TRANS-CALEDON TUNNEL AUTHORITY

METSI BOPHELO BOREHOLE PROJECT-NORTH WEST PROVINCE

GROUNDWATER EXPLORATION

AT

LOGAGENG

MARCH 2012

DOCUMENT NUMBER

107014	**LOG**	**2012**

Compiled by

aurecon

Project Title:	Groundwater Exploration at Logageng
Location:	Logageng, North West Province
Co-ordinates (WGS84):	S 25.94579^0 S 24.69226^0
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1 INTRODUCTION

Trans-Caledon Tunnel Authority (TCTA) appointed Aurecon to perform a groundwater exploration program in the vicinity of the village of Logageng in the North West Province as part of the Metsi Bophelo Borehole Project. The program consisted of the following:

1. Desk Study.
2. Borehole Siting by means of a ground geophysical survey.
3. Appointment of a drilling contractor and supervising the drilling of 8 boreholes.
4. Appointment of a pumptest contractor and yield and quality testing of 3 boreholes.
5. Report on the findings and management recommendations.

This report is not intended to be an exhaustive description of the exploration program, but rather a summary of the most important findings & management recommendations which should be used for the equipping of the boreholes to feed into the reticulation system and possible future groundwater exploration.

2 AVAILABLE INFORMATION

The following information was available and was used in the investigation:

- 1:250 000 Geological Map (2624 Vryburg).
- 1:500 000 Geohydrological Map (2522 Vryburg)

3 DESK STUDY

3.1 Location

The village of Logageng is located ~95km west of Mafikeng in the North West Province and 12km south of the Botswana-South Africa border with coordinates (S25.933689° E24.687921°). It is accessible from the R375 via the R376 linking Setlagole with Logageng.

3.2 Geology & Geohydrology

According to the 1:250 000 geological map (2524 Mafikeng), the study area is underlain by several different lithological units. The area is underlain by deposits of Aeolian sand from the Gordonia formation, Kalahari Group, as well as siliceous sandstone, pebble conglomerate, gritstone and silcrete, also of the Kalahari group.

A narrow band of differing geology is exposed by the Setlagole River that runs through the area in a north westerly-south easterly direction. This band consists of variegated banded jaspilite, jaspilite and chert, as well as basic lava with interbedded banded ironstone, pillow lava and rhyolite as well as green schist of the Kraaipan Group. Calcrete deposits from the Tertiary Era are also present. The logs obtained from drilling confirmed the geology.

Based on the 1:500 000 geohydrological map (2522 Vryburg), Logageng is situated on a fractured aquifer type. A successful borehole in this fractured aquifer has a potential yield of 360 to 1800 l/h. In terms of groundwater quality, the map shows that the electrical conductivity in the majority of the boreholes range between 0 and 300 mS/m with NO_3-N concentration generally exceeding 10 mg/l.

3.3 Groundwater Recharge

The study area falls within quaternary catchment D41B. The mean annual precipitation and annual recharge figures for this quaternary catchment is presented in Table 1. The values used were derived from the WR90 data set as contained in the "Groundwater Resources Directed Measures" software (Version 4.0.0.0) developed by the Department of Water Affairs and the Water Research Commission.

Table 1. Rainfall & Recharge in Quaternary Catchment D41B

	D41B
Mean Annual Rainfall (mm)	443
Annual Recharge (mm)	9.9
Annual Recharge (%)	2.2

4 GEOPHYSICAL SURVEY

Borehole siting is primarily concerned with the location of geological discontinuities, as higher borehole yields are generally associated with such features. Apart from direct geological observation, which is the most satisfactory method of borehole location where it can be practised, potential groundwater bearing discontinuities can be located either by remote sensing methods or surface geophysical methods. Only ground geophysics was used for this program as no remote sensing data was available.

After a desk study and taking distances to existing infrastructure into account, it was decided to perform ground geophysical surveys in 8 areas as shown in Map 3 in Appendix A.

A combination of the magnetic (proton magnetometer), electro-magnetic (GEONICS EM-34) and the resistivity method (Abem-Lund Terrameter) was used to conduct the survey. The location of the traverses is presented in Appendix A while the geophysical profiles and selected drilling targets are presented in Appendix B.

5 BOREHOLE DRILLING

After completion of the geophysical survey and interpretation of the results, eight boreholes were drilled by Coenraad Malan Drilling from Klerksdorp during August 2012 using an air percussion drilling rig. Based on the desk study, the average depth of boreholes in the area exceeds a 150 meters and it was decided to drill boreholes 160 meters deep. Five of the boreholes were drilled on geophysical anomalies while three boreholes were drilled adjacent to existing boreholes which had been vandalised. It was decided to re-drill existing boreholes due to a combination of local knowledge identifying historically high yielding boreholes and taking existing infrastructure (pipelines, electricity, etc.) into account. A summary of the newly drilled boreholes are presented in Table 2 and the location of the boreholes are presented in Appendix A. Detailed borehole logs are presented in Appendix C.

Table 2. Summary of the newly drilled boreholes around Logageng

Successful Boreholes						
BH No.	**S (WGS84)**	**E (WGS84)**	**Depth (m)**	**Dia. (mm)**	**Water strikes**	**Blow Yield (l/h)**
LBH 8	25.94633	24.69183	160	171	140 & 150	6000
LBH 9	25.94971	24.71037	160	171	61	1500
LBH 12	25.94250	24.71772	160	171	48 & 121-124	6000
Unsuccessful Boreholes						
BH No.	**S (WGS84)**	**E (WGS84)**	**Depth (m)**	**Dia. (mm)**	**Water strikes**	**Blow Yield (l/h)**
LBH 4	25.95498	24.70440	160	171	None	Dry
LBH 5	25.92077	24.66821	160	171	None	Dry
LBH 10	25.94261	24.69815	160	171	None	Dry
LBH 11	25.93557	24.70144	144	171	None	Dry
LBH 13	25.94250	24.71772	160	171	None	Dry

6 PUMP TESTING OF SUCCESFULL BOREHOLES

Upon completion of the drilling, Trans Africa Water Services from Pretoria conducted pump tests on the 3 successful boreholes. Aurecon supervised the testing to ensure that the “DWAF Standard Guidelines for Pump Testing” were adhered to.

A step test followed by 24 hour Constant Discharge Test & Recovery Monitoring was performed on the boreholes. Pump test data sheets are presented in Appendix F. Background information on the details of pumptesting is presented in the following paragraphs. Background information on the details of pump testing is presented in the following paragraphs.

6.1 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.

The following tests were performed on the boreholes: (1) Stepped Discharge Test; (2) Constant Discharge Test and (3) Recovery Monitoring.

6.1.1 Stepped Discharge Test

Also known as a step drawdown test, it is performed to assess the productivity of a borehole. It also serves to more clearly define the optimum yield at which the borehole can be subjected to constant discharge testing. The test involves pumping the borehole at three or more sequentially higher pumping rates each maintained for an equal length of time, generally not less than 60 minutes. The magnitude of the water level drawdown in the borehole in response to each of these pumping rates is measured and recorded in accordance with a prescribed time schedule.

6.1.2 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. The test duration is usually between 24 and 74 hours.

6.1.3 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.

7 CALCULATING THE SUSTAINABLE YIELD OF THE BOREHOLE

Data acquired during pumptesting of the boreholes was used to calculate the sustainable yield of the tested boreholes. The sustainable yield of a borehole can be defined as the discharge rate that will not cause the water level to drop below the major fracture network supplying water to the borehole. The distance between the static water level and this position is also generally referred to as the available drawdown (AD). The major water strike is obtained through observation during drilling supervision or can be more accurately detected from diagnostic plots compiled from the pumping test data. The water level in the borehole should never drop below the position of the main fracture.

The Flow Characterisation Method (more commonly referred to as the “FC-Method”) developed by the Institute of Groundwater Studies at the University of the Free State was used to calculate the sustainable yield of the boreholes. The FC-Method calculates the sustainable yield of a borehole by using recharge, derivatives, boundary information and error propagation. The results of the calculation of the sustainable yield are presented in and the FC-Solutions in Appendix D.

Table 3. Results of the sustainable yield calculations

Borehole nr.	Depth (m)	Static Water Level (m)	Available Drawdown (m)	Sustainable Yield (l/h) Pumping 24 hours/day	Sustainable Yield (l/h) Pumping 12 hours/day	Volume/day (m^3)
LBH 8	160	69.86	70	1440	2880	34.6
LBH 9	160	30.6	30	Borehole has too low yield to justify equipping of borehole with any pump other than handpump.		
LBH 12	160	18.49	102	2880	5760	69.1
			TOTAL VOLUME/DAY (m^3)			**103.7**

Based on the available data, it can be concluded that a total volume of **103.7 m^3/day** can be safely abstracted from the tested boreholes.

8 GROUNDWATER QUALITY

A pumped water sample were collected from each borehole towards the end of the pump test and submitted to Clean Stream Scientific Services (SANAS accredited laboratory) for a major cation/anion analysis. Laboratory reports of the chemical analysis are presented Appendix E. The analytical results were compared with the SABS drinking water standards (SANS 241:2006, edition 6.1) (Table 4). Water is classified according to their suitability for human consumption:

- Class I: Recommended operational limit.
- Class II: Maximum allowable concentration for short term use only.

Table 4. Chemical parameters compared to SANS 241:2006 (edition 6.1) drinking water standards

Sample Nr.	LBH8	LBH9	LBH12			Class I	Class II
Ca	86.94	92.83	30.47			150	300
Mg	37.22	31.52	13.77			70	100
Na	38.40	20.17	6.12			200	400
K	3.24	2.24	1.07			50	100
Mn	0.09	0.14	0.24			0.1	1
Fe	0.00	0.00	0.00			0.2	2
F	0.19	0.49	0.00			1	1.5
NO_3-N	0.62	0.58	0.90			10	20
NH_4-N	0.00	0.00	0.00			0.94	1.87
Cl	29	15	5			200	600
SO_4	4	0	0			400	600
TDS	419	369	133			1000	2400
pH	7.91	7.59	7.19			5.0 - 9.5	4.0 - 10.0
EC	68	64	25			150	370

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

EC measurements in mS/m, other parameters in mg/ℓ

From Table 4 it can be concluded that the water quality in boreholes LBH9 and 12 can be classified as Class 2 due to increased Manganese concentrations. The concentrations falls within the 0.1-1 mg/l category with no health risk posed. Moderate staining of clothes and fixtures may occur after extended use as well as an objectionable metallic taste. No other chemical parameter tested for exceed the Class 1 standard in these boreholes.

Borehole LBH8 falls within Class 1 standards and is fit for human consumption.

Pumping and blending of water originating from boreholes LBH8, 9 and 12 to a common reservoir would most probably increase the blended water quality to Class 1 making it ideal and fit for human consumption.

9 MANAGEMENT RECOMMENDATIONS

Based on the desk study, field work and interpretation of available and newly acquired data, Table 5 was compiled which summarises management recommendations for the newly tested boreholes. This data should be used by the relevant engineer who is responsible for the equipping of the borehole.

Table 5. Management recommendations for newly drilled boreholes

Borehole nr.	Coordinates (WGS84)		Depth (m)	*SWL (m)	#Dynamic WL (m)	Diameter (mm)	Sustainable Yield (l/h) 24h/day (12h/day)	Volume/day (m^3)	Proposed depth of pump installation (m)	Water Quality (SANS 241)	Comments
	S	E									
LBH-8	25.94633	24.69183	160	69.86	80	171	1440 (2280)	34.6	130	Class 1	Borehole ready to be equipped and commisioned with excellent water quality.
LBH-9	25.94971	24.71037	160	30.6	~	171	Handpump	~	50	Class 2	Borehole ready to be equipped and commisioned. Water falls within Class 2 water quality due to slight elevated Manganese concentrations. No health effects.
LBH-12	25.94250	24.71772	160	18.49	40	171	2880 (5760)	69.1	110	Class 2	Borehole ready to be equipped and commisioned. Water falls within Class 2 water quality due to slight elevated Manganese concentrations. No health effects.
						Total volume/day (m^3)		**104**			

** Static Water level*
 # Water level stabilises at this level during pumping

Furthermore, the following recommendations are made with regards to the management of boreholes at Logageng:

- Boreholes should not be pumped at a pumping rate exceeding the calculated sustainable yield.
- A groundwater monitoring system should be implemented. Water samples for chemical analysis should be taken on a three monthly basis and water levels should be measured on a monthly basis. This would act as an early warning system. Should a sudden decrease in water levels occur, borehole yields should be adapted accordingly. Automatic borehole loggers could also be installed.
- Care must be taken not to develop and build potential pollution sources (french drains, septic tanks, pit latrines, livestock kraals, etc.) close to and upstream from boreholes.

A number of existing boreholes (Table 6) with pump houses, etc. was identified during the exploration program and is currently not in operation. The location of these boreholes is presented in the locality map in Appendix A. An existing pipeline also connects these boreholes with the village of Logageng. These boreholes should be pumptested, water quality tested and if found feasible, equipped and connected to the current water reticulation system.

Table 6. Existing boreholes to be pumptested

Borehole nr.	Lat (WGS 84)	Long (WGS 84)	Equipment	Condition
BH3	S25.93622	E24.71634	Monopump, no engine	Good condition, ready to be pumptested
BH4	S25.92504	E24.72805	Monopump, no engine	Good condition, ready to be pumptested
BH5	S25.92585	E24.72790	Monopump, no engine	Good condition, ready to be pumptested

Further groundwater exploration at Logageng can also be considered. Based on data acquired during this investigation, Aurecon proposes alternative geophysical methods to site boreholes. The very thick sand cover warrants to apply siting using a combination of DC Resistivity & CSAMT (Controlled Source Audio Magneto-tellurics) – (Geometrics Stratagem) methods. Furthermore, a drilling depth of 200 m is recommended.

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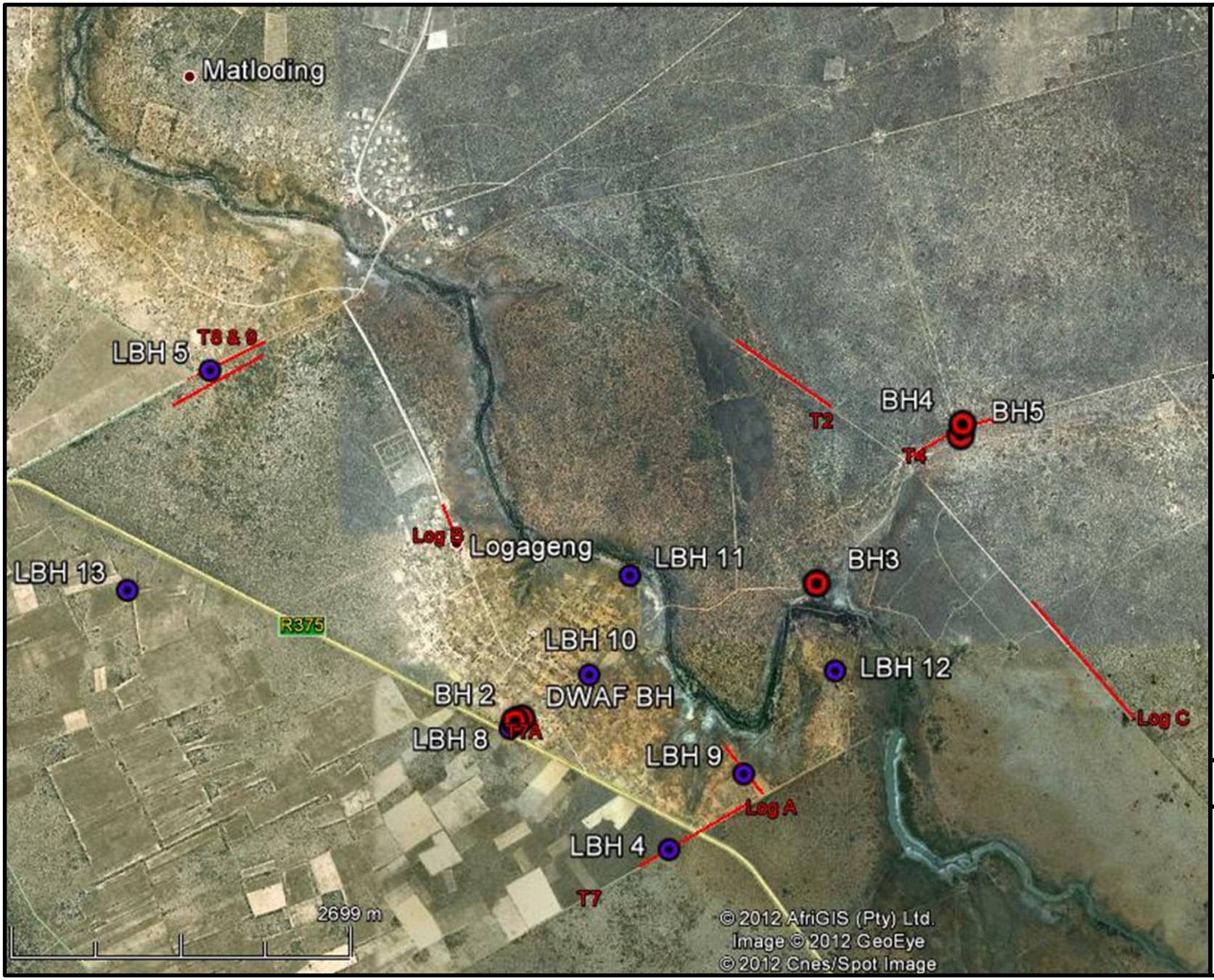
APPENDIX A

LOCALITY MAP SHOWING BOREHOLE & GEOPHYSICAL SURVEY LOCATIONS



Project Title:

METSI BOPHELO BOREHOLE PROJECT-NORTH WEST PROVINCE

Map Title:

Logageng: Geophysical Traverses , Newly Drilled Boreholes & Existing Boreholes

Map Number:

Map 1

LEGEND

- Newly Drilled Boreholes
- Geophysical Traverse (label at start of line)
- Existing Boreholes

N

Project nr: 107014/NW

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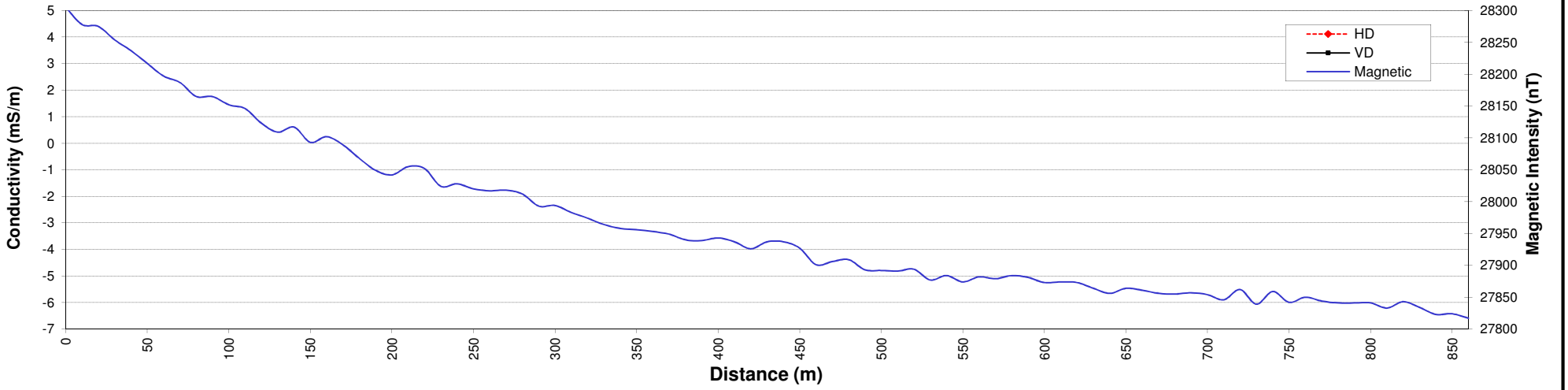
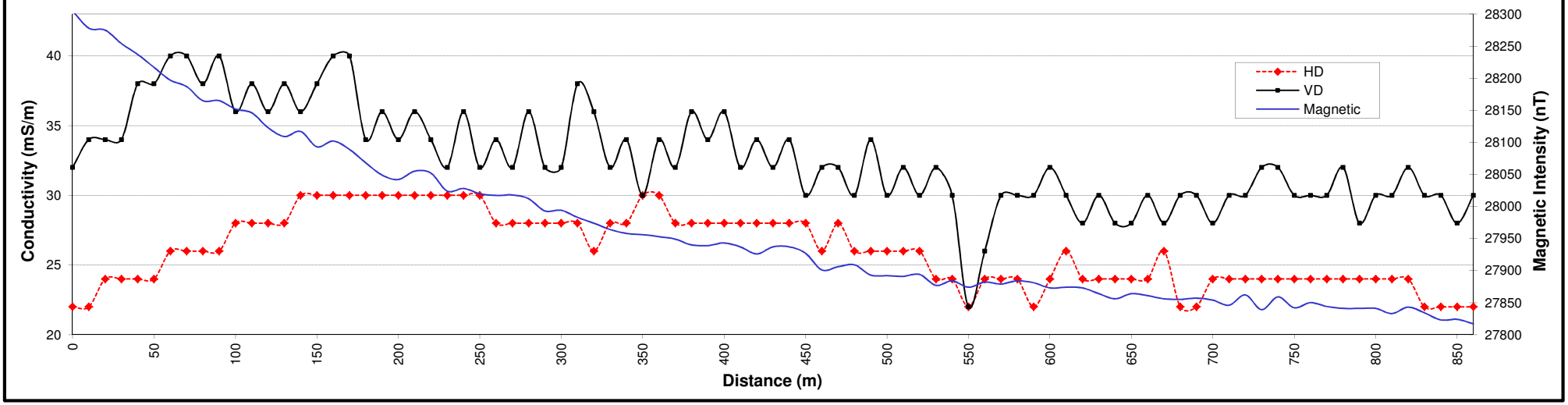
APPENDIX B

GROUND GEOPHYSICAL PROFILES

EM-34 (L=20m) & MAGNETIC PROFILE



EM-34 (L=40m) & MAGNETIC PROFILE



Project:	Metsi Bophelo	**Profile Number:**	L8	**Start Coordinate:**	**S**	25.92071
Project Number:	107014	**Profile Direction:**	NE-SW	***(WGS84)***	**E**	24.67487
Survey Area:	Logageng	**Station Spacing:**	10m	**End Coordinate:**	**S**	25.92370
Date of Survey:	Jul-11	**Coil Spacing:**	40m		**E**	24.66700

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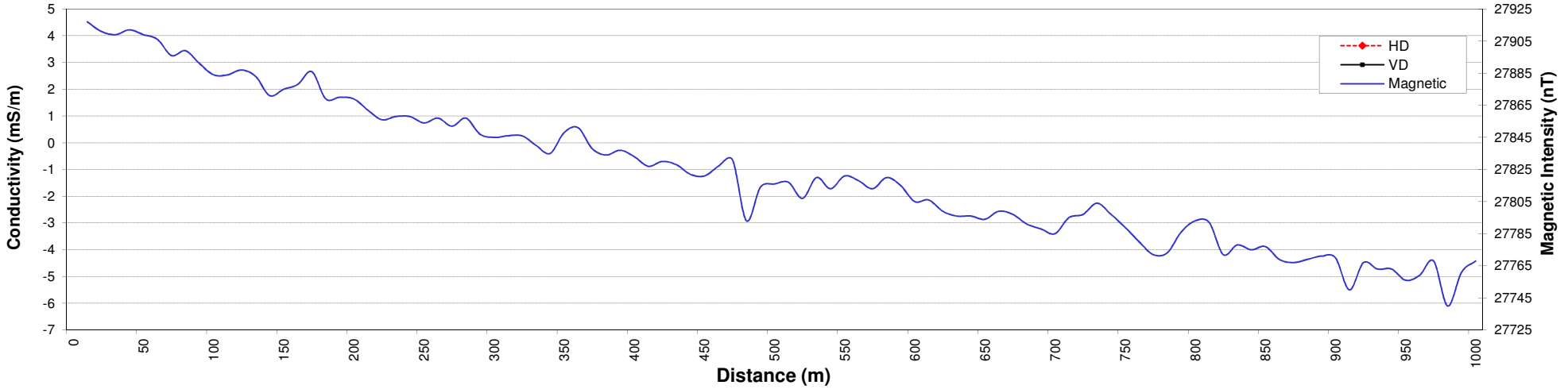
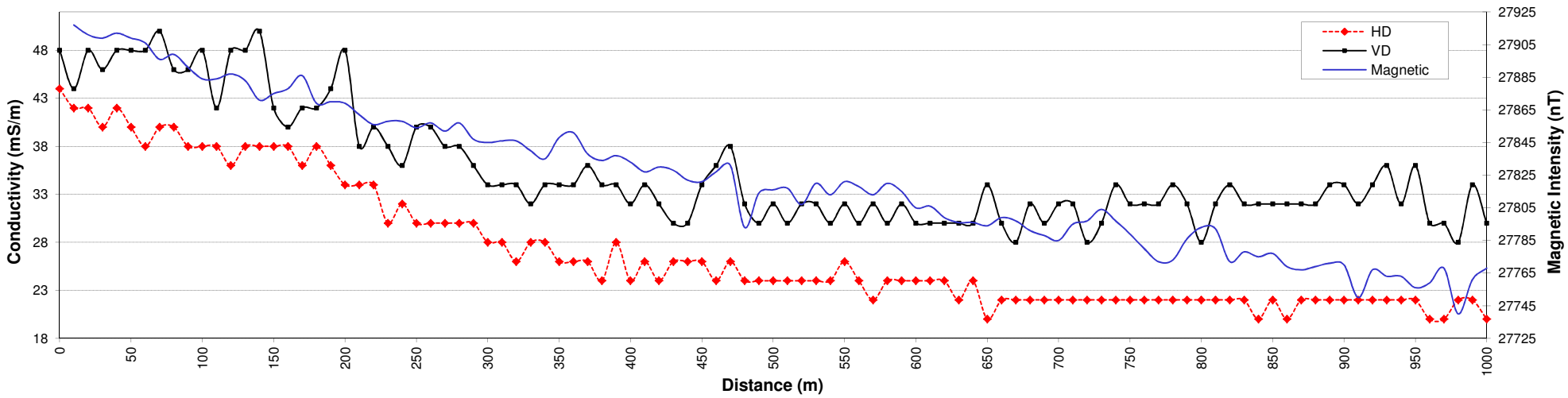
EM-34 (L=20m) & MAGNETIC PROFILE



EM-34 (L=40m) & MAGNETIC PROFILE



Project:	Metsi Bophelo	**Profile Number:**	L9	**Start Coordinate:**	**S**	25.91937
Project Number:	107014	**Profile Direction:**	E-W	***(WGS84)***	**E**	24.67148
Survey Area:	Logageng	**Station Spacing:**	10m	**End Coordinate:**	**S**	25.92321
Date of Survey:	12/07/2011	**Coil Spacing:**	40m		**E**	24.66280

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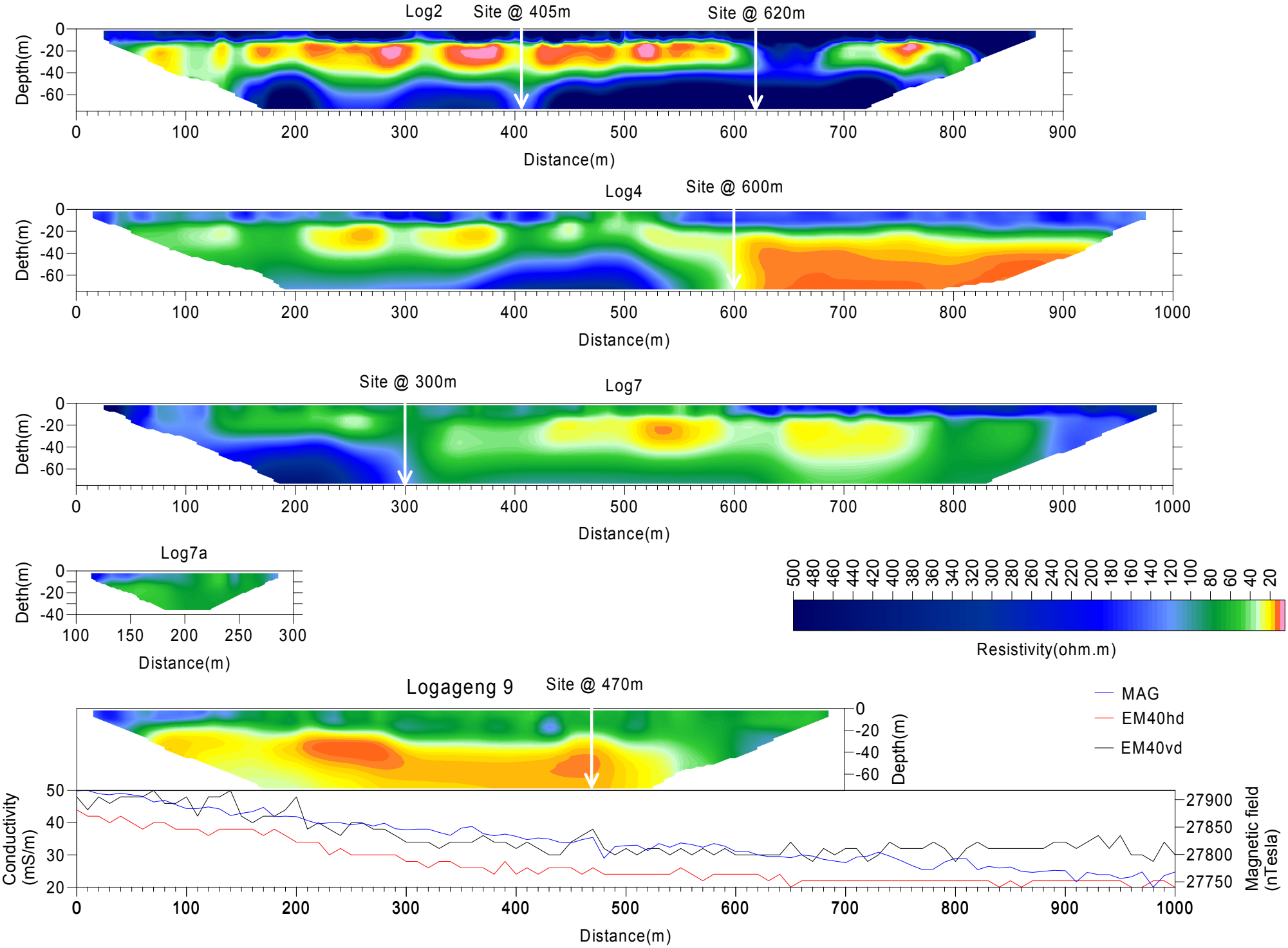
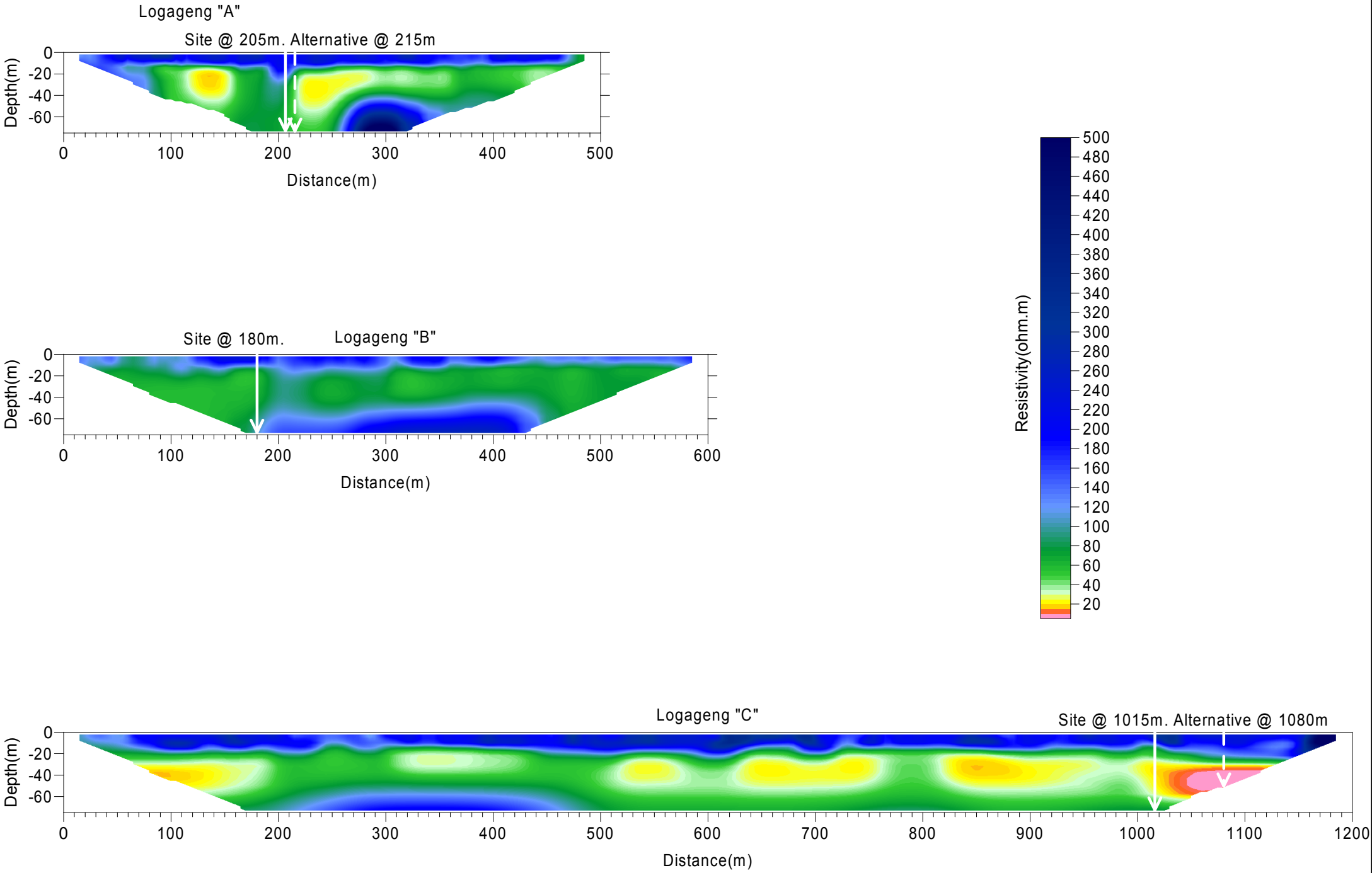

Log2
Site @ 405m
Site @ 620m
Depth(m)
0
-20
-40
-60
0
100
200
300
400
500
600
700
800
900
Distance(m)
Log4
Site @ 600m
Deth(m)
1000
Site @ 300m
Log7
Log7a
100
150
200
250
300
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
Resistivity(ohm.m)
Logageng 9
Site @ 470m
MAG
EM40hd
EM40vd
Conductivity (mS/m)
50
40
30
20
Magnetic field (nTesla)
27900
27850
27800
27750


Logageng "A"
Site @ 205m. Alternative @ 215m
Depth(m)
0
-20
-40
-60
0
100
200
300
400
500
Distance(m)
Site @ 180m.
Logageng "B"
Depth(m)
0
-20
-40
-60
0
100
200
300
400
500
600
Distance(m)
Resistivity(ohm.m)
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
Logageng "C"
Site @ 1015m. Alternative @ 1080m
Depth(m)
0
-20
-40
-60
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
Distance(m)

APPENDIX C

BOREHOLE LOGS

Borehole Construction and Geological Log - LBH4

Date compiled: 2011/10/27

BASIC SITE INFORMATION: ***Site Identifier:*** 2625AC00011 ***Number:*** LBH 4 ***Site type:*** Borehole

Distr./Farm No.: ***Site Name/Des.:*** LOGAGENG

Region Type: ***Region Descr.:***

Longitude [°]:	25.954980	***Reg./BB.:***	***Topo-set.:***	Flat surface, plain	***Depth [m]:*** 160.00
Latitude [°]:	24.704400	***G-Nr.:***	***Site status:***	In use	***Col. ht. [m]:***
Altitude [m]:			***Site purp.:***	Exploration	***Diam. [mm]:*** 170
Coord. acc.:	Accurate to within 10 units		***Use applic.:***		***Drain. reg.:***
Coord. meth.:	Global Positioning System		***Equipment:***	No equipment	***Rep. inst.:*** AFR

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

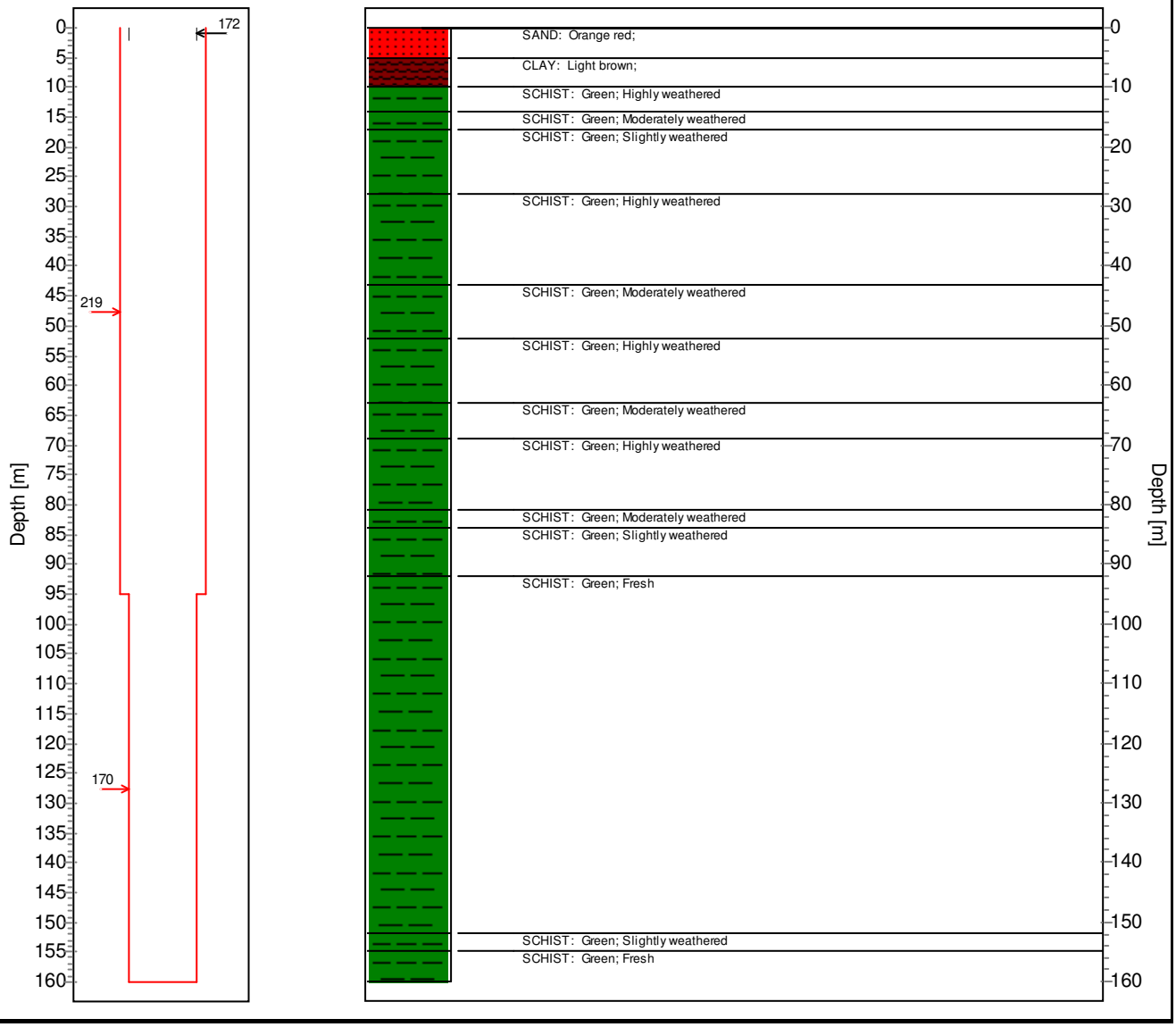
Hole — Hole diameter [mm] (165)

Casing (plain / perforated, sloted) — Casing diameter [mm] (152)

Screen / Mesh Screen — Waterlevel with date meas.

Piezometer — Piezometer (Nr. & Diameter [mm]) (0:50)

Construction | Lithology



COMMENT:

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Borehole Construction and Geological Log - LBH5

Date compiled: 2011/10/27

BASIC SITE INFORMATION: ***Site Identifier:*** 2625AC00012 ***Number:*** LBH 5 ***Site type:*** Borehole

Distr./Farm No.: ***Site Name/Des.:*** LOGAGENG

Region Type: ***Region Descr.:***

Longitude [°]:	25.920770	***Reg./BB.:***	***Topo-set.:***	Flat surface, plain	***Depth [m]:*** 160.00
Latitude [°]:	24.668210	***G-Nr.:***	***Site status:***	In use	***Col. ht. [m]:***
Altitude [m]:			***Site purp.:***	Exploration	***Diam. [mm]:*** 170
Coord. acc.:	Accurate to within 10 units		***Use applic.:***		***Drain. reg.:***
Coord. meth.:	Global Positioning System		***Equipment:***	No equipment	***Rep. inst.:*** AFR

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

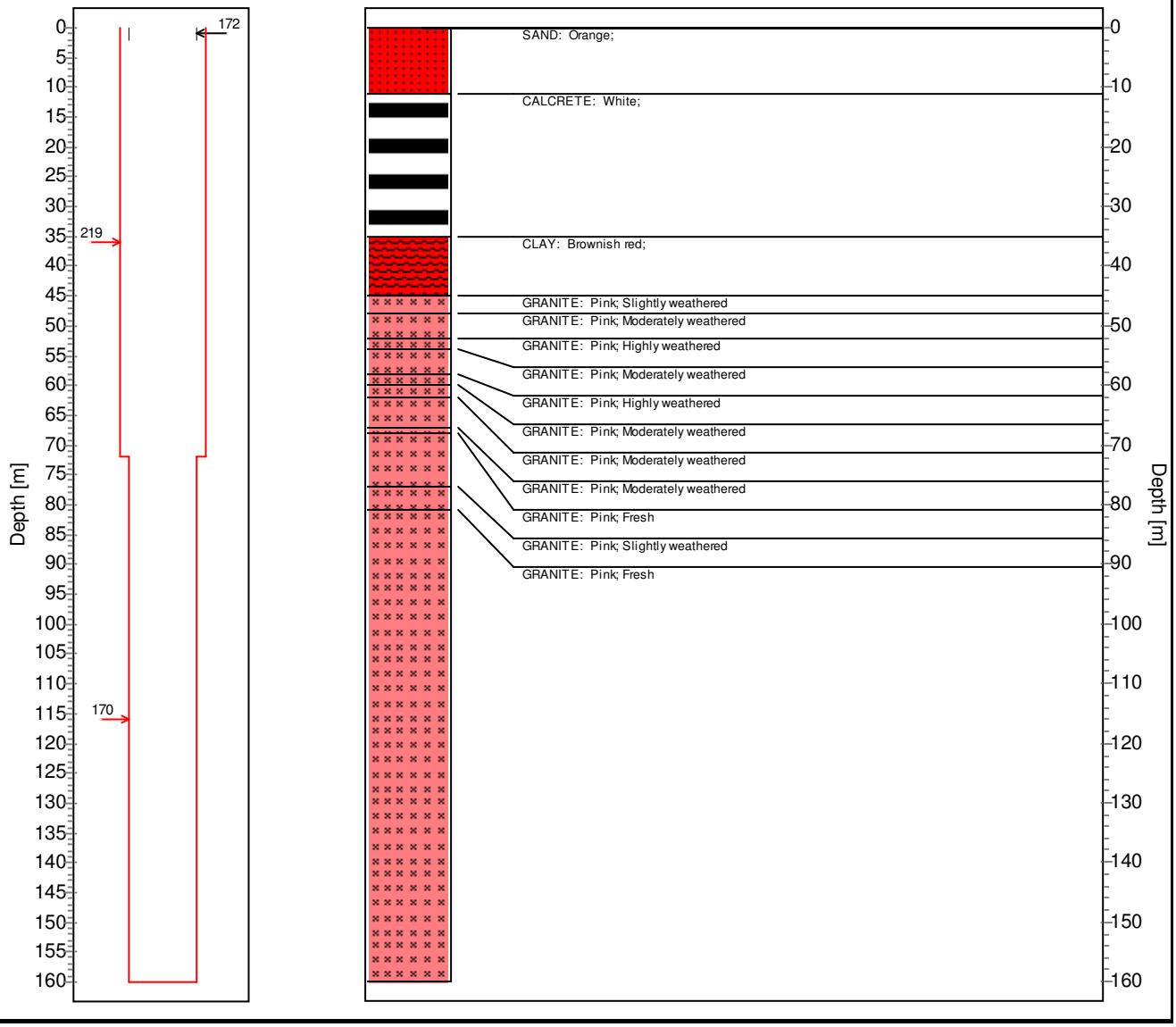
Hole — Hole diameter [mm] (165)

Casing (plain / perforated, sloted) — Casing diameter [mm] (152)

Screen / Mesh Screen — Waterlevel with date meas.

Piezometer — Piezometer (Nr. & Diameter [mm]) (0:50)

Construction | Lithology



COMMENT:

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Borehole Construction and Geological Log - LBH8

Date compiled: 2011/10/27

BASIC SITE INFORMATION: ***Site Identifier:*** 2524AA00001 ***Number:*** LBH 8 ***Site type:*** Borehole

Distr./Farm No.: ***Site Name/Des.:*** LOGAGENG

Region Type: ***Region Descr.:***

Longitude [°]:	25.946330	***Reg./BB.:***	***Topo-set.:***	Flat surface, plain	***Depth [m]:*** 160.00
Latitude [°]:	24.691830	***G-Nr.:***	***Site status:***	In use	***Col. ht. [m]:*** 0.24
Altitude [m]:			***Site purp.:***	Exploration	***Diam. [mm]:*** 170
Coord. acc.:	Accurate to within 10 units		***Use applic.:***		***Drain. reg.:***
Coord. meth.:	Global Positioning System		***Equipment:***	No equipment	***Rep. inst.:*** AFR

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

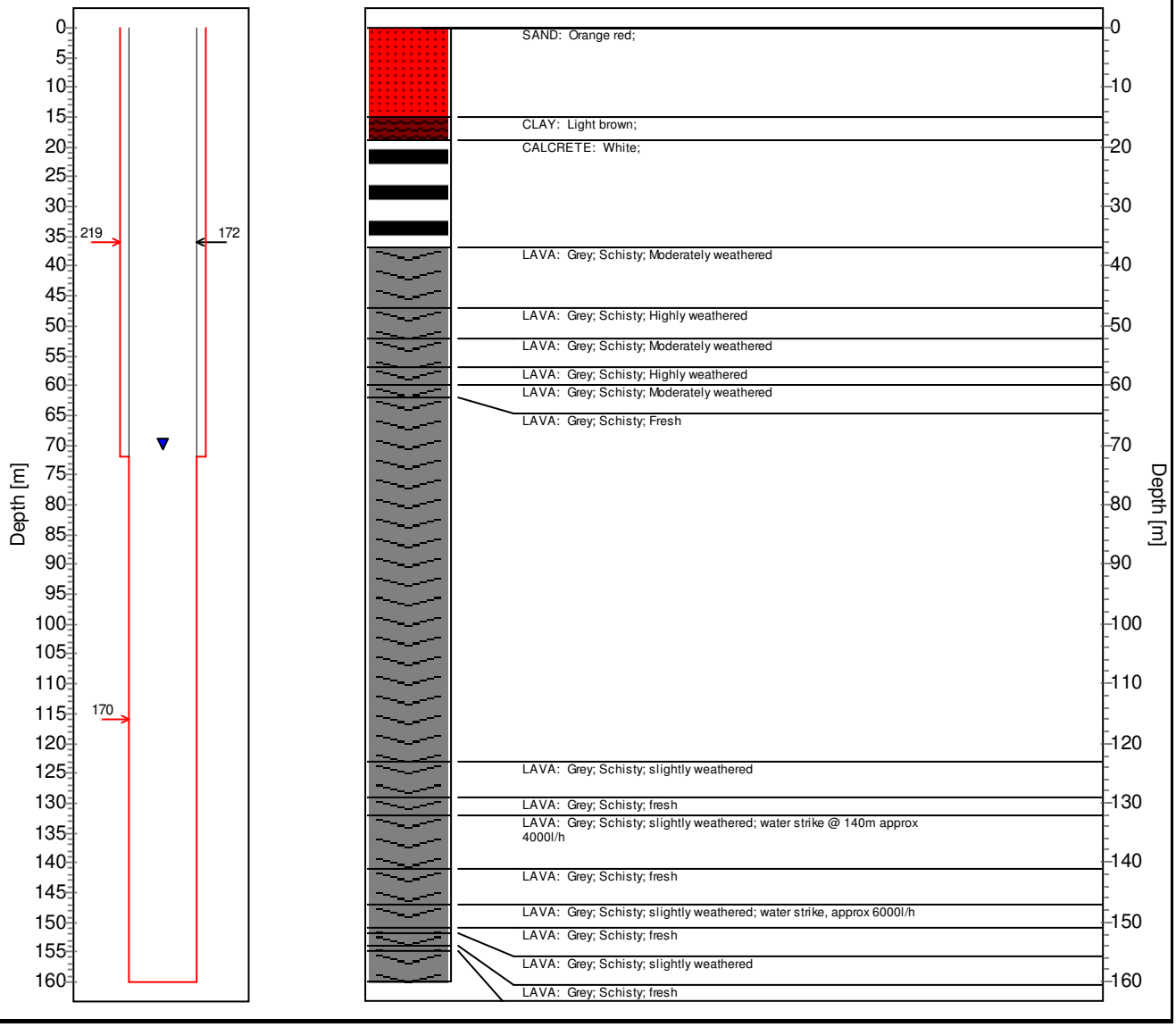
Hole — Hole diameter [mm] 165

Casing (plain / perforated, sloted) — Casing diameter [mm] 152

Screen / Mesh Screen — Waterlevel measured: 01/09/11

Piezometer — Piezometer (Nr. & Diameter [mm]) 0:50

Construction | Lithology



COMMENT:

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Borehole Construction and Geological Log - LBH9

Date compiled: 2011/10/27

BASIC SITE INFORMATION: ***Site Identifier:*** 2524AA00002 ***Number:*** LBH 9 ***Site type:*** Borehole

Distr./Farm No.: ***Site Name/Des.:*** LOGAGENG

Region Type: ***Region Descr.:***

Longitude [°]:	25.949710	***Reg./BB.:***	***Topo-set.:***	Flat surface, plain	***Depth [m]:*** 160.00
Latitude [°]:	24.710370	***G-Nr.:***	***Site status:***	In use	***Col. ht. [m]:*** 0.35
Altitude [m]:			***Site purp.:***	Exploration	***Diam. [mm]:*** 170
Coord. acc.:	Accurate to within 10 units		***Use applic.:***		***Drain. reg.:***
Coord. meth.:	Global Positioning System		***Equipment:***	No equipment	***Rep. inst.:*** AFR

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

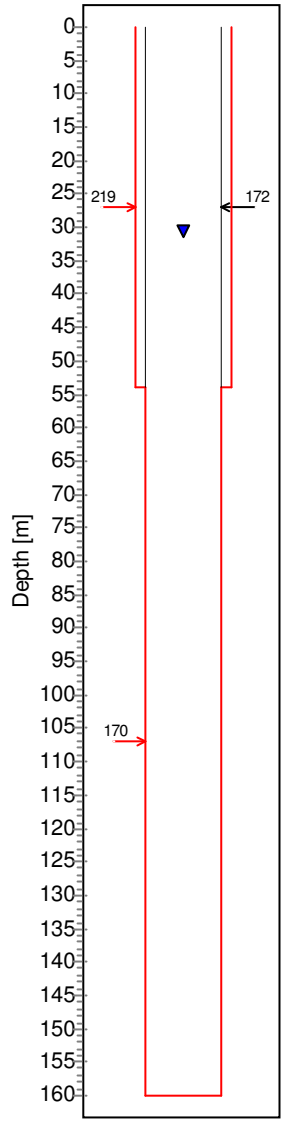
Hole — 165 → Hole diameter [mm]

Casing (plain / perforated, sloted) — 152 ← Casing diameter [mm]

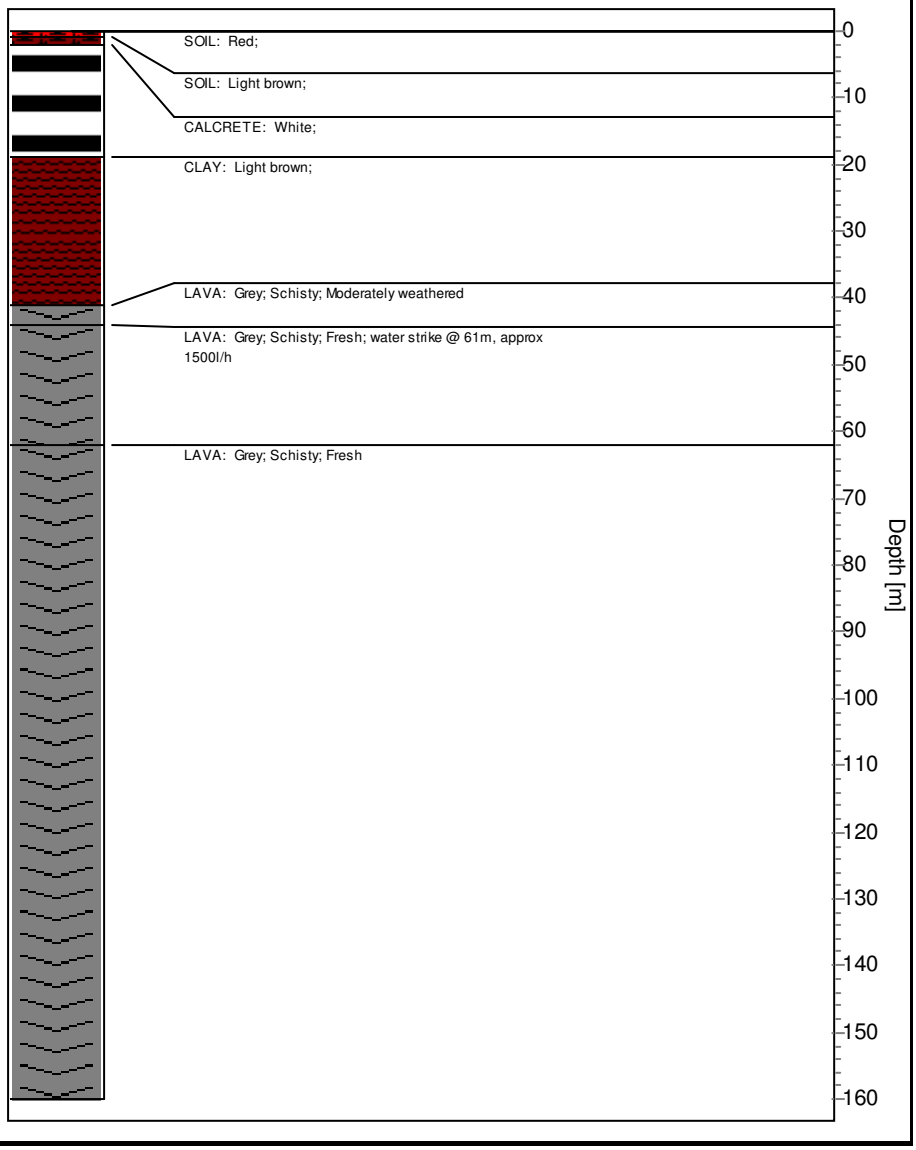
Screen / Mesh Screen — ▼ Waterlevel measured: 27/10/11

Piezometer — 0:50 → Piezometer (Nr. & Diameter [mm])

Construction



Lithology



COMMENT:

Aurecon Centre
Lynnwood Bridge Office Park
4 Daventry Street
Lynnwood Manor 0081
+27 12 427 2000

Borehole Construction and Geological Log - LBH10

Date compiled: 2011/10/26

BASIC SITE INFORMATION: ***Site Identifier:*** 2524AA00003 ***Number:*** LBH 10 ***Site type:*** Borehole

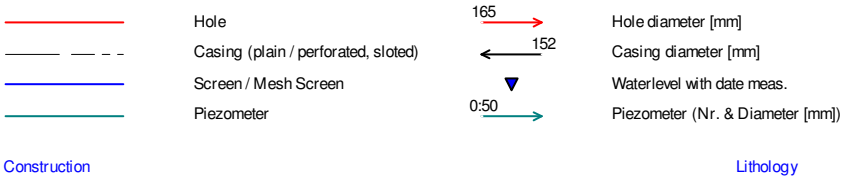
Distr./Farm No.: ***Site Name/Des.:*** LOGAGENG

Region Type: ***Region Descr.:***

Longitude [°]:	25.942610	***Reg./BB.:***	***Topo-set.:***	Flat surface, plain	***Depth [m]:*** 160.00
Latitude [°]:	24.698150	***G-Nr.:***	***Site status:***	In use	***Col. ht. [m]:***
Altitude [m]:			***Site purp.:***	Exploration	***Diam. [mm]:*** 170
Coord. acc.:	Accurate to within 10 units		***Use applic.:***		***Drain. reg.:***
Coord. meth.:	Global Positioning System		***Equipment:***	No equipment	***Rep. inst.:*** AFR

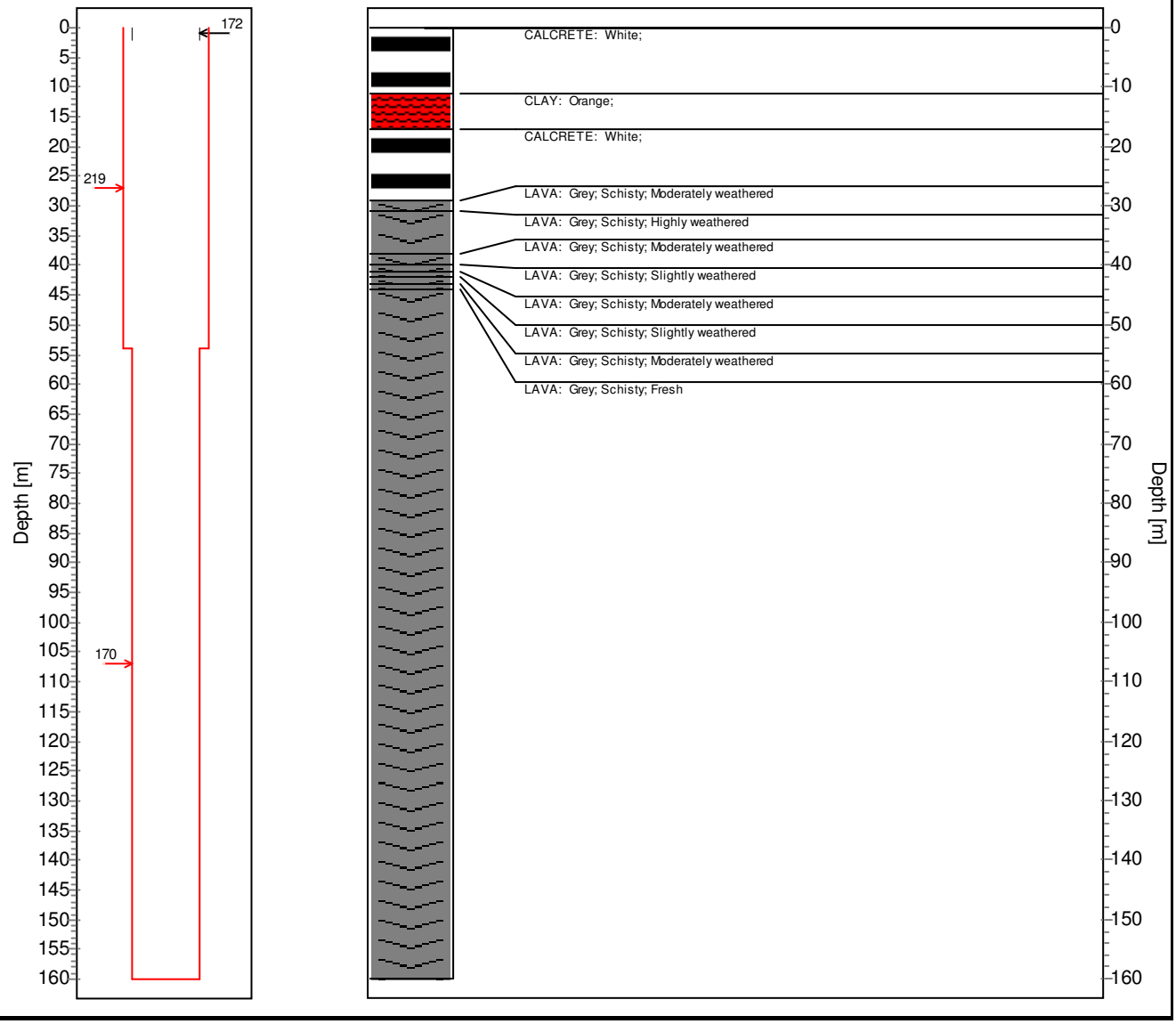
Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend



Construction

Lithology



COMMENT:

Aurecon Centre
Lynnwood Bridge Office Park
4 Daventry Street
Lynnwood Manor 0081
+27 12 427 2000

Borehole Construction and Geological Log - LBH11

Date compiled: 2011/10/27

BASIC SITE INFORMATION: ***Site Identifier:*** 2524AA00004 ***Number:*** LBH 11 ***Site type:*** Borehole

Distr./Farm No.: ***Site Name/Des.:*** LOGAGENG

Region Type: ***Region Descr.:***

Longitude [°]:	25.935570	***Reg./BB.:***	***Topo-set.:***	Flat surface, plain	***Depth [m]:*** 144.00
Latitude [°]:	24.701440	***G-Nr.:***	***Site status:***	In use	***Col. ht. [m]:***
Altitude [m]:			***Site purp.:***	Exploration	***Diam. [mm]:*** 170
Coord. acc.:	Accurate to within 10 units		***Use applic.:***		***Drain. reg.:***
Coord. meth.:	Global Positioning System		***Equipment:***	No equipment	***Rep. inst.:*** AFR

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

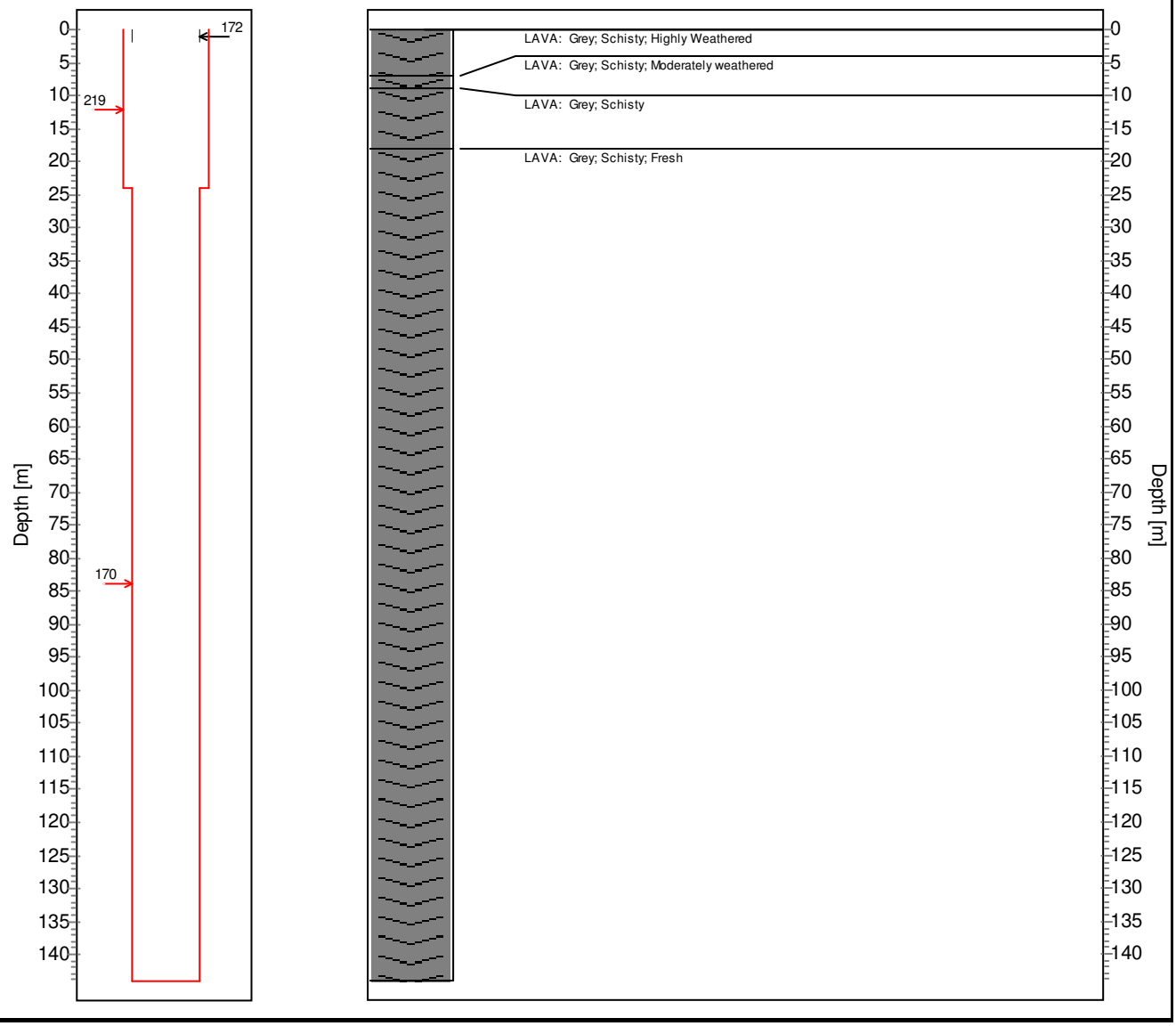
Construction and Geohydrological Legend

Hole — Hole diameter [mm] (165)

Casing (plain / perforated, sloted) — Casing diameter [mm] (152)

Screen / Mesh Screen — Waterlevel with date meas.

Piezometer — Piezometer (Nr. & Diameter [mm]) (0:50)



COMMENT:

Aurecon Centre
Lynnwood Bridge Office Park
4 Daventry Street
Lynnwood Manor 0081
+27 12 427 2000

Borehole Construction and Geological Log - LBH12

Date compiled: 2011/10/27

BASIC SITE INFORMATION: ***Site Identifier:*** 2524AA00005 ***Number:*** LBH 12 ***Site type:*** Borehole

Distr./Farm No.: ***Site Name/Des.:*** LOGAGENG

Region Type: ***Region Descr.:***

Longitude [°]:	25.942500	***Reg./BB.:***	***Topo-set.:***	Flat surface, plain	***Depth [m]:*** 160.00
Latitude [°]:	24.717720	***G-Nr.:***	***Site status:***	In use	***Col. ht. [m]:*** 0.21
Altitude [m]:			***Site purp.:***	Exploration	***Diam. [mm]:*** 170
Coord. acc.:	Accurate to within 10 units		***Use applic.:***		***Drain. reg.:***
Coord. meth.:	Global Positioning System		***Equipment:***	No equipment	***Rep. inst.:*** AFR

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

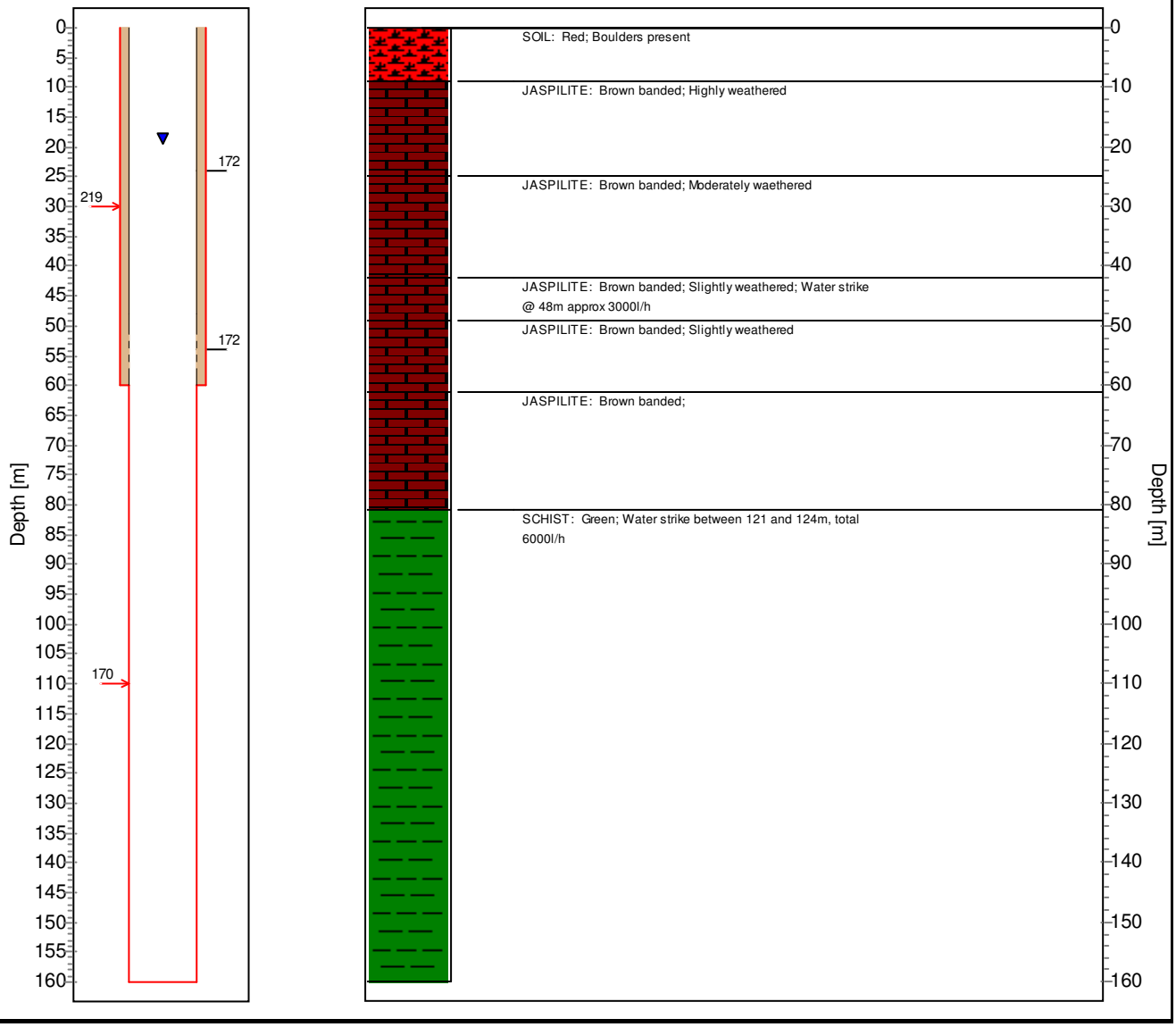
Hole — 165 — Hole diameter [mm] — Gravel (> 2mm)

Casing (plain / perforated, sloted) — 152 — Casing diameter [mm]

Screen / Mesh Screen — Waterlevel measured: 20/09/11

Piezometer — 0:50 — Piezometer (Nr. & Diameter [mm])

Construction Lithology



COMMENT:

aurecon

Aurecon Centre
Lynnwood Bridge Office Park
4 Daventry Street
Lynnwood Manor 0081
+27 12 427 2000

Borehole Construction and Geological Log - LBH13

Date compiled: 2011/10/27

BASIC SITE INFORMATION: ***Site Identifier:*** 2524AA00006 ***Number:*** LBH 13 ***Site type:*** Borehole

Distr./Farm No.: ***Site Name/Des.:*** LOGAGENG

Region Type: ***Region Descr.:***

Longitude [°]:	25.936270	***Reg./BB.:***	***Topo-set.:***	Flat surface, plain	***Depth [m]:*** 160.00
Latitude [°]:	24.661530	***G-Nr.:***	***Site status:***	In use	***Col. ht. [m]:***
Altitude [m]:			***Site purp.:***	Exploration	***Diam. [mm]:*** 170
Coord. acc.:	Accurate to within 10 units		***Use applic.:***		***Drain. reg.:***
Coord. meth.:	Global Positioning System		***Equipment:***	No equipment	***Rep. inst.:*** AFR

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Construction and Geohydrological Legend

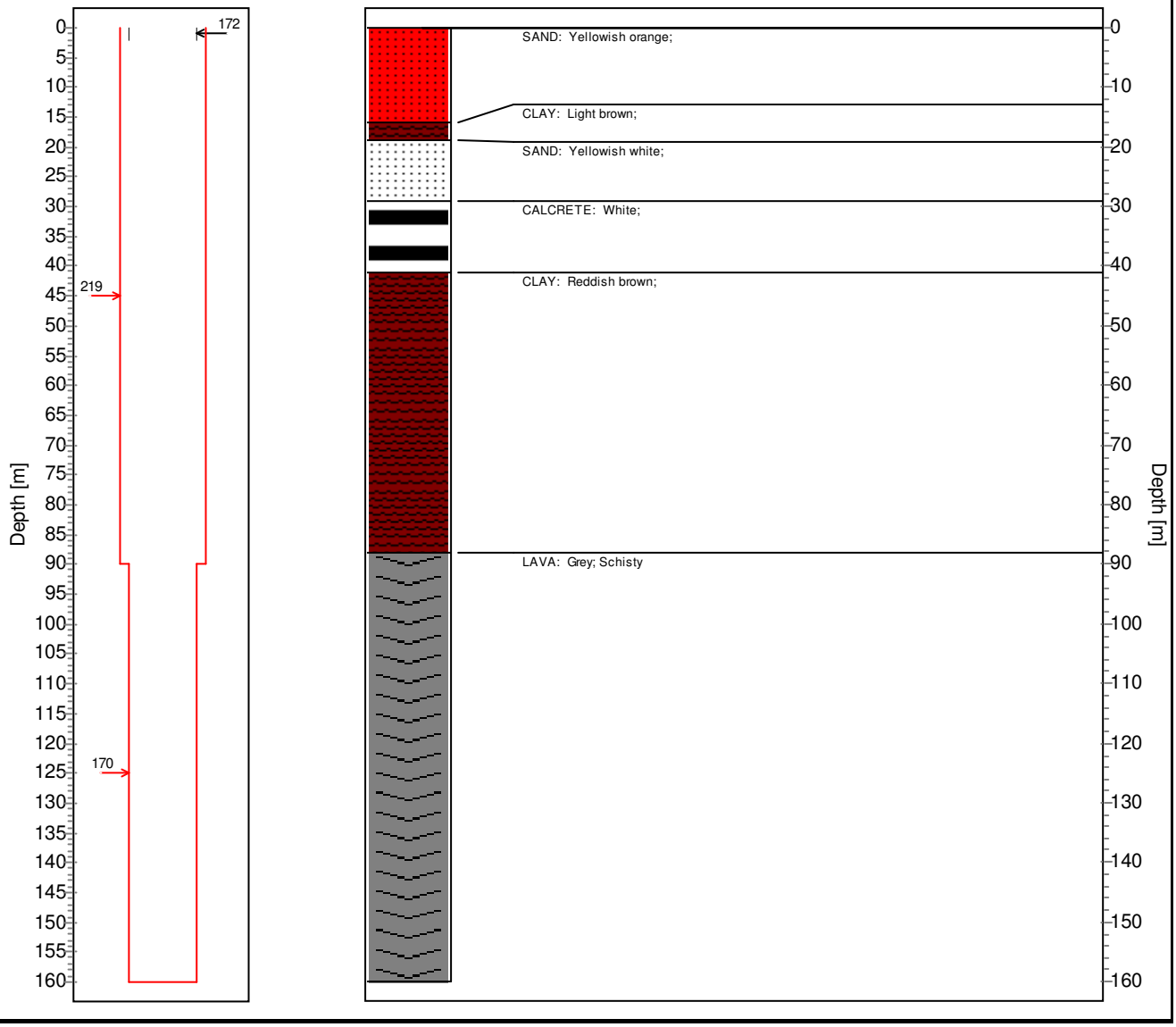
Hole — Hole diameter [mm] (165)

Casing (plain / perforated, sloted) — Casing diameter [mm] (152)

Screen / Mesh Screen — Waterlevel with date meas.

Piezometer — Piezometer (Nr. & Diameter [mm]) (0:50)

Construction | Lithology



COMMENT:

Aurecon Centre
Lynnwood Bridge Office Park
4 Daventry Street
Lynnwood Manor 0081
+27 12 427 2000

APPENDIX D

CALCULATION OF SUSTAINABLE YIELD (FC – SOLUTIONS)

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

LBH8

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	47.41	47.41	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	0.6	5.36E-05	S-late	Change r_e
s_a (available drawdown), sigma_s = (enter)	70		Sigma_s from risk	
Annual effective recharge (mm) =	9	88.00	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	9.85	End time and drawdown of test	
Average maximum derivative = (enter)	6.5	6.5	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)	2.08	2.08	Read from derivative graph	
	T-early[m^2/d] =	4.56	Aqui. thick (m)	40
T and S estimates from derivatives	T-late [m^2/d] =	1.45	Est. S-late =	2.20E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	2.20E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

(No values of T and S are necessary)

	No boundaries	Maximum influence of boundaries at long time: 1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	133.35	152.11	170.86	227.12
Q_sust (l/s) =	0.40	0.35	0.31	0.23
	Best case	→		**Worst case**

Average Q_sust (l/s) = 0.32

with standard deviation= 0.07

(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) → 1.45

S-late = (enter) → 5.00E-04

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	2	70	5.79E-04	6.88
BH2	2	277	9.07E-03	4.13
s_(influence of BH1,BH2) =	65.32	39.27	2.66E-04	7.66

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) → 3.00 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

LBH9

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	37.79	37.79	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	0.2	1.21E-05	S-late	Change r_e
s_a (available drawdown), sigma_s = (enter)	4		Sigma_s from risk	
Annual effective recharge (mm) =	0	4.00	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	50.37	End time and drawdown of test	
Average maximum derivative = (enter)	49.9	49.9	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)	8.11	8.11	Read from derivative graph	
	T-early[m^2/d] =	0.39	Aqui. thick (m)	40
T and S estimates from derivatives	T-late [m^2/d] =	0.06	Est. S-late =	2.20E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	2.20E-03	S-estimate could be wrong	

BASIC SOLUTION

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

	No boundaries	Maximum influence of boundaries at long time: 1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	1268.93	1411.82	1554.70	1983.36
Q_sust (l/s) =	0.00	0.00	0.00	0.00
	Best case	→		**Worst case**

Average Q_sust (l/s) = 0.00
with standard deviation= 0.00

(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) → 0.06
S-late = (enter) → 5.00E-04

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!	#NUM!	#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!	#NUM!	#NUM!	#NUM!

2. INFLUENCE OF OTHER BOREHOLES →

	Q (l/s)	r (m)	u_r	W(u,r)
BH1	2	70	1.32E-02	3.76
BH2	2	277	2.07E-01	1.19
s_(influence of BH1,BH2) =	816.43	259.07	3.86E-03	4.98

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) → 3.00 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)	15.00
Total amount of water allowed to be abstracted per month (m^3) =	38880

COMMENTS

Q_sust with 68% safety =
Q_sust with 95% safety =

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

LBH12

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	39.74	39.74	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	1.2	1.32E-05	S-late	Change r_e
s_a (available drawdown), sigma_s = (enter)	102		Sigma_s from risk	
Annual effective recharge (mm) =	9	120.00	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	22	End time and drawdown of test	
Average maximum derivative = (enter)	14.1	14.1	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)	7.93	7.93	Read from derivative graph	
	T-early[m^2/d] =	2.39	Aqui. thick (m)	40
T and S estimates from derivatives	T-late [m^2/d] =	1.35	Est. S-late =	2.20E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	2.20E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

(No values of T and S are necessary)

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
		Maximum influence of boundaries at long time		
sWell (Extrapol.time) =	173.02	213.30	253.58	374.43
Q_sust (l/s) =	0.83	0.68	0.57	0.38
	Best case	→		**Worst case**

Average Q_sust (l/s) = 0.59

with standard deviation= 0.19

(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) →	1.35			
S-late = (enter) →	5.00E-04			
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	2	70	6.22E-04	6.81
BH2	2	277	9.74E-03	4.06
s_(influence of BH1,BH2) =	69.43	41.46	2.00E-04	7.94
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) →	3.00	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 =

APPENDIX E

LABORATORY REPORTS

CLEAN STREAM
Scientific Services (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: 6395 **Project:** Aurecon-Logageng

Date of certificate: 03 Oct 2011
Date accepted: 29 Sep 2011
Date completed: 03 Oct 2011

Lab no:			68556	68557	68558
Date sampled:			28 Sep 2011	28 Sep 2011	28 Sep 2011
Sample type:			Water	Water	Water
Locality description			LBH11	LBH8	LBH9
Analyses:		**Method**			
A	pH	CSM 20	7.19	7.91	7.59
A	Electrical conductivity (EC) mS/m	CSM 20	25.02	68.10	63.90
A	Total dissolved solids (TDS) mg/l	CSM 06	133	419	369
A	Total alkalinity mg/l	CSM 01	125.5	366.3	343.9
A	Chloride (Cl) mg/l	CSM 02	5.2	28.8	14.7
A	Sulphate (SO4) mg/l	CSM 03	<0.132	4.10	<0.132
A	Nitrate (NO3) mg/l as N	CSM 06	0.623	0.577	0.900
A	Ammonium(NH4) mg/l as N	CSM 05	<0.015	<0.015	<0.015
A	Orthophosphate (PO4) mg/l as P	CSM 04	0.081	0.043	0.091
A	Fluoride (F) mg/l	CSM 11	<0.183	0.191	0.491
A	Calcium (Ca) mg/l	CSM 30	30.465	86.943	92.831
A	Magnesium (Mg) mg/l	CSM 30	13.772	37.219	31.518
A	Sodium (Na) mg/l	CSM 30	6.12	38.40	20.17
A	Potassium (K) mg/l	CSM 30	1.065	3.241	2.241
A	Aluminium (Al) mg/l	CSM 31	<0.006	<0.006	<0.006
A	Iron (Fe) mg/l	CSM 31	<0.006	<0.006	<0.006
A	Manganese (Mn) mg/l	CSM 31	0.239	0.092	0.139
A	Total hardness mg/l	CSM 26	133	370	362

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. 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)

APPENDIX F

PUMPTESTING FIELD SHEETS

TRANS AFRICA WATER SERVICES

BOREHOLE TEST CONTROL SHEET

Borehole Number:	LBH8	Old/Alternative Number:		
Contractor:	Trans Africa	Supervisor: Ruben		
Operator	Phinias	Rig Number: No 1		

EXISTING EQUIPMENT

Type of Pump	Depth	Condition	Drive Unit	Condition	Pumphouse	Condition
~	~	~	~	~	~	~

TESTING EQUIPMENT

Pump type	Depth Installed	Date and Time (started)		Date and Time (Completed)	
BH100	90	16/09/2011	13:00	16/09/2011	16:00

MULTI-RATE OR STEPTEST DETAILS

Step	Duration (min)	Recovery (min)	Yield (l/s)	Drawdown (m)
1	60.00		0.33	2.36
2	60.00		0.64	7.87
3	60.00		1.30	19.37
4				
5				
Calibration				
TOTAL:	180.00	440.00		
COMMENT:				

CONSTANT RATE DISCHARGE TEST

Type of pump	Depth Installed	Date and Time (started)		Date and Time (Completed)	
BH100	90	17/09/2011	08:00	18/09/2011	08:00
Yield (l/s)	Drawdown (m)	Duration (min)		Recovery (min)	
0.63	9.85	1440		1200	
TOTAL (Multi-ra					
COMMENT:					

GENERAL

Establishment	From:		To:			Distance (km)
Site Move	From		To			Distance (km)
	Village	Borehole #	Village	Borehole #		
	Logageng	LBH9	Logageng	LBH8		
Maintenance	Work Time (hr)		Parts Re-place/repair		Travelling (km)	
After Test Measurements	Water Level	70.1	Borehole Depth	160.00	Casing Depth	
REMARKS:						
Signed for Contractor:			Signed for Consultant:			

BOREHOLE TEST RECORD SHEET

REQUEST NO:		MAP REFERENCE:		REGION: North West	
BOREHOLE NO: LBH9		COORDINATES (DD-MM-SS)	Lo:	DISTRICT: Mafiking	
ALT. BH. NO:		LATITUDE:	X:	FARM NAME:	
ALT. BH. NO:		LONGITUDE:	Y:	VILLAGE: Logageng	
BOREHOLE DEPTH (m):	160.00	DATUM LEVEL ABOVE CASING (m):	0.53	EXISTING PUMP:	
WATER LEVEL (mbgl):	69.86	CASING HEIGHT (magl):	0.24	CONTRACTOR:	
DEPTH OF PUMP (m):	90.00	BH DIAM. (PUMP INLET) (mm):	165.00	PUMP TYPE: BH100	

MULTI-RATE DISCHARGE TEST AND RECOVERY

DISCHARGE RATE 1					DISCHARGE RATE 2					DISCHARGE RATE 3				
DATE: 16/09/2011		TIME: 13:00			DATE: 16/09/2011		TIME: 14:00			DATE: 16/09/2011		TIME: 15:00		
TIME	DRAWDOWN	YIELD	TIME	RECOVERY	TIME	DRAWDOW	YIELD	TIME	RECOVERY	TIME	DRAWDOWN	YIELD	TIME	RECOVERY
(min)	(m)	(l/s)	(min)	(m)	(min)	(m)	(l/s)	(min)	(m)	(min)	(m)	(l/s)	(min)	(m)
1	0.36		1		1	2.95		1		1	8.25		1	14.33
2	0.58		2		2	3.26		2		2	8.92		2	10.12
3	0.66		3		3	3.44	0.46	3		3	9.35	1.36	3	6.26
5	0.74		5		5	3.68	0.53	5		5	9.88		5	4.41
7	0.83	0.35	7		7	3.86		7		7	10.36		7	3.77
10	0.99		10		10	4.45	0.62	10		10	10.95	1.35	10	3.25
15	1.22		15		15	4.84		15		15	11.40		15	3.03
20	1.50	0.34	20		20	5.24		20		20	11.83		20	2.92
30	0.17		30		30	6.17	0.63	30		30	12.66		30	2.84
40	1.93		40		40	7.06		40		40	14.47	1.30	40	2.70
50	2.17	0.33	50		50	7.52	0.64	50		50	16.55		50	2.58
60	2.36		60		60	7.87		60		60	19.37	1.20	60	2.37
70			70		70			70		70	PI	0.96	70	2.13
80			80		80			80		80	PI	0.95	80	1.80
90			90		90			90		90	PI	0.95	90	1.52
100			100		100			100		100			100	1.23
110			110		110			110		110			110	0.94
120			120		120			120		120			120	0.71
150			150		150			150		150			150	0.46
180			180		180			180		180			180	0.40
240			240		240			240		240			240	0.35
300			300		300			300		300			300	0.31
410			410		410			410		410			410	0.26
440			440		440			440		440			440	0.23

DISCHARGE RATE 4					DISCHARGE RATE 5					YIELD (CALIBRATION) TEST				
DATE:		TIME:			DATE:		TIME: 20:00			DATE:		TIME:		
TIME	DRAWDOWN	YIELD	TIME	RECOVERY	TIME	DRAWDOW	YIELD	TIME	RECOVERY	TIME	DRAWDOWN	YIELD	TIME	RECOVERY
(min)	(m)	(l/s)	(min)	(m)	(min)	(m)	(l/s)	(min)	(m)	(min)	(m)	(l/s)	(min)	(m)
1			1		1			1		1			1	
2			2		2			2		2			2	
3			3		3			3		3			3	
5			5		5			5		5			5	
7			7		7			7		7			7	
10			10		10			10		10			10	
15			15		15			15		15			15	
20			20		20			20		20			20	
30			30		30			30		30			30	
40			40		40			40		40			40	
50			50		50			50		50			50	
60			60		60			60		60			60	
70			70		70			70		70			70	
80			80		80			80		80			80	
90			90		90			90		90			90	
100			100		100			100		100			100	
110			110		110			110		110			110	
120			120		120			120		120			120	
150			150		150			150		150			150	
180			180		180			180		180			180	
240			240		240			240		240			240	
300			300		300			300		300			300	
410			410		410			410		410			410	
440			440		440			440		440			440	

COMMENTS: 1)

BOREHOLE TEST RECORD SHEET

REQUEST NO:		MAP REFERENCE:		REGION:	North West
BOREHOLE NO:	LBH8	COORDINATES (dd-mm-ss)	Lo:	DISTRICT:	Mafikeng
ALT. BH. NO:		LATITUDE:	X:	FARM NAME:	
ALT. BH. NO:		LONGITUDE:	Y:	VILLAGE:	Logageng

BOREHOLE DEPTH (m):	160	DATUM LEVEL ABOVE CASING (m):	0.53	EXISTING PUMP
WATER LEVEL (mbgl):	69.86	CASING HEIGHT (magl):	0.24	NONE
DEPTH OF PUMP (m):	90	BH DIAM. (PUMP INLET) (mm):	165.00	Contract dgm

CONSTANT RATE DISCHARGE TEST AND RECOVERY

TEST STARTED		TEST COMPLETED		DURATION (min):	1440
DATE: 17/09/2011	TIME: 08:00	DATE: 18/09/2011	TIME: 08:00	TYPE OP PUMP:	BH100

"NOTE"	Distance between discharge and observation holes in m.		OBSERV. HOLE 1			OBSERV. HOLE 2		OBSERV. HOLE 3		
			Nr:			Nr:		Nr:		
DISCHARGE BOREHOLE			Distance:			Distance:		Distance:		
TIME	DRAWDOWN	YIELD	TIME	RECOVERY	TIME	DRAWDOWN	TIME	DRAWDOWN	TIME	DRAWDOWN
(min)	s' (m)	(l/s)	(min)	s' (m)	(min)	(m)	(min)	(m)	(min)	(m)
1	0.43		1	7.34	1		1		1	
2	0.78		2	5.65	2		2		2	
3	1.12		3	4.47	3		3		3	
5	1.33		5	4.06	5		5		5	
7	1.74	0.45	7	3.55	7		7		7	
10	2.03	0.53	10	3.24	10		10		10	
15	2.40	0.61	15	3.13	15		15		15	
20	2.68		20	2.88	20		20		20	
30	2.91		30	2.52	30		30		30	
40	3.26		40	2.33	40		40		40	
60	3.55	0.62	60	2.16	60		60		60	
90	3.72		90	1.95	90		90		90	
120	3.95	0.61	120	1.77	120		120		120	
150	4.19	0.61	150	1.63	150		150		150	
180	4.42	0.6	180	1.51	180		180		180	
210	4.94		210	1.44	210		210		210	
240	5.30	0.63	240	1.32	240		240		240	
300	5.77		300	1.14	300		300		300	
360	6.15	0.63	360	0.98	360		360		360	
420	6.42		420	0.72	420		420		420	
480	6.74	0.59	480	0.53	480		480		480	
540	7.05	0.63	540	0.46	540		540		540	
600	7.28		600	0.41	600		600		600	
720	7.90	0.62	720	0.34	720		720		720	
840	8.37		840	0.26	840		840		840	
960	8.61		960	0.19	960		960		960	
1080	8.93	0.63	1080	0.11	1080		1080		1080	
1200	9.26	0.62	1200	0.00	1200		1200		1200	
1320	9.57	0.62	1320		1320		1320		1320	
1440	9.85	0.63	1440		1440		1440		1440	
1800			1800		1800		1800		1800	
2280			2280		2280		2280		2280	
2880			2880		2880		2880		2880	
3480			3480		3480		3480		3480	
3900			3900		3900		3900		3900	
4320			4320		4320		4320		4320	
4920			4920		4920		4920		4920	
5760			5760		5760		5760		5760	

TOTAL TIME PUMPED (m	1440	NOTE:	t" = total time since pumping started
AVERAGE YIELD (l/s):	0.60		t" = time since pumping started

COMMENTS: 1).

TRANS AFRICA WATER SERVICES

BOREHOLE TEST CONTROL SHEET

Borehole Number:	LBH9	Old/Alternative Number:		
Contractor:	Trans Africa	Supervisor: Ruben		
Operator	Phinias	Rig Number: No 1		

EXISTING EQUIPMENT

Type of Pump	Depth	Condition	Drive Unit	Condition	Pumphouse	Condition
~	~	~	~	~	~	~

TESTING EQUIPMENT

Pump type	Depth Installed	Date and Time (started)		Date and Time (Completed)	
BH100	90	13/09/2011	11:00	13/09/2011	13:05

MULTI-RATE OR STEPTEST DETAILS

Step	Duration (min)	Recovery (min)	Yield (l/s)	Drawdown (m)
1	60.00		0.21	16.75
2	60.00		0.41	43.14
3	5.00		0.60	58.68
4				
5				
Calibration				
TOTAL:	125.00	440.00		
COMMENT:				

CONSTANT RATE DISCHARGE TEST

Type of pump	Depth Installed	Date and Time (started)		Date and Time (Completed)	
BH100	90	14/09/2011	08:00	15/09/2011	08:00
Yield (l/s)	Drawdown (m)	Duration (min)		Recovery (min)	
0.20	50.37	1440		1440	
TOTAL (Multi-ra					
COMMENT:					

GENERAL

Establishment	From:	PTA	To:	Logageng		Distance (km)
Site Move	From		To			Distance (km)
	Village	Borehole #	Village	Borehole #		480
			Logageng	LBH9		
Maintenance	Work Time (hr)		Parts Re-place/repair		Travelling (km)	
After Test Measurements	Water Level	30.95	Borehole Depth	160.00	Casing Depth	
REMARKS:						
Signed for Contractor:			Signed for Consultant:			

BOREHOLE TEST RECORD SHEET

REQUEST NO:		MAP REFERENCE:		REGION: North West	
BOREHOLE NO: LBH9		COORDINATES (DD-MM-SS)	Lo:	DISTRICT: Mafiking	
ALT. BH. NO:		LATITUDE:	X:	FARM NAME:	
ALT. BH. NO:		LONGITUDE:	Y:	VILLAGE: Logageng	
BOREHOLE DEPTH (m):	160.00	DATUM LEVEL ABOVE CASING (m):	0.37	EXISTING PUMP:	
WATER LEVEL (mbgl):	30.60	CASING HEIGHT (magl):	0.35	CONTRACTOR:	
DEPTH OF PUMP (m):	90.00	BH DIAM. (PUMP INLET) (mm):	165.00	PUMP TYPE: BH100	

MULTI-RATE DISCHARGE TEST AND RECOVERY

DISCHARGE RATE 1					DISCHARGE RATE 2					DISCHARGE RATE 3				
DATE: 13/09/2011		TIME: 11:00			DATE: 13/09/2011		TIME: 12:00			DATE: 13/09/2011		TIME: 13:00		
TIME	DRAWDOWN	YIELD	TIME	RECOVERY	TIME	DRAWDOW	YIELD	TIME	RECOVERY	TIME	DRAWDOWN	YIELD	TIME	RECOVERY
(min)	(m)	(l/s)	(min)	(m)	(min)	(m)	(l/s)	(min)	(m)	(min)	(m)	(l/s)	(min)	(m)
1	0.78		1		1	17.25		1		1	45.60		1	53.02
2	1.30		2		2	17.87		2		2	48.78		2	49.33
3	1.96		3		3	18.36	0.36	3		3	53.08	0.60	3	47.50
5	2.48	0.36	5		5	18.72		5		5	58.68		5	43.46
7	3.17	0.24	7		7	19.68	0.40	7		7	PI	0.34	7	39.77
10	4.88		10		10	21.34		10		10	PI	0.33	10	36.82
15	5.79		15		15	23.46	0.42	15		15	PI	0.33	15	30.39
20	7.82	0.23	20		20	25.43		20		20			20	29.51
30	9.00		30		30	30.02	0.41	30		30			30	14.48
40	12.40	0.22	40		40	35.34		40		40			40	10.17
50	14.68		50		50	40.43	0.41	50		50			50	6.33
60	16.75	0.21	60		60	43.14		60		60			60	4.64
70			70		70			70		70			70	3.42
80			80		80			80		80			80	2.57
90			90		90			90		90			90	1.88
100			100		100			100		100			100	1.53
110			110		110			110		110			110	1.26
120			120		120			120		120			120	1.08
150			150		150			150		150			150	0.70
180			180		180			180		180			180	0.63
240			240		240			240		240			240	0.55
300			300		300			300		300			300	0.51
410			410		410			410		410			410	0.48
440			440		440			440		440			440	0.44

DISCHARGE RATE 4					DISCHARGE RATE 5					YIELD (CALIBRATION) TEST				
DATE:		TIME:			DATE:		TIME: 20:00			DATE:		TIME:		
TIME	DRAWDOWN	YIELD	TIME	RECOVERY	TIME	DRAWDOW	YIELD	TIME	RECOVERY	TIME	DRAWDOWN	YIELD	TIME	RECOVERY
(min)	(m)	(l/s)	(min)	(m)	(min)	(m)	(l/s)	(min)	(m)	(min)	(m)	(l/s)	(min)	(m)
1			1		1			1		1			1	
2			2		2			2		2			2	
3			3		3			3		3			3	
5			5		5			5		5			5	
7			7		7			7		7			7	
10			10		10			10		10			10	
15			15		15			15		15			15	
20			20		20			20		20			20	
30			30		30			30		30			30	
40			40		40			40		40			40	
50			50		50			50		50			50	
60			60		60			60		60			60	
70			70		70			70		70			70	
80			80		80			80		80			80	
90			90		90			90		90			90	
100			100		100			100		100			100	
110			110		110			110		110			110	
120			120		120			120		120			120	
150			150		150			150		150			150	
180			180		180			180		180			180	
240			240		240			240		240			240	
300			300		300			300		300			300	
410			410		410			410		410			410	
440			440		440			440		440			440	

COMMENTS: 1)

BOREHOLE TEST RECORD SHEET

REQUEST NO:		MAP REFERENCE:		REGION:	North West
BOREHOLE NO:	LBH9	COORDINATES (dd-mm-ss)	Lo:	DISTRICT:	Mafikeng
ALT. BH. NO:		LATITUDE:	X:	FARM NAME:	
ALT. BH. NO:		LONGITUDE:	Y:	VILLAGE:	Logageng

BOREHOLE DEPTH (m):	160	DATUM LEVEL ABOVE CASING (m):	0.37	EXISTING PUMP
WATER LEVEL (mbgl):	30.6	CASING HEIGHT (magl):	0.35	NONE
DEPTH OF PUMP (m):	90	BH DIAM. (PUMP INLET) (mm):	165.00	Contract dgm

CONSTANT RATE DISCHARGE TEST AND RECOVERY

TEST STARTED		TEST COMPLETED		DURATION (min):	1440
DATE: 14/09/2011	TIME: 08:00	DATE: 15/09/2011	TIME:	TYPE OP PUMP:	BH100

"NOTE"	Distance between discharge and observation holes in m.		OBSERV. HOLE 1			OBSERV. HOLE 2			OBSERV. HOLE 3	
			Nr:			Nr:			Nr:	
DISCHARGE BOREHOLE			Distance:			Distance:			Distance:	
TIME	DRAWDOWN	YIELD	TIME	RECOVERY	TIME	DRAWDOWN	TIME	DRAWDOWN	TIME	DRAWDOWN
(min)	s' (m)	(l/s)	(min)	s' (m)	(min)	(m)	(min)	(m)	(min)	(m)
1	0.84		1	45.17	1		1		1	
2	1.42		2	40.06	2		2		2	
3	1.89		3	36.66	3		3		3	
5	2.53	0.35	5	31.41	5		5		5	
7	3.22	0.29	7	27.50	7		7		7	
10	4.75		10	24.36	10		10		10	
15	5.98	0.23	15	21.44	15		15		15	
20	6.53		20	18.73	20		20		20	
30	7.20		30	14.58	30		30		30	
40	8.00	0.19	40	9.94	40		40		40	
60	9.89	0.2	60	5.27	60		60		60	
90	10.78	0.22	90	4.62	90		90		90	
120	12.67	0.2	120	4.27	120		120		120	
150	14.75	0.23	150	3.83	150		150		150	
180	16.03	0.22	180	3.45	180		180		180	
210	18.56		210	3.19	210		210		210	
240	20.62		240	2.96	240		240		240	
300	22.38	0.2	300	2.62	300		300		300	
360	24.17	0.21	360	2.37	360		360		360	
420	26.68	0.21	420	2.16	420		420		420	
480	28.03		480	1.85	480		480		480	
540	30.10		540	1.66	540		540		540	
600	32.06	0.2	600	1.43	600		600		600	
720	34.87		720	1.17	720		720		720	
840	37.14		840	1.02	840		840		840	
960	39.70		960	0.94	960		960		960	
1080	41.68	0.21	1080	0.81	1080		1080		1080	
1200	44.00		1200	0.76	1200		1200		1200	
1320	47.12	0.2	1320	0.70	1320		1320		1320	
1440	50.37	0.2	1440	0.65	1440		1440		1440	
1800			1800		1800		1800		1800	
2280			2280		2280		2280		2280	
2880			2880		2880		2880		2880	
3480			3480		3480		3480		3480	
3900			3900		3900		3900		3900	
4320			4320		4320		4320		4320	
4920			4920		4920		4920		4920	
5760			5760		5760		5760		5760	

TOTAL TIME PUMPED (m	1440	NOTE:	t" = total time since pumping started
AVERAGE YIELD (l/s):	0.22		t" = time since pumping started

COMMENTS: 1).

TRANS AFRICA WATER SERVICES

BOREHOLE TEST CONTROL SHEET

Borehole Number:	LBH12	Old/Alternative Number:		
Contractor:	Trans Africa	Supervisor: Ruben		
Operator	Phinias	Rig Number: No 1		

EXISTING EQUIPMENT

Type of Pump	Depth	Condition	Drive Unit	Condition	Pumphouse	Condition
~	~	~	~	~	~	~

TESTING EQUIPMENT

Pump type	Depth Installed	Date and Time (started)		Date and Time (Completed)	
BH100	74	19/09/2011	00:00	19/09/2011	15:10

MULTI-RATE OR STEPTEST DETAILS

Step	Duration (min)	Recovery (min)	Yield (l/s)	Drawdown (m)
1	60.00		0.54	6.83
2	60.00		1.03	14.03
3	60.00		2.02	42.48
4	10.00		3.03	54.79
5				
Calibration				
TOTAL:	190.00	440.00		
COMMENT:				

CONSTANT RATE DISCHARGE TEST

Type of pump	Depth Installed		Date and Time (started)		Date and Time (Completed)	
BH100	74		20/09/2011	08:00	21/09/2011	08:00
Yield (l/s)	Drawdown (m)		Duration (min)		Recovery (min)	
1.22	22		1440		1200	
TOTAL (Multi-ra						
COMMENT:						

GENERAL

Establishment	From:		To:			Distance (km)
Site Move	From		To			Distance (km)
	Village	Borehole #	Village	Borehole #		
	Logageng	LBH8	Logageng	LBH12		
Maintenance	Work Time (hr)		Parts Re-place/repair		Travelling (km)	
After Test Measurements	Water Level	18.7	Borehole Depth	160.00	Casing Depth	
REMARKS:						
Signed for Contractor:			Signed for Consultant:			

BOREHOLE TEST RECORD SHEET

REQUEST NO:		MAP REFERENCE:		REGION: North West	
BOREHOLE NO: LBH12		COORDINATES (Dec. Deg.)	Lo:	DISTRICT: Mafiking	
ALT. BH. NO:		LATITUDE: 25.94250	X:	FARM NAME:	
ALT. BH. NO:		LONGITUDE: 24.71772	Y:	VILLAGE: Logageng	
BOREHOLE DEPTH (m):	160.00	DATUM LEVEL ABOVE CASING (m):	0.51	EXISTING PUMP:	
WATER LEVEL (mbgl):	18.49	CASING HEIGHT (magl):	0.21	CONTRACTOR:	
DEPTH OF PUMP (m):	74.00	BH DIAM. (PUMP INLET) (mm):	165.00	PUMP TYPE: BH100	

MULTI-RATE DISCHARGE TEST AND RECOVERY

DISCHARGE RATE 1					DISCHARGE RATE 2					DISCHARGE RATE 3				
DATE: 19/09/2011		TIME: 13:00			DATE: 19/09/2011		TIME: 13:00			DATE: 19/09/2011		TIME: 14:00		
TIME	DRAWDOWN	YIELD	TIME	RECOVERY	TIME	DRAWDOW	YIELD	TIME	RECOVERY	TIME	DRAWDOWN	YIELD	TIME	RECOVERY
(min)	(m)	(l/s)	(min)	(m)	(min)	(m)	(l/s)	(min)	(m)	(min)	(m)	(l/s)	(min)	(m)
1	0.44		1		1	7.26		1		1	14.79		1	
2	1.07		2		2	7.90		2		2	15.88		2	
3	1.82	0.68	3		3	8.68	1.07	3		3	17.54	1.89	3	
5	2.33	0.54	5		5	9.42	1.03	5		5	19.40		5	
7	2.65		7		7	10.15		7		7	21.44	2.03	7	
10	3.12		10		10	10.88	1.03	10		10	23.08		10	
15	4.20	0.53	15		15	11.62		15		15	28.85	2.01	15	
20	4.87		20		20	12.20	1.02	20		20	30.86		20	
30	5.50		30		30	12.74	1.02	30		30	34.45	2.02	30	
40	6.16	0.55	40		40	13.00		40		40	37.12		40	
50	6.34	0.54	50		50	13.18	1.03	50		50	39.64	2.02	50	
60	6.83		60		60	14.03		60		60	42.48		60	
70			70		70			70		70			70	
80			80		80			80		80			80	
90			90		90			90		90			90	
100			100		100			100		100			100	
110			110		110			110		110			110	
120			120		120			120		120			120	
150			150		150			150		150			150	
180			180		180			180		180			180	
240			240		240			240		240			240	
300			300		300			300		300			300	
410			410		410			410		410			410	
440			440		440			440		440			440	

DISCHARGE RATE 4					DISCHARGE RATE 5					YIELD (CALIBRATION) TEST				
DATE:		TIME:			DATE:		TIME: 20:00			DATE:		TIME:		
TIME	DRAWDOWN	YIELD	TIME	RECOVERY	TIME	DRAWDOW	YIELD	TIME	RECOVERY	TIME	DRAWDOWN	YIELD	TIME	RECOVERY
(min)	(m)	(l/s)	(min)	(m)	(min)	(m)	(l/s)	(min)	(m)	(min)	(m)	(l/s)	(min)	(m)
1	43.63		1	47.13	1			1		1			1	
2	44.13	2.91	2	34.86	2			2		2			2	
3	48.19		3	30.24	3			3		3			3	
5	50.14	3.04	5	25.17	5			5		5			5	
7	52.73		7	20.16	7			7		7			7	
10	54.79	3.03	10	13.15	10			10		10			10	
15	PI	2.10	15	6.36	15			15		15			15	
20	PI	2.07	20	3.46	20			20		20			20	
30	PI	1.97	30	2.43	30			30		30			30	
40			40	2.23	40			40		40			40	
50			50	2.10	50			50		50			50	
60			60	1.85	60			60		60			60	
70			70	1.80	70			70		70			70	
80			80	1.73	80			80		80			80	
90			90	1.64	90			90		90			90	
100			100	1.56	100			100		100			100	
110			110	1.43	110			110		110			110	
120			120	1.29	120			120		120			120	
150			150	1.10	150			150		150			150	
180			180	0.93	180			180		180			180	
240			240	0.71	240			240		240			240	
300			300	0.52	300			300		300			300	
410			410	0.36	410			410		410			410	
440			440	0.14	440			440		440			440	

COMMENTS: 1)

BOREHOLE TEST RECORD SHEET

REQUEST NO:		MAP REFERENCE:		REGION:	North West
BOREHOLE NO:	LBH12	COORDINATES (Dec. Deg.)	Lo:	DISTRICT:	Mafikeng
ALT. BH. NO:		LATITUDE: 25.94250	X:	FARM NAME:	
ALT. BH. NO:		LONGITUDE: 24.71772	Y:	VILLAGE:	Logageng

BOREHOLE DEPTH (m):	160	DATUM LEVEL ABOVE CASING (m):	0.51	EXISTING PUMP
WATER LEVEL (mbgl):	18.49	CASING HEIGHT (magl):	0.21	NONE
DEPTH OF PUMP (m):	74	BH DIAM. (PUMP INLET) (mm):	165.00	Contract dgm

CONSTANT RATE DISCHARGE TEST AND RECOVERY

TEST STARTED		TEST COMPLETED		DURATION (min):	1440
DATE: 20/09/2011	TIME: 08:00	DATE: 21/09/2011	TIME: 08:00	TYPE OP PUMP:	BH100

"NOTE" Distance between discharge and observation holes in m.

DISCHARGE BOREHOLE					OBSERV. HOLE 1		OBSERV. HOLE 2		OBSERV. HOLE 3	
					Nr:		Nr:		Nr:	
					Distance:		Distance:		Distance:	
TIME	DRAWDOWN	YIELD	TIME	RECOVERY	TIME	DRAWDOWN	TIME	DRAWDOWN	TIME	DRAWDOWN
(min)	s' (m)	(l/s)	(min)	s' (m)	(min)	(m)	(min)	(m)	(min)	(m)
1	0.94		1	18.12	1		1		1	
2	0.15		2	15.32	2		2		2	
3	2.17		3	13.47	3		3		3	
5	3.58	0.94	5	10.04	5		5		5	
7	4.09	1.13	7	8.14	7		7		7	
10	4.97	1.23	10	7.06	10		10		10	
15	5.66		15	5.25	15		15		15	
20	6.33		20	3.37	20		20		20	
30	6.54	1.22	30	2.96	30		30		30	
40	8.47		40	2.63	40		40		40	
60	10.93	1.22	60	2.33	60		60		60	
90	13.02		90	2.12	90		90		90	
120	15.88	1.23	120	1.83	120		120		120	
150	16.74		150	1.50	150		150		150	
180	17.47	1.23	180	1.22	180		180		180	
210	17.85		210	0.96	210		210		210	
240	18.26		240	0.73	240		240		240	
300	18.63		300	0.58	300		300		300	
360	18.90	1.22	360	0.51	360		360		360	
420	19.33		420	0.46	420		420		420	
480	19.54		480	0.40	480		480		480	
540	19.81	1.21	540	0.35	540		540		540	
600	20.16		600	0.29	600		600		600	
720	20.52	1.22	720	0.19	720		720		720	
840	20.77		840	0.14	840		840		840	
960	21.05		960	0.10	960		960		960	
1080	21.17		1080	0.06	1080		1080		1080	
1200	21.42	1.21	1200	0.00	1200		1200		1200	
1320	21.70	1.21	1320		1320		1320		1320	
1440	22.00	1.22	1440		1440		1440		1440	
1800			1800		1800		1800		1800	
2280			2280		2280		2280		2280	
2880			2880		2880		2880		2880	
3480			3480		3480		3480		3480	
3900			3900		3900		3900		3900	
4320			4320		4320		4320		4320	
4920			4920		4920		4920		4920	
5760			5760		5760		5760		5760	

TOTAL TIME PUMPED (m	1440	NOTE:	t" = total time since pumping started
AVERAGE YIELD (l/s):	1.19		t" = time since pumping started

COMMENTS: 1).