



*Water Use Licence Application
Geohydrological Assessment:
Farm RE/781 Jarrahnup, Bot River*

REPORT:

GEOSS Report No: 2018/02-52

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10 April 2018

EXECUTIVE SUMMARY

Mr Willie Dique from Roelcor approached GEOSS – Geohydrological & Spatial Solutions International (Pty) Ltd to compile and submit a Water Use License Application (WULA) for the groundwater use at the farm RE/781, Bot River. Groundwater is currently abstracted from three production boreholes.[§]

The groundwater is used for agricultural purposes (irrigation) and for industrial use. Regarding the legal aspect of the proposed groundwater use, the following details have relevance:

Quaternary Catchment:	G40G
Property Size (ha):	510.63
General Authorization (m³/ha/a):	400
General authorization zone:	F
General authorization volume (m³/a):	40 000 (Maximum GA limit per farm) (1 st Sept 2016)
Maximum sustainable volume from the three boreholes (m³/a)	254 390.4
Existing Lawful Use (m³/a)	100 000
Is General Authorization exceeded?	Yes

The calculation in the table above indicates that the groundwater use has to be licensed with the Department of Water and Sanitation (DWS). It is a requirement from DWS that a geohydrological report must accompany the groundwater portion of the said license application. GEOSS was appointed to complete the geohydrological report.

With regard to the groundwater resources of the study area, the geological setting is favourable for the occurrence of groundwater. On assessment of the geological map the Groundwater Response Unit (GRU) have an extent of about 200 km². Using the GRAII recharge values the direct vertical recharge is calculated to be in the region of 35 425 800 m³/a for the GRU. The firm yield of the GRU is calculated to be 1 876 369.24m³/a.

The firm yield of the GRU is far in excess of the predicted water requirement of the farm. The volume for which an existing water use license has been granted is 100 000m³/a, much less than the firm yield of the GRU with a volume of 1 876 369.24 m³/a. The license application volume is therefor considered to be well within the sustainable supply volume of the aquifer. It is important to note that a conservative approach was used to calculate

[§] At a meeting with Mr Dique on 10 April 2018 – GEOSS was informed a WULA is no longer required as an ELU of 100 000 m³/a was recently awarded.

the recharge and firm yield volumes and that the actual volumes are believed to be higher than the calculated volumes.

The boreholes have also been correctly tested in terms of yield to determine the sustainable safe yield that can be abstracted from the aquifer system. The yield tests indicate that the property may sustainably abstract 254 390.4 m³/a from the aquifer system. The proposed use is also linked to the safe yield of the borehole and aquifer over-abstraction is very unlikely to occur.

The groundwater is uncontaminated and of good quality. It is completely suitable for the intended use, and even for domestic use is classified as “Ideal water quality” according to the Department of Water Affairs classification for domestic water supply. The groundwater will be used for agricultural purposes (irrigation) and for domestic use.

A groundwater requirement and supply analysis for the farm is provided below:

GROUNDWATER REQUIREMENT

- The current requirement for the farm is 50 000m³/a. The volume of the existing water use licence is 100 000 m³/a.

GROUNDWATER SUPPLY

- The total safe groundwater yield for the borehole is 254 390.4 m³/a (8.1 L/s). The current available supply will meet the current requirement.

Based on the results obtained during the geohydrological investigation it is recommended that the application be approved however it is recommended the owner implements certain groundwater “best management practices”. It is important to note that these best management practises are merely a recommendation.

These include:

- The boreholes must be equipped with an observation tube (40 mm Class 10 PVC) to enable the water levels to be recorded easily and for easy installation of data loggers; a flow meter (pulse signal) and a sampling tap. An adjustable timer switch should also be installed to ensure the borehole doesn't pump for longer than 12 hours continuously
- During summer the water level should be measured daily (towards the end of the 12 hour pumping cycle) and recorded in a database. Note this is a conservative safe yield (for use throughout the year). It is feasible that more groundwater can be

abstracted and to accurately determine how much more water can be abstracted the borehole should be equipped with a continuous water level data logger.

- The appropriate borehole pump must be installed, i.e. not an over-sized pump that is choked with a gate valve. If the monitoring shows that more water can be abstracted, then the duration of pumping time will be increased (not the flow rate).
- The borehole and pump should be serviced annually. A water sample should also be collected annually and the flow rate and volume of water abstracted recorded monthly (along with the measured water level).
- A geohydrologist should review the above information to ensure optimal groundwater abstraction and management occurs.

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ABBREVIATIONS

ch	collar height
L/s	litres per second
m	metres
mbch	metres below collar height
mbgl	metres below ground level
mg/L	milligrams per litre
mm/a	millimetres per annum
mS/m	milliSiemens per meter
NGA	National Groundwater Archive
WGS84	Since the 1st January 1999, the official co-ordinate system for South Africa is based on the World Geodetic System 1984 ellipsoid, commonly known as WGS84, with the ITRF91 (epoch 1994.0) co-ordinates of the Hartebeesthoek Radio Astronomy Telescope used as the origin of this system. This new system is known as the Hartebeesthoek94 Datum.

GLOSSARY OF TERMS

- Aquifer:** a geological formation, which has structures or textures that hold water or permit appreciable water movement through them [from National Water Act (Act No. 36 of 1998)].
- Borehole:** includes a well, excavation, or any other artificially constructed or improved groundwater cavity which can be used for the purpose of intercepting, collecting or storing water from an aquifer; observing or collecting data and information on water in an aquifer; or recharging an aquifer [from National Water Act (Act No. 36 of 1998)].
- Fractured aquifer:** Fissured and fractured bedrock resulting from decompression and/or tectonic action. Groundwater occurs predominantly within fissures and fractures.
- Groundwater:** water found in the subsurface in the saturated zone below the water table or piezometric surface i.e. the water table marks the upper surface of groundwater systems.
- Transmissivity:** the rate at which a volume of water is transmitted through a unit width of aquifer under a unit hydraulic head (m^2/d); product of the thickness and average hydraulic conductivity of an aquifer.

Suggested reference for this report:

GEOSS (2018). Water Use Licence Application - Geohydrological Assessment: Farm RE/781, Jarrahnup, Bot River. GEOSS Report Number: 2018/02-52. GEOSS - Geohydrological & Spatial Solutions International (Pty) Ltd. Stellenbosch, South Africa.

Cover photo:

The Roelcor Botriver Piggery entrance sign

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Review by:

Louise Soltau (10 April 2018).

1. INTRODUCTION

Mr Willie Dique from Roelcor approached GEOSS – Geohydrological & Spatial Solutions International (Pty) Ltd to compile and submit a Water Use License Application (WULA) for the groundwater use at the farm RE/781, Bot River. Groundwater is currently abstracted from three production boreholes for which details are shown in **Table 1**.

Table 1: Proposed production boreholes details.

Borehole	Latitude (WGS84)	Longitude (WGS84)	Elevation (approx.) mamsl	Yield (L/s)	Pump duration (h/day)	Volume (m ³ /a)
Boorgat 1 (Main)	-34.293497°	19.207615°	141	9	16	189 216
Boorgat 2 (Sandgat)	-34.294207°	19.203610°	120	1	16	21 024
Boorgat 3 (Forest)	-34.295495°	19.206798°	146	2.1	16	44 150.4

The groundwater is used for agricultural purposes (irrigation) and for industrial use. Regarding the legal aspect of the proposed groundwater use, the following details have relevance:

Table 2: General Authorisation limit for the farm.

Quaternary Catchment:	G40G
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General authorization zone:	F
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Existing Lawful Use for the farm (m³/a)	100 000
Is General Authorization exceeded?	Yes

The calculation in **Table 2** indicates that the groundwater use will have to be licensed with the Department of Water and Sanitation (DWS). It is a requirement from DWS that a geohydrological report must accompany the groundwater portion of the said license application. GEOSS was appointed to complete the geohydrological report.

2. TERMS OF REFERENCE (T0R)

The main objectives of this project are to:

- Determine the sustainable long term safe yield as well as the quality of the groundwater.
- Complete an assessment of the groundwater use in the area by means of a hydrocensus.
- Document the above findings in a format fully compatible with the requirements for a water use license application (which is to be submitted to Department of Water and Sanitation (DWS)).

3. REGIONAL SETTING

3.1 General

Geographically, the farm is in Botriver, which is approximately 20 kms south-west of Caledon and approximately 20 kms south-east of Grabouw, in the Western Cape. The farm is situated across quaternary catchments G40G and G40F in the Breede Water Management Area. These quaternary catchments are approximately 220,5 km² and 422.5 km² in extent and has a General Authorisation (GA) of 400 and 150 m³/a/ha. Most of the farm occurs within quaternary catchment G40G and this catchment information is used for the assessment. The study area, within a regional context, is shown in **Figure 1**.

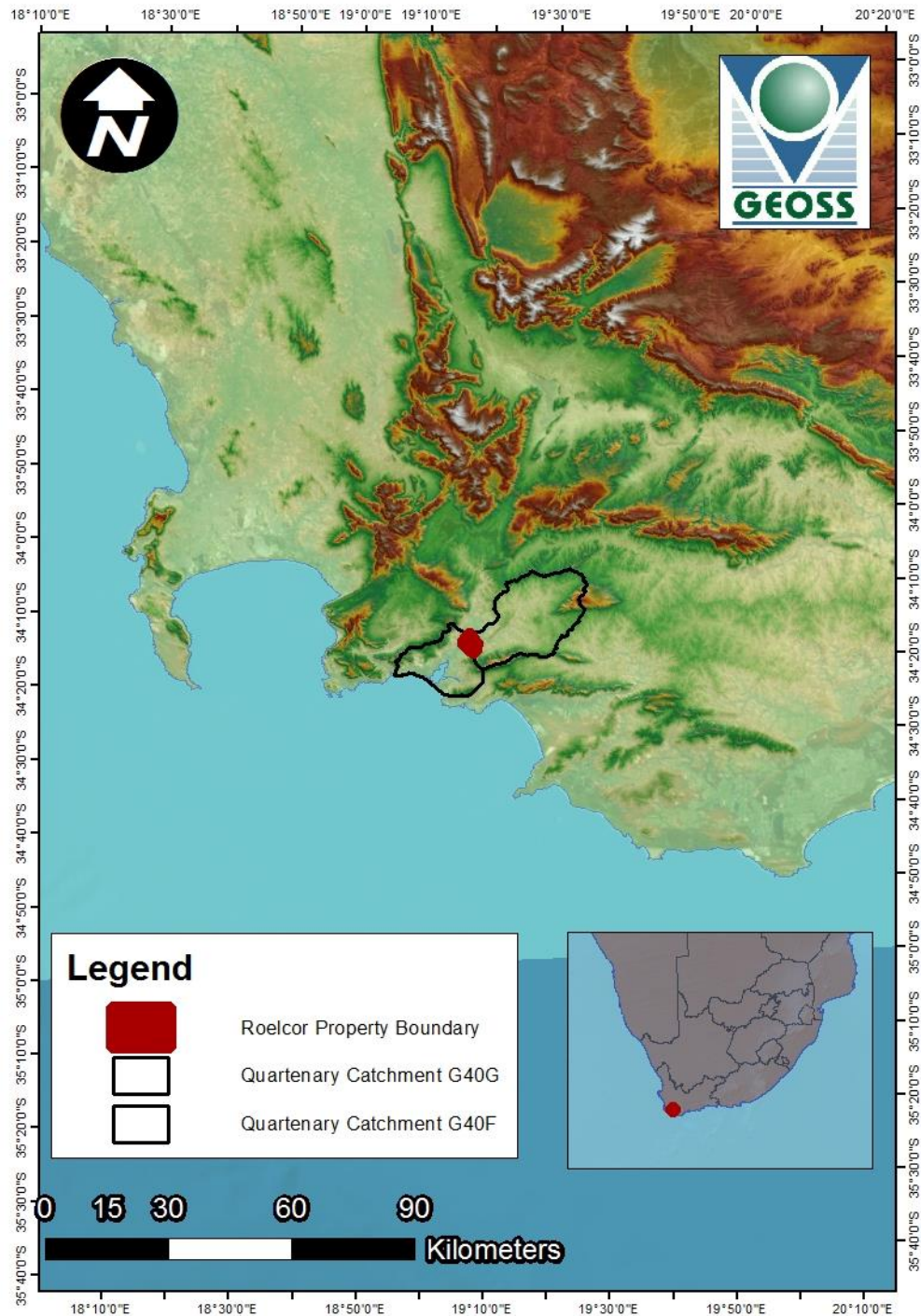


Figure 1: Locality map indicating the position of the farm in a regional setting.

3.2 Climate

Botrivier experiences a Mediterranean Climate with cold wet winters and hot dry summers. **Figure 2** shows the monthly average air temperature and average rainfall distribution for Botrivier. Botrivier receives a mean annual precipitation average of 723.85 mm/a. The peak groundwater recharge period will thus be in the winter. The mean annual recharge is 135.9 mm. During the summer months groundwater plays a crucial role in meeting irrigation requirements. **Figure 3** shows the monthly average rainfall and monthly average evaporation.

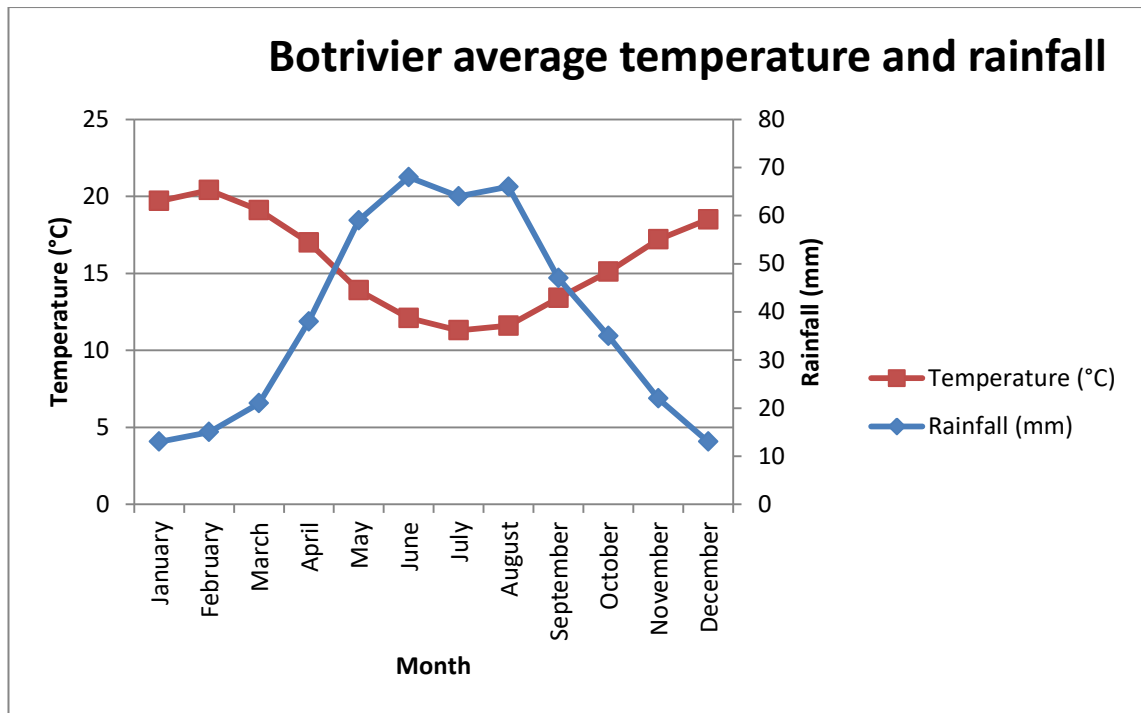


Figure 2: Monthly average air temperature and rainfall distribution.

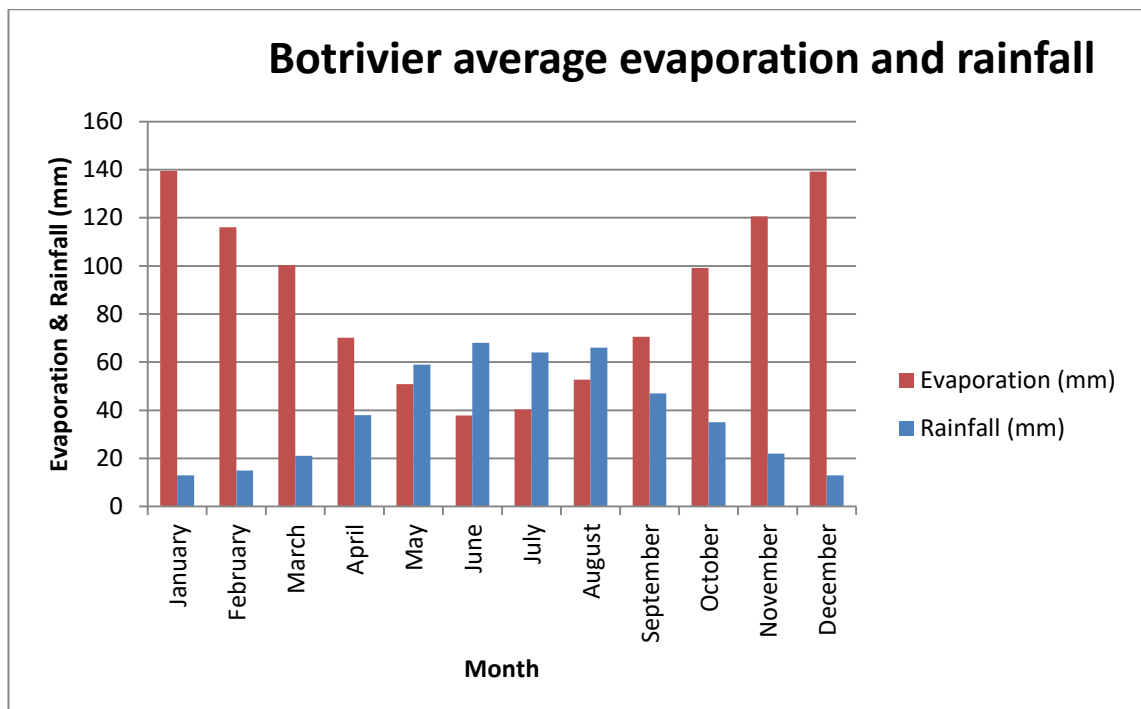


Figure 3: Monthly average rainfall and evaporation distribution.

4. REGIONAL GEOLOGY

The Geological Survey of South Africa (now the Council for Geoscience) has mapped the area at 1:250 000 scale (3419, Worcester). The regional geological setting is shown in **Table 3**.

Table 3: Geological formations within the study area.

	Code	Group/Suite	Description
	Alluvium	Quaternary	Gravelly, Alluvium
	Dt	Tra-Tra Fm.	Micaceous, sandy shale and mudstone, alternating siltstone and minor sandstone
	Dh	Hex river Fm.	Light-grey feldspathic sandstone, subordinate thin siltstone, gritstone and conglomerate
	Dv	Voorstehoek Fm.	Dark-grey fossiliferous shale, mudstone and siltstone, thin sandstone beds
	Dga	Gamka Fm.	Dark-grey, rather lithic and feldspathic sandstone and siltstone, subordinate shale and conglomerate
	Dg	Gydo Fm.	Black to dark grey fossiliferous shale, mudstone and siltstone
	Dr	Rietvlei Fm.	Light-grey, well-bedded quartzitic/ feldspathic sandstone, subordinate siltstone and shale
	Ss	Skurweberg Fm.	Light-grey, thick bedded, coarser grained quartzitic sandstone, cross bedded with grit and pebble stringers and lenticles

The area is mostly underlain by the arenaceous and argillaceous rocks of the Bokkeveld and Table Mountain Groups. This is mainly the intercalated shale and sandstone lithologies of various thicknesses which are partly overlain by quaternary alluvial deposits.

The site is directly underlain by seven different lithologies. The southernmost point of the site is underlain by the Rietvlei Fm. feldspathic sandstones. This is the formation in which the boreholes were drilled into. The middle area of the property is underlain by the Gamka Formation shales. The northernmost part of the property is underlain by mainly sandstones with varying shale, siltstone and mudstones. There is also a notable east-west fault running through the upper half of the property.

Just past the property lies the Skurweberg Formation quartzitic sandstones that has a northeast-southwest trend. Within 4 kms of the property boundary lies the Babylonstoring Mountains, consisting of the highly folded and faulted arenaceous rocks of the Table Mountain Group.

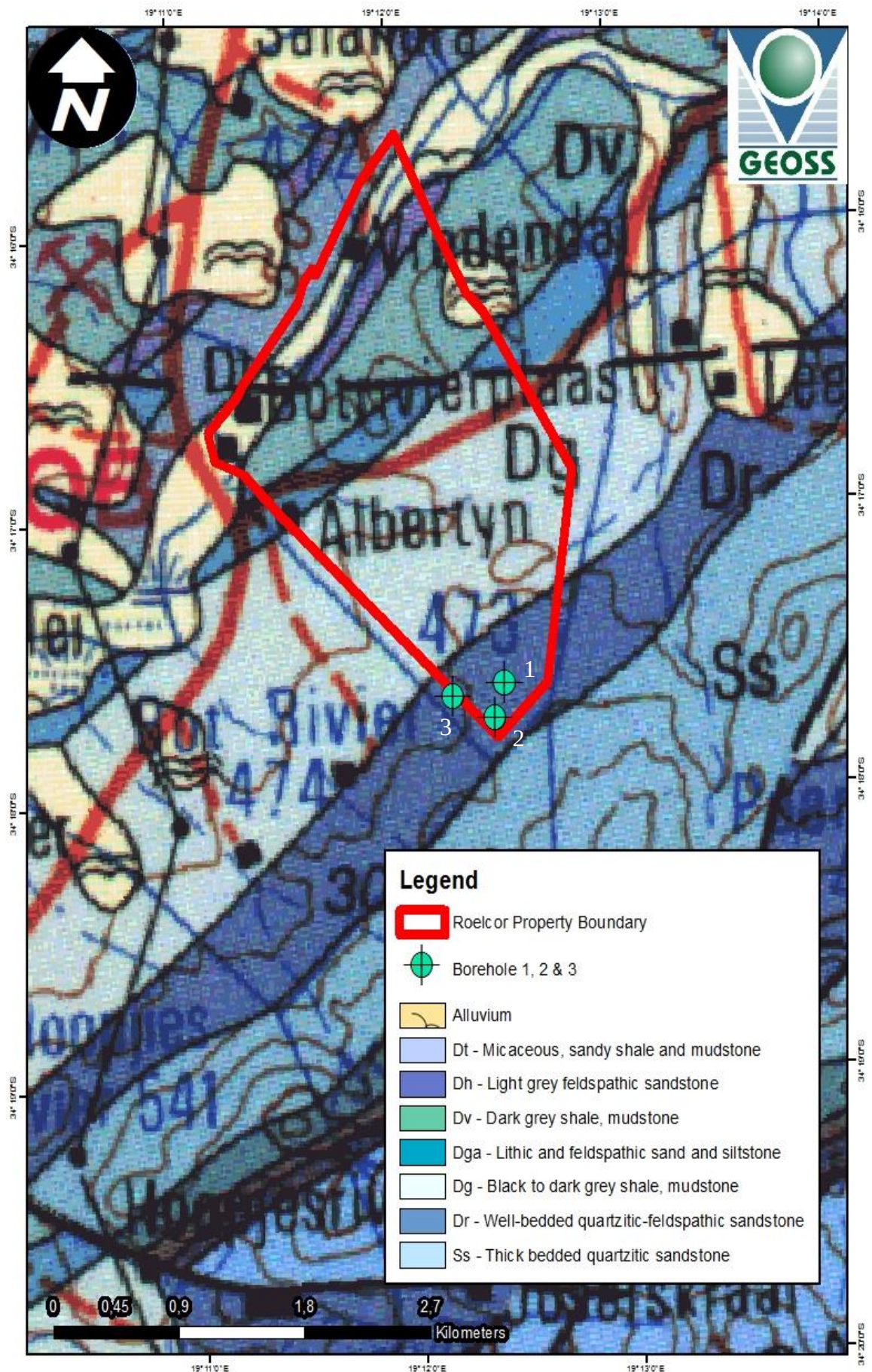


Figure 4: Regional geological setting for Roelcor Piggery, Botrivier.

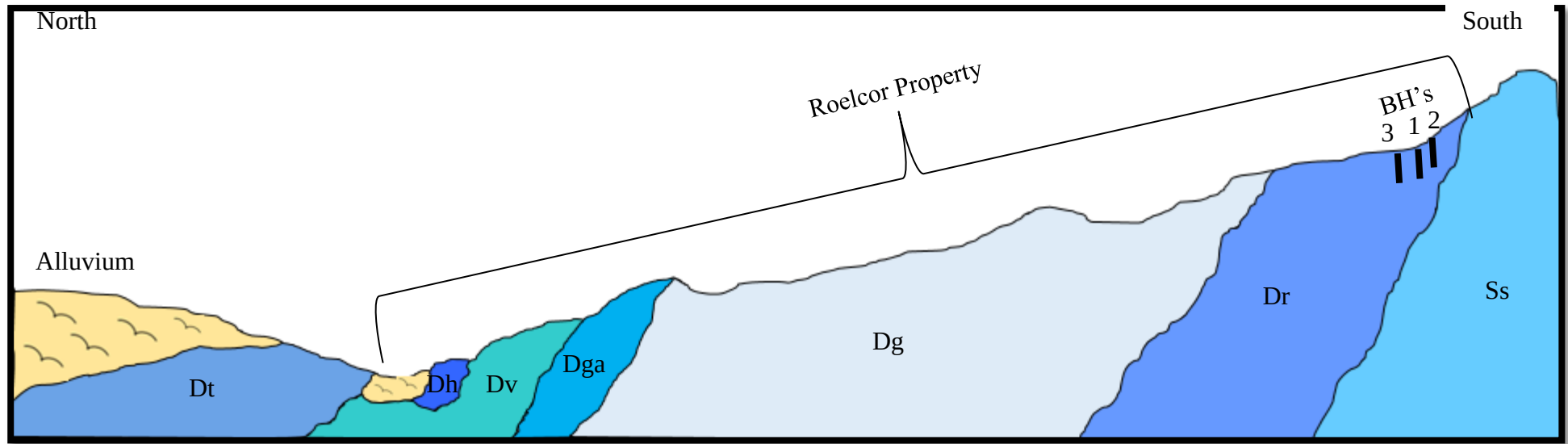


Figure 5: Conceptual schematic of a geological cross section of the area.

5. REGIONAL HYDROGEOLOGY

5.1 Aquifer Yield

According to the 1:500 000 scale groundwater map of Botrivier (3317 Cape Town) the area does host a fractured aquifer (i.e. the bedrock constitutes a fractured aquifer) with an average borehole yield of 0.5 L/s to 2 L/s.

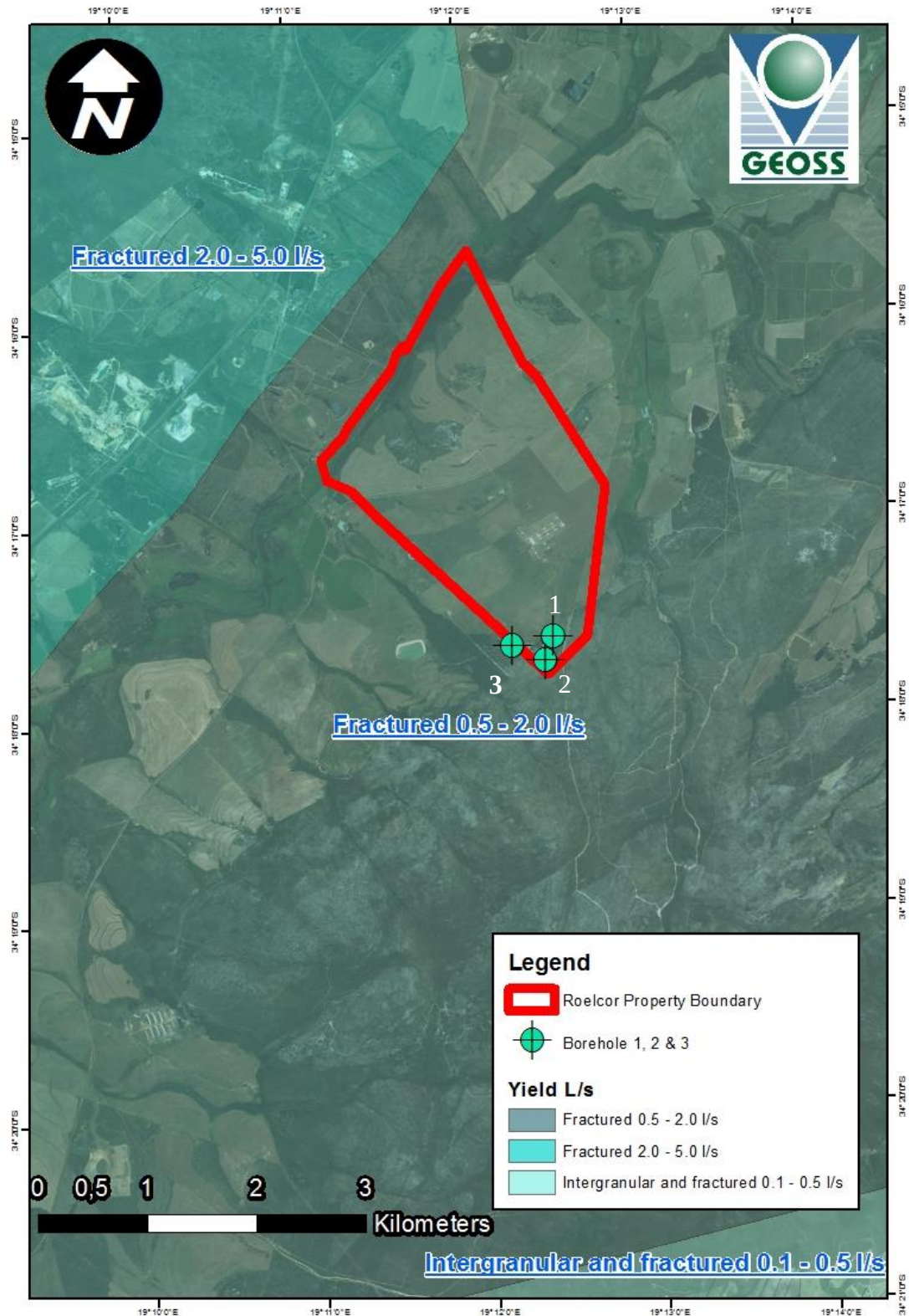


Figure 6: Regional aquifer type and yield for the study area and surrounds (DWAF, 2000).

5.2 Aquifer quality

The groundwater map indicates the fractured aquifer wherein the boreholes are drilled, have a water quality as indicated by the electrical conductivity in the range of 0 – 70 mS/m which, in terms of domestic supply, is Class 0 (i.e. ideal) (DWAF, 1998). It is also noted that the EC ranges between 70 and 300 mS/m to the east of the property and further north and east.

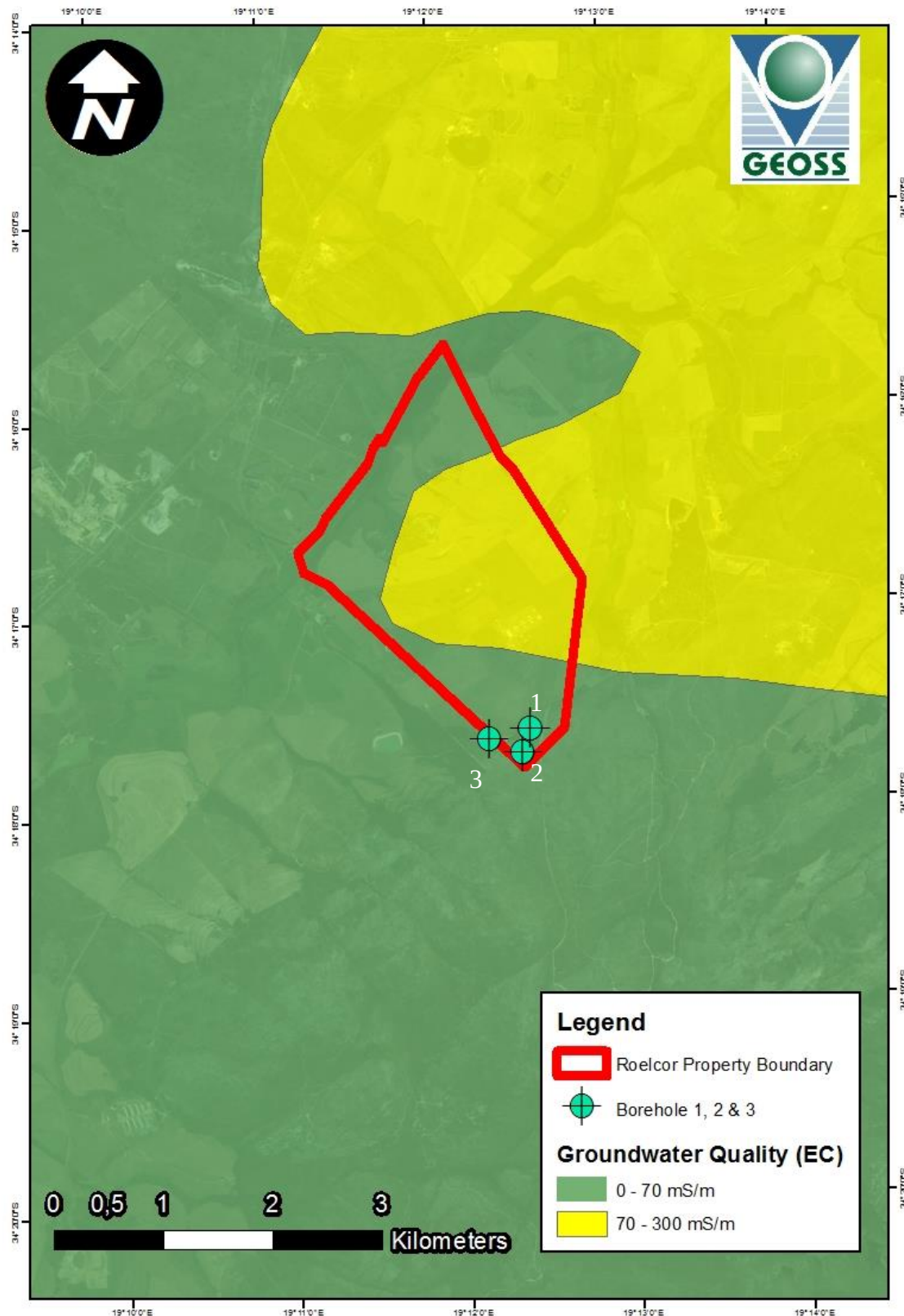


Figure 7: Regional groundwater quality for the study area and surrounds (DWAF, 2000).

6. VOLUME AND PURPOSE OF WATER USE

The farm is located mostly within Quaternary Catchment G40G, and thus the General Authorisation regarding groundwater abstraction is 400 m³/ha/a. The total area of the farm is 510.63 ha and therefore a total of 204 252 m³/a could be abstracted but the maximum General Authorisation was limited to 40 000 m³/a (1st September 2016). An existing lawful use of 100 000 m³/a was granted by the Department of Water and Sanitation (DWS).

The farm abstracts groundwater from three production boreholes. The water requirement for the farm was calculated as 50 000m³/a. The production boreholes were correctly yield tested (according to SANS 10299_4-2003) and the results used to estimate the sustainable (i.e. long term and safe) yield of the borehole. The total conservative volume, which can be abstracted from the borehole, is 254 390.4 m³/a and the total requested volume for the farm is 50 000 m³/a. It is planned to use the groundwater for agricultural (irrigation) and for domestic use. A monthly water management plan is provided in **Table 4**.

Table 4: Water management plan for the farm.

Month	Total required volume for farm (m ³ /annum)	Maximum recommended volume from boreholes (m ³ /annum)
January	4167	21 199
February	4167	21 199
March	4167	21 199
April	4167	21 199
May	4167	21 199
June	4167	21 199
July	4167	21 199
August	4167	21 199
September	4167	21 199
October	4167	21 199
November	4167	21 199
December	4167	21 199
TOTAL (m³/a)	50 000	254 390

7. AQUIFER FIRM YIELD MODEL

In order to evaluate the sustainable volume of groundwater that can be abstracted from the aquifer for the farm, the Aquifer Firm Yield Model (AFYM) was utilised (WRC, 2012). The model uses a single cell “Box Model” approach and makes use of a critical management water level, below which aquifer storage levels cannot be drawn down, to provide estimates of aquifer firm and assured yields.

The “Box Model” approach is schematically presented in **Figure 8**.

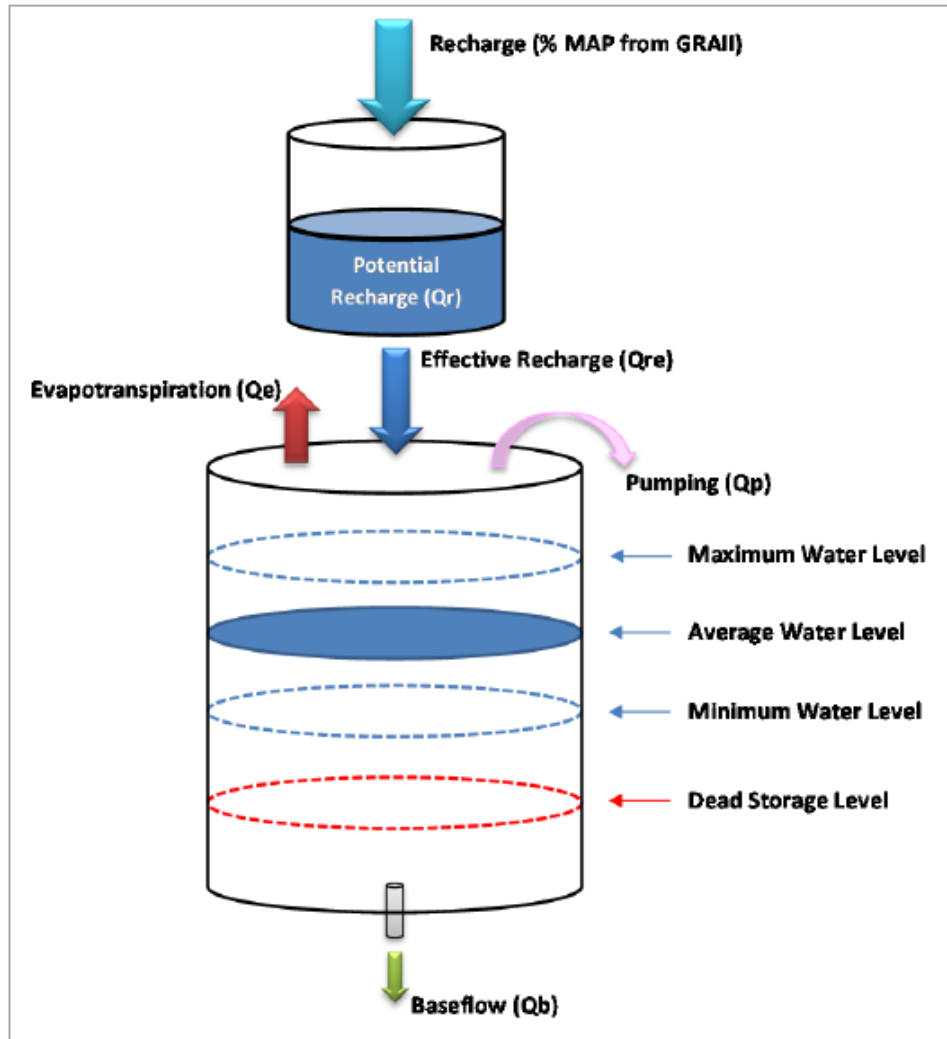


Figure 8: Aquifer Firm Yield lumped box model (WRC, 2012).

An evaluation was completed using the Aquifer Firm Yield model (WRC, 2012), and the results are presented in **Table 5**. The Input parameters used for the catchment are the default values presented in WRC (2012). These are taken from datasets like WR2005 (e.g. rainfall data) (Middleton and Bailey, 2008) and GRAII (e.g. specific yield and recharge (%MAP)) (DWAF, 2005), and others generated during the WRC (2012) (e.g. recharge threshold and riparian zone (% catchment area)). The parameters and results for quaternary catchments G40G, G40F and G40E, with a total area of 920.51km², and a total GRU area of 200 km² are all presented in **Table 5**.

Table 5: Hydrogeological Parameters for Quaternary catchment G40G, G40F and G40E (WRC, 2012).

Parameter	G40G	G40F	G40E
Quaternary Catchment Area (km ²)	220.5	422.5	277.6
Groundwater Level (mbgl)	12.3	16.2	13
Max Drawdown (m)	5	5	5
Specific Yield	0.002047	0.00132	0.001908
Current Use (l/s)	0.4	0.3	9.2
Firm Yield (l/s)	142,3	212	106.6
Firm Yield (l/s/km ²)	0.6454	0.5018	0.384
Recharge %	8.9	5.1	5.5
Recharge Threshold (mm)	60	21	60
MAP (mm)	723.8	515.3	721.8
Hydrological MAR (mm)	135.9	51.4	134.9
Hydrological MAE(mm)	1415	1400	1415
Baseflow: Default (Mm ³ /a)	18.02	0	12.91
ET Model	Linear	Linear	Linear
ET Extinction Depth (m)	4	4	4
Riparian Zone (%)	2.7	2.9	3.6

The Aquifer Firm Yield Model was run, and the Aquifer Firm Yield was determined to be 4 490 646.48 m³/a (142.3 L/s) with a recharge of 14 204 200m³/a for the catchment G40G.

The Aquifer Firm Yield Model was run, and the Aquifer Firm Yield was determined to be 6 690 211.2 m³/a (212 L/s) with a recharge of 11 034 000m³/a for the catchment G40F.

The Aquifer Firm Yield Model was run, and the Aquifer Firm Yield was determined to be 3 364 040.16 m³/a (106.6 L/s) with a recharge of 10 187 600 m³/a for the catchment G40E.

The results of the Aquifer Firm Yield Model for Quaternary Catchment G40G, G40F, and G40E are presented in **Table 6**.

Table 6: Results of the Aquifer Firm Yield Model for Quaternary Catchment G40G, G40F and G40E.

Name	Q [L/s]	Q [m ³ /month]	Q [m ³ /a]
G40G	142,3	368 841,6	4 490 646,48
G40F	212	549 504	6 690 211,2
G40E	106.6	276 307.2	3 364 040.16

For this study area there are clear geological features that enable the definition of a more localised aquifer (i.e. a geohydrological response unit (GRU)). The borehole is drilled into a fractured rock aquifer.

G40G:

On assessment of the geological map the GRU of G40G have an extent of approximately 130 km². Using the GRAII recharge values the direct vertical recharge (minimum recharge volume) is calculated to be in the region of 14 204 200m³/a for the G40G GRU. The firm yield of the G40G GRU is calculated to be 2 647 906.94 m³/a, which is estimated to be 58.97% of recharge.

G40F:

On assessment of the geological map the GRU of G40F have an extent of approximately 70 km². Using the GRAII recharge values the direct vertical recharge (minimum recharge volume) is calculated to be in the region of 11 034 000m³/a for the G40F GRU. The firm yield of the GRU is calculated to be 1 108 437.36 m³/a, which is estimated to be approximately 16.57% of recharge.

G40E:

On assessment of the geological map the GRU of G40E have an extent of approximately 38 km². Using the GRAII recharge values the direct vertical recharge (minimum recharge volume) is calculated to be in the region of 10 187 600m³/a for the G40E GRU. The firm yield of the GRU is calculated to be 461 707.6m³/a, which is estimated to be approximately 13.73% of recharge.

The Botrivier property lies within the G40G, G40F and G40E quaternary catchments. The influence and extent of the GRU extends over all three catchments and their respective percentages of influence are determined by the area of the GRU and its extent into each respective catchment.

- GRU(G40G) = 58.9% of the abstraction comes from the G40G quaternary catchment
- GRU(G40F) = 16.6% of the abstraction comes from the G40F quaternary catchment
- GRU(G40E) = 13.7 % of the abstraction comes from the G40E quaternary catchment

The total GRU taking into account the abstraction percentages from each quaternary catchment, is seen in **Table 7**.

Table 7: Final Results of the Aquifer Firm Yield Model for influence of the GRU

Quaternary Catchment	GRU Area [km ²]	Quaternary Catchment Area (in km ²)	Direct Vertical Recharge [m ³ /a]	Firm yield [m ³ /a]
G40G	130	220.5	14 204 200	1 540 180.19
G40F	70	422.5	11 034 000	184 000.6
G40E	38	277.6	14 204 200	152 188.45
Total (km²)	238	920.6	35 425 800	1 876 369.24

It is important to note that a conservative approach was used to calculate the recharge and firm yield volumes and that the actual volumes are believed to be higher than the calculated volumes.

The firm yield of the GRU is far in excess of the predicted water requirement of the farm. The application volume is therefore considered to be within the sustainable supply volume of the aquifer.

8. SITE SPECIFIC ASSESSMENT

8.1 Site visit and Hydrocensus

No data was retrieved from the National Groundwater Archive (NGA) within a 1km radius of the property. A hydrocensus was completed on 17 August 2017 within 1 km of the property boundary, and involved visiting any identified boreholes and land owners/users in the area. Any information pertaining to the abstraction, yield and quality of groundwater was sought. Unfortunately there weren't many boreholes found, only one borehole which is not in use, had a strong sulphur smell and was very saline.

The details of the hydrocensus are listed in **Table 8**, including comment obtained from the consultation process. The farm/property locations, as visited during the hydrocensus, are presented in **Maps 1 and 2 (Appendix A)**.

After a complete hydrocensus was carried out it was established that there are borehole or groundwater usage in the 1km radius zone that surrounds the study area.

Table 8: Hydrocensus borehole information.

	H_BH1
Latitude	-34,2723°
Longitude	19,2079°
RWL (mbgl)	39.79
EC (mS/m)	1320
Comments/address	Leeu Rivier farm Abandoned borehole that is very saline and has a strong sulphur smell
Photo	

9. BOREHOLE TESTING

9.1 Borehole yield testing

The three boreholes were correctly tested (according to SANS 10299_4-2003 guidelines) in terms of yield to determine the sustainable safe yield that can be abstracted from the aquifer system.

For each of the boreholes, the yield test involved an initial step test constituting 4 one hour intervals where the borehole was pumped at a constant rate for each hour. The abstraction rate was incrementally increased for each step. This test was followed by a constant discharge test (CDT) where the borehole was pumped at a constant rate for an extended period of time. The CDT was followed by water level recovery monitoring. The yield test certificates are included in **Appendix B**. The pumping test data was analysed using the Excel-based FC Programme developed by the Institute for Groundwater Studies (IGS) at the University of the Free State in Bloemfontein. This method evaluates fractal pumping tests and well performance and makes use of derivatives, boundary information and error propagation to evaluate the sustainable yield of the boreholes.

9.1.1 Boorgat 1 (Main)

Boorgat 1 was yield tested between 20 and 22 June 2017 by De Villiers Visser Irrigation. The borehole is 130 m deep, the rest water level (RWL) was at 28.88 mbgl and the pump was installed at 120 mbgl for the yield test.

The initial step test involved four steps, the yields for the step test were as follows:

- step 1 = 8.33 L/s;
- step 2 = 13.89 L/s;
- step 3 = 19.44 L/s and
- step 4 = 27.78 L/s.

Figure 9 shows the time-series drawdown as well as the different pumping rates.

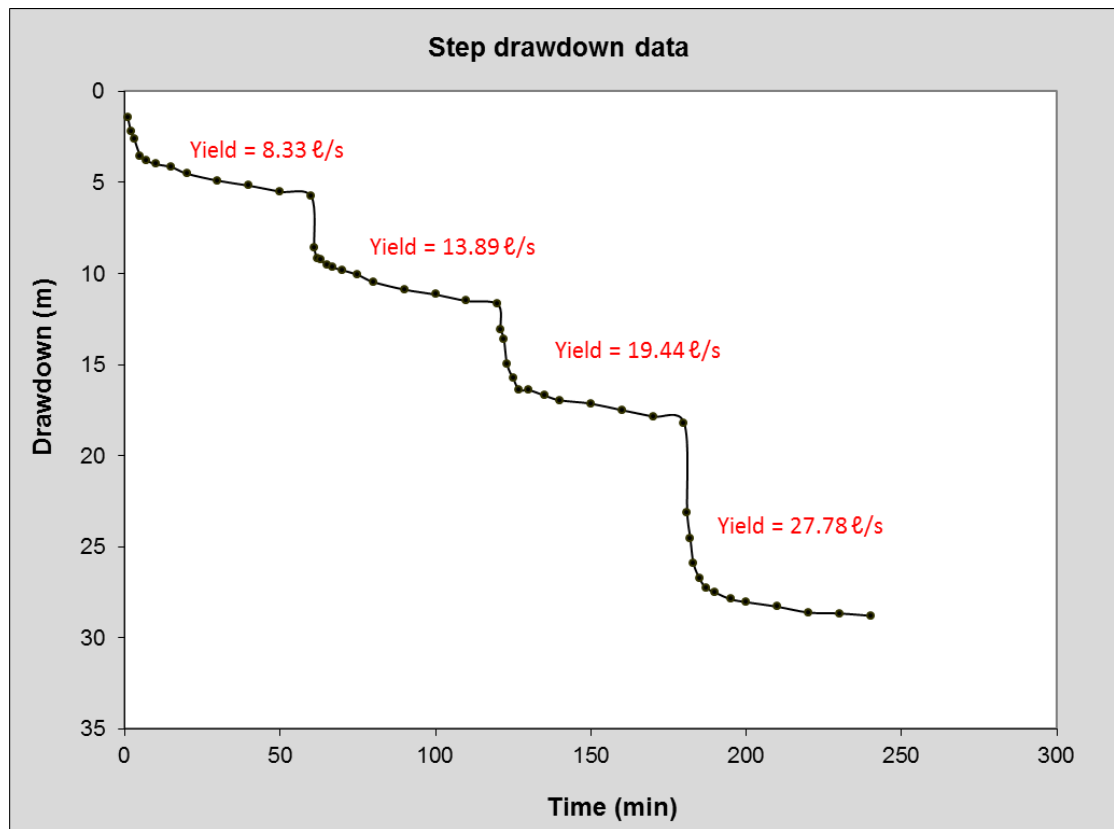


Figure 9: Step Test drawdown graph (Boorgat 1).

Based on the borehole response to the step tests it was decided to conduct the CDT at a rate of 20.83 L/s and the water level was drawn down to 39.76 m below the rest water level after 24 hours of pumping. The semi-log plot of the drawdown with time is shown in **Figure 10**.

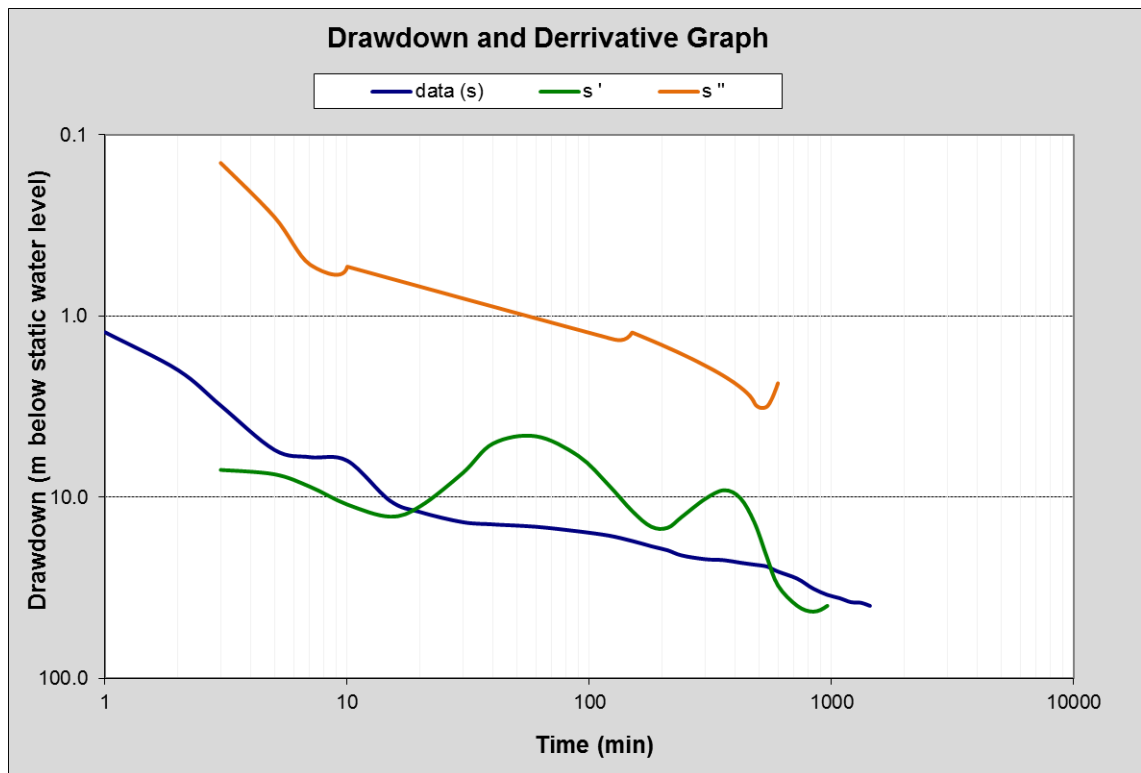


Figure 10: Semi-Log plot of the time-series drawdown and derivatives during the CDT (Boorgat 1).

The log-log plot of the CDT is shown in **Figure 11** and after 24 hours of pumping the water level was drawn down to 39.76 m below the rest water level.

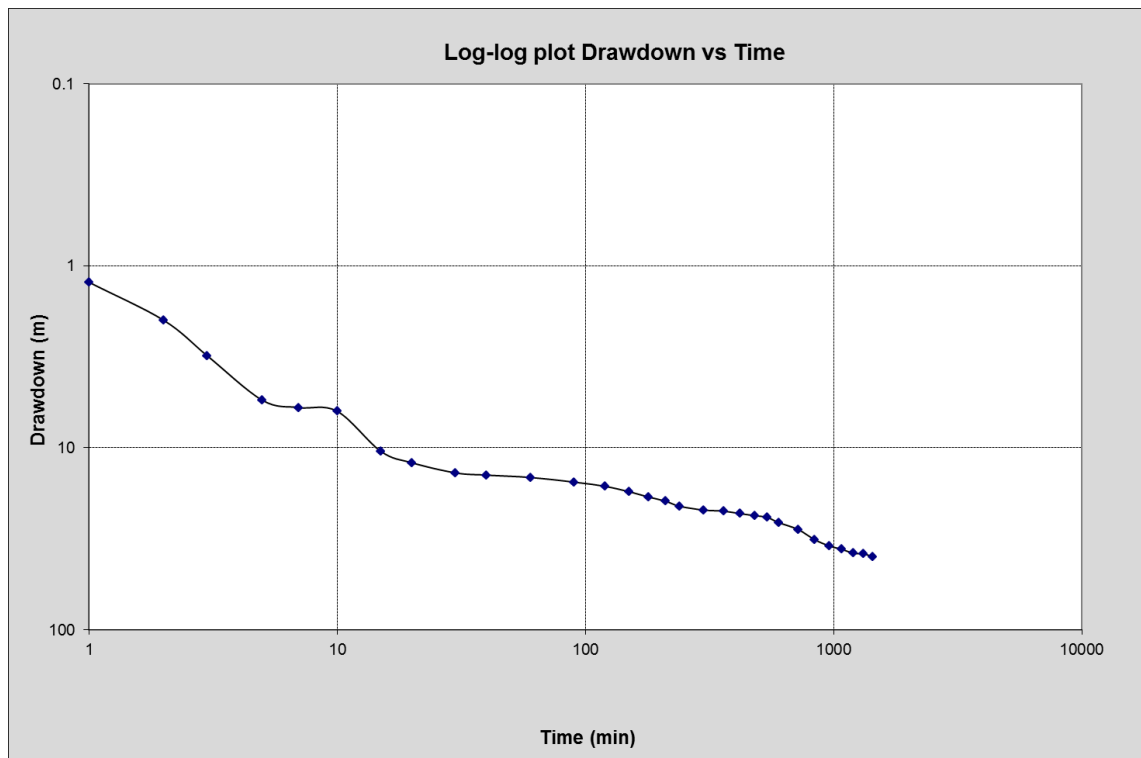


Figure 11: Log-Log plot of the time-series water level drawdown (Boorgat 1).

Based on the data analysis, the sustainable yield of the borehole is recommended to be 9 L/s pumping for 16 hours per day. The borehole pump should be installed at 120 mbgl. The recommended yield amounts to 393.9 m³/day and 180 277 m³/a. The summary is reflected in **Table 9**. Using the Cooper Jacob method the estimated Transmissivity is 10 m²/d. The maximum water level drawdown is 61.5 mbgl.

Table 9: Summary of pumping test analysis (Boorgat 1).

Summary			Main	BH1					
Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m ² /d)		Late T (m ² /d)		S	AD used
☐	Basic FC	5.27	3.73	39		7.7		1.10E-03	80.0
☐	Advanced FC			39		7.7		1.00E-03	80.0
☐	FC inflection point	3.06	2.09						39.0
☒	Cooper-Jacob	7.00	4.53			10.0		7.78E-04	80.0
☐	FC Non-Linear	12.41	10.95			120.0		6.00E-05	80.0
☐	Barker	3.56	1.61	K _f =	79419		S _s =	1.00E-07	80.0
	Average Q _{sust} (l/s)	7	#DIV/0!	b =	2.15	Fractal dimension n =		1.32	
	Recommended abstraction rate (L/s)		7	for 24 hours per day					
	Hours per day of pumping	16	9	L/s for 16		hours per day			

9.1.2 Boorgat 2 (Sandgat)

Boorgat 2 was yield tested between 21 and 23 June 2017 by De Villiers Visser Irrigation. The borehole is more than 150 m deep, the rest water level (RWL) was at 9.60 mbgl and the pump was installed at 120 mbgl for the yield test.

The initial step test involved three steps. The yields for the step test were as follows:

- step 1 = 1.11 L/s;
- step 2 = 2.22 L/s and
- step 3 = 2.78 L/s.

Figure 12 shows the time-series drawdown as well as the different pumping rates.

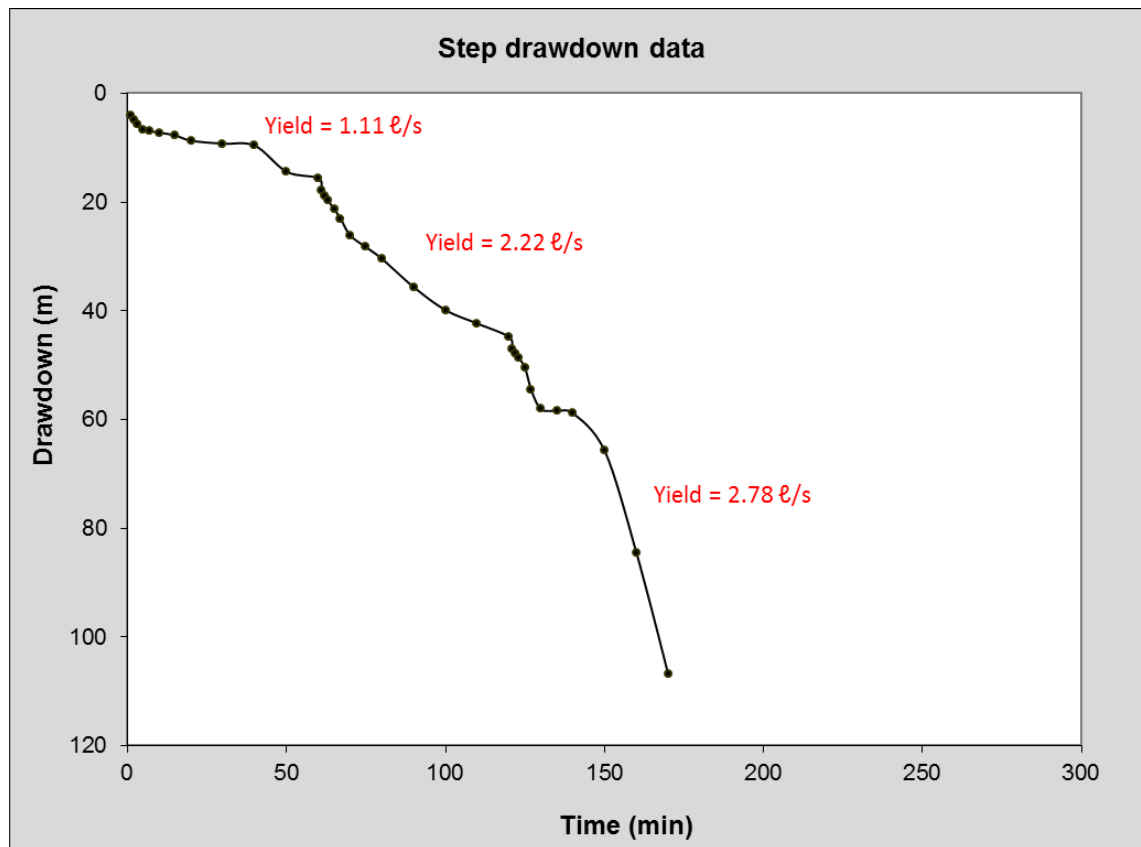


Figure 12: Step Test drawdown graph (Boorgat 2).

Based on the borehole response to the step tests it was decided to conduct the CDT at a rate of 1.25 L/s and the water level was drawn down to 42.99 m below the rest water level after 24 hours of pumping. The semi-log plot of the drawdown with time is shown in **Figure 13**.

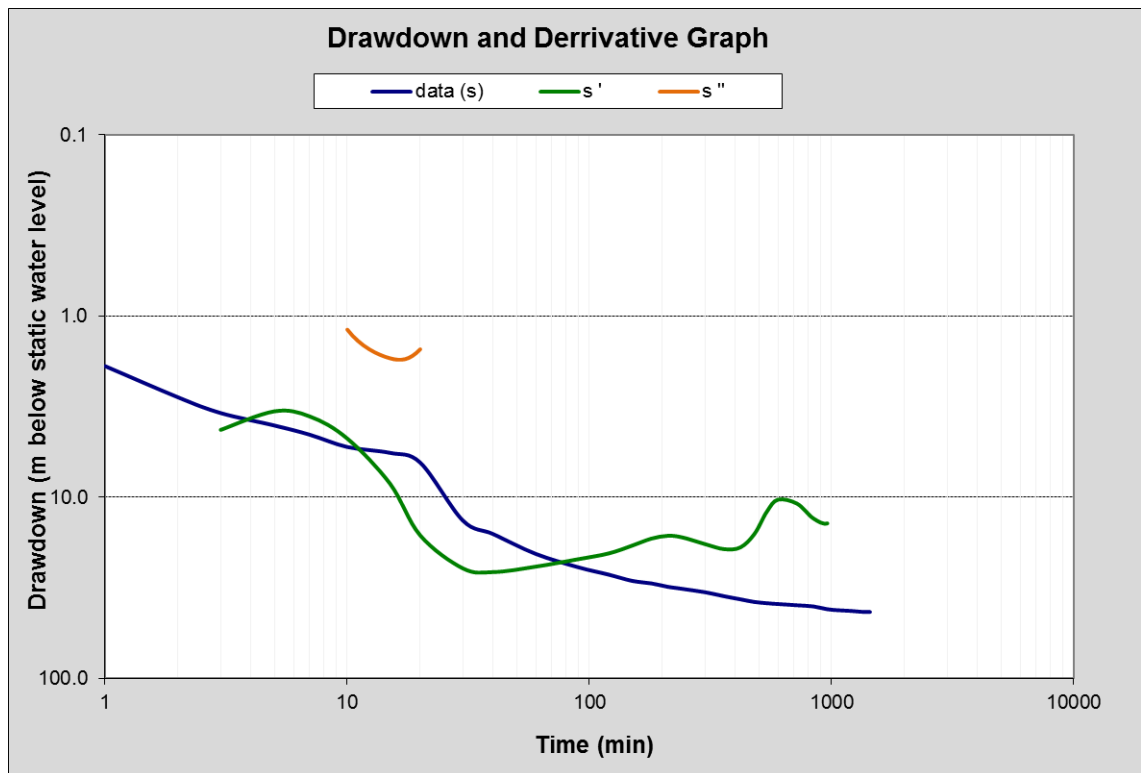


Figure 13: Semi-Log plot of the time-series drawdown and derivatives during the CDT (Boorgat 2).

The log-log plot of the CDT is shown in **Figure 14** and after 24 hours of pumping the water level was drawn down to 42.99 m below the rest water level.

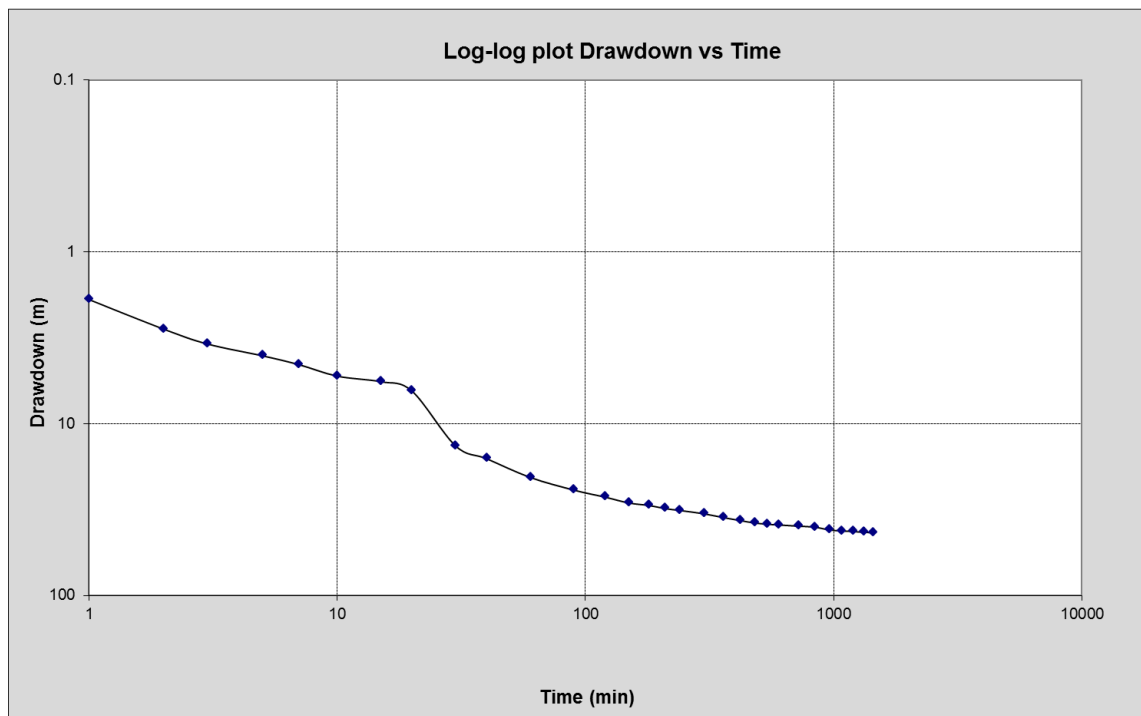


Figure 14: Log-Log plot of the time-series water level drawdown (Boorgat 2).

The recovery of the water level (**Figure 15**) was monitored for 1.5 hours. The recovery of the water level was rapid, after 1.5 hours the WL was 7.53 m below the RWL. This is 82.5% recovery.

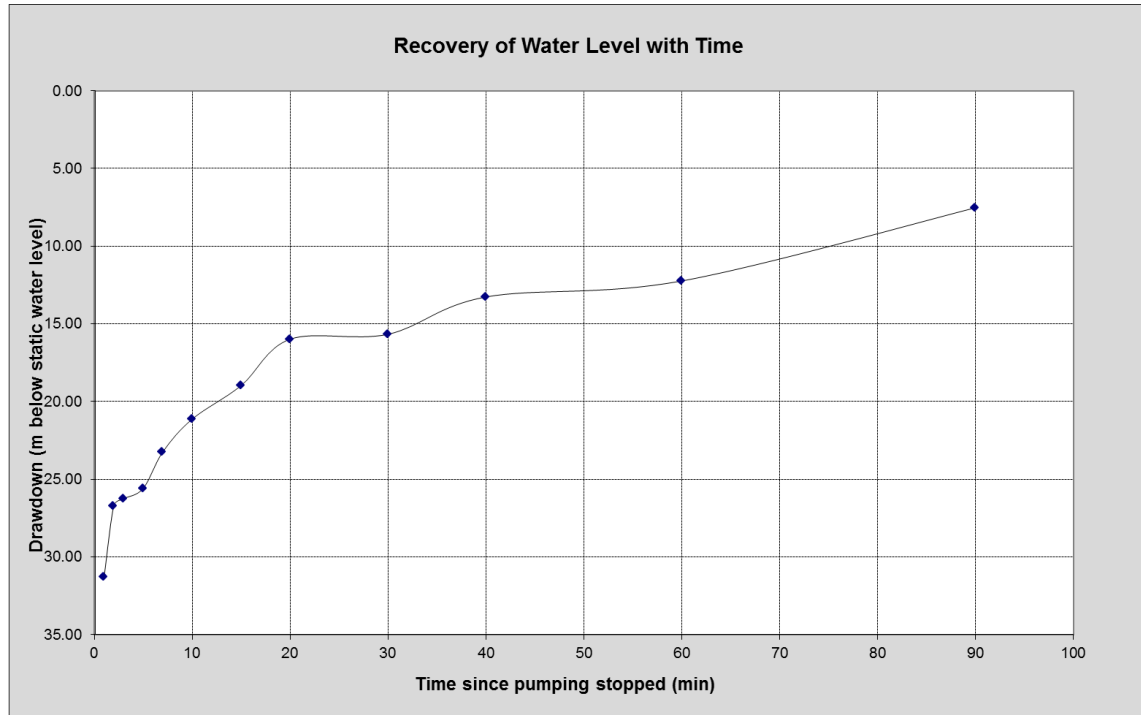


Figure 15: Water level recovery graph (Boorgat 2).

Based on the data analysis, the sustainable yield of the borehole is recommended to be 1 L/s pumping for 16 hours per day. The borehole pump should be installed at 120 mbgl. The recommended yield amounts to 56.4 m³/day and 20 603 m³/a. The summary is reflected in **Table 10**. Using the Cooper Jacob method the estimated Transmissivity is 1.8 m²/d. The maximum water level drawdown is 73.6 mbgl.

Table 10: Summary of pumping test analysis (Boorgat 2).

Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m ² /d)	Late T (m ² /d)	S	AD used
☒	Basic FC	0.70	0.41	2	1.0	1.10E-03	100.0
☐	Advanced FC			2	1.0	1.00E-03	100.0
☐	FC inflection point	0.43	0.21				43.0
☒	Cooper-Jacob	0.90	0.58		1.8	2.85E-07	100.0
☒	FC Non-Linear	0.73	0.65		2.0	1.00E-01	100.0
☐	Barker	0.32	0.08	K _f = 21043	S _s =	1.00E-07	100.0
	Average Q _{sust} (l/s)	0.8	0.11	b = 0.33	Fractal dimension n =	1.39	
	Recommended abstraction rate (L/s)	0.8		for 24 hours per day			
	Hours per day of pumping	16	1	L/s for 16	hours per day		

9.1.3 Boorgat 3 (Forest)

Boorgat 3 was yield tested between 26 and 28 June 2017 by De Villiers Visser Irrigation. The borehole is more than 150 m deep, the rest water level (RWL) was at 20.21 mbgl and the pump was installed at 120 mbgl for the yield test.

The initial step test involved four steps. The yields for the step test were as follows:

- step 1 = 1.39 L/s;
- step 2 = 2.22 L/s;
- step 3 = 2.78 L/s and
- step 4 = 3.33 L/s.

Figure 16 shows the time-series drawdown as well as the different pumping rates.

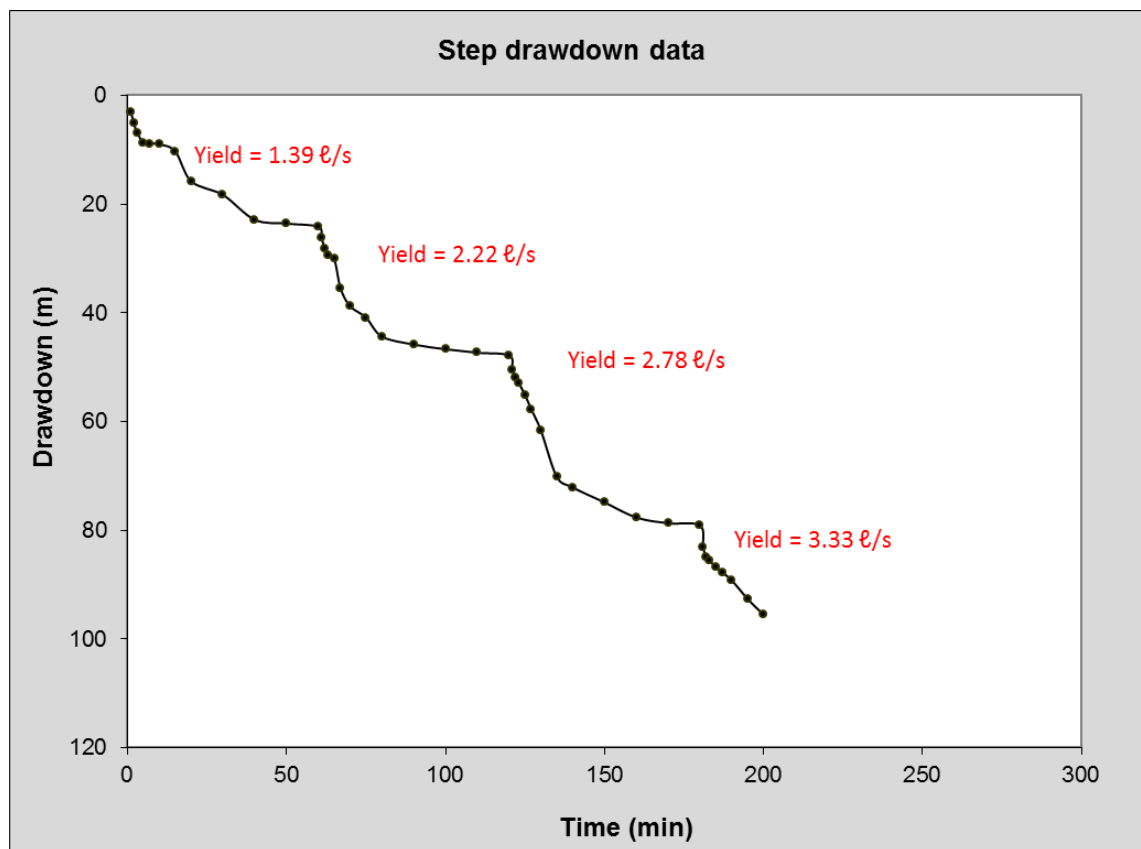


Figure 16: Step Test drawdown graph (Boorgat 3).

Based on the borehole response to the step tests it was decided to conduct the CDT at a rate of 1.8 L/s and the water level was drawn down to 53.2 m below the rest water level after 24 hours of pumping. The semi-log plot of the drawdown with time is shown in Figure 17.

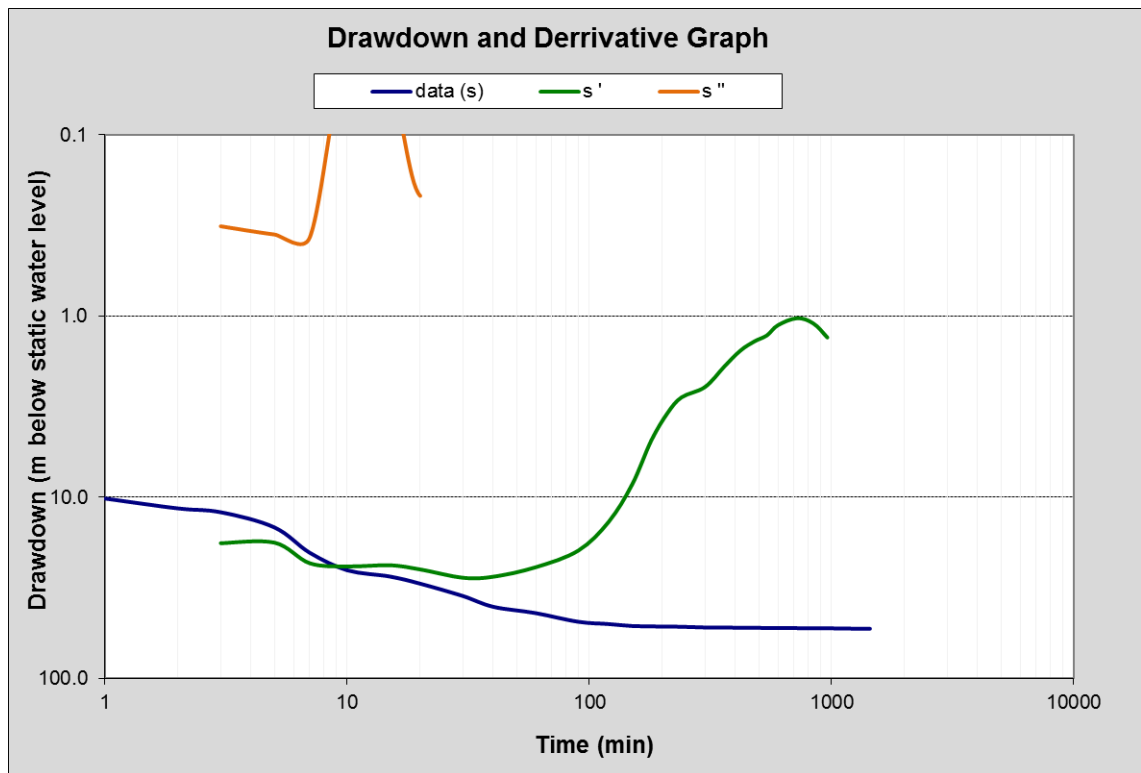


Figure 17: Semi-Log plot of the time-series drawdown and derivatives during the CDT (Boorgat 3).

The log-log plot of the CDT is shown in **Figure 18** and after 24 hours of pumping the water level was drawn down to 53.2 m below the rest water level.

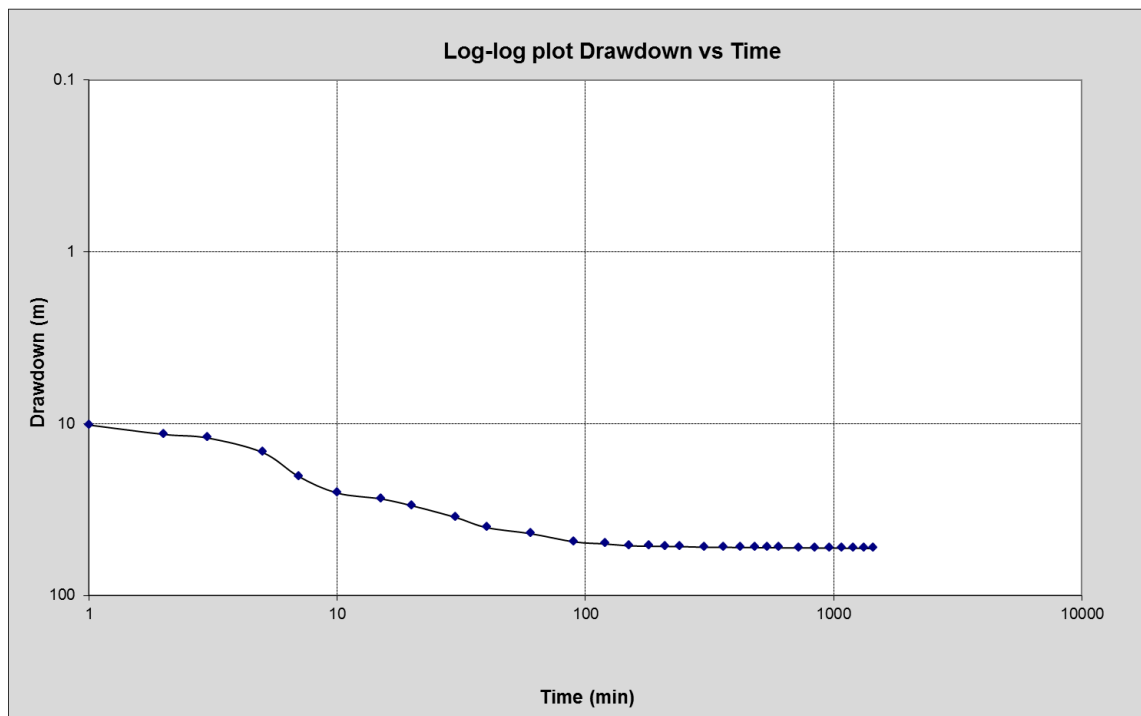


Figure 18: Log-Log plot of the time-series water level drawdown (Boorgat 3).

The recovery of the water level (**Figure 19**) was monitored for 2.5 hours. The recovery of the water level was slow, after 2.5 hours the WL was 1.94 m below the RWL. This is 96.4% recovery.

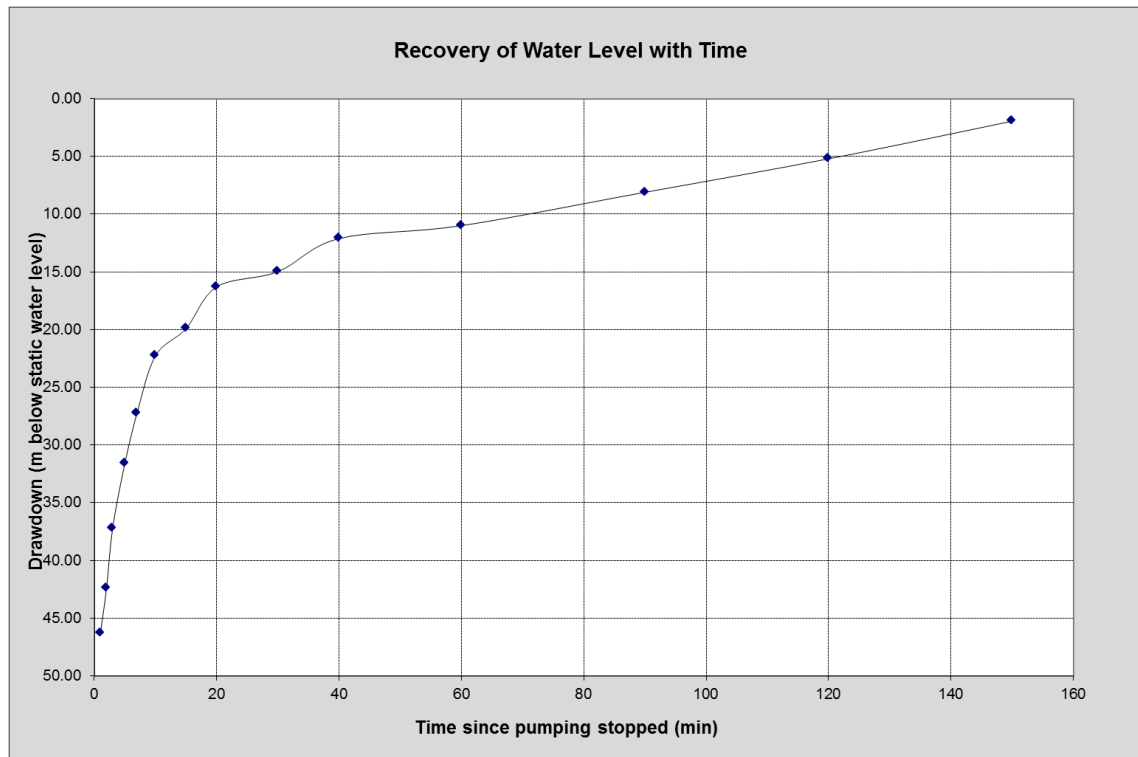


Figure 19: Water level recovery graph (Boorgat 3).

Based on the data analysis, the sustainable yield of the borehole is recommended to be 2.1 L/s pumping for 16 hours per day. The borehole pump should be installed at 120 mbgl. The recommended yield amounts to 119.9 m³/day and 43 781 m³/a. The summary is reflected in **Table 11**. Using the Cooper Jacob method, the estimated Transmissivity is 14.0 m²/d. The maximum water level drawdown is 65.5 mbgl.

Table 11: Summary of pumping test analysis (Boorgat 3).

Summary				Main	BH3					
Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m ² /d)		Late T (m ² /d)		S	AD used	
☐	Basic FC	1.24	0.57	2		2.1		1.10E-03	100.0	
☐	Advanced FC			2		2.1		1.00E-03	100.0	
☐	FC inflection point	1.46	0.19						52.0	
☒	Cooper-Jacob	1.65	1.07			14.0		6.14E-28	100.0	
☐	FC Non-Linear	0.69	0.61			5.0		1.00E-05	100.0	
☐	Barker	0.89	0.29	K _f =	49		S _s =	1.00E-07	100.0	
	Average Q _{sust} (l/s)	1.7	#DIV/0!	b =	0.56	Fractal dimension n =		1.75		
	Recommended abstraction rate (L/s)		1.7	for 24 hours per day						
	Hours per day of pumping	16	2.1	L/s for	16	hours per day				

9.1.4 Summary of boreholes yield testing

The yield test data indicates that the farm may sustainably abstract 254 390 m³/a from the aquifer system. The production boreholes (Boorgat 1, Boorgat 2 and Boorgat 3) have good recovery (rapid increase of the water level after pumping).

The boreholes abstraction rates and basic management guidelines are listed in **Table 12**. These are the safe yield of the boreholes, and aquifer over-abstraction is unlikely to occur if these rates are adhered to. Note this is a conservative yield (for use throughout the year).

Table 12: Summary of boreholes abstraction and management guidelines.

Borehole ID	Yield		Pump duration (h/day)	Volume		Pump depth (m)	Max. water level (mbgl)
	L/s	L/h		(m ³ /d)	(m ³ /a)		
Boorgat 1 (Main)	9	32 400	16	393.9	180 277	120	61.5
Boorgat 2 (Sandgat)	1	3 600	16	56.4	20 603	120	73.6
Boorgat 3 (Forest)	2.1	7 560	16	119.9	43 781	120	65.5

9.2 Groundwater quality

A groundwater sample was collected at the production boreholes and submitted for inorganic chemical analysis to a SANS accredited laboratory (Bemlab) in the Western Cape. The certificate of analysis for all the samples is presented in **Appendix C**.

The chemistry results obtained have been classified according to the SANS241-1: 2015 standards for domestic water. **Table 13** enables an evaluation of the water quality with regards to the various limits. **Table 14** presents the water chemistry analysis results, colour coded according to the SANS241-1: 2015 drinking water assessment standards.

Table 13: Classification table for specific limits (according to SANS 241-1:2015).

Acute Health
Aesthetic
Chronic health
Operational
Acceptable

Table 14: Classified production borehole results (according to SANS 241-1:2015).

Analyses	Boorgat 1 (Main)	Boorgat 3 (Forest)	Boorgat 2 (Sandgat)	SANS 241-1:2015
pH (at 25 °C)	6.6	4.9	6.5	≥5 - ≤9.7 Operational
Conductivity (mS/m) (at 25 °C)	19.4	27	21.3	≤170 Aesthetic
Total Dissolved Solids (mg/l)	124	173	137	≤1200 Aesthetic
Sodium (mg/l as Na)	16.0	35.6	19.5	≤200 Aesthetic
Potassium (mg/l as K)	7.2	1.5	6.4	N/A
Magnesium (mg/l as Mg)	2.4	4.2	3.2	N/A
Calcium (mg/l as Ca)	6.5	1.6	6.3	N/A
Chloride (mg/l as Cl)	32	81	40	≤300 Aesthetic
Sulphate (mg/l as SO ₄)	5	8	4	≤250 Aesthetic ≤500 Acute Health
Nitrate Nitrogen (mg/l as N)	<0,36	<0,36	<0,36	≤11 Acute Health
Total Alkalinity (mg/l as CaCO ₃)	66	7	66	N/A
Fluoride (mg/l as F)	0.3	0	0.3	≤1.5 Chronic Health
Manganese (mg/l as Mn)	4.4	0.04	5.3	≤0.1 Aesthetic ≤0.4 Chronic Health
Iron (mg/l as Fe)	0.4	0.3	0.1	≤0.3 Aesthetic ≤2 Chronic Health
Copper (mg/l as Cu)	<0,02	<0,02	<0,02	≤2 Chronic Health
Zinc (mg/l as Zn)	<0,03	0.07	<0,03	≤5 Aesthetic

The chemistry results obtained have been classified according to the DWAF (1998) standards for domestic water. **Table 15** enables an evaluation of the water quality with regards to the various parameters measured (DWAF, 1998). **Table 16** presents the water chemistry analysis results colour coded according to the DWAF drinking water assessment standards.

Based on the assessment criteria, according to SANS 241-1:2015, the water does not fall within the allowable limits for drinking water and the water might have to be treated to be fit for purpose.

Table 15: Classification table for the surface water and groundwater results (DWAF, 1998).

Blue	(Class 0)	Ideal water quality - suitable for lifetime use.
Green	(Class I)	Good water quality - suitable for use, rare instances of negative effects.
Yellow	(Class II)	Marginal water quality - conditionally acceptable. Negative effects may occur.
Red	(Class III)	Poor water quality - unsuitable for use without treatment. Chronic effects may occur.
Purple	(Class IV)	Dangerous water quality - totally unsuitable for use. Acute effects may occur.

Table 16: Classified production borehole results (according to DWAF, 1998).

Sample Marked :	Boorgat 1	Boorgat 3	Boorgat 2	DWA (1998) Drinking Water Assessment Guide				
				Class 0	Class I	Class II	Class III	Class IV
pH	6.6	4.9	6.5	5-9.5	4.5-5 & 9.5-10	4-4.5 & 10-10.5	3-4 & 10.5-11	< 3 & >11
Conductivity (mS/m)	19.4	27	21.3	<70	70-150	150-370	370-520	>520
	mg/L							
Total Dissolved Solids	124	173	137	<450	450-1000	1000-2400	2400-3400	>3400
Sodium (as Na)	16	35.6	19.5	<100	100-200	200-400	400-1000	>1000
Potassium (as K)	7.2	1.5	6.4	<25	25-50	50-100	100-500	>500
Magnesium (as Mg)	2.4	4.2	3.2	<70	70-100	100-200	200-400	>400
Calcium (as Ca)	6.5	1.6	6.3	<80	80-150	150-300	>300	
Chloride (as Cl)	32	81	40	<100	100-200	200-600	600-1200	>1200
Sulphate (as SO ₄)	5	8	4	<200	200-400	400-600	600-1000	>1000
Nitrate& Nitrite (as N)	<0,36	<0,36	<0,36	<6	6.0-10	10.0-20	20-40	>40
Fluoride (as F)	0.3	0	0.3	<0.7	0.7-1.0	1.0-1.5	1.5-3.5	>3.5
Manganese (as Mn)	4.43	0.04	5.32	<0.1	0.1-0.4	0.4-4	4.0-10.0	>10
Iron (as Fe)	0.4	0.3	0.1	<0.5	0.5-1.0	1.0-5.0	5.0-10.0	>10
Copper (as Cu)	<0,02	<0,02	<0,02	<1	1-1.3	1.3-2	2.0-15	>15
Zinc (as Zn)	<0,03	0.07	<0,03	<20	>20			

A number of chemical diagrams have been plotted for the three groundwater samples collected and these are useful for chemical characterisation of the water. The chemistry of the samples has been plotted on a tri-linear diagram known as a Piper diagram (**Figure 20**). The Piper diagram is a graphical plot of the relative concentrations of major cations (calcium – Ca, magnesium – Mg and sodium and potassium – Na+K) and anions (sulphate – SO_4 , chloride – Cl and alkalinity (carbonate and hydrogen carbonate) – $\text{CO}_3 + \text{HCO}_3$) in the water. The Piper diagram is used to provide a visual interpretation of the dominant cations and anions. This diagram indicates the distribution of cations and anions in separate triangles and then a combination of the chemistry in the central diamond. Water with similar chemical signatures will plot in close proximity to one another on the diagram.

From **Figure 20** (central diamond) the production boreholes groundwater sample is classified as having mainly a sodium – chloride hydrofacies. This is a typical water signature for the geological setting of the area.

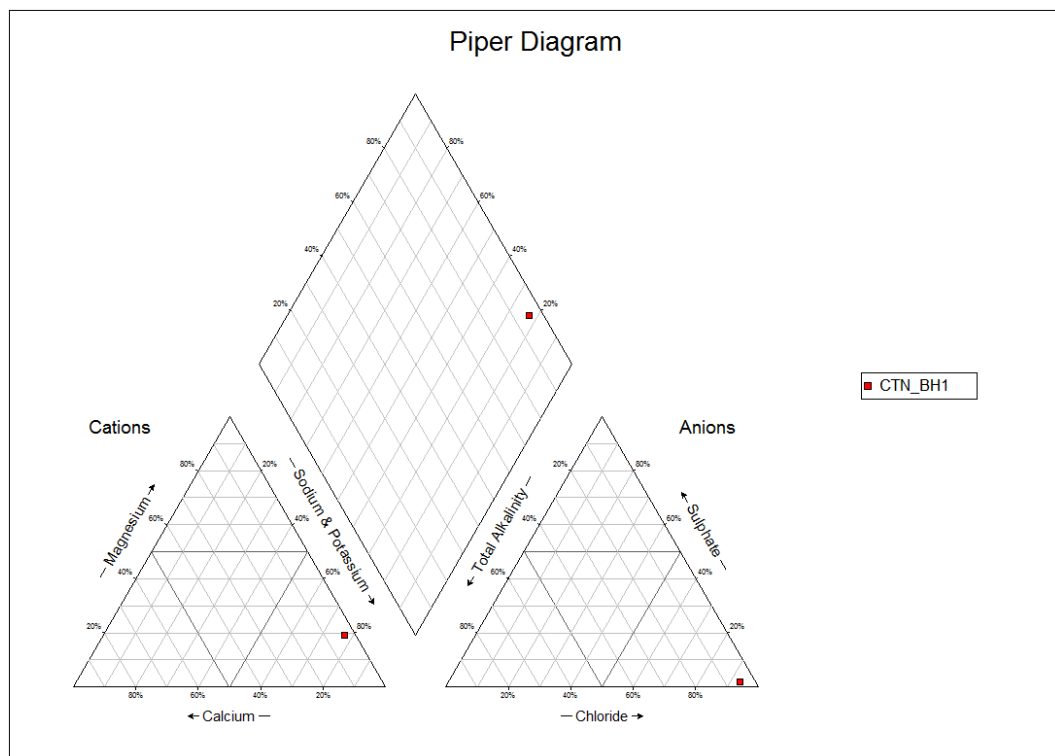


Figure 20: Piper diagram of the production borehole groundwater sample.

Another type of chemical diagram also represents water quality and that is called a Stiff diagram (**Figure 21**). The Stiff diagram is a graphical representation of the relative concentrations of the cations (positive ions) and anions (negative ions). This diagram shows concentrations of cations and anions relative to each other (not as a percentage as with Piper) and direct reference can be made to specific salts in the water. The Stiff diagram for the samples from the production boreholes is shown in **Figure 21**. From the shape of the Stiff diagram the major ions present in the water can be compared.

It is clear that the groundwater sample collected from borehole CTN_BH1 (Boorgat 1) is dominated by Na+K and Cl and that the groundwater has a low dissolved mineral concentration and in terms of general chemistry the groundwater is ideal for human consumption.

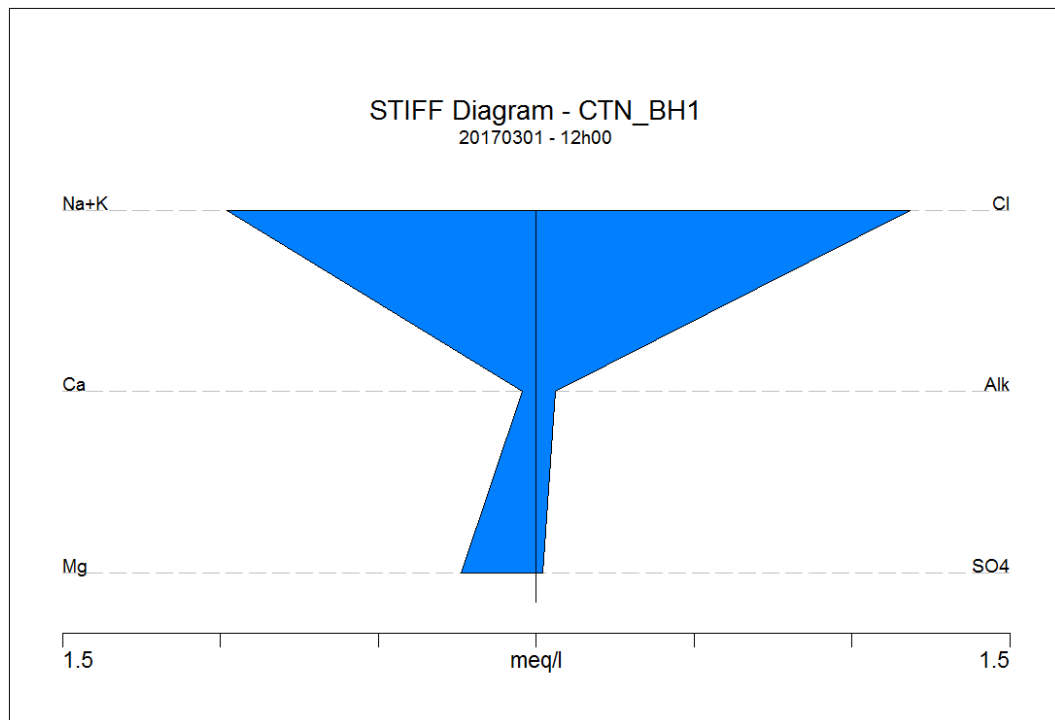


Figure 21: Stiff diagram of the production boreholes groundwater sample.

The groundwater sample is plotted on a SAR diagram to determine the suitability of the water for irrigation (**Figure 22**). The groundwater can be used for irrigation due to the low sodium and low salinity hazard.

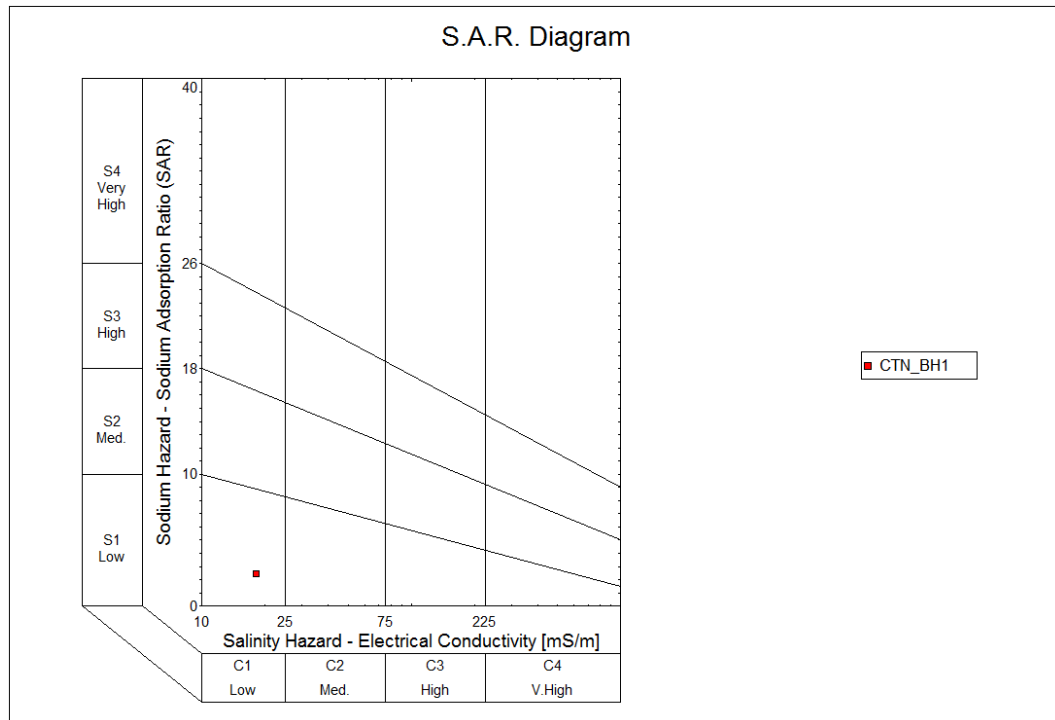


Figure 22: SAR diagram of the production borehole groundwater sample.

10. DISCUSSION

A search of the National Groundwater Archive (NGA) showed no boreholes located within 1 km of the farm boundary. It was confirmed that only one other groundwater user occurs within the 1 km radius of the property. This borehole is not in use due to poor water quality.

With regard to the groundwater resources of the study area, the geological setting is favourable for the occurrence of groundwater. On assessment of the geological map the Groundwater Response Unit (GRU) have an extent of about 200 km². Using the GRAII recharge values the direct vertical recharge is calculated to be in the region of 35 425 800 m³/a for the GRU. The firm yield of the GRU is calculated to be 1 876 369.24 m³/a.

The firm yield of the GRU is far in excess of the predicted water demand of the farm. The license application volume is therefor considered to be within the sustainable supply volume of the aquifer. It is important to note that a conservative approach was used to calculate the recharge and firm yield volumes and that the actual volumes are believed to be higher than the calculated volumes.

The borehole has also been correctly tested in terms of yield to determine the sustainable safe yield that can be abstracted from the aquifer system. The yield test indicates that the property may sustainably abstract 254 390 m³/a from the aquifer system. The proposed use is also the linked to the safe yield of the borehole and aquifer over-abstraction is very unlikely to occur.

The groundwater is mostly of good quality, but some parameters exceed guideline limits (SANS, 2015 and DWAF, 1998). The water might have to be treated to be fit for purpose. The groundwater will be used for agricultural purposes (irrigation) and for domestic use.

A groundwater requirement and supply analysis for the farm is provided below:

GROUNDWATER REQUIREMENT

- The current requirement for the farm is 50 000 m³/a. This is the volume requested in this license application.

GROUNDWATER SUPPLY

- The total safe groundwater yield for the borehole is 254 390.4 m³/a. The current available supply will meet the current requirement.

11. RECOMMENDATIONS

Based on the results obtained during the geohydrological investigation it is recommended that the application be approved however it is recommended the owner implements certain groundwater “best management practices”. It is important to note that these best management practises are merely a recommendation.

These include:

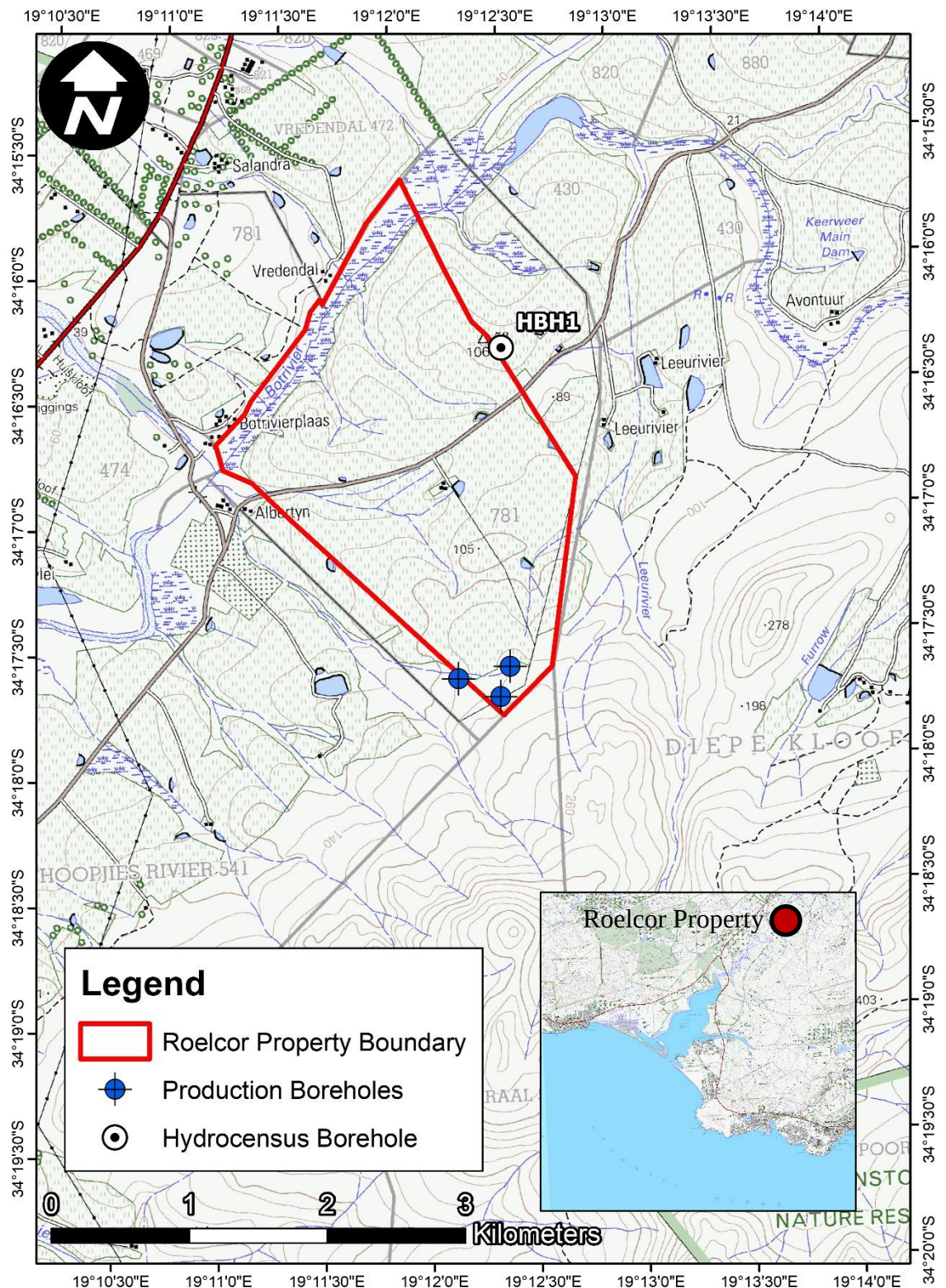
- The boreholes must be equipped with an observation tube (40 mm Class 10 PVC) to enable the water levels to be recorded easily and for easy installation of data loggers; a flow meter (pulse signal) and a sampling tap. An adjustable timer switch should also be installed to ensure the borehole doesn't pump for longer than 12 hours continuously
- During summer the water level should be measured daily (towards the end of the 12 hour pumping cycle) and recorded in a database. Note this is a conservative safe yield (for use throughout the year). It is feasible that more groundwater can be abstracted and to accurately determine how much more water can be abstracted the borehole should be equipped with a continuous water level data logger.
- The appropriate borehole pump must be installed, i.e. not an over-sized pump that is choked with a gate valve. If the monitoring shows that more water can be abstracted, then the duration of pumping time will be increased (not the flow rate).
- The borehole and pump should be serviced annually. A water sample should also be collected annually and the flow rate and volume of water abstracted recorded monthly (along with the measured water level).

A geohydrologist should review the above information to ensure optimal groundwater abstraction and management occurs.

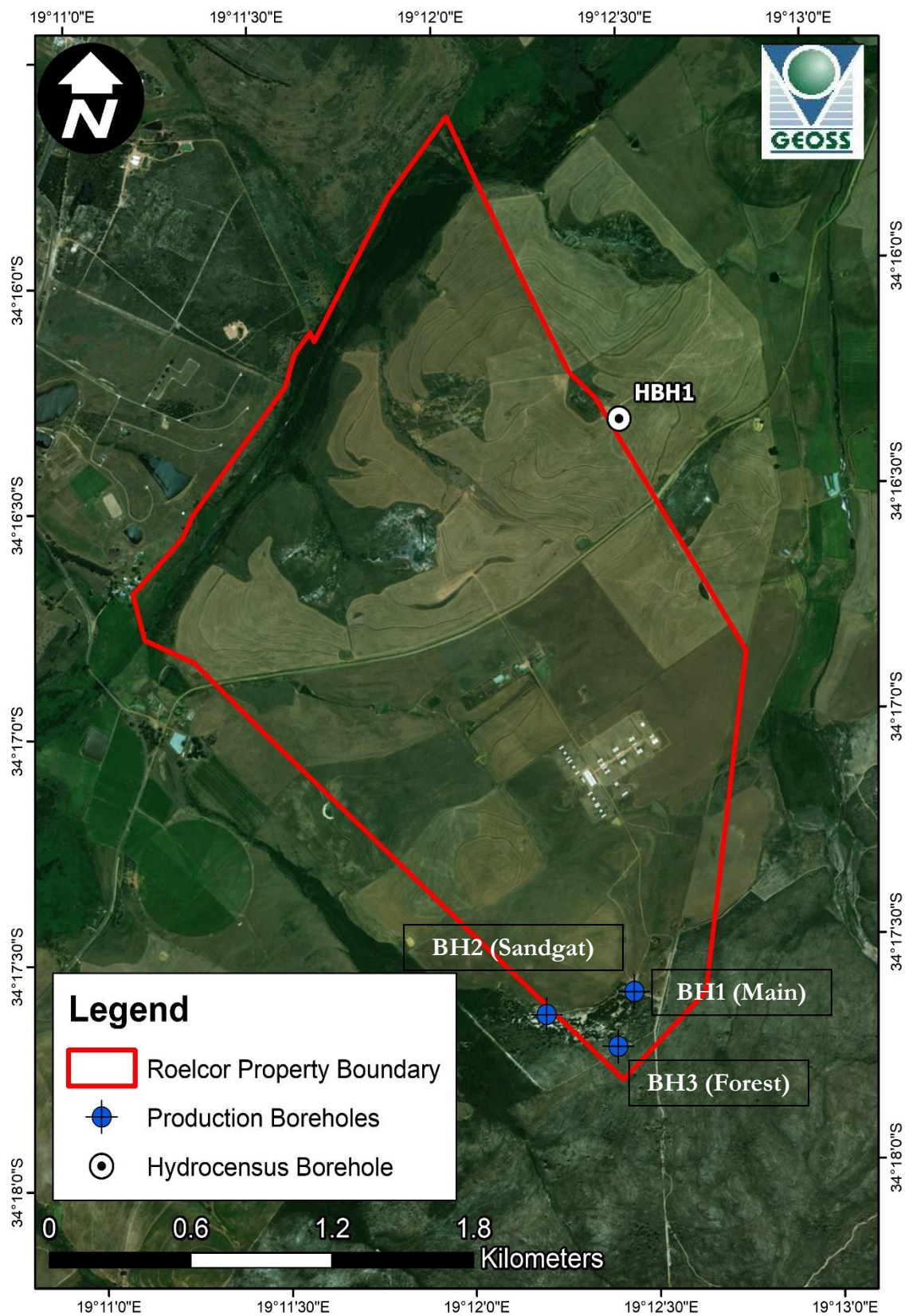
12. REFERENCES

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- DWAF (1998). The National Water Act, No 36. Department of Water Affairs and Forestry. Pretoria.
- DWAF (2005). Groundwater Resources Assessment Project, Phase II (GRAII). Department of Water Affairs and Forestry, Pretoria.
- Meyer, P. S., (2001). An explanation of the 1:500 000 General Hydrogeological map Cape Town 3317. Department of Water Affairs and Forestry, Pretoria.
- National Water Act (1998). The National Water Act, No 36. Department of Water Affairs and Forestry. Pretoria.

13. APPENDIX A: MAPS



Map 1: The study site and NGA boreholes superimposed on a 1:50 000 scale topocadastral map (3219).



Map 2: The study site and NGA borehole superimposed on an aerial photograph.

14. APPENDIX B: YIELD TEST DATA

Boorgat 1 – STEP TEST

FORM 5 E														
STEPPED DISCHARGE TEST & RECOVERY														
BOREHOLE TEST RECORD SHEET														
PROJ NO: T-4172-1				MAP REFERENCE:				PROVINCE: WESTERN CAPE						
BOREHOLE NO: 1				CO-ORDINATES:				DISTRICT: BOTRIVIER						
ALT BH NO:				LATITUDE:				SITE NAME: ROELCOR						
ALT BH NO:				LONGITUDE:										
BOREHOLE DEPTH (m): 130m				DATUM LEVEL ABOVE CASING (m): 0m				EXISTING PUMP:						
WATER LEVEL (mgl): 27.75				CASING HEIGHT (mgl): 0.180m				CONTRACTOR: DE VILLIERS VISSER BESPR. BK						
DEPTH OF PUMP (m): 120m				DIAM PUMP INLET (mm): 0.100m				PUMP TYPE: BESTAANDE POMP						
STEPPED DISCHARGE TEST & RECOVERY														
DISCHARGE RATE 1					DISCHARGE RATE 2					DISCHARGE RATE 3				
DATE: 20/06/2017		TIME: 18H00			DATE: 20/06/2017		TIME: 19H00			DATE: 20/06/2017		TIME: 20H00		
TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY
(MIN)	DOWN (M)	(L/H)	(MIN)	(M)	(MIN)	DOWN (M)	(L/H)	(MIN)	(M)	(MIN)	DOWN (M)	(L/H)	(MIN)	(M)
1	29.20	30 000	1		1	36.35	50 000	1		1	40.80	70 000	1	
2	29.95	30 000	2		2	36.94	50 000	2		2	41.34	70 000	2	
3	30.35	30 000	3		3	37.00	50 000	3		3	42.72	70 000	3	
5	31.28	30 000	5		5	37.27	50 000	5		5	43.51	70 000	5	
7	31.54	30 000	7		7	37.42	50 000	7		7	44.14	70 000	7	
10	31.74	30 000	10		10	37.56	50 000	10		10	44.14	70 000	10	
15	31.90	30 000	15		15	37.82	50 000	15		15	44.44	70 000	15	
20	32.26	30 000	20		20	38.21	50 000	20		20	44.70	70 000	20	
30	32.65	30 000	30		30	38.63	50 000	30		30	44.89	70 000	30	
40	32.92	30 000	40		40	38.90	50 000	40		40	45.25	70 000	40	
50	33.25	30 000	50		50	39.25	50 000	50		50	45.60	70 000	50	
60	33.51	30 000	60		60	39.43	50 000	60		60	45.95	70 000	60	
70			70		70			70		70			70	
80			80		80			80		80			80	
90			90		90			90		90			90	
100			100		100			100		100			100	
110			110		110			110		110			110	
120			120		120			120		120			120	
pH			150		pH			150		pH			150	
TEMP		C	180		TEMP		C	180		TEMP		C	180	
EC		ms/cm	210		EC		ms/cm	210		EC		ms/cm	210	
DISCHARGE RATE 4					DISCHARGE RATE 5					DISCHARGE RATE 6				
DATE: 20/06/2017		TIME: 21H00			DATE:		TIME:			DATE:		TIME: 300		
TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY
(MIN)	DOWN (M)	(L/H)	(MIN)	(M)	(MIN)	DOWN (M)	(L/H)	(MIN)	(M)	(MIN)	DOWN (M)	(L/H)	(MIN)	(M)
1	50.90	100 000	1		1			1		1			0	
2	52.29	100 000	2		2			2		2			0	
3	53.65	100 000	3		3			3		3			0	
5	54.50	100 000	5		5			5		5			0	
7	55.00	100 000	7		7			7		7			0	
10	55.26	100 000	10		10			10		10			0	
15	55.63	100 000	15		15			15		15			0	
20	55.79	100 000	20		20			20		20			0	
30	56.04	100 000	30		30			30		30			0	
40	56.36	100 000	40		40			40		40			0	
50	56.41	100 000	50		50			50		50			0	
60	56.54	100 000	60		60			60		60			0	
70			70		70			70		70			0	
80			80		80			80		80			0	
90			90		90			90		90			0	
100			100		100			100		100			0	
110			110		110			110		110			0	
120			120		120			120		120			0	
pH			150		pH			150		pH			0	
TEMP		C	180		TEMP		C	180		TEMP		C	0	
EC		ms/cm	210		EC		ms/cm	210		EC		ms/cm	0	
			240					240					0	
			300					300					0	
			360					360					0	

Boorgat 1 – CONSTANT TEST**FORM 5 F****CONSTANT DISCHARGE TEST & RECOVERY****BOREHOLE TEST RECORD SHEET**

PROJ NO: T-4172-1	MAP REFERENCE:	PROVINCE: WESTERN CAPE
BOREHOLE NO: 1	CO-ORDINATES:	DISTRICT: BOTRIVIER
ALT BHNO:	LATITUDE:	SITE NAME: ROELCOR
ALT BHNO:	LONGITUDE:	
BOREHOLE DEPTH: 130m	DATUM LEVEL ABOVE CASING (m): 0m	EXISTING PUMP:
WATER LEVEL (mbgl): 28.88	CASING HEIGHT (magl): 0.180m	CONTRACTOR: DE VILLIERS VISSER BESPR. BK
DEPTH OF PUMP (m): 120m	DIAM PUMP INLET (mm): 0.100m	PUMP TYPE: BESTAANDE POMP

CONSTANT DISCHARGE TEST & RECOVERY

TEST STARTED				TEST COMPLETED				DURATION:			
DATE: 21/06/2017		03H00		DATE: 22/06/2017		TIME: 03H00		TYPE OF PUMP:			
DISTANCE BETWEEN DISCHARGE:				OBSERVATION HOLE 1				OBSERVATION HOLE 2			
AND OBSERVATION HOLES IN M:				NR:				NR:			
DISCHARGE BOREHOLE				Distance:				Distance:			
TIME	DRAW	YIELD	TIME	RECOVERY	TIME	Drawdown	Recovery	TIME	Drawdown	Recovery	Conductivity
(MIN)	DOWN (M)	(L/H)	MIN	(M)	(min)	m	(m)	(min)	(m)		millisiemens
1	30.11	75 000	1	66.51	1			1			
2	30.87	75 000	2	66.14	2			2			
3	32.00	75 000	3	65.77	3			3			
5	34.36	75 000	5	65.36	5			5			
7	34.89	75 000	7	65.00	7			7			
10	35.17	75 000	10	64.86	10			10			
15	39.33	75 000	15	64.44	15			15			
20	40.96	75 000	20	64.09	20			20			
30	42.61	75 000	30	63.61	30			30			
40	43.00	75 000	40	63.25	40			40			
60	43.43	75 000	60	63.11	60			60			
90	44.31	75 000	90	60.87	90			90			
120	45.16	75 000	120	60.77	120			120			
150	46.31	75 000	150	58.81	150			150			
180	47.52	75 000	180	54.44	180			180			
210	48.51	75 000	210	52.28	210			210			
240	49.82	75 000	240	50.11	240			240			
300	50.86	75 000	300	46.26	300			300			
360	51.14	75 000	360	45.73	360			360			
420	51.87	75 000	420	45.11	420			420			
480	52.44	75 000	480	44.63	480			480			
540	53.00	75 000	540		540			540			
600	54.60	75 000	600		600			600			
720	57.00	75 000	720		720			720			
840	60.85	75 000	840		840			840			
960	63.46	75 000	960		960			960			
1080	64.98	75 000	1080		1080			1080			
1200	66.80	75 000	1200		1200			1200			
1320	67.11	75 000	1320		1320			1320			
1440	68.64	75 000	1440		1440			1440			
1560			1560		1560			1560			
1680			1680		1680			1680			
1800			1800		1800			1800			
1920			1920		1920			1920			
2040			2040		2040			2040			
2160			2160		2160			2160			
2280			2280		2280			2280			
2400			2400		2280			2280			
2520			2520		3120			3120			
2640			2640		2640			2640			
2760			2760		2760			2760			
2880			2880		2880			2880			
3000			3000		3000			3000			

Boorgat 2 – STEP TEST

FORM 5 E															
STEPPED DISCHARGE TEST & RECOVERY															
BOREHOLE TEST RECORD SHEET															
PROJ NO: T-4172-2		MAP REFERENCE:		PROVINCE: WESTERN CAPE											
BOREHOLE NO. 3 SANDBOORGA		CO-ORDINATES:		DISTRICT: BOTRIVIER											
ALT BH NO:		LATITUDE:		SITE NAME: ROELCOR											
ALT BH NO:		LONGITUDE:													
BOREHOLE DEPTH (m)		DATUM LEVEL ABOVE CASING (m): 0.340m		EXISTING PUMP:											
WATER LEVEL (m bgl): 9.60		CASING HEIGHT (magl): 0.380m		CONTRACTOR: DE VILLIERS VISSER BESPR. BK											
DEPTH OF PUMP (m): 120m		DIAM PUMP INLET (mm): 0.050m		PUMP TYPE: QFN 25-25/7.5KW.											
STEPPED DISCHARGE TEST & RECOVERY															
DISCHARGE RATE 1					DISCHARGE RATE 2					DISCHARGE RATE 3					
DATE: 21/06/2017		TIME: 18h30				DATE: 21/06/2017		TIME: 19h30				DATE: 21/06/2017		TIME: 20h30	
TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY	
(MIN)	DOWN (M)	(L/H)	(MIN)	(M)	(MIN)	DOWN (M)	(L/H)	(MIN)	(M)	(MIN)	DOWN (M)	(L/H)	(MIN)	(M)	
1	13.60	4 000	1		1	27.52	8 000	1		1	56.59	10 000	1		
2	14.51	4 000	2		2	28.55	8 000	2		2	57.44	10 000	2		
3	15.19	4 000	3		3	29.24	8 000	3		3	58.24	10 000	3		
5	16.21	4 000	5		5	30.92	8 000	5		5	60.14	10 000	5		
7	16.52	4 000	7		7	32.66	8 000	7		7	64.23	10 000	7		
10	16.81	4 000	10		10	35.71	8 000	10		10	67.70	10 000	10		
15	17.32	4 000	15		15	37.89	8 000	15		15	68.02	10 000	15		
20	18.30	4 000	20		20	40.04	8 000	20		20	68.43	10 000	20		
30	18.84	4 000	30		30	45.25	8 000	30		30	75.35	10 000	30		
40	19.20	4 000	40		40	49.49	8 000	40		40	94.11	10 000	40		
50	24.00	4 000	50		50	51.94	8 000	50		50	116.44	10 000	50		
60	25.20	4 000	60		60	54.42	8 000	60		60			60		
70			70		70			70		70			70		
80			80		80			80		80			80		
90			90		90			90		90			90		
100			100		100			100		100			100		
110			110		110			110		110			110		
120			120		120			120		120			120		
pH			150		pH			150		pH			150		
TEMP		C	180		TEMP		C	180		TEMP		C	180		
EC		ms/cm	210		EC		ms/cm	210		EC		ms/cm	210		
DISCHARGE RATE 4					DISCHARGE RATE 5					DISCHARGE RATE 6					
DATE: 21/06/2017		TIME: 21h30				DATE:		TIME:		DATE:		TIME:			
TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY	
(MIN)	DOWN (M)	(L/H)	(MIN)	(M)	(MIN)	DOWN (M)	(L/H)	(MIN)	(M)	(MIN)	DOWN (M)	(L/H)	(MIN)	(M)	
1			1		1			1		1			1		
2			2		2			2		2			2		
3			3		3			3		3			3		
5			5		5			5		5			5		
7			7		7			7		7			7		
10			10		10			10		10			10		
15			15		15			15		15			15		
20			20		20			20		20			20		
30			30		30			30		30			30		
40			40		40			40		40			40		
50			50		50			50		50			50		
60			60		60			60		60			60		
70			70		70			70		70			70		
80			80		80			80		80			80		
90			90		90			90		90			90		
100			100		100			100		100			100		
110			110		110			110		110			110		
120			120		120			120		120			120		
pH			150		pH			150		pH			150		
TEMP		C	180		TEMP		C	180		TEMP		C	180		
EC		ms/cm	210		EC		ms/cm	210		EC		ms/cm	210		
			240					240					240		
			300					300					300		
			360					360					360		

Boorgat 2 – CONSTANT TEST**FORM 5 F****CONSTANT DISCHARGE TEST & RECOVERY****BOREHOLE TEST RECORD SHEET**

PROJ NO: T-4172-2	MAP REFERENCE:	PROVINCE: WESTERN CAPE
BOREHOLE NO: 3 SANDBOORGAT	CO-ORDINATES:	DISTRICT: BOTRIVIER
ALT BHNO:	LATITUDE:	SITE NAME: ROELCOR
ALT BHNO:	LONGITUDE:	
BOREHOLE DEPTH:	DATUM LEVEL ABOVE CASING (m): 0.340m	EXISTING PUMP:
WATER LEVEL (mbgl) 15.31	CASING HEIGHT (magl): 0.380m	CONTRACTOR: DE VILLIERS VISSER BESPR. BK
DEPTH OF PUMP (m): 120m	DIA PUMP INLET (mm): 0.050m	PUMP TYPE: QFN25-25/7.5kW.

CONSTANT DISCHARGE TEST & RECOVERY

TEST STARTED				TEST COMPLETED				DURATION:			
DATE: 22/06/2017		09H00		TIME:		TYPE OF PUMP:					
DISTANCE BETWEEN DISCHARGE:				OBSERVATION HOLE 1		OBSERVATION HOLE 2					
AND OBSERVATION HOLES IN M:				NR:		NR:					
DISCHARGE BOREHOLE				Distance:		Distance:					
TIME (MIN)	DRAWN (M)	YIELD (L/H)	TIME (MIN)	RECOVERY (M)	TIME (min)	Drawdown (m)	Recovery (m)	TIME (min)	Drawdown (m)	Recovery	Conductivity (millisiemens)
1	17.20	4 500	1	46.60	1			1			
2	18.12	4 500	2	42.02	2			2			
3	18.74	4 500	3	41.57	3			3			
5	19.33	4 500	5	40.90	5			5			
7	19.83	4 500	7	38.55	7			7			
10	20.59	4 500	10	36.44	10			10			
15	21.00	4 500	15	34.28	15			15			
20	21.75	4 500	20	31.30	20			20			
30	28.76	4 500	30	30.98	30			30			
40	31.28	4 500	40	27.55	40			40			
60	35.85	4 500	60	28.58	60			60			
90	39.66	4 500	90	22.84	90			90			
120	42.05	4 500	120		120			120			
150	44.26	4 500	150		150			150			
180	45.19	4 500	180		180			180			
210	46.50	4 500	210		210			210			
240	47.29	4 500	240		240			240			
300	48.76	4 500	300		300			300			
360	50.50	4 500	360		360			360			
420	51.90	4 500	420		420			420			
480	53.14	4 500	480		480			480			
540	53.75	4 500	540		540			540			
600	54.16	4 500	600		600			600			
720	54.76	4 500	720		720			720			
840	55.34	4 500	840		840			840			
960	56.81	4 500	960		960			960			
1080	57.40	4 500	1080		1080			1080			
1200	57.72	4 500	1200		1200			1200			
1320	58.17	4 500	1320		1320			1320			
1440	58.30	4 500	1440		1440			1440			
1560			1560		1560			1560			
1680			1680		1680			1680			
1800			1800		1800			1800			
1920			1920		1920			1920			
2040			2040		2040			2040			
2160			2160		2160			2160			
2280			2280		2280			2280			
2400			2400		2400			2400			
2520			2520		2520			2520			
2640			2640		2640			2640			
2760			2760		2760			2760			
2880			2880		2880			2880			
3000			3000		3000			3000			
3120			3120		3120			3120			
3240			3240		3240			3240			

Boorgat 3 – STEP TEST

FORM 5 E														
STEPPED DISCHARGE TEST & RECOVERY														
BOREHOLE TEST RECORD SHEET														
PROJ NO: T-4172-3				MAP REFERENCE:				PROVINCE: WESTERN CAPE						
BOREHOLE NO: 2				CO-ORDINATES:				DISTRICT: BOTRIVIER						
ALT BH NO:				LATITUDE:				SITE NAME: ROELCOR						
ALT BH NO:				LONGITUDE:										
BOREHOLE DEPTH (m)				DATUM LEVEL ABOVE CASING (m): 0.270m				EXISTING PUMP: ST-35-36/4kW.						
WATER LEVEL (m bgl): 20.21				CASING HEIGHT (magl): 0.340m				CONTRACTOR: DE VILLIERS VISSER BESPR. BK						
DEPTH OF PUMP (m): 120m				DIAM PUMP INLET (mm): 0.050m				PUMP TYPE: QFM 25-25 7.5kW.						
STEPPED DISCHARGE TEST & RECOVERY														
DISCHARGE RATE 1					DISCHARGE RATE 2					DISCHARGE RATE 3				
DATE: 26/06/2017		TIME: 23H30			DATE: 27/06/2017		TIME: 00H30			DATE: 27/06/2017		TIME: 01H30		
TIME (MIN)	DRAW DOWN (M)	YIELD (L/H)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/H)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/H)	TIME (MIN)	RECOVERY (M)
1	23.17	5 000	1		1	46.44	8 000	1		1	70.65	10 000	1	
2	25.29	5 000	2		2	48.36	8 000	2		2	72.12	10 000	2	
3	27.12	5 000	3		3	49.61	8 000	3		3	73.12	10 000	3	
5	28.84	5 000	5		5	50.30	8 000	5		5	75.37	10 000	5	
7	29.05	5 000	7		7	55.73	8 000	7		7	78.05	10 000	7	
10	29.21	5 000	10		10	59.00	8 000	10		10	81.90	10 000	10	
15	30.49	5 000	15		15	61.09	8 000	15		15	90.44	10 000	15	
20	36.00	5 000	20		20	64.59	8 000	20		20	92.36	10 000	20	
30	38.51	5 000	30		30	66.05	8 000	30		30	95.11	10 000	30	
40	43.09	5 000	40		40	66.91	8 000	40		40	97.88	10 000	40	
50	43.78	5 000	50		50	67.56	8 000	50		50	98.94	10 000	50	
60	44.38	5 000	60		60	68.05	8 000	60		60	99.33	10 000	60	
70			70		70			70		70			70	
80			80		80			80		80			80	
90			90		90			90		90			90	
100			100		100			100		100			100	
110			110		110			110		110			110	
120			120		120			120		120			120	
pH			150		pH			150		pH			150	
TEMP		C	180		TEMP		C	180		TEMP		C	180	
EC		ms/cm	210		EC		ms/cm	210		EC		ms/cm	210	
DISCHARGE RATE 4					DISCHARGE RATE 5					DISCHARGE RATE 6				
DATE: 27/06/2017		TIME: 02H30			DATE:		TIME:			DATE:		TIME: 300		
TIME (MIN)	DRAW DOWN (M)	YIELD (L/H)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/H)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/H)	TIME (MIN)	RECOVERY (M)
1	103.44	12 000	1		1			1		1			0	
2	105.11	12 000	2		2			2		2			0	
3	105.78	12 000	3		3			3		3			RPM	
5	107.04	12 000	5		5			5		5			TIME	RECOVERY
7	108.00	12 000	7		7			7		7			(MIN)	(M)
10	109.44	12 000	10		10			10		10			0	
15	112.89	12 000	15		15			15		15			0	
20	115.77	12 000	20		20			20		20			0	
30			30		30			30		30			0	
40			40		40			40		40			0	
50			50		50			50		50			0	
60			60		60			60		60			0	
70			70		70			70		70			0	
80			80		80			80		80			0	
90			90		90			90		90			0	
100			100		100			100		100			0	
110			110		110			110		110			0	
120			120		120			120		120			0	
pH			150		pH			150		pH			0	
TEMP		C	180		TEMP		C	180		TEMP		C	0	
EC		ms/cm	210		EC		ms/cm	210		EC		ms/cm	0	
			240					240					0	
			300					300					0	
			360					360					0	

Boorgat 3 – CONSTANT TEST**FORM 5 F****CONSTANT DISCHARGE TEST & RECOVERY****BOREHOLE TEST RECORD SHEET**

PROJ NO: T-4172-3	MAP REFERENCE:	PROVINCE: WESTERN CAPE
BOREHOLE NO: 2	CO-ORDINATES:	DISTRICT: BOTRIVIER
ALT BHNO:	LATITUDE:	SITE NAME: ROELCOR
ALT BHNO:	LONGITUDE:	
BOREHOLE DEPTH:	DATUM LEVEL ABOVE CASING (m): 0.270m	EXISTING PUMP: ST-3536/4kW.
WATER LEVEL (mbgl): 20.9	CASING HEIGHT (magl): 0.340m	CONTRACTOR: DE VILLIERS VISSER BESPR. BK
DEPTH OF PUMP (m): 120m	DIAM PUMP INLET (mm): 0.050m	PUMP TYPE: QFM 25-25 7.5kW.

CONSTANT DISCHARGE TEST & RECOVERY

TEST STARTED					TEST COMPLETED					DURATION:				
DATE: 27/06/2017		TIME: 12H00		DATE: 28/06/2017		TIME: 12H00		TYPE OF PUMP:						
DISTANCE BETWEEN DISCHARGE:					OBSERVATION HOLE 1		OBSERVATION HOLE 2							
AND OBSERVATION HOLES IN M:					NR:		NR:							
DISCHARGE BOREHOLE					Distance:		Distance:							
TIME (MIN)	DRAW DOWN (M)	YIELD (L/H)	TIME (MIN)	RECOVERY (M)	TIME (min)	Drawdown (m)	Recovery (m)	TIME (min)	Drawdown (m)	Recovery (m)			Conductivity (millisiemens)	
1	31.07	6 480	1	67.20	1			1						
2	32.43	6 480	2	63.32	2			2						
3	33.00	6 480	3	58.11	3			3						
5	35.57	6 480	5	52.50	5			5						
7	41.17	6 480	7	48.11	7			7						
10	46.20	6 480	10	43.16	10			10						
15	48.29	6 480	15	40.81	15			15						
20	50.90	6 480	20	37.19	20			20						
30	56.00	6 480	30	35.88	30			30						
40	61.13	6 480	40	33.01	40			40						
60	64.52	6 480	60	31.89	60			60						
90	59.59	6 480	90	29.00	90			90						
120	71.00	6 480	120	26.10	120			120						
150	72.24	6 480	150	22.84	150			150						
180	72.55	6 480	180		180			180						
210	72.68	6 480	210		210			210						
240	72.80	6 480	240		240			240						
300	73.23	6 480	300		300			300						
360	73.33	6 480	360		360			360						
420	73.40	6 480	420		420			420						
480	73.50	6 480	480		480			480						
540	73.57	6 480	540		540			540						
600	73.64	6 480	600		600			600						
720	73.69	6 480	720		720			720						
840	73.78	6 480	840		840			840						
960	73.82	6 480	960		960			960						
1080	73.90	6 480	1080		1080			1080						
1200	74.00	6 480	1200		1200			1200						
1320	74.09	6 480	1320		1320			1320						
1440	74.10	6 480	1440		1440			1440						
1560			1560		1560			1560						
1680			1680		1680			1680						
1800			1800		1800			1800						
1920			1920		1920			1920						
2040			2040		2040			2040						
2160			2160		2160			2160						
2280			2280		2280			2280						
2400			2400		2480			2480						
2520			2520		3120			3120						
2640			2640		2640			2640						
2760			2760		2760			2760						
2880			2880		2880			2880						
3000			3000		3000			3000						
3120			3120		3120			3120						
3240			3240		3240			3240						

15. APPENDIX C: LABORATORY CERTIFICATE



16 Van der Berg Crescent
Gant's Centre
Strand

Tel. (021) 853-1490
Fax (021) 853-1423

E-Mail admin@bemlab.co.za

P O Box 684
Somerset Mall,
7137

Vat Reg. Nr. 4200161414

CERTIFICATE OF ANALYSES

Report Nr.: WT009657.DOC

Julian Conrad
GEOSS (Pty) Ltd
Unit 19, Technostell Building
9 Quantum Street, Technopark
Stellenbosch
7600

Date received: 30-06-2017
Order nr.: #2096 PhB

Sampled by client

Water Analyses Report

Origin	Lab. Nr.	pH @ 25°C	EC @ 25°C mS/m	Na mg/l	K mg/l	Ca mg/l	Mg mg/l	Fe mg/l	Cl mg/l	CO ₃ ²⁻ mg/l	HCO ₃ ⁻ mg/l	SO ₄ mg/l	B mg/l	Mn mg/l	Cu mg/l	Zn mg/l	P mg/l	NH ₄ -N mg/l	NO ₃ -N mg/l	*F mg/l	*TDS mg/l
Boorgat 1	9657	6.6	19.4	16.0	7.2	6.5	2.4	0.4	32.0		80.0	5	0.09	4.43	<0.02	<0.03	0.03	<0.28	<0.36	0.3	124.0
Boorgat 3	9658	4.9	27.0	35.6	1.5	1.6	4.2	0.3	81.0		9.0	8	0.15	0.04	<0.02	0.07	<0.01	<0.28	<0.36	0.0	173.0
Sandgat	9659	6.5	21.3	19.5	6.4	6.3	3.2	0.1	40.0		80.0	4	0.14	5.32	<0.02	<0.03	<0.01	<0.28	<0.36	0.3	137.0

Origin	Lab. Nr.	Alkalinity mg/l	Date Sampled	Temperature at reception (°C)	Date Analysed
Boorgat 1	9657	66.00	27/06/2017	16.7	03/07/2017
Boorgat 3	9658	<11.49	28/06/2017	17.1	03/07/2017
Sandgat	9659	66.00	Unknown	15.9	03/07/2017

* = Not SANAS Accredited

Statement: The reported results may be applied only to samples received. Any recommendations included with this report are based on the assumption that the samples were representative of the source from which they were taken.

Notes:

To ensure sample integrity, samples are stored only for seven days after release of the report. Thereafter it is disposed of and a fresh sample will be required if additional analyses are requested.

Results marked with "Not SANAS Accredited" in this report are not included in the SANAS Schedule of Accreditation for this laboratory. These results relate to the items tested.

This test report shall not be reproduced except in full, without written approval of the laboratory.

CO₃²⁻ analysis only applicable in case of pH > 7.5.

Refer to [website](http://www.bemlab.co.za) for uncertainty of measurement and referenced methods.

Sample condition: Samples received in good condition.


Dr. Pieter Raath
General Manager


Lauren Taylor
Technical Signatory(Microbiology)

04-07-2017
Date reported

—————END OF REPORT—————