Reg No. 2000/002014/07

2.2(3685)

THULAMAHAXI SPORT STADIUM WATER SUPPLY PROJECT –

ROLLE 235 KU & EDINBURGH 228 KU

GEOHYDROLOGICAL INVESTIGATION

FOR

DOMBO & DU PLESSIS

MR02/001

NORTHERN PROVINCE

BUSHBUCK RIDGE AREA

FINAL REPORT

MARCH 2002

Project Manager: C. Roos

Project Leader: N. Sonnekus

Maps & Report prepared by: C. Roos

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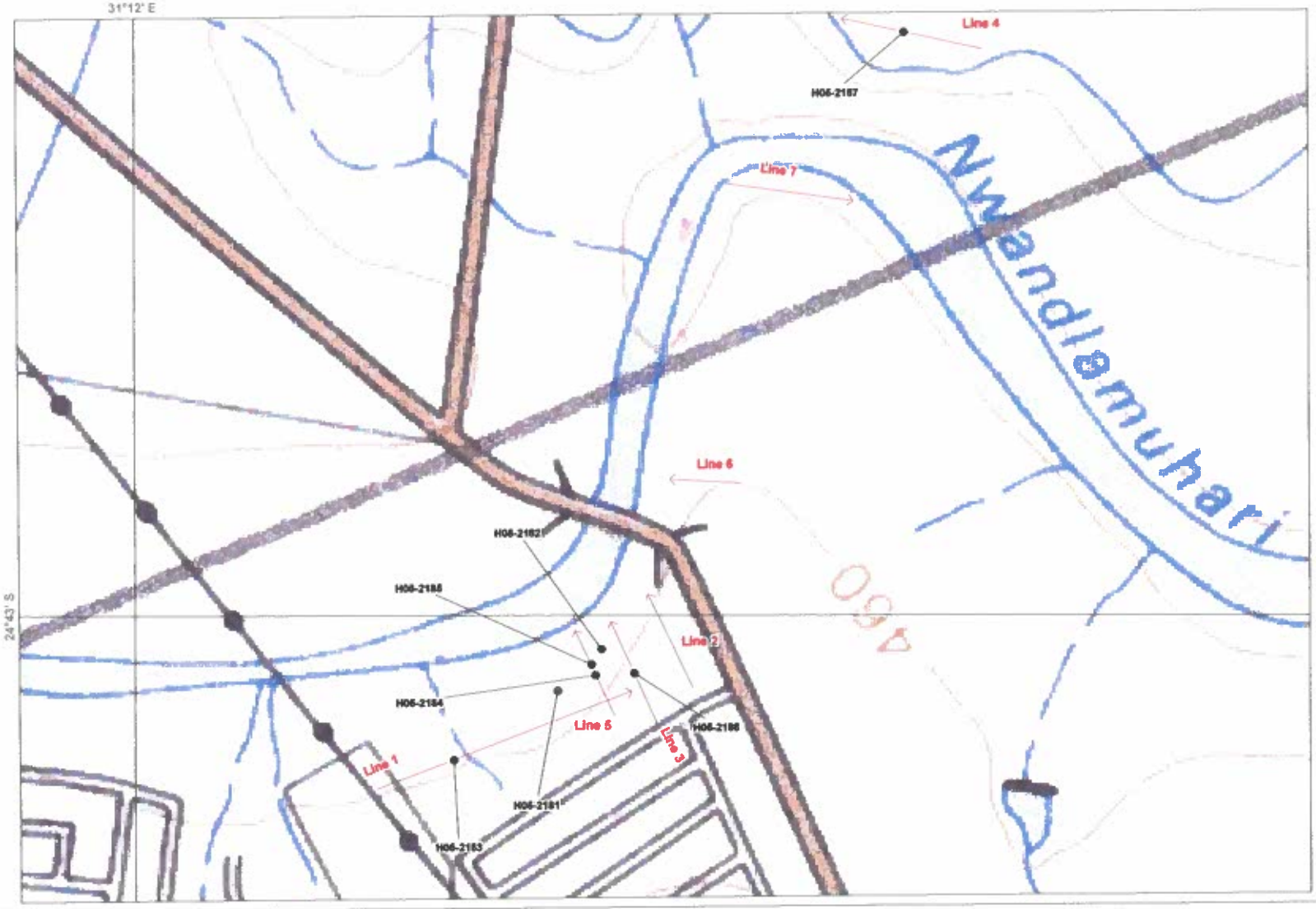

Recommended Yield (m³/day)

- Not Recommended
- 1 to 5
- 10 to 15
- 15 to 20

Existing Equipment

- ●No equipment
- ▲Handpump

Geophysical traverse

Scale & Projection:

Gauss Conform Projection
Central Meridian 31° East
Clarke 1880 Spheroid

Reference: 2431 CA
1:50 000 Toposheet

0 0.15 0.3
kilometers

Area of Detail:

Prepared by:

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On Behalf of:

Department of Water Affairs & Forestry
P/Bag X9506
Pietersburg
0700

2002/03/14

1. INTRODUCTION:

1.1. Background:

VSA Leboa Consulting was requested by Dombo & Du Plessis in January 2002 to investigate the groundwater potential of an area along the Nwandlamuhari River, near the Thulamahaxi Sport Stadium and to drill and test a production borehole in the area to supply water for irrigation purposes.

1.2. Location:

The area of investigation is situated on the northern side of the village of Thulamahaxi on the farms Rolle 235 KU and Edinburgh 228 KU, Bushbuck Ridge Area, Northern Province. It is framed by lines of latitude 24°42' and 24°44'S and lines of longitude 31°12' and 31°13'E and falls on 1:50 000 toposheet 2431 CA Acornhoek.

1.3. Objective:

The aim of the investigation was to drill and test a production borehole in the area to supply water to the Thulamahaxi Sport Stadium for irrigation purposes.

1.4. Methodology and project development:

The geohydrological investigation was executed in a phased approach:

Phase 1: Geological and geophysical investigation in the indicated area to delineate any structures or zones of deep weathering that could have a bearing on the occurrence of groundwater in the area.

Phase 2: Testing of existing borehole H05-2181 to establish groundwater potential of the area.

Phase 3: Drilling of 4 identified targets in the area of investigation (H05-2183, H05-2184, H05-2185, H05-2186).

Phase 1b: Further geophysical investigation north of the indicated area.

Phase 3b: Drilling of 1 additional borehole along identified structure (H05-2187).

Phase 6: Final Report and Recommendations

2. PHYSIOGRAPHY:

2.1. Morphology, soil & vegetation:

Physiographically, the area of investigation comprises undulating terrain along the Nwandlamuhari River with elevations of between 440 and 480 m amsl. The area is underlain by moderate to deep sandy loam with *Tropical Bush & Savanna* the dominating veld type (Acock, 1988).

2.2. Climate and rainfall:

The area of investigation falls within the **X32C** quaternary sub-catchment area as defined by the Water Research Commission in their 1994 report (Midgley *et al.*, 1994). This sub-catchment area is characterized by a mean annual precipitation of between 700 and 800mm and a mean annual runoff of 50 to 100mm. Evaporation figures per annum are in the order of 1500 to 1600mm.

3. GEOLOGY:

3.1. Cunning Moor Tonalite

The greater portion of the area of investigation is underlain by the Cunning Moor Tonalite. This 2600 Ma old leucocratic intrusion is medium-grained and consists of plagioclase and quartz with lesser amounts of microcline and biotite. Characteristically, it contains large (up to 3 mm in length), euhedral, poikilitic grains of sphene. Although generally massive, foliation of the tonalite is seen in some parts of the intrusion.

The Cunning Moor Toanalite is characterized by its very low groundwater potential unless intersecting lineaments or fault zones are encountered. Extensive geohydrological work done in the Bushbuck Ridge Area under the Critical Intervention Program of DWAF in the period 1995 to 1998 as well as ongoing projects in the area indicates that the production boreholes drilled in the Cunning Moor Tonalite rarely exceeds 0.8 l/s with 0.1L/s to 0.5 L/s recommended yields for 8-24 hour duty cycles commonly found.

North of the Nwandlamuhari River the Makutswi Gneiss dominates but existing data for the area indicates that more than 75% of all boreholes drilled on or near this contact where dry holes except where lineaments were encountered.

4. GEOPHYSICAL INVESTIGATION:

A detailed geophysical investigation was done employing Ground Magnetic and Frequency Domain Electromagnetic (EM-34) methods, to identify and delineate zones of deep weathering and/or geological structures in an attempt to locate the most suitable drill targets. These structures are primary targets as they could act as possible groundwater conduits that could yield a sustainable source.
Appropriate electromagnetic survey parameters in terms of coil separation and frequency selection were employed according to the terrain conditions with sample intervals of 10m for the EM-34 and 5m for the magnetometer been employed.

4.1. Magnetic method

The different magnetic susceptibilities of the different rock types result in contrasting magnetic signatures. Analysis of the amplitude or intensity of the magnetic anomalies as well as its graphical shape bears some direct relationship to the magnetic mineral content, size, depth, shape and orientation of the buried body or structure. Hence, the magnetic data may be interpreted to represent dykes, geological contacts and faults that may have a bearing on the occurrence, storage and movement of the groundwater. These geological structures are primary targets in selecting drilling sites for groundwater exploration.

A Chemtron model G5 proton-precision magnetometer (Fig.1) was used, measuring directly the strength of the total magnetic field at a given locality.

Figure 1 : The Chemtron model G5 proton-precision magnetometer.

4.2. Frequency Domain Electromagnetic Methods

4.2.1. EM-34

The operating principles of the EM-34 system are briefly discussed below. The technique provides rapid and easy measurement of terrain conductivities and facilitates the detection of steeply dipping conductor type targets such as dykes, fracture zones, faults etc. through electromagnetic coupling.

The EM-34 (Fig.2) is a moving transmitter and receiver system, which measures the ratio of the quadrature component of the secondary magnetic field to the free space primary magnetic field. The transmitter and receiver units are connected by a cable, acting as a reference to the primary magnetic field.

Figure 2: The EM-34 System.

The twenty and forty metres coil separations used for the EM-34 profiling allowed relatively rapid surveying and, in general, low noise levels.

The receiver unit is calibrated to indicate apparent conductivity (1-300 mS/m). At low values of terrain conductivity (<100 mS/m), apparent conductivities are linearly proportional to actual conductivities. For resistive terrains (low conductivities), the vertical depth of exploration over the homogeneous or horizontally stratified earth for coil separations of 10, 20 or 40m are 15, 30 and 60m (horizontal coils) and 7.5, 15 and 30m (vertical coils) respectively. The lateral extent of the volume of the earth, whose conductivity is sensed, approximates the vertical depth and small changes in conductivity (5 to 10 mS/m) are readily and accurately measured.

4.3. Geophysical results:

Table 1 gives a short summary of the geophysical investigation and the resulting drilling targets identified:

Table 1: Summary of geophysical investigations:

Farm	Traverse no.	Length	Geophysical Techniques Used	Targets identified	Target description
Rolle 235 KU	Line 1	380m	Magnetic	Line 1/111m	Zone of deep weathering
Rolle 235 KU	Line 2	140m	Magnetic	-	-
Rolle 235 KU	Line 3	155m	Magnetic & EM-34	Line 3/85m	Zone of deep weathering, fractures
Edinburgh 228 KU	Line 4	200m	Magnetic & EM-34	Line 4/105m	Dyke
Rolle 235 KU	Line 5	80m	Magnetic	Line 5/45m Line 5/60m	Zone of deep weathering Fractures
Rolle 235 KU	Line 6	100m	Magnetic	-	-
Edinburgh 228 KU	Line 7	180m	Magnetic	-	-

5. PERCUSSION DRILLING

Boreholes were drilled and field marked to specifications as laid down by the Department of Water Affairs and Forestry in their *"Minimum Standards and Guidelines for Groundwater Resource Development for the community Water Supply and Sanitation Program"*.

The method employed for the sinking of the water supply borehole was that of rotary air percussion drilling employing a down-the-hole (TDH) hammer. This drilling technique is ideally suited for hard rock formations.

Figure 3 : The rotary air percussion drill rig.

The cuttings brought to the surface by air return from the bore were collected and described for each meter drilled. The lithologies described are presented in borehole logs in the Appendix, together with all other relevant information pertaining to and obtained from the boreholes.

Water intersections were recorded, and blow yields measured using a V-notch. By using a dip meter, the static water level of the borehole was determined.

Boreholes were completed to 165mm diameter with steel casing installed from surface, through unstable, unconsolidated or fractured material.

5.1. Drilling results:

The drilling results are summarized in Table 2 with detailed borehole logs presented in the Appendix.

Table 2: Summary of drilling results:

BOREHOLE	DEPTH	WATERSTRIKE	AQUIFER	BLOWYIELD
H05-2183	35m	13m, 16m	Small-scale fractures	0.2L/s
H05-2184	30m	11m	Weathering	0.05L/s
H05-2185	65m	11m, 14m, 27m	Small-scale fractures	0.3L/s
H05-2186	55m	21m, 23m, 26.9m	Small-scale fractures	0.21L/s
H05-2187	30m	-	-	Dry

6. TESTPUMPING AND RESULTS

The correct operation and utilisation of boreholes result from the assessment of the productive capacity (sustainable yield) of the borehole as well as the productivity of the aquifer supporting the borehole. Such knowledge is provided by data analysis of boreholes subjected to detailed pumping test programs. Test pumping provides a means of identifying potential constraints on the performance of a borehole and on the exploitation of the groundwater resource. The recognition and understanding of these constraints would result in proper groundwater utilization and management. The existing borehole (H05-2181) was subjected to a calibration test, a step drawdown test.

6.1. Calibration test:

A preliminary **calibration test** is done at the beginning of every pumptest to determine the yield of the step drawdown test, to determine the efficiency of the pump to be used and to reveal any borehole construction problems (sand pumping).

6.2. Step drawdown test:

The **step drawdown test** is performed to assess the efficiency of the borehole, and to determine at which rate a longer duration test (constant discharge test) can be performed. It entails pumping the hole at two or more sequentially higher pumping rates each maintained for an equal length of time (generally not less than 60 minutes and seldom longer than 120 minutes). The magnitude by which the water level in the borehole drops (known as the **drawdown**) in response to these known pumping rates is measured and recorded in accordance with a prescribed time schedule. The water level is also measured and recorded, again to a prescribed time schedule, for a period of time immediately following the period of pumping. This represents the period of recovery in which the water level rises towards its starting level before pumping.

6.3. Results:

H05-2181 was subjected to a calibration test and step tests to gain knowledge of the aquifer responses in the area and determine its potential as production borehole. Although the H05-2181 aquifer exhibited an inflow of 0.7L/s into the borehole, it exhibited a slow recovery rate and water losses, resulting in a final recommended yield of only 0.15L/s for 8 hour duty cycle (see attached Management Recommendation) therefore only suitable for a handpump.

Table 3: Summary of testing results:

BOREHOLE	STATUS	TESING PROGRAM	RECOVERY	RECOMMENDATION
H05-2181	Existing	Calibration test 1x Step Test (100min)	91% in 1.8x pumping time	0.15L/s for 8 hour pumping cycle. Casing not to DWAF Standard Slow recovery rates.

7. HYDROCHEMISTRY:

Groundwater samples were collected from the tested borehole. The sample was sent to the Polokwane Municipal Council Laboratory in Pietersburg for preliminary analysis as well as to the DWAF Laboratory in Pretoria for a full analysis of the main hydrochemical concentrations (macro elements) in the groundwater sample. Elements analyzed for include: Ca, Mg, Na, K, Cl, NO_3, SO_4, PO_4, NH_4, CO_2, HCO_3. As soon as the chemistry results are available it would be forwarded as an addendum to this report.

8. CONCLUSIONS & RECOMMENDATIONS:

The low groundwater potential of the area as well as the absence of any dominant structures in the are of investigation, only leaves the following options for a water source in the area:

- Increase the investigation area to at least 2km radius, into the Makutswi Gneiss north of the river, where the groundwater potential is higher and linear structures are prominent.
- Abstract water directly from the Nwandlamuhari River either by a pump or a borehole drilled in the river in the dry season, and utilizing a submersible.

9. REFERENCES:

ACOCKS, J.P.H., (1988). Veld Types of South Africa. *Memoirs of the Botanical Survey of South Africa* no. 57, 146pp.

MIDGLEY, D.C., PITMAN, W.V., MIDDLETON, B.J. (1994). *Surface water resources of South Africa 1990*. WRC Report no 298/6.2/94, Vol. V1 Appendices (First edition).

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Date compiled: 3/18/02

SITE INFORMATION

	SITE LOCATION									GEOHYDROLOGY				MANAGEMENT RECOMMEND.			
	Number:	District	Site name/Description	Site type:	Longitude [°]:	Latitude [°]:	Altitude [m]	Col. ht. [m]	Diam. [mm]	Depth [m]	Water l. [m]	Yield[l/s]	Rec. abs.[l/s]	Depth to intk. [m]	Dis. rate[l/s]	Duty c. [hrs/d]	Daily abs. [m³/d]
5	H05-2182	NPKU235	ROLLE/THULAMAHAXI	B	31.2052501	24.7161111	640.00	0.30	170	1.00				30.00	0.15	8	4.32
0	H05-2181	NPKU235	ROLLE/THULAMAHAXI	B	31.2046389	24.7166389	460.00	0.37	165	44.63	0.23				0	0	
1	H05-2185	NPKU235	ROLLE/THULAMAHAXI	B	31.2051112	24.7163056	460.00	0.30	165	65.00		0.30			0	0	
2	H05-2186	NPKU235	ROLLE/THULAMAHAXI	B	31.2057223	24.7164722	475.00	0.30	165	55.00		0.22			0	0	
3	H05-2183	NPKU235	ROLLE/THULAMAHAXI	B	31.2036668	24.7173889	460.00	0.30	165	35.00		0.18			0	0	
4	H05-2184	NPKU235	ROLLE/THULAMAHAXI	B	31.2051667	24.7164444	461.00	0.30	165	30.00		0.05					
5	H05-2187	NPKU228	EDINBURGH/THULAMAHAXI	B	31.2090278	24.7084722	480.00	0.30	165	30.00		0.05					
										Maximum:	65.00	0.23	0.30	30.00	0.15		4.32
										Minimum:	1.00	0.23	0.05	30.00	0.15		4.32
										Sum:			0.80		0.15		4.32
										Average:	37.23	0.23	0.16	30.00	0.15		4.32

RY:

Site Type:
B = Borehole

es: 7

NOTE:
"Yield" represents cumulative blow yield
The recommended abstraction ("Rec. abs.")
is based on a 24 hour duty cycle
(based on test pumping result)

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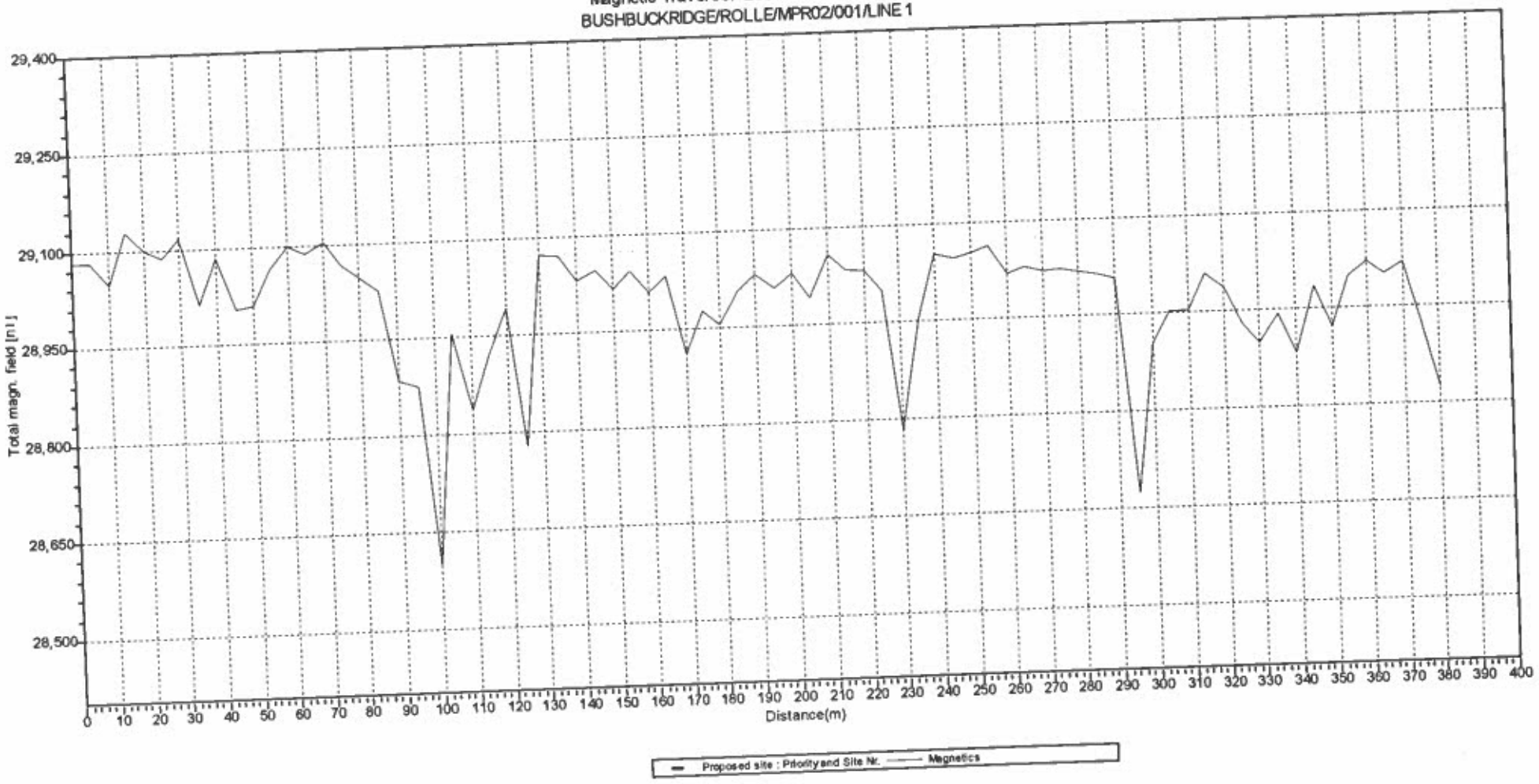
Date compiled: 3/12/02

hysical Traverse Line 1

Magnetic Traverse: 20020208TRAV0001
BUSHBUCKRIDGE/ROLLE/MPR02/001/LINE 1



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: Bushbuck Ridge
: Rolle 235 KU
tion: Thulamahadi Village
ction: NW-SE
ectno.: MPR02/001
: 18/02/2002

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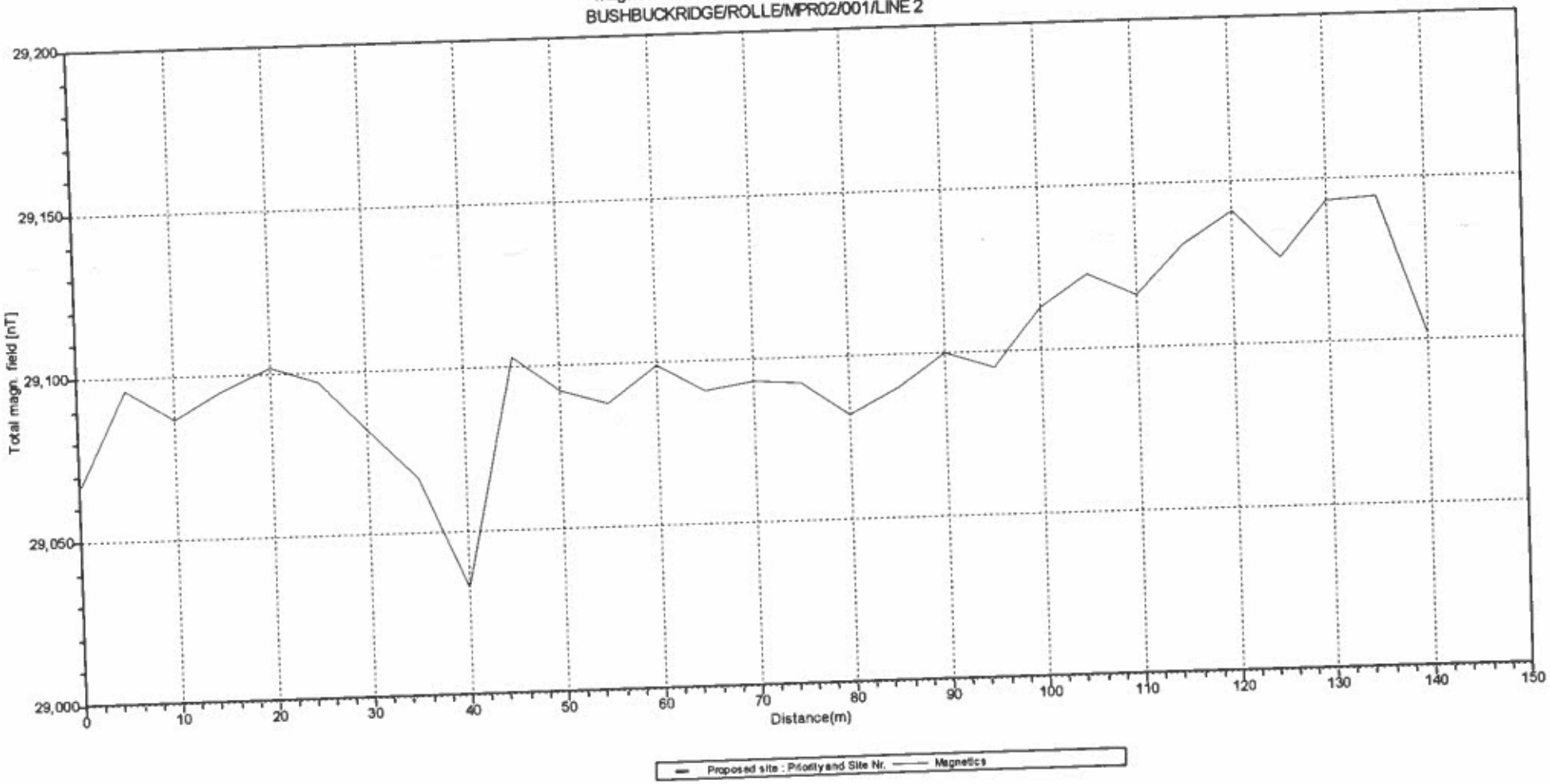
Date compiled: 3/12/02

ohysical Traverse Line 2

Magnetic Traverse: 20020222TRAV0001
BUSHBUCKRIDGE/ROLLE/MPR02/001/LINE 2



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: Bushbuck Ridge
n: Rolle 235 KU
ation: Thulamahadi Village
ction: S-N
ectno.: MPR02/001
s: 16/02/2002

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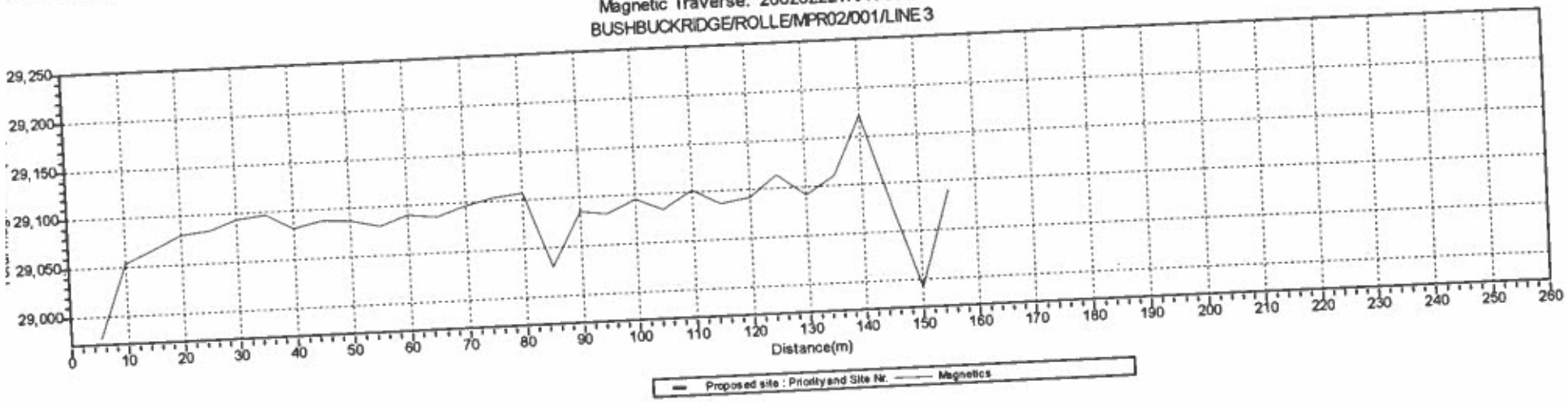
Date compiled: 3/12/02

hysical Traverse Line 3

Magnetic Traverse: 20020222TRAV0002
BUSHBUCKRIDGE/ROLLE/MPR02/001/LINE 3



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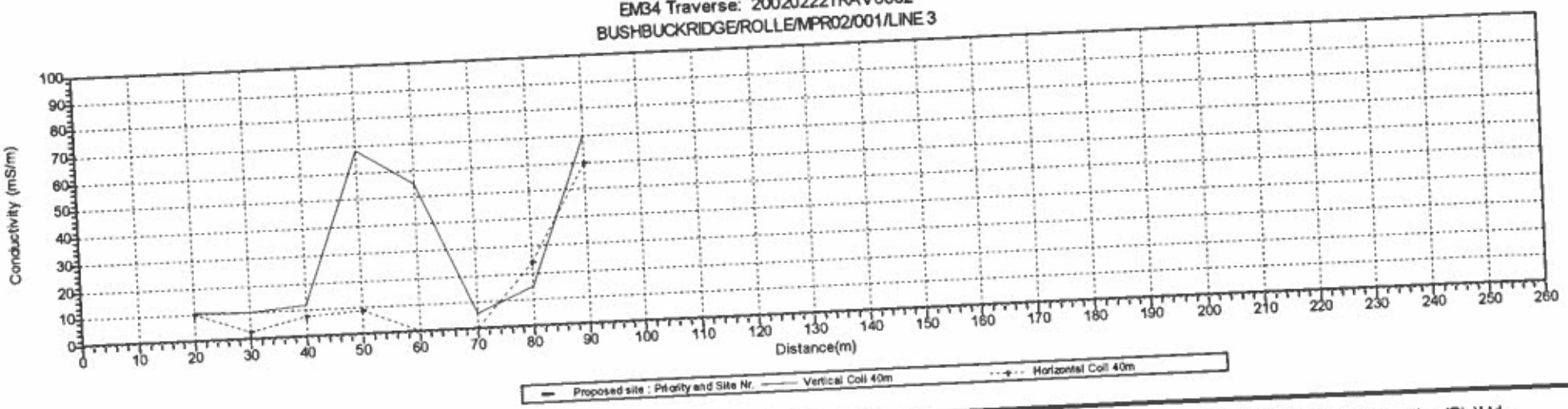
BUSHBUCKRIDGE/ROLLE/MPR02/001/LINE 3



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OJECT DESCRIPTION:
nt: Dombo & du Plessis
a: Bushbuck Ridge
n: Rolle 235 KU
ation: Thulamahasi Village
ection: NE-SW
jectno.: MPR02/001
e: 22/02/2002

Date compiled: 3/12/02

hysical Traverse Line 4

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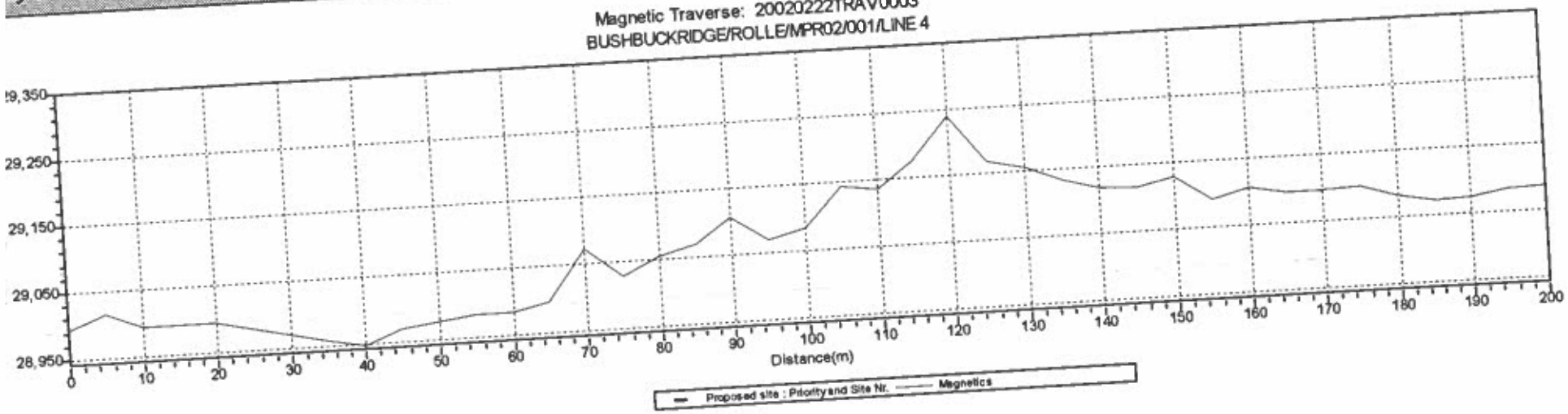
BUSHBUCKRIDGE/ROLLE/MPR02/001/LINE 4



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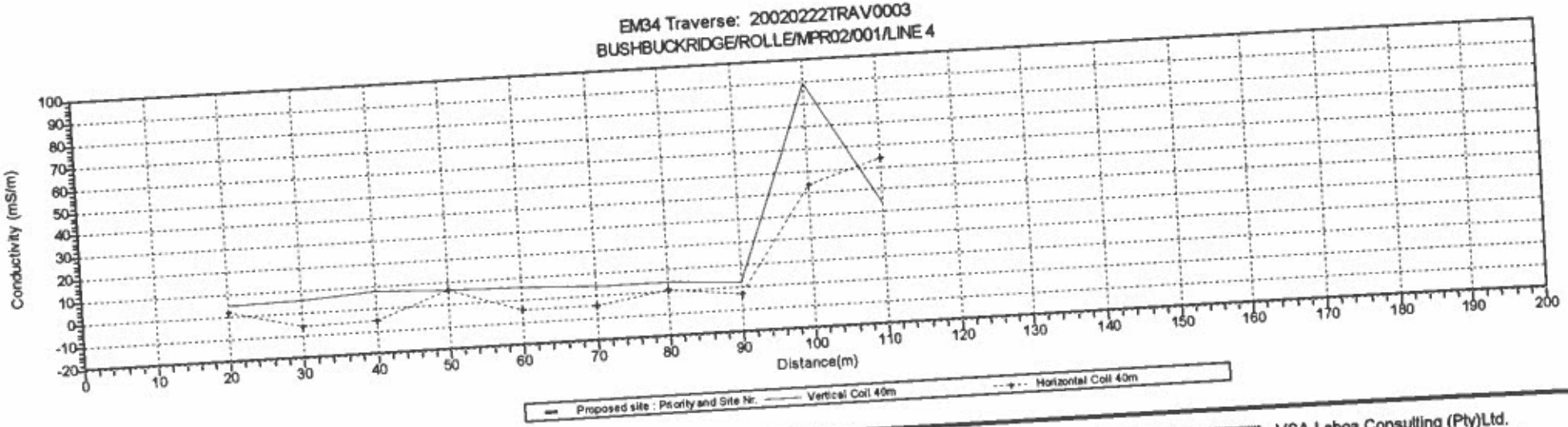

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e: Bushbuck Ridge
m: Rolle 235 KU
cation: Thulamahazi Village
ection: E-W
ojectno.: MPR02/001
te: 22/02/2002

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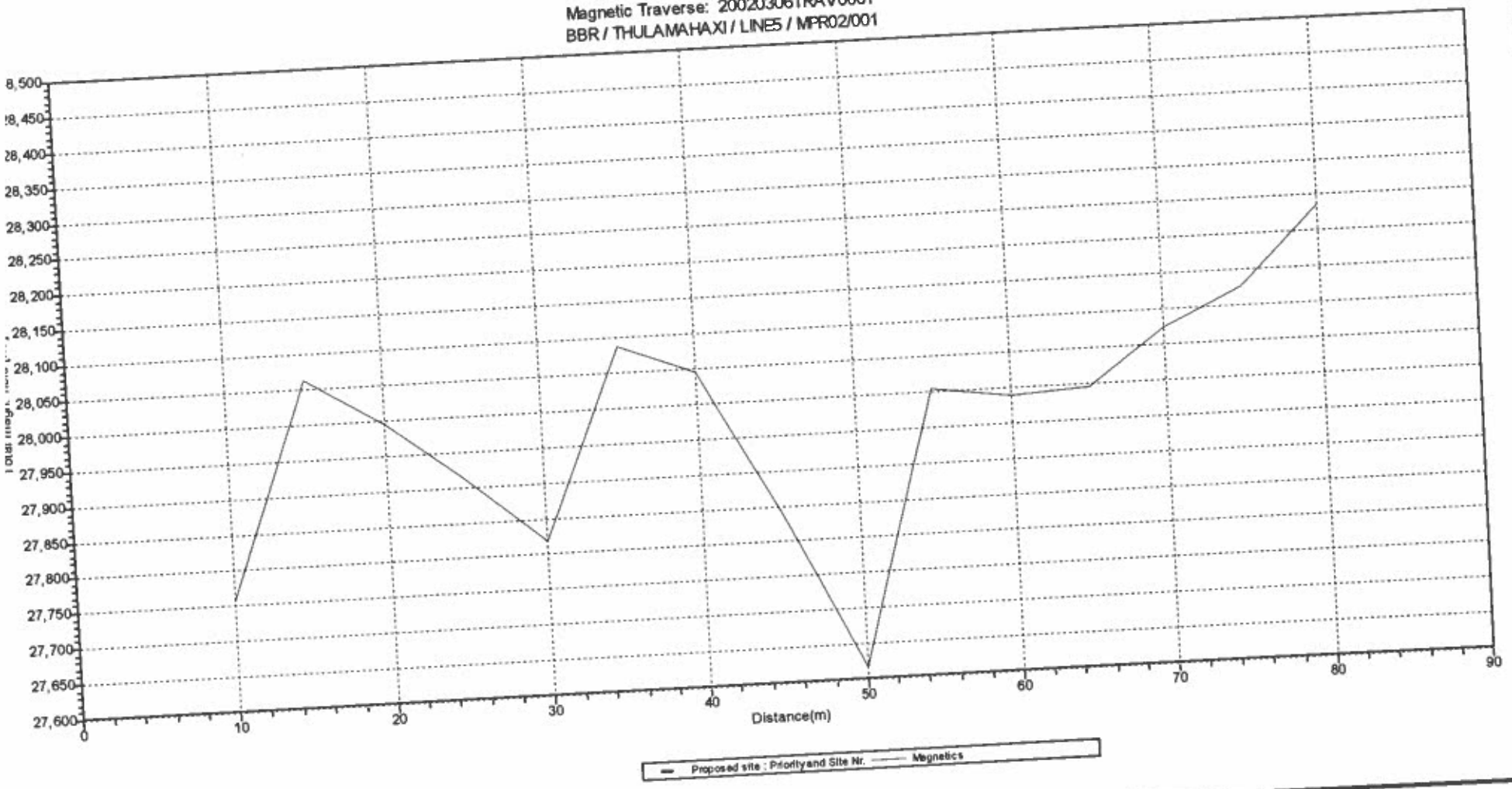
Magnetic Traverse: 20020306TRAV0001
BBR / THULAMAHAXI / LINE5 / MPR02/001



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JECT DESCRIPTION:
t: Dombo & du Plessis
: Bushbuck Ridge
n: Rolle 235 KU
ation: Thulamahaxi Village
ction: SE-NW
jectno.: MPR02/001
e: 08/03/2002

Date compiled: 3/12/02

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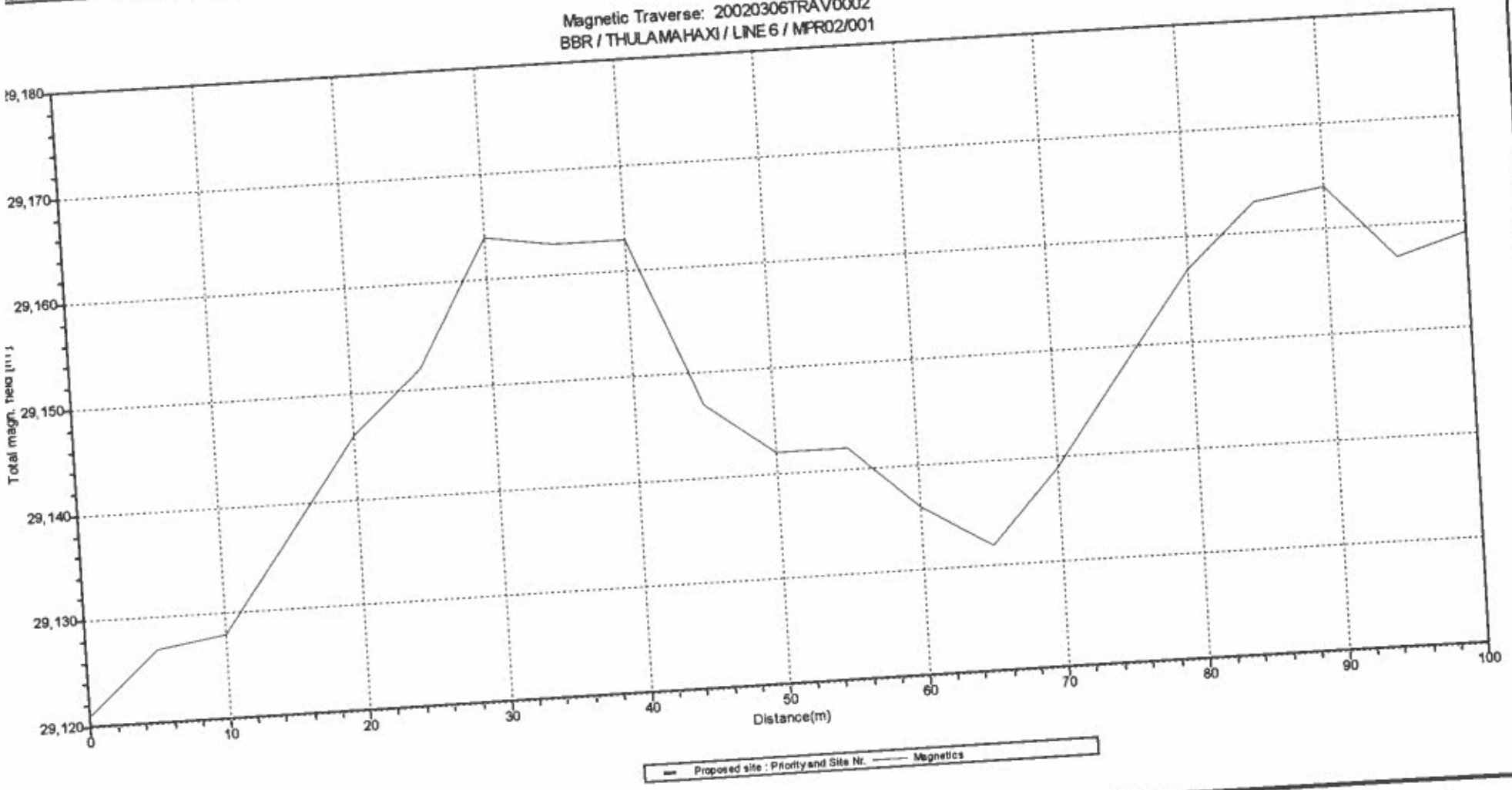
Magnetic Traverse: 20020306TRAV0002
BBR / THULAMAHAXI / LINE 6 / MPR02/001



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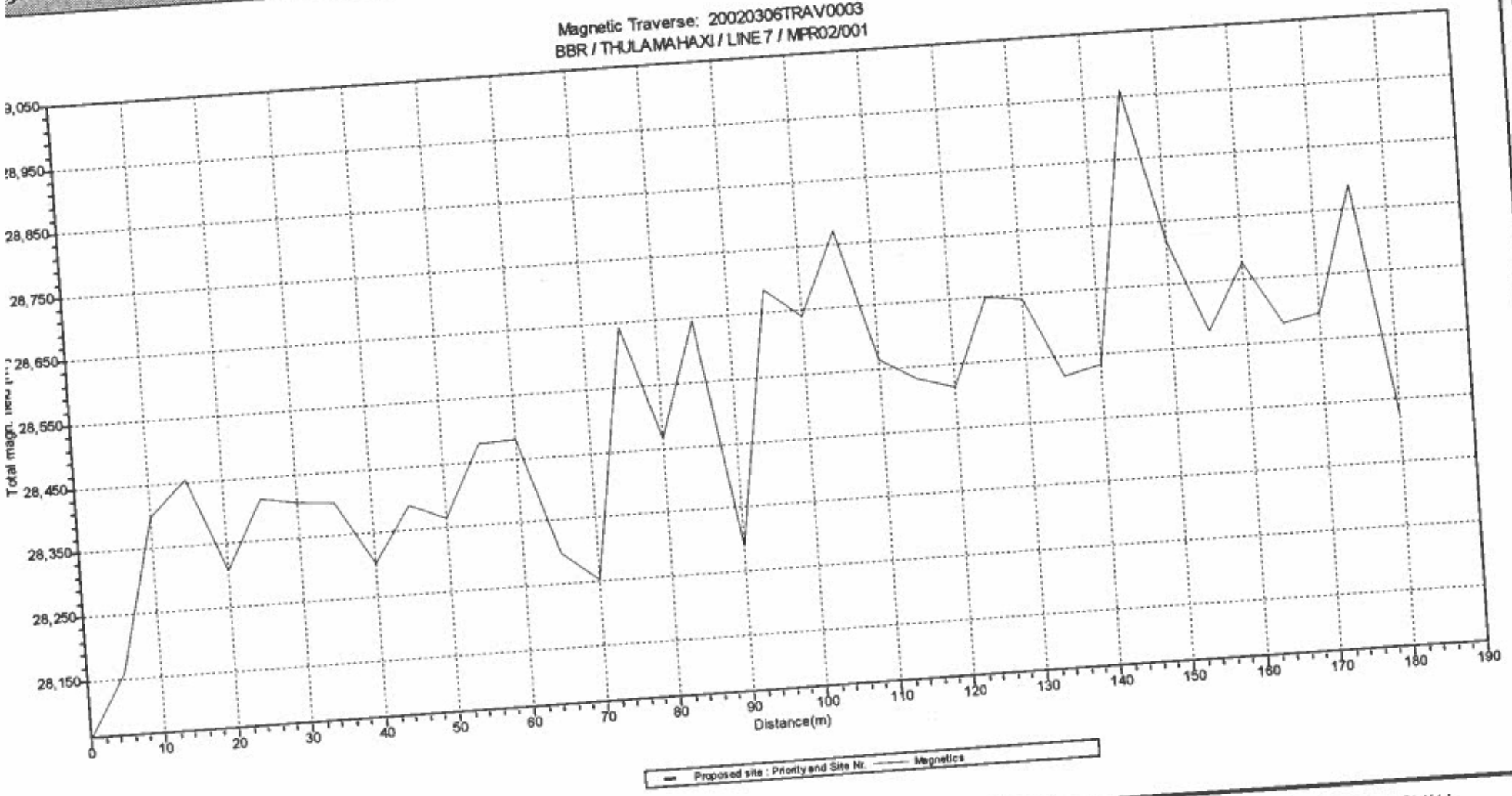
OJECT DESCRIPTION:
ent: Dombo & du Plessis
ea: Bushbuck Ridge
rm: Rolle 235 KU
cation: Thulamahaxi Village
rection: E-W
ojectno.: MPR02/001
ate: 06/03/2002

Date compiled: 3/12/02

ysical Traverse Line 7

Magnetic Traverse: 20020306TRAV0003
BBR / THULAMAHAXI / LINE 7 / MPR02/001



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OJECT DESCRIPTION:
ient: Dombo & du Plessis
ea: Bushbuck Ridge
rm: Rolle 235 KU
ocation Thulamahaxi Village
irection: W-E
rojectno.: MPR02/001
ate:06/03/2002

MANAGEMENT RECOMMENDATIONS

Date compiled: 3/12/02

BASIC SITE INFORMATION:

Site Identifier: 2431CAV1020 **Number:** H05-2181 **Site type:** Borehole

Distr./Farm No.: NPKU235 **Site Name/Descr.:** ROLLE/THULAMAHAXI

Longitude [°]:	31.2046389	**Alt. No. 1:**		**Diam. [mm]:**	165
Latitude [°]:	24.7166389	**Alt. No. 2:**	H051301	**Depth [m]:**	44.63
Altitude [m]:	460.00	**Rep. Inst.:**	VSA	**Col. ht. [m]:**	0.37

Water lev. [m]: 0.23
WL status: Static
Date WL meas.: 20020214

EXISTING EQUIPMENT:

Pump:
Type of Inst.: No equipment
Manufacturer:
Pulley Diam. [mm]:
Depth to Intk. [m]: 0

Engine:
Manufacturer:
Type of Power: No equipment
Power Rating [kW] 0
Pulley Diam. [mm]:

USE APPLICATION:

Site Status: Unused
Purpose: Production (water supply)
Consumer: Non-urban
Application: Domestic - all purposes

WATER CHEMISTRY:

Sample No.: **Date sampled:** **Depth sampl. [m]:** **Comment:**

Main Parameters:

pH:	**Na:**	**Cl:**	**NO3 as N:**
EC: [mS/m]	**K:**	**SO4:**	**F:**
TDS:	**Si:**	**CaCO3:**	
T. Alk.:	**Al:**		
Ca:	**Fe:**		
Mg:	**Mn:**		

Calculated Parameters:
Langel.:
Aggr-Ind:
Ion-bal:

Bacteriol. Parameters:
E.Coli:
Faec. co:
Total Co:
SPC:

Concentrations in [mg/l]; Bact. param. in counts/100ml; Chemistry Standard: SABS for human consumption
† Value exceeds recommended maximum limit ‡ Value exceeds maximum allowable limit
¦ Value exceeds recommended minimum limit ¡ Value exceeds minimim allowable limit

CASING DETAILS:

Depth to Top [m]	to Bot. [m]	Diam. [mm]	Material	Thickn. [mm]	Type of openings	Openings [mm]: Length	Width	Hor. Dist.	Vert. Dist.
0.00	3.68	170	Steel	2					

TESTING DETAILS:

Description	Date	Durat. [min]	Depth to intk. [m]	Disch. rate[l/s]	Drawd. [m]	Recovery [m]	%	[min]	T [m²/d]	Storage	Comment
CAL TEST 1	20020213	15	38.00	0.45	6.34						
CAL TEST 2	20020213	15	38.00	0.65	10.89						
CAL TEST 3	20020213	15	38.00	0.98	27.70						
CAL TEST 4	20020213	15	38.00	0.88	37.25	0.80	97	180			
STEP TEST 1	20020214	100	38.00	0.34	6.77	0.58	91	180			

RECOMMENDATIONS:

Prior.	Rec. equipm.	Depth to intk. [m]	Type of power	Duty cyc. [hrs]	Disch. rate [l/s]	Water quality	Dyn. water level [m]	Crit. water level [m]
1	Hand pump	30.00	Hand	8	0.15	AWAIT	8.00	18.00

Note: The water was clean during testing with no reported problems. The casing installed in the borehole is not to DWAF spesification. Abstraction yield recommendation is based on 1x 100 minute step drawdown test and calibration test.

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MANAGEMENT RECOMMENDATIONS

Date compiled: 3/12/02

BASIC SITE INFORMATION:

Site Identifier: 2431CAV0105 *Number:* H05-2182 *Site type:* Borehole

Distr./Farm No.: NPKU235 *Site Name/Descr.:* ROLLE/THULAMAHAXI

Longitude [°]:	31.2052501	*Alt. No. 1:*		*Diam. [mm]:*	170	*Water lev. [m]:*	
Latitude [°]:	24.7161111	*Alt. No. 2:*	H050773	*Depth [m]:*	1.00	*WL status:*	
Altitude [m]:	640.00	*Rep. inst.:*	VSA	*Col. ht. [m]:*	0.30	*Date WL meas.:*	

EXISTING EQUIPMENT:

Pump:

Type of Inst.: No equipment *Pulley Diam. [mm]:*

Manufacturer: *Depth to Intk. [m]:*

Engine:

Manufacturer: *Power Rating [kW]*

Type of Power: No equipment *Pulley Diam. [mm]:*

USE APPLICATION:

Site Status: Unused

Purpose:

Consumer:

Application:

WATER CHEMISTRY:

Sample No.: *Date sampled:* *Depth sampl. [m]:* *Comment:*

Main Parameters:			Calculated Parameters:	Bacteriol. Parameters:
pH:	*Na:*	*Cl:*	*Langel.:*	*E.Coli:*
EC: [mS/m]	*K:*	*NO3 as N:*	*Aggr-Ind:*	*Faec. co:*
TDS:	*Si:*	*SO4:*	*Ion-bal:*	*Total Co:*
T. Alk.:	*Al:*	*F:*	*CaCO3:*	*SPC:*
Ca:	*Fe:*			
Mg:	*Mn:*			

Concentrations in [mg/l]; Bact. param. in counts/100ml; Chemistry Standard: SABS for human consumption
† Value exceeds recommended maximum limit ‡ Value exceeds maximum allowable limit
ǀ Value exceeds recommended minimum limit ¡ Value exceeds minimim allowable limit

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Borehole Construction and Geological Log

Date compiled: 3/12/02

BASIC SITE INFORMATION:

Site Identifier: 2431CAV1023 **Number:** H05-2183 **Site type:** Borehole

Site Name/Descr.: ROLLE/THULAMAHAXI

Distr./Farm No.: NPKU235

Longitude [°]:	31.2036668
Latitude [°]:	24.7173889
Altitude [m]:	460.00
Coord. acc.:	Accurate to within 100 units
Coord. meth.:	Global Positioning System

Alt. No. 1:

Alt. No. 2:

Topo-set.:	In or along river
Site status:	Unused
Site purp.:	Exploration
Use applic.:	
Equipment:	No equipment

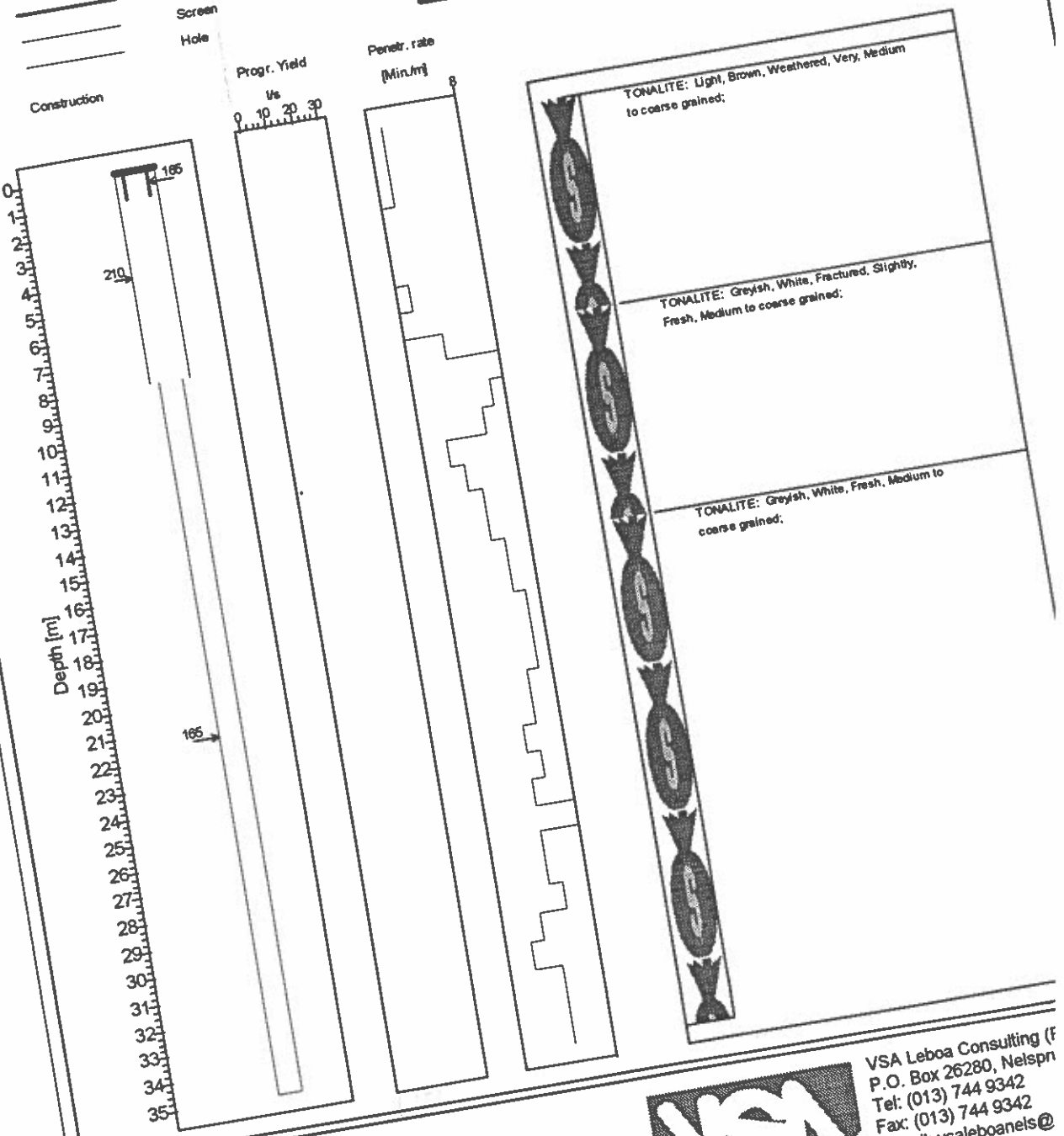
Depth [m]:	35.00
Collar h. [m]:	0.30
Drain. reg.:	X32C
Diam. [mm]:	165
Rep. inst.:	VSA

Construction and Geohydrological Legend

Perforated Casing
Plain Casing
Screen
Hole
Construction

19980720 — Water level and date
165 — Hole diam. [mm]
152 — Casing diam. [mm]
Welded cap

Lithology



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COMMENT:

Borehole Construction and Geological Log

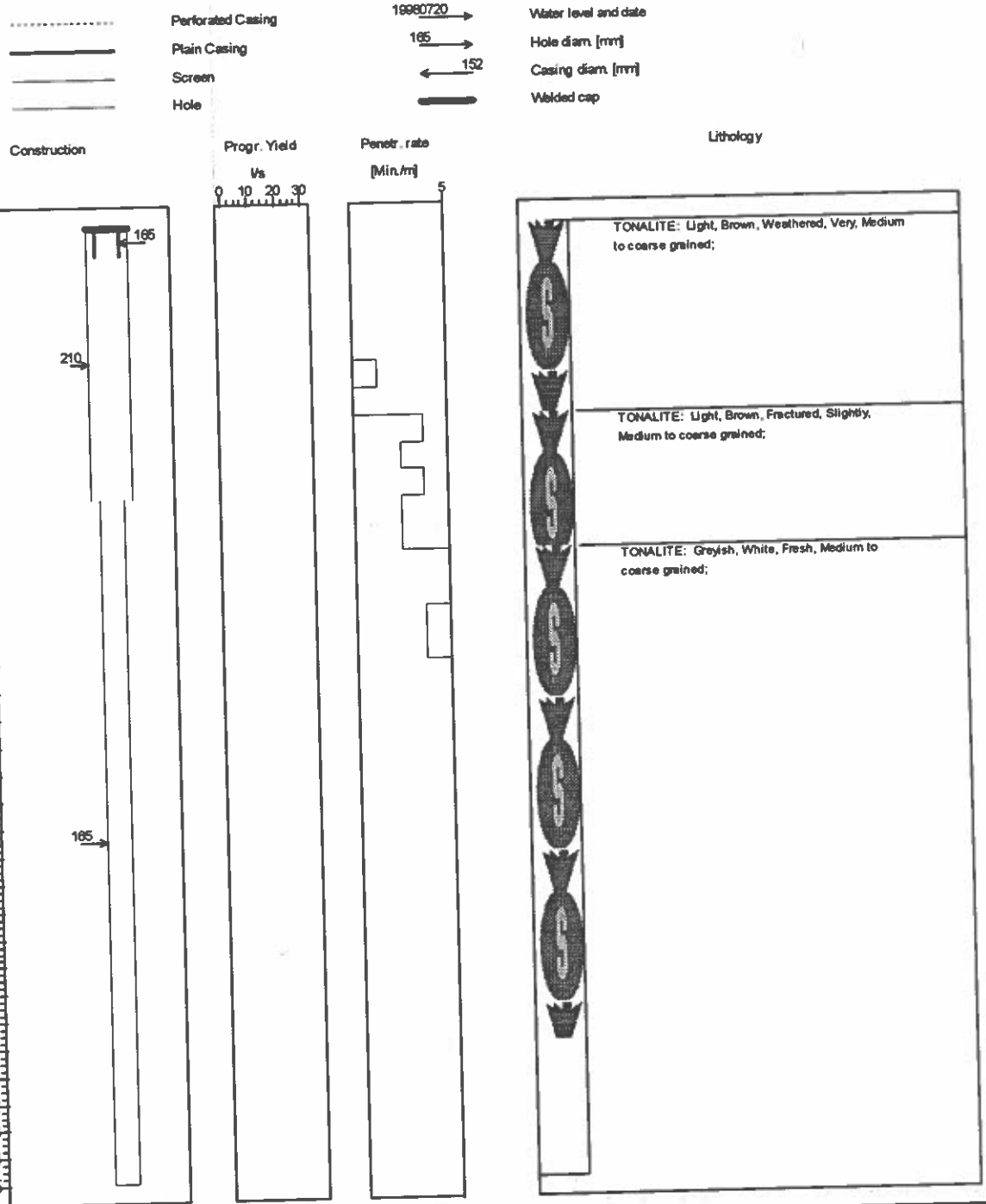
Date compiled: 3/12/02

BASIC SITE INFORMATION: *Site Identifier:* 2431CAV1024 *Number:* H05-2184 *Site type:* Borehole

Distr./Farm No.: NPKU235 *Site Name/Descr.:* ROLLE/THULAMAHAXI

Longitude [°]: 31.2051667	*Alt. No. 1:*	*Topo-set.:* In or along river	*Depth [m]:* 30.00
Latitude [°]: 24.7164444	*Alt. No. 2:*	*Site status:* Unused	*Collar h. [m]:* 0.30
Altitude [m]: 461.00		*Site purp.:* Exploration	*Drain. reg.:* X32C
Coord. acc.: Accurate to within 100 units		*Use applic.:*	*Diam. [mm]:* 165
Coord. meth.: Global Positioning System		*Equipment:* No equipment	*Rep. inst.:* VSA

Construction and Geohydrological Legend



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Borehole Construction and Geological Log

Date compiled: 3/12/02

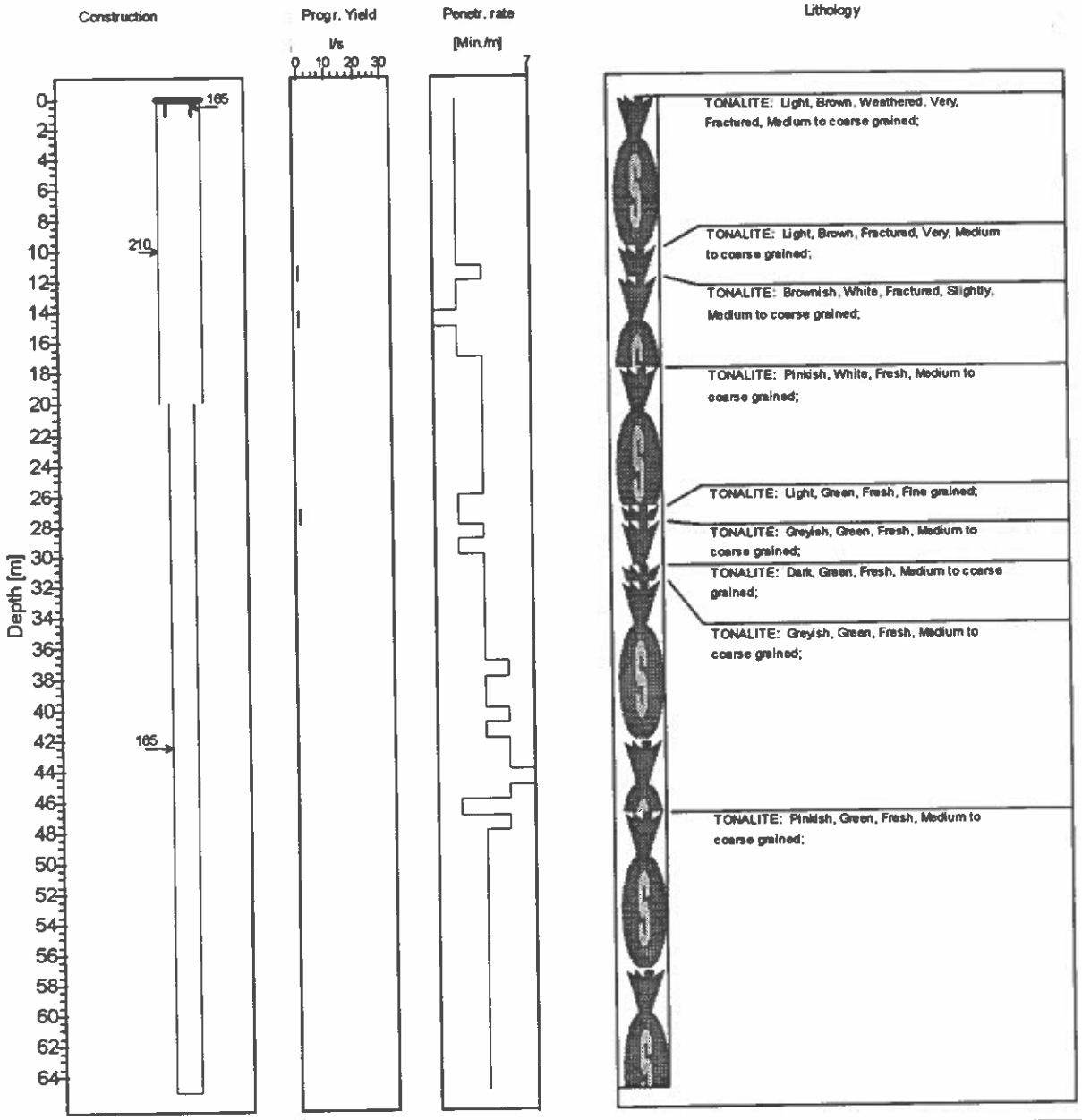
BASIC SITE INFORMATION: *Site Identifier:* 2431CAV1021 *Number:* H05-2185 *Site type:* Borehole

Distr./Farm No.: NPKU235 *Site Name/Descr.:* ROLLE/THULAMAHAXI

Longitude [°]:	31.2051112	*Alt. No. 1:*	*Topo-set.:*	In or along river	*Depth [m]:* 65.00
Latitude [°]:	24.7163056	*Alt. No. 2:*	*Site status:*	Unused	*Collar h. [m]:* 0.30
Altitude [m]:	460.00		*Site purp.:*	Exploration	*Drain. reg.:* X32C
Coord. acc.:	Accurate to within 100 units		*Use applic.:*		*Diam. [mm]:* 165
Coord. meth.:	Global Positioning System		*Equipment:*	No equipment	*Rep. inst.:* VSA

Construction and Geohydrological Legend

Perforated Casing
Plain Casing
Screen
Hole
19980720 → Water level and date
165 → Hole diam. [mm]
← 152 Casing diam. [mm]
Welded cap



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Borehole Construction and Geological Log

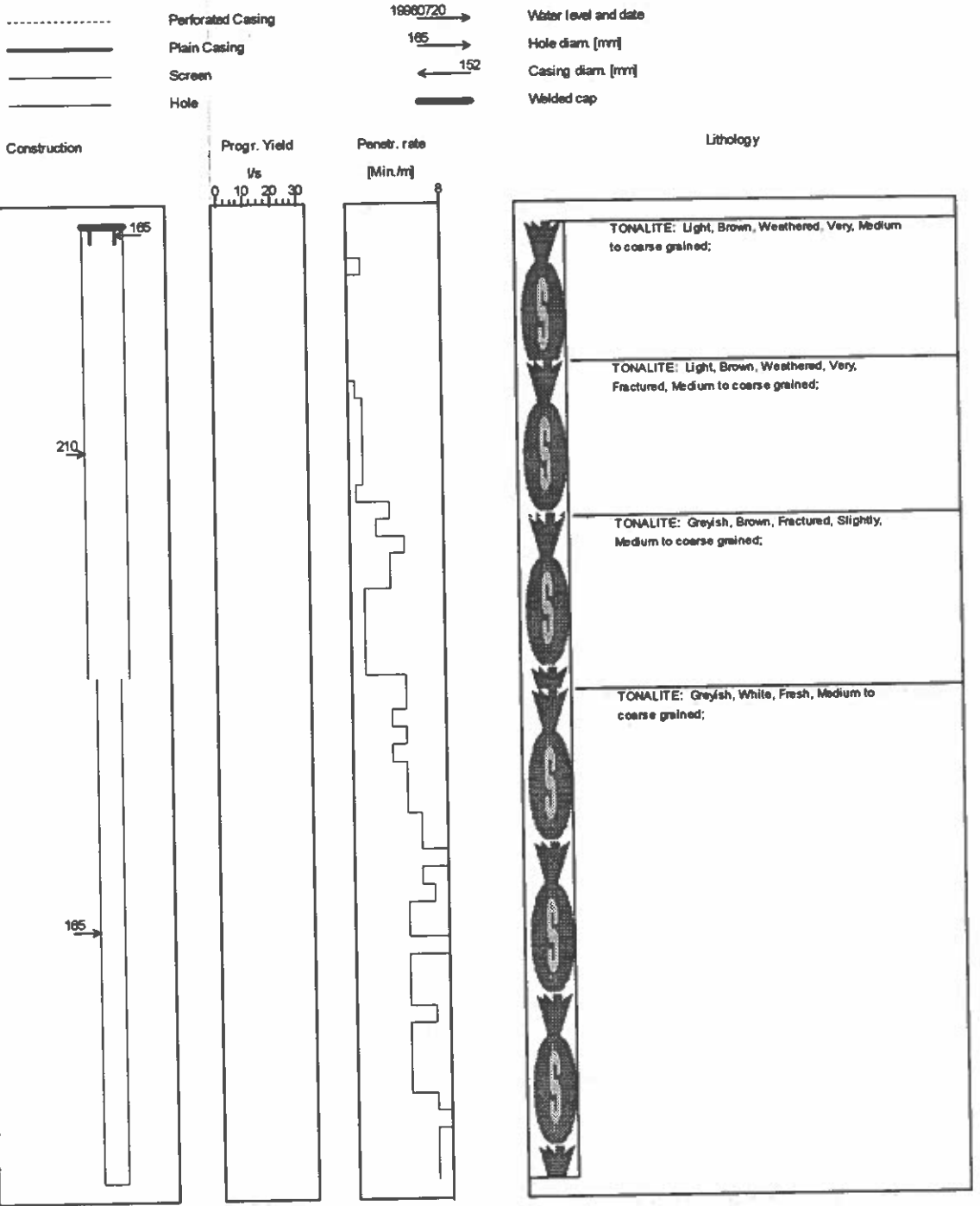
Date compiled: 3/12/02

BASIC SITE INFORMATION: *Site Identifier:* 2431CAV1022 *Number:* H05-2186 *Site type:* Borehole

Distr./Farm No.: NPKU235 *Site Name/Descr.:* ROLLE/THULAMAHAXI

Longitude [°]:	31.2057223	*Alt. No. 1:*	*Topo-set.:*	In or along river	*Depth [m]:* 55.00
Latitude [°]:	24.7164722	*Alt. No. 2:*	*Site status:*	Unused	*Collar h. [m]:* 0.30
Altitude [m]:	475.00		*Site purp.:*	Exploration	*Drain. reg.:* X32C
Coord. acc.:	Accurate to within 100 units		*Use applic.:*		*Diam. [mm]:* 165
Coord. meth.:	Global Positioning System		*Equipment:*	No equipment	*Rep. inst.:* VSA

Construction and Geohydrological Legend



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Borehole Construction and Geological Log

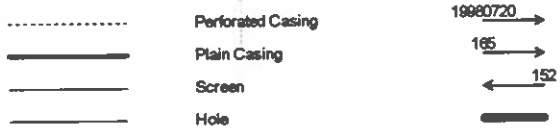
Date compiled: 3/12/02

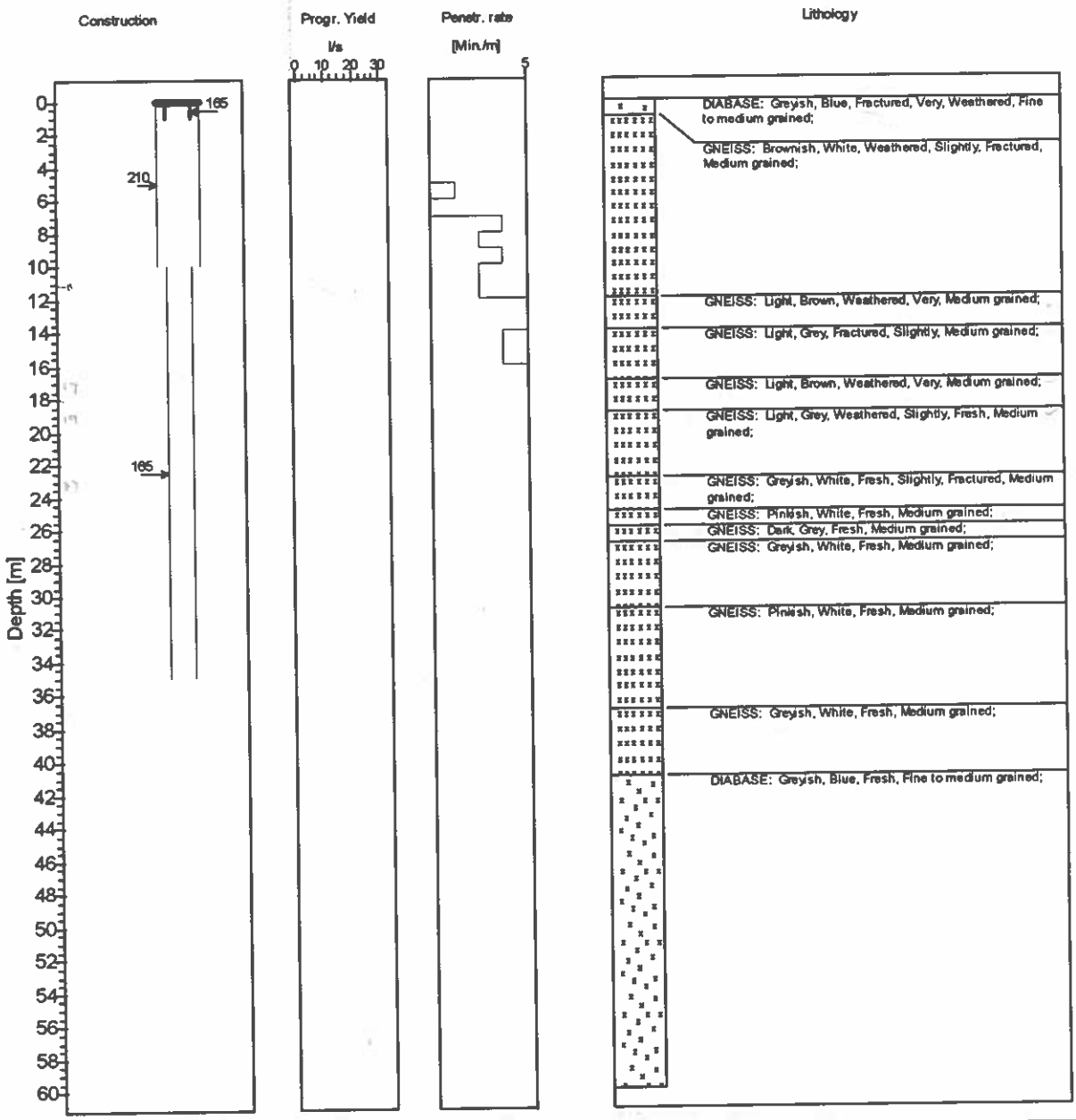
BASIC SITE INFORMATION: *Site Identifier:* 2431CAV1025 *Number:* H05-2187 *Site type:* Borehole

Distr./Farm No.: NPKU228 *Site Name/Descr.:* EDINBURGH/THULAMAHAXI

Longitude [°]:	31.2090278	*Alt. No. 1:*	*Topo-set.:*	Hillside (slope)	*Depth [m]:* 30.00
Latitude [°]:	24.7084722	*Alt. No. 2:*	*Site status:*	Unused	*Collar h. [m]:* 0.30
Altitude [m]:	480.00		*Site purp.:*	Exploration	*Drain. reg.:* X32C
Coord. acc.:	Accurate to within 100 units		*Use applic.:*		*Diam. [mm]:* 165
Coord. meth.:	Global Positioning System		*Equipment:*	No equipment	*Rep. inst.:* VSA

Construction and Geohydrological Legend





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