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Africa Geo-Environmental Services (Pty) Ltd.

Geohydrological Investigation and Source Development for the Supply of Groundwater to Proposed Villages at Steilloop, Waterberg District Municipality

Prepared for:

JFK Consultants (Pty) Ltd

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Source Development: **AG/R/04/05/10**

Geohydrological Investigation and Source Development for the Supply of Groundwater to Villages at Steilloop, Waterberg District Municipality

27 May 2004

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Notations and terms

Advection is the process by which solutes are transported by the bulk motion of the flowing groundwater.

Anisotropic is an indication of some physical property varying with direction.

Cone of depression is a depression in the groundwater table or potentiometric surface that has the shape of an inverted cone and develops around a borehole from which water is being withdrawn. It defines the area of influence of a borehole.

A *confined aquifer* is a formation in which the groundwater is isolated from the atmosphere at the point of discharge by impermeable geologic formations; confined groundwater is generally subject to pressure greater than atmospheric.

Dispersion is the measure of spreading and mixing of chemical constituents in groundwater caused by diffusion and mixing due to microscopic variations in velocities within and between pores.

Drawdown is the distance between the static water level and the surface of the cone of depression.

Effective porosity is the percentage of the bulk volume of a rock or soil that is occupied by interstices that are connected.

Groundwater table is the surface between the zone of saturation and the zone of aeration; the surface of an unconfined aquifer.

A *fault* is a fracture or a zone of fractures along which there has been displacement.

Hydrodynamic dispersion comprises of processes namely mechanical dispersion and molecular diffusion.

Hydraulic conductivity (**K**) is the volume of water that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area measured perpendicular to the area [L/T]. Hydraulic conductivity is a function of the permeability and the fluid's density and viscosity.

Hydraulic gradient is the rate of change in the total head per unit distance of flow in a given direction.

Heterogeneous indicates non-uniformity in a structure.

Karstic topography is a type of topography that is formed on limestone, gypsum, and other rocks by dissoloution, an is characterised by sinkholes, caves and underground drainage.

Mechanical dispersion is the process whereby the initially close group of pollutants are spread in a longitudinal as well as a transverse direction because of velocity distributions.

Molecular diffusion is the dispersion of a chemical caused by the kinetic activity of the ionic or molecular constituents.

Observation borehole is a borehole drilled in a selected location for the purpose of observing parameters such as water levels.

Permeability is related to hydraulic conductivity, but is independent of the fluid density and viscosity and has the dimensions L^2. Hydraulic conductivity is therefore used in all the calculations.

Piezometric head (ϕ) is the sum of the elevation and pressure head. An unconfined aquifer has

a water table and a confined aquifer has a *piezometric surface*, which represents a pressure head. The piezometric head is also referred to as the hydraulic head.

Porosity is the percentage of the bulk volume of a rock or soil that is occupied by interstices, whether isolated or connected.

Pumping tests are conducted to determine aquifer or borehole characteristics.

Recharge is the addition of water to the zone of saturation; also, the amount of water added.

Sandstone is a sedimentary rock composed of abundant rounded or angular fragments of sand set in a fine-grained matrix (silt or clay) and more or less firmly united by a cementing material.

Shale is a fine-grained sedimentary rock formed by the consolidation of clay, silt or mud. It is characterised by finely laminated structure and is sufficiently indurated so that it will not fall apart on wetting.

Specific storage (S_0), of a saturated confined aquifer is the volume of water that a unit volume of aquifer releases from storage under a unit decline in hydraulic head. In the case of an unconfined (phreatic, watertable) aquifer, *specific yield* is the water that is released or drained from storage per unit decline in the watertable.

Static water level is the level of water in a borehole that is not being affected by withdrawal of groundwater.

Storativity is the two-dimensional form of the specific storage and is defined as the specific storage multiplied by the saturated aquifer thickness.

Total dissolved solids (TDS) is a term that expresses the quantity of dissolved material in a sample of water.

Transmissivity (T) is the two-dimensional form of hydraulic conductivity and is defined as the hydraulic conductivity multiplied by the saturated thickness.

An *unconfined, watertable or phreatic aquifer* are different terms used for the same aquifer type, which is bounded from below by an impermeable layer. The upper boundary is the watertable, which is in contact with the atmosphere so that the system is open.

Vadose zone is the zone containing water under pressure less than that of the atmosphere, including soil water, intermediate vadose water, and capillary water. This zone is limited above by the land surface and below by the surface of the zone of saturation, that is, the water table.

Water table is the surface between the vadose zone and the groundwater, that surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere.

LIST OF ABBREVIATIONS

Abbreviation	Description
MAMSL	Meter Above Mean Sea Level
MBGL	Meter Below Ground Level
MBGL	Meter Below Ground Level (i.e. depth)
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
EIA	Environmental Impact Assessment
EMPR	Environmental Management Programme Report
DWAF	Department of Water Affairs and Forestry
NWA	National Water Act
NEMA	National Environmental Management Act
TWQR	Target Water Quality Range
TDS	Total Dissolved Solids
Ec	Electrical Conductivity

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1 INTRODUCTION

Africa Geo-Environmental services (Pty) Ltd known as AGES, formerly known as Southern Africa GeoConsultants, was requested to conduct geohydrological investigation in order to ensure sustainable groundwater supplies to 4 villages in Steilloop within the greater Waterberg District Municipality.

AGES was appointed by Mr. J.G Fourie of JFK Consultants (Pty) Ltd to conduct the required geohydrological investigation, and to facilitate the necessary actions leading to successful source development.

1.1 Terms of reference and scope of work

The terms of reference and scope of work is defined in the project plan (AG-PP-03-12-08).

1.1.1 Objectives of the investigation

The objectives of the project would be to:

1. Supply villages within the Steilloop Area with sustainable groundwater resources, that is fit for human consumption.

1.1.2 Scope of this project

In order to reach the stated objective, the following actions were conducted:

1. Detailed geophysical surveys to identify the most suitable area for drilling purposes.
2. Evaluation of the identified target areas by means of exploration drilling.
3. Exploration drilling at the most suitable sites, with the development of successful boreholes for groundwater production.
4. Yield testing of successful boreholes to determine the sustainable yield of the boreholes.
5. Sampling and analysis groundwater samples to ensure its suitability for the drinking purposes.
6. Rendering utilisation and management recommendations to ensure the long term sustainability of the groundwater sources.
7. Compilation of a geohydrological report in order to support the licensing of water usage according to the National Water Act (Act 36 of 1998), if required. All geohydrological data obtained during the investigation will be reported to the Department of Water Affairs and Forestry for inclusion in the Provincial Geohydrological Database.

1.1.3 Information sources

The following sources of information were used during the investigation:

- Geological map
  - 2328 PIETERSBURG, 1985; scale 1: 250 000.

- Topographical map
  - 2328 DB GILEAD, Third Edition, 1986; scale 1: 50 000.
  - 2328 CB MARKEN, Second Edition, 1983; scale 1:50 000.
  - 2328 DA SKRIKFONTEIN, Second Edition,1983;scale1:50 000.
- AERIAL PHOTOGRAPHS
  - Job 868, Strip 19, Numbers 091 to 094; scale 1: 50 000.
  - Job 868, Strip 18, Numbers 125 to 138, 1988; scale 1: 50 000

1.1.4 Study area

The study areas are detailed in Map 1 (Appendix D) and include the following villages:

Lekhureng Village

This village is located on a portion of the farm, La Pucilla 693 LR in the Mogalakwena Municipal Area, of the Waterberg District in Limpopo Province. The village is located directly to the north of the main road between Polokwane and Steilloop and approximately 10 km west of Tibanefontein.

Ga-Tshipana Village

Ga-Tshipana is located on a portion of the farm, La Pucilla 693 LR in the Mogalakwena Municipal Area, of the Waterberg District, Limpopo Province. This village is the closest to Lekhureng. The distance between the two villages is approximately 1 km.

Ga-Musi Village

This village is located on a portion of the farm, Tevredenheid 660 LR and is approximately 89 km to the south west of Lekhureng and Ga-Tshipana. Villages.

Ga-Chere Village

Ga-Chere is located on a portion of the farm, Tevredenheid 660 LR and is approximately 2 km to the east of Ga-Musi village in the Mogalakwena Municipal area, of the Waterberg District, Limpopo Province.

2 METHODOLOGY

2.1 Geophysical Survey

Geophysical surveys were conducted at each site to detect the contact areola of intrusive dykes using geophysical techniques that combines resistivity profiling and sounding. This technique indicates zones of lower resistivity both vertically, and horizontally, ideal for the accurate site of boreholes into targets along the contacts of dyke at a point where the resistivity is lower, below the regional water table.

A proton magnetometer was used to accurately identify the position and orientation of the dyke, while the resistivity technique was used to identify the location and depth of the target zones.

The MaxMin II EM system was used for the rapid and simple measurement of site conductivities, which facilitates the detection of steeply dipping conductive targets (for example: dykes, fracture zones and faults) by means of electro-magnetic coupling.

2.2 Groundwater sampling

Nine groundwater samples were taken during April and May 2004 from selected boreholes by means of purging, according to the protocol compiled by Weaver, 1992. Groundwater level depths and field parameters were recorded prior to sampling. Samples were analysed at ERWAT Laboratory for chemical constituents detailed in Appendix C. .

3 RESULTS

3.1 Site Characterisation and Resource Development– Lekhureng Village

3.1.1 Regional Geological setting

The area is underlain by leucocratic migmatite, gneiss, grey and pink hornblende-biotite gneiss, grey biotite gneiss; minor muscovite-bearing granite, pegmatite and gneiss of Hout River Gneiss (Map 1, Appendix D). Specific zones within the gneiss, may present targets for successful borehole development, due to localised variations in the geology.

Higher groundwater potentials may be associated to zones of deeper weathering within the gneiss. The deeper weathering is related to a variation in chemical composition of the gneiss, or a contact areola surrounding an intrusive dyke. The dolerite dyke intrusions in the vicinity may thus offer an opportunity for preferential weathering along the contact zones, and were investigated for possible borehole development.

Scattered pegmatite outcrop was noted within some portions of the site; evidence of an east west and northeast striking diabase dyke was also noticed in the southern and northern side of the site.

Heat associated with the intrusion of the dolerite dyke into the already altered granitic gneiss will have caused re-melting and subsequent re-setting of the minerals in the country rock. This contact zone along the intrusive dyke may form preferential flow paths for groundwater, and is targeted for exploration drilling.

It should be noted that the area exhibits a low regionally groundwater potential and that

successful boreholes will need to be sited within the narrow bands associated with local variations in the geology.

3.1.2 Existing Boreholes

Three existing boreholes were surveyed and is summarised in Table 5. These boreholes were in use and had an average depth of 40 m. The average static water level was 12.4 mbdl. Water quality was on average Class 3, based on elevated fluoride concentrations.

3.1.3 Geophysical survey

Geophysical surveys, incorporating (the proton magnetometer with a station interval of 5 m and the resistivity meter with 10-m electrode spacing and a 10 m station interval) were conducted along 2 profile lines. The graphical results of these surveys are included as Appendix A and are summarised in Table 1.

Table 1 Geophysical Results – Lekhureng Village

Line No	Line distance and direction	Magnetic anomalies (m)	MaxMin Anomalies/ Ressistivity (m)	Interpretation	Siting	BH Number
Lekhureng geophysics line – 1	990 m W - E	510 - 720	510 – 720 (RES)	contact between pegmatite and gneiss, with significant weathering associated with the contact zone or fractured zone within the pegmatite	**510m** and **710 m** along profile line 1and targets the deeply weathered zone occurring between the contact zone of pegmatite and gneiss	H04-2116 and H04-2117 and H04-2120
Lekhureng geophysics line – 2	1180 E - W	680 and 1560	680 and 1560 (RES)	contact zone between pegmatite and gneiss, with significant weathering associated with the zone of contact between the pegmatite and gneiss	**680 m** and **1560 m** along profile line 2 and targets the deeply weathered zone occurring between the contact zone of pegmatite and gneiss.	

3.1.4 Source Development

2328DB
A62E
LR 693 La Rucilla PTN. Lekhureng

3.1.4.1 Borehole H04-2116

Borehole H04-2116 was drilled at drilling site Lekhureng 1/510, and is located at the following co-ordinates (Map 3): 23.57151 S

28.92706 E

This borehole was drilled at a diameter of 254 mm from the surface to a depth of 5.5 meters, after which a bit with a diameter of 165 mm was used to the final depth of 81 m. The borehole was abandoned due to its low yield and no casing was installed. A detailed log is included in Appendix B.

The drill penetrated a top reddish brown sandy clay soil, to a depth of 1 m, after which moderately weathered calcrete was encountered to a depth of 6 m. Highly weathered sand stone was encountered at a depth of between 6 and 9 m, followed by highly weathered reddish brown coarse grained pegmatite to a depth of 11 m.

Highly weathered sandstone was encountered between 11 and 21 m, after which moderately weathered pegmatite was intercepted to a depth of 25 m. Greyish black highly weathered dolerite was encountered between 25 and 36 m, there after light reddish brown coarse pegmatite slightly weathered pegmatite intercepted to a final depth of 81 m.

A water strike of 0.2 L/sec was encountered at 20 m. The final blow yield was found to be 0.2 L/sec.

No further tests were conducted due to the low yield of this borehole.

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A62E
LR 693 La Rucilla PTN. Lekhureng

3.1.4.2 Borehole H04-2117

This borehole was drilled at Lekhureng 1/710, and is located at the following co-ordinates (Map 3):

23.57202 S

28.92870 E

3.1.4.2.1 Drilling

This borehole was drilled at a diameter of 254 mm from the surface to a depth of 42 m, after which a bit with the diameter of 165 mm was used to the final depth of 61 m. Solid steel casing with an inside diameter of 177 mm was installed from the surface to a depth of 42 m, with a total of 5 solids and 2 perforated casing. A detailed log is included in Appendix B.

The drill penetrated a layer of dark brown sand clay soil, to a depth of 2 m, after which calcrete was intercepted to a depth of 3 m. Creamy reddish highly weathered pegmatite was encountered between 3 and 17 meters, followed by the greyish black highly weathered dolerite to a depth of 19 m.

The layer of creamy reddish medium grained highly weathered pegmatite was encountered

between 19 and 39 m, after which the layer of moderately weathered amphibolite was intercepted to a depth of 41 m. Finally the moderately weathered pegmatite was encountered to a depth of 61 m.

A water strike of 16 L/sec was encountered at 19 meters, 21 L/sec was also encountered at 35 m and finally 21 L/sec was intercepted at the depth of 59 m. The final blow yield was found to be 21 L/sec.

3.1.4.2.2 Pump Testing

The static groundwater level was 7 m below the datum level. The testing pump was installed at a depth of 57 mbdl, resulting in a maximum drawdown of 49.40 m. The following tests were conducted:

- The yield tests commenced with a calibration test that consisted of four 15-minute steps, conducted at yields of between 6 and 21 L/s, resulting in a total drawdown of 49.40 m.
- This was followed by a stepped discharge test composed of three 100-minute steps conducted at yields of between 12 and 18 L/s, resulting in a total drawdown of 25.55 m (translating to 96 % of the available drawdown).
- A constant discharge test was conducted at an average yield of 16 L/s over a period of 48 hrs, resulting in a total drawdown of 17 m (translating to 87.50 % of the available drawdown).

Recovery was relatively good, with the groundwater level returning to within 100 % of its original level after a period of 48 hours.

The recommended maximum daily yield for this borehole (24h/day) is 5 L/s. Results are summarised in Table 5.

3.1.4.2.3 Water Quality Analysis

The groundwater abstracted from this borehole classified as being of marginal quality (Class 2) according to the drinking water standards of the Departments of Water Affairs and Forestry, and is thus conditionally acceptable. The results are detailed in Appendix C.

2328DB
A62E
LR 693 La Pucilla PTN. Lekhureng

3.1.4.3 Borehole H04-2120

Borehole H04-1306 was drilled at Lekhureng Village, at the following co-ordinates (Map 3): 23.571950 S
28.928720 E

3.1.4.3.1 Drilling

This borehole was drilled at a diameter of 254-mm from the surface to a depth of 32 m, after which a bit with the diameter of 165 mm was used to the final depth of 41 m. Solid steel casing with an inside diameter of 177 mm was installed from the surface to a depth of 32 m, of which 26 m solid casing and 6 m perforated casing. A detailed log is included in Appendix B.

The drill penetrated a top dark greyish black sand clay soil, to a depth of 1 m, after which creamy

white coarse moderately weathered calcrete was intercepted to a depth of 6 m. The layer of highly weathered coarse-grained sand stone was encountered between 6 and 8 m, after which highly weathered reddish brown coarse grained pegmatite intercepted to a depth of 9 m. The pegmatite was followed by the layer of highly weathered coarse grained sand stone between 9 and 11 m. the sand stone was followed by the layer of slightly weathered light reddish brown pegmatite from a depth of 11 to 21 m. Pegmatite was underlain by the greyish black fine grained highly weathered dolerite from the depth of 21 to 36 m. The dolerite was underlain by the layer of slightly weathered reddish brown pegmatite to the final depth of 41 m.

A water strike of 5 L/sec was encountered at 20 meters. The final blow yield was found to be 5 L/sec. A steel cap was welded across the top of the steel casing; concrete slab was used on the surrounding.

3.1.4.3.2 Testing

The static groundwater level was measured at 6.61 m below the datum level (located 0.27 m above the natural ground surface), with a total borehole depth of 41 m being reported. The testing pump was installed at a depth of 36 mbdl, resulting in a maximum drawdown of 4 m. The following tests were conducted:

- The yield tests commenced with a calibration test composed of four 15-minute steps, conducted at yields of between 1 and 7 L/s, resulting in a total drawdown of 4 m.
- This was followed by a stepped discharge test composed of two 100-minute steps conducted at yields of between 2 and 6 L/s, resulting in a total drawdown of 4.6 m (translating to 96 % of the available drawdown).
- A constant discharge test was conducted at an average yield of 5 L/s over a period of 24 hrs, resulting in a total drawdown of 4.53 m (translating to 87.50 % of the available drawdown).

Recovery was relatively good, with the groundwater level returning to within 100 % of its original level after a period of 24 hours.

It was recommended that the maximum daily yield for this borehole (24h/day) is 2.5 L/s. Results are summarised in Table 5.

3.1.4.3.3 Water Quality Analysis

Water from this borehole classified as Class 2 (Marginal) quality based on elevated sodium, chloride, nitrate, fluoride and chloride concentrations. Results is summarised in Appendix C. All concentrations were however within the SABS maximum allowable limit specified for drinking water.

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A62E
LR683 La Pucilla PTN. Lethuseng

3.1.4.4 Borehole H04-1306

This is an existing borehole, no exploration drilling was undertaken, only testing. Borehole H04-1306 is located at the following co-ordinates (Map 3): 23.57143 S
28.93554 E

3.1.4.4.1 Testing

The static groundwater level was 9 m below the datum level (located 0.27 m above the natural ground surface), with a total borehole depth of 49.70 m being reported. The testing pump was installed at a depth of 15 mbdl, resulting in a maximum possible drawdown of 32.30 m. The following tests were conducted:

- The yield tests commenced with a calibration test composed of four 15-minute steps, conducted at yields of between 4 and 21 L/s, resulting in a total drawdown of 32.30 m being achieved.
- This was followed by a stepped discharge test composed of three 100-minute steps conducted at yields of between 12 and 18 L/s, resulting in a total drawdown of 19.22 m being achieved (translating to 96 % of the available drawdown).
- A constant discharge test was conducted at an average yield of 16 L/s over a period of 48 hrs, resulting in a total drawdown of 18 m being achieved (translating to 87.50 % of the available drawdown).

Recovery was relatively good, with the groundwater level returning to within 100 % of its original level after a period of 48 hours.

It was recommended that the maximum daily yield for this borehole (24h/day) is 5 L/s per 24 h pumping cycle. Results are summarised in Table 5.

3.1.4.4.2 Water Quality Analysis

The groundwater abstracted from this borehole classifies as being of poor quality (Class 3) according to the drinking water standards of the Departments of Water Affairs and Forestry, due to elevated fluoride concentrations (1.7 mg/L). Fluoride concentrations were however still within the maximum allowable limit, specified by the SABS for domestic water use. Fluoride concentrations between 1.5 mg/L and 3.5 mg/L may cause dental mottling in most continuous users with no other health effects.

3.2 Site Characterisation – Ga-Tshipana Village

3.2.1 Regional Geological setting

Ga-Tshipana has a similar regional geological setting than Lekhureng. Locally, the northern site is underlain by soil, sand, alluvium and calcrete that is associated with the Matla River passing the village. As with Lekhureng, higher groundwater potentials may be associated with zones of deeper weathering within the gneiss which is related to a variation in chemical composition of the gneiss, or a contact areola surrounding an intrusive dyke. The dolerite dyke intrusions in the vicinity may thus offer an opportunity for preferential weathering along the contact zones, and were investigated for possible borehole development.

It should be noted that the area exhibits a low regionally groundwater potential and that successful boreholes will need to be sited within the narrow bands associated with local variations in the geology.

3.2.2 Existing Boreholes

Five existing boreholes were surveyed (H04-0520, H04-0888, H04-0944, H04-0945 and H04-0947) (Map 3, Appendix D). Boreholes had an average depth of 57 m and static water level of 15 mbdl. Boreholes H04-0888 and H04-0947 were identified as high yielding boreholes.

3.2.3 Geophysical survey

Geophysical surveys, incorporating the proton magnetometer with a station interval of 5 m and the SARIS resistivity meter (with 10 m electrode spacing and a 10 m station interval) were conducted along 1 profile line. Graphical results of these surveys were included in Appendix A and are summarised in Table 3.

Table 2 Geophysics summary – Ga-Tshipana Village

Line No	Line distance and direction	Magnetic anomalies (m)	MaxMin Anomalies/ Ressistivity (m)	Interpretation	Siting	BH Number
Ga-Tshipana geophysics line-1	1880 m E-W	1330 and 1670	1330 and 1670 (RES)	indicate the presence of a contact zone between pegmatite and gneiss, with significant weathering associated with the zone of contact	**1330 m** and **1670 m** along profile line 1 and targets the deeply weathered zone occurring between the contact zone of pegmatite and gneiss.	**H04-2118 and H04-2119**

3.2.4 Source Development

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A62E
LR691 Sour Apple Tree PTN. Ga-Tshipana

3.2.4.1 Borehole H04-2118

Borehole H104-2118 was drilled at Ga-Tshipana 1/1670 and is located at the following co-ordinates (Map 3, Appendix D): 23.580680 S
28. 952930 E

3.2.4.1.1 Drilling

This borehole was drilled at a diameter of 254-mm from the surface to a final depth of 31 m. Solid steel casing with an inside diameter of 177 mm was installed from the surface to a depth of 31 m, of which 4 m solid casing and 1 m perforated casing. A detailed log is included in

Appendix B.

The drill penetrated a top reddish brown fine sandy clay soil, to a depth of 2 m, after which creamy white medium grained moderately weathered calcrete was intercepted to a depth of 5 m. The layer of highly weathered light reddish coarse-grained pegmatite was encountered between 5 to the final depth of 31m.

A water strike of 5 L/sec was encountered at 19 meters. The final blow yield was found to be 5 L/sec.

3.2.4.1.2 Testing

The static groundwater level was 12.07 m below the datum level, with a total borehole depth of 31.20 m. The testing pump was installed at a depth of 27 mbdl, resulting in a maximum possible drawdown of 11.77 m. The following tests were conducted:

- The yield tests commenced with a calibration test composed of four 15-minute steps, conducted at yields of between 1 and 7 L/s, resulting in a total drawdown of 11.77 m.
- This was followed by a stepped discharge test composed of three 100-minute steps conducted at yields of between 1 and 7 L/s, resulting in a total drawdown of 11.77 m (translating to 99.4 % of the available drawdown).
- A constant discharge test was conducted at an average yield of 5 L/s over a period of 24 hrs, resulting in a total drawdown of 11.77 m (translating to 97.84 % of the available drawdown).

Recovery was relatively good, with the groundwater level returning to within 100 % of its original level after a period of 24 hrs.

The recommended maximum yield for a 24 h pump cycle is 2.5 L/s.

3.2.4.1.3 Water Quality Analysis

Water quality from this borehole classified as **Class 2** water quality based on the DWAF classification system for domestic water use. Elevated fluoride concentrations were observed. Values were however still within the maximum value specified by the SABS for Class II (maximum allowable) water (Appendix C).

2 328 DB
A62 E
LR 691 Sour Apple Tree PTN. Ga-Tshipana

3.2.5 Borehole H04-2119

This borehole was drilled at Ga-Tshipana 1/1670, and is located at the following co-ordinates (Map 3, Appendix D): 23.578860 S
28.951030 E

3.2.5.1 Drilling

This borehole was drilled at a diameter of 254 mm from the surface to a depth of 5.5 meters, after which a bit with a diameter of 165 mm was used to the final depth of 28 m. A detailed log is included in Appendix B.

The drill penetrated a top reddish brown fine sandy clay soil to a depth of 2 m, after which the

moderately weathered calcrete was encountered to a depth of 8 m. Highly weathered, light reddish coarse grained pegmatite was encountered to the final depth of 28 m.

A water strike of 0.2 L/sec was encountered at 17 m. The final blow yield was found to be 0.2 L/sec.

No further tests were conducted due to the low blow yield

3.2.6 Borehole H04-0520

Borehole H04-0520 is an existing borehole and is located at the following co-ordinates (Map 3, Appendix D) :

23.77444 S
28.11500 E

3.2.6.1 Testing

The static groundwater level 16.21 m below the datum level, with a total borehole depth of 79.45 m. The testing pump was installed at a depth of 78 mbdl, resulting in a maximum possible drawdown of 16.11m. The following tests were conducted:

- The yield tests commenced with a calibration test composed of three 15-minute steps, conducted at yields of between 1 and 5 L/s, resulting in a total drawdown of 16.11 m.
- This was followed by a stepped discharge test composed of three 100-minute steps conducted at yields of between 1 and 4 L/s, resulting in a total drawdown of 16.11 m (translating to 96 % of the available drawdown).
- A constant discharge test was conducted at an average yield of 4 L/s over a period of 24 hrs, resulting in a total drawdown of 16.11 m (translating to 87.50 % of the available drawdown).

Recovery was relatively good, with the groundwater level returning to within 100 % of its original level after a period of 24 hours.

The recommended maximum yield for a 24 h cycle was 0.5 L/s.

3.2.6.2 Water Quality Analysis

The groundwater abstracted from this borehole classifies as being of marginal quality (Class 2) according to the drinking water standards of the Departments of Water Affairs and Forestry, due to elevated fluoride, nitrate, sodium and chloride.

3.2.7 Borehole H04-0947

This borehole was an existing borehole, located at the following co-ordinates (Map 3, Appendix D):

23.58382 S
28.95984 E

3.2.7.1 Testing

The static groundwater level was 15.70 m below the datum level, with a total borehole depth of 55.25 m being reported. The testing pump was installed at a depth of 51 mbdl, resulting in a maximum possible drawdown of 15.43m. The following tests were conducted:

- The yield tests commenced with a calibration test composed of four 15-minute steps, conducted at yields of between 8 and 28 L/s, resulting in a total drawdown of 15.43m.
- This was followed by a stepped discharge test composed of three 100-minute steps conducted at yields of between 10 and 25 L/s, resulting in a total drawdown of 15.43 m (translating to 96 % of the available drawdown).

Recovery was relatively good, with the groundwater level returning to within 90 % of its original level after a period of 5 hours.

The recommended maximum yield for a 24h pumping cycle per day was 8 L/s.

3.2.7.2 Water Quality Analysis

The groundwater abstracted from this borehole classifies as being of poor quality (Class 3, DWAF, 1998) due to elevated fluoride concentrations (1.8 mg/L). Values are still below the maximum allowable concentrations, specified by the SABS for domestic water use. Values below 3.5 mg/L may cause dental mottling in continues users and no other health effects are expected at these concentrations.

2328DB
A62E
LR 691 Sour Apple Tree PTN. 9a-Tshipong.

3.2.8 Borehole H04-0945 ✓

This is an existing borehole, located at the following co-ordinates:

23.58445 S
28.96236 E

3.2.8.1 Testing

The static groundwater level was 14.8 m below the datum level (located 14.62 m above the natural ground surface), with a total borehole depth of 37.91 m being reported. The testing pump was installed at a depth of 36.50 mbdl, resulting in a maximum possible drawdown of 14.62m. The following tests were conducted:

- The yield tests commenced with a calibration test composed of two 15-minute steps, conducted at yields of between 0.5 and 1 L/s, resulting in a total drawdown of 14.62m.

Recovery was relatively good, with the groundwater level returning to within 90 % of its original level after a period of 5 hours.

No further steps done, due to the unstable condition of the borehole.

3.2.9 Borehole H04-0944

This was an existing borehole, located at the following co-ordinates (Map 3, Appendix D:

23.58461 S

28.96286 E

3.2.9.1 Testing

No testing was conducted, since the borehole was found to be dry at the time of testing. No further steps have been undertaken.

3.3 Site characterisation and source development: Ga-Musi Village

3.3.1 Regional Geological setting

The area is underlain by soil, sand, alluvium and calcrete of Quaternary age and some parts is underlain by coarse-grained purplish brown sandstone; conglomerate and boulders of conglomerate of Mogalakwena Formation Waterberg Group (Map 1, Appendix D).

Higher groundwater potential may be associated with a contact areola surrounding an intrusive dyke. The dolerite dyke intrusions in the vicinity may thus offer an opportunity for preferential weathering along the contact zones, and were investigated for possible borehole development.

Scattered dolerite outcrop was noted within some portions of the site; evidence of an east west and northeast striking diabase dyke was also noticed in the southern and northern side of the site.

This contact areola along the intrusive dyke may form preferential flow paths for groundwater, and is targeted for exploration drilling.

It should be noted that the area exhibits a low regionally groundwater potential and that successful boreholes will need to be sited within the narrow bands associated with local variations in the geology.

3.3.2 Existing Boreholes

Five existing boreholes were identified in Ga-Musi (Map 3, Appendix D). The average depth of the boreholes was 80 m, with an average static water level of 12 mbgl. Pump tests were performed on H03-1027, H03-2434 and H03-2439 (only calibration).

3.3.3 Geophysical survey

Geophysical surveys were conducted along 5 profile lines, incorporating the proton magnetometer (with a station interval of 5 m), the SARIS resistivity meter (with 10 m electrode spacing and a 10 m station interval) and the MaxMin II meter (with 50 m electrode spacing and a 10 m station interval). Graphical results of these surveys were included as Appendix A and summarised in Table 3.

Table 3 Summary of geophysical survey in Ga-Musi Village

Line No	Line distance and direction	Magnetic anomalies (m)	MaxMin Anomalies (m)	Interpretation	Siting	BH Number
Ga-Musi geophysics line-1	380 m NS	300 - 370	300 - 370	Intrusive dolerite dyke, i.e at a distance of between 300 and 370 m along this profile line.	**370 m** along profile line, targeting contact areola along the intrusive dyke	**H03-3281**
Ga-Musi geophysics line-2	700 m EW	40 - 60	40 - 60	These anomalies are deemed to indicate the presence of intrusive dolerite dyke	**40m** along profile line 2 and targets the deep soil, contact areola along intrusive dyke.	**H03-3284**
Ga-Musi geophysics line-3	300 m SN	260 - 280		Intrusive dolerite dyke, i.e at a distance of between 260 and 280 m along this profile line.	**600 m** along profile line 1A and targets deep soil; and contact areola along intrusive dyke.	**H03-3285**
Ga-Musi geophysics line-4	710 m SE - NW	80 - 370	80 – 370 (Ressistivity)	Indicate the presence of intrusive dolerite dyke, i.e at a distance of between 80 and 370 m along this profile line	**370 m** along profile line 4 and targets contact areola along intrusive dyke	
Ga-Musi geophysics line-5	210 m S - N	170 - 190	170 – 190 (Ressistivity)	indicate the presence of intrusive dolerite dyke, i.e at a distance of between 170 and 190 m along this profile line	**80 m** along profile line 4 and targets contact areola along intrusive dyke	**H03-3287 and H03-3289**

3.3.4 Source Development

3.3.4.1 Borehole H03-3281

Borehole H03-3281 was drilled at Ga-Musi 1/370 and is located at the following co-ordinates (Map 3, Appendix D): 23.54420 S
28.47353 E

3.3.4.1.1 Drilling

This borehole was drilled at a diameter of 254-mm from the surface to a depth of 5.5 m, after that a drill bit with a diameter of 165 mm was used to a final depth of 81 m. Solid steel casing with an inside diameter of 177 mm was installed from the surface to a depth of 5.5 m. A detailed log is included in Appendix B.

The drill penetrated a top reddish brown fine sandy clay soil, to a depth of 2 m, after which greyish black slightly weathered dolerite was intercepted to a final depth of 81 m.

A water strike of 0.2 L/sec was encountered at 20 meters. The final blow yield was found to be 0.2 L/sec.

A steel cap was welded across the top of the steel casing; concrete slab was used on the surrounding.

3.3.4.1.2 Testing

The yield characteristic of this borehole was not determined due to its low blow yield.

3.3.4.2 Borehole H03-3284

Borehole H03-3284 was drilled at Ga-Musi drilling site 2/40 and is located at the following co-ordinates (Map 3, Appendix D):

23.54154 S
28.48160 E

3.3.4.2.1 Drilling

This borehole was drilled at a diameter of 254-mm from the surface to a depth of 5.5 m, after that a drill bit with a diameter of 165 mm was used final depth of 61 m. No casing installed. A detailed log is attached as Appendix B.

The drill penetrated a top reddish brown fine sandy clay soil, to a depth of 1 m, after which greyish black slightly weathered dolerite was intercepted to a final depth of 61 m.

A water strike of 0.2 L/sec was encountered at 17 meters. The final blow yield was found to be 0.2 L/sec.

No casing installed, only pole planted.

3.3.4.2.2 Testing

The yield characteristic of this borehole was not determined due to its low blow yield.

2328CB
A62D
LR658 Vogelpan PTN. Ga-Musi

3.3.4.3 Borehole H03-3285

Borehole H03-3285 was drilled at Ga-Musi drilling site Ga-Musi 1A/600 and is located at the following co-ordinates[1]: 23.541840 S
28.483200 E

3.3.4.3.1 Drilling

This borehole was drilled at a diameter of 254-mm from the surface to a depth of 17 m, after that a drill bit with a diameter of 165 mm was used final depth of 46 m. Solid steel casing with an inside diameter of 177 mm was installed from the surface to a depth of 17 m, of which 11 m was solid casing and 6 m was perforated casing. A detailed log is included in Appendix B.

The drill penetrated a top reddish brown fine sandy clay soil, to a depth of 2 m, after which highly weathered sand stone was intercepted to a depth of 11 m, a greyish black highly weathered dolerite was intercepted to a final depth of 46 m.

A water strike of 2.5 L/sec was encountered at 17 meters. The final blow yield was found to be 2.5 L/sec.

A steel cap was welded across the top of the steel casing; concrete slab was used on the surrounding.

3.3.4.3.2 Testing

The static groundwater level was found to occur at a depth of 4.55 m below the datum level (located 14.43 m above the natural ground surface), with a total borehole depth of 45.82 m. The testing pump was installed at a depth of 40.50 mbdl, resulting in a maximum drawdown of 14.43m. The following tests were conducted:

- The yield tests commenced with a calibration test composed of six 15-minute steps, conducted at yields of between 1 and 4 L/s, resulting in a total drawdown of 14.43m.
- This was followed by a stepped discharge test composed of two 100-minute steps conducted at yields of between 2 and 5 L/s, resulting in a total drawdown of 14.43 m (translating to 96 % of the available drawdown).

A constant discharge test was conducted at an average yield of 3.3 L/s over a period of 24 hrs, resulting in a total drawdown of 14.43 m (translating to 80 % of the available drawdown).

Recovery was relatively good, with the groundwater level returning to within 80 % of its original level after a period of 24 hours.

The maximum abstraction per 24h pumping cycle was recommended at 0.8 L/s.

3.3.4.3.3 Water Quality Analysis

The groundwater abstracted from this borehole classified as being of dangerous quality (Class 4) due to elevated nitrate concentrations. These concentrations also exceeded the SABS maximum allowable specification of 20 mg/L for domestic water use. Without proper treatment, this water is unacceptable for continuous use.

2328CB
A62D
LR 450 Vigaen PTN Vigaen

3.3.4.4 Borehole H03-3287

Borehole H03-3287 was drilled at Ga-Musi drilling site Ga-Musi 5/370 and is located at the following co-ordinates (Map 3, Appendix D):

23.578860 S
28.476160 E

3.3.4.4.1 Drilling

This borehole was drilled at a diameter of 254-mm from the surface to a depth of 5.5 m, after that a drill bit with a diameter of 165 mm was used final depth of 61 m. No casing installed due to the low yield of the borehole. A detailed log is included in Appendix C.

The drill penetrated a top reddish brown fine sandy clay soil, to a depth of 1 m, after which slightly weathered dolerite was intercepted to a final depth of 61 m.

A water strike of 0.5 L/sec was encountered at 16 meters. The final blow yield was found to be 0.5 L/sec.

This borehole was abandoned and no casing installed.

3.3.4.4.2 Testing

The yield characteristic of this borehole was not determined due to its low blow yield.

2329CB
A62D
660LR Tevredenhof PTN. Ga-Musi

3.3.4.5 Borehole H03-3289

Borehole H03-3289 was drilled at Ga-Musi drilling site Ga-Musi 5/220 and is located at the following co-ordinates (Map 3, Appendix D):

23.552620 S
28.476090 E

3.3.4.5.1 Drilling

This borehole was drilled at a diameter of 254-mm from the surface to a depth of 5.5 m, after that a drill bit with a diameter of 165 mm was used final depth of 61 m. This borehole was dry and no casing installed. A detailed log is included in Appendix B.

The drill penetrated a top reddish brown fine sandy clay soil, to a depth of 1 m, after which slightly weathered dolerite was intercepted to a final depth of 61 m.

A water strike of 0.2 L/sec was encountered at 18 meters. The final blow yield was found to be 0.2 L/sec.

This borehole was abandoned due to its low blow yield.

3.3.4.5.2 Testing

The yield characteristic of this borehole was not determined due to its low blow yield.

2328CA
A50G
P.C van Tenerietc LR 470 PTN. Mmatladi

3.3.4.6 Borehole H03-1027

Borehole H03-1027 is an existing borehole, located at the following co-ordinates (Map 3, Appendix D):

23.55036 S 2328CB
28.11500 E A62D
GR3? LR660 Tevredenheid PTN. Ga-Musi

- 23 54971
29.47661

3.3.4.6.1 Testing

The static groundwater level was found to occur at a depth of 7.76 m below the datum level (located 7.47 m above the natural ground surface), with a total borehole depth of 97.30 m. The testing pump was installed at a depth of 52.50 mbdl, resulting in a maximum drawdown of 44.74m. The following tests were conducted:

- The yield tests commenced with a calibration test composed of six 15-minute steps, conducted at yields of between 0.4 and 2 L/s, resulting in a total drawdown of 44.74m.
- This was followed by a stepped discharge test composed of two 60-minute steps and one 30-minute step conducted at yields of between 1 and 1.6 L/s, resulting in a total drawdown of 44.74 m (translating to 96 % of the available drawdown).
- A constant discharge test was conducted at an average yield of 1L/s over a period of 12 hrs, resulting in a total drawdown of 12.56 m (translating to 80 % of the available drawdown).

Recovery was poor, with the groundwater level returning to within 40 % of its original level after a period of 24 hours.

The recommended maximum abstraction per 24 hour cycle was 0.4 L/s.

3.3.4.6.2 Water Quality Analysis

The groundwater abstracted from this borehole classified as being marginal water quality (Class 2; DWAF, 1998) due to elevated nitrate concentrations. Concentrations were however still within the maximum allowable limit, specified by the SABS for domestic water use.

2328DA
A62B
LR 741 Eerste Geluk PTN Diphitshi

3.3.4.7 Borehole H03-2434

Borehole H03-2434 is an existing borehole and is located at the following co-ordinates (Map 3, Appendix D):

23.74000 S 2328CB
28.71306 E A62D
GR1? LR 658 Vogelpan PTN. Ga-Musi

23.53005
29.45144

3.3.4.7.1 Testing

The static groundwater level was 1.53 m below the datum level (located 1.26 m above the natural ground surface), with a total borehole depth of 54.25 m. The testing pump was installed at a depth of 40.50 mbdl, resulting in a maximum drawdown of 10.55 m. The following tests were conducted:

- The yield tests commenced with a calibration test composed of six 15-minute steps, conducted at yields of between 0.4 and 6 L/s, resulting in a total drawdown of 10.55m.
- This was followed by a stepped discharge test composed of three 100-minute steps conducted at yields of between 2 and 6.6 L/s, resulting in a total drawdown of 19.29 m (translating to 96 % of the available drawdown).
- A constant discharge test was conducted at an average yield of 5L/s over a period of 24 hrs, resulting in a total drawdown of 15.38 m (translating to 80 % of the available drawdown).

Recovery was relatively good, with the groundwater level returning to within 100 % of its original level after a period of 24 hours.

The maximum abstraction rate per 24h pumping cycle was 1 L/s.

3.3.4.7.2 Water Quality Analysis

The groundwater abstracted from this borehole classifies as being poor water quality (Class 3), due to elevated nitrate concentrations. Values also exceeded the SABS specification for Class II (maximum allowable) and are thus not suitable for human consumption without treatment.

2 328CB
A62D
LR 660 Tevrdenhoek PTM Ga-Mus

3.3.4.8 Borehole H03-2439

Borehole H03-2434 was an existing borehole and is located at the following co-ordinates (Map 2, Appendix D): 23.548140 S

28.487720 E

3.3.4.8.1 Testing

The static groundwater level 26.24 m below the datum level (located 25.97 m above the natural ground surface) with a total borehole depth of 90.05 m. The testing pump was installed at a depth of 58.50 mbdl, resulting in a maximum drawdown of 32.22m. The following tests were conducted:

- The yield tests commenced with a calibration test composed of three 15-minute steps, conducted at yields of between 0.4 and 0.8 L/s, resulting in a total drawdown of 32.22m.

Recovery was poor, with the groundwater level returning to within 40 % of its original level after a period of 40 minutes.

3.3.4.8.2 Water Quality Analysis

The groundwater abstracted from this borehole classified as being dangerous water quality (Class 4) according to the drinking water standards of the Departments of Water Affairs and Forestry, and is thus totally unsuitable for use. This is due to high nitrate concentrations. Nitrate concentrations also exceeded the SABS specification for Class II (maximum allowable) water quality.

3.4 Site characterisation and source development - Ga-Chere Village

3.4.1 Regional Geological setting

The area exhibits similar geology than Ga-Musi Village (Section3.3.1) (Map 2).

Higher groundwater potentials may be associated with a contact areola surrounding an intrusive dyke. The dolerite dyke intrusions in the vicinity may thus offer an opportunity for preferential weathering along the contact zones, and were investigated for possible borehole development.

This contact areola along the intrusive dyke may form preferential flow paths for groundwater, and is targeted for exploration drilling.

It should be noted that the area exhibits a low regionally groundwater potential and that successful boreholes will need to be sited within the narrow bands associated with local variations in the geology

3.4.2 Existing boreholes

Six existing boreholes were identified in the village of which two were tested (H03-2426 and H03-2439). The average depth of boreholes was 91 m and the average static water level was measured at 23 mbdl (Map 3).

3.4.3 Geophysical survey

Geophysical surveys were conducted along 5 profile lines, incorporating the proton magnetometer (with a station interval of 5 m), the SARIS resistivity meter (with 10 m electrode spacing and a 10 m station interval) and the MaxMin II meter (with 50 m electrode spacing and a 10 m station interval). Graphical results of these surveys were included as Appendix A and summarised in Table 4.

Table 4 Summary of geophysical survey in Ga-Chere Village

Line No	Line distance and	Magnetic anomalies	MaxMin Anomalies	Interpretation	Siting	BH Number

	direction	(m)	(m)			
Ga-Chere Geophysics line 1	300 m N-S	250 - 270	250 - 270	indicate the presence of intrusive dolerite dyke	250m along profile line 1 and targets the contact areola along the intrusive dyke.	**H03-3282**
Ga-Chere Geophysics line 2	500 m W- E	180 - 320	180 - 320	indicate the presence of intrusive dolerite dyke	370 m along profile line 2 and targets contact areola along intrusive dyke.	**H03-3283**
Ga-Chere Geophysics line 3	700 m W - E	280 and 300	280 and 300	indicate the presence of intrusive dolerite dyke	300 m along profile line 3 and targets deep soil; and contact areola along intrusive dyke.	
Ga-Chere Geophysics line 4	400 m N - S	260 - 300	260 - 300	indicate the presence of intrusive dolerite dyke	280 m along profile line 4 and targets contact areola along intrusive dyke	**H03-3288**
Ga-Chere Geophysics line 5	210 m E - W	70 - 100	70 - 100	indicate the presence of intrusive dolerite dyke		

2328DA
A62D
LR 660 Tevredenheid PTN. Mongatane

3.4.4 Source Development

3.4.4.1 Borehole H03-3282

Borehole H03-3282 was drilled at Ga-Chere drilling site Ga-Chere 2/250 and is located at the following co-ordinates (Map 3, Appendix D): 23.55731 S
28.51120 E

3.4.4.1.1 Drilling

This borehole was drilled at a diameter of 254-mm from the surface to a depth of 5.5 m, after that a drill bit with a diameter of 165 mm was used final depth of 81 m. The borehole was dry and no casing was installed. A detailed log is included in Appendix B.

The drill penetrated a top reddish brown fine sandy clay soil, to a depth of 2 m, after which greyish black slightly weathered dolerite intercepted to a final depth of 81 m.

No water strikes encountered in this borehole. A pole number was planted.

3.4.4.1.2 Testing

The borehole was dry, hence no testing undertaken.

2328DA
A62D
LR660 Tevredenheid PTN. Mongatane

3.4.4.2 Borehole H03-3283

Borehole H03-3283 was drilled at Ga-Chere drilling site Ga-Chere 2/370 and is located at the following co-ordinates (Map 3, Appendix D): 23.55724 S
28.51251 E

3.4.4.2.1 Drilling

This borehole was drilled at a diameter of 254-mm from the surface to a depth of 5.5 m, after that a drill bit with a diameter of 165 mm was used final depth of 81 m. No casing was installed. A detailed log is included in Appendix B.

The drill penetrated a top reddish brown fine sandy clay soil to a depth of 2 m, after which greyish black slightly weathered dolerite was intercepted to a final depth of 81 m.

A water strike of 0.2 L/sec was encountered at 73 meters. The final blow yield was 0.2 L/sec.

No casing was installed, only pole planted.

3.4.4.2.2 Testing

The yield characteristic of this borehole was not determined due to its low blow yield.

2328DA
A62D
LR660 Tevredenheid PTN. Mongatane

3.4.4.3 Borehole H03-3286

Borehole H03-3286 was drilled at Ga-Chere drilling site Ga-Chere 3/370 and is located at the following co-ordinates (Map 3, Appendix D): - 23.56137 S
28.51579 E

3.4.4.3.1 Drilling

This borehole was drilled at a diameter of 254-mm from the surface to a depth of 36 m, after that a drill bit with a diameter of 165 mm was used to a final depth of 81 m. Solid steel casing with an inside diameter of 177 mm was installed from the surface to a depth of 36 m, of which 5 m was solid casing and 1 m was perforated casing (Appendix B).

The drill penetrated a top reddish brown fine sandy soil, to a depth of 1 m, after which moderately weathered sand stone was intercepted to a depth of 30 m, a highly weathered pinkish sandstone was encountered between 30 and 65 m, creamy pinkish moderately weathered sandstone was intercepted to a final depth of 81 m.

A water strike of 2.5 L/sec was encountered at 19 meters. The final blow yield was found to be 2.5 L/sec.

A steel cap was welded across the top of the steel casing; concrete slab was used on the surrounding.

3.4.4.3.2 Testing

The static groundwater level was found to occur at a depth of 21.46 m below the datum level (located 21.19 m above the natural ground surface), with a total borehole depth of 80.90 m being reported. The testing pump was installed at a depth of 52.50 mbdl, resulting in a maximum drawdown of 31.04 m. The following tests were conducted:

- The yield tests commenced with a calibration test composed of six 15-minute steps, conducted at yields of between 1 and 4 L/s, resulting in a total drawdown of 31.04 m.
- This was followed by a stepped discharge test composed of three 60-minute steps conducted at yields of between 1 and 3.3 L/s, resulting in a total drawdown of 21.58 m (translating to 96 % of the available drawdown).
- A constant discharge test was conducted at an average yield of 1.8 L/s over a period of 24 hrs, resulting in a total drawdown of 14.93 m (translating to 50 % of the available drawdown).

Recovery was relatively good, with the groundwater level returning to within 80 % of its original level after a period of 24 hours.

The maximum abstraction rate recommended for this borehole per 24 h pumping cycle is 0.8 L/s.

3.4.4.3.3 Water Quality Analysis

The groundwater abstracted from this borehole classified as being dangerous quality (Class 4), due to elevated nitrate concentrations, according to the drinking water standards of the Departments of Water Affairs and Forestry, and is thus unacceptable water. These values also exceeded the SABS specification for Class II (maximum allowable) quality.

2328DA
A62D
LR 660 Terrace-head PTN. Mongatane.

3.4.4.4 Borehole H03-3288

Borehole H03-3288 was drilled at Ga-Chere drilling site Ga-Chere 4/280 and is located at the following co-ordinates (Map 3, Appendix D) : 23.559980 S

28.520110 E

3.4.4.4.1 Drilling

This borehole was drilled at a diameter of 254-mm from the surface to a depth of 49 m, after that a drill bit with a diameter of 165 mm was used final depth of 56 m. Solid steel casing with an inside diameter of 177 mm was installed from the surface to a depth of 49 m, of which 6.1 m was solid casing and 2 m was perforated casing (Appendix B).

The drill penetrated a top reddish brown fine sandy clay soil, to a depth of 2 m, after which moderately weathered ferecrete was encountered to depth of 7 m, highly fractured quartzite was intercepted between 7 and 16 m, after which pinkish reddish brown highly weathered sand stone was encountered to the depth of 47 m. The layer of highly weathered quartzite was encountered between 47 and 49 m, after which highly weathered dolerite was intercepted to a final depth of

56 m.

A water strike of 5 L/sec was encountered at 20 meters. The final blow yield was found to be 5 L/sec.

A steel cap was welded across the top of the steel casing; concrete slab was used on the surrounding.

3.4.4.4.2 Testing

The static groundwater level was found to occur at a depth of 18.46 m below the datum level (located 18.19 m above the natural ground surface), with a total borehole depth of 56.38 m. The testing pump was installed at a depth of 45 mbdl, resulting in a maximum possible drawdown of 11 m. The following tests were conducted:

- The yield tests commenced with a calibration test composed of four 15-minute steps, conducted at yields of between 1 and 8 L/s, resulting in a total drawdown of 11 m.
- This was followed by a stepped discharge test composed of three 100-minute steps conducted at yields of between 2 and 6 L/s, resulting in a total drawdown of 11 m (translating to 96 % of the available drawdown).
- A constant discharge test was conducted at an average yield of 6 L/s over a period of 24 hrs, resulting in a total drawdown of 11 m being achieved (translating to 100 % of the available drawdown).

Recovery was relatively good, with the groundwater level returning to within 100 % of its original level after a period of 24 hours.

3.4.4.4.3 Water Quality Analysis

Water from this borehole classified as Class 3 quality according to DWAF criteria. Nitrate concentrations also exceeded the maximum allowable limit, specified by the SABS for domestic water.

2 328DA
A62B
LR 722 Buffelshoek PTN. Koppeng

3.4.4.5 Borehole H03-2426

Borehole H03-2426 was an existing borehole, located at the following co-ordinates (Map 3, Appendix D:

23.724720 S 23.56047
28.738330 E 28.51620

CRIP
2 328DA
A62D LR660 Tevredenheid PTN. Mongalane.

3.4.4.5.1 Testing

The static groundwater level was 19.92 m below the datum level (located 19.65 m above the natural ground surface), with a total borehole depth of 61.65 m being reported. The testing pump was installed at a depth of 58.50 mbdl, resulting in a maximum drawdown of 18.60 m. The following tests were conducted:

- The yield tests commenced with a calibration test composed of five 15-minute steps, conducted at yields of between 1 and 1.6 L/s, resulting in a total drawdown of 18.60 m.
- This was followed by a stepped discharge test composed of three 60-minute steps

conducted at yields of between 1 and 2 L/s, resulting in a total drawdown of 38.33 m (translating to 96 % of the available drawdown).

- A constant discharge test was conducted at an average yield of 1 L/s over a period of 24 hrs, resulting in a total drawdown of 14.65 m (translating to 100 % of the available drawdown).

Recovery was relatively good, with the groundwater level returning to within 40 % of its original level after a period of 24 hours.

The maximum recommended abstraction rate per 24 h pumping cycle was 0.2 L/s.

3.4.4.5.2 Water Quality Analysis

The groundwater abstracted from this borehole classifies as being dangerous quality (Class 4) according to the drinking water standards of the Departments of Water Affairs and Forestry, and is thus unacceptable for domestic water use without treatment. Concentrations also exceeded the maximum allowable limit specified by the SABS for domestic water.

2 328DA
A62C
:R722 Buffelshoek PTN. Kgapeng

3.4.4.6 Borehole H03-2431

Borehole H03-2431 was an existing borehole drilled at Ga-Chere village at the following co-ordinates (Map 3, Appendix D):

23.704440 S 23.56167
28.722500 E 28.50946
2 328DB
A62D
660LR Tevedenhoek PTN Mongalene

3.4.4.6.1 Testing

The static groundwater level was 25.63 m below the datum level (located 25.36 m above the natural ground surface), with a total borehole depth of 120.80 m being reported. The testing pump was installed at a depth of 58 mbdl, resulting in a maximum drawdown of 32.87 m. The following tests were conducted:

- The yield tests commenced with a calibration test composed of six 15-minute steps, conducted at yields of between 0.3 and 3.3 L/s, resulting in a total drawdown of 32.87 m.

- This was followed by a stepped discharge test composed of two 60-minute steps and 10-minute step conducted at yields of between 1.7 and 1.8 L/s, resulting in a total drawdown of 32.60 m (translating to 96 % of the available drawdown).
- A constant discharge test was conducted at an average yield of 1 L/s over a period of 24 hrs, resulting in a total drawdown of 15.29 m (translating to 100 % of the available drawdown).

Recovery was relatively good, with the groundwater level returning to within 80 % of its original level after a period of 24 hours.

The maximum recommended abstraction rate per 24 h pumping cycle was 0.2 L/s.

3.4.4.6.2 Water Quality Analysis

The groundwater abstracted from this borehole classifies as being poor water quality (Class 3) according to the drinking water standards of the Departments of Water Affairs and Forestry, and is thus unsuitable for use without treatment. The poor quality is associated with elevated nitrate concentrations.

4 SUMMARY AND CONCLUSIONS

4.1 General

Table 5 presents a project summary and the utilisation recommendations for the boreholes to be used for supplementing the Steilloop Villages water requirements.

4.2 Lekhureng Village

4.2.1 Borehole H04-1306

- The borehole can be used for the abstraction of a maximum volume of **432 m^3** of groundwater per day, translating to a maximum pumping rate of 5 L/sec over a pumping period of 24 hours daily.
- The pump should be installed at a depth of 30 metres below ground level.
- The groundwater abstracted from this borehole is of poor quality (class 3) for drinking purposes, as a result of elevated fluoride concentrations (DWAF, 1998). However, fluoride concentrations are still within the maximum acceptable limit specified by the SABS for domestic water use. At the fluoride concentrations reported in this borehole, dental mottling is expected, but no other health effects.

4.2.2 Borehole H04-2117

- A maximum volume of **432 m^3** of groundwater can be abstracted from this boreholes per day, translating to a maximum pumping rate of 5 L/sec over a pumping period of 24 hours daily.
- The pump should be installed at a depth of 24 metres below ground level.
- The groundwater abstracted from this borehole is of marginal quality (class 2) for drinking purposes, and is conditionally acceptable, negative effects, such as dental mottling may occur to some sensitive groups. Fluoride concentrations are still within the maximum allowable limit proposed by the SABS for domestic water use. No other health effects are expected at these concentrations.

4.2.3 Borehole H04-2120

- The borehole can be used for the abstraction of a maximum volume of 216 m3 of groundwater per day, translating to a maximum pumping rate of 2.5 L/sec over a pumping period of 24 hours daily.
- The pump should be installed at a depth of 27 metres below ground level.
- Water from this borehole is of marginal quality based on the DWAF assessment criteria. Elevated sodium, nitrate, chloride and fluoride concentrations were observed. Health effects, such as dental mottling may occur in sensitive groups.

4.3 Ga-Tshipana Village

4.3.1 Borehole H04-0520

- A maximum volume of **42.20 m³** of groundwater can be abstracted from this borehole per day. This amounts to a maximum pumping rate of 0.5 L/sec over a 24 h pumping cycle.
- The pump should be installed at a depth of 27 metres below ground level.
- The groundwater abstracted from this borehole is of marginal quality (class 2) for drinking purposes and is conditionally acceptable. Health effects may occur in sensitive populations. All concentrations were however within the maximum allowable limit specified by the SABS.

4.3.2 Borehole H04-0947

- The maximum recommended abstraction volume from this borehole is **691 m³** per day, translating to a maximum pumping rate of 8 L/sec over a pumping period of 24 hours daily.
- The pump should be installed at a depth of 45 metres below ground level.
- The groundwater abstracted from this borehole is of poor quality (class 3) for drinking purposes based on the DWAF criteria. This was due to elevated fluoride concentrations. Values were however still within the maximum allowable limit of 2 mg/L specified by the SABS for drinking water. Dental mottling may occur at these concentrations, but no other health effects are expected.

4.3.3 Borehole H04-2118

- The borehole can be used for the abstraction of a maximum volume of 216 m3 of groundwater per day, translating to a maximum pumping rate of 2.5 L/sec over a pumping period of 24 hours daily.
- The pump should be installed at a depth of 21 metres below ground level.
- Water from this borehole classified as marginal water quality, based on elevated Fluoride concentrations (DWAF, 1998). Concentrations were however still below the SABS specification for maximum allowable. Except for dental mottling, no other health effects are expected at these concentrations.

4.4 Ga-Musi Village

4.4.1 Borehole H03-1027

- A maximum volume of **34.56 m³** of groundwater can be abstracted from this borehole on a daily basis. This translates to a maximum pumping rate of 0.4 L/sec over a pumping period of 24 hours.
- The pump should be installed at a depth of 42 metres below ground level.

- The groundwater abstracted from this borehole is of marginal quality (class 2) for drinking purposes (Health and aesthetic properties), and is suitable for the majority of people without adverse effects.

4.4.2 Borehole H03-2434

- The borehole can be used for the abstraction of a maximum volume of **86.40 m ^{3}** of groundwater per day, translating to a maximum pumping rate of 1 L/sec over a pumping period of 24 hours daily.
- The pump should be installed at a depth of 24 metres below ground level.
- The groundwater abstracted from this borehole is of poor quality (class 3) for drinking purposes (Health and aesthetic properties), and is unsuitable for use without treatment. This is due to elevated nitrate concentrations. Nitrate concentrations also exceeded the SABS maximum allowable specification for drinking water. Health effects that may occur at these concentrations include methaemoglobinaemea in infants and mucous membrane irritation in adults. It is recommended that this water be treated or mixed with water of suitable quality.

4.4.3 Borehole H03-2439

- A maximum volume of **4.32 m ^{3}** of groundwater per day can be abstracted from this boreholes, translating to a maximum pumping rate of 0.05 L/sec over a pumping period of 24 hours daily.
- The pump should be installed at a depth of 42 metres below ground level.
- Based on elevated nitrate concentrations, the groundwater abstracted from this borehole is of dangerous quality (class 4) for drinking purposes and is totally unsuitable for use,. Acute effects may occur that include methaemoglobinaemea in infants and mucous membrane irritation in adults. Nitrate concentrations also exceeded the SABS specification for Class II (maximum allowable) water. It is recommended that water be treated prior consumption.

4.4.4 Borehole H03-3285

- The borehole can be used for the abstraction of a maximum volume of **69.12 m ^{3}** of groundwater per day, translating to a maximum pumping rate of 0.80 L/sec over a pumping period of 24 hours daily.
- The pump should be installed at a depth of 32 metres below ground level.
- The groundwater abstracted from this borehole is of dangerous quality (class 4) for drinking purposes (Health and aesthetic properties), and is totally unsuitable for use, acute effects may occur. The same recommendations apply as with borehole H03-2439.

4.5 Ga-Chere Village

4.5.1 Borehole H03-2426

- A maximum daily volume of **17.28 m³** of groundwater can be abstracted from this borehole, translating to a maximum pumping rate of 0.20 L/sec over a pumping period of 24 hours daily.
- The pump should be installed at a depth of 40 metres below ground level.
- The groundwater abstracted from this borehole is of dangerous quality (class 4) for drinking purposes (Health and aesthetic properties), and is unsuitable for use, without treatment. Acute effects may occur at present nitrate concentrations. Treatment options should be investigated.

4.5.2 Borehole H03-2431

- The borehole can be used for the abstraction of a maximum volume of **17.28 m³** of groundwater per day, translating to a maximum pumping rate of 0.20 L/sec over a pumping period of 24 hours daily.
- The pump should be installed at a depth of 40 metres below ground level.
- The groundwater abstracted from this borehole is of poor quality (class 3) for drinking purposes (Health and aesthetic properties), and is unsuitable for use without treatment, chronic effects may occur in infants or sensitive individuals. Nitrate concentrations also exceeded the SABS specification for Class II water quality (maximum allowable). Should this borehole be utilised, treatment options or alternatives should be investigated.

4.5.3 Borehole H03-3286

- The borehole can be used for the abstraction of a maximum volume of 69.12 m3 of groundwater per day, translating to a maximum pumping rate of 0.8 L/sec over a pumping period of 24 hours daily.
- The pump should be installed at a depth of 60 metres below ground level.
- The groundwater abstracted from this borehole is of dangerous quality (class 4) for drinking purposes (Health and aesthetic properties), and is totally unsuitable for use, acute effects may occur. This is due to elevated nitrate concentrations.

4.5.4 Borehole H03-3288

- A maximum recommended daily volume of **216 m³** can be abstracted from this borehole, which translates to a pumping rate of 2.5 L/sec over a pumping period of 24 hours daily.
- The pump should be installed at a depth of 42 metres below ground level.
- The groundwater abstracted from this borehole is of poor quality and classified as Class 3 water based on DWAF criteria. Water from this borehole is unsuitable for use without treatment, acute effects may occur. This is due to elevated nitrate concentrations, as was observed in the other boreholes within this village – the same recommendations

regarding water quality apply..

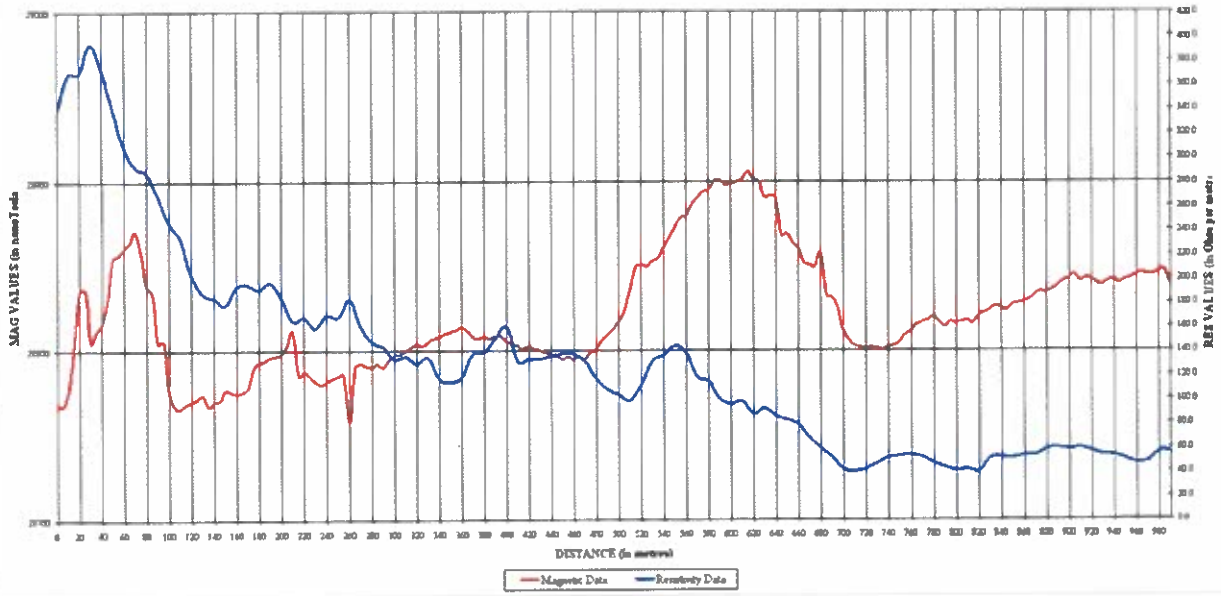
5 RECOMMENDATIONS

The following recommendations are made:

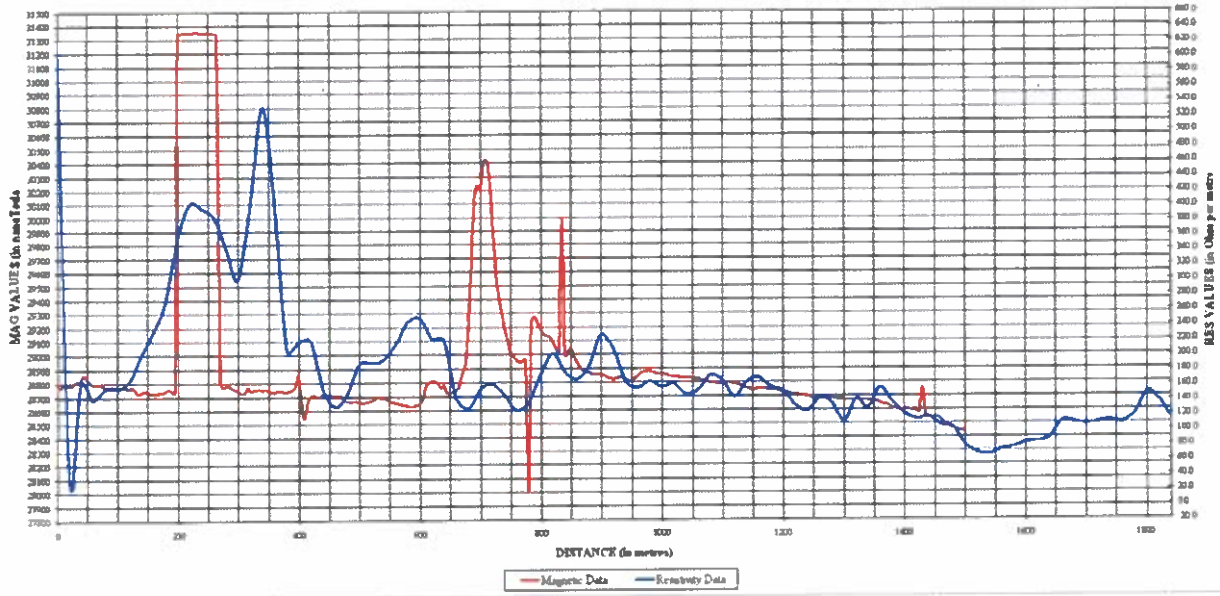
1. Recommended pumping rates should be **implemented** and groundwater levels monitored on a regular bases to detect any changes in trends.
2. Should the water level drop to within **2 metres** of the pump intake during regular pumping, then the pumping rate should be reduced. Results of recorded abstraction rates, abstraction volumes, and water levels may then be re-evaluated.
3. **Flow meters** should be installed on all production boreholes in order to monitor monthly abstraction rates.
4. **Fluoride concentrations** within Lekhureng and Ga-Tshipana villages exceeded on average the DWAF guideline value for Class 2 (marginal water quality) and may cause dental mottling in sensitive populations. The concentrations were however still within the SABS specification for Class II (maximum allowable) water quality. It is recommended that future production boreholes be drilled to just before the contact with the Gabbro's (Mr F Botha, MSc thesis).
5. **Nitrate concentrations** within Ga-Musi and Ga-Chere Villages are very high and exceeded both the DWAF Guideline values and SABS specifications for acceptable water. Treatment options should be evaluated or alternatives, such as mixing be investigated. The origin of nitrate pollution should be investigated.
6. The National Water Act (Act 36 of 1998) specifies that certain water uses need to be licensed. This licensing process will ensure a sustainable and equitable water supply for environmental and domestic use. Should the abstraction of groundwater **exceed 10m^3** per property per day, then according to the Section 21(a), *(Taking water from a resource)* the use **must be licensed**.
7. Supplying bulk water to communities is a listed activity under Section 21 of the Environmental Conservation Act, 1989 and specifies that an Environmental Impact Assessment be conducted.

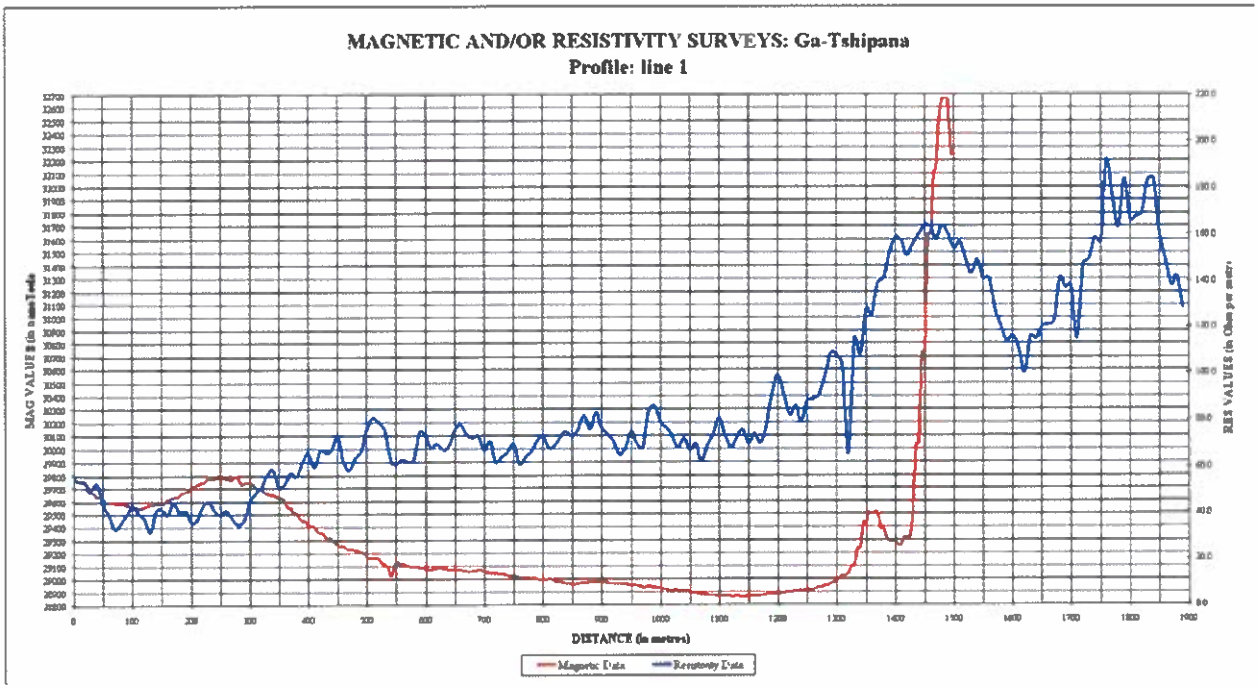
6 APPENDIX A: GEOPHYSICS

MAGNETIC AND/OR RESISTIVITY SURVEYS: Lekhureng line 1

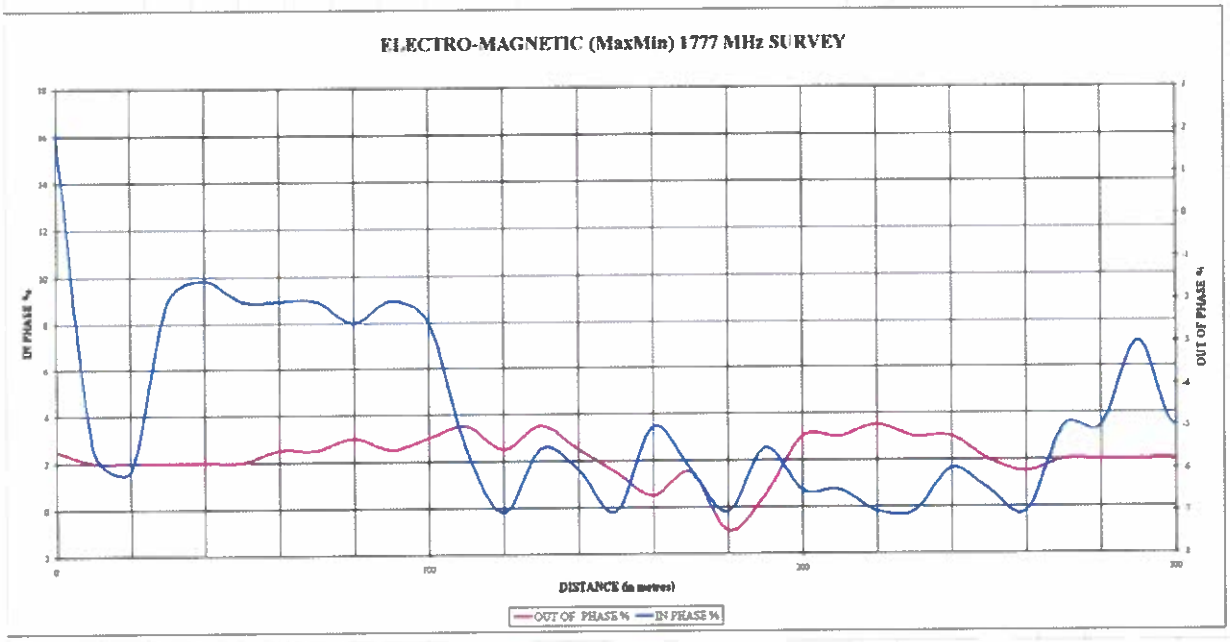


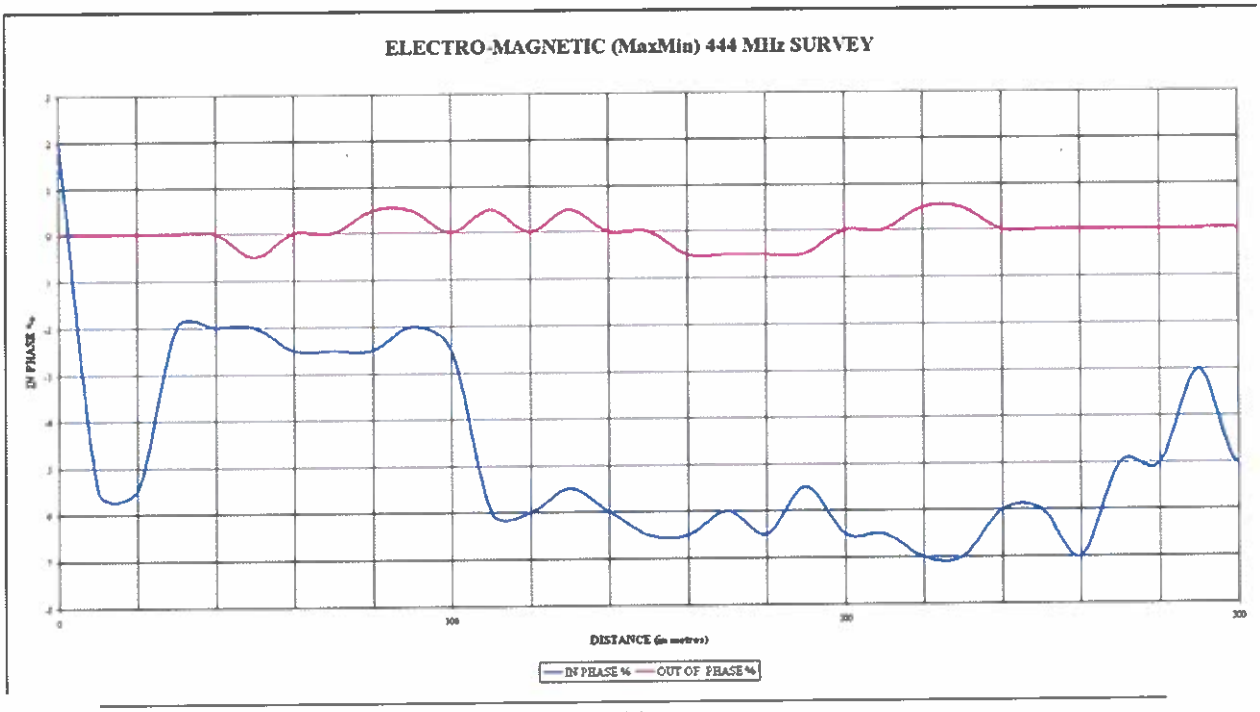
MAGNETIC AND/OR RESISTIVITY SURVEYS: Lekhureng line 2

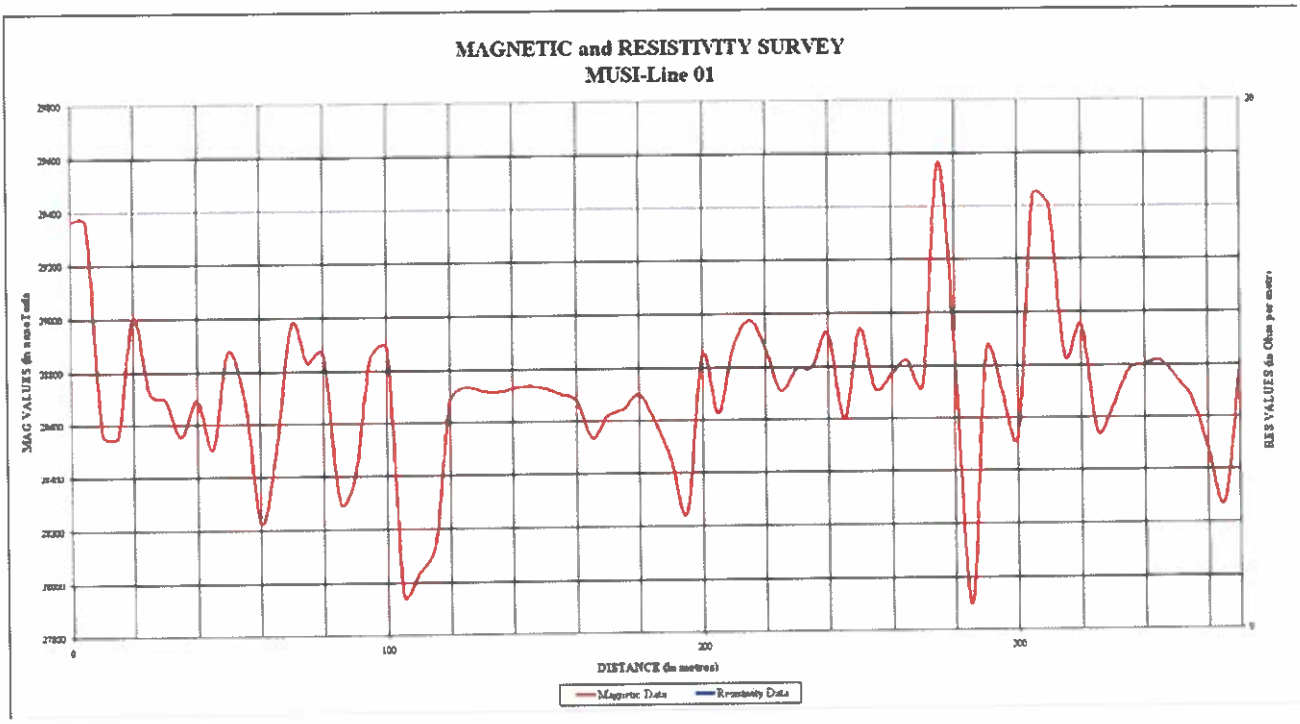


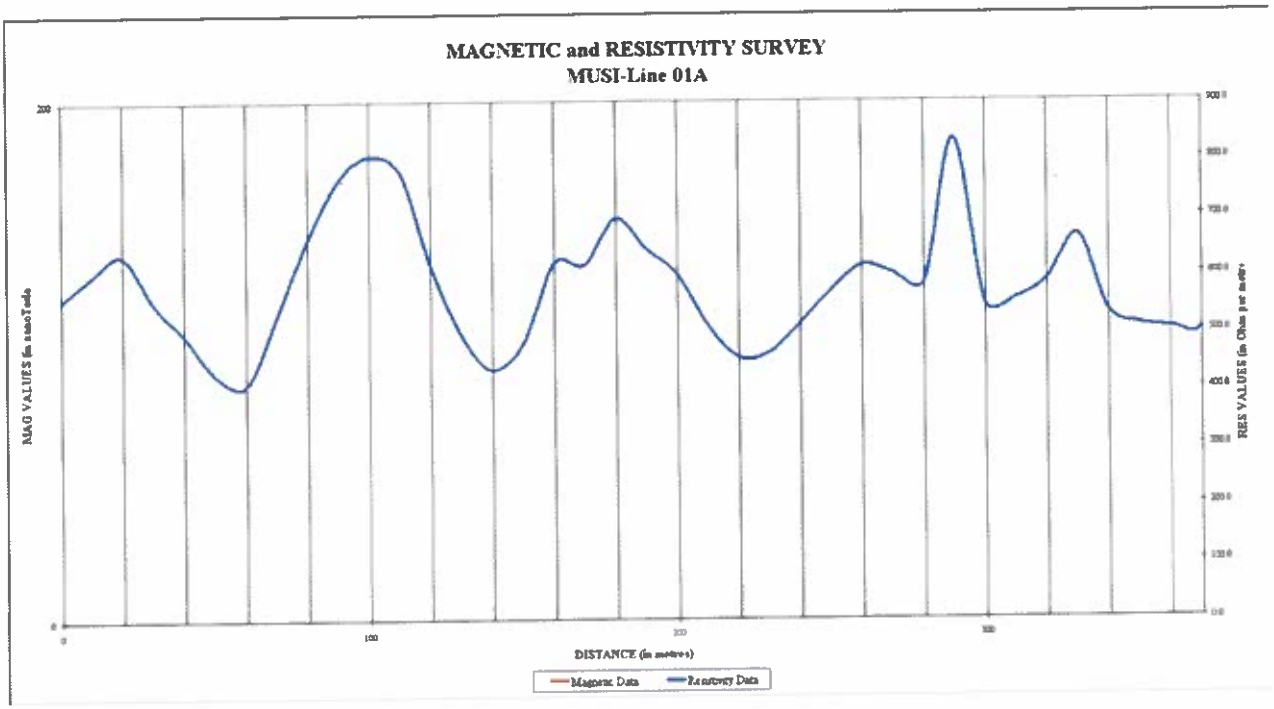

MAGNETIC AND/OR RESISTIVITY SURVEYS: Ga-Tshipana
Profile: line 1
DISTANCE (in metres)
Magnetic Data
Resistivity Data

Ga-musi Water Supply - Profile Line 01

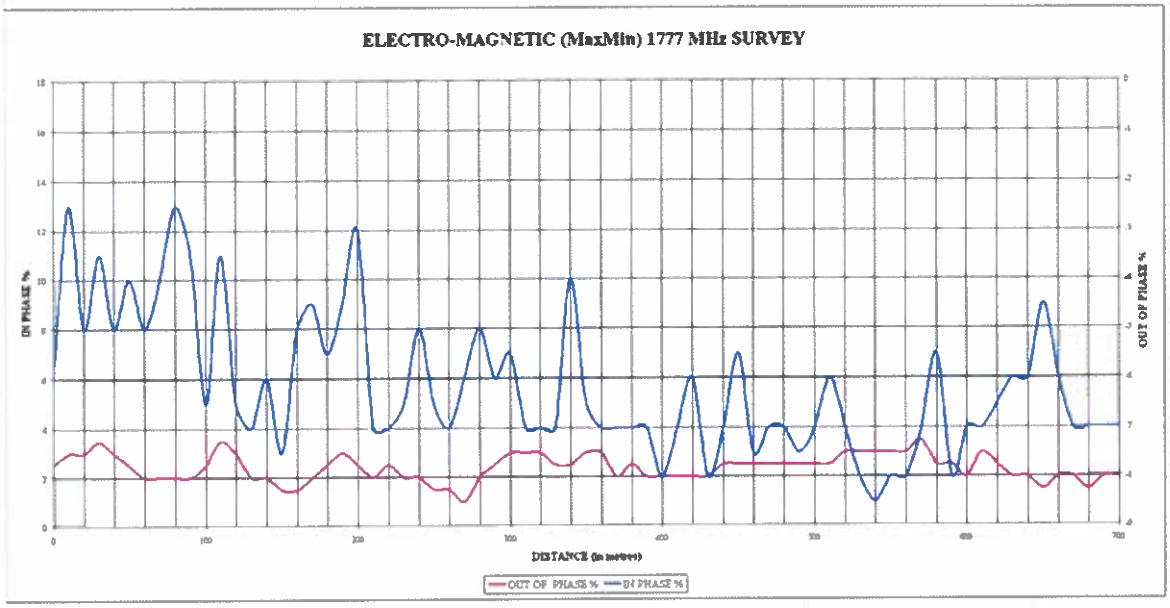


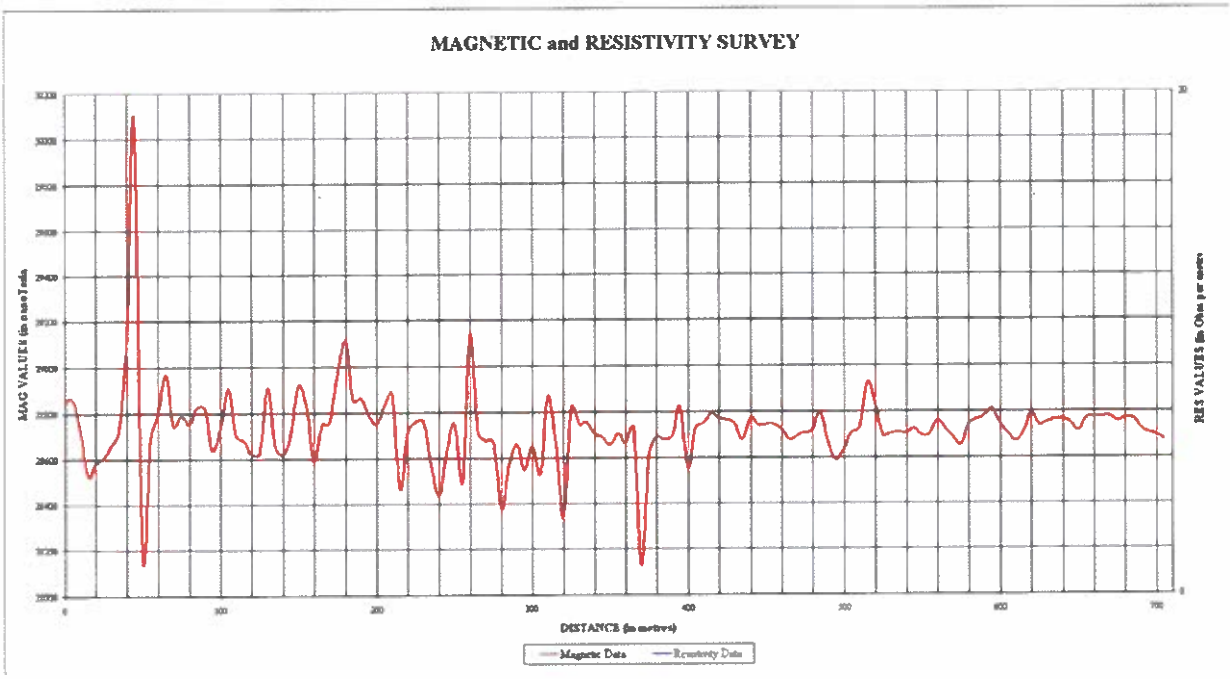



MAGNETIC and RESISTIVITY SURVEY
MUSI-Line 01
MAG VALUES (in nanoTesla
RES VALUES (in Ohm per meter)
DISTANCE (in metres)
Magnetic Data
Resistivity Data

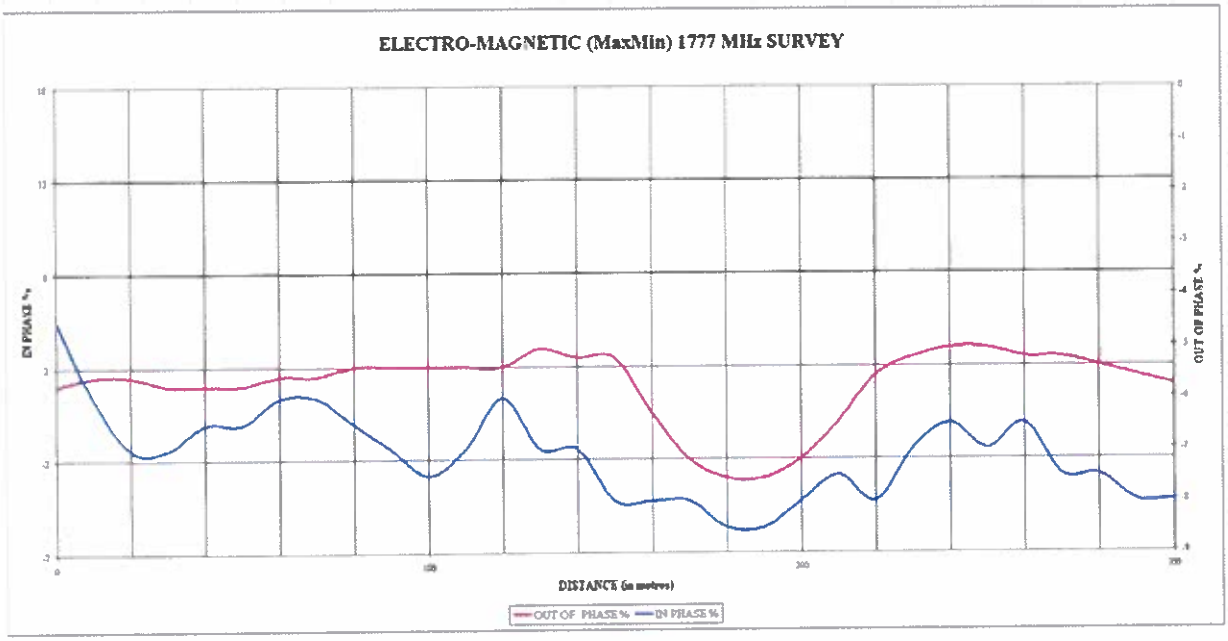

MAGNETIC and RESISTIVITY SURVEY
MUSI-Line 01A
MAG VALUES (in nanoTesla
RES VALUES (in Ohm per meter)
DISTANCE (in metres)
Magnetic Data
Resistivity Data

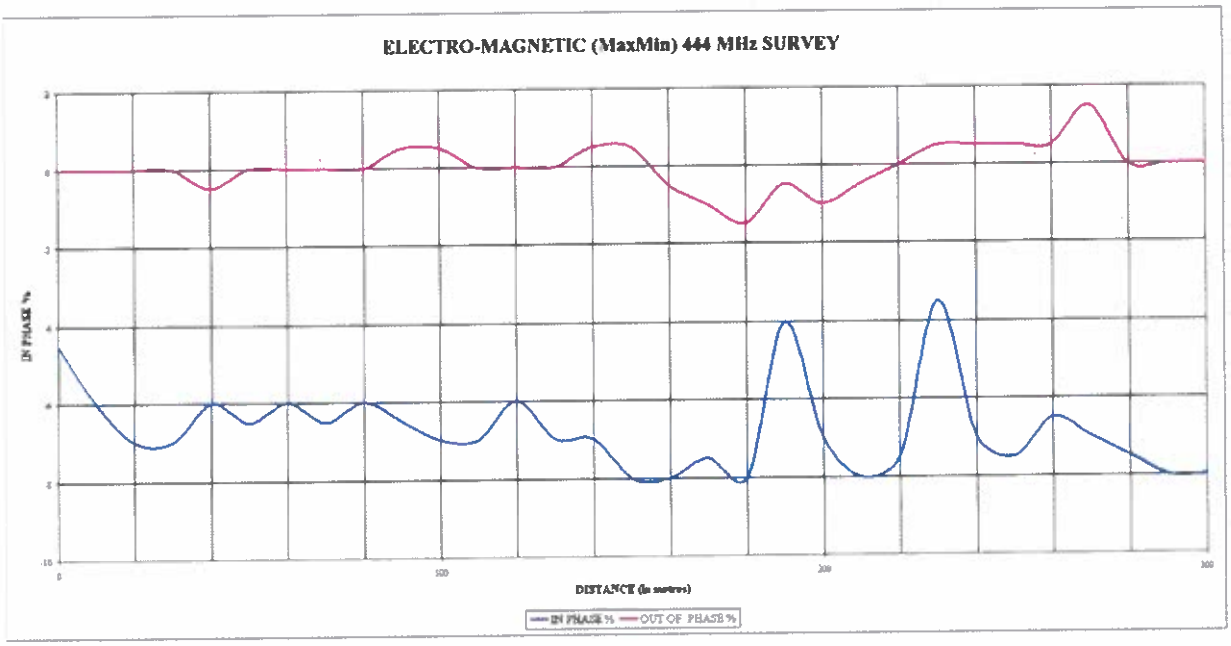
Ga-musi Water Supply - Profile Line 02

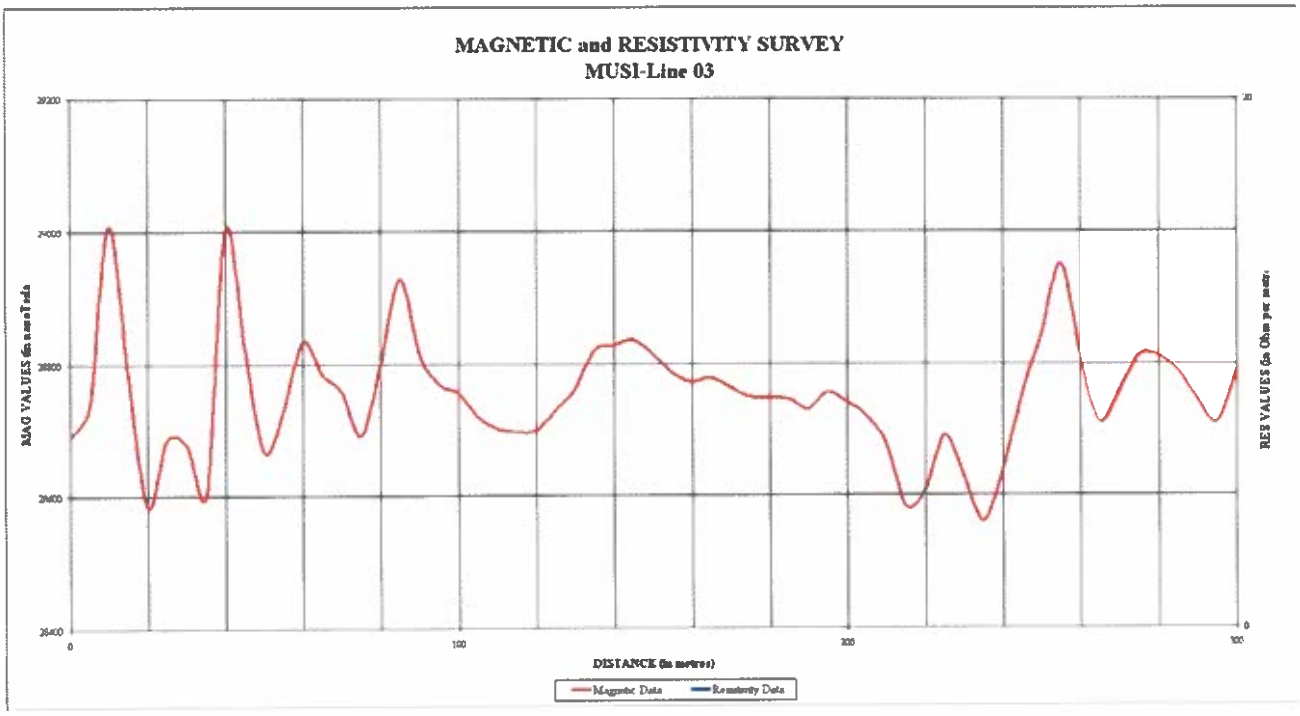


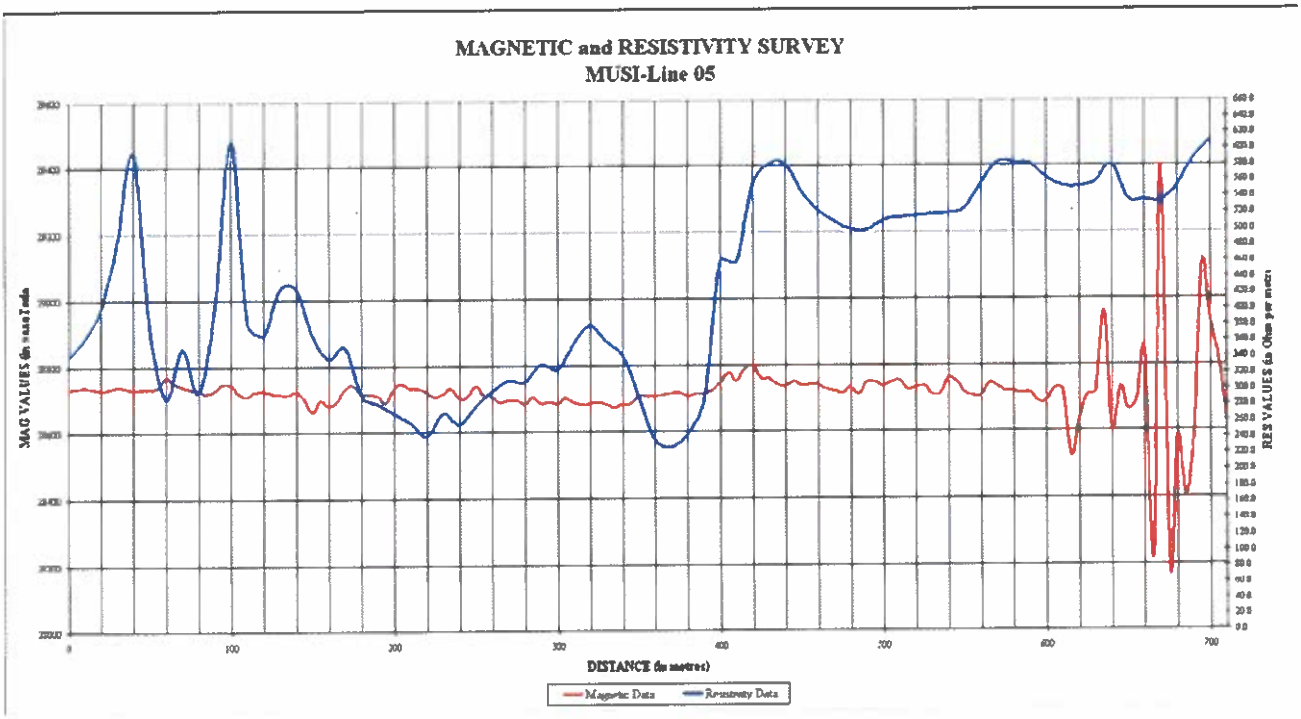


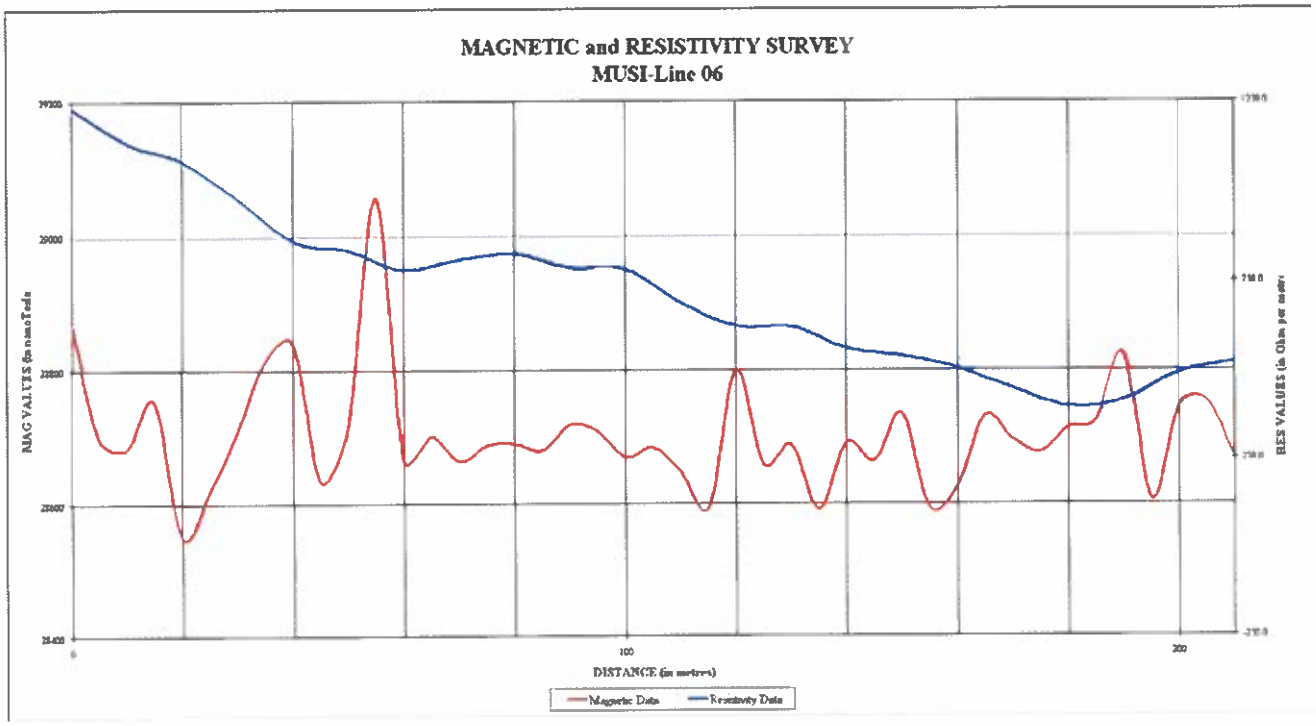
Ga-musi Water Supply - Profile Line 03



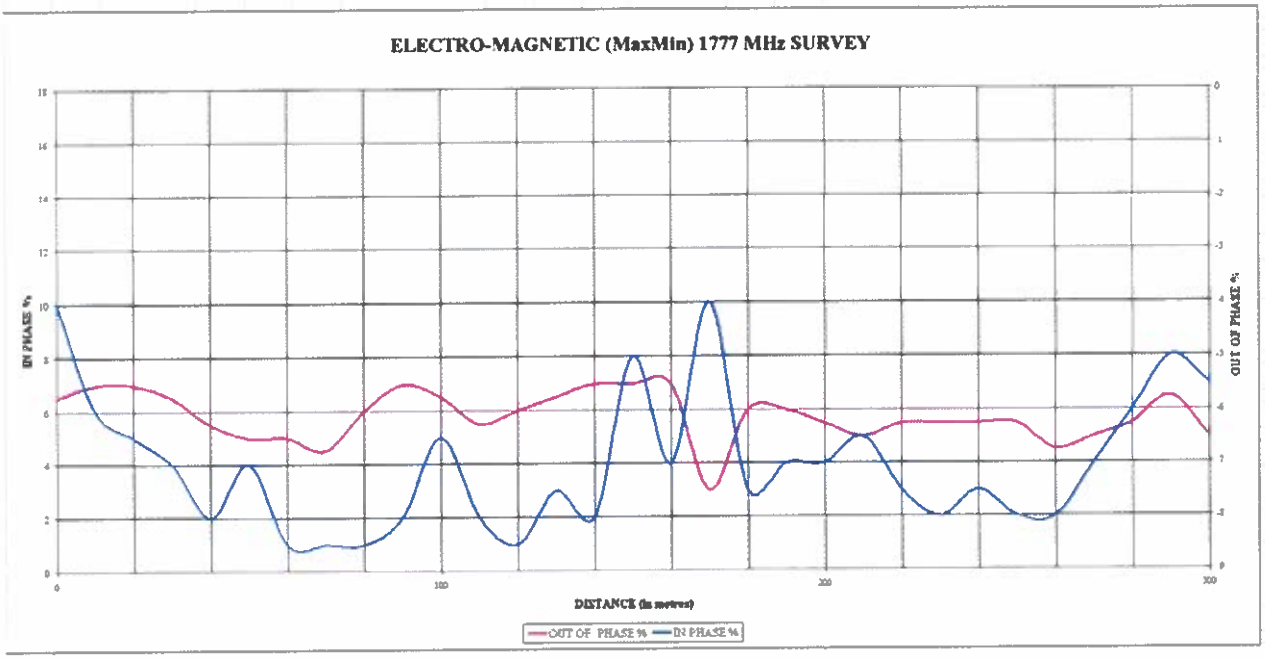


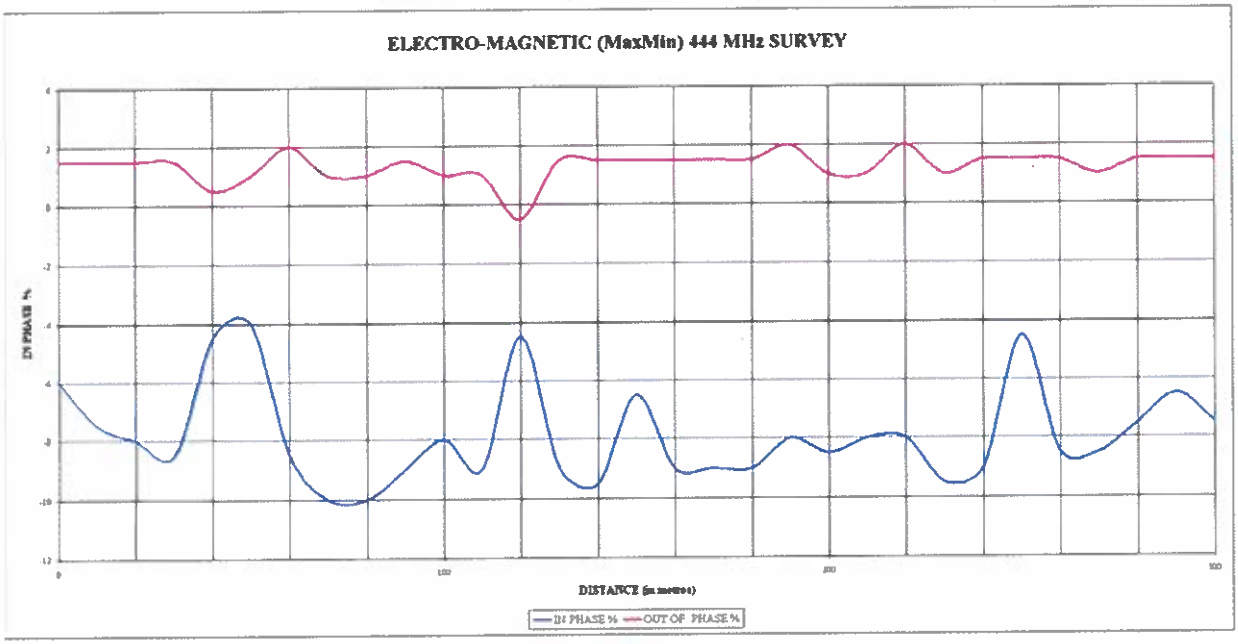

MAGNETIC and RESISTIVITY SURVEY
MUSI-Line 03
MAG VALUES (in nanoTesla
RES VALUES (in Ohm per metre
DISTANCE (in metres)
Magnetic Data
Resistivity Data

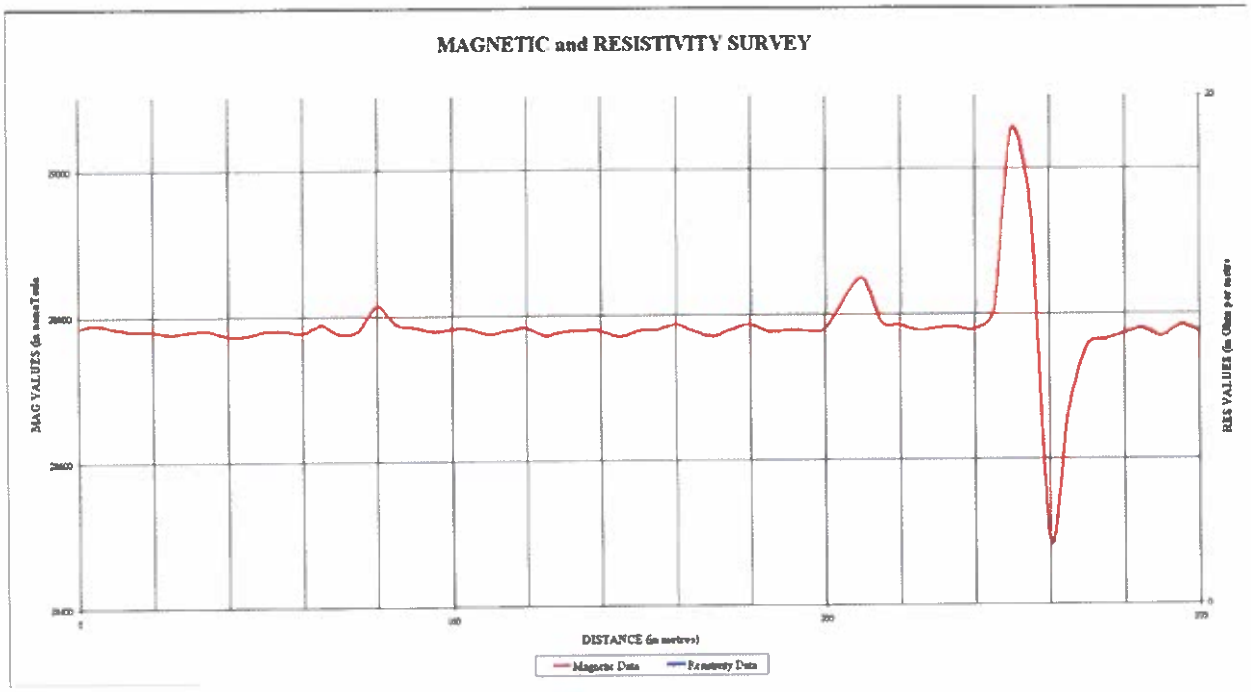

MAGNETIC and RESISTIVITY SURVEY
MUSI-Line 05
MAG VALUES (in nanoTesla
RES VALUES (in Ohm per metre
DISTANCE (in metres)
Magnetic Data
Resistivity Data


MAGNETIC and RESISTIVITY SURVEY
MUSI-Line 06
MAG VALUES (in nano Tesla
RES VALUES (in Ohm per meter
DISTANCE (in meters)
Magnetic Data
Resistivity Data

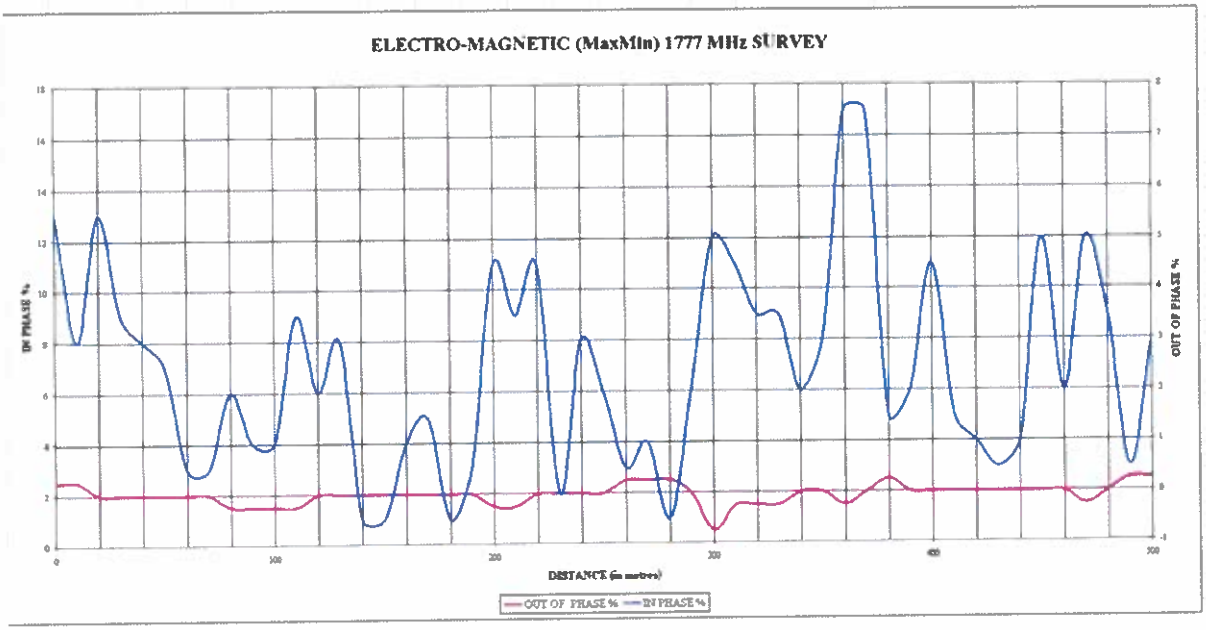
Ga Chere Water Supply - Profile Line 01

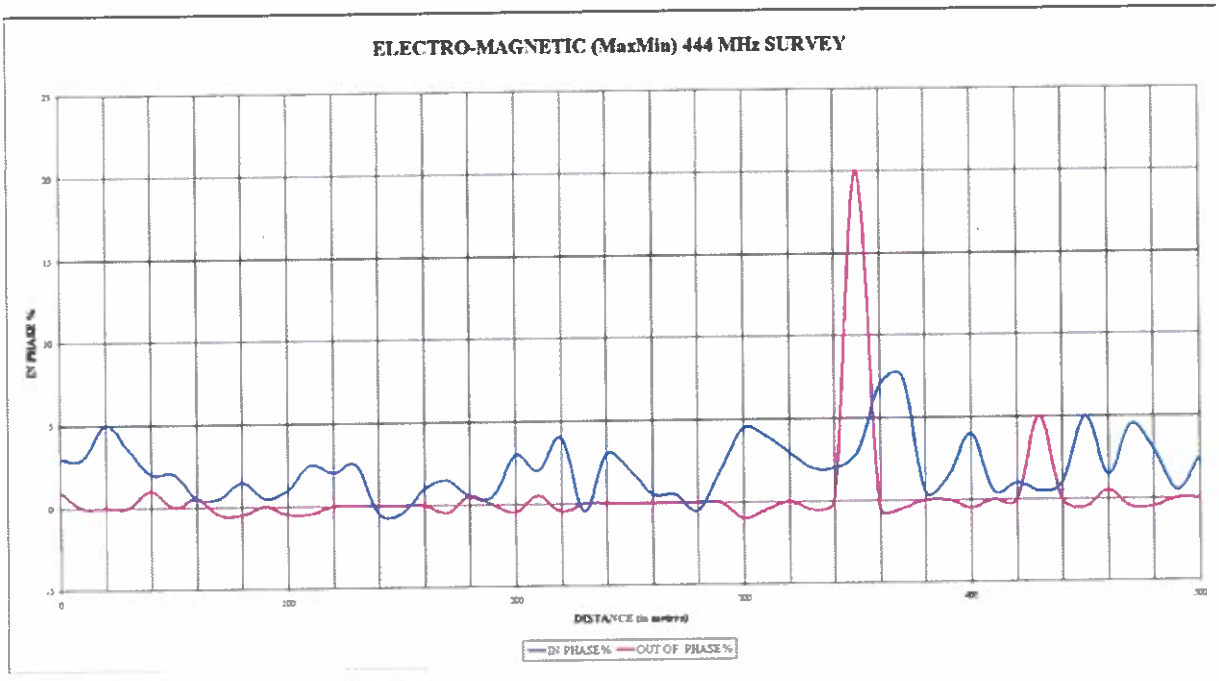


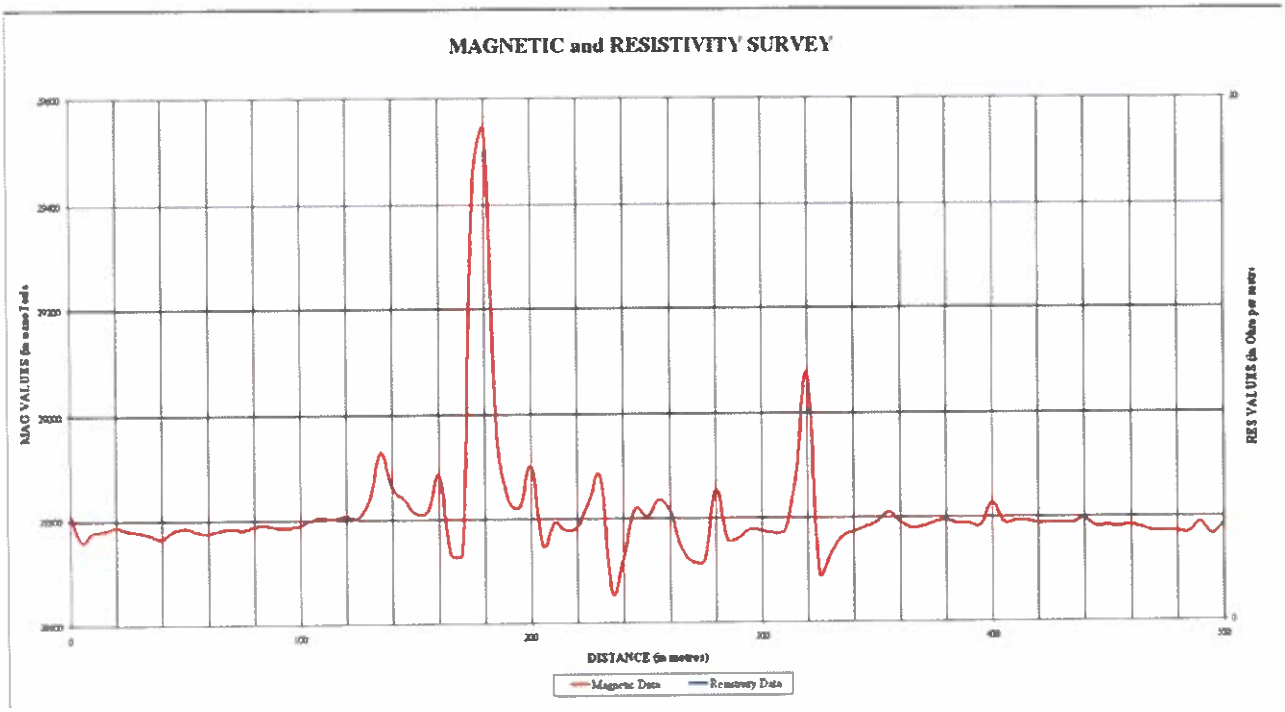



MAGNETIC and RESISTIVITY SURVEY
MAG VALUES (in nanoTesla
RES VALUES (in Ohm per metre
DISTANCE (in metres)
Magnetic Data
Resistivity Data

Ga-Chere Water Supply - Profile Line 02

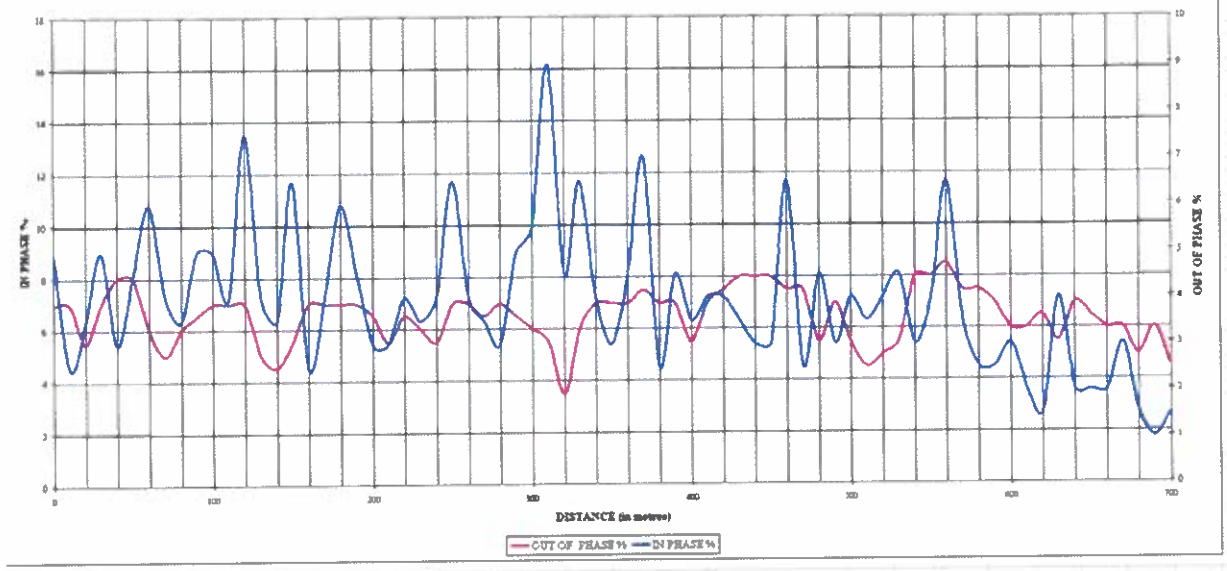




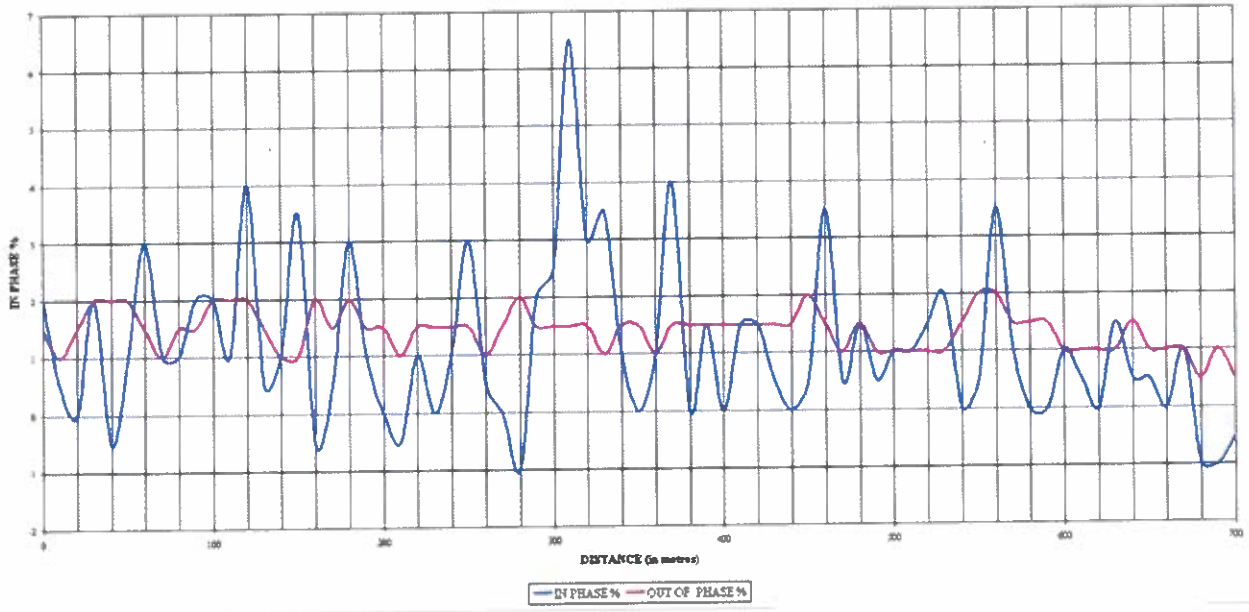

MAGNETIC and RESISTIVITY SURVEY
MAG VALUES (in nano Tesla
RES VALUES (in Ohm per metre
DISTANCE (in metres)
Magnetic Data
Resistivity Data

Chere Water Supply - Profile Line 03

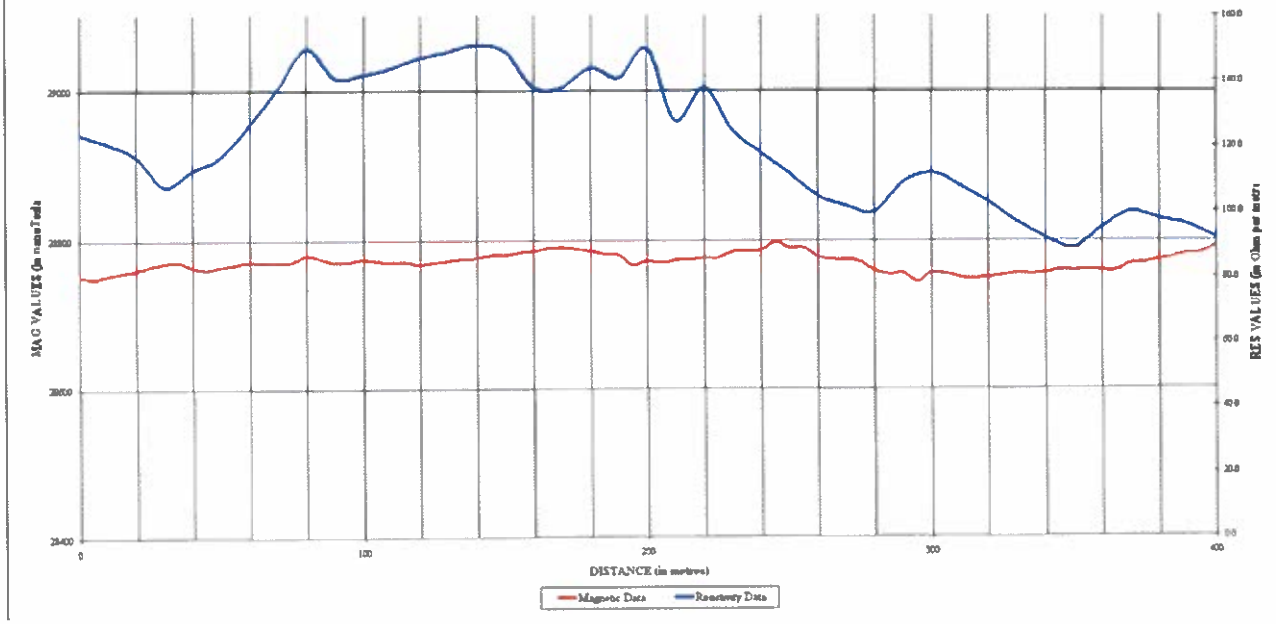
ELECTRO-MAGNETIC (MaxMin) 1777 MHz SURVEY



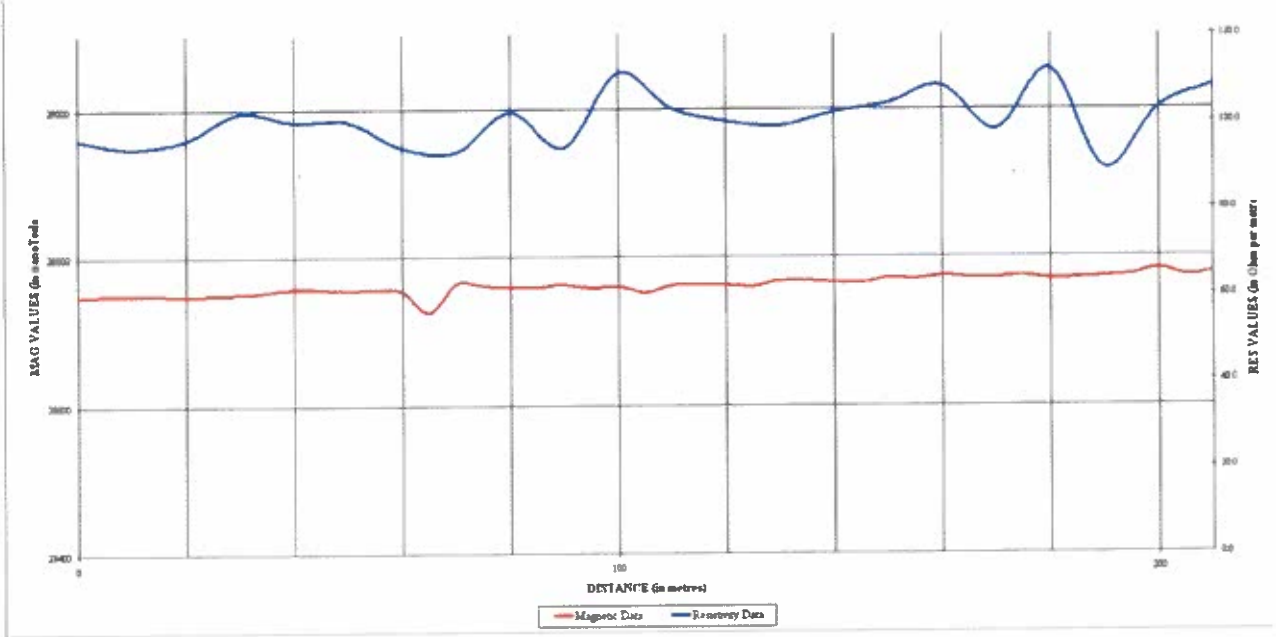
ELECTRO-MAGNETIC (MaxMin) 444 MHz SURVEY



MAGNETIC and RESISTIVITY SURVEY: Chere 04



MAGNETIC and RESISTIVITY SURVEY: Chere 05

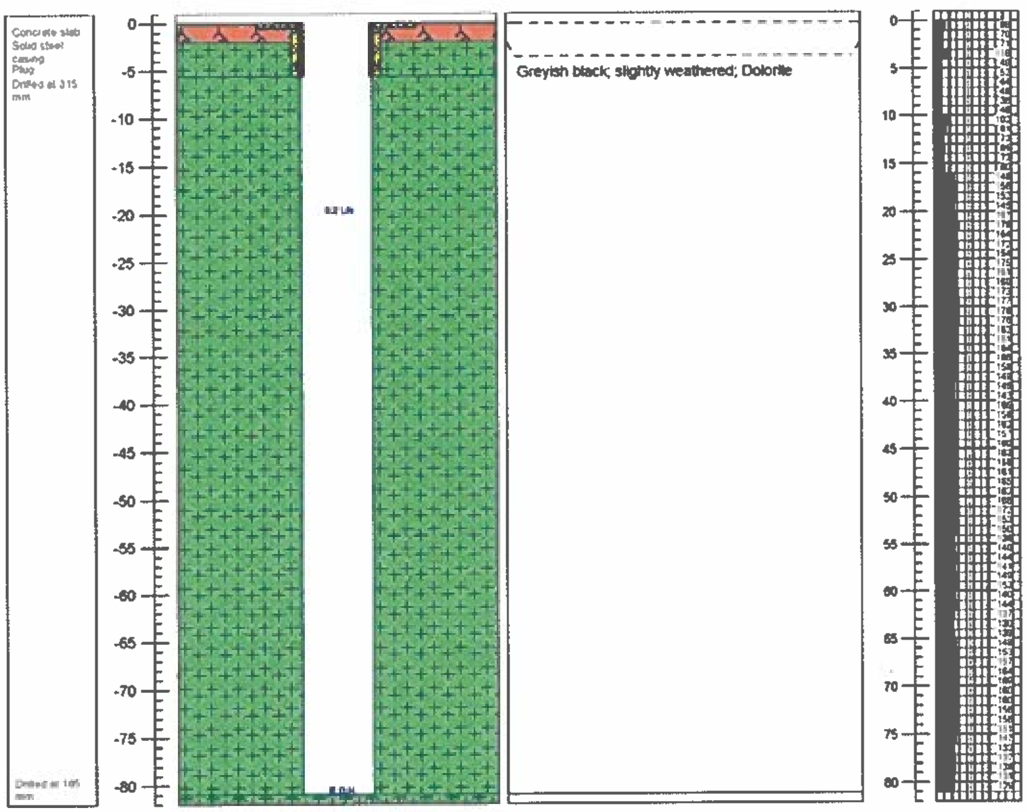


7 APPENDIX B: BOREHOLE LOGS

BOREHOLE CONSTRUCTION AND GEOLOGICAL LOG

PROJECT NAME:		***Borehole Number:***	**H03-3281**
LOCALITY:	Ga-Musi	GROUND SURFACE ELEVATION:	N/A
DRILLING COMPANY:	Ramotse	DATUM ELEVATION:	N/A
DRILLING METHOD:	Air Percussion	STATIC WATER LEVEL:	N/A
GEOLOGIST:	Vincent	BLOW YIELD:	0.2 L/s
DATE STARTED:	18-Mar-04	LATITUDE:	23.5442
DATE COMPLETED:	19-Mar-04	LONGITUDE:	28.47353
TOTAL DEPTH:	81mbdl	DATE LOGGED:	26-May-04

ELEVATION | BOREHOLE CONSTRUCTION WITH LITHOLOGY AND WATER STRIKES | LITHOLOGY DESCRIPTION | DEPTH (m) | PENETRATION RATE



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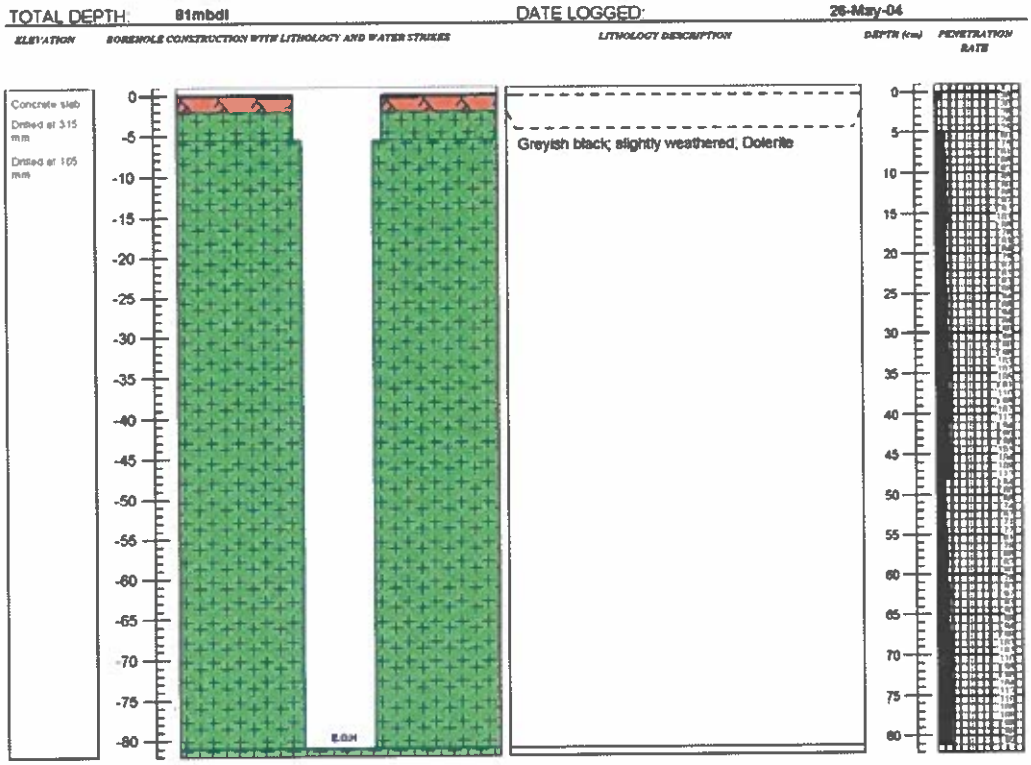
webpage: [illegible]

Notes: Geophisics Profile Line Ga-Mus 1/270

Borehole Number: **H03-3281**

BOREHOLE CONSTRUCTION AND GEOLOGICAL LOG

PROJECT NAME:		*Borehole Number:*	*H03-3282*
LOCALITY:	Ga-Chere	GROUND SURFACE ELEVATION:	N/A
DRILLING COMPANY:	Ramotse	DATUM ELEVATION:	N/A
DRILLING METHOD:	Air Percussion	STATIC WATER LEVEL:	N/A
GEOLOGIST:	Vincent	BLOW YIELD:	
DATE STARTED:	19-Mar-04	LATITUDE:	23.55731
DATE COMPLETED:	19-Mar-04	LONGITUDE:	28.5112
TOTAL DEPTH:	81mbdl	DATE LOGGED:	26-May-04



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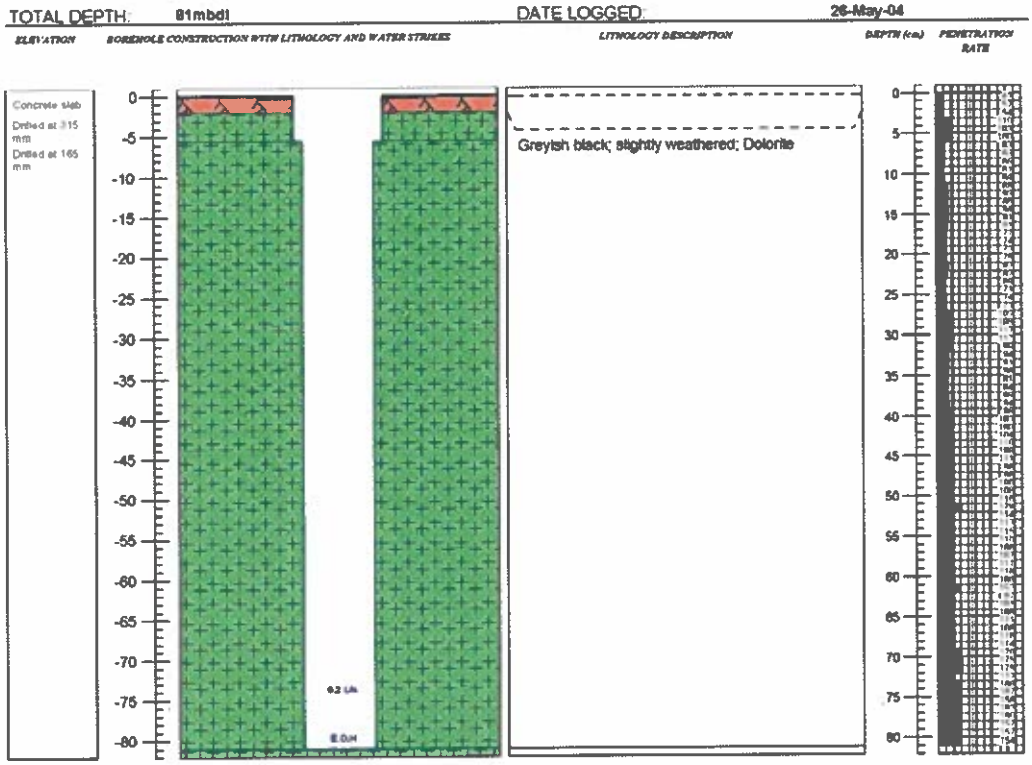
Notes: Geophysics Profile Line Chere 2/250

Borehole Number: *H03-3282*

BOREHOLE CONSTRUCTION AND GEOLOGICAL LOG

PROJECT NAME:		*Borehole Number:*	*H03-3283*
LOCALITY:	Ga-Chere	GROUND SURFACE ELEVATION:	N/A
DRILLING COMPANY:	Ramotse	DATUM ELEVATION:	N/A
DRILLING METHOD:	Air Percussion	STATIC WATER LEVEL:	N/A
GEOLOGIST:	Vincent	BLOW YIELD:	0.2 L/s
DATE STARTED:	20-Mar-04	LATITUDE:	23.55724
DATE COMPLETED:	20-Mar-04	LONGITUDE:	28.51251
TOTAL DEPTH:	81mbdl	DATE LOGGED:	26-May-04



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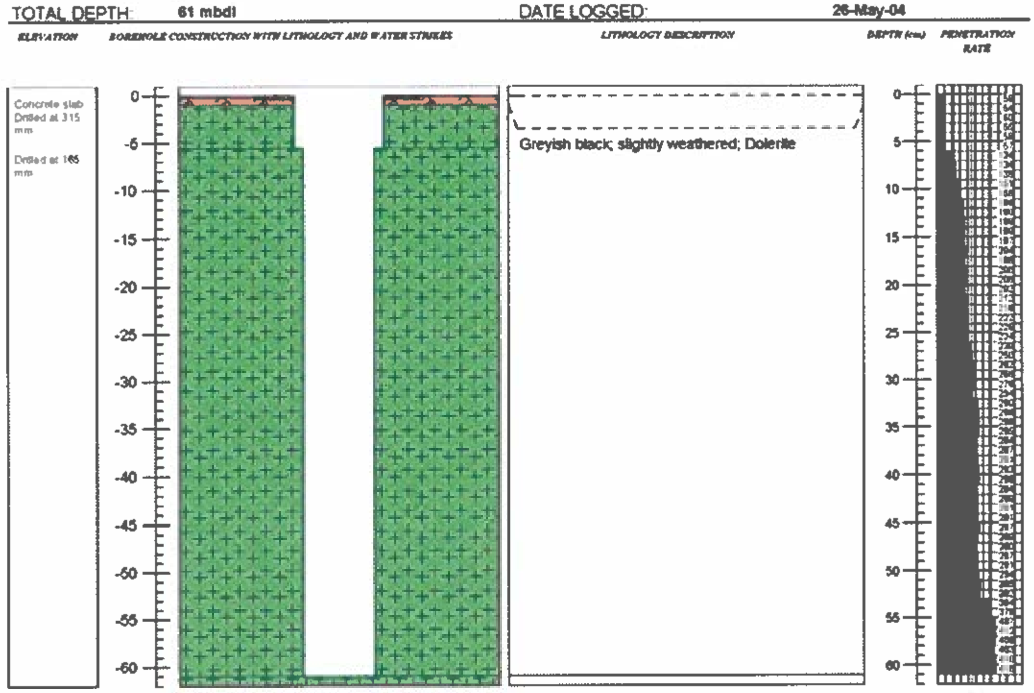
Notes: Geophysics Profile Chere Line 2/370

Borehole Number: ***H03-3283***

BOREHOLE CONSTRUCTION AND GEOLOGICAL LOG

PROJECT NAME:		***Borehole Number:***	***H03-3284***
LOCALITY:	Ga-Musi	GROUND SURFACE ELEVATION:	N/A
DRILLING COMPANY:	Ramotse	DATUM ELEVATION:	N/A
DRILLING METHOD:	Air Percussion	STATIC WATER LEVEL:	N/A
GEOLOGIST:	Vincent	BLOW YIELD:	
DATE STARTED:	22-Mar-04	LATITUDE:	23.54164
DATE COMPLETED:	22-Mar-04	LONGITUDE:	28.4816
TOTAL DEPTH:	61 mbdl	DATE LOGGED:	26-May-04



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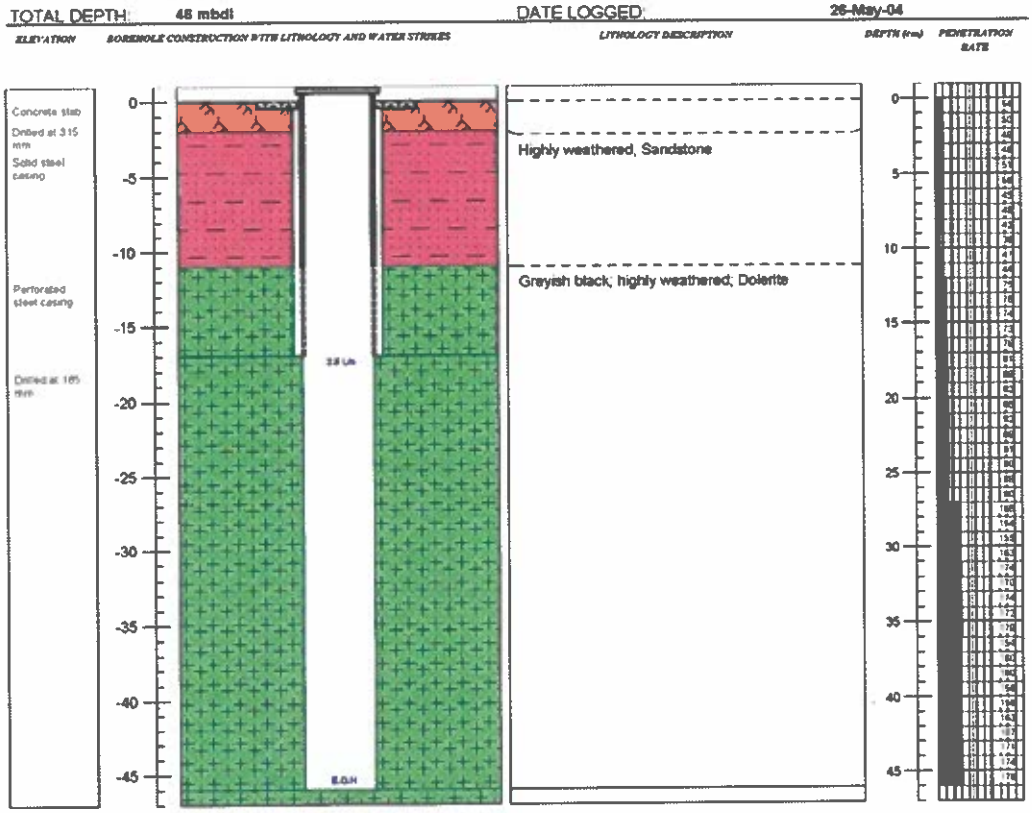
Fax.: 012 - [illegible]
e-mail: [illegible]
webpage: [illegible]

Notes: Geophysics Profile Line Ga-Musi 2/40

Borehole Number: ***H03-3284***

BOREHOLE CONSTRUCTION AND GEOLOGICAL LOG

PROJECT NAME:		***Borehole Number:***	***H03-3285***
LOCALITY:	Ga-Musi	GROUND SURFACE ELEVATION:	N/A
DRILLING COMPANY:	Ramotse	DATUM ELEVATION:	N/A
DRILLING METHOD:	Air Percussion	STATIC WATER LEVEL:	N/A
GEOLOGIST:	Vincent	BLOW YIELD:	2.5
DATE STARTED:	24-Mar-04	LATITUDE:	23.64184
DATE COMPLETED:	24-Mar-04	LONGITUDE:	28.4832
TOTAL DEPTH:	48 mbdl	DATE LOGGED:	26-May-04



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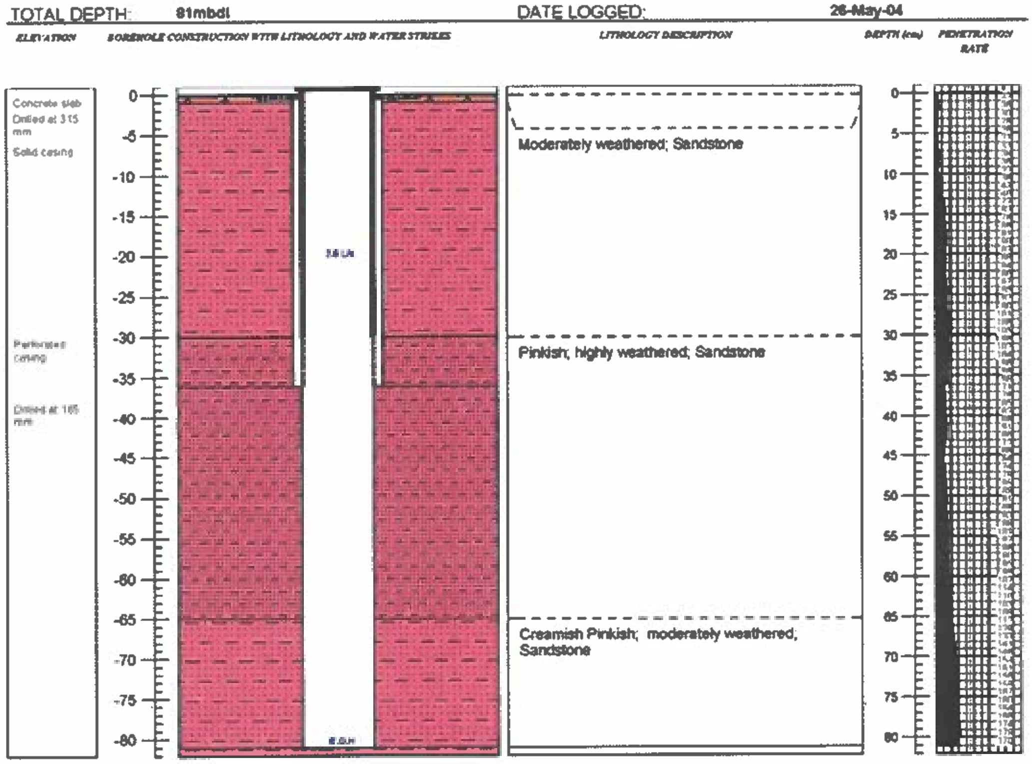
webpage: www.ages-group.com

Notes: Geophysics Profile Line 1A/600

Borehole Number: ***H03-3285***

BOREHOLE CONSTRUCTION AND GEOLOGICAL LOG

PROJECT NAME:		***Borehole Number:***	**H03-3286**
LOCALITY:	**Ga-Chere**	GROUND SURFACE ELEVATION:	**N/A**
DRILLING COMPANY:	**Ramotse**	DATUM ELEVATION:	**N/A**
DRILLING METHOD:	**Air Percussion**	STATIC WATER LEVEL:	**21.46 mbdl**
GEOLOGIST:	**Vincent**	BLOW YIELD:	**2.5**
DATE STARTED:	**25-Mar-04**	LATITUDE:	**238.56137**
DATE COMPLETED:	**25-Mar-04**	LONGITUDE:	**28.51579**
TOTAL DEPTH:	**81mbdl**	DATE LOGGED:	**26-May-04**



GAUTENG OFFICE

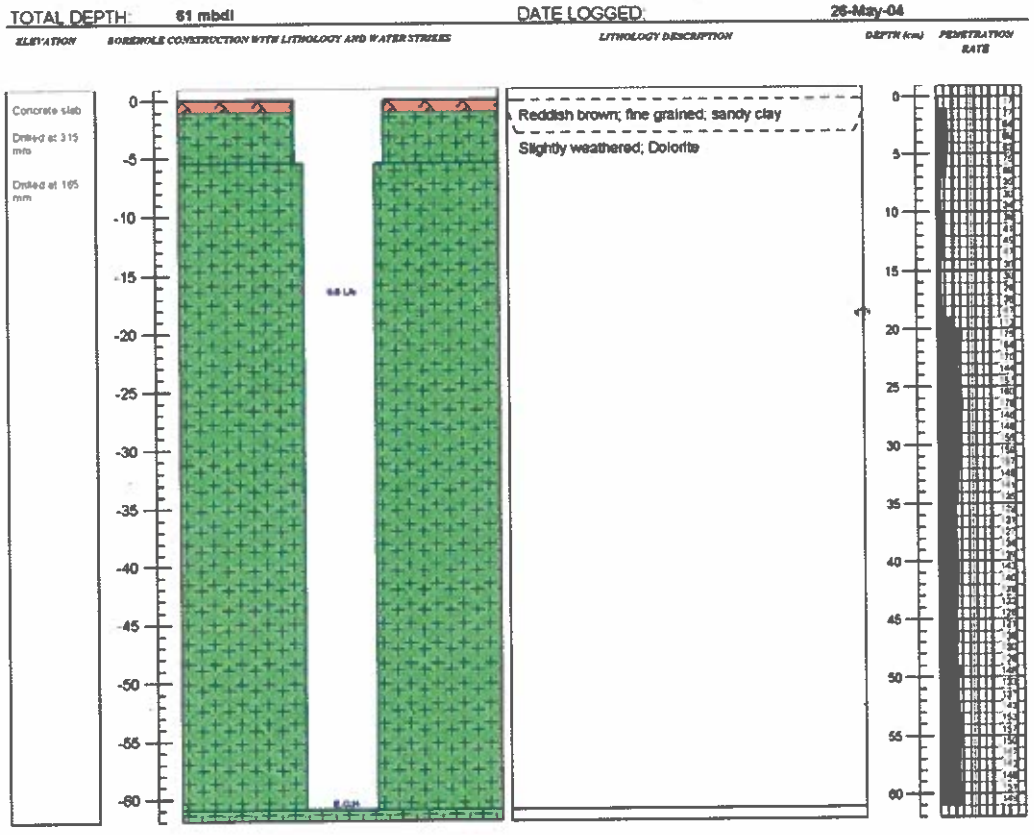
PERSEQUOR

Notes: Geophysics Profile Chere Line 3/300

Borehole Number: **H03-3286**

BOREHOLE CONSTRUCTION AND GEOLOGICAL LOG

PROJECT NAME:		*Borehole Number:*	*H03-3287*
LOCALITY:	Ga-Musi	GROUND SURFACE ELEVATION:	N/A
DRILLING COMPANY:	Ramotse	DATUM ELEVATION:	N/A
DRILLING METHOD:	Air Percussion	STATIC WATER LEVEL:	N/A
GEOLOGIST:	Vincent	BLOW YIELD:	0.5
DATE STARTED:	21-Apr-04	LATITUDE:	23.57886
DATE COMPLETED:	21-Apr-04	LONGITUDE:	28.47616
TOTAL DEPTH:	61 mbdl	DATE LOGGED:	26-May-04



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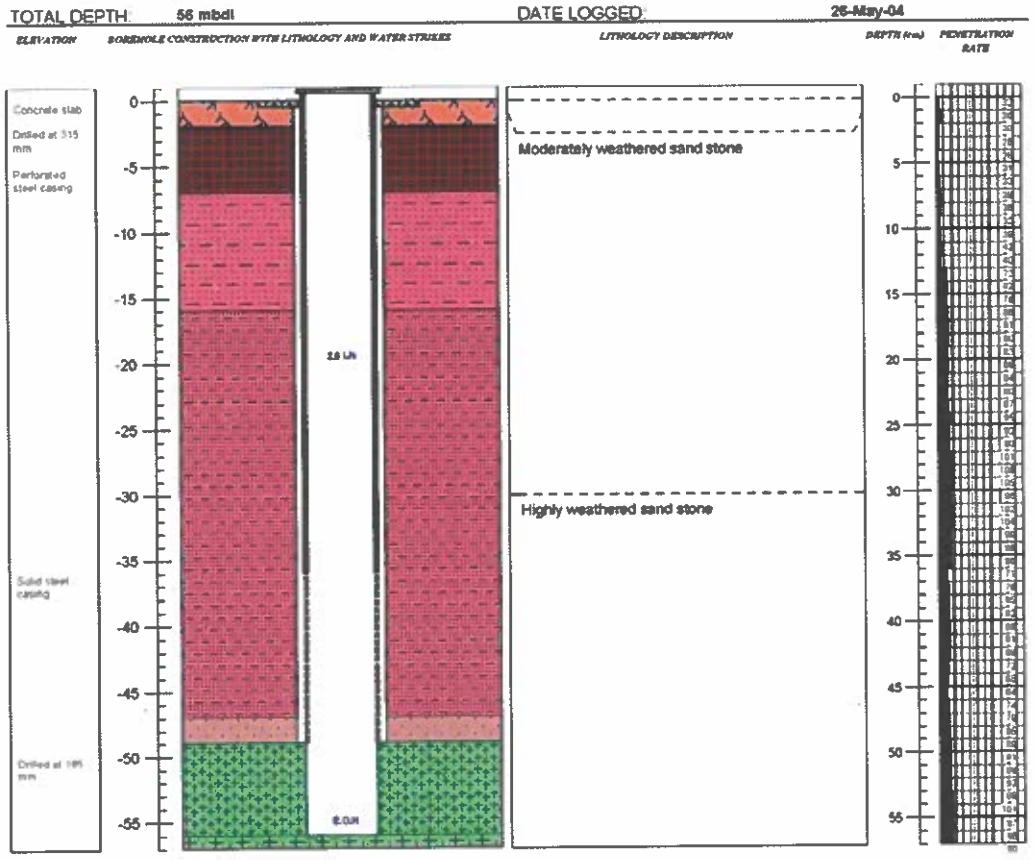
Notes: Geophysics Profile Line Ga-Musi 4/370

Borehole Number: *H03-3287*

BOREHOLE CONSTRUCTION AND GEOLOGICAL LOG

PROJECT NAME:		*Borehole Number:*	*H03-3288*
LOCALITY:	Ga-Chere	GROUND SURFACE ELEVATION:	N/A
DRILLING COMPANY:	Ramotse	DATUM ELEVATION:	N/A
DRILLING METHOD:	Air Percussion	STATIC WATER LEVEL:	N/A
GEOLOGIST:	Vincent	BLOW YIELD:	5
DATE STARTED:	21-Apr-04	LATITUDE:	23.55998
DATE COMPLETED:	22-Apr-04	LONGITUDE:	28.52011
TOTAL DEPTH:	56 mbdl	DATE LOGGED:	26-May-04



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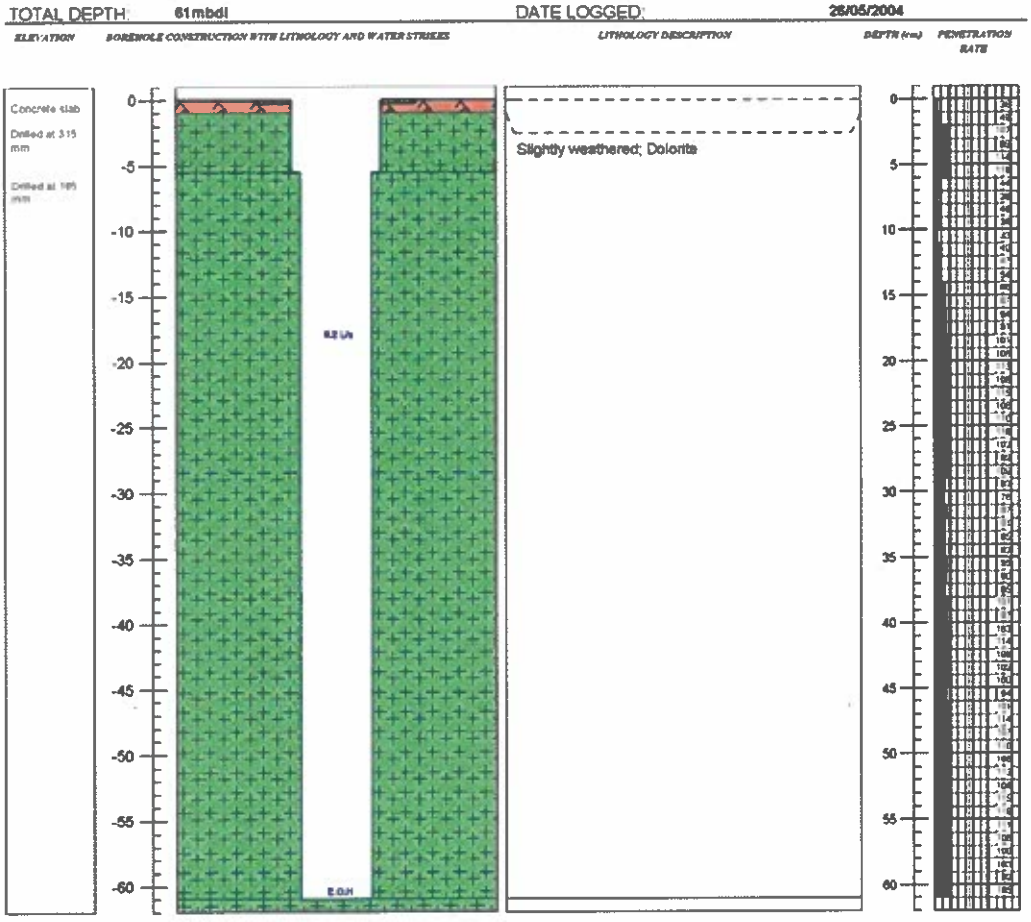
Notes: Geophysics Profile Chere Line 4/280

Borehole Number: *H03-3288*

BOREHOLE CONSTRUCTION AND GEOLOGICAL LOG

PROJECT NAME:		***Borehole Number:***	***H03-3289***
LOCALITY:	Ga-Musi	GROUND SURFACE ELEVATION:	N/A
DRILLING COMPANY:	Ramotse	DATUM ELEVATION:	N/A
DRILLING METHOD:	Air Percussion	STATIC WATER LEVEL:	N/A
GEOLOGIST:	Vincent	BLOW YIELD:	0.2 L/s
DATE STARTED:	22-Apr-04	LATITUDE:	23.55262
DATE COMPLETED:	22-Apr-04	LONGITUDE:	28.47609
TOTAL DEPTH:	61mbdl	DATE LOGGED:	26/05/2004



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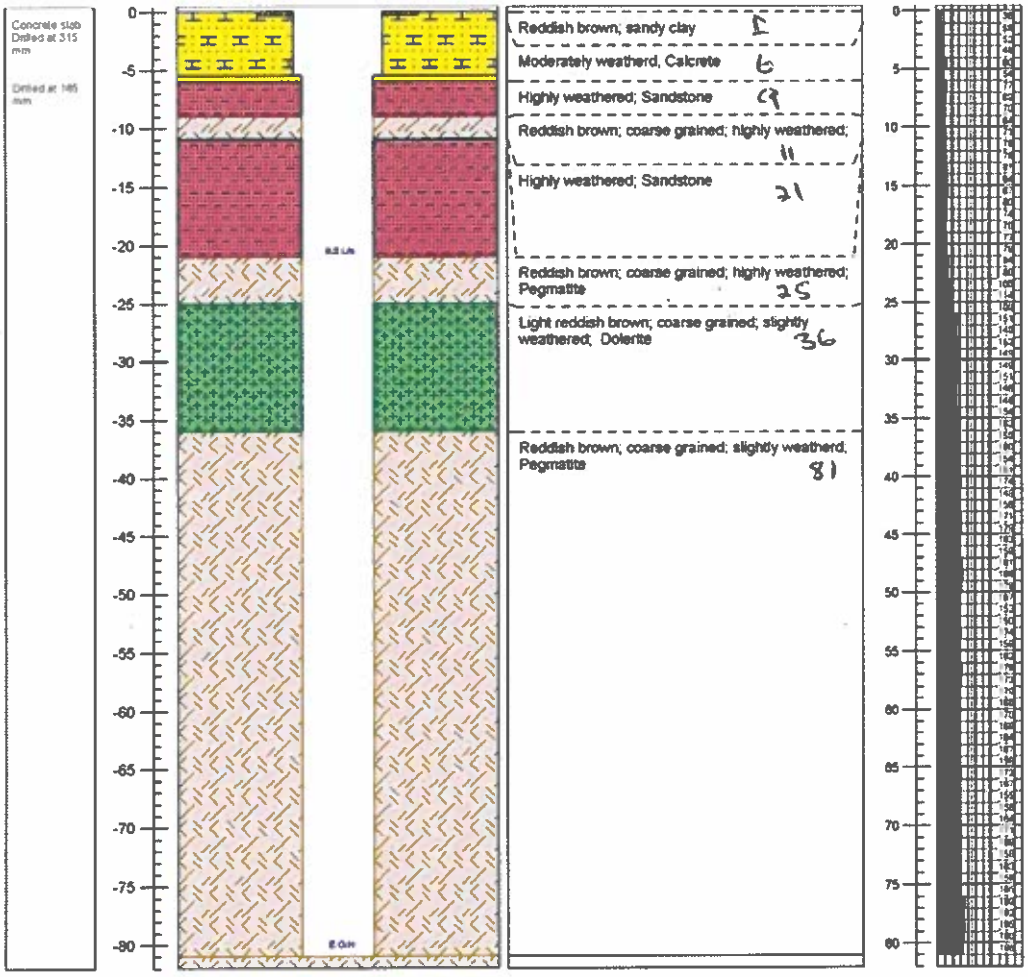
webpage: www.egat-group.com

Notes: Geophysical Profile Line Ga-Musi 4/220

Borehole Number: ***H03-3289***

BOREHOLE CONSTRUCTION AND GEOLOGICAL LOG

PROJECT NAME:		*Borehole Number:*	*H04-2116*
LOCALITY:	Lekhureng	GROUND SURFACE ELEVATION:	N/A
DRILLING COMPANY:	Ramotse	DATUM ELEVATION:	N/A
DRILLING METHOD:	Air Percussion	STATIC WATER LEVEL:	N/A
GEOLOGIST:	Vincent	BLOW YIELD:	0.2 L/s
DATE STARTED:	16-Mar-04	LATITUDE:	23.57151
DATE COMPLETED:	16-Mar-04	LONGITUDE:	28.92706
TOTAL DEPTH:	81mbdl	DATE LOGGED:	26/05/2004



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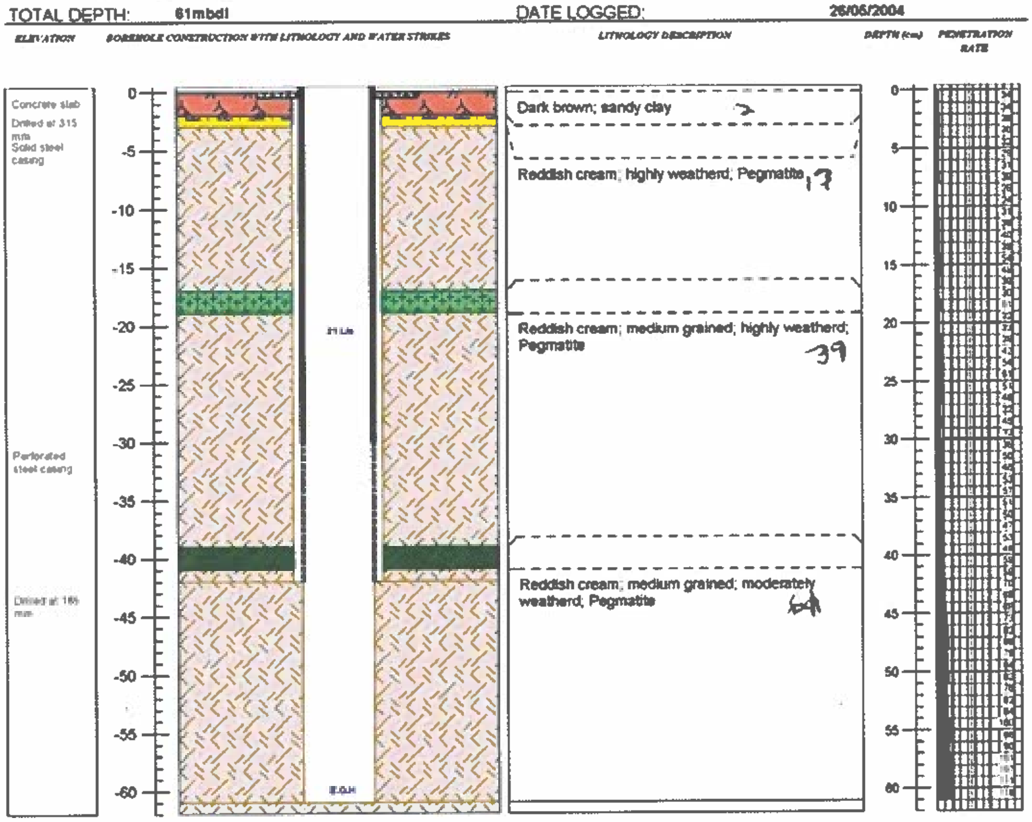
Notes: Geophysics Profile line Lekhureng 1 1/510

Borehole Number: *H04-2116*

BOREHOLE CONSTRUCTION AND GEOLOGICAL LOG

PROJECT NAME:		*Borehole Number:*	**H04-2117**
LOCALITY:	Lekhureng	GROUND SURFACE ELEVATION:	N/A
DRILLING COMPANY:	Ramotse Drilling	DATUM ELEVATION:	N/A
DRILLING METHOD:	Air Percussion	STATIC WATER LEVEL:	7 mbdl
GEOLOGIST:	Vincent	BLOW YIELD:	21 L/s
DATE STARTED:	16-Mar-04	LATITUDE:	23°.57202
DATE COMPLETED:	16-Mar-04	LONGITUDE:	28°.92870
TOTAL DEPTH:	61mbdl	DATE LOGGED:	26/06/2004



GAUTENG OFFICE
Office no 24, First Floor
[illegible]
[illegible]
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Fax: 012 - 349 [illegible]
e-mail: [illegible]
webpage: [illegible]

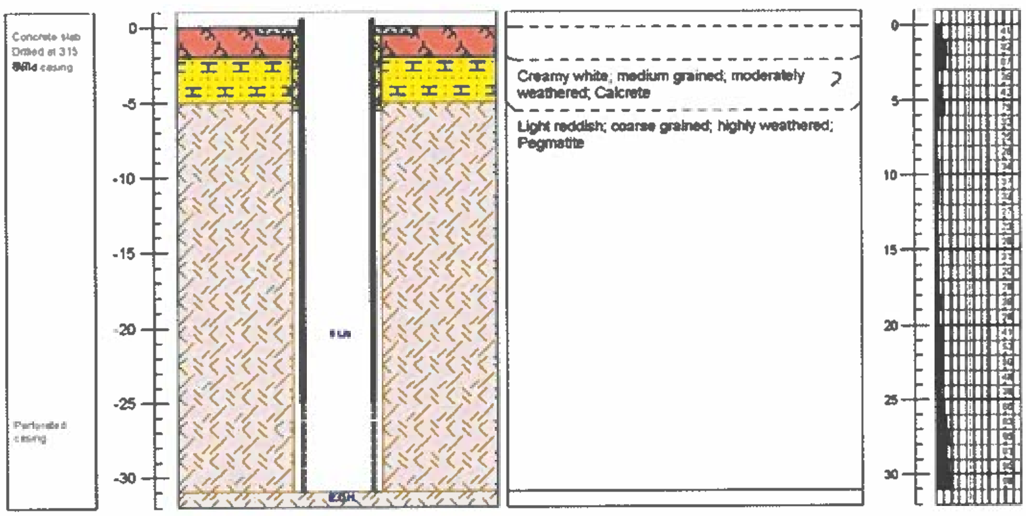
Notes: Geophysics Profile line Lekhureng 1/710

Borehole Number: **H04-2117**

BOREHOLE CONSTRUCTION AND GEOLOGICAL LOG

PROJECT NAME:		*Borehole Number:*	***H04-2118***
LOCALITY:	Ga-Tshipana	GROUND SURFACE ELEVATION:	N/A
DRILLING COMPANY:	Ramotse	DATUM ELEVATION:	N/A
DRILLING METHOD:	Air Percussion	STATIC WATER LEVEL:	12.7 mbdl
GEOLOGIST:	Vincent	BLOW YIELD:	5 L/s
DATE STARTED:	19/04/2004	LATITUDE:	23°.580680
DATE COMPLETED:	19/04/2004	LONGITUDE:	28°.852930
TOTAL DEPTH:	31 mbdl	DATE LOGGED:	26/04/2004

ELEVATION | BOREHOLE CONSTRUCTION WITH LITHOLOGY AND WATER STRIKES | LITHOLOGY DESCRIPTION | DEPTH (m) | PENETRATION RATE



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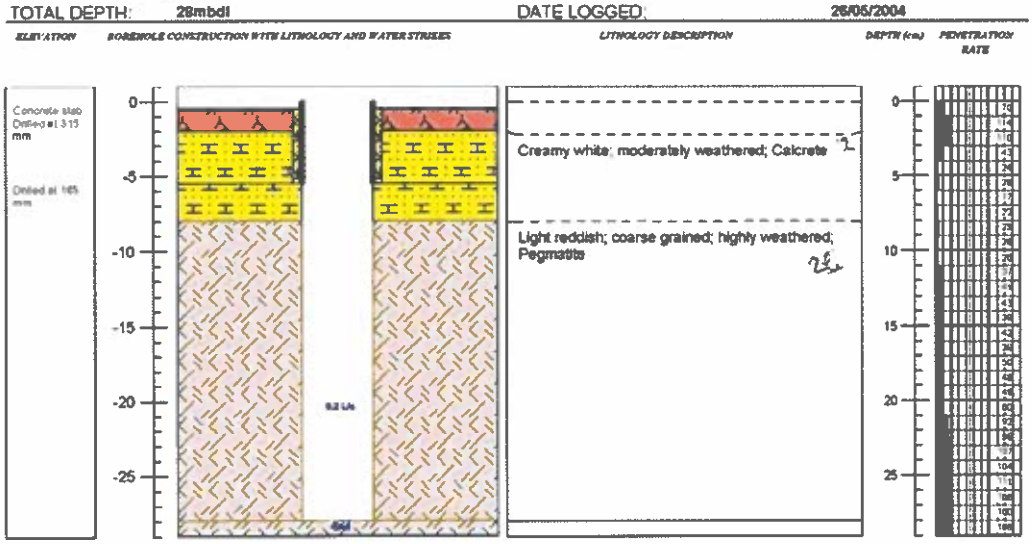
webpage: [illegible]

Notes: Geophysics Profile line Ga-Tsh 1/1320

Borehole Number: ***H04-2118***

BOREHOLE CONSTRUCTION AND GEOLOGICAL LOG

PROJECT NAME:		***Borehole Number:***	***H04-2119***
LOCALITY:	Ga-Tshipana	GROUND SURFACE ELEVATION:	N/A
DRILLING COMPANY:	Ramotse	DATUM ELEVATION:	N/A
DRILLING METHOD:	Air Percussion	STATIC WATER LEVEL:	N/A
GEOLOGIST:	Vincent	BLOW YIELD:	0.2 L/s
DATE STARTED:	20/04/2004	LATITUDE:	23°.57888
DATE COMPLETED:	20/04/2004	LONGITUDE:	28°.951030
TOTAL DEPTH:	28mbdl	DATE LOGGED:	26/05/2004



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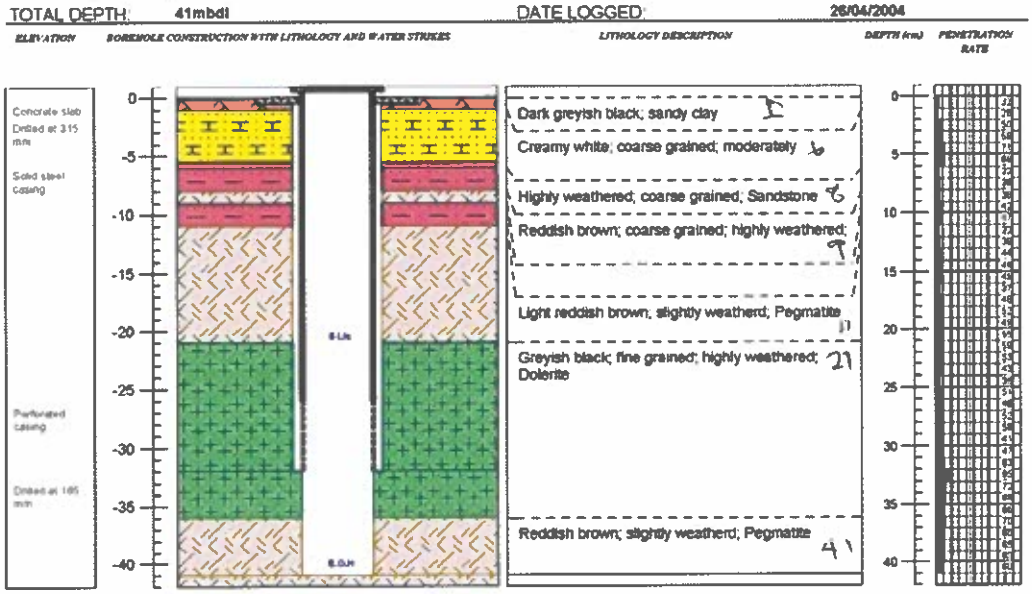
Notes: Geophysics Profile line Ga-Tshi 1/1620

Borehole Number: ***H04-2119***

BOREHOLE CONSTRUCTION AND GEOLOGICAL LOG

PROJECT NAME:		***Borehole Number:***	***H04-2120***
LOCALITY:	Lekhureng	GROUND SURFACE ELEVATION:	N/A
DRILLING COMPANY:	Ramotse Drilling	DATUM ELEVATION:	N/A
DRILLING METHOD:	Air Percussion	STATIC WATER LEVEL:	6.61 mbdl
GEOLOGIST:	Vincent	BLOW YIELD:	5 L/s
DATE STARTED:	20/04/2004	LATITUDE:	23°.571950
DATE COMPLETED:	21/04/2004	LONGITUDE:	28°.928720
TOTAL DEPTH:	41mbdl	DATE LOGGED:	26/04/2004



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Notes: Geophysics Profile line Lekhureng 1/720

Borehole Number: ***H04-2120***

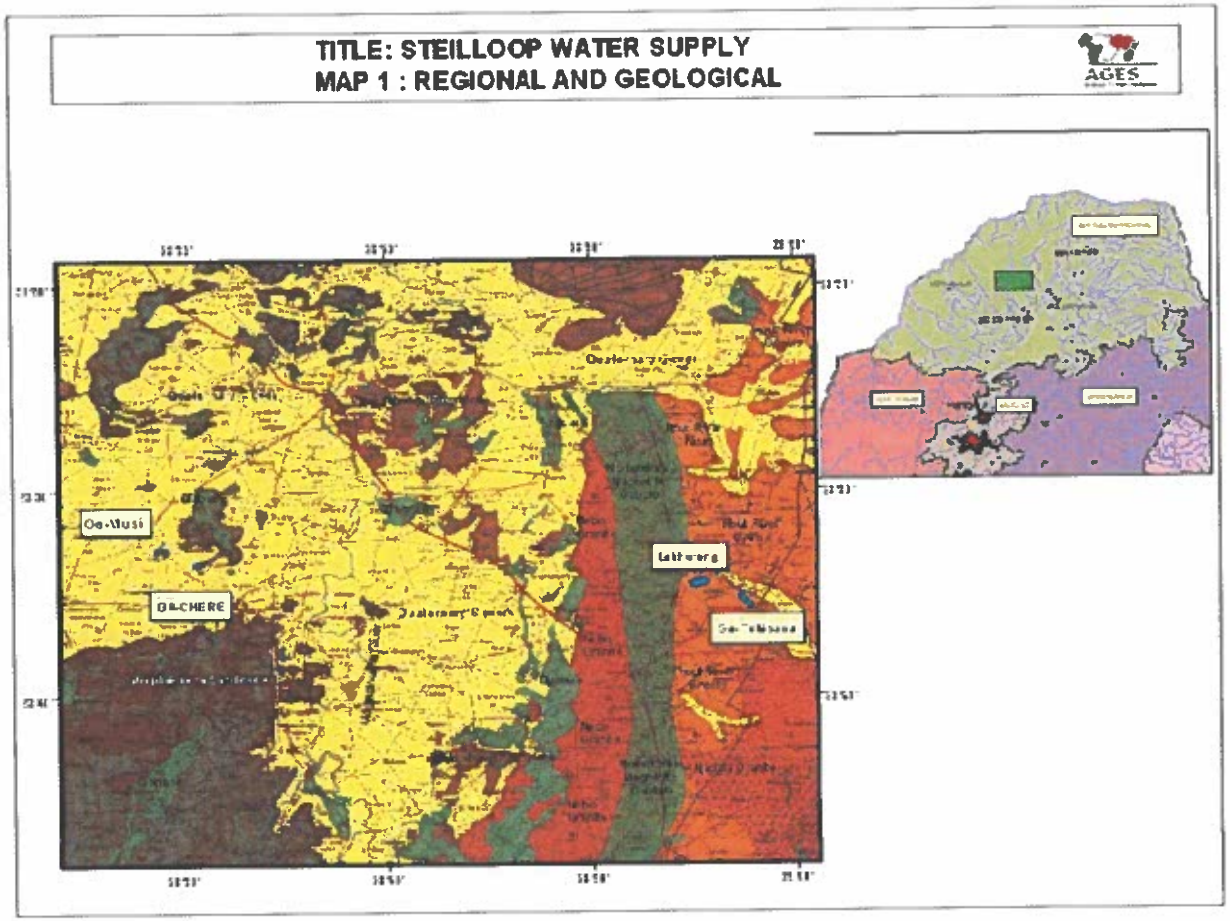
8 APPENDIX C: WATER QUALITY RESULTS

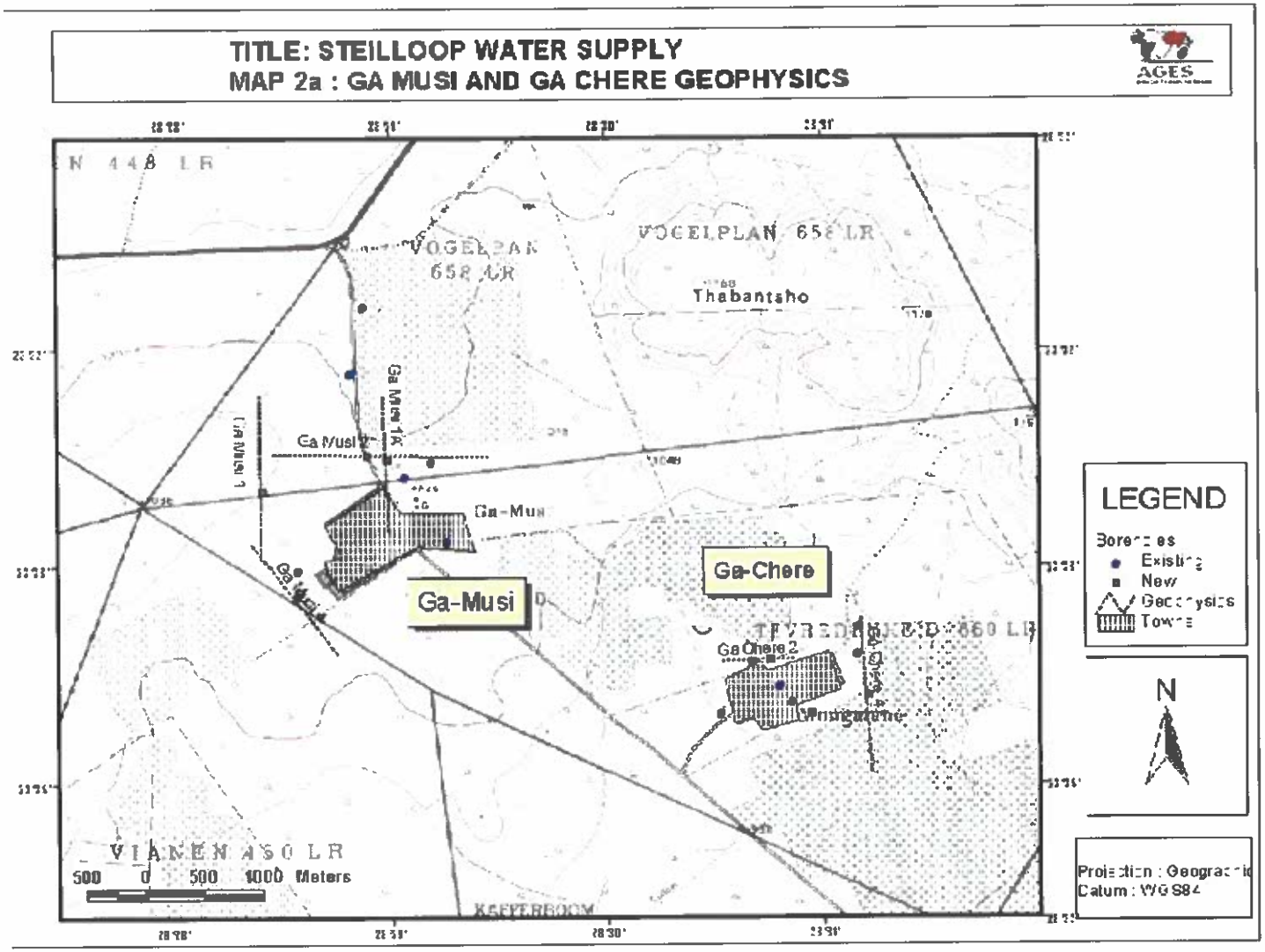
Site number	Date sampled	Village name	Lat	Long	Ca mg/L	Mg mg/L	K mg/L	Na mg/L	NH4-N mg/L	SO_4 mg/L	NO_3 - N mg/L	Cl mg/L	F mg/L	C.O.D mg/L	Ortho Phoseph ate mg/L	pH	EC (mS/cm)	TDS (mg/L)	DWAF Water Quality Classes
H03-2426	23-Mar-04	Ga-Chere	23.72472	28.73833	120	48.9	9.6	126.4	0	28	82	239	0.5	0	0.1	6.5	186	1430	NO3-N
H03-2431	23-Mar-04	Ga-Chere	23.70444	28.7225	83	32.5	3.6	76.3	0.1	12	34	135	0.6	0	0.1	7.7	132	1050	NO3-N
H03-3285	30-Mar-04	Ga-Chere	25.58137	28.51579	91	38.6	3.2	87.7	0	18	58	180	0.4	0	0	6.8	154	1196	NO3-N
H03-3286	29-Apr-04	Ga-Chere	23.55998	28.52011	84	46	2.2	73.0	0.2	16	39	125	0.5	0	0	7.3	157	1070	NO3-N
H03-3285	29-Mar-04	Ga-musi	23.54184	28.4832	149	71.0	3.5	192.9	0	21	132	178	0.3	0	0	6.6	175	1732	NO3-N
H03-1027	25-Mar-04	Ga-musi	23.55036	28.47623	41	15.6	2.9	21.6	0	0	17	10	0.2	0	0.3	6.7	50	460	NO3-N
H03-2434	27-Mar-04	Ga-musi	23.74	28.71306	74	28.9	3.7	62.8	0	11	39	62	0.6	0	0.1	6.8	94	792	NO3-N
H03-2439	24-Mar-04	Ga-musi	23.54614	28.48772	62	24.8	4.1	97.6	0.3	17	45	127	0.3	0	0	6.7	107	948	NO3-N
H04-0947	24-Mar-04	Ga-Tshipana	23.58382	28.95984	30	21.4	9.5	280.8	0.2	56	0	292	1.8	0	0.1	7.5	157	1086	F
H04-0520	24-Mar-04	Ga-Tshipana	23.77444	28.115	49	30.8	13	266.8	0	38	31	278	1.3	0	0	7.4	178	1224	Na, NO-3, Cl, F, TDS
H04-0945	24-Mar-04	Ga-Tshipana	23.58445	28.96236	34	21.5	10	240.8	0.2	64	8	239	1.9	14	0.2	7.3	157	1228	F
H04-2118	22-Apr-04	Ga-Tshipana	23.58068	28.95293	26.6	15.8	7.6	174.3	0.2	65	4	118	1.6	0	0	8	105	829	F
H04-1306	24-Mar-04	Lekhureng	23.57143	28.93554	22	19.3	10.1	266.8	0.3	52	0	186	1.7	0	0.1	7.4	143	1046	F
H04-2120	25-Apr-04	Lekhureng	23.57195	28.92672	85	28.0	21.2	241.8	0.4	61	13	213	1.3	0	0	7.4	189	1332	Na, NO-3, Cl, F, TDS
H04-2112	24-Mar-04				34	39.4	9.9	265.8	1.6	47	13	243	1.4	0	0	7.1	175	1209	Na, NO-3, Cl, F, TDS
Average					42.58	23.64	10.00	191.33	0.32	37.90	14.72	167.90	1.20	1.40	0.08	7.23	139.60	992.60	
Min					22.00	15.60	2.90	21.60	0.00	0.00	0.10	10.00	0.20	0.00	0.00	6.70	50.00	460.00	
Max					85.00	30.80	21.20	280.00	1.60	64.00	44.50	278.00	1.90	14.00	0.30	8.00	180.00	1278.00	
Stdev					20.13	6.97	6.05	98.63	0.47	21.30	16.36	85.99	0.62	4.43	0.10	0.41	44.13	264.31	
Detection Limit					NA	NA	NA	NA	0.10	10	NA	NA		10	0.1	NA	NA	NA	
SABS Max Allowable (2001)					300	100	100	400	2	600	20	600	2		NA	4 - 10	370	2400	
DWAF TWQR (1996)					32	30	50	100	NA	200	6	100	1		NA	6 - 9	70	450	

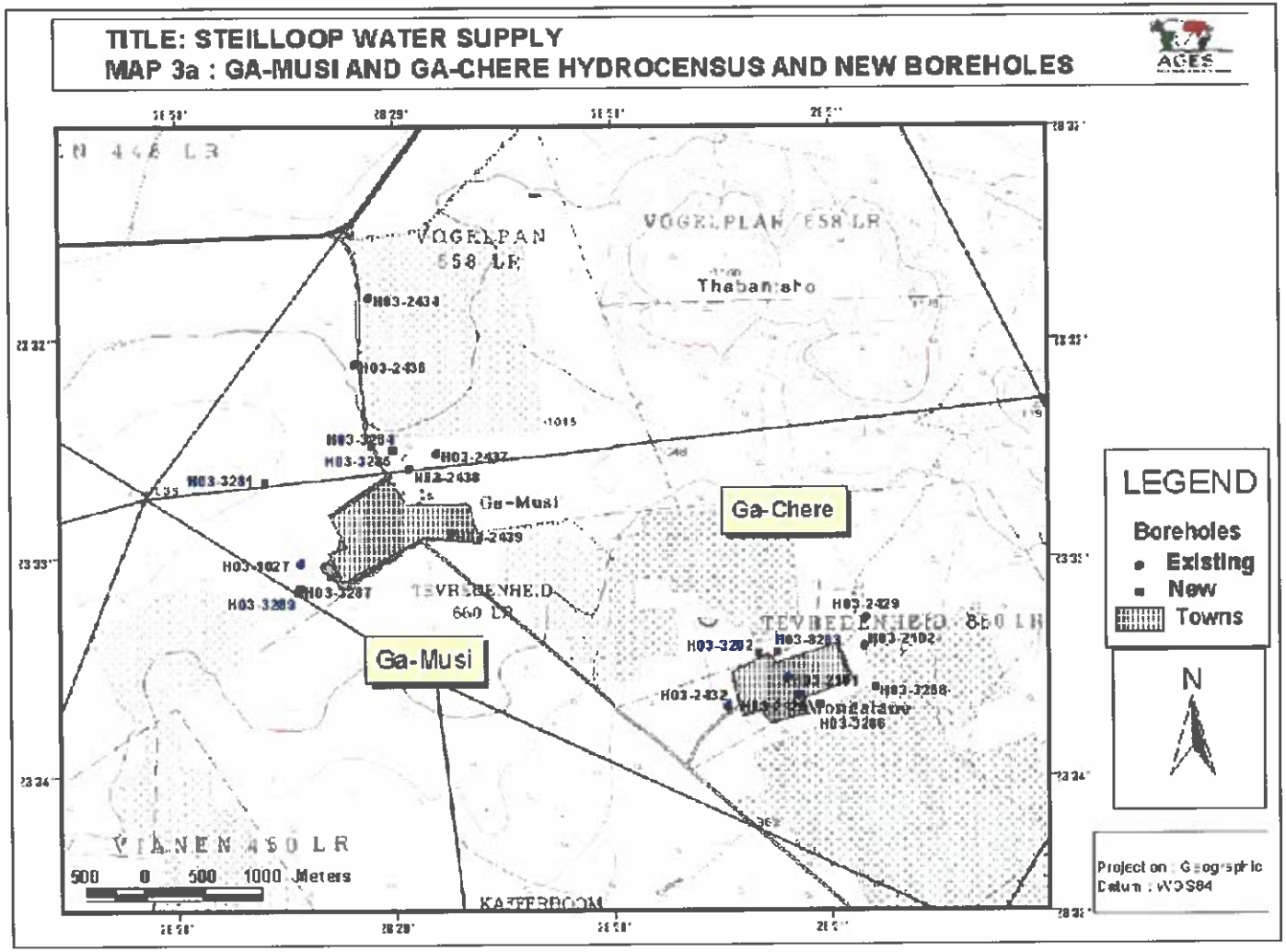
Colour	Class	Water quality Classes (DWAF 1996)
Blue	0	Ideal – suitable for lifetime use
Green	1	Good – suitable for use, rare instances of negative effects
Yellow	2	Marginal – conditionally acceptable. Negative effects may occur in some sensitive groups
Red	3	Poor – unsuitable for use without treatment. Chronic effects may occur
Purple	4	Dangerous – totally unsuitable for use. Acute effects may occur

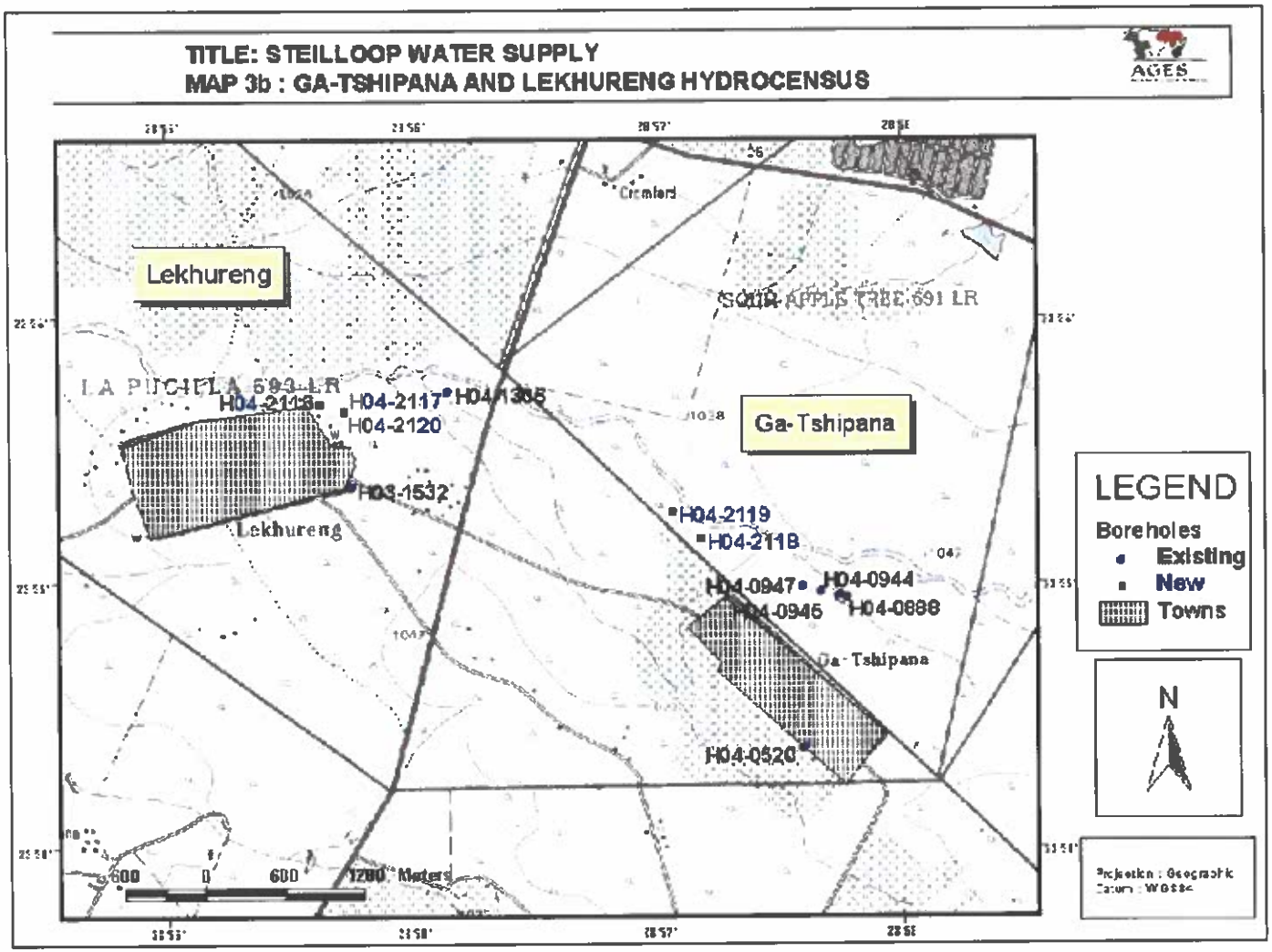
TWQR (DWAF 1996) Total Water Quality Range
For each water quality constituent there is a No Effect Range. This is the range of concentrations or levels at which the presence of that constituent would have no known or anticipated adverse effect on the fitness of water for a particular use or on the protection of aquatic ecosystems. These ranges were determined by assuming long-term continuous use (life-long exposure) and incorporate a margin of safety.

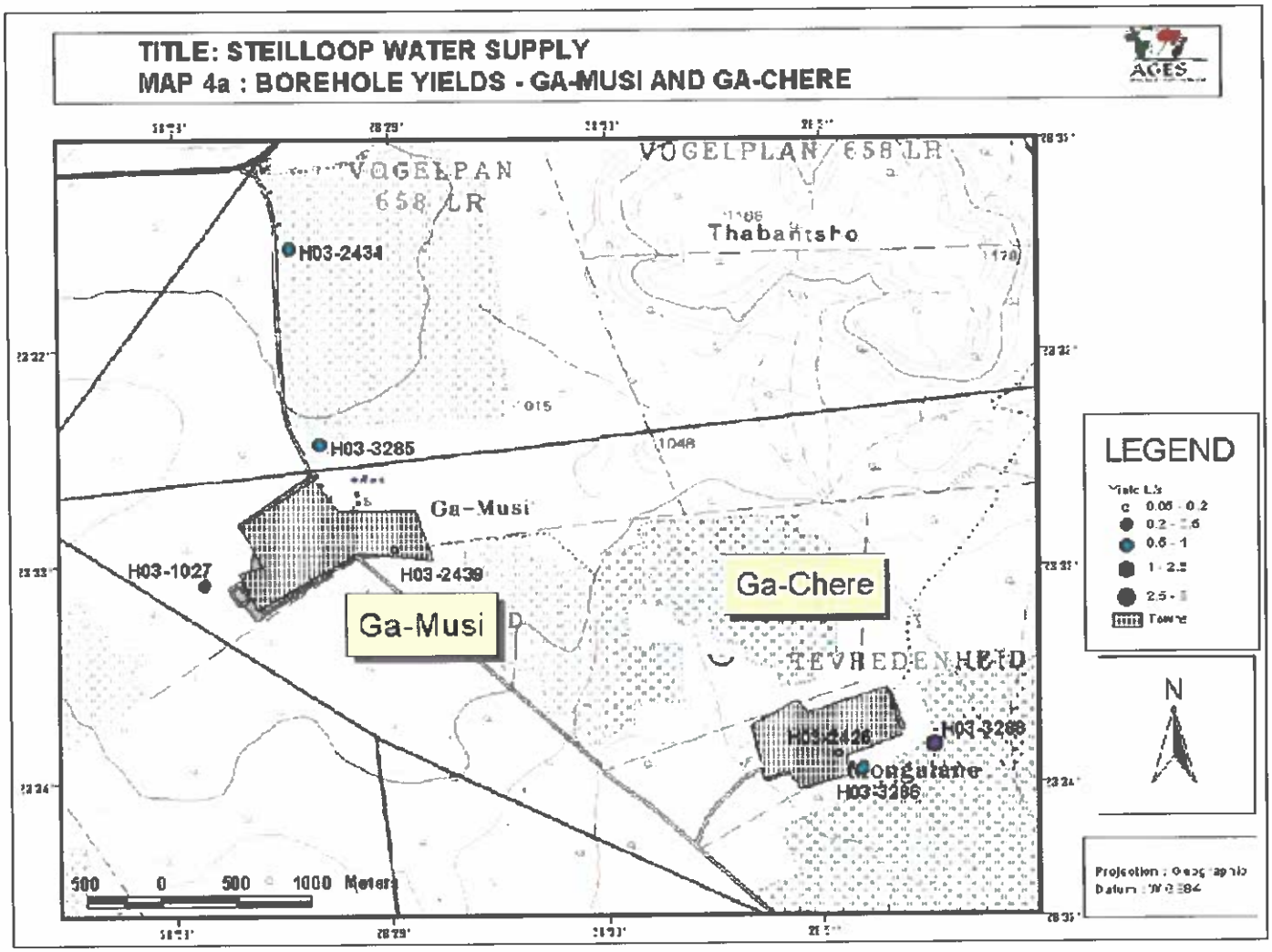
9 APPENDIX D: GIS MAPS

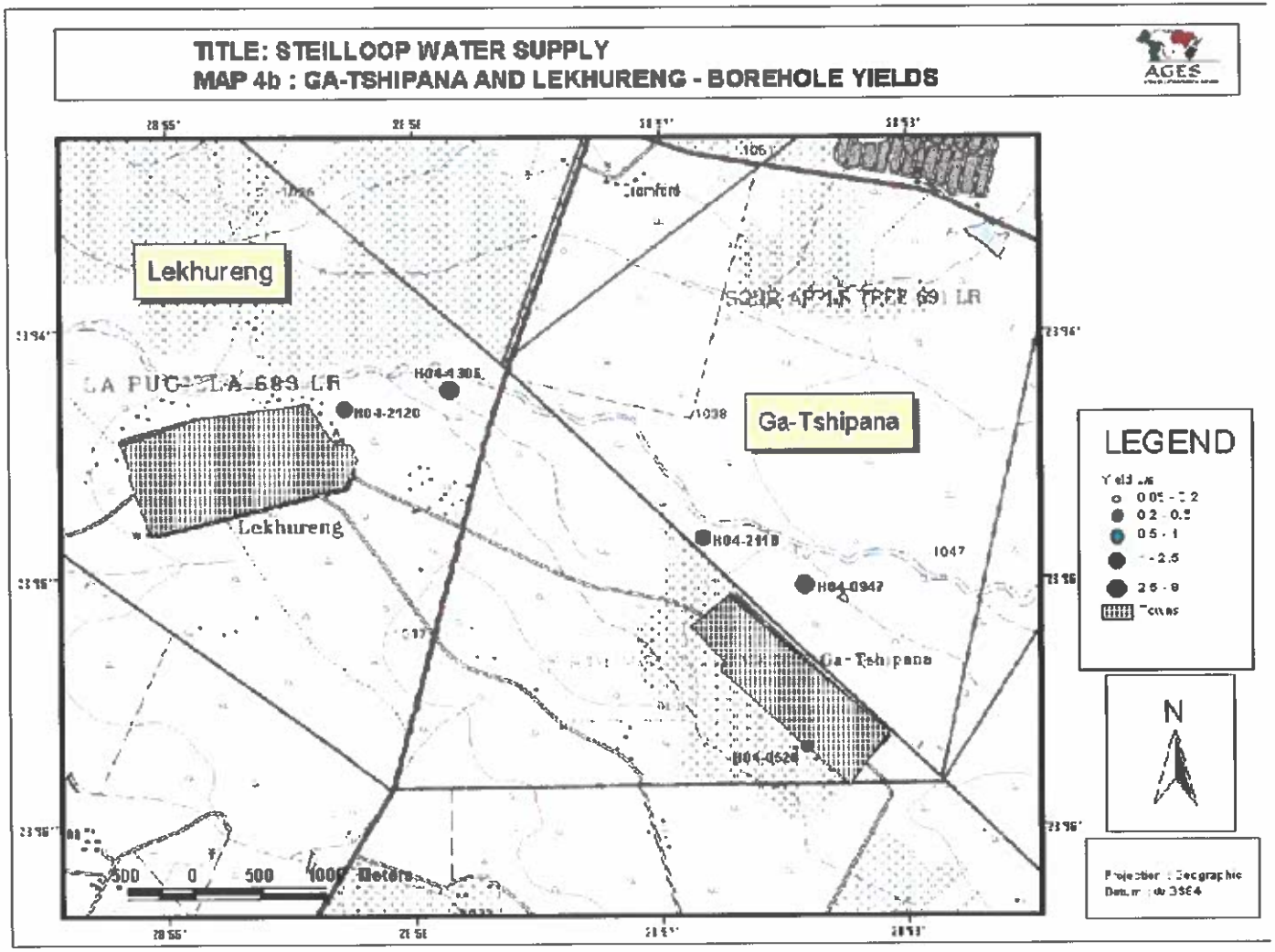

TITLE: STEILLOOP WATER SUPPLY
MAP 1 : REGIONAL AND GEOLOGICAL
AGES
OMARURU
OKAHANDJA

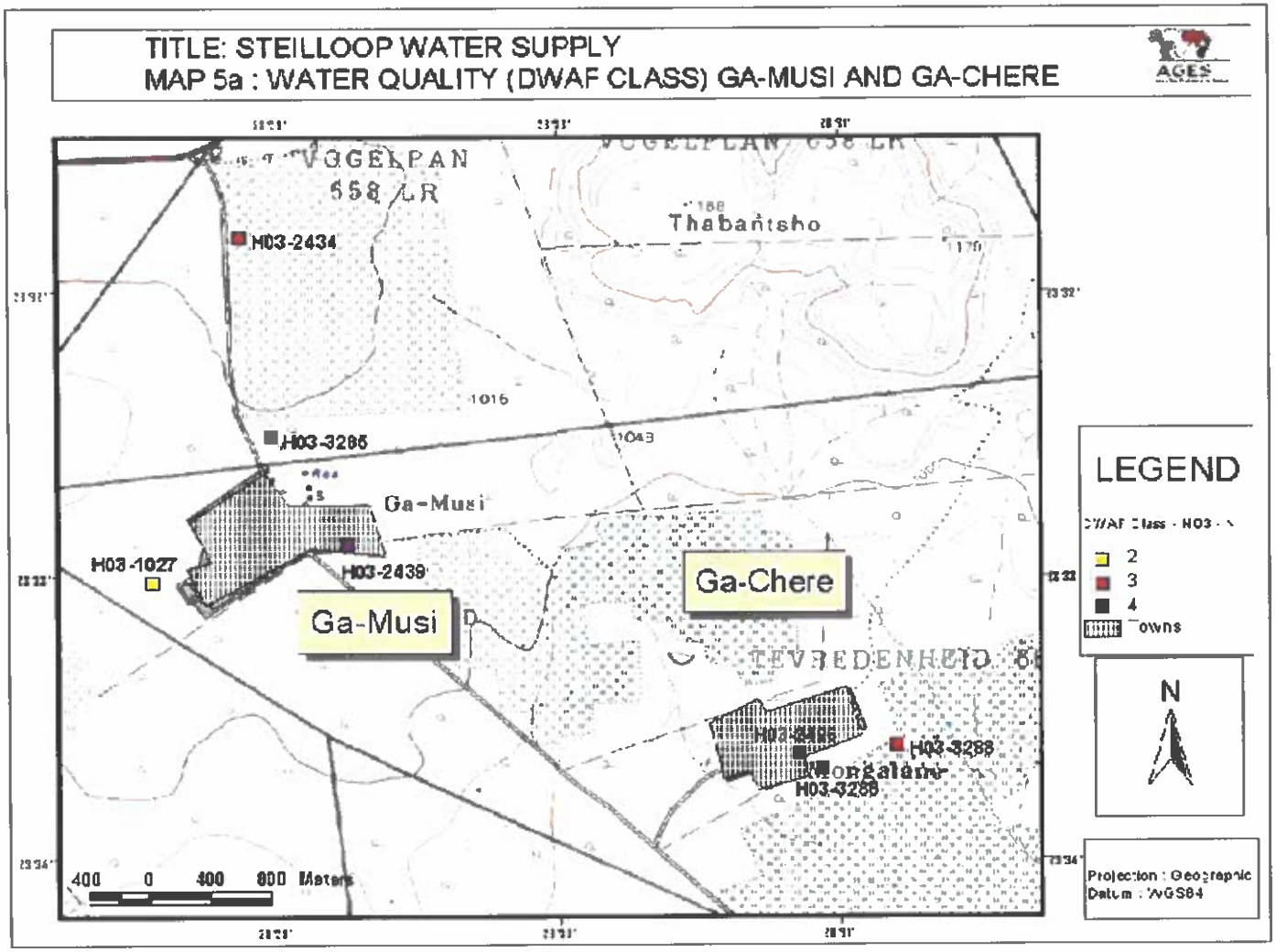

TITLE: STEILLOOP WATER SUPPLY
MAP 2a : GA MUSI AND GA CHERE GEOPHYSICS
AGES
N 448 LR
VOGELPAN 658 LR
VOGELPLAN 658 LR
Thabantsho
Ga Musi 1A
Ga Musi 1
Ga-Mus
Ga-Musi
Ga-Chere
Ga Chere 2
Phiri
VIANEN 450 LR
500 0 500 1000 Meters
KEFFERSKOOM
LEGEND
Boreholes
Existing
New
Geophysics
Towns
N
Projection : Geographic
Datum : WGS84

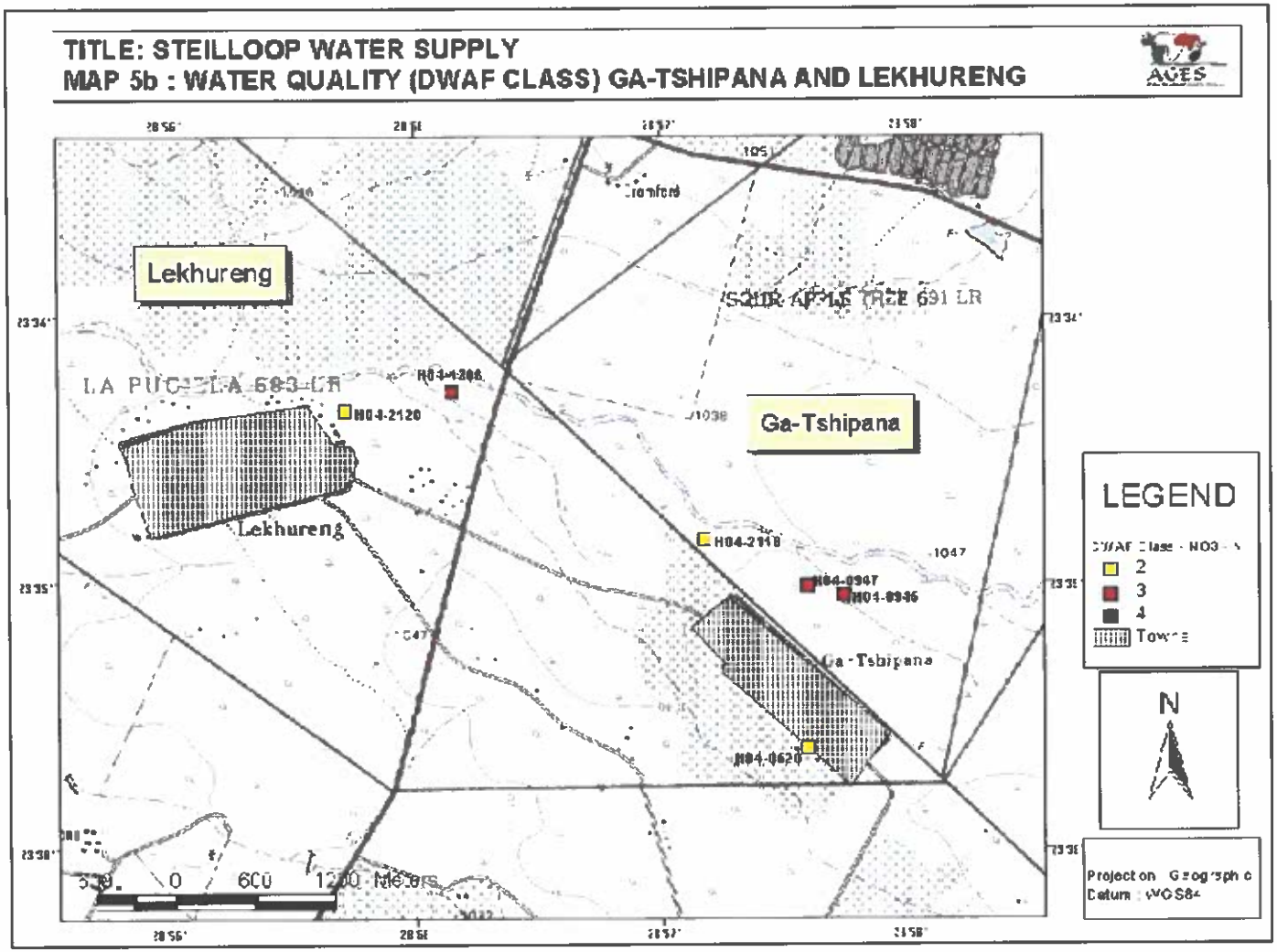

TITLE: STEILLOOP WATER SUPPLY
MAP 3a : GA-MUSI AND GA-CHERE HYDROCENSUS AND NEW BOREHOLES
ACES
VOGELPAN 558 LR
Thabantsho
H03-2434
H03-2436
H03-3284
H03-3285
H03-2437
H03-3281
H03-2438
Ga-Musi
Ga-Chere
H03-2439
H03-3027
H03-3287
H03-3289
TEVREDENHED 660 LR
H03-2429
H03-3282
H03-3283
H03-2102
H03-2431
H03-2432
H03-3288
Pontalaire
H03-3286
VLAKFONTEIN 450 LR
500 0 500 1000 Meters
KAFFERSKOM
LEGEND
Boreholes
Existing
New
Towns
N
Projection : Geographic
Datum : WGS84


TITLE: STEILLOOP WATER SUPPLY
MAP 3b : GA-TSHIPANA AND LEKHURENG HYDROCENSUS
AGES
Lekhureng
Ga-Tshipana
H04-2116
H04-2117
H04-1305
H04-2120
H03-1532
H04-2119
H04-2118
H04-0947
H04-0944
H04-0945
H04-0888
H04-0520
Cremlord
LA PUCHELA 693 LR
SOUTH APPLS TREE 691 LR
Ga-Tshipana
600 0 600 1200 Meters
LEGEND
Boreholes
Existing
New
Towns
N


TITLE: STEILLOOP WATER SUPPLY
MAP 4a : BOREHOLE YIELDS - GA-MUSI AND GA-CHERE
AGES
VOGELPAN 658 LR
VOGELPLAN 658 LR
Thabantsho
H03-2434
H03-3285
Ga-Musi
H03-1027
H03-2439
Ga-Musi
Ga-Chere
TEVREDENHEID
H03-2426
H03-3288
Monguluane
H03-3286
LEGEND
0.2 - 0.5
0.5 - 1
1 - 2.5
2.5 - 5
Town
N
500 0 500 1000 Meters


TITLE: STEILLOOP WATER SUPPLY
MAP 4b : GA-TSHIPANA AND LEKHURENG - BOREHOLE YIELDS
AGES
Lekhureng
Ga-Tshipana
LA PUC-LA-683 LR
H04-4305
H04-2120
H04-2118
H04-0947
H04-0528
1038
1047
Lekhureng
Ga-Tshipana
LEGEND
0.2 - 0.5
0.5 - 1
2.5 - 9
N
500 0 500 1000 Meters


TITLE: STEILLOOP WATER SUPPLY
MAP 5a : WATER QUALITY (DWAF CLASS) GA-MUSI AND GA-CHERE
AGES
VOGELPAN 558 LR
Thabantsho
H03-2434
H03-3285
Ga-Musi
H03-1027
H03-2439
Ga-Chere
Ga-Musi
TEVREDENHEID
H03-3288
H03-3288
400 0 400 800 Meters
LEGEND
2
3
4
Towns
N
Projection : Geographic
Datum : WGS84


TITLE: STEILLOOP WATER SUPPLY
MAP 5b : WATER QUALITY (DWAF CLASS) GA-TSHIPANA AND LEKHURENG
AGES
Lekhureng
Ga-Tshipana
LA PUCELA 683 LR
S2DR AP 15 THE 691 LR
H04-2120
H04-2118
H04-0620
Lekhureng
Ga-Tshipana
LEGEND
2
3
4
Towns
N
0
600
1200 METERS
Projection Geographic
Datum : WGS84

OREHOLE NO. :	H04-0520		PROJECT:	WATERBERG DISTRICT MUNICIPALITY	
LTERNATIVE NO. :			SITE NAME:	CHIPANA	
OREHOLE DEPTH (mbdl):	79.45	CASING DEPTH (mbdl):	3.62	PUMP TYPE USED:	MONO BP 30
EPTH OF PUMP (mbdl):	78.00	CASING HEIGHT (magl):	0.10	OPERATOR:	WONDER MUALA
UMP INLET DIAMETER (mm):		CASING ID (mm):	165	CONTRACTOR:	RAMOTSE DEVELOPMENT
TATIC WATER LEVEL (mbdl):	16.21	DATUM LEVEL (magl):	0.07	SUPERVISOR:	LUCAS MODIMANA
IRST WATER STRIKE (mbgl):		CLIENT:		DEPTH AFTER TEST (mbgl):	
AIN WATER STRIKE (mbgl):		LATITUDE:		WATERLEVEL AFTER TEST (mbgl):	
VAILABLE DRAWDOWN		LONGITUDE:		EC (mS/m):	pH: TDS (ppm):

USA-data
gpm- hel data.

28,959668

23,5955919

8/2/12.

EST DESCRIPTION	STEP	1	2	3	4	5	6	TOTAL:	
ALIBRATION TEST:								(min)	(hrs)
EST DURATION (Minutes)		15	15	15				45	0.75
EST YIELD (l/s)		1.41	3.46	6.25				MAXIMUM YIELD (l/s):	6.2
RAWDOWN (m)		2.45	6.80	61.50	61.50	61.50	61.50	MAXIMUM DRAWDOWN:	61.5
ECOVERY (m)							0.18	TIME (min):	150.0
ULTI-RATE / STEP DRAWDOWN:								(min)	(hrs)
EST DURATION (Minutes)		100	100	100	0	0	0	300	5.00
EST YIELD (l/s)		1.51	3.09	4.46				MAXIMUM YIELD (l/s):	4.5
RAWDOWN (m)		3.3	7.30	12.02				MAXIMUM DRAWDOWN:	12.0
ECOVERY (m)							0.14	TIME (min):	210.0

RECOVERY TEST			
Cal (min)	Steps (min)	CD (min)	Total (min)
150	210	780	1140
TIME TOTAL (hrs):			19.00
CD - DRAWDOWN TOTALS (m):			
AVAILABLE DRAWDOWN	UTIL-ISED	% UTILISED	
0.00	13.14	#DIV/0!	

CONSTANT DISCHARGE TEST	TEST DURATION (min)	TEST DURATION (hrs)	TEST YIELD (l/s)	DRAWDOWN (m)	RECOVERY: (m)	RECOVERY: %	RECOVERY: (min)	RECOVERY: (hrs)
	1440	24.00	4.03	13.14	0.00	100.00	780	13.00
OBSERVATION BOREHOLES:	No. of boreholes	720 (min)	1440 (min)	2880 (min)	OTHER (min) nr.	OTHER (min) Time	TOTAL: (min)	TOTAL: (hrs)
							0	0.00

DESCRIPTION:	QUANTITY:	UNIT:
ESTABLISHMENT		Sum
INTER HOLE MOVE > 10 km		Km.
FROM: SITE NAME:		
BOREHOLE No:		
INTER HOLE MOVE < 10 km:		No.
REMOVAL AND RE-ERECTION OF PUMP HOUSE:		No.
REMOVAL OF EXISTING EQUIPMENT:		No.
RE-INSTALLATION OF EXISTING EQUIPMENT:		No.
WORK TIME RATE (REPAIRS):		Hour
STANDING TIME:		Hour

SUMMARY

DESCRIPTION:	QUANTITY:	UNIT:
STRAIGHTNESS TEST:		No.
VERTICALITY TEST:		No.
CASING DETECTION:		No.
STEEL BOREHOLE COVER:		No.
BOREHOLE MARKING:		No.
SITE CLEANING / FINISHING:		No.
REPORTING & DATA RECORDING:		No.
SLUG TEST:		No.
LAYFLAT (m):		m

STEPPED DISCHARGE TEST AND RECOVERY

BOREHOLE NO. :	H04-0520	STATIC WATER LEVEL (mbdl):	16.21	DEPTH OF PUMP (mbdl):	78.00

DISCHARGE RATE 1

DATE: 16-Mar-04
TIME: 9:00 AM

Time (min)	Drawdown (m)	Yield (l/s)
0	0.00	
1	0.98	
2	1.12	1.02
3	1.24	
5	2.26	1.60
7	2.47	
10	2.68	
15	2.84	1.61
20	3.00	
30	3.06	
40	3.12	1.60
50	3.18	
60	3.22	
70	3.23	1.60
80	3.24	
90	3.25	1.62
100	3.26	
110		
120		

Average yield (l/s): 1.50833

Recovery 1

Time (min)	Recovery (m)
0	3.26
1	
2	
3	
5	
7	
10	
15	
20	
30	
40	
50	
60	
70	
80	
90	
100	
110	
120	
150	
180	
210	
240	

DISCHARGE RATE 2

DATE: 16-Mar-04
TIME: 10:40 AM

Time (min)	Drawdown (m)	Yield (l/s)
0	3.26	
1	6.10	
2	6.16	3.13
3	6.46	
5	6.57	3.07
7	6.78	
10	6.90	
15	6.95	3.08
20	6.99	
30	7.04	
40	7.08	3.05
50	7.12	
60	7.18	
70	7.20	3.09
80	7.23	
90	7.25	3.10
100	7.30	
110		
120		

Average yield: 3.08667

Recovery 2

Time (min)	Recovery (m)
0	7.30
1	
2	
3	
5	
7	
10	
15	
20	
30	
40	
50	
60	
70	
80	
90	
100	
110	
120	
150	
180	
210	
240	

DISCHARGE RATE 3

DATE: 16-Mar-04
TIME: 12:20 PM

Time (min)	Drawdown (m)	Yield (l/s)
0	7.30	
1	10.21	
2	10.34	
3	10.42	
4	10.56	
7	10.70	4.12
10	10.86	
15	10.90	
20	10.98	4.68
30	11.06	
40	11.20	
50	11.38	4.50
60	11.50	
70	11.68	
80	11.88	4.50
90	11.94	
100	12.02	4.50
110		
120		

Average yield: 4.46

Recovery 3

Time (min)	Recovery (m)
0	12.02
1	
2	
3	
5	
7	
10	
15	
20	
30	
40	
50	
60	
70	
80	
90	
100	
110	
120	
150	
180	
210	
240	

DISCHARGE RATE 4

DATE:
TIME:

Time (min)	Drawdown (m)	Yield (l/s)
0	12.02	
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
50		
60		
70		
80		
90		
100		
110		
120		
150		
180		
210		
240		
300		
360		
420		
480		

Average yield:

Recovery 4

Time (min)	Recovery (m)
0	12.02
1	
2	
3	
5	
7	
10	
15	
20	
30	
40	
50	
60	
70	
80	
90	
100	
110	
120	
150	
180	
210	
240	
300	
360	
420	
480	
540	
600	
660	
720	

DISCHARGE RATE 5

DATE:
TIME:

Time (min)	Drawdown (m)	Yield (l/s)
0	12.02	
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
50		
60		
70		
80		
90		
100		
110		
120		
150		
180		
210		
240		
300		
360		
420		
480		

Average yield:

Recovery 5

Time (min)	Recovery (m)
0	12.02
1	
2	
3	
5	
7	
10	
15	
20	
30	
40	
50	
60	
70	
80	
90	
100	
110	
120	
150	
180	
210	
240	
300	
360	
420	
480	
540	
600	
660	
720	

DISCHARGE RATE 6

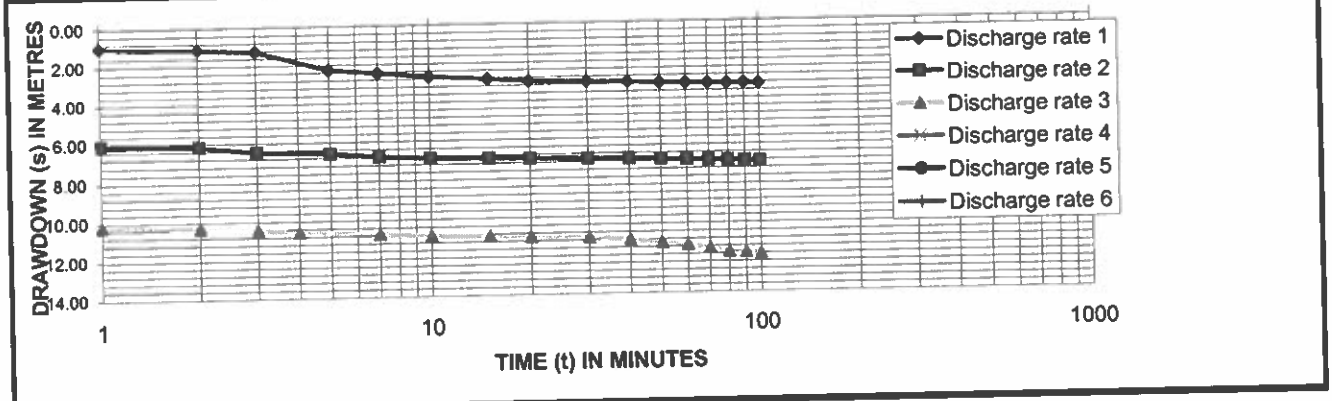
DATE:
TIME:

Time (min)	Drawdown (m)	Yield (l/s)
0	12.02	
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
50		
60		
70		
80		
90		
100		
110		
120		
150		
180		
210		
240		
300		
360		
420		
480		

Average yield:

Recovery

Time (min)	Recovery (m)
0	12.02
1	1.82
2	1.78
3	1.72
5	1.62
7	1.58
10	1.50
15	1.29
20	1.20
30	1.15
40	1.09
50	1.01
60	0.96
70	0.88
80	0.74
90	0.62
100	0.56
110	0.48
120	0.42
150	0.31
180	0.2
210	0.14
240	
300	
360	
420	
480	
540	
600	
660	
720	



BOREHOLE NO:	H04-0520		OBSERVATION BOREHOLE 1			OBSERVATION BOREHOLE 2			OBSERVATION BOREHOLE 3		
PUMP DEPTH (mbdl):		78.00	No. :			No.			No.		
WATER LEVEL (mbdl):		16.21	DATUM LEVEL (magl):			DATUM LEVEL (magl):			DATUM LEVEL (magl):		
TEST STARTED	DATE:	16-Mar-04	CASING DEPTH (mbdl):			CASING DEPTH (mbdl):			CASING DEPTH (mbdl):		
	TIME:	7:00 PM	BOREHOLE DEPTH :			BOREHOLE DEPTH :			BOREHOLE DEPTH :		
TEST COMPLETED	DATE:		WATER LEVEL:			WATER LEVEL:			WATER LEVEL:		
	TIME:		DISTANCE (m):			DISTANCE (m):			DISTANCE (m):		
TIME - PUMPED (min):		1440	TIME RECOVERY(min):		780	TOTAL TEST TIME:		2220	AVERAGE YIELD (l/s):		4.03

Time (min)	Drawdown (m)	Yield (l/s)	Recovery (m)	Time (min)	Drawdown (m)	Rec (m)	Time (min)	Drawdown (m)	Rec (m)	Time (min)	Drawdown (m)	Rec (m)
0			13.14	0	0.00		0	0.00		0	0.00	
1	3.02		5.12	1			1			1		
2	3.17		4.38	2			2			2		
3	3.22	3.55	3.17	3			3			3		
5	4.68		2.84	5			5			5		
7	6.50		2.62	7			7			7		
10	7.47	4.06	2.50	10			10			10		
15	8.21		2.45	15			15			15		
20	8.40		2.40	20			20			20		
30	8.71	4.06	2.25	30			30			30		
40	8.94		2.12	40			40			40		
60	9.30	4.07	1.80	60			60			60		
90	9.62		1.70	90			90			90		
120	9.86		1.50	120			120			120		
150	9.99	4.08	1.39	150			150			150		
180	10.16		1.28	180			180			180		
210	10.24		1.20	210			210			210		
240	10.31	4.10	1.11	240			240			240		
300	10.39		1.04	300			300			300		
360	10.50		0.87	360			360			360		
420	10.68	4.10	0.65	420			420			420		
480	10.75		0.47	480			480			480		
540	10.84		0.30	540			540			540		
600	10.97	4.05	0.22	600			600			600		
660	11.06		0.15	660			660			660		
720	11.10	4.08	0.09	720			720			720		
780	11.18		0.04	780			780			780		
840	11.34		0.00	840			840			840		
900	11.53	4.06		900			900			900		
960	11.94			960			960			960		
1020	12.20			1020			1020			1020		
1080	12.46	4.06		1080			1080			1080		
1140	12.59			1140			1140			1140		
1200	12.72	4.06		1200			1200			1200		
1260	12.81			1260			1260			1260		
1320	12.89	4.06		1320			1320			1320		
1380	12.97			1380			1380			1380		
1440	13.14	4.06		1440			1440			1440		
1500				1500			1500			1500		
1560				1560			1560			1560		
1620				1620			1620			1620		
1680				1680			1680			1680		
1740				1740			1740			1740		
1800				1800			1800			1800		
1860				1860			1860			1860		
1920				1920			1920			1920		
1980				1980			1980			1980		
2040				2040			2040			2040		
2100				2100			2100			2100		
2160				2160			2160			2160		
2220				2220			2220			2220		
2280				2280			2280			2280		
2340				2340			2340			2340		
2400				2400			2400			2400		
2460				2460			2460			2460		
2520				2520			2520			2520		
2580				2580			2580			2580		
2640				2640			2640			2640		
2700				2700			2700			2700		
2760				2760			2760			2760		
2820				2820			2820			2820		
2880				2880			2880			2880		