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PROPOSED SU CASA BURIAL ESTATE DEVELOPMENT
TIER 1 GROUNDWATER RISK ASSESSMENT

by

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for

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November 2022

EXECUTIVE SUMMARY

The proposed Su Casa Burial Estate development (the site) is located in the Emalahleni Municipality of Mpumalanga Province, about 17 km west of the town of Emalahleni. It comprises an area of *c*.26 ha on which it is proposed to establish, *inter alia*, a cemetery, chapel, admin offices, landscaping, roads and two ponds and associated amenities. Mr Tim van Stormbroek of Amber Earth (Pty) Ltd appointed Peter Rosewarne, independent groundwater consultant, to carry out a groundwater risk assessment for the Environmental Impact Assessment as part of the permit application for the development.

The scope of work comprised review of available information including topographical, geological and hydrogeological maps, a soils report and references related to cemeteries and groundwater. On 12 October 2022, Eaglesage requested an update to the report to cover eco-hydrological aspects stipulated by the Department of Water and Sanitation.

Based on the information analysed in this mainly desktop study, the following conclusions are drawn:

- The site is located in quaternary catchment B20G with local drainage to the south and then west in the Grootspruit.
- There are industrial and mining sites to the north and east of the site, including coal and lime plants, ferroalloys and Elandsfontein Colliery, with slimes dams and waste rock dumps immediately to the east.
- The northern part of the site is located on sandstones and shales of the Wilge River Formation of the Waterberg Group, while the southern part overlies shales of the Pretoria Group.
- Soils at the site are of low agricultural potential.
- The local aquifer is an intergranular & fractured and fractured type with a low to moderate yield potential, with median borehole yields of 0.5 – 2 ℓ/s.
- There are nine registered boreholes located within a 5 km radius of the site and six additional boreholes were found during the hydrocensus, two on the site, which are out of order and not used and four that are used for domestic and agricultural purposes.
- Groundwater in the region and site area occurs at 10 – 40 mbgl.
- Groundwater flow direction is inferred to be to the south from the main southern part of the site and possibly to the north from a very small northern part.
- Groundwater in the area is of generally good to moderate quality with an indicated EC of 70 – 300 mS/m and likely to be of a calcium/magnesium bicarbonate type.
- Groundwater from boreholes on two surrounding properties is of excellent quality with very low EC, acidic pH and very low concentrations of major and minor ions.
- The potential receptors for any groundwater contamination from the site are boreholes 1, 2 and 3 and the minor stream to the east of the site.
- Groundwater from any boreholes established on-site should not be used for domestic purposes because of the risk of contamination from the burials. It can be used for irrigation and wash-down of surfaces and dust suppression.
- The site has a moderate groundwater risk according to this Tier 1 assessment.

- The EIS for the site is moderate and alterations to the PES, i.e. possible deterioration in groundwater quality, will be limited to the site and buffer areas.

It is recommended that the following mitigation measures/monitoring be carried out:

- Digging of geotechnical test pits on site to assess soil characteristics such as thickness, clay content and permeability.
- Establishment of an “upstream” and a “downstream” monitoring borehole, for which use the two on-site boreholes 5 and 6 could possibly be adapted.
- Establishment of a lateral buffer zone of 65 m from the site boundaries for rivers, wells and springs.
- Establishment of a lateral buffer zone of 350 m from the site boundaries for drinking water sources.
- The taking of a water sample from the upstream and downstream boreholes prior to the establishment of the cemetery and laboratory analysis for pH, EC, TDS, Na, K, Mg, Ca, Cl, SO_4, NO_3, F, Fe, Mn, Cu, Ni, Cd, Cr, Zn, Al, B and Total Alkalinity, plus bacteriological/pathogen indicators.
- Taking of a water sample on a biannual basis from these boreholes and analysis for the above parameters.
- Compilation of a monitoring record of water levels and quality and assessment of the data by a hydrogeologist every six months. Submission of reports to the DHSWS, as required by them. Continuation or modification of the monitoring programme as dictated by results or regulatory authorities.

Abbreviations

c.	*circa*, approximately
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	electrical conductivity
ℓ/s	litres per second
MAP	mean annual precipitation
mbgl	metres below ground level
mamsl	metres above mean sea level
mg/ℓ	milligrams per litre
mm	millimetres
mS/m	millie-Siemens per metre
TDS	Total Dissolved Solids

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PROPOSED SU CASA BURIAL ESTATE DEVELOPMENT GROUNDWATER RISK ASSESSMENT

1. Introduction

The proposed Su Casa Burial Estate development (the site) is located in the Emalahleni Municipality of Mpumalanga Province, about 17 km west of the town of Emalahleni. It comprises an area of *c*.26 ha on which it is proposed to establish, *inter alia*, a cemetery, chapel, admin offices, roads, landscaping, two ponds and associated amenities. Mr Tim van Stormbroek of Amber Earth (Pty) Ltd contacted Peter Rosewarne, independent groundwater consultant, to submit a proposal for a groundwater risk assessment for the Environmental Impact Assessment as part of the permit application to the Department of Environment Affairs (DEA). This proposal was subsequently accepted on 7 February 2022. The report produced was then updated in October/November 2022, on instruction by Eaglesage (Pty) Ltd, to include a section on the eco-hydrological perspective, as required by the Department of Water and Sanitation (DWS).

This groundwater risk assessment report is structured as follows:

- Section 2: Scope of Work
- Section 3: Background Information
- Section 4: Groundwater
- Section 5: Groundwater Risk Assessment
- Section 6: Eco-Hydrological Perspective
- Section 7: Monitoring
- Section 8: Conclusions and Recommendations
- Section 9: References

A locality plan is shown in **Figure 1** (Figures in **Appendix A** at the back of this report).

2. Scope of Work

The work carried out for this study comprised:

- Review of available information including topographical (1:50 000 scale topographical sheet 2529CC, Witbank), geological (Council for Geoscience published geological map, sheet 2528, Pretoria) and hydrogeological map (Department of Water Affairs and Forestry [DWAF] published hydrogeological map at 1:500 000 scale, sheet 2526, Johannesburg and accompanying explanation booklet).
- Review of the report by The Biodiversity Company of February 2022 which covers *inter alia* agricultural properties of the soils underlying the site.
- Interrogation of the National Groundwater Information System of the Department of Human Settlements, Water and Sanitation (DHSWS), NGIS (formerly the National Groundwater Archive) for information on registered boreholes in the site surrounds.

- Site visit by Amber Earth to carry out a hydrocensus to gain additional knowledge of local groundwater use and take groundwater samples for laboratory analysis; and
- Synthesis of the above information into a Tier 1 groundwater risk assessment as described in this report.

3. Background Information

3.1 Surrounding Land Use

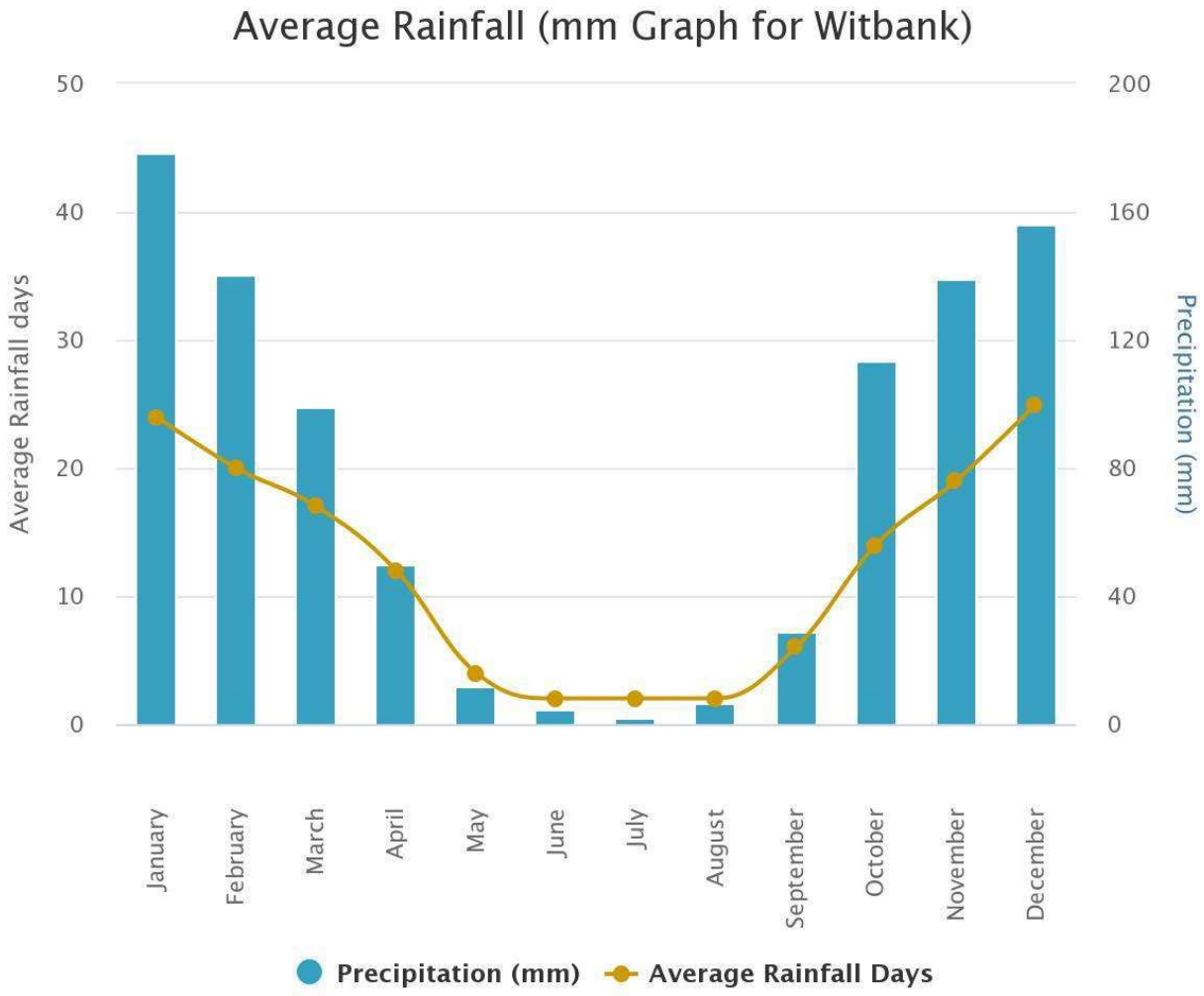
The site is located in the eastern Highveld in an area of mixed grazing, cultivation, open veld and coal mining. There is an underground coal mine immediately to the east of the site, with slimes dams and a large waste rock dump. Apart from the extent of the surface operations, there is no information available on these workings as to their depth and extent. Elandsfontein Colliery is located immediately to the southeast of the site. Other industrial sites include a coal plant to the north and a lime plant and ferroalloys to the east.

3.2 Topography

The topography of the area is hilly with the site being located at *c*.1 520 – 1 540 m above mean sea level (mamsl) (see **Figure 2**). The topography largely reflects the underlying geology, with hills and ridges formed of resistant sandstones and the softer Ecca Group to the east giving rise to a more subdued topography. The site appears to straddle a mini-watershed, with slopes to the north from a very small northern part and slopes to the south in the main southern part.

3.3 Climate

The site falls within the summer rainfall region of South Africa and has a warm temperate climate. Mean Annual Precipitation (MAP) is 790 mm at Witbank with the wettest months being October to March and the driest month being June. Average temperature low/high is 16/28^{o}C in January and 7/19^{o}C in June. The monthly distribution of the mean annual precipitation (MAP) at Witbank is shown graphically below (**Graph 1**).



Graph 1: Average Monthly Precipitation at Witbank

3.4 Surface Water

The main drainage in the area is effected by the perennial Brugspruit and Grootspruit. The former drains quaternary catchment B11K and flows to the north (see **Figure 1**). The site is situated in quaternary catchment B20G which is drained locally by the Grootspruit. A tributary of this river passes by the eastern boundary of the site at c.375 m at its closest point. There are a number of impoundments along this river which flows to the west and then northwest.

3.5 Soils

The agricultural soils survey identified three soil types occurring on the site, Mispah, Clovelly and Glenrosa. Unfortunately, there is no description of whether these are sandy or clayey soils or what their relative permeabilities might be. A literature description of these soils from the Duvha Power Station area near Witbank gives the following characteristics for Clovelly soils:

- Well drained;
- 15 – 45% clay.

Mispah and Glenrosa have similar characteristics and are of poor agricultural potential. It is advisable to carry out some on-site geotechnical test pitting and soil testing to firm-up on the nature and thickness of soils at the site.

3.6 Geology

The local and more regional geology is shown in **Figure 3**, which is based on the geological map, sheet 2528 Pretoria, published by the Council for Geoscience. The geology can be conveniently divided into three zones:

- The eastern half is underlain by sedimentary rocks of the Ecca Group, Karoo Supergroup with some dolerite intrusions;
- The site and area to the north and west of it is underlain by sediments of the Waterberg Group;
- The area to the south of the site is underlain by sediments and diabase of the Pretoria Group and Dwyka Group tillite.

The northern part of the site is situated on sandstones and grits of the Wilge River Formation of the Waterberg Group. The southern part overlaps the unconformity between these rocks and those of the Pretoria Group, which here are mainly shaley in character. Based on this geology it can be assumed that soils developed on the sandstones will be mainly sandy and possibly thinly developed while those on the shales will tend to be more clayey and thicker.

4. Groundwater

4.1 Aquifer Type

The main aquifer in the area comprises of a combination of weathered and fractured zones and is classed by the DWAF as an intergranular and fractured aquifer (see **Figure 4**). This has a mainly low to moderate groundwater potential with the aquifer at the site and surrounds being classed as d3, i.e. a median borehole yield of 0.5 – 2.0 ℓ/s. The northern part of the site is classified as a fractured rock aquifer b3, also with median borehole yields of 0.5 – 2 ℓ/s. This band corresponds to the Wilge River Formation sandstones.

4.2 Groundwater Use

The NGIS of the DHSWS was interrogated to obtain the positions and any details on depth, yield, use and groundwater quality of existing registered boreholes in the site area and surrounds (**Figure 4**). Four registered boreholes are located within 1 – 3 km to the east of the site but with no useful information. A further five boreholes are located within 5 km of the site.

The hydrocensus found six boreholes, two on the site and four on adjacent properties. Information obtained is fairly sparse but the two boreholes on the proposed site, boreholes 5 and 6 on **Figure 4**, were not functional at the time of the site visit (March 2022). The others are used for domestic and agricultural purposes (**Table 1**). One of the on-site boreholes will be rehabilitated for site use. However, water from this borehole must not be used for domestic purposes, only for irrigation and wash-down and dust suppression on surfaces due to the risk of groundwater contamination, as outlined in **Subsection 5.1**.

With the information obtained from the hydrocensus it is not possible to determine the sustainable yield of the on-site boreholes but, if they were previously equipped with pumps, they presumably at

least yielded sufficient groundwater to meet domestic use requirements.

Table 1: Data from the Hydrocensus

Landowner of portion 18 and 24	**Portion 21**	**Portion 10**
Owner: Johan Liebenberg	**Owner: Piet Joubert**	**Owner: Applicant**
Comments: Lives on portion 24 where all their farm development it. Nothing developed on portion 18 – only use it for grazing. The three boreholes below are all on Portion 24 and the owner pumps from them alternatively as needed. He uses it for domestic and agricultural purposes. The sample collected come from the JoJo tanks that receive water from all three boreholes.	Comments: Lives on the portion and all farm development is within portion 21. He uses the water from the borehole for domestic and agricultural purposes. Sample collected represents the borehole below and no other source.	Comment: There are two boreholes on the property. Neither were functional at the time of the hydrocensus and neither are currently being used.
Borehole 1: -25.89433251 29.05931097 Depth: c.100m – water level at c.23m	Borehole 4: -25.89145657 29.05614395 Depth: c.40m	Borehole 5: -25.89253758 29.06052668 Depth: ?m – water at ?m
Borehole 2: -25.89407885 29.05930527 Depth: c.100m – water level at c.40m		Borehole 6: -25.89163212 29.05789141 Depth: ?m – water at ?m
Borehole 3: -25.89380317 29.05960064 Depth: c.72m – water level at ?m		

4.3 Groundwater Levels

The nearest information to the site on groundwater levels comes from four boreholes at differing directions and about 4 – 5 km from the site. Groundwater levels vary between 10, 13 and 28 m below ground level (mbgl). Information obtained by the landowner of portion 18 and 24 indicates an approximate water level of 23 and 40 m in two of his boreholes.

4.4 Groundwater Recharge

According to the Groundwater Resource Assessment Phase 2 project data (DWAF, 2005) the area has a recharge potential of about 6% of the MAP. This is an area of relatively high recharge because of the MAP of 790 mm, which is high by regional South African norms (average precipitation in South Africa is 464 mm[1]).

[1] SA Weather and Climate

4.5 Groundwater Flow Direction

Groundwater flow generally follows the topography and inferred flow directions are to the southeast in the southern site area and possibly to the north from a very small area in the northern parts, as indicated on **Figure 4**. Boreholes 1, 2 and 3 are in the projected groundwater flow path from the site.

4.6 Groundwater Quality

According to the published hydrogeological map (**Figure 6**), the area has groundwater with an electrical conductivity (EC) of 70 – 300 mS/m, i.e. of good to moderate quality. The groundwater associated with the Wilge River Formation is typically of good quality and of a calcium-magnesium bicarbonate nature. Poorer quality groundwater is likely to be associated with the coal mining area to the east. This area is likely to show more elevated EC, acidic pH, and elevated concentrations of typically Na, SO_4, F and boron, characteristics typical of groundwater impacted by coal mining.

Water samples were taken from boreholes 1, 2 and 3 (composite sample from holding tank) and Borehole 4. The results of the laboratory chemical analyses by WATERLAB, Pretoria, are shown in **Table 2**.

Table 2: Laboratory Analyses of Groundwater Samples from the Hydrocensus

Determinand (mg/ℓ unless otherwise stated)	**Boreholes 1. 2 and 3**	**Borehole 4**	**SANAS 241-2015 Drinking water recommended limits**
pH (pH units)	6.8	5.3	5 - 9.7
EC (mS/m)	10.4	3.4	<170
TDS	54	14	<1 200
Na	4	1	200
K	0.6	<0.5	-
Ca	7	2	-
Mg	4	1	-
Cl	6	<2	300
SO_4	14	8	250
TAL (as $CaCO_3$)	20	<5	-
NO_3 (as N)	0.2	<0.1	11
F	0.3	0.3	1.5
Total PO_4	<0.2	0.2	-
Cu	<0.01	0.088	2
Zn	0.106	0.112	5
Metals scan	<0.01	<0.01	-

The analytical results show that the site area groundwater is of very good quality. The groundwater from Borehole 4 is almost of rainwater quality and is acidic, which probably accounts for the Cu and Zn being slightly raised due to dissolving of copper or brass fittings and galvanised steel, respectively, by the acidic water. The groundwater from Borehole 1 appears to be of very good quality and fit for domestic use, according to the composite sample obtained from the holding tank.

5. Groundwater Risk Assessment

5.1 Source-Pathway-Receptor Analysis

There are three essential elements that must be present and connected before there is a possibility for an environmental risk to be manifest, namely:

- A **source** of the chemical in or on the land that has the potential to cause harm or to cause pollution of the surrounding environment;
- A **pathway** or a route by which a receptor can be exposed to, or be affected by, a contaminant;
- A **receptor** that could be adversely affected by a contaminant, such as people, livestock or an ecological system.

Each of these elements can exist independently, but it is only when there are linkages between all three of them that a potential risk exists.

Sources

The only source of contamination that is considered here is a cemetery and the potential constituents of any leachate arising therefrom. Some information gleaned from various references on this is summarised below.

Cemeteries are among the chief anthropogenic sources of pollution and contamination of water in urban areas and beyond. In the process of decomposition of a human body, 0.4 – 0.6 ℓ of leachate per 1 kg of body weight is produced (Zychowski and Bryndal, 2015). This leachate contains 60% water and 30% salts in the form of ions containing nitrogen, phosphorus, Cl, HCO_3, Ca, Na, compounds of various metals (e.g., Ti, Cr, Cd, Pb, Fe, Mn, Ni), and 10% of organic substances. This liquid is characterized by high EC, pH and chemical oxygen demand values. The contaminants come from the body and can include chemical substances applied in chemotherapy and embalming processes (e.g., arsenic, formaldehyde and methanol), makeup (e.g., cosmetics, pigments and chemical compounds), as well as various additional items, such as fillings, cardiac pacemakers, paints, varnishes, metal hardware elements, iron nails, etc. These leachates also contain microorganisms that may pollute substrates, surface water and groundwater. The microorganisms chiefly include bacteria, viruses, intestinal fungi and protozoa. The possible impact of the Covid 19 virus also needs to be considered, which has been found in some of the City of Cape Town's water treatment plants.

A study of a municipal cemetery on the Cape Flats in Cape Town area was carried out by Engelbrecht (1998). He reported the occurrence of groundwater pollution in the unconsolidated surface sands at the site, which are not dissimilar to those occurring at the site. Twenty-one wellpoints were installed in the cemetery grounds and one outside the cemetery for sampling and quantifying the groundwater quality. The results showed an increase of colony-forming units for all microbiological indicators,

indicating that the groundwater within the cemetery area was extremely polluted compared with the expected regional groundwater quality. According to Engelbrecht, pathogenic bacteria, viruses, protozoa and helminths reached the groundwater, causing elevated concentrations above the regional groundwater quality (as represented by a nearby municipal borehole). Plus, potassium, ammonium, nitrate and nitrite, along with dissolved organic carbon and EC showed increased concentrations in all the wellpoints in addition to high levels of *E. coli*, faecal streptococci and staphylococcus aureus.

Pathways

These could include:

- Passage through the unsaturated zone depending on its thickness and drainage characteristics;
- Bedding planes, horizontal and vertical fractures, joints and dolerite intrusion contact zones.

Receptors

These could include:

- Humans and livestock through the use of contaminated groundwater and/or surface water;
- Ecosystems such as streams/rivers.

Analysis

The groundwater vulnerability map produced by the GRA2 (**Figure 5**) was compiled on a 1 x 1 km grid and is only suited to an initial regional assessment, not a site-specific one. However, as an indication, the map shows the site and surrounds to have a moderate groundwater vulnerability.

There is no registered groundwater use within 1 km of the site but four active boreholes were located adjacent to the site and two inactive boreholes on the site in the hydrocensus. The only potential receptors appear to be these boreholes and the stream running past the eastern boundary of the site, c.300 m laterally distant from the nearest part of the site.

A Tier 1 risk assessment has been carried out following the Environment Agency P223 guidance, with some modifications to suit the site conditions. It is largely a qualitative assessment at this stage because of a lack of test pit soil profiles and site boreholes. It can be updated to a Tier 2 or 3 assessment as necessary. The geological, hydrological and hydrogeological information presented in **Section 4** has been ranked using **Table 3** and a simple scoring system (**Table 4**) to generate an overall vulnerability score for the site (**Table 5**). The aggregate score from **Table 5** was then ranked according to EA P223 guidance as follows:

- Low vulnerability 8 – 32.
- Moderate vulnerability 32 – 56.
- High vulnerability 56 – 80.

Table 3: Groundwater Vulnerability Ranking

Ranking	Very Low	Low	Moderate	High	Very High
Soil type	Clay			Sand	
Soil thickness	>5 m	3-5 m	3 m	0-3 m	Absent

Ranking	Very Low	Low	Moderate	High	Very High
Depth to water table	>20 m	15-20 m	10-15 m	5-9 m	<5 m
Flow mechanism	Intergranular				Fractured
Aquifer classification			Minor		Major
Abstraction	>500 m	300-500 m	200-300 m	100-200 m	<100 m
Surface drainage	>100 m	>70-100 m	>50-70 m	>30-50 m	<30 m
Faults	>300 m	200-300 m	100-200 m	<100 m	Underlying

Table 4: Groundwater Vulnerability Scoring Chart

Vulnerability	Score
Very Low	1-2
Low	3-4
Moderate	5-6
High	7-8
Very High	9-10

Table 5: Site Groundwater Vulnerability Assessment

Factor	Site Characteristics	Ranking	Score Range
Soils	Sand and clay	Low-moderate	3-6
Soil thickness	Thin sand, thicker clay	Moderate	5-6
Depth to water table	10-40 m in fractured aquifer	Low	3-4
Flow type	Intergranular weathered zone, fractured in underlying rocks	Moderate	5-6
Aquifer	Moderate	Low to moderate	3-6
Faults	None mapped	Very Low	1-2
Abstraction	None at the site but on one 'downstream' property	High	7-8

Factor	Site Characteristics	Ranking	Score Range
Surface drainage	A drainage channel present to east of site	Low	3-4

Based on the current level of information, this Tier 1 groundwater risk assessment assigns a score of 30 – 42 for the site, meaning it has a moderate vulnerability, in line with the regional assessment of the GRA2. Other independent assessments may come up with slightly differing scores, but it seems reasonable to conclude that, based on current knowledge, the site is suitable for development as a cemetery. This is dependent on application of the eco-hydrological buffer zones discussed in **Section 6**.

6. Eco-Hydrological Perspective

The DWS require the following aspects to be investigated:

- Determine the sources of water for the watercourses and quantify the contribution of each source;
- Indicate expected impacts and provide proposed mitigation measures;
- Indicate expected Present Ecological State (PES) and Ecological Impact Sensitivity (EIS) changes;
- Show and quantify level of modification to the flow drivers; and
- Determine a scientific buffer that will protect the watercourses and associated flow drivers based on all studies conducted.

For this groundwater risk assessment, watercourses and flow drivers have been taken to mean aquifers and groundwater flow directions, respectively.

The source of water to the aquifer is natural recharge from precipitation. In **Subsection 4.4**, recharge was stated to be approximately 6% of the MAP of 790 mm, which equates to 474 m^3/ha/a. The expected impacts will be on groundwater quality as outlined in **Subsection 6.1**. Typical contaminants from cemeteries include, *E.coli*, pathogens, ammonia, nitrate, and an increase in EC. Groundwater levels at the site are reportedly 23 – 40 mbgl and so there would appear to be a relatively thick unsaturated zone present which will provide mitigation by means of attenuation of the infiltration of contaminants.

There will be minimal modification to the flow drivers, which for groundwater will be throughflow of groundwater from upstream, i.e. from the north and northeast. However, the site is situated on a ridge and a small portion of the northern part of the site will drain towards the north-northwest.

Research carried out by the Faculty of Natural and Agricultural Sciences at the University of Pretoria (? 2015) derived the following buffer zones for cemeteries:

- Minimum depth to the water table of 4.0 m;
- Lateral distance to rivers, wells or springs of 30 – 100 m; and
- Lateral distance to a drinking water source of 250 – 500 m.

The minimum and maximum lateral distances relate to the expected speed of groundwater movement so aquifers with higher hydraulic conductivity/transmissivity would require a larger lateral separation from a cemetery. Groundwater levels at the site are reportedly 23 – 40 mbgl and so comfortably exceed the

minimum requirement in this respect. The DWAF aquifer classification indicates moderate to low borehole yields at the site and surrounds and so a conservative buffer under bullet points two and three above would be 65 m and 375 m, respectively. These are shown on **Figure 7**. It is concluded that the EIS for the site is moderate and that alterations to the PES, i.e. possible deterioration in groundwater quality, will be limited to the site and buffer areas.

7. Monitoring

It is recommended that monitoring boreholes be established at the upstream (north) and downstream (south) boundaries of the site. On-site boreholes 5 and 6 could possibly be adapted for this purpose. The following groundwater monitoring activities are recommended:

- The taking of a water sample from “Upstream” (No 6) and “Downstream” (No 5) boreholes prior to the establishment of the cemetery. Laboratory analysis for:
    - Physical parameters pH, EC, TDS;
    - Major ions, Na, K, Mg, Ca, Cl, SO_4, NO_3 and Total Alkalinity;
    - Trace ions and metals, F, As, Fe, Mn, Pb, Cd, Cu, Cr, Ni, Cd, Zn and Al;
    - Bacteriological indicators.
- Taking of a water sample on a biannual basis from these boreholes and analysis for the above parameters;
- Compilation of a monitoring record of quality and assessment of the data by a hydrogeologist annually. Continuation or modification of the monitoring programme as dictated by results; and as directed by the DEA/DWS.

8. Conclusions and Recommendations

Based on the information presented above, the following conclusions are drawn:

- The site is located in quaternary catchment B20G with local flow to the south and then to the west along the Grootspruit.
- There are industrial and mining sites to the north and east of the site, including coal and lime plants, ferroalloys and Elandsfontein Colliery, with slimes dams and waste rock dumps immediately to the east.
- The northern part of the site is located on sandstones and shales of the Wilge River Formation of the Waterberg Group, while the southern part overlies shales of the Pretoria Group.
- Soils at the site are of low agricultural potential.
- The local aquifer is an intergranular & fractured and fractured type with a low to moderate yield potential, with median borehole yields of 0.5 – 2 ℓ/s.
- There are nine registered boreholes located within a 5 km radius of the site but none (registered) within 1 km.

- There are two non-functional boreholes on the site and a further four functional boreholes on adjacent properties.
- Groundwater in the region and site area occurs at 10 – 40 mbgl.
- Groundwater flow direction is inferred to be to the southeast from the southern part of the site and possibly to the north from a very small area of the northern part.
- Groundwater in the area is of generally good to moderate quality with an indicated EC of 70 – 300 mS/m and likely to be of a calcium/magnesium bicarbonate type.
- Groundwater in the site area is of very good quality with EC of 3.4 – 10.4 mS/m, acidic pH and very low concentrations of all major and minor ions.
- The potential receptors for any contamination from the site via groundwater are boreholes 1, 2 and 3 and the minor stream to the east of the site.
- The site has a moderate groundwater risk according to this Tier 1 assessment.
- The EIS for the site is moderate and alterations to the PES, i.e. possible deterioration in groundwater quality, will be limited to the site and buffer areas.

It is recommended that the following mitigation measures/monitoring be carried out:

- Digging of geotechnical test pits on site to assess soil characteristics such as thickness, clay content and permeability.
- Establishment of an upstream and a downstream monitoring borehole, for which use the two on-site boreholes 5 and 6 could possibly be adapted.
- Establishment of a lateral buffer zone of 65 m from the site boundaries for rivers, wells and springs.
- Establishment of a lateral buffer zone of 350 m from the site boundaries for drinking water sources.
- The taking of a water sample from these boreholes prior to the establishment of the cemetery and laboratory analysis for pH, EC, TDS, Na, K, Mg, Ca, Cl, SO_4, NO_3, F, Fe, Mn, Cu, Ni, Cd, Cr, Zn, Al, As and Total Alkalinity, plus bacteriological/pathogen indicators.
- Taking of a water sample on a biannual basis from these boreholes and analysis for the above parameters.
- Compilation of a monitoring record of water levels and quality and assessment of the data by a hydrogeologist every six months. Submission of reports to the DHSWS, as required by them. Continuation or modification of the monitoring programme as dictated by results or the regulatory authorities.

9. References

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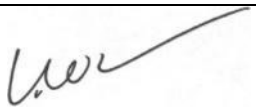
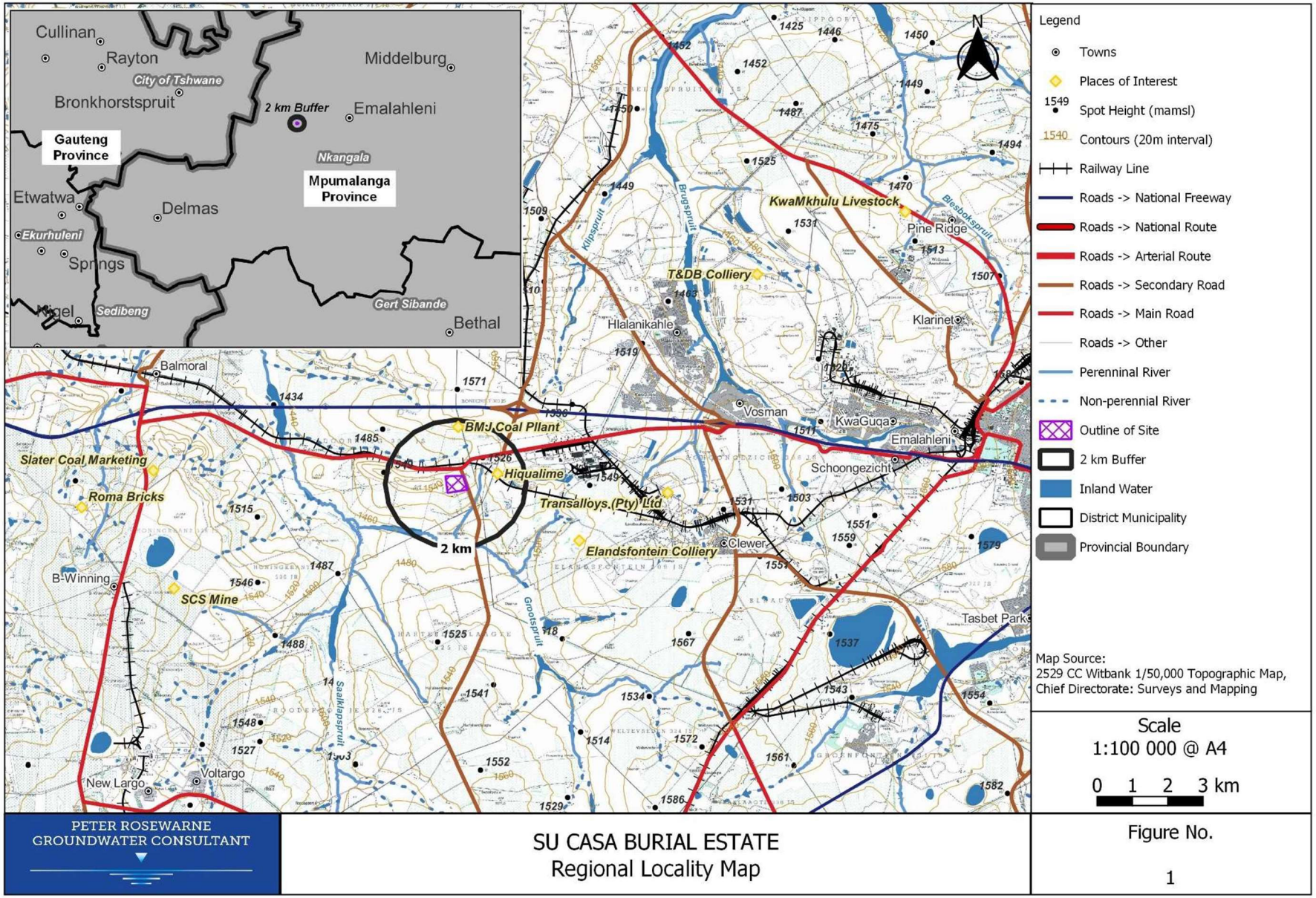
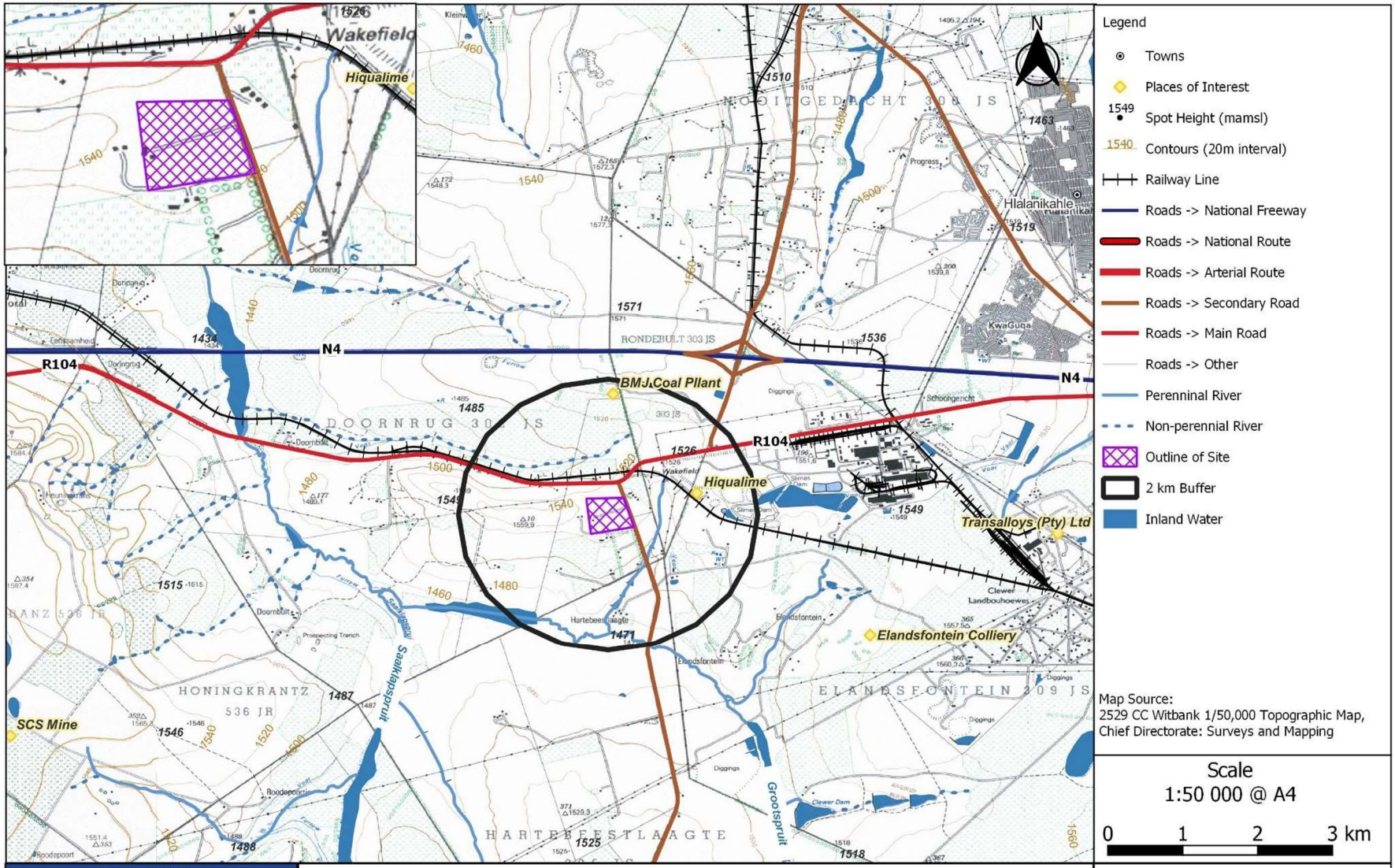
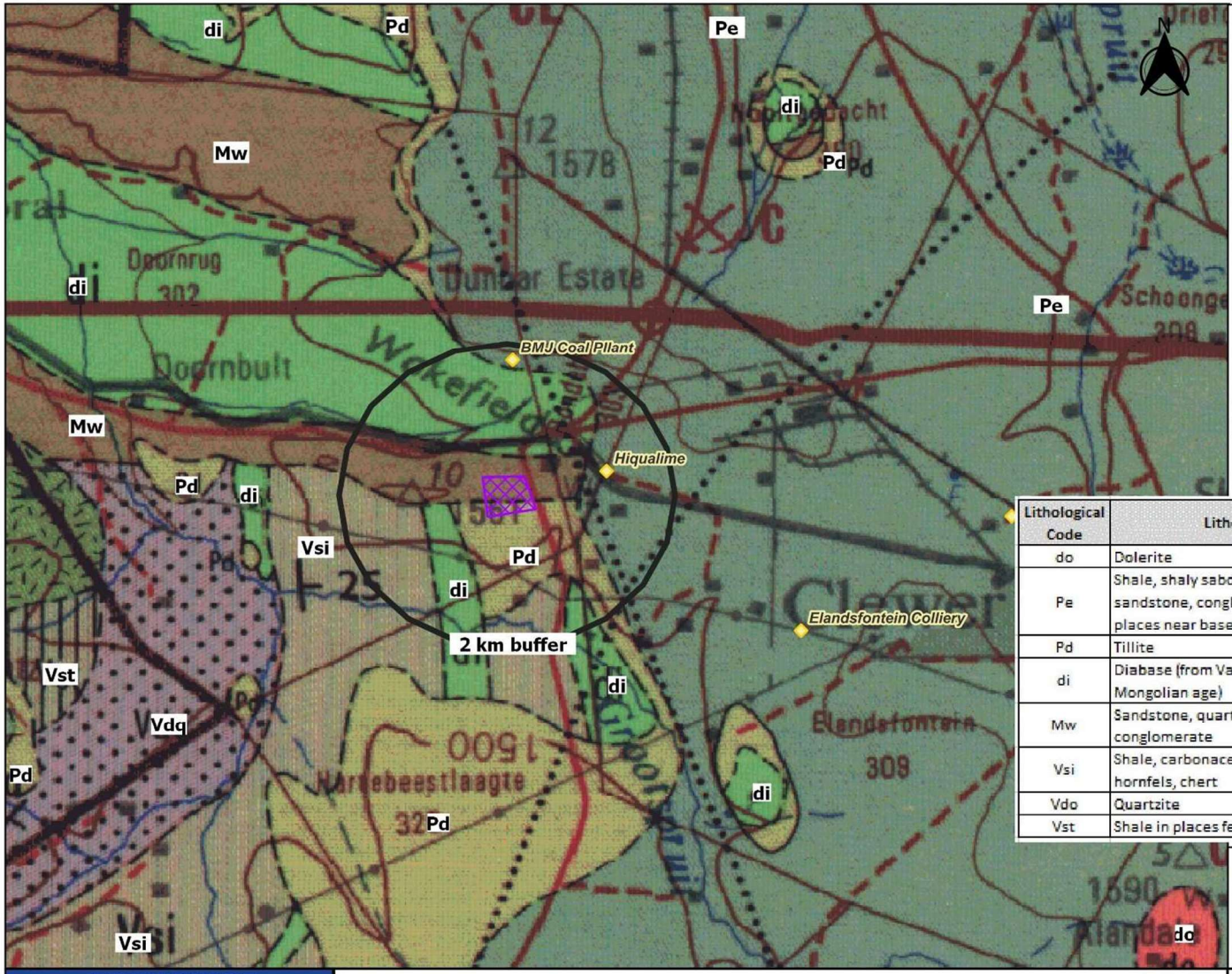


Peter Rosewarne *Pr.Sci.Nat. MSc*
Groundwater Consultant

Appendix A: Figures


Cullinan
Rayton
City of Tshwane
Middelburg
Bronkhorstspruit
2 km Buffer
Emalahleni
Gauteng Province
Nkangala
Mpumalanga Province
Etwatwa
Delmas
Ekurhuleni
Springs
Nigel
Sedibeng
Gert Sibande
Bethal
Balmoral
Slater Coal Marketing
Roma Bricks
B-Winning
SCS Mine
New Largo
Voltargo
BM:J.Coal Plant
Higualime
Transalloys.(Pty) Ltd
2 km
Elandsfontein Colliery
Clewer
T&DB Colliery
Hlalanikahle
KwaMkhulu Livestock
Pine Ridge
Klarinet
Vosman
KwaGuqa
Emalahleni
Schoongezicht
Tasbet Park
Brugspruit
Klipspruit
Grootspruit
Saalklapspruit
Biesbokspruit
N
Legend
Towns
Places of Interest
Spot Height (mamsl)
Contours (20m interval)
Railway Line
Roads -> National Freeway
Roads -> National Route
Roads -> Arterial Route
Roads -> Secondary Road
Roads -> Main Road
Roads -> Other
Perenninal River
Non-perennial River
Outline of Site
2 km Buffer
Inland Water
District Municipality
Provincial Boundary
Map Source:
2529 CC Witbank 1/50,000 Topographic Map,
Chief Directorate: Surveys and Mapping
Scale
1:100 000 @ A4
0 1 2 3 km
PETER ROSEWARNE
GROUNDWATER CONSULTANT
SU CASA BURIAL ESTATE
Regional Locality Map
Figure No.
1


Legend
Towns
Places of Interest
Spot Height (mamsl)
Contours (20m interval)
Railway Line
Roads -> National Freeway
Roads -> National Route
Roads -> Arterial Route
Roads -> Secondary Road
Roads -> Main Road
Roads -> Other
Perenninal River
Non-perennial River
Outline of Site
2 km Buffer
Inland Water
Map Source:
2529 CC Witbank 1/50,000 Topographic Map,
Chief Directorate: Surveys and Mapping
Scale
1:50 000 @ A4
0 1 2 3 km
N
Wakefield
Hiqualime
N4
R104
BMJ Coal Pllant
Transalloys (Pty) Ltd
Elandsfontein Colliery
SCS Mine
Hlalanikahle
KwaGuqa
DOORNRUG 303 JS
RONDEBULT 303 JS
HONINGKRANTZ 536 JR
ELANDSFONTEIN 309 JS
HARTEBEESTLAAGTE
PETER ROSEWARNE
GROUNDWATER CONSULTANT
SU CASA BURIAL ESTATE
Site Locality and Topography
Figure No.
2



Lithological Code	Lithology	Formation	Group/ Sequence
do	Dolerite		
Pe	Shale, shaly sabdstone, grit, sandstone, conglomerate, coal in places near base and top	Ecca	Karoo Sequence
Pd	Tillite	Dwyka	
di	Diabase (from Vaalian to post Mongolian age)		
Mw	Sandstone, quartzitic in places; conglomerate	Wilgerivier	Waterberg Group
Vsi	Shale, carbonaceous im places; hornfels, chert	Silverton	Pretoria Group
Vdo	Quartzite	Daspoort	
Vst	Shale in places ferruginous	Strubenkop	

Scale
1:50 000 @ A4

0 1 2 3 km

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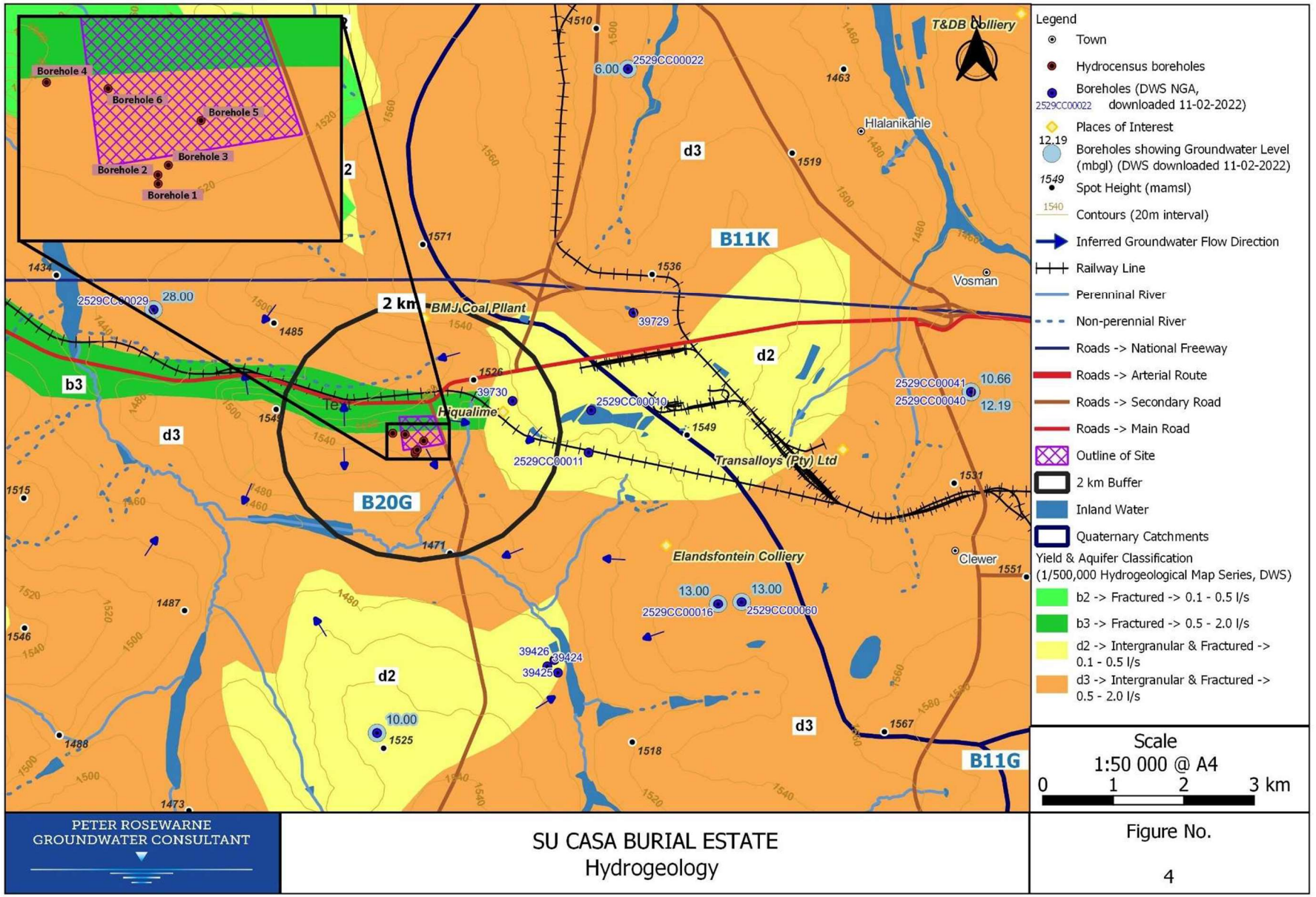
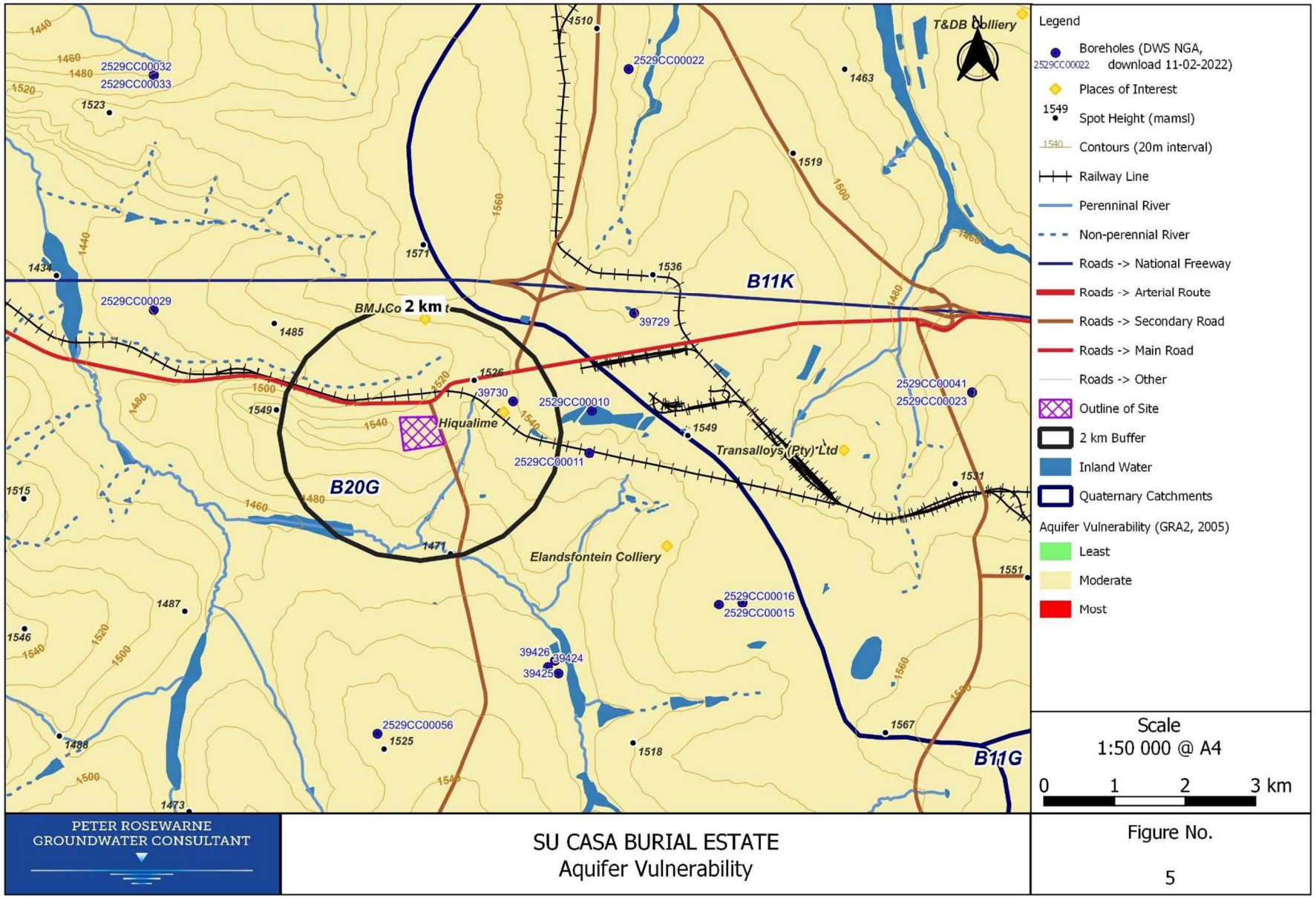
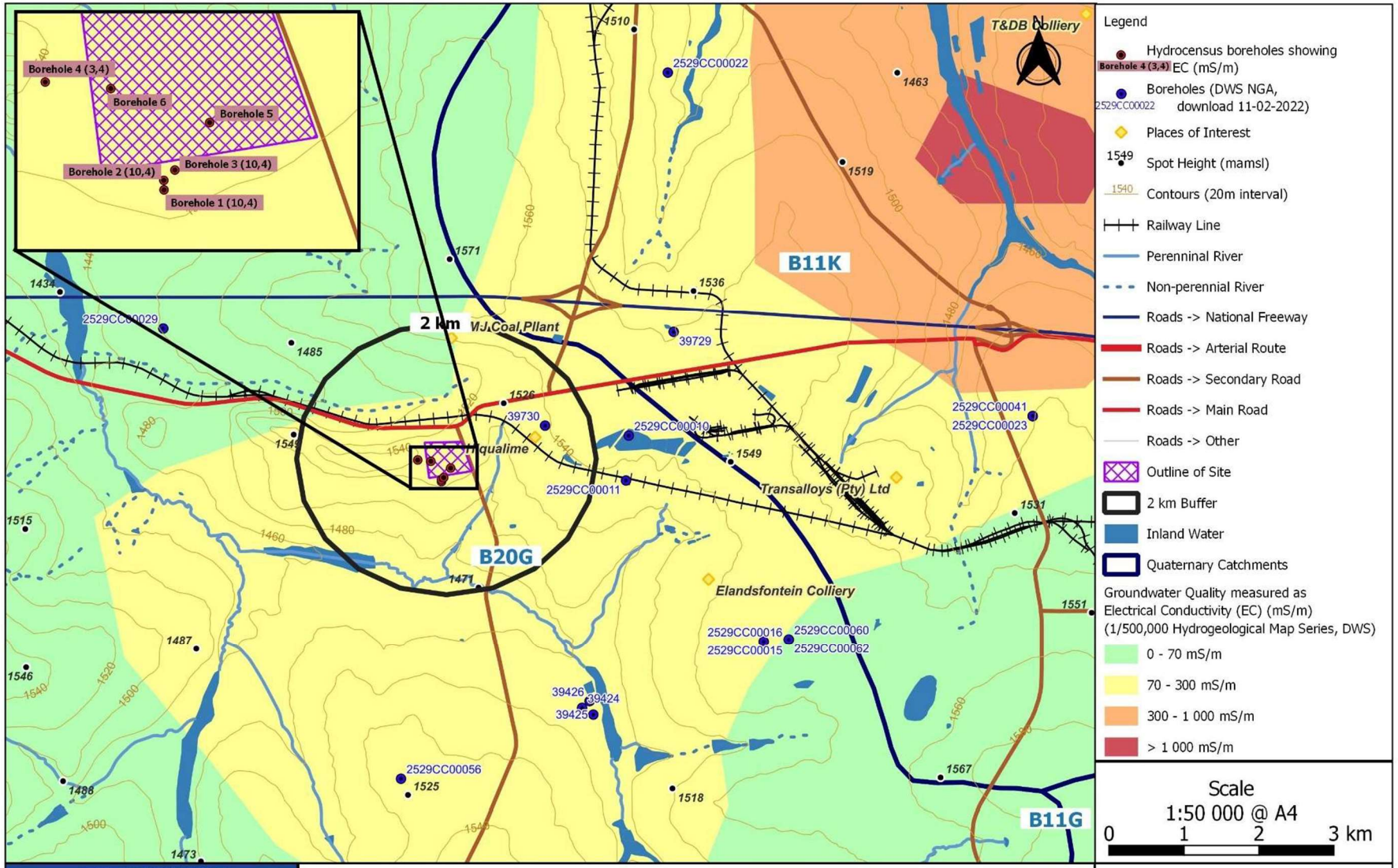
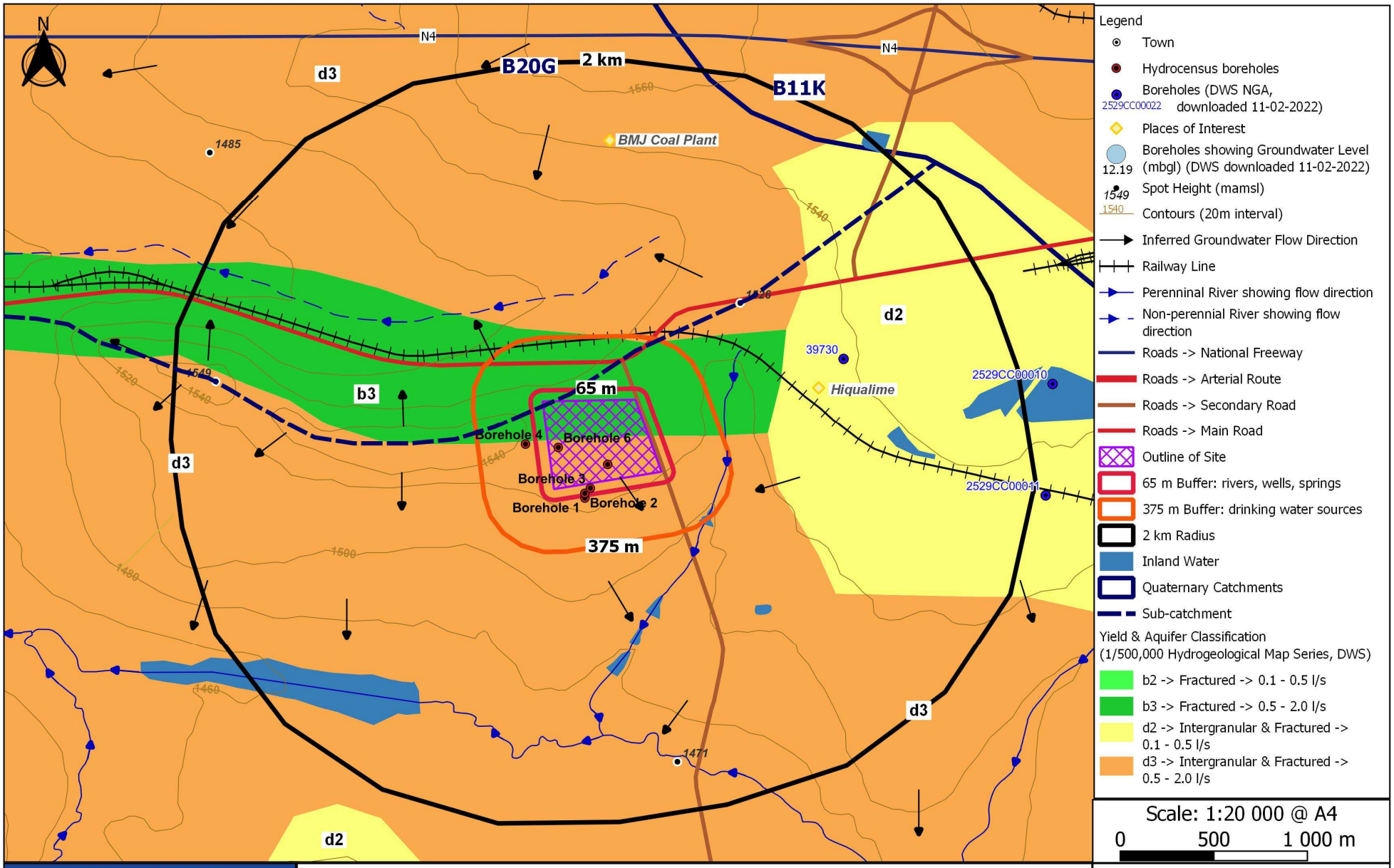
SU CASA BURIAL ESTATE
Geology

Figure No.
3


Borehole 4
Borehole 6
Borehole 5
Borehole 3
Borehole 2
Borehole 1
2
2 km
BMJ Coal Plant
Hlalanikahle
T&DB Colliery
Vosman
Hiqualime
Transalloys (Pty) Ltd
Elandsfontein Colliery
Clewer
B11K
B20G
B11G
d3
d2
b3
2529CC00022
2529CC00029
2529CC00010
2529CC00011
2529CC00041
2529CC00040
2529CC00016
2529CC00060
39729
39730
39426
39424
39425
6.00
28.00
10.66
12.19
13.00
13.00
10.00
Legend
Town
Hydrocensus boreholes
Boreholes (DWS NGA, downloaded 11-02-2022)
Places of Interest
Boreholes showing Groundwater Level (mbgl) (DWS downloaded 11-02-2022)
Spot Height (mamsl)
Contours (20m interval)
Inferred Groundwater Flow Direction
Railway Line
Perenninal River
Non-perennial River
Roads -> National Freeway
Roads -> Arterial Route
Roads -> Secondary Road
Roads -> Main Road
Outline of Site
2 km Buffer
Inland Water
Quaternary Catchments
Yield & Aquifer Classification
(1/500,000 Hydrogeological Map Series, DWS)
b2 -> Fractured -> 0.1 - 0.5 l/s
b3 -> Fractured -> 0.5 - 2.0 l/s
d2 -> Intergranular & Fractured -> 0.1 - 0.5 l/s
d3 -> Intergranular & Fractured -> 0.5 - 2.0 l/s
Scale
1:50 000 @ A4
0 1 2 3 km
PETER ROSEWARNE
GROUNDWATER CONSULTANT
SU CASA BURIAL ESTATE
Hydrogeology
Figure No.
4


T&DB Colliery
2529CC00032
2529CC00033
2529CC00022
2529CC00029
2529CC00010
2529CC00011
2529CC00041
2529CC00023
2529CC00016
2529CC00015
2529CC00056
39729
39730
39426
39424
39425
B11K
B11G
B20G
2 km
Hiqualime
Transalloys (Pty) Ltd
Elandsfontein Colliery
Legend
Boreholes (DWS NGA, download 11-02-2022)
Places of Interest
Spot Height (mamsl)
Contours (20m interval)
Railway Line
Perenninal River
Non-perennial River
Roads -> National Freeway
Roads -> Arterial Route
Roads -> Secondary Road
Roads -> Main Road
Roads -> Other
Outline of Site
2 km Buffer
Inland Water
Quaternary Catchments
Aquifer Vulnerability (GRA2, 2005)
Least
Moderate
Most
Scale
1:50 000 @ A4
0 1 2 3 km
PETER ROSEWARNE
GROUNDWATER CONSULTANT
SU CASA BURIAL ESTATE
Aquifer Vulnerability
Figure No.
5


Borehole 4 (3,4)
Borehole 6
Borehole 5
Borehole 2 (10,4)
Borehole 3 (10,4)
Borehole 1 (10,4)
2 km
T&DB Colliery
B11K
B20G
B11G
MJ Coal Plant
Transalloys (Pty) Ltd
Elandsfontein Colliery
2529CC00022
2529CC00029
2529CC00010
2529CC00011
2529CC00041
2529CC00023
2529CC00016
2529CC00015
2529CC00060
2529CC00062
2529CC00056
39729
39730
39426
39424
39425
Legend
Hydrocensus boreholes showing EC (mS/m)
Boreholes (DWS NGA, download 11-02-2022)
Places of Interest
Spot Height (mamsl)
Contours (20m interval)
Railway Line
Perenninal River
Non-perennial River
Roads -> National Freeway
Roads -> Arterial Route
Roads -> Secondary Road
Roads -> Main Road
Roads -> Other
Outline of Site
2 km Buffer
Inland Water
Quaternary Catchments
Groundwater Quality measured as Electrical Conductivity (EC) (mS/m)
(1/500,000 Hydrogeological Map Series, DWS)
0 - 70 mS/m
70 - 300 mS/m
300 - 1 000 mS/m
> 1 000 mS/m
Scale
1:50 000 @ A4
0 1 2 3 km
PETER ROSEWARNE
GROUNDWATER CONSULTANT
SU CASA BURIAL ESTATE
Groundwater Quality measured as Electrical Conductivity (EC) (mS/m)
Figure No.
6



PETER ROSEWARNE
GROUNDWATER CONSULTANT

SU CASA BURIAL ESTATE
Eco-Hydrological Perspective

Figure No.

7

Appendix B: Laboratory Analysis Certificate

WATERLAB

WATERLAB (Pty) Ltd
Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

23B De Havilland Crescent
Persequor Techno Park
Meiring Naudé Drive
Pretoria

P.O. Box 283, Persequor Park, 0020
Tel: +2712 - 349 - 1066
Fax: +2786 - 654 - 2570
e-mail: admin@waterlab.co.za

sanas T0391

CERTIFICATE OF ANALYSES

GENERAL WATER QUALITY PARAMETERS

Date received: 2022-03-18 Date completed: 2022-04-06
Project number: 1000 Report number: 108412 Order number:

Client name: Amber Earth Contact person: Mr. T. van Stormbrook
Address: P.O Box 75166, Lynnwood Ridge, 0046 e-mail: tim@amberearth.co.za
Telephone: 082 482 6202 Facsimile: Mobile: 082 482 6202

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification	
			Cem 01	Cem 04
Sample Number			156473	156474
Date/Time Sampled			N/A	N/A
pH - Value @ 25 °C	A	WLAB065	6.8	5.3
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	10.4	3.4
Total Dissolved Solids @ 180°C	A	WLAB003	54	14
Suspended Solids at 105°C	A	WLAB004	<1.0	<1.0
Colour in PtCo Units	A	WLAB006	1	<1
Turbidity in N.T.U	A	WLAB005	0.5	0.9
Total Alkalinity as $CaCO_3$	A	WLAB007	20	<5
P-Alkalinity as $CaCO_3$	A	WLAB023	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	A	WLAB023	20	<5
Carbonate Alkalinity as $CaCO_3$	A	WLAB023	<5	<5
Hydroxide Alkalinity as $CaCO_3$	A	WLAB023	<5	<5
Bicarbonate as HCO_3	A	WLAB023	24	5
Carbonate as CO_3	A	WLAB023	<5	<5
Hydroxide as OH	A	WLAB023	0	0
Chloride as Cl	A	WLAB046	6	<2
Sulphate as SO_4	A	WLAB046	14	8
Fluoride as F	N	WLAB014	0.3	0.3
Nitrate as N	A	WLAB046	0.2	<0.1
Nitrite as N	A	WLAB046	<0.05	<0.05
Bromide as Br	S	—	<0.1	<0.1
Total Phosphate as P	N	WLAB031	<0.2	<0.2
Ortho Phosphate as P	A	WLAB046	0.1	<0.1
Free and Saline Ammonia as N	A	WLAB046	<0.1	<0.1
Semi quantitative ICP-scan	N	WLAB050	See Below	See Below
% Balancing	N	—	98.1	90.0

J. Ngobeza - Chemical Technical Signatory

A = Accredited N = Not Accredited S = Subcontracted
Tests marked "Not SANAS Accredited" in this report are not included in the SANAS Scope of Accreditation for this Laboratory.
Results marked "Subcontracted Test" in this report are not included in the SANAS Scope of accreditation for this Laboratory.

Sample condition acceptable unless specified on the report.

Page 1 of 4

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