HYDROGEOLOGICAL ASSESSMENT STUDY FOR A PROPOSED PHOTO VOLTAIC SOLAR FARM TO BE LOCATED ON REMAINING EXTENT PORTION 3 OF THE FARM ROOIKRAAL 156 IR, LOCATED IN THE GAUTENG PROVINCE.

Prepared for

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EXECUTIVE SUMMARY

This document presents the results of a Hydrogeological Assessment study which aims to establish a reference of hydrogeological data to form part of a Water Use Licence (WUL) application.

The developer, Merchant Energy, wants to develop a Photo Voltaic Solar farm on the Remaining Extent Portion 3 of the farm Rooikraal 156 IR. The water demand is 24 700m3/annum or 67m3/d.

One groundwater abstraction borehole had to be drilled, and yield tested for the project. This one borehole is available which will be used to supply in the water demand for the Photo Voltaic Solar Farm.

The surface area of Remaining Extent of Portion 3 of the farm Rooikraal is 223.2582ha in extent. The aim of this study is to serve as a Geohydrological study for a Water Use Licence (WUL) application. HK Geohydrological Services Pty Ltd was appointed by Merchant Energy to do the hydrogeological study.

A desk study was performed to gather relevant geological and geohydrological information. A hydro - census followed the desk study to establish information such as water level and borehole depths in existing boreholes in the region of the site. The purpose of this survey was to gather relevant hydrogeological information to study the groundwater regime, hydrogeological information of current groundwater use, water level depth and borehole coordinates in the area. Two boreholes located on the farm portion and around the farm portion could be visited during the field visits. One water level depth could be measured in the two boreholes visited during the field visit. One borehole is destroyed and could not be used to measure a water level depth.

A geological and walk-over study was done to determine the in-situ geology. An attempt was made to rehabilitate the two existing boreholes. None of the two boreholes could be rehabilitated. One borehole was re-drilled next to the old borehole that could not be rehabilitated. Borehole drilling supervision was done during the drilling process of the borehole. This borehole was submitted to borehole yield testing procedures. The borehole yield test data was interpreted, and a sustainable water abstraction rate was calculated and recommended.

A water sample was taken from the tested borehole to be analysed for water quality purposes. The water quality was measured against drinking water standards.

The scale of abstraction was calculated by using the surface area of the farm portion. The surface area of the farm portion was also used to calculate groundwater recharge. The groundwater demand was measured against the groundwater recharge on the farm portion. A groundwater monitoring program was proposed to facilitate groundwater monitoring during the implementation phase of the project.

During the hydrogeological study the following conclusions could be made:

- The water demand for the Solar Farm from groundwater will be 24 700m^3/a or 67m^3/d.
- The one available groundwater production boreholes BH 1 can be recommended for 216m^3/d to supply in the water demand for the planned Solar Farm on Remaining Extent Portion 3 of the farm Rooikraal 156 IR.
- Based on the calculations for the surface area of Remaining Extent Portion 3 of the farm Rooikraal 156 IR, from which the borehole at the mentioned farm portion can gain groundwater, the abstraction is 13.5 % of groundwater recharge and can be classified as Category A – Small Scale Abstraction (<60%) of recharge on the catchment area.
- The mean groundwater recharge on the Remaining Extent Portion 3 of the farm Rooikraal 156 IR, is calculated to be in the order of 82.2mm/a or 11.3% of MAP or 183 518m^3/a or 502.8m^3/d or 11.6ℓ/s for 12h/d.
- The chemical water quality analyses of the one borehole BH 1 show that none of the chemical parameters analysed for, is above the standard limits. Chemically the water of this borehole is good quality water that can be used for domestic, and irrigation use without treatment to improve the chemical water quality.
- The Total Coliform count is 13 CFU/100mℓ, which means that the water must be chlorinated and filtrated prior to human consumption.
- The groundwater recharge figure calculated in this study and the borehole yield tests show that the water demand of 67m^3/d is sustainable for long term water abstraction.

The following recommendation can be made:

- Use water as a scarce commodity.
- Do not over abstract the borehole.
- Follow the groundwater monitoring plan as stipulated in this report.

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1. INTRODUCTION

1.1 Background

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The developer, Merchant Energy, wants to develop a Photo Voltaic Solar farm on the Remaining Extent Portion 3 of the farm Rooikraal 156 IR. The water demand is 24 700m3/annum or 67m3/d.

One groundwater abstraction borehole had to be drilled, and yield tested for the project. This one borehole is available which will be used to supply in the water demand for the Photo Voltaic Solar Farm.

The surface area of Remaining Extent of Portion 3 of the farm Rooikraal is 223.2582ha in extent. The aim of this study is to serve as a Geohydrological study for a Water Use Licence (WUL) application. HK Geohydrological Services Pty Ltd was appointed by Merchant Energy to do the hydrogeological study.

1.2 Scope of investigation

The scope of work can be defined as follows:

1) Desk study of the geology and groundwater regime.
2) Hydro-census of existing boreholes and surface water bodies in a radius around the planned development area.
3) Drilling supervision and presenting of borehole drilling information.
4) Borehole yield testing supervision and presenting borehole yield test data.
5) Taking of one water sample from the borehole for chemical and bacteriological quality analyses.
6) Interpretation of the data set of the constant discharge test of the borehole submitted to borehole yield testing procedures.
7) Compilation of a Category A Geohydrological study report which will contain the hydro-census information, geological description, groundwater flow directions, surface water bodies and boreholes.
8) Groundwater monitoring network and monitoring program for long term monitoring of the groundwater regime.

1.3 Water use licence application information

To abstract water from an aquifer on a large scale for commercial farming activities, a water use

license will be needed. A Regional - Initial calculation is done to determine the amount of information necessary for each new Water Use License Application (WULA) for groundwater abstraction.

Scale of abstraction for the surface area of Remaining Extent of Portion 3 of the Farm Rooikraal 156 IR.

The calculations for the scale of abstraction for the planned activities are based on the following:

- Size of the property ($Area_{prop}$). Surface area of the land portions is 223.2582ha in extent.
- Recharge – HP (RE). Groundwater recharge taken as 82.2mm per annum. (Calculation in Section 6.3)
- Existing use volumes (ABS_{ex}). $0m^3/d$ or $0m^3/a$
- New use volumes (ABS_{new}). $67m^3/d$ or $24\ 700m^3/a$.
- Scale of abstractions (ABS_{scale})

Calculations: -

Groundwater Recharge

$Area_{prop\ x}$ RE		=	RE $_{area}$ (m^3/a)
$Area_{prop}$	= $2.232582Km^2$	=	$2\ 232\ 582\ m^2$
RE		=	82.2mm/annum
$2\ 232\ 582m^2$ x (0.0822m)		=	**$183\ 518\ m^3/a$ or $502.8m^3/d$**

Groundwater Demand

ABS_{ex} + ABS $_{new}$		=	ABS total (m^3/a)
$0m^3/d + 67m^3/d$		=	**$24\ 700m^3/a$ or $67m^3/d$**

The Scale of Abstraction is:

ABS_{scale}	=	(ABS $_{total}$ / RE $_{Area}$) x 100
	=	($24\ 700m^3/a$ / $183\ 518m^3/a$) x 100
	=	**13.5 %**

Scale of abstraction for the surface area of Remaining Extent Portion 3 of the farm Rooikraal 156 IR.

Based on the calculations for the delineated groundwater catchment area, the abstraction is classified as Category A – Small Scale Abstraction (<60%) of recharge on the catchment area. The geohydrological report is therefore a Category A study. The Category A study requirements are taken from the Water Use License Application Requirements of the Department of Human Settlement, Water and Sanitation (DHSWS) Former Department of Water and Sanitation (DWS).

Category A

- Volume and purpose of water required.

- Detail borehole on the property in question. Information to be collected for each borehole should at least include pump installation depth, borehole depth, depth of water level, yield of the borehole, depth of water strike(s), volume abstracted (daily, weekly, monthly).
- Proximity to surface water discharges (springs, seeps, wetlands, streams, rivers, lakes) and groundwater dependent ecosystems.
- Geo-referenced map of the property in question, with boreholes, surface water features, geological features, physical structures (houses, stores, irrigation equipment) and current pollution sources (septic tanks, pit latrines, petrol/ diesel tanks, irrigation areas) depicted.
- Monitoring program - weekly water levels, weekly rainfall.

The Department of Water Affairs and Forestry recommends that the following measures be taken when testing boreholes for sustainable yields and to provide the following information:

- Refer to test procedures in the South African National Standards Code No.: SANS 10299.
- Perform a three (3) hour stepped draw down test to determine the discharge rate of the intended constant rate test OR;
- The constant discharge test should be done at approximately $^2/_3$ of the blow yield of the borehole.
- For **HOUSEHOLD** use it as recommended that an 8-hour constant rate test be performed with the draw down and the recovery measured.
- For **IRRIGATION** it as recommended that a 24 constant rate test should be performed whiles the draw down and the recovery is measured. This test could also be performed for intended **BULK WATER SUPPLY** for a volume of up to 150 000 m^3 per annum.
- For **BULK WATER SUPPLY** in excess of 150 000 m^3 per annum it is recommended that a 72-hour constant rate test should be performed while the draw down and the recovery of the bore hole is measured.
- All data as obtained above should be attached to the relevant Water Use License Application forms, together with an analysis of the data (including draw down curves) and recommendation for the sustainable yield of the borehole(s), by a qualified Geo-hydrologist.

2. CLIMATE AND REGIONAL SETTING

2.1 Catchment area

The proposed development is in the Gauteng Province in quaternary sub-catchment C22C. Refer to Map 1. The proposed development is located south of Boksburg and west of Springs.

2.2 Climate

The climate at the proposed development area is warm with wet summers with cold and dry winters.

2.3 Rainfall

The site is in Weather Bureau section number 0476 and in rainfall zone C2B. The rainfall period for station 0476403 covers the years from 1905 to 1989. The Mean Annual Precipitation (MAP) for the period from 1904 to 1989 is 728mm/a. Rainfall occurs as typical summer thunderstorms with lightning and strong winds. Summer rainfall is typically from November to March, in which approximately 74.79% of rainfall normally occurs. The typical dry period is between April and October each year, covering the winter months.

2.4 Evaporation

The proposed development is in Evaporation Zone 11A. The closest Evaporation station A2E009, the Jan Smuts station, is located approximately 20km north of the proposed development and gives a mean annual evaporation (MAE) of 1765 mm for the S-Pan value. The evaporation measurements cover the year 1957 to 1965.

2.5 Drainage area

The site is in Hydro Zone C with a Mean Annual Runoff (MAR) of 20 to 50mm per annum.

3. METHODOLOGY

A desk study was performed to gather relevant geological and geohydrological information. A hydro - census followed the desk study to establish information such as water level and borehole depths in existing boreholes in the region of the site. The purpose of this survey was to gather relevant hydrogeological information to study the groundwater regime, hydrogeological information of current groundwater use, water level depth and borehole coordinates in the area. Two boreholes located on the farm portion and around the farm portion could be visited during the field visits. One water level depth could be measured in the two boreholes visited during the field visit. One borehole is destroyed and could not be used to measure a water level depth.

A geological and walk-over study was done to determine the in-situ geology. An attempt was made to rehabilitate the two existing boreholes. None of the two boreholes could be rehabilitated. One borehole was re-drilled next to the old borehole that could not be rehabilitated. Borehole drilling supervision was done during the drilling process of the borehole. This borehole was submitted to borehole yield testing procedures. The borehole yield test data was interpreted, and a sustainable water abstraction rate was calculated and recommended.

A water sample was taken from the tested borehole to be analysed for water quality purposes. The water quality was measured against drinking water standards.

The scale of abstraction was calculated by using the surface area of the farm portion. The surface area of the farm portion was also used to calculate groundwater recharge. The groundwater demand was measured against the groundwater recharge on the farm portion. A groundwater

monitoring program was proposed to facilitate groundwater monitoring during the implementation phase of the project.

4. GEOLOGICAL SETTING

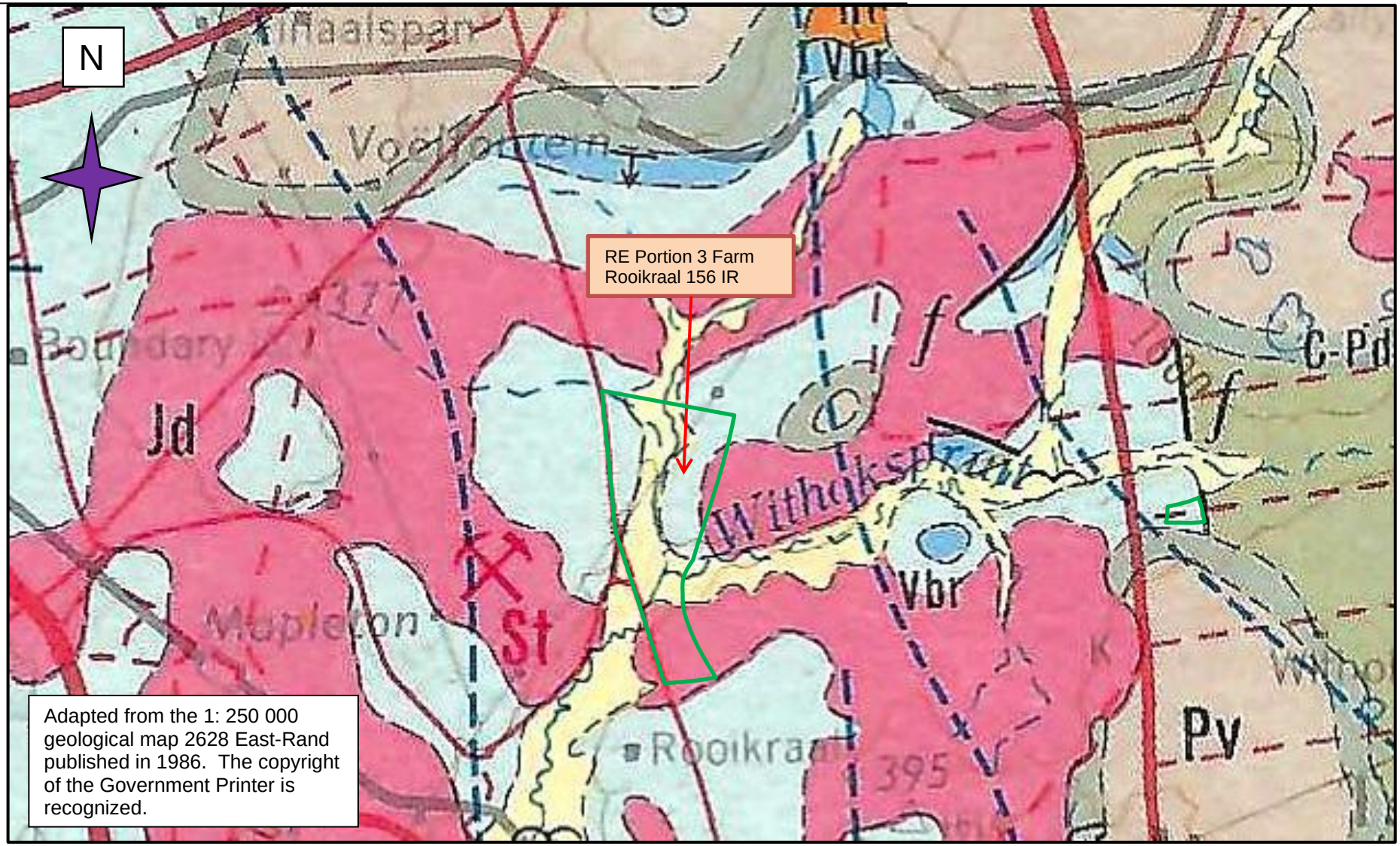
The 1:250 000 Geological Series map no 2626 West Rand indicates that the area of interest lies on the Transvaal sequence on the Chuniespoort Group and the Malmanie Subgroup which consists of Dolomite, chert and remnants of chert.

Below in Table 1 is a short summary of the lithology of the interested area. The geology map is below on Map 2, which show the regional geology. The boundary of the Remaining Extent of Portion 3 of the farm Rooikraal 156 IR, is marked in green on Map 2.

Table 1: Summary of the Lithology of the area.

		SEDIMENTARY AND VOLCANIC ROCKS					INTRUSIVE ROCKS	
Era		Group	Subgroup	Formation	Lithology	Colour	Colour	Lithology
QUATERNARY					Alluvium			
JURASSIC							Jd	Dolerite
PERMIAN	KAROO SEQUENCE	ECCA		Vryheid	Sandstone, shale, coal	Pv		
				Dwyka	Diamichtite and shale	C-Pd		
VAALIUM	TRANSVAAL SEQUENCE	PRETORIA		Hekpoort	Andesite , conglomerate	Vh		
				Boshoek	Quartzo feldspathic gneiss	Vbo		
				Timeball Hill	Ferugenous shale, hornfels	Vt		
		CHUNIESPOORT	Malmanie		Dolomite, chert and remnants of chert	Vmd		

Map 1: Regional locality map.



Map 2: Map Series 1: 250 000 Geological map 2628 East-Rand (Not to Scale).

5. FIELD WORK

5.1 Hydro census data

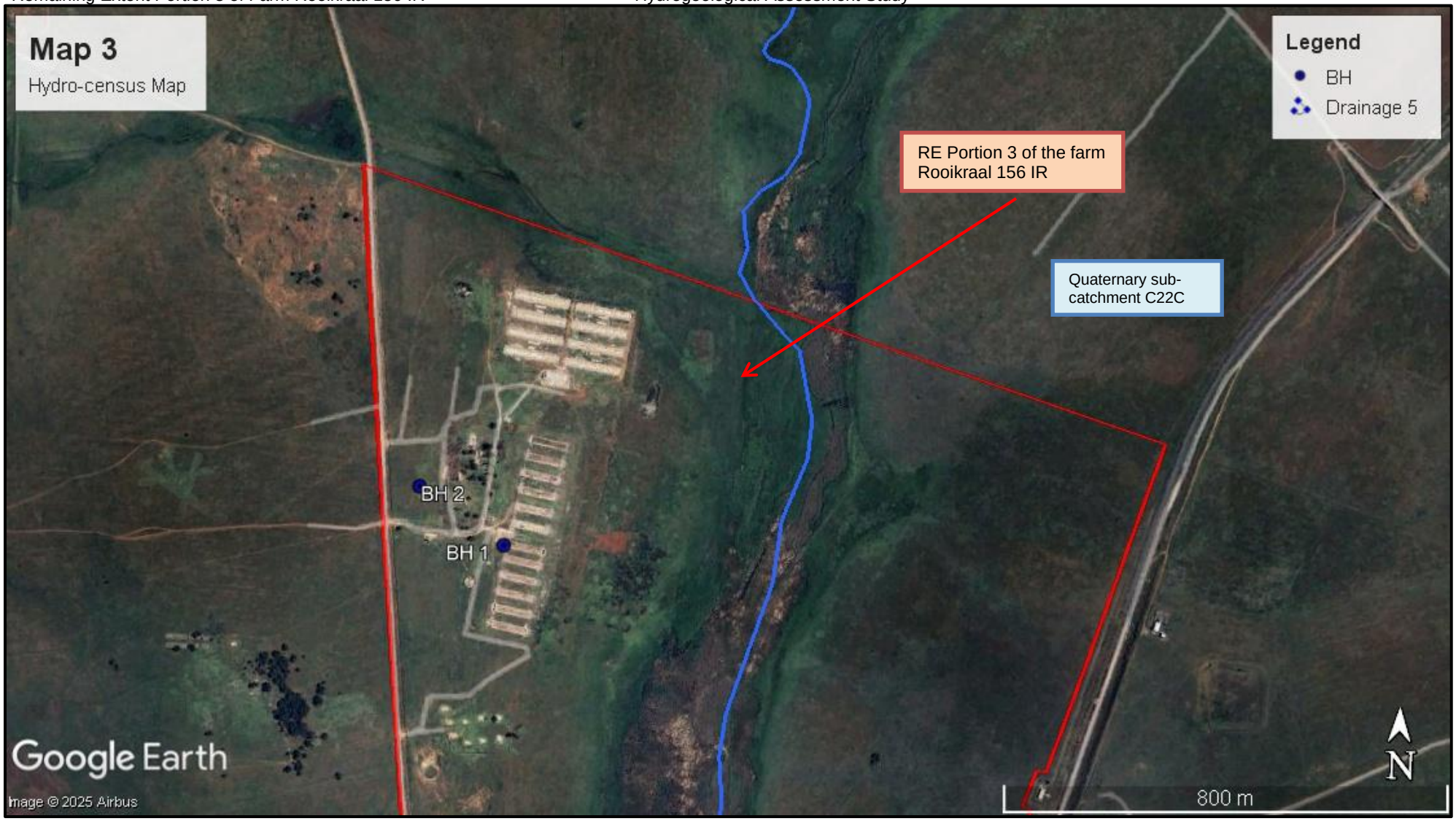
The hydro-census aimed to gather information such as water level depths, borehole depth where possible, water end-user and contact details of owners of the boreholes.

Only two boreholes could be found in the region on the Remaining Extent of Portion 3 of the farm Rooikraal 156. Water level depths could be taken in one (BH 1) of the two boreholes. The other borehole is destroyed. The water level depth measured in the one borehole measured 9.00 metres below ground level (mbgl).

No other boreholes do exist in at least a two km radius from the site boundary. The positions of the boreholes visited, are given on Map 3 and 4 with more information on water level depths and coordinates in Table 2 below. Map 4 is a more detailed map and shows the positions of the boreholes and surface water tributaries in more detail.

TABLE 2: Borehole hydro census details

BH	Lat	Long	Altitude (mamsl)	WL Depth (mbgl)	WL height (mamsl)	Remarks
Boreholes located on Remaining Extent of Portion 3 of the farm Rooikraal 156 IR.						
BH 1	-26.321800°	027.290720°	1563	9.00	1554	Newly drilled borehole. Not equipped.
BH 2	-26.320892°	027.289178°	1568	---	---	Borehole destroyed



Map 3: Regional Hydro Census Map.

Map 4: Detail hydro-census map.

5.2 Borehole Drilling

Borehole drilling supervision was done of the one borehole that was drilled. The borehole was drilled on 22 January 2025. The geology and borehole construction data were gathered during the drilling process. Casing was placed from surface to 24 meters below ground level. The blow out yield was measured at the end of the drilling of the borehole. The blow out yield was estimated to be 5ℓ/s. Dolomite and chert were drilled from 0 meters to 24 meters in depth.

Table 3 below shows the data gathered during the drilling process.

TABLE 3: Lithology and borehole construction information

Borehole Number	Position on Geophysical Traverse	Borehole Depth	Blow out yield	Geology
BH 1	15 meters south of the existing destroyed borehole	24	±5 ℓ/s	0.- 6: Chert, Brown, weathered. 6 – 9: Dolomite, Blue, fresh. 9 – 35, Chert, Brownish, blue, weathered, fresh. WS 15 to 20m **Casing** 0 – 12m 165mm, solid 12 – 35m 165mm, perf

5.3 Test pumping of newly drilled production borehole

The one borehole BH 1 was submitted to a step test and constant discharge test of 24 hours or 1440 minutes by using professional yield testing equipment. The water level response to water abstraction was measured constantly during the tests to be able to calculate the aquifer parameters Storativity and Transmisivity. The water level depth of the borehole was constantly measured during the entire test procedure of the borehole.

A borehole yield test normally consists of a Step Test and a Constant Discharge Test with a recovery test to follow the step test and the constant yield test. The borehole yield tests were conducted according to the standards laid down in the publication of the Department of Water Affairs and Forestry, ***"Minimum Standards and guidelines for Groundwater Resource Development for the Community Water Supply and Sanitation Program".***

A **step-drawdown test** is intended to investigate the capability of an aquifer under variable discharge rate conditions. In a step test, the discharge rate in the pumping well is increased from an initially low constant rate through a sequence of pumping intervals of progressively higher pumping rates (Kruseman and de Ridder 1990). In each step of the test, the drawdown in the pumping well is allowed to stabilize. Each step is conducted for an hour period before the discharge rate is increased to the next step. After the step test the pump is switched off and the water level allowed recovering. Based upon the finding of the step test and the recovery test after the step test, the yield at which the constant rate discharge test will be performed is selected.

A **Constant Discharge Test** consists of pumping a borehole at a specific rate for a duration of 24 hours (in this case), with a sudden switch off, of the pump after the pump cycle, with a recovery test following immediately afterwards. The Constant Discharge Curves was analyzed by using the Basic FC, FC inflection point, Cooper-Jacob and Barker/Bangoy methods, to give an indication of Transmisivity and Storativity values. The borehole yield test is described below.

Borehole yield testing

Borehole **BH 1 (S-26.321800˚ and E028.290720˚)**

Borehole depth is 35.57m. The borehole has a static water level depth, measured at 9.00 metres below ground level. Professional yield test pump equipment was used to do the borehole yield test.

The borehole was pumped for two steps of 60 minutes at rates of 3.0ℓ/s, and 4.29ℓ/s. The water level draw-down was measured constantly during these steps. The water level draw-down after the steps measured 0.08, and 0.12 metres below the original static water level. The water level did not reach pump inlet. A maximum inflow yield was not measured. The pump was switched off and the water level allowed to recover.

The borehole was submitted to a constant discharge test with duration of 24 hours at an average rate of 4.0ℓ/s. The pump was switched off after 1440 minutes or 24 hours. The water level drawdown was measured at 0.36 metres below the original static water level. The borehole was allowed to recover for 1440 minutes. The water level recovered back to 0.08 meters below the original water level in the allowed 1440 minutes. This can be regarded as a slow recovery rate. Table 4 below gives more information on the yield test of the one borehole that was submitted to borehole yield testing procedures.

TABLE 4: Test pumping results

BH No **BH Depth & Static Water Level**	**Step Test**				**Constant Discharge Test**			**Comment on the Water Level Recovery Rate of the Constant Discharge Test**
	Step No.	**Rate (l/s)**	**Dur (min)**	**Draw down (m)**	**Rate (l/s)**	**Dur (min)**	**Draw down (m)**	
BH 1 Tested 03/03/2025 Depth: 35.57m Static Water Level: 9.00m	1 2	60 60	60 60	0.08 0.12	4.0	1440	0.36	78% in 1440 min
ST - Step Test Dur. – Duration. CDT - Constant Discharge Test D/D – Draw down. SWL - Static Water Level in metres below ground level								

5.4 Borehole abstraction recommendation

The Constant Discharge Curve of the borehole was analysed by using the Flow Characteristic program which was developed by the Institute of Groundwater Studies of the University of the Free State. The Basic FC, FC inflection point, Cooper-Jacob and Barker/Bangoy methods was used to calculate the Transmisivity and Storativity values. The average recommended abstraction rate (based on a 24 hour duty cycle) of these methods were used to calculate the recommended yield for 12 hours per day. The recommended abstraction rate for the borehole is given for each individual method described above. The average recommended abstraction rate for the borehole is given in Table 5 below. A summary of the methods used for the recommended abstraction rate and the Graphical presentations of the draw down curve and recovery curve can be found below. Table 4 listed above, gives a summary of the pump test data.

TABLE 5: Recommended abstraction volumes for the production borehole

Borehole No.	Recommended abstraction rate		Dynamic water Level (mbgl)	Comments
	In ℓ/s for 12h/d	In m^3/d		
BH 1	5	216	10	Water level depth is 9.00 (mbgl)
Total volume recommended		**216**		

The water demand figure for the proposed development is 67m^3/d or 24 700m^3/a. The borehole BH 1 can deliver 216m^3/d to be able to sustain the water demand of 67m^3/d. The water abstraction will be sustainable for long term use. The groundwater recharge on the proposed development area is 502.8m^3/d.

6. CHEMICAL PARAMETERS

6.1 Water quality sampling

One water sample was taken from borehole BH 1. Refer to Map 4 for the location of the borehole with regards to the site boundaries and other infrastructure.

6.2 Water quality parameters

The water sample was preserved and delivered to Aquatico Laboratories, an accredited water laboratory, to be analysed for water quality purposes. The analyses include the major cation and anions, Total Coliform Bacteria count parameters and E. coli parameters. The results of the chemical and bacteriological analyses performed on the groundwater sample are presented in Table 7. The quality of water is classified according to the SANS 241-1 and 2: 2015 as in the Publication “South African National Standard” Part 1 and Part 2, SABS. Refer to the Water Quality Analyses Certificate from Aquatico Laboratory for the original water analyses. Table 6 below gives the risk guideline involved for using the water for domestic purposes.

Chemical Water Quality

Water quality analyses not available yet at 18/02/2025

The chemical water quality analyses of the one borehole BH 1 show that none of the chemical parameters analysed for, is above the standard limits. Chemically the water of this borehole is good quality water that can be used for domestic, and other use without treatment to improve the chemical water quality.

Bacteriological Water Quality

Water quality analyses not available yet at 18/02/2025

The Total Coliform count is ???? CFU/100mℓ, which means that the water must be chlorinated and filtrated prior to human consumption.

Table 6: Risk guideline legend

Aesthetic	Determinand that taints water with respect to taste, odour and colour and that does not pose an unacceptable health risk if present at concentration values exceeding the numerical limits specified.
Operational	Determinand that is essential for assessing the efficient operation of treatment systems and risks to infrastructure.
Acute Health - 1	Routinely quantifiable determinand that poses an immediate health risk if consumed with water at concentration values exceeding the numerical limits specified.
Acute Health - 2	Determinand that is presently not easily quantifiable and lacks infomration pertaining to viability and human infectivity which, however, does pose immediate unacceptable health risks if consumed with water at concentration values exceeding the numerical limits specified.
Chronic Health	Determinand that poses an unacceptable health risk if ingested over an extended period if present at concentration values exceeding the numerical limits specified.
	Exceeds Acute health - 1, Acute health - 2 and Chronic health guideline values
	Exceeds only Operational and Aesthetic guideline values

Table 7: Water quality analyses for Borehole BH 1.

Determinant	Unit	Risk	Standard limits	BH 1
pH value at 25 C	pH units	Operational	≥ 5 to ≤ 9.7	
Electric Conductivity at 25 C	mS/m	Aesthetic	≤ 170	
Total Dissolved Solids	mg/ℓ	Aesthetic	≤ 1200	
Total alkalinity	Mg CaCO3/l			
Chloride as Cl	mg/ℓ	Aesthetic	≤ 300	
Sulphate as SO4	mg/ℓ	Acute health - 1	≤ 500	
Nitrate (NO3) mg/ℓ N	mg/ℓ	Acute health - 1	≤ 50	
Total oxidised nitrogen as N	mg/ℓ			
Ammonia as N	mg/ℓ	Aesthetic	≤ 1.5	
Orthophosphate (PO4) as P	mg/ℓ			
Fluoride as F	mg/ℓ	Chronic health	≤ 1.5	
Calcium as Ca	mg/ℓ			
Magnesium as Mg	mg/ℓ			
Sodium as Na	mg/ℓ	Aesthetic	≤ 200	
Potassium as K	mg/ℓ			
Aluminium as Al	mg/ℓ	Operational	≤ 0.3	
Iron as Fe	mg/ℓ	Chronic health	≤ 2	
Manganese as Mn	mg/ℓ	Chronic health	≤0.5	
E.coli	CFU/100mℓ	Acute health – 1	Not detected	
Total coliform	CFU/100mℓ	Acute health - 2	≤10	
Total hardness	mg$CaCO_3$/ℓ			

7. GEOLOGICAL AND HYDROGEOLOGICAL ASSESSMENT

7.1 Regional groundwater level depth and groundwater contours

Water level depths could be measured in the one borehole that was redrilled and submitted to borehole yield testing procedures. The other borehole BH 2 was destroyed. The water level depth measured in borehole BH 1 is 9.00mbgl.

7.2 Regional groundwater movement

A chert and dolomite aquifer forms a karstic groundwater regime. Boreholes developed in this karst aquifer can be regarded as a high yielding aquifer. Groundwater recharge into this aquifer can also be regarded as high to very high. No other groundwater abstraction is taking place in a 2km radius from the proposed borehole BH 1. The groundwater movement in the dolomite aquifer is in a south westerly direction. The topography also dips towards a south westerly direction.

The Transmisivity and Storativity values of a dolomite aquifer is expected to be exceptionally high with Transmisivity values ranging from 400 to 800m^2/d.

The topography of the region is relative flat forming a large valley to the south-east of the site. This river drains towards the south-west. Groundwater movement will also be towards the south-west.

The blue arrows on Map 5 show the regional surface and groundwater movement directions according to the regional topography. The groundwater and surface water flow directions in general are from the topographic high areas in the north of the site towards the topographical low areas in the south west of the site.

7.3 On site surface water drainage and groundwater movement.

On the site, surface water drainage and groundwater flow are towards the topographic low point which is formed by the large valley and drainage on site. Groundwater is constantly flowing towards the site from the topographical high area which is to the north of the site. The constant flow of groundwater from the north will have a positive effect on the long-term sustainability of the groundwater source of the dolomite aquifer feeding the groundwater production borehole.

7.4 Groundwater recharge for Remaining Extent Portion 3 of the farm Rooikraal 156 IR.

For a water use licence application (WULA), the Department of Human Settlements, Water and Sanitation requires that the surface area of the development be used to calculate the groundwater recharge volume. This will ensure that at 100% abstraction of groundwater recharge, each owner will, theoretically, abstract only the volume of water recharged on his own property. In practice the flow of groundwater is not bound by man-made borders, but rather by the surface topography and the geology.

The groundwater recharge program from Gerrit van Tonder and Yongzin Xu, to estimate groundwater recharge and groundwater reserve, was used to estimate a mean groundwater recharge figure. This was done for the groundwater catchment area delineated by the boundary of the Remaining Extent Portion 3 of the farm Rooikraal 156 IR. The mean value of the soil, geology, Vegter, Acru, Harvest Potential and Chloride methods were used, together with a weighting ratio, to estimate the groundwater recharge figure for the farm portion.

Table 8, listed below, gives the mean groundwater recharge figure, calculated by the six methods mentioned, on the development area defined by the property boundary. The Table summarizes all the methods used, as well as the weighting ratios used. For instance, a weighting ratio of 5 was given for the Vegter method, which in this case seems to be a conservative value and 5 for the soil methods, which is in line with the Vegter Method.

The mean groundwater recharge for Remaining Extent on Portion 3 of the farm Rooikraal 156 IR

is calculated to be in the order of 82.2mm/a or 11.3% of MAP or 183 518m^3/a or 502.8m^3/d or 11.6ℓ/s for 12h/d.

Table 8: Groundwater recharge on the Remaining Extent Portion 3 Farm Rooipoort 156 IR

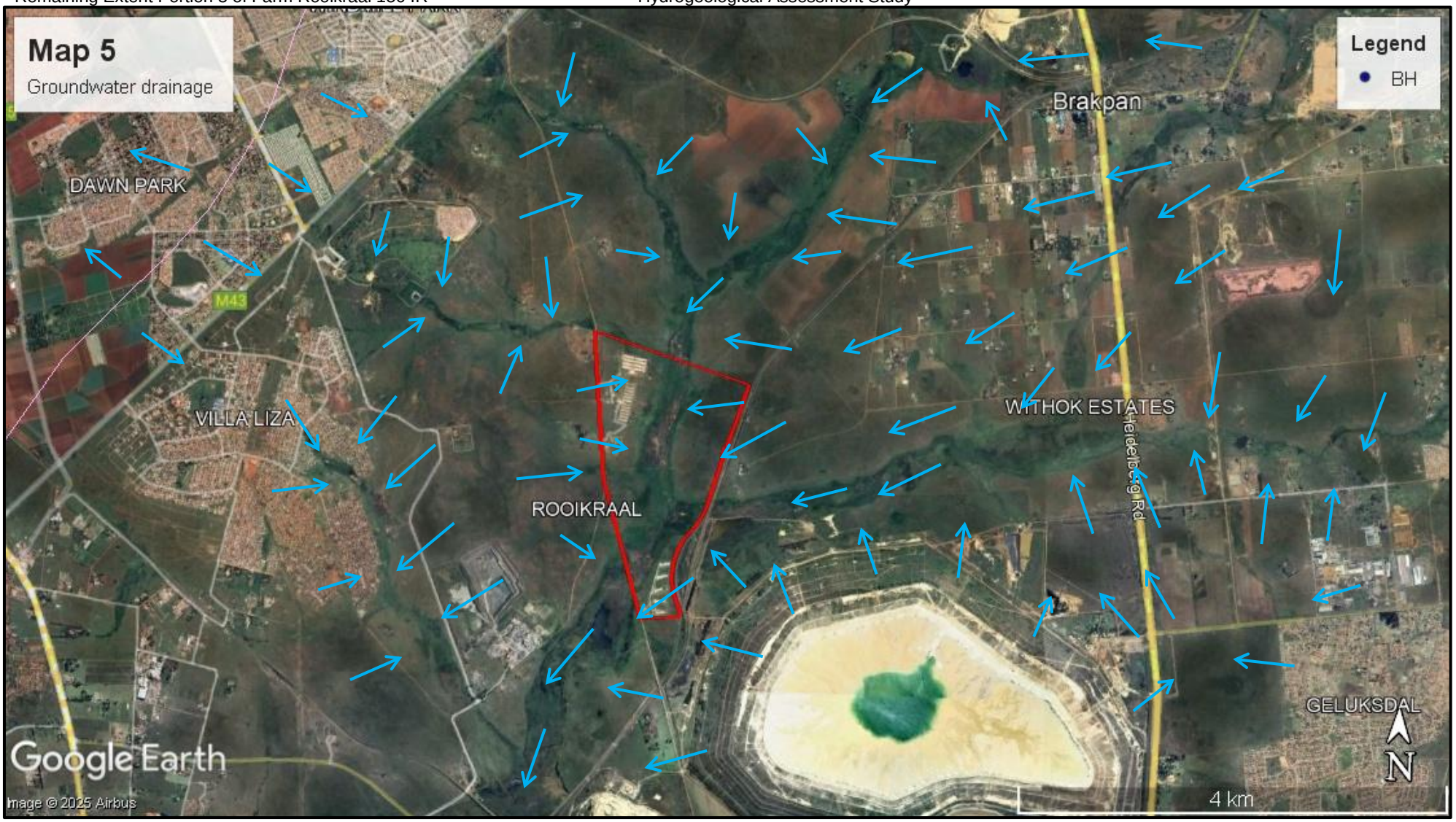
Summary of Recharge — MAIN

Remaining Extent Portion 3 Farm Rooipoort 156 IR

Method	mm/a	% of rainfall	Certainty (Very High=5 ; Low=1)
CI	97,1	13,3	5
SVF: Equal Volume		#DIV/0!	
SVF: Fit			
CRD			
Qualified Guesses :			
Soil	80,1	11,0	4
Geology	83,7	11,5	4
Vegter	95,0	13,0	5
Acru	20,0	2,7	1
Harvest Potential	80,0	11,0	5
Expert's guesses			
Base Flow (minimum Re)	20,0	2,7	1
^{2} H displacement method			
Carbon 14 method			
EARTH Model			
Groundwater Flow Model			
Average recharge	82,2	11,3	
Recharge =	82,2	11,3	

=	0,183518	Mm^3/a	
=	502,79	m^3/d	
=	5,82	L/s	

Area (Km^2) =	2,232582
Annual Rainfall (mm) =	728



Map 5: Expected groundwater flow directions. (Light blue arrows)

8. MONITORING PROTOCOL

It is important to have a monitoring system in place to monitor the potential impacts on the environment such as water level depth differences and groundwater quality in the area around borehole BH 1.

The focus of a monitoring system must be to monitor possible water level decreasing and quality differences before the environment is damaged. The one borehole BH 1 must be used as groundwater monitoring facility. Table 9 and Table 10 describe the frequency and parameters to be monitored.

Monitoring programs are site-specific and need to be tailored to meet a specific set of needs or expectations (DWA 1998). The approach followed in developing this monitoring protocol was taken from the DWAF Best Practice Guideline – G3: Water Monitoring Systems (DWA, 2006b).

8.1 Monitoring objectives

Monitoring, measuring, evaluating, and reporting are key activities of the monitoring program. These actions are designed to evaluate possible changes in the physical and chemical nature of the aquifer and geo-sphere and to predict/detect potential impacts on the ground water.

The key objectives of the monitoring of groundwater changes are:

1. To provide reliable groundwater data that can be used for management purposes.
2. The early detection of changes in groundwater quality and quantity.
3. Provide an on-going performance record on the efficiency of the Water Management Plan.
4. Obtain information that can be used to redirect and refocus the Water Management Plan.
5. Determine compliance with environmental laws, standards and the water use licence and other environmental authorizations.
6. Refine the conceptual and numerical (management) models.

This will ensure that management is timely warned of problems and unexpected impacts that might occur and can be positioned to implement mitigation measures at an early stage.

8.2 Possible geohydrological risk sources

Potential risk sources:

1. No pollution sources are created with this Solar Farm development.
2. Lowering of the water table due to water abstraction.

8.3 Receiving environment.

The following hydrological units may be impacted by the project and related activities:

- The aquifer below the Remaining Extent Portion 3 of the farm Rooikraal 156 IR may lower during abstraction periods but will recover back during rainfall periods.

8.4 Monitoring network

The one groundwater production borehole must be used as groundwater monitoring facility. The location of this boreholes can be seen on Map 3 and Map 4 and the coordinates can be found on Table 2.

8.5 Monitoring frequency

The proposed monitoring facility must be sampled annually and analysed for bacteriological parameters and micro and macro chemical parameters.

Table 9: Monitoring Frequency

Site name	Chemistry sampling	Water level depth measurements
1 Groundwater production borehole BH 1 (Refer to Table 2)	Annually	Monthly

8.6 Sampling parameters

An accredited laboratory, with the necessary quality assurance, must carry out analysis of key samples. Quality control measures should be in place and may include blanks, standards, duplicates, caution-anion balances etc. This will ensure consistency in monitoring and the verification and validation of water quality data. Data from groundwater quality monitoring must be stored together electronically to enable trend analysis and waste load calculations to be carried out.

Table 10: Sampling Parameters

Sample Type	Field measurements	Laboratory analysis: Chemical and Bacteriological
Groundwater	Water level depth monthly in the 1 borehole BH 1.	Refer to Table 7 and Appendix A

8.7 Sampling procedures

The sampling procedure for groundwater should be done according to the protocol by Weaver, 1992. The actions can be summarised as follows:

1. For pH and EC, calibrate the field instruments before every sampling run. Read the manufacturers manual and instructions carefully before calibrating and using the instrument.
2. Sample for chemical constituents – remove the cap of the plastic 1 litre sample bottle, but do not contaminate inner surface of cap and neck of sample bottle with hands. Fill the sample bottle without rising.
3. Leave sample air space in the bottle (at least 2.5 cm) to facilitate mixing by shaking before

examination.

4. Replace the cap immediately.
5. Complete the sample label with a water-resistant marker and tie the label to the neck of the sample bottle with a string or rubber band. The following information should be written on the label.
    a. A unique sample number and description
    b. The date and time of sampling
    c. The name of the sampler
6. Place sample in a cooled container (e.g., cool box) directly after collection. Try and keep the container dust-free and out of any direct sunlight. Do not freeze samples.
7. See to it that the sample gets to the appropriate laboratory as soon as possible.
8. Samples for chemical analysis should reach the laboratory preferably within seven days.

9. CONCLUSIONS

During the hydrogeological study the following conclusions could be made:

- The water demand for the school and irrigation activities of the sports fields from groundwater will be **63 072m^3/a or 172.8m^3/d.**
- The one available groundwater production boreholes can be recommended for 172.8m^3/d to supply in the water demand for Portions 31 and 34 of the farm Waldrift 599 IQ.
- Based on the calculations for the delineated Topographical catchment area from which the boreholes at the two farm portions can gain groundwater, the abstraction is classified as Category A – Small Scale Abstraction (<60%) of recharge on the catchment area.
- The mean groundwater recharge on the delineated Topographical catchment area, is calculated to be in the order of 61.3mm/a or 9.8% of MAP or 496 359.5m^3/a or 1359.9m^3/d or 31.5ℓ/s for 12h/d.
- The chemical water quality analyses of the one borehole BH 1 show that none of the chemical parameters analysed for, is above the standard limits. Chemically the water of this borehole is good quality water that can be used for domestic, and irrigation use without treatment to improve the chemical water quality.
- The Total Coliform count is 13 CFU/100mℓ, which means that the water must be chlorinated and filtrated prior to human consumption.
- The groundwater recharge figure calculated in this study and the borehole yield tests show that the water demand of 172.8m^3/d is sustainable for long term water abstraction.

10. RECOMENDATIONS

The following recommendation can be made:

- Use water as a scarce commodity.
- Do not over abstract the boreholes.
- Follow the groundwater monitoring plan as stipulated in this report.

REFERENCES

1. American Geological Institute, **Glossary of Geology**, (Robert L. Bates and Julia A. Jackson, Ed), 1980.
2. Department of Water Affairs and Forestry, **SOUTH AFRICAN WATER QUALITY GUIDELINES** - Volume 1 DOMESTIC USE, Second Edition 1996.
3. Department of Mineral and Energy Affairs, **Stratigraphy of South Africa, Handbook 8**, (The South Africa Committee for Stratigraphy), 1980.
4. Johnson MR, Anhaeusser CR and Thomas RJ, **The Geology of South Africa**, 2006.
5. Water Research Commission, **Manual on Quantitative Estimation of Groundwater Recharge and Aquifer Storativity**, (DB Bredenkamp et al), June 1995.
6. Water Research Commission & Department of Water Affairs and Forestry, **Groundwater Resources of the Republic of South Africa**, (JR Vegter). August 1995.

APPENDIX A

Water quality analysis from Aquatico Laboratory

aquatico Laboratories (Pty). Ltd.

ilac-MRA sanas Testing Laboratory T0685

Test Report

Client: HK Geohydrological Services
Address: 25ste laan, 327, Villieria, Pretoria
Report no: 179087
Project: HK Geohydrological Services

Date of report: 20 March 2024
Date accepted: 12 March 2024
Date completed: 20 March 2024
Date received: 12 March 2024

Lab no:					48486
Date sampled:					12-Mar-24
Aquatico sampled:					No
Sample type:					Water
Locality description:					Waldrift BH1
		Analyses	**Unit**	**Method**	
A	AQL	pH @ 25°C	pH	ALM 20	7.06
A	AQL	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	55.2
A	AQL	Total dissolved solids (TDS)	mg/l	ALM 26	371
A	AQL	Total Alkalinity	mg $CaCO_3$/l	ALM 01	259
A	AQL	Chloride (Cl)	mg/l	ALM 02	14.1
A	AQL	Sulphate (SO_4)	mg/l	ALM 03	18.1
A	AQL	Nitrate (NO_3) as N	mg/l	ALM 06	4.26
A	AQL	Total oxidised nitrogen as N	mg/l	ALM 06	4.26
A	AQL	Ammonium (NH_4) as N	mg/l	ALM 05	0.048
A	AQL	Orthophosphate (PO_4) as P	mg/l	ALM 12	<0.005
A	AQL	Fluoride (F)	mg/l	ALM 08	0.724
A	AQL	Calcium (Ca)	mg/l	ALM 30	51.3
A	AQL	Magnesium (Mg)	mg/l	ALM 30	33.9
A	AQL	Sodium (Na)	mg/l	ALM 30	26.8
A	AQL	Potassium (K)	mg/l	ALM 30	2.08
A	AQL	Aluminium (Al)	mg/l	ALM 31	0.227
A	AQL	Iron (Fe)	mg/l	ALM 31	<0.004
A	AQL	Manganese (Mn)	mg/l	ALM 31	<0.001
A	AQL	E.coli	CFU/100ml	ALM 40	<1
A	AQL	Total coliform	CFU/100ml	ALM 40	13
A	AQL	Total hardness	mg $CaCO_3$/l	ALM 26	268

A = Accredited N = Non accredited Sub = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report ; Results relate only to the items received and tested ; Results reported against the limit of detection; Results marked 'Non SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory; Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation; The report shall not be reproduced except in full without approval of the laboratory

M. Swanepoel
Technical Signatory

APPENDIX B

Borehole yield testing information

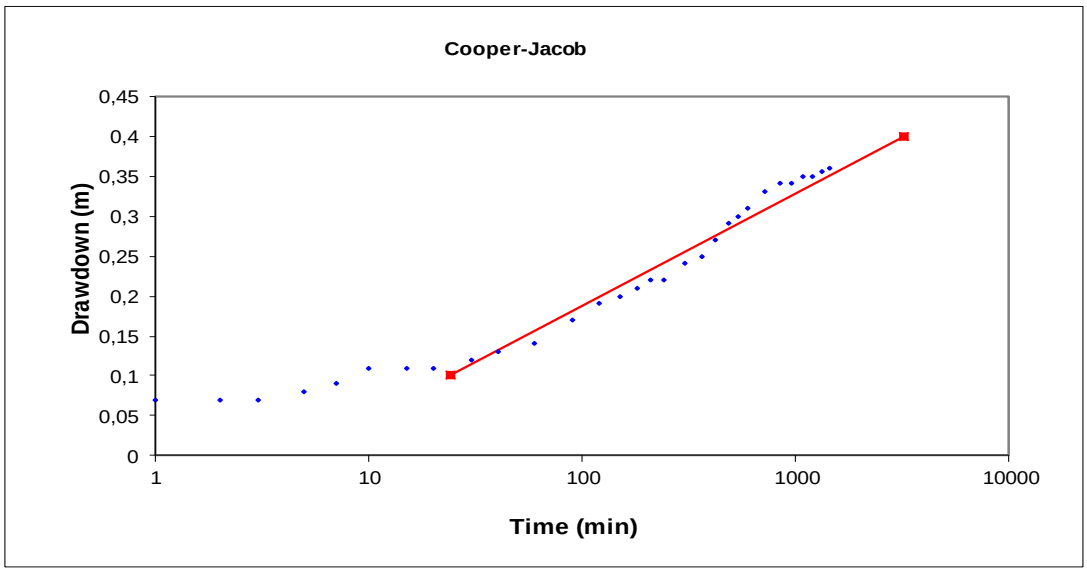
Cooper-Jacob method

Main | Theis | Cooper-Jacob 2

BH 1 Farm Rooikraal

T(m^2/d) =	447,5		r_e (m)=	1,52	1,52
S =	1,44E+00		Q (l/s) =	4	

	No boundaries	1 no-flow	2 no-flow	Closed	
Q_sust	95,26	47,63	31,43	23,81	including influence of bh's
Avg. Q_sust =		49,53	std. dev =	32,06	

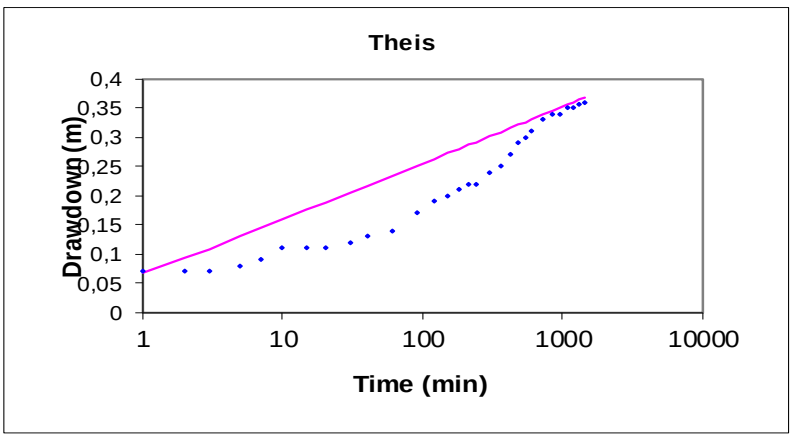


x0	y0	x1	y1
24,2	0,1	3201	0,4

Theis

T (m2/d)	S	r
653	9,71E-03	5,00

Top



Summary

Main

BH 1 Farm Rooikraal

Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S	AD used
☑	**Basic FC**	29,46	21,21	903	210,8	1,98E-03	18,0
☐	**Advanced FC**			903	210,8	1,00E-03	18,0
☐	**FC inflection point**	0,31	0,24				5,2
☑	**Cooper-Jacob**	49,53	32,06		447,5	1,44E+00	18,0
☐	**FC Non-Linear**	2,49	2,20		34,0	5,06E-03	18,0
☑	**Barker**	38,71	33,37	K_f = 51	S_s =	1,65E-03	18,0
	Average Q_sust (l/s)	**39,23**	**10,05**	b = 22,22	Fractal dimension n =	1,80	

Recommended abstraction rate (L/s)		**5,00**	for 24 hours per day
Hours per day of pumping	**12**	**7,07**	L/s for 12 hours per day

Amount of water allowed to be abstracted per month	**12960**	m^3
Borehole could satisfy the basic human need of	**17280**	persons
Is the water suitable for domestic use (Yes/No)	**Y**	