva nerva	Scarce Ranger	?	?
Lepidochrysops ortygia	Koppie Blue	0	1
Acraea anacreon	Orange Acraea	?	?

4.3.2. Fruit chafers

Table 4: Fruit chafer species (Coleoptera: Scarabaeidae: Cetoninae) in Gauteng Province that are known to be of high conservation priority. No = 0; Yes = 1.

SPECIES	RESIDENT AT SITE	NOT FOUND/ UNLIKELY TO OCCUR AT SITE
Ichnestoma stobbiai	1	0
Trichocephala brincki	0	1

4.3.3. Baboon spiders

Table 5: Baboon spiders species (Araneae: Teraphosidae) that are of known high conservation priority in the Gauteng Province. No = 0; Yes = 1.

SPECIES	RESIDENT AT SITE	NOT FOUND/ UNLIKELY TO OCCUR AT SITE
Brachionopus pretoriae	0	0

4.3.4. Trapdoor spiders

Table 6: Front-eyed or spurred trapdoor spiders species (Araneae: Idiopidae) that are of known high conservation priority in the Gauteng Province. No = 0; Yes = 1.

SPECIES	RESIDENT AT SITE	NOT FOUND/ UNLIKELY TO OCCUR AT SITE
Galeosoma pilosum	0	1
Galeosoma robertsi	0	1
Galeosoma scutatum	0	1
Segregara monticola	0	1

4.3.4. Rock scorpions

Table 7: Rock scorpion species (Scorpiones: Ischnuridae) that are of known high conservation priority in the Gauteng Province. No = 0; Yes = 1.

SPECIES	RESIDENT AT SITE	NOT FOUND/ UNLIKELY TO OCCUR AT SITE
Hadogenes gracilis	0	1
Hadogenes gunningi	1	0

4.4 Invertebrate biodiversity

Though many parts of the site have been modified, a variety of habitats still remain and the invertebrate diversity is suspected to be high. Invertebrate diversity at the rocky ridges is interesting and more additions could be made to the present species list.

5. DISCUSSION

5.1. Status of threatened butterfly species at the site

Studies about the vegetation and habitat of threatened butterfly species in South Africa showed that ecosystems with a unique combination of features are selected by these often localised threatened butterfly species (Deutschländer and Bredenkamp 1999; Edge 2002, 2005; Terblanche, Morgenthal & Cilliers 2003; Lubke, Hoare, Victor & Ketelaar 2003; Edge, Cilliers & Terblanche, 2008). Threatened butterfly species in South Africa can then be regarded as bio-indicators of rare ecosystems.

Six species of butterfly in Gauteng are listed in the revised red list and South African Red Data Book: butterflies (G.A. Henning, Terblanche & Ball, 2009). The expected presence or not of the threatened butterfly species follows.

Chrysoritis aureus **(Golden Opal/ Heidelberg Copper)**
The proposed global red list status for *Chrysoritis aureus* according to the most recent IUCN criteria and categories is Vulnerable [VU B1ab(ii,iv)+2ab(ii,iv); D2] (G.A. Henning, Terblanche & Ball, 2009). *Chrysoritis aureus* (Golden Opal/ Heidelberg Copper) is a resident where the larval host plant, *Clutia pulchella* is present. However, the distribution of the butterfly is much more restricted than that of the larval host plant (S.F. Henning 1983; Terblanche, Morgenthal & Cilliers 2003). One of the reasons for the localised distribution of *Chrysoritis aureus* is that a specific host ant *Crematogaster liengmei* must also be present at the habitat. Research revealed that *Chrysorits aureus* (Golden Opal/ Heidelberg Copper) has very specific habitat requirements, which include rocky ridges of upper slopes with a steep southern slope (Terblanche, Morgenthal & Cilliers (2003). Though *Clutia pulchella*, the host plant is present in similar rocky landscapes as at the habitats of *Chrysoritis aureus*, it is highly unlikely that the butterfly is present. The host ant *Crematogaster liengmei* appears to be absent – only another *Crematogaster* species (Photo 4) has been found at the rocks where the host plant is present. Nectar sources at the rocky ridges also appear to be relatively poor. *Chrysoritis aureus* has never been found at rocky ridges with *Clutia pulchella* in the Magaliesberg, despite exploration by a number of butterfly collectors of this mountain series over decades. *Chrysoritis aureus* has not been found during the present surveys.

Aloeides dentatis dentatis (**Roodepoort Copper)**
The proposed global red list status for *Aloeides dentatis dentatis* according to the most recent IUCN criteria and categories is Vulnerable [VU B2ab(ii,iii); D2] (G.A. Henning, Terblanche & Ball, 2009). *Aloeides dentatis dentatis* colonies are found where one of its host plants *Hermannia depressa* or *Lotononis eriantha* is present. Larval ant association is with *Lepisiota capensis* (S.F. Henning, 1983; S.F. Henning & G.A. Henning, 1989). The habitat requirements of *Aloeides dentatis dentatis* are complex and not fully understood yet. See Deutschländer and Bredenkamp (1999) for the description of the vegetation and habitat

characteristics of one locality of *Aloeides dentatis* subsp. *dentatis* at Ruimsig, Roodepoort, Gauteng Province. Recently new colonies of *Aloeides dentatis dentatis* have been discovered in the new section of the Suikerbosrand Nature Reserve (Terblanche & Edge 2007). There is no ideal habitat for *Aloeides dentatis* subsp. *dentatis* on the site and it is highly unlikely that the butterfly is present at the site.

***Lepidochrysops praeterita* (Highveld Blue)**
The proposed global red list status for *Lepidochrysops praeterita* according to the most recent IUCN criteria and categories is Endangered [E A2c; B1ab(iv)+2ab(iv)] (G.A. Henning, Terblanche & Ball, 2009). *Lepidochrysops praeterita* is a butterfly that occurs where the larval host plant *Ocimum obovatum* is present (Pringle, G.A. Henning & Ball, 1994), but the distribution of the butterfly is much more restricted than the distribution of the host plant. *Lepidochrysops praeterita* is found on selected rocky ridges and rocky hillsides in parts of Gauteng, the extreme northern Free State and the North-West Province. The site falls outside the known extent of occurrence of *Lepidochrysops praeterita* (G.A. Henning, Terblanche & Ball, 2009). No ideal habitat appears to be present for the butterfly on the site. It is highly unlikely that *Lepidochrysops praeterita* would be present on the site.

***Metisella meninx* (marsh sylph)**
The marsh sylph butterfly, *Metisella meninx*, is listed as a threatened species by Henning, Terblanche & Ball (2009). It should be noted *Metisella meninx* is at present regarded as a species of conservation concern in the Rare category (which is not a formal IUCN category) as a rare habitat specialist (Mecenero, S. et al. *In prep.* South African butterfly atlas. Part of SABCA: South African Butterfly Conservation Assessment: A joint project of the Animal Demography Unit (ADU) of the University of Cape Town, the South African National Biodiversity Institute (SANBI) and the Lepidopterist's Society of Africa (LepSoc). http://sabca.adu.org.za). Though *Metisella meninx* is more widespread and less threatened than perceived before, it should be regarded as a localised rare habitat specialist of conservation priority, which is associated with suitable patches of grass at wetlands. The larval host plant of *Metisella meninx* is rice grass, *Leersia hexandra* (G.A. Henning & Roos 2001). Unlike many other threatened butterfly species in South Africa no specific association with ant species is present in the early stages of the life cycle of the *Metisella meninx*. The ideal habitat of *Metisella meninx* is treeless marshy areas where *Leersia hexandra* (rice grass) is abundant. No ideal habitat for *Metisella meninx* appears to be present.

***Platylesches dolomitica* (Dolomite Hopper)**
The proposed global red status for *Platylesches dolomitica* according to the most recent IUCN criteria and categories is Vulnerable [VU D2] (G.A. Henning, Terblanche & Ball, 2009). *Platylesches dolomitica* is a rare butterfly of which the habitat, presumably dolomite ridges, is still poorly known. *Platylesches dolomitica* could be found at the rocky ridges at the site. This recently described butterfly has been found to be widespread and not threatened or of particular conservation concern (Mecenero, S. et al. *In prep.* South African butterfly atlas. Part of SABCA: South African Butterfly Conservation Assessment: A joint project of the Animal Demography Unit (ADU) of the University of Cape Town, the South African National Biodiversity Institute (SANBI) and the Lepidopterist's Society of Africa (LepSoc). http://sabca.adu.org.za).

***Orachrysops mijburghi* (Mijburgh's Blue)**
The proposed global red status for *Orachrysops mijburghi* according to the most recent IUCN criteria and categories is Vulnerable [VU D2] (G.A. Henning, Terblanche & Ball, 2009). *Orachrysops mijburghi* favours grassland depressions where specific *Indigofera* plant species occur (Edge, 2005; Terblanche & Edge 2007; G.A. Henning, Terblanche & Ball 2009). The Heilbron population of *Orachrysops mijburghi* in the Free State uses *Indigofera evansiana* as a larval host plant while the Suikerbosrand population in Gauteng uses *Indigofera dimidiata* as a larval host plant (Edge 2005; Terblanche & Edge 2007). There is

no suitable habitat for *Orachrysops mijburghi* on the site and it is unlikely that *Orachrysops mijburghi* would be present on the site.

Conclusion on threatened butterfly species
There appears to be no threat to any threatened butterfly species if the study site is developed.

5.2. Status of invertebrates of special conservation significance

Table 3 lists the butterfly species (Lepidoptera: Hesperiidae, Papilionidae, Pieridae, Nymphalidae and Lycaenidae) that are of known high conservation priority in the Gauteng Province. None of the above butterfly species were found on the site, or are likely to be resident at the site. There appears to be no threat to the butterfly species of high conservation significance if the developments are approved.

Table 4 lists the fruit chafer beetle species (Coleoptera: Scarabaeidae: Cetoninae) that are of known high conservation priority in the Gauteng Province.

***Ichnestoma stobbiai* (rare fruit chafer beetle)**
Ichnestoma stobbiai is an endangered fruit chafer (Scarabaeidae: Cetoniinae) that occurs in small habitat fragments of South Africa (Kryger & Scholtz, 2008). The adults of this species are short-lived and the females are flightless. Thus, the vagility of these beetles is extremely low (Kryger & Scholtz, 2008). The Cetoniinae (Coleoptera: Scarabaeidae) genus *Ichnestoma* Gory & Percheron, 1833 currently comprises 13 described species and is endemic to South Africa. The species *I. stobbiai* Holm, 1992 is thought to occur in a very restricted area in and around Gauteng Province and all habitat patches should be protected (Kryger & Scholtz, 2008; Deschodt, Scholtz & Kryger, 2009). Unlike most cetoniine larvae, the larvae of this species usually occur in dolomitic to cherty, well-drained soils (Deschodt, Scholtz & Kryger, 2009). *Ichnestoma* larvae feed under the soil surface and also pupate under the soil surface in specific grassland areas (Perissinotto, Smith & Stobbiai, 1999). All the habitat requirements of *Ichnestoma stobbiai* in these grassland patches are not fully understood yet, but it is normally a rocky area (dolomite to chert: see Deschodt, Scholtz & Kryger, 2009), consisting of grassland with a variety of indigenous grass species. From personal experience few trees occur in such patches, with species diverse grassland that are well developed in terms of succession. Rocks, often well-embedded in the soil, are scattered throughout such areas. There is suitable habitat for *Ichnestoma stobbiai* at the site and this beetle has been found previous to this study at the site.

There would be a threat to the rare and localised fruit chafer beetle, *Ichnestoma stobbiai* if some patches of the rocky ridge are developed.

Table 5 lists the baboon spider species (Araneae: Teraphosidae) that are of known high conservation priority in the Gauteng Province. None of the above baboon spider species were found on the site, or are likely to be resident at the site. There appears to be no threat to the baboon spider species of high conservation significance if the development is approved.

Table 6 lists the trapdoor spider species (Araneae: Teraphosidae) that are of known high conservation priority in the Gauteng Province. Most trapdoor spider species in general are regarded as being sensitive to environmental changes. There appears to be no threat to the trapdoor spider species of high conservation significance if the development is approved.

Table 7 lists the rock scorpion species (Scorpiones: Ischnuridae) that are of known high conservation priority in the North-West Province and Gauteng Province. Distribution of

Hadogenes gunningi is wider than perceived in the past and this unique scorpion does not qualify for threatened status (see Engelbrecht 2005). It remains however a localised species of conservation concern. *Hadogenes gunningi* is present at some patches of the rocky ridge at the site. There will be a threat to *Hadogenes gunningi* if some patches of the rocky ridge are developed.

5.3 Invertebrate biodiversity

Though many parts of the site have been modified, a variety of habitats still remain and the invertebrate diversity is suspected to be high. Invertebrate diversity at the rocky ridges is interesting and more additions could be made to the present species list. If a conservation area at the site is maintained and more indigenous plant species is cultivated in residential areas a very valuable contribution to invertebrate conservation can be made.

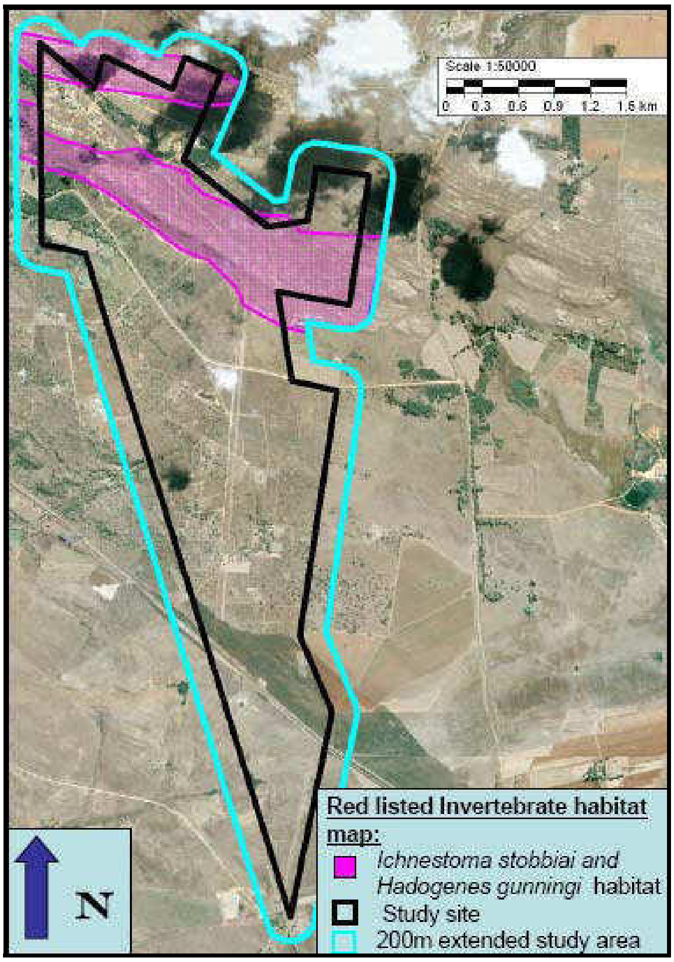


Figure 2: Map with a sensitive area, where the invertebrate biodiversity is high or where extant and potential habitats of *Ichnestoma stobbiai* are present.

6. IMPACTS AND MITIGATION MEASURES

Habitat conservation is the key to the conservation of invertebrates such as threatened butterflies (Deutschländer and Bredenkamp 1999; Edge 2002, 2005; Terblanche, Morgenthal & Cilliers 2003; Lubke, Hoare, Victor & Ketelaar 2003; Edge, Cilliers & Terblanche, 2008). Furthermore corridors and linkages may play a significant role in insect conservation (Pryke & Samways, 2003, Samways, 2005).

Urbanisation is a major additional influence on the loss of natural areas (Rutherford & Westfall 1994). In the Gauteng Province the pressure to develop areas is high since its infrastructure allows for improvement of human well-being in some way. Urban nature conservation issues in South Africa are overshadowed by the goal to improve human well-being, which focuses on aspects such as poverty, equity, redistribution of wealth and wealth creation (Cilliers, Müller & Drewes 2004). Nevertheless the conservation of habitats is the key to invertebrate conservation, especially for those red listed species that are very habitat specific. This is also true for any detailed planning of corridors and buffer zones for invertebrates. Though proper management plans for habitats are not in place, setting aside special ecosystems is in line with the resent Biodiversity Act (2004) of the Republic of South Africa.

Corridors are important to link ecosystems of high conservation priority. Such corridors or linkages are there to improve the chances of survival of otherwise isolated populations (Samways, 2005). How wide should corridors be? The answer to this question depends on the conservation goal and the focal species (Samways, 2005). For an African butterfly assemblage this is about 250m when the corridor is for movement as well as being a habitat source (Pryke and Samways 2003). Hill (1995) found a figure of 200m for dung beetles in tropical Australian forest. In the agricultural context, and at least for some common insects, even small corridors can play a valuable role (Samways, 2005). Much more research remains to be done to find refined answers to the width of grassland corridors in South Africa. The width of corridors will also depend on the type of development, for instance the effects of the shade of multiple story buildings will be quite different from that of small houses.

To summarise: In practice, as far as urban developments are concerned, the key would be to prioritise and plan according to special ecosystems.

In the case of this study site, there appears to be no loss of sensitive species and particularly sensitive habitats if a development, <u>which excludes the ridges and associated rocky plateau</u>, is approved. There would be a loss of connectivity of particular conservation importance if the developments are approved, with the exception rocky ridges.

Impacts:

- The loss of habitat
- The loss of sensitive species. Sensitive species are regarded here as the invertebrate species that are listed in Tables 1-4 and constitutes the invertebrate species that are red listed or of known particular high conservation importance. *Ichnestoma stobbiai*, a rare and endangered beetle species, is present on the site. Another invertebrate species of conservation concern *Hadogenes gunningi* (rock scorpion) is also present on the site. Both these species are associated with the rocky ridge at the site. During the operational phase, the significance of loss of habitat is expected to be high without and low with mitigation.
- The loss of habitat connectivity and open space

Mitigation measures:

- Proposed developments should be strictly confined to the areas planned for development and the remains of semi-natural vegetation along the water course should be conserved.
- No exotic invasive plant species should be planted in the areas to be developed, if the development is approved.

- A buffer zone of at least 30m should be allocated to all rocky ridges, rocky plateaus and wetlands beyond which no disturbance or vehicles should be allowed during the constructional and operational phases.
- Where infrastructural developments cross a wetland zone, the development should be confined strictly to the area where the development crosses over.

7. RECOMMENDATION

- It is highly recommended that the rocky ridges and rocky plateaus <u>not</u> be considered for future development.
- Wetlands if rehabilitated to include more indigenous vegetation could enhance invertebrate diversity at the site.
- If developments are approved the following recommendations apply:
  - It is recommended that where possible within overall conservation goals of this site, exotic vegetation should be removed and eradicated, especially invasive exotic species such as *Acacia decurrens* (green wattle).
  - Indigenous plant species are important for invertebrate conservation and if the development is approved, indigenous trees and vegetation should be conserved where possible.
  - There should be a focus to conserve patches of natural grassland and woodland vegetation.

8. CONCLUSION

The general biodiversity of invertebrates appears to be moderate at the residential areas and very low at patches of exotic trees (exotic *Acacia*, *Eucalyptus*). In contrast diversity of indigenous invertebrate species, such as reflected by beetles, butterflies and scorpions, appears to be high at the rocky ridge. There is considerable scope for the rocky ridges, including the rocky plateau to be corridors of considerable conservation importance.

A localised scorpion species, *Hadogenes gunningi* (rock scorpion) has been found at the rocky ridge. *Ichnestoma* stobbiai, an endangered fruit chafer (Scarabaeidae: Cetoniinae) that occurs in small habitat fragments of South Africa (Kryger & Scholtz, 2008) has been found at the site during previous studies. There is habitat that appears to be suitable for this rare beetle at the site. The adults of this species are short-lived and the females are flightless. Thus, the vagility of these beetles is extremely low (Kryger & Scholtz, 2008). The Cetoniinae (Coleoptera: Scarabaeidae) genus *Ichnestoma* Gory & Percheron, 1833 currently comprises 13 described species and is endemic to South Africa. The species *I. stobbiai* Holm, 1992 is thought to occur in a very restricted area in and around Gauteng Province and all habitat patches should be protected (Kryger & Scholtz, 2008; Deschodt, Scholtz & Kryger, 2009). Unlike most cetoniine larvae, the larvae of this species usually occur in dolomitic to cherty, well-drained soils (Deschodt, Scholtz & Kryger, 2009). *Ichnestoma* larvae feed under the soil surface and also pupate under the soil surface in specific grassland areas (Perissinotto, Smith & Stobbiai, 1999). All the habitat requirements of *Ichnestoma stobbiai* in these grassland patches are not fully understood yet, but it is normally a rocky area (dolomite to chert: see Deschodt, Scholtz & Kryger, 2009), consisting of grassland with a variety of indigenous grass species. From personal experience few trees occur in such patches, with species diverse grassland that are well developed in terms of succession. Rocks, often well-embedded in the soil, are scattered throughout such areas. There would be a threat to this rare and localised fruit chafer beetle, *Ichnestoma stobbiai*, if the rocky ridge is included in future developments.

Efforts by the local community to compile an inventory of invertebrates at the site, is to be commended and would hopefully be continued.

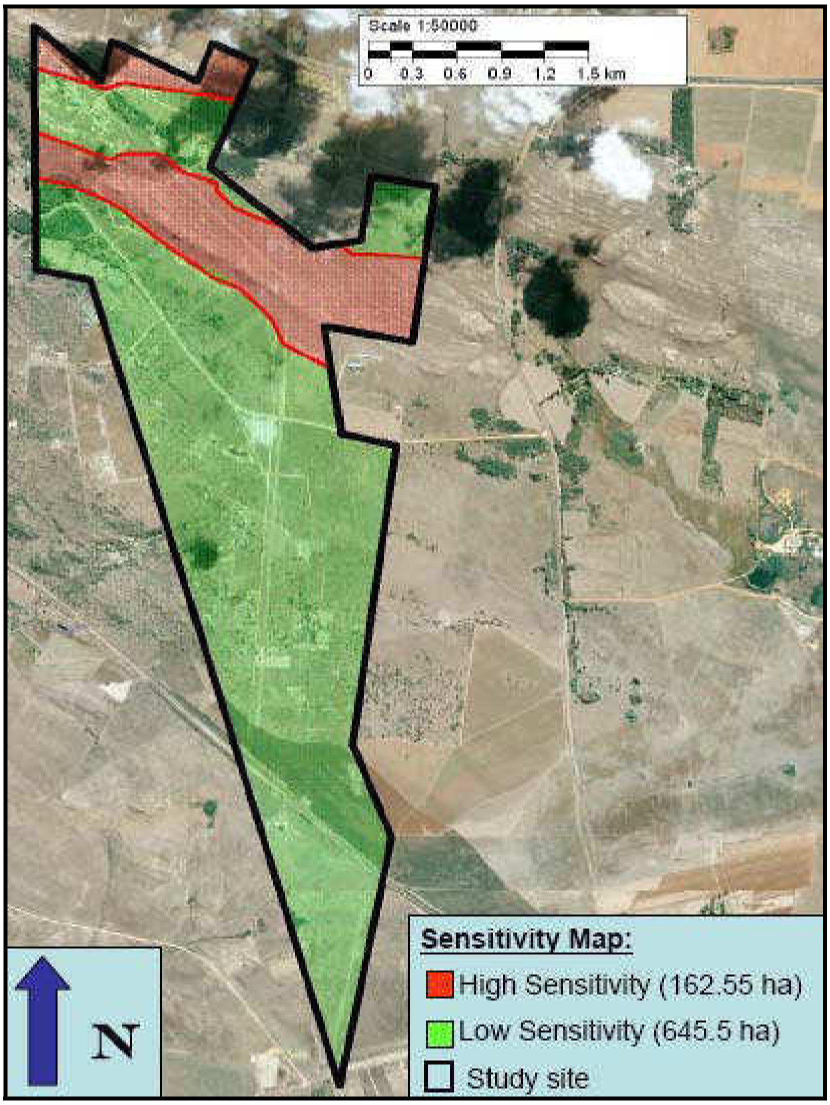


Figure 3: Invertebrate sensitivity map

9. REFERENCES

Cilliers, S.S., Müller, N. & Drewes, E. 2004. Overview on urban nature conservation: situation in the western-grassland biome of South Africa. *Urban forestry and urban greening* 3: 49-62.

Dippenaar-Schoeman, A.S. 2002. Baboon and trapdoor spiders in southern Africa: an identification manual. Plant Protection Research Institute Handbook No. 13. Pretoria: Agricultural Research Council.

Deschodt, C.M. Scholtz, C.H. & Kryger, U. 2009. *Ichnestoma stobbiai* Holm 1992 Scarabaeidae: Cetoniinae), a range-restricted species of conservation concern. *African Entomology* 17(1): 43-50.

Deutschländer, M.S. & Bredenkamp, C.J. 1999. Importance of vegetation analysis in the conservation management of the endangered butterfly *Aloeides dentatis* subsp. *dentatis* (Swierstra) (Lepidoptera: Lycaenidae). *Koedoe* 42(2): 1-12.

Dippenaar-Schoeman, A.S. & Jocqué, R. 1997. African spiders: an identification manual. Plant Protection Research Institute Handbook No. 9. Pretoria: Agricultural Research Council.

Edge, D.A. 2002. Some ecological factors influencing the breeding success of the Brenton Blue butterfly, *Orachrysops niobe* (Trimen) (Lepidoptera: Lycaenidae). *Koedoe*, 45(2): 19-34.
Edge, D.A. 2005. Ecological factors influencing the survival of the Brenton Blue butterfly, *Orachrysops niobe* (Trimen) (Lepidoptera: Lycaenidae). North- West University, Potchefstroom, South Africa (Thesis - D.Phil.).
Edge, D.A., Cilliers, S.S. & Terblanche, R.F. 2008. Vegetation associated with the occurrence of the Brenton Blue butterfly. *South African Journal of Science* 104: 505 - 510.
Engelbrecht, I. 2005. Habitat distribution and modelling and estimating Minimum Viable Area for population persistence for three Arachnids of conservation interest in Gauteng Province. Research report submitted in partial fulfilment of the requirements for the degree of MSc at University of Witwatersrand, Johannesburg, South Africa.
Filmer, M.R. 1991. Southern African spiders: an identification guide. Cape Town: Struik.
Gardiner, A.J. & Terblanche, R.F. 2010. Taxonomy, biology, biogeography, evolution and conservation of the genus *Erikssonia* Trimen (Lepidoptera: Lycaenidae). *African Entomology* 18(1): 171 – 191.
Henning, G.A. & Roos, P.S. 2001. Threatened butterflies of South African wetlands. *Metamorphosis* 12(1): 26-33.
Henning, G.A., Terblanche, R.F. & Ball, J.B. (eds) 2009. South African Red Data Book: butterflies. *SANBI Biodiversity Series* 13. South African National Biodiversity Institute, Pretoria. 158 p.
Henning, S.F. 1983. Biological groups within the Lycaenidae (Lepidoptera). *Journal of the Entomological Society of Southern Africa* 46(1): 65-85.
Henning, S.F. 1987. Outline of Lepidoptera conservation with special reference to ant associated Lycaenidae. *Proceedings of the first Lepidoptera conservation Symposium, Roodepoort*: *Lepidopterists' Society of southern Africa*: 5-7.
Henning, S.F. & Henning, G.A. 1989. South African Red Data Book: butterflies. *South African National Scientific Programmes Report* No. 158. Pretoria: CSIR. 175 p.
Hill, C.J. 1995. Conservation corridors and rainforest insects. (*In* Watt, A.D., Stork, N.E. & Hunter, M.D. (*eds*.), Forests and Insects. London: Chapman & Hall. p. 381-393.)
Holm, E. & Marais, E. 1992. Fruit chafers of southern Africa. Hartebeespoort: Ekogilde.
Kryger, U. & Scholtz, C.H. 2008. Phylogeography and conservation of the rare South African Fruit Chafer *Ichnestoma stobbiai* (Scarabaeidae: Cetoniinae). In: *Evolutionary Biology from concept to application* IV: 181-196.
Leeming, J. 2003. Scorpions of southern Africa. Cape Town: Struik.
Leroy, A. & Leroy, J. 2003. Spiders of southern Africa. Cape Town: Struik.
Low, A.B. & Rebelo, A.G. (Eds.) 1996. Vegetation of South Africa, Lesotho and Swaziland. Pretoria: Department of Environmental Affairs and Tourism.
Lubke, R.A., Hoare, D., Victor, J. & Ketelaar, R. 2003. The vegetation of the habitat of the Brenton Blue Butterfly, *Orachrysops niobe* (Trimen), in the Western Cape, South Africa. *South African Journal of Science* 99: 201-206.
Mecenero, S. et al. *In prep.* South African butterfly atlas. Part of SABCA: South African Butterfly Conservation Assessment: A joint project of the Animal Demography Unit (ADU) of the University of Cape Town, the South African National Biodiversity Institute (SANBI) and the Lepidopterist's Society of Africa (LepSoc). http://sabca.adu.org.za.
Mucina, L. & Rutherford, M.C. *eds*. 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. Pretoria: South African National Biodiversity Institute. 807 p.
Mucina, L., Rutherford, M.C., and Powrie, L.W. *eds*. 2005. Vegetation map of South Africa, Lesotho and Swaziland, 1:1 000 000 scale sheet maps. Pretoria: South African National Biodiversity Institute.
Perissinotto, R., Smith, T.J. & Stobbia, P. 1999. Description of the adult and larva of *Ichnestoma pringlei* n.sp. (Coleoptera: Scarabaeidae: Cetoniinae), with notes on its biology and ecology. *Tropical Zoology*, 12: 219-229.

Pringle, E.L., Henning, G.A. & Ball, J.B. *eds.* 1994. Pennington's Butterflies of Southern Africa. Cape Town: Struik Winchester.
Pryke, S.R. & Samways, M.J. 2003. Width of grassland linkages for the conservation of butterflies in South African afforested areas. *Biological Conservation* 101: 85-96.
Rutherford, M.C. & Westfall, R.H. 1994. Biomes of southern Africa: An objective categorisation, 2nd ed. Memiors of the Botanical Survey of South Africa, Vol. 63, pp. 1-94. Pretoria: National Botanical Institute.
Samways, M.J. 2005. Insect diversity conservation. Cambridge: Cambridge University Press. 342 p.
South Africa. 2004. National Environmental Management: Biodiversity Act No. 10 of 2004. Pretoria: Government Printer.
South African Butterfly Conservation Assessment (SABCA): A joint project of the Animal Demography Unit (ADU) of the University of Cape Town, the South African National Biodiversity Institute (SANBI) and the Lepidopterist's Society of Africa (LepSoc). http://sabca.adu.org.za.
Terblanche, R.F., Morgenthal, T.L. & Cilliers, S.S. 2003. The vegetation of three localities of the threatened butterfly species *Chrysoritis aureus* (Lepidoptera: Lycaenidae). *Koedoe* 46(1): 73-90.
Terblanche, R.F. & Edge, D.A. 2007. The first record of an *Orachrysops* in Gauteng. *Metamorphosis* 18(4): 131-141.
Van Oudtshoorn, F. 1999. Guide to grasses of southern Africa. Pretoria: Briza.
Van Wyk, B. & Malan, S. 1998. Field Guide to the Wild Flowers of the Highveld. Cape Town: Struik.

Appendix A

List of butterfly species that have been and which are likely to be recorded at the site.

Compiled by R.F. Terblanche
Sources of names and identifications:
Henning, Terblanche & Ball (2009); Pringle, Henning & Ball (1994); Woodhall (2005)

FAMILIES, SUBFAMILIES AND SPECIES	COMMON NAMES ENGLISH/ AFRIKAANS
FAMILY: PAPILIONIDAE	SWALLOWTAIL FAMILY SWAELSTERTFAMILIE
SUBFAMILY PAPILIONINAE	SWALLOWTAILS AND SWORDTAILS SWAELSTERTE EN SWAARDSTERTE
Papilio demodocus (Esper, 1798)	**Citrus Swallowtail** Lemoenswaelstert
Papilio nireus lyaeus Doubleday, 1845	**Green-banded Swallowtail** Groenlintswaelstert
FAMILY PIERIDAE	WHITES, YELLOWS AND TIPS WITJIES, GELETJIES EN PUNTJIES
SUBFAMILY COLIADINAE	YELLOWS AND CLOUDED YELLOWS GELETJIES EN WOLK-ORANJES
Catopsilia florella (Fabricius, 1775)	**African Migrant** Afrikaanse Migreerder
Colias electo electo (Linnaeus, 1763)	**African Clouded Yellow** Afrikaanse Wolk-oranje
Eurema brigitta brigitta (Stoll, 1780)	**Broad-bordered Grass Yellow** Grasveldgeletjie
SUBFAMILY PIERINAE	WHITES AND TIPS SUBFAMILY WITJIES EN PUNTJIES SUBFAMILIE
Belenois aurota aurota (Fabricius, 1793)	**Brown-veined White** Grasveldwitjie
Belenois creona severina (Stoll, 1781)	**African Common White** Afrikaanse Gewone Witjie
Colotis antevippe gavisa (Wallengren, 1857)	**Red Tip** Rooipuntjie
Colotis euippe omphale (Godart, 1819)	**Smoky Orange Tip** Donker-oranjepuntjie
Colotis evagore antigone (De Boisduval, 1836)	**Small Orange Tip** Klein-oranjepuntjie
Colotis evinina evinina (Wallengren, 1857)	**Common Orange Tip** Gewone Oranjepuntjie
Colotis eris eris (Klug, 1829)	**Banded Gold Tip** Goudpuntjie
Colotis subfasciatus subfasciatus (Swainson, 1833)	**Lemon Traveller Tip** Suurlemoensmous
Mylothris agathina agathina (Cramer, 1779)	**Common Dotted Border** Gewone Spikkelrandjie/ Voëlentwitjie
Mylothris rueppelli haemus (Trimen, 1879)	**Twin Dotted Border** Oranjevlerkspikkelrandjie
Pinacopteryx eriphia eriphia	**Zebra White**

(Godart, 1819)	Kwagga
Pontia helice helice (Linnaeus, 1764)	**African Meadow White** Bontrokkie
FAMILY NYMPHALIDAE	BRUSH-FOOTED BUTTERFLIES BORSELPOOTSKOENLAPPERS
SUBFAMILY DANAINAE	MONARCH SUBFAMILY MONARG-SUBFAMILIE
Danaus chrysippus chrysippus (Linnaeus, 1758)	**African Monarch** Afrikaanse Melkbosskoenlapper
SUBFAMILY CHARAXINAE	CHARAXES SUBFAMILY DUBBELSTERT SUBFAMILIE
Charaxes jasius saturnus Butler, 1866	**Saturn Foxy Charaxes** Saturnus-koppiedubbelstert
SUBFAMILY SATYRINAE	BROWNS SUBFAMILY BRUINTJIES-SUBFAMILIE
Paternympha narycia (Wallengren, 1857)	**Spotted-eye Brown** Koloogbruintjie
Stygionympha wichgrafi wichgrafi Van Son, 1955	**Wichgraf's Hillside Brown** Wichgraf-rantbruintjie
SUBFAMILY BIBLIDINAE	BYBLIA SUBFAMILY BIBLIA SUBFAMILIE
Byblia ilithyia (Drury, 1773)	**Spotted Joker** Leliegrasvegter
SUBFAMILY NYMPHALINAE	PANSY SUBFAMILY GESIGGIE SUBFAMILIE
Catacroptera cloanthe cloanthe (Stoll, 1781)	**Pirate** Seerower
Hypolimnas misippus (Linnaeus, 1764)	**Common Diadem** Gewone Na-aper/ Blouglans
Junonia hierta cebrene Trimen, 1870	**Yellow Pansy** Geelgesiggie
Junonia oenone oenone (Linneaus, 1758)	**Blue Pansy** Blougesiggie
Junonia orithya madagascariensis Guenée, 1865	**Eyed Pansy** Padwagtertjie
Precis archesia archesia (Cramer, 1779)	**Garden Commodore** Rots-blaarvlerk
Vanessa cardui (Linnaeus, 1758)	**Painted Lady** Sondagsrokkie
SUBFAMILY HELICONIINAE	ACRAEA SUBFAMILY ACRAEA SUBFAMILIE
Acraea horta (Linneaus, 1764)	**Garden Acraea** Tuinrooitjie
Acraea natalica natalica De Boisduval, 1847	**Natal Acraea** Natal-se-rooitjie
Acraea neobule neobule Doubleday, 1847	**Wandering Donkey Acraea** Dwaalesel-rooitjie
Acraea stenobea (Wallengren, 1860)	**Suffused Acraea** Dorslandrooitjie
Telchinia rahira rahira De Boisduval, 1833	**Marsh Acraea** Moerasrooitjie
Telchinia serena *(=Acraea eponina)*	**Small Orange Acraea**

Fabricius, 1775	Klein-oranjerooitjie
Phalanta phalantha aethiopica (Rothschild & Jordan, 1903)	**African Leopard Butterfly** Afrikaanse Luiperdskoenlapper
SUBFAMILY LIMENITIDINAE	BUSH-GLIDER SUBFAMILY BOSDANSER SUBFAMILIE
Hamanumida daedalus (Fabricius, 1775)	**Guineafowl Butterfly** Tarentaal-skoenlapper
FAMILY LYCAENIDAE	BLUES AND COPPERS BLOUTJIES EN KOPERVLERKIES
SUBFAMILY PORITIINAE	
Alaena amazoula (Boisduval, 1847)	**Yellow Zulu** Geelzoeloe
SUBFAMILY THECLINAE	HAIRSTREAKS AND COPPERS LANGSTERTE EN KOPERVLERKIES
Aloeides henningi Tite & Dickson, 1973	**Henning's Copper** Henning-se-kopervlerkie
Axiocerses tjoane (Wallengren, 1857)	**Common Scarlet** Ralierooivlerkie
Cigaritis mozambica (Bertoloni, 1850)	**Mozambique Bar** Mosambiek-se-streepvlerkie
Cigaritis natalensis (Westwood, 1852)	**Natal Bar** Natal-se-streepvlerkie
Deudorix antalus (Hopffer, 1855)	**Brown Playboy** Bruinspelertjie
Leptomyrina henningi Dickson, 1976	**Henning's Black-eye** Henning-se-swartogie
SUBFAMILY POLYOMMATINAE	BLOUTJIES AND CILIATED BLUES BLOUTJIES EN KORTSTERTJIES
Actizera lucida (Trimen, 1883)	**Rayed Blue** Witstreepbloutjie
Anthene amarah amarah (Guérin-Méneville, 1849)	**Black-striped Hairtail** Swartstreep-kortstertjie
Anthene butleri livida (Trimen, 1881)	**Pale Hairtail** Vaalkortstertjie
Anthene definita definita (Butler, 1899)	**Common Hairtail** Donkerkortstertjie
Azanus jesous jesous (Guérin-Méneville, 1849)	**Topaz-spotted Blue** Hemels-kolbloutjie
Azanus moriqua (Wallengren, 1857)	**Thorn-tree Blue** Doringboombloutjie
Azanus ubaldus (Stoll, 1782)	**Velvet-spotted Blue** Fluweel-kolbloutjie
Cacyreus marshalli Butler, 1898	**Geranium Bronze** Pelargoniumbrons
Cacyreus virilis Stempffer, 1936	**Mocker Bronze** Na-aperbloutjie
Chilades trochylus (Freyer, 1843)	**Grass Jewel Blue** Grasjuweeltjie
Cupidopsis cissus cissus (Godart, 1824)	**Common Meadow Blue** Vleibloutjie
Cupidopsis jobates jobates	**Tailed Meadow Blue**

(Hopffer, 1855)	Aasbloutjie
Eicochrysops messapus mahallakoaena (Wallengren, 1857)	**Grassland Cupreous Copper** Grasveldkoperbloutjie
Lampides boeticus (Linneaus, 1767)	**Longtailed Pea Blue** Langstert-ertjiebloutjie
Lepidochrysops patricia (Trimen, 1887)	**Patricia Blue** Patricia-bloutjie
Lepidochrysops plebeia plebeia (Butler, 1898)	**Twin-spot Blue** Dubbelkolbloutjie
Leptotes brevidentatus (Tite, 1958)	**Short-toothed Blue** Korttandbloutjie
Leptotes pirithous pirithous (Linnaeus, 1767)	**Common Blue** Gewone bloutjie
Pseudonacaduba sichela sichela (Wallengren, 1857)	**Dusky Blue** Dowwebloutjie
Tarucus sybaris sybaris (Hopffer, 1855)	**Dotted Blue** Spikkelbloutjie
Tuxentius melaena melaena (Trimen, 1887)	**Black Pie** Swartbontetjie
Uranothauma nubifer nubifer (Trimen, 1895)	**Black Heart** Swarthartjie
Zintha hintza hintza (Trimen, 1864)	**Hintza Pie** Hintza-bontetjie
Zizeeria knysna (Trimen, 1862)	**Sooty Blue** Duwweltjiebloutjie
Zizula hylax (Fabricius, 1775)	**Gaika Blue** Gaika-bloutjie
FAMILY HESPERIIDAE	SKIPPERS DARTELAARS
SUBFAMILY COELIADINAE	POLICEMEN KONSTABELS
Coeliades forestan forestan (Stoll, 1782)	**Striped Policeman** Witbroekkonstabel
Coeliades pisistratus (Fabricius, 1793)	**Two-pip Policeman** Dubbelkolkonstabel
SUBFAMILY PYRGINAE	SANDMEN AND ELFINS SANDMANNETJIES EN ELWE
Eretis umbra umbra (Trimen, 1862)	**Small Marbled Elf** Umbra-kabouter
Gomalia elma elma (Trimen, 1862)	**Green-marbled Sandman** Asjas-sandmannetjie
Spialia diomus ferax (Wallengren, 1863)	**Common Sandman** Kwagga-sandmannetjie
Spialia dromus (Plötz, 1884)	**Forest Sandman** Woudsandmannetjie
Spialia mafa mafa (Trimen, 1870)	**Mafa Sandman** Mafa-sandmannetjie
Spialia spio (Linnaeus, 1764)	**Mountain Sandman** Bergsandmannetjie
SUBFAMILY HETEROPTERINAE	SYLPHS WALSERTJIES
Metisella meninx	**Marsh Sylph**

(Trimen, 1873)	Moeraswalsertjie
Metisella willemi (Wallengren, 1857)	**Netted Sylph** Willem-walsertjie
Tsitana tsita (Trimen, 1870)	**Grassland Dismal Sylph** Grasveld Donkerwalsertjie
SUBFAMILY HESPERIINAE	RANGERS AND SWIFTS WAGTERTJIES EN RATSVLIEËRS
Gegenes niso niso (Linneaus, 1764)	**Common Hottentot Skipper** Gewone hotnot
Gegenes pumilio gambica (Mabille, 1878)	**Dark Hottentot Skipper** Donkerhotnot
Kedestes barberae barberae (Trimen, 1873)	**Barber's Ranger** Barber-se-wagtertjie
Pelopidas mathias (Fabricius, 1798)	**Black-banded Swift** Swartmerk-ratsvlieër
Pelopidas thrax inconspicua (Bertoloni, 1850)	**White-branded Swift** Witmerk-ratsvlieër
Platylesches ayresii (Trimen, 1889)	**Peppered Hopper** Ayres-se-hoppertjie

F

GALAGO ENVIRONMENTAL

Fauna and Flora Specialists

638 Turf Street
Wingate Park, 0181
Tel: 012-345 4891
Fax: 086 675 6136
Email: Vanessam@lantic.net
VAT No: 4080227657

Ecological conditions of the ridge

of

PORTION 31 AND 38 AND THE REMAINDER OF KLEINFONTEIN 368 JR AND PORTION 14, 63 AND 68 OF DONKERHOEK 365 JR

February 2012

Report author: Reinier Terblanche (M.Sc, Pr.Sci.Nat)

DECLARATION OF INDEPENDENCE:

I, Reinier F. Terblanche (670409 5201 084) declare that I:

- am committed to biodiversity conservation but concomitantly recognize the need for economic development. Whereas I appreciate the opportunity to also learn through the processes of constructive criticism and debate, I reserve the right to form and hold my own opinions and therefore will not willingly submit to the interests of other parties or change my statements to appease them

- abide by the Code of Ethics of the S.A. Council for Natural Scientific Professions

- act as an independent specialist consultant in the field of Ecology

- am subcontracted as specialist consultant by Galago Environmental CC for the proposed Kleinfontein and Donkerhoek development project described in this report

- have no financial interest in the proposed development other than remuneration for work performed

- have or will not have any vested or conflicting interests in the proposed development

- undertake to disclose to the Galago Environmental CC and its client as well as the competent authority any material information that have or may have the potential to influence the decision of the competent authority required in terms of the Environmental Impact Assessment Regulations, 2006.

Reinier F. Terblanche

CONTENTS PAGE

FIGURES:

1. INTRODUCTION

A survey of ecological conditions was required for the ridge in the area known as Portion 31 and 38 and the remainder of Kleinfontein 368 JR and Portions 14, 63, 67 and 68 of Donkerhoek 365 JR (elsewhere referred to as the site). The survey focused on ecological conditions that should be taken into account in the impact study.

1.1 Objectives of the habitat study

The objectives of the habitat study on ecological conditions are to provide:
- An outline of the habitats that are present;
- An outline of vegetation assemblages (communities) present with an estimate of the dominant species that are present at rocky ridges;
- An estimate of the degradation;
- An outline of compositional aspects of exotic species, indigenous pioneer species and indigenous plant species of higher ecological status based on broad subjective observations and quantitative surveys;
- Estimates of degradation and impacts of disturbances on the vegetation; and
- Functional aspects of ecosystems at the site.

1.2 Scope of study

- A survey consisting of four visits of key elements of habitats on the site and surveys of vegetation composition.
- Integration of literature and field observations to evaluate the ecological conditions on the ridge.

2. STUDY AREA

The study site is situated at the intersection of the Savanna - and Grassland Biomes (Mucina & Rutherford 2006). Landscape at the site could be divided into a west-east directed rocky ridge and flatter areas with very few rocks on gentle slopes. Vegetation type at the rocky ridge is Gold Reef Mountain Bushveld but with a relatively low cover of indigenous trees. Grassland at the flats is represented by Rand Highveld Grassland (Mucina & Rutherford 2006). The site is part of the summer-rainfall region with dry winters. Frost is frequent in the winter, but less common on the ridges and hills (Mucina & Rutherford, 2006). Mean annual precipitation varies from 600 – 750mm a year.

The ridge at the site is surrounded by thornveld, grassland at the flats, some cultivated fields, wetland vegetation along streambeds and built-up areas. A highway (N4) cuts between the northern section of the ridge at the site and other ridges further to the north. A smaller tar road exists between the ridge at the site and a chain of ridges to the east.

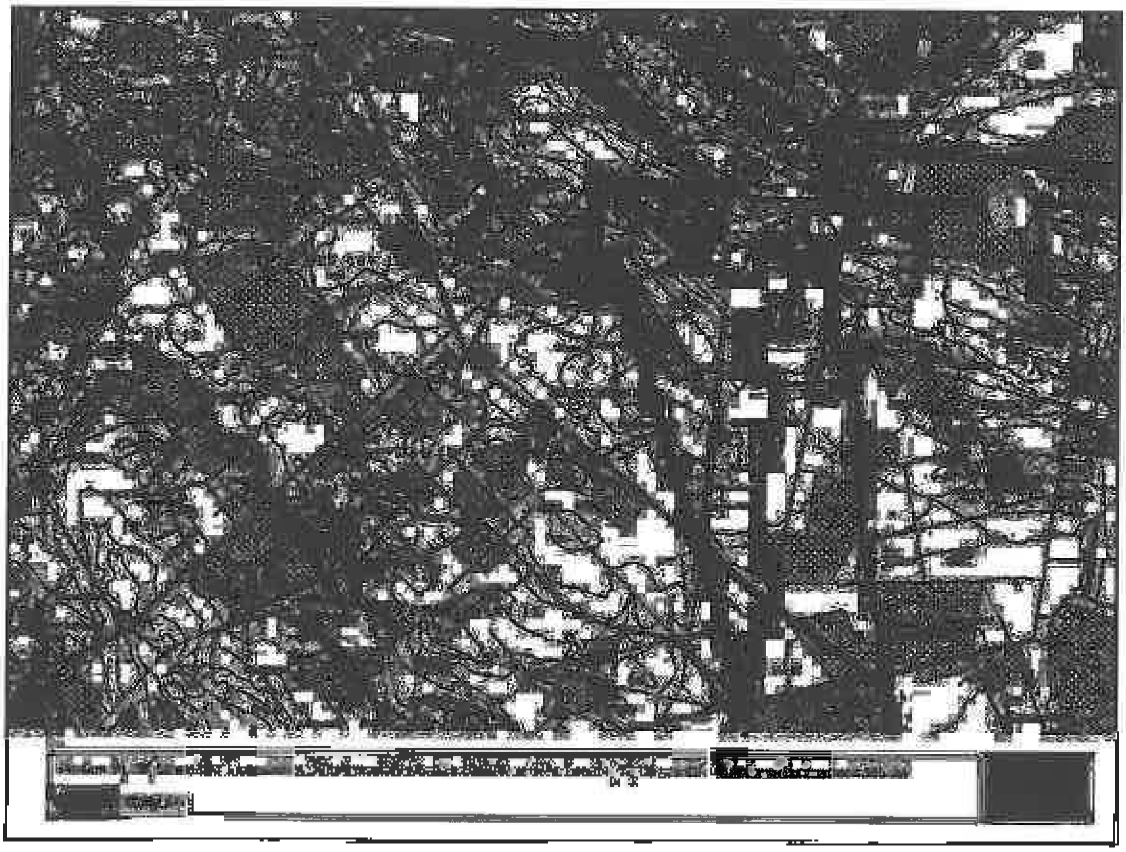


Figure 1: Locality map of the study area

3. METHODS

Surveys were conducted on 31 March 2011, 29 April 2011, 15 May 2011 and 12 September 2011.

3.1 Habitat characteristics

The habitat was investigated by noting habitat structure (rockiness, slope, plant structure/ physiognomy).

3.2 Vegetation assemblages (communities)

Relatively homogenous vegetation assemblages (communities) were identified based on overall appearance (mainly physiognomy) and composition (conspicuous dominant species). Transects consisting of 50 points, at each consecutive metre along a 50m steel measuring tape, was applied in apparent representative parts of the relatively homogenous vegetation assemblages to establish dominant plant species in the grassland.

Identification of plant species during the species composition surveys were based on various literature resources, or where deemed necessary, by experts on certain taxonomic groups. Field guides such as those by Manning (2003), Smit (2008), Van Oudtshoorn (1999), Van Wyk and Malan (1998), Van Wyk and Van Wyk (1997), Van Wyk and Smith (2003), Germishuizen (2003) and Pooley (1998) were used to identify plant species and find additional information about plant species. Retief and Herman (1997) were consulted to find information about diagnostic characteristics and the broad distribution of species. Main sources to obtain information about the status, origin and identification of problem plants and alien invasive plant species were Bromilow (2001) and Henderson (2001). Pfab (2002) as well as Pfab and Victor (2002) were used as the guideline for threatened, data deficient and near threatened plant species of the Gauteng Province. Updated information from GDARD was also consulted. For the most recent treatise of scientific names and broad distributions, Germishuizen, Meyer & Steenkamp (2006) were followed to compile the lists of species.

Braun-Blanquet scale was used to estimate cover on various scales (Werger, 1973; Mueller-Dombois & Ellenberg, 1974). Though subjective, the method is rapid to use, and problems with subjectivity may have been overemphasized (Kent & Coker, 1992). Braun-Blanquet scale, with its five classes from 0-100 per cent, is given in Table 1. Cover is estimated visually as a percentage, but stratified or multiple layering of vegetation will often result in total cover abundances well over 100 per cent (Kent & Coker, 1992).

Table 1: Braun-Blanquet cover scale (Werger, 1973; Mueller-Dombois & Ellenberg, 1974; Kent & Coker, 1992).

Scale	Description
R	one or a few individuals with less than 1% cover of the total sample plot area
+	occasional and less than 1% of total sample plot area
1	abundant and with very low cover, or less abundant but with higher cover, 1 - 5 % cover of total sample plot area
2	abundant with > 5 - 25 % cover of total sample plot area, irrespective of the number of individuals
2A	> 5 - 12.5 % cover, irrespective of number of individuals
2B	> 12.5 – 25 % cover, irrespective of the number of individuals
3	> 25 - 50 % cover of total sample plot area, irrespective of the number of individuals
4	> 50 - 75 % cover of total sample plot area, irrespective of the number of individuals
5	> 75 % cover of total sample plot area, irrespective of the number of individuals

3.3 Ecological conditions

At the time of the present survey, the terms of reference for ecological conditions are not available in as much detail as the requirements for biodiversity studies. Here an approach has been followed to describe ecological conditions that are relevant to potential development or to note possible exclusion of any development.

The veld condition is often an important aspect of overall ecological conditions at a chosen site. The veld condition can be determined in various ways. Two techniques that are commonly used are the ecological index, which yields a veld condition index, and the occurrence or absence of key grass species (Bothma, 2002; Van Rooyen, 2002). Different veld condition assessment methods that have an ecological base have been proposed by various researchers in South Africa including Dyksterhuis (1949), Foran, Tainton & Booysen (1978), Hardy & Hurt (1989), Mentis (1983), Tainton (1988), Tainton, Edwards & Mentis (1980). These methods use key grass species or grass species with allocated ecological status to determine veld condition. Degradation models (Bosch & Gauch, 1991) can also be used to assess veld condition. Directly or indirectly, these methods are based more on responses of grass species to mega-herbivores and in addition at the higher rainfall areas also based on responses of grass species to fire. A good veld condition is therefore close to a good rangeland condition, which is not necessarily ideal for the conservation of smaller fauna and flora, especially at ridges where soils are naturally poor in nutrients. For the purposes of this study the application of these methods are doubtful to apply for three main reasons.

Firstly, natural grassland on rocky ridges may contain a low frequency or abundance of grass species that are of high ecological status in terms of grazing by megaherbivores, even though a patch may be ideal for rare flora and smaller fauna. For example a *Melinis nerviglumis – Aristida transvaalensis* community, which is inhabited by a number of grass species of lower ecological status, was found to includo the ideal habitats of the rare and red-listed Heidelberg Copper butterfly, *Chrysoritis aureus* (Terblanche, Morgenthal & Cilliers, 2003). Threatened insect species often require habitats that are to some extent disturbed, for example the Brenton Blue Butterfly, *Orachrysops niobe* (Edge, Cilliers & Terblanche, 2008). Secondly, the diversity of indigenous forb species, and not necessarily grass species, is often of paramount importance for smaller fauna and flora. Thirdly, especially within and on the fringes of urban areas, pioneer forbs, shrubs and trees may be more important to indicate degradation of ecosystems than low ecological status grass species. Patches opened up by excavations do not necessarily follow the same succession pattern as patches that are opened up by overgrazing or fire.

Though not suitable for assessing ecological conditions in open grassland/savanna or rocky ridges the Riparian Vegetation Index method (Kemper, 2001) provided useful information that could be incorporated as guidance for ecosystems that are not wetlands as well. Vegetation adjacent to the rocky ridges has also been studied though the main focus remains the rocky ridges.

3.4. Limitations

It should be emphasized that the survey can by no means represent a full account of all the species and their abundances on the site. Full analyses, such as complete randomised sampling or detailed stratified random sampling, followed by detailed ordination analyses are not practical within the time constraint and objectives of the study. Survey methods and analyses were adapted to fulfil the objectives of the study within its practical limitations. The site was visited in March 2011, April 2011, May 2011 and September 2011 which overall comprise an optimal series of surveys to document ecological conditions.

4. RESULTS AND DISCUSSION

Table 2 provides an outline of the main vegetation assemblages (communities) at the site with emphasis on the quartzite ridge vegetation. Only one community associated with the ridges at the site, has been identified.

Table 3 lists the species with a high fidelity to the vegetation assemblages locally at the site. Fidelity classes from preferential, selective to exclusive (Kent & Coker, 1992) are used here to indicate habitat specificity locally at the site. Some of the species with a high fidelity are widespread in Gauteng but are indicative of locally unique ecosystems. In the case of this study some plant species with a high fidelity at certain rocky habitats also stands out as being particularly habitat specific in the regional and international context.

Table 4 gives an outline of growth forms, bare patches and rockiness at each of the identified plant community.

Table 5 gives a summary of the ecological conditions of the main vegetation assemblage at the rocky ridge.

Figure 1 illustrates of the main vegetation assemblage identified for the interpretation of ecological conditions at the ridge at the site.

A discussion of the results in tables 2, 3, 4 and 5 and Figure 1 then follows.

Table 2: List of vegetation assemblages at the site and a summary of the most dominant plant species recorded from each assemblage with 50m transect surveys (basal cover). Most dominant species are listed as well as the relative frequency of other species (combined).

Description of plant assemblage*	Habitat type (biotope)	Number of 50m transects used	Species	Relative frequency: percentage
Loudetia simplex – Tristachya rehmannii community	Quartzite ridges: *Grassland with few trees*	8	*Loudetia simplex* *Tristachya rehmannii* *Aristida junciformis* Other species	32 20 12 36
Patches of *Acacia karroo* woodland and grassland	Gentle slopes or flats with grassland and scattered trees	No transects (Not part of ridge)		Grassland with sparsely scattered trees
Patches of exotic trees *Acacia decurrens* (green wattle) and *Eucalyptus camaldulensis* (red river gum) trees		No transects (Not part of ridge)		Conspicuous concentrations of exotic *Eucalyptus* trees
Traces of wetland vegetation	Vegetation along seasonal streambeds	No transects (Not part of ridge)		Grass species *Imperata cylindrica*, characteristic

Figure 2: Vegetation community at the ridge in terms of ecological conditions

Table 3: Summary of characteristic species of the main vegetation assemblages of the site.

Description of plant assemblage*	**Characteristic species with high degree of fidelity, including species that appear to be locally exclusive, selective or preferential in the study area**		
	Species/ groups	Growth form	Fidelity
***Loudetia simplex – Tristachya rehmannii* community**	*Loudetia simplex*	Grass	Selective
	Aristida junciformis subsp. *galpinii*	Grass	Preferential
	Aristida transvaalensis	Grass	Exclusive
	Digitaria diagonalis var. *diagonalis*		Preferential
	Digitaria monodactyla	Grass	Preferential
	Monocymbium ceresiiforme	Grass	Preferential
	Panicum natalense	Grass	Selective
	Schizachyrium sanguineum	Grass	Selective
	Adromischus umbraticola	Herb (Succulent)	Exclusive
	Euphorbia davyi	Herb (Succulent)	Exclusive
	Aloe pretoriensis	Shrub (Succulent)	Exclusive
	Searsia magalismontana	Shrublet	Exclusive
	Parinari capensis	Shrublet	Exclusive
	Clutia pulchella	Shrub	Exclusive
	Protea welwitschii	Shrub	Preferential
Patches of *Acacia karroo* woodland and grassland	*Acacia karroo*	*Acacia karroo* woodland patches and grassland	n/a
	Acacia caffra		
	Hyparrhenia hirta		
	Themeda triandra		
	Eragrostis chloromelas		
	Elionurus muticus		
Patches of exotic trees: *Acacia decurrens* or *Eucalyptus camaldulensis*	*Acacia decurrens* or *Eucalyptus camaldulensis* with poor representation of other species	Tall trees with sparse grass and herb stratum	n/a
Wetland vegetation	Indigenous grasses such as *Imperata cylindrica*	Mainly grasses.	n/a

Characteristic species are here indicated to be those plant species that are rare or absent elsewhere at the site i.e. with a high degree of fidelity to certain vegetation communities at the site.

Table 4: Outline of growth forms, bare patches and rockiness at each of the identified plant communities.

Description of plant assemblage*	Habitat type (biotope)	Vegetation structure Cover abundance (the sum of estimates are often more than 100% because trees and other growth forms may overlap)	
Loudetia simplex – Tristachya rehmannii community	Quartzite ridge:	Trees	+
		Shrubs	2
		Forbs/ herbaceous	1
		Grasses	4
		Rocks	2
		Bare ground	1

Note the cover abundance comprises an overall estimate for each community and are based on general observations as well as the transect surveys. It constitutes a subjective estimate of cover abundances for the entire site according to Braun-Blanquet cover scale (as if each identified plant community constitutes a relevé). The maximum cover of each growth form whether it is basal cover of crown cover has been chosen.

Table 5: Summary of the ecological conditions of the main vegetation assemblages at the site. Categories: Very low, Low, Moderate, High, Very high, Confirmed.

Community	***Loudetia simplex - Aristida transvaalensis* community**
Biotope	Quartzite ridge
Unique habitat of threatened plant species	**Low**
Unique habitat for plant species of conservation concern, excluding threatened species	**Confirmed** *Adromischus umbraticola* subsp. *umbraticola* (Near Threatened)
Diversity of indigenous plant species	**High**
Unique habitat for threatened fauna	**Confirmed** *Ichnestoma stobbiai*
Cover-abundance of total indigenous plant species	**High**
Grazing importance	**Moderate**
Connectivity, intactness	**Moderate (towards the east)**
***Ecologically negative edge effects from surrounding areas**	**Moderate**
***Ecologically negative edge effects to surrounding areas**	**Very low**

- Ecologically negative edge effects are those edge effects that compromise the overall ecological function and integrity of an area.

Outline of plant assemblage at the quartzite ridge at the site

Vegetation at the rocky ridges could be divided into numerous communities, sub-communities and variants which fall beyond the scope of this study. In this study sheet rock at the plateau was also included in the rocky ridge section because it is an integrated part of the rocky ridge system.

Loudetia simplex – Tristachya rehmannii community (assemblage):
Grass species such as *Loudetia simplex, Tristachya rehmannii, Tristachya leucothrix, Aristida junciformis* subsp. *galpinii, Aristida transvaalensis, Digitaria monodactyla, Digitaria diagonalis* var. *diagonalis, Schizachyrium sanguineum, Panicum natalense* and *Monocymbium ceresiiforme* are conspicuous at the rocky ridge grassland. However, typical of ecosystems with a high diversity, a wealth of other grass species are present, and the dominance of certain species are not clear throughout the rocky ridge area, therefore the high percentage of other species in Table 2. A number of indigenous forb- and shrub species are present, and though the cover of trees are naturally sparse, clumps of indigenous trees that contain a number of species are present at secluded spots.

A number of plant species including shrubs, herbs and grasses show a high fidelity to the quartzite ridges including the list of grass species mentioned above. Succulents such as *Adromischus umbraticola* and *Euphorbia davyi* are not only particular to the ridge but abundant. Another distinct succulent *Aloe pretoriensis,* which has exceptionally tall inflorescences relative to the size of the plant, is also confined to the rocky ridge. *Clutia pulchella* (lightning bush), *Parinari capensis* (dwarf mobola), *Searsia magalismontana, Xerophyta retinervis* (monkey's tail) and *Protea welwitschii* are shrubs which are confined to the rocky patches (Table 3). A long list of plant species at the site with a high fidelity to the rocky outcrops and sheet rock could be compiled. Structurally the plant assemblage at the rocky ridge consists mainly of indigenous grassland with some scattered trees and shrubs, or clumps of trees where conditions permit. Overall cover of indigenous trees at the rocky ridge is sparse, leaving rocky grassland that are suitable habitat for a unique assemblage of grass species, shrubs and herbaceous species (Table 4).

Plant species of particular conservation concern are present in the *Loudetia simplex – Tristachya rehmannii* assemblage. Most notable is *Adromischus umbraticola* which is listed as Near Threatened (Raimondo *et al.* 2009) and also in the updated red list of 2011. An exceptional concentration of the Near Threatened *Adromischus umbraticola* is recorded at the site and the local rocky ridge must constitute one of the core habitats for this plant species. *Ichnestoma stobbiai,* a threatened beetle species, has during studies prior to this investigation, been found to be present at some patches of the rocky ridge at the site.

Plant assemblages at the rocky ridge is susceptible to edge effects from the nearby built-up areas and invasion by exotic tree species, especially *Acacia decurrens* (green wattle).

General remarks
The grazing importance of the area appears to be moderate, but contains a variety and abundance of plant species that would suit even larger herbivores. A number of grass species with limited grazing value such as *Loudetia simplex* and *Aristida junciformis* are dominant at some patches of the quarzite rocky ridge and care should be taken to consider the carrying capacity of the area. The rocky ridge area is large enough to be of relevance to a limited number of large or medium sized antilopes. Some mammalian species such as red hartebeest, black wildebeest, blesbok and plains zebra have been reintroduced into the conservation area at the site. Medium sized antelope such as impala, *Aepyceros melampus* and grey rhebok (vaalribbok), *Pelea capreolus*, are also found whilst smaller antelope such as duiker, *Sylvicapra grimmia* survive at the conservation area. In addition smaller animals can benefit from the conservation of the indigenous vegetation at the rocky ridges. A good example is the population of rock elephant shrews, *Elephantulus myurus*, at the site that benefits from the favourable and protected rocky habitats at the site.

There are patches of vegetation with a conspicuous high frequency of the bankrupt bush, *Seriphium plumosum* (= *Stoebe vulgaris*). These shrubs usually occur in nutrient poor soils but become more abundant where overgrazing has occurred.

A carefully planned burning programme could enhance diversity in the vegetation at the site. Such a programme is likely to increase the diversity of herbaceous plant species in the grassland, which in some patches appear to be relatively poor (in part possibly due to the nutrient poor soils). Rotational burning could for example benefit antilopes such as the grey rhebok, *Pelea capreolus* that needs patches of taller grass for cover, but also patches with shorter grass for feeding (see Apps 2000). A burning programme should involve a qualified specialist.

The rocky ridge at the site should be regarded as a stepping stone corridor with rocky ridges elsewhere in the local area. Rocky ridges are important for a number of ecological processes, including its function as a controller of water inputs into wetlands, fire-protection for some species and different microclimates for certain fauna and flora (Samways, 1994; Lowrey and Wright, 1987; Pfab 2001). In the case of this study there is ample scope for the rocky ridge as a stepping stone or semi-continuous corridor of conservation importance.

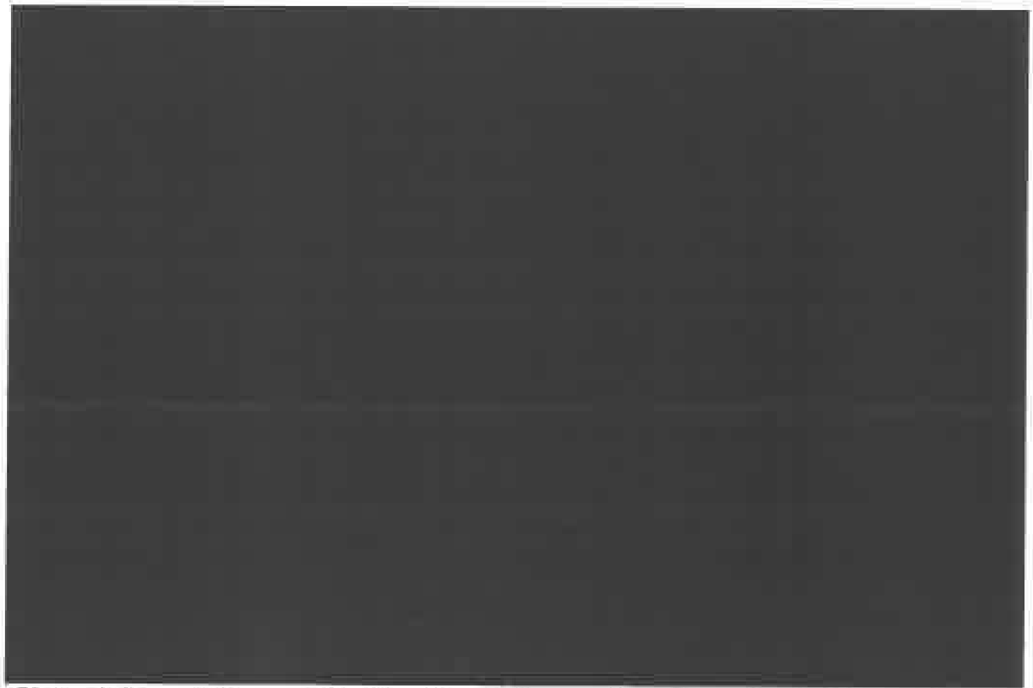


Photo 1: View of the quartzite ridge. Vegetation consists of grassland with trees that are only found in favourable secluded areas.
Photo: September 2011, R.F. Terblanche.

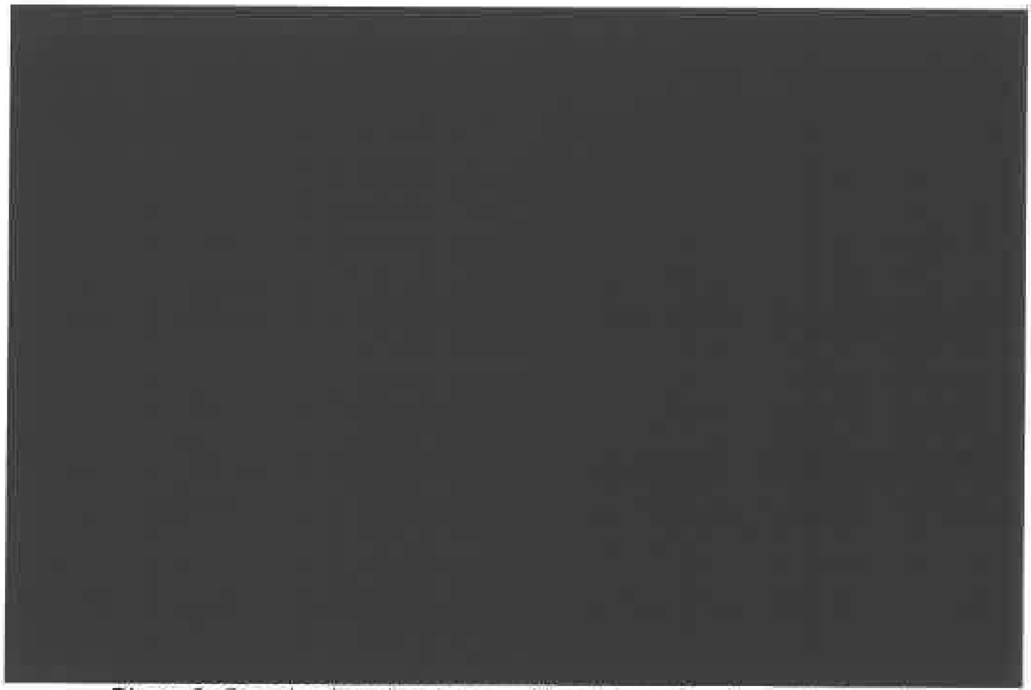


Photo 2: Grassland on the plateau with patches of rocks or sheet rock.
Photo: September 2011, R.F. Terblanche.

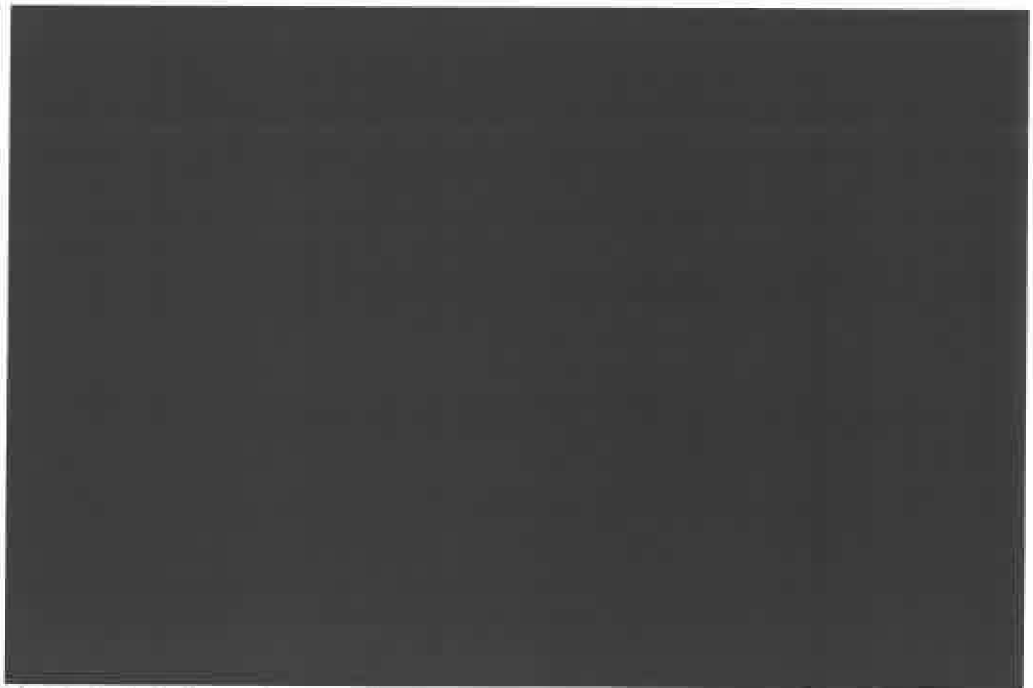


Photo 3: *Seriphium plumosum* (bankrupt bush) is denser where possible overgrazing has taken place. *Seriphium plumosum* naturally occurs in nutrient poor soils.
Photo: September 2011, R.F. Terblanche.

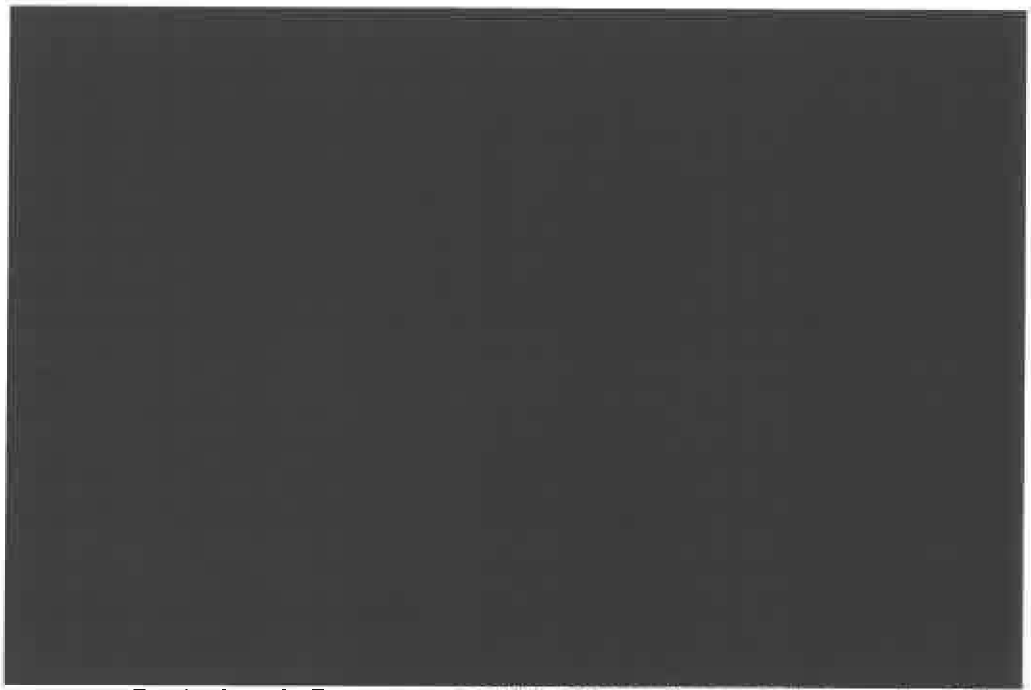


Photo 4: Patch of exotic *Eucalyptus camaldulensis* (red river gum), in the centre of the picture, at the flats adjacent to the rocky ridge.
Photo: September 2011, R.F. Terblanche.

Photo 5: Exotic and invasive *Acacia decurrens* (green wattle) in flower at the site.
Photo: September 2011, R.F. Terblanche.

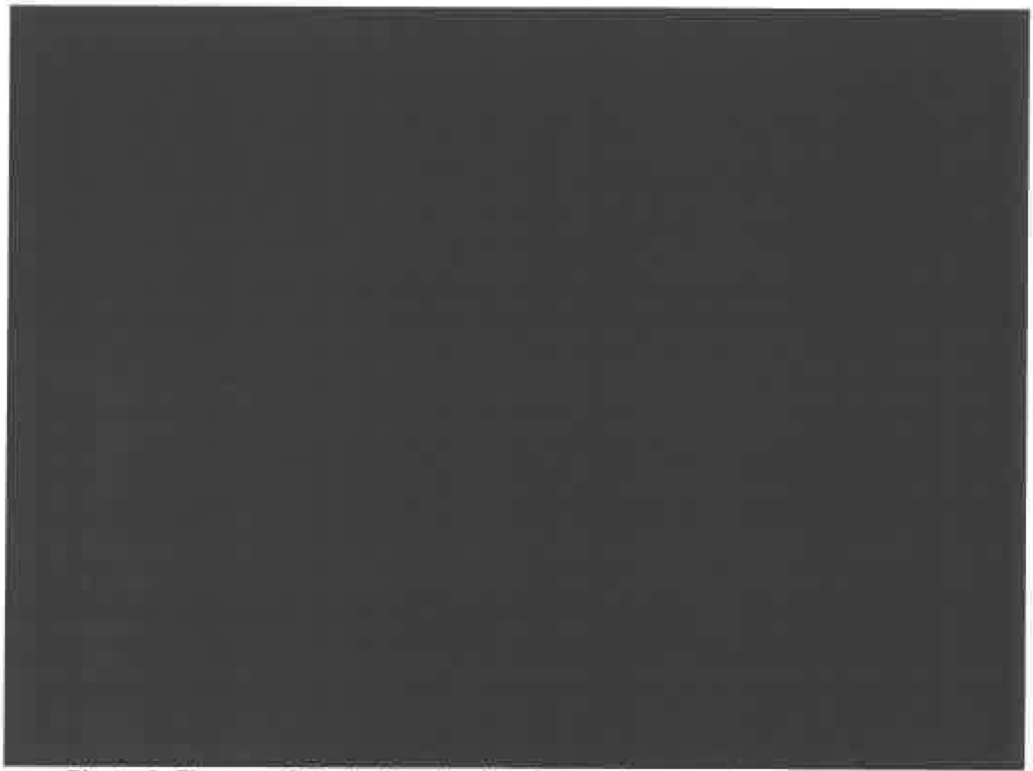


Photo 6: Flowers of *Euphorbia davyi*, an interesting succulent plant, at the site.
Photo: September 2011, R.F. Terblanche.

Photo 7: *Xerophyta retinervis* (monkey's tail) and *Aloe pretoriensis*, with its exceptional tall inflorescence, at the rocky ridge.
Photo: September 2011, R.F. Terblanche.

5. CONCLUSION

- The quartzite rocky ridge at the site contains unique grassland with scattered trees or clumps of trees and can be viewed as somewhat atypical to Gold Reef Mountain Bushveld.
- Overall the diversity of indigenous flora and fauna at the rocky ridges appears to be high. An interesting diversity of succulents is present at the site owing to the interplay of an open, but rocky, habitat.
- *Adromischus umbraticola* a Near Threatened succulent species (Raimondo et al 2009) is remarkably numerous at the rocky ridge at the site. Ridges at the site probably constitute one of the core habitats for this plant species.
- The vegetation at the ridge is susceptible to invasion by exotic trees, especially the extensive patches of exotic *Acacia decurrens* (green wattle) in the vicinity, and also between different sections of the ridge.
- A threatened and rare beetle species was found at the site by earlier exploring efforts prior to this study. Rocky ridge and plateau with rocks appear to be a habitat which is suitable for *Ichnestoma stobbiai*. *Ichnestoma stobbiai* is an endangered fruit chafer (Scarabaeidae: Cetoniinae) that occurs in small habitat fragments of South Africa (Kryger & Scholtz, 2008). The adults of this species are short-lived and the females are flightless. Thus, the vagility of these beetles is extremely low (Kryger & Scholtz, 2008). The species *I. stobbiai* Holm, 1992 is thought to occur in a very restricted area in and around Gauteng Province and all habitat patches should be protected (Kryger & Scholtz, 2008; Deschodt, Scholtz & Kryger, 2009). Unlike most cetoniine larvae, the larvae of this species usually occur in dolomitic to cherty, well-drained soils (Deschodt, Scholtz & Kryger, 2009). Further investigations may determine the local distribution of this rare beetle in more exact terms.
- Fire and frost probably play an important role in maintaining the dominant grassland at the ridge. If burning of veld is applied a specialist should be consulted. There is clearly scope for rotational block-burning at the site which could benefit plant diversity and faunal diversity.
- There are patches of vegetation with a conspicuous high frequency of the bankrupt bush, *Seriphium plumosum* (= *Stoebe vulgaris*). These shrubs usually occur in nutrient poor soils but become more abundant where overgrazing has occurred. Overgrazing could be limited by considering the carrying capacity and local climatic conditions on a continuous basis. On the other hand underutilizing of the field is also not ideal.
- Though a Class 2 rocky ridge is present it is believed that near pristine patches of rocky ridge, which are present at the site, should be conserved and maintained.
- The rocky ridge at the site should clearly be regarded as a sensitive ecosystem.
- In an increasingly urbanised region, the possible conservation importance value of rocky ridges is underlined at the site both in terms of high diversity of indigenous species.
- Continued conservation actions should include:
  - ➢ The eradication of invasive exotic plant species at the site, especially the large patches of exotic invasive *Acacia decurrens* (green wattle) trees which occupy habitat that could otherwise have been available for indigenous species.
  - ➢ An ecological management plan for the rocky ridge which could include lay-out of hiking trails and rotational burning.
- The present efforts to audit and conserve the biodiversity at the site are to be commended and will hopefully be continued. There is clearly scope for the rocky ridge at the site to be a conservation area of importance.

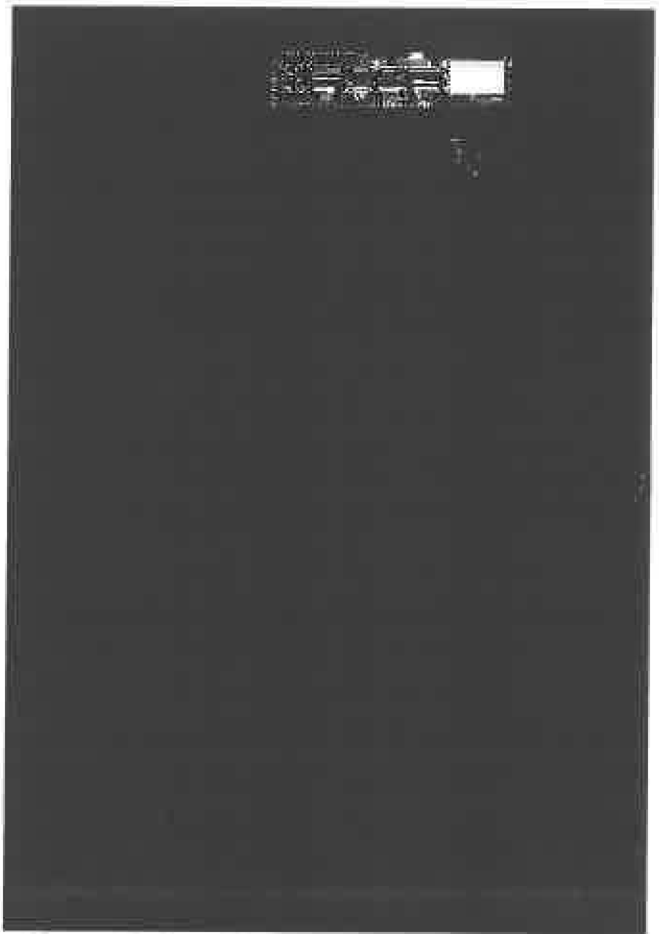


Figure 3: Sensitivity map of the ridge on site

6. REFERENCES

Bosch, O.J.H. & Gauch, H.G. 1991. The use of degradation gradients for the assessment and ecological interpretation of range condition. Journal of the Grassland Society of southern Africa. 8: 138-146.

Bothma, J. du P. (ed.). 2002. Game ranch management. 4th ed. Van Schaik, Pretoria.

Bromilow, C. 2001. Problem Plants of South Africa. Pretoria: Briza Publications. 258 p.

Deschodt, C.M. Scholtz, C.H. & Kryger, U. 2009. *Ichnestoma stobbiai* Holm 1992 Scarabaeidae: Cetoniinae), a range-restricted species of conservation concern. *African Entomology* 17(1): 43-50.

Dyksterhuis, E.J. 1949. Condition and management of rangeland based on quantitative ecology. *Journal of Rangeland Management* 2: 104-115.

Edge, D.A., Cilliers, S.S. & Terblanche, R.F. 2008. Vegetation communities at the Brenton Blue butterfly reserve. *South African Journal of Science* (in press).

Foran, B.D., Tainton, N.M. & Booysen, P. de V. 1978. The development of a technique for assessing veld condition of three grassland types in Natal. Proceedings of the Grassland Society of southern Africa 13: 27-34.

Germishuizen, G. 2003. Illustrated guide to the wild flowers of northern South Africa.

Germishuizen, G., Meyer, N.L. & Steenkamp (*eds*) 2006. A checklist of South African plants. Southern African Botanical Diversity Network Report No. 41. SABONET, Pretoria.

Hardy, M.B. & Hurt, C.R. 1989. An evaluation of condition assessment techniques in Highland Sourveld. *Journal of the Grassland Society of southern Africa* 6: 51-58.

Henderson, L. 2001. Alien weeds and invasive plants. Plant Protection Research Institute handbook No. 12. Pretoria: Agricultural Research Council. 300 p.

Kent, M. & Coker, P. 1992. Vegetation description and analysis: a practical approach. Wiley, New York.

Kryger, U. & Scholtz, C.H. 2008. Phylogeography and conservation of the rare South African Fruit Chafer *Ichnestoma stobbiai* (Scarabaeidae: Cetoniinae). In: *Evolutionary Biology from concept to application* IV: 181-196.

Lemmer, P. & Coetzer, L.A. 2010. Flora assessment of Road K105 and Alignments. Report for GDARD by Galago Environmental.

Lowrey, T.K. & Wright, S. 1987. The flora of the Witwatersrand. Vol. 1: The Monocotyledonae. Witwatersrand University Press, Johannesburg.

Manning, J. 2003. Photographic guide to the wildflowers of South Africa. Pretoria: Briza Publications. 352 p.

Marais, V. & du G. Harrison, J. 2008. Invertebrate habitat assessment K105 and Alignments. Report for GDARD by Galago Environmental.

Mentis, M.T. 1983. Towards objective veld condition assessment. Proceedings of the Grassland Society of southern Africa 18: 77-80.

Mucina, L. & Rutherford, M.C. *eds.* 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. Pretoria: South African National Biodiversity Institute. 807 p.

Mucina, L., Rutherford, M.C., and Powrie, L.W. *eds*. 2005. Vegetation map of South Africa, Lesotho and Swaziland, 1:1 000 000 scale sheet maps. Pretoria: South African National Biodiversity Institute.

Mueller-Dombois, D. & Ellenberg, H. 1974. Aims and methods of vegetation ecology. Wiley, New York.

Pfab, M.F. 2001. Departmental policy, final draft: development guidelines for ridges. GDACE: Directorate of Nature Conservation.

Pfab, M.F. 2002. Priority ranking scheme for Red Data plants in Gauteng, South Africa. *South African Journal of Botany* (68): 299-303.

Pfab, M.F. & Victor, J.E. 2002. Threatened plants of Gauteng, South Africa. *South African Journal of Botany* (68): 370-375.

Pooley, E. 1998. A field guide to wild flowers: KwaZulu-Natal and the eastern region. Durban: Natal Flora Publications Trust (c/o Natal Herbarium). 630 p.

Raimondo, D., Von Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D.A. & Manyama, P.A. (eds) 2009 Red list of South African Plants 2009. *Strelitzia* 25. South African National Biodiversity Institute, Pretoria. 668 p.

Retief, E. & Herman, P.P.J. 1997. Plants of the northern provinces of South Africa: keys and diagnostic characteristics. Strelitzia 6. Pretoria: National Botanical Institute. 681 p.

Samways, M.J. 1994. Insect conservation biology. Chapman & Hall, London

Smit, N. 2008. A field guide to the Acacias of South Africa. Briza, Pretoria.

South Africa. 2004. National Environmental Management: Biodiversity Act No. 10 of 2004. Pretoria: Government Printer.

Tainton, N.M., Edwards, P.J. & Mentis, M.T. 1980. A revised method for assessing veld condition. Proceedings of the Grassland Society of southern Africa 15: 37-42.

Terblanche, R.F., Morgenthal, T.L. & Cilliers, S.S. 2003. The vegetation of three localities of the threatened butterfly species *Chrysoritis aureus* (Lepidoptera: Lycaenidae). *Koedoe* 46(1): 73-90.

Van Oudtshoorn, F. 1999. Guide to grasses of southern Africa. Pretoria: Briza. 288 p.

Van Rooyen, N. 2002. Veld management in the savannas. In: Bothma, J. du P. (ed.). 2002. Game ranch management, 4th ed. 571-617. Van Schaik, Pretoria.

Van Wyk, B. & Malan, S. 1998. Field Guide to the Wild Flowers of the Highveld. Cape Town: Struik. 353 p.

Van Wyk, B. & Van Wyk, P. 1997. Field guide to trees of southern Africa. Cape Town: Struik. 536 p.

Van Wyk, B.E. & Smith, G.F. 2003. Guide to the aloes of South Africa. 2[nd] ed. Pretoria: Briza Publications. 304 p.

Van Wyk, B. & Van Wyk, P. 1997. Field guide to trees of southern Africa. Cape Town: Struik.

Annexure G(v)

HERITAGE IMPACT
ASSESSEMENT

PHASE 1 HERITAGE IMPACT ASSESSMENT FOR THE PROPOSED KLEINFONTEIN MIXED LAND USE DEVELOPMENT ON PORTIONS 38, 90, 96 AND THE REMAINING EXTENT OF THE FARM KLEINFONYEIN 368 JR AND ON PORTIONS 63, 67, 68 AND THE REMAINING EXTENT OF PORTION 14 OF THE FARM DONKERHOEK 365 JR TO BE KNOWN AS "KLEINFONTEIN NEDERSETTING"

Prepared by:

Leonie Marais-Botes

BA (Cultural History and Archaeology) (UP), BA (Hons) Cultural History (UP), Post Grad Dip Museology (UP), Cert Conservation of Traditional Buildings (Univ of Canberra), Post Grad Dip: Heritage (Wits)
Heritage experience: 18 years.

868 Endeman Street
Wonderboom South
Pretoria
0084

Tel: 082 5766253

For

Bokamoso Landscape Architects and Environmental Consultants

February 2012

DISCLAIMER:

Although all possible care is taken to identify/find all sites of cultural importance during the initial survey of the study area, the nature of archaeological and historical sites are as such that it is always possible that hidden or sub-surface sites could be overlooked during the study. Leonie Marais-Botes will not be held liable will not be held liable for such oversights or for the costs incurred as a result thereof.

CONTENTS PAGE

ABOUT THIS REPORT

The heritage report must reflect that consideration has been given to the history and heritage significance of the study area and that the proposed work is sensitive towards the heritage resources and does not alter or destroy the heritage significance of the study area.

The heritage report must refer to the heritage resources currently in the study area.

The opinion of an independent heritage consultant is required to evaluate if the proposed work generally follows a good approach that will ensure the conservation of the heritage resources.

The National Heritage Resources Act (Act 25 of 1999) and the National Environmental Management Act (Act 107 of 1998) are the guideline documents for a report of this nature.

Leonie Marais-Botes was appointed by Bokamoso Landscape Architects and Environmental Consultants toprepare a Phase 1 Heritage Impact Assessment (HIA) for a proposed mixed use development on Portions 38, 90, 96 and the Remaining Extent of the Farm Kleinfontein 368 JR and on Portions 63, 67, 68 and the Remaining Extent of Portion 14 of the Farm Donkerhoek 365 JR to be known as "KleinfonteinNedersetting".

EXECUTIVE SUMMARY

The study area is located south of Cullinan, just south of the N4 and west of the R515 in the Kungwini Municipality. The development is approx. 10km from Rayton. Kleinfontein was established in 1992 and activities within the site are managed by “KleinfonteinBoerebelangeKoöperatiefBeperk”.

This project may impact on any types and ranges of heritage resources that are outlined in Section 3 of the National Heritage Resources Act (Act 25 of 1999) Consequent a Heritage Impact Assessment (HIA) was commissioned by Bokamoso Landscape Architects and Environmental Consultants and conducted by Leonie Marais-Botes (Heritage Practitioner).

A number of heritage sites and objects of significance were identified in the study area.

INTRODUCTION

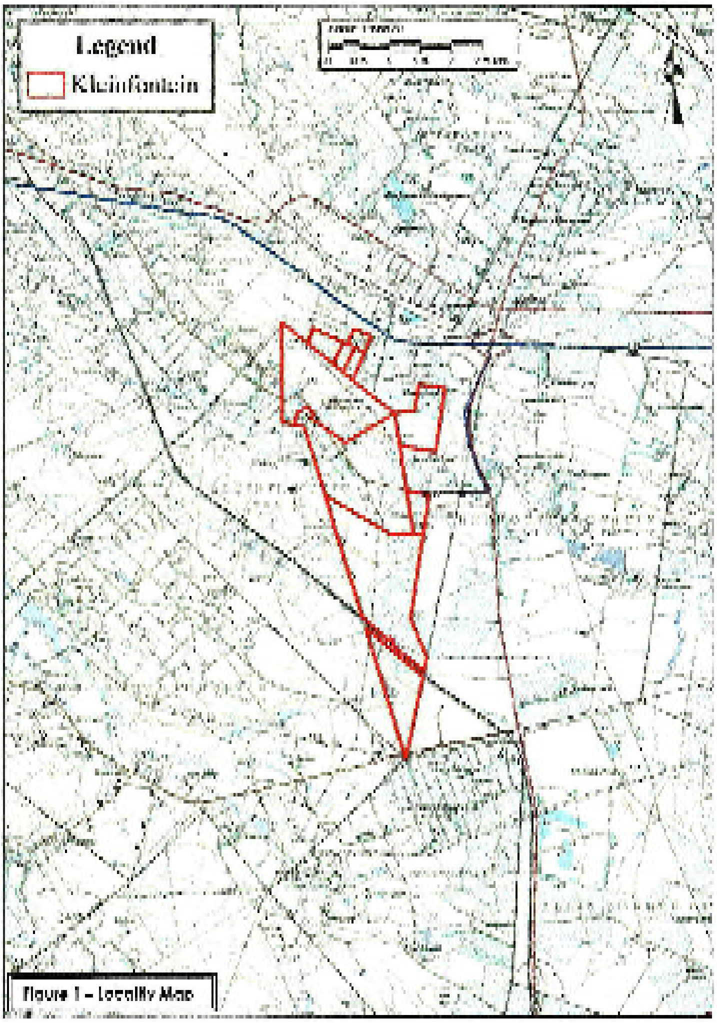
The “KleinfonteinBoerebelangeKoöperatiefBeperk” is planning a Land Development Area (LDA) for a proposed mixed land use development on Portions 38, 90, 96 and the Remaining Extent of the farm Kleinfontein 368 JR and on Portions 63, 67, 68 and the Remaining Extent of Portion 14 of the FarmDonkerhoek 365 JR to be known as the “KleinfonteinNedersetting”. The study area is approx. 721 ha in extent and is situated in the area of jurisdiction of the City of Tshwane Metropolitan Municipality.

Activities in the greater study area include:

- Formal and Informal Housing
- Commercial Activities (formal and informal)
- Tourism
- Farming

LOCATION OF THE STUDY AREA

The study area is located south of Cullinan, just south of the N4 and west of the R515 in the Kungwini Municipality. The proposed development is approx. 10km from Rayton in the Gauteng Province.



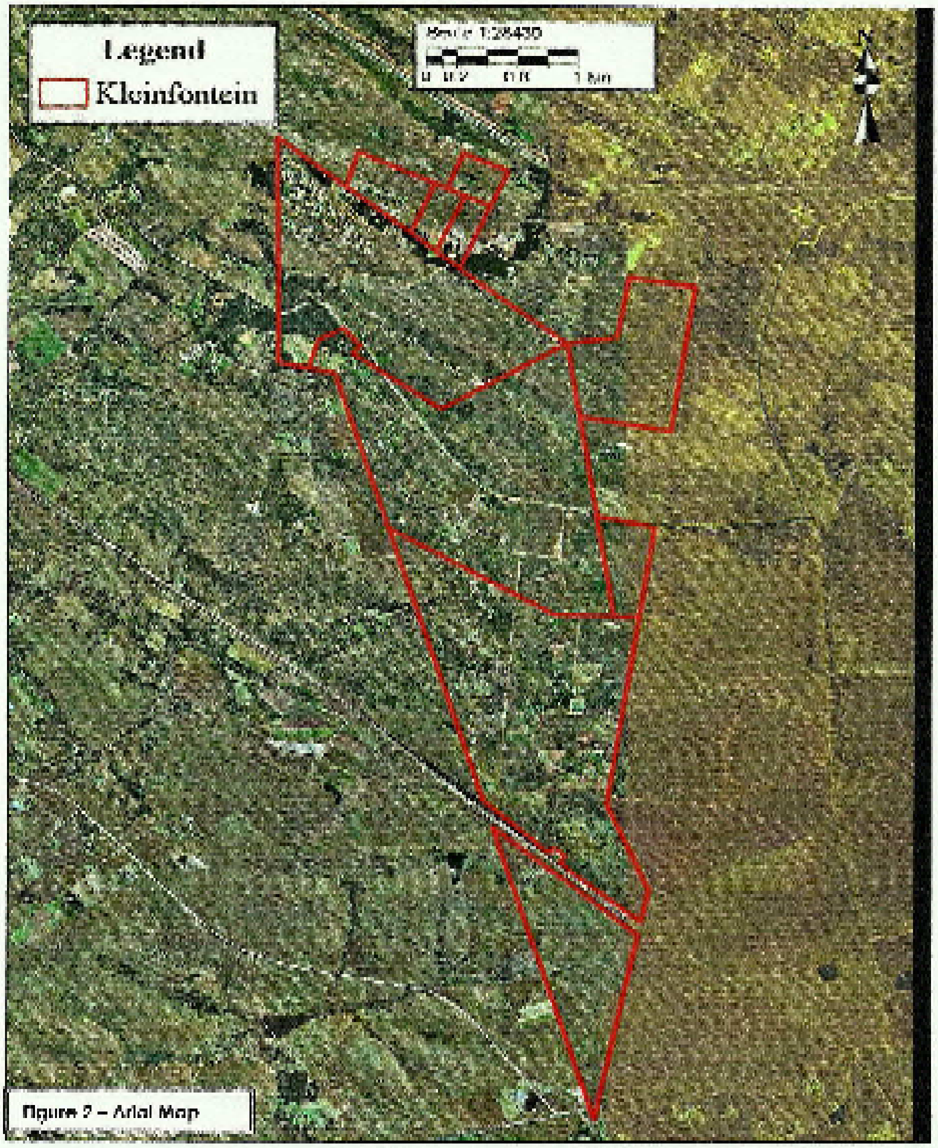


Figure 2 – Arial Map

DESCRIPTION OF THE STUDY AREA

The study area is divided into two sections, the northern living area and the southern small holdings area. A gravel road divides these two areas. The northern part is home to various game species such as Zebra, Wildebeest and other antelope. Steep rocky outcrops of ecological importance characterize the area. Approx. central co-ordinates are S 25º 48' 54.52" and E 028º 29' 43.97".

METHOD

The objective of this study was not to undertake a detailed heritage survey, but to gain an overall understanding of the heritage sensitivities of the area and indicate how they may be impacted on through development activities. The survey took place on 15 February 2012.

In order to establish heritage significance the following method was followed:

- Investigation of primary resources (archival information)
- Investigation of secondary resources (literature and maps)
- Physical evidence (site investigation)
- Determining Heritage Significance

LEGASLATIVE REQUIREMENTS

The National Heritage Resources Act (Act 25 of 1999)

According to the above mentioned act the following is protected as cultural resources:

a. Archaeological artefacts, structures and sites older than 100 years
b. Ethnographic art objects (e.g. prehistoric rock) art and ethnography
c. Objects of decorative and visual arts
d. Military objects, structures and sites older than 75 years
e. Historical objects, structures and sites older than 60 years
f. Proclaimed heritage sites
g. Cemeteries and graves older than 60 years
h. Meteorites and fossils
i. Objects, structures and sites of technological value.

The national estate includes the following:

a. Places, buildings, structures and equipment of cultural significance
b. Places to which oral traditions are attached or which are associated with living heritage
c. Historical settlements and townscapes

d. Landscapes and features of cultural significance
e. Geological sites of scientific or cultural importance
f. Archaeological and palaeontological importance
g. Graves and burial grounds
h. Sites of significance relating to the history of slavery
i. Movable objects (e.g. archaeological, palaeontological, meteorites, geological specimens, military, ethnographic, books etc.

PROPOSED KLEINFONTEIN MIXED LAND DEVELOPMENT TO BE KNOWN AS "KLEINFONTEIN NEDERSETTING"

1. BRIEF BACKGROUND HISTORY OF THE AREA

The first owner of the farm Kleinfontein

The first owner of the farm Kleinfontein was David Adolph Michael Botha (1806-1879). The extent of the orinal farm was 1658 morgen.

In 1866 the western part, where Kleinfontein are currently situated, was transferred to his youngest son Johannes Jacobus (Kootjie) Botha (21 April 1839-10 June 1932). He farmed the land until he passed away.

After the Battle of Donkerhoek/Diamond Hill (11-12 June 1900) Kootjie Botha fenced the English cemetery and maintained the said cemetery.[1]

The Battle of Donkerhoek/Diamond Hill 11-12 June 1900

The Battle of Donkerhoek/Diamond Hill that occurred during the Anglo-Boer War (1899-1902) was the largest military battle in the history of Pretoria and occurred partially on the farm Donkerhoek therefor sometimes referred to as the Battle of Donkerhoek. It was part of the British strategy to lure the Boer defence away from Pretoria after the successful annexation of the capital on 5 June 1900, but also part of the Boer strategy to limited British access to the country east of Pretoria. General Louis Botha's men took up defence positions on 9-10 June 1900 on the hills east of Pretoria the main aim was to block the road and railway line to the east. Lord Roberts attacked on 11-12 June 1900 and occupied Diamond Hill. General Botha was afraid that this action will enable the British forces to occupy his other defences. In the night of 12/13 June he decided to stop the battle and retreat to the east. The British succeeded to drove the Boer forces from Pretoria and the Boers succeeded indelaying the British advance. Both parties claimed victory.[2]

[1]E.J.M. Baumbach, Op padnaonstoekoms. Kleinfontein se geskiedenis en ontwikkeling.
[2]J.H. Breytenbach, Die Geskiedenis van die TweedeVryheidsoorlog (6).

Other important happenings:

Rebellion

On Monday 26 October 1914, General Chris Muller, Field Cornets P.Viljoen and M.Bredenkamp and approx. 42 other men met at JJ (Kootjie) Botha's residence to object to the then government's decision to invade German-West Africa (South West Africa/Namibia).

December 1938

An original ox-wagon dating from 1853 symbolizing the Blood River wagon left Kleinfontein for the Voortrekker Monument site for the 100th anniversary celebration of the Great Trek.

June 1985

Diamond Hill Military Cemetery is declared a National Monument (current status Provincial Heritage Site)

December 1988

The 150th anniversary of the Great Trek is celebrated on Kleinfontein.[3]

2. FINDINGS

2.1 PRE-COLONIAL HERITAGE SITES

The Stone Age

The period referred to as the Stone Age is the period in history when lithic (stone) material was mainly used to produce tools.[4] In South Africa the Stone Age can be divided in three periods:

Early Stone Age (ESA) 2 million – 150 000 years ago
Middle Stone Age (MSA) 150 000 – 30 000 years ago
Late Stone Age (LSA) 40 000 –to approx. 1850 AD[5]

Various stone tools are located on the northern ridge of the farm.

[3]E.J.M. Baumbach, Op padnaonstoekoms. Kleinfontein se geskiedenis en ontwikkeling.
[4]P.J. Coertze& R.D. Coertze, VerklarendevakwoordeboekvirAntropologie en Argeologie.
[5]S.A. Korsman& A. Meyer, Die Steentydperk en rotskuns in *J.S. Bergh (red.) Geskiedenisatlas van Suid-Afrika. Die viernoordelikeprovinsies.*

The so-called Northern Ridge of the Farm Kleinfontein

Stone tools mainly dating from the Middle and Late Stone Age were collected on the Northern Ridge (S 25º 48' 08.4" E 028º 29' 21.2")

The Iron Age

The Iron Age is the name associated with the period in human history when metal was mainly used to produce artefacts.[6]

According to van der Ryst & Meyer (1999) the Iron Age in South Africa provincial can be divided in two phases;

Early Iron Age (EIA) 250 – 900AD
Late Iron Age (LIA) 1000 – 1850AD[7]

Huffman (2007) however includes a Middle Iron Age. His dates are as follow;

[6] P.J. Coertze& R.D. Coertze, VerklarendevakwoordeboekvirAntropologie en Argeologie
[7] M.M. van der Ryst& A. Meyer, Die Ystertydperk in J.S. Bergh (red.)*Geskiedenisatlas van Suid-Afrika. Die viernoordelikeprovinsies*.

Early Iron Age (EIA) 250 – 900AD
Middle Iron Age (MIA) 900 – 1300AD
Late Iron Age 1300 – 1840AD[8]

No sites/artefacts associated with the above were identified in the study area.

2.2 HISTORICAL PERIOD HERITAGE SITES

Anglo-Boer War entrenchment (S 25º 48’ 14.9” E 028º 29’ 25.5”)

In a radius from the GPS waypoint S 25º 48’ 12.7” E 028º 29’ 24.5” approx. 6 entrenchments are visible. These entrenchments are located in an ecological sensitive area

[8]T.N. Huffman, A Handbook to the Iron Age: The Archaeology of Pre-Colonial Farming Societies in Southern Africa

Botha's sheep "kraal" (enclosure)

Diamond Hill Military Cemetery (S 25º 48' 22.3" and E 028º 29' 24.1")

Marker erected by the "Pretoria Streekskomiteevir die herdenking van die TweedeVryheidsoorlog" 10 June 2000 (S 25º 48' 20.3" E 028º 29' 26.3")

Rock pile 150th anniversary of the Great Trek 1988 (S 25º 48’09.3’’ E 028º 29’ 18.5’’)

.2.3 ORIGINAL LANDSCAPE

Some areas featuring the original landscapes survived.

2.4 INTANGIBLE HERITAGE

The intangible heritage related to the study area is most likely found in the stories of past and present residents of the greater study area.

3. ADDITIONAL SITES OF CULTURAL SIGNIFICANCE IDENTIFIED IN THE STUDY AREA

Modern Cemetery (S 25º 48’ 20.9” E 028º 29’ 21.3”)

All graves and cemeteries are of high significance and are protected by various laws. Legislation with regard to graves included the National Heritage Resources Act (Act 25 of 1999) whenever graves are 60 years and older. Other legislation with regard to graves includes those when graves are exhumed and relocated, namely the Ordinance on Exhumations (no 12 of 1980) and the Human Tissues Act (Act 65 of 1983 as amended).

The possibility of sub-surface graves always exists. In the case of a sub-surface grave/graves being discovered the South African Police Service (SAPS) must be contacted. If the graves are identified as historical a heritage practitioner should be contacted.

4. OPPORTUNITIES, RESTRICTIONS, IMPACTS

- In a radius from the GPS waypoint S 25º 48’ 12.7” E 028º 29’ 24.5” various historical sites including approx. 6 Anglo-Boer War (1899-1902) entrenchments, the Botha sheep “kraal” (enclosure) and the northern ridge where various stone tools have been collected, this area is of great importance and no development should be allowed here.
- If archaeological finds are unearthed during excavations in the non-sensitive parts of the study area, work should stop and an archaeologist contacted to evaluate the situation.
- The archaeological potential of the study area should be investigated.
- All identified heritage sites in the study area are protected by the National Heritage Resources Act, Act 25 of 1999 and may only be altered or removed with the necessary approval of the relevant heritage authority.
- All graves and cemeteries are of high significance whether historical or recent.

5. THE WAY FORWARD

- A section 38 application in line with the National Heritage Act (Act 25 of 1999) should be submitted to the Provincial Heritage Authority of Gauteng for comments.

6. REFERENCES

Baumbach, E.J.M. Op pad na ons toekoms. Kleinfontein se geskiedenis en ontwikkeling 1853 – 2008. Unpublished work.

Bergh, J.S. Geskiedenisatlas van Suid-Afrika. Die vier noordelike provinsies. Pretoria 1999

Breytenbach, J.H. Geskiedenis van die Tweede Vryheidsoorlog 1899-1902 (6). Pretoria, 1996.

Coertze, P.J. & Coertze R.D. Verklarende vakwoordeboek vir Antropologie en Argeologie. Pretoria 1996

Huffman, T.N. A Handbook to the Iron Age: The Archaeology of Pre- Colonial Farming Societies in Southern Africa. University of KwaZulu-Natal Press 2007

Annexure G(vi)

ELECTRICAL REPORT

DRAFT

SERVICES REPORT
ELECTRICAL RETICULATION
KLEINFONTEIN

MIXED USE DEVELOPMENT ON PORTIONS 38, 90, 96 OF THE FARM KLEINFONTEIN 368JR AND ON PORTIONS 63, 67, 68 AND REMAINDER OF PORTION 14 OF THE FARM DONKERHOEK 365JR

GAUTENG PROVINCE

BURO TECH

PlanPractice
townplanners

PREPARED BY:

BURO TECH CONSULTING ENGINEERS CC
PO Box 59887
KARENPARK
0118

Tel: 012 542 1010
Fax: 012 542 2097
Email: burotech@burotech.co.za

TOWNPLANNER:

PLANPRAKTYK STADSBEPLANNERS
PO Box 35895
MENLO PARK
0102

Tel: 012 362 1741
Fax: 012 362 0983
Email: info@practicegroup.co.za

PREPARED FOR:

Kleinfontein Boerebelange Koöperatief Bpk
Po Box 925
Rayton
1001

Tel: 012 802 1583
Fax: 012 802 1584
Email: kleinadmin@kleinfontein.net

DATE: **January 2012** **PROJECT:** **PE15**

Version 0

EXECUTIVE SUMMARY

The existing development known as Kleinfontein is currently supplied by Eskom via the Tweedracht/Donkerhoek 11kV feeder. From consumer accounts, the unconfirmed Notified Maximum Demand is estimated at 1.2MVA.

Based on Preliminary Zoning / Usage Allocation tables from the Townplanners and allocating loading as per NRS guidelines, the final estimated Maximum Demand for future development should be ±11.8MVA.

The development is situated within the supply jurisdiction of City of Tshwane.

DRAFT

SERVICES REPORT

ELECTRICAL RETICULATION

MIXED USE DEVELOPMENT ON PORTIONS 38, 90, 96 OF THE FARM KLEINFONTEIN 368JR AND ON PORTIONS 63, 67, 68 AND REMAINDER OF PORTION 14 OF THE FARM DONKERHOEK 365JR

GAUTENG PROVINCE

Contents: **Page**

ADDENDA:

PREPARED BY: BURO TECH CONSULTING ENGINEERS CC (012) 542 1010

DRAFT

SERVICES REPORT

ELECTRICAL RETICULATION

MIXED USE DEVELOPMENT ON PORTIONS 38, 90, 96 OF THE FARM KLEINFONTEIN 368JR AND ON PORTIONS 63, 67, 68 AND REMAINDER OF PORTION 14 OF THE FARM DONKERHOEK 365JR

GAUTENG PROVINCE

1. INTRODUCTION AND BACKGROUND

1.1 Brief

Kleinfontein Boerebelange Koöperatief Beperk has appointed PlanPractice Town Planners to apply for the establishment of mixed-use land development on,

- Portions 38, 90, 96 of the Farm Kleinfontein 368JR and
- on Portions 63, 67, 68 and Remainder of Portion 14 of the Farm Donkerhoek 365JR

Buro Tech Consulting Engineers CC was appointed by Kleinfontein Boerebelange Koöperatief Beperk on 16th September 2011 as the Professional Electrical Engineers on the project.

1.2 Scope of the Report

The scope of this report covers the investigation of the existing electrical infrastructure as well as the planning of the electricity supply to the developments including the electrical reticulation of the future proposed development. The scope of the report can briefly be summarised as follows:

- Obtaining of information on existing infra structure,
- Determining and planning of proposed future Medium Voltage electrical connections and reticulation,
- Determining and planning of proposed future Low Voltage electrical reticulation,
- Confirmation of specifications for purposes of services agreement,
- Determining of financial implications (future reports).

1.3 Availability of Information

Information was obtained as follows:

- Site visit on 19 October 2011. During this inspection various 11kV Eskom supply points were visited.

- Meeting with the developers and professional team on 21 October 2011. In this meeting information was obtained regarding the Zoned Usage, the electricity supply area and any existing infrastructure e.g. boreholes.
- A Site visit on 06 December 2011 to obtain the information regarding the existing Eskom connections from Mr Steyn van Schalkwyk.
- A Site visit with Mr Piet Jansen also an electrician responsible for maintenance and operation existing electrical infrastructure on 18 January 2012. A sample inspection was done on a typical Low Voltage Metering Kiosk and Miniature Substation.
- Zoning plans and usage schedules from PlanPractice Townplanners dated 17 November 2011 with supplementary information on 29 November 2011.

1.4 Services Negotiations

Service negotiations and agreements will be finalised between the client and the local supply authority. The area currently falls within the jurisdiction of the City of Tshwane. Eskom however is the official supply authority to the area. No City of Tshwane supply networks could be identified during the various site inspections. A formal letter was requested from City of Tshwane to give approval for Eskom to provide electricity to the existing and future developments (see Addendum 2)

2. DESCRIPTION OF EXISTING SYSTEMS

The main supply to the development is currently an Eskom supply, from the Tweedracht Substation via the Donkerhoek 11kV overhead feeder.

The various boreholes and agricultural holdings are supplied via 11kV overhead lines, through pole mounted transformers of various kVA ratings. Reticulation within the residential portion of the development is from the overhead feeders, through MV Eskom bulk metering. Internally supply to the houses is by means of 11kV underground cables to miniature substations and from the miniature substations via Low Voltage underground copper cables to outdoor ground mounted metering cubicles, with the final connection to the houses using underground house connection cables.

Limited visual inspections revealed that the work was done according to acceptable standards.

3. LOAD ESTIMATE

3.1 The total load estimate of the mixed-use development is as follows:

Calculation were done as follows:

Residential 01		5.0	kVA (ADMD)
Residential 04		3.5	kVA (ADMD)
Business 01	(Shops, Offices, Prof. Rooms)	90	VA/m²
Industrial Uses		100	VA/m²
Institutional	(Institution, Place of Worship/Instruction)	80	VA/m²
Agricultural		7.0	kVA (ADMD)
Educational	(Place of Instruction, Place of Worship)	80	VA/m²
Various Special	(Workshops, Telecomms, Security, etc.)	Dependent of Allocated Usage	

3.2 The load estimate for the total development can thus be summarised as follows:

KLEINFONTEIN **LOAD ESTIMATE CALCULATIONS**

Erf Detail	Rights Applied For			Development Potential					Loading	Load	Load (kVA)
Erf No(s)	Area (ha)	Type		Erven	Units	DENSITY Units /Ha /Erf	FSR	m²	kVA [ADMD]	Factor (VA/m²)	Calculated per Formula (load factor x building area)
1 - 782	24.87 ha	Residential 1	Dwelling houses	782	782	1 u/erf			7.0 kVA		5,474 kVA
783 - 859	3.81 ha	Residential 2	Dwelling houses and block of flats	77	229	60 u/ha			3.5 kVA		802 kVA
860 - 862	1.90 ha	Residential 2	Dwelling houses and block of flats	3	29	15 u/ha			5.0 kVA		145 kVA
863 - 875	13.99 ha	Business 1	Shops, offices and Professional rooms	13			50%	69,950 m²		90 VA/m²	6,296 kVA
876 - 927	11.66 ha	Industrial 1	Industrial uses	52			90%	104,940 m²		25 VA/m²	2,624 kVA
928	0.35 ha	Institutional	Institutions, Place of Public Worship and Place of Instruction	1			60%	2,100 m²		80 VA/m²	168 kVA
928 - 1126	294.63 ha	Agricultural	Dwelling houses	199	597	3 u/erf			7.0 kVA		4,179 kVA
1127	3.41 ha	Educational	Place of Instruction and Place of Public Worship	1			50%	17,050 m²		80 VA/m²	1,364 kVA
1128 - 1129	1.49 ha	Special	Cemetery and Funeral Parlour	2					20 kVA		40 kVA
30 - 1143, 1214	214.00 ha	Special	Private Open Space	15					3 kVA		45 kVA
1144	1.00 ha	Special	Workshop, Maintenance and Storage	1					50 kVA		50 kVA
1145	0.18 ha	Special	Industrial Use , Public Garage and Shop	1					70 kVA		70 kVA
1146 - 1148	0.24 ha	Special	Engineering Services, including reservoir, pump station, electrical substation and associated maintenance facilities	3					60 kVA		180 kVA
1149	16.10 ha	Special	Engineering Services, including reservoir, pump station, electrical substation and associated maintenance facilities and **sewerage treatment plant**	1					250 kVA		250 kVA
1150 - 1155	1.82 ha	Special	Place of Amusement, Social Hall, Place of Public worship, Place of Instruction and Public Office	6			80%	10,920 m²		85 VA/m²	928 kVA
1156	1.87 ha	Special	Telecommunication Centre	1					25 kVA		25 kVA
1	4.78 ha	Special	Private Open Space and Social Halls	1					60 kVA		60 kVA
1159 - 1160	0.37 ha	Special	Access Structure and Gatehouse	2					15 kVA		30 kVA
1203 - 1213	88.78 ha	Undetermined	Dwelling Houses and Agricultural buildings	11	11				7.0 kVA		77 kVA
1201 - 1202	18.92 ha	Undetermined	Dwelling Houses and Agricultural buildings	2	2			0 m²	7.0 kVA		14 kVA
								Residential Sub-Total			**10,691 kVA**
								Other Sub-Total			**12,129 kVA**
								Diversity Applied		**80%**	**18,256 kVA**
TOTAL ESTIMATED LOAD (kVA)										**Say**	**18.300 MVA**

4. POINT OF SUPPLY

4.1 Supply to existing facilities is via the Eskom, Tweedracht/Donkerhoek 11kV feeder which falls within the Eskom Cullinan T.S.A.

4.2 The development however fall within the jurisdiction of City of Tshwane. No Tshwane infrastructure could be identified during the site visits.

4.3 Currently Eskom is the licensed supplier to all existing facilities and residential units with extensive infrastructure (Overhead Lines and Pole Mounted Transformers) present in the area.

4.4 An application was submitted to City of Tshwane in which Tshwane should indicate whether they would be interested in providing supply to the new proposed mixed-use development. Due to lack of infrastructure, it is expected that Tshwane will not be in a position to cater for any existing or future development.

4.5 To this effect, a formal application is being processed to Eskom North-West region for the supply of future development of the area.

4.6 At the date of this report, neither authority was in a position to give feedback yet.

5. PROPOSED EXTERNAL RETICULATION SYSTEM

5.1 MV Reticulation:

i. The proposed internal reticulation system will be at 11kV with a combination of Overhead Lines and Underground Cables.

ii. External MV Reticulation networks to be provided in accordance with supply authority requirements and specifications.

5.2 LV Reticulation:

i. The proposed internal LV reticulation system will be an underground reticulation cable network. The 415V reticulation (to SANS 1418) will be by means of 4-core Aluminium or Copper PVC/SWA/PVC cables.

ii. Provision will be made for 1-phase and 3-phase consumer feeds via outdoor metering cubicles, to the various facilities.

iii. Maximum demand metering (Enermax type or similar) will be provided on the boundary of business stands.

iv. It is proposed that split pre-payment consumer metering be provided inside the dwellings.

v. The complete reticulation will be provided with earthing systems and lighting protection.

vi. Only the minimum area lighting will be provided on strategic places. The luminaires will have low power consumption and the possibility to use solar power type streetlights is will be investigated.

5.3 Standards:

The complete installation will be according to the standard specifications as set out in NRS/SANS and Eskom Specification.

6. DESIGN PARAMETERS:

The design parameters are as follows:

6.1	Supply voltage	11kV
6.2	Transformer capacity	16 – 800kVA (11kV / 415V / 240V)
6.3	Medium voltage	11kV
6.4	Frequency	50Hz
6.5	Transformer earth	5 ohm
6.6	Symmetrical fault level	250MVA
6.7	Impulse withstand required	95kV
6.8	One minute power frequency withstand voltage	18kV
6.9	Normal low voltage	400V / 231V

6.10	Earthing to consumers	Earthing integral with 25mm² house connection
6.11	Declared voltage	231V
6.12	Voltage regulation limits assumed voltage drop in system for low voltage design : (I) 11kV network (ii) Low voltage	 3% max 9% max up to consumer DB

7. CONTRIBUTIONS

The contributions still need to be determined.

8. FINANCIAL IMPLICATIONS

8.1 This will be covered in future reports.

9. ENERGY EFFICIENCY MEASURES

9.1 Heat Pump Water Heating Systems

Heat Pump Systems are the preferred method for the heating of water. Using a third of the energy, when compared with Standard Hot Water Cylinders, this type of technology is ideally suited for developments of this nature, where a large number of Residential units are clustered together.

In addition to that, designing the system in such a way that the heated water is continuously circulated in dedicated hot water reticulation networks/pipes servicing all residential units, will result in hot water being immediately available.

Users diversity also results in the Cumulative Installed Heating Capacity needed to produce enough hot water to service the units, to be significantly less, when compared with numerous dedicated hot water systems, in a one per unit configuration.

9.2 Solar Panel Water Heating Systems

The usage of solar panels for the heating of the water for the geysers will also be considered for the development. It is one of the most feasible methods to save electricity with a system that is environmental friendly with very low carbon foot print. The units comprise basically of a solar collector/heat exchanger panel mounted on the roofs of the residential units. The geyser is equipped with an electrical heating element as back up together with a thermostat control to assist with the heating process when the sun energy is inadequate.

9.3 Electricity Generation and Gas

Solar panels for the generation of electricity were considered for the dwellings on the proposed development. However, the panels cannot yet be implemented cost effectively in South Africa because of the extremely high initial capital layout and associated maintenance problems with batteries etc. The usage of electricity can possibly be complimented by gas for heating purposes such as for stoves and geysers.

10. SERVITUDES

The Servitudes will be registered as may be required.

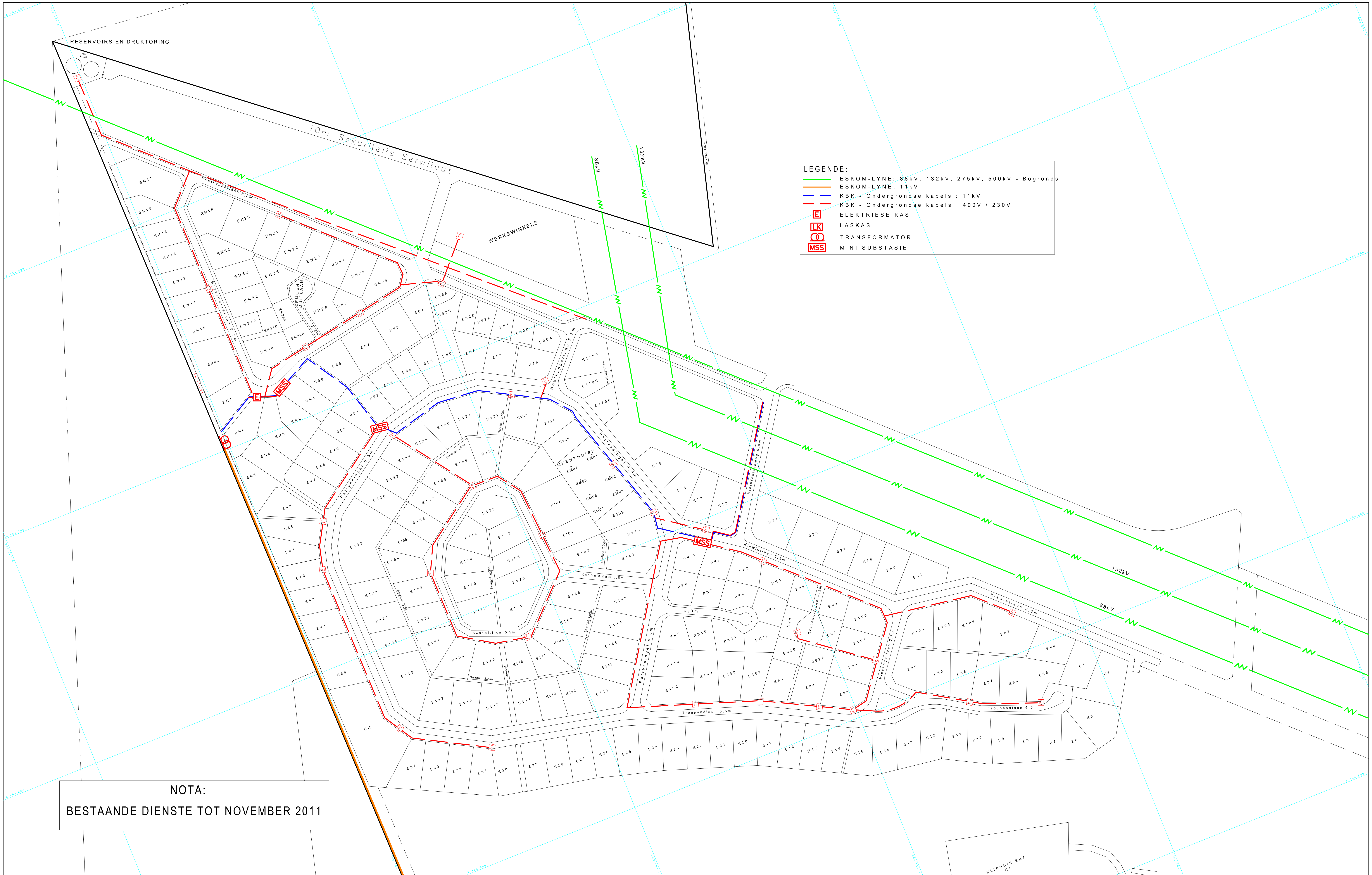
11. TELEPHONE RETICULATION

Telephone services [Sleeves and Ducts] to be included in the civil services by the Civil Engineers as may be required.

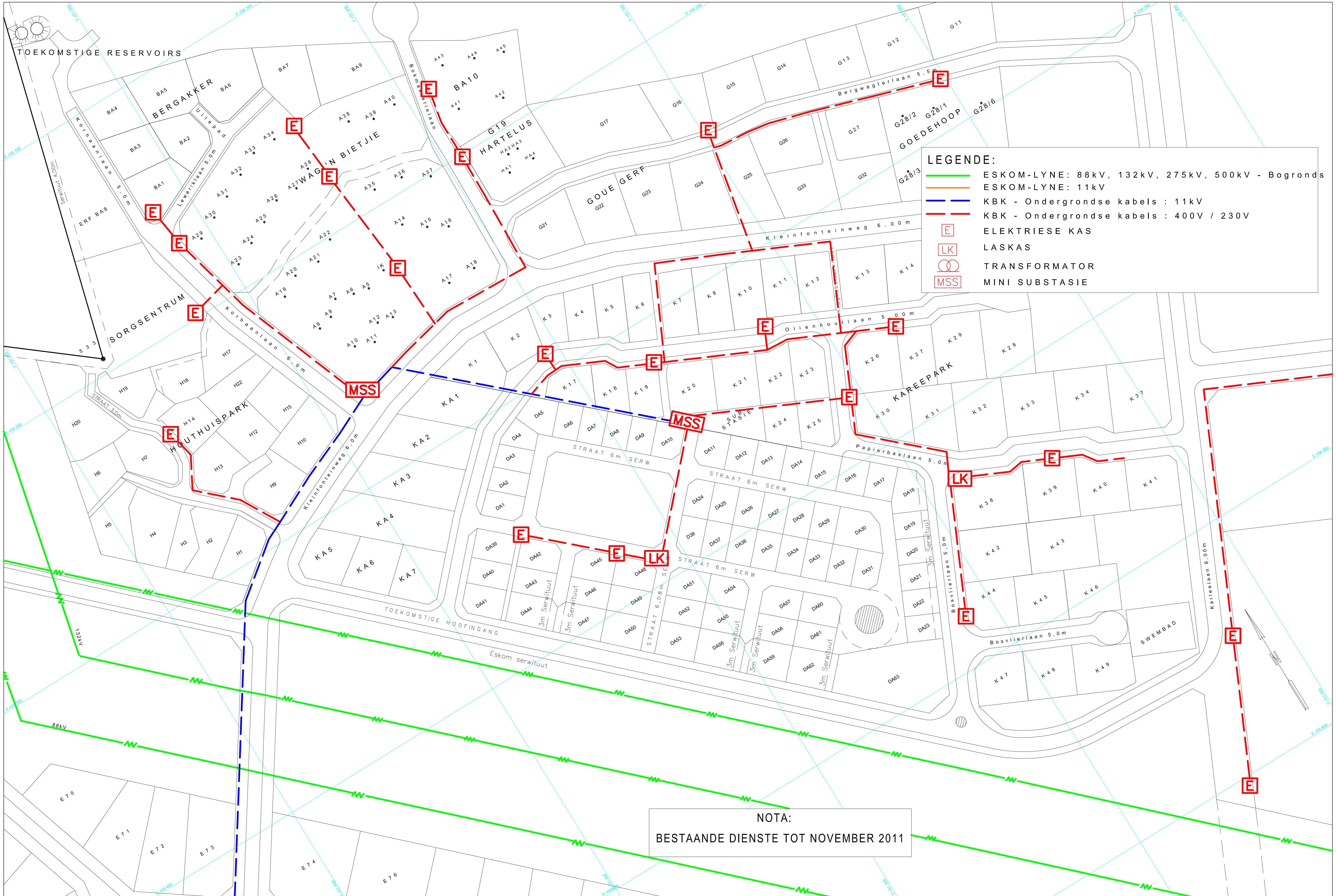
--oo0oo—

Addendum 1

Drawing: Existing Internal Electrical Reticulation



KLEINFONTEIN BOEREBELANGE KOÖPERATIEF BEPERK TEL 012 - 8021583 E-POS kleinadmin@kleinfontein.net FAKS 012 - 8021584	NEDERSETTING ELEKTRIESE DIENSTE PLAN		WYSIGINGS	NAGESIEN	DATUM		WYSIGINGS	NAGESIEN	DATUM	TEKENING NR. UO1E 1 GETEKEN: W van Romburgh DATUM: 28/07/2011 CAD VERW KFTN2011_NEDERSETTING1000	SKAAL 1:1 000
		0	1STE KOPIE	NDB	14/11/11	3					
		1	KABEL BYVOEGINGS	NDB	30/11/11	4					
		2				5					



NOTA:
BESTAANDE DIENSTE TOT NOVEMBER 2011

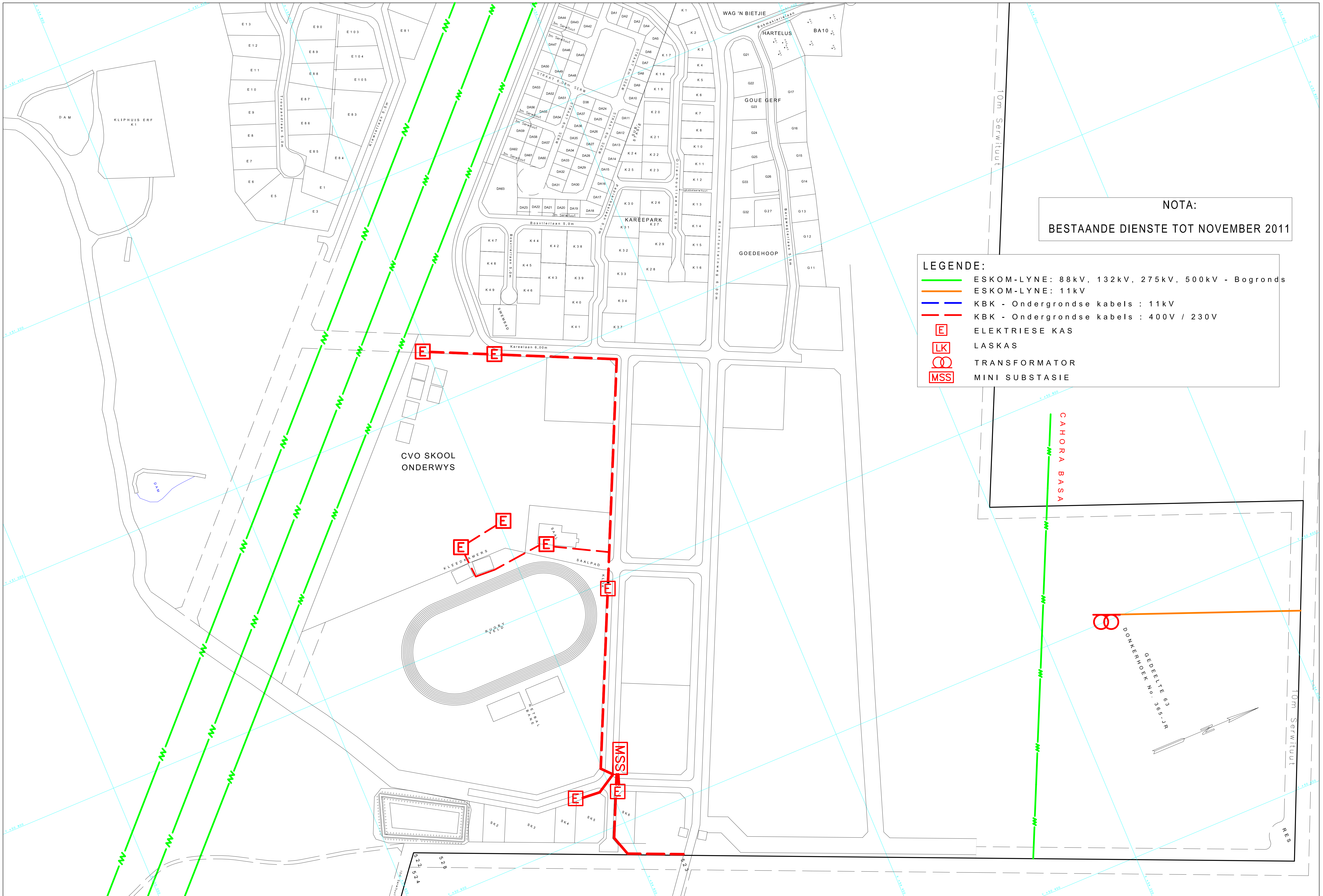
KLEINFONTEIN BOEREBELANGE
KOÖPERATIEF BEPERK
TEL 012 - 8021583 E-POS kleinadmin@kleinfontein.net FAKS 012 - 8021584

HOUTHUISPARK, SORGSENTRUM, BERGAKKER, WAG'NBIETJIE, GOUE GERF, DAGBREEK WOONWAPARK, KAREEPARK
ELEKTRIESE DIENSTE PLAN

	WYSIGINGS	NAGESIEN	DATUM
0	1STE KOPIE	NDB	14/11/11
1	KABEL BYVOEGING	NDB	30/11/11
2			

	WYSIGINGS	NAGESIEN	DATUM
3			
4			
5			

TEKENING NR.
UO2E 1
GETEKEN: W van Romburgh DATUM: 29/08/2011
CAD VERW KFTN2011_UITLEGTE UO2
SKAAL 1:500



NOTA:

BESTAANDE DIENSTE TOT NOVEMBER 2011

LEGENDE:

- ESKOM-LYNE: 88kV, 132kV, 275kV, 500kV - Bogronds
- ESKOM-LYNE: 11kV
- KBK - Ondergrondse kabels : 11kV
- KBK - Ondergrondse kabels : 400V / 230V
- E ELEKTRIESE KAS
- LK LASKAS
- TRANSFORMATOR
- MSS MINI SUBSTASIE

KLEINFONTEIN BOEREBELANGE
KOÖPERATIEF BEPERK
TEL 012 - 8021583 E-POS kleinadmin@kleinfontein.net FAKS 012 - 8021584

NEDERSETTING OOS EN HOEWE 63

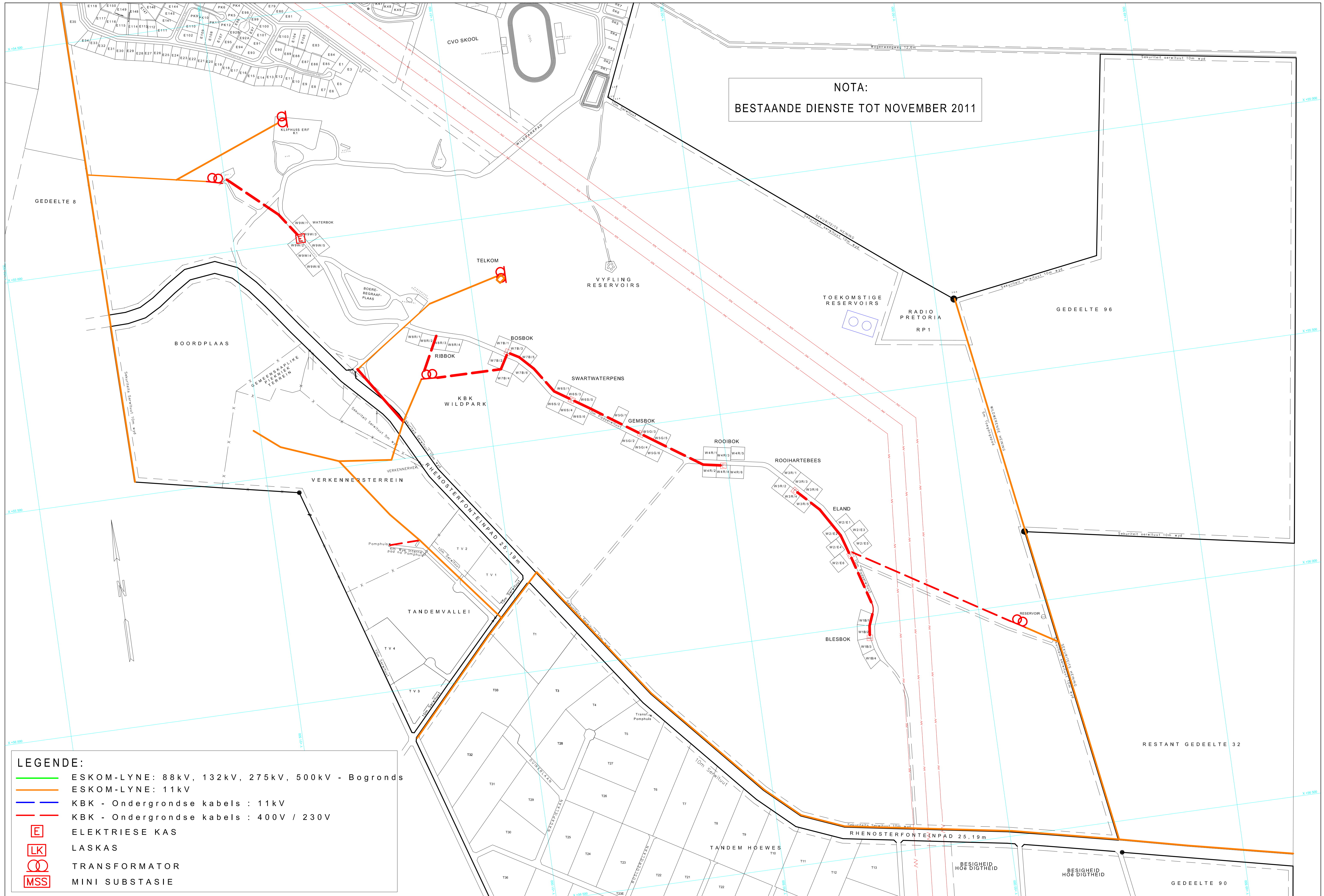
ELEKTRIESE DIENSTE PLAN

	WYSIGINGS	NAGESIEN	DATUM		WYSIGINGS	NAGESIEN	DATUM
0	1STE KOPIE	NDB	14/11/11	3			
1	BYVOEGING BY SAAL	NDB	30/11/11	4			
2				5			

TEKENING NR.
UO3E 1

GETEKEN: W van Romburgh DATUM: 29/08/2011
CAD VERW KFTN_2011_UITLEGTE UO3

SKAAL 1:1000



KLEINFONTEIN BOEREBELANGE KOÖPERATIEF BEPERK

TEL 012 - 8021583 E-POS kleinadmin@kleinfontein.net FAKS 012 - 8021584

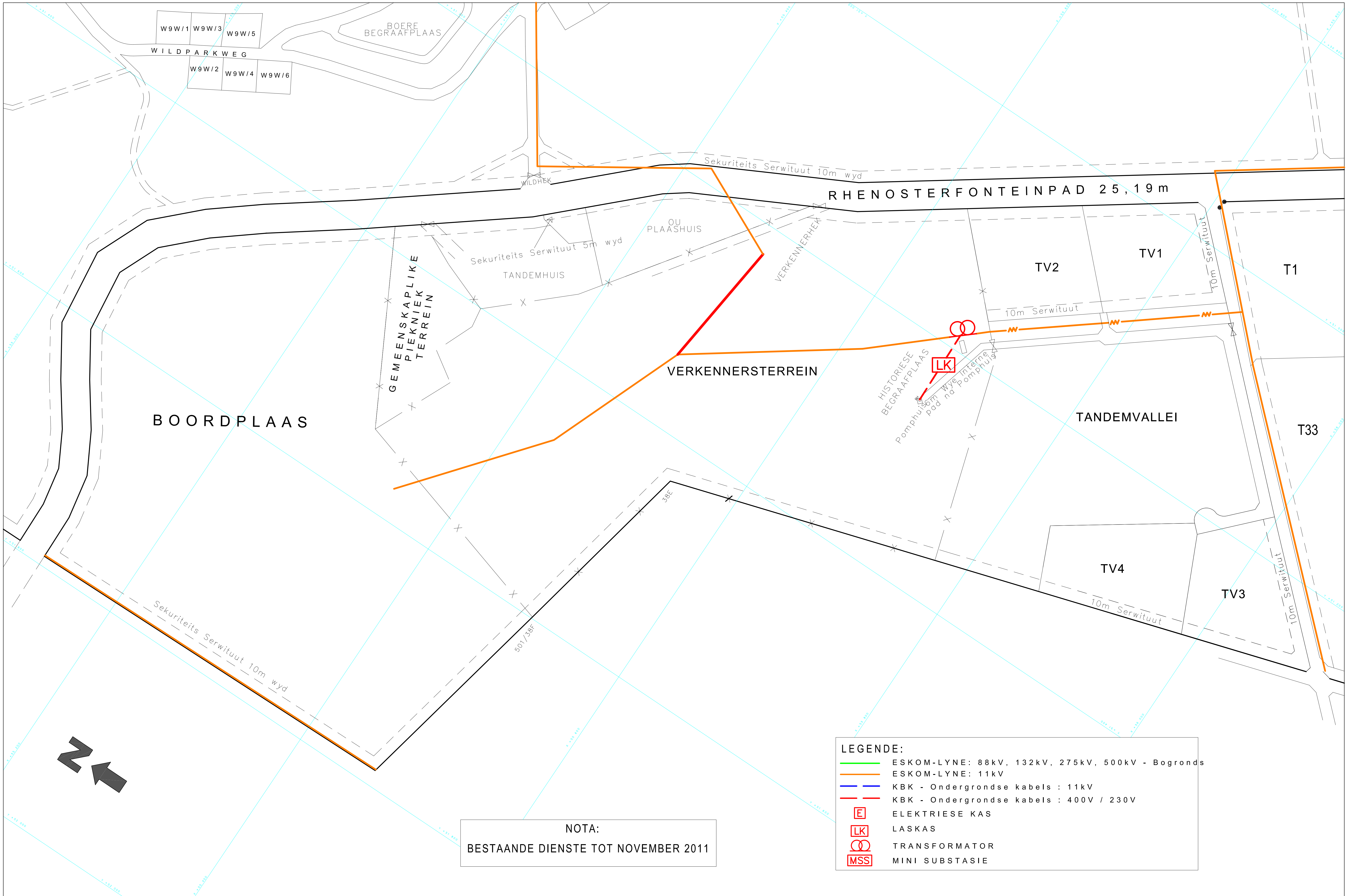
WILDPARK EN GEDEELTE 96 ELEKTRIESE DIENSTE PLAN

	WYSIGINGS	NAGESIEN	DATUM		WYSIGINGS	NAGESIEN	DATUM
0	1STE KOPIE	NDB	14/11/11	3			
1	KLEIN KORREKSIES	NDB	30/11/11	4			
2				5			

TEKENING NR. UO4E 1

GETEKEN: W van Romburgh DATUM: 25/07/2011
CAD VERW KFTN_2011_UO4

SKAAL 1:2500



LEGENDE:

- ESKOM-LYNE: 88kV, 132kV, 275kV, 500kV - Bogronds
- ESKOM-LYNE: 11kV
- KBK - Ondergrondse kabels : 11kV
- KBK - Ondergrondse kabels : 400V / 230V
- E — ELEKTRIESE KAS
- LK — LASKAS
- TRANSFORMATOR
- MSS — MINI SUBSTASIE

NOTA:

BESTAANDE DIENSTE TOT NOVEMBER 2011

KLEINFONTEIN BOEREBELANGE KOÖPERATIEF BEPERK

TEL 012 - 8021583 E-POS kleinadmin@kleinfontein.net FAKS 012 - 8021584

BOORDPLAAS EN TANDEMVALLEI ELEKTRIESE DIENSTE PLAN

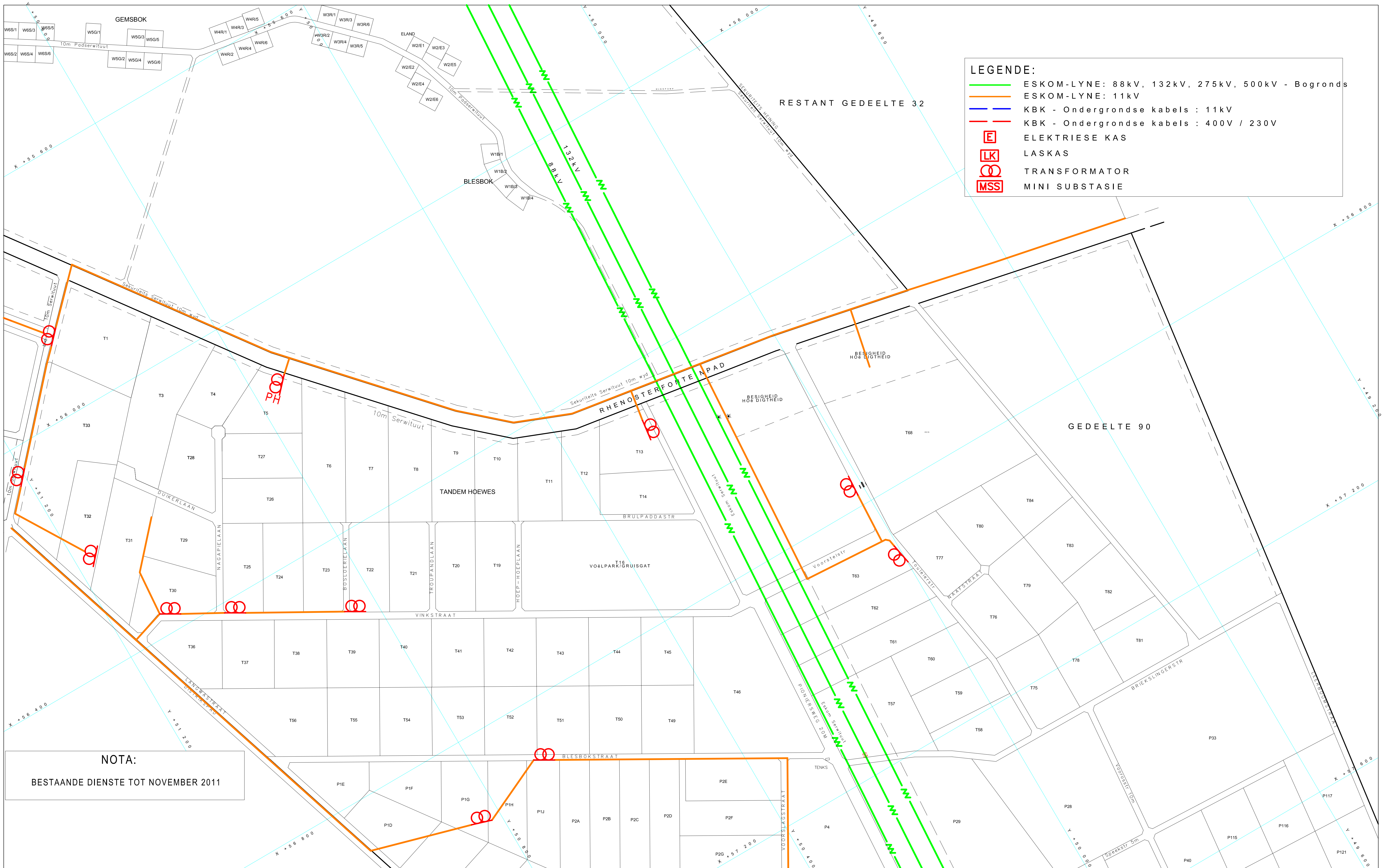
	WYSIGINGS	NAGESIEN	DATUM		WYSIGINGS	NAGESIEN	DATUM
0	1STE KOPIE	NDB	14/11/11	3			
1	KLEIN KORREKSIES	NDB	30/11/11	4			
2				5			

TEKENING NR. UO5E 1

GETEKEN: W van Romburgh DATUM: 25/07/2011

CAD VERW KFTN2011_BOORDPLAASTANDEM1000

SKAAL 1:1000



KLEINFONTEIN BOEREBELANGE
KOÖPERATIEF BEPERK

TEL 012 - 8021583 E-POS kleinadmin@kleinfontein.net FAKS 012 - 8021584

TANDEM HOEWES
ELEKTRIESE DIENSTE PLAN

	WYSIGINGS	NAGESIEN	DATUM		WYSIGINGS	NAGESIEN	DATUM
0	1STE KOPIE	NDB	14/11/11	3			
1	KLEIN KORREKSIES	NDB	30/11/11	4			
2				5			

TEKENING NR.
UO6E 1
GETEKEN: W van Romburgh DATUM: 25/07/2011
CAD VERW KFTN_2001_TANDEMTERREIN2000

SKAAL 1:2000

	WYSIGINGS	NAGESIEN	DATUM		WYSIGINGS	NAGESIEN	DATUM
0	1STE KOPIE	NDB	14/11/11	3			
1	KLEIN BYVOEGINGS	NDB	30/11/11	4			
2				5			

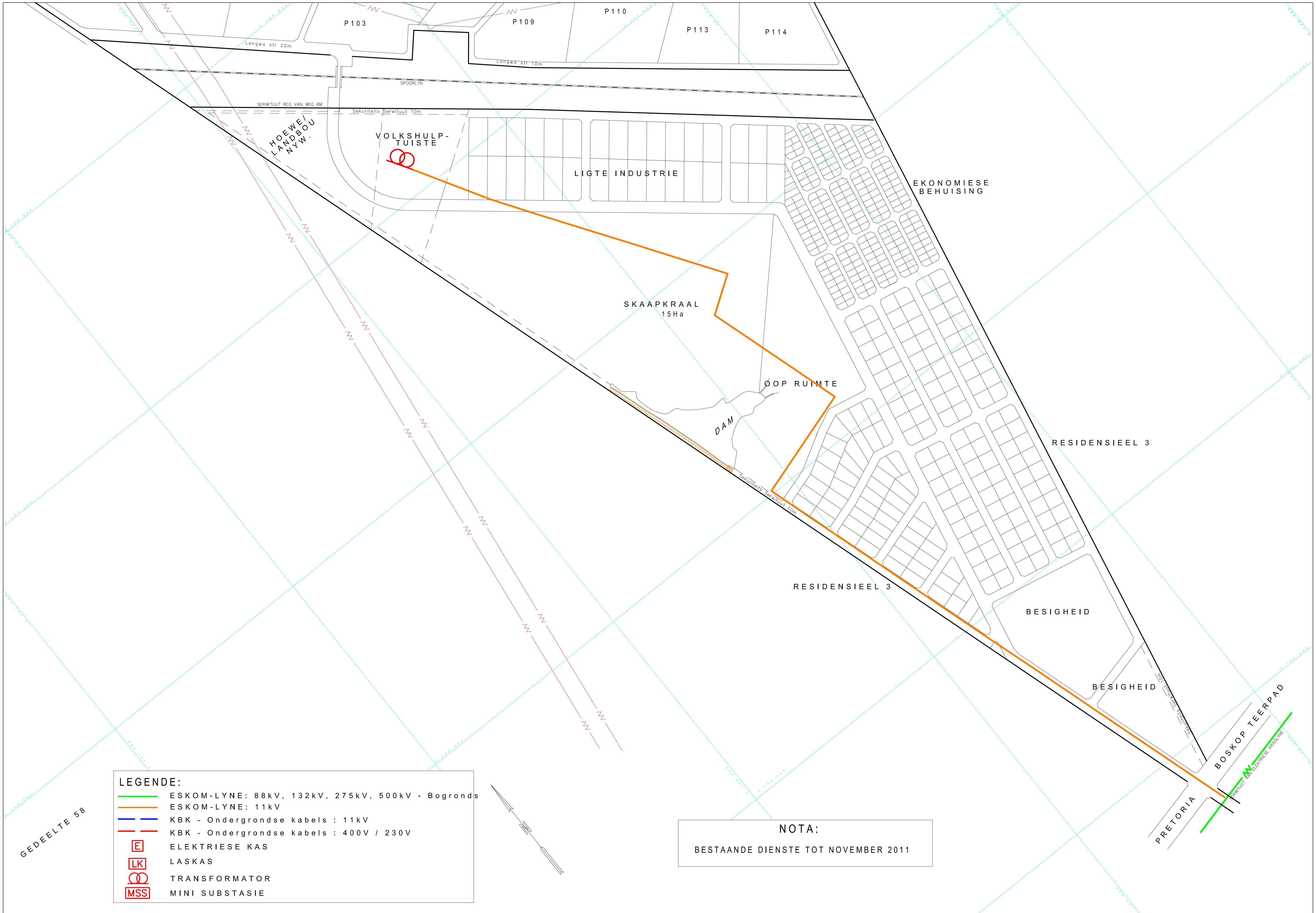
PIONIERSHOEWES
ELEKTRIESE DIENSTE PLAN

KLEINFONTEIN BOEREBELANGE
KOÖPERATIEF BEPERK
TEL 012 - 8021583
E-POS kleinadmin@kleinfontein.net
FAKS 012 - 8021584

TEKENING NR.
UO7E 1

SKAAL 1:2500

GETEKEN: W van Romburgh DATUM: 25/07/2011
CAD VERW KF7N_2011_UITLEG UO8



KLEINFONTEIN BOEREBELANGE KOÖPERATIEF BEPERK

TEL 012 - 8021583 E-POS kleinadmin@kleinfontein.net FAKS 012 - 8021584

SUIDELIKE HOEWES ELEKTRIESE DIENSTEPLAN

	WYSIGINGS	NAGESIEN	DATUM		WYSIGINGS	NAGESIEN	DATUM
0	1STE KOPIE	NDB	14/11/11	3			
1	KLEIN KORREKSIES	NDB	30/11/11	4			
2				5			

TEKENING NR. UO8E 1

GETEKEN: W van Romburgh DATUM: 22/07/2011
CAD VERW KFTN_2011_UITLEGTE UO9

SKAAL 1:2000

Addendum 2

Relevant Municipality Correspondence

Tshwane Letter
Eskom Applications (to follow)

Tel: (012) 542 1010
Fax: (012) 542 2097
Email: burotech@burotech.co.za

BURO TECH

Buro Tech Consulting Engineers CC 141 Main Street Heatherdale PO Box 59887 Karen Park 0118

EMAIL MESSAGE

To:	**TSHWANE METRO**	**From:**	Ralph Gordon
		Cell:	082 601 4588
eMail:	FrankG@TSHWANE.GOV.ZA	**Fax No:**	012 542 2097
For Attention:	Mr. Frank Gibbon	**Tel Nr:**	012 542 1010
Date:	2012 01 20	**E-mail:**	RalphG@burotech.co.za
Page:	**1 of 2**	**Ref:**	PE15/STA

RE: TOWNSHIP DEVELOPMENT OF:
PORTIONS 38, 90, 96 OF THE FARM KLEINFONTEIN 368JR AND ON PORTIONS 63, 67, 68 AND REMAINDER OF PORTION 14 OF THE FARM DONKERHOEK 365JR IN GAUTENG PROVINCE

SUPPLY AUTHORITY:

Dear Sir,

With reference to that above as well as the attached locality map in Google Earth Format the following:

The above proposed development is located within your municipal jurisdiction area. However, Eskom is the supplier of electricity to the existing farm. It does not appear that City of Tshwane have any electrical infrastructure near the proposed development.

We herewith wish to request City of Tshwane to issue us with a formal letter, which will authorise Eskom to supply electricity to the proposed development.

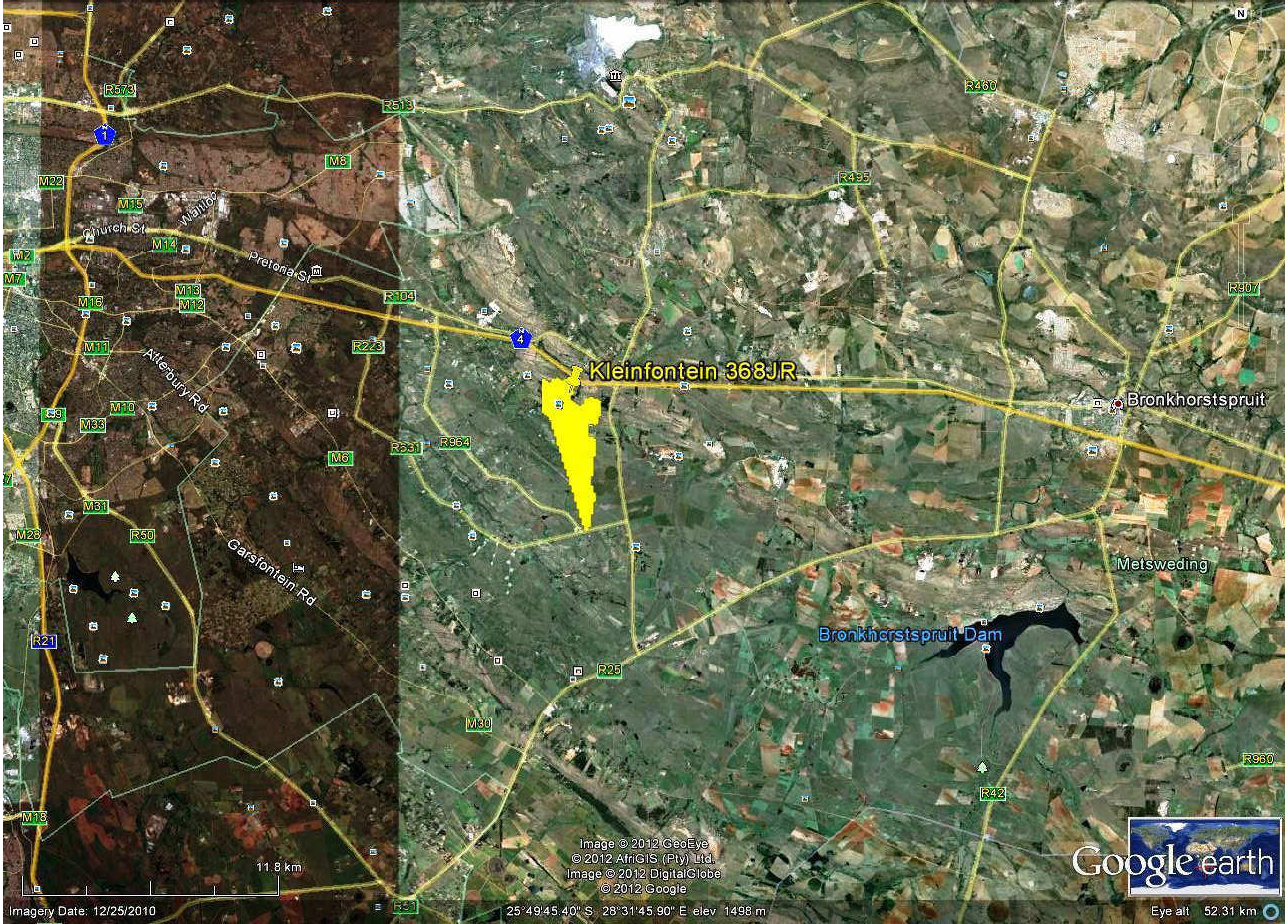
Based on Preliminary Zoning/Usage allocations by the town planners Final Notified Maximum Demand (NMD) should be in the order of 17.6MVA, with the existing NMD estimated to be approximately 1.2MVA.

Your assistance in this regard will be highly appreciated.

Kind Regards

R Gordon (Pr Techni Eng)

Enclosure: Google Earth Locality Map



Kleinfontein 368JR
Bronkhorstspruit
Bronkhorstspruit Dam
Metsweding
Pretoria St
Church St
Atterbury Rd
Garsfontein Rd
11.8 km
Image © 2012 GeoEye
© 2012 AfriGIS (Pty) Ltd.
Image © 2012 DigitalGlobe
© 2012 Google
Imagery Date: 12/25/2010
25°49'45.40" S 28°31'45.90" E elev 1498 m
Eye alt 52.31 km
Google earth

Annexure G(vii)

WATER CONSUMPTION
FIGURES

COMMENTS ON UNIT WATER CONSUMPTION FIGURES IN PVA ENGINEER`S REPORT FOR THE KLEINFONTEIN DEVELOPMENT

It was noticed that the unit water consumption figures used in the report are those that generally apply to normal urban and rural developments in the RSA.

The Kleinfontein development is however in many respects unique, which have a large impact on water consumption.

Fortunately Kleinfontein`s water was metered from an early date and reliable figures are available over the last 11 years. These figures have been analysed in detail as shown in the attachment and differ considerably from the figures used generally in the RSA.

It is however not a case that the low water consumption is due to a high water price as the same low consumption figures were also experienced right from the beginning when the price of water was fairly low. It is also not only the lower income groups in the community that use less water, as the general low water consumption figures apply to all income groups.

The reason for this situation lies in the topography of Kleinfontein and the characteristics of the population, both of which are basically permanent features:

Kleinfontein has developed high up on the slopes of the Magaliesberg. Water pressures will always be relatively low as there will never be a high differential head between the reservoirs and the water users. (Water consumption drops very fast with decreasing water head).

Kleinfontein is a development catering for a cultural group with a specific entrenched outlook on nature. Water is deemed precious and is not wasted. Hardened and indigenous plants and succulents requiring little water are mainly planted. No exotic trees and shrubs, which generally cannot live on rain only, are allowed in open areas and parks. Collecting rainwater from roofs is encouraged. Households are generally self sufficient and owners prefer to water their own gardens which result in the most efficient use of water. Again it is a case of preference and not subject to income as it applies to all walks of life in the development and it will therefore not change in the future as the culture is entrenched in the development.

There is therefore no reason that the actual water consumption figures are used for Kleinfontein for the design of water reticulations, the sizing of pumps, the operation of boreholes, etc. From an environmental perspective, it will also be the correct path to follow as it preserves the area, prevents the over-exploitation of boreholes, protects the ground water and the landscape and will cause a smaller carbon footprint by decreasing the extent of manufactured pipework. It is also the intention of the management of Kleinfontein to regulate water consumption at this lower rate.

The necessary water storage of 48h as for pumping schemes will however still apply but will be based on actual average water consumption in Kleinfontein. Fire water provision will be in accordance with the Red Book.

We make the enclosed attachment with actual measured unit consumption figures for Kleinfontein available for use by all the consultants in the DFA Formalisation Team. Should you have any query on any figure or require the actual unit consumption figure of Kleinfontein for another category, please be free to contact me.

We would therefore appreciate it if the actual Kleinfontein water consumption unit rates are used as a basis in lieu of the estimated RSA unit rates for the formalisation of Kleinfontein in the interest of the environment.

We will also appreciate it if you could point out the actual measured consumption figures in the Tribunal hearing, should anybody complain about unit consumption figures being too low.

Yours faithfully,

Niël de Beer
Chairman KBK Formalisation Coordinating Team

Annexure G(viii)

TRAFFIC REPORT

TECHWORLD
consulting ENGINEERS

<< Tel: +27 12 998 3541
<< Fax: +27 12 993 5506
<< Cell: +27 83 447 9961
<< Email: admin@techworld.co.za

<< Room 101
Sunbird Park
Cnr Delfi & Sunbird Ave
Garsfontein ext 15
South Africa

<< PO Box 12530
Hatfield
0028
South Africa

Traffic Engineering
Transportation Planning
Transport Economy
Project Management
Project Financing & Viability

TRAFFIC INVESTIGATION:

TOWNSHIP ESTABLISHMENT FOR THE KLEINFONTEIN SETTLEMENT

February 2012

TITLE OF REPORT:

TRAFFIC INVESTIGATION:

TOWNSHIP ESTABLSIHMENT FOR THE KLEINFONTEIN SETTLEMENT

DATE: February 2012	**STATUS OF REPORT:** Final Report

CLIENT:

KLEINFONTEIN BOEREBELANGE KOOPERATIEF BEPERK
PO Box 925
Rayton
1001

CONTACT PERSON: Mr. JJ Groenewald

PROJECT NUMBER:	**REPORT NUMBER:**
TW526	Traffic Report_Kleinfontein Settlement_22Feb12

PREPARED BY:

TECHWORLD (Pty) Ltd

P O Box12530

Hatfield 0028

Tel: (012) 998 – 3541

DESCRIPTION OF PROJECT:

This is a scoping report for a traffic investigation in support of the planned township establishment of the Kleinfontein Settlement.

PROJECT TEAM: AUTHOR (S) OF REPORT: CHECKED AND DISTRIBUTION APPROVAL:	Pieter Kruger for TECHWORLD	

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

TABLE OF ANNEXURE

1 INTRODUCTION AND SCOPE

The formalization and expansion of the Kleinfontein Settlement to the east of Pretoria, i.e. formal township establishment, is planned. This proposed township is situated on the Remainder, Portion 38, Portion 90 and Portion 96 of the farm Kleinfontein 368 JR and the remainder of Portion 14, Portion 63, Portion 67 and Portion 68 of the farm Donkerhook 365 JR.

The township comprises about 793.51 ha and is bordered by the N4 Freeway towards the north, Road D483 (Cullinan Road R515) towards the east, Road D631 (Boschkop Road) towards the south, and Road D964 (Donkerhoek Road) towards the west. In the vicinity of the application site, the planned alignment of Route K169 is on the existing alignment of Road D483, the planned alignment of Route K40 is on the existing alignment of Road D631, and the planned alignment of Route K54 / K205 (N) is on the existing alignment of Road D964.

An existing railway line separates a small southern section of the site from the remainder of the site.

The proposed development of the Kleinfontein Settlement is a very low density rural development that comprises of a large percentage (37%) of agricultural stands of about 1.5ha in extent. In total about 1,590 residential units, 174,350 m^2 commercial space (Business 1 and Industrial 1), and 48,270 m^2 institutional space (Institutional 1, Educational, Places of Amusement / Public Worship, and Social Halls) can be developed.

The Site Layout Plan (attached as *Appendix A*) shows that a large portion of the site will be used for open space, roads, and ancillary uses. Only about 361.22 ha or 46% of the total site will be used for the stated land uses that will directly contribute to trip generation.

The Kleinfontein Settlement is located to the east of the planned Hazeldean Precinct (attached as *Appendix B*) which is a large high-density residential development with supporting commercial facilities. The two development areas however are not comparable in terms of their expected trip generation and traffic impact.

Refer to *Figure 1* and *Figure 2* (attached).

2 EXISTING AND PLANNED ROAD NETWORK

2.1 PWV MAJOR ROAD NETWORK

The PWV major road network in this area is shown in *Figure 2*. This figure shows that the application site is surrounded / bordered by planned provincial roads and freeways, namely Routes K169, K40, and K54 / K205 (N) in the immediate vicinity of the site, and PWV 17 further towards the west.

In the immediate vicinity of the site, planned Route K169 follows the existing alignment of Road D483 (Cullinan Road), planned Route K40 follows the existing alignment of Road D631 (Boschkop Road), while planned Route K54 / K205 (N) follows the existing alignment of Road D964 (Donkerhoek Road).

Access to the freeway network (i.e. the N4 Freeway) is obtained via the D483 / N4 interchange.

The regional accessibility of the application site is excellent, given the major road network planning in the immediate vicinity of the site.

2.1.1 ROAD RESERVE REQUIREMENTS

None of the planned K-routes transverses the application site although the most southern point of the application site is bordered by the road reserve for Route K40. The appropriate road reserve for this route will be provided by the application site. Refer to *Figure 2* and *Appendix A*.

2.1.2 PLANNING STATUS OF PROVINCIAL ROADS

The following is the status of the provincial roads in this area:

- *The preliminary design of Route K169 is completed only for a section of this road that crosses the planned alignment of Route K40. The same applies for Route K40 to the west of Route K169. These route sections however have not been accepted by the EC of Gautrans and have also not been gazetted.*

- *Preliminary design has been completed, accepted by the EC, and published in the Provincial Gazette for Route K54 in this area (PRS 86/153 – Report No 1487 – EC date 2002/05/22).*

- *No preliminary design has been done for Route K205 (N) in this area.*

Routes K169 and K205 (N) are located more than 500m from the application site.

In terms of the stipulations of the Gauteng Infrastructure Act of 2001, a Section 7 Report is thus required only for Route K40.

2.1.3 OTHER PROVINCIAL ROADS

The only other provincial road that is affected by the application site is Road D1342. This is an existing Class 3 provincial road that transverses the application site and is known as the Rhenosterfontein Road. Although a new alignment is shown on the PWV Major Roads Plan through the application site – assumingly to follow a more direct line towards the east - no detailed planning was done to support this proposal. This section of route can therefore follow the alignment of the existing Rhenosterfontein Road through the application site.

The alignment and required road reserve of 30m for Road D1342 will have to be determined and kept out of the township.

Refer to *Figure 2* and *Appendix A*.

2.2 TSHWANE ROAD MASTER PLAN

The Tshwane Road Master Plan, attached as *Figure 3*, does not cover the study area for the application. This road master plan has to be extended in an eastern direction to include the newly incorporated areas of Kungwini.

Recent attempts to develop a road master plan for this area are shown in *Figure 4*. This plan also does not include the application site and has no status.

The Road Master Plan for Tshwane will have to be extended in an eastern direction to accommodate the planned development.

2.3 ACCESS

Access to the area is currently obtained from a Northern Access Road connected to Road D483 (Route K169) approximately 640m south of the Southern Terminal of the N4 / D483 Interchange and directly from Road D1342 (Rhenosterfontein Road) at a few positions.

Additional access can also be obtained in future directly from Road D631 (Route K40) approximately 1.2km from the future intersection of Route K40 with Route K 205 (N).

The existing railway line however separates the southern section – and this new access – from the remainder of the application site. Refer to *Appendix A*.

3 FUNDING OF REQUIRED TRANSPORTATION SERVICES AND ROAD NETWORK IMPROVEMENTS

Limited funding from local authorities for the required infrastructure and transportation service improvements to sustain development has lately resulted in developers providing most of this funding through the direct improvement of the road network in the vicinity of application sites.

The applicant for this township will also contribute to the road network by providing the required road infrastructure to support the development.

Densification is taking place in the eastern areas of Tshwane – formerly Kungwini - that includes large planned areas such as the Hazeldean Precinct. All these applications must contribute to the road network in the study area.

4 EXPECTED TRAFFIC IMPACT OF DEVELOPMENT

4.1 APPLICATION

The land uses included in the application are the following (refer to *Appendix A*):

Table 4-1: Planned Land Uses

Land Use	Erven	Area	Development Control		Developable Land Use	
	no	ha	Extent	Unit	Extent	Units
Residential 1	782	24.87	1.00	unit/erf	782	units
Residential 2	80	5.71	15-60	units/ha	214	units
Business 1	13	13.99	0.50	FSR	69,950	sqm
Industrial 1	52	11.66	0.90	FSR	104,400	sqm
Institutional 1	1	0.35	0.60	FSR	2,100	sqm
Agricultural	198	294.63	3.00	units/erf	594	units
Educational	1	3.41	0.50	FSR	17,050	sqm
Special for Cemetery & Funeral Parlour	2	1.49				

Land Use	**Erven**	**Area**	**Development Control**		**Developable Land Use**	
	no	ha	**Extent**	**Unit**	**Extent**	**Units**
Special for Private Open Space	14	214.00				
Special for Workshop, Maintenance	1	1.00	0.50	coverage		
Special for Public Garage, Shop, Industrial	1	0.16	0.50	coverage		
Special for Engineering Services	3	0.24				
Special for Sewer Works	1	16.10				
Special for Place of Amusement	6	1.82	0.80	FSR	14,560	sqm
Special for Telecommunication	1	1.87				
Special for Private Open Space and Social Hall	2	4.78			14,560	sqm
Special for Access Control	2	0.37				
Special for Internal Access	40	87.89				
Undetermined	13	107.70	10%-20%	coverage		
Public Road	0	1.39				
TOTAL	**1214**	**793.51**				
SUMMARY	**Units**				**1,590**	**Residential**
	m^2				**174,350**	**Commercial**
	m^2				**48,270**	**Institutional**

The Kleinfontein Settlement / Township are a very low density rural development that comprises of a large percentage (37%) of agricultural stands of about 1.5ha in extent. In total about 1,590 residential units, 174,350 m^2 commercial space (Business 1 and Industrial 1), and 48,270 m^2 institutional space (Institutional 1, Educational, Places of Amusement / Public Worship, and Social Halls) can be developed.

The stated land uses will only comprise about 361.22 ha or 46% of the total area. The remainder will be used for open space, roads, and ancillary uses.

4.2 EXPECTED TRIP GENERATION

The expected private vehicle trip generation of the application is based on very conservative estimates at this stage and amounts to about 3,845 weekday peak hour trips.

Table 4-2: Expected Trip Generation

DESCRIPTION	AREA (HA)	DEVELOPMENT CONTROL	UNIT	EXTENT OF LAND USE	UNITS	PEAK HOUR TRIPS
Residential 1	24.87	1.00	unit/erf	782	units	782
Residential 2	5.71	15-60	units/ha	214	units	182
Business 1	13.99	0.50	FSR	69,950	sqm	1749
Industrial 1	11.66	0.90	FSR	104,400	sqm	835
Agricultural	294.63	3.00	units/erf	594	units	297
TOTAL						**3845**

The expected trip generation of the application translates to uniform development over the total area of the site at a FAR of 0.20 to 0.25 and trip rates of 0.20 to 0.25 / 100 m^2 GLA; i.e. a very low intensity development.

4.3 EXISTING TRAFFIC DEMAND VERSUS SUPPLY IN THE STUDY AREA

Figure 5 shows the existing (2010 and 2011) traffic demand in the study area in terms of average 12-hour and daily traffic counts on the various road linkages.

All the roads in the study area are currently two-lane provincial roads. The daily capacity of a two-lane road depends on the type of terrain, the percentage no-passing zones / bypassing lanes, directional distribution, the percentage heavy vehicles, and the percentages traffic in the peak hours.

For the particular study area however, the daily capacity is at least 10,000 vehicles per day.

It is evident from inspection of *Figure 5* that the capacity - in general - of the existing road network in the area is sufficient to support the planned development.

Specific bottlenecks that will have to be investigated further include the following:

- Terminals of D483 (Cullinan Road) / N4 interchange;
- Intersection D483 (Cullinan Road) and Northern Access Road (Access);
- Intersection D483 (Cullinan Road) and Road D964 (Rhenosterfontein Road) (Access);
- Intersection Road D483 (Cullinan Road) and Road D631 (Boschkop Road);
- Intersection Road D483 (Cullinan Road) and Road P6/1 (Bapsfontein Road);
- Intersection Road D964 (Donkerhoek Road) and Road D631 (Boschkop Road);
- Intersection Road D631 (Boschkop Road) and Road D2762 (Graham Road);

4.4 REQUIRED TRANSPORTATION SERVICES AND INFRASTRUCTURE TO SERVE APPLICATION

4.4.1 PUBLIC TRANSPORTATION

Public transportation will play an increasingly important role to serve the urban areas in South Africa given that private transportation is not sustainable and the promotion of public transportation is stated government policy.

The role of public transportation will thus be investigated for this application and the required public transportation services and facilities will be provided.

4.4.2 ROAD NETWORK

The required upgrading of the road network will be determined to serve the application. This will entail the upgrading of Road D1342 (Renosterfontein Road) as well as the following intersections:

- Northern Access Road (existing) with Road D483;
- Road D1342 (existing Renosterfontein Road) with Road D483;
- Southern Access Road (new road) with Road D631;

In addition, the potential bottlenecks in the network – listed in *Section 4.3* - will be assessed from a capacity and operational point of view.

The scope of these improvements can only be determined at a later stage when more information is available; i.e. phased development plan, and more detail on the planned land uses.

5 MITIGATION MEASURES AND ROADS AND STORM WATER CONTRIBUTIONS

The applicant is committed to implement the required road mitigation measures to accommodate the additional traffic in terms of the findings of a comprehensive traffic impact study when the execution of this study is possible.

6 CONCLUSIONS

1. The formalization and expansion of the Kleinfontein Settlement to the east of Pretoria is planned. This proposed township is situated on the Remainder, Portion 38, Portion 90 and Portion 96 of the farm Kleinfontein 368 JR and the remainder of Portion 14, Portion 63, Portion 67 and Portion 68 of the farm Donkerhoek 365 JR.

2. The township comprises about 793.51 ha and is bordered by the N4 Freeway towards the north, Road D483 (Cullinan Road R515) towards the east, Road D631 (Boschkop Road) towards the south, and Road D964 (Donkerhoek Road) towards the west.

3. In the immediate vicinity of the site, planned Route K169 follows the existing alignment of Road D483 (Cullinan Road), planned Route K40 follows the existing alignment of Road D631 (Boschkop Road), while planned Route K54 / K205 (N) follows the existing alignment of Road D964 (Donkerhoek Road).

4. The regional accessibility of the application site is excellent, given the major road network planning in the immediate vicinity of the site.

5. None of the planned K-routes transverses the application site although the most southern point of the application site is bordered by the road reserve for Route K40. The appropriate road reserve for this route will be provided by the application site.

6. In terms of the stipulations of the Gauteng Infrastructure Act of 2001, a Section 7 Report is required only for Route K40.

7. The only other provincial road that is affected by the application site is Road D1342. This is an existing Class 3 provincial road that transverses the application site and is known as the Rhenosterfontein Road. Although a new alignment is shown on the PWV Major Roads Plan through the application site – assumingly to follow a more direct line towards the east - no detailed planning was done to support this proposal. This section of route can therefore follow the alignment of the existing Rhenosterfontein Road through the application site. The alignment and required road reserve of 30m for this road will have to be determined and kept out of the township.

8. The Tshwane Road Master Plan does not cover this area. This road master plan has to be extended in an eastern direction to include the newly incorporated areas of Kungwini.

9. Access to the area is currently obtained from a Northern Access Road connected to Road D483 (Route K169) approximately 640m south of the Southern Terminal of the N4 / D483 Interchange and directly from Road D1342 (Rhenosterfontein Road) at a few positions. Additional access can also be obtained in future directly from Road D631 (Route K40) approximately 1.2km from the future intersection of Route K40 with Route K 205 (N).

10. Limited funding from local authorities for the required infrastructure and transportation service improvements to sustain development has lately resulted in developers providing most of this funding through the direct improvement of the road network in the vicinity of application sites. The applicant for this township will also contribute to the road network by providing the required road infrastructure to support the development.

11. The Kleinfontein Settlement / Township are a very low density rural development that comprises of a large percentage (37%) of agricultural stands of about 1.5ha in extent. In total about 1,590 residential units, 174,350 m^2 commercial space (Business 1 and Industrial 1), and 48,270 m^2 institutional space (Institutional 1, Educational, Places of Amusement / Public Worship, and Social Halls) can be developed.

12. The expected private vehicle trip generation of the application is based on very conservative estimates at this stage and amounts to about 3,845 weekday peak hour trips.

13. The expected trip generation translates to uniform development over the whole site at a FAR of 0.20 to 0.25 and trip rates of 0.20 to 0.25 / 100 m^2 GLA; i.e. a very low intensity development.

14. All the roads in the study area are currently two-lane provincial roads. The daily capacity of a two-lane road depends on the type of terrain, the percentage no-passing zones / bypassing lanes, directional distribution, the percentage heavy vehicles, and the percentages traffic in the peak hours. For the specific study area however, the daily capacity is at least 10,000 vehicles per day.

15. It is evident from inspection of the existing traffic demand in the study area that the capacity - in general - of the existing road network in the area is sufficient to support the planned development. Specific bottlenecks that will have to be investigated include the following:

- Terminals of D483 (Cullinan Road) / N4 interchange;
- Intersection D483 (Cullinan Road) and Northern Access Road (Access);
- Intersection D483 (Cullinan Road) and Road D964 (Rhenosterfontein Road) (Access);
- Intersection Road D483 (Cullinan Road) and Road D631 (Boschkop Road);
- Intersection Road D483 (Cullinan Road) and Road P6/1 (Bapsfontein Road);
- Intersection Road D964 (Donkerhoek Road) and Road D631 (Boschkop Road);
- Intersection Road D631 (Boschkop Road) and Road D2762 (Graham Road);

16. The required upgrading of the road network will still be determined to serve the application. This will entail the upgrading of Road D1342 (Renosterfontein Road) as well as the following intersections:

- Northern Access Road (existing) with Road D483;
- Road D1342 (existing Renosterfontein Road) with Road D483;
- Southern Access Road (new road) with Road D631;

17. In addition, the potential bottlenecks in the network – listed in *Section 4.3* - will be assessed from a capacity and operational point of view. The scope of these improvements can only be determined at a later stage when more information is available; i.e. phased development plan, and more detail on the planned land uses.

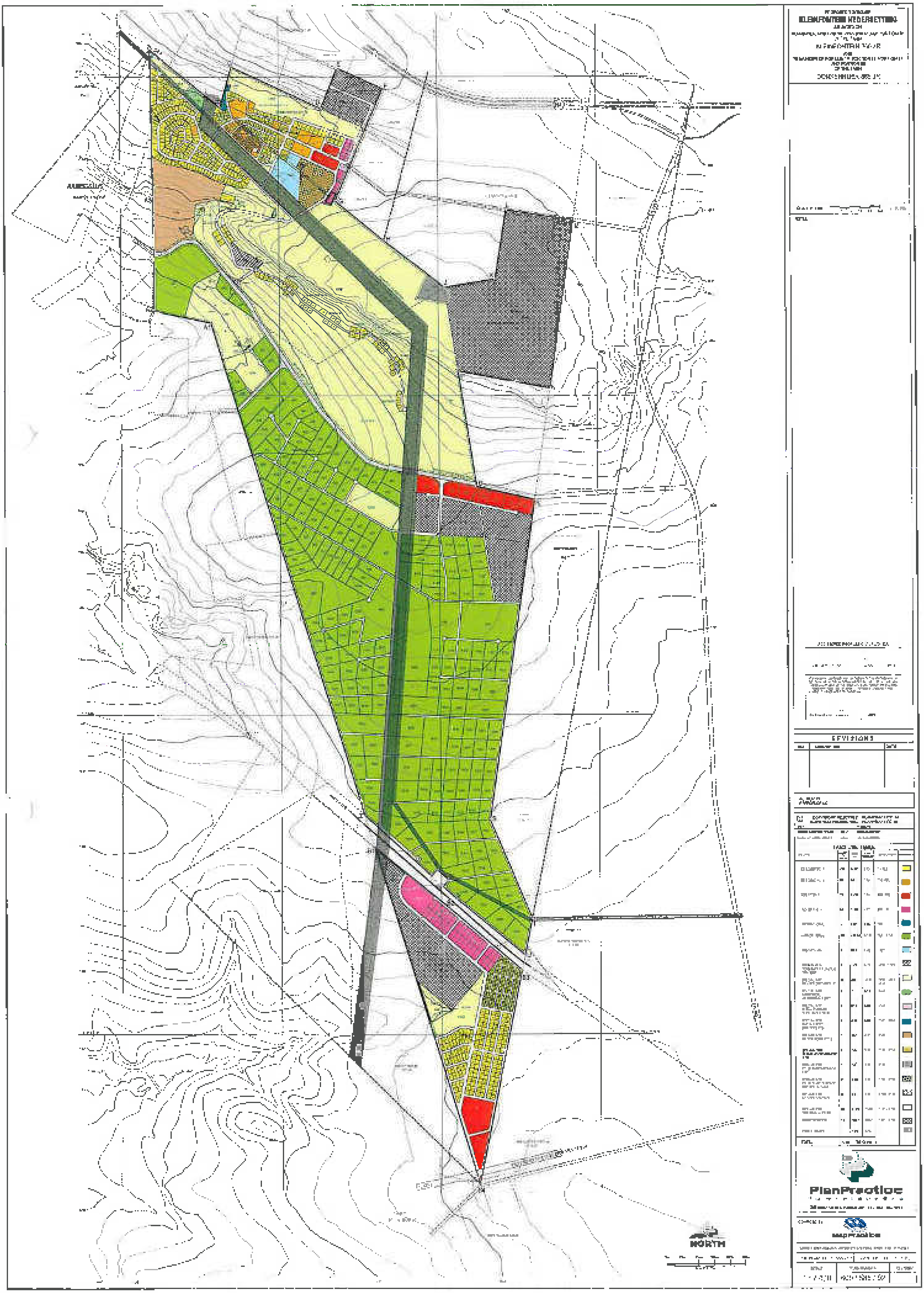
7 RECOMMENDATION

A comprehensive traffic impact study will be submitted for this application in due course.

The applicant is committed to his fair share in road mitigation measures by means of direct road construction. This will be done in a phased manner.

FIGURES

ANNEXURES

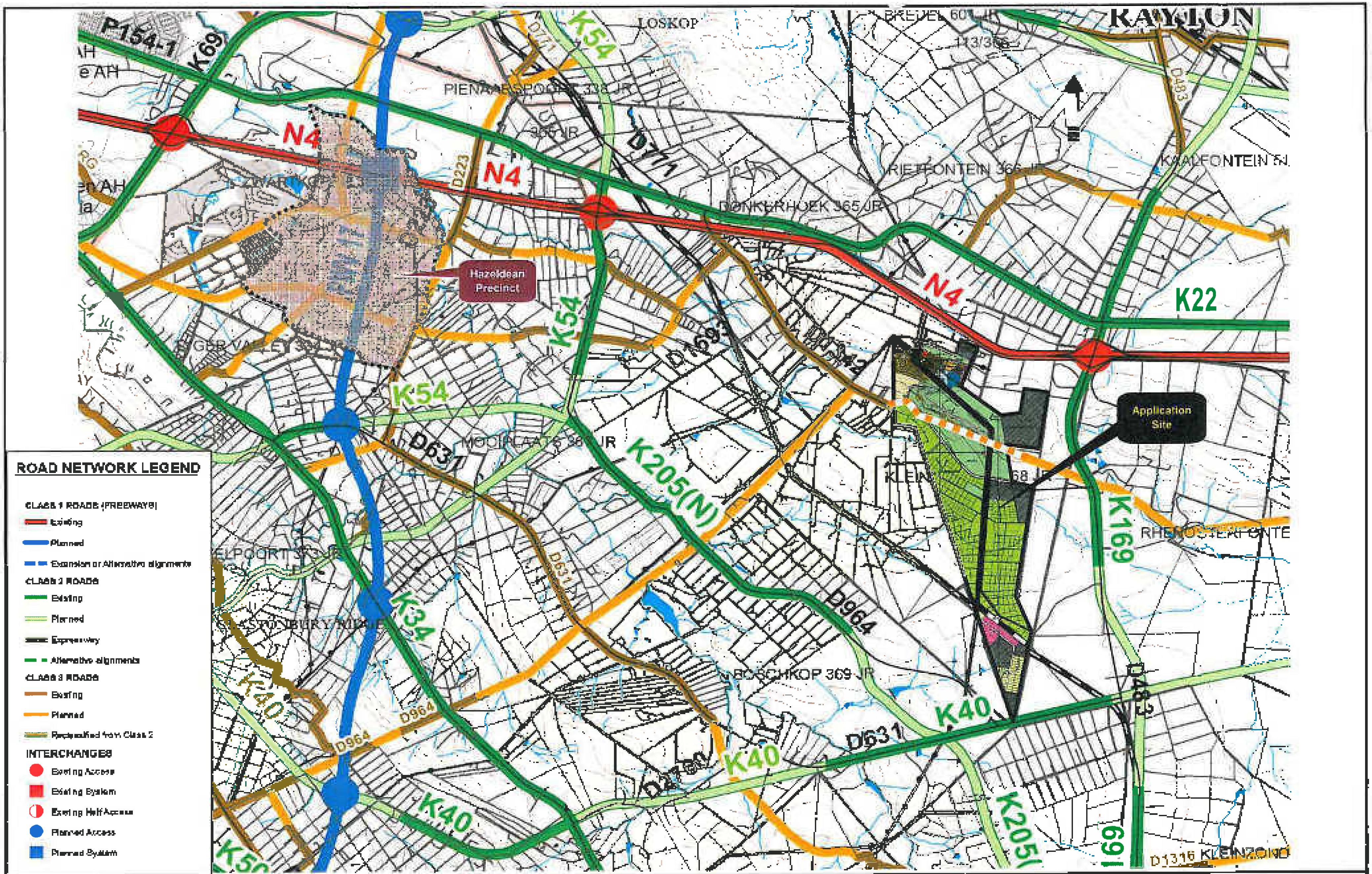

REVISIONS
PlanPractice
NORTH

Hazeldean

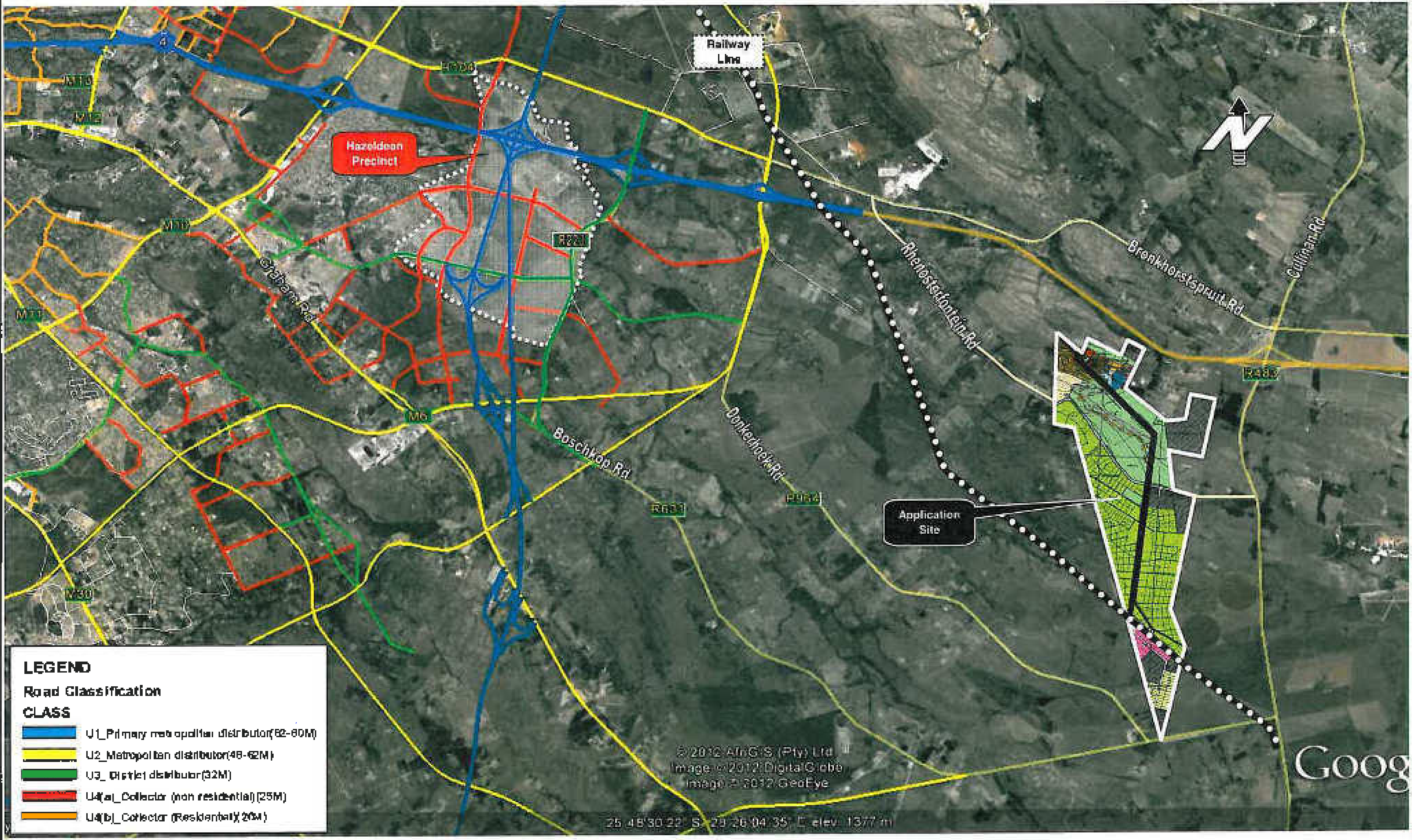
FULL CIRCLE LIVING

Abland Sable Abreal Sahreal SiVEST

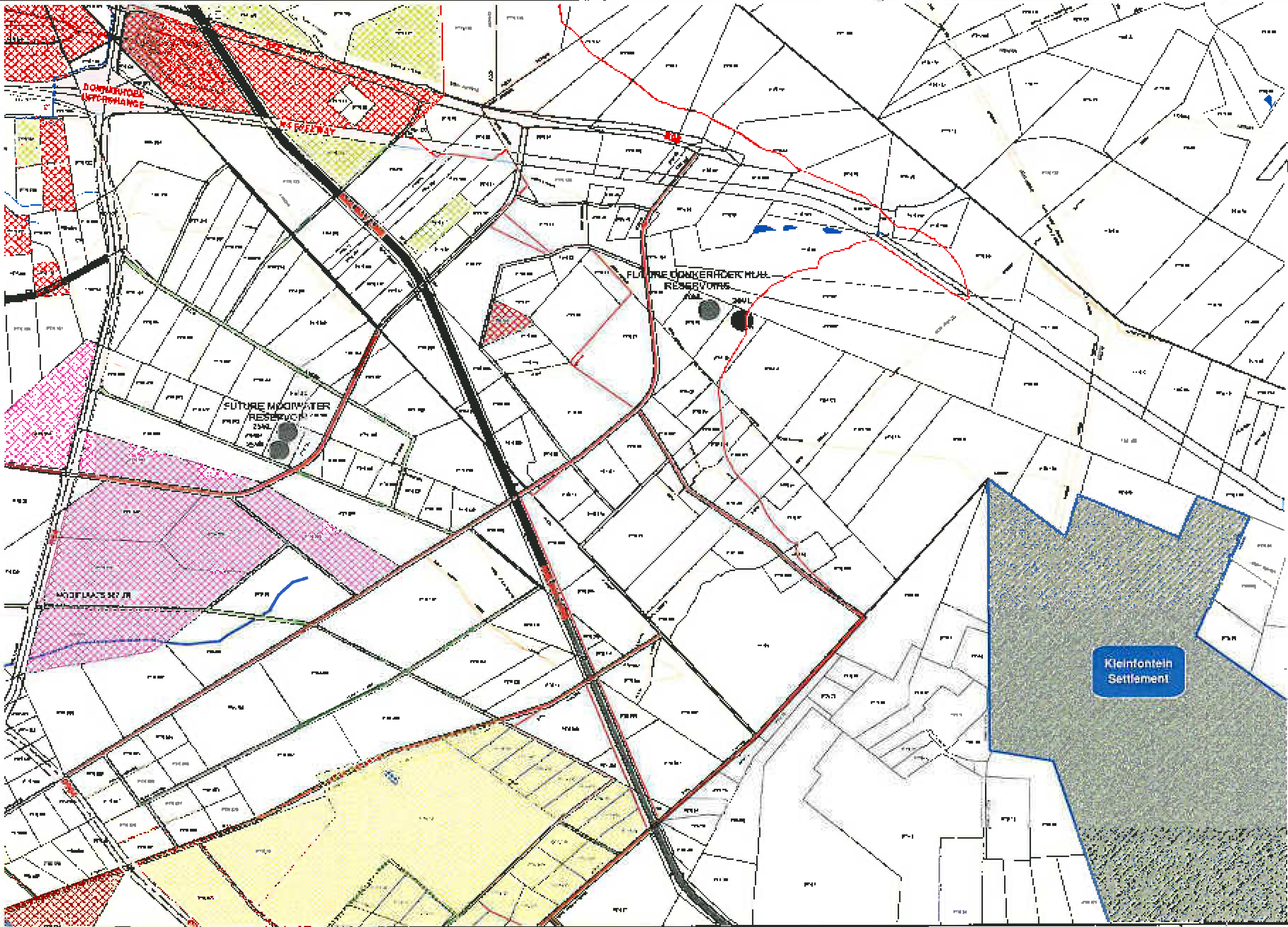
TECHWORLD	KLEINFONTEIN SETTLEMENT	Locality Plan and Existing Road Network	FIGURE 1



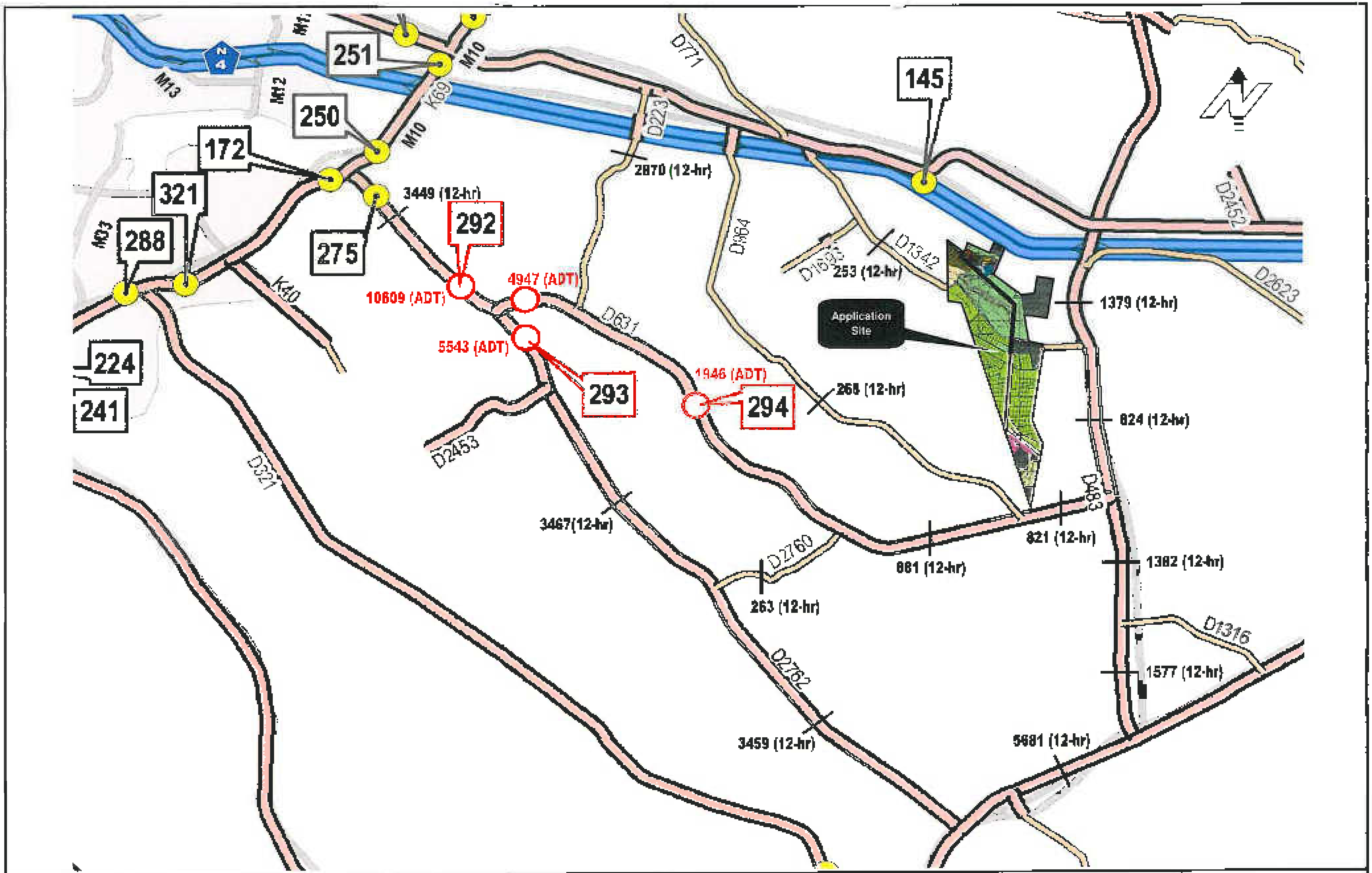
TECHWORLD	KLEINFONTEIN SETTLEMENT	PWV Major Road Network	FIGURE 2



TECHWORLD	KLEINFONTEIN SETTLEMENT	Tshwane Road Master Plan	FIGURE 3



TECHWORLD	KLEINFONTEIN SETTLEMENT	Eastern Extension of Tshwane Road Master Plan	FIGURE 4



KLEINFONTEIN SETTLEMENT	Existing 12-Hour and Daily (2010 / 2011) Traffic Demand in Study Area	FIGURE 5