GEOHYDROLOGICAL ASSESSMENT REPORT FOR ER318 PROJECT FREE STATE

April 2023
Ref: 005759R01

For:

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VERIFICATION PAGE	Form 4.3.1
	Rev 13

TITLE:

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JG AFRIKA REF. NO.	DATE:	REPORT STATUS
005759R01	14/04/2023	First Issue

CARRIED OUT BY:	COMMISSIONED BY:
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SYNOPSIS

Specialist geohydrological assessment for ER318 Rhino Oil and Gas Project in the Free State

KEY WORDS:

Geology, geohydrology, hydrocensus, water quality status quo, numerical groundwater model, risk and impact

QUALITY VERIFICATION

This report has been prepared under the controls established by a quality management system that meets the requirements of ISO9001: 2015 which has been independently certified by DEKRA Certification

Verification	Capacity	Name	Signature	Date
Checked by	Geohydrologist Executive Associate	Rainier Dennis Robert Schapers		14 Apr 2023
Authorised by	Executive Associate	Robert Schapers		14 Apr 2023

Filename:	https://jgafrika.sharepoint.com/sites/Job5759-team-102-WIP-Internal-ES/Shared Documents/102-WIP-Internal-ES/105-Reports/005759R01 ER318 Geohydro Report.docx

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GEOHYDROLOGICAL ASSESSMENT REPORT FOR ER318 PROJECT FREE STATE

1 INTRODUCTION

This report presents the results of a geohydrological assessment carried out for the exploration right ER318 for Rhino Oil and Gas near Welkom and Kroonstad in the Free State. The geohydrological report has been prepared as a specialist study in support of environmental authorisation. The scope of work incorporated the following key phases:

1. Desktop Study
2. Hydrocensus
3. Conceptual and Numerical Modeling
4. Site Sensitivity Screening and Groundwater Impact Assessment.

We refer to our revised proposal reference 005324 2117104.1/rs, titled “Geohydrological Proposal for ER 318 for Rhino Oil & Gas Exploration Welkom to Kroonstad Area”, dated 17 February 2022. JG Afrika (Pty) Ltd were appointed to proceed with the assessment under purchase order DBKM20-44627,4705523148 dated 17 March 2022.

2 INFORMATION SUPPLIED

The following information has been used in the preparation of this report:

Reports, Documents and Guidelines

- Report reference 720.18034.00020 of SLR Consulting (South Africa) (Pty) Ltd, titled ” Rhino Oil and Gas - Project Description”, draft report No.1, January 2023
- Government Notice No. 326 of April 2017. National Environmental Management Act, 1998 (Act No. 107 Of 1998). Amendments to the Environmental Impact Assessment Regulations, 2014
- Government Notice R267 of March 2017. National Water Act, 1998 (Act No. 36 of 1998). Regulations Regarding the Procedural Requirements for Water Use Licence Applications and Appeals
- The Department of Water Affairs, First Edition, February 2010. Operational Guideline: Integrated Water and Waste Management Plan
- Parsons RP (1995). A South African Aquifer System Management Classification. WRC Report No. 77/95, Water Research Commission, Pretoria
- Craig, H. (1961). Isotopic Variations in Meteoric Waters. Science, 133, 1702–1703.

Maps and Drawings

- Map Sheet titled, “2726 Kroonstad”, at a scale of 1:250 000, digital version, of the Geological Map Series, supplied by the Department of Mineral and Energy Affairs
- Map Sheet titled, “Kroonstad 2726”, at a scale of 1:500 000, first edition, dated 2000, of the Hydrogeological Map Series of the Republic of South Africa, supplied by the Directorate: Geohydrology, of the Department of Water Affairs and Forestry.

Data

- Digital files of SLR Consulting (South Africa) (Pty) Ltd named ER318_Rev.shp and EIA_First22wells_toSLR_Nov22.kmz received on 7 March 2022 and 15 November 2022 respectively

- National Groundwater Archive (NGA) digital information, as supplied by The Department of Water and Sanitation (DWS) as at November 2022
- Water Allocation Resource Management System (WARMS) digital information, as supplied by The Department Water and Sanitation (DWS) as at January 2023
- Google Earth Pro version 7.3.3 of July 2021.

3 SITE DESCRIPTION

The ER318 project comprises 14 (No.) sites spread over 14 (No.) farms. The spatial extent of the sites is approximately 200000 ha. The project area extends approximately 50 km west and 54 km north of the town of Welkom in the Free State. The distribution of the sites is present in Figure 1, and site list is presented in Table 1.

Table 1: Summary Site List

Site Designation	ER
Site A	ER318
Site B	ER318
Site C	ER318
Site D	ER318
Site E	ER318
Site F	ER318
Site G	ER318
Site H	ER318
Site I	ER318
Site J	ER318
Site K	ER318
Site L	ER318
Site M	ER318
Site N	ER318

The project comprises the drilling of 14 (No.) exploratory wells within the identified target areas to determine the commercial viability of the sites and the project areas as a whole. Viable wells will be capped and secured, while unsuccessful wells will be decommissioned. Drilling will be carried out using the rotary air percussion and/or mud rotary drilling techniques to anticipated depths of up to 1000 m. The wells will be drilled by telescoping to smaller diameters as the depth progresses. The initial drill diameter of 273 mm will extend to an anticipated depth of 50 m and cased off with a conductor pipe to isolate any shallow water bearing fractures. The second drill diameter of 168 mm will be extended within the conductor pipe to between 400 and 800 m depth and additional casing installed within the conductor casing and cemented in place to seal the hole from surface. The final drill diameter of 137 mm will extend within the casing to between 600 and 1200 m depth and will be open. The detailed project description and methodology is given in the SLR Project Description Report[1].

[1] Report reference 720.18034.00020 of SLR Consulting (South Africa) (Pty) Ltd, titled " Rhino Oil and Gas - Project Description", draft report No.1, January 2023

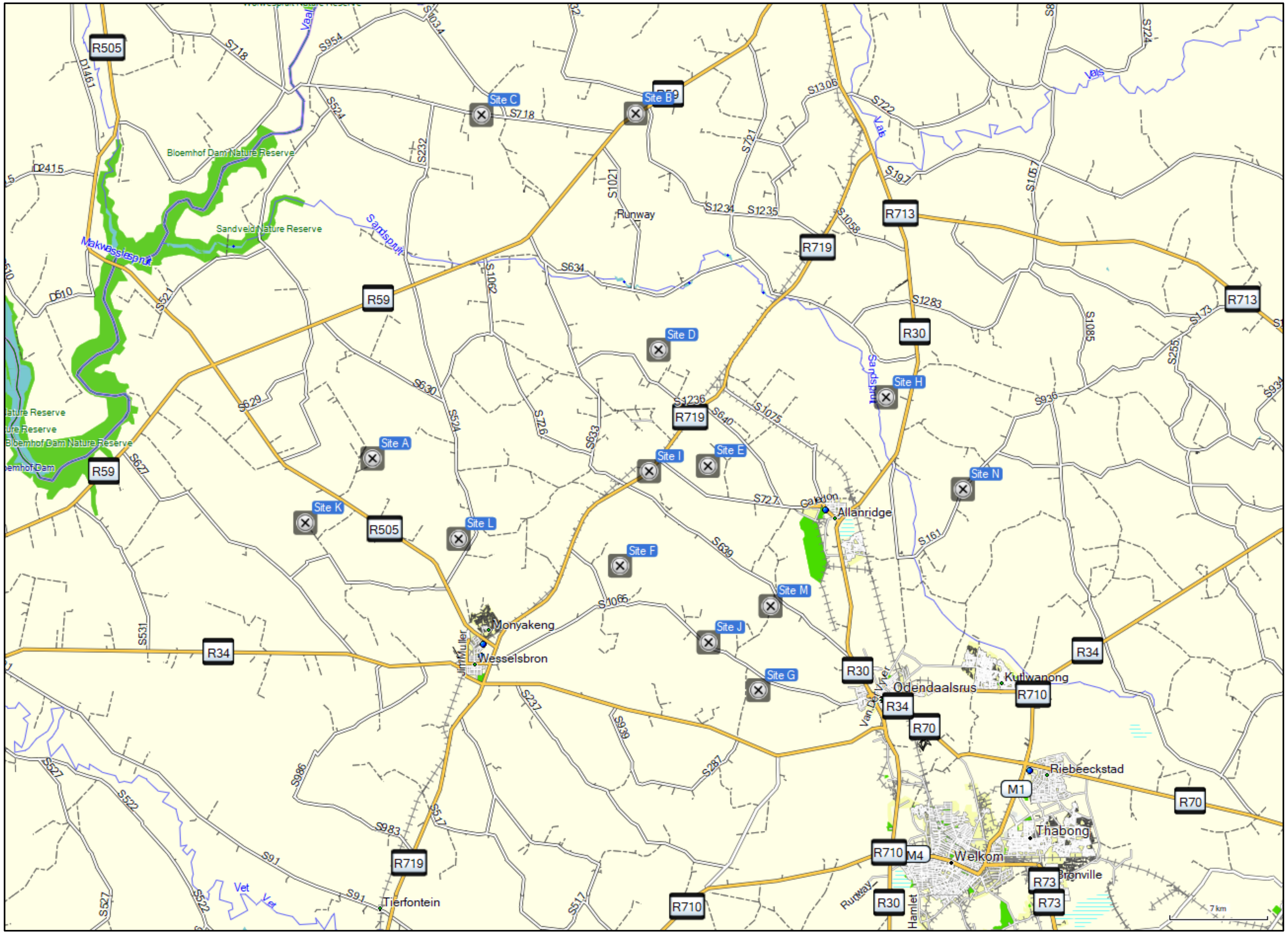


Figure 1: Site Locality

4 DESKTOP REVIEW AND SITE ASSESSMENT

4.1 Introduction

The information gathered from the desktop and site assessment has been used for the development of a numerical groundwater model as presented in Section 5 and 6. The purpose of the numerical groundwater model is to establish groundwater flow directions at each site and to assess fate and transport of potential contaminants to guide the risk assessment.

4.2 Topography and Drainage

The topography and drainage of the project area is presented in Figure 2. Quaternary catchments and rainfall stations used in the model development are also shown. A summary of the quaternary catchment hydrological parameters are presented in Table 2.

Table 2: Summary of Quaternary Hydrological Parameters

Quaternary	MAP (mm/a)	MAR (mm/a)	MAE (mm/a)	Recharge (mm/a)
C25B	509	5.0	1750	21.0
C25C	522	5.4	1825	29.5
C25F	481	3.6	1850	15.4

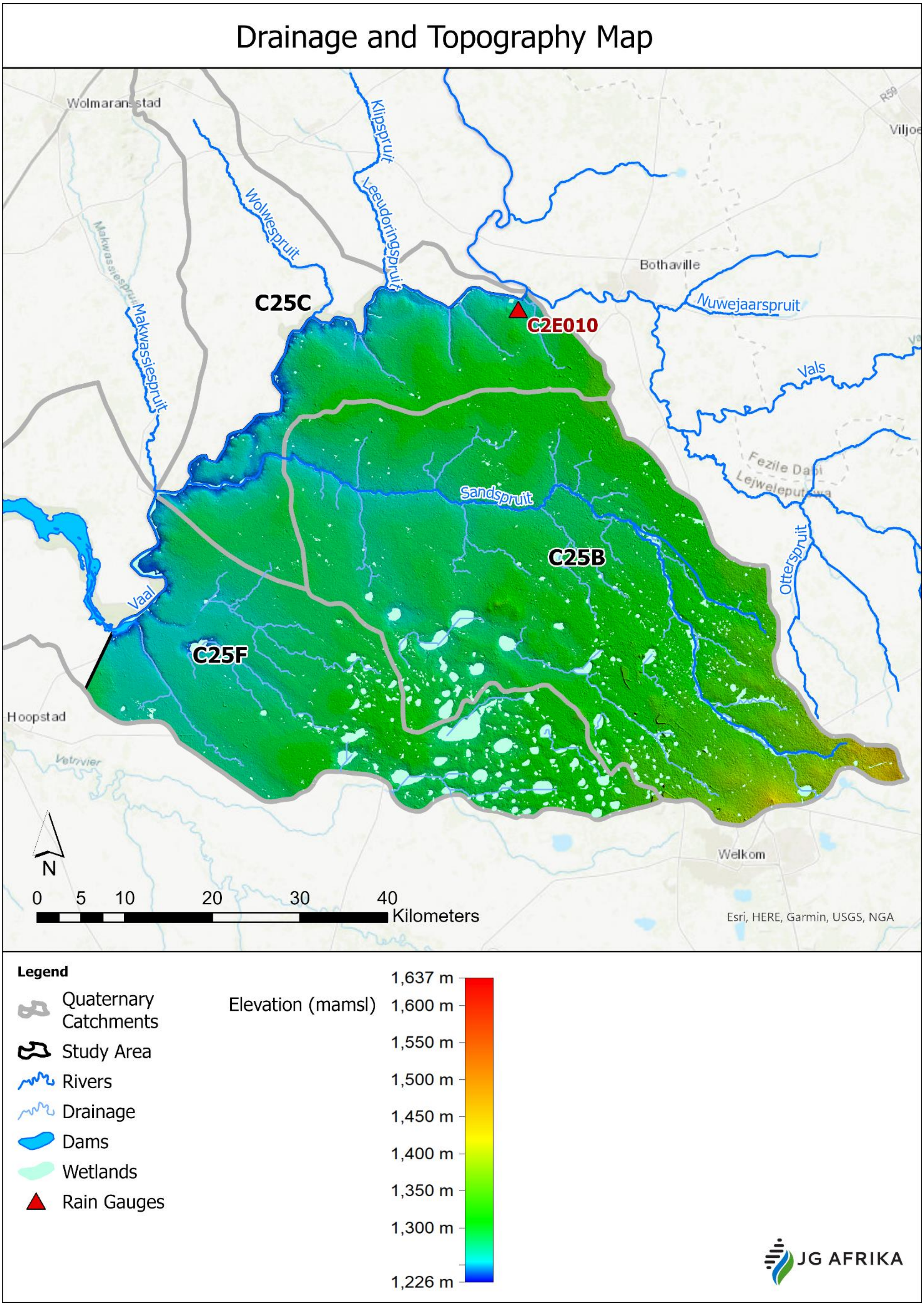


Figure 2: Topography and Drainage

4.3 Rainfall

The mean annual precipitation (MAP) values for the quaternary catchments are presented in Table 2. In addition, rainfall station C2E010 was identified in the project area. The rainfall gauge information is presented in Table 3.

Table 3: Rainfall Gauge Information

Gauge	Description	Longitude	Latitude	Monthly Data Range
C2E010	Balkfontein	26.50416	-27.40694	1969-05-04 to 2022-04-30

A comparison of the MAP for each of the quaternaries and the rainfall station are presented in Figure 3 and Figure 4. Only precipitation values related to water level monitoring are presented here and the light blue bars relate to the gauging station. The long-term (1968 - 2021) monthly average rainfall based on the rain gauge is presented in Figure 4. The respective rain gauge MAP is slightly higher than the average of the quaternary MAP values.

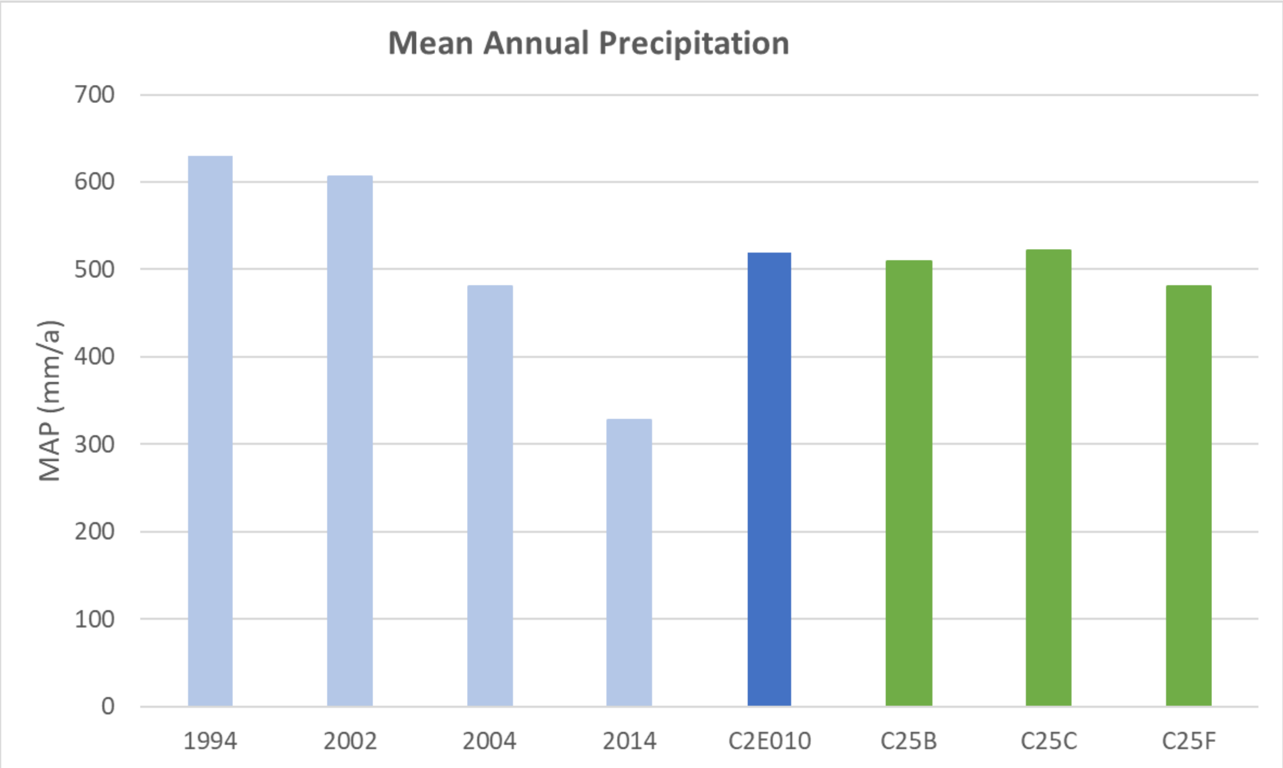


Figure 3: Mean Annual Precipitation

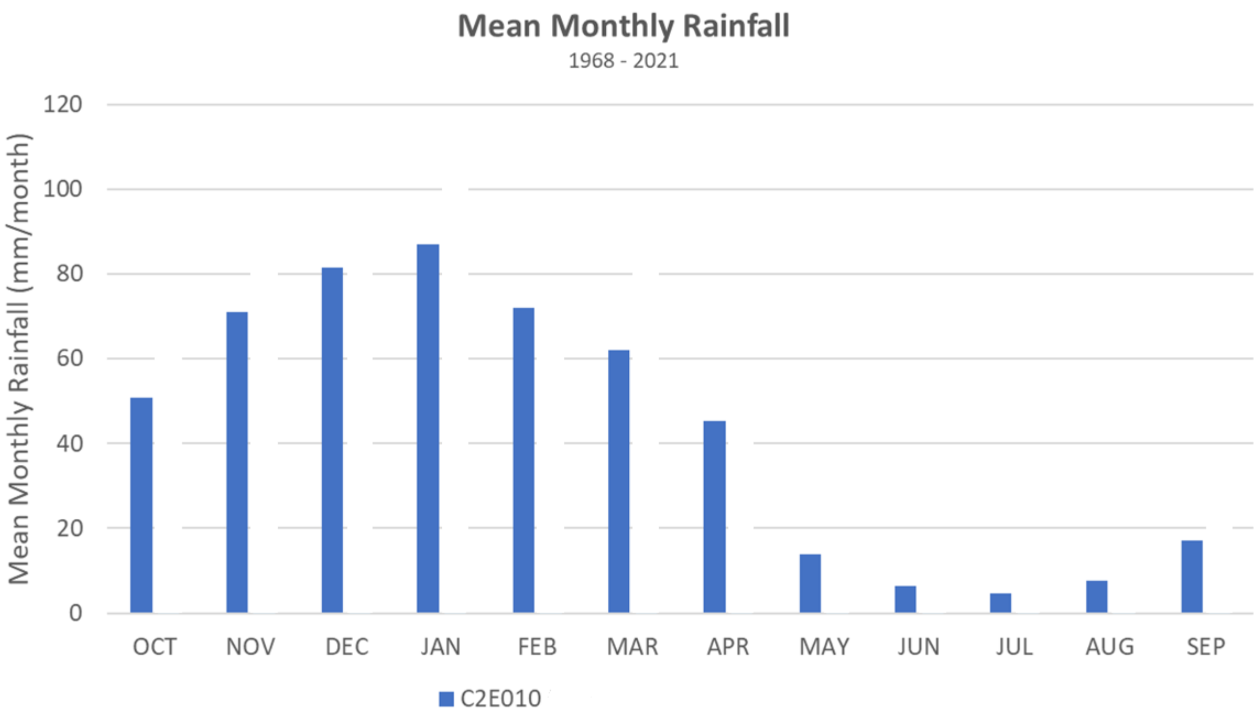


Figure 4: Monthly Average Rainfall

4.4 Regional Geology

The regional geology of the area comprises sandstone and shale of the Volksrust Formation of the Ecca Group. The shale and sandstone is overlain extensively by Quaternary aged sand of aeolian origin. The sandstone and shale has been intruded locally by Post Karoo dolerite in the form of dykes and sills. The shale and sandstone is further underlain by basalt and andesite of the Allanridge Formation of the Ventersdorp Supergroup, and is evident as outcrops in the isolated areas of the north eastern portion of the project area. The regional geology is presented in Figure 5.

The borehole logs extracted from NGA boreholes in the project area are presented in Annexure B. The geological lithologies were used to construct the layers in the groundwater model development discussed in Section 6.

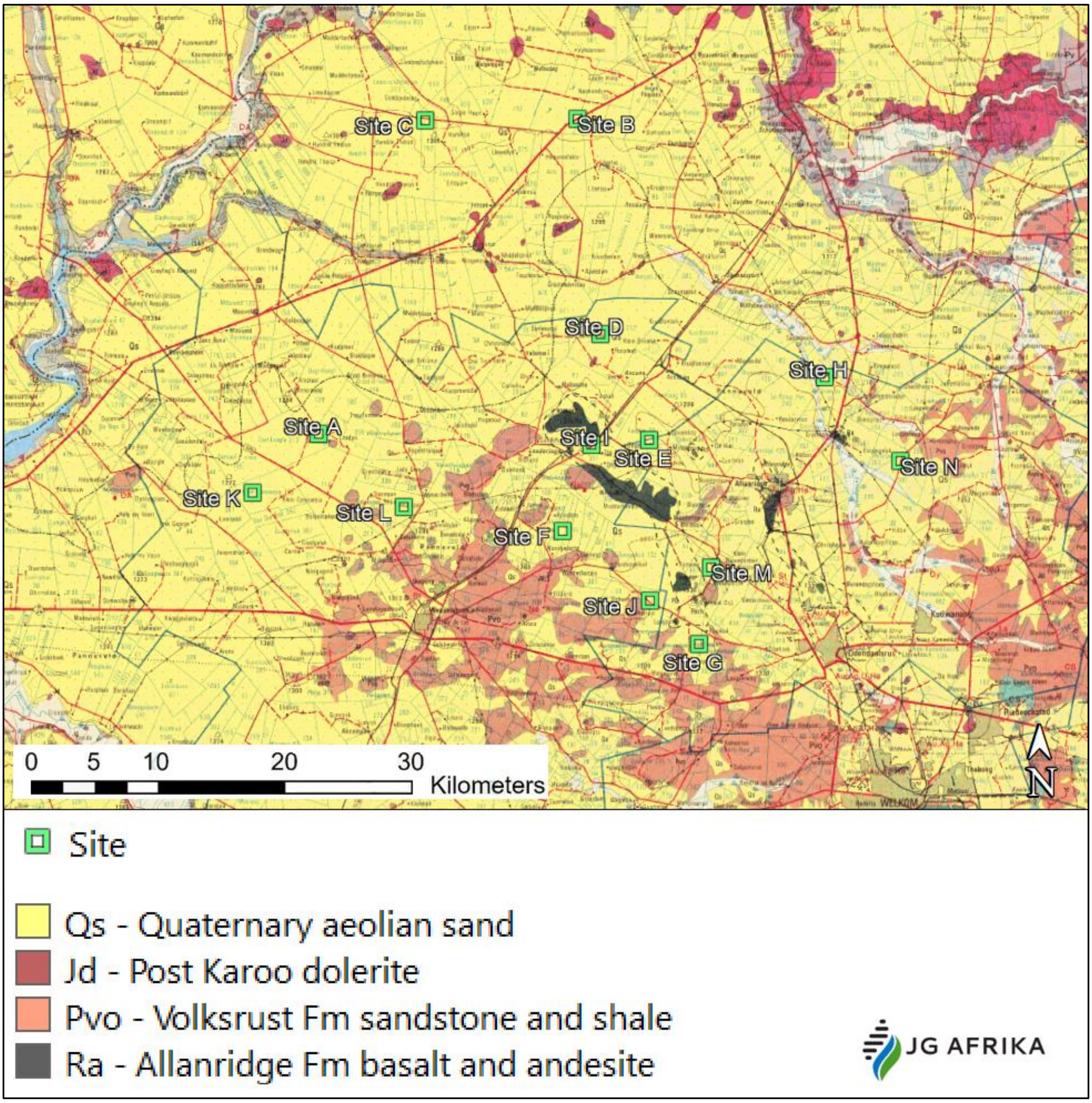


Figure 5: Regional Geology

4.5 Regional Geohydrology

The regional geohydrology of the northern half of the project area can be broadly described as predominantly arenaceous rocks (d2) comprising sandstone. The principal groundwater occurrence is from an intergranular and fractured aquifer type, with median borehole yields in the range 0.1 to 0.5 l/s. The aquifer is characterised as a medium to low yielding Minor aquifer in terms of the South African Aquifer Classification System.

The regional geohydrology of the southern half of the project area can be broadly described as predominantly argillaceous rocks (d3) comprising shale and mudstone. The principal groundwater occurrence is from an intergranular and fractured aquifer type, with median borehole yields in the range 0.5 to 0.2 l/s. The aquifer is characterised as a medium to low yielding Minor aquifer in terms of the South African Aquifer Classification System.

North of the project area, the regional geohydrology can be broadly described as predominantly mafic intrusive rocks (d3) comprising dolerite. The principal groundwater occurrence is from an intergranular and fractured aquifer type, with median borehole yields in the range 0.5 to 0.2 l/s. The aquifer is characterised as a medium to low yielding Minor aquifer in terms of the South African Aquifer Classification System.

The regional geohydrology of the project area is presented Figure 6.

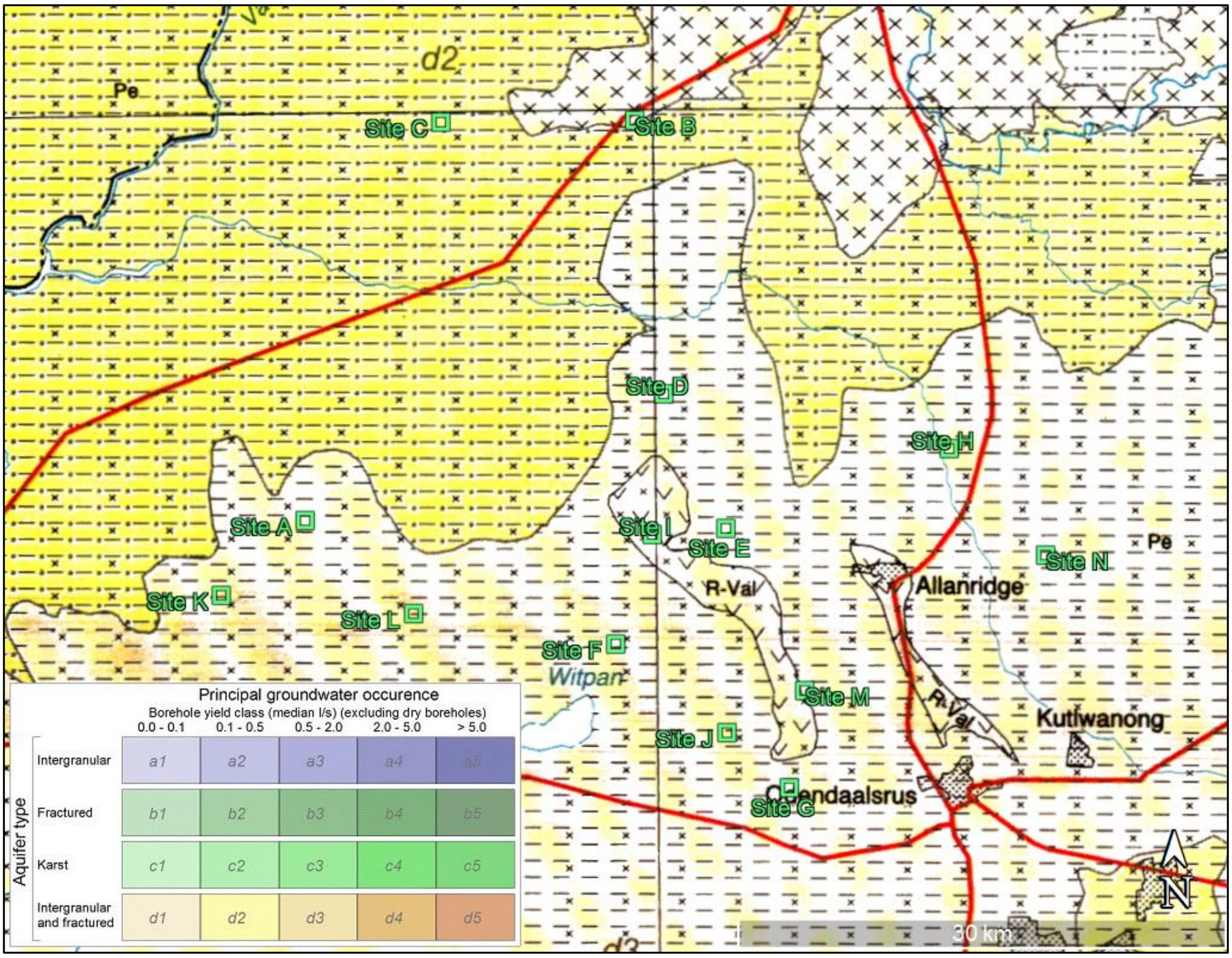


Figure 6: Regional Geohydrology

4.6 Regional Magnetic Mapping

Regional magnetic mapping is presented in Figure 7. The mapping indicates that magnetic flux across the project area has a range of 29515 to 32022 nT. The magnetic mapping indicates distinct and major structures in the project area, particularly along the southern boundary and through the centre of the project area. These features have a west to east, and north west to south east orientation respectively.

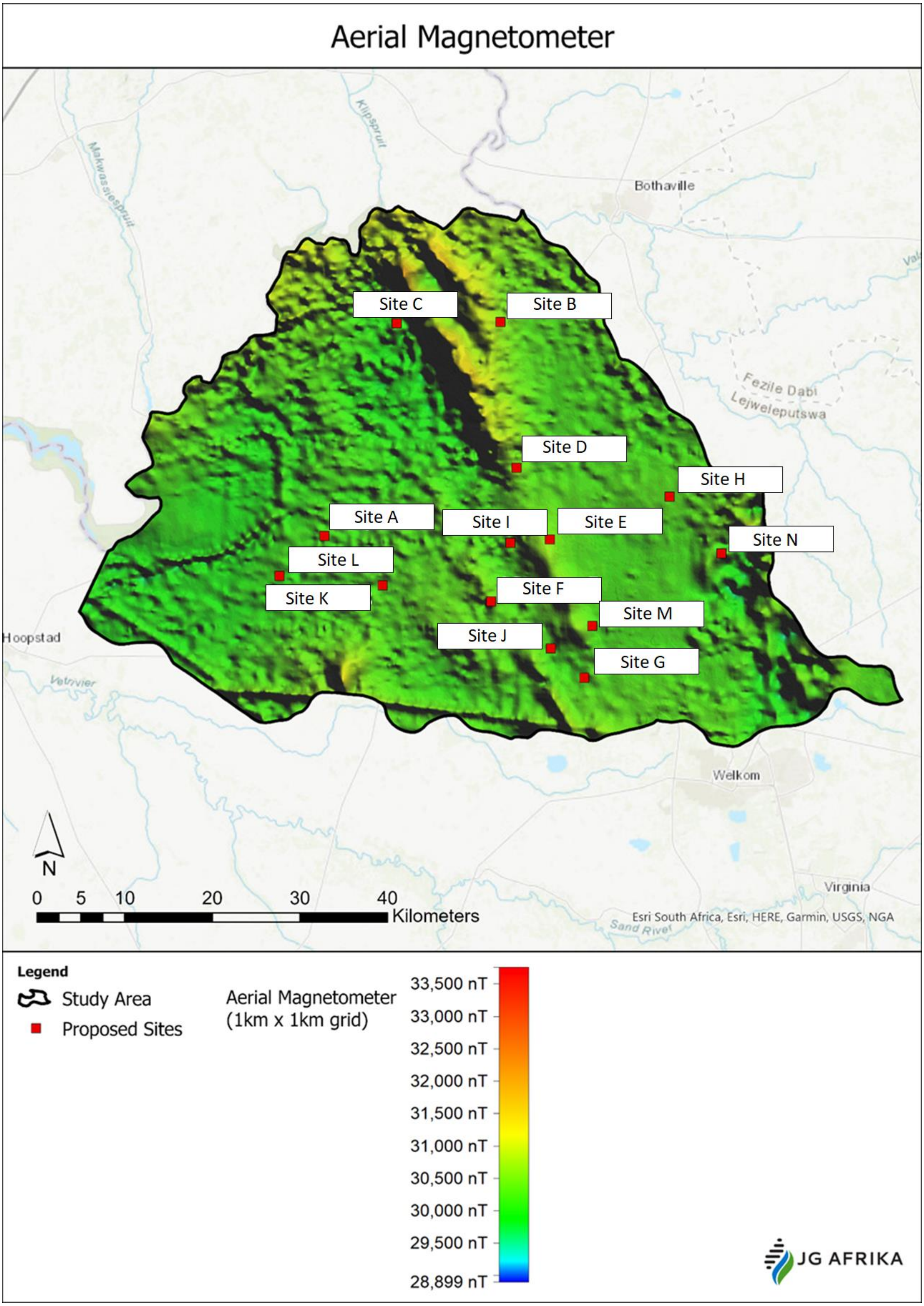


Figure 7: Regional Magnetic Mapping

4.7 Existing Groundwater Resources

The National Groundwater Archive (NGA) and Water Allocation Resource Management System (WARMS) of the DWS were interrogated to establish the existence of any groundwater resources and groundwater use in proximity to the sites. The resource information was used for the groundwater model development discussed in Section 6. NGA and WARMS resource information is presented in Annexure C.

Field verified resources identified during the site assessment for sampling are presented in Table 4. The distribution of the NGA, WARMS and field verified resources are presented in Figure 8.

Table 4: Summary Field Hydrocensus Information

Right	Site ID	SAMPLE ID	Resource Latitude	Resource Longitude	Accuracy (m)	Status	Water Level (m)	Equipment	Comment (condition, observed use, etc)
ER318	Site A	S05	-27.72510	26.28335	60	In use		submersible	general use, coords are 60 m from bh, located in lion enclosure, sampled from tap
ER318	Site B								
ER318	Site C	S04	-27.50435	26.37476	10	In use		windmill	livestock watering, pump at 12 m depth
ER318	Site D	S03	-27.66166	26.51401	10	In use	6.20	submersible	general use, sample from tap while pump running
ER318	Site E	S08	-27.69985	26.52885	10	not used		windmill	not used, windmill operates but poor condition
ER318	Site F	S19	-27.79127	26.46883	10	not used		windmill	windmill not functional, coloumns disconnected
ER318	Site G								
ER318	Site H	S18	-27.68369	26.85930	10	not used		windmill	not in use, headworks equipment damaged
ER318	Site I	S06	-27.73602	26.50594	10	In use		windmill	livestock watering, pump at 12 m
		S07	-27.73248	26.50824	10	In use		windmill	livestock watering, 60 m from S06
ER318	Site J								
ER318	Site K	S02	-27.76478	26.23450	10	In use		submersible	bh used as backup, sample from tap, has high salinity, rainwater harvesting is used
ER318	Site L	S01a	-27.76478	26.32325	10	In use		submersible	commercial use, total 6 boreholes at facility, sample talken from tap (composite)
		S01b	-27.76509	26.32458	10	not used	6.46	none	open borehole, not in use, poor recovery
		S01c	-27.76435	26.32531	10	In use	14.46	submersible	redrilled bh, used for domestic and agricultural use
ER318	Site M	S09	-27.81843	26.58991	10	not used	0.83	windmill	not in use, open borehol
ER318	Site N	S10	-27.74054	26.75264	10	not used	4.21	windmill	not in use
		S11	-27.76015	26.75991	10	not used	7.21	windmill	not in use

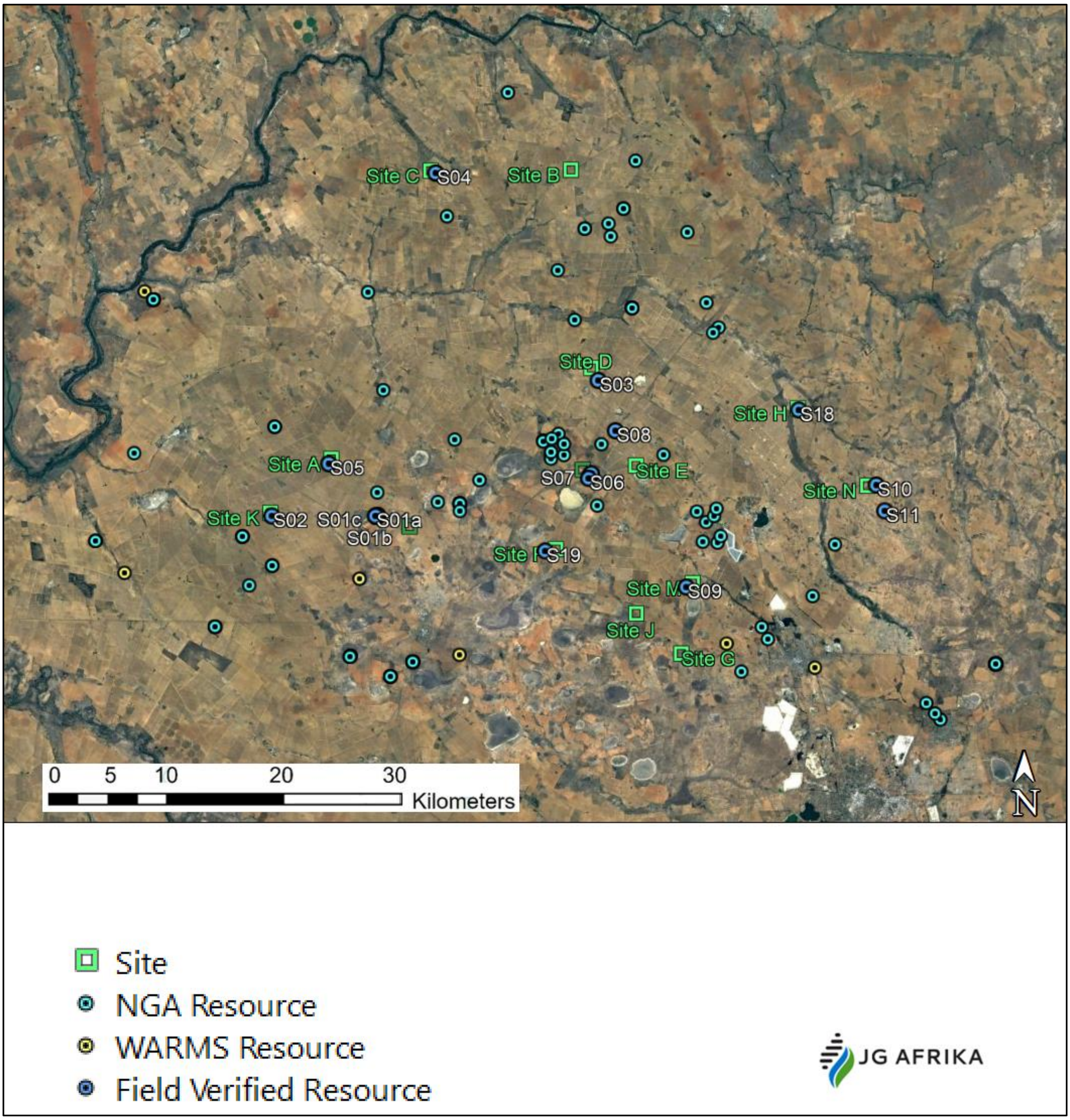


Figure 8: Hydrocensus

4.8 Water Quality Status Quo

Groundwater samples were collected by JG Afrika from boreholes identified and field verified during the site assessment, to establish the baseline groundwater quality status quo. Sampling was carried out from 29 November 2022 to 1 December 2022. Samples were submitted to EPL Laboratory for analysis of selected compounds of the Domestic Consumption SANS241 (2015) suite, to assess the potability and suitability of use. Samples were also submitted to iThemba labs for isotope analysis.

The results of analysis were compared to the SANS241 (2015) Drinking Water Standards screening guidelines. The summary results of analysis are presented in Table 5 and the laboratory certificates of analysis are presented in Annexure D.

Table 5: Summary Results of Groundwater Analysis

Sample Position		Site L	Site K	Site D	Site C	Site A	Site I		Site E	Site M	Site N		SANS 241 : 2015 Drinking Water		
Sample Date		29-Nov-22	29-Nov-22	29-Nov-22	29-Nov-22	29-Nov-22	30-Nov-22	30-Nov-22	30-Nov-22	01-Dec-22	01-Dec-22	01-Dec-22			
Sampled by		BS	BS	BS	BS	BS	BS	BS	BS	BS	BS	BS			
Sample Method		submersible	submersible	submersible	windmill	submersible	windmill	windmill	windmill	windmill	windmill	windmill	Upper Limits		
Report Date		21-Dec-22													
Laboratory Certificate Number		41076													
Laboratory Sample Reference		S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	Acute health / Chronic health	Aesthetic	Operational
Determinand	Unit														
Micro biological determinands															
E. coli or faecal coliforms	Count per 100 mL	200	0	0	0	0	1500	0	0	2160000	0	0	Not detected		
Total coliforms	Count per 100 mL	900	0	200	0	300	2400	0	0	4970000	1500	300			≤ 10
Heterotrophic plate count	Count per mL	46	37	157	40	92	335	0	21	27300	57	31			1 000
Physical and aesthetic determinands															
Colour	mg/L Pt-Co	<10	25.59	<10	10.33	<10	30.73	<10	33.93	221.1	<10	12.84		15	
Conductivity at 25 °C	mS/m	156.4	413.8	85.7	113	204.8	92.4	104.4	199.2	151.4	123.2	110.7		170	
Total dissolved solids	mg/L	1228	2787	601	964	1214	587	636	1409	1131	785	658		1200	
Turbidity	NTU	3.99	2.09	0.05	0.69	0.25	5.17	0.28	4.95	290.9	0.54	2.38		5	1
pH at 25 C	pH units	7.67	7.81	7.91	7.38	7.77	7.7	7.79	7.96	7.76	7.9	8.15			5 to 9.7
Chemical determinands — macro-determinands															
Nitrate as N	mg/L	59.58	<0.5	29.06	59.24	28.23	4.34	10.28	17.78	<0.5	18.1	13.33	11		
Nitrite as N	mg/L	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	0.9		
Combined nitrate-nitrite	-	59.58	<0.5	29.06	59.24	28.23	4.34	10.28	17.78	<0.5	18.1	13.33	1		
Sulphate as SO42–	mg/L	60.22	198.4	54.03	76.73	145.2	34.08	55.28	158.9	<2	77.92	55.19	500	250	
Fluoride as F–	mg/L	0.33	0.88	0.47	<0.05	0.43	0.6	0.56	0.53	0.65	0.47	0.52	1.5		
Ammonia as N	mg/L	0.03	0.14	<0.02	<0.02	0.03	0.04	<0.02	<0.02	11.11	<0.02	<0.02		1.5	
Chloride as Cl–	mg/L	229.8	1245	56.35	85.64	220.7	57.97	87.47	351.5	78.39	138.5	84.15		300	
Calcium as Ca	mg/L	124.4	107.5	49.02	97.91	129.8	78.69	65.28	115.9	30.77	64.33	19.21		150/300*	
Magnesium as Mg	mg/L	49.46	66.32	21.22	42.3	47.32	35.32	31.05	71.67	13.74	30.61	9.93	70/100*		
Potassium as K	mg/L	4.58	7.31	3.3	4.91	9.33	2.26	1.78	14.16	16.79	14.47	7.65	50/100*		50/100*
Sodium as Na	mg/L	94.96	604.9	69.99	32.39	184	83.23	93.76	146.5	263	124.4	149.4		200	
Zinc as Zn	mg/L	0.44	0.37	0.15	0.07	<0.05	0.11	0.11	<0.05	0.35	<0.05	0.32		5	
Chemical determinands — micro-determinands															
Aluminium as Al	µg/L	120	210	150	380	170	140	170	110	210	230	210	300		
Antimony as Sb	µg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	20		
Arsenic as As	µg/L	10	10	<10	10	10	10	10	10	20	10	<10	10		
Barium as Ba	µg/L	210	190	50	140	80	90	100	150	140	50	80	700		
Boron as B	µg/L	<500	1040	<500	<500	<500	<500	<500	<500	<500	<500	<500	2400		
Cadmium as Cd	µg/L	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	3		
Total chromium as Cr	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	50		
Cobalt as Co	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	500*		
Copper as Cu	µg/L	70	100	80	90	90	40	50	80	<10	60	70	2000		
Cyanide (recoverable) as CN–	µg/L	3	2	<2	3	<2	6	2	7	<2	2	<2	200		
Iron as Fe	µg/L	50	290	50	120	90	330	60	480	4190	60	220	2000	300	
Lead as Pb	µg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10		
Manganese as Mn	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	380	<50	<50	400	100	
Mercury as Hg	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	6		
Nickel as Ni	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	70		
Selenium as Se	µg/L	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	40		
Uranium as U	µg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	30		
Vanadium as V	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	200*		
Chemical determinands — organic determinands															
Total organic carbon as C	mg/L	<10	<10	<10	<10	<10	<10	<10	<10	24.39	<10	<10	10		
Phenols	µg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10		10	
Isotopes															
d D	(‰)	-18.0	-24.7	-18.6	-15.6	-24.0	-15.4	-24.4	-19.9	-25.4	-23.4	-26.1			
d^{18}O	(‰)	-2.9	-4.5	-3.6	-3.2	-4.0	-2.7	-4.0	-3.5	-4.3	-3.8	-4.2			

* SANS 241:2006 Limits -	Class I	Class II
* SANS 241:2011 Limits -	chronic health	acute health

The results of analysis indicate that for the compounds analysed, nitrate and combined nitrate/nitrate regularly exceed the acute health screening limit. *E.Coli* occasionally exceeded the acute health limit. Aluminium, arsenic, iron and total organic carbon exceeded the chronic health limit in isolated samples.

The operational and aesthetic limits were exceeded in numerous samples for total coliforms, colour, conductivity, total dissolved solids, turbidity and iron, with isolated exceedances for total plate counts, ammonia, chloride, sodium and manganese.

Typically the groundwater is unsuitable for potable use and the likely sources of compounds of concern are related to agricultural activities.

For the isotope analysis, the results are presented in the common delta-notation, expressed as per mil deviation relative to the known mean ocean water (SMOW) standard. The $\delta^{18}O$ versus δD space relative to the Global Meteoric Water Line (GMWL, Craig, 1961) is presented in Figure 9.

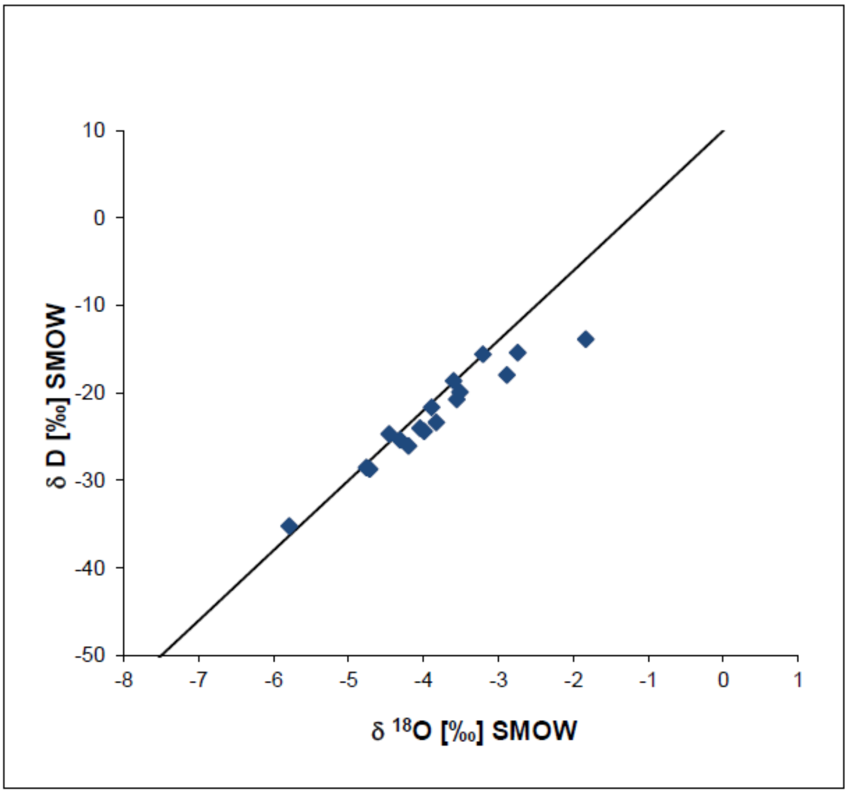


Figure 9: Stable Isotope Data Relative to Global Meteoric Water Line (Craig, 1961)

4.9 Groundwater Occurrence

The groundwater occurrence for the project area is presented in Figure 10. These delineations form the basis for the distribution of hydraulic conductivities and recharge in the groundwater model development discussed in Section 6. NGA and field verified boreholes are shown for spatial reference.

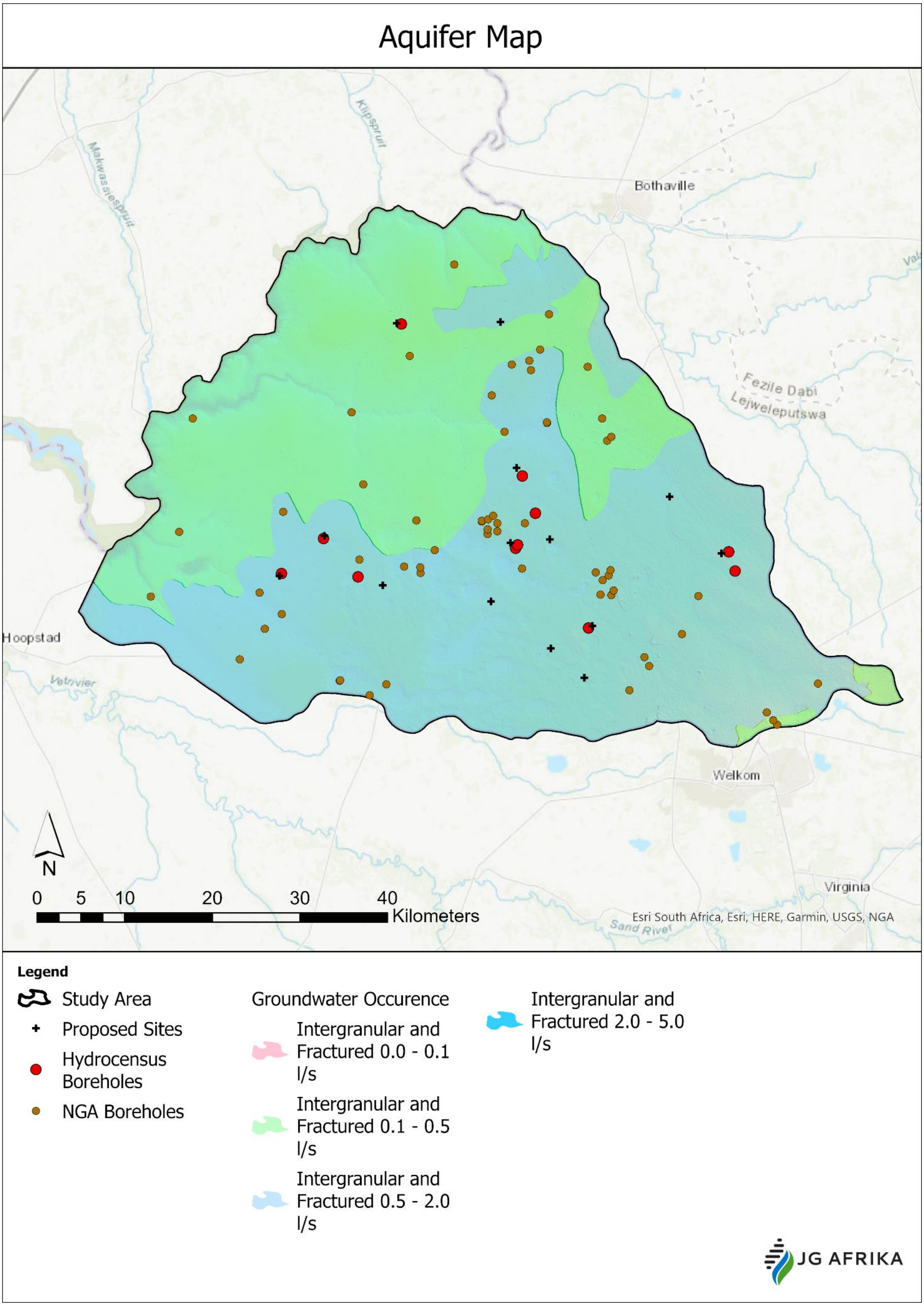


Figure 10: Groundwater Occurrence

4.10 Aquifer Vulnerability

The DRASTIC aquifer vulnerability method makes use of seven (7) factors to calculate the vulnerability index value:

- Depth to groundwater (D) – determines the maximum distance contaminants travel before reaching the aquifer
- Net recharge (R) – the amount of water that is able to travel from ground surface to the water table
- Aquifer (A) – the composition of the aquifer material
- Soil media (S) – the uppermost portion of the unsaturated zone
- Topography (T) – the slope of the ground surface
- Impact of vadose zone (I) – the type of material present between the bottom of the soil zone and water table
- Hydraulic conductivity of the aquifer (C) – indicates the aquifer's ability to allow for the flow of water to occur.

This vulnerability index is used to determine the aquifer's vulnerability to pollution with the index range from 1 to 200, where 200 represents the theoretical maximum aquifer vulnerability. The DRASTIC map for the project area is presented in Figure 11. The maximum index in the project area is 50% of the vulnerability scale.

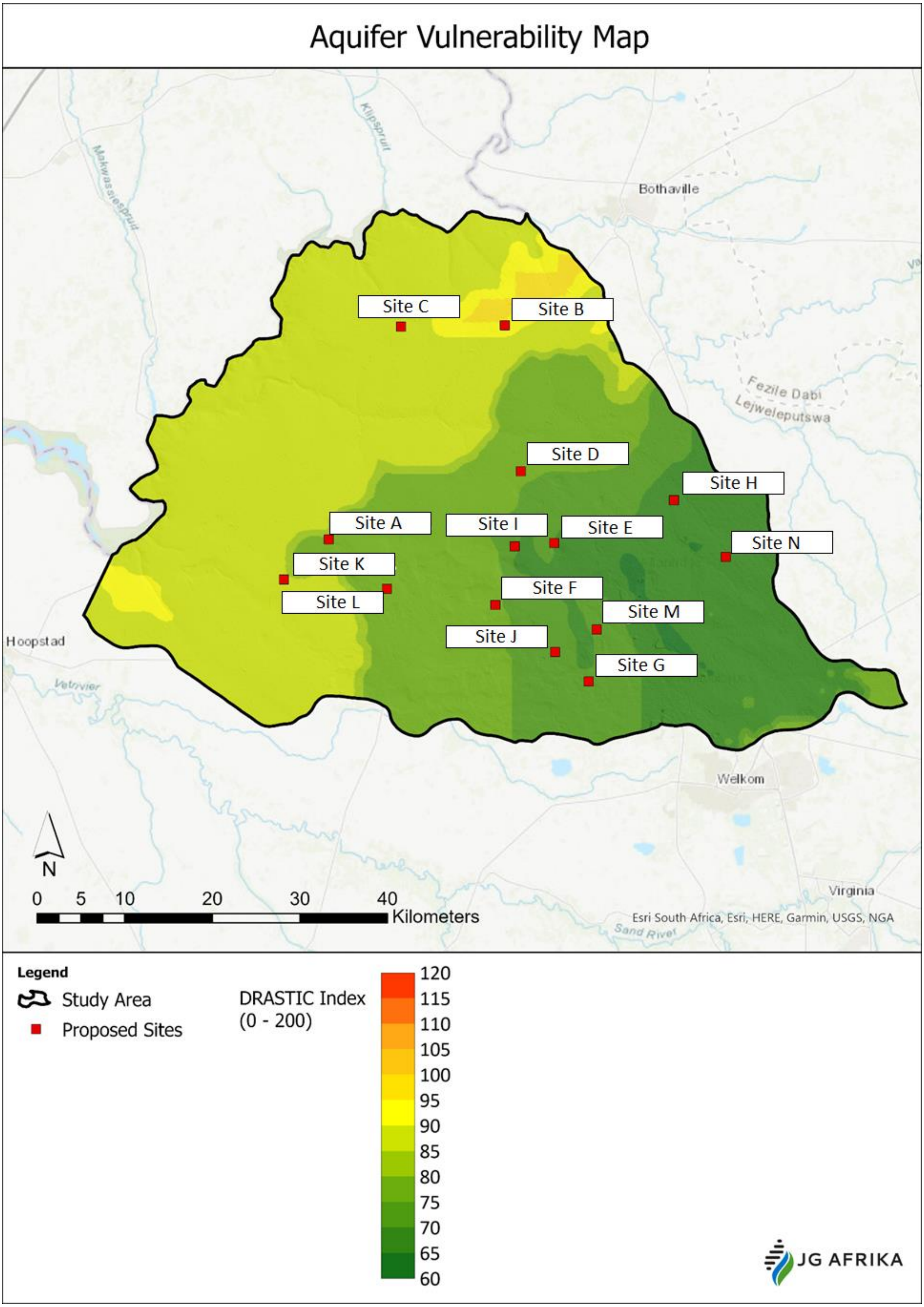


Figure 11: Aquifer Vulnerability

4.11 Regional Water Levels

There exists a high correlation between surface elevation and groundwater level across the project area as presented in Figure 12. Both historic water levels from NGA as well as the field verified data support this trend. Due to limited water level information, resources with water level data as far back as 1994 were considered.

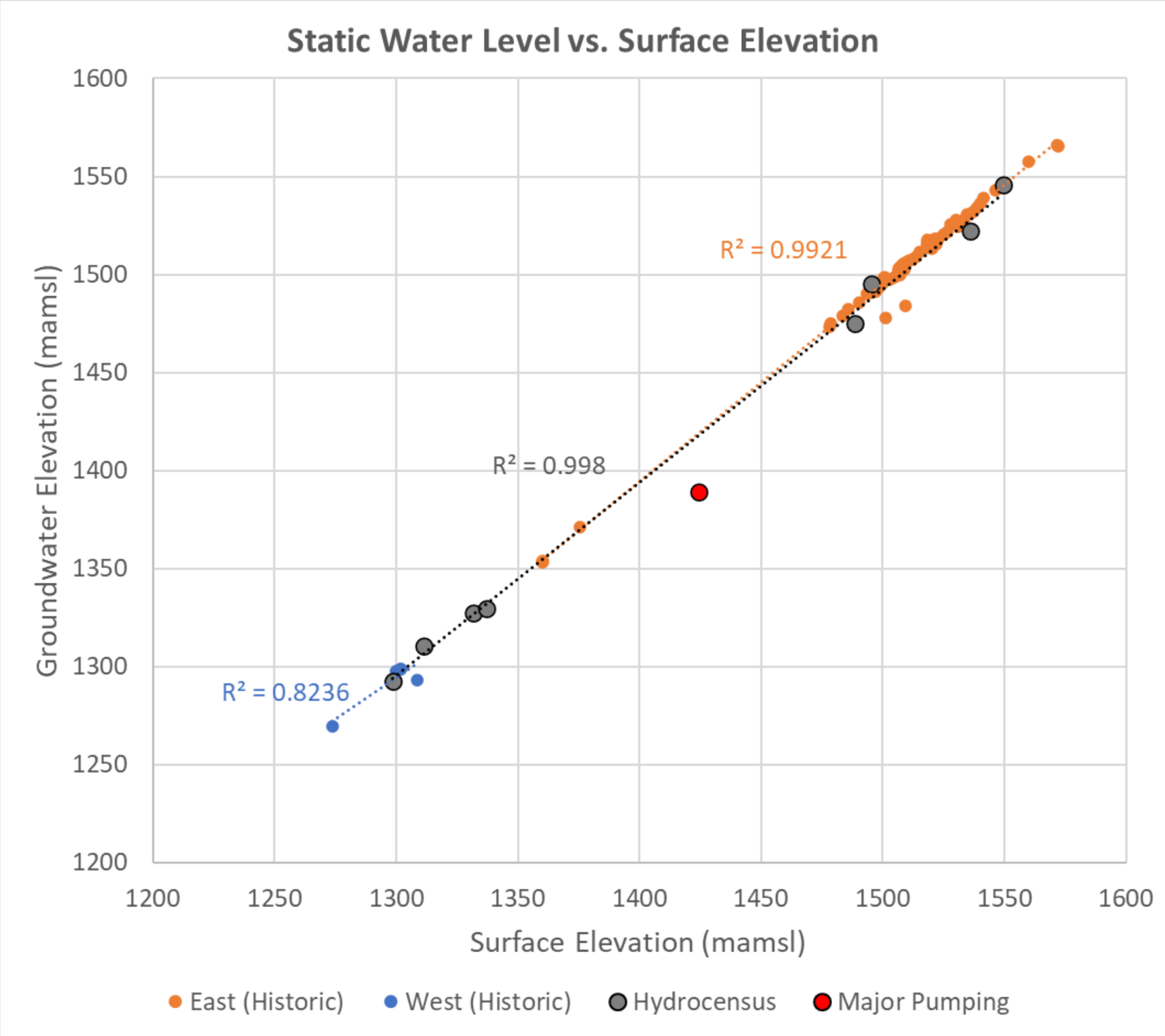


Figure 12: Groundwater Level Correlation with Surface Elevation

Many historic resources within the NGA plot on top of each other or in a L shape with only an offset of a few meters between each borehole. Historically, before GPS technology, surveyors assigned all the boreholes within a farm boundary to the farm centroid. This resulted in many resources not being found in the field due to inaccurate coordinates. The implication of this is that the associated data does not relate to the coordinate specified. These boreholes were excluded from the groundwater model development, therefore the calibration dataset is smaller than the actual number of boreholes presented in Annexure C.

5 CONCEPTUAL MODEL DEVELOPMENT

5.1 Introduction

The development of the conceptual model relies on the availability of geological data. The borehole logs used in the model development are presented in Annexure B and used in setting up a three layer conceptual model. All borehole logs were simplified into three layers as shown in Table 6. Not all three layers exist everywhere in the model domain.

Table 6: Layer Distribution of Conceptual Model

Layer Number	Description
1	Sandstone
2	Shale
3	Sandstone

5.2 Visualization of Model Layers

The visualization of the conceptual model layers for the project area is presented in Figure 13 looking from south to north over the project area. The top sandstone layer is not present across the entire domain and the middle shale layer and bottom sandstone layer also pinches out in certain parts of the model domain. The conceptual model relied on the interpolation of the borehole logs since no field verification was carried out.

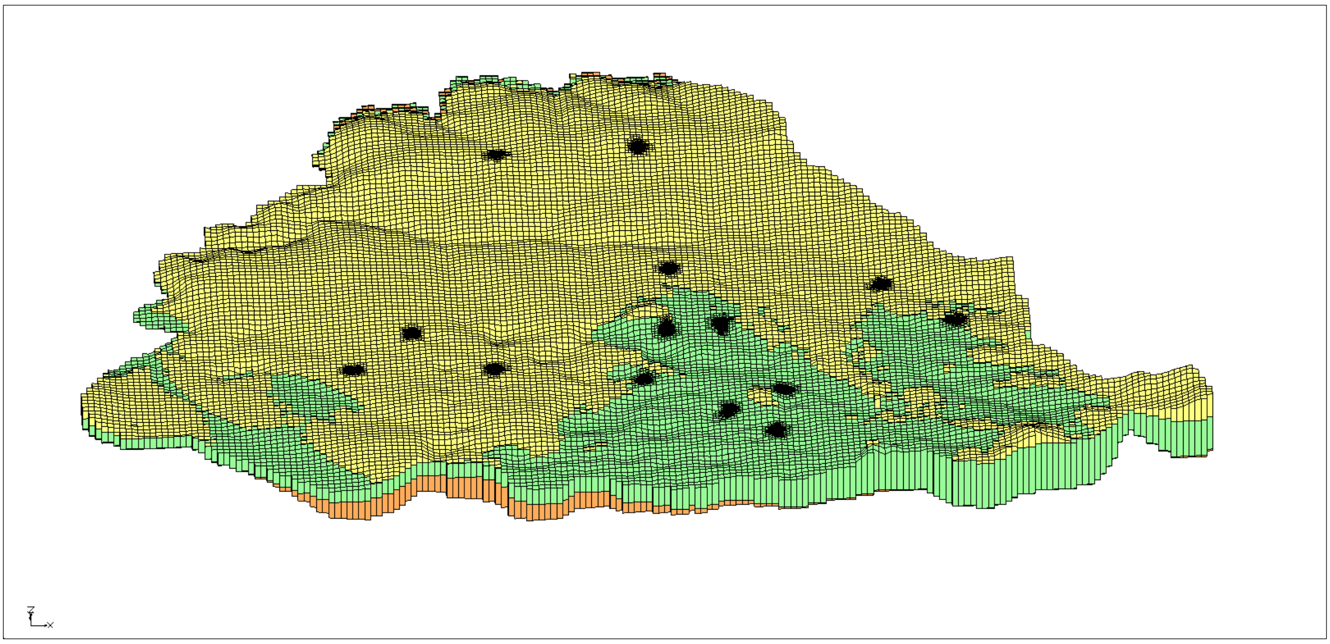


Figure 13: Three Layer Conceptual Model

6 NUMERICAL GROUNDWATER FLOW MODEL

6.1 Assumptions and Limitations

The numerical groundwater model is based on the layered conceptual model presented in Section 5, which was derived from the review of the information presented in the desktop and site assessment.

For the model setup, the following typically needs to be described:

- Geological and hydrogeological features

- Boundary conditions of the study area (based on the geology and hydrogeology)
- Initial water levels of the study area
- The processes governing groundwater flow
- Assumptions for the selection of the most appropriate numerical code.

Field data is essential in solving the conditions listed above and developing the numerical model into a site-specific groundwater model. Specific assumptions related to the available field data include:

- The top of the aquifer is represented by the generated groundwater heads
- The available geological/hydrogeological information was used to describe the different aquifers. The available information on the geology and field measurements are considered as correct. Limited hydrocensus sites were available, thus the NGA data was used as the status quo of the study area. Since the NGA also lack timeseries water level, all data after 2000 was used to obtain water levels over the project area. Contradicting water levels in areas with a high borehole density were evident, as this relates to a different rainfall recharge from 2000 to 2022. The general water level trend in the project area were assumed to be correct
- Many aquifer parameters have not been determined in the field and therefore have to be estimated. In the absence of pump test data, aquifer parameters and hydraulic conductivities were determined through the model calibration process.

In order to develop a model of an aquifer system, certain assumptions have to be made. These include:

- The system is initially in equilibrium and therefore in steady state[2], even though natural conditions have been disturbed
- No abstraction boreholes were included in the initial model
- The boundary conditions assigned to the model are considered correct
- The impacts of other activities (e.g. agriculture) have not been taken into account.

A numerical groundwater model is a representation of the real system. It is therefore at most an approximation, and the level of accuracy depends on the quality of the data that is available. This implies that there are always errors associated with groundwater models due to uncertainty in the data, and the capability of numerical methods to describe natural physical processes.

In addition to the model limitations, the following limitation and assumptions apply to the modelling:

- No transient calibration could be done as in the absence of time series monitoring data, only steady-state conditions were considered
- Specific storage and porosity values were taken from literature as these were not available for a transient mass transport simulation
- As no pumping rates were available on production boreholes, estimates were used in the scenario modelling.

[2] In steady state systems, inputs and outputs are in equilibrium so that there is no net change in the system with time. In transient simulations, the inputs and outputs are not in equilibrium so there is a net change in the system with time. Steady state models provide average, long-term results. Transient models should be used when the groundwater regime varies over time.

6.2 Generation of a Finite Difference Network

In order to investigate the behaviour of aquifer systems in time and space, it is necessary to employ a mathematical model. MODFLOW, a modular three-dimensional finite difference groundwater flow model was the software used during this investigation. It is an internationally accepted modelling package, which calculates the solution of the groundwater flow equation using the finite difference approach.

The simulation model used in this modelling study is based on three-dimensional groundwater flow as described by the following equation:

$$\frac{\partial}{\partial x}(K_x\frac{\partial h}{\partial x})+\frac{\partial}{\partial y}(K_y\frac{\partial h}{\partial y})+\frac{\partial}{\partial z}(K_z\frac{\partial h}{\partial z})\pm W=S\frac{\partial h}{\partial t}$$

where,

h	=	Hydraulic head
Kx, Ky, Kz	=	Hydraulic conductivity in different directions
S	=	Storage coefficient
t	=	Time
W	=	Source (recharge) or sink (pumping) per unit area
x, y, z	=	Coordinate into model

For steady state conditions the groundwater flow equation reduces to the following:

$$\frac{\partial}{\partial x}(K_x\frac{\partial h}{\partial x})+\frac{\partial}{\partial y}(K_y\frac{\partial h}{\partial y})+\frac{\partial}{\partial z}(K_z\frac{\partial h}{\partial z})\pm W=0$$

Groundwater Modelling System (GMS) 10.7 was used to develop the conceptual and numerical models. GMS is a groundwater modelling application from Aquaveo in Utah, United States of America, for building and simulating groundwater models. It features 2D and 3D geostatistics, stratigraphic modeling and a unique conceptual model approach. Currently supported models include MODFLOW, MODPATH, MT3DMS, RT3D, FEMWATER, SEEP2D, and UTEXAS. Esri Arc GIS was used to generate output maps.

6.3 Model Grid

The network was constructed using a cell size of 500 x 500 m over the model extent with a grid refinement of 25m x 25m over a 1km radius around the proposed sites. The model grid for the project area is presented in Figure 14.

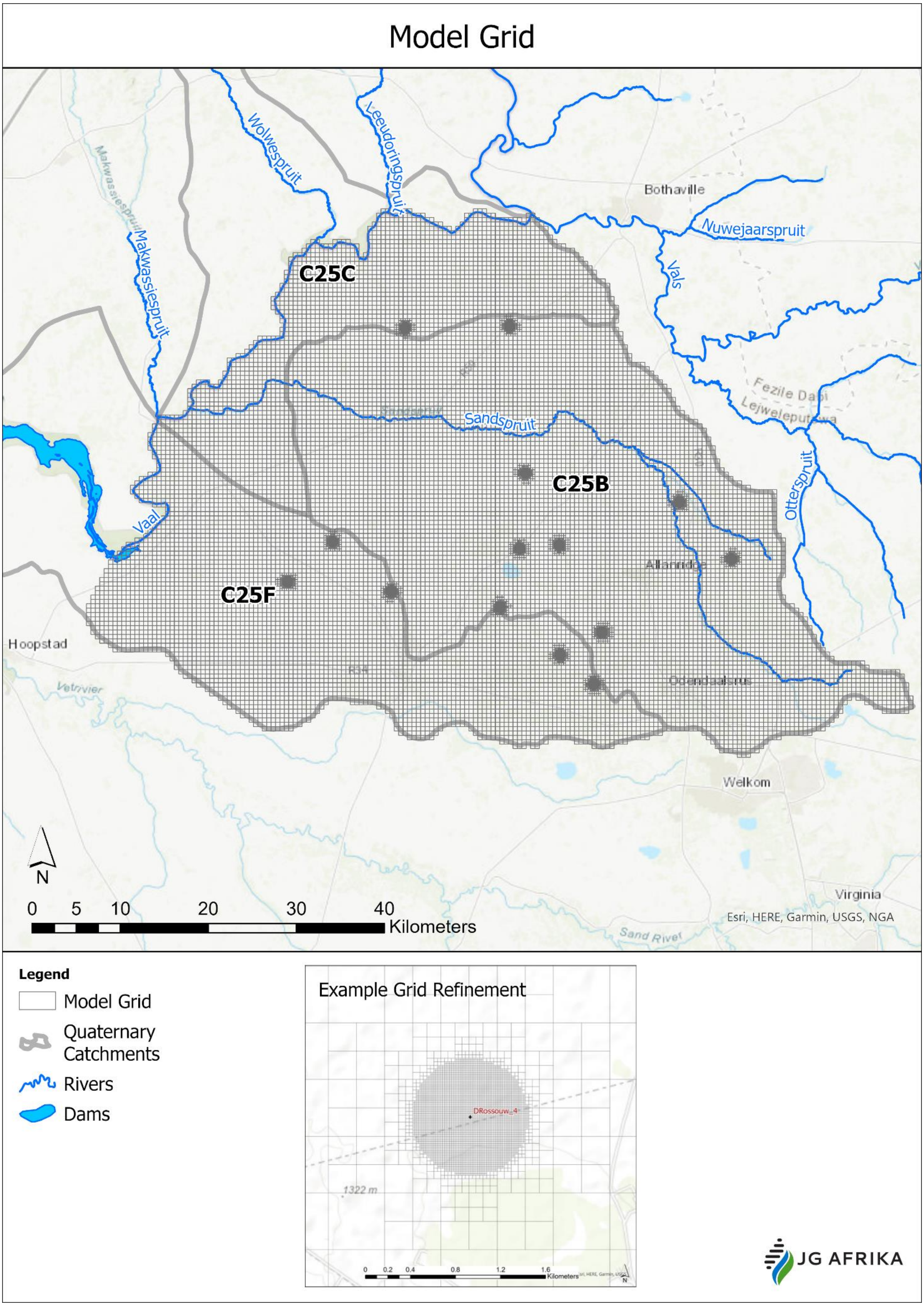


Figure 14: Model Grid

6.4 Boundary Conditions

One of the first and most demanding tasks in groundwater modelling is that of identifying the model area and its boundaries. A model boundary is the interface between the model area and the surrounding environment. Conditions on the boundaries have to be specified. Boundaries occur at the edges of the model area and at locations in the model area where external influences are represented, such as rivers, wells, and leaky impoundments.

Criteria for selecting hydraulic boundary conditions are primarily topography, hydrology and geology. The topography and/or geology may yield boundaries such as impermeable strata or a potentiometric surface controlled by surface water, or recharge/discharge areas such as inflow boundaries along mountain ranges. The flow system allows the specification of boundaries in situations where natural boundaries are a great distance away.

Boundary conditions must be specified for the entire boundary and may vary with time. At a given boundary section just one type of boundary condition can be assigned. As an example, it is not possible to specify groundwater flux and groundwater head at an identical boundary section. Boundaries in groundwater models can be specified as:

- Dirichlet (also known as fixed head or constant concentration) boundary conditions
- Neuman (or specified flux) boundary conditions
- Cauchy (or a combination of Dirichlet and Neuman) boundary conditions
- General Head Boundary (GHB) (also known as a head dependant flux boundary).

The rivers in the model grid were considered constant head boundaries and the wetlands and drainage lines were treated as drains in the model domain.

Dykes were not explicitly accounted for in the model although there are major magnetic structures visible in the magnetic mapping. Generally, dykes are modelled as no flow boundaries, but it is unlikely that these major structures are all no flow boundaries. Further, the depth of these structures was not available.

6.5 Model Parameters

Groundwater models consists of sources and sinks to add and remove water from the domain to maintain the overall model water balance. This section describes the model parameters assigned to each layer of the model.

6.5.1 Recharge

As no groundwater chloride concentrations were available for use in the chloride mass-balance method, and no time series water levels were available for the use in a water balance method, recharge could not be calculated and the default recharge values obtained from the GRAII project were used. The recharge values are presented in Table 7.

Table 7: Recharge Values

Quaternary	MAP (mm/a)	Recharge as % MAP	Recharge (m/d)
C25B	509	4.0%	0.00005578
C25C	522	5.7%	0.00008152
C25F	481	3.2%	0.00004217
Average	504	4.3%	0.00005938

Recharge zones were chosen to align with the groundwater occurrence areas within the model boundaries. The zone numbers are presented in Figure 15 and summarised in Table 8.

Table 8: Summary of Recharge Values

Zone	Study Area	Recharge (m/d)	Recharge %
1	West	0.00008107	5.7%
2	West	0.00004551	3.2%
3	West	0.00004551	3.2%

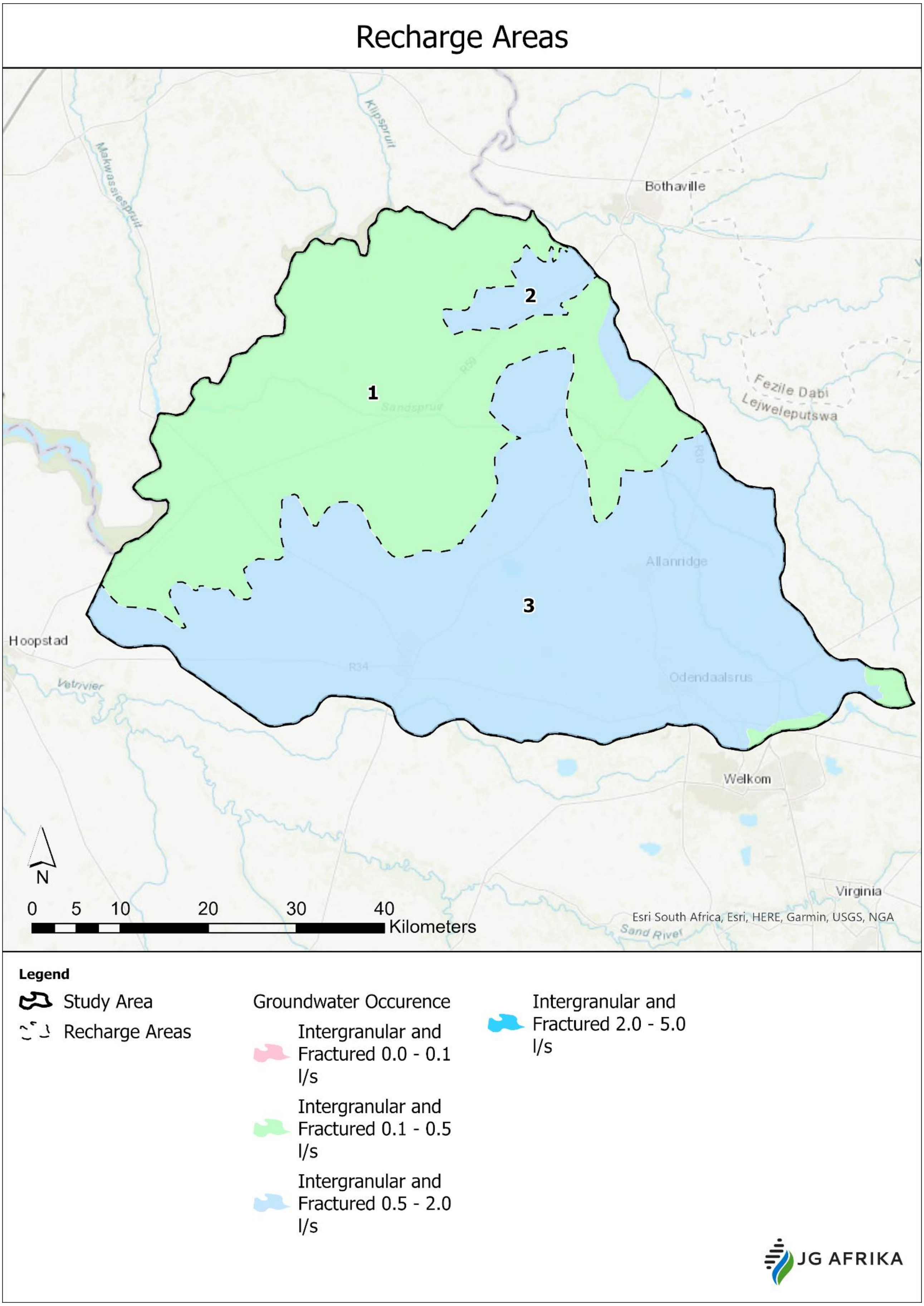


Figure 15: Recharge Zone Numbers

6.5.2 Hydraulic Conductivities

Since no aquifer tests were available, the hydraulic conductivities were determined through the calibration process by keeping the recharge values within a tight range around values obtained from the GRAII database.

The horizontal hydraulic conductivities are related to the groundwater occurrence units, therefore each unit in each layer was calibrated with a hydraulic conductivity. Calibration is non-unique, therefore aquifer tests would be required to obtain a better hydraulic conductivity range to calibrate against. The geometric mean of the horizontal hydraulic conductivities of selected layers are presented in Table 9, and a vertical anisotropy factor of 10 was used throughout the model.

Table 9: Summary of Hydraulic Conductivities for Model Layers

Layer No.	Layer	Hydraulic Conductivity (m/d)
Layer 1	Sandstone	0.586466
Layer 2	Shale	0.464172
Layer 3	Sandstone	0.088411

6.6 Initial Conditions

The model was initialized with parameter values as presented above. Initial water levels were required to solve the steady-state equation. The regional borehole water levels were discussed in Section 4. As a high correlation between the average water levels and topography was observed, the Bayesian interpolation method to generate water levels across the entire domain is well suited. The Bayesian method employs Bayes' probability theorem that describes the probability of an observation, based on prior knowledge of conditions that might be related to the observation. The main advantage of using the Bayesian interpolation is that water levels can also be extrapolated to areas where no water level information exists. Using known elevation data, the probability calculation can be used to estimated water levels. The resultant water level map for the project area representing the initial model water levels is presented in Figure 16.

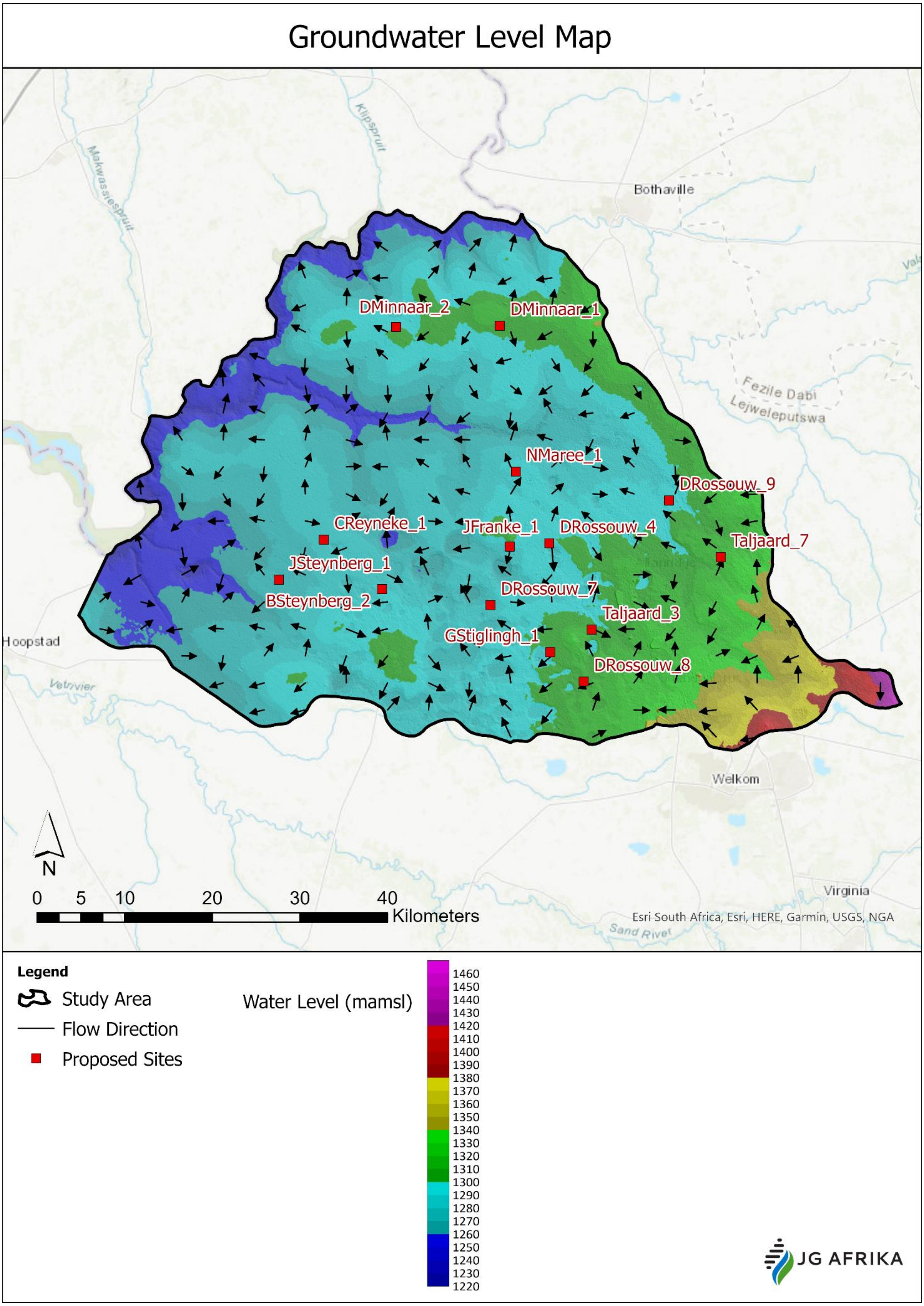


Figure 16: Initial Model Water Levels

7 MODEL CALIBRATION

The steady state head distribution is dependent upon the recharge, hydraulic conductivity, sources, sinks, and boundary conditions specified. For a given recharge component and set of boundary conditions, the head distribution across the aquifer under steady-state conditions can be obtained for a specific hydraulic conductivity value. The simulated head distribution can then be compared to the measured head distribution and the hydraulic conductivity or recharge values can be altered until an acceptable correlation between measured and simulated heads is obtained. The advantage of a steady state model is that the parameter for storage coefficient is not required to solve the groundwater flow equation, therefore there are fewer unknown parameters to determine.

The calibration process was done by changing the model parameters for hydraulic conductivity and keeping the recharge within a tight range of the obtained values. Borehole water levels were used to calibrate the steady state groundwater flow model until an acceptable correlation was obtained. The spatial distribution of these boreholes and calibration state is presented in Figure 17. The error bars indicate a ±5 m variation and all green boreholes lie within this range when comparing observed and simulated water levels.

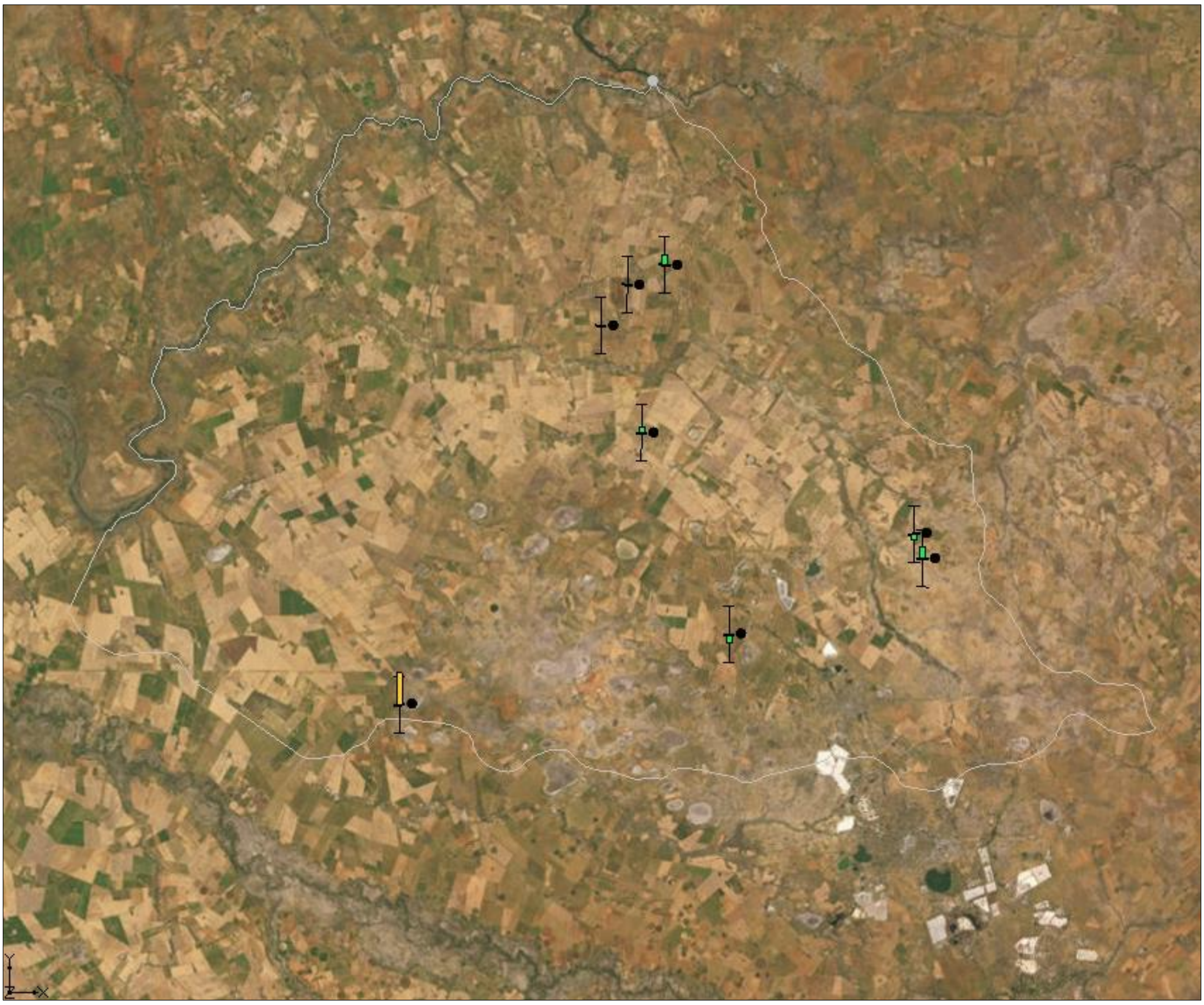


Figure 17: Calibration State of Boreholes

The observed versus simulated water levels for each calibration borehole is presented in Figure 18 This shows a high correlation over the project area.

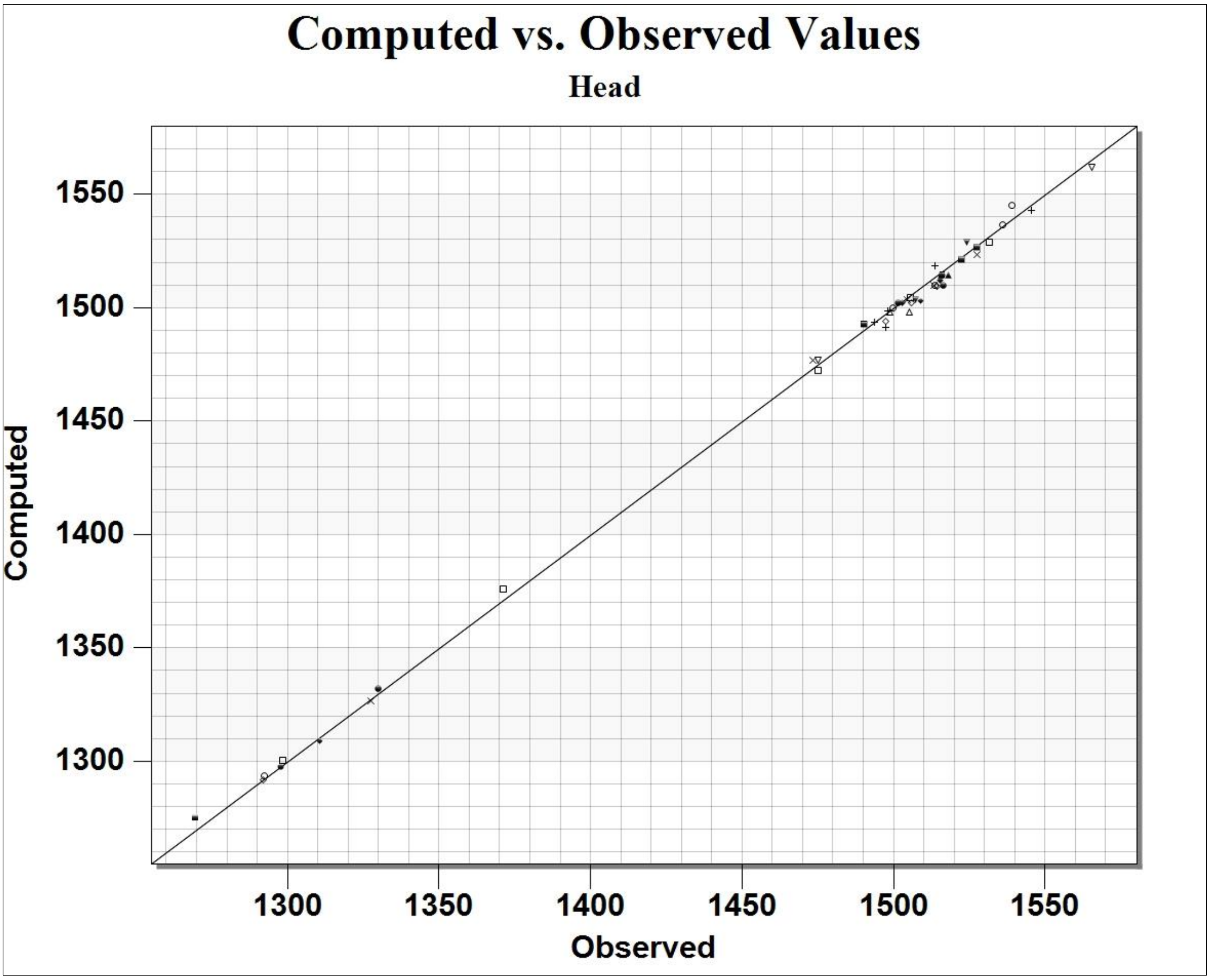


Figure 18: Correlation Between Observed and Simulated Water Levels

Not all observation boreholes were used in the calibration process due to contrasting water levels of some boreholes in close proximity to each other. Possible reasons for water level anomalies could be one of the following:

- Water levels measured at different periods in time which are subject to different rainfall and different site conditions. Only water levels measured between 2000 and 2023 were considered to reduce the temporal window, but at the same time, get a good spatial distribution of water levels over the area
- Some boreholes intersect different aquifer systems or geological features like faults or dykes. To account for these types of borehole responses, substantial monitoring data is required to understand the water level behaviour. Furthermore, borehole construction could also play an important role in water level response.

8 MODEL SCENARIOS

8.1 Introduction

The generic scenario considered for each of the proposed sites was the well casing integrity has hypothetically deteriorated to the extent that some pollutant could enter any of the three layers of the model. A percentage model is used to determine the pollution plume footprint. The percentage model assumes conservative mass transport, therefore if the source concentration is known, the plume concentration is obtained my multiplying the source concentration with the plume percentage.

8.2 Methodology

The calibrated numerical groundwater flow model was used and pumping boreholes were introduced into the model, as the change in hydraulic gradients could influence the direction of the plume migration. During the hydrocensus, it was not possible to establish the abstraction rates of existing boreholes, so an estimate was made based on the inferred type of use. Estimated abstraction rates are presented in Table 10.

Table 10: Estimated Abstraction at Field Verified Sites

ID	Equipment	Comment (condition, observed use, etc)	Estimated Abstraction
S01	submersible	commercial use, 6 boreholes at facility, sample	2
S02	submersible	borehole used as backup, sample from tap, has	0
S03	submersible	general use, sample from tap while pump	1
S04	windmill	livestock watering, pump at 12 m depth	5
S05	submersible	general use, coordinates are 60 m from	1
S06	windmill	livestock watering, pump at 12 m	5
S07	windmill	livestock watering, 60 m from S06	5
S08	windmill	not used, windmill operates but poor condition	3
S09	windmill	not in use, open borehole	0
S10	windmill	not in use	0
S11	windmill	not in use	0

In addition to the field verified boreholes, registered use resources were obtained from the WARMS database, and these boreholes were also introduced as pumping boreholes at the rates specified. The WARMS boreholes are presented in Table 11. Pumping boreholes introduced into the model for scenario modelling are presented in Figure 19.

Table 11: WARMS Borehole Pumping Rates

Registration ID	Longitude	Latitude	Use (L/s)
20030967	26.62450	-27.86146	0.58
23051830	26.70037	-27.87958	0.78
23053428	26.12539	-27.59425	0.70
23047793	26.32450	-27.76618	0.95
23035181	26.10782	-27.80812	0.57
23041129	26.30950	-27.81256	0.23
23031176	26.39533	-27.87034	0.26
23014060	27.63564	-27.95593	0.01
23002698	27.54044	-27.58133	48.40
23015960	27.27952	-27.65038	0.48
23002625	27.55925	-27.95315	0.28
23002625	27.55925	-27.95315	0.84
23002625	27.55925	-27.95315	7.81
23002625	27.54397	-27.96701	1.27
23002625	27.55925	-27.96148	0.28
23002625	27.58842	-27.93926	1.11
23002625	27.55925	-27.95315	0.37
23002625	27.55925	-27.95315	0.56
23002625	27.55925	-27.95315	0.37
23087419	27.68505	-27.50442	0.17
23002643	27.69121	-27.56428	5.79
23000529	27.59121	-27.52678	0.09
23020286	27.33425	-27.34484	0.34
23086125	27.33136	-27.35375	0.90
23018967	27.48009	-27.57483	0.29
23018967	27.46620	-27.56845	0.58
23018967	27.48009	-27.57483	0.69

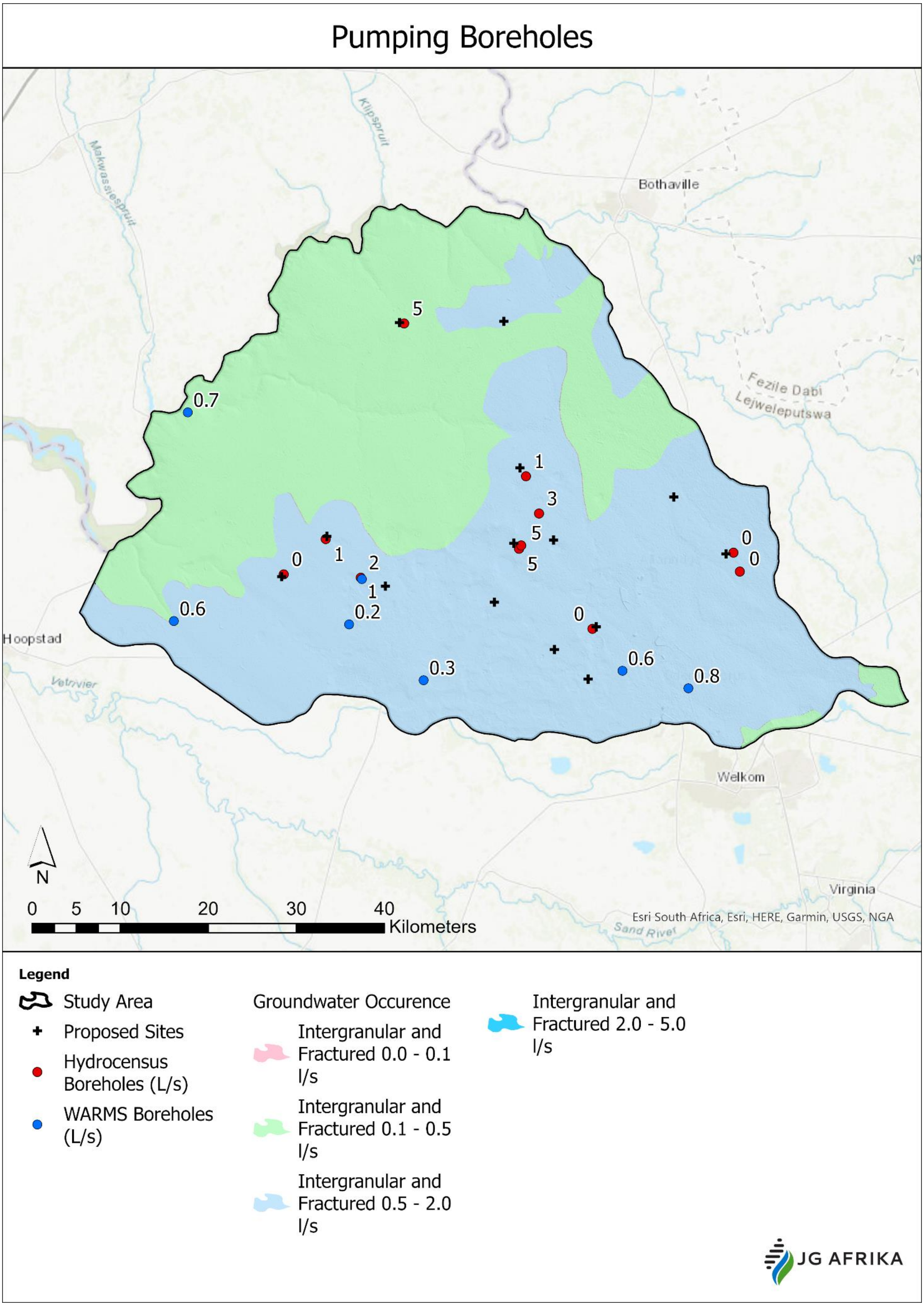


Figure 19: Pumping Boreholes

9 MODEL RESULTS (STEADY STATE)

Evaluating the general response of the expected plume movements, the following can be said for the majority of the sites:

- The plume movement over 100 years does not extend far (Max 670 m). This is based on estimated aquifer parameters and not field verified aquifer test data
- In areas where a wetland or pan is in close proximity to the proposed site, the plume moves in the direction of the wetland or pan, as this is modelled as a groundwater discharge zone.
- The shallow groundwater conditions (<200m depth) were considered most relevant for development of model scenarios as these aquifers are the source of many water supply boreholes in the project area, and present the greatest risk. Deeper aquifers, as per those being targeted by the Rhino exploration programme, are lower risk and modelled plumes will have less lateral extent.

The graphical plume outputs are presented in Figure 20 to Figure 33.

Figure 20: Modelled Plume - Site A

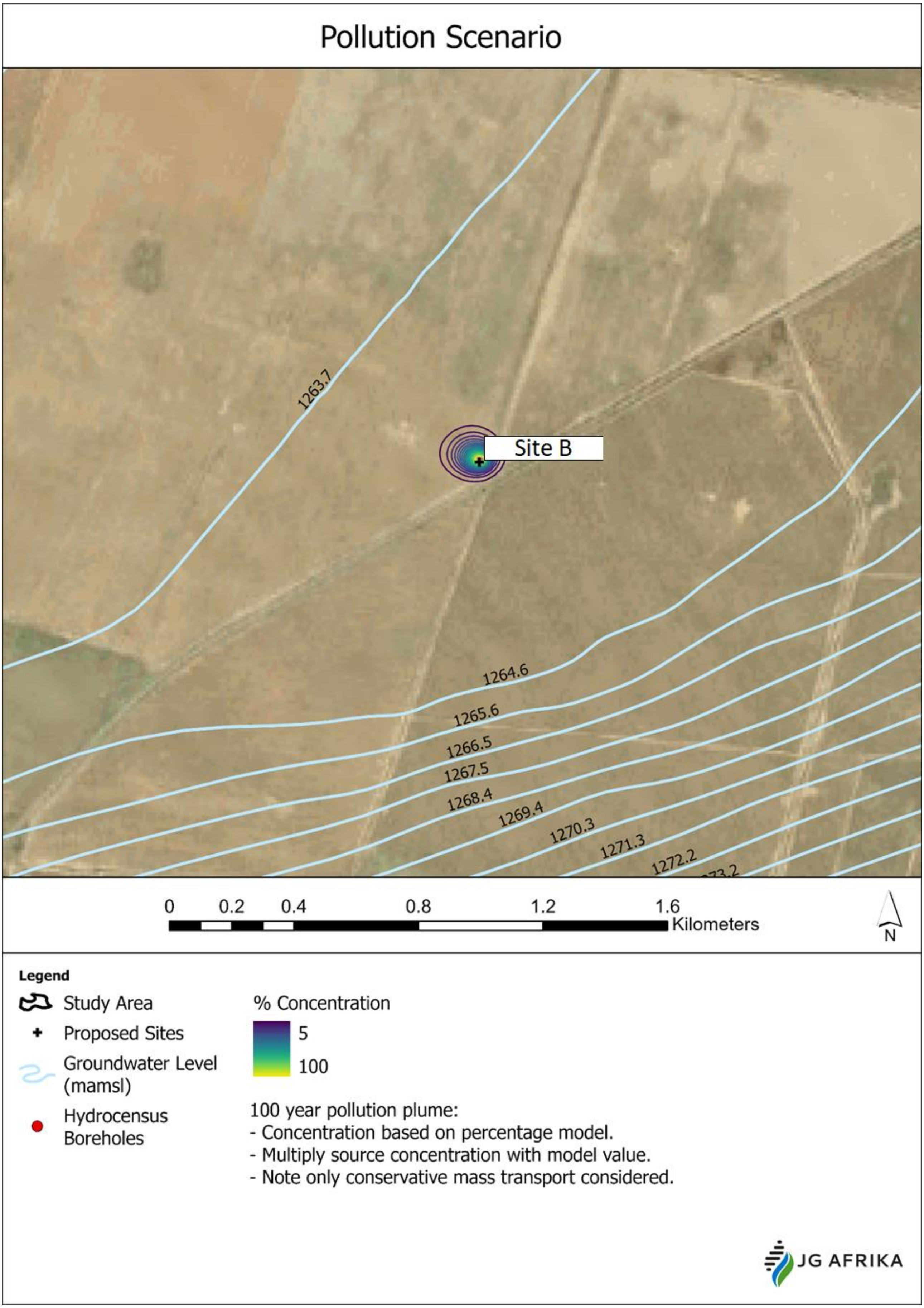


Figure 21: Modelled Plume - Site B

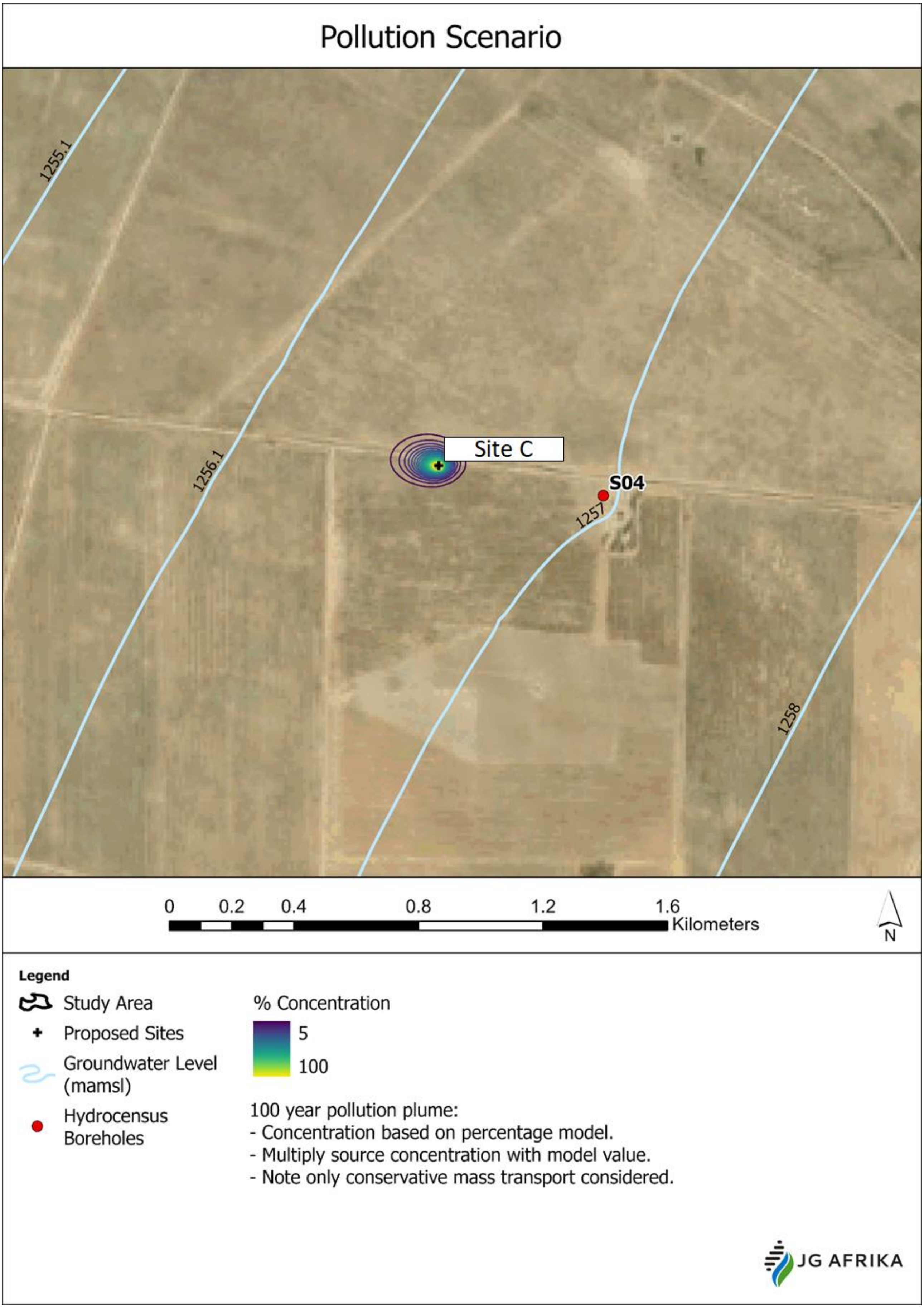


Figure 22: Modelled Plume - Site C

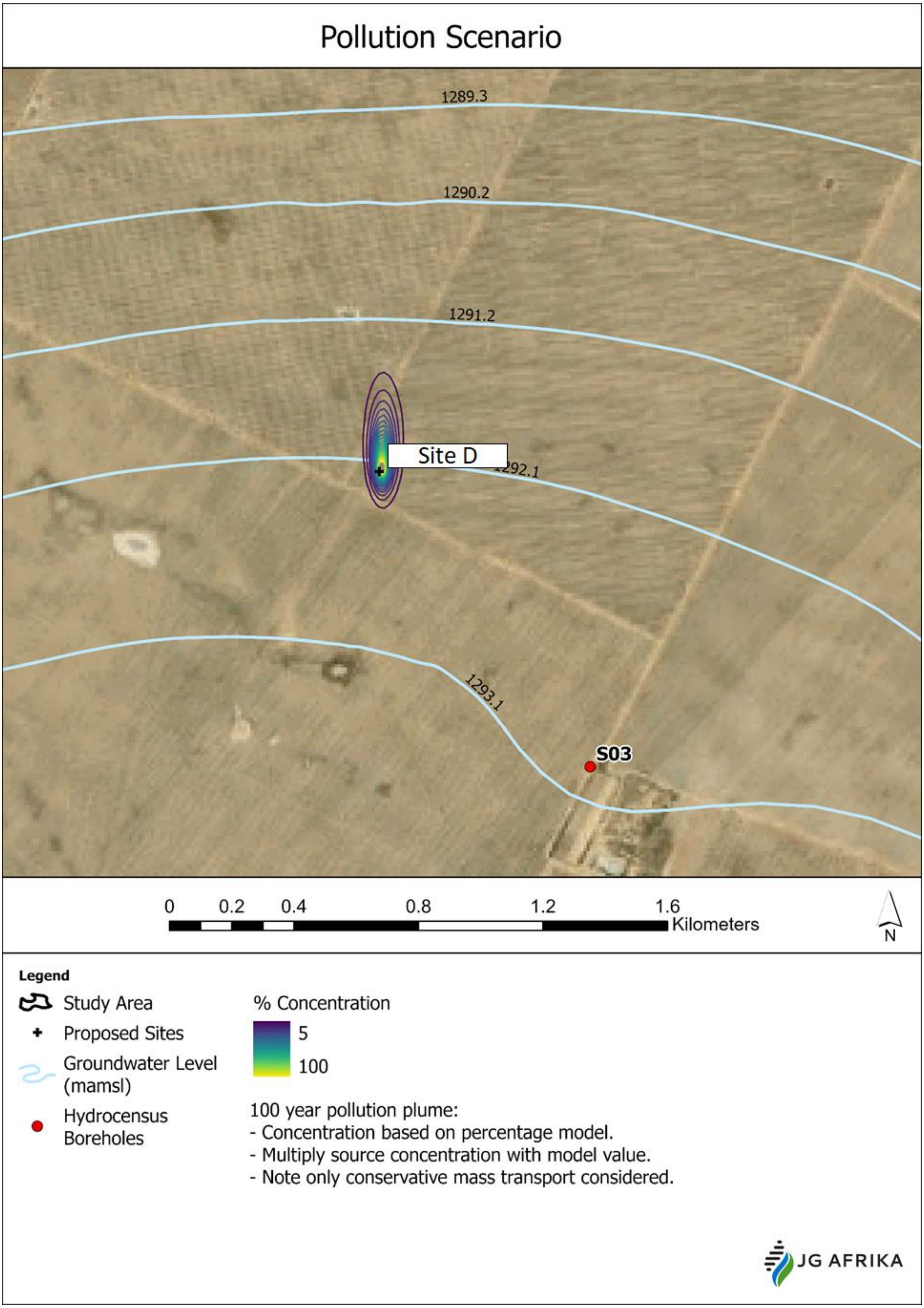


Figure 23: Modelled Plume - Site D

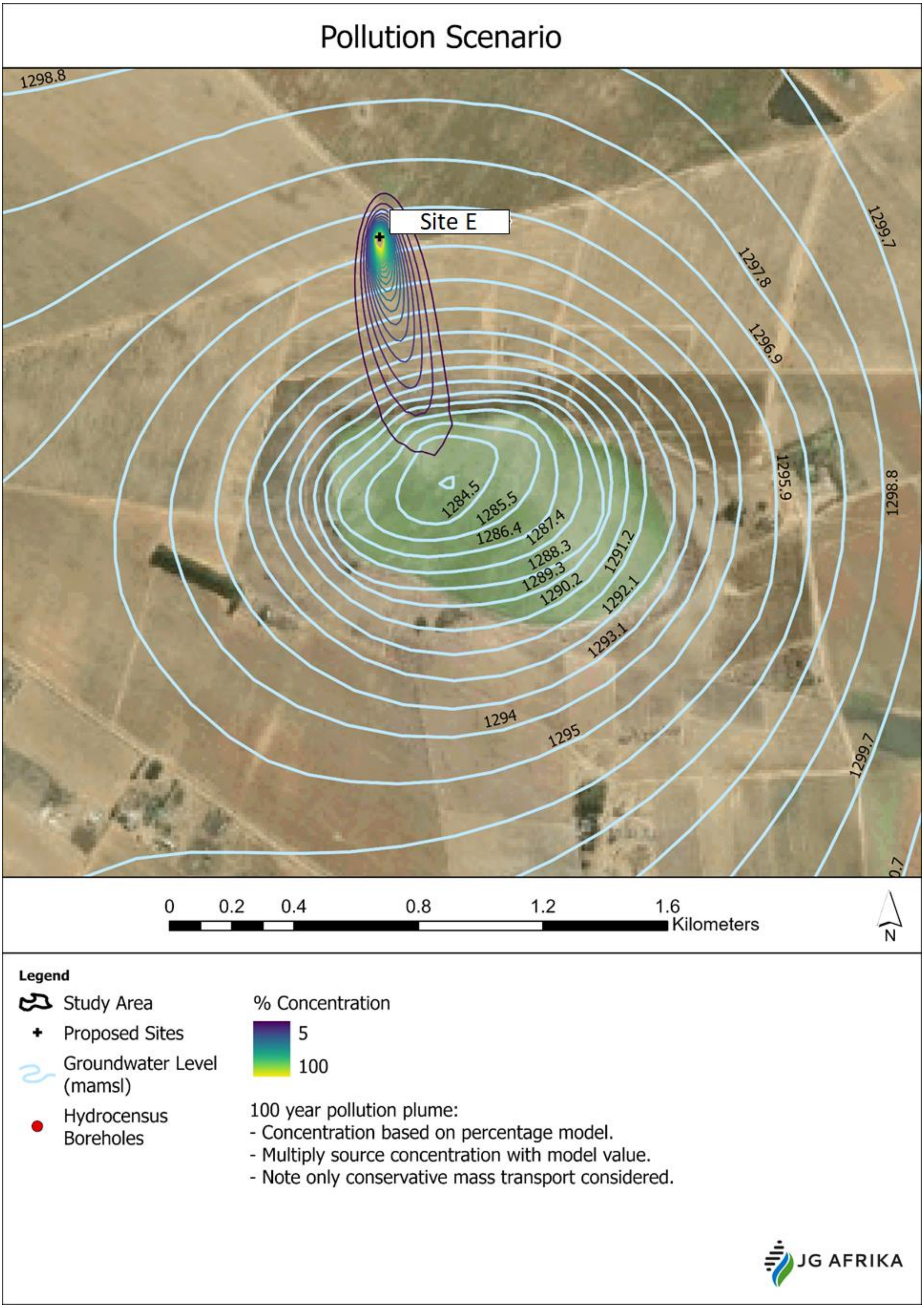


Figure 24: Modelled Plume - Site E

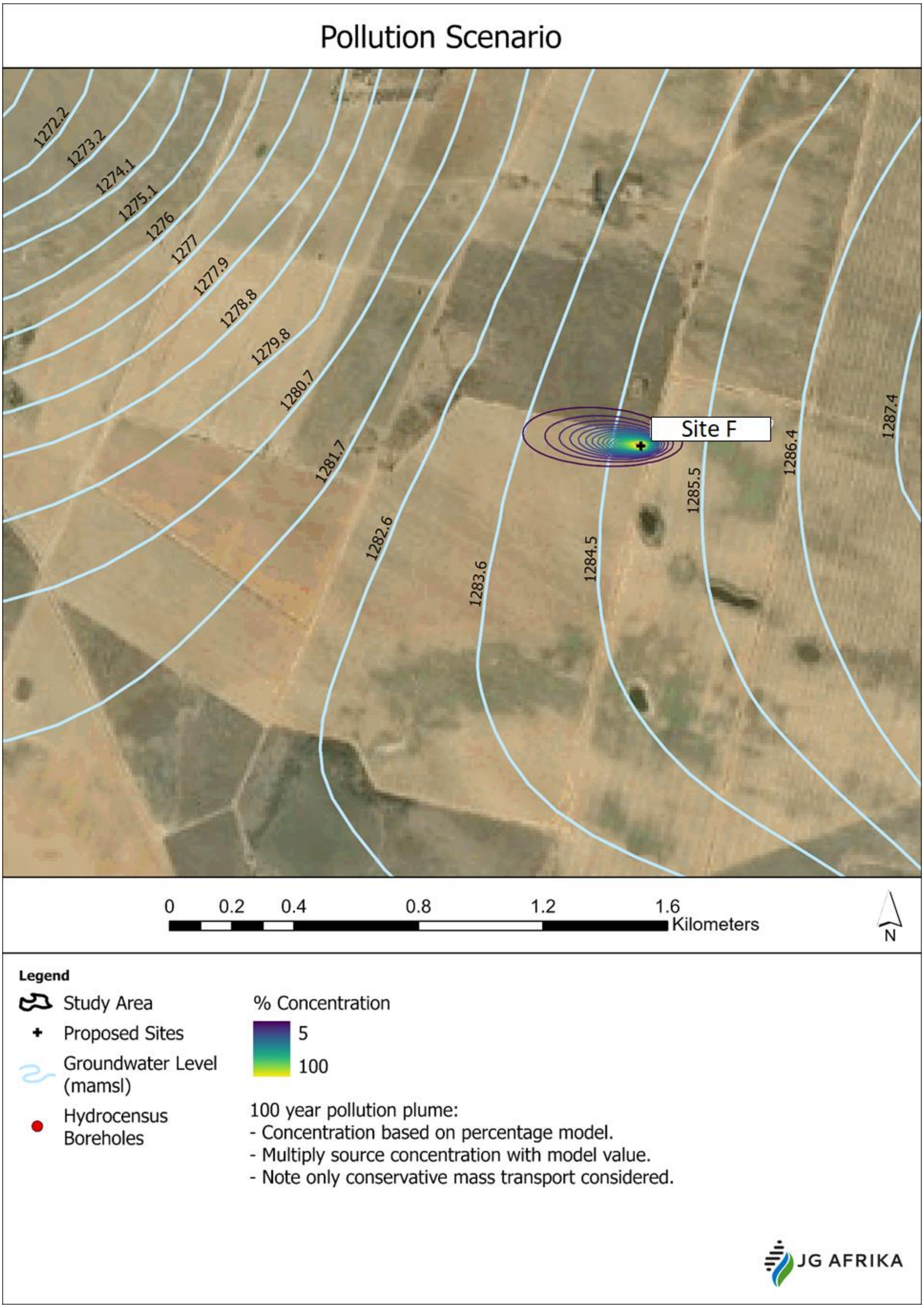


Figure 25: Modelled Plume - Site F

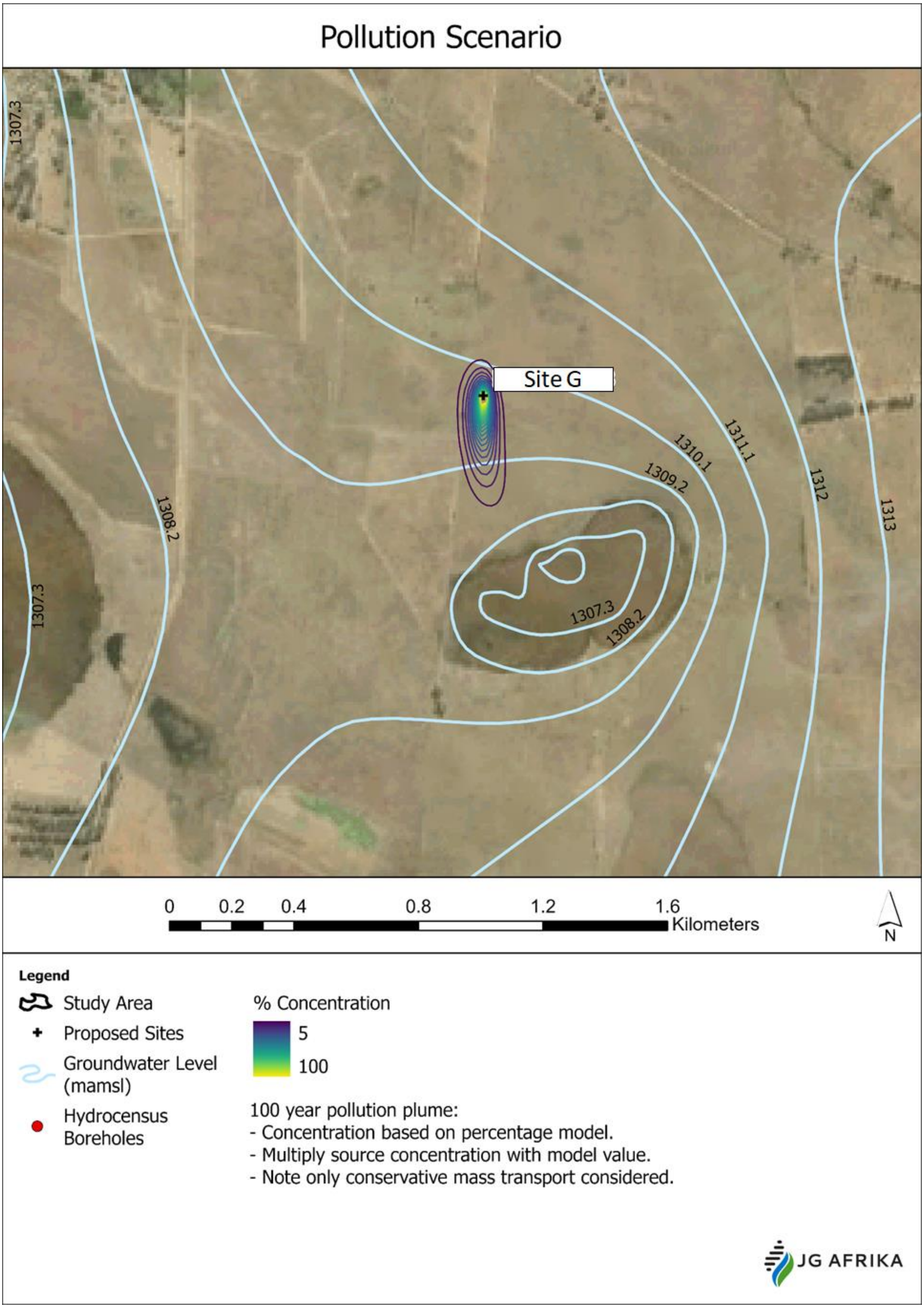


Figure 26: Modelled Plume - Site G

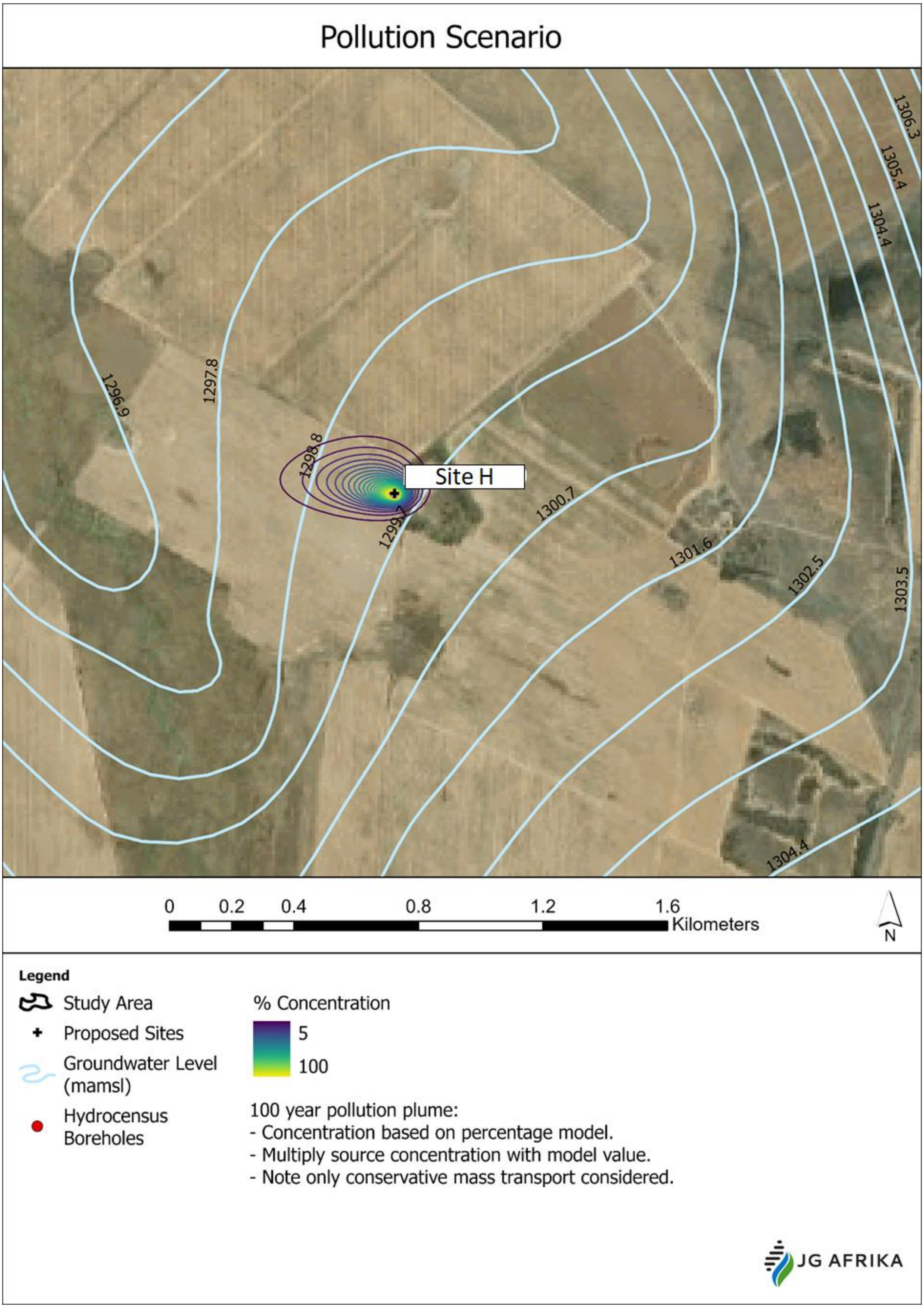


Figure 27: Modelled Plume - Site H

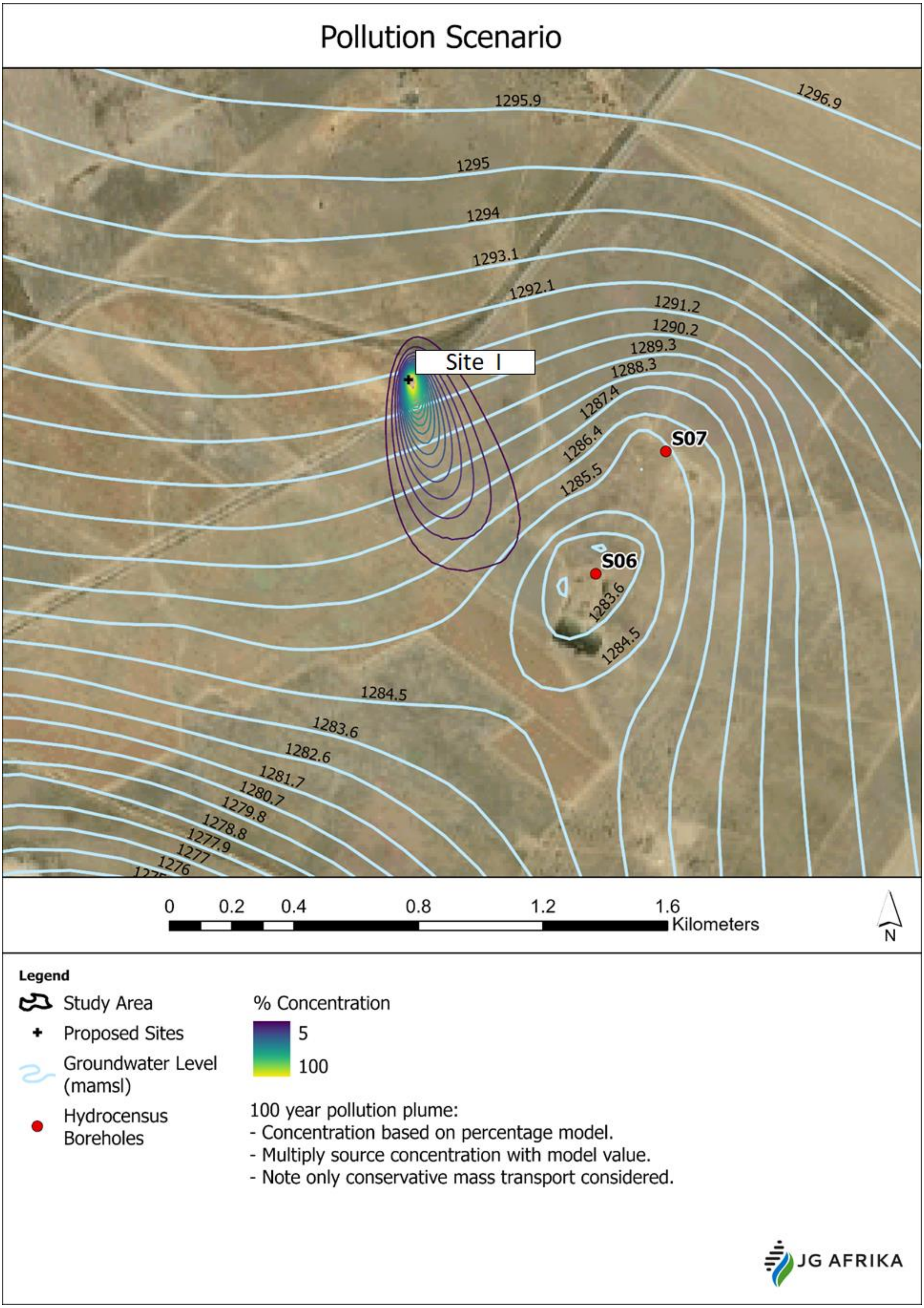


Figure 28: Modelled Plume - Site I

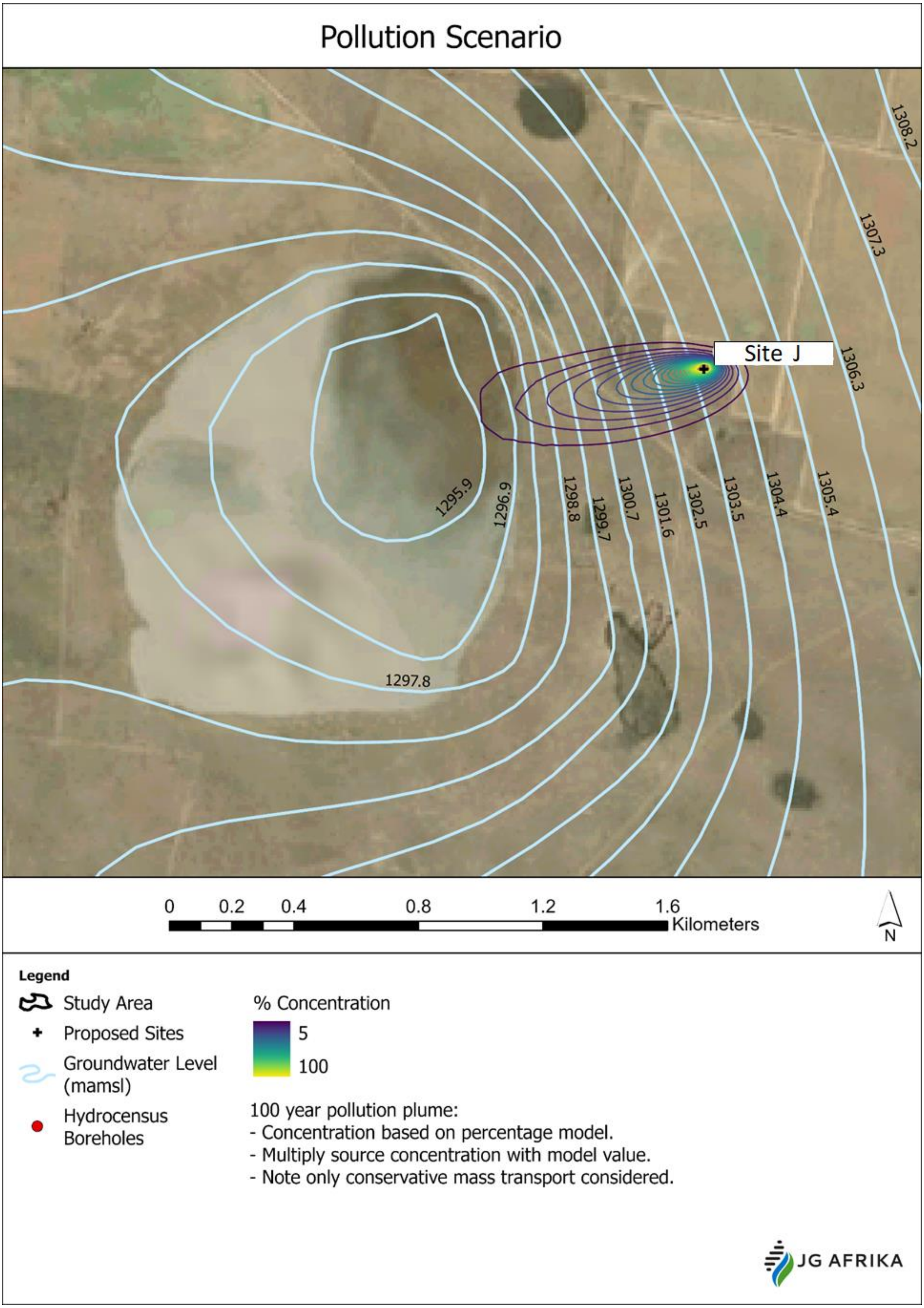


Figure 29: Modelled Plume - Site J

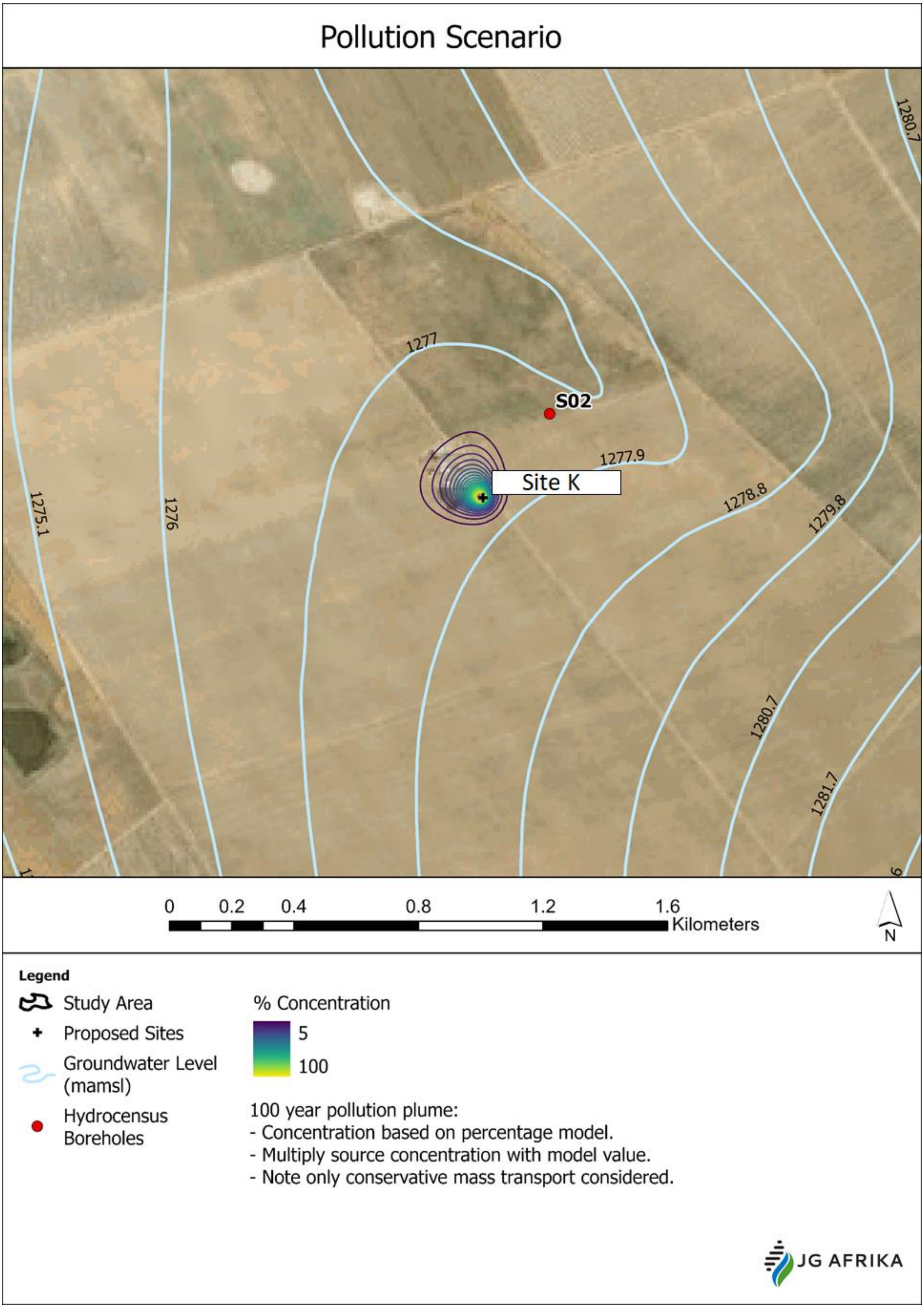


Figure 30: Modelled Plume - Site K

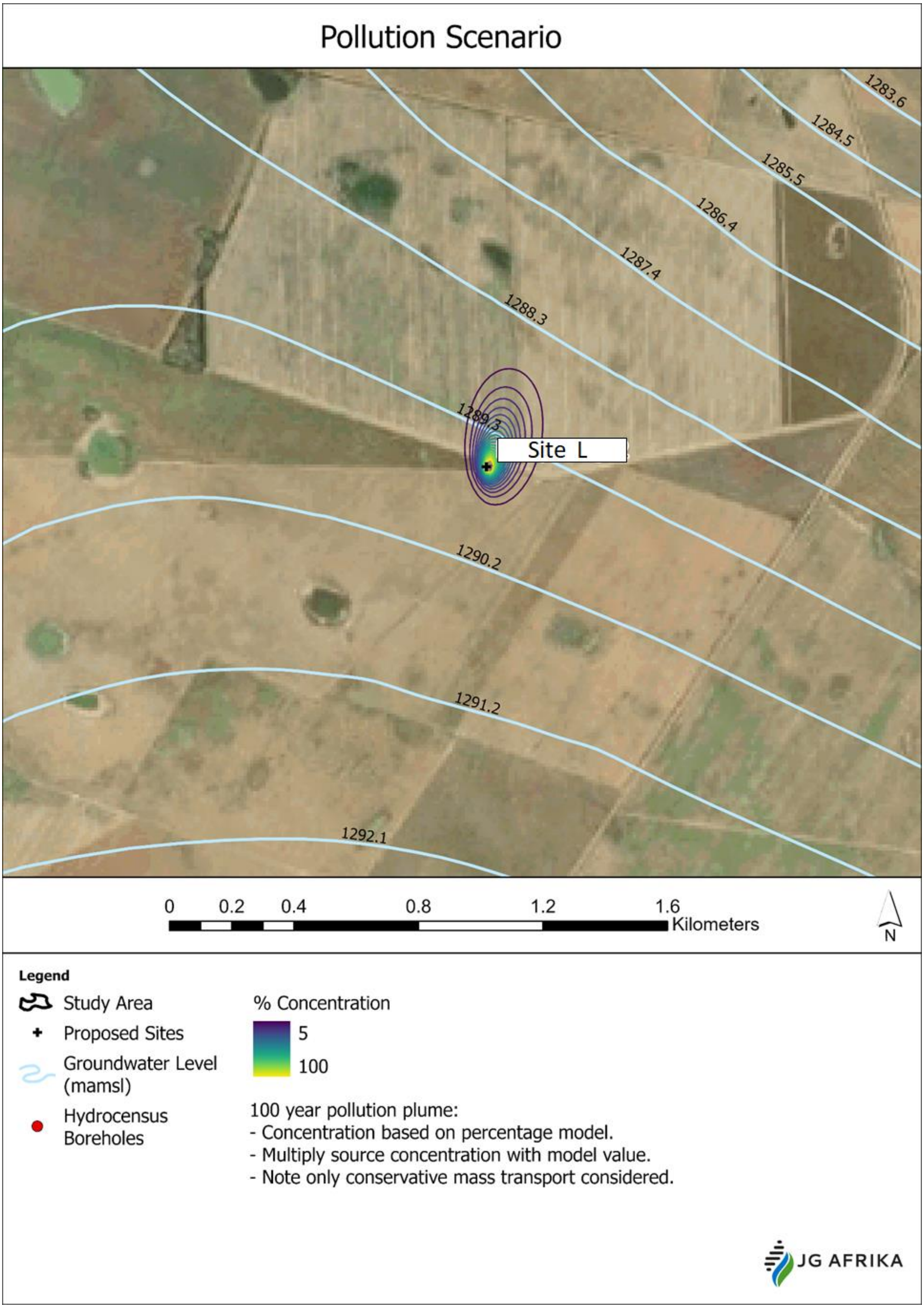


Figure 31: Modelled Plume - Site L

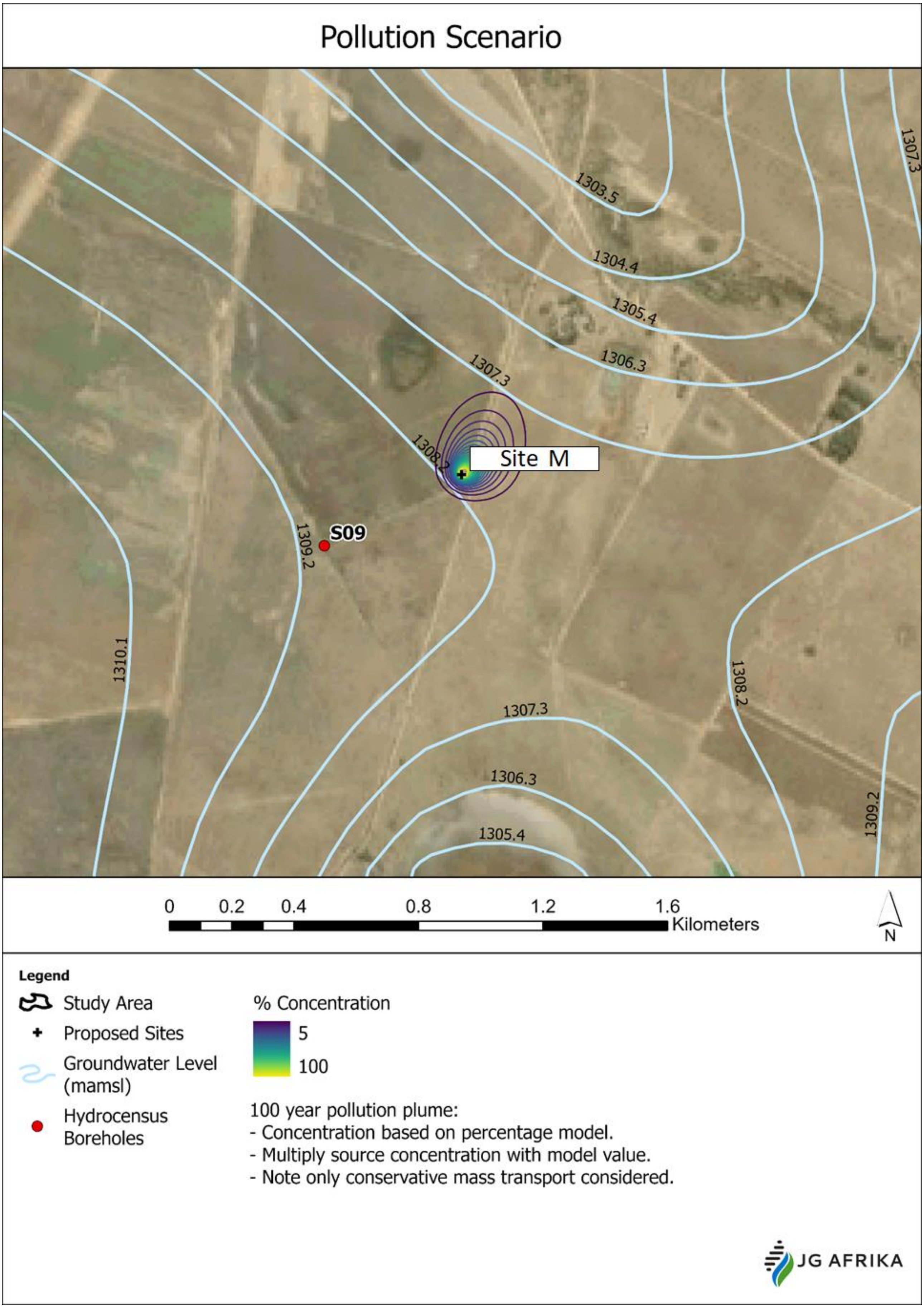


Figure 32: Modelled Plume - Site M

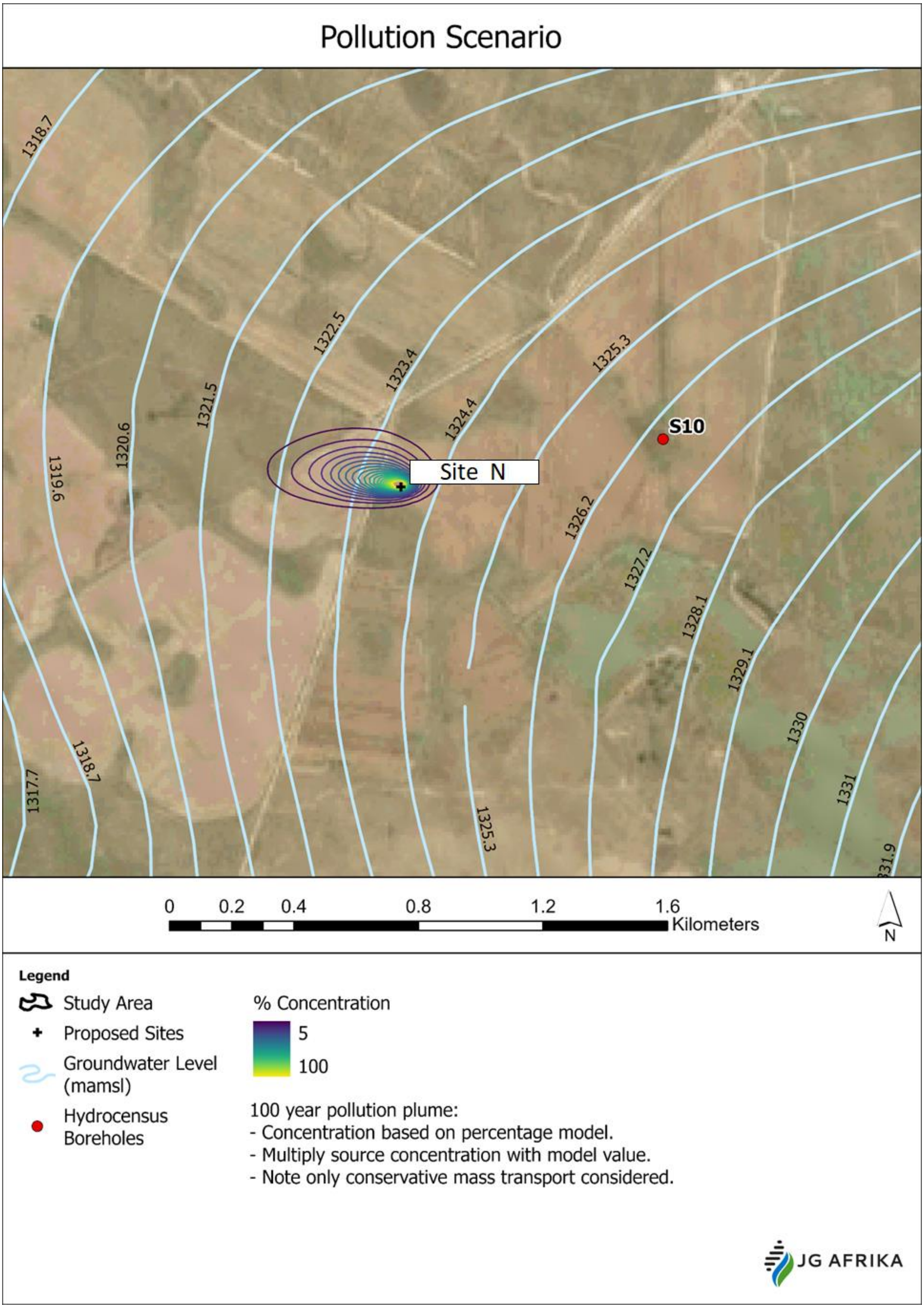


Figure 33: Modelled Plume - Site N

10 GEOHYDROLOGICAL RISK AND IMPACT

10.1 Geohydrological Potential

The project area is underlain by shale and sandstone which has been intruded by dolerite in isolated areas. The geohydrology is a medium to low yielding intergranular fractured rock aquifer. The project area falls within two (2 No.) aquifer class units which are classified as Minor.

10.2 Vulnerability

Vulnerability is considered *Low to Medium*. Factors considered in the vulnerability rating include depth to groundwater and contaminant loading. The depth to groundwater is expected to be variable in the range 1 to 20 mbgl. The cover sands are inferred to be relatively thick at most sites, which will provide some filtration to underlying rock aquifers. The associated Parsons Groundwater Quality Management System gives the site a Low Level of Protection index when comparing vulnerability as the second variable.

TABLE A and B: Ratings for the Groundwater Quality Management classification system.			
AQUIFER SYSTEM MANAGEMENT CLASSIFICATION		SECOND VARIABLE CLASSIFICATION AQUIFER VULNERABILITY CLASSIFICATION	
Class	Points	Class	Points
Sole Source Aquifer System	6	High	3
Major Aquifer System	4	Medium	2
Minor Aquifer System	2	Low	1
Non-aquifer System	0		
Special Aquifer System	0 - 6		
TABLE C: Appropriate level of groundwater protection required, based on the Groundwater Quality Management classification			
GQM INDEX	LEVEL OF PROTECTION		
< 1	Limited protection		
01-03	Low level protection		
03-06	Medium level protection		
06-10	High level protection		
> 10	Strictly non-degradation		

Variable 1	Variable 2
Aquifer System	Second Variable Description
Minor Aquifer System	Vulnerability
	Low Medium
2	1.5
GQM Index	Level of Protection
3.0	Low level protection

10.3 Strategic Value

The strategic value is considered *Medium.* The strategic value of groundwater is based on existing groundwater use. Use of the groundwater resource was identified near many of the sites. The primary use for the groundwater is for domestic and agricultural applications. The associated Parsons Groundwater Quality Management System gives the site a *Medium Level of Protection* index when comparing strategic value as the second variable.

TABLE A and B: Ratings for the Groundwater Quality Management classification system.			
AQUIFER SYSTEM MANAGEMENT CLASSIFICATION		SECOND VARIABLE CLASSIFICATION AQUIFER VULNERABILITY CLASSIFICATION	
Class	Points	Class	Points
Sole Source Aquifer System	6	High	3
Major Aquifer System	4	Medium	2
Minor Aquifer System	2	Low	1
Non-aquifer System	0		
Special Aquifer System	0 - 6		
TABLE C: Appropriate level of groundwater protection required, based on the Groundwater Quality Management classification			
GQM INDEX	LEVEL OF PROTECTION		
< 1	Limited protection		
01-03	Low level protection		
03-06	Medium level protection		
06-10	High level protection		
> 10	Strictly non-degradation		

Variable 1	Variable 2
Aquifer System	Second Variable Description
Minor Aquifer System	Strategic Value
	Medium
2	2
GQM Index	Level of Protection
4.0	Medium level protection

Other contaminant sources in the project area are typically associated with agricultural practices, including livestock activities, crop management through fertilizers, and on site sanitation facilities of communities. These activities are already impacting on water quality in the area.

10.4 Quantitative Environmental Risk Assessment and Mitigation

The quantitative environmental risk assessment (ERA) is presented in Annexure E. The ERA identifies general and construction phase activities that may impact on the groundwater receiving environments. The Significance Points (SP) score is calculated from the following equation using ranking scales:

$$SP = probability \times (duration + scale + magnitude)$$

The ERA for the groundwater receiving environment is summarised in Table 12. All activities identified scored *LOW* for the pre mitigation ratings. Most scores can be reduced further with the introduction of mitigation measures include in Table 12.

Table 12: Summary Risk Assessment Scoring

Significance / Consequence	Activity Description	Probability	Duration	Scale	Magnitude	Significance	PRE MITIGATION SP SCORE and RATING	>60 indicates high environmental significance <30 indicates low environmental significance	Mitigation	POST MITIGATION SP SCORE and RATING	>60 indicates high environmental significance <30 indicates low environmental significance	SP Reduction
General Site Activities												
Quality	Contamination of soils and groundwater from sanitation infrastructure; 1. leaks and/or loss of containment from portable toilets 2. low permeability soils 3. shallow bedrock	improbable to low	immediate	site	minor	low negative	1.5(1+1+2) = 6	LOW	Approved disposal contractor per implementation of the EMP, with routine management	1(1+1+2) = 4	LOW	-2
	Contamination of soils and groundwater from hydrocarbon and hazardous sources; 1. leaks from standing plant and equipment at off site holding and on site 2. spills from refuelling of plant on site and fuel storage systems 3. spills from maintenance of plant on site 4. washing of plant and equipment at off site holding and on site 5. hazardous storage areas	medium	short to medium	site to local	moderate	medium high negative	3(2.5+1.5+6) = 30	LOW	Drip trays, spill response per implementation of the EMP, brown fields storage, appropriate compaction layer	2.5(2.5+1.5+5) = 23	LOW	-8
	General geohydrological setting considerations 1. Future decant of contaminated waters from bores from exploratory drilling 2. deterioration of groundwater quality from abstraction from bores 3. Recharge of groundwater systems 4 increased impacts from shallow groundwater systems	improbable	immediate	site	minor	low negative	1(1+1+2) = 4	LOW	Unlikely	1(1+1+2) = 4	LOW	0
	Contamination of groundwater systems through exploratory drilling and creating of conduits to deeper aquifers	medium to high	immediate	site	moderate	medium high negative	3.5(1+1+6) = 28	LOW	Casing and grouting per implementation of the method statement, approved and experienced contractor, decommission bores if compromised	3(1+1+5) = 21	LOW	-7
	Impacts on downstream groundwater users	low to medium	permanent	site	moderate	medium high negative	2.5(5+1+6) = 30	LOW	Set buffer zones around sites based on model results and inform landowners, construct sanitary seals at existing resources if necessary, conduct routine water quality monitoring of nearby resources, decommission compromised resources and provide alternative supplies	2(5+1+5) = 22	LOW	-8
Quantity	Impacts on groundwater quantity	low	short	site	minor	low negative	2(2+1+2) = 10	LOW	Specify source of industrial water for drilling operations if not from a groundwater resource. Expected quantities will be low	2(2+1+2) = 10	LOW	0
Construction and Drilling Activities												
Quality	Contamination of soils and groundwater from site excavation areas; 1. increased turbidity loading and microbiological loading 2. mobilisation of existing elevated compounds in the soil matrix	low to medium	immediate	site	minor to low	low medium negative	2.5(1+1+3) = 13	LOW	Limit excavations and footprint, stormwater management, implement the EMP	2(1+1+3) = 10	LOW	-3
	Contamination of soils and groundwater from drilling activities/techniques including; 1. from return water sumps during drilling (mud rotary) with seepage or major loss of containment 2. from surface returning drill chips (air percussion) and temporary surface storage 3. from surface returning contaminated groundwater and temporary surface storage	high	immediate	site	low to moderate	medium high negative	4(1+1+5) = 28	LOW	Per implantation of the method statement and EMP; routine sludge removal and appropriate disposal, reuse, recycling, rapid response, backup storage tanks and pumps	3.5(1+1+4) = 21	LOW	-7
	Contamination of soils and groundwater from drilling activities/techniques including; 1. compromised construction and installation of casing and seals 2. use of hazardous drill additives 3. concrete batching	medium to high	immediate	site	moderate	medium high negative	3.5(1+1+6) = 28	LOW	Use alternate non hazardous drill additives, per the implementation of the method statement; use approved and experienced contractor, consider sanitary seals for headworks construction, carry out on site testing and decommission comprised holes	2(1+1+5) = 14	LOW	-14
	Contamination of groundwater from compromised decommissioned bores	low to medium	permanent	site	moderate	medium high negative	2.5(5+1+6) = 30	LOW	Casing and grouting per specifications and implementation of the method statement, approved and experienced contractor, apply tremie system when installing seals and grout, post decommission inspections and monitoring	2(5+1+4) = 20	LOW	-10
	Impacts on downstream groundwater users	low to medium	permanent	site	moderate	medium high negative	2.5(5+1+6) = 30	LOW	Set buffer zones around sites based on model results and inform landowners, construct sanitary seals at existing resources if necessary, conduct routine water quality monitoring of nearby resources, decommission compromised resources and provide alternative supplies	2(5+1+5) = 22	LOW	-8
Quantity	Impacts on groundwater quantity	low	short	site	minor	low negative	2(2+1+2) = 10	LOW	Specify source of industrial water for drilling operations if not from a groundwater resource. Expected quantities will be low	2(2+1+2) = 10	LOW	0

10.5 Mitigation Measures

Significance scores can in most instances be reduced by applying suggested mitigation measures as presented in Table 12 . The mitigations measures for activities suggested in Table 12 are not exhaustive. It must be noted that risk and mitigation has been heavily considered in the development of the Project Description and Method Statement[3]. Implementation of this plan will ensure the mitigations are in place.

11 CONCLUSIONS

This report presents the results of a geohydrological assessment carried out for exploration right ER318 for Rhino Oil and Gas near Welkom and Kroonstad in the Free State. The geohydrological report has been prepared as a specialist study in support of the environmental authorisation process. The aim of the assessment was to characterise the geohydrological setting, and to determine the risk of potential impacts by the activities on the receiving groundwater environment.

The project area is underlain by an intergranular and fractured aquifer that is medium to low yielding. The underlying aquifer class units are classified as *Minor*. The observed depth to groundwater was typically recorded in the range 1 to 20 mbgl. The aquifer vulnerability is low to medium. The Parsons Groundwater Quality Management System gives the site a Low Level of Protection index for the second variable vulnerability. The strategic value is medium. The Parsons Groundwater Quality Management System gives the site a Medium Level of Protection index for the second variable strategic value.

The risk and impact of the activities was reviewed by means of a quantitative environmental risk assessment (ERA) as developed for by the Operational Guideline: Integrated Water and Waste Management Plan. The ERA identified all listed activities to score LOW. Many activity scores can be further reduced with the application of appropriate mitigation measures, by focusing on the probability and magnitude factors. All mitigation measures (Table 12) should be considered to reduce potential impacts and risk.

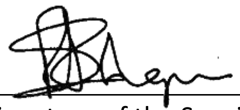
[3] Report reference 720.18034.00020 of SLR Consulting (South Africa) (Pty) Ltd, titled ” Rhino Oil and Gas - Project Description”, draft report No.1, January 2023

Annexure A: Declaration of Specialist

DECLARATION OF THE SPECIALIST

I ROBERT SCHAPERS, as the appointed Specialist hereby declare/affirm the correctness of the information provided or to be provided as part of the application, and that:

- In terms of the general requirement to be independent:
  - other than fair remuneration for work performed in terms of this application, have no business, financial, personal or other interest in the development proposal or application and that there are no circumstances that may compromise my objectivity; or
  - ~~am not independent, but another specialist (the "Review Specialist") that meets the general requirements set out in Regulation 13 of the NEMA EIA Regulations has been appointed to review my work (Note: a declaration by the review specialist must be submitted);~~
- I have disclosed to ~~the applicant~~, the EAP, ~~the Review EAP (if applicable), the Department and I&APs~~ all material information that has or may have the potential to influence the decision of the Department or the objectivity of any Report, plan or document prepared or to be prepared as part of the application; and
- I am aware that a false declaration is an offence in terms of Regulation 48 of the EIA Regulations.



Signature of the Specialist:

14 April 2023

Date:

JG AFRIKA (PTY) LTD

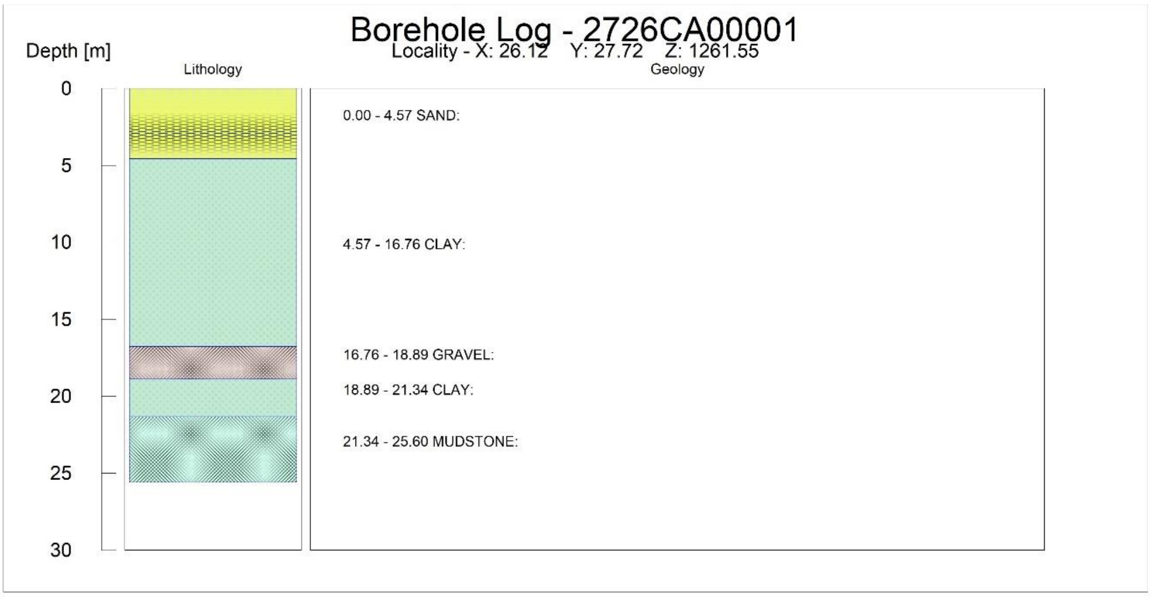
Name of company (if applicable):

Annexure B: NGA Borehole Logs


Borehole Log - 2726DA00003
Depth [m]
Locality - X: 26.54 Y: 27.53 Z: 1302.00
Lithology
Geology
0
5
10
15
20
25
30
35
40
45
0.00 - 43.00 SAND:

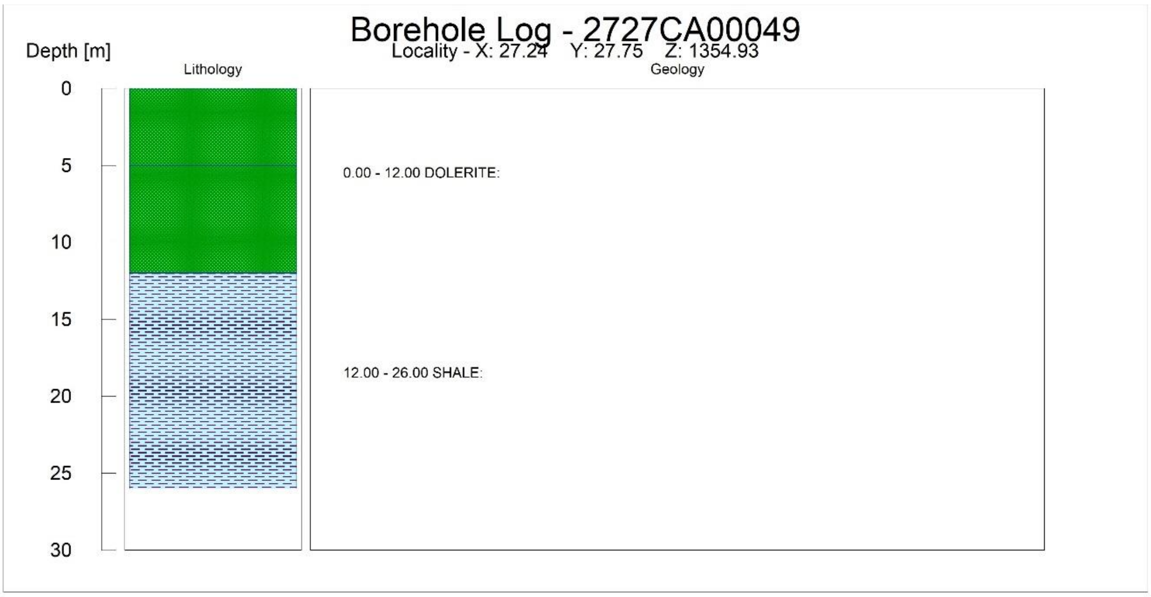

Borehole Log - 2727AD00008
Depth [m]
Locality - X: 27.42 Y: 27.45 Z: 1392.97
Lithology
Geology
0
5
10
15
20
25
30
35
40
45
50
0.00 - 12.19 SHALE:
12.19 - 36.57 DOLERITE:
36.57 - 46.93 SHALE:

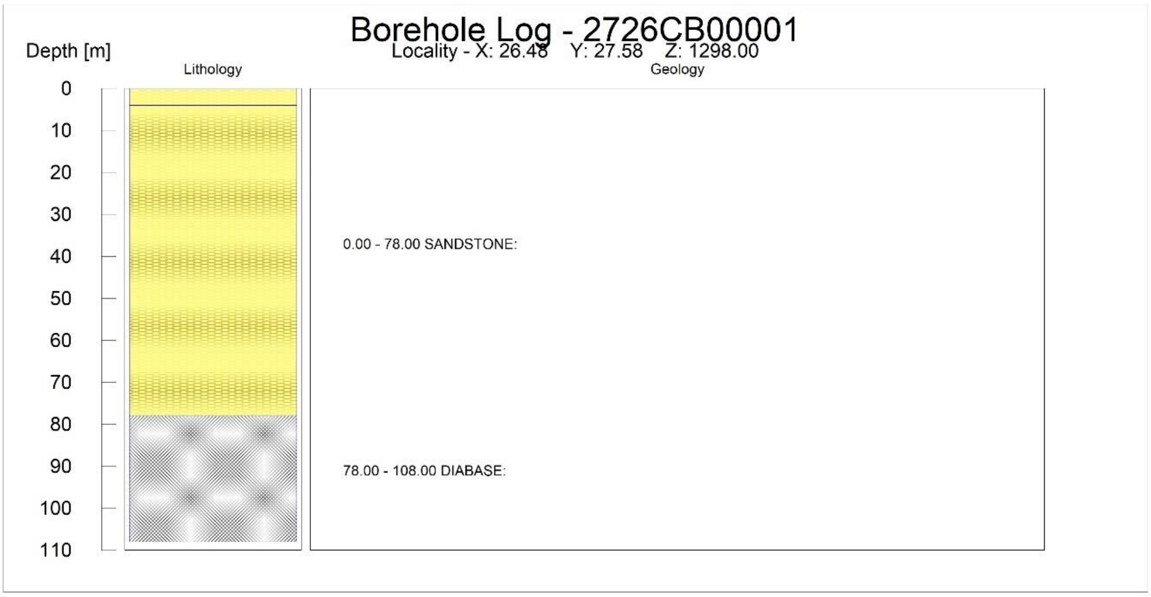

Borehole Log - 2726BC00001
Locality - X: 26.55 Y: 27.49 Z: 1317.95
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
0.00 - 12.00 CLAY:
12.00 - 70.00 SANDSTONE:


Borehole Log - 2726CA00001
Locality - X: 26.12 Y: 27.72 Z: 1261.55
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
0.00 - 4.57 SAND:
4.57 - 16.76 CLAY:
16.76 - 18.89 GRAVEL:
18.89 - 21.34 CLAY:
21.34 - 25.60 MUDSTONE:

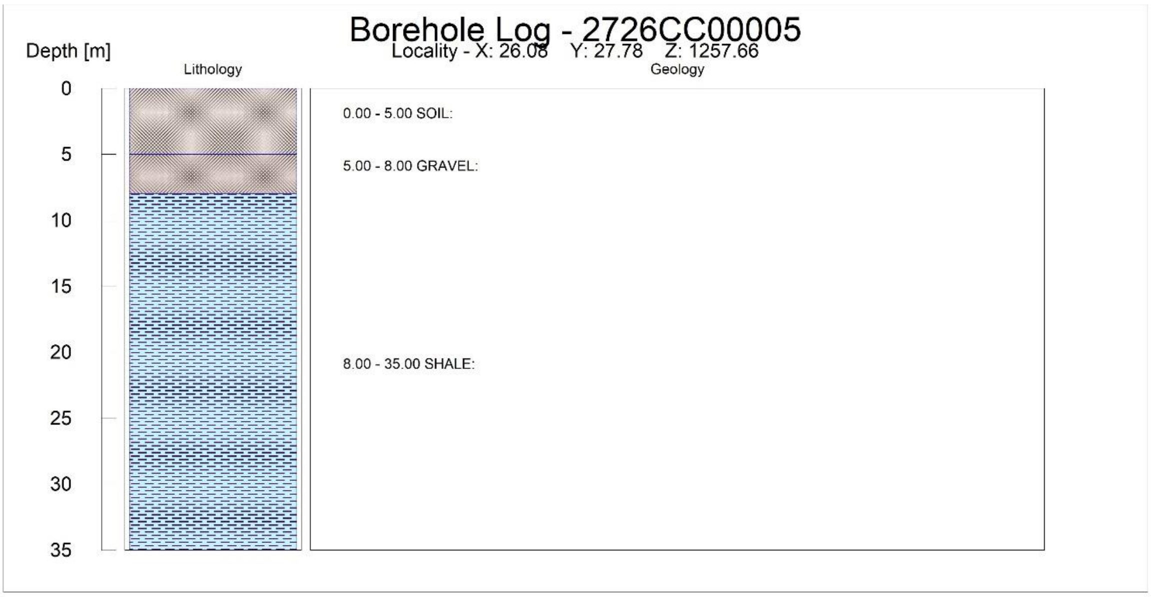

Borehole Log - 2726CA00002
Locality - X: 26.13 Y: 27.60 Z: 1268.20
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
35
40
45
0.00 - 7.00 SOIL:
7.00 - 45.00 SANDSTONE:

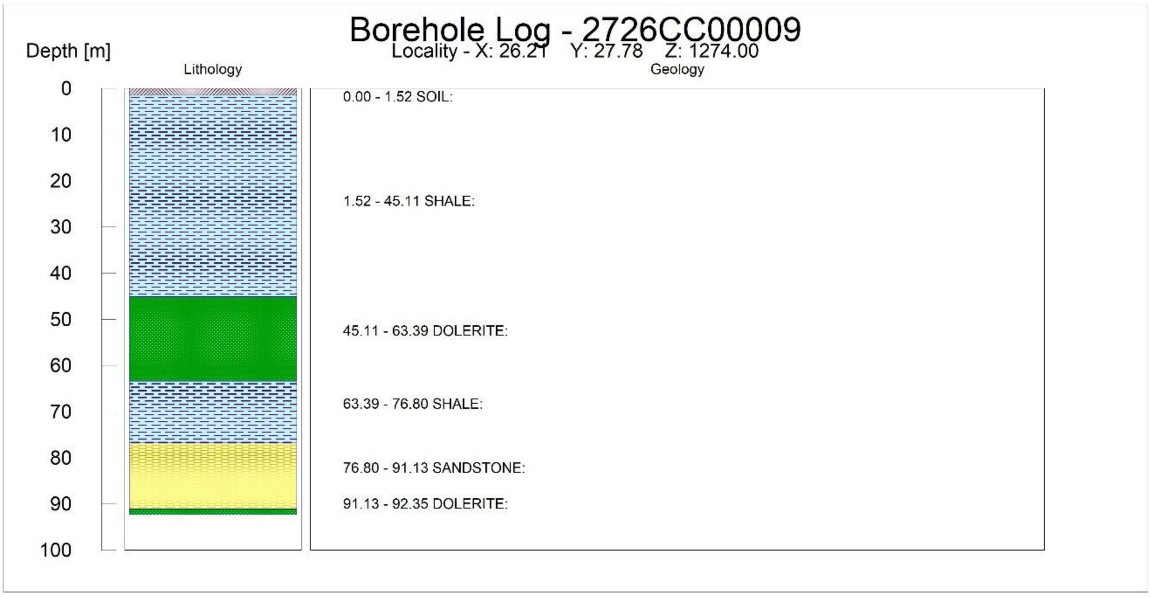

Borehole Log - 2726CA00047
Locality - X: 26.24 Y: 27.70 Z: 1284.00
Depth [m]
Lithology
Geology
0
5
10
15
20
25
0.00 - 0.91 SOIL:
0.91 - 20.11 DOLERITE:
20.11 - 20.42 SANDSTONE:
20.42 - 21.03 DOLERITE:

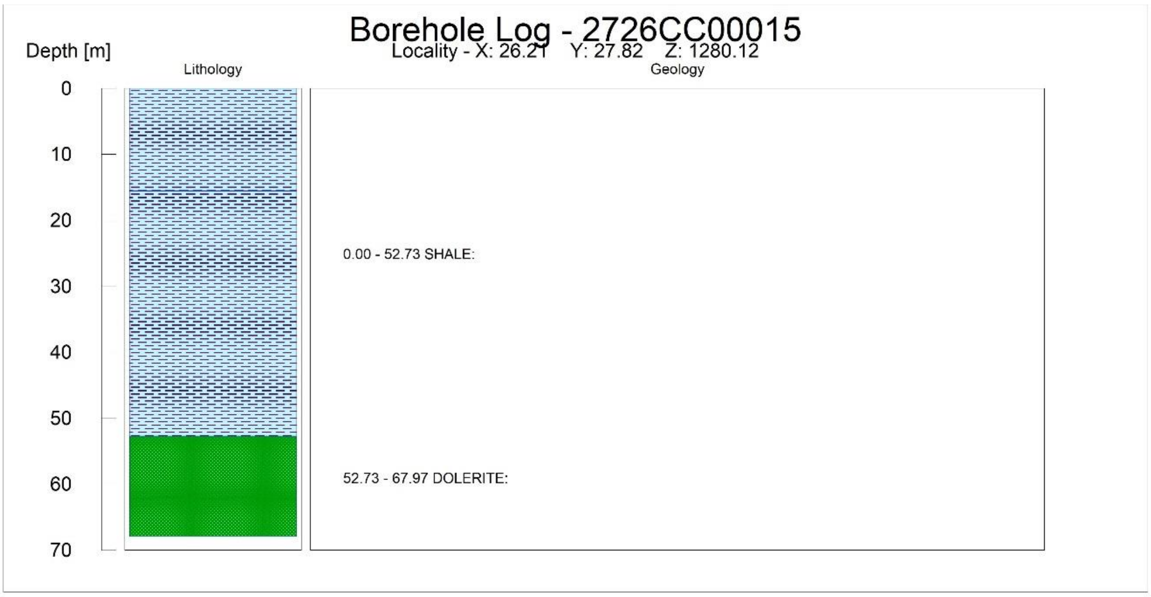

Borehole Log - 2727CA00049
Locality - X: 27.24 Y: 27.75 Z: 1354.93
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
0.00 - 12.00 DOLERITE:
12.00 - 26.00 SHALE:

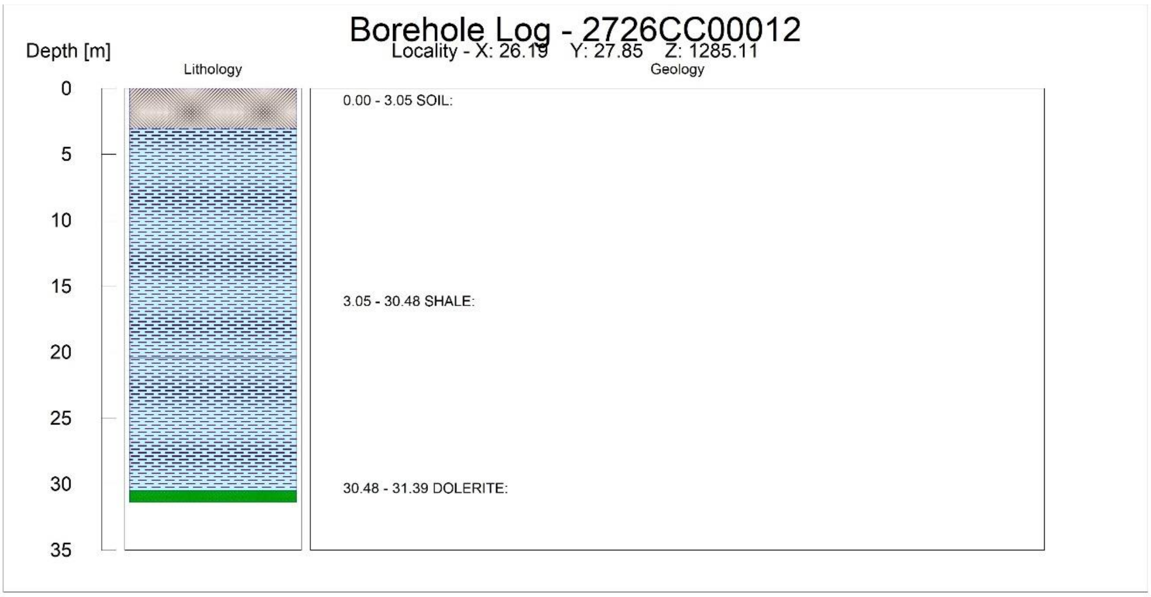

Borehole Log - 2726CB00001
Locality - X: 26.48 Y: 27.58 Z: 1298.00
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
80
90
100
110
0.00 - 78.00 SANDSTONE:
78.00 - 108.00 DIABASE:

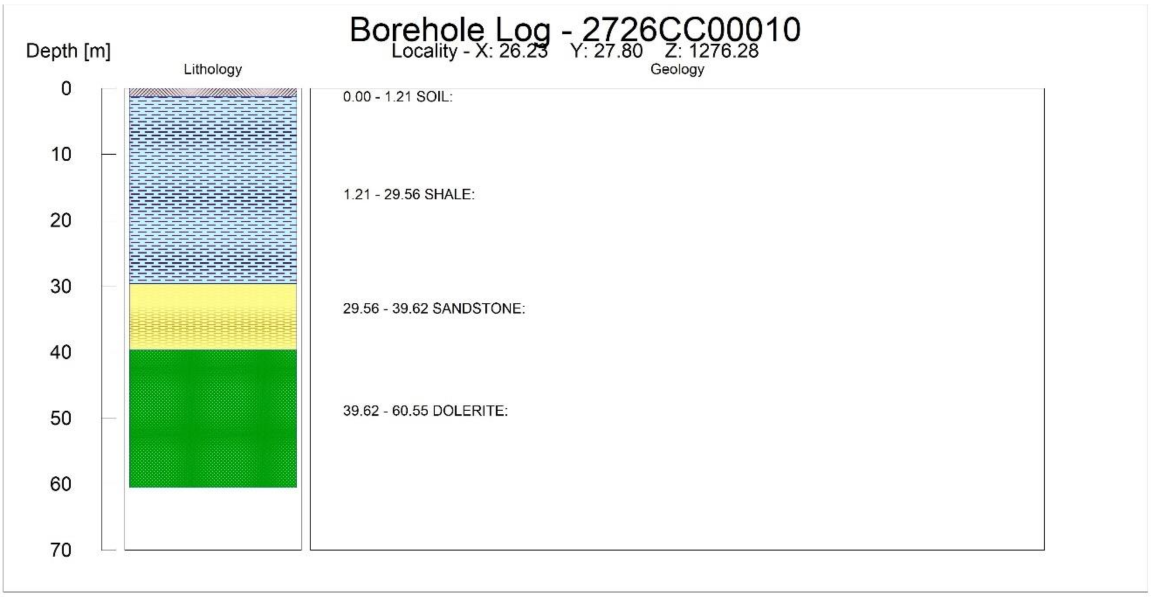

Borehole Log - 2726CB00002
Locality - X: 26.48 Y: 27.72 Z: 1310.99
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
0.00 - 20.00 GRAVEL:
20.00 - 60.00 SHALE:

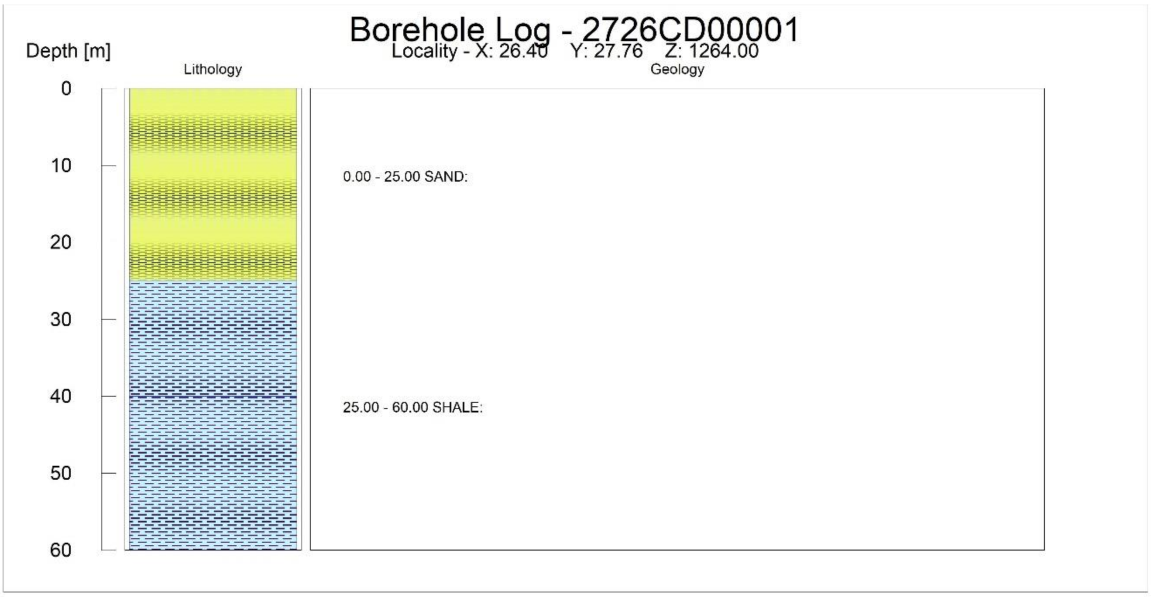

Borehole Log - 2726CC00005
Locality - X: 26.08 Y: 27.78 Z: 1257.66
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
35
0.00 - 5.00 SOIL:
5.00 - 8.00 GRAVEL:
8.00 - 35.00 SHALE:

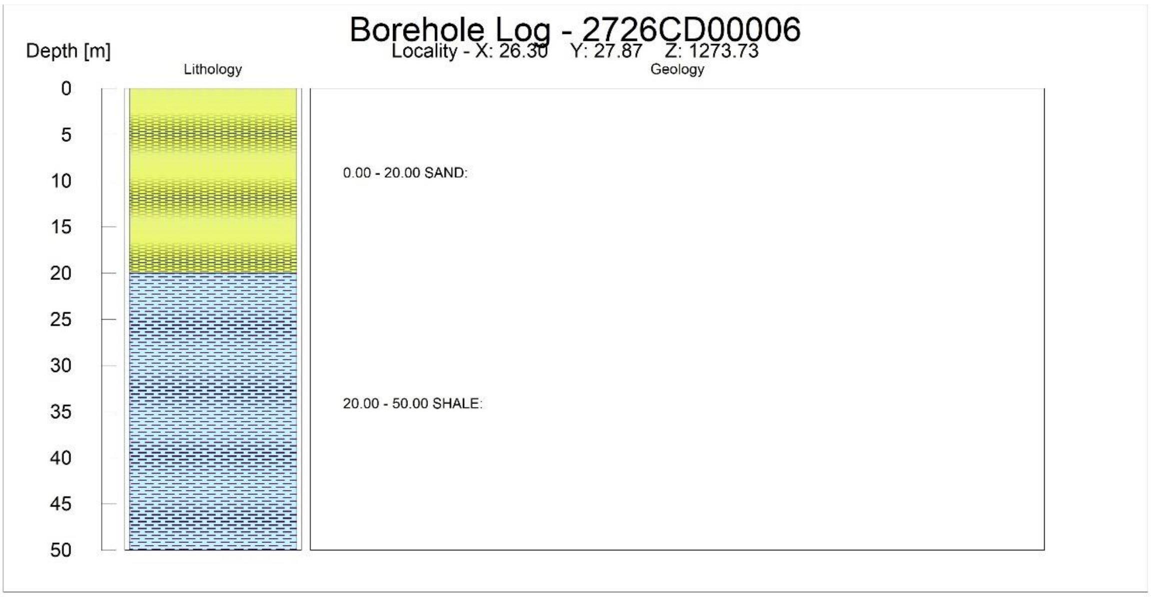

Borehole Log - 2726CC00009
Locality - X: 26.21 Y: 27.78 Z: 1274.00
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
80
90
100
0.00 - 1.52 SOIL:
1.52 - 45.11 SHALE:
45.11 - 63.39 DOLERITE:
63.39 - 76.80 SHALE:
76.80 - 91.13 SANDSTONE:
91.13 - 92.35 DOLERITE:

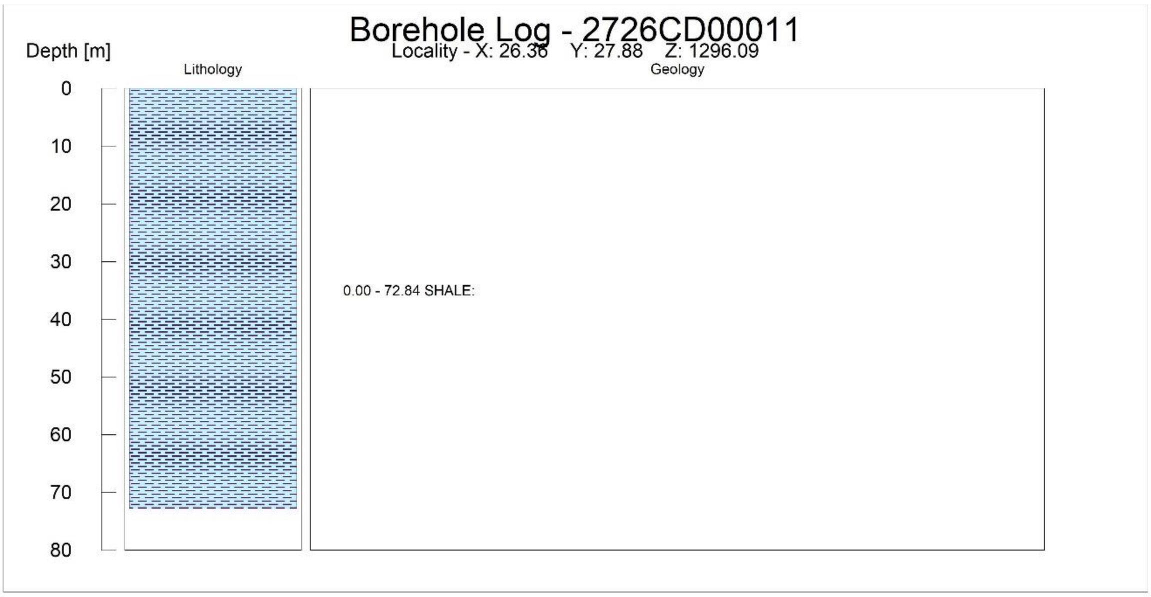

Borehole Log - 2726CC00015
Locality - X: 26.21 Y: 27.82 Z: 1280.12
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
0.00 - 52.73 SHALE:
52.73 - 67.97 DOLERITE:

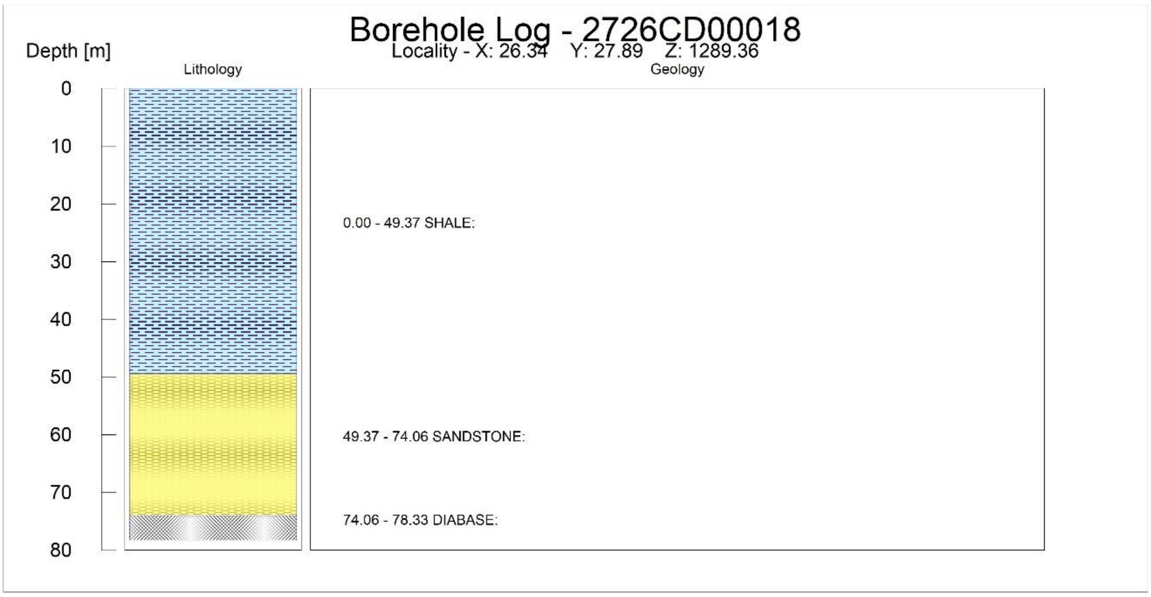

Borehole Log - 2726CC00012
Locality - X: 26.19 Y: 27.85 Z: 1285.11
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
35
0.00 - 3.05 SOIL:
3.05 - 30.48 SHALE:
30.48 - 31.39 DOLERITE:

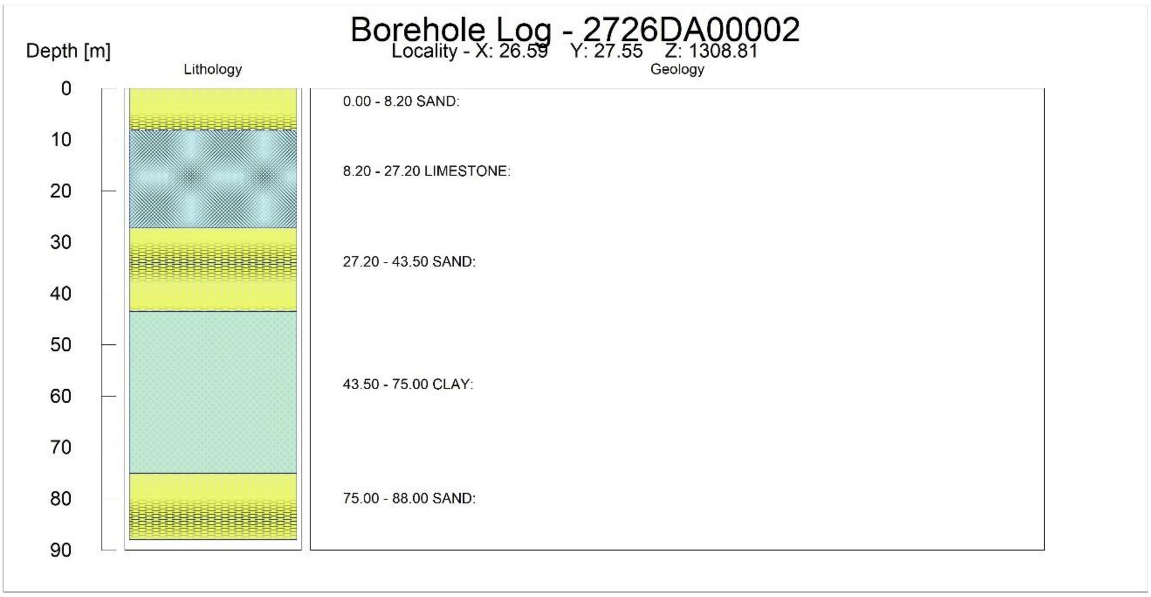

Borehole Log - 2726CC00010
Locality - X: 26.23 Y: 27.80 Z: 1276.28
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
0.00 - 1.21 SOIL:
1.21 - 29.56 SHALE:
29.56 - 39.62 SANDSTONE:
39.62 - 60.55 DOLERITE:


Borehole Log - 2726CD00001
Locality - X: 26.40 Y: 27.76 Z: 1264.00
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
0.00 - 25.00 SAND:
25.00 - 60.00 SHALE:


Borehole Log - 2726CD00006
Locality - X: 26.30 Y: 27.87 Z: 1273.73
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
35
40
45
50
0.00 - 20.00 SAND:
20.00 - 50.00 SHALE:


Borehole Log - 2726CD00011
Locality - X: 26.36 Y: 27.88 Z: 1296.09
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
80
0.00 - 72.84 SHALE:

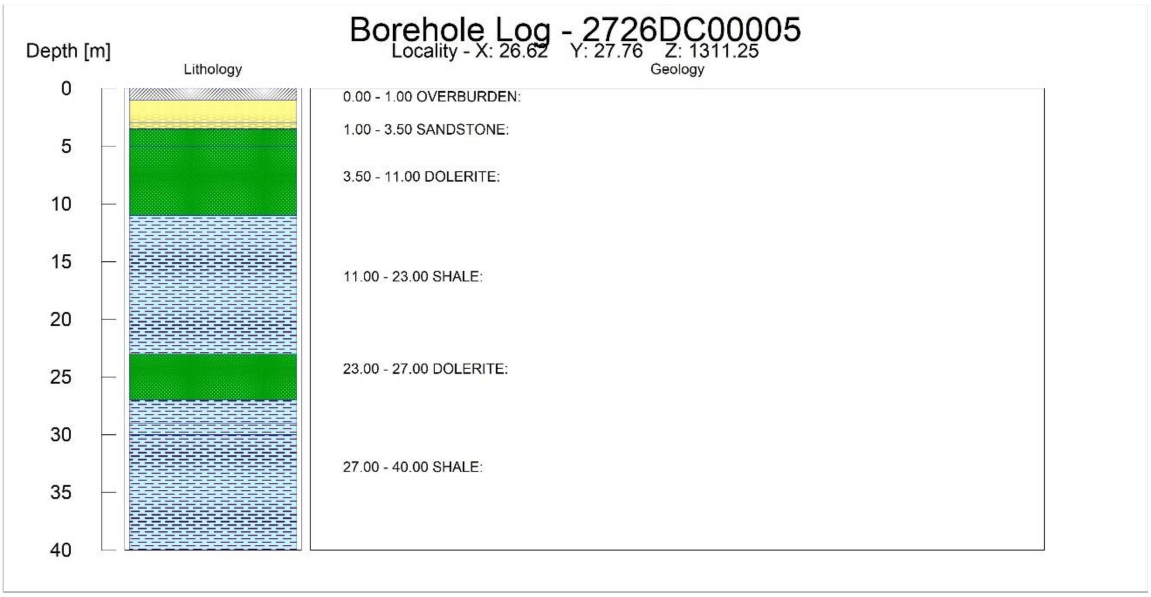

Borehole Log - 2726CD00018
Locality - X: 26.34 Y: 27.89 Z: 1289.36
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
80
0.00 - 49.37 SHALE:
49.37 - 74.06 SANDSTONE:
74.06 - 78.33 DIABASE:

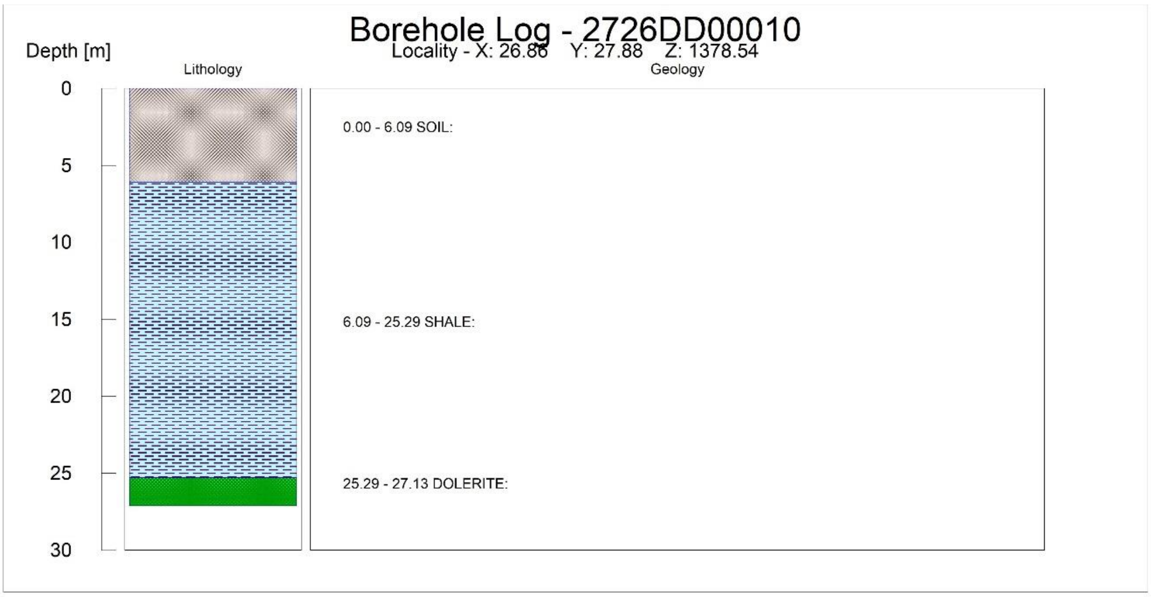

Borehole Log - 2726DA00002
Locality - X: 26.59 Y: 27.55 Z: 1308.81
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
80
90
0.00 - 8.20 SAND:
8.20 - 27.20 LIMESTONE:
27.20 - 43.50 SAND:
43.50 - 75.00 CLAY:
75.00 - 88.00 SAND:

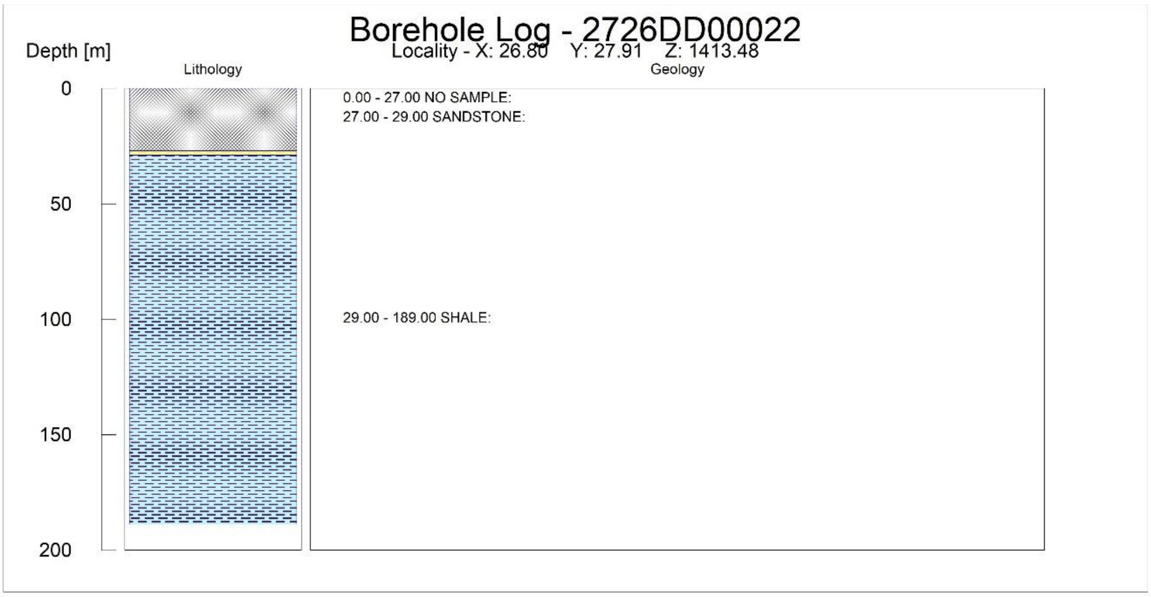

Borehole Log - 2726DA00003
Locality - X: 26.54 Y: 27.53 Z: 1302.00
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
35
40
45
0.00 - 43.00 SAND:


Borehole Log - 2726DA00004
Locality - X: 26.52 Y: 27.55 Z: 1301.43
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
35
40
45
0.00 - 43.00 SAND:

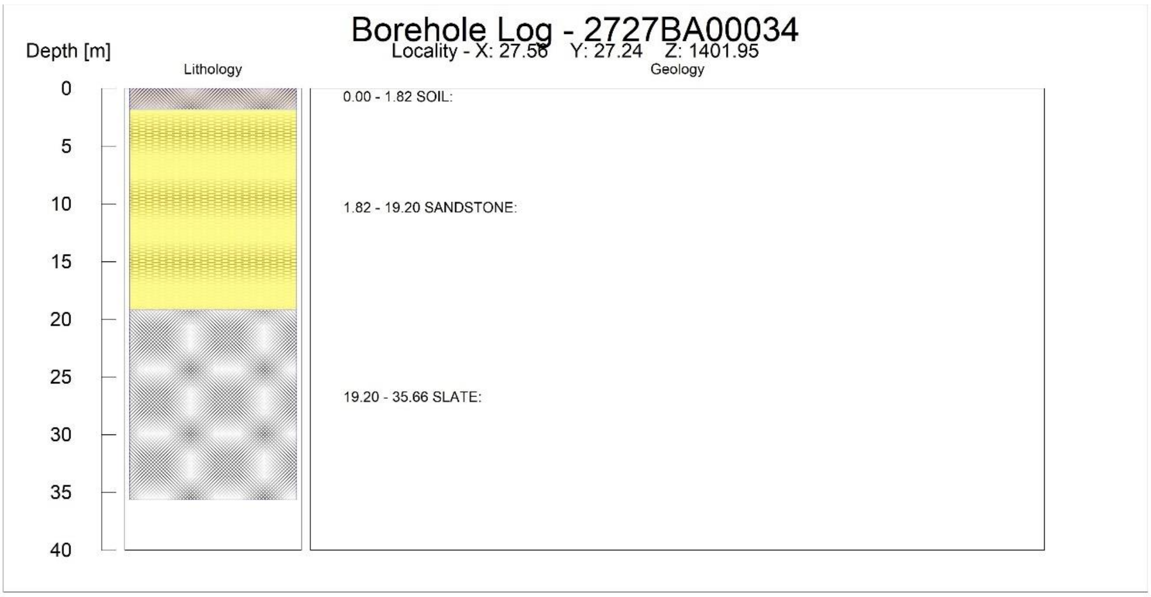

Borehole Log - 2726DC00002
Locality - X: 26.66 Y: 27.86 Z: 1328.42
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
35
0.00 - 35.00 SHALE:

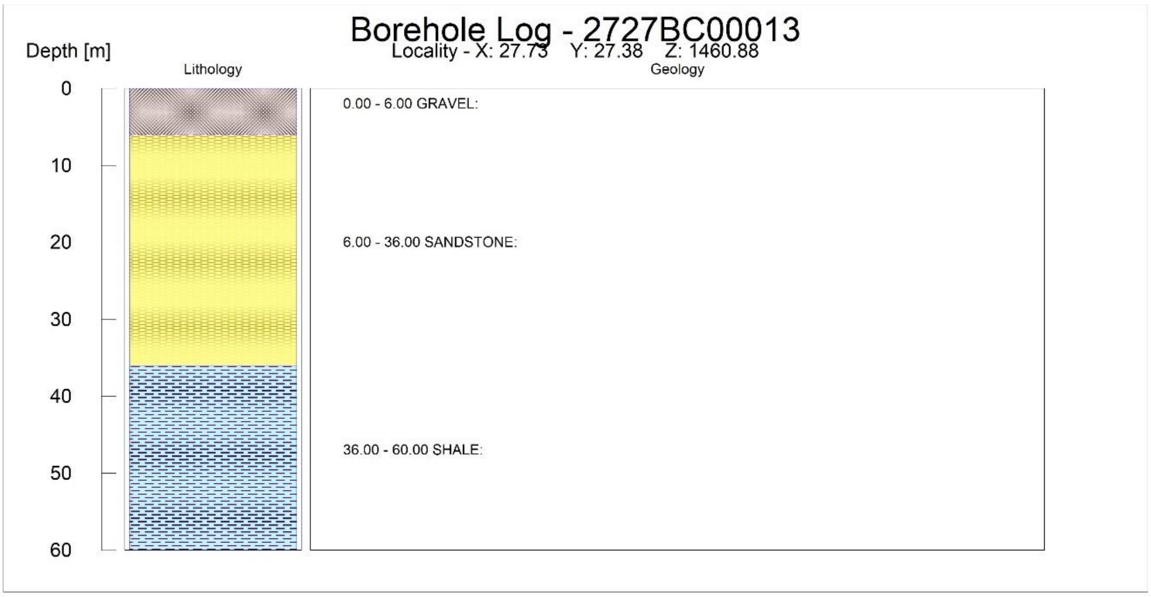

Borehole Log - 2726DC00005
Locality - X: 26.62 Y: 27.76 Z: 1311.25
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
35
40
0.00 - 1.00 OVERBURDEN:
1.00 - 3.50 SANDSTONE:
3.50 - 11.00 DOLERITE:
11.00 - 23.00 SHALE:
23.00 - 27.00 DOLERITE:
27.00 - 40.00 SHALE:

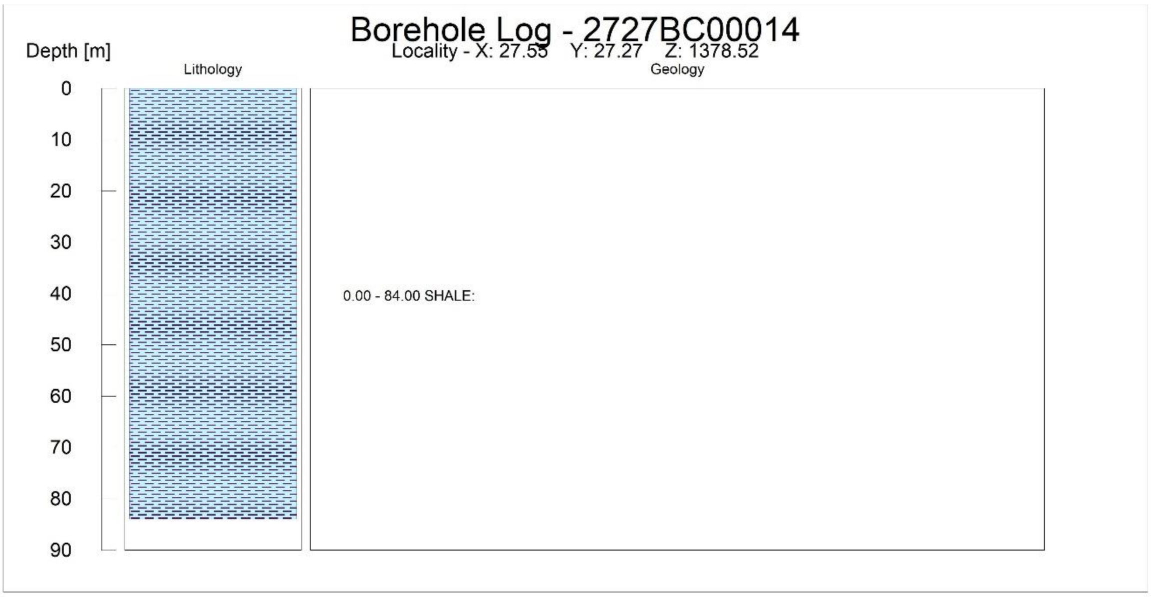

Borehole Log - 2726DD00010
Locality - X: 26.86 Y: 27.88 Z: 1378.54
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
0.00 - 6.09 SOIL:
6.09 - 25.29 SHALE:
25.29 - 27.13 DOLERITE:

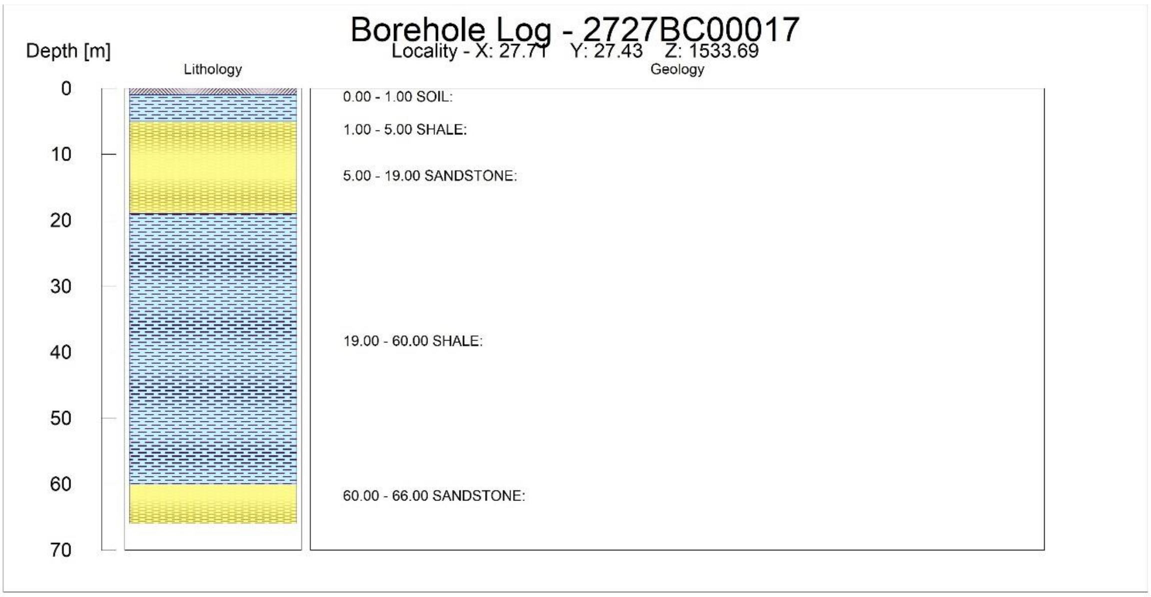

Borehole Log - 2726DD00022
Locality - X: 26.80 Y: 27.91 Z: 1413.48
Depth [m]
Lithology
Geology
0
50
100
150
200
0.00 - 27.00 NO SAMPLE:
27.00 - 29.00 SANDSTONE:
29.00 - 189.00 SHALE:


Borehole Log - 2727AD00012
Locality - X: 27.49 Y: 27.48 Z: 1421.64
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
0.00 - 10.00 SOIL:
10.00 - 66.00 SHALE:


Borehole Log - 2727BA00034
Locality - X: 27.56 Y: 27.24 Z: 1401.95
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
35
40
0.00 - 1.82 SOIL:
1.82 - 19.20 SANDSTONE:
19.20 - 35.66 SLATE:

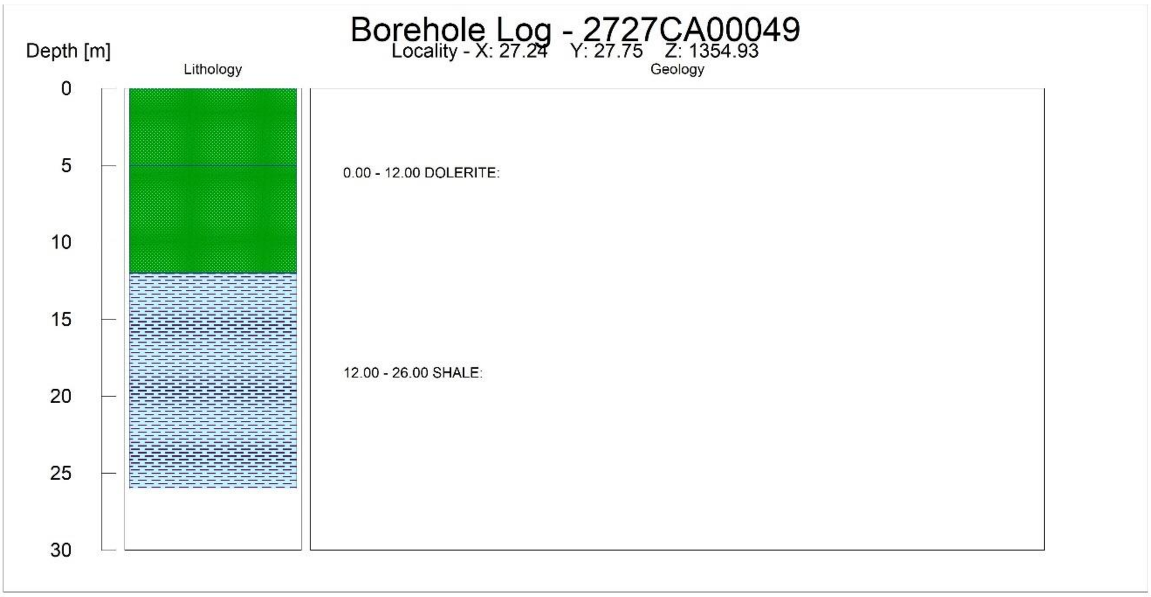

Borehole Log - 2727BC00013
Locality - X: 27.73 Y: 27.38 Z: 1460.88
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
0.00 - 6.00 GRAVEL:
6.00 - 36.00 SANDSTONE:
36.00 - 60.00 SHALE:

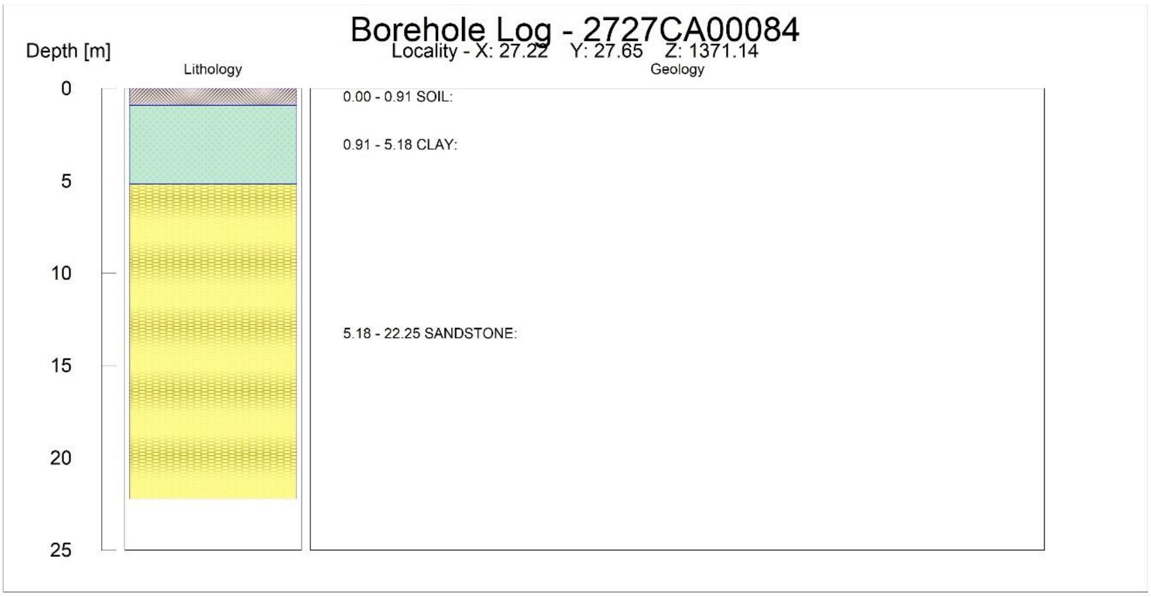

Borehole Log - 2727BC00014
Locality - X: 27.55 Y: 27.27 Z: 1378.52
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
80
90
0.00 - 84.00 SHALE:

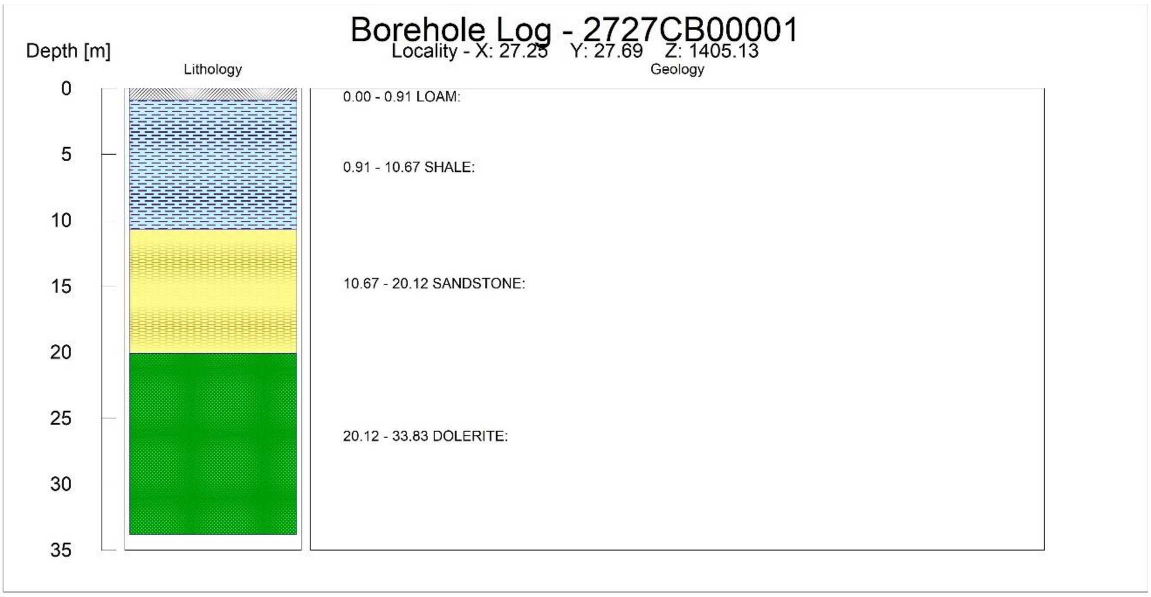

Borehole Log - 2727BC00017
Locality - X: 27.71 Y: 27.43 Z: 1533.69
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
0.00 - 1.00 SOIL:
1.00 - 5.00 SHALE:
5.00 - 19.00 SANDSTONE:
19.00 - 60.00 SHALE:
60.00 - 66.00 SANDSTONE:

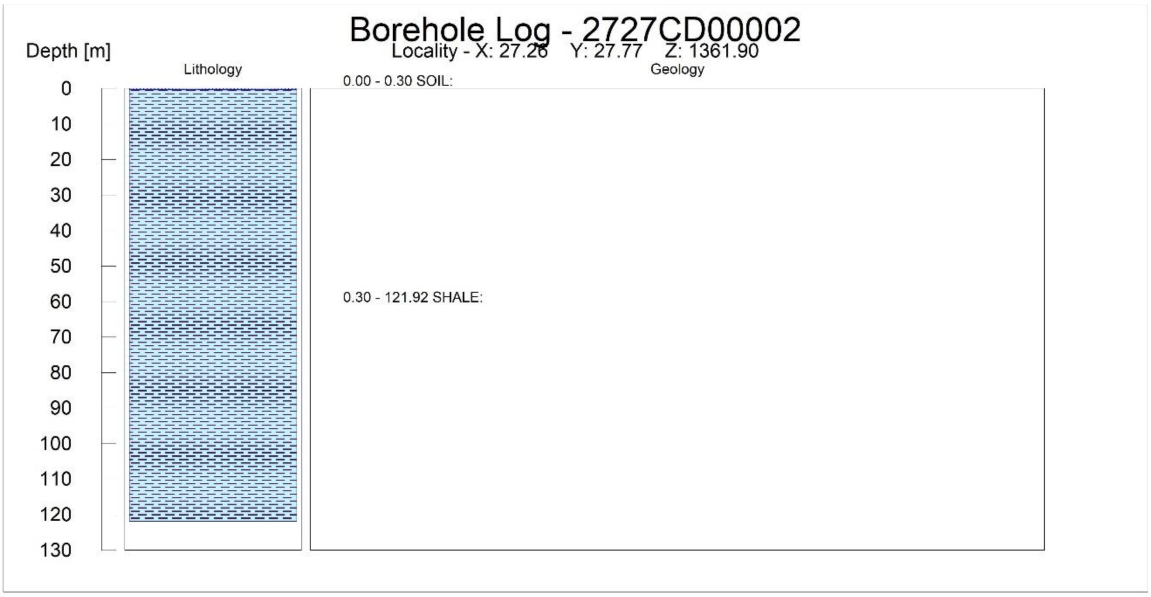

Borehole Log - 2727BC00020
Locality - X: 27.67 Y: 27.26 Z: 1396.99
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
0.00 - 25.00 DOLERITE:
25.00 - 38.00 SANDSTONE:
38.00 - 105.00 SHALE:
105.00 - 109.00 SANDSTONE:
109.00 - 139.00 SHALE:
139.00 - 144.00 SANDSTONE:


Borehole Log - 2727CA00016
Locality - X: 27.23 Y: 27.62 Z: 1430.34
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
0.00 - 0.91 CLAY:
0.91 - 1.52 SANDSTONE:
1.52 - 27.43 DOLERITE:
27.43 - 60.96 SHALE:


Borehole Log - 2727CA00049
Locality - X: 27.24 Y: 27.75 Z: 1354.93
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
0.00 - 12.00 DOLERITE:
12.00 - 26.00 SHALE:

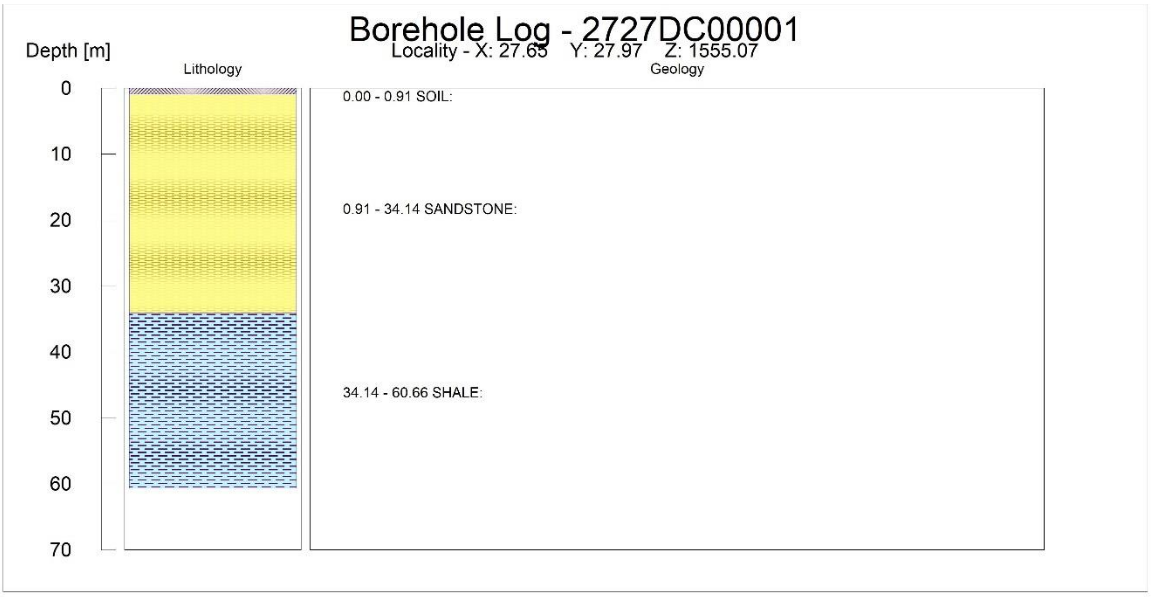

Borehole Log - 2727CA00084
Locality - X: 27.22 Y: 27.65 Z: 1371.14
Depth [m]
Lithology
Geology
0
5
10
15
20
25
0.00 - 0.91 SOIL:
0.91 - 5.18 CLAY:
5.18 - 22.25 SANDSTONE:

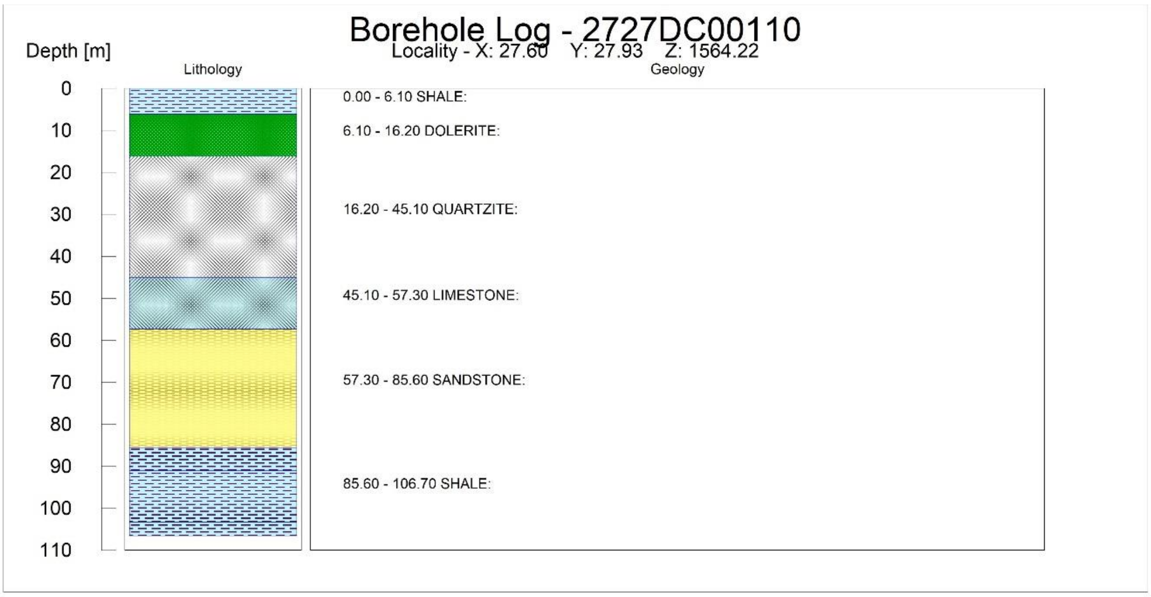

Borehole Log - 2727CB00001
Locality - X: 27.25 Y: 27.69 Z: 1405.13
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
35
0.00 - 0.91 LOAM:
0.91 - 10.67 SHALE:
10.67 - 20.12 SANDSTONE:
20.12 - 33.83 DOLERITE:

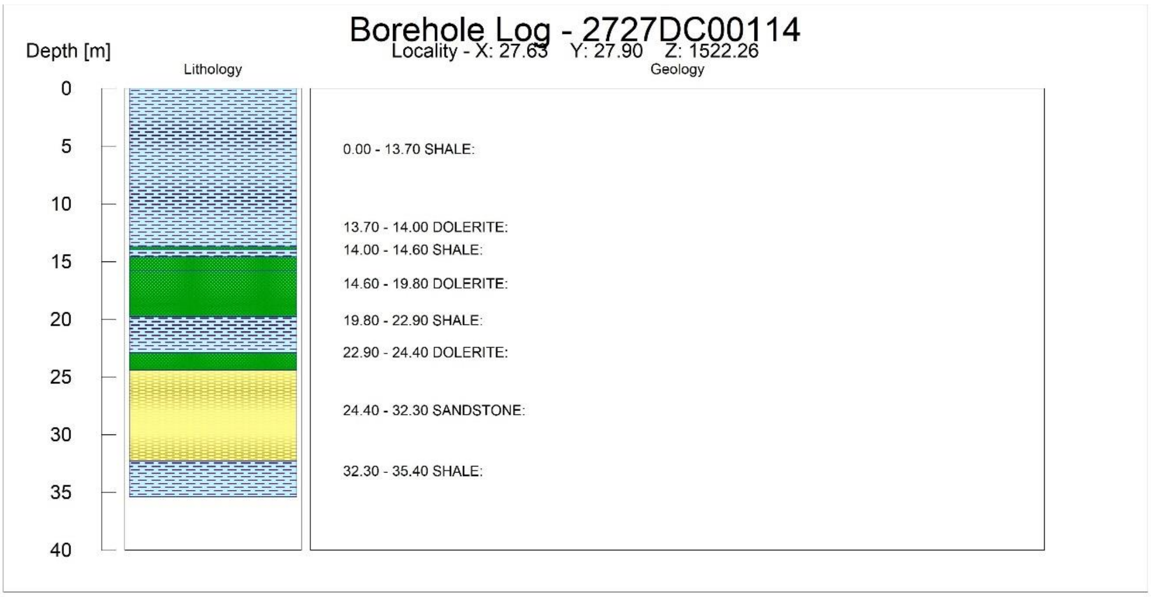

Borehole Log - 2727CD00002
Locality - X: 27.26 Y: 27.77 Z: 1361.90
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
80
90
100
110
120
130
0.00 - 0.30 SOIL:
0.30 - 121.92 SHALE:

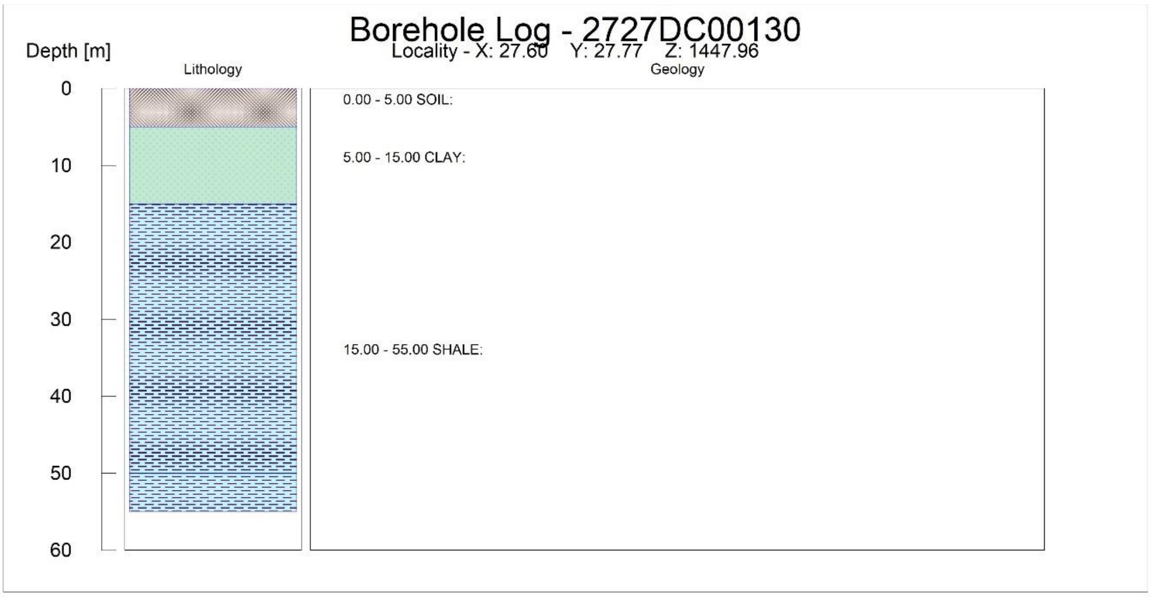

Borehole Log - 2727CD00005
Locality - X: 27.41 Y: 27.93 Z: 1426.09
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
35
40
45
50
0.00 - 0.91 SOIL:
0.91 - 9.14 CLAY:
9.14 - 18.59 SHALE:
18.59 - 46.94 SANDSTONE:

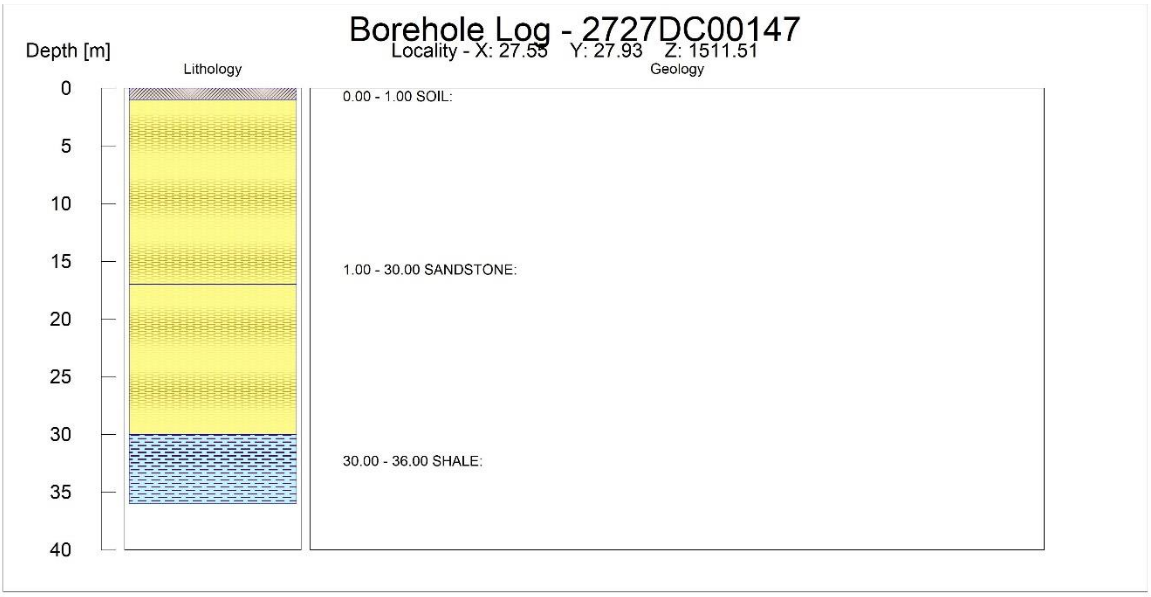

Borehole Log - 2727DA00213
Locality - X: 27.73 Y: 27.68 Z: 1561.48
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
80
0.00 - 3.00 SHALE:
3.00 - 4.00 GRAVEL:
4.00 - 54.00 DOLERITE:
54.00 - 66.00 SANDSTONE:
66.00 - 76.00 SHALE:


Borehole Log - 2727DC00001
Locality - X: 27.65 Y: 27.97 Z: 1555.07
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
0.00 - 0.91 SOIL:
0.91 - 34.14 SANDSTONE:
34.14 - 60.66 SHALE:


Borehole Log - 2727DC00110
Locality - X: 27.60 Y: 27.93 Z: 1564.22
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
70
80
90
100
110
0.00 - 6.10 SHALE:
6.10 - 16.20 DOLERITE:
16.20 - 45.10 QUARTZITE:
45.10 - 57.30 LIMESTONE:
57.30 - 85.60 SANDSTONE:
85.60 - 106.70 SHALE:


Borehole Log - 2727DC00114
Locality - X: 27.63 Y: 27.90 Z: 1522.26
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
35
40
0.00 - 13.70 SHALE:
13.70 - 14.00 DOLERITE:
14.00 - 14.60 SHALE:
14.60 - 19.80 DOLERITE:
19.80 - 22.90 SHALE:
22.90 - 24.40 DOLERITE:
24.40 - 32.30 SANDSTONE:
32.30 - 35.40 SHALE:


Borehole Log - 2727DC00130
Locality - X: 27.60 Y: 27.77 Z: 1447.96
Depth [m]
Lithology
Geology
0
10
20
30
40
50
60
0.00 - 5.00 SOIL:
5.00 - 15.00 CLAY:
15.00 - 55.00 SHALE:


Borehole Log - 2727DC00147
Locality - X: 27.55 Y: 27.93 Z: 1511.51
Depth [m]
Lithology
Geology
0
5
10
15
20
25
30
35
40
0.00 - 1.00 SOIL:
1.00 - 30.00 SANDSTONE:
30.00 - 36.00 SHALE:

UTM 36S Projected Data

Borehole Name	X (m)	Y (m)	Z (mamsl)	Water Level (mamsl)	Water Level (mbgl)	Depth (mbgl)
MW05	582633.1	8213004.9	216.6	215.1	1.5	35
MW11	582591.4	8212851.4	216.4	214.5	1.9	35
PZ09	582433.5	8212729.0	216.8	214.9	1.9	6.8
S4-Hnew05	577335.0	8216549.0	173.45	171.3	2.15	106
A-HA008	569835.0	8218383.0	130.14	127.2	2.94	36
A-HA008A	569819.0	8218348.0	130.95	127.8	3.15	38
S6-H003B	581168.0	8216083.0	187.81	184.4	3.41	25
S5-HA003	576492.0	8222867.0	135.25	131.8	3.45	22.5
S6-H008B	580785.0	8217681.0	164.42	160.9	3.52	17
S6-H003	581220.0	8216098.0	187.56	184	3.56	88
S6-H002	581806.0	8218480.0	205.93	202.3	3.63	103
S6-H008	580808.0	8217719.0	165.03	161.3	3.73	186
S5-HA004	576528.0	8222849.0	135.42	131.6	3.82	24
A-HA009F	569356.1	8216622.1	131.77	127.7	4.07	
PZ01	582909.4	8212835.7	225.7	221.6	4.1	12.7
MW03	582168.6	8212674.2	224.2	220	4.2	19.2
S5-HA006	576409.0	8222402.0	135.74	131.5	4.24	28
S6-H006	582698.0	8217105.0	216.96	212.7	4.26	40
S6-H008A	580805.0	8217695.0	164.81	160.4	4.41	18
S5-HA001	576588.0	8223277.0	136.2	131.6	4.6	23
A-HA009A	569128.0	8216840.0	132.04	127.3	4.74	41
S6-H003A	581171.0	8216079.0	187.56	182.8	4.76	82
S5-HA001A	576602.0	8223263.0	137.27	132.5	4.77	7.5
S5-HA007	576452.0	8222369.0	136.33	131.5	4.83	22
S4-H004	577904.0	8216544.0	179.55	174.7	4.85	157
S5-HA005	576570.0	8222839.0	136.71	131.7	5.01	26
A-HA009	569138.0	8216791.0	133.7	128.6	5.1	41
S5-HA002	576617.0	8223248.0	137.76	132.5	5.26	7
S4-H005	578227.0	8215018.0	188.13	182.4	5.73	102
S1-H002B	582808.0	8215242.0	197.37	191.6	5.77	30
S5-H003B	577822.0	8220024.0	151.42	145.4	6.02	25
S1-H002	582802.0	8215186.0	197.51	191.4	6.11	127
S3-H003A	573516.0	8217337.0	149.85	143.7	6.15	81
S3-H003	573511.0	8217417.0	149.49	143.3	6.19	117
PS2ANA003	586142.3	8209877.5	201.61	195.4	6.21	16.48
S5-H003	577803.0	8220017.0	151.15	144.7	6.45	27
PZ12	582591.0	8210785.0	233.27	226.8	6.47	13.27
S6-183	581135.0	8216976.0	181.7	175.2	6.5	47.8
S1-329	582629.0	8215330.0	197	190.5	6.5	10
S6-180	581091.0	8216952.0	182.2	175.6	6.6	8.5
B-H016A	586062.0	8208539.0	191	184.4	6.6	14
PS2ANA008	587031.7	8210166.0	209.06	202.4	6.66	31.13
S6-182	581179.0	8217000.0	181.7	174.9	6.8	9
B-H016	586060.0	8208522.0	191	184.2	6.8	106
S3-H001	573023.0	8216990.0	151.12	144.3	6.82	140
S1-327	582617.0	8215075.0	197.6	190.7	6.9	13
S5-H001	576607.0	8222290.0	138.33	131.4	6.93	24
PS5NA006	576451.9	8222368.9	135.9	128.9	7	12.23
PZ11	582219.2	8212564.3	229.5	222.4	7.1	12.5
S5-H003A	577850.0	8220069.0	152.71	145.6	7.11	30
S3-H001A	573027.0	8216913.0	149.54	142.4	7.14	100
INS2ANA001	585526.8	8212851.2	220.3	213.1	7.2	21.51
S1-328	582524.0	8215518.0	197.9	190.6	7.3	71
APP01	569302.2	8217269.6	132.72	125.4	7.32	

Geotech-01	589060.0	8209514.0	202.97	195.6	7.37	125.08
APP02	569304.8	8217129.3	132.76	125.2	7.56	29
S2-H003A	586879.0	8212587.0	225.89	218.3	7.59	42
APP05	569215.3	8216176.0	132.72	125.1	7.62	30
INS2ANA002	585236.6	8213485.5	221.43	213.8	7.63	20.58
APP03	569301.5	8216969.4	132.86	125.2	7.66	29.5
APP04	569199.7	8216050.3	132.68	125	7.68	27
S2-H004B	587502.0	8211265.0	216.75	208.7	8.05	30
S2-H003	586859.0	8212567.0	225.91	217.8	8.11	222
S2-H006	587438.0	8211880.0	222.56	214.4	8.16	120
B-H017	585878.0	8211368.0	210	201.8	8.2	95
S6-162	581805.0	8215662.0	192.9	184.6	8.3	11
INS2ANA003	585712.0	8212500.7	218.82	210.4	8.42	21.17
S6-222	581111.0	8217190.0	181.9	173.3	8.6	94
S6-H004C	581754.0	8217116.0	187.92	179.3	8.62	109
S1-H004	583459.0	8215160.0	199.25	190.4	8.85	121
B-H018	586345.0	8210511.0	208	199.1	8.9	101.4
MW08	583464.0	8212534.0	238	229.1	8.9	43
S2-H001	588332.0	8210575.0	218.75	209.8	8.95	150
B-H018A	586358.0	8210506.0	208	199	9	15.5
PS2ANA007	588013.5	8208127.6	193.48	184.2	9.28	18.9
S4-H006	575376.0	8216847.0	167.39	157.8	9.59	312
Geotech-02	589579.0	8210688.0	226.35	216.6	9.75	71.12
S4-H006A	575347.0	8216866.0	165.97	156.2	9.77	30
S6-H004A	581770.0	8217141.0	184.92	175.1	9.82	108
S6-177	582015.0	8215634.0	195	185	10	16
B-H005A	585625.0	8209858.0	204	193.8	10.2	14
B-H005	585627.0	8209832.0	205	194.8	10.2	57
S1-H001	581679.0	8213857.0	207.5	197.2	10.3	117
S1-H001A	581777.0	8213921.0	206.46	196	10.46	110
ROVINA003	569280.2	8215998.2	129.39	118.9	10.49	28
UGW20	580575.0	8217470.0	167.1	156.6	10.5	15
B-H011A	583861.0	8211939.0	232	221.4	10.6	15
S2-H004	587496.0	8211281.0	215.78	205	10.78	132
S6-178	582037.0	8215639.0	194.9	184.1	10.8	51
ROVINA001	569563.0	8217688.3	130.51	119.6	10.91	30
B-H014	581416.0	8208310.0	188	177	11	118
UGW5	582353.9	8215627.0	200	188.9	11.1	68
Chipanga-7A	578156.0	8219004.0	158.2	146.9	11.3	
S1-H005	581315.0	8213844.0	211.34	200	11.34	45.5
S6-H001	582503.0	8215684.0	202.36	191	11.36	42
S6-H006A	582695.0	8217104.0	216.77	205.4	11.37	100
UGW19	580560.0	8217461.0	173.7	162.3	11.4	15
S6-161	581827.0	8215674.0	195.5	184.1	11.4	21
S6-H004B	581773.0	8217134.0	184.94	173.5	11.44	40
S4-Hnew02	578757.0	8216340.0	193.27	181.5	11.77	80
S1-Hnew01	583477.0	8216000.0	202.87	191.1	11.77	50
S2-H005	588470.0	8211206.0	224.3	212.5	11.8	144
B-H014A	581409.0	8208296.0	188	176	12	16
B-H010	582758.0	8213733.0	216	204	12	81
S4-Hnew01	578773.0	8216321.0	194.95	182.8	12.15	60
S6-194	581678.0	8216016.0	196.2	183.8	12.4	40
S6-197	582185.0	8216096.0	196.1	183.7	12.4	84
S6-175	581972.0	8215624.0	196.4	183.9	12.5	36
S6-168	581503.0	8216096.0	196.7	184.2	12.5	13.5
ROVINA002	569304.6	8216781.3	130.08	117.4	12.68	36
B-H011	583844.0	8211934.0	232	219.3	12.7	57

S6-206	581575.0	8216793.0	189.1	176.3	12.8	51
S6-208	581756.0	8217065.0	189.3	176.4	12.9	45
S2-H004A	587493.0	8211302.0	217.87	204.9	12.97	129
B-H012A	582155.0	8213071.0	219	206	13	13
S6-214	581531.0	8216769.0	189.2	175.9	13.3	38.5
MW10	583268.0	8211689.0	243.6	230.3	13.3	48.6
S6-166	581937.0	8215733.0	196.7	183.2	13.5	15
S1-Hnew03-Obs	583515.0	8215968.0	204.84	191.2	13.64	50
S6-215	581509.0	8216757.0	190.2	176.5	13.7	35
S6-169	581611.0	8216158.0	198	184.3	13.7	45.5
S6-218	581487.0	8216745.0	190.1	176	14.1	25
S6-216	582223.0	8217214.0	190.3	176.1	14.2	30
S2-H007	588122.0	8211944.0	242.47	228.2	14.27	97
S6-219	581465.0	8216733.0	190.6	176.2	14.4	20.5
S6-210	581640.0	8216829.0	190.9	176.4	14.5	49
S6-204	581421.0	8216709.0	193.1	178.2	14.9	80
S6-172	581697.0	8216209.0	198.7	183.6	15.1	19.5
S6-171	581719.0	8216221.0	199	183.6	15.4	20.5
S4-Hnew03	578802.0	8216293.0	199.79	184.3	15.49	60
Geotech-05	578699.0	8215998.0	201.79	186.3	15.49	40.12
S6-220	581443.0	8216721.0	192.2	176.5	15.7	25
S6-191	581748.0	8215840.0	200.2	184.5	15.7	18
MW07	583516.0	8212744.0	240.9	225.1	15.8	45.9
MW09	583240.0	8211904.0	243.5	227.6	15.9	48.5
S4-H002A	578688.0	8215695.0	197.05	180.7	16.35	75
S4-H002	578700.0	8215717.0	197.18	180.8	16.38	141
Geotech-04	589316.0	8209629.0	208	191.6	16.4	53.06
S6-211	581662.0	8216841.0	193.5	176.5	17	70
S1-Hnew02-Obs	583602.0	8216060.0	211.19	194.1	17.09	60
B-H003	585952.0	8214153.0	243.09	225.7	17.39	98
S6-213	581553.0	8216781.0	193.9	176.5	17.4	71
S6-212	581684.0	8216853.0	194.1	176.5	17.6	70
S6-221	581284.0	8217174.0	177.7	160	17.7	19
PZ04	582654.4	8212715.2	243.8	224.5	19.3	25.8
S4-Hnew04	578751.0	8215766.0	200.15	180.6	19.55	100
PZ10	582234.5	8212525.4	243.92	223.3	20.62	22.92
S5-H004A	576661.0	8220388.0	156.19	135.3	20.89	57
S5-H004B	576614.0	8220538.0	156.96	135.8	21.16	100
RG04NA001	588210.1	8207236.6	181.85	159.9	21.95	21.9
B-H010A	582744.0	8213732.0	215	193	22	22
B-H012	582152.0	8213062.0	219	197	22	67
PS4NA001	575927.0	8216221.0	174.32	152	22.32	22.72
S5-H004	576626.0	8220443.0	155.72	133.2	22.52	54
S4-H002B	578696.0	8215694.0	197.15	174.6	22.55	30
B-H006	584402.0	8212300.0	242	219.4	22.6	55
PS1NA002	581037.8	8211999.1	239.9	217.1	22.8	21.4
PZ07	582474.2	8212633.6	243.9	220.7	23.2	26.9
PS4NA004	578766.4	8216322.4	194.91	171.4	23.51	60
B-H009	582042.0	8212597.0	230	206.4	23.6	52
B-H015	583561.0	8212694.0	238	214	24	57
PS2ANA006	583794.7	8212633.8	241.74	217.6	24.14	30.65
S6-201	581064.0	8217322.0	184.8	160.6	24.2	36
Geotech-03	578753.0	8215968.0	206.92	182	24.92	137.05
PS2ANA001	588466.2	8211202.7	223.88	198.9	24.98	15.4
S6-199	581086.0	8217334.0	185.4	160.2	25.2	42.5
B-H001A	576684.0	8214928.0	206.43	180.2	26.23	50

B-H001	576676.0	8214940.0	206.6	179.8	26.8	102
MW02	581748.6	8212291.3	244	217.2	26.8	49
PS1NA001	581025.5	8214035.0	223.7	196.7	27	30
PS2ANA005	583190.3	8209880.7	240.86	211.5	29.36	30.61
MW01	581894.4	8211867.8	248.78	218.1	30.68	49.8
PS2ANA002	590380.7	8208943.9	211.38	178.5	32.88	150.2
PS2ANA004	585102.3	8208050.7	205.36	168.4	36.96	33
WDS2ANA003	587107.5	8208653.4	241.12	200.8	40.32	
B-H007	584733.0	8209587.0	214	168.8	45.2	60
PN001NA002	586379.7	8211993.4	250.71	205.3	45.41	
PS4NA003	578746.1	8215972.5	206.31	159.9	46.41	90
WDS2ANA004	587107.5	8208653.4	241.12	193.3	47.82	
PN001NA001	586379.7	8211993.4	250.71	177.5	73.21	

Annexure C: NGA and WARMS Resource Summary Information

ER	NGA ID	LONGITUDE	LATITUDE	ELEV	DEPTH
318	2526DAV0019	26.56992	-27.71811	1305	
318	2726AD00065	26.43630	-27.44324	1295	35.0
318	2726BC00001	26.54546	-27.49490	1318	70.0
318	2726CA00001	26.11630	-27.71713	1262	25.6
318	2726CA00002	26.13296	-27.60046	1268	45.0
318	2726CA00003	26.13297	-27.60046	1268	100.0
318	2726CA00004	26.13296	-27.60047	1268	95.0
318	2726CA00005	26.13298	-27.60046	1268	85.0
318	2726CA00046	26.23685	-27.69713	1284	18.3
318	2726CA00047	26.23685	-27.69712	1284	21.0
318	2726CB00001	26.47908	-27.57824	1298	5.0
318	2726CB00002	26.48463	-27.71852	1311	60.0
318	2726CB00003	26.47352	-27.71629	1315	25.0
318	2726CB00004	26.48463	-27.71018	1325	100.0
318	2726CB00005	26.47352	-27.72130	1303	45.0
318	2726CB00006	26.47991	-27.70240	1306	60.0
318	2726CB00007	26.47408	-27.70602	1306	40.0
318	2726CB00008	26.46686	-27.70824	1299	80.0
318	2726CB00009	26.46686	-27.70740	1300	40.0
318	2726CC00005	26.08296	-27.78379	1258	35.0
318	2726CC00006	26.08296	-27.78380	1258	25.0
318	2726CC00007	26.20907	-27.78048	1274	77.7
318	2726CC00008	26.20907	-27.78046	1274	99.4
318	2726CC00009	26.20907	-27.78047	1274	92.4
318	2726CC00010	26.23463	-27.80269	1276	60.6
318	2726CC00011	26.23463	-27.80268	1276	53.6
318	2726CC00012	26.18548	-27.84909	1285	31.4
318	2726CC00013	26.18547	-27.84909	1285	21.6
318	2726CC00014	26.18546	-27.84907	1285	31.1
318	2726CC00015	26.21490	-27.81768	1280	68.0
318	2726CD00001	26.39546	-27.75546	1264	60.0
318	2726CD00002	26.39546	-27.75547	1264	62.0
318	2726CD00003	26.39547	-27.75547	1264	60.0
318	2726CD00004	26.39547	-27.75548	1264	62.0
318	2726CD00006	26.30130	-27.87185	1274	50.0
318	2726CD00007	26.30130	-27.87184	1274	85.0
318	2726CD00010	26.35519	-27.87575	1296	50.0
318	2726CD00011	26.35520	-27.87575	1296	72.8
318	2726CD00012	26.35521	-27.87574	1296	61.0
318	2726CD00013	26.35518	-27.87574	1296	39.6
318	2726CD00014	26.35518	-27.87573	1296	34.7
318	2726CD00017	26.33602	-27.88686	1289	42.1
318	2726CD00018	26.33601	-27.88685	1289	78.3
318	2726CD00019	26.33601	-27.88684	1289	50.3
318	2726CD00020	26.33601	-27.88683	1289	66.8

318	2726CD00021	26.30185	-27.87130	1274	64.0
318	2726CD00022	26.30186	-27.87129	1274	39.6
318	2726DA00002	26.58991	-27.54907	1309	33.5
318	2726DA00003	26.53519	-27.53132	1302	43.0
318	2726DA00004	26.52435	-27.55240	1301	43.0
318	2726DA00005	26.54263	-27.60646	1277	
318	2726DA00006	26.50213	-27.54657	1300	
318	2726DA00007	26.53519	-27.53132	1302	
318	2726DA00008	26.50213	-27.54657	1300	
318	2726DC00001	26.65463	-27.84879	1320	48.0
318	2726DC00002	26.65991	-27.85796	1328	35.0
318	2726DC00003	26.61337	-27.76456	1309	43.0
318	2726DC00004	26.60661	-27.76922	1302	40.0
318	2726DC00005	26.61546	-27.75897	1311	40.0
318	2726DC00006	26.59866	-27.76124	1302	32.0
318	2726DC00007	26.60382	-27.78411	1308	37.0
318	2726DC00008	26.61645	-27.78478	1309	40.0
318	2726DC00009	26.61915	-27.77982	1310	36.0
318	2726DD00010	26.85574	-27.87630	1379	27.1
318	2726DD00011	26.85574	-27.87629	1379	28.0
318	2726DD00012	26.85575	-27.87630	1379	32.0
318	2726DD00013	26.85574	-27.87629	1379	28.7
318	2726DD00014	26.85574	-27.87630	1379	35.4
318	2726DD00015	26.85575	-27.87630	1379	39.3
318	2726DD00016	26.85576	-27.87629	1379	60.5
318	2726DD00017	26.85574	-27.87629	1379	29.1
318	2726DD00018	26.85574	-27.87630	1379	76.0
318	2726DD00019	26.85575	-27.87629	1379	76.0
318	2726DD00022	26.80366	-27.91408	1413	189.0
318	2726DD00025	26.80830	-27.91869	1417	80.0
318	47546	26.39550	-27.76110	1272	
318	47547	26.41230	-27.73760	1279	
318	47548	26.32473	-27.74706	1291	
318	47549	26.37660	-27.75430	1285	
318	47550	26.32990	-27.66940	1273	
318	47551	26.39102	-27.70685	1288	
318	47553	26.54281	-27.60684	1279	
318	47554	26.31673	-27.59498	1251	
318	47555	26.38424	-27.53730	1302	
318	47556	26.52241	-27.54268	1302	
318	47557	26.54281	-27.60684	1279	
318	47558	26.61213	-27.62538	1287	
318	47559	26.61692	-27.62139	1287	
318	47560	26.51669	-27.71024	1300	
318	47561	26.51317	-27.75683	1294	
318	47562	26.49362	-27.61584	1272	

318	47563	26.60640	-27.60250	1289	
318	47564	26.63722	-27.88273	1328	
318	47565	26.79620	-27.90620	1403	
318	47566A	26.69820	-27.82520	1332	
318	47567	26.71720	-27.78594	1324	

ER	WARMS Registration ID	Longitude	Latitude	Use (L/s)
318	20030967	26.62450	-27.86146	0.58
318	23051830	26.70037	-27.87958	0.78
318	23053428	26.12539	-27.59425	0.70
318	23047793	26.32450	-27.76618	0.95
318	23035181	26.10782	-27.80812	0.57
318	23041129	26.30950	-27.81256	0.23
318	23031176	26.39533	-27.87034	0.26

Annexure D: Laboratory Certificates of Analysis

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TEST REPORT
41076A

Client and Project Information

Client:	JG Afrika				
Address:	1ste Floor, Block C Westville	**Attention:**	Robert Schapers	**Project number:**	5759
	Durban	**Tel:**	(031) 275 5502	**Project name:**	ROG
	3629	**Email:**	schapersr@jgafrika.com		

Sample Information

				Date Received:	2022/12/05
Sample ID:	**S01**	**Matrix:**	Water	**Date Analysed:**	2022/12/05
Units:	mg/l [ppm] (unless stated elsewhere)	**Container:**	Plastic	**Date Issued:**	2022/12/21

Cations and Metals

Al	0.12	**Cd**	<0.003	**K**	4.58	**Pb**	<0.01	**U***	<0.03
As	0.01	**Co**	<0.05	**Mg**	49.46	**Sb**	<0.01		
B	<0.5	**Cr**	<0.05	**Mn**	<0.05	**Se**	0.01		
Ba	0.21	**Cu**	0.07	**Na**	94.96	**V**	<0.05		
Ca	124.40	**Fe**	0.05	**Ni**	<0.05	**Zn**	0.44		

Anions (Discrete Analyser)

Cl	229.80	**NO2 as N**	<0.13	**SO4**	60.22	**NO3 + NO2 as N**	59.58
F	0.33	**NO3 as N**	59.58				

Other Parameters

pH	7.67	**Turbidity (NTU)***	3.99	**E.coli (colonies/100ml)***	200
EC (µs/cm)	1564	**NH3 as N***	0.03	**Total Coliforms (colonies/100ml)***	900
TDS	1228	**Total Phenol***	<0.01	**Total Plate Count (colonies/ml)***	46
TOC*	<10	**Colour (hazen)***	<10		
Free CN*	0.003	**Hg***	<0.005		

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ENVIRONMENTAL POLLUTION LABORATORY

TEST REPORT 41076A

Client and Project Information

Client:	JG Afrika				
Address:	1ste Floor, Block C Westville Durban 3629	**Attention:**	Robert Schapers	**Project number:**	5759
		Tel:	(031) 275 5502	**Project name:**	ROG
		Email:	schapersr@jgafrika.com		

Sample Information

Sample ID:	**S02**	**Matrix:**	Water	**Date Received:**	2022/12/05
				Date Analysed:	2022/12/05
Units:	mg/l [ppm] (unless stated elsewhere)	**Container:**	Plastic	**Date Issued:**	2022/12/21

Cations and Metals

Al	0.21	**Cd**	<0.003	**K**	7.31	**Pb**	<0.01	**U***	<0.03
As	0.01	**Co**	<0.05	**Mg**	66.32	**Sb**	<0.01		
B	1.04	**Cr**	<0.05	**Mn**	<0.05	**Se**	<0.01		
Ba	0.19	**Cu**	0.10	**Na**	604.90	**V**	<0.05		
Ca	107.50	**Fe**	0.29	**Ni**	<0.05	**Zn**	0.37		

Anions (Discrete Analyser)

Cl	1245.00	**NO2 as N**	<0.13	**SO4**	198.40	**NO3 + NO2 as N**	<0.5
F	0.88	**NO3 as N**	<0.5				

Other Parameters

pH	7.81	**Turbidity (NTU)***	2.09	**E.coli (colonies/100ml)***	0
EC (µs/cm)	4138	**NH3 as N***	0.14	**Total Coliforms (colonies/100ml)***	0
TDS	2787	**Total Phenol***	<0.01	**Total Plate Count (colonies/ml)***	37
TOC*	<10	**Colour (hazen)***	25.59		
Free CN*	0.002	**Hg***	<0.005		

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ENVIRONMENTAL POLLUTION LABORATORY

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TEST REPORT 41076A

Client and Project Information

Client:	JG Afrika				
Address:	1ste Floor, Block C Westville	**Attention:**	Robert Schapers	**Project number:**	5759
	Durban	**Tel:**	(031) 275 5502	**Project name:**	ROG
	3629	**Email:**	schapersr@jgafrika.com		

Sample Information

				Date Received:	2022/12/05
Sample ID:	**S03**	**Matrix:**	Water	**Date Analysed:**	2022/12/05
Units:	mg/l [ppm] (unless stated elsewhere)	**Container:**	Plastic	**Date Issued:**	2022/12/21

Cations and Metals

Al	0.15	**Cd**	<0.003	**K**	3.30	**Pb**	<0.01	**U***	<0.03
As	<0.01	**Co**	<0.05	**Mg**	21.22	**Sb**	<0.01		
B	<0.5	**Cr**	<0.05	**Mn**	<0.05	**Se**	<0.01		
Ba	0.05	**Cu**	0.08	**Na**	69.99	**V**	<0.05		
Ca	49.02	**Fe**	0.05	**Ni**	<0.05	**Zn**	0.15		

Anions (Discrete Analyser)

Cl	56.35	**NO2 as N**	<0.13	**SO4**	54.03	**NO3 + NO2 as N**	29.06
F	0.47	**NO3 as N**	29.06				

Other Parameters

pH	7.91	**Turbidity (NTU)***	0.05	**E.coli (colonies/100ml)***	0
EC (µs/cm)	857	**NH3 as N***	<0.02	**Total Coliforms (colonies/100ml)***	200
TDS	601	**Total Phenol***	<0.01	**Total Plate Count (colonies/ml)***	157
TOC*	<10	**Colour (hazen)***	<10		
Free CN*	<0.002	**Hg***	<0.005		

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EPL ENVIRONMENTAL POLLUTION LABORATORY

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TEST REPORT 41076A

Client and Project Information

Client:	JG Afrika				
Address:	1ste Floor, Block C Westville	**Attention:**	Robert Schapers	**Project number:**	5759
	Durban	**Tel:**	(031) 275 5502	**Project name:**	ROG
	3629	**Email:**	schapersr@jgafrika.com		

Sample Information

				Date Received:	2022/12/05
Sample ID:	**S04**	**Matrix:**	Water	**Date Analysed:**	2022/12/05
Units:	mg/l [ppm] (unless stated elsewhere)	**Container:**	Plastic	**Date Issued:**	2022/12/21

Cations and Metals

Al	0.38	**Cd**	<0.003	**K**	4.91	**Pb**	<0.01	**U***	<0.03
As	0.01	**Co**	<0.05	**Mg**	42.30	**Sb**	<0.01		
B	<0.5	**Cr**	<0.05	**Mn**	<0.05	**Se**	<0.01		
Ba	0.14	**Cu**	0.09	**Na**	32.39	**V**	<0.05		
Ca	97.91	**Fe**	0.12	**Ni**	<0.05	**Zn**	0.07		

Anions (Discrete Analyser)

Cl	85.64	**NO2 as N**	<0.13	**SO4**	76.73	**NO3 + NO2 as N**	59.24
F	<0.05	**NO3 as N**	59.24				

Other Parameters

pH	7.38	**Turbidity (NTU)***	0.69	**E.coli (colonies/100ml)***	0
EC (µs/cm)	1130	**NH3 as N***	<0.02	**Total Coliforms (colonies/100ml)***	0
TDS	964	**Total Phenol***	<0.01	**Total Plate Count (colonies/ml)***	40
TOC*	<10	**Colour (hazen)***	10.33		
Free CN*	0.003	**Hg***	<0.005		

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Client and Project Information

Client:	JG Afrika				
Address:	1ste Floor, Block C Westville	**Attention:**	Robert Schapers	**Project number:**	5759
	Durban	**Tel:**	(031) 275 5502	**Project name:**	ROG
	3629	**Email:**	schapersr@jgafrika.com		

Sample Information

				Date Received:	2022/12/05
Sample ID:	**S05**	**Matrix:**	Water	**Date Analysed:**	2022/12/05
Units:	mg/l [ppm] (unless stated elsewhere)	**Container:**	Plastic	**Date Issued:**	2022/12/21

Cations and Metals

Al	0.17	**Cd**	<0.003	**K**	9.33	**Pb**	<0.01	**U***	<0.03
As	0.01	**Co**	<0.05	**Mg**	47.32	**Sb**	<0.01		
B	<0.5	**Cr**	<0.05	**Mn**	<0.05	**Se**	<0.01		
Ba	0.08	**Cu**	0.09	**Na**	184.00	**V**	<0.05		
Ca	129.80	**Fe**	0.09	**Ni**	<0.05	**Zn**	<0.05		

Anions (Discrete Analyser)

Cl	220.70	**NO2 as N**	<0.13	**SO4**	145.20	**NO3 + NO2 as N**	28.23
F	0.43	**NO3 as N**	28.23				

Other Parameters

pH	7.77	**Turbidity (NTU)***	0.25	**E.coli (colonies/100ml)***	0
EC (µs/cm)	2048	**NH3 as N***	0.03	**Total Coliforms (colonies/100ml)***	300
TDS	1214	**Total Phenol***	<0.01	**Total Plate Count (colonies/ml)***	92
TOC*	<10	**Colour (hazen)***	<10		
Free CN*	<0.002	**Hg***	<0.005		

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TEST REPORT
41076A

Client and Project Information

Client:	JG Afrika				
Address:	1ste Floor, Block C Westville	**Attention:**	Robert Schapers	**Project number:**	5759
	Durban	**Tel:**	(031) 275 5502	**Project name:**	ROG
	3629	**Email:**	schapersr@jgafrika.com		

Sample Information

				Date Received:	2022/12/05
Sample ID:	**S06**	**Matrix:**	Water	**Date Analysed:**	2022/12/05
Units:	mg/l [ppm] (unless stated elsewhere)	**Container:**	Plastic	**Date Issued:**	2022/12/21

Cations and Metals

Al	0.14	**Cd**	<0.003	**K**	2.26	**Pb**	<0.01	**U***	<0.03
As	0.01	**Co**	<0.05	**Mg**	35.32	**Sb**	<0.01		
B	<0.5	**Cr**	<0.05	**Mn**	<0.05	**Se**	<0.01		
Ba	0.09	**Cu**	0.04	**Na**	83.23	**V**	<0.05		
Ca	78.69	**Fe**	0.33	**Ni**	<0.05	**Zn**	0.11		

Anions (Discrete Analyser)

Cl	57.97	**NO2 as N**	<0.13	**SO4**	34.08	**NO3 + NO2 as N**	4.34
F	0.60	**NO3 as N**	4.34				

Other Parameters

pH	7.70	**Turbidity (NTU)***	5.17	**E.coli (colonies/100ml)***	1500
EC (µs/cm)	924	**NH3 as N***	0.04	**Total Coliforms (colonies/100ml)***	2400
TDS	587	**Total Phenol***	<0.01	**Total Plate Count (colonies/ml)***	335
TOC*	<10	**Colour (hazen)***	30.73		
Free CN*	0.006	**Hg***	<0.005		

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TEST REPORT
41076A

Client and Project Information

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	Durban	**Tel:**	(031) 275 5502	**Project name:**	ROG
	3629	**Email:**	schapersr@jgafrika.com		

Sample Information

				Date Received:	2022/12/05
Sample ID:	**S07**	**Matrix:**	Water	**Date Analysed:**	2022/12/05
Units:	mg/l [ppm] (unless stated elsewhere)	**Container:**	Plastic	**Date Issued:**	2022/12/21

Cations and Metals

Al	0.17	**Cd**	<0.003	**K**	1.78	**Pb**	<0.01	**U***	<0.03
As	0.01	**Co**	<0.05	**Mg**	31.05	**Sb**	<0.01		
B	<0.5	**Cr**	<0.05	**Mn**	<0.05	**Se**	<0.01		
Ba	0.10	**Cu**	0.05	**Na**	93.76	**V**	<0.05		
Ca	65.28	**Fe**	0.06	**Ni**	<0.05	**Zn**	0.11		

Anions (Discrete Analyser)

Cl	87.47	**NO2 as N**	<0.13	**SO4**	55.28	**NO3 + NO2 as N**	10.28
F	0.56	**NO3 as N**	10.28				

Other Parameters

pH	7.79	**Turbidity (NTU)***	0.28	**E.coli (colonies/100ml)***	0
EC (µs/cm)	1044	**NH3 as N***	<0.02	**Total Coliforms (colonies/100ml)***	0
TDS	636	**Total Phenol***	<0.01	**Total Plate Count (colonies/ml)***	0
TOC*	<10	**Colour (hazen)***	<10		
Free CN*	0.002	**Hg***	<0.005		

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6) Uncertainty of measurement for all methods included in the SANAS Schedule of Accreditation is available on request.

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TEST REPORT 41076A

Client and Project Information

Client:	JG Afrika				
Address:	1ste Floor, Block C Westville	**Attention:**	Robert Schapers	**Project number:**	5759
	Durban	**Tel:**	(031) 275 5502	**Project name:**	ROG
	3629	**Email:**	schapersr@jgafrika.com		

Sample Information

				Date Received:	2022/12/05
Sample ID:	S08	**Matrix:**	Water	**Date Analysed:**	2022/12/05
Units:	mg/l [ppm] (unless stated elsewhere)	**Container:**	Plastic	**Date Issued:**	2022/12/21

Cations and Metals

Al	0.11	**Cd**	<0.003	**K**	14.16	**Pb**	<0.01	**U***	<0.03
As	0.01	**Co**	<0.05	**Mg**	71.67	**Sb**	<0.01		
B	<0.5	**Cr**	<0.05	**Mn**	<0.05	**Se**	<0.01		
Ba	0.15	**Cu**	0.08	**Na**	146.50	**V**	<0.05		
Ca	115.90	**Fe**	0.48	**Ni**	<0.05	**Zn**	<0.05		

Anions (Discrete Analyser)

Cl	351.50	**NO2 as N**	<0.13	**SO4**	158.90	**NO3 + NO2 as N**	17.78
F	0.53	**NO3 as N**	17.78				

Other Parameters

pH	7.96	**Turbidity (NTU)***	4.95	**E.coli (colonies/100ml)***	0
EC (µs/cm)	1992	**NH3 as N***	<0.02	**Total Coliforms (colonies/100ml)***	0
TDS	1409	**Total Phenol***	<0.01	**Total Plate Count (colonies/ml)***	21
TOC*	<10	**Colour (hazen)***	33.93		
Free CN*	0.007	**Hg***	<0.005		

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TEST REPORT
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Client and Project Information

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Address:	1ste Floor, Block C Westville	**Attention:**	Robert Schapers	**Project number:**	5759
	Durban	**Tel:**	(031) 275 5502	**Project name:**	ROG
	3629	**Email:**	schapersr@jgafrika.com		

Sample Information

				Date Received:	2022/12/05
Sample ID:	**S09**	**Matrix:**	Water	**Date Analysed:**	2022/12/05
Units:	mg/l [ppm] (unless stated elsewhere)	**Container:**	Plastic	**Date Issued:**	2022/12/21

Cations and Metals

Al	0.21	**Cd**	<0.003	**K**	16.79	**Pb**	<0.01	**U***	<0.03
As	0.02	**Co**	<0.05	**Mg**	13.74	**Sb**	<0.01		
B	0.50	**Cr**	<0.05	**Mn**	0.38	**Se**	<0.01		
Ba	0.14	**Cu**	<0.01	**Na**	263.00	**V**	<0.05		
Ca	30.77	**Fe**	4.19	**Ni**	<0.05	**Zn**	0.35		

Anions (Discrete Analyser)

Cl	78.39	**NO2 as N**	<0.13	**SO4**	<2	**NO3 + NO2 as N**	<0.5
F	0.65	**NO3 as N**	<0.5				

Other Parameters

pH	7.76	**Turbidity (NTU)***	290.90	**E.coli (colonies/100ml)***	2160000
EC (µs/cm)	1514	**NH3 as N***	11.11	**Total Coliforms (colonies/100ml)***	4970000
TDS	1131	**Total Phenol***	<0.01	**Total Plate Count (colonies/ml)***	27300
TOC*	24.39	**Colour (hazen)***	221.10		
Free CN*	<0.002	**Hg***	<0.005		

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Address:	1ste Floor, Block C Westville	**Attention:**	Robert Schapers	**Project number:**	5759
	Durban	**Tel:**	(031) 275 5502	**Project name:**	ROG
	3629	**Email:**	schapersr@jgafrika.com		

Sample Information

				Date Received:	2022/12/05
Sample ID:	**S10**	**Matrix:**	Water	**Date Analysed:**	2022/12/05
Units:	mg/l [ppm] (unless stated elsewhere)	**Container:**	Plastic	**Date Issued:**	2022/12/21

Cations and Metals

Al	0.23	**Cd**	<0.003	**K**	14.47	**Pb**	<0.01	**U***	<0.03
As	0.01	**Co**	<0.05	**Mg**	30.61	**Sb**	<0.01		
B	<0.5	**Cr**	<0.05	**Mn**	<0.05	**Se**	<0.01		
Ba	0.05	**Cu**	0.06	**Na**	124.40	**V**	<0.05		
Ca	64.33	**Fe**	0.06	**Ni**	<0.05	**Zn**	<0.05		

Anions (Discrete Analyser)

Cl	138.50	**NO2 as N**	<0.13	**SO4**	77.92	**NO3 + NO2 as N**	18.10
F	0.47	**NO3 as N**	18.10				

Other Parameters

pH	7.90	**Turbidity (NTU)***	0.54	**E.coli (colonies/100ml)***	0
EC (µs/cm)	1232	**NH3 as N***	<0.02	**Total Coliforms (colonies/100ml)***	1500
TDS	785	**Total Phenol***	<0.01	**Total Plate Count (colonies/ml)***	57
TOC*	<10	**Colour (hazen)***	<10		
Free CN*	0.002	**Hg***	<0.005		

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Client and Project Information

Client:	JG Afrika				
Address:	1ste Floor, Block C Westville	**Attention:**	Robert Schapers	**Project number:**	5759
	Durban	**Tel:**	(031) 275 5502	**Project name:**	ROG
	3629	**Email:**	schapersr@jgafrika.com		

Sample Information

				Date Received:	2022/12/05
Sample ID:	**S11**	**Matrix:**	Water	**Date Analysed:**	2022/12/05
Units:	mg/l [ppm] (unless stated elsewhere)	**Container:**	Plastic	**Date Issued:**	2022/12/21

Cations and Metals

Al	0.21	**Cd**	<0.003	**K**	7.65	**Pb**	<0.01	**U***	<0.03
As	<0.01	**Co**	<0.05	**Mg**	9.93	**Sb**	<0.01		
B	<0.5	**Cr**	<0.05	**Mn**	<0.05	**Se**	<0.01		
Ba	0.08	**Cu**	0.07	**Na**	149.40	**V**	<0.05		
Ca	19.21	**Fe**	0.22	**Ni**	<0.05	**Zn**	0.32		

Anions (Discrete Analyser)

Cl	84.15	**NO2 as N**	<0.13	**SO4**	55.19	**NO3 + NO2 as N**	13.33
F	0.52	**NO3 as N**	13.33				

Other Parameters

pH	8.15	**Turbidity (NTU)***	2.38	**E.coli (colonies/100ml)***	0
EC (µs/cm)	1107	**NH3 as N***	<0.02	**Total Coliforms (colonies/100ml)***	300
TDS	658	**Total Phenol***	<0.01	**Total Plate Count (colonies/ml)***	31
TOC*	<10	**Colour (hazen)***	12.84		
Free CN*	<0.002	**Hg***	<0.005		

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National Research Foundation | iThemba LABS Laboratory for Accelerator Based Sciences

Environmental Isotope Laboratory

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Report

Reference: JGA001

Date: 25th January 2023

Environmental isotope analysis on seventeen (17) water samples

submitted by Robert Schapers

JG Afrika

— —

M.J. Butler, M. Mabitsela

confidential

1. General

Seventeen water samples were submitted by Mr R. Schapers of JG Afrika for D/H ($^2H/^1H$) and $^{18}O/^{16}O$ analysis. The samples were received on the 5th of December 2022.

2. Stable Isotope Analysis

Water D/H ($^2H/^1H$) and $^{18}O/^{16}O$ ratios were analysed in the laboratory of the Environmental Isotope Laboratory (EIL) of iThemba LABS, Johannesburg.

The equipment used for stable isotope analysis consists of a Los Gatos Research (LGR) Liquid Water Isotope Analyser. Laboratory standards, calibrated against international reference materials, are analysed with each batch of samples. The analytical precision is estimated at 0.5‰ for O and 1.5‰ for H.

Analytical results are presented in the common delta-notation:

$$\delta^{18}O(‰) = \left[\frac{(^{18}O/^{16}O)_{sample}}{(^{18}O/^{16}O)_{standard}} - 1 \right] \times 1000$$

which applies to D/H ($^2H/^1H$), accordingly. These delta values are expressed as per mil deviation relative to a known standard, in this case standard mean ocean water (SMOW) for $\delta^{18}O$ and δD.

3. Results

The analytical results are presented in Tables 1 and 2 and partially illustrated in Figure 1.

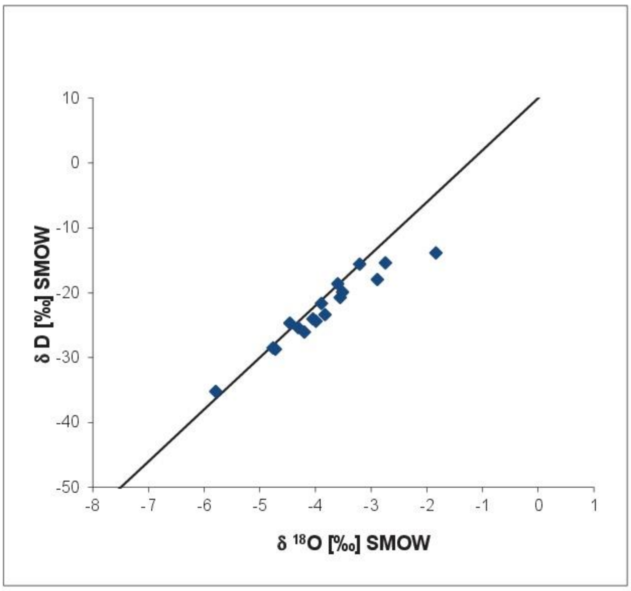

Figure 1: Stable isotope data relative to Global Meteoric Water Line (Craig, 1961).

The stable isotope analyses for all samples data could be well reproduced within the expected analytical error limits. Figure 1 shows these data in a $\delta^{18}O$ vs. δD space relative to the Global Meteoric Water Line (GMWL, Craig, 1961).

4. References

Craig, H. (1961). Isotopic variations in meteoric waters. *Science*, **133**, 1702–1703.

Table 1: Analytical Results

			Deuterium	Oxygen-18
Lab No	Field Name	Description	δD‰ SMOW	δ^{18}O‰ SMOW
JGA 001	S01	2022/11/29	-18.0	-2.89
JGA 002	S02	2022/11/29	-24.7	-4.46
JGA 003	S03	2022/11/29	-18.6	-3.60
JGA 004	S04	2022/11/29	-15.6	-3.21
JGA 005	S05	2022/11/29	-24.0	-4.05
JGA 006	S06	2022/11/30	-15.4	-2.74
JGA 007	S07	2022/11/30	-24.4	-3.99
JGA 008	S08	2022/11/30	-19.9	-3.52
JGA 009	S09	2022/12/01	-25.4	-4.31
JGA 010	S10	2022/12/01	-23.4	-3.83
JGA 011	S11	2022/12/01	-26.1	-4.20
JGA 012	S12	2022/12/02	-28.7	-4.72
JGA 013	S13	2022/12/02	-28.5	-4.76
JGA 014	S14	2022/12/02	-21.7	-3.89
JGA 015	S15	2022/12/02	-20.8	-3.56
JGA 016	S16	2022/12/02	-13.9	-1.84
JGA 017	S17	2022/12/03	-35.2	-5.79

Table 2: Stable isotope aliquot determinations

			Deuterium			Oxygen-18		
Lab No.	Field Name:	Description	analysis	Batch	δD‰ SMOW	analysis	Batch	δ^{18}O‰ SMOW
JGA 001	S01	2022/11/29	a	2023/01/23	-17.9	a	2023/01/23	-2.86
			b		-18.0	b		-2.92
				avg.:	**-18.0**		**avg.:**	**-2.89**
				diff.:	*0.1*		*diff.:*	*0.07*
JGA 002	S02	2022/11/29	a	2023/01/19	-24.3	a	2023/01/19	-4.49
			b		-25.1	b		-4.43
				avg.:	**-24.7**		**avg.:**	**-4.46**
				diff.:	*0.8*		*diff.:*	*0.07*
JGA 003	S03	2022/11/29	a	2023/01/19	-18.9	a	2023/01/19	-3.56
			b		-18.3	b		-3.64
				avg.:	**-18.6**		**avg.:**	**-3.60**
				diff.:	*0.6*		*diff.:*	*0.08*
JGA 004	S04	2022/11/29	a	2023/01/19	-15.3	a	2023/01/19	-3.27
			b		-15.9	b		-3.15
				avg.:	**-15.6**		**avg.:**	**-3.21**
				diff.:	*0.5*		*diff.:*	*0.13*
JGA 005	S05	2022/11/29	a	2023/01/20	-23.6	a	2023/01/20	-4.00
			b		-24.4	b		-4.09
				avg.:	**-24.0**		**avg.:**	**-4.05**
				diff.:	*0.8*		*diff.:*	*0.09*
JGA 006	S06	2022/11/30	a	2023/01/23	-15.5	a	2023/01/23	-2.75
			b		-15.3	b		-2.74
				avg.:	**-15.4**		**avg.:**	**-2.74**
				diff.:	*0.1*		*diff.:*	*0.01*

JGA 007	S07	2022/11/30	a	2023/01/19	-24.6	a	2023/01/19	-3.96
			b		-24.2	b		-4.03
				avg.:	**-24.4**		**avg.:**	**-3.99**
				diff.:	*0.5*		*diff.:*	*0.08*
JGA 008	S08	2022/11/30	a	2023/01/19	-19.6	a	2023/01/19	-3.51
			b		-20.2	b		-3.52
				avg.:	**-19.9**		**avg.:**	**-3.52**
				diff.:	*0.6*		*diff.:*	*0.01*
JGA 009	S09	2022/12/01	a	2023/01/20	-25.5	a	2023/01/20	-4.33
			b		-25.3	b		-4.29
				avg.:	**-25.4**		**avg.:**	**-4.31**
				diff.:	*0.2*		*diff.:*	*0.04*
JGA 010	S10	2022/12/01	a	2023/01/19	-23.4	a	2023/01/19	-3.82
			b		-23.4	b		-3.84
				avg.:	**-23.4**		**avg.:**	**-3.83**
				diff.:	*0.0*		*diff.:*	*0.03*
JGA 011	S11	2022/12/01	a	2023/01/19	-25.8	a	2023/01/19	-4.19
			b		-26.4	b		-4.21
				avg.:	**-26.1**		**avg.:**	**-4.20**
				diff.:	*0.5*		*diff.:*	*0.02*
JGA 012	S12	2022/12/02	a	2023/01/19	-28.9	a	2023/01/19	-4.70
			b		-28.5	b		-4.73
				avg.:	**-28.7**		**avg.:**	**-4.72**
				diff.:	*0.4*		*diff.:*	*0.03*
JGA 013	S13	2022/12/02	a	2023/01/19	-28.3	a	2023/01/19	-4.73
			b		-28.8	b		-4.80
				avg.:	**-28.5**		**avg.:**	**-4.76**
				diff.:	*0.5*		*diff.:*	*0.07*
JGA 014	S14	2022/12/02	a	2023/01/19	-21.7	a	2023/01/19	-3.87
			b		-21.7	b		-3.92
				avg.:	**-21.7**		**avg.:**	**-3.89**
				diff.:	*0.0*		*diff.:*	*0.04*
JGA 015	S15	2022/12/02	a	2023/01/19	-20.7	a	2023/01/19	-3.56
			b		-20.8	b		-3.56
				avg.:	**-20.8**		**avg.:**	**-3.56**
				diff.:	*0.0*		*diff.:*	*0.00*
JGA 016	S16	2022/12/02	a	2023/01/23	-13.9	a	2023/01/23	-1.78
			b		-13.9	b		-1.89
				avg.:	**-13.9**		**avg.:**	**-1.84**
				diff.:	*0.0*		*diff.:*	*0.11*
JGA 017	S17	2022/12/03	a	2023/01/20	-35.2	a	2023/01/20	-5.81
			b		-35.2	b		-5.77
				avg.:	**-35.2**		**avg.:**	**-5.79**
				diff.:	*0.0*		*diff.:*	*0.04*

Annexure E: Quantitative Environmental Risk Assessment (ERA) Guideline

Ref: Department of Water Affairs	*February 2010*
Operational Guideline: Integrated Water and Waste Management Plan	

In terms of a quantitative environmental risk assessment (ERA), the assessment will be based on:

- Probability of occurrence which describes the likelihood of the impact actually occurring and is indicated as:-
  - Improbable, where the likelihood of the impact is very low;
  - Probable, where there is a distinct possibility of the impact to occur;
  - Highly probable, where it very likely that the impact will occur;
  - Definite, where the impact will occur regardless any management measure.
- Consequence of occurrence in terms of:
  - Nature of the impact;
  - Extent of the impact, either local, regional, national or across international borders;
  - Duration of the impact, either short term (0-5 years), medium term (6-15 years) or long-term (the impact will cease after the operational life of the activity) or permanent, where mitigation measures by natural processes or human intervention will not occur;
  - Intensity of the impact, either being low, medium or high effect on the natural, cultural and social functions and processes.
- Significance level of the risk posed by the water use, which is determined through a synthesis of the probability of occurrence and consequence of occurrence.

The applicant will have to rank the risks based on the quantitative assessment as described above into high, medium, or low risks. Management measures need to be identified to mitigate, prevent and /or reduce the risk. These measures will primarily be focussed on the risks identified as high in the ranking matrix, but will also include measures for medium and low risks. The management measures will be taken forward in the IWMP as part of the water use authorisation process.

In order to assess each of the factors for each impact the ranking scales as contained in Table 7-1 could be used. Once the factors had been ranked for each impact, the environmental significance of each impact could be assessed by applying the following formula:

SP = (magnitude + duration + scale) x probability

where SP is defined as significance points.

Table 7-1: Ranking Scales for ERA

PROBABILITY = P	**DURATION** = D
5 – Definite / don't know	5 – Permanent
4 – High probable	4 – Long-term ceases with operational life)
3 – Medium probability	3 – Medium-term (5 – 15 years)
2 – low [probability	2 – Short-term (0-5 years)
1 – Improbable	1 - Immediate
0 - None	
SCALE = S	**MAGNITUDE** = M
5 – International	10 – Very high / Don't know
4 – National	8 – High
3 – Regional	6 – Moderate
2 – Local	4 – Low
1 – Site	2 – Minor
0 – None	

The maximum value of significance points (SP) is 100. Environmental effects could therefore be rated as either high (H), moderate (M), or low (L) significance on the following basis:

- More than 60 points indicates high (H) environmental significance
- Between 30 – 60 points indicate moderate (M) environmental significance
- Less than 30 points indicates low (L) environmental significance.