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SOIL AND AGRICULTURAL POTENTIAL ASSESSMENT FOR THE PROPOSED KRANSPAN MINING RIGHT EXTENSION PROJECT

Albert Luthuli Municipality, Mpumalanga Province, South Africa

September 2022

CLIENT

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1 Introduction

The Biodiversity Company was commissioned by ABS Africa (Pty) to conduct a soil and agricultural capability assessment for the proposed Kranspan Mining Right Extension Project that is situated on the farms Roodebloem 51 IT and Vaalbank 212 IS, near the town of Carolina in the Mpumalanga Province.

This assessment will be undertaken in consideration of National Environmental Management Act (NEMA) regulations and protocols (DEA, 2020) relevant to the Environmental Impact Assessment (EIA) for the Kranspan Mining Right Extension Area (MREA) associated with the proposed open cast mining activities.

The MREA, referred to as the project area herein, is located approximately 18 km southwest of Carolina in the Mpumalanga Province. The company is now seeking to expand the Kranspan MRA through the inclusion of two prospecting right areas (PRAs) situated to the south-west and east of the Kranspan MRA.

The purpose of this specialist assessment is to provide relevant input into the environmental authorisation process for the proposed activities associated with the open cast mining. This report, after taking into consideration the findings and recommendations provided by the specialist herein, should inform and guide the Environmental Assessment Practitioner (EAP) and regulatory authorities, enabling informed decision making, as to the ecological viability of the proposed project.

1.1 Specialist Details

Report Name	**SOIL AND AGRICULTURAL POTENTIAL ASSESSMENT FOR THE PROPOSED KRANSPAN MINING RIGHT EXTENSION PROJECT**
Submitted to	
Report Writer and Fieldwork	**Maletsatsi Mohapi** Maletsatsi Mohapi is a Soil scientist in the field of Natural and Agricultural sciences. Maletsatsi is a soil and wetland specialist, with an experience in soil identification, soil classification, wetland delineation and wetland monitoring. Maletsatsi completed her MSc in Agriculture at the University of the Free State in 2021. Maletsatsi is also a member of the Soil Science Society of South Africa (SSSSA).
Report Reviewer	**Andrew Husted** Andrew Husted is Pr Sci Nat registered (400213/11) in the following fields of practice: Ecological Science, Environmental Science and Aquatic Science. Andrew is an Aquatic, Wetland and Biodiversity Specialist with more than 15 years' experience in the environmental consulting field.
Declaration	The Biodiversity Company and its associates operate as independent consultants under the auspice of the South African Council for Natural Scientific Professions. We declare that we have no affiliation with or vested financial interests in the proponent, other than for work performed under the Environmental Impact Assessment Regulations, 2017. We have no conflicting interests in the undertaking of this activity and have no interests in secondary developments resulting from the authorisation of this project. We have no vested interest in the project, other than to provide a professional service within the constraints of the project (timing, time, and budget) based on the principals of science.

1.2 Terms of Reference

The Terms of Reference (ToR) included the following:

- Conducting a soil and agricultural potential assessment which includes a description of the physical properties which characterise the soil within the proposed area of development of the relevant portions of the property;
- The minimum requirement of the Agricultural Assessment in Government Notice 320 of 2020 (GN 320) stipulates that a 50 m buffered development envelope must be assessed with the screening tool (hereon referred to as the "50 m Regulated area");
- The findings from the assessment were used to determine the existing land capability and current land use of the entire surface area of the relevant portions of the project area;
- Soil resources were analysed in areas where the relief, soil colour and/or physical properties change in random patterns as part of a reconnaissance survey;
- The soil classification was done according to the Soil Classification Working Group, 2018.The following attributes must be included at each observation:
  - Soil form and family (Soil Classification Working Group, 2018);
  - Soil depth;
  - Estimated soil texture;
  - Soil structure, coarse fragments, calcareousness;
  - Buffer capacities;
  - Underlying material;
  - Current land use; and
  - Land capability.
- Soils samples were taken from the top-and subsoils relevant to the proposed open cast mining areas and sent off for a standard and textural analysis.

2 Project Description

The proposed Kranspan Mining Right Extension Project that will be situated on the farms Roodebloem 51 IT and Vaalbank 212 IS, is found on both the eastern and western farms along the R36 regional road and approximately 18 km southwest of the Carolina town in the Mpumalanga Province (see Figure 2-1). Apart from the proposed open cast mining areas, the following infrastructure was proposed for the mining operation (see Figure 2-2):

- Contractors Yard;
- ROM stockpiles;
- Pollution Control Dams (PCDs);
- Coal Processing Plant and Product Stockpile Area;
- Haul Roads

- Overburden Stockpiles; and
- Siding.

The predominant land uses surrounding the project area includes mining, agriculture (crops and livestock) and watercourses.

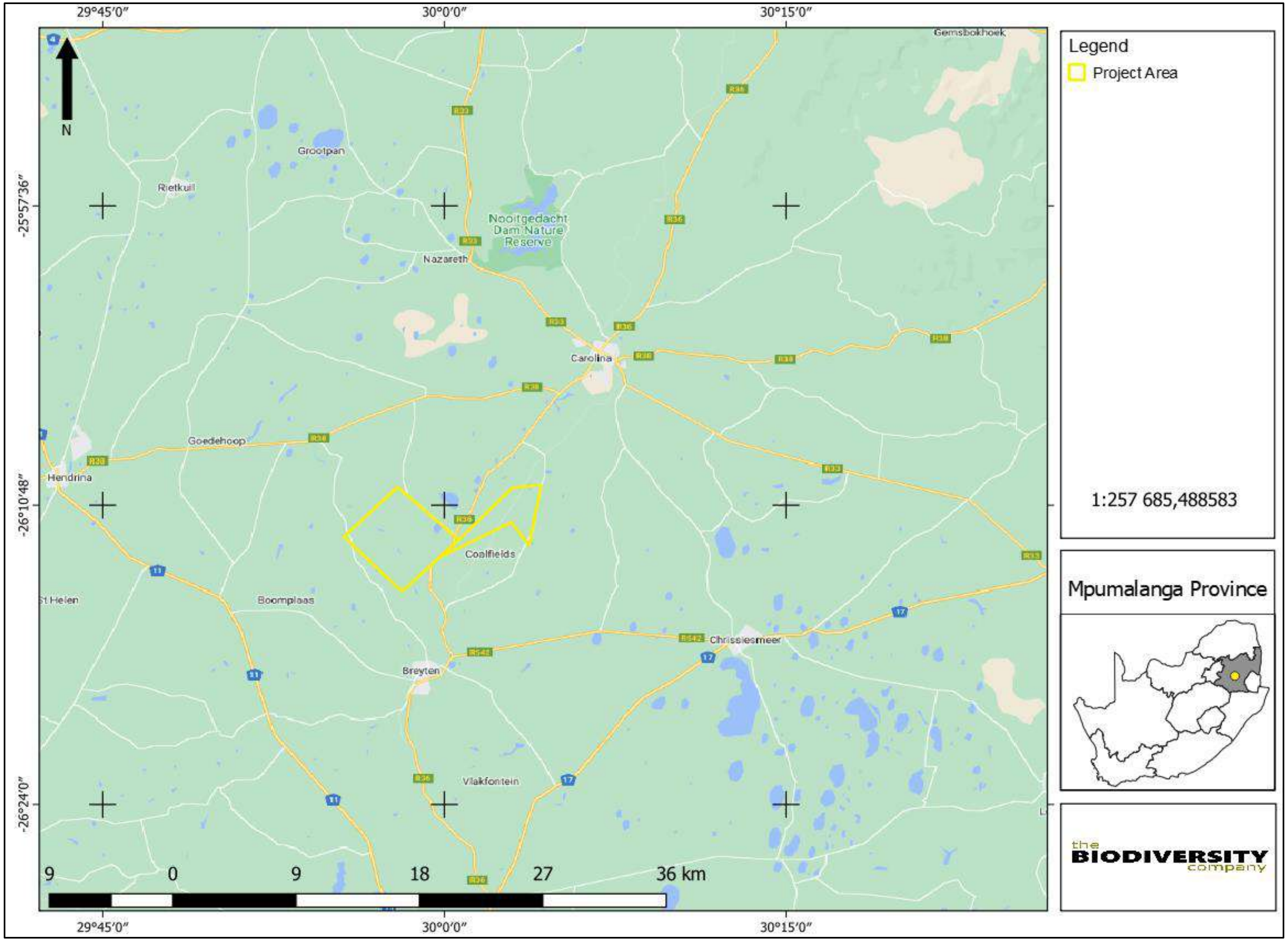

Figure 2-1 Locality of the project area

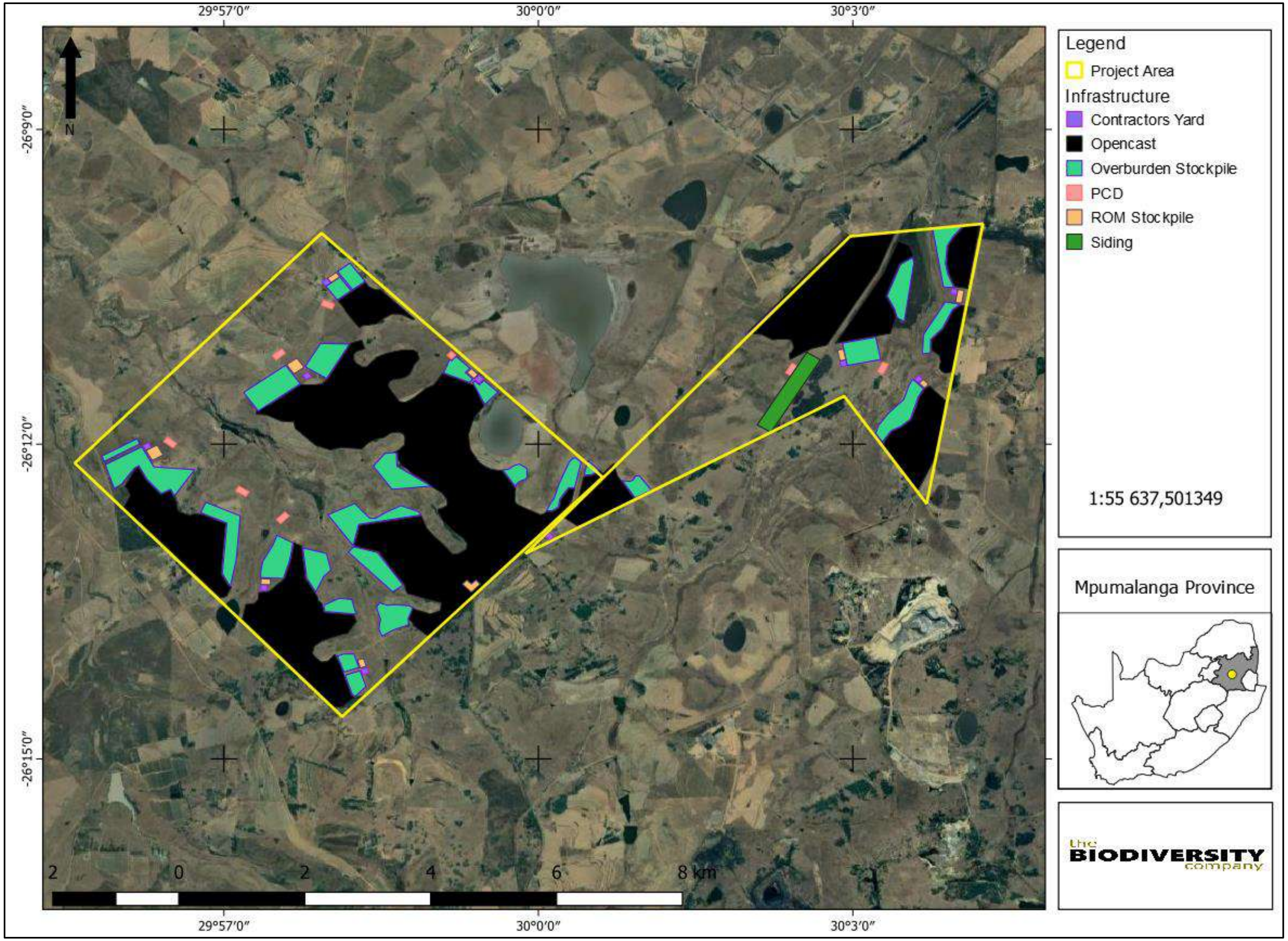

Figure 2-2 Project proposed infrastructure

Figure 2-3 Map showing 50 m Regulated area of the proposed project area

3 Key Legislative Requirements

Currently, various pieces of legislation and related policies exist that guide and direct the land user in terms of land use planning both on a national and provincial level. This legislation includes, but is not limited to:

- The Constitution of the Republic of South Africa (Act 108 of 1996);
- Sub-division of Agricultural Land Act (Act 70 of 1970);
- Municipal Structures Act (Act 117 of 1998);
- Municipal Systems Act (Act 32 of 2000); and
- Spatial Planning and Land Use Management Act, 16 of 2013 (not yet implemented).

The above mentioned are supported by additional legislation that aims to manage the impact of development on the environment and the natural resource base of the country. Related legislation to this effect includes:

- Conservation of Agricultural Resources Act (Act 43 of 1983);
- Environment Conservation Act (Act 73 of 1989);
- National Environmental Management Act (Act 107 of 1998); and
- National Water Act (Act 36 of 1998).

3.1 National Environmental Management Act (Act No. 107 of 1998)

The National Environmental Management Act (NEMA) (Act 107 of 1998) and the associated Regulations as amended in April 2017 and the GN 320 (20 March 2020) Protocol for the Specialist Assessment and Minimum Report Content Requirements for Environmental Impacts on Agricultural Resources, states that prior to any development taking place within a wetland or riparian area, an environmental authorisation process needs to be followed. This could follow either the Basic Assessment Report (BAR) process or the Scoping and EIA process depending on the scale of the impact.

4 Methodology

4.1 Desktop Assessment

The elevation and slope percentage of the project area was determined by means of SAGA software, which was used to assist in determining the agricultural potential of the project area.

4.2 Field Survey

The site was traversed by vehicle and on foot. A soil auger was used to determine the soil form/family and depth. The soil was hand augured to the first restricting layer or 1.5 m. Soil survey positions were recorded as waypoints using a handheld GPS. Soils were identified to the soil family level as per the "Soil Classification: A Natural and Anthropogenic System for South Africa" (Soil Classification Working Group, 2018). Landscape features such as existing open trenches were also helpful in determining soil types and depth.

4.3 Agricultural Potential Assessment

Land capability and agricultural potential will be determined by a combination of soil, terrain, and climate features. Land capability is defined by the most intensive long-term sustainable use of land under rain-fed conditions. At the same time an indication is given about the permanent limitations associated with the different land use classes (Smith, 2006).

Land capability is divided into eight classes, and these may be divided into three capability groups. Table 4-1 shows how the land classes and groups are arranged in order of decreasing capability and ranges of use. The risk of use increases from class I to class VIII (Smith, 2006).

Table 4-1 Land capability class and intensity of use (Smith, 2006)

Land Capability Class	Increased Intensity of Use									Land Capability Groups
I	W	F	LG	MG	IG	LC	MC	IC	VIC	Arable Land
II	W	F	LG	MG	IG	LC	MC	IC		
III	W	F	LG	MG	IG	LC	MC			
IV	W	F	LG	MG	IG	LC				
V	W	F	LG	MG						Grazing Land
VI	W	F	LG	MG						
VII	W	F	LG							
VIII	W									Wildlife
W - Wildlife		**MG - Moderate Grazing**			**MC - Moderate Cultivation**					
F- Forestry		**IG - Intensive Grazing**			**IC - Intensive Cultivation**					
LG - Light Grazing		**LC - Light Cultivation**			**VIC - Very Intensive Cultivation**					

The land potential classes are determined by combining the land capability results and the climate capability of a region as shown in Table 4-2. The final land potential results are then described in Table 4-3.

Table 4-2 The combination table for land potential classification

Land capability class	Climate capability class							
	C1	C2	C3	C4	C5	C6	C7	C8
I	L1	L1	L2	L2	L3	L3	L4	L4
II	L1	L2	L2	L3	L3	L4	L4	L5
III	L2	L2	L3	L3	L4	L4	L5	L6
IV	L2	L3	L3	L4	L4	L5	L5	L6
V	Vlei	Vlei	Vlei	Vlei	Vlei	Vlei	Vlei	Vlei
VI	L4	L4	L5	L5	L5	L6	L6	L7
VII	L5	L5	L6	L6	L7	L7	L7	L8
VIII	L6	L6	L7	L7	L8	L8	L8	L8

Table 4-3 The Land Potential Classes.

Land potential	Description of land potential class
L1	Very high potential: No limitations. Appropriate contour protection must be implemented and inspected.
L2	High potential: Very infrequent and/or minor limitations due to soil, slope, temperatures, or rainfall. Appropriate contour protection must be implemented and inspected.
L3	Good potential: Infrequent and/or moderate limitations due to soil, slope, temperatures, or rainfall. Appropriate contour protection must be implemented and inspected.
L4	Moderate potential: Moderately regular and/or severe to moderate limitations due to soil, slope, temperatures, or rainfall. Appropriate permission is required before ploughing virgin land.
L5	Restricted potential: Regular and/or severe to moderate limitations due to soil, slope, temperatures, or rainfall.
L6	Very restricted potential: Regular and/or severe limitations due to soil, slope, temperatures, or rainfall. Non-arable
L7	Low potential: Severe limitations due to soil, slope, temperatures, or rainfall. Non-arable
L8	Very low potential: Very severe limitations due to soil, slope, temperatures, or rainfall. Non-arable

The land capability of the proposed footprint was compared to the National Land Capability which was refined in 2014- 2016. The National Land Capability methodology is based on a spatial evaluation modelling approach and a raster spatial data layer consisting of fifteen (15) land capability evaluation values (Table 4-4), usable on a scale of 1:50 000 – 1:100 000 (DAFF, 2017). The previous system is based on a classification approach, with 8 classes (Table 4-1).

Table 4-4 National Land Capability Values (DAFF, 2017)

Land Capability Evaluation Value	Land Capability Description
1	Very low
2	
3	Very Low to Low
4	
5	Low

6	Low to Moderate
7	
8	Moderate
9	Moderate to High
10	
11	High
12	High to Very High
13	
14	Very High
15	

4.4 Current Land Use

Land use was identified using aerial imagery and then ground-truthed while out in the field. The possible land use categories are:

- Mining;
- Bare areas;
- Agriculture crops;
- Natural veld;
- Grazing lands;
- Plantation;
- Urban;
- Built-up;
- Waterbodies; and
- Wetlands.

4.5 Soil Sampling

The topsoil and subsoil of 25 soil profiles in selected undisturbed areas (focussing on proposed open cast areas) (see Figure 4-1) were sampled and sent for fertility and textural class analysis. The results from these tests were attached in the report (Appendix B Soil Results) following the analysis procedure.

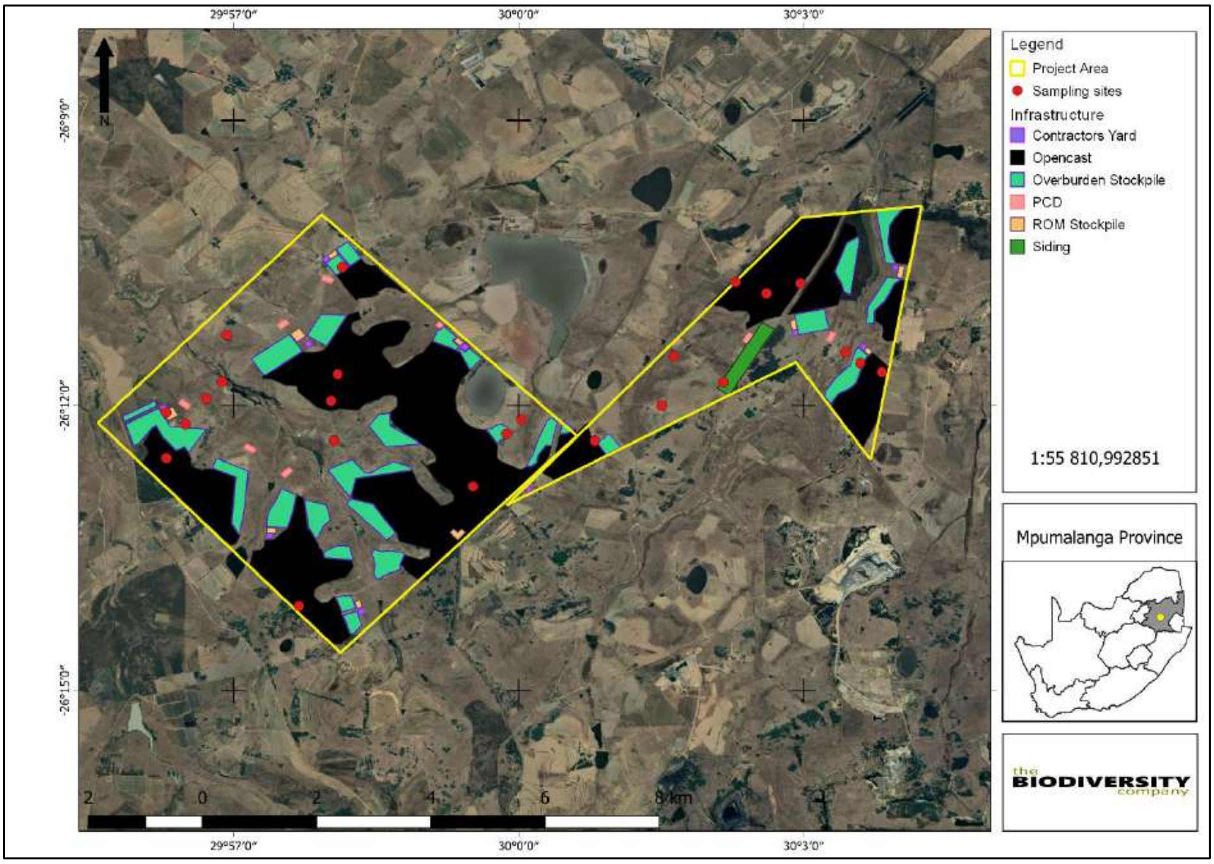

Figure 4-1 Sampling sites relevant to the open cast areas and other proposed infrastructure

4.6 Limitations

The following limitations should be noted for the assessment:

- A soil stripping guideline is not part of this assessment; and
- The GPS used for water resource delineations is accurate to within five meters. Therefore, the wetland delineation plotted digitally may be offset by at least five meters to either side.

5 Receiving Environment

5.1 Desktop Assessment

The following sections include desktop results and the results from field observations relevant to the agricultural potential of the assessment area.

5.2 Soils and Geology

According to the land type database (Land Type Survey Staff, 1972 - 2006), the project area is characterised by the Bb 15 and Bb 21 land types. The Bb 15 land type is characterised with mostly Glencoe, Clovelly, Longlands and Katspruit soil forms following the Soil Classification Working group (1991) with the occurrence of other soils also in the landscape. The Bb 21 land type commonly has Avalon and Kroonstad soils with the presence of rocky and shallow profiles also occurring in the terrains. Figure 5-1 and Figure 5-2 illustrate the respective terrain units relevant to the Bb 15 and Bb 21 land types with the expected soils illustrated in Table 5-1 and Table 5-2.

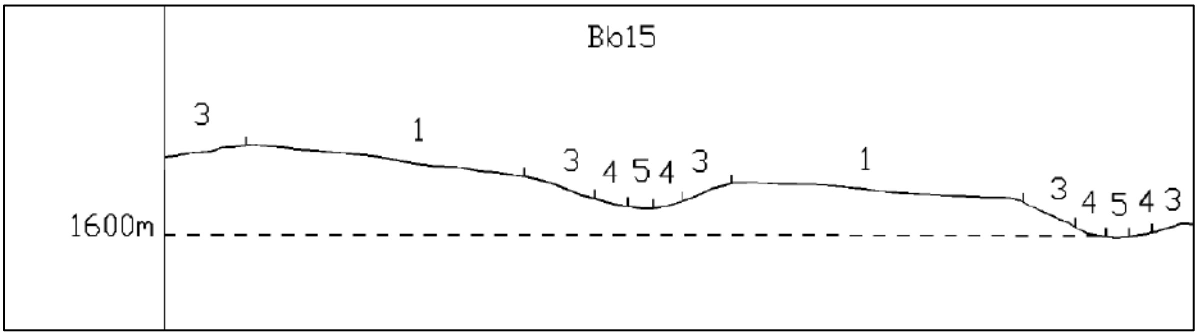

Figure 5-1 Illustration of land type Bb 15 terrain units (Land Type Survey Staff, 1972 – 2006

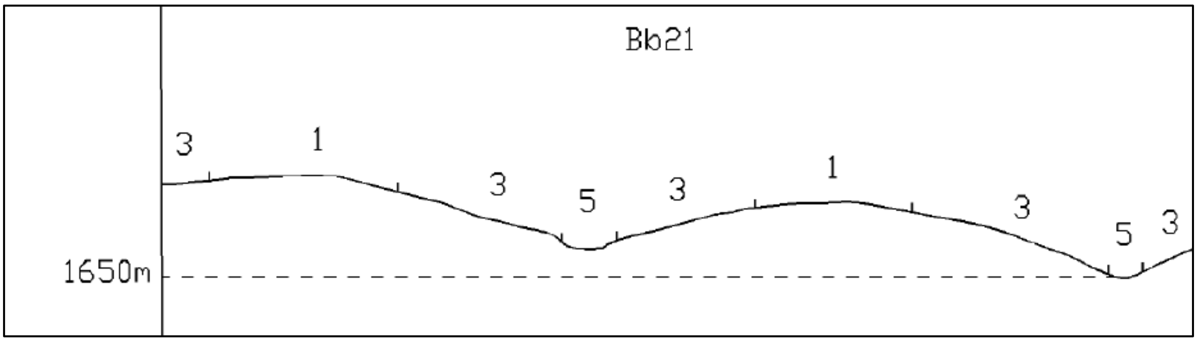

Figure 5-2 Illustration of land type Bb 21 terrain units (Land Type Survey Staff, 1972 – 2006)

Table 5-1 Soils expected at the respective terrain units within the Bb 15 land type (Land Type Survey Staff, 1972 - 2006)

Terrain units							
1 (50%)		**3 (40%)**		**4 (5%)**		**5 (5%)**	
Glencoe	25%	Clovelly	25%	Longlands	30%	Katspruit	50%
Mispah	25%	Mispah	15%	Avalon	20%	Willowbrook, Rensburg	30%
Clovelly	20%	Avalon	15%	Kroonstad	20%	Kroonstad	20%
Hutton	10%	Glencoe	10%	Mispah	10%		
Avalon	5%	Wasbank	10%	Wasbank	10%		
Wasbank	5%	Cartref	10%	Katspruit	5%		
Cartref	5%	Hutton	5%	Willowbrook, Rensburg	5%		
Pan	5%	Longlands	5%				
		Bare rock	5%				

Table 5-2 Soils expected at the respective terrain units within the Bb 21 land type (Land Type Survey Staff, 1972 – 2006)

Terrain units					
1 (30%)		3 (60%)		5 (10%)	
Mispah	20%	Avalon	30%	Kroonstad	30%
Glencoe	20%	Glencoe	10%	Katspruit	30%
Clovelly	15%	Longlands, Wasbank	10%	Mispah	20%
Glenrosa	10%	Clovelly	10%	Longlands, Wasbank	20%
Avalon	10%	Hutton	10%		
Cartref	5%	Glenrosa	10%		
Wasbank	5%	Cartref	5%		
Hutton	5%	Mispah	5%		
Pan	5%	Kroonstad	5%		
Bare rock	5%	Bare rock	5%		

According to Mucina & Rutherford (2006), the geology and soils aspect of this region is characterised by plinthic catena soils, with also the occurrence of red sandy soils of the Bb 15 and Bb 21 land types. Upland duplex and margalitic soils are rare in this region. The geology of this region includes shale, shaly sandstone, grit, sandstone, and conglomerate of the Ecca Group; tillite and shale of the Dwyka Formation, Karoo Sequence and dolerite of the Bb 15 and Bb 21 land types.

5.3 Climate

The assessment area is characterised by a strongly seasonal summer rainfall, with very dry winters. The mean annual precipitation (MAP) of the assessment area is approximately 726 mm and is relatively uniform across most the area but increases significantly in the extreme southeast. Incidence of frost ranges between 13 to 42 days a year and occurs more at higher elevations (see Figure 5-3).

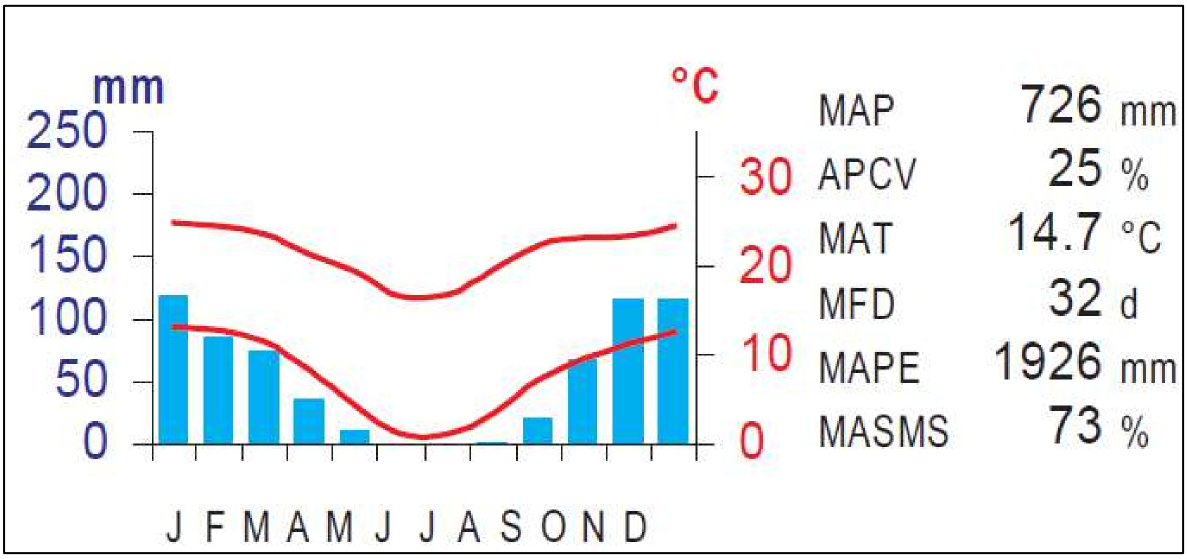

Figure 5-3 Climate for the project area

5.4 Terrain

The Digital Elevation Model (DEM) indicates a range in elevation of 1 616 Metres Above Sea Level (MASL) to 1 757 MASL (see Figure 5-4).

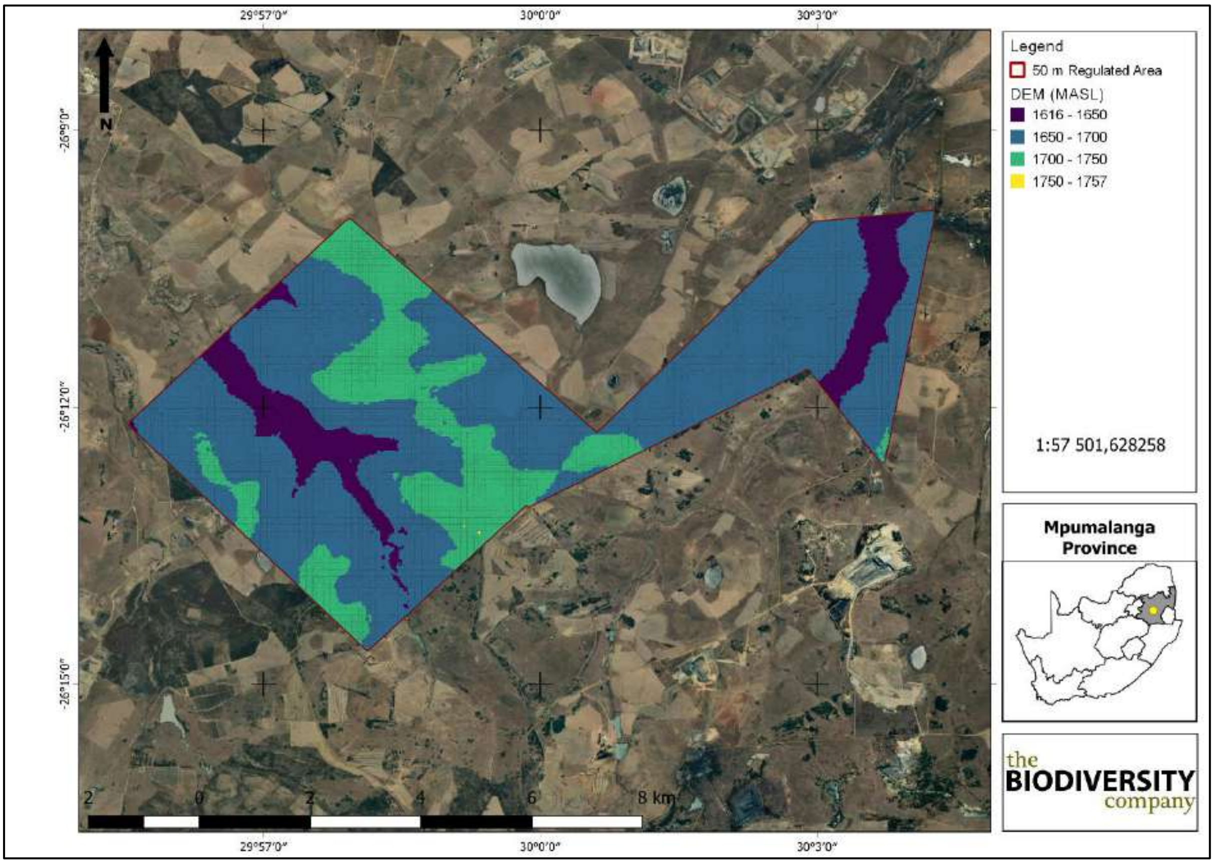

Figure 5-4 Digital elevation model (MASL)

The slope percentage of the project area has been calculated and illustrated in Figure 5-5. Most of the project area is characterised by a slope percentage between 0 to 20%, with some smaller patches within the project area characterised by a slope percentage ranging from 60 to 70 %. This illustration indicates a non-uniform topography in scattered areas the majority of the area being characterised by a gentle slope.

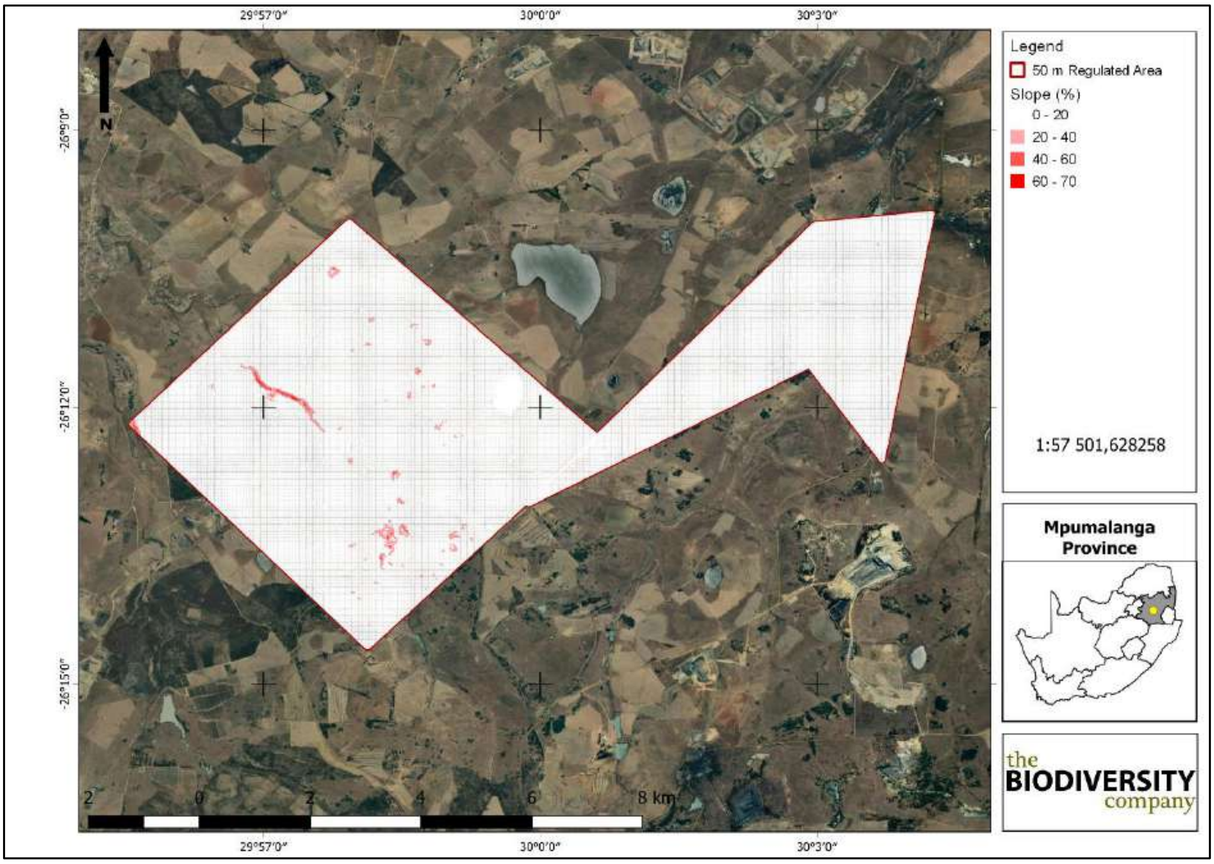

Figure 5-5 Slope percentage of the project area

6 Field Survey

6.1 Soil Profiles and Diagnostic Horizons

Soil profiles were sampled and studied up to a depth of 1.5 m to identify specific diagnostic horizons which are vital in the soil classification process as well as determining the agricultural potential and land capability. During the site assessment, various soil forms were identified. These soil forms have been delineated and illustrated in Figure 6-1 and described according to depth, clay percentage, indications of surface crusting, signs of wetness and percentage rock (also see Table 6-1). The following diagnostic horizons were identified during the site assessment (see Figure 6-2 and Figure 6-3):

- Organic topsoil;
- Melanic topsoil;
- Orthic topsoil;
- Gley horizon;
- Albic horizon;
- Gleyic horizon;
- Yellow brown horizon;
- Red apedal horizon;
- Soft plinthic horizon;
- Hard plinthic horizon
- Neocutanic horizon;
- Alluvial horizon;
- Lithic horizon; and
- Hard rock horizon.

6.1.1 Organic Topsoil

According to (SASA, 1999), the Organic topsoil contains a high concentration of organic carbon, hence the dark colour of the soil type. The layer contains soil carbon ranging between 10% to 20%. This soil type forms under prolonged periods of saturation, which decreases the decomposition rate and ensures the formation of hemic or fibrous material.

6.1.2 Melanic Topsoil

Melanic horizon consists of a moderate to stronger blocky structured topsoil with dark colours and a high base status. The topsoil has less than 10% organic carbon and lacks both cracks and slickensides. According to the Soil Classification Working Group (2018), melanic topsoil develops in all climate conditions, from arid to humid climates in geomorphologically youthful landscapes not subjected to strong pedological weathering.

6.1.3 Orthic Topsoil

Orthic topsoil is mineral horizons that have been exposed to biological activities and varying intensities of mineral weathering. The climatic conditions and parent material ensure a wide range of properties differing from one Orthic A topsoil to another (i.e., colouration, structure etc) (Soil Classification Working Group, 2018).

6.1.4 Gley Horizon

Gley horizons that are well developed will have homogenous dark to light grey colours with smooth transitions. Stagnant and reduced water over long periods is the main factor responsible for the formation of a Gley horizon and could be characterised by green or blue tinges due to the presence of a mineral called Fougerite which includes sulphate and carbonate complexes. Even though grey colours are dominant, yellow and/or red striations can be noticed throughout a Gley horizon. The structure of a Gley horizon mostly is characterised as strong pedal, with low hydraulic conductivities and a clay texture, although sandy Gley horizons are known to occur. The Gley soil form commonly occurs at the toe of hillslopes (or benches) where lateral water inputs (sub-surface) are dominant and the underlaying geology is characterised by a low hydraulic conductivity. The Gley horizon usually is second in diagnostic sequence in shallow profiles yet is known to be lower down in sequence and at greater depths (Soil Classification Working Group, 2018).

6.1.5 Albic Horizon

Albic horizons are often characterised by uniform white-greyish colours from the residual clay and quartz particles making up the matrix of the horizon. The main characteristic of this diagnostic horizon is a bleached colouration, which is a resultant product of distinct redox and ferrolysis pedological processes combined with eluvial processes. According to the Soil Classification Working Group (2018), albic horizons often receive lateral sub-surface flows from hillslope processes.

6.1.6 Gleyic Horizon

Gleyic horizon is characterised by variable low chroma matrix colours that are grey and light yellow. The morphology of the horizon indicates less reduction of iron minerals and a shorter inundation as compared to the Gley horizon; therefore, it exhibits both the redoximorphic and oximorphic properties. The horizon displays low chroma colours on the ped exterior and high chroma colouration within the ped interior.

6.1.7 Yellow brown apedal Horizon

The yellow brown apedal horizon is similar to that of the Red Apedal horizon in all aspects except for the colour and the iron-oxide processes involved with the colouration thereof. This diagnostic soil horizon rarely occurs in parent rock high in iron-oxides and will rather be associated with Quartzite, Sandstone, Shale, and Granites.

6.1.8 Red apedal Horizon

The red apedal diagnostic soil horizon has no well-formed peds, but rather small porous aggregates. The poor structure associated with this diagnostic profile is a result of weathering processes under well drained oxidising conditions. Iron-oxide precipitations form on the outside of soil particles (hence the red colour) and non-swelling clays dominate the clay particles. This diagnostic soil horizon is widely spread across South Africa and can be associated with any parent material expected (Soil Classification Working Group, 1991).

6.1.9 Soft Plinthic Horizon

The accumulations of iron (and in some cases manganese) as hydroxides and oxides with the presence of high chroma striations and concretions with black matrixes are associated with the Soft Plinthic horizon. This diagnostic horizon forms due to fluctuating levels of saturation. The iron and manganese concentration result in soft marks within the soil matrix which transform in concretions with high consistencies (Soil Classification Working Group, 1991).

If this process continues for long enough periods, a massive continues impermeable layer of hard plinthite forms. A Soft Plinthic horizon and a Hard Plinthic horizon can be distinguished from one another by means of a simple spade test. A Soft Plinthic horizon can be penetrated by means of a spade in wet conditions whereas a Hard Plinthic horizon cannot (Soil Classification Working Group, 1991). According to Soil Classification Working Group (2018), this horizon commonly occurs as a result of hillslope hydrology in flat, sandy landscapes. This horizon is known to have an apedal structure together with the presence of concretions.

6.1.10 Hard Plinthic Horizon

Hard plinthic horizon is similar to that of Soft Plinthic horizon except, it has a concretionary structure that is cemented together and prominent red, brown, yellow, black and/or grey colours. The horizon cannot be easily dislodged with hand tools.

6.1.11 Neocutanic Horizon

The horizon is a young weakly-structured subsurface layer with variations in the soil matrix. The horizon is commonly associated to the processes of transportation of materials usually colluvial or alluvial origins in the valley bottoms or flats terrains and river terraces that have been subjected to an intermediate stage of pedogenic changes. The colour differences in the neocutanic horizon are usually caused by illuvial material that coats weak structural units.

6.1.12 Alluvial Horizon

Alluvial horizon comprises of a subsoil showing limited evidence of pedogenic horizonation, although a diagnostic topsoil may be present. The horizon consists of unconsolidated soil material and partly weathered hard rock fragments that are manifested as generally horizontal layers caused by alluvial deposits.

6.1.13 Lithic Horizon

Lithic horizon consists of friable soil-like morphology that resulted from pedogenic alteration, ranging from strong weathering of the underlying country rock to partially weathering of the hard rock fragments. The subsoil may express a gleying characteristics in a form of iron mineral reduction, when subjected to saturation conditions.

6.1.14 Hard rock Horizon

Hard rock horizon comprises of hard rock characterised with primarily physical weathering ranging from fractured and solid rock lacking soil development between the fractures. The underlain parent material includes igneous, sedimentary, and metamorphic rocks. The horizon restricts most root penetrations of plants except for some selected annual trees and shrubs which can grow through the fractured sections in specialized ecological niche environments.

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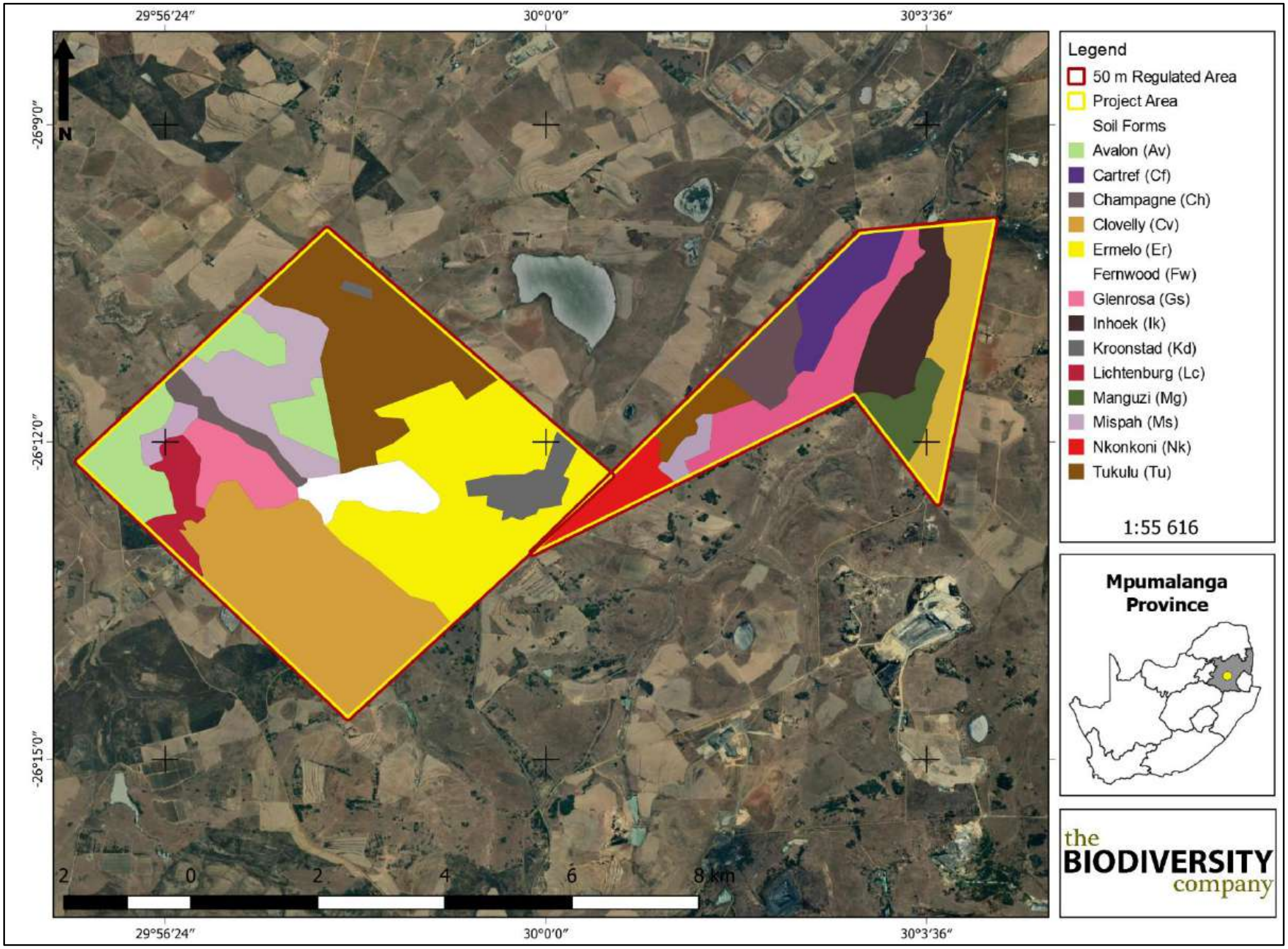

Figure 6-1 ***Soil delineations within the project area***

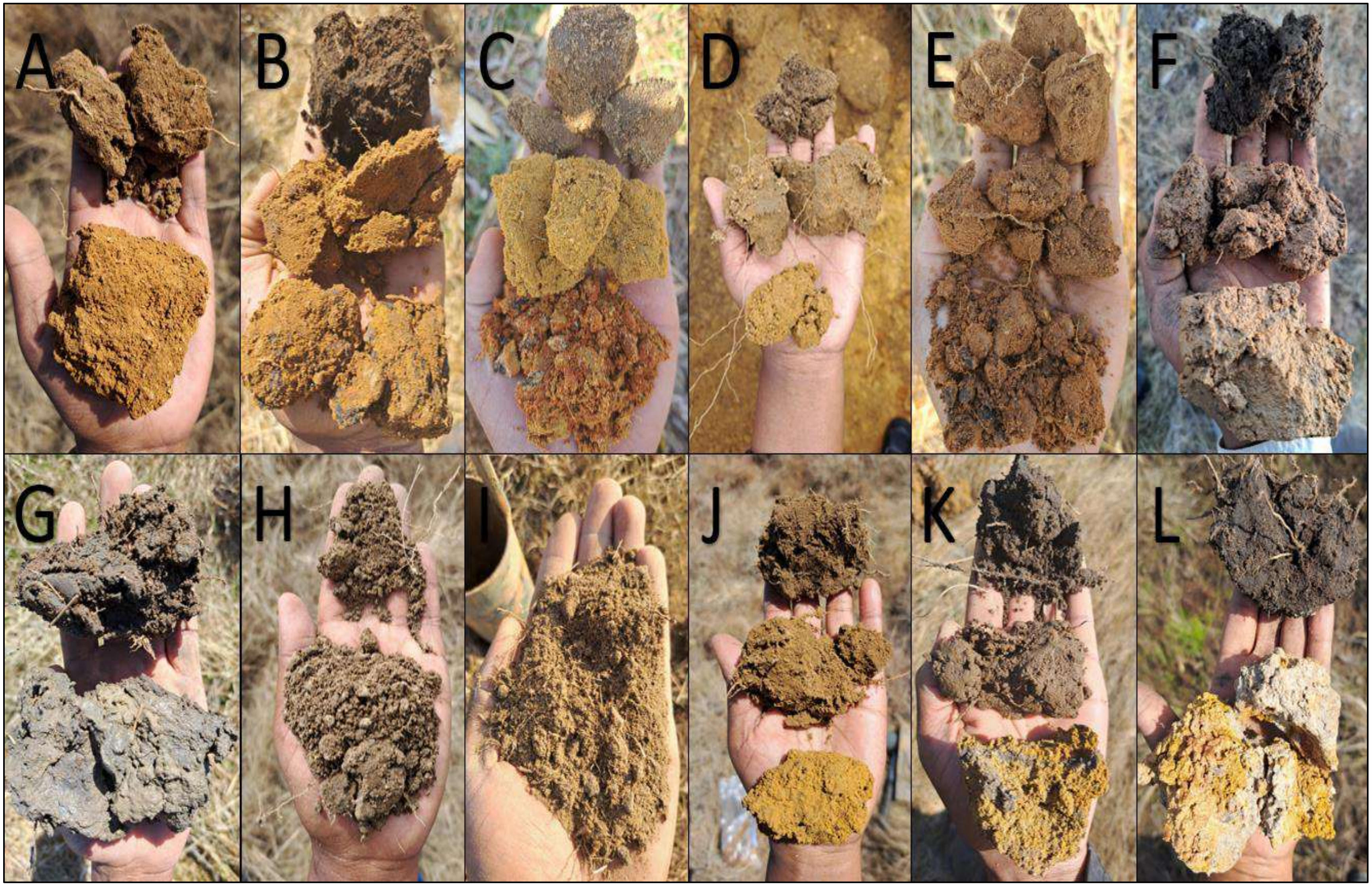

Figure 6-2 ***Soil forms identified within the project area. A) Ermelo, B) Glencoe, C) Avalon, D) Cartref, E) Nkonkoni, F) Kroonstad, G) Fernwood, H) Glenrosa, I) Mispah, J) Tukulu, K) Manguzi, and L) Champagne soil form.***

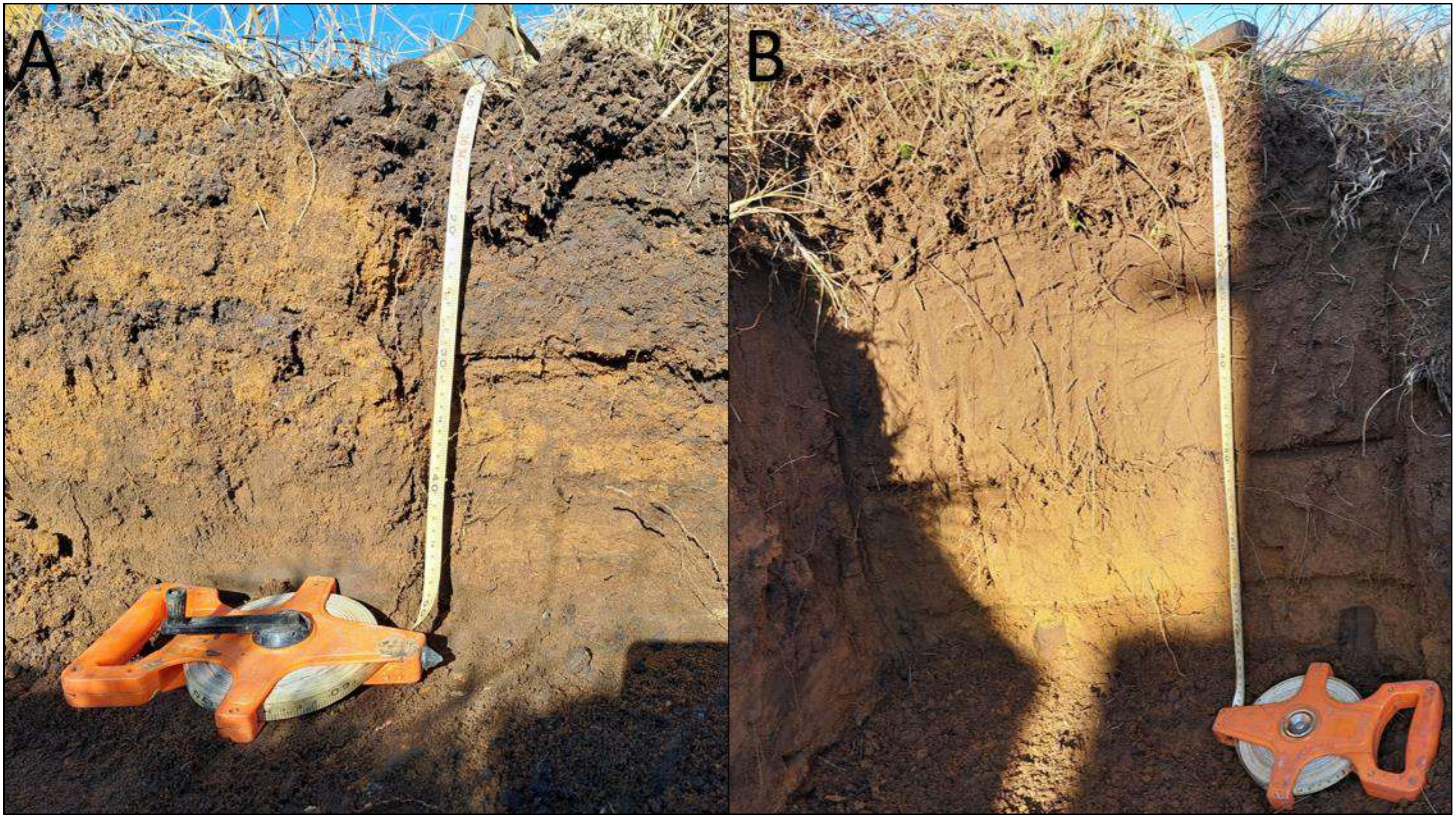

Figure 6-3 Summary of soils identified within the project area

Table 6-1 Description of the soil form found within the proposed project area

	A-horizon					B-horizon				B-horizon/C-horizon			
	Depth (mm)	Clay (%)	Signs of wetness	Rock %	Surface crusting	Depth (mm)	Clay (%)	Signs of wetness	Rock %	Depth (mm)	Clay (%)	Signs of wetness	Rock %
***Champagne**	*340	>15	W4	0	None	*340 - 700	20 - 25	W4	10	N/A			
***Ermelo**	*640	0 - 15	None	0	None	*640 –1200	15 - 20	None	0	N/A			
Fernwood	250	0 - 15	W4	0	None	250 - 1200	15 - 20	W4	0	N/A			
***Glenrosa**	*250	15 - 20	None	0	None	*250 - 380	15 - 20	None	30	N/A			
***Glenrosa**	*150	0 - 15	None	0	None	*150 - 350	15 - 20	None	40	N/A			
***Inhoek**	*300	25 - 30	None	0	None	*300 – 500	0 - 15	W2	5	N/A			
Manguzi	200	0 - 15	W4	0	None	200 – 550	0 - 15	W4	0	N/A			
Mispah	150	0 - 15	None		None	>150	0 - 15	None	100	N/A			
Avalon	300	0 - 15	None	0	None	300 - 600	0 - 15	None	0	600 - 1200	0 - 15	W2	Only plinthic
***Cartref**	*150	0 - 15	None	0	None	*150 - 350	15 - 20	None	0	*350 - 580	15 - 20	None	30
Clovelly	320	0 - 15	None	0	None	320 – 480	0 - 15	None	0	480 - 600	0 - 15	None	20
Kroonstad	230	0 - 15	W2	0	None	230 – 450	15 - 20	W4	0	450 – 870	30 - 35	W4	30
Lichtenburg	200	0 - 15	None	0	None	200 – 360	0 - 15	None	0	360 - 800	0 - 15	None	Only plinthic
Nkonkoni	300	0 - 15	None	0	None	300 - 600	0 - 15	None	0	600 - 1200	0 - 15	None	40
***Tukulu**	*300	0 - 15	W2	0	None	*300 - 400	15 - 20	W2	0	*400 -1200	20 - 25	W4	5

W4- Semi-permanently or permanently wet with water visible on surface.

W2- Temporarily wet during wet season. No mottling within top 200 mm with signs of wetness between 200 and 500 mm.

(*)- The delineated soil forms differ significantly in terms of depths. The value illustrated in the above-mentioned table represents the average depth between all identified soils for the specific soil form.

6.2 Agricultural Potential

Agricultural potential is determined by a combination of soil, terrain, and climate features. Land capability classes reflect the most intensive long-term use of land under rain-fed conditions.

The land capability is determined by the physical features of the landscape including the soils present. The land potential or agricultural potential is determined by combining the land capability results and the climate capability for the region.

6.2.1 Climate capability

The climatic capability has been determined by means of the Smith (2006) methodology, of which the first step includes determining the climate capability of the region by means of the MAP and annual Class A pan (potential evaporation) (see Table 6-2).

Table 6-2 Climatic capability (step 1) (Scotney et al. 1987)

Central Sandy Bushveld region				
Climatic Capability Class	**Limitation Rating**	**Description**	**MAP: Class A pan Class**	**Applicability to site**
C1	None to Slight	Local climate is favourable for good yields for a wide range of adapted crops throughout the year.	0.75-1.00	
C2	Slight	Local climate is favourable for a wide range of adapted crops and a year-round growing season. Moisture stress and lower temperature increase risk and decrease yields relative to C1.	0.50-0.75	
C3	Slight to Moderate	Slightly restricted growing season due to the occurrence of low temperatures and frost. Good yield potential for a moderate range of adapted crops.	0.47-0.50	
C4	Moderate	Moderately restricted growing season due to the occurrence of low temperatures and severe frost. Good yield potential for a moderate range of adapted crops but planting date options more limited than C3.	0.44-0.47	
C5	Moderate to Severe	Moderately restricted growing season due to low temperatures, frost and/or moisture stress. Suitable crops at risk of some yield loss.	0.41-0.44	
C6	Severe	Moderately restricted growing season due to low temperatures, frost and/or moisture stress. Limited suitable crops that frequently experience yield loss.	0.38-0.41	
C7	Severe to Very Severe	Severely restricted choice of crops due to heat and moisture stress.	0.34-0.38	✔
C8	Very Severe	Very severely restricted choice of crops due to heat and moisture stress. Suitable crops at high risk of yield loss.	0.30-0.34	

According to Smith (2006), the climatic capability of a region is only refined past the first step if the climatic capability is determined to be between climatic capability 1 and 6. Given the fact that the climatic capability has been determined to be “C7” for the project area, no further steps will be taken to refine the climate capability.

6.2.2 Land Capability

The land capability was determined by using the guidelines described in “The farming handbook” (Smith, 2006). The delineated soil forms were clipped into three different slope classes (0-2%, 2-5% and >5%) to determine the land capability of each soil form. The delineated soil forms were then grouped together in three different land capability classes (land capability 3, 4 and 6). As per example, the Champagne soil form will classify as a Land Capability (LC) 2 within the first slope class (0-2%), a Land Capability (LC) 3 for the second slope class (2-5%) and a LC 4 for the third class (>5%) (see Table 6-3).

It is however worth noting, that even though the slope percentage of an area plays a considerable role in the formation and morphology of soil forms, the slope class is not the only parameter used to determine land capability. All parameters listed in Table 6-3 are also used to calculate land capability together with slope percentage. Key parameters used to determine the land capability include topsoil texture, depth, and the permeability class of a soil form. The land capabilities for the project area are calculated and described in Table 6-4 and Table 6-5 and illustrated in Figure 6-5.

Table 6-3 Land capability calculations as per the slope classes relevant to the project area for the Champagne soil form

Soil Form	Slope Class	Calculated Land Capability
Champagne	0-2%	LC2
	2-5%	LC3
	>5%	LC4

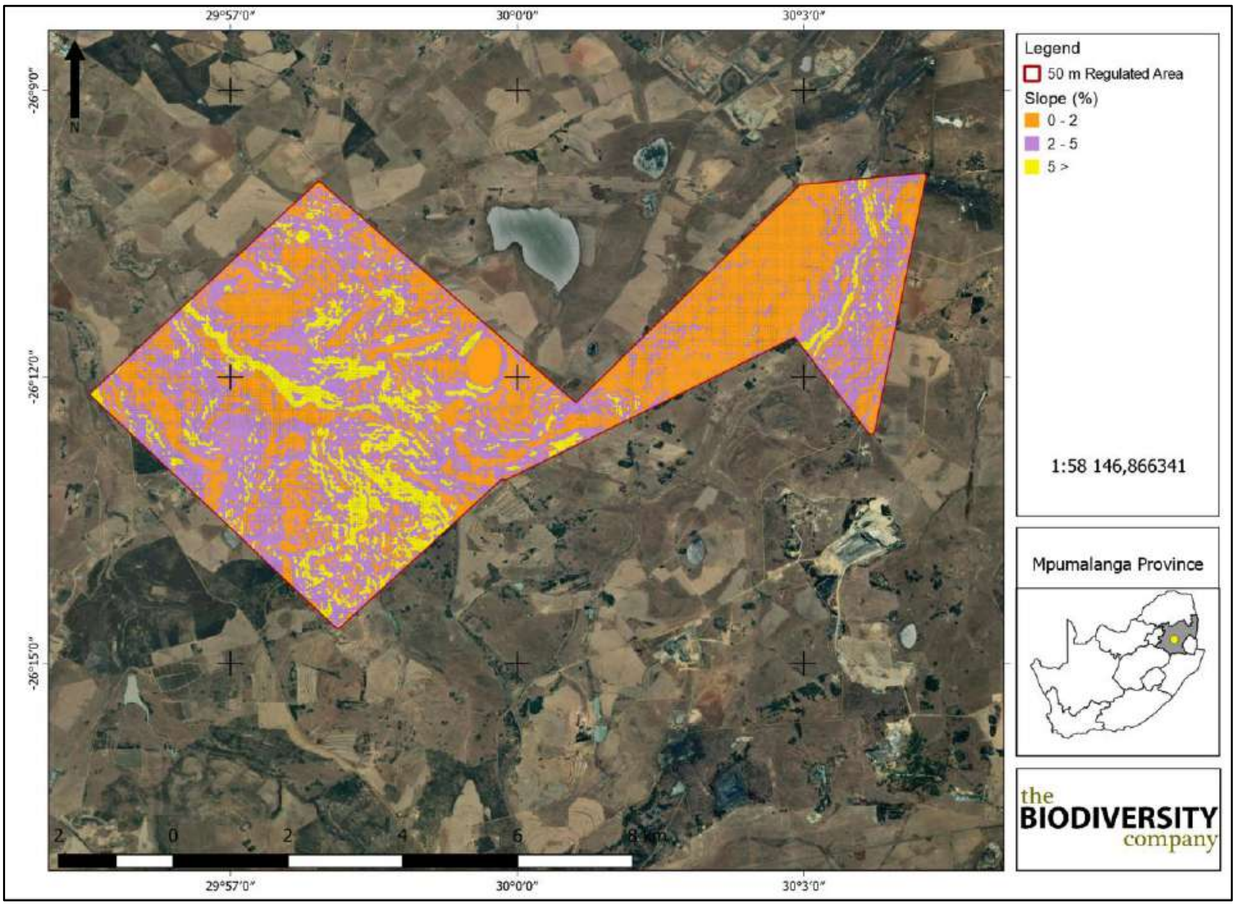

Figure 6-4 Three slope classes relevant to the land capability calculation methodology

Name	Soil Form	Area (m²)			Land Capability classes			
					III	IV	VI	Total
Av	Avalon	1910959		**Area (m²)**	8683637	23396224	17700575	49780436
Ms	Mispah	403913		**%**	17,44387	46,99883	35,55729	100
Lc	Lichtenburg	1162128						
Gs	Glenrosa	1517371						
Cv	Clovelly	8539789						
Ch	Champagne	758088						
Fw	Fernwood	1399163						
Ms	Mispah	3067051		**Index**	**LC**			
Kd	Kroonstad	1175681		Grey	IV			
Er	Ermelo	8683637		Orange	III			
AV	Avalon	819236		Yellow	VI			
Kd	Kroonstad	85086						
Tu	Tukulu	6530901						
Av	Avalon	811308						
Nk	Nkonkoni	1365418						
Ms	Mispah	422069						
Tu	Tukulu	842186						
Ch	Champagne	1407843						
Gs	Glenrosa	2960523						
Mg	Manguzi	1113419						
Ik	Inhoek	2385472						
Cv	Clovelly	2742573						
Cf	Cartref	1938434						

Table 6-4 Land capability classes percentages

Table 6-5 Land capability for the soils within the project area

Land Capability Class	Definition of Class	Conservation Need	Use-Suitability	Percentage of Land Capability within Project Area	Land Capability Group	Sensitivity
III	Moderate limitations. Some erosion hazard.	Special conservation practice and tillage methods.	Rotation of crops and ley (50%).	17.44%	Arable	High
IV	Severe limitations. Low arable potential. High erosion hazard.	Intensive conservation practice.	Long-term leys (75%).	46.99%	Arable	Moderate
VI	Limitations preclude cultivation. Suitable for perennial vegetation.	Protection measures for establishment, e.g., sod- seeding	Veld, pasture, and afforestation.	35.56%	Non-Arable	Low

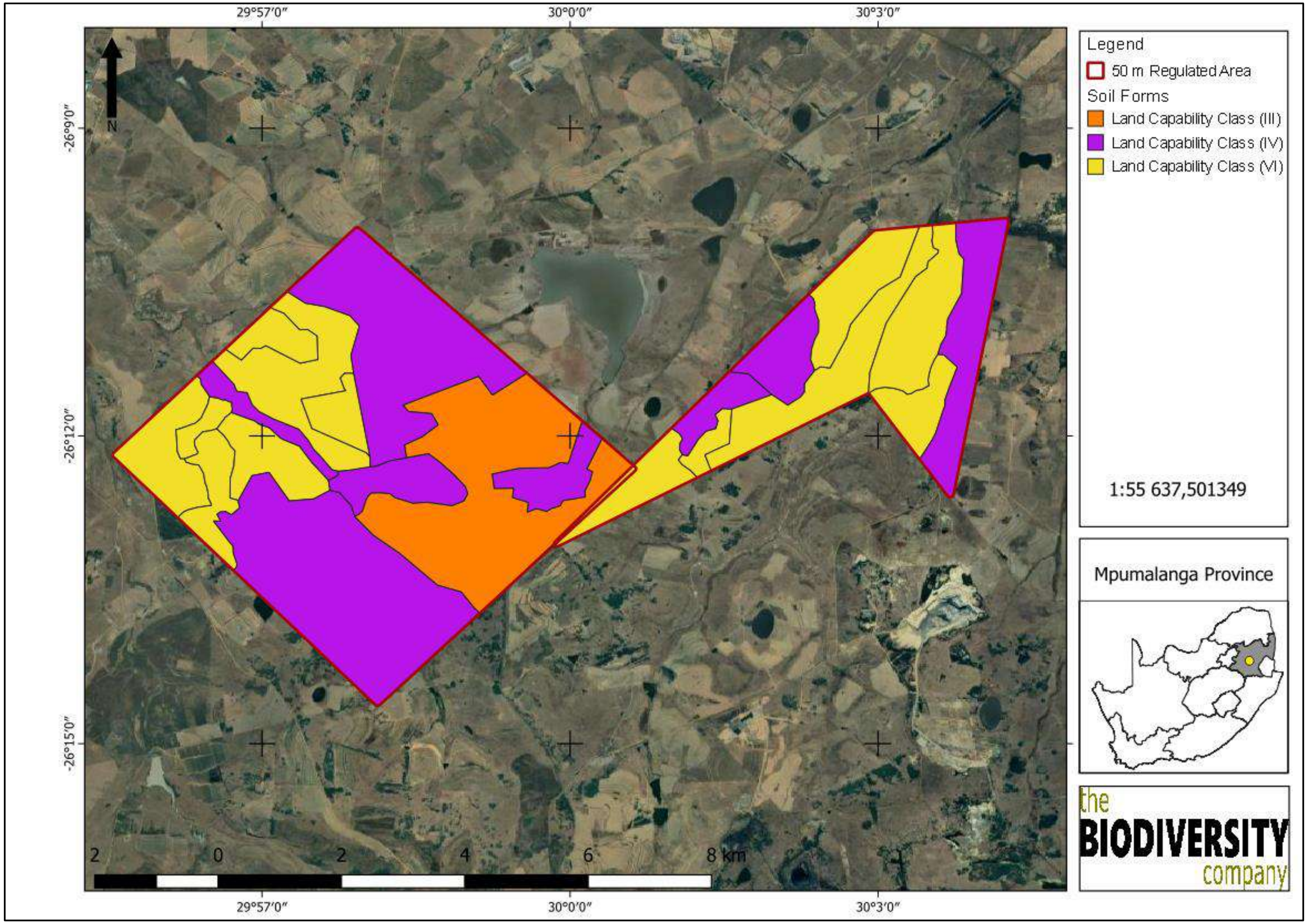

Figure 6-5 Land capability classes for the project area

6.2.3 Land Potential

The methodology in regard to the calculations of the relevant land potential levels are illustrated in Table 6-6 and Table 6-7. From the three land capability classes, two land potential levels have been determined by means of the Guy and Smith (1998) methodology. Land capability III and IV is similar to the DAFF, (2017) land capability V and VIII have both been reduced to a land potential L5 respectively. The land capability of VI has been reduced to a land potential of L6.

Figure 6-6 Land potential of the proposed study area.

Table 6-6 Land potential from climate capability vs land capability (Guy and Smith, 1998)

Land Capability Class	Climatic Capability Class							
	C1	C2	C3	C4	C5	C6	C7	C8
LC1	L1	L1	L2	L2	L3	L3	L4	L4
LC2	L1	L2	L2	L3	L3	L4	L4	L5
LC3	L2	L2	L2	L2	L4	L4	L5*	L6
LC4	L2	L3	L3	L4	L4	L5	L5*	L6
LC5	Vlei	Vlei	Vlei	Vlei	Vlei	Vlei	Vlei	Vlei
LC6	L4	L4	L5	L5	L5	L6	L6*	L7
LC7	L5	L5	L6	L6	L7	L7	L7	L8
LC8	L6	L6	L7	L7	L8	L8	L8	L8

*Land potential level applicable to climatic and land capability

Table 6-7 ***Land potential for the soils within the project area (Guy and Smith, 1998)***

Land Potential	Percentage	Description of Land Potential Class	Sensitivity
5	42.86%	**Restricted potential:** Regular and/or moderate to severe limitations due to soil, slope, temperatures, or rainfall.	Moderate
6	57.14%	**Very restricted potential**: Regular and/or severe limitations due to soil, slope, temperatures, or rainfall. Non-arable.	Low

6.2.4 Current Land Use

The project area consists of six different land uses, namely crop fields, mining, wetlands, natural veld, plantation and grazing lands (see Figure 6-7).

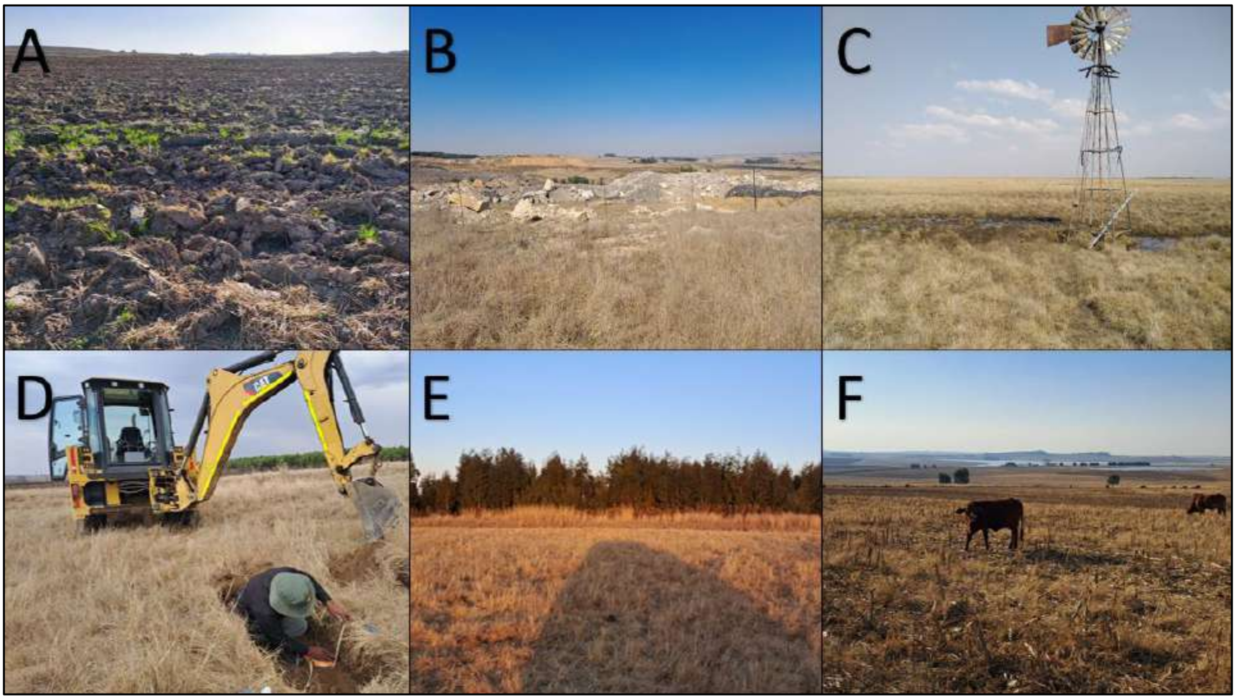

Figure 6-7 ***Land use identified within the project area. A) Crop fields, B) Mining (Disturbed area), C) Wetland, D) Natural veld, E) Plantation, F) Grazing land (livestock)***

7 Soil Chemical and Physical Properties

According to the Chamber of Mines South Africa/Coaltech (2007), one of the main objectives for rehabilitation is to restore the disturbed area back to the land capability conditions prior to mining activities. The land capability of the surrounding area has therefore been determined as the reference land capability. Additionally, samples were taken (see Figure 4-1) from the surrounding areas to be sent to the lab for fertility tests. These results will also be used as reference for post-rehabilitation targets. These reference conditions will assist the responsible party in the rehabilitation process. The reference conditions should be achieved during rehabilitation to ensure that the conditions prior to development be restored.

7.1 Soil Physical Properties

Physical properties are defined by particle size distribution (soil textural classes) which refers to the percentage clay, silt, and sand. All of the samples taken were sent for analysis. The average soil texture for all the soil samples is illustrated in Table 7-1.

Table 7-1 Results for physical properties for the sampled soils

Sample Site	Horizon	Clay %	Silt %	Sand %
1 (Glenrosa)	Topsoil	16	4	80
	Subsoil	16	8	76
2 (Cartref)	Topsoil	10	4	86
	Subsoil	16	8	76
	Subsoil	18	6	76
3 (Champagne)	Topsoil	16	8	76
	Subsoil	28	6	66
4 (Ermelo)	Topsoil	14	4	82
	Subsoil	20	8	72
7 (Tukulu)	Topsoil	10	10	86
	Subsoil	16	4	80
	Subsoil	22	6	72
10 (Inhoek)	Topsoil	26	8	66
	Subsoil	8	2	90
15 (Glenrosa)	Topsoil	8	8	84
	Subsoil	16	8	76

7.2 Soil Chemical Properties

Guidelines for relevant chemical properties are illustrated in Table 7-2, (Fertilizer Society of South Africa, 2007). The results from the chemical analysis are illustrated in Table 7-3. It is vital that the disturbed area be rehabilitated in such a way that not only the reference conditions be reached but that the recommended values described below be reached. This will ensure that vegetation can be established with greater ease and flourish.

Table 7-2 Guidelines for soil chemical properties

Guidelines (mg/kg)					
	Low Values			High Values	
Calcium (Ca)	<200			>3000	
Magnesium (Mg)	<50			>300	
Potassium (K)	<40			>250	
Phosphorus (Ph)	<5			>35	
Sodium (Na)	<50			>200	
pH (KCl)					
Very Acidic	Acidic	Slightly Acidic	Neutral	Slightly Alkaline	Alkaline
<4	4.0-5.9	6-6.7	6.8-7.2	7.3-8	>8
Phosphate (P) P bray 2 (mg/kg)					
Very Low	Low	Moderate	High	Very High	
0-8	9-15	16-20	21-30	>31	
Na:K ratio					
0.001-0.9	**>0.99**				

Table 7-3 Chemical property results from the surrounding land uses

Site	Horizon	Phosphorus (Bray 2) (mg/kg)	pH (KCl)	Exchangeable Cations **Na (mg/kg)**	**K (mg/kg)**	**Ca (mg/kg)**	**Mg (mg/kg)**	Na:K
1	A	4.1	4.4	0.07	0.18	1.6	0.67	0.39
	B	2.7	4.5	0.06	0.18	1.5	0.85	0.33
2	A	11.6	4.5	0.13	0.18	2.4	0.58	0.72
	B	2.6	4.1	0.05	0.10	0.32	0.17	0.5
	C	2.7	4.3	0.08	0.07	0.47	0.23	1.14
3	A	3.4	3.9	0.20	0.35	1.1	0.60	0.57
	B	2.2	3.9	0.19	0.20	0.79	0.88	0.95
4	A	<2.2	4.4	0.05	0.15	0.72	0.46	0.33
	B	<2.2	4.1	0.07	0.20	0.28	0.08	0.35
7	A	2.5	4.1	0.16	0.28	0.82	0.41	0.57
	B	<2.2	4.2	0.06	0.20	0.36	0.24	0.3
	C	5.6	4.3	0.09	0.40	0.20	0.48	0.23
10	A	2.3	4.1	0.17	0.48	3.5	2.1	0.35
	B	2.8	4.3	0.07	0.06	0.65	0.33	1.17
15	A	86.3	4.1	0.12	0.58	4.7	1.6	0.21
	B	24.8	4.0	0.05	0.22	0.78	0.50	0.23

Phosphorus (Bray 2)

According to the Fertilizer Handbook (Fertilizer Society of South Africa, 2007), the recommended phosphorus value will be between 16 mg/kg and 12 mg/kg, which is classified as moderate. Anything higher or lower than that will be defined as low or high.

All the sample sites within the project area are characterised by an unsuitable phosphorus level. Majority of the sampling sites within the project area are characterised by very low (<5) phosphorus levels. It is worth noting that sample site 2-A topsoil has been determined to have 11.6 mg/kg of phosphorus, which can be characterised as slightly moderate. However, sample site15-A topsoil and 15-B subsoil exhibited the highest phosphorus levels of 86.3 and 24.8 mg/kg respectively within the project area.

Plants use phosphorus as a source of energy used to assist the process of photosynthesis as well as respiration, (Hazelton & Murphy, 2007). Therefore, by increasing the phosphate levels by means of ameliorants and/or fertiliser, an increase in plant growth could be expected which will add significance to the rehabilitation process.

pH (KCl)

The recommended pH level will be between 6.8 and 7.2, (Fertilizer Society of South Africa, 2007). Reaching this value will be very difficult and, in some cases, impractical, therefore, it is recommended that a pH of at least 5.5 be reached seeing that this level of pH will decrease most of the risks involved with an acidic soil. Figure 7-1 indicates the pH level where nutrients become available. Acidic soils are characterised by nutrient deficiency and lacks organic matter, which is vital to healthy soil (Fertilizer Society of South Africa, 2007). The pH of the project site could and should be increased by applying relevant amounts of dolomitic lime to aim for a neutral level. A soil pH lower than 5 potentially could cause aluminium and manganese toxicity as well as calcium deficiency.

Sample sites 3-A topsoil and 3-B subsoil are classified as very acidic and are characterised with an unsuitable pH level. Even though acidic, the following samples are deemed suitable;

- Sample site 1-A (topsoil);
- Sample site 1-B (subsoil);
- Sample site 2-A (topsoil);
- Sample site 2-B (subsoil);
- Sample site 2-C (subsoil);
- Sample site 4-A (topsoil);
- Sample site 4-B (subsoil);
- Sample site 7-A (topsoil);
- Sample site 7-B (subsoil);
- Sample site 7-C (subsoil);
- Sample site 10-A (topsoil);
- Sample site 10-B (subsoil);
- Sample site 15-A (topsoil); and

- Sample site 15-B (subsoil).

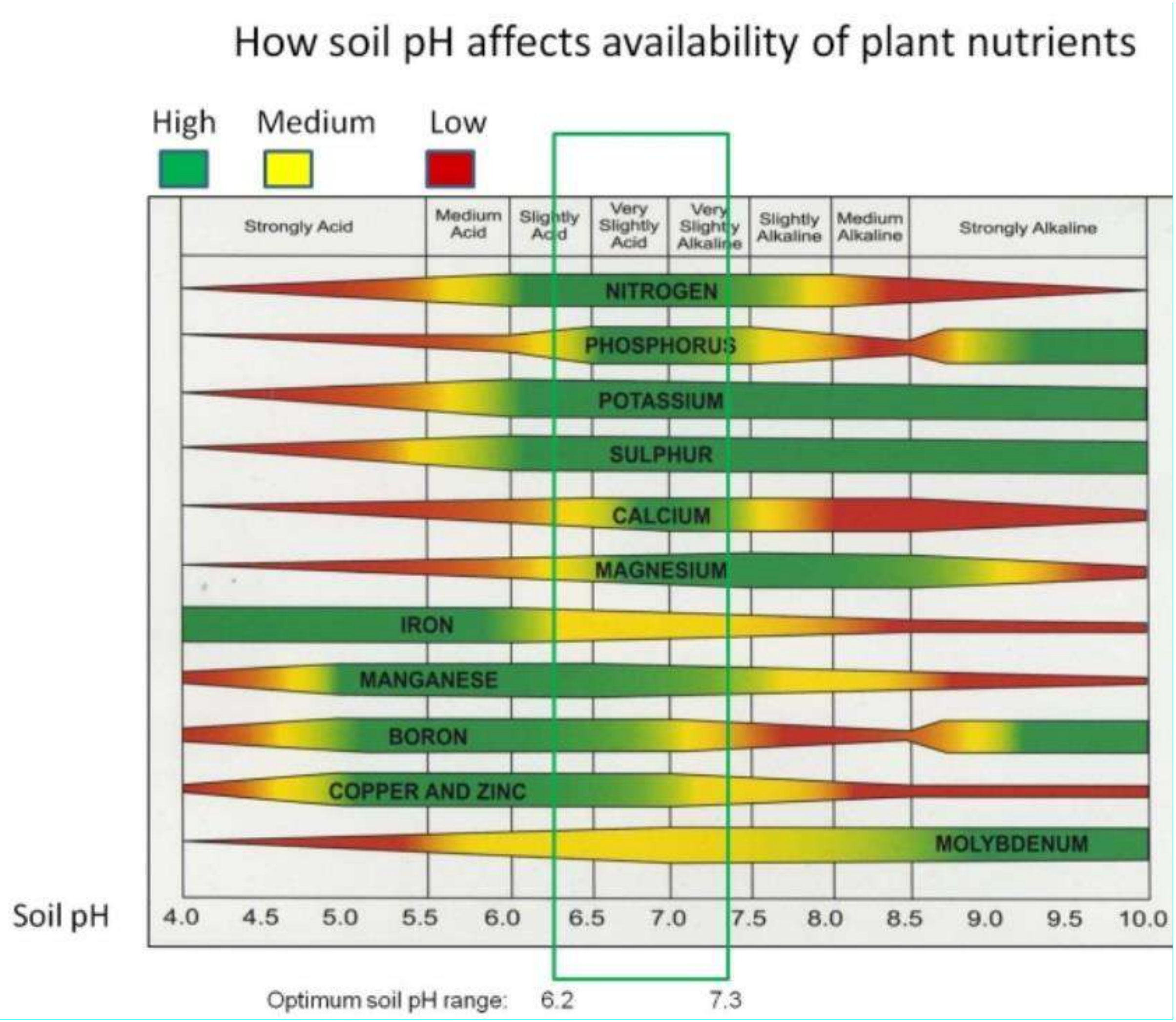

Figure 7-1 Indication of the nutrient availability at certain pH levels

Sodium (Na)

All the sample sites show low sodium concentrations. The recommended sodium concentration lies between 50 mg/kg and 200 mg/kg. It is however important to notice that the Na: K relationships for most samples are deemed suitable.

The following samples are characterised by unsuitable Na: K values;

- Sample site 2-C (subsoil); and
- Sample site 10-B (subsoil).

The sodium concentrations within soil should always be lower than potassium. If sodium levels exceed that of potassium, the sodium cations will replace that of potassium on a Cation Exchange Capacity (CEC) point of view seeing that plants require large amounts of potassium compared to other elements, (Fertilizer Society of South Africa, 2007).

Potassium (K)

The recommended potassium levels are between 40 mg/kg and 250 mg/kg, (Fertilizer Society of South Africa, 2007). Potassium is vital for healthy plant growth due to the integral role this element plays in the size, shape, strength, and colour of plants, (Fertilizer Society of South Africa, 2007). All the sample sites within the project area are deemed to have an unsuitable potassium that is below 1 mg/kg, characterised as very low.

Calcium (Ca)

According to (Fertilizer Society of South Africa, 2007) the recommended calcium levels range between 200 mg/kg and 3000 mg/kg. Calcium plays an integral part in rectifying acidity and is vital for plants as a basic need. Calcium should be present within the root zone for easy abstraction by roots and pods, (Fertilizer Society of South Africa, 2007). All the sample sites within the project area are deemed to have an unsuitable calcium that is below 3 mg/kg, characterised as very low.

Magnesium (Mg)

According to (Fertilizer Society of South Africa, 2007), the recommended magnesium concentrations range between 50 mg/kg and 300 mg/kg. All the sample sites within the project area are deemed to have an unsuitable magnesium that is below 2 mg/kg, characterised as very low.

8 Sensitivity Analysis

8.1 Methodology

This methodology includes the compilation of detailed shapefiles with specific attributes. Three main components form part of this methodology, namely;

- Feature layer;
- Overall sensitivity layer; and
- Legislative constraint layer.

All identified features will be rated according to the sensitivity of the feature as well as threats posed by proposed activities. These sensitivity rankings are described and illustrated in Table 8-1.

Table 8-1 Sensitivities relevant to the methodology

	Sensitivities				
	Least Concern	Low	Moderate	High	No-Go
Broad Class Description	The inherent feature status and sensitivity is already degraded. The proposed development will not affect the current status and/or may result in a positive impact. These features would be the preferred alternative for the project or infrastructure placement.	The proposed development will have not had a significant effect on the inherent feature status and sensitivity.	The proposed development will negatively influence the current status of the feature.	The proposed development will negatively significantly influence the current status of the feature.	The proposed development cannot legally or practically take place.
Scoring	0	1	2	3	+99

8.2 Feature Layer

Various soils forms have been identified within the mining boundaries, which all have been grouped into two main land potential levels, namely Land Potential level 5 and 6 (see Table 6-6). These features were used to determine the sensitivity of resources relevant to this assessment.

Figure 8-1 Feature layers within the mining boundaries

8.3 Overall Sensitivity

All features mentioned in Section 11.2- "Feature Layer" have been scored a sensitivity rating as per the EIMS and TBC methodology. All land potential categories will be impeded upon to some extent by the proposed mining activities (and ancillary infrastructure). The soil forms land potential identified in Figure 8-1 were related to the respectively sensitivities category themes in Figure 8-2.The land potential level 5 was scored to have a "Moderate" sensitivity. The land potential level 6 was scored "Low" sensitivities (least concern).

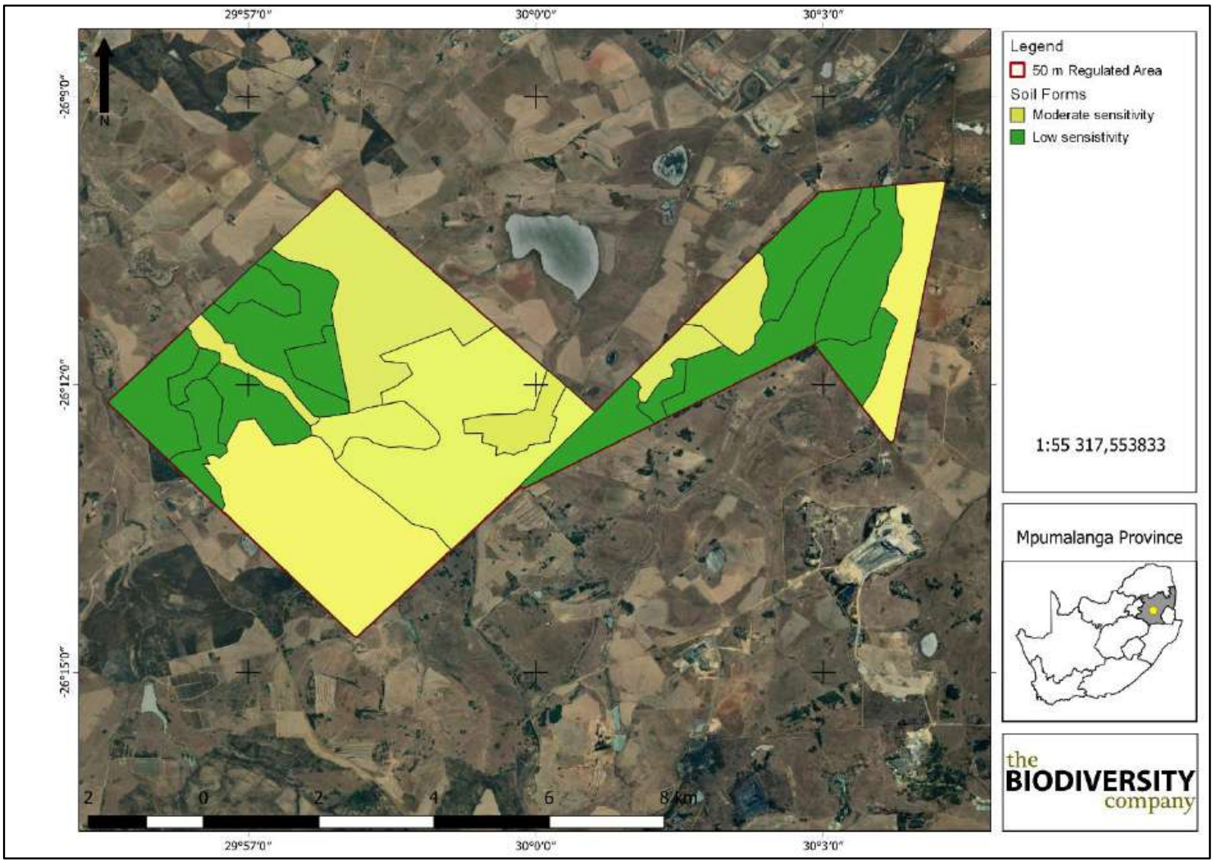

Figure 8-2 Overall sensitivity of identified Land potential features

8.4 Legislative Constraints

8.4.1 Land Capability Sensitivity

According to DAFF (2017), three sensitivity classes are located within the 50 m regulated area, namely "Very low to Low", "Low to Moderate", and "Moderate to High" (see Figure 8-3). It is therefore worth noting that the baseline findings corelates well with that of DAFF (2017).

Figure 8-3 Land capability sensitivity of the project area (DAFF, 2017)

8.4.2 Crop Boundary Sensitivity

A set of historic crop fields are illustrated by the DEA screening tool (2022) and have been classified as having "High" sensitivity (see *Figure 8-4*). The crop fields are characterised by all the identified soil forms within the project area except for the Cartref and Manguzi soil forms, which then constitutes (in this case) a land potential class of 5 to 6, which resembles "Restricted potential" to "Very restricted potential" conditions for cultivation.

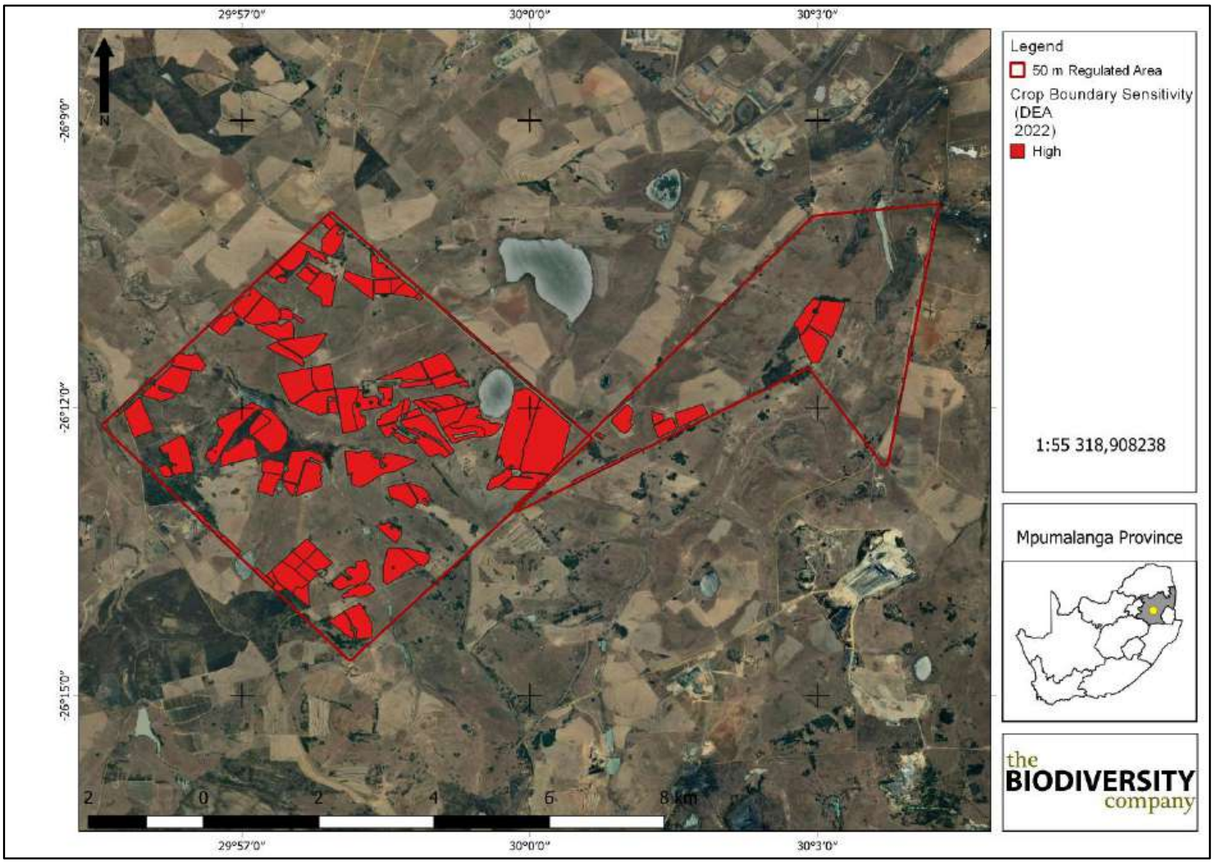

Figure 8-4 Crop boundary sensitivity (DEA Screening Tool, 2022)

9 Impact Assessment

Potential impacts were evaluated against the data captured during the fieldwork to identify relevance to the project area, specifically the proposed development footprint area. The relevant impacts were then subjected to a prescribed impact assessment methodology (Appendix C Impact and Risks Assessment Index).

9.1 Impact and Risk Assessment Methodology

The risk assessment was completed according to the consequence rating as illustrated based on Table 9-1.

Table 9-1 Impact assessment ratings

Aspect	Score	Criteria
Duration	7	Permanent
	6	Beyond project life
	5	Project Life
	4	Long term
	3	Medium term
	2	Short term
	1	Immediate
Extent	7	International
	6	National
	5	District
	4	County
	3	Local
	2	Site-specific
	1	Very limited
Intensity	-7	Extremely high - negative
	-6	Very high - negative
	-5	High - negative
	-4	Moderately high - negative
	-3	Moderate - negative
	-2	Low - negative
	-1	Very low - negative
	0	Negligible
	1	Very low - positive
	2	Low - positive
	3	Moderate - positive
	4	Moderately high - positive
	5	High - positive
	6	Very high - positive
	7	Extremely high - positive

Probability	7	Certain
	6	Highly probable
	5	Likely
	4	Probable
	3	Unlikely
	2	Improbable
	1	Highly unlikely
Significance	>-108	Major - Negative
	(-73) – (-108)	Moderate - Negative
	(-36) – (-72)	Minor - Negative
	(-1) – (-35)	Negligible - Negative
	1 - 35	Negligible – Positive
	36 – 72	Minor – Positive
	73 – 108	Moderate – Positive
	>108	Major - Positive

9.2 Alternatives Considered

No alternatives were considered in this assessment.

9.3 Agriculture Impact Assessment

9.3.1 Current impacts

The current impacts observed during surveys are listed below. Photographic evidence of a selection of these impacts is shown below.

- Water abstraction;
- Farm roads, Powerlines and mining roads (and associated traffic and wildlife road mortalities);
- Overgrazed agricultural lands;
- Erosion;
- Mining; and
- Vegetation removal.

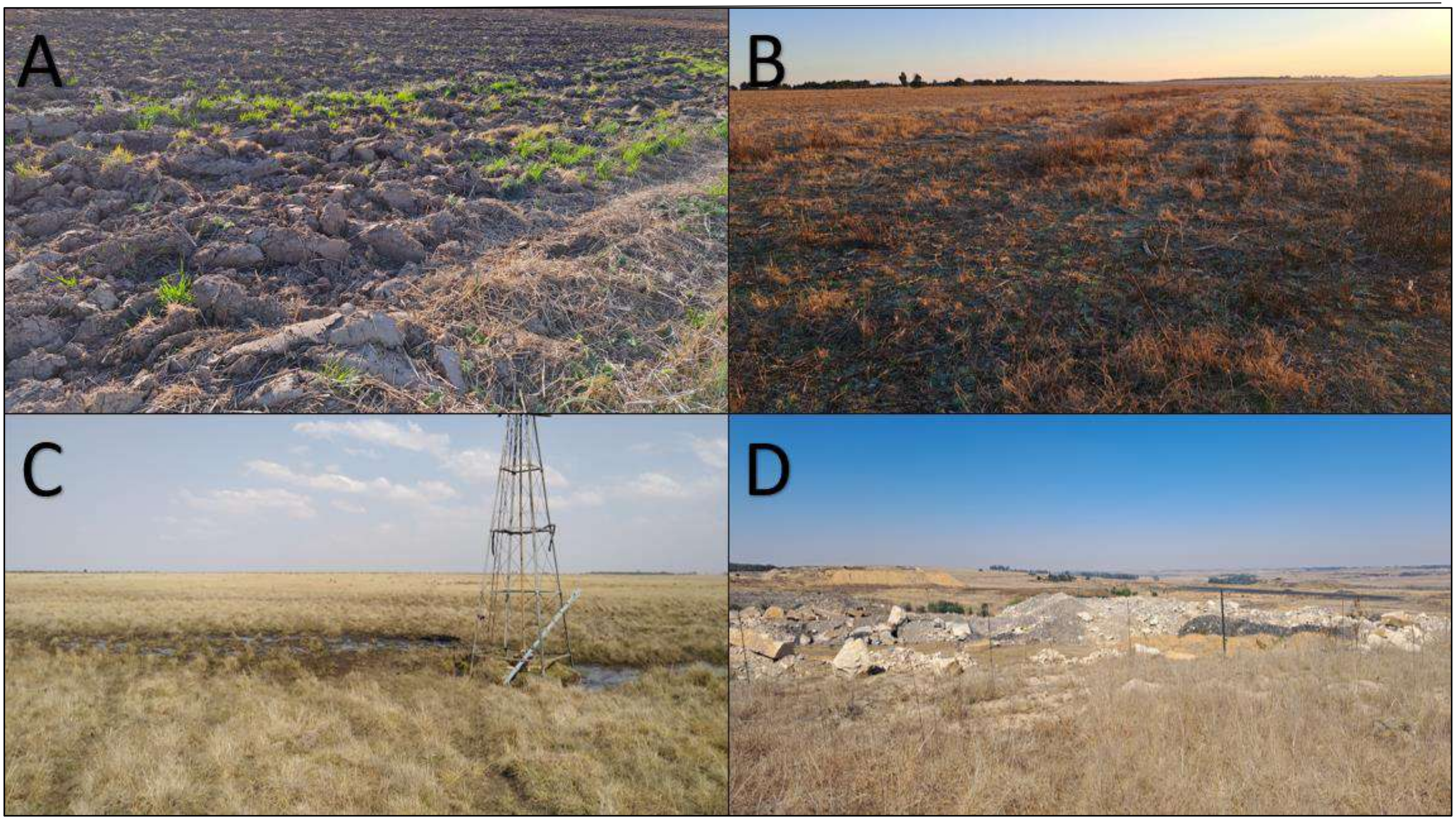

Figure 9-1 Current impacts observed during the field survey: A) Crop fields, B) Sheet erosion, C) Roads crossing through wetlands, and D) Open cast mine.

9.3.2 Initial Impact – No-go Scenario

It is anticipated that the proposed mining activities will have an adverse effect on the quality of the soil resources (combination of climatic conditions and soil properties). These impacts can be mitigated by means of intensive ongoing rehabilitation strategies, correct stripping, and stockpiling strategies as well as post-mining remediation. Benefits associated to the preservation can include retention of the current potential of the identified areas, minimum potential landowner engagement processes and evaluation of possible compensation scenarios. Nonetheless, due to the moderate to low land capability and restrictive land potential of the project area, no-go scenarios were not determined.

9.3.3 Proposed Layout

The proposed layout of the mining activities, as well as the extent of the existing active mining are presented in Figure 9-2. The figure provided below forms the only aspects considered in this impact assessment.

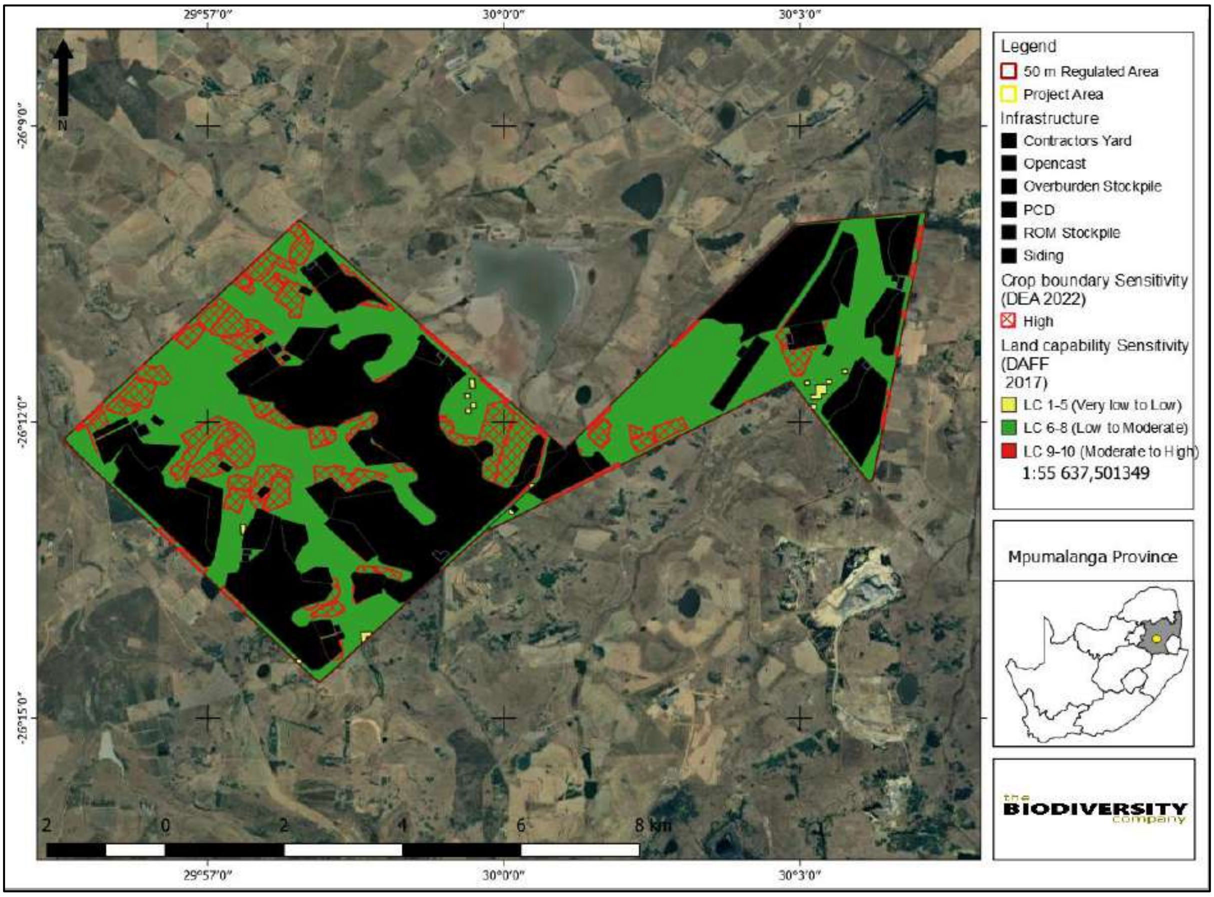

Figure 9-2 Layout of the proposed mining activities in relation to agricultural sensitivity

9.3.4 Anticipated Impacts

Table 9-2 presents the aspects anticipated for the proposed open cast mining operations as well as ancillary activities (contractor's yard, open cast, overburden stockpile, PCD, ROM stockpile and sliding).

Table 9-2 Anticipated impacts for the proposed open cast mining on agricultural resources

Main Impact	Project activities that can cause loss/impacts to habitat (especially with regard to the proposed infrastructure areas)	Secondary impacts anticipated

Loss of land capability	• Construction, operation and decommissioning of roads • Construction, operation and decommissioning of office space • Construction, operation and decommissioning of stockpiles • Construction and backfilling of open cast pits • Excavation of soil and mining resources • Water treatment • Processing activities; and • Mixing of soil	• Erosion; • Soil degradation; • Compaction; • Increase in salinity; • Land contamination; and • Loss of soil via aeolian processes.

9.3.5 Ancillary infrastructure (Offices and Workshops)

- The proposed mining area, contractor's yard, open cast, overburden stockpile, PCD, ROM stockpile and siding are all located within "Low to Moderate" sensitivity areas.

9.3.5.1 Planning Phase

The planning phase for the construction and operation of contractor's yard (offices and haul roads) will lead to compaction and erosion of soil resources due to increased traffic, which could result in the loss of land capability. Minimal disturbance will also occur to the land capability during the exploration drilling and borehole drilling planning phase.

It is however worth noting that limited impacts are expected for the planning phase of the ancillary infrastructure aspects. The pre- and post- mitigation significance ratings have been scored **"Negligible – Negative".**

Mitigation

- Limited mitigation is required given the fact that both the pre- and post- mitigation significance ratings have been scored "**Negligible – Negative**." Further mitigation is however detailed in Section 10 "Specialist Management Plan" to ensure the conservation of sensitive receptors.

9.3.5.2 Construction Phase

The construction phase for the proposed contractor's yard (office areas and haul roads) will lead to compaction and erosion of soil resources due to altered surface dynamics, the presence of hardened surfaces and general degradation of soil resources, which could result in the loss of land capability.

It is however worth noting that limited impacts are expected for the construction phase of the ancillary infrastructure aspects. The pre- and post- mitigation significance ratings have been scored **"Minor – Negative".**

Mitigation

- Limited mitigation is required given the fact that both the pre- and post- mitigation significance ratings have been scored "**Negligible – Negative**." Further mitigation is however detailed in Section 10 "Specialist Management Plan" to ensure the conservation of sensitive receptors, especially that pertaining to rehabilitation after decommissioning.

9.3.5.3 Operational Phase

The operational phase for the proposed contractor's yard (office areas and haul roads) will lead to compaction and erosion of soil resources due to altered surface dynamics, increased traffic, foot movement and the general presence of foundations, which could result in the loss of land capability.

It is however worth noting that limited impacts are expected for the operational phase of the ancillary infrastructure aspects. The pre- and post- mitigation significance ratings have been scored **"Negligible – Negative".**

Mitigation

- Limited mitigation is required given the fact that both the pre- and post- mitigation significance ratings have been scored "**Negligible – Negative**". Further mitigation is however detailed in Section 10 "Specialist Management Plan" to ensure the conservation of sensitive receptors, especially that pertaining to rehabilitation after decommissioning.

9.3.5.4 Decommissioning Phase

The decommissioning phase for the proposed contractor's yard (office areas and haul roads) will lead to compaction and erosion of soil resources predominantly due to increased traffic, demolition of buildings and other infrastructure etc. which could result in the loss of land capability.

It is however worth noting that limited impacts are expected for the decommissioning phase of the ancillary infrastructure aspects. The pre- and post- mitigation significance ratings have been scored **"Negligible – Negative".**

Mitigation

- Limited mitigation is required given the fact that both the pre- and post- mitigation significance ratings have been scored "**Negligible – Negative**." Further mitigation is however detailed in Section 10 "Specialist Management Plan" to ensure the conservation of sensitive receptors, especially that pertaining to rehabilitation after decommissioning.

9.3.5.5 Rehabilitation Phase

The rehabilitation phase for the proposed contractor's yard (office areas and haul roads) will lead to compaction and erosion of soil resources predominantly due to increased traffic associated with rehabilitation which could result in the loss of land capability.

It is however worth noting that limited impacts are expected for the rehabilitation phase of the ancillary infrastructure aspects. The pre- and post- mitigation significance ratings have been scored **"Negligible – Negative".**

Mitigation

- Limited mitigation is required given the fact that both the pre- and post- mitigation significance ratings have been scored "**Negligible – Negative**." Further mitigation is however detailed in Section 10 "Specialist Management Plan" to ensure the conservation of sensitive receptors.

Table 9-3 Impact assessment for the proposed ancillary activities during the planning, construction, operation, decommissioning and rehabilitation phase

Code	Phase	Impact	Post-mitigation									
			Duration	Extent	Intensity	Probability	Significance	Duration	Extent	Intensity	Probability	Significance
Agriculture	Planning	Loss of land capability	Immediate	Very limited	Low - negative	Unlikely	Negligible - negative	Immediate	Very limited	Very low - negative	Improbable	Negligible - negative
Agriculture	Construction	Loss of land capability	Short term	Site-specific	Moderately high - negative	Likely	Minor - negative	Short term	Site-specific	Moderate - negative	Probable	Negligible - negative
Agriculture	Operational	Loss of land capability	Project life	Site-specific	Moderate - negative	Probable	Negligible - negative	Life term	Site-specific	Low - negative	Unlikely	Negligible - negative
Agriculture	Decommissioning	Loss of land capability	Medium term	Site-specific	Moderate- negative	Probable	Negligible - negative	Short term	Site-specific	Low - negative	Unlikely	Negligible - negative
Agriculture	Rehabilitation	Loss of land capability	Medium term	Site-specific	Very low - negative	Highly unlikely	Negligible - negative	Short term	Site-specific	Very low - negative	Highly unlikely	Negligible - negative

9.3.6 Stockpiling

- The proposed stockpiles are located within a “Low to Moderate” sensitivity areas.

9.3.6.1 Planning Phase

The planning phase for the construction and operation of stockpiles will lead to compaction and erosion of soil resources due to the increase of traffic.

It is however worth noting that limited impacts are expected for the planning phase of the stockpiles aspect. The pre- and post- mitigation significance ratings have been scored **“Negligible – Negative”.**

Mitigation

- Limited mitigation is required given the fact that both the pre- and post- mitigation significance ratings have been scored “**Negligible – Negative**”. Further mitigation is however detailed in Section 10 “Specialist Management Plan” to ensure the conservation of sensitive receptors.

9.3.6.2 Construction Phase

The construction phase for the proposed stockpiles will lead to compaction and erosion of soil resources due to altered surface dynamics, the increased volume of traffic (dump trucks in specific) and general degradation of soil resources, which could result in the loss of land capability.

It is however worth noting that limited impacts are expected for the construction phase of the stockpiles aspect. The pre- and post- mitigation significance ratings have been scored **“Negligible – Negative”**.

Mitigation

- Limited mitigation is required given the fact that both the pre- and post- mitigation significance ratings have been scored “**Negligible – Negative**”. Further mitigation is however detailed in Section 10 “Specialist Management Plan” to ensure the conservation of sensitive receptors, especially that pertaining to rehabilitation after decommissioning as well as best practice maintenance of stockpiles.

9.3.6.3 Operational Phase

The operational phase for the proposed stockpiles will lead to compaction and erosion of soil resources due to the sheer weight of the stockpiles, the slope of the stockpiles which will induce overland flow and increased traffic which could result in the loss of land capability.

It is however worth noting that some impacts are expected for the operational phase of the stockpiles aspect. The pre- and post- mitigation significance ratings have been scored **“Minor – Negative”** and **“Negligible – Negative”** respectively.

Mitigation

Some mitigation will be required given the fact that the pre- and post- mitigation significance ratings have been scored **“Minor – Negative”** and **“Negligible – Negative”** respectively. Further mitigation is detailed in Section 10 “Specialist Management Plan” to ensure the conservation of sensitive receptors, especially that pertaining to rehabilitation after decommissioning as well as best practice maintenance of stockpiles.

9.3.6.4 Decommissioning Phase

The decommissioning phase for the proposed stockpiles will lead to compaction and erosion of soil resources predominantly due to increased traffic which could result in the loss of land capability.

It is however worth noting that limited impacts are expected for the decommissioning phase of the ancillary infrastructure aspects. The pre- and post- mitigation significance ratings have been scored **"Negligible – Negative.**

Mitigation

- Limited mitigation is required given the fact that both the pre- and post- mitigation significance ratings have been scored "**Negligible – Negative**." Further mitigation is however detailed in Section 10 "Specialist Management Plan" to ensure the conservation of sensitive receptors, especially that pertaining to rehabilitation after decommissioning.

9.3.6.5 Rehabilitation Phase

The rehabilitation phase for the proposed stockpiles will lead to compaction and erosion of soil resources predominantly due to increased traffic associated with rehabilitation which could result in the loss of land capability.

It is however worth noting that limited impacts are expected for the rehabilitation phase of the stockpiles aspect. The pre- and post- mitigation significance ratings have been scored **"Negligible – Negative".**

Mitigation

- Limited mitigation is required given the fact that both the pre- and post- mitigation significance ratings have been scored "**Negligible – Negative**". Further mitigation is however detailed in Section 10 "Specialist Management Plan" to ensure the conservation of sensitive receptors.

Table 9-4 Impact assessment for the proposed stockpiling activities during the planning, construction, operation, decommissioning and rehabilitation phase

Code	Phase	Impact	Pre-mitigation						Post-mitigation					
			Duration	Extent	Intensity	Consequence	Probability	Significance	Duration	Extent	Intensity	Consequence	Probability	Significance
Agriculture	Planning	Loss of land capability	Immediate	Very limited	Very low - negative	Negligible	Unlikely	Negligible - negative	Immediate	Very limited	Very low - negative	Negligible	Improbable	Negligible - negative
Agriculture	Construction	Loss of land capability	Short term	Site-specific	Moderately high - negative	Slightly detrimental	Probable	Negligible - negative	Short term	Site-specific	Moderate - negative	Slightly detrimental	Unlikely	Negligible - negative
Agriculture	Operational	Loss of land capability	Medium term	Local	High - negative	Highly detrimental	Probable	Minor - negative	Beyond project life	Site-specific	Moderate - negative	Moderately detrimental	Unlikely	Negligible - negative
Agriculture	Decommissioning	Loss of land capability	Short term	Site-specific	Moderately high - negative	Slightly detrimental	Unlikely	Negligible - negative	Short term	Site-specific	Moderate - negative	Slightly detrimental	Improbable	Negligible - negative
Agriculture	Rehabilitation	Loss of land capability	Medium term	Site-specific	Moderate - negative	Slightly detrimental	Unlikely	Negligible - negative	Medium term	Site-specific	Low - negative	Slightly detrimental	Highly unlikely	Negligible - negative

9.3.7 Open Cast Mining

- The proposed open cast mining schedule and varying allocated mining stages of the different proposed pits areas are located within a "Low to Moderate" sensitivity area following the DEA Screening Tool, (2022) agricultural themes.

9.3.7.1 Planning Phase

The planning phase for the construction and operation of open cast mining areas will lead to compaction and erosion of soil resources due to increased traffic, which could result in the loss of land capability.

It is however worth noting that limited impacts are expected for the planning phase of the stockpiles aspects. The pre- and post- mitigation significance ratings have been scored **"Negligible – Negative".**

Mitigation

- Limited mitigation is required given the fact that both the pre- and post- mitigation significance ratings have been scored "Negligible – Negative". Further mitigation is however detailed in Section 10 "Specialist Management Plan" to ensure the conservation of sensitive receptors.

9.3.7.2 Construction Phase

The construction phase for the proposed open cast mining activity will lead to compaction and erosion of soil resources due to increased traffic, stripping activities and the general degradation of soil resources, which could result in the loss of land capability.

It is worth noting that some impacts are expected for the construction phase of the open cast mining activities, which predominantly relates to soil stripping activities. The pre- and post- mitigation significance ratings have been scored **"Moderate – Negative"** and **"Minor – Negative"** respectively**.**

Mitigation

- Significant mitigation is required to ensure a decrease in the final significance rating from "**Moderate – Negative**" to "**Minor – Negative**". Further mitigation is however detailed in Section 10 "Specialist Management Plan" to ensure the conservation of sensitive receptors, especially that pertaining to best practice soil stripping and stockpiling guidelines and recommendations.

9.3.7.3 Operational Phase

The operational phase for the proposed open cast mining activities will lead to the removal of soil resources together with bedrock, which will result in the loss of land capability to some extent.

It is worth noting that significant impacts are expected for the operational phase of the open cast mining aspects. The pre- and post- mitigation significance ratings have been scored **"Moderate – Negative"** and **"Minor – Negative"** respectively.

Mitigation

- Significant mitigation is required to ensure a decrease in the final significance rating from "**Moderate – Negative**" to "**Minor – Negative**". All mitigation measures and recommendations pertaining to open cast mining and the conservation of soil resources are detailed in Section 10 "Specialist Management Plan".

9.3.7.4 Decommissioning Phase

The decommissioning phase for the proposed open cast mining areas will lead to compaction and erosion of soil resources predominantly due to increased traffic relating to backfilling activities, which could result in the loss of land capability.

It is worth noting that some impacts are expected for the decommissioning phase of the stockpiling aspects. The pre- and post- mitigation significance ratings have been scored **“Minor – Negative”.**

Mitigation

- Mitigation measures are not expected to decrease the significance rating given the fact that both the pre- and post- mitigation significance ratings have been scored “**Minor – Negative**”. Further mitigation is however detailed in Section 10 “Specialist Management Plan” to ensure the conservation of sensitive receptors, especially that pertaining to best practice soil stockpiling and backfilling guidelines and recommendations.

9.3.7.5 Rehabilitation Phase

The rehabilitation phase for the proposed open cast mining areas will lead to compaction and erosion of soil resources predominantly due to increased traffic associated with rehabilitation which could result in the loss of land capability.

It is however worth noting that limited impacts are expected for the rehabilitation phase of the open cast mining aspects. Even though, the extent of most phases can have impacts to the surrounding area of due to effects like dust movement, sediment transportation, translocation, possible contaminates spill migrations towards water resources, busting vibrations and noise. However, the pre- and post-mitigation significance ratings have been scored **“Negligible – Negative”.**

Mitigation

- Limited mitigation is required given the fact that both the pre- and post- mitigation significance ratings have been scored “**Negligible – Negative**.” Further mitigation is however detailed in Section 10 “Specialist Management Plan” to ensure the conservation of sensitive receptors.

Table 9-5 Impact assessment for the proposed open cast mining activities during the planning, construction, operation, decommissioning and rehabilitation phase

Code	Phase	Impact	Pre-mitigation						Post-mitigation					
			Duration	Extent	Intensity	Consequence	Probability	Significance	Duration	Extent	Intensity	Consequence	Probability	Significance
Agriculture	Planning	Loss of land capability	Immediate	Very limited	Very low - negative	Negligible	Improbable	Negligible - negative	Immediate	Very limited	Very low - negative	Negligible	Highly unlikely	Negligible - negative
Agriculture	Construction	Loss of land capability	Long term	Local	Very High - negative	Highly detrimental	Certain	Moderate - negative	Medium term	Local	Moderate- negative	Highly detrimental	Highly Probable	Minor - negative
Agriculture	Operational	Loss of land capability	Long term	Local	Very high - negative	Highly detrimental	Certain	Moderate - negative	Medium term	Local	Moderate - negative	Highly detrimental	Highly probable	Minor - negative
Agriculture	Decommissioning	Loss of land capability	Medium term	Local	Moderately high - negative	Moderately detrimental	Probable	Minor - negative	Short term	Site - specific	Moderate - negative	Moderately detrimental	Probable	Minor - negative
Agriculture	Rehabilitation	Loss of land capability	Long term	Site - specific	Moderate - negative	Moderately detrimental	Unlikely	Negligible - negative	Long term	Site - specific	low - negative	Moderately detrimental	Unlikely	Negligible - negative

9.3.8 Unplanned Events

The following section focusses on those aspects that could be damaging towards soil resources but are unexpected considering that all mitigation measures and recommendations will be strictly adhered to. Table 9-6 illustrates potential aspects that could result in unplanned events.

Table 9-6 Summary of unplanned events for the project

Unplanned Event	Potential Impact	Mitigation
Hydrocarbon spills into the surrounding environment	Contamination of soil resources	A spill response kit must be available at all times. The incident must be reported on and if necessary, a pedologist must investigate the extent of the impact and provide rehabilitation recommendations.
General land contamination	Dust pollution, overland flow contamination and other potential inorganic contaminants could contaminate soil resources during the Life of Mine (LOM)	A post-mining rehabilitation strategy must be conducted which includes testing soil resources for inorganic contaminants
Acid Mine Drainage	Contamination of water and soil resources	The probability of AMD must be determined, if required, a suitable monitoring plan formulated and implemented

9.3.9 Cumulative Impact

The cumulative impact for the proposed mining area as well as its surroundings has been considered for this assessment. It is worth noting that large portions of high sensitivity soil resources (as per the DEA screening tool) have already been significantly modified. Therefore, it is the specialist's opinion that the cumulative impact towards soil resources is regarded to be moderate due to the associated land potential sensitivity ranging from low to moderate, with restricted potential for agriculture.

9.3.10 Irreplaceable Loss

It is the specialist's opinion that, if all best practice mitigation, rehabilitation, and monitoring guidelines be followed, the degradation and loss of soil resources can be minimised to an acceptable level. This statement is further backed by Chamber of Mines South Africa/Coaltech (2007), which mentions that soil resources that have been stockpiled for up to 20 years still proved a decent grow medium, if all stripping, stockpiling, remediation, monitoring and ongoing rehabilitation strategies are strictly adhered to.

9.3.11 Recommendations

The following recommendations are suggested:

- A 100 m soil survey grid must be implemented to acquire more accurate information regarding soil depth and distribution;
- A rehabilitation plan focussed on the ongoing rehabilitation and reseeding of stockpiles must be implemented; and
- A post-closure rehabilitation plan must be compiled taking into consideration the pre-mining baseline conditions stipulated in this report.

9.3.12 Potential Rehabilitation Targets

It is recommended that the land capability III and IV areas be rehabilitated back to "Arable" post-mining. This includes (Chamber of Mines of South Africa, 2007):

- Rehabilitated areas exceeding a depth of 0,6 m;
- The soil resources forming part of rehabilitated areas cannot be saline or sodic;
- The slope percentage must have a lower value than 2.0 after multiplying the slope percentage with the erodibility factor; and
- In using a nomograph, a nominal value of 1% organic matter should be used.

All land capability VI areas must be rehabilitated back to grazing, which include the following (Chamber of Mines of South Africa, 2007):

- Soil depth must be greater than 0,25 m.

Furthermore, it is recommended that the remediation take place aimed at reaching the current fertility of soils as much as possible.

10 Specialist Management Plan

The recommended mitigation measures and the respective timeframes, targets and performance indicators are presented in Table 10-2. The mitigations within this section have been taken into consideration during the impact assessment in cases where the post-mitigation environmental risk is lower than that of the pre-mitigation environmental risk.

The following recommendations have been made for the construction, operational, decommissioning and rehabilitation phase to ultimately ensure that closure is obtained within reasonable time after the life of mine (LOM).

10.1 Monitoring During the Construction Phase

The project area should be monitored by-annually for the soil disturbance (compaction and erosion) at areas earmarked for mining and supporting infrastructures. In incidents where soil compaction and/or erosion does occur, action plans should be implemented to apply mitigation measures.

10.2 Monitoring During the Operational Phase

Soil samples taken on site by a soil scientist in this report and sent to the lab for fertility tests before the operational phase should be used as soil baseline data at the rehabilitation stage. Therefore, soil analysis and sampling will not be necessary at this stage. The results will be used to compare soil fertility of the topsoil prior and after the operation phase of the mine, which will thereby conclude if any degradation of the soil's chemical properties did occur. Since soil erosion occurs due to surface disturbance, monitoring should take place annually up until the start of the decommissioning phase. A specialist should suggest mitigation measures thereafter to rectify any degradation.

10.3 Monitoring During the Decommissioning Phase

The project area should be monitored monthly for soil erosion. In cases where soil erosion does occur, action plans should be implemented to apply mitigation measures and to avoid these areas as much as possible in future.

10.4 Monitoring During the Rehabilitation Phase

Soil samples should be taken on site to the lab for fertility tests within the first month of rehabilitation. The results thereof should be compared to the results obtained as baseline data and after construction to conclude the findings of the change in the topsoil's chemical properties. Annual soil sampling post rehabilitation is applicable to arable post closure land uses, and not applicable to grazing land. Soil sampling at this stage must be informed by the level of vegetation cover established during the rehabilitation phase. The relevant specialist can suggest mitigation measures thereafter to rectify any degradation. Therefore, annual soil sampling should be carried out within the same season as the previous sampling in all the arable post closure land uses until closure is obtained.

Compaction and erosion should be monitored within the first month to gain knowledge of areas impacted upon during the decommissioning phase. Rehabilitation of these sites should take place by means of the rehabilitation guidelines provided. Thereafter, similar monitoring and the accompanied mitigation measures should be applied every six months until closure is obtained.

A post-mining land capability assessment should form part of a yearly monitoring program to assess the rehabilitated areas against the land capability targets set.

Table 10-1 Management actions including requirements for timeframes, roles, and responsibilities

Action plan				
Phase	**Management action**	**Timeframe for implementation**	**Responsible party for implementation**	**Responsible party for monitoring/audit/review**
Planning phase	Proper planning of mining sequences	At least 6 months prior to the implementation of soil stripping	Applicant	Applicant
	Acquire stripping and stockpiling guideline	At least 2 months prior to the implementation of soil stripping	Applicant	Applicant
	Acquire rehabilitation and monitoring plans	At least 2 months prior to the implementation of soil stripping	Applicant	Applicant
	Proper investigation into ideal locations for the construction of all the infrastructure on site	At least 5 months prior to the implementation of soil stripping	Applicant	Applicant
Construction	Bush clearing of all bushes and trees taller than one meter	This activity should be finished at least a week prior to any stripping of topsoil, the construction of the wash plant.	Applicant Contractor	Applicant Eco Environmental authority
	Assign and demarcate all access routes	This activity should be finished at least two weeks prior to any stripping of topsoil, the construction of stockpiles/discard dump and the construction of the wash plant.	Applicant ECO	Applicant Eco Environmental authority
	Stripping of topsoil	During the first month	Applicant ECO Contractor	Applicant Eco Environmental authority
	Stockpile the stripped soils in designated stockpile areas	During and after the soil stripping process.	Applicant ECO Contractor	Applicant Eco Environmental authority
	Vegetate these stockpiles according to the rehabilitation plan	During and after the completion of the stockpiles.	Applicant Contractor	Applicant Eco Environmental authority
Operation	Continuously monitor erosion on site	During the timeframe assigned for the Life of Mine (LOM).	Applicant	Applicant Eco Environmental authority
	Monitor compaction on site	During the timeframe assigned for the Life of Mine (LOM).	Applicant	Applicant Eco Environmental authority
Decommissioning	Assign proper storm water management plans	This activity would be part of the architectural layout during the construction phase. A site-based assessment should be carried out two months prior to the decommissioning phase to ensure that all storm water management plans are adequate.	Applicant ECO	Applicant Eco Environmental authority
	After the completion of the project the area is to be cleared of all infrastructure;	Within the first two months after the completion of the project.	Applicant ECO	Applicant Eco

			Contractor	Environmental authority
	The foundations to be removed.	Directly after the completion of the area clearance.	Applicant ECO Contractor	Applicant Eco Environmental authority
	Topsoil to be replaced for rehabilitation purposes;	After the completion of the foundation removal.	Applicant ECO Contractor	Applicant Eco Environmental authority
Rehabilitation and closure	All rehabilitated areas should be assessed for signs of compaction, fertility, and erosion.	Within the first month after the successful decommissioning of the area.	Applicant	Applicant Eco Environmental authority
	Annual soil sampling post rehabilitation is applicable to arable post closure land uses, and not applicable to grazing land. Soil sampling at this stage must be informed by the level of vegetation cover established during the rehabilitation phase;	Within the first month after successful rehabilitation as well as yearly for the next 5 years to ensure that a sustainable soil resource is established.	Applicant	Applicant Eco Environmental authority
	Compacted areas are to be ripped to loosen the soil structure and vegetation cover re-instated;	Monitoring compaction should take place every six months. In cases where compaction is identified, ripping should take place within the next month after detection.	Applicant	Applicant Eco Environmental authority
	If erosion occurs, corrective actions (erosion berms) must be taken to minimize any further erosion from taking place;	Monitoring erosion should take place every six months whilst monitoring for compaction. In cases where erosion is identified, relevant mitigation measures should take place within the next month after detection.	Applicant	Applicant Eco Environmental authority

Table 10-2 Mitigation measures including requirements for timeframes, roles, and responsibilities

Activity	Mitigation Measures	Phase	Time Frame	Responsible party for implementation	Monitoring party (frequency)	Target	Performance indicator (Monitoring tool
Relevant planning	• Proper planning of mining sequences; • Stripping and stockpiling guidelines; and • rehabilitation and monitoring plans.	Planning	Prior to kick-off of construction	Applicant	Applicant	Ensure compliance with relevant legislation	No legal directives Legal compliance audit scores (Legal register) (ECO Monthly Checklist/Report)
Site clearance and topsoil removal prior to the commencement of physical construction activities.	• Ensure proper storm water management designs are in place; • If any erosion occurs, corrective actions (erosion berms) must be taken to minimize any further erosion from taking place; • If erosion has occurred, topsoil should be sourced and replaced and shaped to reduce the recurrence of erosion; • Only the designated access routes are to be used to reduce any unnecessary compaction; • Compacted areas are to be ripped to loosen the soil structure; • The topsoil should be stripped by means of an excavator bucket, and loaded onto dump trucks; • Stockpiles must be kept to a maximum height of 12 m if space allows. Soil can be stockpiled to a height of 20m where it is absolutely necessary, keeping the 20m footprint as small as possible. • A soil fertility and post-mining land capability assessment must be done to address any compaction or fertility issues that may arise from the stockpiling (Post-rehabilitation).	Constructio n Operation	Ongoing	Applicant Contractor ECO	Contractors EO (Daily) Mine EO (Weekly) ECO (Monthly)	Ensure compliance with relevant legislation	No legal directives Legal compliance audit scores (Legal register) (ECO Monthly Checklist/Report)

	• Topsoil is to be stripped when the soil is dry, as to reduce compaction; • Bush clearing contractors will only clear bushes and trees larger than 1m the remaining vegetation will be stripped with the top 0.3 m of topsoil to conserve as much of the nutrient cycle, organic matter, and seed bank as possible; • The subsoil approximately 0.3 – 0.8 m thick will then be stripped and stockpiled separately; • The handling of the stripped topsoil will be minimized to ensure the soil's structure does not deteriorate significantly; • Compaction of the removed topsoil must be avoided by prohibiting traffic on stockpiles; • Stockpiles should only be used for their designated final purposes; and • The stockpiles will be vegetated (details contained in rehabilitation plan) in order to reduce the risk of erosion, prevent weed growth and to reinstitute the ecological processes within the soil. • Prevent any spills from occurring. Machines must be parked within hard park areas and must be checked daily for fluid leaks; • If a spill occurs, it is to be cleaned up immediately and reported to the appropriate authorities; • All vehicles are to be serviced in a correctly bunded area or at an off-site location; • Leaking vehicles will have drip trays place under them where the leak is occurring; and						

	• If there are leaks the pipelines must be repaired immediately.						
• **Operation and maintenance of the topsoil stockpiles.** • **Decommissioning; and** • **Rehabilitation of the Project area will be undertaken. includes the ripping of the compacted soil surfaces, spreading of topsoil and establishment of vegetation.**	• Ensure proper storm water management designs are in place; • If erosion occurs, corrective actions (erosion berms) must be taken to minimize any further erosion from taking place; • If erosion has occurred, topsoil should be sourced and replaced and shaped to reduce the recurrence of erosion; • Only the designated access routes are to be used to reduce any unnecessary compaction; • Compacted areas are to be ripped to loosen the soil structure and vegetation cover re-instated; • Implement land rehabilitation measures as defined in rehabilitation report. • Follow rehabilitation guidelines; • The topsoil should be moved by means of an excavator bucket, and loaded onto dump trucks; • Topsoil is to be moved when the soil is dry, as to reduce compaction; • After the completion of the project the area is to be cleared of all infrastructure; • The foundations to be removed; • Topsoil to be replaced for rehabilitation purposes; • The handling of the stripped topsoil will be minimized to ensure the soil's structure does not deteriorate; and • Stockpiles should only be used for their designated final purposes. • Prevent any spills from occurring. Machines must be parked within hardpark	Operation, Decommissioning and Rehabilitation.	Ongoing	Applicant Contractor ECO	Contractors EO (Daily) Mine EO (Weekly) ECO (Monthly)	Ensure compliance with relevant legislation	No legal directives Legal compliance audit scores (Legal register) (ECO Monthly Checklist/Report)

	areas and must be checked daily for fluid leaks; • If a spill occurs, it is to be cleaned up immediately and reported to the appropriate authorities; • All vehicles are to be serviced in a correctly bunded area or at an off-site location; • Leaking vehicles will have drip trays place under them where the leak is occurring; • Pipelines must be maintained; • Pipeline must be checked regularly for leaks; and • If there are leaks the pipelines must be repaired immediately.						
• **Rehabilitation of the Project area will be undertaken. includes the ripping of the compacted soil surfaces, spreading of topsoil and establishment of vegetation.** • **Post-closure monitoring and rehabilitation will determine the level of success of the rehabilitation, as well as to identify any additional measures that have to be undertaken to ensure that the mining area is restored to an adequate state. Monitoring will include soil fertility and erosion.**	• The rehabilitated area must be assessed once a year for compaction, fertility, and erosion; • Annual soil sampling post rehabilitation is applicable to arable post closure land uses, and not applicable to grazing land. Soil sampling at this stage must be informed by the level of vegetation cover established during the rehabilitation phase; • Compacted areas are to be ripped to loosen the soil structure and vegetation cover re-instated; • If erosion occurs, corrective actions (erosion berms) must be taken to minimize any further erosion from taking place; • If erosion has occurred, topsoil should be sourced and replaced and shaped to reduce the recurrence of erosion; and • Only the designated access routes are to be used to reduce any unnecessary compaction.	Rehabilitation, Closure, and monitoring	During monitoring	Applicant ECO Soil Specialist	ECO (Yearly) Soil Specialist (Yearly)	Ensure compliance with relevant legislation	No legal directives Legal compliance audit scores (Legal register) (ECO Monthly Checklist/Report)

10.5 General Stripping and Stockpiling Methodology

The following sections are based on the basic methodologies of soil stripping and stockpiling, it is worth noting that a thorough soil stripping guideline still must be compiled.

10.5.1 Soil Stripping

According to Chamber of Mines of South Africa (2007), soil stripping is deemed to be a key rehabilitation activity given the slow regeneration rate of soil. Successful soil stripping will ensure sufficient soil to use for backfilling and topsoil purposes, which is vital to rehabilitation. According to Chamber of Mines of South Africa (2007), it is vital to strip and stockpile the topsoil separately from that of the subsoil given the importance of topsoil in regard to fertility and seed bank. Soils with a substantial difference in physical properties also should be stockpiles separately, with the most common separations being based on topsoil, subsoil, and clay content (Chamber of Mines of South Africa, 2007).

10.5.2 Soil Stockpiling

According to Chamber of Mines of South Africa (2007), stockpiling must be minimised with direct soil replacements being the preferred alternative (if possible). Wherever stockpiling is the only feasible alternative, it is of the utmost importance that proper stockpile configuration and locations be focussed on. Soils stockpiles for up to 20 years provide a reasonable growth medium in cases where remediation is successfully carried out. Such remediation includes amelioration, irrigation, reseeding, tillage etc. (depending on the nature and properties of post-mining land capability and fertility). Regardless, it is essential that stockpiles be kept to a minimum, that stockpiling periods be kept short and that stockpiles be remanded as little as possible (Chamber of Mines of South Africa, 2007).

11 Conclusion

11.1 Baseline

Several soil forms were identified within the project area. The most sensitive soils in the assessment footprint area includes, the Avalon, Clovelly, Ermelo, Nkonkoni and Tukulu soil forms. All soils were classed as having land capability classes III, IV and VI. Majority of the soil forms within the project area falls within the land capability class VI, which is characterised by non-arable lands that are used for veld, pasture and afforestation.

The above-mentioned land capability classes were classified into two different land potential categories. The land capability class III and IV are both classified with a land potential 5. Land capability class VI is classified as a land potential level 6. These land potential levels have been determined by means of a combination of land capability (i.e., depths, clay percentage etc.) and climatic conditions. The L5 is characterised by "Restricted potential: Regular and/or moderate to severe limitations due to soil, slope, temperature or rainfall"; and L6 is characterised by "Very restricted potential: Regular and/or severe limitations due to soil, slope, temperatures or rainfall". The L5 and L6 land potentials are non-arable lands. The overall sensitivity of the assessment area can be categorised as "moderate" which also concurs with the agricultural themes for the DEA Screening Tool (2022).

11.2 Impact Statement

The impact assessment indicates a "Minor – Negative" post-mitigation significance rating for open cast mining during the construction, operational and decommissioning phase. It is the specialist's opinion that the degradation of soil resources is unavoidable, but manageable. Various mitigation measures pertaining to proper stripping and stockpiling strategies, reseeding of stockpiles, ongoing monitoring as well as ongoing rehabilitation have been described throughout this report to ensure such management. Furthermore, the findings from the impact assessment indicates "Negligible -Negative" impacts from the proposed ancillary and stockpile aspects.

Therefore, it is the specialist's opinion that the proposed mining activities may proceed on the condition that all mitigation measures and recommendations throughout this report be strictly adhered to (including meeting rehabilitation targets).

11.3 Potential Rehabilitation Targets

It is recommended that the land capability III and IV areas be rehabilitated back to "Arable" post-mining. This includes (Chamber of Mines of South Africa, 2007);

- Rehabilitated areas exceeding a depth of 0,6 m;
- The soil resources forming part of rehabilitated areas cannot be saline or sodic;
- The slope percentage must have a lower value than 2.0 after multiplying the slope percentage with the erodibility factor; and
- In using a nomograph, a nominal value of 1% organic matter should be used.

Land capability VI areas must be rehabilitated back to grazing, which include the following (Chamber of Mines of South Africa, 2007);

- Soil depth must be greater than 0,25 m.

Furthermore, it is recommended that the remediation take place aimed at reaching the current fertility of soils as much as possible.

12 References

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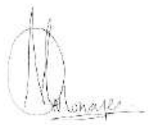
13 Appendices

13.1 Appendix A Specialist declarations

DECLARATION

I, Maletsatsi Mohapi, declare that:

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the competent authority; and the objectivity of any report, plan, or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of Section 24F of the Act.



Maletsatsi Mohapi

Soil Specialist

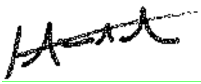
The Biodiversity Company

September 2022

DECLARATION

I, Andrew Husted, declare that:

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the competent authority; and the objectivity of any report, plan, or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of Section 24F of the Act.



Andrew Husted

Wetland Ecologist

The Biodiversity Company

September 2022

13.2 Appendix B Soil Results

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bemlab
A PathCare Company

sanas
Testing Laboratory
T0654

CERTIFICATE OF ANALYSIS

Client: The Biodiversity Company
Consultant: N/A
Address: 777 Peridot Street JUKSKEI PARK 2153
Phone: 0813191225
Contact: Andrew Husted
Email : info@thebiodiversitycompany.com

Report NO: SL2022-01721
No. of Samples: 16
Department: Soil
Condition: Cold

Delivery Date: 29/08/2022
Delivery Time: N/A
Order No/Ref: N/A

Block No.	Lab No.	Depth cm	Type *	pH	Resist. *	H+	P (Bray II)	K	Ex. cations (cmol(+)/kg)				Cu	Zn	Mn	B	Fe *	C	S Am.acet *
				KCl	(ohm)	cmol/Kg	mg/kg	mg/kg	Na	K	Ca	Mg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg
Site 1-A Horizon	SL22-19252	25	Sand	4.4	4650	1.26	4.1	71.5	0.07	0.18	1.6	0.67	1.3	0.71	60.1	0.48	78.9	1.48	6.6
Site 1-B Horizon	SL22-19253	38	Sand	4.5	4100	0.92	2.7	72.5	0.06	0.18	1.5	0.85	1.3	<0.36	31.8	0.59	53.1	1.30	7.8
Site 2-A Horizon	SL22-19254	15	Sand	4.5	2530	1.63	11.6	69.5	0.13	0.18	2.4	0.58	1.8	3.4	45.7	0.62	328	1.97	14.1
Site 2-B Horizon	SL22-19255	35	Sand	4.1	9530	1.49	2.6	41.3	0.05	0.10	0.32	0.17	1.0	<0.36	1.2	0.50	61.8	0.64	24.8
Site 2-C Horizon	SL22-19256	58	Sand	4.3	9770	0.98	2.7	29.1	0.08	0.07	0.47	0.23	0.68	<0.36	<0.52	0.36	41.8	0.52	22.8
Site 3-A Horizon	SL22-19257	34	Sand	3.9	2120	3.19	3.4	135	0.20	0.35	1.1	0.60	1.9	0.95	3.2	0.63	1030	2.41	28.9
Site 3-B Horizon	SL22-19258	70	Sand	3.9	5920	1.44	2.2	79.7	0.19	0.20	0.79	0.88	0.70	<0.36	1.0	0.38	29.6	0.50	33.4
Site 4-A Horizon	SL22-19259	64	Sand	4.4	6320	0.84	<2.2	57.2	0.05	0.15	0.72	0.46	0.49	<0.36	16.4	0.50	41.6	0.79	6.8
Site 4-B Horizon	SL22-19260	120	Sand	4.1	16090	1.29	<2.2	79.0	0.07	0.20	0.28	0.08	<0.33	<0.36	40.4	0.40	16.8	0.43	16.8
Site 7-A Horizon	SL22-19261	30	Sand	4.1	5640	1.76	2.5	108	0.16	0.28	0.82	0.41	0.97	<0.36	9.8	0.68	72.9	1.41	30.4
Site 7-B Horizon	SL22-19262	40	Sand	4.2	10230	1.34	<2.2	80.3	0.06	0.20	0.36	0.24	0.70	<0.36	1.2	0.47	58.5	0.82	12.1
Site 7-C Horizon	SL22-19263	120	Sand	4.3	10100	1.14	5.6	157	0.09	0.40	0.20	0.48	0.37	<0.36	15.2	0.46	12.7	0.24	48.9
Site 10-A Horizon	SL22-19264	30	Sand	4.1	1650	1.86	2.3	186	0.17	0.48	3.5	2.1	3.6	1.3	50.7	0.54	355	1.29	19.7
Site 10-B Horizon	SL22-19265	50	Sand	4.3	5020	0.80	2.8	24.0	0.07	0.06	0.65	0.33	0.60	<0.36	16.2	0.37	73.2	0.52	8.0
Site 15-A Horizon	SL22-19266	15	Sand	4.1	500	3.52	86.3	226	0.12	0.58	4.7	1.6	1.6	12.0	142	1.0	636	2.37	24.6
Site 15-B Horizon	SL22-19267	35	Sand	4.0	2480	1.79	24.8	85.4	0.05	0.22	0.78	0.50	1.0	0.82	8.9	0.72	225	0.90	15.5

Date Analysed: 30/08/2022   Date Analysis Completed:06/09/2022   Date Reported:06/09/2022   Page 1 of 6

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CERTIFICATE OF ANALYSIS

Client:	The Biodiversity Company	Report NO	SL2022-01721	Delivery Date	29/08/2022
Consultant	N/A	No. of Samples	16	Delivery Time	N/A
Address:	777 Peridot Street JUKSKEI PARK 2153	Department	Soil	Order No/Ref	N/A
Phone:	0813191225	Condition	Cold		
Contact:	Andrew Husted				
Email :	info@thebiodiversitycompany.com				

Base Saturation

Orchard	Lab No.	Na %	K %	Ca %	Mg %	T Value cmol/kg	Acid Sat. %
Site 1-A Horizon	SL22-19252	1.85	4.84	42.28	17.71	3.78	33.41
Site 1-B Horizon	SL22-19253	1.71	5.29	42.72	24.21	3.51	26.24
Site 2-A Horizon	SL22-19254	2.64	3.62	48.81	11.80	4.92	33.09
Site 2-B Horizon	SL22-19255	2.35	4.97	15.03	7.98	2.13	69.95
Site 2-C Horizon	SL22-19256	4.37	4.08	25.68	12.57	1.83	53.55
Site 3-A Horizon	SL22-19257	3.68	6.37	20.24	11.04	5.44	58.60
Site 3-B Horizon	SL22-19258	5.43	5.84	22.57	25.14	3.50	41.15
Site 4-A Horizon	SL22-19259	2.25	6.60	32.39	20.69	2.22	37.92
Site 4-B Horizon	SL22-19260	3.64	10.53	14.56	4.16	1.92	67.25
Site 7-A Horizon	SL22-19261	4.66	8.06	23.88	11.94	3.43	51.37
Site 7-B Horizon	SL22-19262	2.72	9.35	16.34	10.90	2.20	60.96
Site 7-C Horizon	SL22-19263	3.90	17.45	8.67	20.81	2.31	49.28
Site 10-A Horizon	SL22-19264	2.10	5.88	43.15	25.89	8.11	22.95
Site 10-B Horizon	SL22-19265	3.66	3.22	33.97	17.24	1.91	41.99
Site 15-A Horizon	SL22-19266	1.14	5.51	44.68	15.21	10.52	33.45
Site 15-B Horizon	SL22-19267	1.50	6.55	23.33	14.95	3.34	53.64

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Consultant	: N/A	No. of Samples	: 16	Delivery Time	: N/A
Address:	: 777 Peridot Street JUKSKEI PARK 2153	Department	: Soil	Order No/Ref	: N/A
Phone:	: 0813191225	Condition	: Cold		
Contact:	: Andrew Husted				
Email :	: info@thebiodiversitycompany.com				

Particle Size Analysis

Orchard	Lab No.	Depth cm	Stone * Vol %	Clay * %	Silt * %	Sand * %	Classification *
Site 1-A Horizon	SL22-19252	25	6.02	16.0	4.0	80.0	FINE SANDY LOAM
Site 1-B Horizon	SL22-19253	38	15.90	16.0	8.0	76.0	FINE SANDY LOAM
Site 2-A Horizon	SL22-19254	15	1.52	10.0	4.0	86.0	LOAMY FINE SAND
Site 2-B Horizon	SL22-19255	35	2.07	16.0	8.0	76.0	FINE SANDY LOAM
Site 2-C Horizon	SL22-19256	58	18.44	18.0	6.0	76.0	FINE SANDY LOAM
Site 3-A Horizon	SL22-19257	34	1.37	16.0	8.0	76.0	FINE SANDY LOAM
Site 3-B Horizon	SL22-19258	70	7.81	28.0	6.0	66.0	SANDY CLAY LOAM
Site 4-A Horizon	SL22-19259	64	2.39	14.0	4.0	82.0	FINE SANDY LOAM
Site 4-B Horizon	SL22-19260	120	1.43	20.0	8.0	72.0	SANDY CLAY LOAM
Site 7-A Horizon	SL22-19261	30	1.68	10.0	10.0	80.0	FINE SANDY LOAM
Site 7-B Horizon	SL22-19262	40	2.35	16.0	4.0	80.0	FINE SANDY LOAM
Site 7-C Horizon	SL22-19263	120	7.27	22.0	6.0	72.0	SANDY CLAY LOAM
Site 10-A Horizon	SL22-19264	30	5.06	26.0	8.0	66.0	SANDY CLAY LOAM
Site 10-B Horizon	SL22-19265	50	1.67	8.0	2.0	90.0	FINE SAND
Site 15-A Horizon	SL22-19266	15	1.99	8.0	8.0	84.0	LOAMY FINE SAND

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CERTIFICATE OF ANALYSIS

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Address: : 777 Peridot Street JUKSKEI PARK 2153
Phone: : 0813191225
Contact: : Andrew Husted
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Report NO : SL2022-01721
No. of Samples : 16
Department : Soil
Condition : Cold

Delivery Date : 29/08/2022
Delivery Time : N/A
Order No/Ref : N/A

Particle Size Analysis

Orchard	Lab No.	Depth cm	Stone * Vol %	Clay * %	Silt * %	Sand * %	Classification *
Site 15-B Horizon	SL22-19267	35	2.99	16.0	8.0	76.0	FINE SANDY LOAM

13.3 Appendix C Impact and Risks Assessment Index

Ancillary activities Phase

Extent of impact	Score	Construction	With mitigation	Operation	With mitigation	Decommissioning	With mitigation	Rehabilitation	With mitigation
International	7								
National	6								
District	5								
County	4	2	2	2	2	2	2	2	1
Local	3								
Site-specific	2								
Very limited	1								
Duration of impact	**Rating**								
Permanent	7								
Beyond project life	6								
Project Life	5								
Long term	4	**2**	1	5	4	3	2	3	2
Medium term	3								
Short term	2								
Immediate	1								
Consequence/Magnitude of impact Intensity	**Rating**								
Extremely high - negative	-7								
Very high - negative	-6								
High - negative	-5								
Moderately high - negative	-4								
Moderate - negative	-3								
Low - negative	-2								
Very low - negative	-1								
Negligible	0								
Very low - positive	1								
Low - positive	2	-4	-3	-3	-2	-3	-2	-3	-2

Extent of impact	Score	Construction	With mitigation	Operation	With mitigation	Decommissioning	With mitigation	Rehabilitation	With mitigation
Moderate - positive	3								
Moderately high - positive	4								
High - positive	5								
Very high - positive	6								
Extremely high - positive	7								
Probability of impact	**Rating**								
Certain	7								
Highly probable	6								
Likely	5								
Probable	4	**5**	4	4	3	4	3	4	3
Unlikely	3								
Improbable	2								
Highly unlikely	1								
Irreplaceable loss of resources?	**Rating**								
Yes	Yes								
No	No	Yes	No	No	No	No	No	No	No
Can impacts be mitigated?	**Rating**								
Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No	No								
Significance	**Rating**								
Major - Negative	>-108								
Moderate - Negative	(-73) – (-108)								
Minor - Negative	(-36) – (-72)								
Negligible - Negative	(-1) – (-35)	-36	-18	-27	-14	-24	-10	-24	-10
Negligible – Positive	1 - 35								
Minor – Positive	36 – 72								
Moderate – Positive	73 – 108								
Major - Positive	>108								

Open Cast Mining Phase

Extent of impact	Score	Construction	With mitigation	Operation	With mitigation	Decommissioning	With mitigation	Rehabilitation	With mitigation
International	7	3	2	3	2	3	2	2	2
National	6								
District	5								
County	4								
Local	3								
Site-specific	2								
Very limited	1								
Duration of impact	**Rating**	**4**	3	4	3	3	2	3	2
Permanent	7								
Beyond project life	6								
Project Life	5								
Long term	4								
Medium term	3								
Short term	2								
Immediate	1								
Consequence/Magnitude of impact Intensity	**Rating**	-6	-5	-6	-5	-4	-3	-3	-2
Extremely high - negative	-7								
Very high - negative	-6								
High - negative	-5								
Moderately high - negative	-4								
Moderate - negative	-3								
Low - negative	-2								
Very low - negative	-1								
Negligible	0								
Very low - positive	1								
Low - positive	2								
Moderate - positive	3								

Extent of impact	Score	Construction	With mitigation	Operation	With mitigation	Decommissioning	With mitigation	Rehabilitation	With mitigation
Moderately high - positive	4								
High - positive	5								
Very high - positive	6								
Extremely high - positive	7								
Probability of impact	**Rating**								
Certain	7								
Highly probable	6								
Likely	5	**7**	6	7	6	4	4	3	2
Probable	4								
Unlikely	3								
Improbable	2								
Highly unlikely	1								
Irreplaceable loss of resources?	**Rating**								
Yes	Yes								
No	No	Yes	No	No	No	No	No	No	No
Can impacts be mitigated?	**Rating**								
Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No	No								
Significance	**Rating**								
Major - Negative	>-108								
Moderate - Negative	(-73) – (-108)								
Minor - Negative	(-36) – (-72)								
Negligible - Negative	(-1) – (-35)	-80	-44	-85	-52	-48	-36	-27	-12
Negligible – Positive	1 - 35								
Minor – Positive	36 – 72								
Moderate – Positive	73 – 108								
Major - Positive	>108								

APPENDIX 8B: HYDROPEDOLOGICAL ASSESSMENT

HYDROPEDOLOGICAL ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED KRANSPAN MINING RIGHT EXTENSION PROJECT

Albert Luthuli Municipality, Mpumalanga Province, South Africa

September 2022

CLIENT

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1 Introduction

The Biodiversity Company was commissioned by ABS Africa (Pty) to conduct a hydropedological assessment for the proposed Kranspan Mining Right Extension Project that is situated on the farms Roodebloem 51 IT and Vaalbank 212 IS, near the town of Carolina in the Mpumalanga Province. This assessment was undertaken in collaboration with Digital Soils Africa.

Quantification of the impacts of land-use change on the environment change requires a clear and holistic identification and understanding of key hydrological drivers and flow paths of the system. Hydropedology is an interactive discipline focusing on landscape scale hydropedological processes in the vadose zone. Hydropedological assessments are used to conceptualise hydrological behaviour of landscapes (e.g., Ticehurst *et al*., 2007; van Tol *et al*., 2011; van Tol *et al*., 2013; Bouwer et al., 2015). This conceptualisation facilitates accurate hydrological model configuration (van Tol *et al*., 2015), to simulate land-use change more efficiently (van Zijl *et al*., 2016).

To understand and quantify the impact of land-use change requires more than an assessment of potential direct loss of resources e.g., loss of high potential soils. It should also address changes in dominant drivers and hence alterations in responses of the system – necessitating a hydropedological assessment. For a description of the value of hydropedological assessments see Van Tol *et al*., 2017 and for a full review of hydropedological research in South Africa see Van Tol, 2020.

1.1 Limitations

The following aspects were considered as limitations;

- Only the slopes and sub-basins affected by the proposed open cast mining area have been assessed;
- No surface impacts (i.e. haul roads, infrastructure, evaporation ponds, topsoil, overburden stockpiles etc) have been included into this report given the irrelevance of these components to a high level hydropedology assessment;
- It has been assumed that the open cast mining area provided to the consultant is correct;
- The GPS used for ground truthing is accurate to within five metres. Therefore, the wetland and the observation site's delineation plotted digitally may be offset by at up to five meters to either side;
- Geohydrological modelling was not part of the hydropedological assessments; and
- All hydropedological models were completed for the 'original' mining layout (dated July 2022) and it has not been deemed necessary to re-model hydropedological processes in the area, due to the reduction in mining area, albeit limited. The 'latest' mining layout (dated March 2023) comprises a reduced disturbance area, which includes a reduction in opencast mining areas.

2 Literature Review

2.1 Hydropedological Flow Paths

Given that hydropedology is a relatively new field, a short literature review has been added on this interdisciplinary research field. This literature is an excerpt from van Tol *et al.,* 2017.

Soil physical properties and hydrology play significant roles in the fundamentals of hydropedology. Physical properties including porosity, hydraulic conductivity, infiltration etc. determine micro preferential flow paths through a soil profile. The hydrology in turn is responsible for the formation of various morphological processes in soil, including mottling, colouration, and the accumulation of carbonate.

These processes are used to construct models illustrating sub-surface flow paths, storage, and interconnection between these flow paths. Hydropedology can therefore be used for a variety of functions. These functions include process-based modelling, digital soil mapping, pollution control management, impact of land use change on water resources, wetland protection, characterising ground and sub-surface flows as well as wetland protection and rehabilitation, of which the latter will be the main focus during this report (see Figure 2-1). The latter mentioned enables effective water resource management regarding wetlands and sub-surface flows in general.

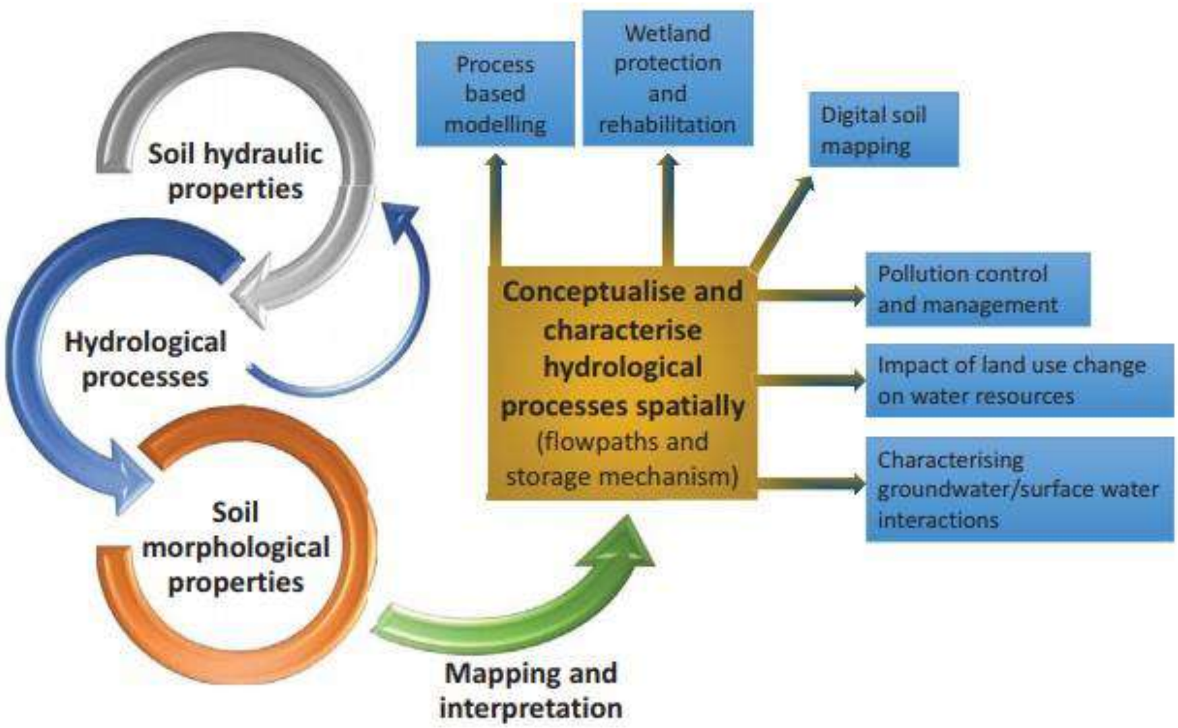

Figure 2-1 Illustration of the interactive nature of hydropedology and its potential applications (van Tol et al., 2017).

As can be seen in Figure 2-2, the hydropedological behaviour of soil types can differ significantly. Figure 2-2 (a) illustrates a typical red coloured soil (top- and sub-soil. This soil type will typically have a vertical flow path throughput the soil profile. Water will therefore infiltrate the topsoil and freely drain into the profile to such an extent that the water rapidly reaches the bedrock. After reaching this layer, water will penetrate the ground water source or be transported horizontally towards lower laying areas. This soil type is known as a recharge soil, given its ability to recharge ground and surface water sources.

Figure 2-2 (b) illustrates interflow soils. Lateral flows are dominant in this soil type and occurs due to differences in the hydraulic conductivity of soil horizons. The "sp" soil horizon restricts vertical movement and promotes lateral flows at the A/B interface. The lighter colour in this profile indicates leaching which is caused by lateral flows which often occurs on top of a bedrock layer due to the impermeable nature thereof. Mottles often occurs above this impermeable layer due to fluctuating water levels, see the magnified illustration in Figure 2-2 (b-i).

Figure 2-2 (c) illustrates responsive soils. This hydropedological soil type is characterised (in this case) by a dark top-soil and a grey coloured sub-soil. Other indicators include mottling and gleying. These soil types are saturated for very long periods. Therefore, rainfall is unlikely to infiltrate this layer and would likely be carried off via overland flow and are mostly fed by lateral sub-surface flows. Shallow soils are equally responsive in the sense that the soil profile will rapidly be saturated during precipitation, after which rainfall will be carried off by means of overland flows.

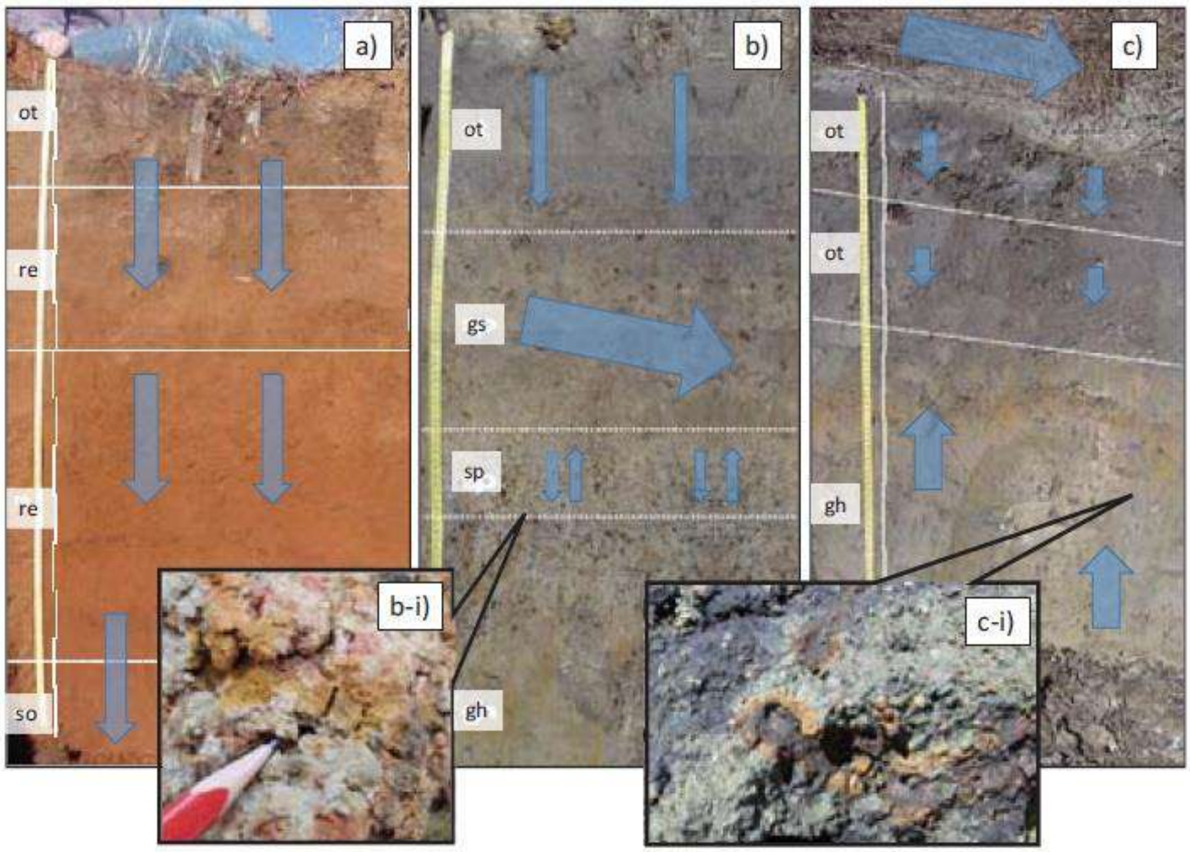

Figure 2-2 Illustration of different hydropedological soil types (van Tol et al., 2017).

A typical example of the hydropedological processes through a hillslope is illustrated in Figure 2-3. In this example, a recharge soil type is located at the upper reaches of the slope. Rainfall infiltrates this soil type and percolates vertically towards the bedrock. Water then, infiltrate into this bedrock given the permeability thereof and could now recharge groundwater or return to the soil in lower lying positions. The second soil type (the interflow zone) indicates lateral flows at the A/B interface and again at the soil/bedrock interface which feeds the responsive zone. The responsive zone is then simultaneously fed by lateral sub-surface flows and ground water recharge.

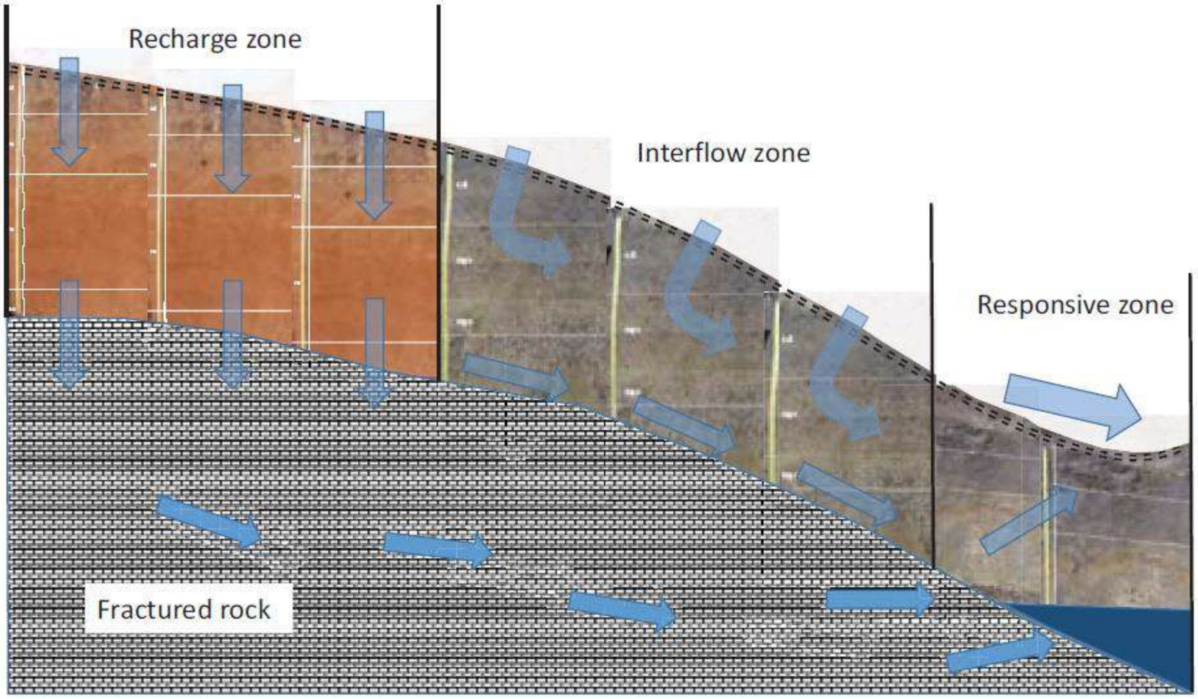

Figure 2-3 Theoretical example of various sub-surface flow paths (van Tol et al., 2017).

The methodology of van Tol *et al.,* (2017) has since been updated to include a "stagnant" hydropedological type. According to van *Tol et al.,* (2019), four different hydropedological types exist, namely Recharge, Interflow, Responsive and Stagnating hydropedological types. These soil types are divided into seven subgroups depending on the morphology of the relevant soil form. The latest addition to this methodology, as mentioned, is known as a stagnating hydropedological type.

This soil type is characterised by restrictive movement of water through profiles (both laterally and vertically) and is dominated by evapotranspiration. The A- and B-horizon of such a soil type usually has a high permeability with morphological indicators indicating very little movement through the profile. Lime and iron concretions as well as cementation of silica are typical indicators of such a soil form.

3 Project Description

The site is located southwest of Carolina and northwest of Chrissiesmeer in the Mpumalanga Province (Figure 3-1). Prospecting rights were obtained for two farms: Vaalbank and Roodebloem. Planned mining infrastructure includes 1748,5 ha of open cast mining, 16 ha of Mine Contractors Yard (Includes ablutions and water supply boreholes), 560 ha of Overburden Stockpiles (including topsoil stockpiles), 16 ha for Pollution Control Dams, 33 ha for ROM Stockpiles, 16 ha for the Coal Processing Plant (Dry Crush and Screening and Wash Plant) and Product Stockpile, 37,8 ha for Siding and about 17 ha for the Haul Roads (Figure 3-2).

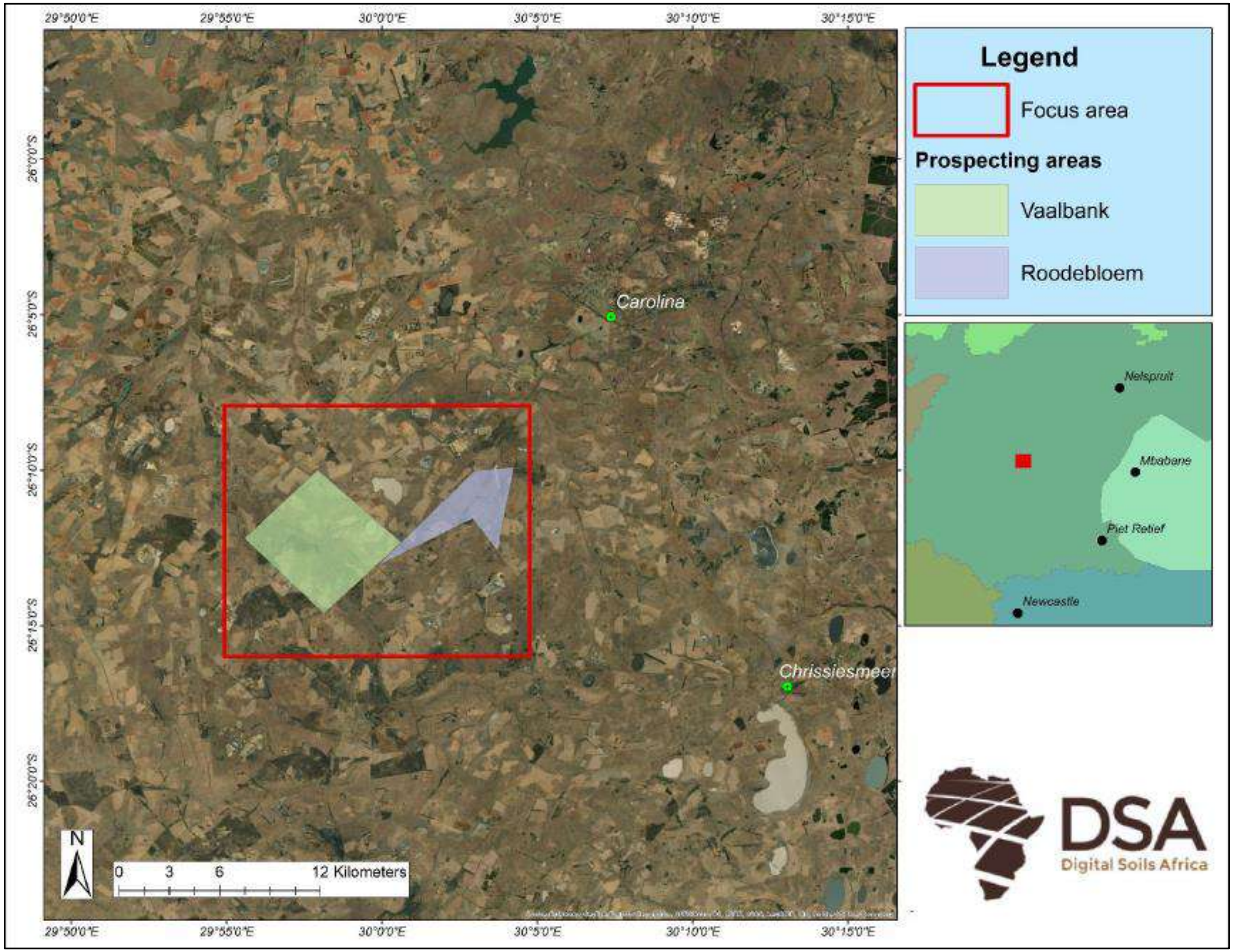

Figure 3-1 Locality map of the project area

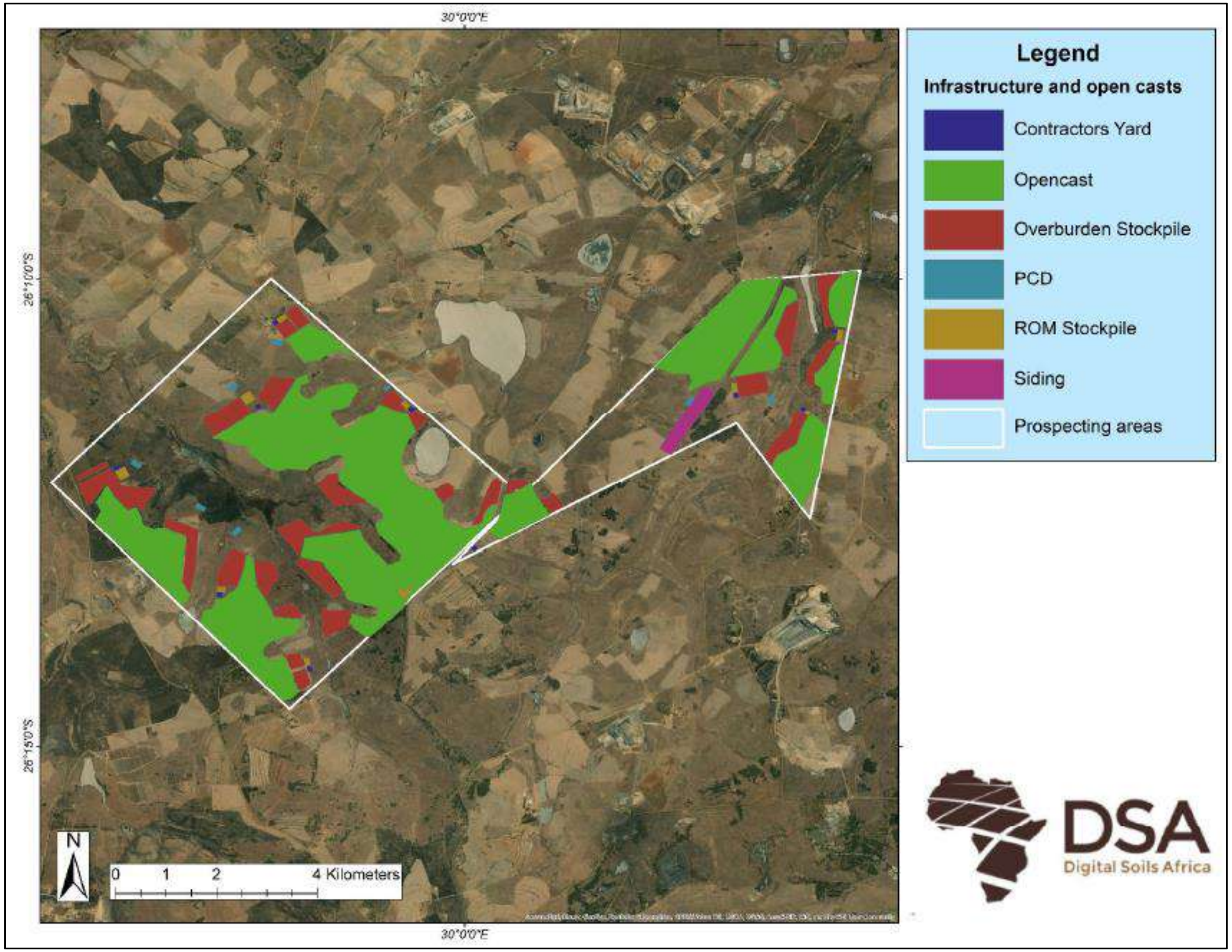

Figure 3-2 Layout of proposed open cast areas, stockpiles, and other development infrastructure.

The annual rainfall is approximately 700 mm per year (Schulze et al., 2007) and natural vegetation forms part of the Eastern Highveld Grassland of the Grassland Biome, with temperate wetland vegetation in and around the prospecting areas (Figure 3-3) (SANBI, 2006). Several other wetlands in and around the prospecting areas were identified following the National Freshwater Ecosystem Priority Areas (NFEPA, 2011) (Figure 3-4). Large parts of the natural vegetation have been converted to agriculture and mining (Figure 3-5). The geology forms part of the Ecca and Dwyka Groups of the Karoo Sequence and is mostly shale, shaly sandstone, grit, sandstone, and conglomerate. The lithology class is siliciclastic rocks (Figure 3-6).

The area drains from the planned mining area towards the northeast and northwest via two prominent drainage lines (Figure 3-7). The majority of the area is flat with relatively steep slopes occurring along the drainage channels (Figure 3-8). Terrain Units (TU) of the midslope i.e., TU3 and TU3(1) are dominant in the western and south parts of the site (Figure 3-9). TU3 is typically convex and TU3(1) more concave. In the north-eastern side, foot slope (TU4) positions are more frequent which could be an indication that wetlands will be more prominent in this area.

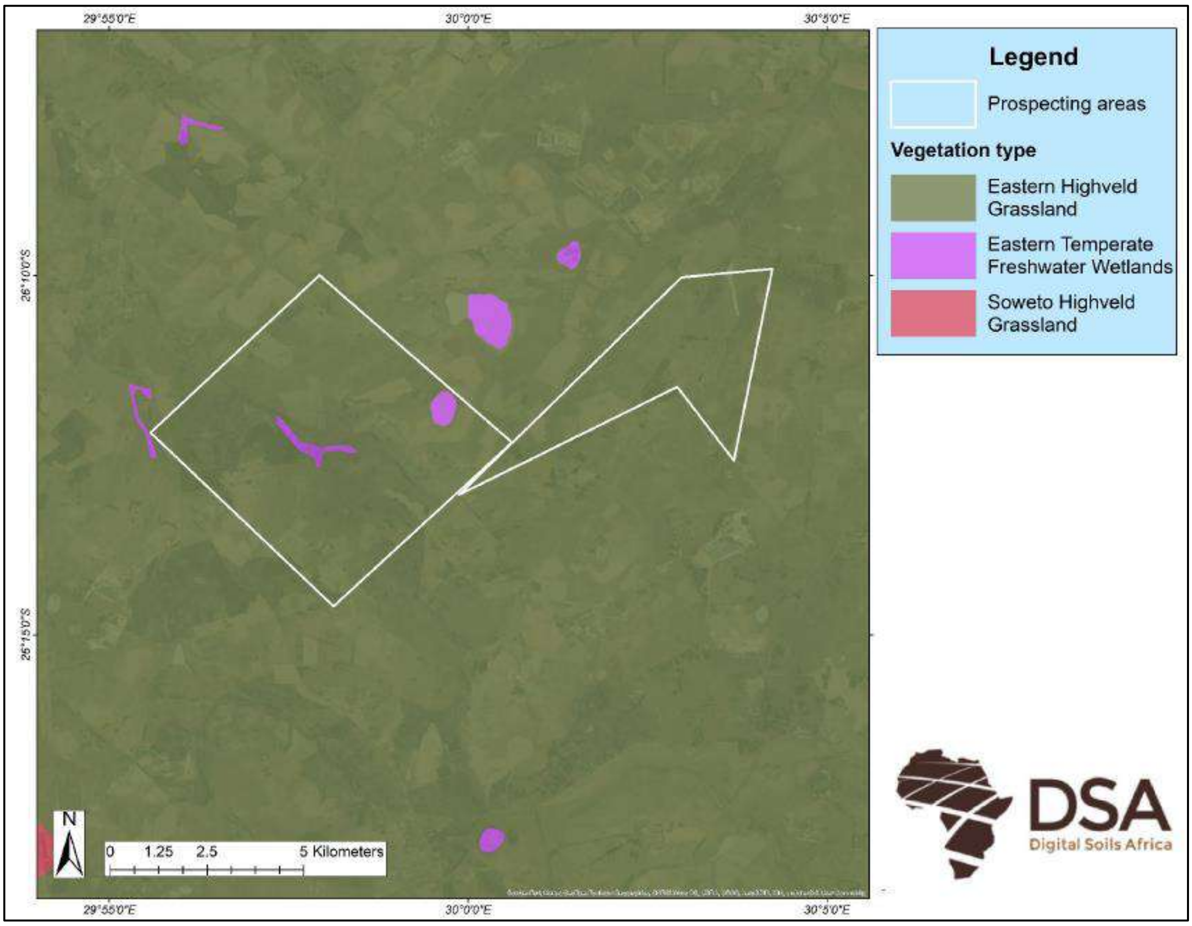

Figure 3-3 Vegetation of the study area (SANBI, 2006)

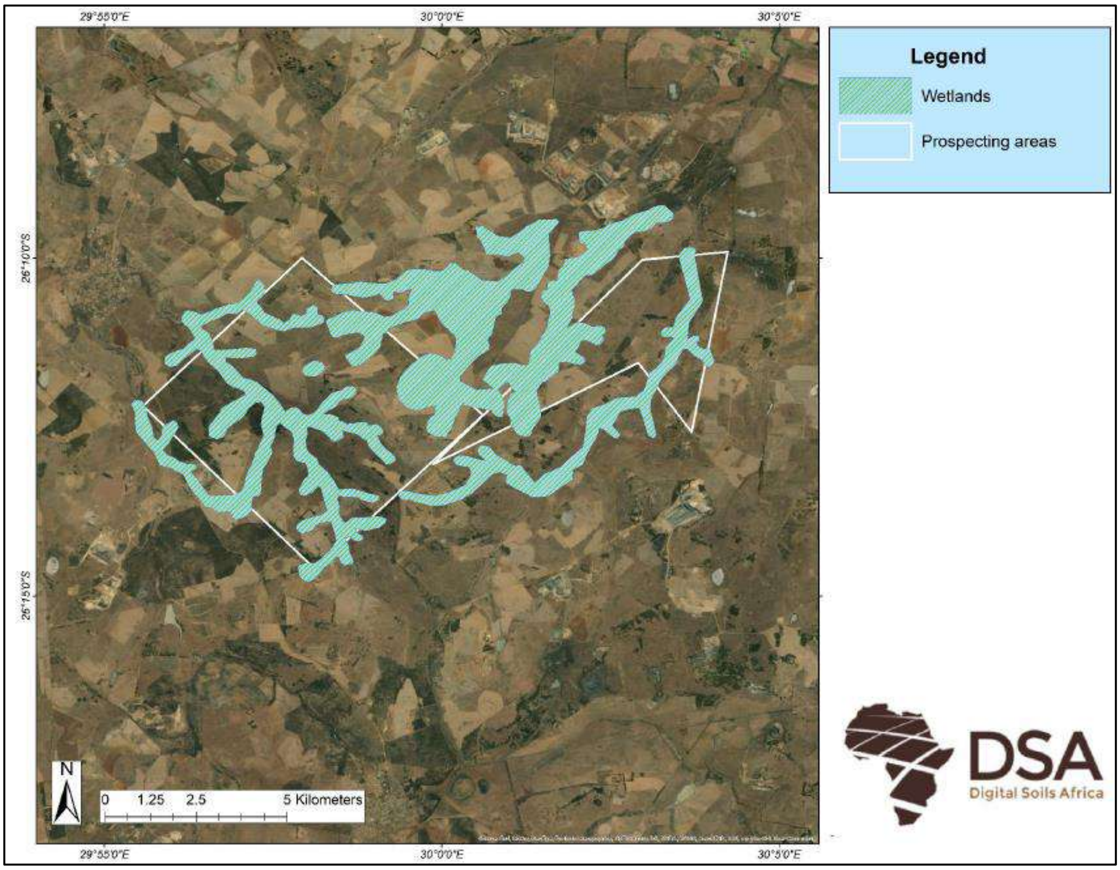

Figure 3-4 Preliminary wetlands and 100m buffers delineated

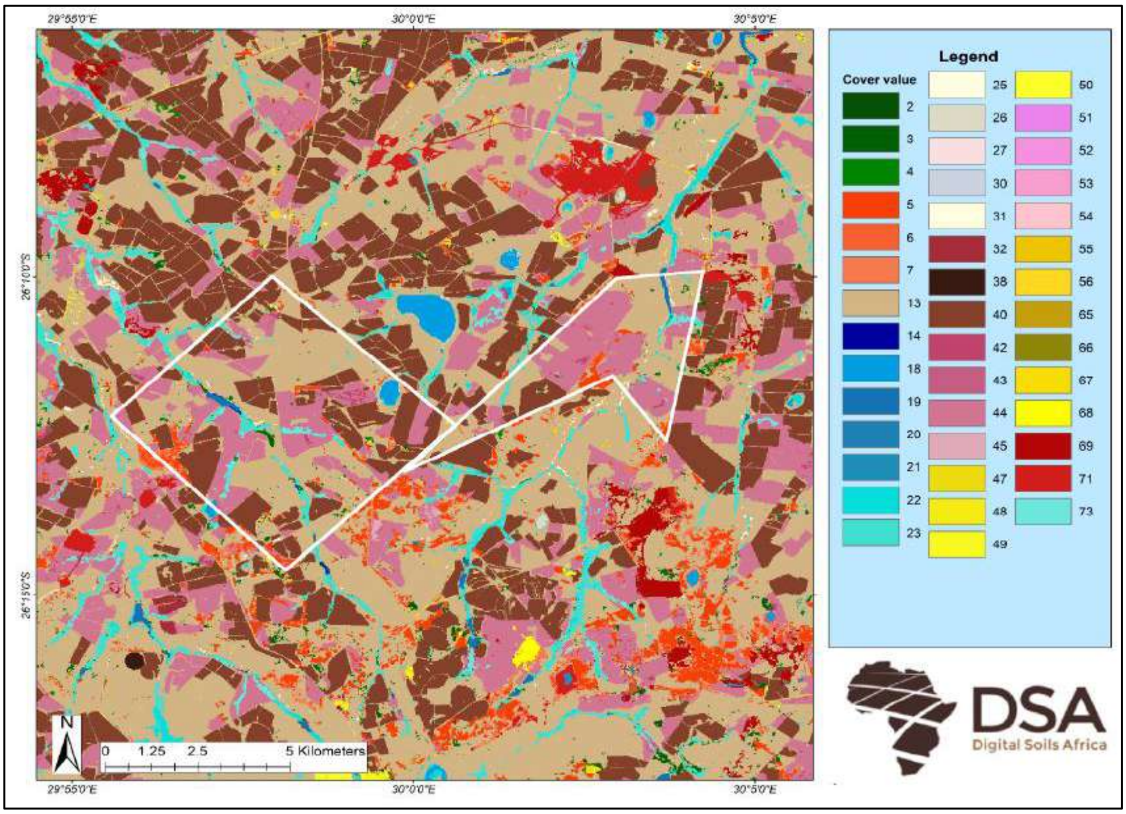

Figure 3-5 Dominant land cover classes on the site from the 2018 land cover (DFFE, 2018)

Table 3-1 Description of landcover classes in Figure 3-5

Value	Class Name	Value	Class Name	Value	Class Name	Value	Class Name
2	Contiguous low forest and thicket	21	Artificial flooded mine pits	40	Fallow land and old fields (trees)	54	Residential informal (bare)
3	Dense forest and woodland	22	Herbaceous wetlands	43	Fallow land and old field (bush)	55	Village scattered (bare and low vegetation / grass)
4	Open woodland	23	Herbaceous wetlands	44	Fallow land and old fields (grass)	56	Village dense (bare and low vegetation / grass)
5	Contiguous and dense plantation forest	25	Natural rock surfaces	45	Fallow land and old fields (bare)	65	commercial
6	Open and sparse plantation forest	26	Dry pans	47	Residential formal (tree)	66	Industrial
7	Temporary unplanned (clear-felled) plantation forest	27	Eroded lands	48	Residential formal (bush)	67	Roads and rails (major linear)
13	Natural grassland	30	Bare riverbed material	49	Residential formal (low vegetation / grass)	68	Mines: surface infrastructure
14	Natural rivers	31	Other bare	50	Residential informal (bare)	69	Mines: extraction pits, quarries
18	Natural pans (flooded at observation times)	32	Cultivated commercial permanent orchards	51	Residential informal (tree)	71	Mine: tailings and resources dumps
19	Artificial dams (including canals)	38	Commercial annual crops pivot irrigated	52	Residential informal (bush)	73	Fallow land and old fields (wetlands)
20	Artificial sewage ponds	40	Commercial annual crops rain-fed	53	Residential informal (low vegetation /grass)		

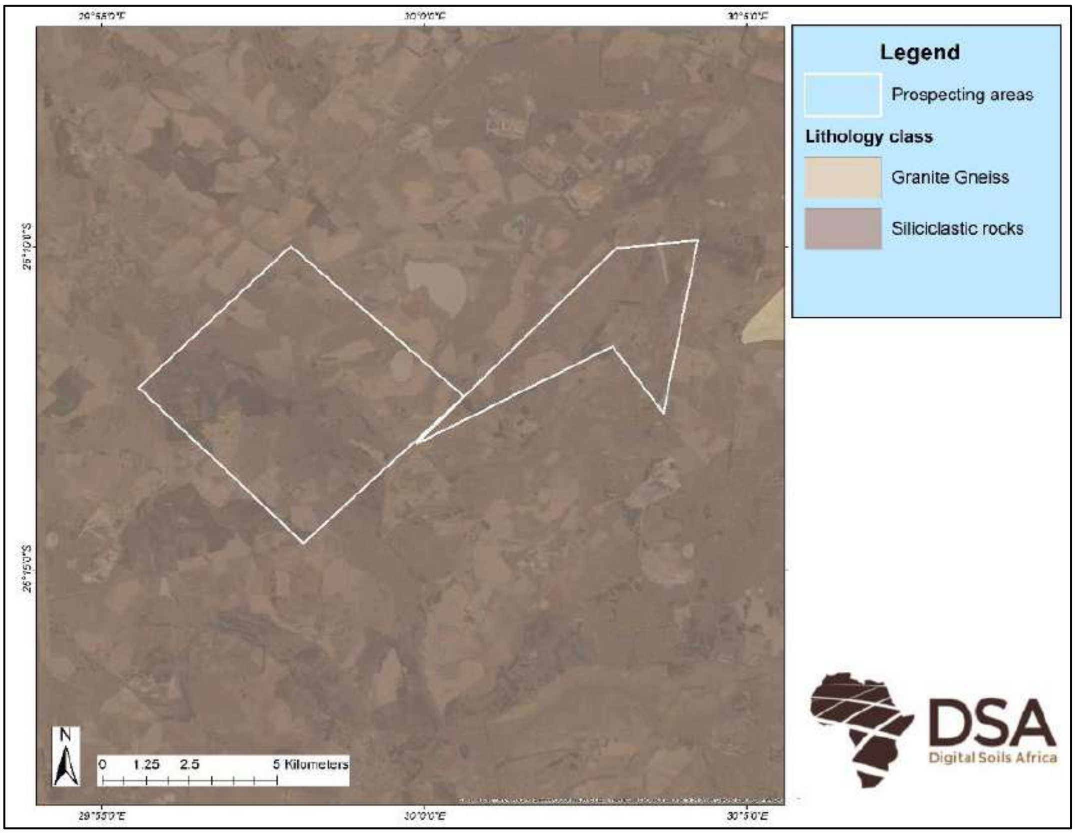

Figure 3-6 Lithology of the study area

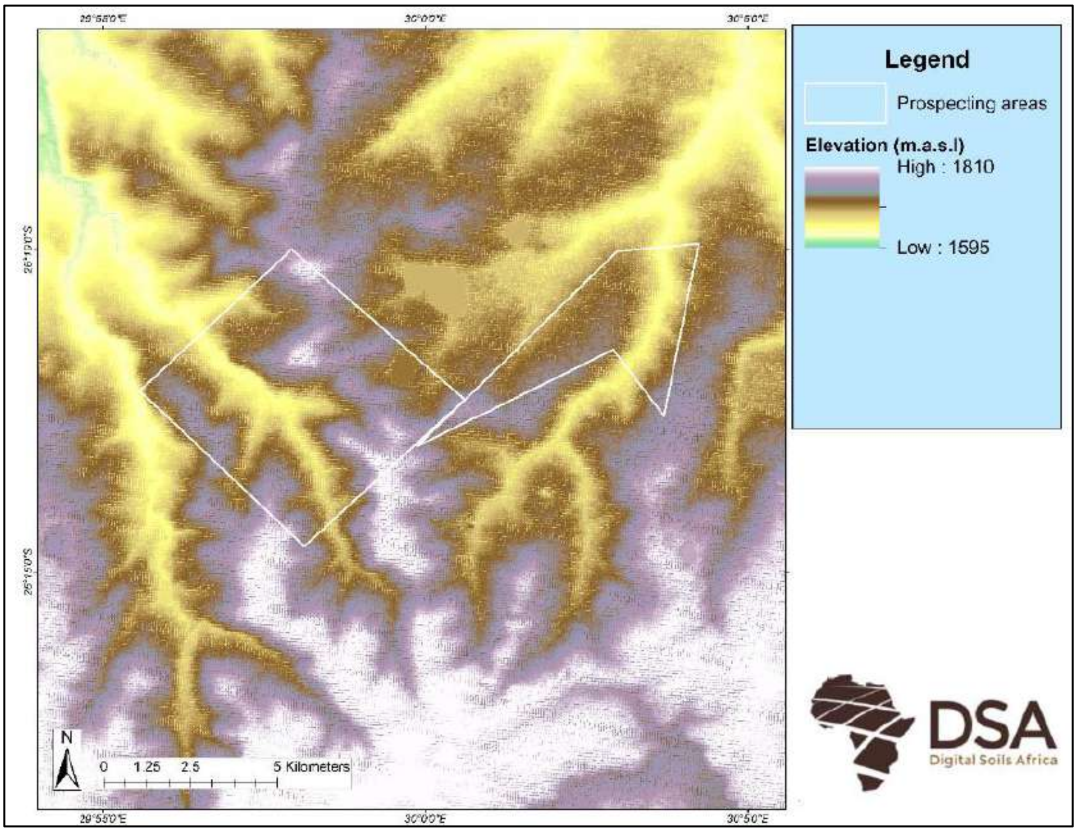

Figure 3-7 Elevation of the site from a 30 m STRM DEM

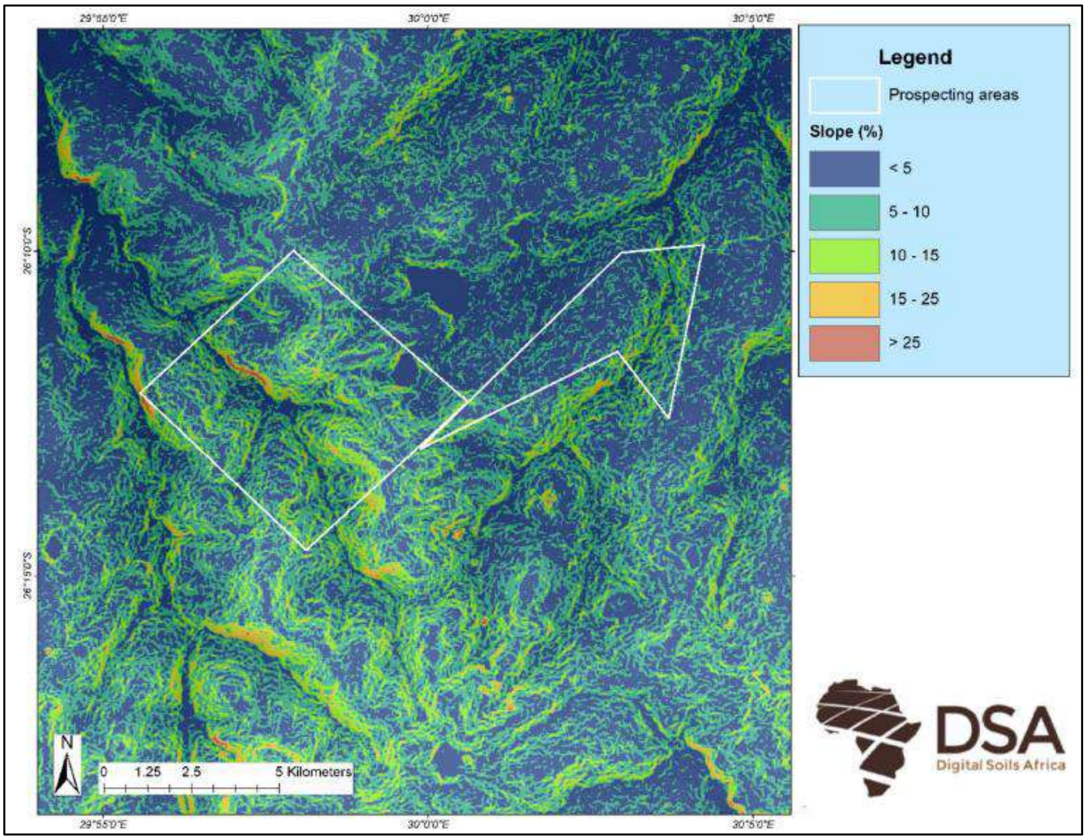

Figure 3-8 Slope (%) of the site, derived from a 30 m SRTM DEM

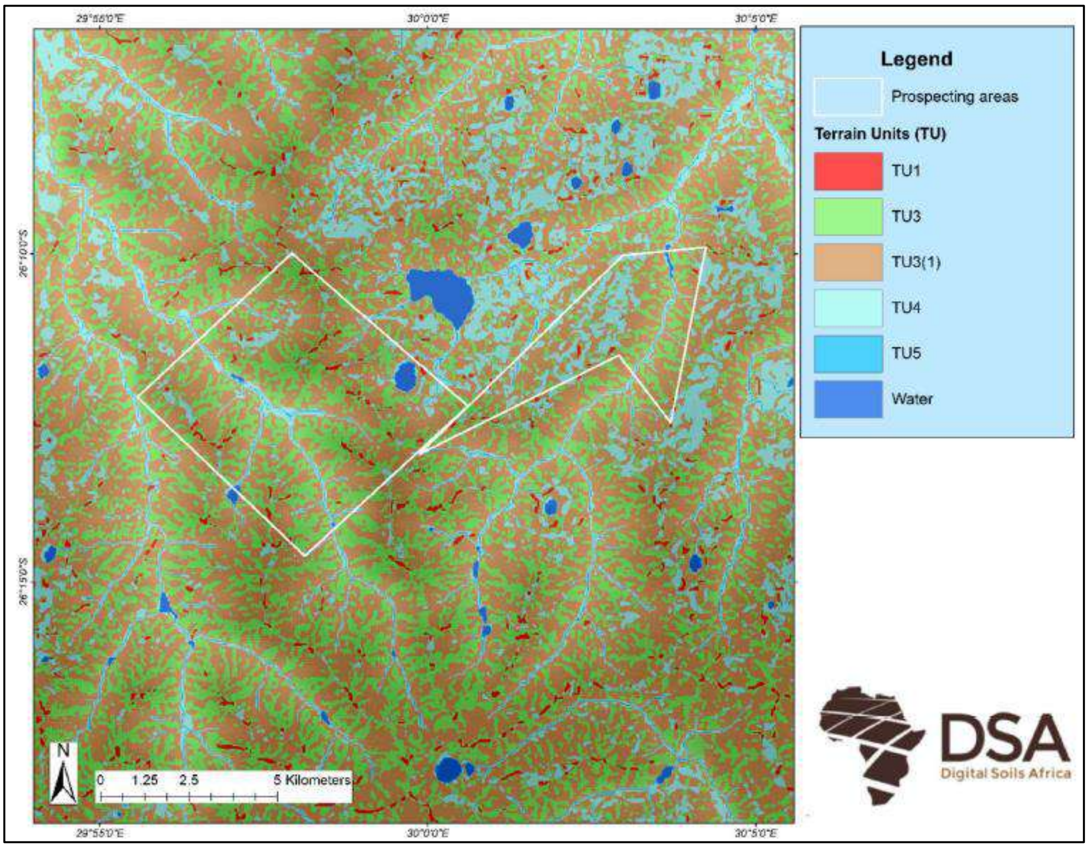

Figure 3-9 Terrain Units of the site (van der Berg, 2021)

4 Key Legislative Requirements

Currently, various pieces of legislation and related policies exist that guide and direct the land user in terms of land use planning both on a national and provincial level. This legislation includes, but is not limited to:

- The Constitution of the Republic of South Africa (Act 108 of 1996);
- Sub-division of Agricultural Land Act (Act 70 of 1970);
- Municipal Structures Act (Act 117 of 1998);
- Municipal Systems Act (Act 32 of 2000); and
- Spatial Planning and Land Use Management Act, 16 of 2013.

The above mentioned are supported by additional legislation that aims to manage the impact of development on the environment and the natural resource base of the country. Related legislation to this effect includes:

- Conservation of Agricultural Resources Act (Act 43 of 1983);
- Environment Conservation Act (Act 73 of 1989);
- National Environmental Management Act (Act 107 of 1998); and
- National Water Act (Act 36 of 1998).

4.1 National Environmental Management Act (Act No. 107 of 1998)

The National Environmental Management Act (NEMA) (Act 107 of 1998) and the associated Regulations as amended, states that prior to any development taking place within a wetland or riparian area, an environmental authorisation process needs to be followed. This could follow either the Basic Assessment Report (BAR) process or the Scoping and Environmental Impact Assessment (EIA) process depending on the scale of the impact.

5 Methodology

The main approach of this assessment is based on the protocols compiled by van Tol *et al.,* (2021) and issued by the DWS. According to these protocols, four main steps are required depending on the level of the hydropedology assessment;

1. Identification of dominant hillslopes;
2. Conceptualise hillslope hydrological responses;
3. Quantification of hydraulic properties and flowrates; and
4. Quantification of hydropedological fluxes.

For impact assessments associated with activities that pose significant threats on the interflow volumes of a landscape or activities that are expected to drastically change the dynamics of a landscape (i.e. open cast mining), all four steps are required. For those activities that only include minor impacts (i.e. installation of a pipeline), only the first two steps are required.

5.1 Desktop assessment

The following information sources were considered for the desktop assessment;

- Aerial imagery (Google Earth Pro);
- Land Type Data (Land Type Survey Staff, 1972 - 2006)

- Contour data (5 m); and
- Mucina & Rutherford (2006).

5.2 Field Procedure

The slopes within the project area have been assessed during the desktop assessment to identify possible transects that will represent typical terrain and soil distribution patterns. These locations were then altered slightly during the survey depending on the extent of vegetation, slopes, access, and any features that will improve the accuracy of data acquired. A site visit was conducted where 15 soil profiles were opened. Soils were described in accordance with the South African soil classification (Soil Classification Working Group, 2018). Undisturbed core samples were collected of representative horizons. Selected hydraulic properties (particle size distribution, bulk density, saturated hydraulic conductivity, and water retention characteristics) were measured by Vans Lab in Bloemfontein. The soils and their associated properties were then regrouped based on their dominant hydropedological behaviour in accordance with van Tol & Le Roux (2019) (see Figure 5-1).

5.3 Hydropedological Interpretations

South African soils can be grouped into seven distinct hydropedological groups. Groups relevant to the site area are briefly discussed below:

Recharge soils: Soils without any morphological indication of saturation in the profile. Vertical flow through and out of the profile into the underlying bedrock is the dominant flow direction.

These soils can either be shallow on fractured rock with limited contribution to evapotranspiration (**recharge shallow**) or deep freely drained soils which can contribute significantly to evapotranspiration (**recharge deep**).

Interflow soils: Two types of interflow soils occur, those where interflow is dominant at the A/B horizon interface and those where interflow is dominant at the soil/bedrock interface. The first type occurs in duplex soils where the textural discontinuity facilitates build-up of water in the topsoil (**interflow shallow**). In the second, freely drained soils overly relatively impermeable bedrock. Hydromorphic properties signify periodic saturation associated with a water table at the soil bedrock/interface (**interflow deep**). The duration and magnitude of lateral flow in interflow soils depend on the rate of ET, position in the hillslope (lateral addition/release), slope angle and the anisotropy in permeability between conducting and impeding layer.

Responsive soils: These soils 'respond' quickly to rain events and typically generate overland flow. These soils can either be shallow and overly relatively impermeable bedrock, with limited storage capacity which is quickly exceeded following a rain event (**responsive shallow**). Or they are soils with morphological indications of long periods of saturation. Since these soils are close to saturation during the rainy season additional precipitation will typically flow overland due to saturation excess (**responsive wet**).

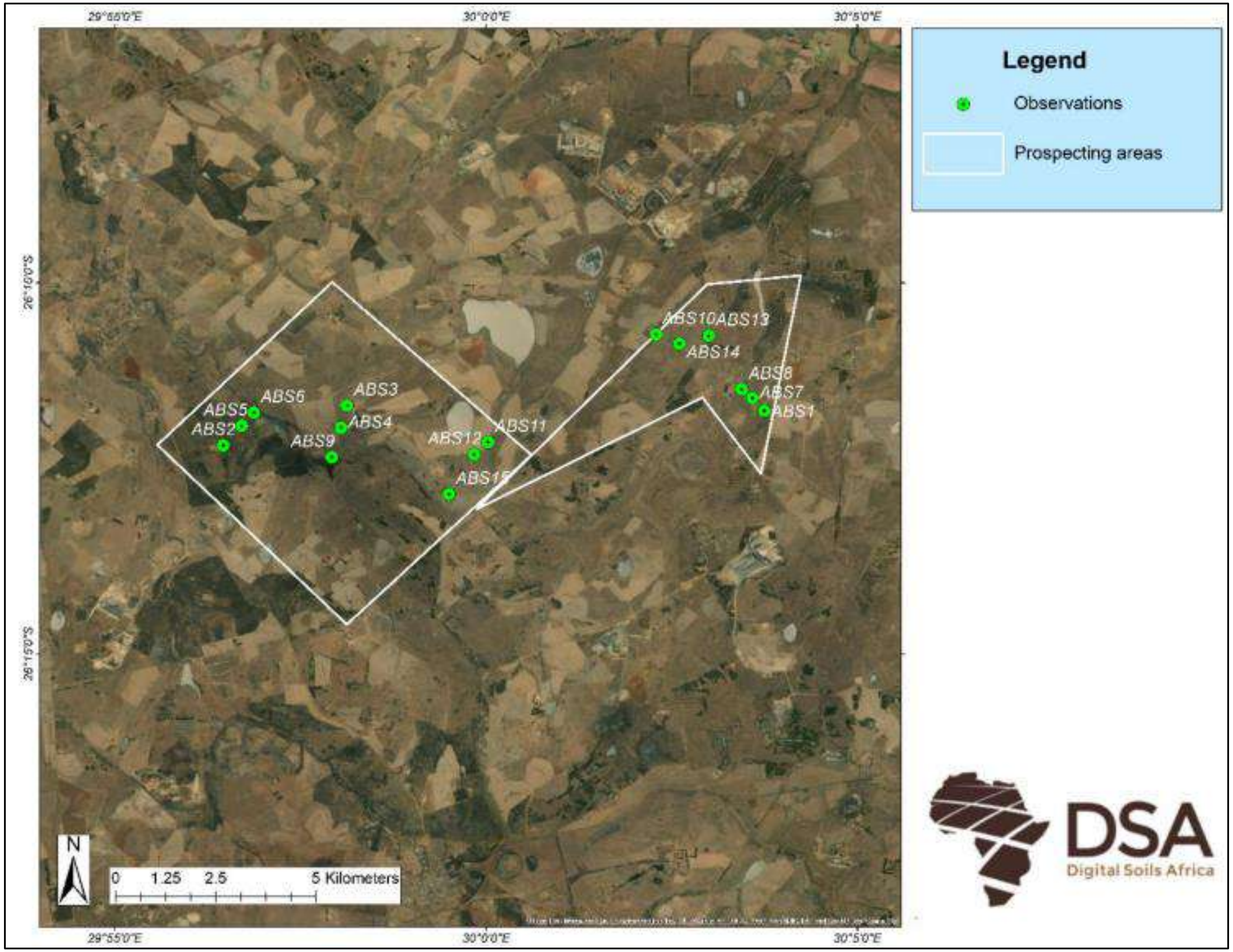

Figure 5-1 Transects and Observation Sites

5.3.1 Identification of Soil Types and Hydrological Soil Types

Soil types have been identified according to the South African soil classification (Soil Classification Working Group, 1991) after which the link between soil forms and hydropedological response were established (van Tol & Le Roux, 2019), and the soils regrouped into various hydropedological soil types as shown in Table 5-1.

Table 5-1 Hydrological soil types of the studied hillslopes (van Tol et al., 2019).

Hydrological Soil Type	Description	Subgroup	Symbol
Recharge	Soils without any morphological indication of saturation. Vertical flow through and out the profile into the underlying bedrock is the dominant flow direction. These soils can either be shallow on fractured rock with limited contribution to evapotranspiration or deep freely drained soils with significant contribution to evapotranspiration.	Shallow	
		Deep	
Interflow (A/B)	Duplex soils where the textural discontinuity facilitates build-up of water in the topsoil. Duration of drainable water depends on rate of ET, position in the hillslope (lateral addition/release) and slope (discharge in a predominantly lateral direction).	A/B	
Interflow (Soil/Bedrock)	Soils overlying relatively impermeable bedrock. Hydromorphic properties signify temporal build of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction.	Soil/Bedrock	
Responsive (Shallow)	Shallow soils overlying relatively impermeable bedrock. Limited storage capacity results in the generation of overland flow after rain events.	Shallow	
Responsive (Saturated)	Soils with morphological evidence of long periods of saturation. These soils are close to saturation during rainy seasons and promote the generation of overland flow due to saturation excess.	Saturated	
Stagnating	In these soils outflow of water is limited or restricted. The A and/or B horizons are permeable but morphological indicators suggest that recharge and interflow are not dominant. These includes soils with carbonate accumulations in the subsoil, accumulation and cementation by silica, and precipitation of iron as concretions and layers. These soils are frequently observed in climate regions with a very high evapotranspiration demand. Although infiltration occurs readily, the dominant hydrological flowpath in the soil is upward, driven by evapotranspiration.		

5.3.2 Undisturbed Sampling

Undisturbed samples were collected for each of the diagnostic horizons. These samples were sent to *Van's lab* (Pty) Ltd. in Bloemfontein to determine the particle size distribution, saturated hydraulic conductivity (*Ks*), bulk density, and water retention characteristics. A cylindric Poly Vinyl Chloride (PVC) is gently inserted laterally into a diagnostic soil horizon to extract an undisturbed sample of the specific horizon. Wooden lids are then taped to the pipe to ensure that the sample stays intact.

5.4 Modelling

The hydrological model SWAT+ (v 1.2.3) was used for the modelling with QSWAT+ (v. 1.2.2) to set up the watershed. SWAT+ is a revised version of the well-known Soil and Water Assessment Tool (SWAT; Arnold et al., 1998). SWAT is a widely used small watershed to river basin-scale model. It is typically used to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change.

The catchment area (16700 ha) was determined from a 30 m DEM and subdivided into 177 Landscape Units (LSUs). The current land use was obtained from the South African National Land-Cover Database (2013 – 2014) and the DFFE, (2018) land covers with predefined parameters for each of the uses. This current land use was used in the before scenario and the development layout, i.e., open-cast pits, were included as mining (bare) in the land use raster for the after scenario. There were 2558 wetland hydrological response units (HRUs) in the before situation and 2087 in the after scenario.

The hydropedological groups of the survey was used as soil input data. The soil distribution patterns observed during the hydropedological survey were extrapolated to cover the area surrounding the proposed development. The close correlation between topographical attributes and soils, made it possible to use the terrain unit (Figure 5-1) for mapping the soils. A 13-year simulation period was selected (1998 – 2010). Climatic data for this period was obtained from the Climate Forecast System Reanalysis (CFSR, 1979 – 2014) project done by the National Centre for Environmental Prediction (NCEP) (Saha *et al*., 2010). Weather Gen in SWAT+ Editor used daily precipitation, temperature (minimum and maximum, wind speed, solar radiation, and relative humidity from selected stations to generate daily climatic variables for the simulations. The model was allowed two years to settle. Results are presented as changes to the average water balance of the entire area (approximately 16700 ha), affected LSUs and wetland HRUs.

5.5 Impact Assessment Procedure

The criteria used for assessing the significance of the impacts is presented in Table 6-1 and Table 6-2. The procedure considers the current environment, the details of the proposed development and the findings of the hydropedological study. Both positive and negative impacts resulting from the development on the water resources are considered. The significance of the impact is dependent on the consequence and the probability that the impact will occur:

Significance = (Extent + Duration + Magnitude) x Probability

Each criterion is given a score based on the definitions given in Table 5-2. Positive impacts can also be assessed by ranking the Magnitude criteria from high (10) to low (1) in terms of restoring ecosystem patterns, processes, and functioning. Although the criteria used for the assessment of impacts attempts to quantify the significance, it is important to note that the assessment is generally a qualitative process and therefore the application of this criteria is open to interpretation. The process adopted will therefore include the application of scientific measurements and professional judgement to determine the significance of environmental impacts associated with the project. The assessment thus largely relies on experience of the EAP and the information from this hydropedological study.

Where the consequence of an event is not known or cannot be determined, the “precautionary principle” will be adhered to, and the worst-case scenario assumed. Where possible, mitigation measures to reduce the significance of negative impacts and enhance positive impacts will be recommended. The detailed actions, which are required to ensure that mitigation is successful, will be provided in the EMPr, which will form part of the EIR Phase. Consideration will be given to the phase of the project during which the impact occurs. The phase of the development during which the impact will occur, will be noted to assist with the scheduling and implementation of management measures.

Table 5-2 The criteria for components of the impact assessment with description

ASPECTS OF THE IMPACT	DESCRIPTION OF THE CRITERIA	RATING
MAGNITUDE	**Negligible:** Ecosystem pattern, processes and functions will not be impacted	1
	Minor: Minor impact on the environment and processes will occur	2
	Low: Slight impact on ecosystem pattern, process, or function	4
	Moderate: Valued, important or sensitive processes or communities are negatively impacted but general processes and functions will continue in altered way	6
	High: Environment affected to the extent that ecosystem patterns, processes and functions are altered or may cease temporarily. Valued, important and sensitive systems or communities are substantially affected.	8
	Very high: Ecosystem pattern, process and functions are completely destroyed and may permanently cease.	10
EXTENT	**Site only:** Impact remains within footprint	1
	Local: Impact include areas immediately adjacent to site	2
	Regional: Impact includes the greater surrounding area of the site	3
	National: Extent of the impact is applicable to South Africa	4
	Global: Impact has global significance	5
DURATION	**Very short-term**: impact lasts for a very short time (less than a month)	1
	Short-term: impact lasts for a short time (months but less than a year)	2
	Medium-term: impact lasts for the for more than a year but less than the life of operation.	3
	Long-term: impact occurs over the operational life of the proposed extension.	4
	Residual: impact is permanent (remains after mine closure)	5
PROBABILITY	**Highly unlikely**: the impact is highly unlikely to occur	1
	Unlikely: the impact is unlikely to occur	2
	Possible: the impact could possibly occur	3
	Probable: the impact will probably occur	4
	Definite: the impact will occur	5

Table 5-3 Significance ratings used in this study (for positive ratings the colour criteria are presented in reverse i.e., red is low, and green is high

Descriptors	Definitions	Score
Low	The perceived impact will not have a noticeable negative influence on the environment and is unlikely to require management intervention that would incur significant cost.	0 – 19
Low to Moderate	The perceived impact is considered acceptable, and application of recommended mitigation measures recommended.	20 – 39
Moderate	The perceived impact is likely to have a negative effect on the receiving ecosystem, and is likely to influence the decision to approve the activity. Implementation of mitigation measures is required, as is routine monitoring to ensure effectiveness of recommended mitigation measures.	40 – 59
Moderate to High	The perceived impact will have a significant impact on the receiving ecosystem, and will likely to have an influence on the decision-making process. Strict implementation of mitigation measures as provided is required, and strict monitoring and high levels of compliance and enforcement in respect of the impact in question are required.	60 – 79
High	The impact on the receiving ecosystem is considered of high significant and likely to be irreversible, and therefore highly likely to result in a fatal flaw for the project. Alternatives to the proposed activity are to be investigated as impact will have an influence on the decision-making process.	80 - 100

6 Receiving Environment

6.1 Desktop Background Findings

6.1.1 Terrain

The Digital Elevation Model (DEM) indicates a range in elevation of 1 595 Metres Above Sea Level (MASL) to 1 810 MASL (see Figure 3-7). Various convex topographical features are located throughout the project area and its surrounding areas which indicate river lines. The project area is characterised by a non-uniform topography, with a slope percentage ranging from 0 to greater than 25% (see Figure 3-8). Those areas characterised by a low slope percentage are expected to have high ET rates, whereas those areas characterised by higher slope percentages (thus steeper areas) being dominated by interflow.

6.1.2 Geology & Soils

The focus area falls within land type Bb15 and Bb21 with land type Ba22 to the west (Land Type Survey Staff, 1972 – 2002) (Figure 6-2). A land type is an area which can be demarcated at a scale of 1:250 000 with similar soil forming factors and therefore soil distribution patterns. A land type does not represent uniform soil polygons, but rather information regarding the soil distribution patterns. In Ba land types, plinthic soils dominate. The coverage of different soils on different terrain units can be obtained from the land type inventory (Table 6-1 and Table 6-2).

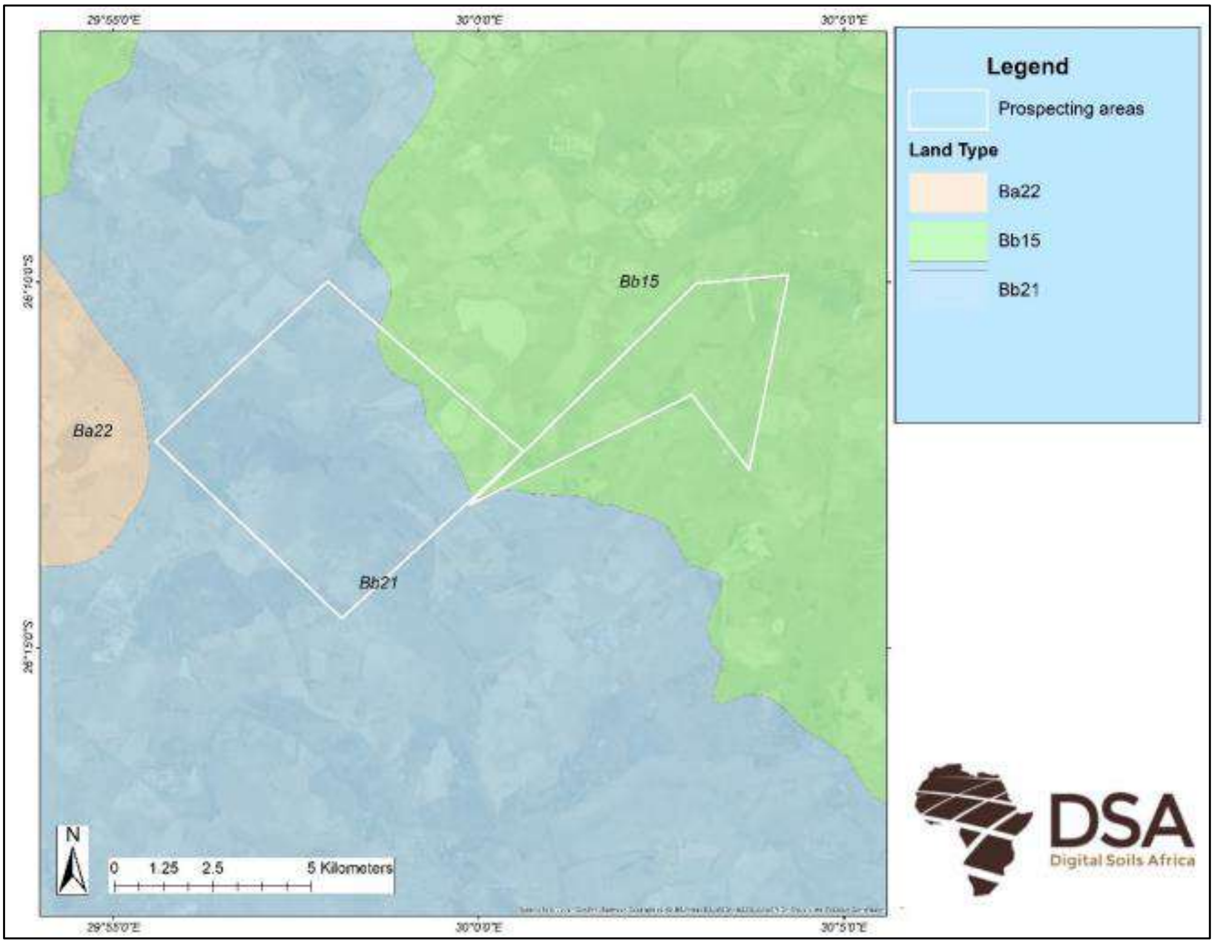

Figure 6-1 Land type of the focus area (Land Type Survey Staff, 1972 – 2002)

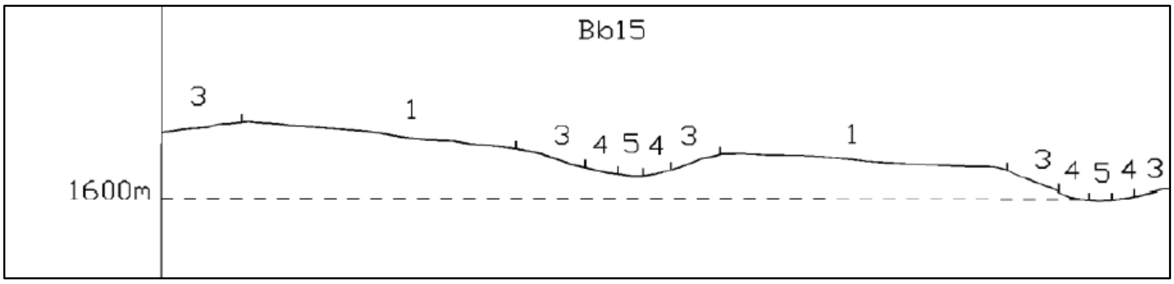

Figure 6-2 Illustration of land type Bb15 terrain units (Land Type Survey Staff, 1972 – 2006)

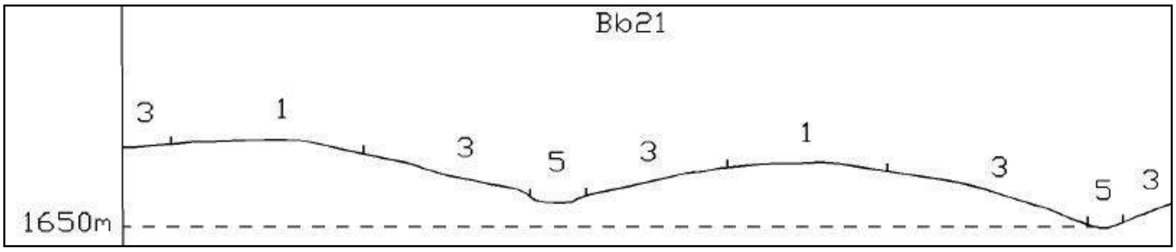

Figure 6-3 Illustration of land type Bb21 terrain units (Land Type Survey Staff, 1972 - 2006)

Table 6-1 Soils expected at the respective terrain units within the Bb15 land type (Land Type Survey Staff, 1972 – 2006)

Terrain Morphological Unit (TMU)							
1 (50%)		3 (40%)		4 (5%)		5 (5%)	
Soil Form	Hydroped[1].	Soil Form	Hydroped.	Soil Form	Hydroped.	Soil Form	Hydroped.
Clovelly (20%)	Recharge (deep)	Clovelly (30%)	Recharge (deep)	Kroonstad (20%)	Interflow (A/B)	Willowbrook (30%)	Responsive (wet)
Glencoe (25%)	Interflow (soil/bedrock)	Avalon (15%)	Interflow (soil/bedrock)	Longlands (30%)	Interflow (A/B)	Katspruit (50%)	Responsive (wet)
Mispah (25%)	Shallow (responsive)	Mispah (10%)	Shallow (responsive)	Avalon (20%)	Interflow (soil/bedrock)		

Table 6-2 Soils expected at the respective terrain units within the Bb21 land type (Land Type Survey Staff, 1972 - 2006)

Terrain Morphological Unit (TMU)					
1 (30%)		3 (60%)		5 (10%)	
Soil Form	Hydroped[1].	Soil Form	Hydroped.	Soil Form	Hydroped.
Clovelly (15%)	Recharge (deep)	Glenrosa (10%)	Recharge (shallow)	Kroonstad (30%)	Interflow (A/B)
Glencoe (20%)	Interflow (soil/bedrock)	Avalon (30%)	Interflow (soil/bedrock)	Katspruit (30%)	Responsive (wet)
Mispah (10%)	Shallow (responsive)	Longlands (10%)	Interflow (A/B)	Longlands (20%)	Interflow (A/B)

According to Mucina & Rutherford (2006), the geology and soils aspect of this region is characterised by red to yellow sandy soils of the Bb land type. The geology of this region includes sandstone and shale of the Madzaringwe Formations (Karoo Supergroup).

6.2 Hillslope Hydrology

The hydropedology survey was conducted in August 2022. The survey was conducted to obtain information required to conceptualise the dominant behaviour of representative hillslopes as well as to provide data for the hydropedological modelling. Five transects were traversed to acquire information regarding the hillslope hydrology, the hydropedological type properties as well as physical properties (i.e., permeability, bulk density, wilting point and texture). The hydropedological types classified during the site assessment are illustrated in Table 7-1.

7 Results

7.1 Soil Associations

Observed soil forms and horizons are presented in Table 7-1 and the associated briefly described below.

Table 7-1 Soil descriptions of the Ilima sites

Soil Obs	Soil form	Family	Horizon	Depth (cm)	Remarks	Hydropedological group
ABS1	Clovelly	1221	Orthic	30		Recharge (deep)
			Yellow brown apedal	50		
			Lithic	90		
ABS2	Lichtenburg	1220	Orthic	20		Recharge (deep)
			Red apedal	35		
			Hard plinthic	80		
ABS3	Tukulu	1120	Orthic	30		Interflow (soil/bedrock)
			Neocutanic	40		
			Gleyic	120		
ABS4	Avalon	1120	Orthic	30		Interflow (soil/bedrock)
			Yellow brown apedal	60		
			Soft plithic	90		
ABS5	Glenrosa	1210	Orthic	25	Saprolithic	Recharge (shallow)
			Lithic	90		
ABS6	Katspruit	1210	Orthic	30	Dark topsoil	Responsive (wet)
			Gley	120		
ABS7	Fernwood	1120	Orthic	40	Dark topsoil	Interflow (A/B)
			Albic	50		
ABS8	Inhoek	1200	Melanic	30	Wetness present in alluvium	Interflow (soil/bedrock)
			Alluvium	50		
ABS9	Fernwood	1120	Orthic	30	Dark topsoil	Interflow (A/B)
			Albic	120		
ABS10	Katspruit	1210	Orthic	30		Responsive (wet)
			Gley	80		
ABS11	Kroonstad	2120	Orthic	30	Dark topsoil	Interflow (A/B)
			Albic	80		
			Gley	120		
ABS12	Kroonstad	1120	Orthic	30	Dark topsoil	Interflow (A/B)
			Albic	60		
			Gley	120		
ABS13	Glenrosa	1110	Orthic	25		Recharge (shallow)
			Lithic	38		
ABS14	Cartref	1210	Orthic	20		Interflow (A/B)
			Albic	35		
			Lithic	70		
ABS15	Ermelo	1220	Orthic	30		Recharge (deep)
			Yellow brown apedal	120		

7.1.1 RECHARGE DEEP – ERMELO/CLOVELLY/LICHTENBURG

In Ermelo and Clovelly soil forms, the orthic horizon overlies a yellow brown apedal horizon (Figure 7-1). In the Clovelly soil a lithic horizon is reached but not encountered in the Ermelo form. In the Lichtenburg soil form, the orthic horizon is underlain by a red apedal horizon on top of a hard plinthic horizon. In this landscape the hard plinthic horizon is likely permeable to water and roots as grey mottles were not observed above the hard plinthic. These soils are freely drained with no morphological indication of saturation. In terms of the hydropedological response, vertical flow into and out of the profile is the dominant flow paths. They are, therefore, recharge (*deep*) soils.

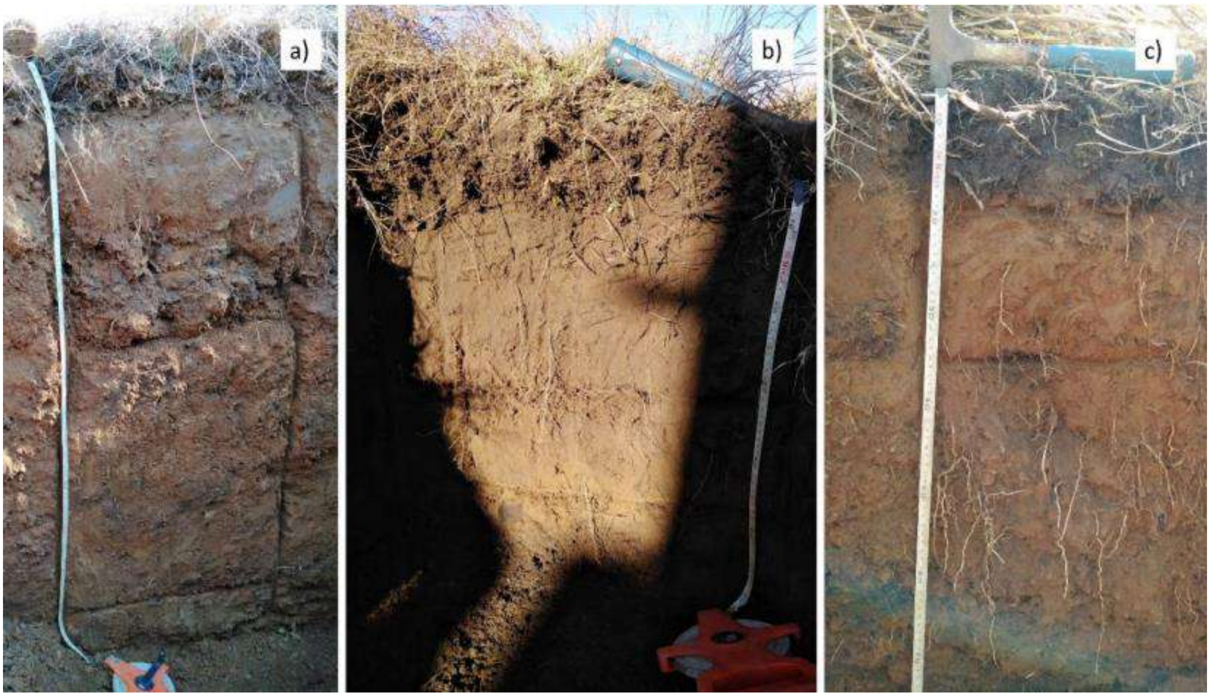

Figure 7-1 Examples of Rechange (deep) soils a) Clovelly, b) Ermelo and c) Lichtenburg.

7.1.2 INTERFLOW (SOIL/BEDROCK) - AVALON/TUKULU/INHOEK

These three soil forms are all marked by morphological evidence of saturation (grey colours) above the soil/bedrock interface (Figure 7-2). In the Avalon and Tukulu soils, orthic horizons overlie freely drained yellow-brown apedal and neocutanic horizons, respectively. In the Inhoek soil form a melanic horizon overlies an alluvial horizon. There is evidence of saturation (grey colours) in the alluvial horizon which is recognised at family level. In these soils water will likely be built-up at the soil bedrock interface during the rainy season from where it flows laterally downslope. These soils were consequently considered Interflow (soil/bedrock) soils.

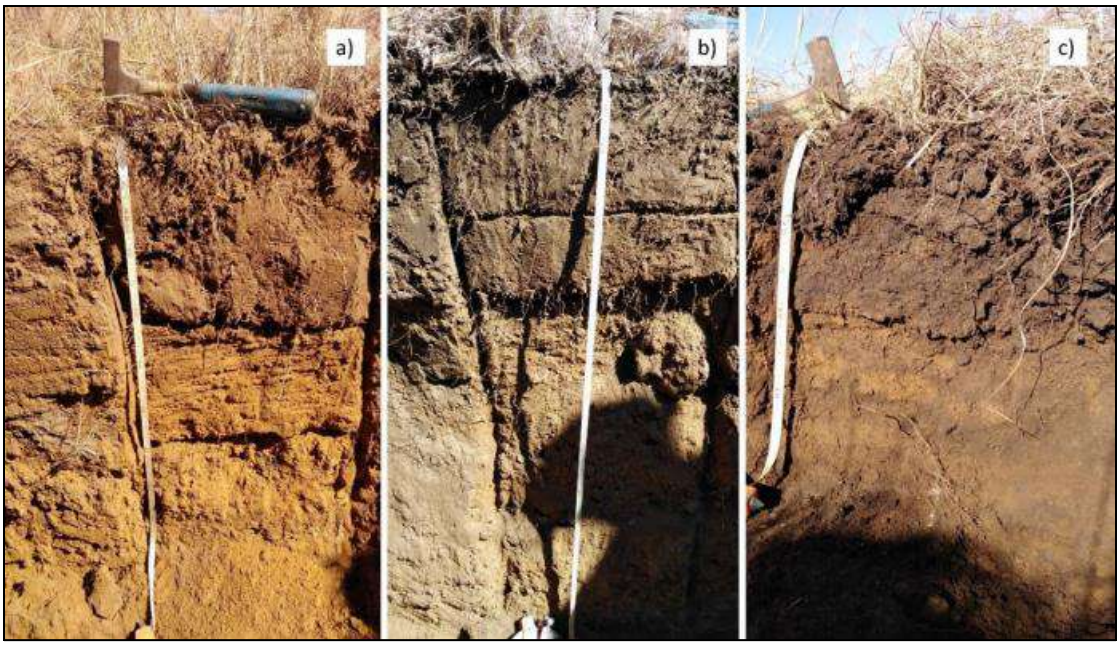

Figure 7-2 Examples of interflow (soil/bedrock) soils a) Avalon, b) Tuluku and c) Inhoek.

7.1.3 SHALLOW SOILS – GLENROSA/CARTREF

Glenrosa soils consist of an orthic horizon overlying a lithic horizon. In this area the lithic horizon was classified as saprolithic, i.e., evidence of saturation was absent (Figure 7-3). This soil is freely drained and regrouped as shallow (recharge)

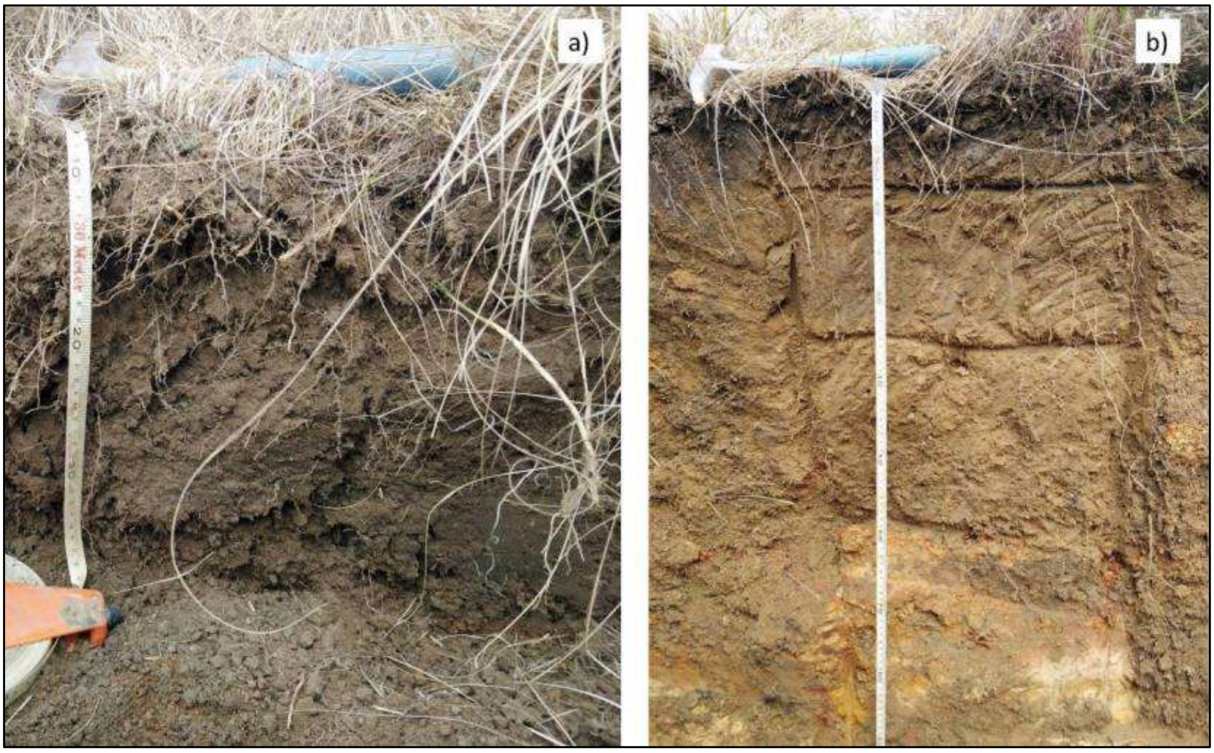

Figure 7-3 Examples of a) a Glenrosa soil, recharge (shallow) and b) a Cartref soil, interflow (soil/bedrock)

In Cartref soils, there is an albic horizon above the lithic horizon. This albic horizon is normally associated with eluviation of organic matter, clays, and colouring agents in the soil in a predominantly lateral direction. Cartref soils are classified as *interflow* (A/B) soils as the lateral flow is generated at the A/B horizon interface.

7.1.4 RESPONSIVE (SATURATED) – KATSPRUIT/KROONSTAD/FERNWOOD

Katspruit and Kroonstad soils were observed adjacent to the stream in the lower TMU4 and 5 positions. The Katspruit soil consists of an orthic horizon overlying a gley horizon (Figure 7-4). The gley horizon shows evidence of reduction due to saturation in the form of grey colours. The Katspruit soils are typically saturated for very long periods. These soils are therefore close to saturation during the rainy season. Overland flow is the dominant process due to saturation excess. Similar processes occur in Kroonstad soils, with the exception that an albic horizon formed above the gley horizon. In this study area, these soils were grouped as responsive (saturated).

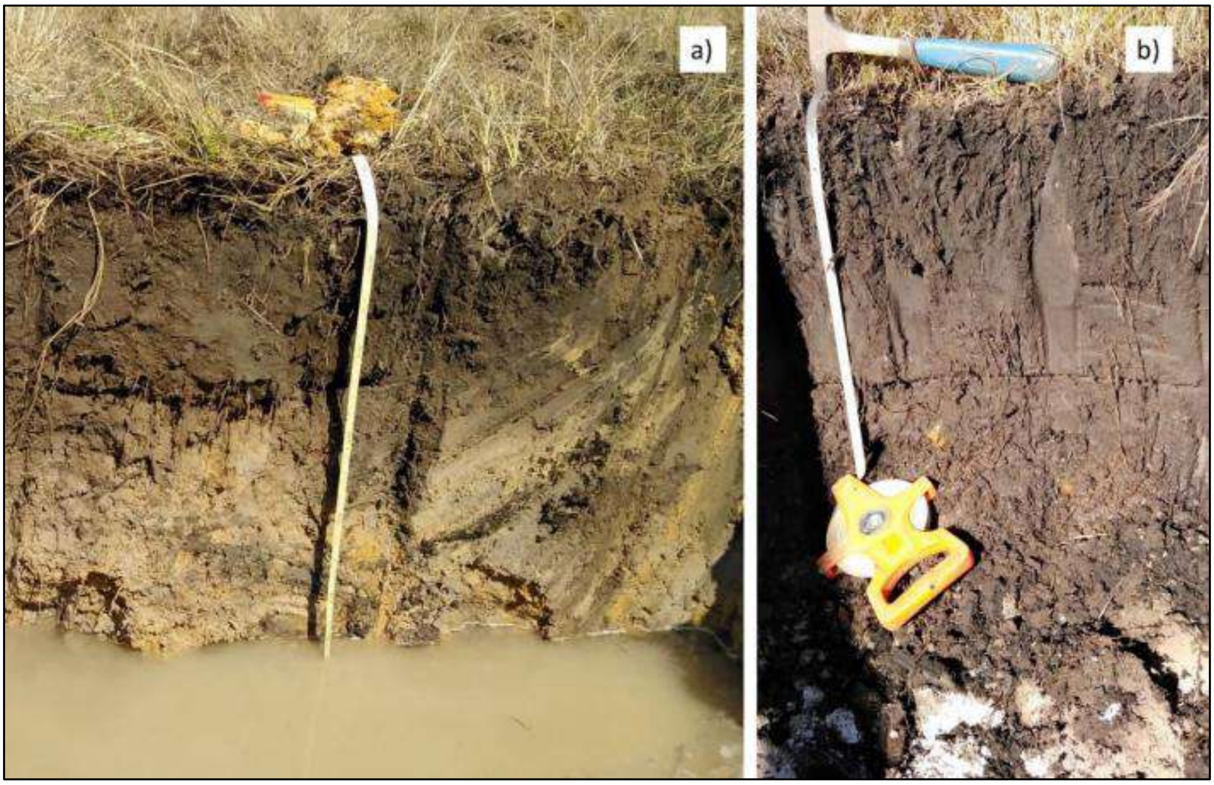

Figure 7-4 Examples of Responsive (wet) soils a) Katspruit and b) Kroonstad.

7.1.5 HYDRAULIC PROPERTIES AND HYDROPEDOLOGICAL MAP

Relevant soil hydraulic properties used as inputs for the simulations are presented for the different representative soil forms and horizons. In general, the topsoil horizons are permeable with relatively low bulk density. The bulk density of the yellow-brown and albic horizons is high, with low conductivity in the latter.

The hydropedological map is presented in Figure 7-5. This map was drawn based on the correlation between observed soils (from the transects) and the terrain unit map. We distinguished between the general soil distribution patterns of the two land types (Figure 6-1). In land type Bb15, Recharge (shallow) soils dominate both the TMU3 (convex) and TMU3(1) (concave and straight) upslope landscape positions. In Bb21, the concave and straight upslope landscape positions were covered by Interflow (soil/bedrock) soils. The area earmarked for development falls mostly on Interflow (soil/bedrock) soils, but part of the footprint is on Interflow (A/B) soils. Based on the properties, farm Vaalbank is dominated with interflow (soil/bedrock) and Roodebloem has a combination of recharge (shallow) and interflow (A/B)

Table 7-2 Selected hydraulic properties of representative horizons

Horizon	Clay	Silt	Sand	D_b [1]	DUL [2]	LL [3]	AWC [4]	K_s [5]
		%		g/cm³		mm/mm		mm/h
Orthic (dry)	19.2	12.1	68.8	1.08	0.13	0.09	0.04	254.8
Orthic (wet)	18.4	11.5	70.1	1.18	0.27	0.09	0.18	2.5
Melanic	28.5	17.4	54.4	0.86	0.15	0.1	0.05	70.2
Yellow brown apedal	27	11.2	62.4	1.41	0.24	0.11	0.13	112.1
Red apedal	17.2	10.1	73.3	1.26	0.17	0.09	0.08	48.0
Albic	19.3	10.5	70.3	1.18	0.19	0.09	0.1	71.0
Lithic	22.9	14.8	63	1.12	0.13	0.09	0.04	93.3
Soft plinthic	24.5	12.8	62.7	1.2	0.31	0.1	0.21	21.9
Gley	28	17.8	54.3	1.26	0.31	0.11	0.2	5.5

[1]Bulk density; [2]Drained Upper Limit; [3]Lower limit; [4]Available Water Capacity; [5]Saturated hydraulic conductivity.

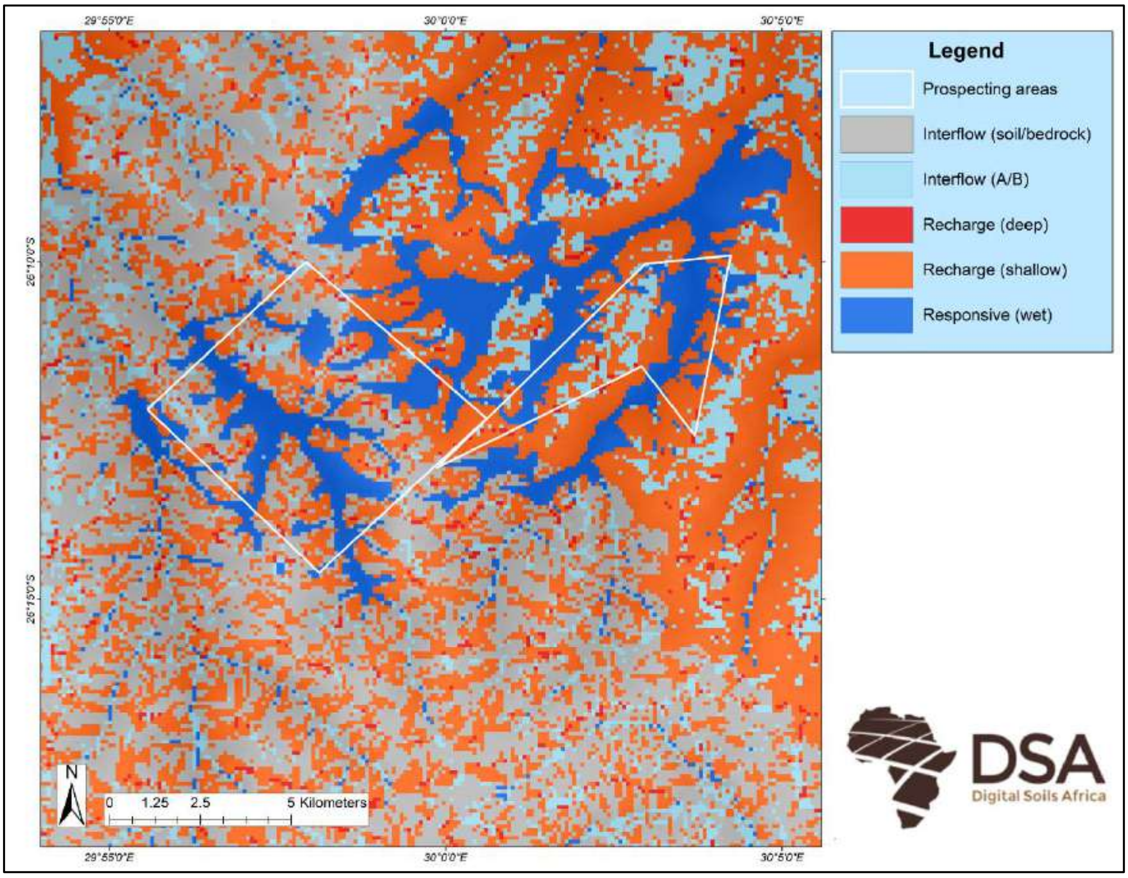

Figure 7-5 Hydropedological map of the study area

7.2 Conceptual Impact Prediction

There are two different soil distribution patterns will result in two different conceptual hydropedological responses.

7.2.1 Land Type BB15

The conceptual hydropedological response of the area covered by land type Bb15 (north-eastern part of study area) is graphically described in Figure 7-6.

1. The upper parts of the slope are covered by shallow (recharge) soils, which will promote vertical drainage into permeable bedrock.
2. This water will then flow gradually via bedrock flow paths downslope and reinfiltrate lower lying positions where it will contribute to subsurface lateral flow.
3. Soil/bedrock lateral flow due to the low permeability of the rock dominates in the footslopes. Water drains vertically through the top and subsoils but then accumulate at the soil/bedrock interface where it will start to flow downslope towards the valley bottom.
4. Evapotranspiration in semi-arid areas is typically responsible for most of the water lost through the soil. It is possible that water which infiltrated the upper part of the hillslope will not reach the valley bottom before being evaporated.
5. The bedrock flow paths, and soil/bedrock lateral flows feed into valley bottom wetlands resulting in prolonged saturation.
6. Due to the prolonged saturation in the valley bottom during rainy season, this area will generate overland flow due to saturation excess.
7. Lateral flow at both the A/B horizon interface and soil/bedrock interface feeds water into the stream.

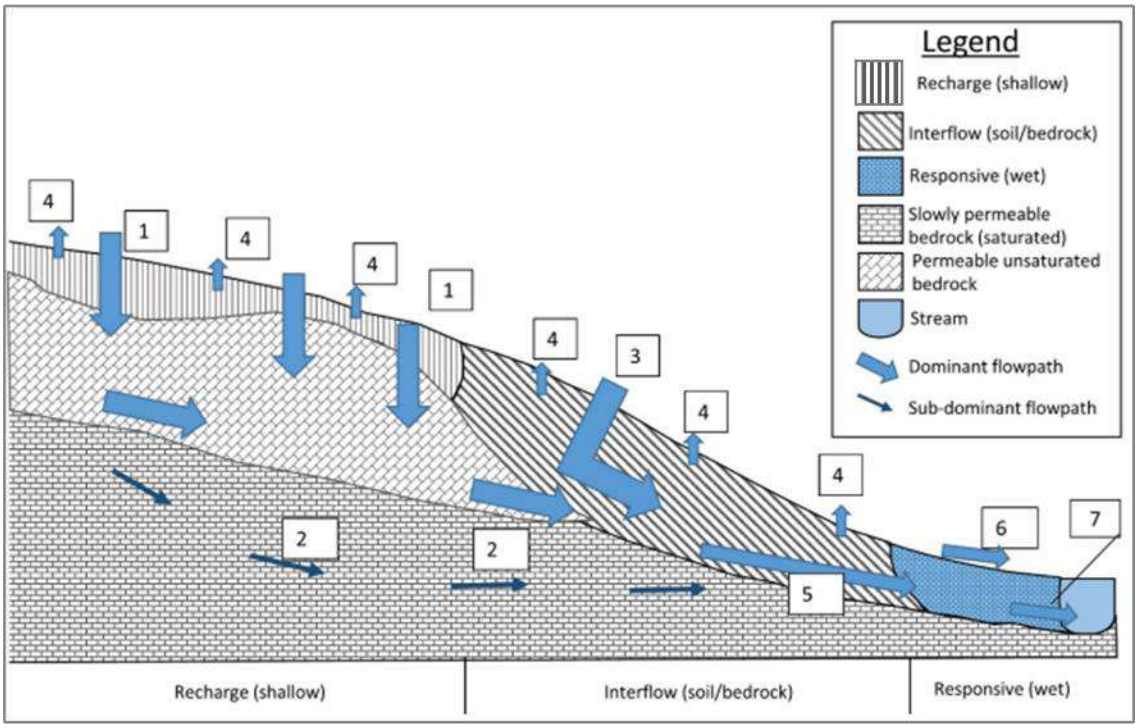

Figure 7-6 Conceptual hydropedological response of hillslopes of area covered by land type Bb15

7.2.2 Land Type BB21

The conceptual hydropedological response of the area covered by land type Bb21 (south-western part of study area) is graphically described in Figure 7-7.

1. The dominant flow path in this area is soil/bedrock lateral flow due to the low permeability of the rock. Water drains vertically through the top and subsoils but then accumulate at the soil/bedrock interface where it will start to flow downslope towards the valley bottom.
2. Slow lateral movement through bedrock fractures can result in return flow to valley bottom soils. This transit time of water through this flow path is long. It will likely take several months before this water returns to the valley bottom soils.
3. The bedrock flow path in feeds back to the Katspruit/Kroonstad soils of the valley bottom resulting in long periods of saturation.
4. Evapotranspiration in semi-arid areas is typically responsible for most of the water lost through the soil. It is possible that water which infiltrated the upper part of the hillslope will not reach the valley bottom before being evaporated.
5. Due to the prolonged saturation in the valley bottom during rainy season, this area will generate overland flow due to saturation excess.
6. Lateral flow at both the A/B horizon interface and soil/bedrock interface feeds water into the stream.

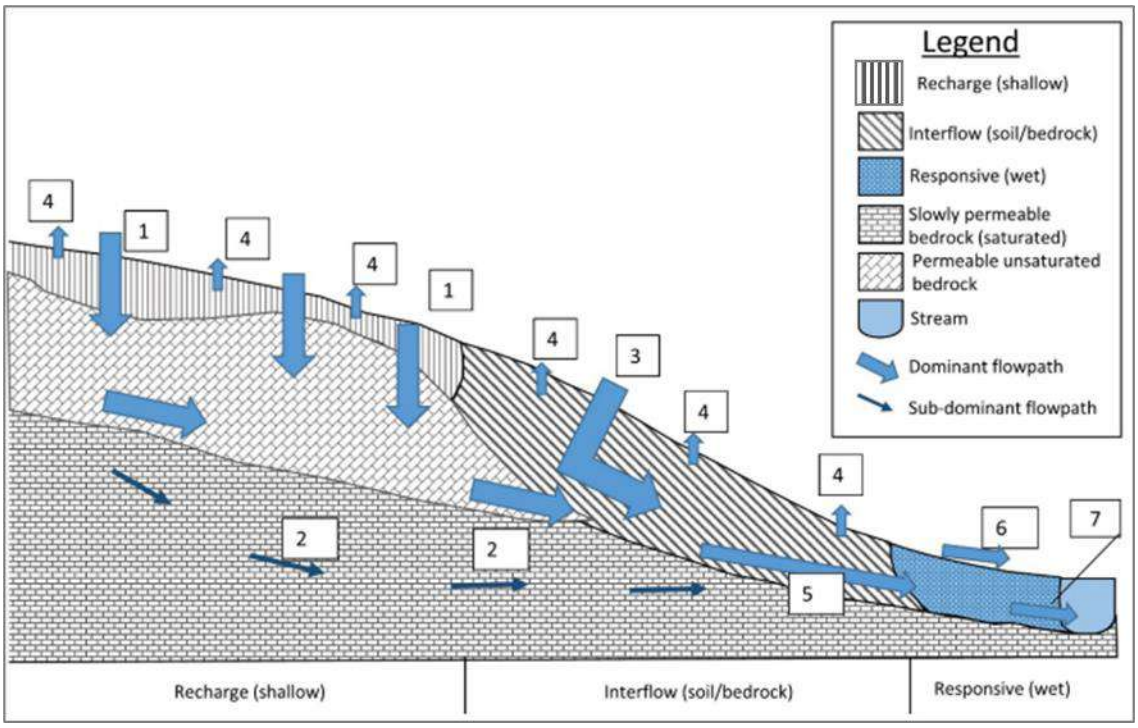

Figure 7-7 Conceptual hydropedological response of hillslope of area covered by land type Bb21

7.3 Potential Impact of development on hydropedological behaviour

7.3.1 IMPACT ON AREA UNDER LAND TYPE BB15

The planned development will mostly mine areas covered by recharge (shallow) soils. If this water is pumped from the pit and forms part of surface water, there will be a reduction in bedrock flow to lower parts of the landscape (Figure 7-8). This in turn will impact the water regimes of the wetlands and the amount of baseflow into the streams. If the open-cast pits are deeper than the level of the interflow soils, it could result that water will flow towards the pit and not the wetland.

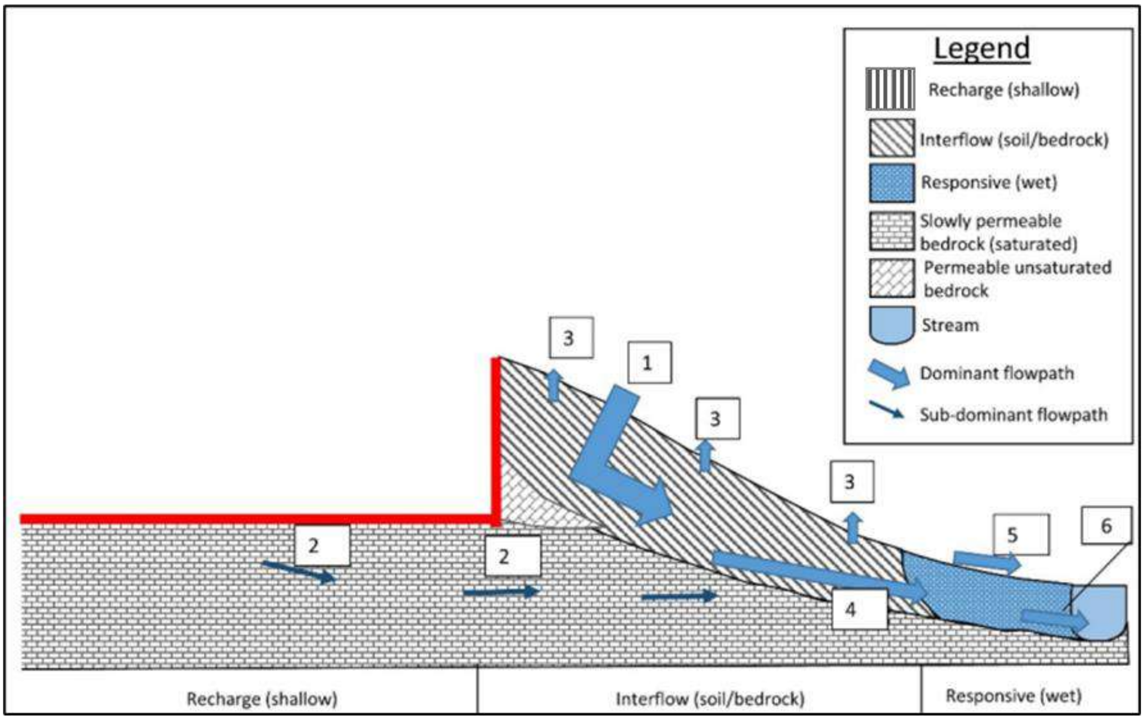

Figure 7-8 Conceptual representation of the impact of open cast mining on the area covered by type Bb15

7.3.2 IMPACT ON AREA UNDER LAND TYPE BB21

The planned development will intersect lateral flow paths feeding the wetland (Figure 7-9). Lateral flow could still occur in areas above the proposed pit and the buffer between the pits and the wetlands could negate the negative impacts. If the open-cast pits are deeper than the level of the interflow soils and/or the wetlands, it could result that water will flow towards the pit and not the wetland.

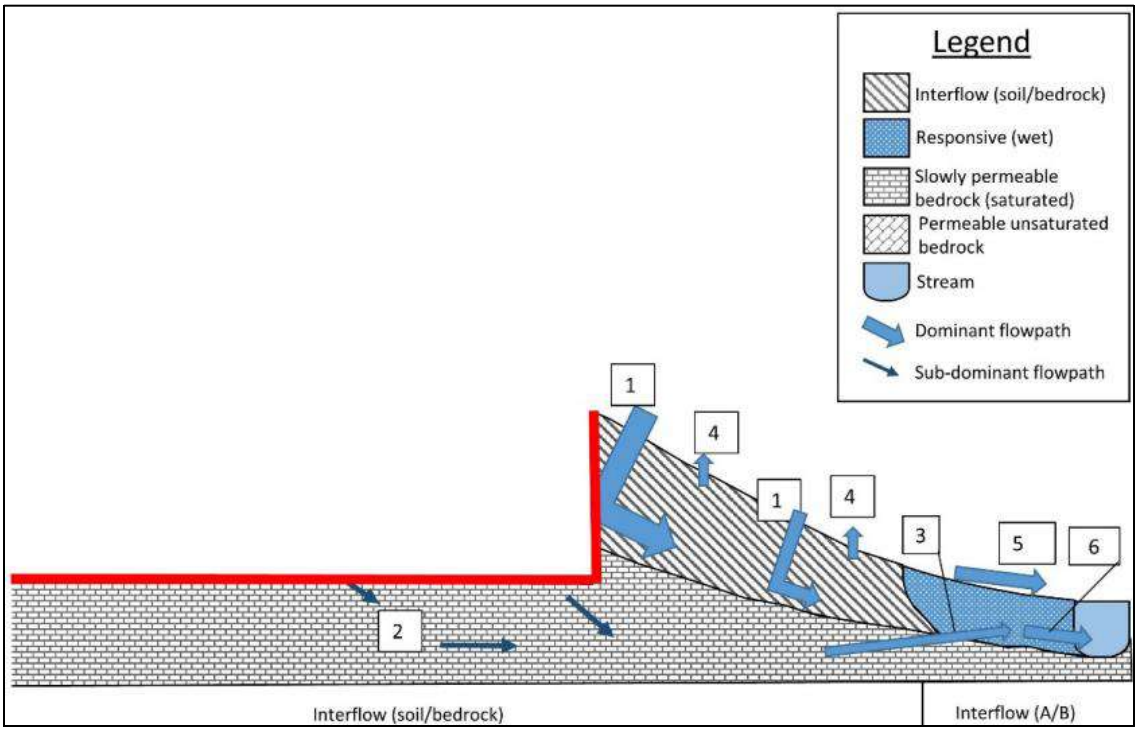

Figure 7-9 Conceptual representation of the impact of open cast mining on the area covered by land type Bb21.

7.4 Modelling Results

Modelling results are presented based on the varying open pit mining sequence schedules for the entire basin (Table 7-3), the LSUs which will be impacted by the development (Table 7-4) as well as the soil water contents of wetland HRUs adjacent to the development (Table 7-5). The results in Table 7-3 to Table 7-5 of the water balance shows that components with a negative percentage represents losses while changes with a positive percentages are gains in the water balance. The changes are then reflected in the overall water balance percentage increases on the selected components. These results should be interpreted with care. The model set-up included the mining area as barren surface in the after scenario. This will generate more overland flow. Depending on the arrangements of channels and streams in the model setup, the increased overland flow can drain directly into a channel (contribute to total water yield), or back into downslope HRUs (contribute to soil water content). In reality, water accumulating in the pits would likely be pumped into the stormwater management drains, and not contribute to soil water. In addition, the draw-down effect of the open cast pit could also not be accounted for in the model set-up. **The impact on wetland water contents will therefore likely be larger than simulated. However, the planned different open cast mining sequence schedules will reduce the impact on the total simulation deductions.**

The lateral flow and percolation will decrease due to the development. Interestingly the simulated percolation under the development footprint will increase (Table 7-4). It is not clear why this is the case but could perhaps be attributed to more overland flow accumulating in concave areas or more deep drainage due to the reduction in transpiration associated with cleared areas. Lower lateral flow and percolation are due to a reduction in the infiltration and an increase in overland flow. Transpiration will decrease due to less vegetation (it was simulated as bare surface), but evaporation should increase. Simulated water contents of wetland soils did not decrease but showed a small increase, likely due to the increase in overland flow towards the wetland HRUs (Table 7-5). Lateral flow from the wetlands to the streams and percolation did, however, decrease considerably. This is however a very small portion of the water balance as the majority of the water will be evaporated. In general, the simulated impact of the development on the wetland water resources will be relatively small, likely due to adequate buffer areas.

Table 7-3 Selected water balance components (mm) for the before and after scenario for the large catchment.

	Before	After	% Change	% of water balance
Rainfall	719.2	719.2		
Streamflow	220.8	213.8	-3.1	30.7
Overland flow	13.5	15.0	10.7	1.9
Lateral flow	207.2	198.8	-4.1	28.8
Percolation	49.5	47.8	-3.3	6.9
ET	450.7	459.4	1.9	62.7
Transpiration	348.7	302.9	-13.1	48.5
Evaporation	102.0	156.5	53.4	14.2
ET0	1852.7	1852.7		

Table 7-4 Selected water balance components (mm) for the before and after scenario for the Land Segments (LSUs) directly impacted by the development.

	Before	After	% Change	% of water balance
Rainfall	719.2	719.2		
Streamflow	236.9	217.1	-8.3	32.9
Overland flow	18.1	23.5	29.7	2.5
Lateral flow	218.7	193.6	-11.5	30.4
Percolation	46.1	48.1	4.3	6.4
ET	437.7	455.8	4.1	60.9
Transpiration	365.9	217.2	-40.6	50.9
Evaporation	71.7	238.5	232.5	10.0
ET0	1853.2	1853.0		

Table 7-5 Selected water balance components and soil water contents (mm) of wetland HRUs adjacent to the development footprint for before and after scenarios.

	Before	After	% Change	% of water balance
Rainfall	719.2	719.2		
Streamflow	30.7	27.2	-11.5	4.3
Overland flow	1.0	1.1	7.8	0.1
Lateral flow	29.7	26.1	-12.1	4.1
Percolation	6.6	5.4	-18.0	0.9
ET	684.9	689.7	0.7	95.2
Transpiration	678.6	683.7	0.7	94.4
Evaporation	6.2	6.0	-4.5	0.9
ET0	1854.1	1854.1		
Soil water				
Profile water	18.9	19.4	2.5	
Topsoil water	6.4	6.8	6.3	

8 Impact assessment

8.1 Increased erosion and sedimentation

Cause: Compaction and surface sealing will result in increased overland flow and potential erosion of terrestrial and wetland soils, head cutting in streams and loss of fertile topsoil.

Mitigation measures: Attenuation ponds and subsurface drains should form an integral part of stormwater plans to reduce overland flow from paved areas and allow water that runs off from roofs to settle and re-infiltrate.

Table 8-1 Assessment of erosion due to increase overland flow on the environment

	Without Mitigation	With Mitigation
Magnitude	Moderate (6)	Low (4)
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Short-term (2)
Probability	Probable (4)	Possible (3)
Significance	48	24

8.2 Decrease in subsurface lateral flow and return flow

Cause: Increased overland flow will result in decreased infiltration and therefore less lateral flow at the soil bedrock/interface or return flow from groundwater. Open cast areas will intercept lateral flow paths and remove connectivity between recharge zones and lateral flow zones. Alteration of this flow path will likely change the wetland water regimes negatively (note with the current buffer areas, the simulated impact of the reduction is small). The draw-down effect of the open cast pit on the waterflows can also occur impacting the wetland water regimes as well.

Mitigation measures: Development footprint should adhere the buffer zones around all wetlands. This will enable water to infiltration and feed laterally into the wetlands. Application of good quality water which accumulates in pits on areas downslope of pit to maintain saturation at the soil/bedrock interface of Interflow (soil/bedrock) soils.

Table 8-2 Assessment of the impact of decreased lateral flow on wetland regimes and water resources

	Without Mitigation	With Mitigation
Magnitude	High (8)	Low (4)
Extent	Local (2)	Local (2)
Duration	Residual (5)	Medium term (3)
Probability	Probable (4)	Probable (4)
Significance	60	36

9 Recommendations and Conclusions

This report assessed the potential impacts of the planned Ilima mining development on hydropedological processes. The soils were described and interpreted hydropedologically. The landscape is dominated by Recharge soils on the crest and Interflow soils with morphological evidence of lateral flows occurring at the soil/bedrock interface in the lower midslope positions. Valley bottom soils are responsive hydromorphic soils due to long periods of saturation. The planned mining footprint adhered to buffer areas around wetlands and although there will still be an anticipated reduction in lateral flow to the wetlands, this would largely be negated by the buffer area. The latter is supported by modelling of the hydrological fluxes through the vadose zone. The dependence of the wetlands on groundwater was not evaluated in this study. This will be an important consideration to avoid drying out of the wetlands due to groundwater draw-down and should be assessed in the geohydrological specialist study. From a hydropedological perspective, the impact of the 'original' development on hydropedological flow paths would be limited and the impacts could be managed sustainably. Further to this, taking into consideration the reduction in the mining footprint, the overall impacts on the total deductible water regimes of the wetlands is likely to be further reduced.

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APPENDIX 8C: TERRESTRIAL ECOLOGY REPORT

TERRESTRIAL ECOLOGY REPORT FOR THE PROPOSED ILIMA COAL COMPANY KRANSPAN MINERAL RIGHTS AREA EXTENSION PROJECT (Carolina, Mpumalanga Province)

Prepared by: De Castro & Brits c.c.

Authors: Tony de Castro (Pr. Nat. Sci) & Lukas Niemand (Pr. Nat. Sci)

DATE: March 2023
STATUS: Draft Report

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1 INTRODUCTION

1.1 Background

The applicant, Ilima Coal Company (Pty) Ltd. ("Ilima"), is the holder of a Mining Right for coal minerals over the Farm Kranspan 49 IT. Ilima has applied for the extension of their approved Mining Right Area (MRA) to incorporate two adjacent Prospecting Right Areas (PRAs), namely Farm Vaalbank 212 IS and Farm Roodebloem 51 IT.

Ilima has appointed ABS Africa (Pty) Ltd as the Environmental Assessment Practitioner (EAP) for the process required to seek Environmental Authorisation for the extension of their approved MRA and ABS Africa has appointed De Castro & Brits Ecological Consultants to conduct the necessary terrestrial ecology studies in support of the required Environmental Impact Assessment.

1.2 Project Description

The applicant's (Ilima Coal Company (Pty) Ltd.) planned operations on the proposed extension area (comprising the Farms Vaalbank 212 IS and Roodebloem 51 IT) entails surface mining of the coal seams as well as the establishment of various mine support infrastructure.

Based on the mine planning studies completed to date, the following is proposed (Figure 1-1):

- The intention for the proposed extension area is surface (opencast) mining, focusing on extraction of the B, CL and E Seam via the roll-over mining method;
- Besides the opencast mining; haul roads, temporary topsoil and overburden stockpiles, ROM stockpiles and pollution control dams will be established on the proposed extension areas as part of the mining process. In addition, temporary container-type office and ablution facilities and potable water abstraction boreholes will be established;
- A coal wash plant with filter press will be established on Farm Roodebloem to process the export coal product. Dry crushing and screening of the local coal product (sold to Eskom) will take place at the existing dry screening and crushing coal plant at the Kranspan Mine; and
- Dewatering of seepage water will be required for the surface mining over the Life of Mine (LoM). Water removed from pits will be retained in pollution control dams and used for mine activities.

Below is a summarised list of the proposed mining activities to be undertaken on the proposed extension areas.

- Exploration geophysical surveying, drilling, pit sampling and trenching;
- Clearing and grubbing;
- Topsoil removal and stockpiling;
- Overburden removal and stockpiling;
- Drilling and blasting (when necessary);
- Excavation of coal and material transfer to a coal stockpile area;
- Beneficiation of the export coal product; and
- Loading, hauling and transport of coal product.

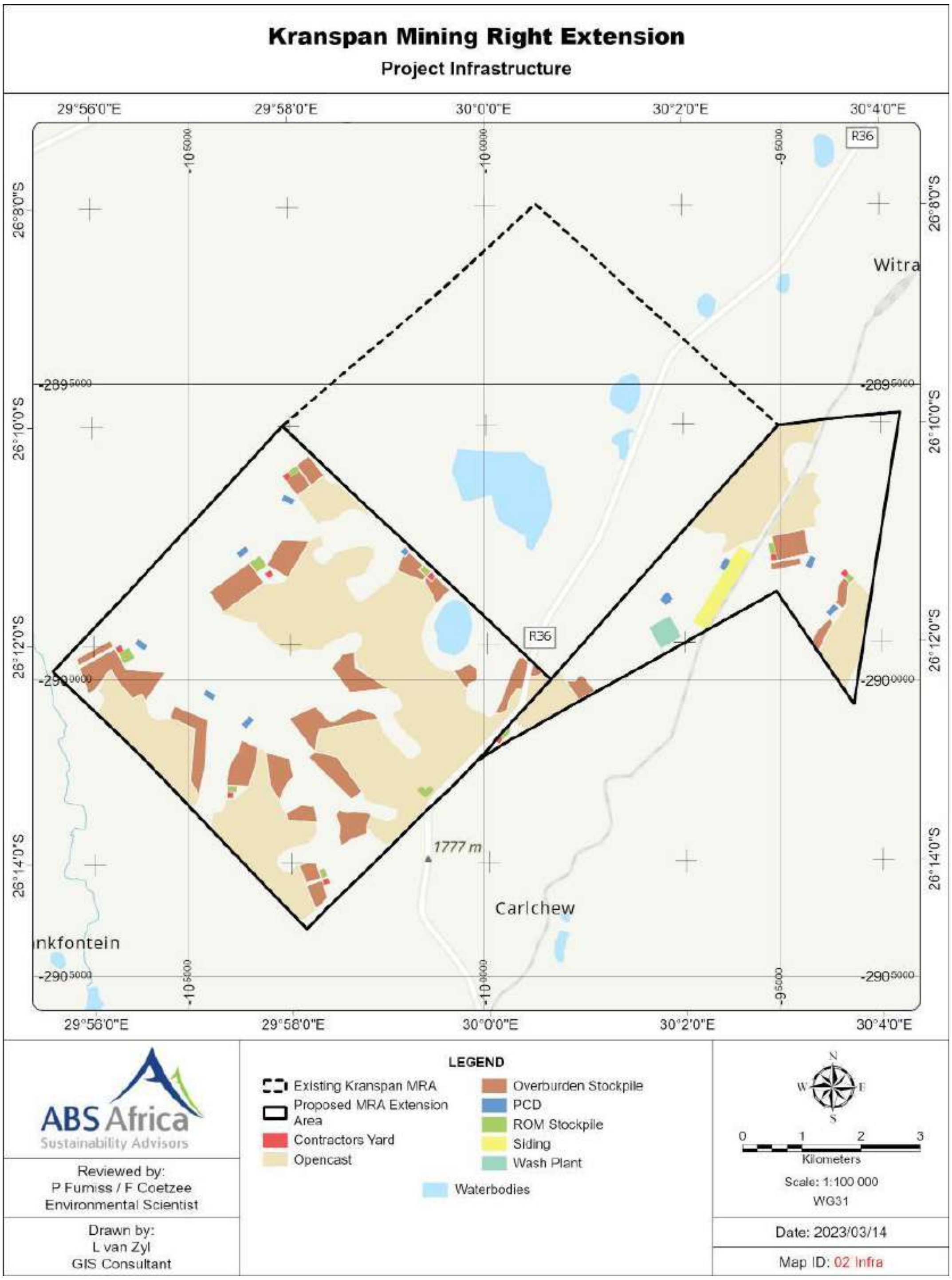

Figure 1-1: Location of Project Infrastructure.

1.3 Report Objectives

The objectives of this report are:

- to provide a scientifically sound baseline description of the receiving environment;
- to provide an objective assessment of the baseline state of the receiving environment including the assessment of the ecological importance of all habitats identified as comprising the receiving environment; and
- to use the objective assessment of the receiving environment as a basis for assessing the significance of project-related impacts on the receiving environment.

1.4 Study Team

Antonio (Tony) De Castro. Tony [B.Sc. (Hons) Botany] entered his current occupation as a professional consultant in the fields of Botany and ecology in 1997, and in 1999 he founded De Castro & Brits c.c., an ecological consulting firm of which he is at present the managing member. He is a registered member (in the fields of Botany and Ecology) of the South African Council for Natural Scientific Professions and conducts specialist work in, inter alia, terrestrial, wetland, and riparian ecosystems of the Savanna and Grassland Biomes of southern Africa. Tony has worked in 13 African countries, has authored several scientific papers and over 570 specialist reports pertaining to biodiversity management, impact assessment, and the sustainable utilisation of natural resources.

Lukas Niemand. Lukas is the founding member of Pachnoda Consulting and has been a professional ecological consultant since 2000. His core services include ecological studies with emphasis on ornithological, faunal and entomological assessments. He has travelled extensively to many remote places as far afield as Marion Island and has worked on numerous international projects pertaining to the African continent (South Africa, Lesotho, Mozambique, Burundi, Congo-Brazzaville, Liberia, Gabon, Zambia, Tanzania, Guinea, Kenya and Ethiopia) and the Middle East (Saudi Arabia). Lukas has worked on urban and mining development projects and has also consulted for various projects involving linear infrastructure, monitoring programmes, biodiversity action plans as well as specific investigations regarding species with rare/elusive life-history traits (e.g., threatened species). Lukas is registered member of the South African Council for Natural Scientific Professions.

1.5 Declaration of Independence

I declare that I have been appointed as an independent consulting ecologist with no affiliation or vested financial interests in the proposed project or project proponent, other than remuneration for work performed. I have no conflicting interests in the undertaking of this activity and have no interests in secondary developments resulting from the authorisation of this project. Remuneration for my services by the proponent is not linked to approval by any decision-making authority responsible for authorising this development. The views expressed in this report are my own and have not been influenced in any way by the proponent.

Antonio D.P. De Castro 10 March 2023

2. SCOPE OF WORK

The Scope of Work (SoW) for the Terrestrial Ecology Assessment presented here was largely determined by the results of the Environmental Screening Tool (EST) report generated for three relevant themes, namely Plant Species, Animal Species and Terrestrial Biodiversity, by ABS Africa. The level of site (Project Area) sensitivity in terms of each of these themes triggered a required specialist assessment and a set of minimum reporting requirements for each theme in accordance to the following Government Notices:

- **Terrestrial Biodiversity Theme** – "Protocol for the specialist assessment and minimum report content requirements for environmental impacts on Terrestrial Biodiversity" (Government Notice No. 320, published in Government Gazette 43110, 20 March 2020).
- **Animal and Plant Themes** – "Protocol for the specialist assessment and minimum report content requirements for environmental impacts on Terrestrial Plant and Animal Species" (Government Notice No. 1150, published in Government Gazette 43855, 30 October 2020).

The approach and methods used in the terrestrial biodiversity assessment present here were informed by the "Guidelines for the implementation of the Terrestrial Fauna and Terrestrial Flora Species Protocols for environmental impact assessments in South Africa" (SANBI, 2020), which provide guidance regarding how specialist studies should be undertaken in order to meet the aforementioned minimum requirements.

The SoW for this project is as follows:

- Provide a baseline description of the PAOI that includes:
    - terrestrial ecosystems present within the PAOI and a description of the main vegetation types/units, threatened ecosystems, ecological connectivity and habitat fragmentation, 'species of conservation concern' and restricted or important habitats;
    - principal ecological drivers or processes within the project area;
    - ecological corridors in the project area;
    - significant landscape features;
    - areas of low ecological sensitivity
- Identify and describe any Critical Biodiversity Areas, Ecological Support Areas and Protected Areas within the PAOI and assess potential project-related impacts on these areas;
- Provide a site-specific Ecological Importance assessment of all habitats represented within the project area;
- Assess the significance of direct, indirect and cumulative impacts of the project on terrestrial biodiversity and recommend appropriate mitigation measures for identified impacts;
- Provide management measures that should be included in the Environmental Management Program (EMP); and
- Provide a substantiated statement regarding the acceptability of the project.

In order to facilitate the verification of adherence to the above-mentioned protocols, compliance checklist have been compiled for each protocol and are included in Appendix 10.

3. PROJECT AREA

The Project Area is situated within the Mpumalanga Province between Carolina and Breyten (Figure 3-1). The Project Area of Influence (PAOI) comprises the proposed mining infrastructure footprints, representing the minimum spatial extent of the project, which are all contained within the 4 956 ha Kranspan MRA Extension Area, which in turn comprises the Farms Roodebloem and Vaalbank (Figure 3-2). All direct impacts, (i.e., new infrastructure footprints), will therefore be confined to the Kranspan MRA Expansion Area, which also contains vast areas where no infrastructure is proposed, but which may be impacted by indirect project-related impacts.

Indirect impacts include ecological "edge effects", such as increased dust emissions, diesel particulate matter, alien plant invasion, disruption of fire and herbivory patterns, and impacts to hydrological regimes and water quality. With the exception of impacts to hydrological regimes and water quality, the impact of these ecological "edge effects" on receptors usually dissipate within 600 m from the source (Pfab, 2006). The majority of significant indirect impacts to biodiversity receptors will therefore be contained within the 4 956 ha Kranspan Extension Area (henceforth also referred to as the Project Area). The 4 956 ha Project Area (PA) is therefore regarded as a suitable PAOI for the assessment of both direct and indirect impacts related to this study.

The Kranspan MRA Extension Area therefore includes all areas of direct impacts plus the vast majority of indirect impacts, other than those related to water quality, which may have an influence on aquatic ecosystems well beyond the boundaries of the study area. For the purposes of this ecological assessment, the 4 956 ha Kranspan MRA Extension Area, is therefore regarded as the Project Area (PA), which includes both the Direct and Indirect PAOI (Figure 3-2). The 4 956 ha Kranspan MRA Extension Area is therefore referred to as the Project Area in this report.

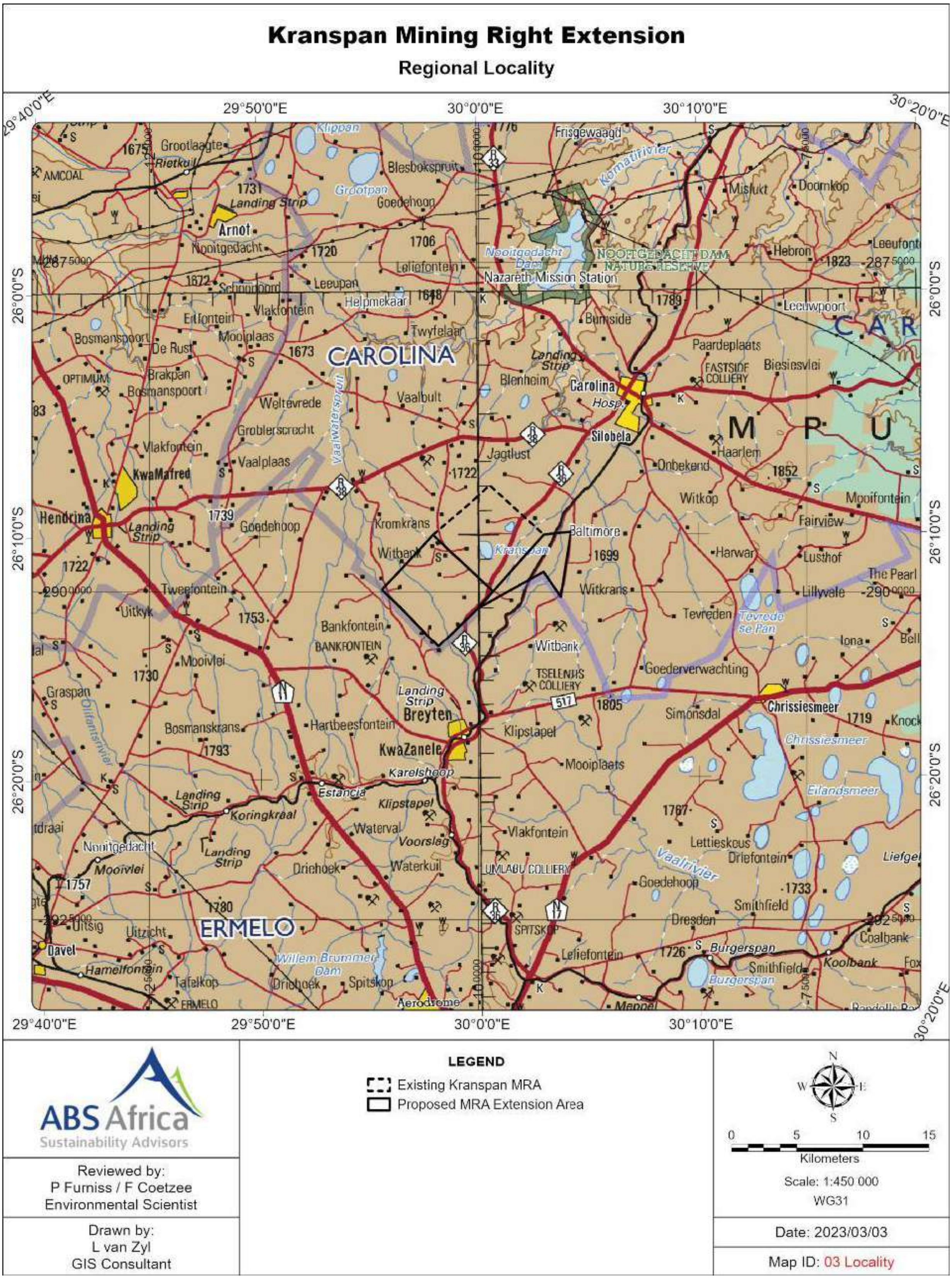

Figure 3-1. Location of the Project Area within the Mpumalanga Province.

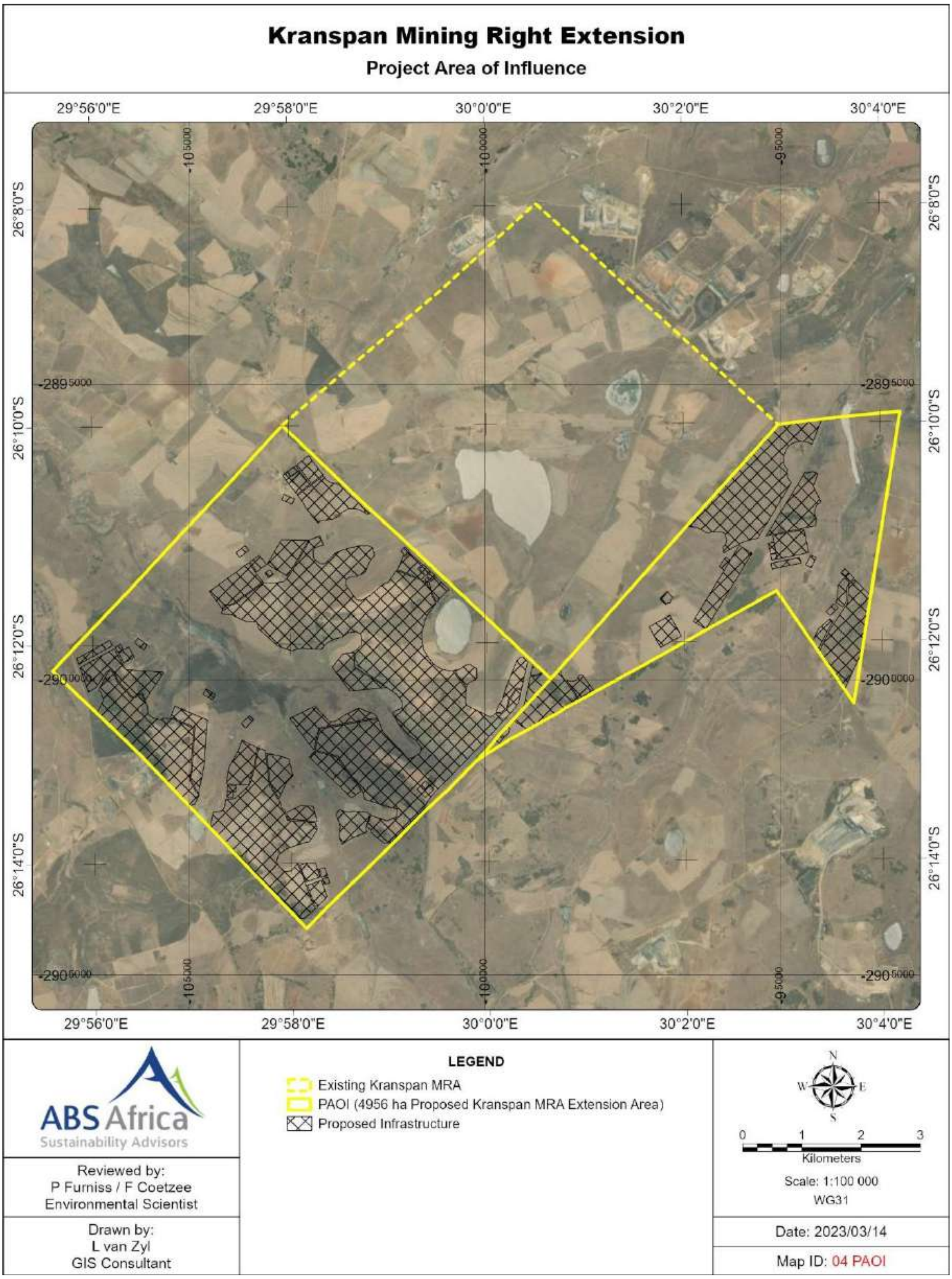

Figure 3-2. Map of the 4 956ha Kranspan MRA Extension area which comprises the Project Area of Influence (PAOI), as well as the final proposed infrastructure layout, which comprises the direct PAOI.

4. APPROACH AND METHODS

The approach and methods used in this study in desktop and fieldwork phases are in accordance with the Species Environmental Assessment Guidelines: Guidelines for the implementation of the Terrestrial Fauna and Terrestrial Flora Species Protocols for environmental impact assessments in South Africa (SANBI, 2020)

4.1 Desktop

4.1.1 Environmental Screening Tool

The Environmental Screening Tool (EST) of the Department of Environment Affairs (DEA) was used by ABS Africa to generate a report for the project area, focusing on three relevant themes, namely Plants, Animals and Terrestrial Biodiversity. This fulfils the requirement of regulation 16(1)(b)(v) of the EIA regulations. The EST report included species that are listed as National Sensitive Species by SANBI, which are species for which locality data needs to remain confidential and may not be released into the public domain. The names of these species have been kept obscured in the version of this report released for public comment. The various threatened and sensitive taxa listed in the EST report were incorporated into the lists of potentially occurring SCC provided in this report.

4.1.2 Flora

Lists of plant species historically recorded (based on herbarium specimens) within the two quarter-degree grids within which the project area is situated (2629BB and 2630AA) were extracted from the Botanical Database of Southern Africa (BODATSA) by Mr Pieter Bester of SANBI upon request of the consultant. BODATSA contains records from the major South African herbaria, namely the National Herbarium in Pretoria (PRE), the Compton Herbarium in Cape Town (NBG and SAM) and the KwaZulu-Natal Herbarium in Durban (NH). Lists of plant 'species of conservation concern' (*sensu* Raimondo *et al*., 2009) historically recorded from the aforementioned grids were also obtained from the Mpumalanga Tourism and Parks Agency's database of historically recorded 'species of conservation concern' (pers. comm. Dr Mervyn Lötter., received 20/10/2022) and from the Environmental Screening Tool (EST) report generated by ABS Africa for the project area.

The obtained integrated list from the above-mentioned sources was then checked against version 2020.1 of the Red List of South African Plants (http://redlist.sanbi.org), which is continuously updated by SANBI's Threatened Species Programme, to confirm the current conservation status of all species in the list. The term 'species of conservation concern' (SCC) is used in this report and refers to all species with a conservation status categorised as threatened (Critically Endangered, Endangered and Vulnerable) Near threatened, Data Deficient, Critically Rare or Rare.

Precise locality records and herbarium label data for SCC confirmed for the project area during the current study, or thought to have a High likelihood of occurrence, were extracted from BODATSA by SANBI's Threatened Species Programme upon request of the author. This data was used to verify aspects such as 'extent of occurrence' and 'area of occupancy' for these species as the latest conservation status assessments for some of these species were conducted more than a decade ago.

Mucina & Rutherford (2006) and its accompanying vegetation mapping was used as the primary information source for providing a regional context for the vegetation and habitats of the study area and it's immediate surrounds, and the terrestrial ecology assessment report compiled by McClelland

(2019) for the directly adjacent, existing Kranspan Mineral rights area was also screened for relevant information relevant to the current terrestrial ecology assessment.

Prior to the conduction of fieldwork, a broad-scale stratification of the 4 956ha project area was carried out using Google Earth Pro aerial imagery (including historical imagery dating back to September 2013) and the relevant topographical and geological maps, and areas of potential untransformed habitat and vegetation (Natural Habitat (*sensu* IFC, 2012) were identified. Fieldwork focused on surveying these areas of Natural habitat and verifying the ecological status (i.e., transformed of untransformed) of areas that could not be categorised with certainty at a desktop level.

4.1.3 Mammals

- The potential occurrence and conservation status of mammal taxa were based on the IUCN Red List (2023) and the recently revised national Red Data Book by Child *et al*. (2016), while mammalian nomenclature was informed by Stuart and Stuart (2015) and Child *et al*. (2016) unless otherwise indicated.
- The historical and extant (contemporary) distribution ranges of mammal taxa sympatric to the project area was sourced from MammalMap[1] (with focus on QDS 2629BB and 2630AC, although neighbouring/peripheral quarter-degree grid cells were also investigated; Figure 4-1) and various applicable field guides (in particular Stuart & Stuart (2015), Skinner & Chimimba (2005), Child *et al*. (2016) and Friedmann & Daly (2004)).
- Additional distributional information on the mammals of the area was also obtained from a terrestrial ecological survey conducted by ECOREX (2019) for the Ilima Coal Company Kranspan Project, as well as data supplied by the Mpumalanga Parks and Tourism Authority (MPTA) and from iNaturalist (http://www.inaturalist.org).

4.1.4 Herpetofauna

- Red List categories were obtained from the conservation assessment conducted by Bates *et al*. (2014).
- Red List categories and listings of amphibian taxa follow Measey (2010),
- The historical and extant (contemporary) distribution ranges of reptile and amphibian taxa sympatric to the project area was sourced from FrogMap[2] and ReptileMap (with focus on QDS 2629BB and 2630AC, although neighbouring/peripheral quarter-degree grid cells were also investigated; Figure 4-1).
- Additional distributional information on the mammals of the area was also obtained from a terrestrial ecological survey conducted by ECOREX (2019) for the Ilima Coal Company Kranspan Project, as well as data supplied by the Mpumalanga Parks and Tourism Authority (MPTA) and from iNaturalist (http://www.inaturalist.org).

4.1.5 Avifauna

- Hockey *et. al*. (2005), Del Hoyo *et al.* (1992-2011) and Harrison *et. al.* (1997) were consulted for general information on the life-history attributes of the relevant bird species. They also provide basic distributional information on a small scale.

[1] Obtained from the Virtual Museum that is administered by the Animal Demography Unit (https://vmus.adu.org.za/).
[2] Obtained from the Virtual Museum that is administered by the Animal Demography Unit (https://vmus.adu.org.za/).

- The conservation status of bird species was categorised according to the global IUCN Red List of threatened species (IUCN, 2023) and a regional conservation assessment by Taylor *et al.* (2015).
- Distributional data was sourced from the first South African Bird Atlas Project (SABAP1) and verified against Harrison *et. al*. (1997) for species corresponding to the quarter-degree grid cells (QDGCs) 2629BB (Kromkrans) and 2630AA (Carolina) (Figure 4-1). The SABAP1 data provides a "snapshot" of the abundance and composition of species recorded within a quarter-degree grid cell (QDGC) which was the sampling unit chosen (corresponding to an area of approximately 15 min lat x 15 min long). It should be noted that the atlas data makes use of reporting rates that were calculated from observer cards submitted by the public as well as citizen scientists. It provides an indication of the thoroughness of which the QDGCs were surveyed between 1987 and 1991.
- Additional distributional data was sourced from the second South African Bird Atlas Project (SABAP2; www.sabap2.adu.org.za). Since bird distributions are dynamic (based on landscape changes such as fragmentation and climate change), SABAP2 was born (and launched on 1 July 2007) from SABAP1 with the main difference being that all sampling is done at a finer scale known as pentad grids (5 min lat x 5 min long, equating to 9 pentads within a QDGC). Therefore, the data is more site-specific, recent and more comparable with observations made during the site visit (due to increased standardisation of data collection). The pentad grids relevant to the current project includes 2610_2955 and 2610_3000 (all eight adjacent pentad grids surrounding grid 2610_2955 were also investigated; Figure 4-2); and
- The choice of scientific nomenclature, taxonomy and common names were recommended by the International Ornithological Committee (the IOC World Bird Names, v.12.2; Gill *et al.*, 2022).
- Additional distributional information on the birds of the area was also obtained from a terrestrial ecological survey conducted by ECOREX (2019) for the Ilima Coal Company Kranspan Project, as well as data supplied by the Mpumalanga Parks and Tourism Authority (MPTA) and from iNaturalist (http://www.inaturalist.org).

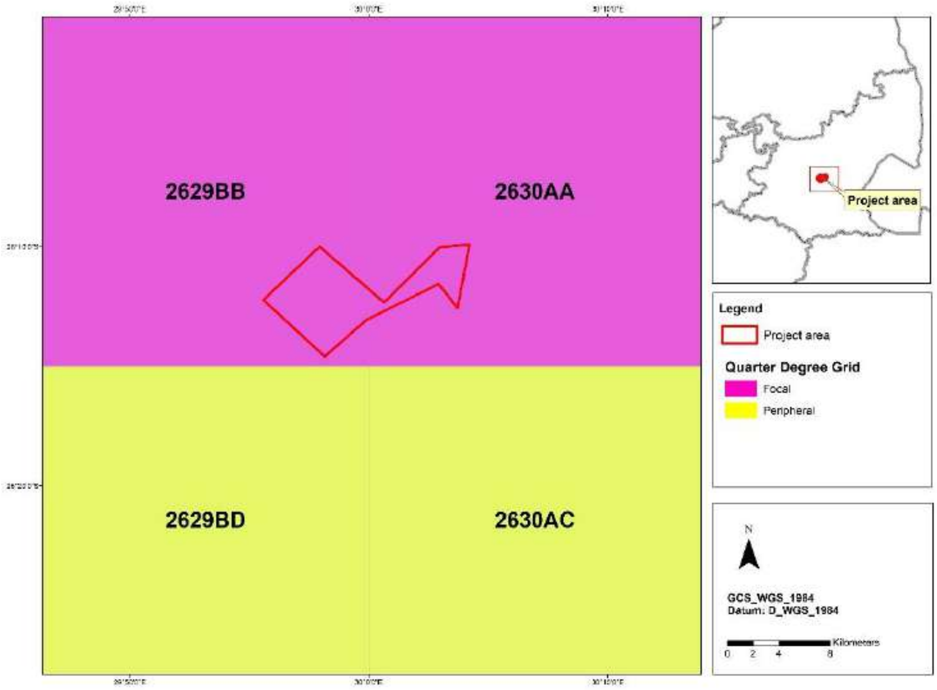

Figure 4-1: Location of the project area in context of the quarter-degree grid cells.

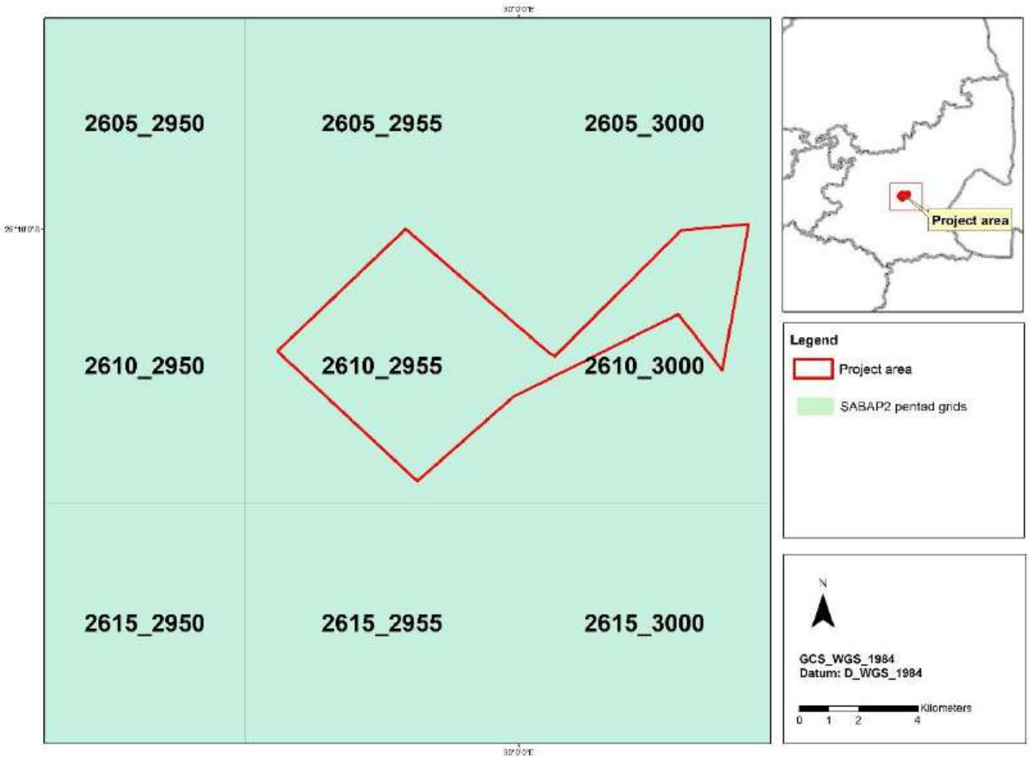

Figure 4-2: Location of the project area in context of the SABAP2 pentad grids.

4.2 Fieldwork

Fieldwork for the floristic and ecological assessment included 3 days of fieldwork conducted in late spring from the 26th to the 28th of October 2022 and 10 days of fieldwork conducted between the 11th and 21st of January 2023 during the height of the Highveld growing season. All fieldwork therefore fell within the recommended ideal survey time for the Grassland biome (October to March) as described in the 'Species Environmental Assessment Guideline (SANBI, 2020). The timing of the botanical fieldwork was informed by the desirability of including some seasonal coverage (i.e. spring and mid-summer) in the botanical surveys so as to maximise the probability of detecting potentially occurring plant 'species of conservation concern' (SCC) that are difficult to detect or identify when not in flower, and so as to meet the scheduling requirements of the Environmental Authorisation application process.

Fieldwork for the faunal assessment included five days of fieldwork conducted between the 17th and 21st of January 2023. Fieldwork for the faunal component coincided with the peak wet (mid-summer) season, which is an ideal survey time to document avifauna when most bird species are displaying (being vocal) and in breeding plumage, and when Palearctic and intra-African migratory species are present. The fieldwork timing also coincided with the peak activity period for frogs and reptiles.

Fieldwork survey methods selected for the various disciplines were those methods considered optimal for the location of SCC and description of plant communities and faunal assemblages in a large area (4 956ha) and within a restricted timeframe, namely 'rapid biological assessment' methods. Selected methods were both site (e.g. vegetation sampling quadrats and point counts for birds) and transect based which allowed for significant coverage of the Natural Habitats of the large project within a combined total of 18 days of fieldwork conducted by the two ecological consultants for this study. More details on discipline specific methodology are provided below.

4.2.1 **Flora**

Botanical surveys were conducted at 193 sites within the project area and species records and notes on vegetation structure were made while travelling between these sites. At each of the193 sites surveyed, the vegetation was classified using visual estimates of woody canopy cover according to the broad-scale structural classification of Edwards (1983), and use was made of a brief ‘timed-meander search’ (TMS) (Goff *et al*., 1982) to compile species inventories. Longer, formal timed-meander searches were conducted at 12 of the 193 sites. The ‘timed-meander search’ method is a semi-quantitative survey procedure that has been shown to be highly effective and time efficient in terms of detecting rare species and documenting α-diversity (Goff *et al*., 1982 and Huebner, 2007). As the final infrastructure layout was not available at the time of the field surveys, desktop top mapping of areas of Natural Habitat (untransformed habitat) and the preliminary layout plan were used to select the localities of sampling sites and TMS surveys / walking transects which covered a total distance of 77.8kms. A map of all 193 sites surveyed and transects walked during field work is provided in Appendix 4 and photographs and data for each of the twelve formal timed-meander searches is provided in Appendices 2 and 3. Routes were selected to traverse representative areas of all habitats and plant communities present, with emphasis placed on highly spatially restricted habitats, habitats most likely to contain potentially occurring plant ‘species of conservation concern’ and species rich plant communities.

An herbarium specimen (A. De Castro & A. Hankey 2024) of the confirmed threatened species Sensitive Species 1200 was collected at the site and submitted to the National Herbarium in Pretoria. Photographs of the confirmed threatened species *Khadia carolinesis* were uploaded onto the iNaturalist website (https://www.inaturalist.org/observations/150400585), which links all research grade observations to the Global Biodiversity Information Facility (GBIF). The specimen data and photographs have also been provided to Dr Mervyn Lötter, curator of the MTPA threatened species database.

4.2.2 Mammals

- Mammals were identified by visual sightings during ad hoc transect walks, while driving, and by means of active searching.
- In addition, mammals were also identified by means of field signs (spoor, droppings, roosting sites or likely habitat types).

4.2.3 Herpetofauna

- Possible burrows, or likely reptile habitat (termitaria, stumps or rocks) were inspected for any inhabitants. Amphibians were also identified by their vocalisations and through likely habitat types (e.g., water features, drainage lines, etc.). However, the herpetofauna assessment focused largely on a desktop review.

4.2.4 Avifauna

- *Point count surveys*: Data was collected by means of 50 point counts, (Buckland et. al., 1993; Figure 4-3). The use of point counts is advantageous since it is the preferred method to use to detect cryptic or elusive species. In addition, it is the preferred method to line transect counts where access is problematic, or when the terrain appears to be complex. It is a good method to use and very efficient for gathering a large amount of data in a short period of time (Sutherland, 2006). At each point, all the bird species seen within approximately 50 m from the centre was recorded along with their respective abundance values. Each point count lasted approximately 10-15 minutes while it was slowly traversed to ensure that all the birds were detected (Sutherland et. al., 2004; Watson, 2003) within the 50 m radius. To maximise the independence of observations, points were positioned approximately 200 m apart. Waterbirds were also counted at 10 wetland features which range from large pans, manufactured impoundments to streams and rivers (Figure 4-3).

- Ad hoc *(random) surveys*: To obtain a more complete inventory of bird species present (apart from those observed during the point counts), all bird species observed while moving between point counts were identified and noted. Particular attention was devoted to suitable roosting, foraging and nesting habitat for threatened or Near Threatened species. Besides visual observations, bird species were identified by means of their calls and other signs such as nests, discarded eggshells and feathers. All observations was also processed and submitted to SABAP2.
- *Playback/broadcasting of bird vocalisations*: The probability of detecting skulking or elusive species was verified by playback of bird calls/songs wherever suitable habitat was detected. Special care was taken to keep disturbance to a minimum and not to affect the bird's natural behaviour (e.g., to prevent unnecessary habituation).
- *Primary analyses and matrix*: All data collected were presented in a matrix, with rows representing the relative abundances of each bird species, and columns representing respective point counts within each of the sampled habitat units (see Niemand, 2001). This matrix formed the bases for the proceeding analyses. The abundances of each species in each habitat type were standardised due to unequal sample sizes of the point counts on each habitat type. Several measures describe the similarity of species abundance values between samples, and in this report the Bray-Curtis similarity index or coefficient was used. The index describes the similarity between species a and b (B-CSab) and was calculated as: B-CSab = (2∑ min (x_ca,x_cb))/(∑x_ca∑x_cb) where xca and xcb are fourth root transformed parameters (abundance, relative densities) of species a and species b, respectively. All multivariate analyses were performed using the software package PRIMER v5.0. This was done by calculating Bray-Curtis similarities between every pair of samples to construct a similarity matrix. This matrix was subsequently used to discriminate between habitat types through cluster analysis and ordination techniques (using non-metric multidimensional scaling) and analysis of similarities. The importance of very abundant species had to be down weighted in order to give some importance to low abundance or rare species. This was achieved by performing a fourth root transformation on the data (Clarke & Warwick, 1994).
- Patterns in community/assemblage composition: The program SIMPER was used to determine the contribution (%) of each species to each habitat type, as well as the consistency of its contribution to the similarity between the different point counts on each habitat type (Clarke & Warwick, 1994). Species with high consistencies represent typical species for the given community. The same program was used to measure the dissimilarity between habitat types. Therefore, species that contribute most to the dissimilarity between two sites are good discriminant/indicator species of the particular habitat (Niemand, 2001).
- Patterns in abundance and diversity: The mean number of species (S) and Shannon-Weaver diversity index (H') were calculated for each habitat type. Please refer to Magurran (1988) for a description of the Shannon-Weaver diversity index.
- Prior to further analyses where species richness values are considered, it is imperative to determine if all bird species present were sufficiently sampled. Species accumulation curves (SAC) provide a means to examine data and sampling efficacy. For this project, the species accumulation curves (SAC) for the point count data were generated using the software program Estimates S (version 9) with 100 randomisations (as recommended in Colwell, 2013). Curves were generated for the full data set (all point counts). Sampling sufficiency

was determined by establishing whether a point had been reached where a line representing one new sample adding one new species was tangent to the curve (Brewer & McCann, 1982). The Michaelis-Menten equation (Soberôn & Llorente 1993) was fitted to the predicted number of species using Estimates S (Raaijmakers, 1987). A satisfactory level of sampling was achieved if 90 % of the bird species were detected, and hence predicted by the model (Moreno & Halffter, 2000).

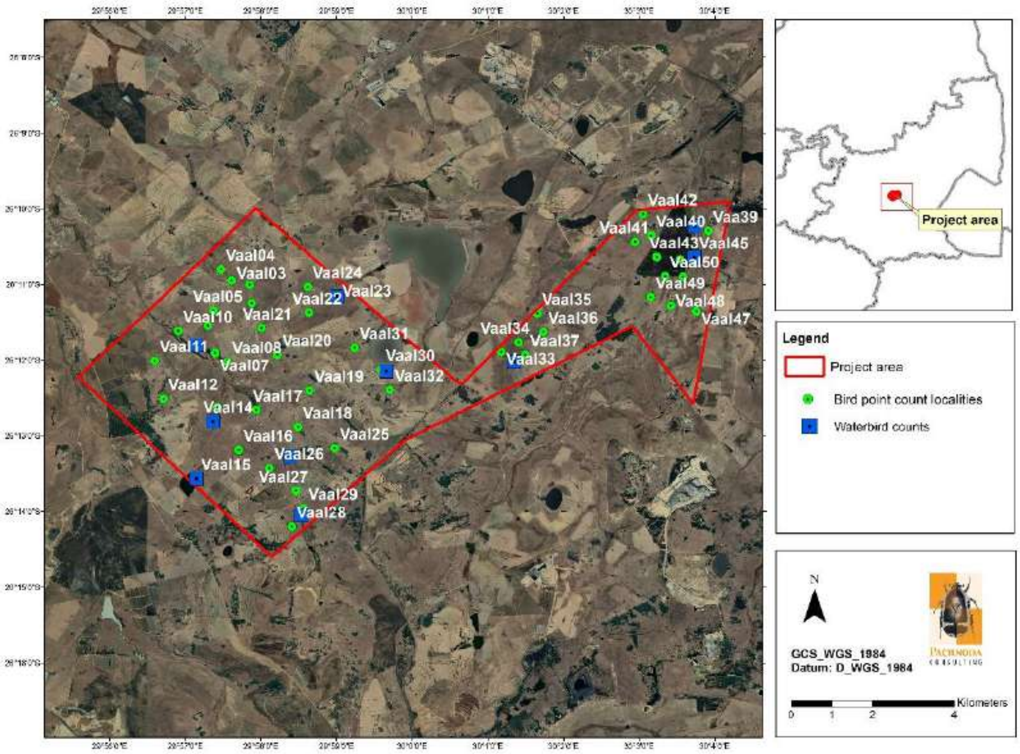

Figure 4-3: The bird point count and waterbird count localities on the project area.

4.3 Assessment of Ecological Importance

The "Guidelines for the implementation of the Terrestrial Fauna and Terrestrial Flora Species Protocols for environmental impact assessments in South Africa" (SANBI, 2020), provides a standardised method for the assessment of Site Ecological Importance (SEI) in relation to a proposed project (including the project footprint and project-related activities). This assessment of ecological importance does not replace the output of the National, web-based Environmental Screening Tool or provincial 'Biodiversity Sector Plans' (or 'Conservation Plans') such as the Mpumalanga Biodiversity Sector Plan (MTPA, 2014) but is rather compliments these resources with a more site-specific ecological assessment that is linked to the Project Area and the proposed project footprint and activities.

Site Ecological Importance (SEI) is one of the most important components of a specialist ecological study as it provides the basis for assessing the significance of potential project-related impacts on the receiving environment.

SEI is considered to be a function of the biodiversity importance (BI) of the receptor (e.g., species of conservation concern, the vegetation/fauna community or habitat type) and its resilience to impacts (receptor resilience [RR]) as follows:

$$SEI = BI + RR$$

BI in turn is a function of conservation importance (CI) and the functional integrity (FI) of the receptor as follows:

$$BI = CI + FI$$

The guidelines (SANBI, 2020) define conservation importance as 'the importance of a site for supporting biodiversity features of conservation concern present, e.g. populations of IUCN threatened (CR, EN and VU) and Near Threatened species (NT), Rare species, range-restricted species, globally significant populations of congregatory species, and areas of threatened ecosystem types, through predominantly natural processes". The criteria for categorising CI are presented in Table 4-1.

Table 4-1. Criteria for determining conservation importance of a receptor (SANBI, 2022).

Conservation Importance	Fulfilling Criteria
Very High	Confirmed or highly likely occurrence of CR, EN, VU or Extremely Rare or Critically Rare species that have a global EOO of < 10 km^2
	Any area of natural habitat of a CR ecosystem type or large area (> 0.1 % of the total ecosystem type extent) of natural habitat of EN ecosystem type
	Globally significant populations of congregatory species (>10% of global population)
High	Confirmed or highly likely occurrence of CR, EN, VU species that have a global Extent of Occurrence of > 10 km^2. IUCN threatened species (CR, EN, VU) must be listed under any criterion other than A. If listed as threatened only under Criterion A, include if there are less than 10 locations or < 10 000 mature individuals remaining.
	Small area (>0.01% but < 0.1 % of the total ecosystem type extent) of natural habitat of EN ecosystem type or large area (> 0.1 %) of natural habitat of VU ecosystem type
	Presence of Rare species
	Globally significant populations of congregatory species (>1% but <10% of global population)
Medium	Confirmed or highly likely occurrence of populations of NT species, threatened species (CR, EN, VU) listed under A criterion only and which have more than 10 locations or more than 10 000 mature individuals.
	Any area of natural habitat of threatened ecosystem type with status of VU
	Presence of range-restricted species
	> 50 % natural habitat with potential to support SCC
Low	No confirmed or highly likely populations of species of conservation concern
	No confirmed or highly likely populations of range-restricted species
	< 50 % of natural habitat with limited potential to support SCC
Very Low	No confirmed and highly unlikely populations of SCC
	No confirmed and highly unlikely populations of range-restricted species
	No natural habitat remaining

The guidelines (SANBI, 2020) define Functional Integrity (FI) as "a measure of the ecological condition of the impact receptor as determined by its remaining intact and functional area, its connectivity to other natural areas and the degree of current persistent ecological impacts". The criteria for categorising FI are presented in Table 4-2.

Table 4-2. Criteria for Functional Integrity (FI).

Functional Integrity	Fulfilling Criteria
Very High	Very large (>100 ha) intact area for any conservation status of regional vegetation type or >5 ha for CR regional vegetation types
	High habitat connectivity serving as functional ecological corridors, limited road network between intact habitat patches
	No or minimal current ecological impacts with no signs of major past disturbance (e.g., ploughing)
High	Large (>20 ha but <100 ha) intact area for any conservation status of regional vegetation type or >10 ha for EN regional vegetation types
	Good habitat connectivity with potentially functional ecological corridors and a regularly used road network between intact habitat patches
	Only minor current ecological impacts (e.g., few livestock utilising area) with no signs of major past disturbance (e.g., ploughing) and good rehabilitation potential
Medium	Medium (>5 ha but <20 ha) semi-intact area for any conservation status of regional vegetation type or > 20 ha for VU regional vegetation types
	Only narrow corridors of good habitat connectivity or larger areas of poor habitat connectivity and a busy used road network between intact habitat patches
	Mostly minor current ecological impacts with some major impacts (e.g., established population of alien and invasive flora) and a few signs of minor past disturbance; moderate rehabilitation potential
Low	Small (>1 ha but <5 ha) area
	Almost no habitat connectivity but migrations still possible across some transformed or degraded natural habitat; a very busy used road network surrounds the area. Low rehabilitation potential
	Several minor and major current ecological impacts
Very Low	Very small (<1 ha) area
	No habitat connectivity except for flying species or flora with wind-dispersed seeds.
	Several major current ecological impacts

Biological Integrity (BI) is derived from a simple matrix of CI and FI as follows:

Table 4-3: Biodiversity Importance matrix.

Biodiversity Importance		Conservation Importance				
		Very High	High	Medium	Low	Very Low
Functional Integrity	Very High	Very High	Very High	High	Medium	Low
	High	Very High	High	Medium	Medium	Low
	Medium	High	Medium	Medium	Low	Very Low
	Low	Medium	Medium	Low	Low	Very Low
	Very Low	Medium	Low	Very Low	Very Low	Very Low

The guidelines (SANBI, 2020) define Receptor Resilience (RR) as "the intrinsic capacity of the receptor to resist major damage from disturbance and/or to recover to its original state with limited or no human intervention. The criteria for categorising RR are presented in Table 4-4.

Table 4-4: Criteria for Receptor Resilience (RR).

Receptor Resilience	Fulfilling Criteria
Very High	Habitat that can recover rapidly (~ less than 5 years) to restore > 70 % of the original species composition and functionality of the receptor functionality, or species that have a very high likelihood of remaining at a site even when a disturbance or impact is occurring, or species that have a very high likelihood of returning to a site once the disturbance or impact has been removed
High	Habitat that can recover relatively quickly (~ 5-10 years) to restore > 70 % of the original species composition and functionality of the receptor functionality, or species that have a high likelihood of remaining at a site even when a disturbance or impact is occurring, or species that have a high likelihood of returning to a site once the disturbance or impact has been removed
Medium	Will recover slowly (~more than 10 years) to restore > 70 % of the original species composition and functionality of the receptor functionality, or species that have a moderate likelihood of remaining at a site even when a disturbance or impact is occurring, or species that have a moderate likelihood of returning to a site once the disturbance or impact has been removed
Low	Habitat that is unlikely to be able to recover fully after a relatively long period: > 15 years required to restore ~less than 50 % of the original species composition and functionality of the receptor functionality, or species that have a low likelihood of remaining at a site even when a disturbance or impact is occurring, or species that have a low likelihood of returning to a site once the disturbance or impact has been removed
Very Low	Habitat that is unable to recover from major impacts, or species that are unlikely to remain at a site even when a disturbance or impact is occurring, or species that are unlikely to return to a site once the disturbance or impact has been removed

Upon the successful determination of both BI and RR as described above, it is possible to evaluate Site Ecological Importance (SEI) from the final matrix as follows:

Table 4-5: Site Ecological Importance matrix.

SEI		Biodiversity Importance				
		Very High	High	Medium	Low	Very Low
Receptor Resilience	Very Low	Very High	Very High	High	Medium	Low
	Low	Very High	Very High	High	Medium	Very Low
	Medium	Very High	High	Medium	Low	Very Low
	High	High	Medium	Low	Very Low	Very Low
	Very High	Medium	Low	Very Low	Very Low	Very Low

Table 4-6: Guidelines for interpreting Site Ecological Importance (SEI) of receptors in the context of the proposed development activities.

Site Ecological Importance	Interpretation in relation to proposed development activities
Very High	Avoidance mitigation - No destructive development activities should be considered. Offset mitigation not acceptable/not possible (i.e., last remaining populations of species, last remaining good condition patches of ecosystems/unique species assemblages). Destructive impacts for species/ecosystems where persistence target remains.
High	Avoidance mitigation wherever possible. Minimisation mitigation – changes to project infrastructure design to limit the amount of habitat impacted; limited development activities of low impact acceptable. Offset mitigation may be required for high impact activities.
Medium	Minimisation & restoration mitigation - development activities of medium impact acceptable followed by appropriate restoration activities
Low	Minimisation & restoration mitigation - development activities of medium to high impact acceptable followed by appropriate restoration activities
Very Low	Minimisation mitigation - development activities of medium to high impact acceptable and restoration activities may not be required

The SEI value for each vegetation unit / broad-scale plant community identified for the Project Area is spatially indicated on the map provided in Figure 5-16.

4.4 Impact Assessment

The first phase of impact assessment is the identification of the various project activities which may impact upon the identified environmental receptors. The identification of significant project activities is supported by the identification of the various receiving environmental receptors and resources. These receptors and resources allow for an understanding of the impact pathways and assessment of the sensitivity of the receiving environment to change. The significance of the impact is then assessed by rating each variable numerically, according to defined criteria as provided in Table 4-7. The purpose of the significance rating of the identified impacts is to develop a clear understanding of the influences and processes associated with each impact.

The severity, spatial scope and duration of the impact together comprise the consequence of the impact; and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact and can obtain a maximum value of 10. The values for likelihood and consequence of the impact are then read from a significance rating matrix as shown in Table 4-8 and Table 4-9.

Table 4-7. Criteria for Assessing the Significance of Impacts.

SEVERITY OF IMPACT	RATING	
Insignificant / non-harmful / non-beneficial	1	CONSEQUENCE
Small / potentially harmful / potentially beneficial	2	
Significant / slightly harmful / slightly beneficial	3	
Great / harmful / beneficial	4	
Disastrous / extremely harmful / extremely beneficial	5	
SPATIAL SCOPE OF IMPACT	**RATING**	
Activity specific	1	
Area specific	2	
Whole project site / local area	3	
Regional	4	
National/International	5	
DURATION OF IMPACT	**RATING**	
One day to one month	1	
One month to one year	2	
One year to ten years	3	
Life of operation	4	
Post closure / permanent	5	
FREQUENCY OF ACTIVITY / DURATION OF ASPECT	**RATING**	LIKELIHOOD
Annually or less / low	1	
6 monthly / temporary	2	
Monthly / infrequent	3	
Weekly / life of operation / regularly / likely	4	
Daily / permanent / high	5	
FREQUENCY OF IMPACT	**RATING**	
Almost never / almost impossible	1	
Very seldom / highly unlikely	2	
Infrequent / unlikely / seldom	3	
Often / regularly / likely / possible	4	
Daily / highly likely / definitely	5	

***Activity**: a distinct process or task undertaken by an organisation for which responsibility can be assigned.*
***Environmental aspect**: an element of an organisation's activities, products or services which can interact with the environment.*
***Environmental impacts**: consequences of these aspects on environmental resources or receptors.*
***Receptors**: comprise but are not limited to people or man-made structures.*
***Resources**: include components of the biophysical environment.*
***Frequency of activity**: refers to how often the proposed activity will take place.*
***Frequency of impact**: refers to the frequency with which a stressor will impact on the receptor.*
***Severity**: refers to the degree of change to the receptor status in terms of the reversibility of the impact; sensitivity of the receptor to a stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent-setting; threat to environmental and health standards.*
***Spatial scope**: refers to the geographical scale of the impact.*
***Duration**: refers to the length of time over which the stressor will cause a change in the resource or receptor.*

The model outcome of the impacts is then assessed in terms of impact certainty and consideration of available information. The NEMA Precautionary Principle is applied in instances of uncertainty or lack of information by increasing assigned ratings or adjusting final model outcomes. In certain instances, where a variable or outcome requires rational adjustment due to model limitations, the model outcomes are adjusted. Arguments and descriptions for such adjustments, as well as arguments for each specific impact assessment are presented in the text and encapsulated in the assessment summary table linked to each impact discussion.

The assessment of impacts is done initially for the scenario where no mitigation measures are implemented. Mitigation measures are then identified and considered for each impact and the analysis is repeated in order to determine the significance of the residual impacts (the impact remaining after the mitigation measure has been implemented).

Table 4-8. Significance Rating Matrix

	CONSEQUENCE (SEVERITY + SPATIAL SCOPE + DURATION)														
LIKELIHOOD (FREQUENCY OF ACTIVITY + FREQUENCY OF IMPACT)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

Table 4-9. Positive/Negative Mitigation Ratings.

COLOUR CODE	SIGNIFICANCE RATING	VALUE	NEGATIVE IMPACT MANAGEMENT RECOMMENDATION	POSITIVE IMPACT MANAGEMENT RECOMMENDATION
	Very High	126-150	Improve current management	Maintain current management
	High	101-125	Improve current management	Maintain current management
	Medium-High	76-100	Improve current management	Maintain current management
	Low-Medium	51-75	Maintain current management	Improve current management
	Low	26-50	Maintain current management	Improve current management
	Very Low	1-25	Maintain current management	Improve current management

4.5 Assumptions and Limitations

A total of sixteen days of field work and eighteen of data analysis, mapping and reporting were available for the completion of the terrestrial ecology assessment presented here, and fieldwork included surveys conducted in both October 2022 and January 2023.

Due to time constraints inherent in a rapid ecological assessment such as that presented here and large size of the project area (4 956 ha) and the fact that almost 40% of the project area comprises Natural Habitat (untransformed habitat), the plant species list provided in Appendix 1 cannot be regarded as comprehensive. The compilation of a complete plant species list for an area the size of the project area in this region of the Mpumalanga Highveld requires surveys to include comprehensive seasonal coverage over a number of years. Based on the author's extensive experience in this region of the Highveld, the plant species list provided in Appendix 1 is likely to include approximately 85% of the plant species actually present within the study area, which provides an accurate indication of the floristic diversity of the project area and is regarded as an appropriate level of accuracy for the nature and objectives of this study. This limitation is also mitigated by the fact that particular emphasis was placed on searching for potentially occurring plant SCC and recommendations for the conduction additional floristic surveys which should be included in the EMP and conducted prior to construction, are provided in this report.

In order to obtain a comprehensive understanding of the faunal communities in the project area, as well as the status of rare or threatened species in the area, faunal surveys should consider investigations at different time scales (across seasons/years) and through replication. However, the authors have conducted extensive faunal surveys on the Mpumalanga Highveld and based on this experience, the current survey is considered to be appropriate for the objectives of this study and is likely to include approximately 70 % - 75% of the vertebrate fauna richness that is expected to be present within the study area. Due to the large size of the area and time constraints, it was decided not to use standard small mammal trapping methods, such as live Sherman traps since the faunal specialists would have needed to check traplines early each morning, which would impose time restrictions to access key habitat types for bird species of conservation concern during the early mornings.

5. BIODIVERSITY BASELINE DESCRIPTION

5.1 Vegetation and Flora

5.1.1 Regional Context

National Biomes and Vegetation Types

The project area is situated within the Grassland Biome which comprises the high elevation central and eastern plateau of South Africa (the 'Highveld') as well as the mountainous areas of the Eastern Cape and KwaZulu-Natal Drakensberg and the mountainous region of Mpumalanga. This area is characterised by summer rainfall and dry winters with regular winter frosts (Mucina & Rutherford, 2006). Four geographically distinct bioregions have been distinguished within the Grassland Biome, namely Drakensberg Grassland, Dry Highveld Grassland, Mesic Highveld Grassland and Sub-escarpment Grassland.

The National Vegetation Types map maps the vegetation of the entire project area and its immediate surrounds as Eastern Highveld Grassland (Gm 12), a vegetation type included in the Mesic Highveld Grassland Bioregion of the Grassland Biome (Mucina & Rutherford, 2006) (Figure 5-1). Eastern Highveld Grassland occurs almost entirely within the Mpumalanga Province, although a small section of the eastern parts of Gauteng is also covered by this vegetation type. Eastern Highveld Grassland occurs on plains between Belfast in the east and Johannesburg in the west, extending southwards to Bethal, Ermelo and to the west of Piet Retief. The conservation status of Eastern Highveld Grassland has been categorised as **Endangered** (Mucina & Rutherford 2006 and Skonow *et al.* 2019), as only a small fraction is conserved in statutory reserves (Nooitgedacht Dam and Jericho Dam Nature Reserves) and approximately 44% has been transformed, primarily by cultivation, plantations, mines, urbanisation and the building of dams. Dominant and common plant species listed for Eastern Highveld Grassland Mucina and Rutherford (2006) are presented in Table 5-1.

Table 5-1: Dominant and common and conspicuous plant taxa of the Eastern Highveld Grassland vegetation type (Mucina and Rutherford 2006). The letter d indicates a dominant.

Growth Form	Eastern Highveld Grassland (GM12)
Dominant Graminoids	*Aristida aequiglumis, A. junciformis, A. congesta, Brachiaria serrata, Cynodon dactylon, Digitaria monodactyla, D.tricholaenoides, Elionurus muticus, Eragrostis chloromelas, E. curvula, E.plana, E. racemosa, E. sclerantha, Heteropogon contortus, Loudetia simplex, Michrochloa caffra, Monocymbium ceresiiforme, Setaria sphacelata, Sporobolus africanus, S. Pectinatus, Themeda triandra, Trachypogon spicatus, Tristachya leucothrix, Tristachya rehmanii.*
Herbs	*Berkheya setifera* (d), *Haplocarpha scaposa*(d), *Justicia anagalloides*(d), *Pelargonium luridum*(d), *Acalypha angustata, Chamaecrista mimosoides, Dicoma anomala, Euryops gilfillanii, E. transvaalensis, Helichrysum aureonitens, H. caespititium, H. callicomum, H. oreophilum, H. rugulosum, Ipomoea crassipes, Pentanisia prunelloides, Selago densiflora, Senecio coronatus, Vernonia oligocephala, Wahlenbergia undulata*.
Geophytic Herbs	*Gladiolus crasifolius, Haemanthus humilis* subsp. *hirsutus, Hypoxis rigidula, Ledebouria ovatifolia*
Succulent Herb	*Aloe ecklonis*
Low Shrubs	*Anthospermum rigidum* subsp. *pumilum, Seriphium plumosum*

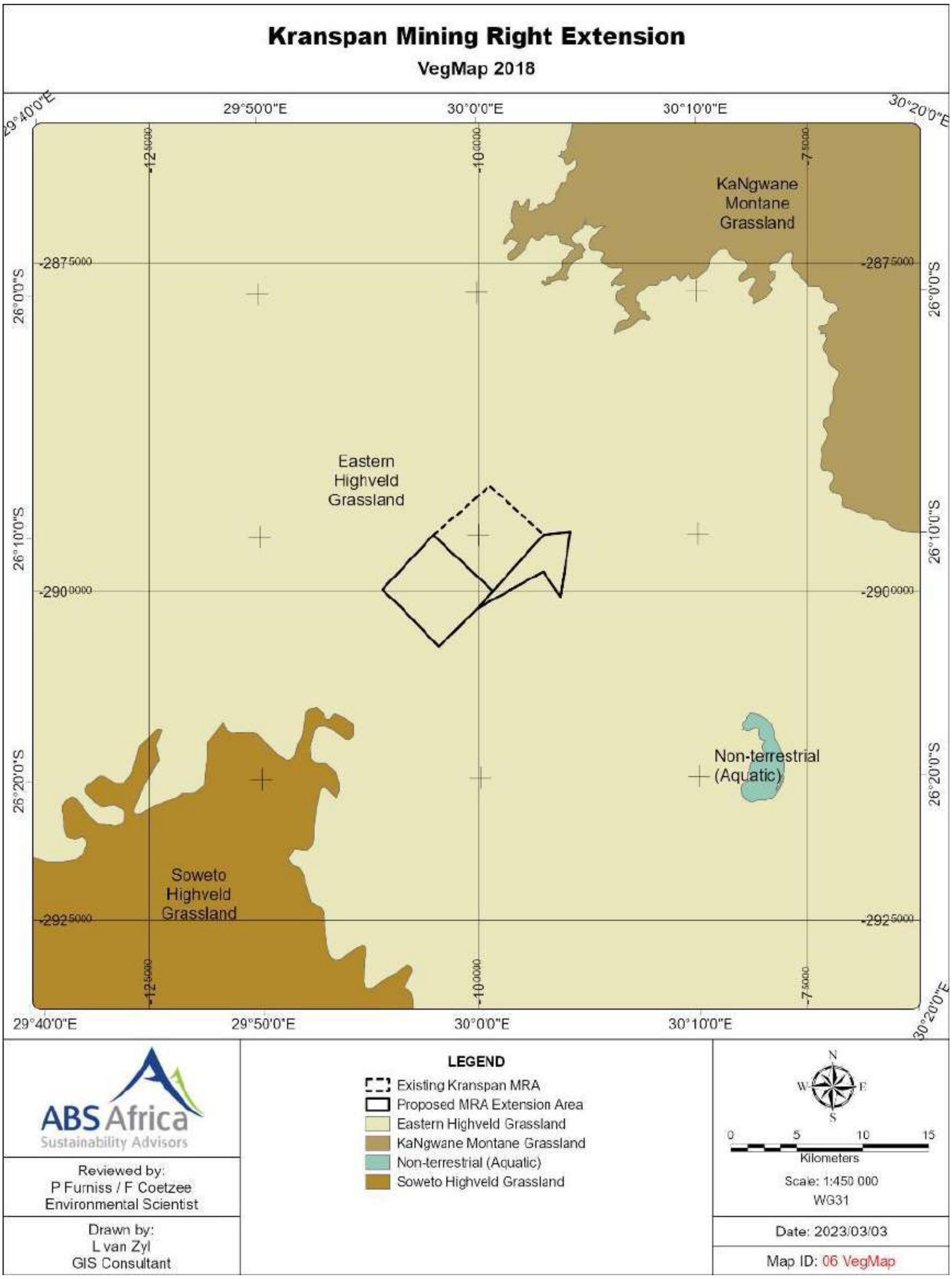

Figure 5-1. National Vegetation Types of the Project Area and its immediate surrounds.

<u>Centres of Plant Endemism</u>

The project area is not situated within any recognised centre of plant endemism (CPE) as defined by Van Wyk & Smith (2001). The project area is also not situated within the more recently described Lydenburg Centre of Plant Endemism (Lötter, 2019) or the Limpopo-Mpumalanga-Eswatini Escarpment region of endemism, an orographic entity that comprises the Mpumalanga escarpment and encompasses various smaller centres of plant endemism (Clark *et al*., 2022).

Listed Threatened Ecosystems

Eastern Highveld Grassland (Gm 12) is currently categorised an Endangered ecosystem (Skowno, 2019) and is gazetted as an Endangered ecosystem in the ‘Revised list of Terrestrial Ecosystems that are Threatened and in need of Protection’ [November 2022 Schedule (Government Gazette no. 47526) of the NEM:BA (Act 10 of 2004)]. Eastern Highveld Grassland has been gazetted as Endangered under Criterion A3 as National land-cover data show that Eastern Highveld Grassland has experienced extensive spatial declines of approximately 70% since 1750. The stated purpose of listing ‘threatened ecosystems,’ is primarily to reduce the rate of ecosystem and species extinction. This includes preventing further degradation and loss of structure, function and composition of threatened ecosystems.

5.1.2 Vegetation Units of the Project Area

Four untransformed vegetation units that represent Natural Habitat as defined by the IFC were identified for the project area (Figure 5-8). The vegetation units selected here have been derived on the basis of structural and functional criteria. The term structure refers to various aspects of vegetation structure such as physiognomy, life-form composition, species composition, species dominance and stand structure (Kent & Coker, 1992). Functional criteria include aspects such a characteristic ecosystem processes, habitat characteristics, habitat suitability for certain threatened species and ecological status (e.g., primary vegetation of untransformed habitats versus secondary vegetation of transformed or severely degraded habitats). A brief description of the four vegetation units comprising Natural Habitat is provided below. A description of one transformed vegetation unit (Modified Habitat *sensu* IFC) which is regarded as ‘Moderately Modified’ in the Mpumalanga Biodiversity Sector Plan (MBSP 2014), namely Secondary Grassland of historically cultivated soils, is also provided below.

A large proportion of the project area comprises habitats completely transformed by anthropogenic impacts such as current cultivation, infrastructure (homesteads, excavations, railway lines, roads etc) and plantations and invasive stands of alien trees. These areas, referred to as ‘Heavily Modified’ in the MBSP (2014) and are not described below.

Untransformed Grassland

The extent of this vegetation unit is approximately 702.1 ha (or 14.3% of the project area), the second largest surface area covered by any of the Natural Habitat vegetation units identified within the project area. This vegetation unit comprises untransformed terrestrial or mesophytic grassland on flat to gently undulating terrain, but also includes a few small, isolated patches of sheet rock habitats with associated shallow to skeletal soils, as well as patches of transitional grassland dominated by terrestrial/mesophytic species but with some hygrophilous floristic elements, on moist or even possibly ‘intermittently’ (*sensu* Ollis *et al*., 2013) saturated soils [‘temporary zone’ *sensu* DWAF (2005) wetland delineation manual] which form an ecotone between terrestrial and wetland habitats. Soils are mostly shallow to moderately deep light brown to brown sandy loams.

The remaining areas of grassland comprising this vegetation unit are representative of untransformed Eastern Highveld Grassland, an Endangered vegetation type and gazetted ‘threatened terrestrial ecosystem’ (Mucina & Rutherford, 2006, Skowno *et al*. 2019) that historically covered all the terrestrial habitats of the project area. The majority of the original extent of this vegetation type, both within the project area and its surrounds, has been completely transformed by cultivation, and to a lesser extent mining, linear infrastructure and alien trees. The remaining untransformed grassland is fragmented into isolated, remnant patches, mostly in places where elevated soil moisture or shallow and/or rocky soils preclude viable cultivation. The remaining area of untransformed grassland within the project area is utilised as grazing on commercial farmland.

In terms of physiognomy, the vegetation comprising this unit can be described as Short Closed Grassland (Edwards, 1983), though there is some variation, in terms of both physiognomy and floristic composition, in accordance with habitat characteristics such as soil type, soil moisture, rockiness, position on the landscape and gradient. The majority of the remnant patches of untransformed grassland comprising this unit are still in good condition. However, moderate veld condition deterioration as a result of the exclusion of fire (leading to moribund vegetation), heavy grazing and possible historical overgrazing by livestock is evident in places. Vegetation canopy cover is generally between 90% and 96% but may be as low as 70% on shallow sandy soils overlying ferricrete and localised patches of sandstone sheetrock and associated skeletal soils have lower vegetation cover.

The typical, mesophytic grassland communities are highly species rich and are strongly dominated by grasses. Dominant grasses include *Digitaria tricholaenoides, Elionurus muticus, Eragrostis racemosa, Themeda triandra*, *Heteropogon contortus* and *Tristachya leucothrix. Aristida diffusa* is a localised dominant on patches of shallow to skeletal soils overlying ferricrete. Sub-dominant grasses include *Aristida aequiglumis, Eragrostis curvula* and *Panicum natalense. Trachypogon spicatus* is a localised sub-dominant on soils with moderately elevated moisture levels. Common grasses include *Alloteropsis semialata, Bewsia biflora, Brachiaria serrata, Ctenium concinnum, Cymbopogon pospischilii, Diheteropogon amplectans, Eragrostis capensis, Eragrostis chloromelas, Eragrostis gummiflua, Eragrostis plana, Harpochloa falx, Microchloa caffra, Rendlia altera, Trachypogon spicatus* and *Tristachya rehmannii.* Common forbs include *Abilgaardia ovata, Acalypha angustata, Anthospermum rigidum, Babiana hypogea, Ocimum obovatum, Blepharis innocua* var. *innocua, Chaenostoma neglectum, Chlorophytum fasiculatum,, Commelina africana, Crabbea acualis, Crassula lanceolata* subsp. *transvaalensis, Crepis hypochaeridea, Cyanotis speciosa, Dicoma anomala* subsp. *anomala, Felicia muricata, Gazania krebsiana, Helichrysum callicomum, Helichrysum rugulosum, Helichrysum oreophilum, Hilliardiella elaeagnoides, Hypochaeris radicata**, Hypoxis rigidula, Justicia angalloides, Kohautia amatymbica, Ledebouria* cf. *ovatiifolia, Ledebouria luteola, Leobordia foliosa, Pentanisia angustifolia, Pollichia campestris, Rhynchosia totta, Richardia brasiliensis**, Senecio coronatus* and *Zornia* cf. *milneana*. The geoxylic suffrutex *Vangueria pygmaea* is common. The small shrub *Seriphium plumosum* is common and may be locally sub-dominant in moist areas degraded by heavy grazing and fire exclusion.

Figure 5-2. Photographs of Untransformed Grassland. Grassland on a patch of shallow soils overlying ferricrete is shown in the top right photograph.

Average species richness measured in sampling quadrats placed within this biodiversity management units (BMU) was 40.4 (n = 13) species per $100m^2$ and species richness varied from 30 to 59 species per $100m^2$, which is high for Highveld grasslands and is marginally the highest figure recorded for any vegetation unit identified within the project area (40.1 species recorded per $100m^2$ in Sandstone Scarp vegetation unit). A total of 240 species were recorded within this vegetation unit, which is the highest total species richness recorded for any vegetation unit in the project area. Species fidelity, which is a reflection of floristic uniqueness, is high, with 85 species recorded in none of the other vegetation units identified for the project area (Table 5-2).

One of the two plant 'species of conservation concern' (SCC) (*sensu* Raimondo *et al.* 2009) recorded within the project area, namely *Khadia carolinensis* (Vulnerable) was recorded on one of the numerous small patches of sandstone sheetrock habitat embedded within this unit (Site A13). *Khadia carolinensis* is dealt with in detail in Section 5.1.4. This unit also provides potentially suitable habitat for one of the two plant 'species of conservation concern' which have not yet been recorded within the project area, but which are considered to have a moderate to high probability of occurring, namely *Aspidoglossum xanthosphaerum* (Vulnerable). Fourteen species that are Protected under the Mpumalanga Nature Conservation Act (MNCA) were also recorded within this vegetation unit (Table 5-4). This vegetation unit is considered to be of high conservation importance.

<u>Sandstone Scarp Shrubland</u>

The extent of this vegetation unit is approximately 102.2 ha (or 2.1% of the project area), the second smallest surface area covered by any of the Natural Habitat vegetation units identified within the project area. This vegetation unit is restricted to low sandstone cliffs, boulder outcrops, scree slopes and extensive sheetrock habitat associated with sandstone scarps situated mostly at lower elevations along valley-bottom wetlands. The largest area of sandstone scarp habitat within the project area, with scarps up to 50m in height and a very high habitat heterogeneity and species richness, is situated between Sites 46 and 113 (Appendix 4) along the valley-bottom wetland tributary of the Vaalwaterspruit on the Farm Vaalbank.

The plant communities comprising this vegetation unit are markedly distinct, in terms of both physiognomy and floristic composition, from those comprising the other Natural Habitats identified for the study area. The vegetation is highly species rich (α-diversity), and the Beta diversity (β-diversity), which is the 'rate of change in species composition across habitats or among communities' is also extremely high. This high botanical diversity is attributable to very high microhabitat diversity caused by marked gradients in habitat characteristics such as slope aspect and gradient, shading, moisture regimes, soil depth and rockiness and vegetation structure (e.g., species composition and dominance and physiognomy) varies greatly in accordance to such habitat gradients. The highest species richness is found in Shrubland on scree slopes directly below cliffs where clumps of shrubs alternate with boulders and grassland in more open patches.

This vegetation unit comprises mostly of a mosaic of small patches of *Pteridium* Closed Herbland, Open to Closed Shrubland, dense Low Thicket (grading to small patches of Short Thicket) and rocky Closed Grassland (*sensu* Edwards, 1983) with high richness of forb species. Also included in this unit are distinct Open Grassland to Low Open Shrubland communities associated with sandstone sheetrock habitats occurring directly above the sandstone scarps. Such sheetrock communities are relatively extensive within this unit and provide the most important habitat for the threatened plant *Khadia carolinensis* (Vulnerable) which was recorded at six localities within this unit. An overall description for this vegetation unit is provided below followed by brief descriptions of the Open Grassland/Low Open Shrubland sandstone sheetrock communities and seep communities.

The fern *Pteridium aquilinum* forms numerous dense, almost monospecific stands on the foot slopes of large scarps. Fourteen of the sixteen Pteridophytes (ferns and fern allies) recorded within the project area were recorded within this vegetation unit and 11 of these 14 species were recorded only from this vegetation unit. Common and widespread (particularly in rocky shaded microhabitats) Pteridopytes include *Blechnum australe, Cheilanthes quadripinnata, Cheilanthes viridis* var. *viridis, Cysopteris fragilis, Mohria vestita, Pellaea callomelanos, Pteris cretica* and *Pityrogramma argentea*. The dominant woody species is the shrub *Diospyros lyciodes.* and Common shrubs are *Heteromorpha arborescens var. abyssinica, Searsia dentata, Searsia pyroides* and *Clutia pulchella.* The woody species that most frequently attain a tree growth form and size (*sensu Edwards*, 1983) are *Diospyros lyciodes* and *Kiggelaria Africana* (up to 7m in height). The alien invasive tree *Acacia dealbata** have already transformed large patches of this scarp habitat and poses a significant threat in terms of habitat transformation within this unit. An exceptionally high richness of climbers (within a high context) is present, including *Clematis brachiata, Cissampelos abyssinica, Dioscorea quartiniana, Rumex sagittatus, Stephania abyssinica, Riocreuxia burchellii, Rubia horrida* and *Smilax anceps*. Common and widespread grasses include *Heteropogon contortus* (often dominant)*, Ehrharta erecta, Elionurus muticus, Eragrostis racemosa, Eragrostis capensis, Eragrostis curvula, Eragrostis gummiflua, Eragrostis plana, Digitaria tricholaenoides, Koeleria capensis, Michrochloa caffra, Sporobolus africana, Setaria sphacelata, Themeda triandra* and *Tristachya leucothrix.* Common and widespread forbs include *Kyllinga erecta, Aeollanthus buchnerianus, Becium obovatum, Berkheya setifera, Bidens bipinnata*, Ceropegia meyerii, Chaenostoma floribundum, Commelina africana, Commelina lapidosa* (shade), *Crassula setuloca, Crassula lanceolata* subsp. *lanceolata* (shade), *Delosperma carolinensis* (chasmophyte), *Cyathula uncinata, Dianthus mooiensis, Gladiolus dalenii, Haemanthus humilis* (rock crevices and thicket floor), *Helichrysum rugulosum, Hilliardiella elaeagnoides, Ipomoea crassipes, Ipomoea ommaneyi, Justicia anagalloides,* (shade), *Impatiens hochtetteri* var. *hochtetteri* (moist, shaded, rocky areas, particularly streambanks), *Leonotis ocymifolia, Nemesia albiflora, Ocimum obovatum, Psammotropha myriantha, Pseudopegolettia tenella, Rhynchosia totta, Rumex acetosella* subsp. *angiocarpus** and *Tephrosia elongata.*

The ca. 0.5ha patch of dense Low/Short Thicket (*sensu* Edwards, 1983) with a woody cover (projected canopy cover) of ca. 90% and a canopy of ca. 5m in height with emergent trees of up to 7m in height (*Kiggelaria africana*) occurs on the steep scree slopes directly below the summit cliffs of the scarp at Site 105 on the farm Vaalbank (Figure 5-3, top left image). This patch of dense short thicket comprises a refuge area (area of suitable habitat in a matric of unsuitable habitat) within the project area and its immediate surrounds for many species (including a large number of fern species) that are typical of Thicket patches on the Mpumalanga escarpment and are rare or have previously been recorded in the grid square 2629BB (see below).

Numerous small seeps with intermittently to seasonally saturated soils are present directly above the sandstone cliffs and on scree slopes below the cliffs. These seep patches are characterised by hygrophytic grasses such as *Andropogon appendiculatus*, *Aristida junciformis*, *Imperata cylindrica, Hyparrhenia dregeana*, *Setaria pumila* and *Setaria sphacelata*, the hygrophytic forbs such as *Centella asiatica, Helichrysum aureonitens* and *Helichrysum setosum* and the scrambler *Rubus rigidus*.

The sheetrock plant communities are distinct from the other plant communities within this BMU in terms of both physiognomy and floristic composition, and contain various plant species that are largely restricted to these communities. Small and isolated patches of such habitat and plant communities do however occur embedded in the Untransformed Grassland vegetation unit. Vegetation cover varies from approximately 20% to 70%. The dominant species include the spike moss *Selaginella dregei* and the grasses *Aristida aequiglumis*, *Digitaria monodactyla*, *Eragrostis chloromelas, Melinis repens* and *Michrochloa caffra*. Common to sub-dominant grasses include *Andropogon schirensis, Aristida transvaalensis, Aristida diffusa, Aristida junciformis Elionurus muticus*, *Eragrostis curvula*, *Eragrostis gummiflua, Eragrostis plana*, *Eragrostis racemosa, Heteropogon contortus*, *Panicum natalense*, *Sporobolus pectinatus* and *Tristachya rehmannii.* Common forbs include *Bulbostylis humilis, Kyllinga erecta, Ocimum obovatum, Chlorophytum fasiculatum, Commelina africana, Crassula setulosa, Cyanotis speciosa, Cyperus rupestris, Dicoma anomala, Euryops laxus, Felicia muricata, Hebenstretia angolensis, Justicia anagalloides, Leobordia divaricata, Listia* sp., *Lindernia wilmsii, Nerine rehmannii, Oldenlandia herbacea, Pseudopegolettia tenella, Psammotropha mucronata* var. *mucronata, Psammotropha myriantha, Chaenostoma neglectum* and *Ursinia nana*. The bryophyte *Bryum* cf. *argenteum* is fairly common and forms dense mats on seasonally moist gravels. The geoxylic suffrutex *Vangueria pygmaea* is common. Shrubs comprise stunted individuals of *Diospyros lyciodes* and the low shrubs *Searsia magalismontanum* and *Searsia tumulicola* var. *meeuseana.* In depressions in the rock which hold water for short periods during the wet season (‘rock tanks’), the characteristic species are *Crassula natans, Commelina subulata* and *Kyllinga pulchella*.

Average species richness measured in the sampling quadrats placed within this vegetation unit was 40.1 (n = 7) species per 100m^2 and species richness varied from 30 to 48 species per 100m^2, which is high for Highveld grasslands and is marginally lower than the highest figure recorded for any vegetation unit identified within the project area (40.4 species recorded per 100m^2 in Untransformed Grassland vegetation unit). A total of 228 species were recorded within this vegetation unit, which is the second highest total species richness recorded for any vegetation unit in the project area and is a remarkable figure considering that this vegetation unit occupies an area of only 102.2ha within the project area. Species fidelity, which is a reflection of floristic uniqueness, is high, with 93 species recorded in none of the other vegetation units identified for the project area (Table 5-2). Of the 194 species recorded during fieldwork but not included in the BODATSA species list for the grids 2629BB and 2630AA (see Section 5.1.3), 94 were recorded within the Sandstone Scarp Shrubland vegetation unit which occupies only 102.2ha (or 2.1%) of the project area, and 46 of these 94 species were recorded exclusively from this vegetation unit. These figures are an indication of the importance of the Sandstone Scarp Shrubland vegetation unit, in terms of botanical biodiversity conservation, within the project area and the surrounding parts of the Mpumalanga Highveld.

One of the two plant 'species of conservation concern' (SCC) (*sensu* Raimondo *et al.* 2009) recorded within the project area, namely *Khadia carolinensis* (Vulnerable) was recorded within Sandstone Scarp Shrubland and this vegetation unit comprises the most extensive and important confirmed habitat for *Khadia carolinensis* within the project area. *Khadia carolinensis* is dealt with in detail in Section 5.1.4. This unit also provides potentially suitable habitat for one of the two plant 'species of conservation concern' which have not yet been recorded within the project area, but which are considered to have a moderate to high probability of occurring, namely *Aspidoglossum xanthosphaerum* (Vulnerable). Five plant species that are Protected under the Mpumalanga Nature Conservation Act (MNCA) were also recorded within this vegetation unit (Table 5-4). This vegetation unit is considered to be of high conservation importance.

Figure 5-3. Photographs of various plant communities comprising the Sandstone Scarp Shrubland vegetation mosaic, which includes, shrubland, thicket, rocky grassland, small seep communities, cliff communities (chasmophyte communities) and sheetrock communities.

Valley-bottom & seep wetlands

The extent of this vegetation unit is approximately 1 077.2 ha (or 21.7% of the project area), the largest surface area cover by any of the Natural Habitat vegetation units identified within the project area. Comprises largely of hygrophytic and hydrophytic grass and/or sedge dominated vegetation of channelled and un-channelled valley-bottom wetlands. Also includes continuous adjacent seeps with seasonally saturated soils [‘seasonal zone’ *sensu* DWAF (2005) and Ollis *et al*., 2013] and, further upslope, ‘intermittently’ (*sensu* Ollis *et al*., 2013) saturated soils of the ‘temporary zone’ (DWAF, 2005) which forms and ecotone between terrestrial and wetland habitats which are clearly differentiated by vegetation physiognomy and species composition and dominance (Figure 5-4). The catchment divide between the Vaalwaterspruit and Boesmanspruit Quartenary Catchments (both art of the Komati River Catchment) runs from south to north through the north-eastern parts of the portion of the Project Area comprising the Farm Vaalbank. The largest valley-bottom wetland systems present in the study area are a tributary of the Vaalwaterspruit which flows from the south-east boundary of the Farm Vaalbank to the north-west through the project area, and a tributary of the Boesmanspruit which flows from north to south through the Farm Roodebloem.

Figure 5-4. Photograph of a typical transitional zone (ecotone) between the Untransformed Grassland (left) and Valley-bottom & seep wetlands (right) vegetation units at Site 21. Transition zone indicated by a band of the tall, dark grey-green sedge *Scripoides burkei*.

Though the wetlands comprising this vegetation unit have been somewhat degraded by a variety of anthropogenic impacts such as damming, altered fire regimes, altered herbivory and altered hydrological patterns and agricultural seepage and runoff, valley-bottom wetlands are known for their resilience to the aforementioned impacts at moderate intensities, and the vegetation of this vegetation unit is still highly species rich (in the context of Highveld wetlands) and still displays what is likely to be its pre-disturbance species richness of indigenous species.

Along the well-developed valley-bottom wetlands, there is strong lateral zonation of vegetation as a result of variations in key habitat parameters such as frequency and duration of soil inundation, speed of flood waters, frequency and duration of soil saturation or elevated soil moisture levels, topography and soil characteristics. Typically, the following major lateral vegetation zones can be distinguished (starting from the upslope ecotone between terrestrial and wetland habitats and ending in the centre of the wetland), but some zones may be absent or poorly developed:

1. Marginally hygrophilous grassland (moist grassland) on intermittently saturated soils (*sensu* Ollis *et al*., 2013). Usually characterised by high cover or dominance of the hygrophytic sedge *Scirpodes burkei.* When dominated by mesophytic (terrestrial) grasses, vegetation still significantly elevated cover of facultative and obligate hygrophytic grasses, sedges and forbs (e.g., *Trachypogon spicatus*, *Eragrostis plana*, *Eragrostis capensis*, *Stiburus alopecuroides, Centella asiatica, Monopsis decipiens* and *Helichrysum aureonitens*). When degraded, this vegetation often becomes encroached by *Seriphium plumosum*. Plant communities contain comparatively high species richness.
2. Dense hygrophilous grassland or grass and sedge dominated marsh vegetation dominated by *Aristida junciformis* subsp. *junciformis,* and hygrophytic grasses and sedges such as *Arundinella nepalensis, Agrostis eriantha, Andropogon huillensis, Imperata cylindrica* and *Kyllinga erecta* are common to sub-dominant. The forb *Monopsis decipiens* is often abundant. The soils of this zone are never inundated by intermittently to seasonally saturated.
3. Dense hygrophilous grassland with *Arundinella neplaensis* dominant and hygrophytic grasses and sedges such as *Aristida junciformis, Andropogon appendiculatus, Eragrostis pattentissima, Cyperus denudatus* and *Fuirena coerulescens* common to sub-dominant. Hygrophytic forbs such as *Senecio gerrardii* and *Helichrysum mundii* are also characteristic of this zone. The soils are seasonally saturated but seldom inundated.
4. Dense hygrophytic or hydrophytic sedge and grass dominated marsh vegetation of the seasonally inundated central zone with seasonally to permanently saturated soils. Dominant species include the grass *Leersia hexandra* and the sedges *Eleocharis dreageana, Cyperus denudatus, Schoenoplectus corymbosus* and *Fuirena pubsecens*. The forb *Persciaria decipiens* is common and characteristic.
5. Where an intermittent channel forms narrow, more or less permanent pools in the central zone of the wetland, these pools are characterised by the hydrophytes (aquatic species) *Isolepis fluitans, Lagarosiphon muscoides, Nymphoides senegalensis* and *Potamogeton pectinatus*. The dominant emergent are *Schoenoplectus corymbosus* and *Juncus effusus.*
6. In permanently saturated soils of the central zones of large valley-bottom wetlands (i.e., Site 44), and in particular in areas directly downstream of dams where the hydrology has been altered, the vegetation comprises dense, species poor reedbeds dominated *Phragmites australis, Typha capensis* or *Juncus effusus* with *Schoenoplectus corymbosus* common.

The dense hygrophilous grassland and grass and sedge dominated marsh vegetation of hillslope seeps connected to valley-bottom wetlands, occur predominantly on seasonally saturated soils (‘seasonal zone’ *sensu* DWAF (2005) and Ollis *et al*., 2013), but occasionally on more of less permanently saturated soils. This vegetation often shows distinct lateral zonation (see broad description of valley-bottom wetland zonation patterns above).

The dominant species include the grasses *Aristida junciformis* subsp. *junciformis* and *Eragrostis plana,* the sedges *Pycreus macranthus, Kyllinga erecta* and *Fuirena coerulecens* and the forb *Centella asiatica.* Sub-dominant species, which may occasionally be localised dominants, include the grasses *Agrostis eriantha, Arundinella nepalensis* and *Eragrostis patentissima,* and the sedge *Pycreus nitidus.* Common grasses, sedges and rushes (graminoids) include *Andropogon appendiculatus, Andropogon eucomis, Agrostis montevidensis*, Andropogon huillensis, Calamgrostis epigeios, Digitaria eriantha, Digitaria eylesii, Eragrostis curvula, Eragrostis planiculmis, Harpochloa falx, Trisetopsis imberbis, Hemarthria altissima, Heteropogon contortus, Hyparhennia dregeana, Stiburus alopecuroides, Koeleria capensis, Leersia hexandra, Panicum schinzii, Paspalum dilatatum*, Themeda triandra, Cyperus denudatus, Fuirena pubescens, Kyllinga melanosperma, Dracoscirpoides ficinoides, Fimbristylis complanata, Fuirena pubescens, Isolepis costata Rhynchospora brownii, Scirpoides burkei, Isolepis costata, Juncus dregeanus* and *Juncus lomatophyllus.* Common forbs include *Cinereria lyrata, Crassula pellucida* subsp. *brachypetala, Haplocarpa lyrata, Conyza bonariensis*, Conyza pinnata, Disa versicolor, Helichrysum aureonitens, Hypericum lallandii, Hypochaeris radicata*, Ledebouria cooperi, Lobelia flaccida, Monopsis decipiens, Nidorella anomala, Pelargonium luridum, Satyrium longicauda var. longicauda, Sebaea grandis, Senecio affinis, Senecio inornatus, Senecio erubescens, Senecio polyodon, Verbena bonariensis** and *Whalenbergia denticulata.*

Average species richness measured in the seven sampling quadrats placed within this vegetation unit was 27.2 (n = 5) species per 100m^2 and species richness varied from 16 to 34 species per 100m^2, which is high for valley-bottom and seep wetlands embedded in Highveld grasslands. A total of 216 species were recorded within this vegetation unit, which is lower total species richness than that recorded in the smaller Untransformed Grassland and Sandstone Scarp Shrubland vegetation units, which is to be expected. Species fidelity, which is a reflection of floristic uniqueness, is the highest recorded for any of the identified vegetation units, with 110 species (or 50.1% of the total species richness) recorded in none of the other vegetation units identified for the project area (Table 5-2).

One of the two plant 'species of conservation concern' (SCC) (*sensu* Raimondo *et al.* 2009) recorded within the project area, namely *Sensitive Species 1200* (Endangered) was recorded at a single site on the margins of a seep wetland within this vegetation unit. *Sensitive Species 1200* is dealt with in detail in Section 5.1.4. This unit does not provide potentially suitable habitat for either of the two plant 'species of conservation concern' which have not yet been recorded within the project area, but which are considered to have a moderate to high probability of occurring (Section 5.1.4), but does provide potentially suitable habitat for one threatened (Vulnerable) species which is considered to have a moderate probability of occurring within the project area, namely the wetland habitat specialist *Sensitive Species 41* (Appendix 5). Eight plant species that are Protected under the Mpumalanga Nature Conservation Act (MNCA) were also recorded within this vegetation unit (Table 5-4). This vegetation unit is considered to be of high conservation importance.

Figure 5-5. Photographs of Valley-bottom & seep wetlands. Channelled valley-bottom wetland (top left); panoramic view of a large unchanneled valley-bottom wetland (top right); hillslope seep on seasonally saturated hydromorphic soils (bottom left); seep on hydromorphic soils that experience temporary saturation.

<u>Pan wetland</u>

This unit comprises a single, large endorheic pan (Allan *et al*., 1995), situated on the north-eastern boundary of the Farm Vaalbank. Th pan has a surface area of approximately 55.7 ha, and therefore has the smallest extent of any of the Natural Habitat units identified for the project area. In accordance with the wetland classification system of Ollis *et al*. (2013), the pan, or 'depression wetland', is an 'endorheic pan' (water exits by means of evaporation and infiltration only). As is the case for the vast majority of the endorheic pans on the Highveld, the pan is likely to be at least moderately saline. In accordance with the zonal classification for 'lentic waterbodies provided by Wetzel (1983), pan habitats include a more or less permanently inundated central area (infralittoral zone) which, based on historical Google Earth Pro aerial imagery is small (less than 3ha) for the shallow pan in the project area, the seasonally or periodically inundated area (eulittoral zone) which comprises the vast majority of the pan's surface area and the directly adjacent, supralittoral zone which often is influence by moisture from the pan but is never inundated and grades indistinguishably to hill slopes seeps within the pan basin.

The vegetation of Highveld endorheic pans was until recently very poorly known but it is now clear that these pans contain endemic species that are habitat specialists adapted to the unique, saline and seasonally or periodically inundated habitat provided by the eulittoral zones of pan floors. A new *Senecio sp.* endemic to the floors of Highveld pans is currently being described (pers. comm., Marinda Koekemoer of SANBI) and *Lessertia phillipsiana* has recently been discovered by the author to be a pan floor endemic and it's conservation status is currently being assessed by SANBI's Threatened Species Programme (will almost be certainly assessed to be a threatened species). Observations during fieldwork and an analysis of the eighteen available Google Earth Pro aerial images for the twenty year period extending from September 2003 to July 2017, indicate that the extent of inundation in the pan during the fieldwork (October 2022 and January 2023) was at its greatest extent since at least 2003 and it is likely that the January 2023 inundation level represents the maximum inundation level (Full Supply Level) of this pan (Figure 5-5). **The highly specialised and unique habitat of the eulittoral zone of the pan floor, which is the habitat were all potentially occurring pan endemics and SCC would occur, could therefore not be surveyed during the October or January fieldwork**. The conservation importance of the pan could hence not be accurately evaluated, and the brief vegetation description provided below is only for the seep community on the pan margins (supralittoral zone).

Extensive untransformed seep wetlands occur only along the north-eastern and north-western margins of the pan and current or historical cultivation extends to within 5m of the maximum inundation level along the remainder of the pan margins. The vegetation of the pan margins grades into the surrounding seeps on the slopes of the pan basin or ends abruptly at currently cultivated lands. The vegetation comprises dense hygrophilous grassland dominated by hygrophytic grasses and sedges. The dominant species include the grasses *Leersia hexandra* and *Panicum hygrocharis* and the sedge *Kyllinga erecta*. Common grasses and sedges include the grasses *Agrostis eriantha, Cynodon dactylon, Eragrostis curvula, Pennisetum sphacelatum, Setaria sphacelata* and *Hemarthria altissima* and the sedges *Cyperus denudatus, Cyperus eragrostis*, Cyperus esculentus*, Cyperus longus, Eleocharis dregeana, Isolepis costata* and *Kyllinga melanosperma.* Common forbs include *Centella asiatica, Cinereria lyrata, Lobelia flaccida, Persicaria lapathifolia* and *Pseudognaphalium luteoalbum*.*

No sampling quadrats were placed within the pan wetland habitat. A total of 56 plant species were recorded within this vegetation unit and recorded species fidelity, which is a reflection of floristic uniqueness, is the lowest recorded for any of the identified vegetation units, with only three species recorded in none of the other vegetation units identified for the project area (Table 5-2). It must however be emphasised that only the supralittoral zone of the pan (margins of the maximum extent of inundation) could be surveyed and the unique pan floor habitats were endemic species and SCC are likely to occur could not be surveyed.

Neither of the two plant ‘species of conservation concern’ (SCC) (*sensu* Raimondo *et al.* 2009) recorded within the project area were recorded or are likely to occur within this vegetation unit. This unit does provides potentially suitable habitat for one of the two plant ‘species of conservation concern’ which have not yet been recorded within the project area, but which are considered to have a moderate to high probability of occurring, namely *Lessertia phillipsiana* (Section 5.1.4). No Protected plant species were recorded within this vegetation unit (Table 5-4). In accordance with the precautionary principle, this vegetation unit is considered to be of high conservation importance.

Figure 5-6. Photographs of Pan wetland.

<u>Secondary Grassland</u>

Secondary Grassland represents a Moderately Modified habitat (*sensu* MBSP 2014) unit and covers a larger surface area within the project area than any of the four identified Natural Habitat vegetation units. This unit comprises secondary grassland of historically cultivated or scoured soils, most of which are marginal agricultural soils that are either too shallow or, more frequently, to wet

for cultivation and have consequently been abandoned for cultivation. Species dominance and species composition vary in accordance with habitat characteristics (e.g., soil type, position in landscape and soil moisture regime) and elapsed time since ploughing, as well as subsequent management regimes (e.g. grazing and burning).
The vegetation unit includes grassland communities on soils where more than approximately five years have elapsed since ploughing and the vegetation is dominated by pioneer grasses and sedges (on hydromorphic soils) indicative of severe disturbance. Species richness is low compared with that of untransformed or primary grassland communities.

Dominant species include the grasses and sedges *Eragrostis curvula*, *Eragrostis gummiflua*, *Eragrostis plana*, *Hyparrhenia dregeana*, *Hyparrhenia hirta* and *Kyllinga erecta*. Common to sub-dominant grasses and sedges include *Agrostis eriantha, Andropogon eucomis, Aristida congesta, Calamagrostis epigeios*, Cynodon dactylon, Heteropogon contortus, Imperata cylindrica, Paspalum dilatatum*, Sporobolus africanus, Trisetopsis imberbis, Pycreus* sp. and *Fuirena coerulescens*. Species richness of forbs is low and common species include *Cinereria lyrata, Helichrysum callicomum, Helichrysum rugulosum, Hypochaeris radicata, Nidorella podocephala, Pseudognaphalium luteoalbum*, Rhynchosia minima* and *Rumex acetosella* subsp. *angiocarpus**. The small shrub *Seriphium plumosum* is also common, and locally dominant in moist, heavily grazed areas.

This vegetation unit comprises secondary vegetation of transformed habitats and has low species richness in terms of indigenous species. Average species richness measured in 100m^2 sampling quadrats placed within this unit was 25.0 (n=3), but many of these species are ruderal weeds, which is typical of such secondary grassland. Species richness of indigenous species increases with elapsed time since ploughing, as secondary succession progresses. The number of ‘characteristic’ species is low and only four of the of the 91 species recorded within this vegetation unit were not recorded within other units (Table 5-2). Secondary succession in Highveld grassland is known to be extremely slow (usually many decades) and often stalls to produce a more or less stable ‘disclimax’ plant community (particularly in rehabilitated areas), which is not representative of natural ‘climax’ or ‘steady state’ vegetation. This vegetation unit does not include potentially suitable habitat for any plant ‘species of conservation concern’ or any of the 28 Protected plant species recorded within the project area. This vegetation of this unit does however provide important biological corridors and significant habitat for various species of fauna.

Figure 5-7. Photographs of Secondary Grassland.

Table 5-2. Extent and total recorded species richness (see Appendix 1) of four identified vegetation units representative of Natural Habitat and one vegetation unit representative of Moderately Modified habitat identified within the Project Area.

Vegetation Unit	Extent (ha)	Percentage of total extent of Project Area	Total number of species and infraspecific taxa recorded within vegetation unit	Number of species recorded exclusively within vegetation unit within the PA
Untransformed Grassland	710.2	14.3%	240	85
Sandstone Scarp Shrubland	102.2	2.1%	228	93
Valley-bottom and seep wetlands	1 077.2	21.7%	216	110
Pan wetland	55.7	1.1%	56	3
Secondary Grassland	1 424.1	28.7%	91	4
Heavily Modified Habitat	1 586.6	32.0%	65	21 (mostly alien species)
TOTAL#	**4 956.0ha**			

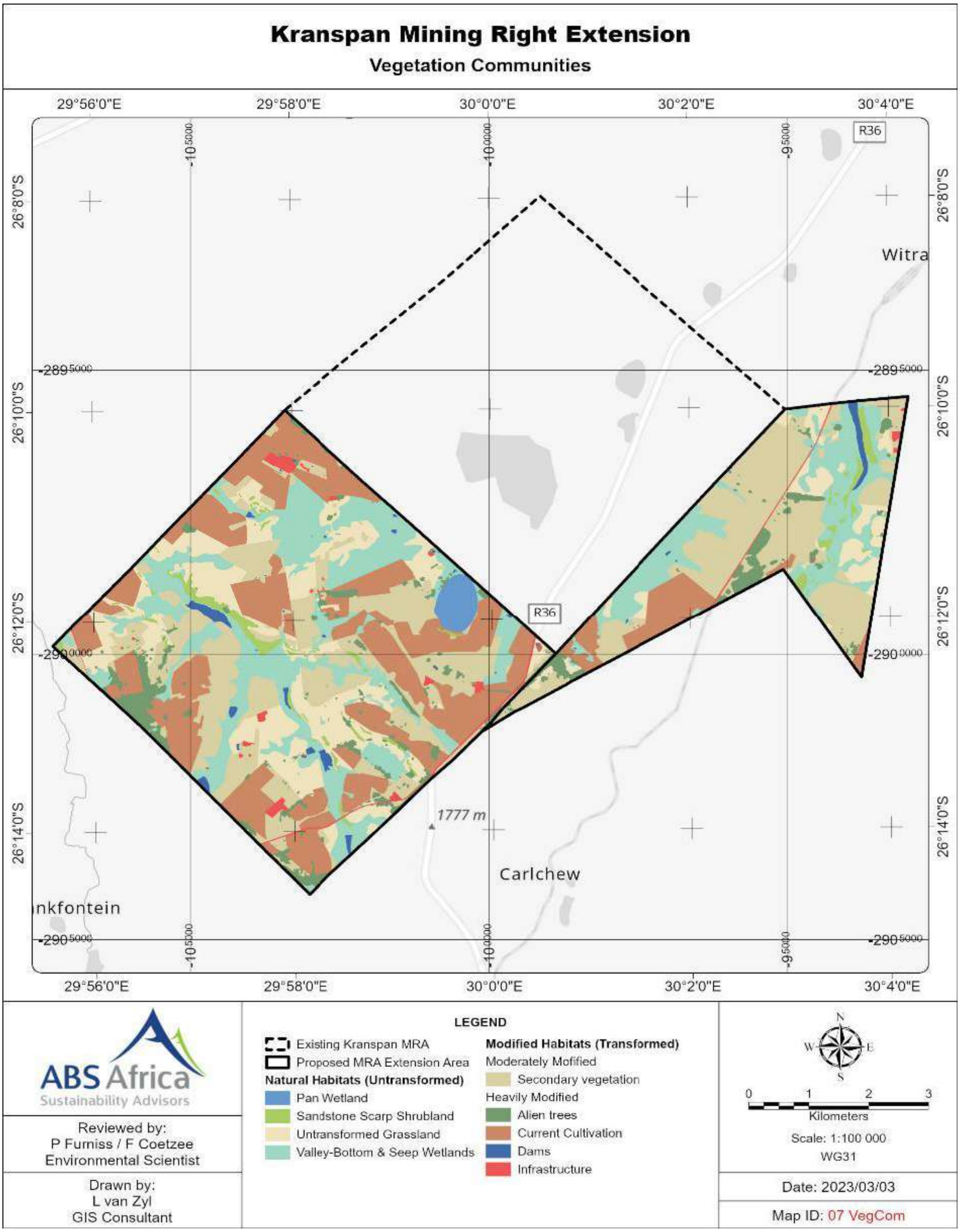

Figure 5-8. Vegetation units (broad-scale plant communities) identified within the Project Area.

5.1.3 Species Richness

A total of 550 plant species and infraspecific taxa were recorded within the 4 956ha Kranspan MRA Extension project area during fieldwork, 484 of which are indigenous taxa, and 66 (12.0%) of which are naturalised aliens. Of the 66 recorded alien species, 17 are listed as declared invasive species in the AIS Regulations (Appendix 1 and Table 5-5). Based on the authors experience of conducting floristic surveys on the Mpumalanga Highveld, the list of 486 indigenous plant species provided in this report probably includes approximately 85% of the indigenous species actually present within the project area.

Of the 484 indigenous species recorded within the project area, 194 (or 40.1%) are not included in the March 2023 BODATSA list of species (based on herbarium records) historically recorded from the quarter-degree grids within which the study area is situated (2629BB and 2630AA). This figure in part reflects the under-collection of herbarium specimens within the grids 2630AA and 2629BB but is also considered to be a strong indication of the high plant species richness of the remaining Natural Habitat of the project area. Of the 194 species not included in the BODATSA species list for the grids 2629BB and 2630AA, 94 were recorded within the Sandstone Scarp Shrubland vegetation unit which occupies only 102.2ha (or 2.1%) of the project area, and 46 of these 94 species were recorded exclusively from this unit. These figures are an indication of the importance of the Sandstone Scarp Shrubland vegetation unit, in terms of botanical biodiversity conservation, within the project area and the surrounding parts of the Mpumalanga Highveld.

The plant families that contribute most to the species richness of the project area are the Poaceae (89 species including 7 aliens), Asteraceae (87 species including 18 aliens), Cyperaceae (42 species including 2 aliens), Fabaceae (40 species including 3 aliens) and Scrophulariaceae (15 species including no aliens).

5.1.4 Species of Conservation Concern

Species of Conservation Concern (*sensu* Raimondo *et al.*, 2009) include threatened (Critically Endangered, Vulnerable and Endangered), Near Threatened, Data Deficient (DDD), Rare and Critically Rare species as listed in the Red list of South African plants (http://redlist.sanbi.org). Eleven plant Species of Conservation Concern (SCC) have either been historically recorded from the within the two quarter-degree grid squares within which the study area is situated (2629AA and 2629BB) or have been modelled as potentially occurring within these quarter-degree grids by SANBI and are listed in the Screening Tool report for the project Area. All eleven of these species are listed in Appendix 5 together with information on their conservation status, habitat requirements and distribution, flowering times and likelihood of occurrence within the project area. Two of the species listed in Appendix 5 were confirmed to occur within the project area during fieldwork, namely *Sensitive Species 1200* and *Khadia carolinensis*, and both species are discussed below. Two other SCC not recorded during fieldwork, but which are extremely difficult to detect due to their small size (*Aspidoglossum xanthosphaerum*) or occurrence in habitat that remains flooded for protracted periods (*Lessertia phillipsiana*), are thought to have a Moderate to High likelihood of occurring within the project area and are also discussed below.

Sensitive Species 1200 (Endangered A2c)

During the field work a sub-population of *Sensitive Species 1200* was recorded at vegetation survey Site 135 (Appendices 4 and 6) in the north-eastern parts of the Farm Roodebloem, directly to the west of a railway line. During a ca. one hour search of the site and seep wetland margins in the surrounding area, a total of 42 plants were found, all in a sparse colony within a ca. 400m^2 area on the on the margins of a seep wetland. It is however considered likely that additional colonies of this species occur in the vast areas of wetland margin habitat situated within the project area and in particular the margins of the wetlands situated to the east of the railway at the recorded locality.

Sensitive Species 1200 is a herb (up to 50cm in height), arising from a perennial, rhizomatous rootstock. The radical leaves are rosulate and usually somewhat adpressed to the ground and have long, stiff bristles on the leaf margins. The flowers are whitish green (Figure 5-9).
According to the Red List assessment (Von Staden 2009) (http://redlist.sanbi.org, accessed March 2023), the habitat of this species is grassland overlying Karoo Sandstone at altitudes of greater than 1600m, and it is stated that it is 'possibly associated with the edges of pans'. Based on the habitat characteristics observed by the author within the project area and at another sub-population recorded by the author within the quarter-degree grid 2629BB on the Farm Jaglust 47 IT, as well as personnel communication with Dr Pieter Winter (SANBI Apiaceae taxonomist), this species is in fact clearly a habitat specialist confined to the margins of valley-bottom and seep wetlands on hydromorphic soils that experience temporary to seasonal saturation and where the vegetation can be described as hygrophilous grassland. This species is therefore seemingly confined to the ecotone between wetland habitat and directly adjacent moist terrestrial grassland.

At the new locality record confirmed within the project area during fieldwork, *Sensitive Species 1200* was confined to hygrophilous grassland on shallow to skeletal, grey-brown sandy loams overlying ferricrete, on the margins of a seep wetland situated on the crest of a gently undulating landscape. The vegetation of the seep comprises dense seasonal marsh vegetation dominated by hygrophytic grasses and sedges. Dominant species are *Aristida junciformis, Fuirena corulescens* and *Kyllinga erecta*. Common to sub-dominant species include *Agrostis eriantha, Andropogon appendiculatus, Cyperus denudatus, Imperata cylindrica* and *Pycreus macranthus*. The hygrophilous grassland directly on the seep margins occupied by *Sensitive Species 1200* is dominated by the grass *Trachypogon spicatus* and common to sub-dominant grasses and sedges include *Andropogon eucomis, Eragrostis racemosa, Eragrostis capensis, Eragrostis curvula, Eragrostis chloromelas, Eragrostis gummiflua, Cyperus sphaerospermus* and *Michrochloa caffra,* Common forbs include *Crabbea acaulis, Gerbera ambigua, Nidrollea anomala* and *Pelargonium luridum.*

Sensitive Species 1200 is a range-restricted species endemic to the Mpumalanga Province where its Area of Occupancy is only 4.15km^2 (SANBI, 2020). Based on a brief analysis conducted during the current study the distribution range ('Extent of Occurrence') of this species is probably less than 2000 km^2. A list of herbarium specimens extracted from SANBI's BODATSA was obtained from SANBI's Threatened Species Programme (Ms Hlengiwe Mtshali, pers. comm. 27/02/2023) and locality records were also obtained from the iNaturalist website. The BODATSA database records contain a total of six herbarium specimens from four localities/sub-populations, one of which is thought to be extinct. The iNaturalist records contain four localities including the one found by the author within the project area. All aforementioned records are restricted to the Breyten, Lothair, Carolina and Hendrina area of the Mpumalanga Highveld. *Sensitive Species 1200* is therefore seemingly currently known from only seven extant localities / sub-populations and has a small Extent of Occurrence (EOO) and the conservation status of this species should therefore be revised by SANBI's Threatened Species Programme.

According to the latest Red List assessment (Von Staden, 2009) (http://redlist.sanbi.org , accessed on 5 February 2023) the entire extent of occurrence of this species comprises grasslands overlying Karoo Sandstones and the main historical and ongoing threat to this species is habitat loss through crop cultivation and increasingly through mining development.

Given the fact that *Sensitive Species 1200* is currently categorised as a threatened species (Endangered A2c), has a small 'Extent of Occurrence' (estimated here as likely to be less than 2 000km^2), an Area of Occupancy (AOO) of only 4.15km^2 (SANBI, 2020) and is seemingly known from only seven extant localities/sub-populations, it is recommended that the sub-population recorded at Site 135 should be conserved *in situ* and protected by a preliminary buffer zone of at least 26ha as shown in Appendix 6. The recommendation for the *in situ* conservation of the recorded sub-population of *Sensitive Species 1200* is in accordance with the 'Species Environmental Assessment Guideline' (SANBI, 2020), the guidelines for EIA recommendations provided in the Red List of South African Plants (Raimondo *et al.* (2009) and the guidelines included in Gauteng guidelines for botanical impact assessment (Pfab, 2001 and 2001b). It is emphasised that the Species Environmental Assessment Guideline (SANBI, 2020) emphasises that "*the removal of SCC from their natural habitat through search and rescue operations followed by translocation of these sub-populations is unacceptable as an impact minimisation mitigation measure*". The guidelines provided in the Red List (Raimondo *et al.,* 2009) and the Species Environmental Assessment Guideline (SANBI, 2020), are reproduced in the 'text box' provided below.

TEXT BOX		
Extract from 'Guidelines for EIA recommendations for taxa of conservation concern found on proposed development sites' provided in Table 4.1 of the Red List of South African Plants (Raimondo *et al*., 2009) and reproduced in Table 10.1 of the Species Environmental Assessment Guideline (SANBI, 2020).		
Status	**Criterion**	**Guideline for Recommendation**
Endangered or Vulnerable	Listed under A only	If the species has a restricted range (EOO < 2 000km^2), recommended no further loss of habitat. If the range size is larger, the taxon is possible long-lived but widespread, and limited habitat loss may be considered under certain circumstances, such as the implementation of an offset whereby another viable, known sub-population is formally conserved in terms of the National Environmental Management: Protected Areas Act, 2003 (Act No. 57 of 2003) (NEMPA), and provided the sub-population to be destroyed does not occur (i) within a threatened ecosystem, or (ii) within an area required for biodiversity conservation in terms of a relevant spatial biodiversity plan, or (iii) on a site associated with additional ecological sensitivities.

The 'Species Environmental Assessment Guideline' (SANBI, 2020) recommends that the destruction of a sub-population (i.e., limited habitat loss) of an Endangered species such as *Sensitive Species 1200* which is listed only under criterion A, should only be considered under circumstances where certain requirements are met. In accordance with these guidelines, the *Sensitive Species 1200* sub-population recorded within the study area should be conserved *in situ* for the following reasons:

- no viable, known sub-population of this species is currently known to be formally conserved in terms of the Protected Areas Act (Act 57 of 2003),
- the terrestrial habitats of the project area comprise grassland vegetation that is representative of Eastern Highveld Grassland (Gm 12), an Endangered national vegetation type (Mucina & Rutherford, 2006) which is also categorised as an Endangered ecosystem (Skowno, 2019) and is included as an Endangered ecosystem in the 'Revised list of Terrestrial Ecosystems that are Threatened and in need of Protection' [November 2022 Schedule (Government Gazette no. 47526) of the NEM;BA (Act 10 of 2004)],
- the *Sensitive Species 1200* locality recorded within the project area lies within an area mapped as a Critical Biodiversity Area – Irreplaceable in the Mpumalanga Biodiversity Sector Plan (MBSP 2014) and a total of 2 233.9 893.4 ha within the study area is mapped as CBA – Irreplaceable or CBA – Optimal (5-14),
- the locality of the sub-population of this species recorded within the project area falls within an area mapped as a 'Priority Focus Areas for protected area expansion' in the National Protected Areas Expansion Strategy (NPAES),

- the project area includes large tracts of untransformed grassland and wetlands and provides habitat for at least one other threatened plant species, namely *Khadia carolinensis* (Vulnerable).

In the event that mining is authorised within the project area, the *in situ* conservation of *Sensitive Species 1200* would require the establishment of a buffer zone that protects the plants and their wetland margin habitat from various 'ecological edge effects' (Pfab, 2001b) such as increased dust emissions, increased alien plant invasion, altered hydrological patterns, disruption of herbivory and pollination and altered fire regimes. The 'Species Environmental Assessment Guideline' (SANBI, 2020) states the following with regards to buffer zones*: 'Buffers should be included for all populations of CR, EN, VU, Rare and Critically Rare species with a minimum distance of 200 m from the edge of a population. However, this distance should be increased by the specialist if consideration of the ecological requirements of the species in question (including the need for connectivity with adjacent suitable habitat) and type of potential impact indicates that a 200 m buffer would be insufficient*."

In order to protect the sub-population of *Sensitive Species 1200* recorded within the project area, and minimum buffer zone of 26ha (see maps in Appendix 6) should be implemented. This minimal buffer includes a 200m buffer around the recorded sub-population which occurs on the margins of a small untransformed seep, as well as a 200m buffer around the seep. The 200m buffer around the seep is intended to prevent impacts to its hydrological regimes (e.g., reduced water influx and desiccation) which are crucial to its ecological functioning. **The adequacy of the minimal 200m buffer should be verified in the field prior to construction by a wetland specialist with input from a geo-hydrologist if necessary and this recommendation should be included in the EMP for the project.** It must be emphasised that the recommended ca. 26ha preliminary buffer is a 'minimal buffer' within which no mining infrastructure should be located, and no mining related activities should occur. Furthermore, it is crucial that the 26ha buffer should not be isolated by mining activities and that ecological connectivity should be maintained by establishing an ecological corridor that link the buffer to areas of Natural Habitat directly to the north and, preferable also to the east that are mapped as CBA-Irreplaceable (MBSP 2014).

<u>*Khadia carolinensis* (Vulnerable A3c)</u>

During the field work, *Khadia carolinensis* was recorded 12 sites representing seven localities or colonies (Table 5-3 and Appendix 6), but is considered likely that additional localities occur in the extensive and widely disturbed patches of sheetrock habitats present in the project area. The six *Khadia carolinensis* localities/colonies situated in the western parts of the project area on the Farm Vaalbank are regarded as comprising a single sub-population (*sensu* IUCN) as all colonies are situated within 2km of other colonies and effective biological corridors comprising largely of Natural Habitat ensure excellent ecological connectivity (Appendix 6). The single *Khadia carolinensis* locality recorded on the Farm Roodebloem at Site 155 is separated from the Vaalbank colonies by a major Provincial Road, a railway line and a distance of more than 8km that comprises largely of Modified Habitat and is therefore regarded as part of a separate sub-population.

Table 5-3. Localities for *Khadia carolinensis* colonies in the project area. All sites and localities are mapped in Appendices 4 and 6.

Locality **(vegetation survey sites)**	**Farm**	**Minimal number of plants**
Site A13	Vaalbank	15
Sites 45 & 46	Vaalbank	200

Locality (vegetation survey sites)	Farm	Minimal number of plants
Sites 58a & 58b	Vaalbank	30
Sites 85, 86a, 86b & 86c	Vaalbank	150
Site 99	Vaalbank	160
Site 107a	Vaalbank	40
Site 155	Roodebloem	218

K. carolinensis is a small (up to 10cm in height), cushion forming succulent with elongated, sharp-tipped, angular leaves arising from a branched underground stem. The flowers are white to pink. This species is a habitat specialist and occurs only on well-drained, sandy loam soils among rocky outcrops, or at the edge of sandstone rock sheets, within Highveld grassland at altitudes of approximately 1700m (Raimondo *et al*., 2009). The soils on which this species occur are shallow to skeletal and it does not tolerate competition from tall dense grasses on deeper soils. The author has also found this species growing on exposed ferricrete at a locality near Ermelo. Photographs of *K. carolinensis* and its habitat within the project area are provided in Figure 5-9.

As is the case throughout its extent of occurrence, within the project area *K. carolinensis* occurs only on skeletal or very shallow soils associated with exposed sandstone sheetrock. These habitats are vegetated by short, sparse grassland comprising species that are adapted to extremes in soil moisture ranging from xeric conditions for most of the year, to waterlogged soils for short periods during the peak rainy season. The soil moisture regimes of these perched and relatively isolated pockets of soil are usually more dependent on direct rainfall than on surface runoff and sub-surface seepage from the surrounding landscape. Common to dominant species co-occurring in the sheetrock associated habitat occupied by *Khadia carolinensis* (i.e. 'companion species') include the grasses and sedges *Aristida* cf. *transvaalensis, Cyperus rupestris, Digitaria monodactyla, Eragrostis chloromelas*, *Eragrostis gummiflua*, *Melinis repens*, *Michrochloa caffra* and *Sporobolus pectinatus* and the spike moss *Selaginella dregei.* Common forbs include *Crassula lanceolata, Crassula setulosa, Leobordia divaricata, Nerine rehmannii, Oldenlandia herbacea, Pellaea callomelanos, Psammotropha mucronata* var. *mucronata, Pseudopegolettia tenella* and *Psammotropha myriantha.*

K. carolinensis is a moderately range restricted species endemic to the Mpumalanga Province where its Area of Occupancy is some 28.34km^2 (SANBI, 2020). Based on a brief analysis conducted during the current study the distribution range ('Extent of Occurrence') of this species is well in excess of 2000km^2 and roughly at least 12 000 km^2. A list of herbarium specimens extracted from SANBI's BODATSA was obtained from SANBI's Threatened Species Programme (Ms Hlengiwe Mtshali, pers. comm. 27/02/2023) and locality records were also obtained from the iNaturalist website. The BODATSA database records contain a total of 57 herbarium specimens representing many localities/sub-populations. The iNaturalist records contain 18 records from at least 13 localities/sub-populations, including the one found by the author within the project area. All aforementioned records are restricted to the area of the Mpumalanga Highveld roughly demarcated by Amersfoort to the south, Witbank to the west, Belfast to the north and Lochiel to the east. In the authors experience many of the sub-populations comprise many hundreds or thousands of plants and it is usually common to abundant in patches of suitable sheetrock habitat.

According to the latest conservation status assessment for this species (Lötter *et al.*, 2007), it is estimated that up to 45% of the 'extent of occurrence' of this species could be destroyed by 2030 should the submitted mining applications be approved (http://redlist.sanbi.org, accessed in March 2022). The two sub-population of this threatened species recorded within the study area must therefore be regarded as being of significant conservation value.

Given the fact that *Khadia carolinensis* is currently categorised as a threatened species (Vulnerable A3c), which is has a relatively restricted 'Extent of Occurrence' comprising localities overlying Karoo Sandstone that are mostly threatened by mining, it is recommended that the sub-populations recorded within the study area should be conserved *in situ*, with no significant reduction in the size of the sub-populations. This recommendation is particularly relevant to the large Vaalbank sub-population. The recommendation for the *in situ* conservation of the recorded sub-populations of *K. carolinensis* is in accordance with the 'Species Environmental Assessment Guideline' (SANBI, 2020), the guidelines for EIA recommendations provided in the Red List of South African Plants (Raimondo *et al.* (2009) and the guidelines included in Gauteng guidelines for botanical impact assessment (Pfab, 2001 and 2001b). The guidelines provided in the Red List (Raimondo *et al.*, 2009) and the Species Environmental Assessment Guideline (SANBI, 2020), are reproduced in the 'text box' provided above in the discussion of *Sensitive Species 1200.*
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The 'Species Environmental Assessment Guideline' (SANBI, 2020) recommends that the destruction of a sub-population (i.e., limited habitat loss) of a Vulnerable species such as *Khadia carolinensis* which is listed only under criterion A, should only be considered under circumstances where certain requirements are met. In accordance with these guidelines, the *Khadia* sub-populations recorded within the study area should be conserved *in situ* for the following reasons:

- no viable, known sub-population of this species is currently known to be formally conserved in terms of the Protected Areas Act (Act 57 of 2003),
- the terrestrial habitats of the project area comprise grassland vegetation that is representative of Eastern Highveld Grassland (Gm 12), an Endangered national vegetation type (Mucina & Rutherford, 2006) which is also categorised as an Endangered ecosystem (Skowno, 2019) and is included as an Endangered ecosystem in the 'Revised list of Terrestrial Ecosystems that are Threatened and in need of Protection' [November 2022 Schedule (Government Gazette no. 47526) of the NEM;BA (Act 10 of 2004)],
- all *K. carolinensis* localities recorded within the project area lie within areas mapped as a Critical Biodiversity Area – Irreplaceable or Critical Biodiversity Area – Optimal in the Mpumalanga Biodiversity Sector Plan (MBSP 2014) and a total of 2 223.9 ha within the project area are mapped as CBA – Irreplaceable or CBA – Optimal (Figure 5-14),
- all localities for this species recorded within the project area fall within areas mapped as a 'Priority Focus Areas for protected area expansion' in the National Protected Areas Expansion Strategy (NPAES).

In the event that mining is authorised within the project area, the *in situ* conservation of *K. carolinensis* would require the establishment of buffer zones that protect the plants and their sandstone sheetrock habitat from various 'ecological edge effects' (Pfab, 2001b), as per the Species Environmental Assessment Guideline' (SANBI, 2020).

In order to protect the two sub-populations of *K. carolinensis* recorded within the project area, and minimum buffer of 200m around the maximum extent of each colony should be implemented (Appendix 6). It must be emphasised that the recommended buffer is a 'minimal buffer' within which no mining infrastructure should be located and no mining related activities should occur. Furthermore, it is crucial that the colonies and their buffers should not be isolated by mining activities and that ecological connectivity should be maintained between the various colonies or recorded localities.

Figure 5-9. Photographs of plant Species of Conservation Concern confirmed to occur in the Project Area. *Khadia carolinensis* (VU) is pictured on the left (plant above and habitat below) and Sensitive Species 1200 is pictured on the right.

Aspidoglossum xanthosphaerum (Vulnerable D2)

Aspidoglossum xanthosphaerum is a threatened species which is currently categorised as Vulnerable based on a conservation assessment done in 2006 (Nicholas & Victor, 2006) which remains valid (http://redlist.sanbi.org accessed in March 2023). *Aspidoglossum xanthosphaerum* is a small (60-150mm in height) and inconspicuous, perennial, geophytic herb belonging to the Apocynaceae Family. This species is extremely difficult to detect and identify when not in flower and is even then difficult to find. The inflorescence comprises dense, terminal umbels of small, tightly clustered yellow flowers, and based on herbarium records, the plants are only known to flower in October and November. Though three days of fieldwork were conducted in the project area in October 2022, the majority of the fieldwork was conducted in January 2023 outside of the known flowering period for this species. *Aspidoglossum xanthosphaerum* is closely related to *Aspidoglossum lammellatum*, which also occurs in the vicinity of Breyten, but is distinguished from this species by the fact that the inflorescence comprises only terminal umbels and lacks auxiliary umbels (pers. com. with Pieter Bester of SANBI). Currently known from 18 specimens and approximately 12 localities (http://posa.sanbi.org and pers. com. P. Bester of SANBI), in south-eastern Mpumalanga and northern KZN around Ermelo, Carolina, Breyten, Wakkerstroom and Utrecht. According to Raimondo *et al*. (2009), recorded in 'montane grassland at marshy sites up to an altitude of 2000m'. The author has however recorded the species from two localities (Wonderfontein and Breyten) in relatively close proximity to the study area, and at both localities it occurred in untransformed mesophytic grassland, and the view that it is predominately a species of mesophytic grassland is supported by P. Bester of SANBI. The Untransformed Grassland and to a lesser extent the Sandstone Scarp Shrubland vegetation units identified for the project area, provide suitable habitat for this species and the likelihood of this highly inconspicuous geophytic herb occurring within the project is considered to be moderate to high.

Lessertia phillipsiana Burtt Davy (Data Deficient – Insufficient Information)

Lessertia phillipsiana is a widespread but very rare poorly known decumbent annual herb belonging to the Fabaceae. *Lessertia phillipsiana* is currently categorised as Data Deficient – Insufficient Information (DDD) (Von Staden, 2016) and is known from only 6 localities, all within the Highveld region (http://posa.sanbi.org, accessed 03/03/2022). Von Staden (2016) stated that the habitat requirements of this species were uncertain and speculated that it possibly occurred in "rocky hills or plains". Observations by the author at two of the six known localities for this species (namely Ogies and Wonderfontein) clearly indicate that it is a habitat specialist that is restricted entirely to the periodically or seasonally inundated floors of semi-saline endorheic pans. An analysis of the SANBI distribution and herbarium specimen data for this species (http://posa.sanbi.org, accessed 03/03/2022) indicated that this species has been recorded at two imprecise localities in the North West Province (near Klerksdorp and Ventersdorp), one locality at an endorheic pan in Gauteng (Randfontein) and three localities from pans in Mpumalanga (near Ogies, Wonderfontein and Chrissiesmeer). This species is therefore almost certainly a habitat specialist that is endemic to Highveld pans and is under-collected owing to its sporadic appearance during dry spells when pan floors are not inundated. A reassessment of the conservation status of this species currently being conducted by the SANBI's threatened species programme is considered very likely to result in the listing of this species as threatened or Near Threatened. The flora of the floor the large endorheic pan located within the project area could not be surveyed during the current study as the pan was fully inundated during both the October 2022 and January 2023 site visits. As this species has been recorded by the author at three adjacent pans at a locality south of Wonderfontein some 20km NNE of the project area, the likelihood of this poorly known DDD species occurring in the pan within the project area is considered moderate to high and the pan floor should be surveyed by a botanist when not inundated during the period from October to March.

5.1.5 Endemic Species

The project area is not situated within any recognised centre of plant endemism (CPE) as defined by Van Wyk & Smith (2001). The project area is also not situated within the more recently described Lydenburg Centre of Plant Endemism (Lötter, 2019) or the Limpopo-Mpumalanga-Eswatini Escarpment region of endemism, an orographic entity that comprises the Mpumalanga escarpment and encompasses various centres of plant endemism (Clark *et al.*, 2022). A few fairly range-restricted species that are endemic to Mpumalanga are however known to occur within the quarter-degree grids within which the project area is situated and two such Mpumalanga endemics were recorded during fieldwork, namely the two threatened species *Khadia carolinensis* and 'Sensitive Species 1200'. Both these species are discussed in the section of this report dealing with species of conservation concern.

5.1.6 Protected Species

Three pieces of legislation which grant protected status to selected indigenous plant species are of relevance to the project area, namely

- National Forests Act (Act 84 of 1998, as amended on the 23rd of September 2010),
- National Environmental Management: Biodiversity Act (Act 10 of 2004, as amended on the 16th of April 2013), and
- Mpumalanga Nature Conservation Act (No.10 of 1998).

Each of these pieces of legislation is briefly discussed below.

Schedule A of the National Forests Act (Act 84 of 1998) lists 47 tree species that are Protected in South Africa and may not be removed or damaged without the granting of a licence by the National Department of Agriculture, Forestry and Fisheries. Though protected, most of these species have large distribution ranges, are common to abundant throughout much of their distribution ranges and are not threatened with extinction. **None of the 47 tree species listed in Schedule A of the National Forests Act occurs within the project area or its immediate surrounds.**

The National Environmental Management: Biodiversity Act (Act 10 of 2004, as amended in April 2013), provides a list of 'Threatened or Protected Species' (TOPS list) which includes plant and animal species that are directly threatened by utilisation and require protection. This Act assigns species threatened by utilisation to one of four categories, namely Critically Endangered, Endangered, Vulnerable and Protected, but it must be emphasised that these categories are not the same as the rigorously defined IUCN Ver. 3.1 categories for threatened plant species (IUCN, 2001). The destruction, collection or trading of any species listed in the Act requires a permit which must be obtained from the MTPA permitting office. **No species listed in the Biodiversity Act were recorded within the project area or are considered likely to occur within the project area or its immediate surrounds.**

A number of plant species occurring in Mpumalanga Province are not considered to be threatened or listed as being species of conservation concern (*sensu* Raimondo *et al*., 2009 and http://redlist.sanbi.org accessed in March 2023), but are protected under Schedules 11 and 12 of the Mpumalanga Nature Conservation Act (No.10 of 1998). Twenty-eight species recorded within the study area are protected plants for which, under Schedule 11 of the Mpumalanga Nature Conservation Act (Act no. 10 of 1998), a permit has to be obtained prior to their removal. These twenty-eight protected species are listed in Appendix 1 and Table 5-4 together with vegetation units in which they have been recorded and those in which they are considered likely to occur.

The damaging or destruction of plant species that are Protected in terms of the National Forest Act (Act 84 of 1998), NEM:BA (Act 10 of 2004, as amended on the 16th of April 2013), or the Mpumalanga Nature Conservation Act (No.10 of 1998) during any future development should be avoided wherever possible, and a permit for the removal or destruction of any such protected plant must be obtained from the provincial authorities (Permitting Office of the MTPA) prior to development. It is recommended that where untransformed Natural Habitat is to be affected by an infrastructure footprints, Protected plant species are rescued and placed in a nursery or donated to a research institute (e.g. SANBI botanical gardens) prior to development, rather than simply being destroyed. Where feasible, viable sub-populations of such species should also be translocated to transformed (including rehabilitation areas) or untransformed areas within the project area which provide potentially suitable habitats, but such translocations will have to be carried out in a manner that ensures that no ecological degradation of the host habitat occurs, and will have to be evaluated by a botanist for each species and each potential translocation area**.**

Table 5-4. List of all 28 plant species thus far recorded within the Project Area which are Protected under Schedule 11 of the MNCA [Mpumalanga Nature Conservation Act (No.10 of 1998)].

Species	**Family**	**Untransformed Grassland**	**Sandstone Scarp Shrubland**	**Valley-bottom & seep wetlands**	**Pan wetland**	**Secondary Grassland**
Aloe ecklonis	Asphodelaceae	X				
Aloe welwitschii	Asphodelaceae	X				
Boophone disticha	Amaryllidaceae	X				
Brunsvigia radulosa	Amaryllidaceae	X				
Ceropegia meyerii	Asclepiadaceae		X			
Corycium dracomontanum	Orchidaceae	X		X		
Corycium nigrescens	Orchidaceae	X		X		
Cyrtanthus breviflorus	Amaryllidaceae			X		
Dioscorea cf. *quartiniana*	Dioscoreaceae	X				
Disa versicolor	Orchidaceae			X		
Disperis micrantha	Orchidaceae		X			
Erica drakensbergensis	Orchidaceae	X		X		
Eucomis autumnalis subsp. *clavata*	Hyacinthaceae	X	X	X		
Eulophia foliosa	Orchidaceae			X		
Eulophia hians var. *hians*	Orchidaceae	X		X		
Gladiolus crassifolius	Iridaceae	X				
Gladiolus dalenii	Iridaceae		X			
Gladiolus ecklonii	Iridaceae					
Gladiolus papilio	Iridaceae			X		
Gladiolus permeabilis	Iridaceae	X				
Haemanthus humilis subsp. *hirsutus*	Amaryllidaceae		X			
Habenaria epipactidea	Orchidaceae	X				
Habinaria filicornis	Orchidaceae			X		
Habenaria sp 1	Orchidaceae			X		
Satyrium longicauda var. *longicauda*	Orchidaceae			X		
Satyrium parviflorum	Orchidaceae			X		
Watsonia pulchra	Iridaceae	X				
Zantedeschia aethiopica	Araceae			X		

5.1.7 Alien Species

During the fieldwork, a total of 550 plant species and infraspecific taxa were recorded within the 4 956ha Kranspan MRA Extension project area, 66 (or 12.0%) of which are naturalised aliens. Of the 66 recorded alien species, 17 are declared alien invasive plant species in terms of the Regulations on Alien and Invasive Species (AIS Regulations) (Table 5-5 and Appendix 1). The AIS Regulations are defined in the National Environmental Management: Biodiversity Act (Act no. 10 of 2014), published in the Government Gazette No. 37886, Notice 599 of 1 August 2014. In terms of the AIS regulation declared alien invasive plant species (as listed in Notice 3 of the Act) must be eradicated or controlled by the landowner using methods that are appropriate for each species and cause the least harm to surrounding biodiversity.

Based on the available literature, the authors experience in the area and observations made during fieldwork, the following 6 recorded alien invasive species are the most aggressive habitat transformers and pose the greatest threat to the Natural Habitats and indigenous vegetation of the project area and its immediate surrounds: *Acacia dealbata**, *Acacia mearnsii**, *Campuloclinium macrocephalum**, *Pyracantha angustifolia** and *Richardia brasiliensis**. *Acacia mearnsii** and *Acacia dealbata** have already transformed extensive areas of Untransformed Grassland and Sandstone Scarp Shrubland within the project area ad are difficult and expensive to eradicate once established. *Campuloclinium macrocephalum**, though not yet a significant habitat transformer within the project area, has spread rapidly throughout the Mpumalanga Highveld region in the last two decades and is an extremely aggressive invader and habitat transformer in untransformed grassland, wetland margins and secondary grassland. *Pyracantha angustifolia** is already well established at low densities in moist untransformed grassland and along wetland margins on the farm Vaalbank and also poses a risk of habitat transformation in sandstone scarp habitats. *Richardia brasiliensis** is a procumbent perennial herb which is not yet a declared alien invasive species in terms of the AIS Regulations but has recently become a well-established ‘special effect weed’ and habitat transformer in moist terrestrial grassland on the Mpumalanga Highveld between Ogies and Breyten (personal observation). Within the project area *Richardia brasiliensis** has invaded significant areas of moist Untransformed Grassland and was recorded at canopy cover values of up 60% and local farmers claim that it is causing a significant loss of grazing.

Table 5-5. List of 17 naturalised alien species recorded within the Project Area that are declared alien invasive plant species in terms of the AIS Regulations.

Species	**AIS Regulations category**	**Untransformed Grassland**	**Sandstone Scarp Shrubland**	**Valley-bottom & seep wetlands**	**Pan wetland**	**Secondary Grassland**	**Highly Modified Habitat**
Acacia dealbata	2	X	X	X		X	X
Acacia mearnsii	2	X	X			X	X
Agrimonia procera	1b		X	X			X
Ailanths altissima	1b						X
Campuloclinium macrocephalum	1b	X		X			
Cirsium vulagare	1b		X	X	X	X	X
Eucalyptus camaldulensis	1b						X
Ipomoea purpurea	1b						X
Nasturium officinale	2			X			
Pennisetum clandestinum	1b (in Protected Areas and wetlands)			X		X	X
Phytolacca octandra	1b						X
Pinus cf. *elliotii*	1b						X
Pyracantha angustifolia	1b	X	X	X			
Solanum elaeagnifolium	1b	X				X	X
Solanum sisymbrifolium	1b	X	X			X	X
Verbena bonariensis	1b		X	X	X	X	X
Verbena rigida	1b	X				X	X

5.2 Mammals

5.2.1 Regional Context

Approximately thirty-two mammal species have been recorded from the project area (corresponding to the QDS 2629BB and 2630AA; *sensu* MammalMap) (Table 5-6). Some of the species listed by MammalMap were introduced as game species (mainly large bovine species such as Blesbok *Damaliscus pygargus phillipsi*), and these were omitted from the list since these are not introduced and not regarded as naturally occurring.

According to the MammalMap results, six species are threatened and/ or Near Threatened (*c*. Oribi *Ourebia ourebi* – EN, Mountain Reedbuck *Redunca fulvorufula* – EN, Highveld Golden Mole *Amblysomus septentrionalis* - NT, Serval *Leptailurus serval* - NT, South African Hedgehog *Atelerix frontalis* – NT and Brown Hyaena *Parahyaena brunnea*).

Approximately 23 species (72 % of the richness) have a high probability to be present on the study area, of which 17 of these species (74 % of species with a high probability of occurrence) were confirmed during the survey (see also Table 5-7). In addition, five of the species recorded from the corresponding QDSs have a moderate probability of occurrence (16 % of the richness), while four of the species have a low probability of occurrence (13 %). The latter species (species with low probabilities of occurrence) either share distribution ranges peripheral to the project area or ecological information on their life histories and taxonomy are scant, thereby rendering their presence on the project area as uncertain or questionable even though suitable habitat is present.

According to MammalMap (for 2629BB and 2630AA), a total of 130 observations of 32 mammal species were documented (Table 5-6). The most well represented orders are rodents (four species) and ungulates (six species). The Common Duiker (*Sylvicapra grimmia* – 15 records) was the dominant species in the area, followed by Oribi (*Ourebia ourebi* – 14 records), Grey Rhebok (*Pelea capreolus* – 8 records), Southern Reedbuck (*Redunca arundinum* – 8 records), Mountain Reedbuck (*Redunca fulvorufula* – 8 records) and Black-backed Jackal (*Canis mesomelas* - 8 records). The dominant species include a guild consisting of herbivorous grassland taxa and one carnivore species.

Table 5-6: An inventory of mammalian taxa recorded for the project region (QDS 2629BB and 2630AA) (*sensu* MammalMap).

Family	Scientific name	Common name	Red list category	Number of QDSs	Number of records	Probability of occurrence
Bathyergidae	*Cryptomys pretoriae (=hottentotus)*	Highveld Mole-rat	Least Concern	1	6	High (confirmed)
Bovidae	*Ourebia ourebi*	Oribi	Endangered	1	14	Moderate
Bovidae	*Pelea capreolus*	Grey Rhebok	Near Threatened	1	8	High (confirmed)
Bovidae	*Raphicerus campestris*	Steenbok	Least Concern	1	5	High (confirmed)
Bovidae	*Redunca arundinum*	Southern Reedbuck	Least Concern	1	8	High (confirmed)
Bovidae	*Redunca fulvorufula*	Mountain Reedbuck	Endangered	1	8	High (confirmed)
Bovidae	*Sylvicapra grimmia*	Common Duiker	Least Concern	2	15	High (confirmed)
Canidae	*Canis mesomelas*	Black-backed Jackal	Least Concern	1	8	High (confirmed)

Family	Scientific name	Common name	Red list category	Number of QDSs	Number of records	Probability of occurrence
Canidae	*Otocyon megalotis*	Bat-eared Fox	Least Concern	1	2	Low
Canidae	*Vulpes chama*	Cape Fox	Least Concern	1	1	High (confirmed)
Chrysochloridae	*Amblysomus septentrionalis*	Highveld Golden Mole	Near Threatened	1	2	Low
Erinaceidae	*Atelerix frontalis*	Southern African Hedgehog	Near Threatened	1	2	Moderate
Felidae	*Caracal caracal*	Caracal	Least Concern	1	2	Moderate
Felidae	*Leptailurus serval*	Serval	Near Threatened	1	3	High (confirmed)
Herpestidae	*Cynictis penicillata*	Yellow Mongoose	Least Concern	1	7	High (confirmed)
Herpestidae	*Herpestes sanguineus*	Slender Mongoose	Least Concern	1	1	Low
Herpestidae	*Suricata suricatta*	Suricate	Least Concern	2	7	High
Hyaenidae	*Parahyaena brunnea*	Brown Hyena	Near Threatened	1	2	Moderate
Hyaenidae	*Proteles cristata*	Aardwolf	Least Concern	1	3	Moderate
Hystricidae	*Hystrix africaeaustralis*	Cape Porcupine	Least Concern	1	1	High (confirmed)
Leporidae	*Lepus victoriae (=saxatilis)*	African Savanna Hare	Least Concern	1	4	High (confirmed)
Macroscelididae	*Elephantulus brachyrhynchus*	Short-snouted Sengi	Least Concern	1	1	Low
Macroscelididae	*Elephantulus myurus*	Eastern Rock Sengi	Least Concern	1	3	High
Muridae	*Mycaelamys namaquensis*	Namaqua Rock Mouse	Least Concern	1	2	High (confirmed)
Muridae	*Gerbilliscus brantsii*	Highveld Gerbil	Least Concern	1	5	High (confirmed)
Muridae	*Mastomys natalensis*	Natal Multimammate Mouse	Least Concern	1	1	High
Muridae	*Rhabdomys pumilio*	Four-striped Grass Mouse	Least Concern	1	1	High (confirmed)
Mustelidae	*Ictonyx striatus*	Striped Polecat	Least Concern	1	3	High
Procaviidae	*Procavia capensis*	Rock Hyrax	Least Concern	1	2	High (confirmed)
Soricidae	*Myosorex varius*	Forest Shrew	Least Concern	1	1	High
Suidae	*Potamochoerus larvatus*	Bushpig	Least Concern	1	1	High (confirmed)
Vespertilionidae	*Neoromicia capensis*	Cape Serotine Bat	Least Concern	1	1	High

#Probability of occurrence, as follows: LOW – suitable habitat occurs although the species is either inherently rare (e.g. occur naturally at very low abundance) OR it has a distribution range that is marginal/peripheral to the study site; MODERATE – habitats on site match available general habitat description for the species, but based on authors experience available microhabitat does not meet the requirements for the species OR, seemingly suitable microhabitat present but species is conspicuous and most available microhabitats searched and species not found and therefore probability of occurrence not considered high, HIGH – habitats on site strongly match the general and microhabitat description for the species, CONFIRMED – species found within study area.

5.2.2 Local Context

Twenty-one mammal species were confirmed within the project area during fieldwork (Table 5-7) which include six (6) rodents, four (4) antelopes, two (2) canids (jackals), two (2) herpestids (mongoose), one (1) leporid (hare and rabbits), one mustelid (otters), one felid (cats), two (2) viverrids (genets and civets), one (1) suid (pigs) and one hyrax. Four of the observed mammal species have been recorded on the project area for the first time (not previously recorded for QDS 2629BB and 2630AA), which include the Cape Clawless Otter (*Aonyx capensis*), Highveld vlei Rat (*Otomys auratus*), African Civet (*Civetticus civetta*) and a genet species (*Genetta* sp.).

One of the confirmed species is the Endangered Mountain Reedbuck (*Redunca fulvorufula*) which is represented by two small sub-populations restricted to the sandstone scarps and adjacent untransformed grassland (particularly on crests). An additional three of the confirmed species (c. Serval *Leptailurus serval*, Cape Clawless Otter *Aonyx capensis* and Highveld Vlei Rat *Otomys auratus*) are Near Threatened, (sensu Child *et al*., 2016) and restricted to the moist grassland bordering the valley-bottom and seep wetlands, including the pan wetland. The vlei Rat was particularly abundant in the project area.

Table 5-7: An inventory of observed mammalian taxa recorded on the project area during the survey (January 2023).

Scientific name	Common name	Red list category	Observed indicators	Habitat preference
Aonyx capensis	Cape Clawless Otter	Near threatened	Spoor	Restricted to the valley-bottom and seep wetlands, including pan wetland
Cryptomys pretoriae (=hottentotus)	Highveld Mole-rat	Least concern	Soil heaps	Widespread on project area
Raphicerus campestris	Steenbok	Least concern	Visual sightings	Uncommon, observed from untransformed grassland
Sylvicapra grimmia	Common Duiker	Least concern	Spoor & visual sightings	Relatively common and widespread on project area
Redunca arundinum	Southern Reedbuck	Least concern	Visual sightings and spoor	Widespread but localised along the edges of valley-bottom and seep wetlands
Redunca fulvorufula	Mountain Reedbuck	Endangered	Visual sightings	Restricted to the sandstone scarp shrubland – known from two sub-populations on the project area
Canis mesomelas	Black-backed Jackal	Least concern	Tracks, scats and visual sightings	Widespread on study area
Leptailurus serval	Serval	Near threatened	Tracks	Restricted to moist grassland bordering valley-bottom and seep wetlands, also along the edges of pan wetland
Atilax paludinosus	Marsh Mongoose	Least concern	Tracks	Abundant although restricted to moist grassland bordering valley-bottom and seep wetlands, also along the edges of pan wetland
Hystrix africaeaustralis	Cape Porcupine	Least concern	Diggings, dens and visual sightings	Widespread, but partial to sandstone scarp shrublands (dens)
Lepus victoriae (=saxatilis)	African Savanna Hare	Least concern	Droppings & visual sightings	Widespread on project area
Mycaelamys namaquensis	Namaqua Rock Mouse	Least concern	Nests	Restricted to sandstone scarp shrubland
Rhabdomys pumilio	Four-striped Grass Mouse	Least concern	Visual sightings	Widespread, but partial to moist grassland along valley-bottom and seep wetlands, also along the edges of pan wetland

Scientific name	Common name	Red list category	Observed indicators	Habitat preference
Gerbilliscus brantsii	Highveld Gerbil	Least concern	Dens/burrows	Widespread at the edge of agricultural lands and secondary vegetation with sandy soil texture.
Cynictis penicillata	Yellow Mongoose	Least concern	Visual sightings and scats	Widespread on project area
Otomys auratus	Highveld Vlei Rat	Near threatened	Grass clippings & droppings	Widespread in moist grassland bordering valley-bottom and seep wetlands, also along the edges of pan wetland
Potamochoerus larvatus	Bushpig	Least concern	Tracks	Widespread on project area
Procavia capensis	Rock Hyrax	Least concern	Visual sightings	Restricted to sandstone scarp shrubland
Genetta sp.	Genet. species	Least concern	Tracks	Widespread on project area
Civetticus civetta	African Civet	Least concern	Latrine	Localised and restricted to the sandstone scarp shrubland which provide roosting habitat
Vulpes chama	Cape Fox	Least concern	Tracks	Uncommon, recorded from untransformed grassland

5.2.3 Species of Conservation Concern

An estimated ten (10) threatened and Near Threatened mammal species could potentially occur within the general vicinity of the project area (Table 5-8). Of these, three Near Threatened species were confirmed on the project area (Figure 5-10), namely the Cape Clawless Otter (*Aonyx capensis*), Serval (*Leptailurus serval*) and Vlei Rat (*Otomys auratus*), while the Near Threatened Swamp Musk Shrew (*Crocidura mariquensis*) is highly likely to be present. In addition a sub-population of Endangered Mountain Reedbuck (*Redunca fulvorufula*) is present and restricted to the sandstone scarps and immediately adjacent grasslands within the project area.

The Serval (*Leptailurus serval*) is listed as Least Concern on the global IUCN Red List, although Child *et al*. (2016) have listed it as Near Threatened. They are always found near water and in areas with sufficient shelter such as tall grass (Skinner & Smithers, 1990) with an abundance of suitable prey which comprises primarily of Murid rodents (e.g., the genera *Mastomys*, *Mus* and *Otomys*). This species is a specialised rodent hunter, appears to be tolerant to agricultural activities and adapts readily to secondary grassland of abandoned cultivation as long as they are not persecuted or persistently disturbed (in Wilson & Mittermeier, 2009). Serval was confirmed to occur within the project area, and it is considered to be a widespread feline within the Mpumalanga highveld. Its widespread occurrence is confirmed by a 100 % trapping success when utilising camera traps within hygrophilous grassland bordering a range of wetland features on both untransformed and post-mined (rehabilitated) habitat in the western Mpumalanga highveld (Niemand, 2017) that are similar in structure and floristic composition to the valley-bottom and seep wetlands and some secondary grasslands in the project area.

The Cape Clawless Otter (*Aonyx capensis*) was also confirmed to occur within the project area, as evidenced by tracks bordering valley-bottom and seep wetlands. The global conservation status of the Cape Clawless Otter was recently uplisted from Least Concern to Near Threatened due to the widespread habitat alteration and degradation of wetland systems within its distribution range (Jacques *et al.*, 2015). Although the Cape Clawless Otter occupies a large distribution range in Africa, recent evidence suggests that the spatial size of its occupied habitat has declined significantly, possibly because of the effects of human conflict for resources such as water and prey (Jacques *et al.*, 2015).

The Vlei Rat (*Otomys auratus*) was previously included in the *Otomys irroratus* group, although recent molecular studies showed that it is in fact a valid species that is strongly associated with the Grassland Biome. *O. auratus* is a seemingly widespread rodent confined to moist grassland and the verges of Highveld vleis within the Grassland Biome, where it feeds voraciously on members of hygrophytic grasses (Poaceae) and sedges (Cyperaceae) and creates distinct runways littered by piles of discarded grass and sedge clippings. It has seemingly declined in some areas owing to the loss of habitat and wetland deterioration, especially through overgrazing and agricultural intensification (Taylor *et al.*, 2016a). The latter often results in the modification of grassland into shrubland habitat at higher altitudes, especially through the proliferation of *Seriphium plumosum* shrubland which leads to colonisation by *Otomys angoniensis* and the displacement *O. auratus*. It is also an important prey item of terrestrial birds of prey (e.g., Marsh Owl (*Asio capensis*) and African Grass-owls (*Tyto capensis*) and Serval (*Leptailurus serval*). The Vlei Rat was observed at several localities on the project area in moist grassland bordering valley-bottom and seep wetlands.

The Swamp Mush Shrew (*Crocidura mariquensis*) is a locally common and widespread shrew species which occupies marshy conditions. It is invariably associated with waterlogged conditions and wetland vegetation of valley-bottom wetlands seeps, pans and dams. In addition, it also utilises the runways of *Otomys* species during foraging and dispersal (Taylor, 1998). This species was previously regarded as Data Deficient (*sensu* Friedmann and Daly, 2004), but its status was recently elevated to the Near Threatened conservation status category (Taylor *et al*., 2016b). Its habitat is becoming severely fragmented and hence patchy, which resulted in sub-populations experiencing poor dispersal and poor population recruitment. This species is therefore highly likely to be present within the project area.

The Mountain Reedbuck sub-population experienced a drastic decline in South Africa owing to habitat fragmentation and genetic bottlenecks, which spurred the recent dramatic upgrade of its conservation status from least concern to Endangered (Taylor *et al.*, 2016). This species prefers mountainous and hilly habitat dominated by grassland, with a preference for rocky grassland with some shrub and tree cover. The Mountain Reedbuck was confirmed (refer Figure 5-10) from the sandstone scarp habitat. It was evident that sandstone scarps and adjacent untransformed crest grasslands provide extensive habitat for the sub-population recorded during the January 2023 survey.

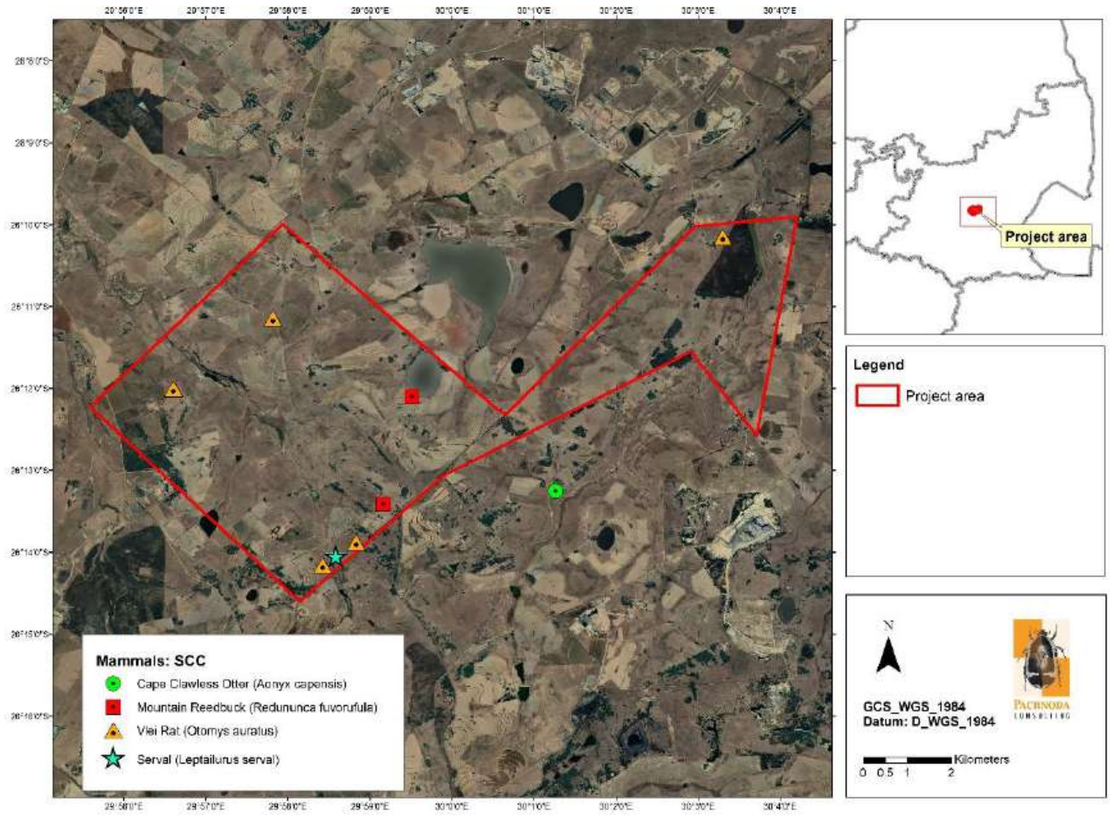

Figure 5-10: Location of threatened and Near Threatened mammal species observed on the project area.

Table 5-8: A summary table of potentially occurring mammal species of conservation concern recorded in the general vicinity of the project area.

Common Name	**Scientific Name**	**Threat Status**	**Habitat**	**Likelihood of Occurrence**	**Rationale**
Cape Clawless Otter	Aonyx capensis	NT	Mainly associated with freshwater habitat, as well as estuaries	High	Confirmed on project area
Serval	Leptailurus serval	NT	Mainly associated with moist rank grassland bordering wetlands and dams.	High	Confirmed on project area
Vlei Rat (highveld form)	Otomys auratus	NT	Associated with moist grassland along the edges of vleis and wetland features.	High	Confirmed on project area
Mountain Reedbuck	Redunca fulvorufula	EN	Associated with mountains and rocky scarps, often in grassland	High	Confirmed on project area
Swamp Mush Shrew	Crocidura mariquensis	NT	Associated with moist grassland along the edges of vleis and wetland features.	High	Suitable habitat was observed along the valley-bottom and seep wetlands for this species to occur
Grey Rhebok	Pelea capreolus	NT	Untransformed undulating grassland, often at high altitude.	High	The untransformed grassland on crests provides suitable habitat for this species to occur.
South African Hedgehog	Atelerix frontalis	NT	A wide variety of terrestrial (dryland) habitat types including urban environments and frequently encountered in urban gardens.	Moderate	The catholic choice of habitat makes predictions regarding its habitat requirements very difficult. However, illegal hunting, agricultural activities, and the presence of hunting dogs on certain parts of the project area may have displaced this species from the area.
Highveld Golden Mole	Amblysomus septentrionalis	NT	Grassland habitat along vleis and streams, mainly on clay soils.	Low	It has a low recording rate according to MammalMap and was last recorded in the area during 1915 (*sensu* MammalMap)
Oribi	Ourebia ourebi	EN	A selective grazer of short sour grassland with a high diversity of graminoid species, especially at high altitude.	Low	Although suitable habitat occurs (untransformed grassland on crests), this species was absent from the project area during the survey
Brown Hyaena	Parahyaena brunnea	NT	Wide range of habitat types in savanna, grassland, fynbos and Karoo biomes	Moderate	Status uncertain, although suitable habitat exists. It is possible that presence of human homesteads and hunting dogs may have displaced this species from the area or that the project area overlaps marginally with the home range of at least one or two individuals

EN = Endangered
NT = Near Threatened

5.2.4 Protected Species

Many mammal species in Mpumalanga are regarded as protected under Schedules 1 (Specially Protected), 2 (Protected), 3 (Ordinary Game) or 4 (Protected Wild Animals) of the Mpumalanga Nature Conservation Act (No. 10 of 1998). Most of the mammal species recorded during fieldwork are protected under Schedule 2. Of all mammal species observed on the project area, the Mountain Reedbuck (*Redunca fulvorufula*), Southern Reedbuck (R. *arundinum*), Steenbok (*Raphicerus campestris*) and Cape Clawless Otter (*Aonyx capensis*) are listed as Protected Game (Schedule 2), while the Common Duiker (*Sylvicapra grimmia*) is listed as Ordinary Game (Schedule 3). However, the Act refers specifically to sustainable utilisation of protected fauna and prohibitions regarding the hunting or harming of these species and is not relevant to the destruction of these species through listed activities such as mining. In addition, all hyraxes, mongoose species, serval, genets, civet and the Cape Fox are listed under Schedule 5, for which no person shall export or remove any of these species from the Province unless he or she is the holder of a permit which authorises him or her to do so.

Three of the mammal species (i.e. Serval (*Leptailurus serval*), Cape Fox (*Vulpes chama*) and Southern Reedbuck (*Redunca arundinum*) observed in the project area during fieldwork are listed as Protected species in the Threatened or Protected Species (TOPS) of the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) as published in Government Notice 255 of 2015.

The Southern Reedbuck (*Redunca arundinum*) merits further discussion which was recorded within the project area during the current survey, and although not a threatened species, it is protected under Schedule 2 of the Mpumalanga Nature Conservation Act (Act 10 of 1998) and in terms of the 'Threatened or Protected Species' (TOPS) list of the National Environmental Management: Biodiversity Act (Act 10 of 2004), and has experienced local decline across much of its former range due to poaching and habitat degradation, especially on unprotected land and within Mpumalanga and the other northern provinces of South Africa. Evidence gathered from similar faunal surveys conducted in the Mpumalanga highveld (Niemand, 2017) suggests that this species is an uncommon resident and the population appears to be highly fragmented. Due to scarcity of Reedbuck within the western and central parts of the Mpumalanga Highveld which closely coincides with coal mining areas, a high risk of genetic isolation of individuals within this sub-population and of the population as a whole, the Southern Reedbuck is considered an important species within the project area and is worthy of protection and conservation effort aimed at maintaining the long-term genetic viability of the sub-population occurring within the study area and its surrounds.

5.2.5 Alien Species

No alien mammal species was recorded during fieldwork. However, it is highly likely that alien species, namely Black Rat (*Rattus rattus*) and House Mouse (*Mus musculus*) could be associated with the homesteads and farm infrastructure on the project area.

5.3 Herpetofauna (amphibians and reptiles)

5.3.1 Regional Context

The project area falls within the Eastern Highveld Grassland national vegetation type of the Mesic Highveld Grassland Bioregion, a summer rainfall region (Mucina & Rutherford, 2006). There is a low level of endemicity for reptiles and frogs in the project area (ca 2-3 reptile species and one frog species) (Figure 5-11).

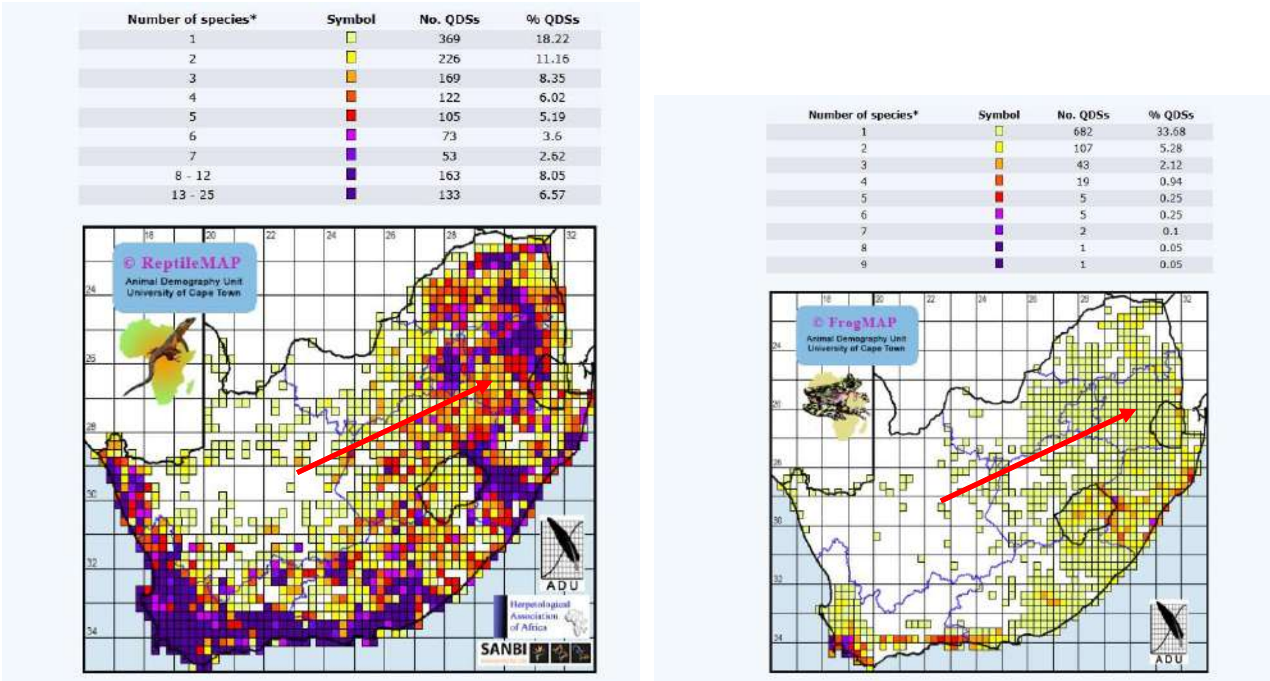

Figure 5-11: Density of endemic species per QDS for reptiles (left) and amphibians (right) in South Africa (project area indicated by red arrow).

5.3.2 Local Context

Fourteen frog species are known to be sympatric to the project area (Table9). Ten of these species have a high probability of occurrence within the project area based on their widespread distribution ranges and their ability to breed in temporary rain-filled depressions and inundated grassland. Of the 14 species expected to be present, seven species were observed within the project area during the fieldwork (Table9), of which Delalande's River Frog (*Amietia delalandii*) and the Common Caco (*Cacosternum boettgeri*) were dominant.

According to Minter *et al.* (2004), the amphibian richness on the project area is moderate (c. 11-20 species) with a low prevalence of endemic species (one species, *Amietia delalandii*). Therefore, the project area is not considered as an important amphibian diversity hotspot.

Table 5-9: A list of amphibian/frog species known from recent observations (*sensu* FrogMap) and historical distributional records corresponding to the project area.

Family	Scientific name	Common name	Red list category	Number of QDSs	Number of records	Probability of occurrence
Bufonidae	*Sclerophrys capensis*	Raucous Toad	Least Concern	2	5	High
Bufonidae	*Sclerophrys gutturalis*	Guttural Toad	Least Concern	2	5	High (confirmed)
Hyperoliidae	*Kassina senegalensis*	Bubbling Kassina	Least Concern	2	6	High (confirmed)
Hyperoliidae	*Semnodactylus wealii*	Rattling Frog	Least Concern	2	9	High (confirmed)
Pipidae	*Xenopus laevis*	Common Platanna	Least Concern	1	2	High
Ptychadenidae	*Ptychadena porosissima*	Striped Grass Frog	Least Concern	1	1	Low

Family	Scientific name	Common name	Red list category	Number of QDSs	Number of records	Probability of occurrence
Pyxicephalidae	*Amietia delalandii*	Delalande's River Frog	Least Concern	2	8	High (confirmed)
Pyxicephalidae	*Amietia poyntoni*	Poynton's River Frog	Least Concern	2	5	High (confirmed)
Pyxicephalidae	*Cacosternum boettgeri*	Common Caco	Least Concern	2	10	High (confirmed)
Pyxicephalidae	*Strongylopus fasciatus*	Striped Stream Frog	Least Concern	2	4	High (confirmed)
Pyxicephalidae	*Strongylopus grayii*	Clicking Stream Frog	Least Concern	2	3	High
Pyxicephalidae	*Tomopterna cryptotis*	Tremelo Sand Frog	Least Concern	2	2	Low
Pyxicephalidae	*Tomopterna natalensis*	Natal Sand Frog	Least Concern	1	1	Moderate
Pyxicephalidae	*Tomopterna tandyi*	Tandy's Sand Frog	Least Concern	1	1	Low

Very few reptile species were observed within the study area with most of the expected species restricted to habitat with a high spatial heterogeneity such as the sandstone scarps. Typical species observed include species such as the widespread Cape Skink (*Trachylepis capensis*) and Speckled Rock Skink (*Trachylepis punctatissima*), while the Rinkhals (*Hemachatus haemachatus*) was observed from the untransformed grassland unit.

A total of 27 reptile taxa are known to be sympatric to the project area (according to ReptileMap; *sensu* Bates *et al*., 2014). According to the habitat types present, the reptile diversity within the project is moderate (Bates *et al.*, 2014). However, 17 (63 %) of these species show a high probability of occurrence (Table 5-10), while the remaining 10 species have a moderate to low probability of occurrence. Species with low probabilities of occurrence are intrinsically rare and comprise sub-populations that are severely fragmented.

Table 5-10: A list of reptile species known from recent observations (*sensu* ReptileMap) and historical distributional records corresponding to the project area.

Family	Scientific name	Common name	Red list category	Number of QDSs	Number of records	Probability of occurrence
Agamidae	*Agama aculeata distanti*	Distant's Ground Agama	Least Concern	2	5	High
Agamidae	*Agama atra*	Southern Rock Agama	Least Concern	2	5	High
Chamaeleonidae	*Chamaeleo dilepis*	Common Flap-neck Chameleon	Least Concern	1	2	Low
Colubridae	*Crotaphopeltis hotamboeia*	Red-lipped Snake	Least Concern	1	1	High
Colubridae	*Dasypeltis scabra*	Rhombic Egg-eater	Least Concern	2	3	High
Colubridae	*Philothamnus semivariegatus*	Spotted Bush Snake	Least Concern	1	4	Moderate
Cordylidae	*Cordylus vittifer*	Common Girdled Lizard	Least Concern	1	2	High
Cordylidae	*Pseudocordylus melanotus melanotus*	Common Crag Lizard	Least Concern	2	5	High
Elapidae	*Elapsoidea sundevallii sundevallii*	Sundevall's Garter Snake	Least Concern	1	1	Moderate
Elapidae	*Hemachatus haemachatus*	Rinkhals	Least Concern	2	6	High (confirmed)

Family	Scientific name	Common name	Red list category	Number of QDSs	Number of records	Probability of occurrence
Gekkonidae	*Lygodactylus ocellatus*	Spotted Dwarf Gecko	Least Concern	1	3	Moderate
Gerrhosaurid ae	*Gerrhosaurus flavigularis*	Yellow-throated Plated Lizard	Least Concern	1	1	Low
Lamprophiid ae	*Aparallactus capensis*	Black-headed Centipede-eater	Least Concern	2	6	High
Lamprophiid ae	*Homoroselaps lacteus*	Spotted Harlequin Snake	Least Concern	1	2	Low
Lamprophiid ae	*Lycodonomorphus laevissimus*	Dusky-bellied Water Snake	Least Concern	1	3	Moderate
Lamprophiid ae	*Psammophis crucifer*	Cross-marked Grass Snake	Least Concern	1	4	Moderate
Lamprophiid ae	*Psammophylax rhombeatus*	Spotted Grass Snake	Least Concern	2	5	High
Lamprophiid ae	*Pseudaspis cana*	Mole Snake	Least Concern	2	6	High
Leptotyphlop idae	*Leptotyphlops scutifrons conjunctus*	Eastern Thread Snake	Least Concern	1	1	High
Scincidae	*Acontias gracilicauda*	Thin-tailed Legless Skink	Least Concern	1	4	Moderate
Scincidae	*Trachylepis punctatissima*	Speckled Rock Skink	Least Concern	2	6	High (confirmed)
Scincidae	*Trachylepis varia sensu lato*	Common Variable Skink Complex	Least Concern	1	3	High
Scincidae	*Trachylepis capensis*	Cape Skink	Least Concern	1	1	High (confirmed)
Typhlopidae	*Afrotyphlops bibronii*	Bibron's Blind Snake	Least Concern	1	6	High
Typhlopidae	*Rhinotyphlops lalandei*	Delalande's Beaked Blind Snake	Least Concern	1	1	High
Viperidae	*Bitis arietans arietans*	Puff Adder	Least Concern	1	2	High
Viperidae	*Causus rhombeatus*	Rhombic Night Adder	Least Concern	1	1	Moderate

5.3.3 Species of Conservation Concern

No herpetofauna of conservation concern were recorded within the project during the current survey or are known to be present according to historical records (sensu ReptileMap and FrogMap). However, it is worth mentioning that the sandstone scarps and associated rocky grassland provide suitable habitat for the Near Threatened Coppery Grass Lizard (*Chamaesaura aenea*) even though this species has not yet been recorded from the project area. This species is notoriously difficult to find or to detect, and since it occurs in fairly pristine grasslands and does not appear to tolerate any significant disturbances or habitat alterations. This species is vulnerable to veld fires and relies heavily on the presence of outcrops or rocky cover, which are absent from the study area, for protection against veld fires. The Coppery Grass Lizard is an exceedingly rare and unobtrusive species and Whittington-Jones *et al.* (2008) recorded only two specimens from Rietvlei Dam Nature Reserve over a period of ca. eight years.

5.3.4 Protected Species

No herpetofauna species listed as protected or regulated by the Threatened or Protected Species (TOPS) Regulations are expected to occur within the project area.

5.3.5 Alien Species

No alien herpetofauna species were observed or are expected in the project area.

5.4 Avifauna

5.4.1 Regional Context

From an avifaunal perspective it is evident that bird diversity is positively correlated with vegetation structure, although floristic richness is not often regarded to be a significant contributor of patterns in bird abundance and their spatial distributions. Grasslands are generally poor in woody plant species, and subsequently support lower bird richness values, it is often considered as an important habitat for many terrestrial bird species such as larks, pipits, korhaans, cisticolas, widowbirds including large terrestrial birds such as Secretary birds, cranes and storks. Many of these species are also endemic or near-endemic to South Africa and display particularly narrow distribution ranges. Due to the restricted spatial occurrence of the Grassland Biome and severe habitat transformation thereof, many of the bird species that are restricted to the grasslands are also threatened or experiencing declining population sizes.

Twenty-six of the bird species that are recorded within the mapping units (pentads) of the project area during the second South African Bird Atlas Project (SABAP2) are endemic and/ or near-endemic species in southern Africa (Table 5-11). This composition represents approximately 16% of all the endemic/near-endemic species[3] in southern Africa. Although the number of endemic species on the project area appears to be relatively low when compared to the national number, at least ten of these species are restricted to the sandstone scarp shrubland and its associated outcrops. The sandstone scarps on the project area are prominent habitat feature which thereby contributed towards an elevated richness of endemic bird species in area. Noteworthy species include Cape Bunting (*Emberiza capensis*), Cape Canary (*Serinus canicollis*), Cape Weaver (*Ploceus capensis*), Cape Grassbird (*Sphenoeacus afer*), Grey-winged Francolin (*Scleroptila afra*) and Mountain Wheatear (*Myrmecocichla monticola*).

However, the Southern Bald Ibis (*Geronticus calvus*) is the only biome-restricted bird species[4] that could potentially occur on the project area. This species is restricted to the Afrotropical Highlands Biome, which in general corresponds to the grasslands and scarps associated with Drakensberge Escarpment (Marnewick *et al.*, 2015).

Table 5-11: Endemic/near-endemic bird species recorded in the general vicinity of the project area.

Common Name	Scientific Name	Observed (Jan 2023)	SABAP2 Reporting Rate			
			Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
Ant-eating Chat	*Myrmecocichla formicivora*	1	85.71	42	10.71	6

[3] Species with core distribution ranges restricted to the geographic boundaries of southern Africa (including Namibia, Botswana, Zimbabwe and Mozambique south of the Zambezi River).
[4] A species with a breeding distribution confined to a single biome. Many biome-restricted species are also endemic to southern Africa.

Common Name	Scientific Name	Observed (Jan 2023)	SABAP2 Reporting Rate			
			Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
Blue Korhaan	*Eupodotis caerulescens*	1	26.53	13	0.00	0
Bokmakierie	*Telophorus zeylonus*	1	57.14	28	3.57	2
Cape Bunting	*Emberiza capensis*	1	6.12	3	0.00	0
Cape Canary	*Serinus canicollis*	1	57.14	28	1.79	1
Cape Longclaw	*Macronyx capensis*	1	93.88	46	8.93	5
Cape Shoveler	*Spatula smithii*	1	32.65	16	7.14	4
Cape Sparrow	*Passer melanurus*	1	75.51	37	3.57	2
Cape Weaver	*Ploceus capensis*	1	20.41	10	0.00	0
Cape White-eye	*Zosterops virens*	1	16.33	8	0.00	0
Cape Grassbird	*Sphenoeacus afer*	1	2.04	1	0.00	0
Cloud Cisticola	*Cisticola textrix*	1	26.53	13	0.00	0
Eastern Clapper Lark	*Mirafra fasciolata*	1	24.49	12	0.00	0
Fiscal Flycatcher	*Melaenornis silens*		14.29	7	0.00	0
Grey-winged Francolin	*Scleroptila afra*	1	12.24	6	0.00	0
Jackal Buzzard	*Buteo rufofuscus*		4.08	2	3.57	2
Mountain Wheatear	*Myrmecocichla monticola*	1	22.45	11	0.00	0
Natal Spurfowl	*Pternistis natalensis*		8.16	4	0.00	0
Northern Black Korhaan	*Afrotis afraoides*	1	2.04	1	0.00	0
Pied Starling	*Lamprotornis bicolor*	1	71.43	35	16.07	9
Pink-billed Lark	*Spizocorys conirostris*		2.04	1	0.00	0
Red-headed Finch	*Amadina erythrocephala*		6.12	3	0.00	0
South African Cliff Swallow	*Petrochelidon spilodera*	1	22.45	11	5.36	3
South African Shelduck	*Tadorna cana*	1	18.37	9	5.36	3
Southern Bald Ibis	*Geronticus calvus*		24.49	12	5.36	3
Yellow Canary	*Crithagra flaviventris*		16.33	8	0.00	0

5.4.2 Local Context

According to the second South African Bird Atlas Project (SABAP2) (www.sabap2.birdmap.africa), 194 bird species[5] are expected to occur in the wider project area (according to nine mapping units/pentad grids; Appendix 8) of which 123 bird species were confirmed during the January 2023 survey (see Appendix 9). The mean SABAP2 richness statistic (www.sabap2.birdmap.africa) for a single full protocol card (corresponding to two hours or more of bird observations) for the project area was 53.57 bird species (range: 22-114 species), implying that the observed species list is a true reflection of the bird richness on the project area given the time spent surveying the project area during the current survey. In addition, the species accumulation curve (SAC) reached an asymptote at approximately nineteen point counts (Figure 5-12). The sampling captured approximately 76% of the number of species predicted by the Michaelis-Menten

[5] Based on 105 submitted cards (of which 49 are full protocol cards where the observation time exceeds 2 hours).

model at 19 point counts. Approximately 88% of the species was captured by 50 counts. Therefore, sampling effort was considered sufficient and recorded most of the species present on the project area during the survey.

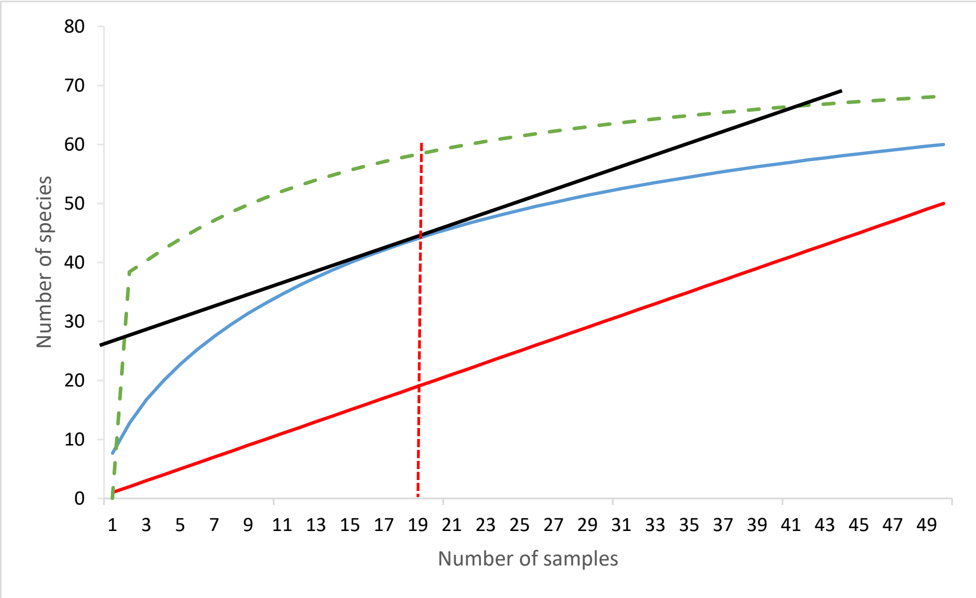

Figure 5-12: The species accumulation curve (SAC) (red line) for bird points sampled during January 2023. The blue line represents an accumulation of one species for every additional point count. The black line is parallel to the blue one and is tangent to the SAC approximately after 19 counts (as represented by the vertical red stippled line). The green stippled line represents the Michaelis-Menten curve.

The species with the highest frequency of occurrence (>50%) on the project area include the Cloud Cisticola (*C. textrix*), Cape Longclaw (*Macronyx capensis*), Zitting Cisticola (*C. juncidis*) and Levaillant’s Cisticola (*C. tinniens*). The dominant composition includes a high proportion of cryptic (dull coloured) insectivorous taxa represented by cisticolid species. These species are widespread on the central highveld grasslands, particularly in the moist grasslands of this region.

Four distinct avifaunal habitat associations (avifaunal assemblages) are present in the project area, namely valley-bottom and seep wetlands, sandstone scarp shrubland, untransformed grassland and secondary vegetation. The sandstone scarp shrubland, followed by the valley-bottom and seep wetlands hold the highest number of bird species on project area (Table 5-12), while the valley-bottom and seep wetlands were also the habitats with the highest average number of birds (number of individuals) (Table 5-12). Each of these assemblages is described briefly below.

Table 5-12: A summary of the observed species richness and number of bird individuals confined to the bird associations on the project area (according to point counts).

Bird Association	Number of species	Average Number of Individuals	Shannon Wiener Index H'(log_e)
Sandstone Scarp Shrubland	46	22.90	3.50
Valley-bottom and seep wetlands	37	34.09	2.42
Untransformed grassland	30	10.43	3.12
Secondary vegetation	13	15.50	2.22

Sandstone Scarp Shrubland

This habitat unit contains a unique bird composition that is restricted to the dense thicket habitat with sandstone boulders and outcrops. Many of the bird species that are restricted to this habitat are rupicolus (habitat specialist confined to outcrops) and in general uncommon to rare on grassland that are characterised by sandstone sheetrock as opposed to sandstone scarp with large bounders and tall vertical cliffs (as observed on the project area).

Species with a high frequency of occurrence: The Cloud Cisticola (*Cisticola textrix*), Zitting Cisticola (*C. juncidis*), Cape Longclaw (*Macronyx capensis*), Southern Masked Weaver (*Ploceus velatus*), Cape White-eye (*Zosterops virens*) and Common Waxbill (*Estrilda astrild*) are dominant (Table 5-13). Many of these species are also prominent on other grassland-dominated units.

Table 5-13: Most frequently recorded bird species in the Sandstone Scarp Shrubland.

Species	Average abundance	Consistency (Sim/SD)	Contribution (%)
Cloud Cisticola	1.00	0.70	20.33
Zitting Cisticola	0.70	0.69	17.12
Cape Longclaw	1.20	0.80	13.27
Southern Masked Weaver	1.20	0.68	7.43
Cape White-eye	1.10	0.52	4.44
Levaillant's Cisticola	1.20	0.35	0.38
Common Waxbill	2.00	0.39	0.39
Malachite Sunbird	0.80	0.85	0.38

Indicator species[6]: Cape Robin-chat (*Cossypha caffra*), Cape Grassbird (*Sphenoeacus afer*), Bar-throated Apalis (*Apalis thoracica*), Cape Bunting (*Emberiza capensis*), Cape Weaver (*Ploceus capensis*), Malachite Sunbird (*Nectarinia famosa*), Mountain Wheatear (*Myrmecocichla monticola*), African Yellow Warbler (*Iduna natalensis*) and Bokmakierie (*Telophorus zeylonus*).

Valley-bottom and seep wetlands

This habitat unit is confined to the various wetland features and moist grassland bordering the valley-bottom and seep wetlands. It also includes the moist and inundated grassland edges of the pan wetland. Some parts of this unit remain inundated for prolonged periods which facilitated the colonisation of dense stands of *Phragmites australis* and *Typha capensis* that are often utilised by euplectine (bishops), ploceids (weavers) and acrocephaline warblers for breeding and foraging purposes. This unit is also a critical important breeding and roosting habitat for the Vulnerable African Grass owl (*Tyto capensis*).

Species with a high frequency of occurrence: The Levaillant's Cisticola (*Cisticola tinniens*), Zitting Cisticola (*C. juncidis*), Cape Longclaw (*Macronyx capensis*), Pale-crowned Cisticola (*Cisticola cinnamomeus*), Southern Red bishop (*Euplectes orix*) and Yellow-crowned Bishop (*E. afer*) are dominant (Table 5-14).

[6] Indicator species refers to a species is restricted to a particular habitat and absent from other habitat.

Table 5-14: Most frequently recorded bird species in the Valley-bottom and seep wetlands.

Species	Average abundance	Consistency (Sim/SD)	Contribution (%)
Levaillant's Cisticola	1.90	1.25	21.33
Zitting Cisticola	0.95	1.06	15.58
Cloud Cisticola	0.81	0.93	13.97
Cape Longclaw	1.14	0.73	11.61
Long-tailed Widowbird	1.43	0.66	9.25
Southern Red Bishop	11.48	0.44	7.68
Pale-crowned Cisticola	0.76	0.49	7.08
Yellow-crowned Bishop	0.62	0.33	2.79

Indicator species: Blacksmith Lapwing (*Vanellus armatus*), Lesser Swamp Warbler (*Acrocephalus gracilirostris*), Little Rush Warbler (*Bradypterus baboecala*), African Snipe (*Gallinago nigripennis*), Baillon's Crake (*Zapornia pussila*), African Rail (*Rallus caerulescens*), Red-chested Flufftail (*Sarothrura rufa*) and Common Reed Warbler (*Acrocephalus scirpaceus*).

Untransformed grassland

This habitat unit is characterised by a floristic composition of mixed terrestrial graminoid species of the climax stage. It is representative of the Eastern Highveld Grassland vegetation type which supports an important grassland avifaunal composition on the Mpumalanga Highveld.

Species with a high frequency of occurrence: The Levaillant's Cisticola (*Cisticola tinniens*), Zitting Cisticola (*C. juncidis*), Cape Longclaw (*Macronyx capensis*), Pale-crowned Cisticola (*Cisticola cinnamomeus*) and Long-tailed Widowbird (*Euplectes progne*) are dominant (Table 5-15).

Table 5-15: Most frequently recorded bird species in the Untransformed Grassland.

Species	Average abundance	Consistency (Sim/SD)	Contribution (%)
Cloud Cisticola	1.07	1.46	36.03
Cape Longclaw	1.14	0.92	23.62
Zitting Cisticola	0.64	0.75	15.91
Long-tailed Widowbird	0.64	0.43	6.14
Pale-crowned Cisticola	0.71	0.34	5.22

Indicator species: Spike-heeled Lark (*Chersomanes albofasciata*), African Pipit (*Anthus cinnamomeus*), Northern Black Korhaan (*Afrotis afraoides*), Common Quail (*Coturnix coturnix*), Wing-snapping Cisticola (*Cisticola ayersii*), Eastern Clapper Lark (*Mirafra fasciolata*) and Blue Korhaan (*Eupodotis caerulescens*).

Secondary vegetation

This habitat unit is characterised by a floristic composition of graminoid species of pioneer and/ or secondary stage due to historical transformations such as ploughing or tilling. It is a unit that is species poor in terms of bird species.

Species with a high frequency of occurrence: The Levaillant's Cisticola (*Cisticola tinniens*), Cloud Cisticola (*C. textrix*) and Cape Longclaw (*Macronyx capensis*) are dominant (Table 5-16).

Table 5-16: Most frequently recorded bird species in the Secondary Vegetation.

Species	Average abundance	Consistency (Sim/SD)	Contribution (%)
Cape Longclaw	2.00	3.45	50.52
Cloud Cisticola	0.75	0.85	23.17
Levaillant's Cisticola	1.50	0.90	19.92

Indicator species: None

Thirty-four (34) waterbird species were recorded at 10 prominent wetland features which range from natural pans and channelled valley-bottom wetlands to in-channel man-made dams. It is evident from Table 5-17 that the Yellow-billed Duck (*Anas undulata*), Blacksmith Lapwing (*Vanellus armatus*), Egyptian Goose (*Alopochen aegyptiacus*) and Red-knobbed Coot (*Fulica cristata*) attained the highest frequency of occurrence on the project area with high numbers (>100 individuals) of Yellow-billed Duck (*Anas undulata*) and Red-knobbed Coot (*Fulica cristata*) recorded. The project area supports a high richness of waterbird species which include a diverse assemblage of waterfowl taxa, wading birds and shorebird taxa (waders).

Table 5-17: A summary of the waterbird counts in the project area.

Species	Stream/river	Dam 1	Dam 2	Dam 3	Dam 4	Dam 5	Pan	Dam 6	Dam 7	Inflow to Dam	Sum	Frequency of occurrence
Yellow-billed Duck (*Anas undulata*)	9	13	7	0	22	7	8	0	39	0	105	70.00%
Blacksmith Lapwing (*Vanellus armatus*)	6	1	3	0	5	0	0	4	6	0	25	60.00%
Egyptian Goose (*Alopochen aegyptiacus*)	13	0	9	2	8	0	2	0	2	0	36	60.00%
Red-knobbed Coot (*Fulica cristata*)	0	2	244	0	17	3	4	0	6	0	276	60.00%
Black-headed Heron (*Ardea melanocephala*)	2	0	3	0	1	0	1	1	0	0	8	50.00%
South African Shelduck (*Tadorna cana*)	7	2	2	0	30	0	8	0	0	0	49	50.00%
Whiskered Tern (*Chlidonias hybrida*)	3	1	0	0	5	0	0	0	5	2	16	50.00%
Grey Heron (*Ardea cinerea*)	2	0	1	0	2	0	0	0	1	0	6	40.00%
Reed Cormorant (*Microcarbo africanus*)	0	0	5	0	4	0	0	0	3	4	16	40.00%
Spur-winged Goose (*Plectropterus gambiensis*)	5	0	3	0	0	2	9	0	0	0	19	40.00%
Cape Shoveler (*Anas smithii*)	2	3	0	0	22	0	0	0	0	0	27	30.00%
Glossy Ibis (*Plegadis falcinellus*)	3	2	0	0	2	0	0	0	0	0	7	30.00%
Little Grebe (*Tachybaptus ruficollis*)	0	0	12	1	2	0	0	0	0	0	15	30.00%
Malachite Kingfisher (*Corythornis cristatus*)	1	0	1	0	0	1	0	0	0	0	3	30.00%
Purple Heron (*Ardea purpurea*)	0	0	0	0	1	0	0	0	1	1	3	30.00%
Red-billed Teal (*Anas erythrorhyncha*)	33	8	0	0	34	0	0	0	0	0	75	30.00%
Red-chested Flufftail (*Sarothrura rufa*)	2	1	0	0	0	0	0	0	0	1	4	30.00%
African Spoonbill (*Platalea alba*)	2	0	2	0	0	0	0	0	0	0	4	20.00%
Common Moorhen (*Gallinula chloropus*)	0	0	0	0	7	0	0	0	0	1	8	20.00%
Little Stint (*Calidris minuta*)	2	0	0	0	10	0	0	0	0	0	12	20.00%
Ruff (*Calidris pugnax*)	2	0	0	0	7	0	0	0	0	0	9	20.00%
Three-banded Plover (*Charadrius tricollaris*)	2	0	0	0	2	0	0	0	0	0	4	20.00%
White-breasted Cormorant (*Phalacrocorax lucidus*)	0	0	4	0	2	0	0	0	0	0	6	20.00%
Wood Sandpiper (*Tringa glareola*)	2	0	0	0	2	0	0	0	0	0	4	20.00%
African Rail (*Rallus caerulescens*)	2	0	0	0	0	0	0	0	0	0	2	10.00%
African Sacred Ibis (*Threskiornis aethiopicus*)	0	8	0	0	0	0	0	0	0	0	8	10.00%
African Swamphen (*Porphyrio madagascariensis*)	0	0	0	0	0	0	0	0	0	4	4	10.00%
Black Crake (*Zapornia flavirostra*)	0	0	0	0	0	0	0	0	0	2	2	10.00%

Species	Stream/river	Dam 1	Dam 2	Dam 3	Dam 4	Dam 5	Pan	Dam 6	Dam 7	Inflow to Dam	Sum	Frequency of occurrence
Black-winged Stilt (*Himantopus himantopus*)	0	0	0	0	2	0	0	0	0	0	2	10.00%
Cape Teal (*Anas capensis*)	0	0	0	0	2	0	0	0	0	0	2	10.00%
Common Greenshank (*Tringa nebularia*)	1	0	0	0	0	0	0	0	0	0	1	10.00%
Great Crested Grebe (*Podiceps cristatus*)	0	0	6	0	0	0	0	0	0	0	6	10.00%
Southern Pochard (*Netta erythrophthalma*)	0	0	0	0	4	0	0	0	0	0	4	10.00%
Western Cattle Egret (*Bubulcus ibis*)	0	0	0	0	0	0	0	0	17	0	17	10.00%

5.4.3 Bird Species of Conservation Concern

Table5-18 provides an overview of threatened and Near Threatened bird species recorded in the project area as well as those previously recorded in the vicinity of the project area, based on their known distribution range and the presence of suitable habitat. According to Table5-18, twelve threatened and Near Threatened bird species have been recorded in the area with three species confirmed from the project area during the survey, namely the globally Near Threatened Blue Korhaan (*Eupodotis caerulescens*), regionally Vulnerable African Grass owl (*Tyto capensis*) and the regionally Vulnerable Denham's Bustard (*Neotis denhami*) (Figure 5-13). The Blue Korhaan was represented by a pair of birds occupying untransformed grassland on Vaalbank, while a pair of Denham's Bustards was located in untransformed grassland on a crest adjacent to the large sandstone scarp system on Vaalbank. An active African Grass Owl roosting site was located within *Imperata cylindrica* grassland on Vaalbank. At least another 16 sites on the project area were identified as optimal breeding and roosting habitat for the African Grass Owl, which consists of dense rank grassland dominated by *Imperata cylindrica, Arundinella nipalensis* and Cyperaceae dominated grassland containing primarily *Carex* sp and *Fuirena* and *Kyllinga* species (Figure 5-13). It is recommended that all potential Grass owl habitat be buffered by at least 170m from the edge of the wetland in accordance with GDARD minimum requirements for biodiversity assessments in Gauteng (GDARD, 2014).

Both the Vulnerable Southern Bald Ibis (*Geronticus calvus*) and Endangered Secretary bird (*Sagittarius serpentarius*) could also occur within the project area, although they are regarded as non-breeding foraging visitors. Both these species are regarded as regular foraging visitors to the untransformed grassland unit and could be present (during foraging bouts) when the grasslands on the project area are burned or during the early summer season after the grasslands were burned. In addition, the pan wetland also provides potential ephemeral foraging habitat for the globally endangered Maccoa Duck (*Oxyura maccoa*) and the regionally Near Threatened Greater Flamingo (*Phoenicopterus roseus*) and Lesser Flamingo (*Phoeniconaias minor*). The latter species have a high likelihood of occurrence but were absent during the survey due to the exceptionally high water levels of many of the pans and impoundments in the area which caused a reduction in salinity levels and eutrophication which is important environmental conditions for the development of their preferred prey items.

The remaining species are irregular visitors to the vicinity of the project area and are only present when resources (e.g., food) are limited elsewhere due to unfavourable environmental conditions (e.g. when many of the large impoundments and pans in the region are dry) or these species occur as vagrants.

Table 5-18: Bird 'species of conservation concern' that have been recorded in the study area based on known distribution ranges (*sensu* SABAP2) and the presence of suitable habitat. Red list categories according to the IUCN (2023)* and Taylor *et al*. (2015). The reporting rates were derived from 2629AC (Evander) and pentad grid 2615_2910.**

Species	Global Conservation Status*	National Conservation Status**	SABAP2 reporting rate	Preferred Habitat	Potential Likelihood of Occurrence in project area
Circus ranivorus (African Marsh Harrier)	-	Endangered	8.16	Restricted to permanent wetlands with extensive reedbeds.	An uncommon foraging visitor to the valley-bottom wetlands.
Eupodotis caerulescens (Blue Korhaan)	Near Threatened	(delisted)	26.53	Prefers extensive open short grassland and cultivated land.	Confirmed and potential breeding resident.

Species	Global Conservation Status*	National Conservation Status**	SABAP2 reporting rate	Preferred Habitat	Potential Likelihood of Occurrence in project area
Falco biarmicus (Lanner Falcon)	-	Vulnerable	4.08	Varied, but prefers to breed in mountainous areas.	An irregular foraging visitor to the area.
Geronticus calvus (Southern Bald Ibis)	Vulnerable	Vulnerable	24.49	A species restricted to montane grassland (especially when burned) and breed/nest on steep cliffs.	Considered to be a regular foraging visitor - probably only occur after the grasslands were recently burned.
Glareola nordmanni (Black-winged Pratincole)	Near Threatened	Near threatened	4.08	A species preferring extensive open grassland, usually near wetlands. Often forages over agricultural land and pastures.	A highly irregular to uncommon non-breeding foraging visitor.
Neotis denhami (Denham's Bustard)		Vulnerable	2.04	Prefers short untransformed high-altitude grassland in undulating topographies.	A breeding resident. At least one pair present on project area.
Oxyura maccoa (Maccoa Duck)	Endangered	Vulnerable	6.25	Large saline pans and shallow impoundments.	Considered to be a regular foraging visitor to the pan wetland and some of the larger impoundments.
Phoeniconaias minor (Lesser Flamingo)	Near Threatened	Near threatened	4.08	Restricted to large saline pans and other inland water bodies containing cyanobacteria.	Considered to be a regular foraging visitor to the pan wetland and some of the larger impoundments.
Phoenicopterus roseus (Greater Flamingo)	-	Near threatened	8.16	Restricted to large saline pans and other inland water bodies.	Considered to be a regular foraging visitor to the pan wetland and some of the larger impoundments.
Polemaetus bellicosus (Martial Eagle)	Endangered	Endangered	2.04	Varied, from open karroid shrub to lowland savanna.	A highly irregular foraging visitor.
Sagittarius serpentarius (Secretarybird)	Endangered	Endangered	6.12	Prefers open grassland or lightly wooded habitat.	A regular to uncommon to fairly regular visitor to the area.
Tyto capensis (African Grass Owl)	-	Vulnerable	8.16	Prefers rank moist grassland that borders drainage lines or wetlands.	A breeding resident – at least one to two pairs present on the project area.

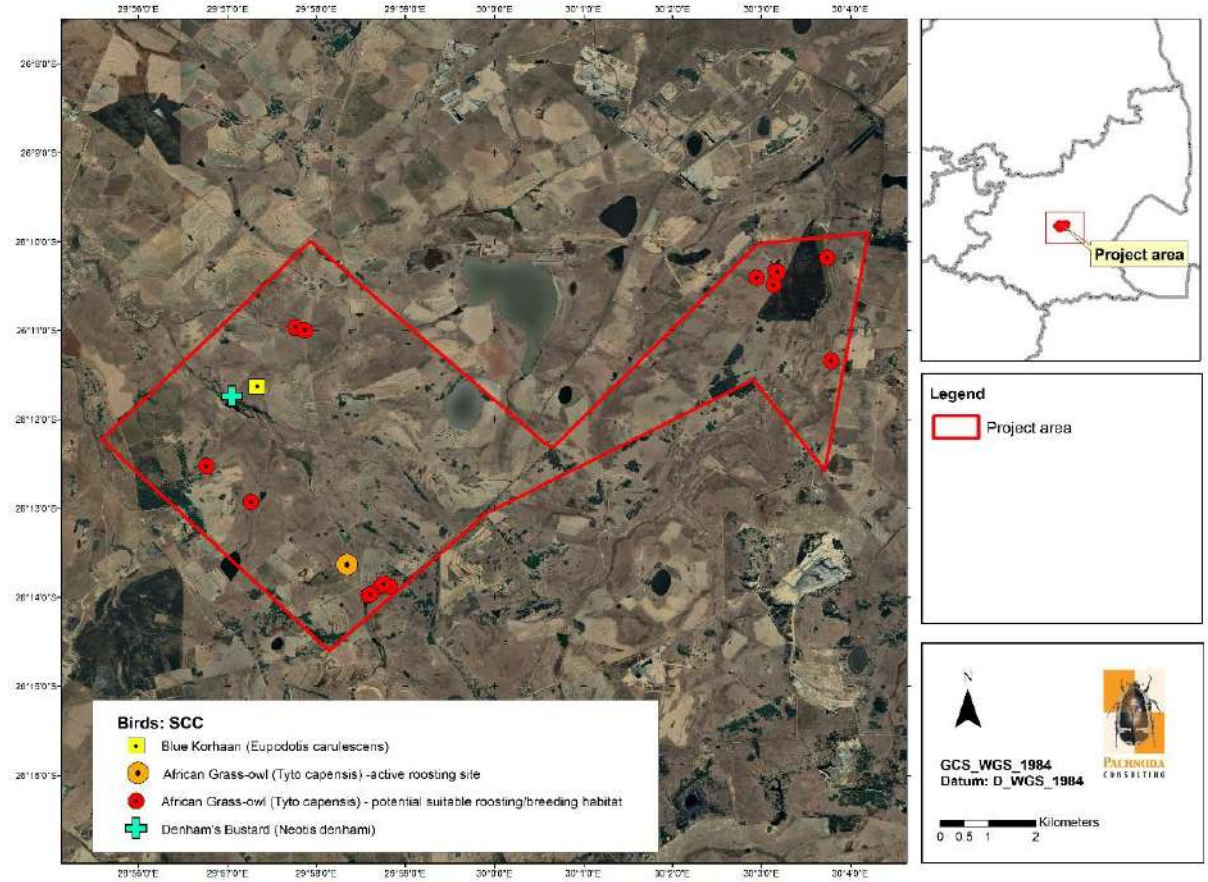

Figure 5-13: The occurrence of threatened and Near Threatened bird species observed on the project area during January 2023.

5.4.4 Protected Species

Most of the bird species in the Mpumalanga Province are regarded as protected under Schedules 2 (Protected), 3 (Ordinary Game) or 5 (Provision of Section 33 apply – permits for relocation or transport) of the Mpumalanga Nature Conservation Act (No. 10 of 1998). The Act refers specifically to sustainable utilisation (including hunting) of protected fauna and prohibitions regarding the collecting or harming of these species, and the legislation is not relevant to the destruction of these species through listed activities such as mining.

The Denham's Bustard (*Neotis denhami*), White-breasted Cormorant (*Phalacrocorax lucidus*), Grey-headed Gull (*Chroicocephalus cirrocephalus*) and the potentially occurring Southern Bald Ibis (*Geronticus calvus*) and flamingo species are listed in the Threatened or Protected Species (TOPS) of the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) as published in Government Notice 255 of 2015.

5.4.5 Alien Species

Three alien bird species was recorded during fieldwork, namely House Sparrow (*Passer domesticus*), Common Myna (*Acridotheres tristis*) and Rock Dove (*Columba livia*). These species were only encountered around human settlements and homesteads and is unlikely to occur in natural habitat in the project area.

5.5 Important Ecological Processes and Ecological Connectivity

Vegetation types are widely and appropriately used as surrogates for ecosystems (SANBI, 2013). The natural vegetation of the entire project area and its immediate surrounds comprises Eastern Highveld Grassland (Gm 12), a vegetation type included in the Mesic Highveld Grassland Bioregion of the Grassland Biome (Mucina & Rutherford, 2006) (Figure 5-1). The Eastern Highveld Grassland of the project area and surrounding parts of Mpumalanga occurs on sandy soils overlying sandstones of the Karoo Supergroup.

The principal ecological characteristics and ecosystem drivers in Mesic Highveld Grasslands (SANBI, 2013 and Tainton, 1999) include:

- Climate, which is characterised by warm, wet summers and cool, dry winters. This, combined with the effects of altitude, results in a long, summer growing season lasting about six to seven months and the rapid build-up of biomass and resulting in high fuel load and regular and potentially intense.
- High natural incidence of fire. The late spring and summer weather is characterised by frequent storms and accompanying lightning strikes, which cause natural fires which maintain the largely treeless character of these grasslands (except on rocky ridges such as the sandstone scarps of the study area which function as 'fire-collars' and support natural shrublands and thicket).
- Grazing is an essential ecosystem driver and these grasslands evolved with evolutionary pressure from large ungulates. Mesic Highveld Grassland is reasonably well adapted to grazing pressure under low to moderate stocking rates with adequate rest periods.
- These grasslands are characterised by the life-history strategies of dominant species. The combined summer grazing/winter burning disturbance regime has resulted in vegetation dominated by plants (mostly grasses) that are perennial and long-lived (mostly hemicryptophytes and geophytes), and that reproduce mostly by vegetative growth with only occasional replacement from seed. This means that these ecosystems do not recover well when areas are cleared and secondary succession is often very slow (Tainton, 1999), as the newly-disturbed ground is rapidly colonised by other annual weeds that initially out-compete slower-growing, perennial grasses. *Hypparhenia hirta* (and other *Hyparrhenia* spp.) often colonises areas disturbed by cultivation and stalls the process of secondary succession creating a disclimax secondary grassland community that may persist for at least 80 years and in many cases, it seems unlikely that that the original grassland "will ever replace these *Hyparrhenia* dominated secondary communities" (Tainton, 1999).
- Hydrological characteristics are also important drivers of Mesic Highveld grasslands which are restricted to relatively high rainfall regions which are vitally important for water production. The characteristically dense vegetation cover traps surface water, slowing runoff and allowing more time for water to drain vertically through the porous soil profile until contacting relatively impermeable sandstone strata and either being stored or moving horizontally and seeping onto the surface where the sandstone strata daylights forming sandstone scarps situated mostly on the lower slopes of the gently undulating terrain.

Along with fire, grazing is the single biggest factor that can influences the ecology of Mesic Highveld grasslands (SANBI, 2013). Fire is in fact a natural and beneficial disturbance of the vegetation structure (including species composition), is essential in nutrient recycling and distribution and, at correct intervals, assists in maintaining elevated levels of biodiversity (Goldammer & de Ronde, 2004). From a planning perspective, any change in land-use that results in a change in the grazing and fire regimes will probably have a significant impact on grassland vegetation (SANBI, 2013 and Tainton, 1999). Pro-active fire management through planned and controlled burning, however, is an essential part of wise landscape management in grasslands.

Many land-use activities place pressure on Mesic Highveld Grasslands which have low resilience to many forms of disturbance. These activities can be broadly divided into those that cause degradation (changes in composition, structure or functioning) and those that result in a complete and irreversible modification (i.e. 'transformation') of the habitat, mostly through complete removal of the vegetation; including catastrophic impacts such as ploughing and opencast mining. The major historical and ongoing threats to Eastern Highveld Grassland, which is an Endangered vegetation type (Mucina & Rutherford, 2006 and Skonow *et al*. 2019) and is Gazetted as an Endangered terrestrial ecosystem (NEM:BA) are cultivation, opencast mining (large coal reserves occur beneath the sandstones on which this vegetation occurs), plantations and invasive stands, urbanisation and the building of dams. The aforementioned impacts not only cause vegetation/habitat loss by also cause habitat fragmentation. **It must be emphasised that habitat fragmentation and migration barriers caused by mining infrastructure such as opencast pits and overburden stockpiles, constitutes far more of a severe impact than habitat fragmentation resulting from Modified (transformed) habitats such cultivated lands.** Furthermore, the ecological 'edge effects', such as increased dust deposition, alien plant invasion and alteration of hydrological regimes (Pfab, 2001b), emanating from habitats transformed by activities such as opencast mining are of far greater severity than those emanating from habitats transformed by historical or current cultivation.

The largest valley-bottom wetland systems present in the study area are a tributary of the Vaalwaterspruit which flows from the south-east boundary of the Farm Vaalbank to the north-west through the project area, and a tributary of the Boesmanspruit which flows from north to south through the Farm Roodebloem. These valley-bottom wetlands and contiguous adjacent areas of untransformed grass and sandstone scarp shrubland are mapped almost entirely as Critical Biodiversity Area: Irreplaceable in the Mpumalanga Biodiversity Sector Plan (MBSP), with smaller areas mapped as CBA: Optimal, comprise the two most important 'biological corridors' within the project area. The prosed project infrastructure will not sever either corridor but will encroach marginally on them and isolate them laterally and cause an increase in 'edge effects' thereby potentially effecting various aspects of ecosystem functioning. In addition to these CBA corridors, the MBSP shows an approximately 51.7 ha area in the north-eastern corner of the project area as an ESA: Landscape Corridor, which is intended to enhance connectivity between areas of CBA-Irreplaceable within the project area and the contiguous area of CBA – Irreplaceable directly to the north of the project area. None of the proposed project infrastructure is situated within this ESA.

The sandstone scarp shrubland, valley-bottom and seep wetlands and contiguous adjacent areas of untransformed grassland show a high ecological connectivity with habitat units of similar structure located adjacent to the project area. These units, in particular the scarps were found to be important habitat for *Redunca* species (reedbuck) and contain nearly 70% of the predicted endemic bird species in the project area. It also contains a unique avifaunal composition, which are restricted to the scarps, and therefore contributed towards the local biodiversity in the area. The wetlands are linear in configuration which function as important dispersal corridors for mammal taxa and important daily flyways for waterbird species commuting between roosting and foraging habitat. More importantly, these wetland and scarp corridors form critical important ecological "links" with CBAs identified by the Mpumalanga Biodiversity Sector Plan (MTPA, 2014). The importance of these "links" will facilitate animal dispersal and to maintain genetic cohesion between sub-populations of species which may become displaced during the proposed mining activities. The sandstone scarps on the Farm Vaalbank between Sites 46 and 113 (Figure 5-8 and Appendix 4) along the large valley-bottom wetland (tributary of the Vaalwaterspruit) represent the best developed and biodiverse sandstone scarps recorded by the authors in the Breyten-Carolina region of Mpumalanga Highveld over decades of conducting surveys in this region. This area of ca. 50m tall sandstone scarp constitutes a refuge area for many species (area of suitable habitat in a matric of unsuitable habitat) within the project area and its immediate surrounds. The vegetation is highly species rich (α-diversity), and the Beta diversity (β-diversity), which is the 'rate of change in species composition across habitats or among communities' is also extremely high. Of the 194 plant species recorded during fieldwork that are not included in the BODATSA species list for the grids 2629BB and 2630AA, 94 were recorded within the Sandstone Scarp Shrubland vegetation unit which occupies only 102.2ha (or 2.1%) of the project area, and 46 of these 94 species were recorded exclusively from this vegetation unit.

In addition, the endorheic pan wetland, is also important from a functional and dynamic perspective at the landscape level since it forms part of an "inter-connected" system or "stepping stones" of pans within the catchment (e.g. Kranspan and Grootpan), meaning that environmental conditions at these pans (e.g. water levels, salinity, food availability, availability of shoreline habitat) are constantly changing. Therefore, none of the pans within the catchment are similar to each other, thereby providing a continuous supply of resources for waterbirds, a safe refuge and nesting habitat for waterbird species, and when some of the smaller pans turn dry, the pan wetland is likely to attract large numbers of waterfowl. The pan is also predicted to be a foraging refuge for flamingos during dry periods. Furthermore, the pan floor, which could not be surveyed during fieldwork as a result of inundation, provides suitable habitat for pan endemic plant species including the *Lessertia phillipsiana* (DDD), a species which is considered likely to be present and is currently undergoing a conservation status assessment which is likely to lead to its listing as a threatened species.

5.6 Mpumalanga Biodiversity Sector Plan (MBSP)

The Mpumalanga Biodiversity Sector Plan (or MBSP) (MTPA, 2014) mapping for the 4 956 ha project area and its immediate surrounds is shown in Figure 5-10. According to the MBSP mapping, the vast majority of vegetation units representing Natural Habitat mapped during the current ecological assessment fall with areas mapped as Critical Biodiversity Areas (CBAs) in the MBSP. Areas mapped in the MBSP as CBA: Irreplaceable comprise 1 893.4ha (or 38.2%) of the project area, areas mapped as CBA: Optimal comprise 330.5ha (or 6.7%) of the project area and a single area mapped as an Ecological Support Areas (ESA): Landscape corridor comprises 51.8 ha (or 1.0%) of the study area. The remainder of the project area is mapped as either Moderately Modified (old lands) or Heavily Modified (current cultivation, infrastructure, alien tree stands etc.) in almost equal measure.

The MBSP mapping of CBAs, coincides very closely with the mapping of the four vegetation units representing Natural Habitat provided in the current report (Figure 5-8) and includes almost all areas of these four vegetation units (Untransformed Grassland, Sandstone Scarp Shrubland, Valley-bottom & seep wetlands and Pan wetland). Almost all areas of the Untransformed Grassland, Sandstone Scarp and Valley-bottom & seep wetlands vegetation units have been classified as **CBA: Irreplaceable,** which also includes small areas of Secondary Grassland of historically cultivated areas**,** while smaller areas of these vegetation units are classified as **CBA: Optimal.** The Pan wetland vegetation unit has been classified as **CBA: Optimal** (Figure 5-14).
Areas mapped as CBA: Irreplaceable and CBA: Optimal in the MBSP are the most important are the most sensitive habitats in the project area and represent the areas where impacts on ecology from any development and would be most significant and undesirable. CBAs are areas that are regarded as essential for meeting provincial biodiversity conservation targets for species, ecosystems and ecological processes (Table 5-19). The desired management objectives for areas categorised as CBA: Irreplaceable are that they should be maintained in a natural state with no further loss of ecosystems, functionality, or species. Permissible land-use is limited to conservation/stewardship with "no flexibility in land-use options" (Table 5-19). **Areas categorised as CBA: Irreplaceable are therefore, by definition, irreplaceable in terms of meeting biodiversity conservation targets and the loss of such areas cannot be mitigated by**

conservation ‘offsets’. The desired management objectives for areas categorised as CBA: Optimal are that they should be maintained in a natural state with no loss of ecosystems, functionality, or species. Permissible land-use is limited to conservation/stewardship and low-impact tourism with “some flexibility in land-use options” (Table 5-19).

Approximately 51.7 ha (or 1.0% of the project area) in the north-eastern corner of the project area comprises an ESA: Landscape corridor, which is seemingly intended to enhance connectivity between areas of CBA-Irreplaceable within the project area and the contiguous area of CBA – Irreplaceable directly to the north of the project area. None of the proposed project infrastructure is situated within this ESA.

Almost all transformed parts of the project area are categorised as either Moderately Modified (old lands) or Heavily Modified (current cultivation, infrastructure, alien tree stands etc.), and these areas falling within these categories are the preferred areas for a wide variety of land-uses, including mining.

Table 5.19. Mpumalanga Biodiversity Sector Plan 2014 (MTPA, 2014) CBA categories and land-use guideline.

MBSP Biodiversity Category	**Description of what is included** (ecosystems, species and processes)	**Primary objective of the Biodiversity Category**	**Permissible land-uses that are unlikely to compromise the biodiversity objective**
Protected Areas – National Parks & Nature Reserves	Protected Areas are formally protected by law and recognised in terms of the Protected Areas Act, including contract protected areas declared through the biodiversity stewardship programme. ‘National Parks and Nature Reserves’ is one of three subcategories and includes formally proclaimed national Parks, nature Reserves, Special nature Reserve, and Forest nature Reserves.	Areas that are meeting biodiversity targets and therefore must be kept in a natural state, with a management plan focused on maintaining or improving the state of biodiversity.	All operational aspects of managing these areas must be subject to their main purpose, which is to protect and maintain biodiversity and ecological integrity, and should be governed by a formally approved management plan and land-use activities that support the primary function of these areas as primary sites for biodiversity conservation. The management plan must identify allowable activities, which should be consistent at least with the CBA-Irreplaceable category.
CBA-Irreplaceable	Areas that are 80-100% irreplaceable for meeting biodiversity conservation targets; or Critical Linkages; or Critically Endangered ecosystems	Maintain in a natural state with no loss of ecosystems, functionality, or species; no flexibility in land-use options.	- Conservation / stewardship
CBA-Optimal	Areas that are optimally located as part of the most efficient solution to meet biodiversity targets.	Maintain in a natural state with no loss of ecosystems, functionality, or species; some flexibility in land-use options.	- Conservation / stewardship - Low-impact tourism
Other Natural Areas	Natural areas which are not identified as CBAs or ESAs, but which provide a range of ecosystem services from their ecological infrastructure.	Minimise habitat and species loss through strategic landscape planning, and ensure basic ecosystem functionality	All land-uses are either ‘Permissible,’ or ‘Permissible under certain conditions’.
Heavily Modified	Transformed areas, where biodiversity and ecological function have been lost to the point that they are not worth considering for conservation at all.	Manage the land-use in a biodiversity-friendly manner aiming to maximise ecological functionality.	Almost all land-uses are ‘Permissible’, with the exception of quarrying / opencast mining and underground mining, which are either ‘Permissible’, or ‘Permissible under certain conditions’.
Moderately Modified – old lands	Areas which were modified within the last 80 years but now abandoned, including old mines and old cultivated lands.	Stabilise and manage to restore ecological functionality, particularly soil carbon and water-related functionality.	Almost all land-uses are ‘Permissible’, with the exception of quarrying / opencast mining and underground mining, which are either ‘Permissible’, or ‘Permissible under certain conditions’.

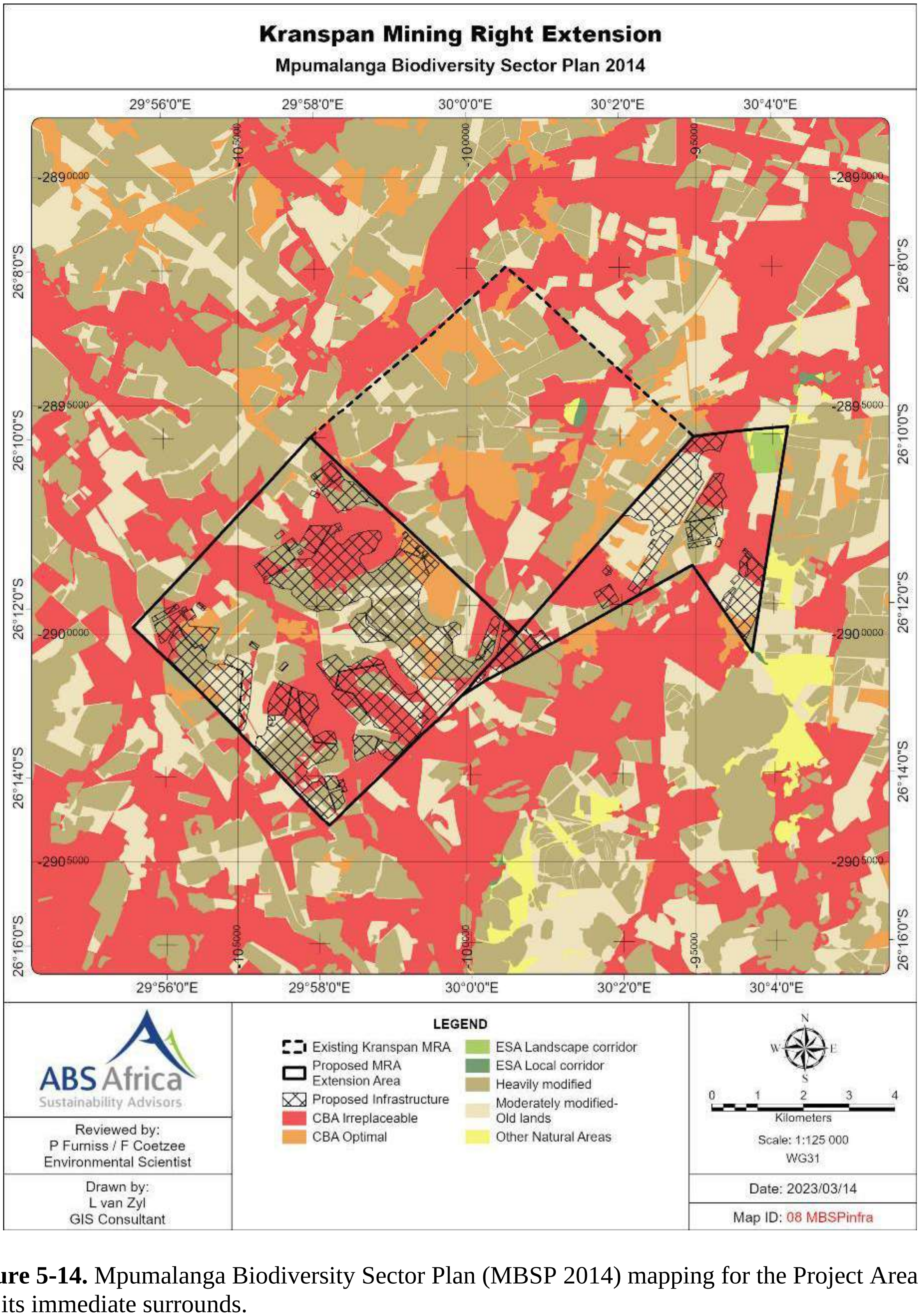

Figure 5-14. Mpumalanga Biodiversity Sector Plan (MBSP 2014) mapping for the Project Area and its immediate surrounds.

5.7 Environmental Screening Tool

In order to achieve compliance with regulation 16(1)(b)(v) of the EIA Regulations (2014), applicants applying for Environmental Authorisation are required to submit a report generated by the Environmental Screening Tool (EST). An EST report was generated for the Project Area and its immediate surroundings, for the three relevant themes, namely Animal, Plant and Terrestrial Biodiversity themes. This EST report was generated by ABS Africa. These results are indicated in Figure 5-15. The drivers for the sensitivity values for each of these themes are listed in Table 5-20, Table 5-21 and Table 5-22 below, where their relevance to the project area is also discussed.

Two threatened plant species listed in the EST report generated for the project area, namely Sensitive Species 1200 (Endangered) and *Khadia carolinensis* (Vulnerable) were confirmed for the project area during fieldwork (Table 5-20). In addition, another threatened plant species listed in the EST report is considered to have a moderate to high likelihood of occurring in the project area, namely *Aspidoglossum xanthosphaerum* (Vulnerable), and *Lessertia phillipsiana* (Data Deficient – Insufficient information [DDD]), a species not listed in the EST report, is also considered to have a moderate to high likelihood of occurring in the large pan situated within the project area. One of the animal species listed in the EST report (Table 5-21), namely the African Grass Owl (*Tyto capensis*), was confirmed in the project area, and the results of fieldwork suggest that it is highly likely that the Southern Bald Ibis (*Geronticus calvus*) could be present as regular foraging visitors to the untransformed grassland of the project area. In addition, both the Denham's Bustard (*Neotis denhami*) and the Mountain Reedbuck (*Redunca fulvorufula*), which were not listed in the EST report, but which are regarded as priority species in the Animal Theme of the Screening Tool, were confirmed to occur within the project area during fieldwork.

The Project Area is not situated within any strategic water source areas (SWSAs), the nearest is located approximately 19 km to the east-northeast. The Project Area overlaps with FEPA sub-catchments in its western portion that are regarded as Ecological Support Areas (ESA) in the freshwater assessment categories of the Mpumalanga Biodiversity Sector Plan (MBSP). The wetland and aquatic ecosystems of the project area are dealt with in more detail in the 'Surface Water Ecosystems Impact Assessment' (Enviross, 2023) conducted for the project.

Table 5-20 Drivers of sensitivity for the Plant Species Theme in the Environmental Screening Tool Report for the Project Area.

Sensitivity	Drivers	Relevance
Low	Low sensitivity	Areas of low sensitivity are not associated with any particular sensitive plant species in the screening tool.
Medium	*Khadia carolinensis*	**Confirmed** at eight localities within the study area.
Medium	Sensitive species 1201	Low likelihood of being present in the PA. Suitable habitat not present in the PA.
Medium	Sensitive species 1200	**Confirmed** at one locality within the study area.
Medium	*Aspidoglossum xanthosphaerum*	Moderate to High likelihood of being present in the PA as suitable habitat is present and species recorded at various localities in close proximity to the PA.
Medium	*Miraglossum davyi*	Low likelihood of being present in the study area. Suitable habitat unlikely to be present and not historically recorded within the Grids 2629BB or 2630AA.
Medium	Sensitive species 41	Moderate likelihood of occurring in the PA. Potentially suitable habitat present in the Valley-

Sensitivity	Drivers	Relevance
		bottom and seep wetland vegetation unit but this is a rare and localised species which has only been collected once within a 20km radius of the site in the last 100 years. This record was made by the author at a site some 15km to the south of the study area in 2009.
Medium	Sensitive species 691	Low likelihood of being present in the PA. Habitat in study area considered marginal for this species and no nearby historical records.
Medium	*Pachycarpus suaveolens*	Low likelihood of occurrence in the PA. A rare and localised species. Nearest known historical locality to the PA is near Ermelo but this record is based on a specimen collected more than a century ago.

Table 5-21. Drivers of sensitivity for the Animal Species Theme in the Environmental Screening Tool Report for the Project Area**.**

Sensitivity	Drivers	Relevance
High	African Grass Owl (*Tyto capensis*)	Confirmed presence in project area
High	Southern Bald Ibis (*Geronticus calvus*)	High probability of occurrence owing to presence of suitable foraging habitat.
High	African Marsh Harrier (*Circus ranivorus*)	Potentially occurs in the project area. Regarded as an uncommon foraging visitor to the valley-bottom and seep wetlands.
Medium	Caspian Tern (*Hydroprogne caspia*)	Potentially an erratic foraging visitor to the pan wetland. Not recorded in corresponding mapping units (sensu SABAP2).
Medium	White-bellied Korhaan (*Eupodotis caerulescens*)	Unlikely to occur on project area. The project area falls outside of the known distribution range of this species.
Medium	Rough-haired Golden Mole (*Chrysospalax villosus*)	Potentially absent from project area. No recent or historical records from project area or neighbouring mapping units (sensu MammalMap).
Medium	Maquassie Musk Shrew (*Crocidura maquassiensis*)	Uncertain but potentially occurs due to availability of suitable habitat. Poorly known and may tolerate a wide range of habitat types. Known to occur in moist grassland along rivers and rocky/montane grassland.
Medium	Spotted-necked Otter (*Hydrictis maculicollis*)	Potentially occurs in the project area. Some of the streams and impoundments provide suitable foraging habitat.
Medium	Oribi (*Ourebia ourebi ourebi*)	Probably absent from project area even though suitable habitat occurs. Intensive searching during transect walks on project area corresponding to suitable habitat failed to detect this species.

Table 5-22. Drivers of sensitivity for the Terrestrial Biodiversity Theme in the Environmental Screening Tool Report for the Project Area.

Sensitivity	Drivers	Relevance
Very High	Critical biodiversity area 1	Large parts of the project area comprise areas mapped in the MBSP (2014) as CBA – Irreplaceable and these areas comprise largely of Natural Habitat (Untransformed Grassland, Sandstone Scarp, Valley-bottom and seep wetland and Pan wetlands) here categorised as being of High Ecological Importance. Sub-populations of two threatened plant species and various threatened animal species have been confirmed to occur in these areas of Natural Habitat of High Ecological Importance. Approximately 1 893.4 ha of areas mapped as CBA-Irreplaceable is included in the proposed project infrastructure footprints.
Very High	Critical biodiversity area 2	Parts of the project area comprise areas mapped in the MBSP (2014) as CBA – Optimal and these areas comprise largely of Natural Habitat (Untransformed Grassland, Sandstone Scarp, Valley-bottom and seep wetland and Pan wetlands) here categorised as being of High Ecological Importance. Sub-populations of one threatened plant species (khadia carolinensis and various threatened animal species have been confirmed to occur in these areas of Natural Habitat of High Ecological Importance. Approximately 330.5 ha of areas mapped as CBA-Optimal is included in the proposed project infrastructure footprints.
Very High	Ecological Support Area: Landscape corridor	Approximately 51.7 ha in the north-eastern corner of the project area (north-eastern corner of the Farm Roodebloem) comprises an ESA: Landscape corridor, which is seemingly intended to enhance connectivity between areas of CBA-Irreplaceable within the project area and the connected area of CBA – irreplicable directly to the north of the project area. None of the proposed project infrastructure is situated within this ESA.
Very High	FEPA Sub-Catchments	FEPA (Freshwater Ecosystem Priority Area) Sub-Catchments are present in the western half of the Project Area on the Farm Vaalbank and form part of the freshwater assessment categories in the Mpumalanga Biodiversity Sector Plan (MBSP). FEPA Sub-Catchments are associated with river ecosystems and threatened/Near Threatened fish species, which are assessed in the 'Surface Water Ecosystems Impact Assessment' (Enviross, 2023) for the Project.
Very High	Protected Areas Expansion Strategy	The project area is located 7.0 km west-southwest from Rentia Kritzinger Private Nature Reserve, 8.3 km west from St Louis Private Nature Reserve, and 6.9 km northwest from Chrissiesmeer Protected Environment. Impacts on terrestrial biodiversity in Protected Areas are expected to be negligible due to the distance between the Project Area and identified Protected Areas and their location in a separate catchment. Priority Focus Areas for protected area expansion (NPAES) occur in patches throughout the project area and coincide largely with the Natural Habitat vegetation units of High Ecological Importance

Sensitivity	Drivers	Relevance
		mapped for the project area. The area (centred around vegetation survey site 107a) of Sandstone Scarp directly to the north of the tributary of the Vaalwaterspruit on the Farm Vaalbank and large, contiguous adjacent areas of Untransformed Grassland and Valley-bottom and seep wetlands are considered to comprise the most conservation worthy and possible viable potential Protected Area within the Project Area. Currently proposed project infrastructure encroaches marginally into the northern parts of this 300ha area.
Very High	Vulnerable ecosystem	Eastern Highveld Grassland (Gm 12) is currently categorised an Endangered ecosystem (Skowno, 2019) and is included as an Endangered ecosystem in the 'Revised list of Terrestrial Ecosystems that are Threatened and in need of Protection' [November 2022 Schedule (Government Gazette no. 47526) of the NEM;BA (Act 10 of 2004)]. The Screening Tool states that the ecosystem status is Vulnerable, but this is because the Screening Tool report was extracted prior to the revised list of threatened terrestrial ecosystems being published in November 2022. The Untransformed Grassland and Sandstone Scarp vegetation units identified within the study area comprise Natural Habitat representative of the Eastern Highveld Grassland vegetation type (Gm 12). A total of ca. 710.2ha of Untransformed Grassland and 102.2ha of Sandstone Scarp was mapped within the project area during the current study.

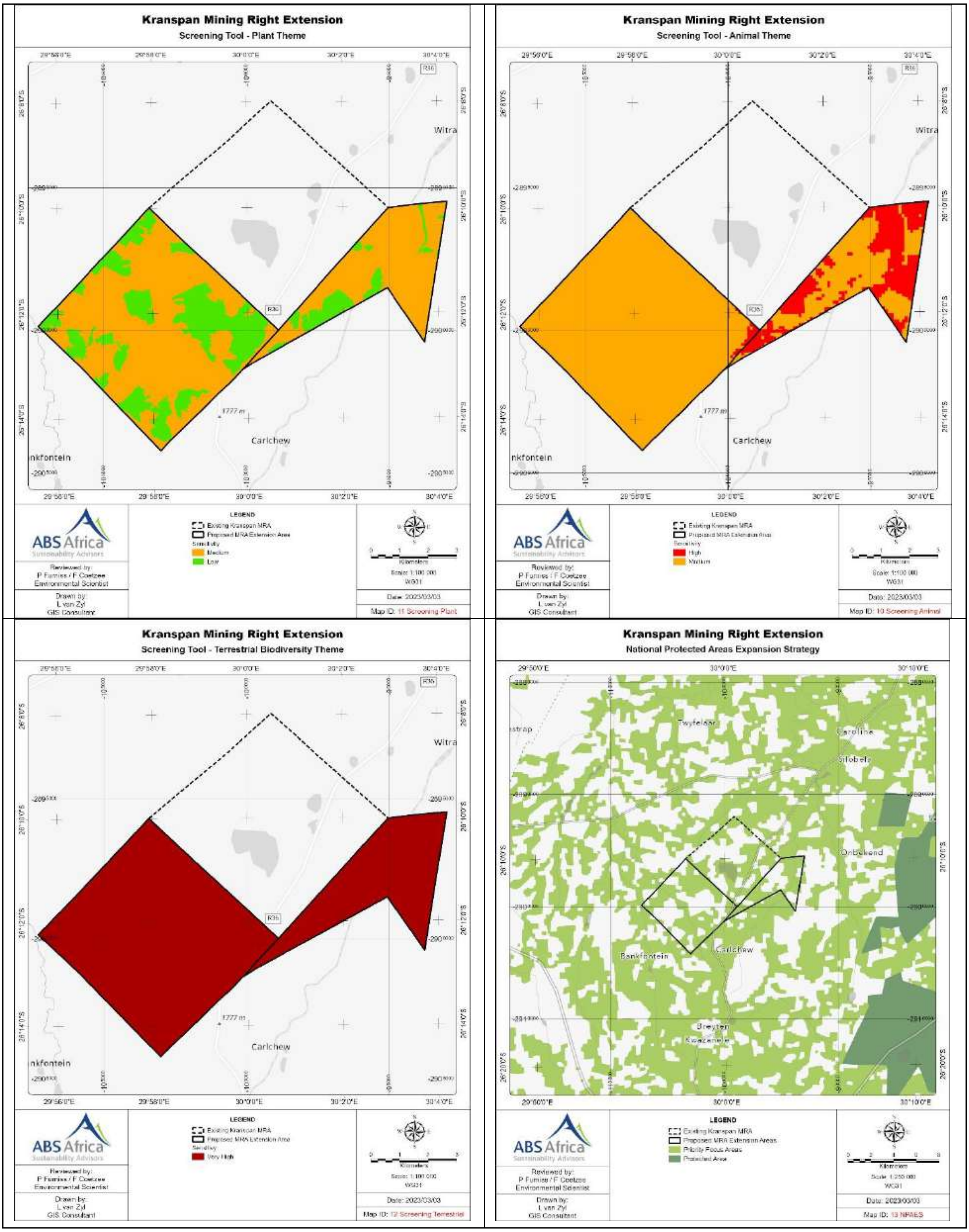

Figure 5-15. Plant, Animal and Terrestrial Biodiversity Themes in the Project Area and map of Priority Focus Areas (National Protected Areas Expansion Strategy) within the PA and its surrounds.

5.8 Site Ecological Importance

The MBSP (MTPA 2014) was compiled at a provincial scale, and it is therefore important that any project area should be subject to a site-specific ecological assessment using relevant methodology and fieldwork of appropriate intensity/duration. Such site-specific analysis does not however replace the MBSP, which assigns biodiversity importance to the project area within the context of the entire province, but rather assesses the Ecological Importance of the project area and the nature of the potential impacts associated with the project. The Ecological Importance of each vegetation unit/habitat was assessed using the methodology Provided in the “Guidelines for the implementation of the Terrestrial Fauna and Terrestrial Flora Species Protocols for environmental impact assessments in South Africa” (SANBI, 2020), which are presented in section 4.3. The assessed EI of each vegetation unit identified within the project area is presented in Table 5-23 and the spatial extent of vegetation unit/habitat is mapped in Figure 5-16.

The four untransformed vegetation units that represent Natural Habitat (*sensu* IFC), namely Untransformed Grassland, Sandstone Scarp Shrubland, Valley-bottom & Seep wetland and Pan wetland, together comprise 39.3% (or 1 945.3ha) of the project area (Table 5-2 and Figure 5-8), and these areas of Natural Habitat are almost entirely mapped as Critical Biodiversity Areas in the MBSP (MTPA, 2014). These four identified Natural Habitat vegetation units (discussed below) are of High Ecological Sensitivity and represent the areas where ecological impacts will be most significant and where the Avoidance option of the Mitigation Hierarchy should be applied.

The Untransformed Grassland vegetation unit was assessed as having a High EI as a result of the fact that is representative of threatened (Endangered) national vegetation type and a threatened (Endangered) ecosystem, the confirmed occurrence of a VU plant species (*Khadia carolinensis*), the moderate to high likelihood of the occurrence of another VU plant species, high functional integrity and low resilience. This vegetation unit was also assessed as having High EI in terms of avifaunal habitat as the result of the confirmed occurrence of one VU and one Near Threatened bird species and the high likelihood of one EN and one VU bird species regularly utilising this habitat as non-breeding foraging visitors. The integrated EI assessment for Untransformed Grassland is therefore High.

The Sandstone Scarp Shrubland vegetation unit was assessed as having a High EI as a result of the fact that is representative of a spatially restricted habitat comprising part of threatened (Endangered) national vegetation type and a threatened (Endangered) ecosystem, the confirmed occurrence of a VU plant species (*Khadia carolinensis*), the moderate to high likelihood of the occurrence of another VU plant species, high functional integrity and low resilience. The high functional integrity of this unit is attributable to the fact that it comprises the largest, contiguous and species rich areas of sandstone scarp habitat recorded by the authors in the Breyten-Carolina region of the Mpumalanga Highveld, constitutes an important refuge area (area of suitable habitat in a matric of unsuitable habitat) for many plant communities and plant and animal species within the project area and its immediate surrounds and, together with the adjacent Valley-bottom and Seep wetlands, functions as a critically important dispersal corridor and flyway for mammal and bird species. This vegetation unit was also assessed as having High EI in terms of avifaunal and mammal assemblages as the result of the confirmed occurrence of one EN mammal species (Mountain Reedbuck) which is largely restricted to and dependent on this habitat within the project area and its immediate surrounds, and one VU bird species. The integrated EI assessment for Sandstone Scarp Shrubland is therefore High.

The Valley-bottom & Seep wetlands vegetation unit was assessed as having a High EI as a result of the fact that is embedded within a threatened (Endangered) national vegetation type and a threatened (Endangered) ecosystem of which it forms an integral component, the confirmed occurrence of an EN plant species (*Sensitive Species 1200*) which is entirely restricted to this habitat and lends high conservation importance to this vegetation unit, the moderate likelihood of the occurrence of another VU plant species, high functional integrity and moderate resilience. The high functional integrity of this unit is in part attributable to the fact that, together with the adjacent Sandstone Scarp Shrubland, it functions as a critically important dispersal corridor and flyway for mammal and bird species. This habitat was also assessed as having High EI in terms of avifaunal and mammal assemblages as the result of the confirmed occurrence of one VU bird species and which is restricted to and dependent on this habitat within the project area and its immediate surrounds, and three Near Threatened mammal species. The integrated EI assessment for Valley-bottom & Seep wetlands is therefore High.

The Pan wetland vegetation unit was assessed as having a High EI as a result of the fact that is embedded within a threatened (Endangered) national vegetation type and a threatened (Endangered) ecosystem and represents a highly spatially restricted habitat for plants and animals, the moderate to high likelihood of the occurrence of DDD plant species which is a pan endemic and highly likely to be categorised as threatened in the immediate future, high functional integrity and low resilience. This vegetation unit was also assessed as having High EI in terms of avifaunal habitat as the result of the high likelihood of at least two Near Threatened bird species regularly utilising this habitat as non-breeding foraging visitors. The integrated EI assessment for Pan wetland is therefore High.

The transformed habitat or Modified Habitat (*sensu* IFC) which comprises approximately 60.7% of the project area has been assessed as being of Low or Very Low EI. Secondary Grassland, which comprises secondary vegetation of habitats historically transformed by ploughing (Modified Habitat *sensu* IFC) and is categorised as a 'Moderately Modified' in the MBSP (MTPA, 2014), has been assigned an integrated EI of Low as a result of its low biodiversity importance and significant (medium) resilience. Habitats completely transformed by anthropogenic impacts such as current cultivation, infrastructure (homesteads, excavations, railway lines, roads etc) and plantations and invasive stands of alien trees are referred to as 'Heavily Modified' in the MBSP (2014) and these transformed habitats have very low biodiversity importance for flora and fauna and high receptor resilience, resulting in an integrated EI of Very Low.

Table 5-23. Ecological Importance of the Vegetation Units / Habitats represented in the Project Area

VEGETATION UNIT	Untransformed Grassland	Sandstone Scarp Shrubland	Valley-bottom & seeps	Pan wetland	Secondary Grassland	Heavily Modified Habitat*
	High	High	High	High	Low	Very Low
MAMMALIAN FAUNA	Medium	High	High	Medium	Low	Very Low
AVIFAUNA	High	High	High	High	Low	Very Low
HERPETOFAUNA	Low	Medium	Medium	Medium	Low	Very Low
INTENGRATED ECOLOGICAL IMPORTANCE	High	High	High	High	Low	Very Low

*Heavily Modified Habitat includes infrastructure (homesteads, roads, quarries, etc), plantations and stands of alien trees, and currently cultivated areas.

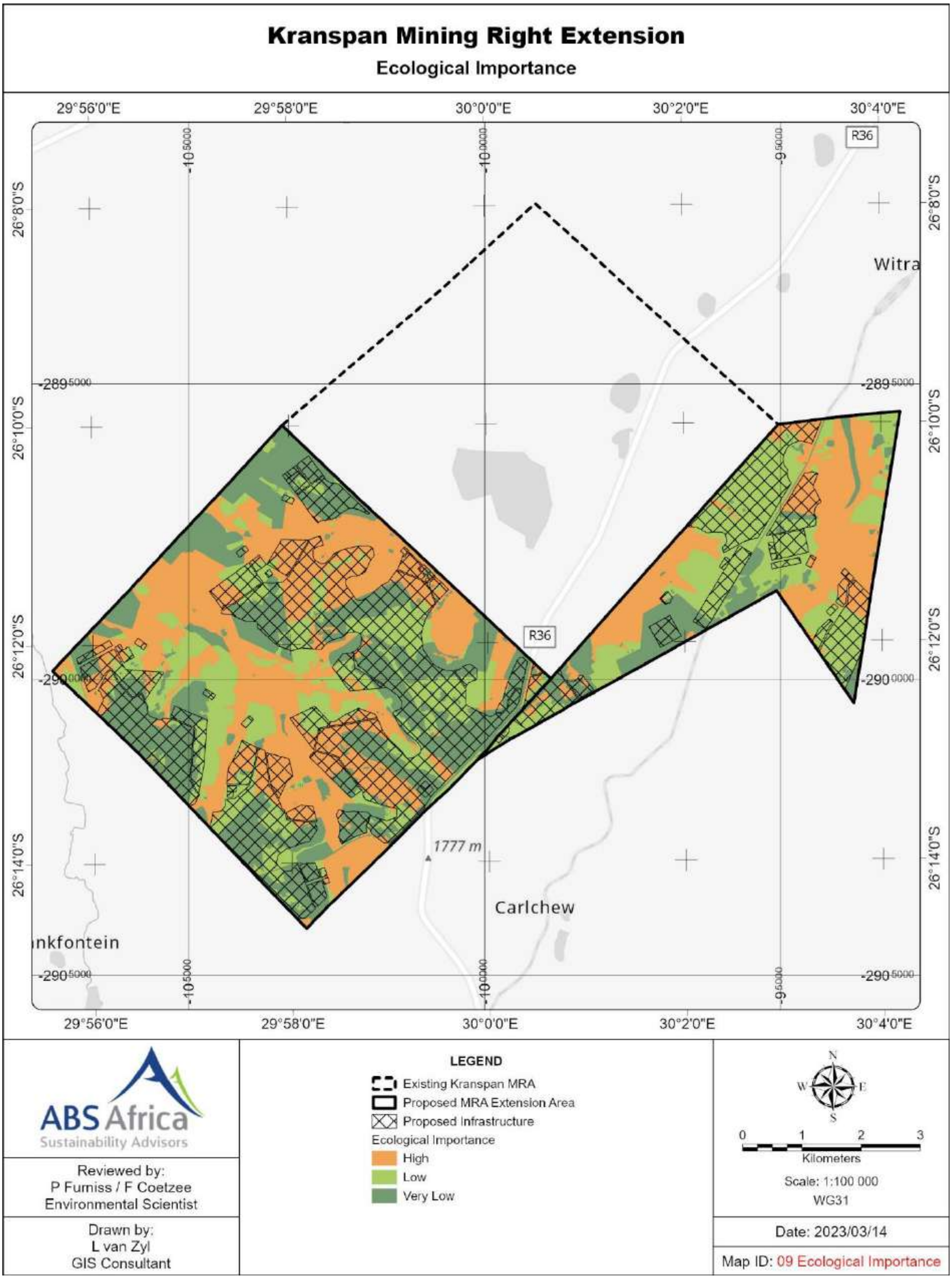

Figure 5-16. Site Ecological Importance (SEI) of the Project Area

6. ASSESSMENT OF IMPACTS AND RECOMMENDED MITIGATION MEASURES

6.1 Flora

The following key impacts to flora have been identified:

6.1.1 Loss of Natural Habitat (untransformed habitat) of High Ecological Importance

The footprints of the proposed project infrastructure layout (mine plan) cover a total surface area of 2 166.9ha, the vast majority of which comprises opencast pits and overburden stockpiles. The SEI assessment of the project area indicated that most (74.8% or 1 621.0 ha) of the project infrastructure footprints are located within Modified Habitats of Low or Very Low SEI, while approximately a quarter (25.2% or 545.9 ha) of the infrastructure footprints are located within three vegetation units (Untransformed Grassland, Sandstone Scarp Shrubland and Valley-bottom & Seep wetlands) representative of Natural Habitat with High EI. The proposed infrastructure footprints therefore include a total of 545.9 ha of Natural Habitat with High EI and these areas which will be lost comprise mostly of Untransformed Grassland (337.1ha) and Valley-bottom & Seep wetlands (199.5ha) but also include smaller areas of Sandstone Scarp Shrubland (9.3 ha). The vast majority of these areas of Natural Habitat with High EI, which are all representative of, or embedded within, a threatened (Endangered) terrestrial ecosystem, will be caused by the construction of opencast pits and overburden stockpiles.

The highly biodiverse and conservation worthy area (ca. 300ha) of sandstone scarps and contiguous areas of untransformed grassland and wetlands on the Farm on the Farm Vaalbank, centered around Sites 105and 107a and extending between Sites 46 and 113 (Section 5-5 and Appendix 4) along the large valley-bottom wetland (tributary of the Vaalwaterspruit), will remain largely unaffected by the proposed infrastructure footprints, with only a ca. 15ha area of Untransformed grassland and seep wetland on the northern boundary of this area being included within the footprints of an opencast pit and an overburden stockpile.

The footprints of the proposed project infrastructure cover a total surface area of 2 166.9ha, which is situated mostly within areas mapped as Modified Habitat in the MBSP but also includes 838.8 ha of areas mapped as Critical Biodiversity Areas (CBAs) in the MBSP (MTPA, 2014). CBAs are areas that are regarded as essential for the attainment of the biodiversity conservation targets for the Mpumalanga Province identified in the MBSP. These areas of CBA which will be lost as a result of the construction of mine infrastructure include 713.1 ha of areas mapped as CBA: Irreplaceable and 125.7ha of areas mapped as CBA: Optimal. According to the MBSP, permissible land-use for CBA: Irreplaceable areas is restricted to conservation / stewardship, and permissible land-uses for CBA: Optimal are conservation / stewardship and low impact tourism.

The current location of infrastructure, and in particular opencast pits and overburden stockpiles, in Natural Habitat of High EI and categorized as CBAs significantly increases the severity of this impact resulting in a **High** impact significance rating. The only option within the mitigation hierarchy that could significantly reduce the significance of this impact would be Avoidance, which would require re-designing the layout to exclude areas High EI and CBAs. Post mitigation (i.e. Avoidance) impacts would be of **Medium-High** significance due to the persistence of residual impacts on areas of Natural Habitat excluded from the footprints. These residual impacts would be the result of habitat fragmentation, loss of connectivity, alteration of hydrological regimes and ecological ‘edge effects’ (e.g. dust emissions and alien plan invasion) caused by project infrastructure.

Project Activity	Terrestrial Biodiversity		Likelihood		Consequence			Significance Rating
	Phase of Project	Pre-Construction, Construction and Operational	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
Clearing of vegetation, excavation, and mine operation	Impact Classification	Negative - Direct and indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Loss of Natural Habitat of High Ecological Importance	5	5	5	2	5	120
			Significance Post- Mitigation					
			4	4	3	3	4	80

Recommended Mitigation measures

The only viable option within the Mitigation Hierarchy (Avoid, Minimise, Restore and Offset) for the impact on CBAs in the project area is Avoidance. According to the MBSP, permissible land-use for CBA: Irreplaceable areas is restricted to conservation/stewardship, and permissible land-uses for CBA: Optimal are conservation/stewardship and low impact tourism. **Open-cast mining is therefore considered to be an incompatible land-use in CBAs by the MBSP**. While the loss of 125.7ha of areas classified as CBA: Optimal could potentially be mitigated by offsets, this would require the conduction of a focused, larger scale study. **The loss of 713.1 ha of areas classified as CBA: Irreplaceable cannot be mitigated through the offset mitigation option and can only be mitigated through Avoidance**. The current mine plan is therefore incompatible with the MBSP land-use guidelines, and if no further revisions of the current infrastructure layout are considered the resulting severe impacts to biodiversity cannot be significantly reduced through any other mitigation options in the mitigation hierarchy.

Furthermore, the national guidelines for biodiversity impact assessment studies (SANBI, 2020) state that in areas of High EI, Avoidance mitigation should be applied wherever possible, and that if minimisation mitigation is applied, only “limited development activities of low impact are acceptable”. The establishment of opencast pits and overburden stockpiles in these areas of High EI constitute impacts of High significance and would therefore be incompatible with the national guidelines (SANBI, 2020).

Avoidance mitigation

- Design opencast areas and other infrastructure footprints to exclude areas of Natural Habitat with High EI situated within areas identified as CBA: Irreplaceable in the MBSP. Particular emphasis should be placed on ensuring that the opencast pit situated in the north western part of the Farm Roodebloem around the recommended 26ha buffer zone for *Sensitive Species 1200* does not isolate the buffer zone form contiguous areas of CBA: Irreplaceable situated to the north of the project area. All project infrastructure should be placed within Modified Habitats with Low or Very Low EI.
- Design opencast areas and other infrastructure footprints to exclude areas of Natural Habitat with High EI situated within areas identified as CBA: Optimal in the MBSP. Where any infrastructure remains located within areas of CBA: Optimal, this impact should be mitigated by the formal protection of offset areas identified within the project area and/or its immediate surrounds by an appropriate specialist assessment.
- Vegetation clearance should be entirely restricted to areas within the infrastructure footprints that have received Environmental Authorisation. The mine should institute an internal permitting procedure (issuing of a ‘permit to clear’) administered by the mines Environmental Division to control and manage vegetation clearance. Where it is possible to

relocate Protected plant species occurring within areas permitted by the Environmental Division for clearing, permits for the relocation of protected plant species should be applied for from the relevant provincial authority and included in the 'permit to clear' procedure.

Mitigation of residual impacts persisting after Avoidance

- All parts of the Project Area that are not lost as a result of the construction of Authorised mining infrastructure should be managed for optimal biodiversity in accordance with a site-specific Biodiversity Management Plan (BMP). This BMP should be based on detailed biodiversity specialist studies that accurately describe the ecosystems and plant and animal species richness of the study area and provide detailed management recommendations for the maintenance and enhancement of current levels of biodiversity. The BMP should include a simple monitoring programme that focuses on the use of repeatable fixed-point photography to monitor representative areas of the four Natural Habitat vegetation units identified for the project area. The BMP should also place emphasis on the management of the highly biodiverse and conservation-worthy area (ca. 300ha) of sandstone scarps and contiguous areas of untransformed grassland and wetlands situated on the Farm Vaalbank, between Sites 46 and 113 along the large valley-bottom wetland (tributary of the Vaalwaterspruit). The BMP should also include detailed management and monitoring recommendations for the two threatened plant species (*Khadia carolinensis* and *Sensitive Species 1200*) confirmed to occur within the project area and their habitat. This recommendation should be incorporated into the EMP for the mine.
- A 'veld management plan' should be developed and implemented for all parts of the project area that are not situated within infrastructure footprints as part of the BMP. All parts of the surface rights areas not being actively mined should be accessible to existing wild herbivores (e.g. Porcupine, Scrub Hare, Duiker, Mountain Reedbuck and Common Reedbuck) or leased to farmers for sustainable grazing by domestic livestock, as sustainable grazing is only essential in preventing the vegetation from becoming moribund and maintaining good veld condition and floristic diversity. Long-term overgrazing can however be detrimental to veld condition and floristic diversity, and the mine should therefore establish the veld condition and carrying capacity of the untransformed parts of its surface rights area on an ongoing basis and ensure that overgrazing is prevented. A crucial component of the 'veld management plan' would be the recommendation of an appropriate 'burning plan' or 'fire management plan' as fire and grazing are closely linked ecosystem drivers. In Mesic Highveld Grasslands, fire is a natural environmental phenomenon that does not normally produce serious residual effects but is in fact a natural and beneficial disturbance of the vegetation structure (including species composition), is essential in nutrient recycling and distribution and, at correct intervals, assists in maintaining high levels of biodiversity (Goldammer & de Ronde, 2004). Appropriate fire cycles must be determined veld condition and fuel load, may vary from approximately two to five (or more) years, and should be determined at two-year intervals by a specialist based on factors such biomass, veld condition and rainfall in the preceding two years.
- In order to limit the severity and frequency of impacts on Natural Habitat resulting from elevated dust emissions, a detailed dust suppression plan should be developed for the mine and the strict implementation of this plan should be regularly audited. The dust suppression plan should detail how dirt roads and other exposed sediments should be kept wet during the dry season while ensuring that water is minimally applied so as to ensure that excess water runoff and consequent erosion and sediment deposition does not occur. This recommendation should be incorporated into the EMP for the mine.

6.1.2 Loss of Plant Species of Conservation Concern (SCC)

Two plant SCC were confirmed to occur within the project area during fieldwork, namely *Sensitive Species 1200* and *Khadia carolinensis.* In addition, two other SCC not recorded during fieldwork but which are extremely difficult to detect due to their small size (*Aspidoglossum xanthosphaerum*) or occurrence in habitat that remains flooded for protracted periods (*Lessertia phillipsiana*), are thought to have a Moderate to High likelihood of occurring within the project area.

Given the fact that *Sensitive Species 1200* is currently categorised as Endangered, has a small 'Extent of Occurrence' (estimated here as likely to be less than 2 000km^2), an Area of Occupancy (AOO) of only 4.15km^2 (SANBI, 2020) and is seemingly known from only seven extant localities/subpopulations, it is recommended that the small sub-population of *Sensitive Species 1200* recorded at a single locality (on the margins of a seep wetland) within the project area should be conserved *in situ* and protected by a preliminary buffer zone of at least 26ha. This recommendation of Avoidance mitigation is in accordance to the national guidelines for biodiversity impact assessment studies (SANBI, 2020) and the recommended 26 ha buffer zone was accommodated by the project proponent in the final revision of the mine plan (infrastructure layout) on which this impact assessment is based. However, the re-designed opencast pit footprint does not make provision for the maintenance of ecological connectivity between the 26ha buffer area and the currently contiguous area of CBA: Irreplaceable situated directly to the north of the buffer area and extending to the north of the project area. Based on the current opencast footprint layout, the 26ha buffer area will be completely isolated to the south, west and north by the opencast pit and maintain only impaired connectivity to the east as a result of the operational railway line. If no provision is made for a viable ecological corridor linking the buffer area to the contiguous area of CBA: Irreplaceable to the north by further re-design of the opencast pit, then crucial drivers of ecosystem functioning (e.g. grazing, fire and pollination) may prove difficult to maintain within the isolated buffer zone without relatively intensive, long-term management and habitat suitability for *Sensitive Species 1200* may deteriorate significantly within the buffer area. The residual impacts to the *Sensitive Species 1200* and its habitat have therefore been assigned Medium-High significance despite the accommodation of a 26ha buffer area in the final layout of the footprint of the opencast pit.

Given the fact that *Khadia carolinensis* is currently categorised as a Vulnerable species which is has a relatively restricted 'Extent of Occurrence' comprising numerous subpopulations overlying Karoo Sandstone that are mostly threatened by mining, it is recommended that the two sub-populations recorded within the project area (one on the Farm Roodebloem and the other on the Farm Vaalbank) should be conserved *in situ* (with a buffer of 200m around each recorded colony) with no significant reduction in the size of the subpopulations . The final mine plan will lead to the loss of one of the six recorded localities/colonies (Site 58a) comprising the Vaalbank subpopulation which is included in the footprint of an opencast pit. The small recorded colony at Site 58a comprises ca. 30 whereas the minimal total number of plant comprising the Vaalbank is 595 plants and many more a likely to be present. The loss of a single colony comprising a small number of plants is unlikely to have a significant impact on the viability of Vaalbank subpopulation of *Khadia carolinensis* and will not significantly impact the conservation status of this species.

Aspidoglossum xanthosphaerum (Vulnerable) and *Lessertia phillipsiana* (DDD) were not recorded during the fieldwork but are extremely difficult to detect and are thought to have a Moderate to high likelihood of occurring within the project area. None of the proposed infrastructure footprints extend into the Pan wetland habitat that provides potentially suitable habitat for *Lessertia phillipsiana.* Various infrastructure footprints include areas of Untransformed Grassland that provides potentially suitable habitat for *Aspidoglossum xanthosphaerum* and these areas should be searched for this species during its flowering time. The possibility of additional threatened plant species, or additional colonies of confirmed threatened species, being present within the project area cannot be totally excluded on the basis of the rapid ecological assessment presented here.

Without the implementation of the additional mitigation measures recommended below, this impact is considered to be of **Medium-High** significance. Implementation of mitigation measures recommended below is likely to reduce this impact to **Low-Medium** significance.

Project Activity	Terrestrial Biodiversity		Likelihood		Consequence			Significance Rating
	Phase of Project	Pre-Construction, Construction and Operational	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
Clearing of vegetation, excavation, and mine operation	Impact Classification	Negative - Direct and indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Loss of Plant Species of Conservation Concern	5	4	4	2	5	99
			Significance Post- Mitigation					
			4	3	3	2	4	63

<u>Recommended Mitigation measures</u>

- In order to protect the subpopulation of *Sensitive species 1200* recorded within the project area, a minimum buffer zone of 26ha was recommended by the specialist and this buffer was accommodated in the final revision of the mine plan provided by the project proponent. **The adequacy of the minimal 200m buffer should be verified in the field prior to construction by a wetland specialist with input from a geo-hydrologist if necessary and this recommendation should be included in the EMP for the project.** It must be emphasised that the recommended ca. 26ha preliminary buffer is a 'minimal buffer' within which no mining infrastructure should be located and no mining related activities should occur. Furthermore, it is crucial that the 26ha buffer should not be isolated by mining activities and that ecological connectivity should be maintained by establishing an effective ecological corridor, to the west of the railway line that links the 26ha buffer to the currently contiguous area of CBA: Irreplaceable situated directly to the north of the buffer area and extending to the north of the project area. Detailed management recommendation for the 26ha buffer should be included in the recommended BMP for the project area; preliminary management recommendations include:
    - The stand of the alien invasive tree *Acacia dealbata** situated within the 26ha buffer should be eradicated prior to construction of the opencast pit and all other occurring alien invasive plants should be controlled on an ongoing basis.
    - A stringent dust control programme should be implemented for the opencast area directly adjacent to the buffer.
    - All blast rock that lands in the buffer area should be removed immediately following each blasting event using hand labour.
    - The entire buffer area should be subject to light grazing and burning at appropriate intervals.
    - Access to the buffer should be strictly controlled and all vehicles entering the area must be authorised and supervised by the mines Environmental Department.
    - The *Sensitive species 1200* subpopulation and its habitat should be monitored annually by a botanist using simple methods such as plant counts, fixed point photography and, when necessary, monitoring of vegetation cover and species composition within a limited number of sampling quadrats.

- o These recommendations should be incorporated into the EMP for the mine.
- In order to protect the two subpopulations of *K. carolinensis* recorded within the project area, a minimum buffer of 200m around the maximum extent of each colony should be implemented. It must be emphasized that the recommended buffers are 'minimal buffers' within which no mining infrastructure should be located and no mining related activities should occur. Furthermore, it is crucial that the colonies and their buffers should not be isolated by mining activities and that ecological connectivity should be maintained between the various colonies or recorded localities as is the case for the current mine plan. It is recommended that research institutions (e.g. SANBI's Walter Sisulu National Botanical Garden) should be afforded and opportunity to rescue some of the *Khadia carolinensis* plants comprising the colony at Site 58a, which is situated within the footprint of an opencast area, for research purposes prior to construction. The recorded *Khadia carolinensis* subpopulations and their habitat should be monitored annually by a botanist using simple methods such as plant counts, fixed point photography and, when necessary, monitoring of vegetation cover and species composition within a limited number of sampling quadrats. Detailed management recommendation management of the recorded *Khadia carolinensis* should be included in the recommended BMP for the project area. This recommendation should be incorporated into the EMP for the mine.
- Any authorised development within any of the four Natural Habitat recorded within the project area should be should be preceded by a thorough search for threatened plant species within the footprint of the development, and in immediately adjacent areas, prior to construction Such searches ('walk-over' surveys) should be conducted by a botanist at the appropriate time of year which coincides with the flowering times of potentially occurring SCC. In the event that any SCC are confirmed, appropriate *in situ* and / or *ex situ* conservation measures should be developed in consultation with the relevant conservation authorities. This recommendation should be incorporated into the EMP for the mine.
- In order to confirm the presence or absence of additional SCC within the project area, and provide a more comprehensive species list that forms a sound basis for site-specific biodiversity management, an additional botanical survey which incorporates seasonal coverage should be conducted for the project area as part of the development of the recommended Biodiversity Management Plan for the mine. This survey should place emphasis on searching potentially suitable habitat for the two SCC that are considered to have a moderate to high likelihood of occurring within the project area, namely *Aspidoglossum xanthosphaerum* (VU) and *Lessertia phillipsiana* (DDD). This recommendation should be incorporated into the EMP for the mine.

6.1.3 Introduction and Proliferation of Alien Invasive Plant Species

Areas of topsoil and subsoils created through construction activities are will provided transformed habitat ideal for the establishment and proliferation of alien invasive plant species.
These concentrations of alien plants in areas disturbed by mining will provide a source of seeds and other propagules which are likely to are likely to be dispersed by mining activities and natural dispersal agents (e.g. wind and water dispersal). Highly aggressive alien invaders and habitat transformers which are already well established in the study area and have seeds that are easily dispersed by mine vehicles (e.g. *Acacia dealbata**), are highly likely to colonise the verges of haul roads and access roads throughout the project area from where they are likely to spread into adjacent areas of Untransformed Habitats of high EI. The large-scale transport of topsoil and subsoil throughout the project area is also likely to cause the spread of alien invasive species. The frequency of the impact is expected to be regular and the impact is likely to occur throughout the life of the operation. The significance of the impact in Natural Habitats is likely to be **Medium-High**, particularly the Sandstone Scarp Shrubland and Untransformed Grassland vegetation units. A

sound Alien Plant Management Plan based on site-specific alien invasive plant surveys and species- and area-specific management recommendations, that is systematically implemented is usually effective in reducing the significance and the post-mitigation impact significance is therefore regarded as **Low-Medium**.

Project Activity	Terrestrial Biodiversity		Likelihood		Consequence			Significance Rating
	Phase of Project	Pre-Construction, Construction Operational and Closure	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
Clearing of vegetation, excavation, and mine operation	Impact Classification	Negative - Direct and indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Introduction & proliferation of alien invasive plant species	4	4	4	3	5	96
			Significance Post- Mitigation					
			4	4	3	2	4	72

Recommended Mitigation measures

- The mine should develop and implement a site-specific integrated Alien Plant Control Programme (as per the AIS Regulations), which identifies the species that pose the greatest threat, in terms of habitat transformation, to Natural Habitat within the project area, and considers all appropriate chemical, mechanical, biological and cultural control methods for the alien species listed in Appendix 1. Emphasis should be placed on controlling the 17 declared alien invasive species listed in Appendix 1 and in particular the five alien invasive habitat transformers identified as posing the greatest threat to the Natural Habitats and indigenous vegetation of the project area and its immediate surrounds, namely *Acacia dealbata**, *Acacia mearnsii**, *Campuloclinium macrocephalum**, *Pyracantha angustifolia** and *Richardia brasiliensis**. This recommendation should be incorporated into the EMP for the mine.
- A team of appropriately equipped and trained should be appointed to conduct continuous alien plant control at the 'priority control sites' identified in the Alien Plant Control Programme. This team should work under the auspices of the mines Environmental Division, which should be tasked with supervising and thoroughly documenting all alien plant control activities. This recommendation should be incorporated into the EMP for the mine.
- Where planting of trees and shrubs around mine offices, workshops and processing facilities is deemed necessary, only trees and shrubs indigenous to the study area and its immediate surrounds should be planted, and these should be grown from locally obtained seeds or other propagules. No trees, alien or indigenous, should be planted anywhere within the Natural Habitats of the project area. The alien invasive grass *Pennisetum clandestinum** (Kikuyu) should not be used for the establishment of lawns at mine premises. This recommendation should be incorporated into the EMP for the mine.

6.1.4 Illegal Utilisation of Plant Resources

The highly species rich Natural Habitats of the project area contain numerous plant species that are popular medicinal plants (e.g. *Boophone disticha* and *Eucomis autumnalis*) which are likely to be targeted by any illegal medicinal plant harvesters entering the project area. The influx of labourers and contractors could result in an increase in the illegal harvesting of medicinal plants. Furthermore, mines often practice lax access control in the parts of their extensive properties that are not being actively utilised for mining activities leading to an increase in illegal medicinal plant harvesting relative to that which occurs on private farmland.

It is currently considered fairly unlikely that illegal plant harvesting will take on a large scale within the project area. Medicinal plant harvesting patterns and pressure can however change rapidly over a short period of time in any given area. The pre-mitigation significance of this impact is rated as **Low-Medium** and can usually be effectively mitigated, leading to a post-mitigation significance rating of **Low**.

Project Activity	Terrestrial Biodiversity		Likelihood		Consequence			Significance Rating
	Phase of Project	Pre-Construction, Construction and Operationa	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
All staff activities that take place outdoors and illegal access by plant collectors	Impact Classification	Negative - Indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Increased illegal utilisation of plant resources due to an influx of mine personnel and trespasses.	3	3	2	3	5	60
			Significance Post- Mitigation					
			2	2	2	2	4	32

<u>Recommended Mitigation measures</u>

- Access by mine personnel and trespasses to all parts of the project area comprising Natural Habitat should be strictly controlled. Access control should be achieved by the erection of a five-strand cattle fence that is permeable to wildlife around the perimeter of the project area, regular signage prohibiting access and regular patrols by mine security personnel. Security personnel tasked with patrolling areas of Natural Habitat should receive basic training in the following aspects:
  - Prevention of illegal plant harvesting and animal poaching.
  - Location of sensitive Natural Habitats and buffer areas for SCC that should form the focus of patrol efforts.
  - Basic environmental sensitivities of the areas they are tasked with patrolling (e.g. areas where vehicle access is prohibited).
  - Procedures for reporting any incidents of illegal access, plant harvesting, poaching and environmental incidents such as accidental fires and pollution spills.

- The damaging or destruction of plant species that are Protected in terms the Mpumalanga Nature Conservation Act (No.10 of 1998) during any future development should be avoided wherever possible, and a permit for the removal or destruction of any such protected plant must be obtained from the provincial authorities (Permitting Office of the MTPA) prior to development. It is recommended that where untransformed Natural Habitat is to be affected by an infrastructure footprints, Protected plant species should be rescued and placed in a nursery or donated to a research institute (e.g. SANBI botanical gardens) prior to development, rather than simply being destroyed. Where feasible, viable subpopulations of such species should also be translocated to transformed (including rehabilitation areas) or untransformed areas within the project area which provide potentially suitable habitats, but such translocations will have to be carried out in a manner that ensures that no ecological degradation of the host habitat occurs, and will have to be evaluated by a botanist for each species and each potential translocation area**.** <u>This recommendation should be incorporated into the EMP for the mine.</u>

6.2 Fauna

The following key impacts to fauna have been identified:

6.2.1 Displacement and Loss of Habitat for Faunal Species

The proposed open cast mining and associated activities will result in the clearing and loss of Natural Habitat. Approximately 545.9 ha of Natural Habitat (comprising vegetation units with High EI) is expected to be lost due to mining activities. Areas which will be lost comprise mostly of Untransformed Grassland (337.1ha) and Valley-bottom & Seep wetlands (199.5ha) and smaller areas of Sandstone Scarp Shrubland (9.3 ha).

In general, the impact caused by opencast mining and the loss of habitat will be of high significance on habitat with high EI. The loss of these habitat units (e.g. Untransformed Grassland and Valley-bottom & Seep Wetlands) will result in the associated displacement of faunal taxa including one EN species (Mountain Reedbuck), two VU species (Denham's Bustard and African Grass-owl) and three NT mammal and one NT bird (all species confirmed to occur within the project area). The only option within the mitigation hierarchy that could reduce the impact significance would be Avoidance, which would reduce the impact significance to Medium-High.

Project Activity	Terrestrial Biodiversity		Likelihood		Consequence			Significance Rating
	Phase of Project	Construction and Operational	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
All mining activities	Impact Classification	Negative - Direct and indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Loss of habitat and displacement of fauna	5	5	5	2	5	120
			Significance Post- Mitigation					
			5	5	2	2	5	90

<u>Recommended Mitigation measures</u>

The direct loss of habitat and subsequent loss and displacement of faunal species of conservation concern can only be significantly mitigated through the application of the Avoidance option of the Mitigation Hierarchy is Avoidance. Applying the Minimise option to impacts with CBAs would be in conflict with the MBSP, which considers opencast mining to be unacceptable in CBAs; major habitats included in CBAs which will be impacted by project infrastructure include Untransformed Grassland, Sandstone Scarp Shrubland and Valley-bottom Wetlands and Seeps. Offsets are often proposed as a mitigation measure, but this option will only be viable if adjacent or nearby relevant habitat providing confirmed habitat for the relevant SCCs is available for purchase for formal conservation. Since offset investigations are beyond the scope of this assessment, the Offset option was not considered. Furthermore, the loss of habitats that are designated as CBA: Irreplaceable cannot be mitigated by Offsets because by definition Irreplaceable Areas cannot be replaced and thus cannot be offset. The current mine plan is therefore incompatible with the MBSP land-use guidelines, and if no further revisions of the current infrastructure layout are considered, the resulting impacts to biodiversity cannot be significantly reduced through any other mitigation options in the mitigation hierarchy.

Mitigation of residual impacts persisting after Avoidance

- Develop and implement a Biodiversity Management Plan with the objective of managing all remaining Natural Habitat through conservative grazing, fire management and continual eradication of alien plant species. The biodiversity management plan should include a ‘veld management plan’ which should be implemented for all parts of the project area that are not utilised for mining activities. Sustainable grazing at conservative stocking rates (by domestic livestock or game) is an essential environmental factor in maintaining veld condition and floristic diversity. Overgrazing can however be detrimental to the vegetation, and the mine should therefore establish the carrying capacity of the untransformed areas of the mine property and ensure that overgrazing is prevented. A crucial component of the ‘veld management plan’ would be the recommendation of an appropriate ‘burning plan’. Appropriate burning intervals for areas that are managed for high biodiversity, are those that mimic the ‘natural’ fire regimes of the area. In the Grassland Biome, fire is a natural environmental factor that does not normally produce serious residual effects and is in fact a natural and beneficial disturbance of the vegetation structure (including species composition), prevents vegetation from becoming moribund, is essential in nutrient recycling and distribution and, at correct intervals, assists in maintaining high levels of biodiversity. Within the study area, appropriate fire cycles will vary from approximately two to six years, but must be determined by factors such biomass, veld condition and rainfall in the preceding two years. This recommendation should be included in the EMP.
- If any faunal species of conservation concern (as indicated in this report) are recorded during the construction/mining phase, the ECO should be informed, and should then issue instructions for its capture, translocation and safe release into suitable habitat within the project area with the relevant permits obtained from the relevant authority if necessary. This recommendation should be included in the EMP.
- All domestic waste generated (if present) during construction and mining operations should be removed from the project area as soon as possible and be disposed of at an authorised landfill to reduce the risk of colonisation by feral mammals, scavengers or competitively superior indigenous bird species (e.g. Pied Crows).
- Personnel and staff should be advised by means of environmental awareness training on the biodiversity importance of the area. The intentional killing of any faunal species (in particular invertebrates, reptiles and snakes) should be avoided by means of awareness programmes presented to the labour force. The labour force should be made aware of conservation issues pertaining to the taxa occurring on the project area. This recommendation should be included in the EMP.

6.2.2 Disruption of Ecological Connectivity and Faunal Dispersal

The open cast mining activities and mine expansion proposed for the project area will aggravate habitat fragmentation and the disruption of natural ecological corridors in the area, thereby impeding the dispersal of faunal species as well as the potential for re-colonisation and recruitment of fauna to the project area during rehabilitation. It is especially sub-populations of medium to large mammal species such as Mountain Reedbuck and Southern Reedbuck that are at risk of becoming fragmented if natural connectivity is disrupted and when the surface area of natural corridors is reduced to the point that these animals can no longer disperse across the project area. The pre-mitigation significance of the impact is assessed as High. Implementation of the measures recommended below could reduce the significance to Medium-High.

Project Activity	Terrestrial Biodiversity		Likelihood		Consequence			Significance Rating
	Phase of Project	Construction and Operational	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
All mining activities	Impact Classification	Negative - Direct and indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Disruption of ecological connectivity and faunal dispersal	5	5	4	3	4	110
			Significance Post- Mitigation					
			4	4	3	3	4	80

Recommended Mitigation measures

- Ensure that construction and mining activities do not extend beyond the authorised infrastructure footprints onto adjacent natural habitat in order to provide displaced fauna the opportunity to disperse into suitable habitat (although potential dispersal by small animals is highly limited).
- It is recommended that prior to commencement of fencing and construction it is ensured that the no large mammal species, especially reedbuck are trapped within any area fenced with security fencing.
- All Natural Habitat which is not part of actively mined areas must **be fenced with standard 5-strand cattle fencing and not diamond mesh security fencing** that will prevent the movement of Reedbuck and other fauna. The relevant conservation scientists of the MTPA should also be approached in order to ascertain the conservation importance of the subpopulations of Mountain Reedbuck and Common Reedbuck that utilise the project area and determine whether further conservation measures are necessary. Such measures may include monitoring, collaboration with surrounding landowners to prevent poaching and ensuring the availability of large and contiguous areas of suitable habitat. This recommendation should be included in the EMP.
- The practice of excavating trenches around the project area as a form of access control should **be prohibited** as such trenches act as lethal 'pitfall traps' and barriers to dispersal of mammals, reptiles and amphibians and are regarded as an unnecessary and severe impact to such fauna occurring within the project area and its immediate surrounds. This recommendation should be included in the EMP.

6.2.3 Illegal Utilisation of Faunal Resources

The presence of a large labour force within the project area during mining activities will increase the risk of illegal utilisation of fauna resources, such as hunting and snaring of antelope, small mammals and birds. It is assumed that labour force will be accommodated in nearby towns and not on site, which would lower this risk of hunting and poaching considerably.

In addition, the project may also result in increased utilisation of natural resources due to potential human encroachment and accessibility to the project area owing to people seeking jobs. This could result in the establishment of illegal settlements on areas consisting of natural habitat on the project area where active mining is absent. The pre-mitigation significance of the impact is assessed as Low-Medium. Implementation of the measures recommended below could reduce the significance to Low.

Project Activity	Terrestrial Biodiversity		Likelihood		Consequence			Significance Rating
	Phase of Project	Construction and Operational	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
All mining activities	Impact Classification	Negative - Direct and indirect	Significance Pre-Mitigation					
	Resulting Impact from Activity	Illegal utilisation of faunal resources	3	3	4	3	5	72
			Significance Post- Mitigation					
			2	2	2	3	5	40

Recommended Mitigation measures

- Contractors should be accommodated off-site (i.e. not within the project area), reducing the risk of poaching and persecution of fauna. This recommendation should be included in the EMP.
- Labour supervisors and SHE officials should monitor the activities of labourers when working away from infrastructure in Natural Habitat.
- Personnel and staff should be advised by means of environmental awareness training on the biodiversity importance of the area. The intentional killing of any faunal species (in particular invertebrates, reptiles and snakes) should be avoided by means of awareness programmes presented to the labour force. The labour force should be made aware of conservation issues pertaining to the taxa occurring on the project area.
- Regular monitoring of the project area, especially areas of natural habitat where active mining activities are absent, is advised to identify areas where illegal settlement may occur. If any illegal erecting of housing occurs, the mine's public liaising officer should immediately advice on a resolution, which may involve a re-location strategy.

7 CONCLUSION

The Environmental Screening Tool (EST) report generated for the 4 946 ha Kranspan MRA Extension Project indicated that the POAI is located within an area that has Very High Sensitivity in the Terrestrial Biodiversity theme, High Sensitivity in the Animal Theme and Medium Sensitivity in the Plant Theme. Fieldwork conducted in October 2022 and January 2023 confirmed presence of all of the drivers of sensitivity for the Terrestrial Biodiversity. Fieldwork also confirmed some of the drivers of sensitivity for the Animal and Plant themes and the established that others are not present or unlikely to be present.

For the Terrestrial Biodiversity theme it can be confirmed that 39.3% (or 1 945.3ha) of the study area comprises Natural Habitat (untransformed habitat) that is highly biodiverse and functionally largely intact and that is almost entirely mapped In the Mpumalanga Biodiversity Sector Plan (MBSP) as CBA: Irreplaceable with smaller areas mapped as CBA: Optimal and one small area (51.7 ha) of ESA: Landscape corridor. The MBSP also maps the portion of the project area comprising the western half of the Farm Vaalbank as a Freshwater Ecosystem Priority Area (FEPA). These Natural Habitats comprise almost entirely of habitats and vegetation which are representative of a threatened terrestrial ecosystem, namely Eastern Highveld Grassland (Endangered), or wetland habitats embedded within it, and include various areas identified as Priority Focus Areas for protected area expansion in the (National Protected Areas Expansion Strategy.

For the Animal Theme, fieldwork confirmed the presence of one sensitivity driver, namely the African Grass Owl (VU) and the high likelihood that another sensitivity driver is present, namely the Southern Bald Ibis (VU). In addition, two other threatened or Near Threatened bird species, namely the Denham’s Bustard (VU) and Blue Korhaan (NT), and four other threatened or Near Threatened mammal species, namely the Mountain Reedbuck (EN), Serval (NT), Cape Clawless Otter (NT) and Highveld Vlei Rate (NT), that are not listed as drivers of sensitivity for the project area were confirmed. The project area contains a sub-population of the Endangered Mountain Reedbuck that is dependent on the Sandstone Scarp Shrubland and surrounding Untransformed Grassland for habitat. The thicket habitat within Sandstone Scarp Shrubland is regarded as unique ecological feature in the project area since it contains many plant and bird species that are largely or entirely restricted to the sandstone scarps within the study area and its immediate surrounds. For the Plant Theme, fieldwork confirmed the presence of two sensitivity drivers, namely *Khadia carolinensis* (VU) and *Sensitive Species 1200* (Endangered), and a moderate-high likelihood that another sensitivity driver is present, namely *Aspidoglossum xanthosphaerum* (VU). In addition, one other plant ‘species of conservation concern’ that is not listed as a sensitivity driver for the project area is thought to have a moderate-high probability of being present within the pan wetland habitat, namely the pan endemic *Lessertia phillipsiana* (DDD). *Sensitive Species 1200* (Endangered) is a highly threatened species which is thought to occur at only seven extant localities/sub-populations, and a minimum buffer zone of 26ha, which should not be isolated by mining infrastructure, has been recommended for the sub-population recorded on the margins of a seep wetland within the project area.

The SEI assessment of the project area indicated that most (74.8% or 1621.0 ha) of the project infrastructure footprints are located within Modified Habitats of Low or Very Low SEI, while approximately a quarter (25.2% or 545.9 ha) of the infrastructure footprints are located within areas of Natural Habitat with High SEI. The proposed infrastructure footprints therefore include a total of 545.9 ha of Natural Habitat with High SEI and these areas which will be lost comprise mostly of Untransformed Grassland (337.1ha) and Valley-bottom & Seep wetlands (199.5ha) but also include smaller areas of Sandstone Scarp Shrubland (9.3 ha).

The CBA mapping provided by the Mpumalanga Biodiversity Sector Plan (MTPA, 2014) and the NEM:BA national list of threatened terrestrial ecosystems were used as the basis for defining the sensitivity of the Terrestrial Biodiversity theme in the EST report extracted for the project area. All terrestrial Natural Habitat within the project area is representative of Eastern Highveld Grassland, a threatened ecosystem categorised as Endangered. The footprints of the proposed project infrastructure layout (mine plan) cover a total surface area of 2 166.9ha, which is situated mostly within areas mapped as Modified Habitat in the MBSP but also includes 713.1 ha of areas mapped as CBA: Irreplaceable and 125.7ha of areas mapped as CBA: Optimal. According to the MBSP, permissible land-use for CBA: Irreplaceable areas is restricted to conservation/stewardship, and permissible land-uses for CBA: Optimal are conservation/stewardship and low-impact tourism. **Opencast mining is therefore considered to be an incompatible land-use in CBAs by the MBSP**. While the loss of 125.7ha of areas classified as CBA: Optimal could potentially be mitigated by offsets, this would require the conduction of a larger scale-study. The loss of 713.1 ha of areas classified as CBA: Irreplaceable cannot be mitigated through the offset mitigation option and can only be mitigated through Avoidance. The current mine plan is therefore in conflict with the MBSP land-use guidelines, and if no further revisions of the current infrastructure layout are considered the resulting severe impacts to biodiversity cannot be significantly reduced through any other mitigation options in the mitigation hierarchy. Likewise, the potential impacts on the confirmed *Sensitive Species 1200* (Endangered) sub-population can only be significantly mitigated by Avoidance (SANBI, 2020). The mine has accommodated a recommended 26ha buffer by re-aligning the layout of one of the opencast pits, but the current layout of the opencast pit does not make provision for the maintenance of ecological connectivity between this buffer zone and the contiguous area of CBA-Irreplaceable habitat to the north.

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APPENDIX 1: List of plant species and infraspecific recorded within the 4 956ha Kranspan MRA Extension project area during the current survey. Species highlighted in red are taxa categorised as 'species of conservation concern' (*sensu* Raimondo *et al*. 2009) as listed in the latest Red List for South African plants (http://redlist.sanbi.org, downloaded Feb 2023). Species nomenclature is according to the South African National Botanical Institute (SANBI) online Red List and BODATSA Databases (http://posa.sanbi.org and http://redlist.sanbi.org). Alien species are indicated by an asterisk.

During the fieldwork, a total of 550 plant species and infraspecific taxa were recorded within the 4 956ha Kranspan MRA Extension project area, 484 of which are indigenous taxa, and 66 (12.0%) of which are naturalised aliens. Of the 66 recorded alien species, 17 are listed as declared invasive species in the AIS Regulations. Of the 484 indigenous species recorded within the project area, 194 (or 40.1%) are not included in the BODATSA list of species (based on herbarium records) historically recorded from the quarter-degree grids within which the study area is situated (2629BB and 2630AA).

						Vegetation / land-cover unit#					
	Species	**Family**	**SCC (Red Data)**	**Protected**	**AIS Regulations Category**	**Untransformed Grassland**	**Sandstone Scarp**	**Valley-bottom & seep**	**Pan wetland**	**Secondary Grassland**	**Transformed / highly Modified habitats #**
	FERNS										
	Adiantum capillus-veneris	Adiantaceae					1				
	Mohria vestita	Anemiaceae					1				
	Blechnum australe	Blechnaceae					1				
	Pteridium aquilinum	Dennstaedtiaceae					1				
	Dryopteris pentheri	Dryopteridaceae					1				
	Dicranopteris linearis	Gleicheniaceae					1				
	Marsilea cf. *capensis*	Marsileaceae						1			
	Ophioglossum cf. *polyphyllum*	Ophioglossaceae						1		1	
	Cheilanthes hirta cf. var. *hirta*	Pteridaceae				1	1				
	Cheilanthes quadripinnata	Pteridaceae					1				
	Cheilanthes viridis var. *viridis*	Pteridaceae				1	1				
	Pellaea calomelanos	Pteridaceae					1				
	Pityrogramma argentea	Pteridaceae					1				
	Pteris cretica	Pteridaceae					1				
	Selaginella dregei	Selaginellaceae				1	1				
	Cysopteris fragilis	Woodsiaceae					1				
	GYMNOSPERMS										
	Pinus cf. *elliottii**	Pinceae			1b						1
	MONOCOTYLEDONS										
	Chlorophytum cooperi	Agavaceae				1					
	Chlorophytum fasciculatum	Agavaceae				1					
	Chlorophytum transvaalense	Agavaceae				1					
	Chlorophytum trichophlebium	Agavaceae				1					
	Boophone disticha	Amaryllidaceae		MNCA		1					
	Brunsvigia radulosa	Amaryllidaceae		MNCA		1					
	Cyrtanthus breviflorus	Amaryllidaceae		MNCA				1			
	Haemanthus humilis subsp. *hirsutus*	Amaryllidaceae		MNCA			1				
	Nerine rehmannii	Amaryllidaceae				1	1				
	Zantedeschia aethiopica	Araceae		MNCA				1			
	Asparagus laricinus	Asparagaceae					1				
	Asparagus virgatus	Asparagaceae					1				
	Aloe ecklonis	Asphodelaceae		MNCA		1					
	Aloe welwitschii	Asphodelaceae		MNCA		1					
	Trachyandra saltii var. saltii	Asphodelaceae				1					
	Commelina africana	Commelinaceae				1	1		1	1	
	Commelina subulata	Commelinaceae					1	1			
	Cyanotis lapidosa	Commelinaceae					1				
	Cyanotis speciosa	Commelinaceae				1	1				
	Abildgaardia ovata	Cyperaceae				1					
	Ascolepis capensis	Cyperaceae						1			
	Bulbostylis cf. *boeckeleriana*	Cyperaceae				1					
	Bulbostylis hispidula subsp. pyriformis	Cyperaceae				1	1				
	Bulbostylis humilis	Cyperaceae						1			
	Bulbostylis sp.	Cyperaceae					1				
	Carex cf. *spartea*	Cyperaceae						1			
	Cyperus congestus	Cyperaceae						1			
	Cyperus denudatus	Cyperaceae						1	1		
	*Cyperus eragrostis**	Cyperaceae						1	1		
	*Cyperus esculentus**	Cyperaceae						1	1	1	1
	Cyperus fastigiatus	Cyperaceae						1			
	Cyperus longus	Cyperaceae						1	1		
	Cyperus obtusiflorus var. obtusiflorus	Cyperaceae				1	1				
	Cyperus obtusiflorus var. flavissimus	Cyperaceae				1	1				
	Cyperus rupestris	Cyperaceae				1	1				
	Cyperus sphaerospermus	Cyperaceae						1			
	Cyperus tenax	Cyperaceae				1					
	Dracoscirpoides ficinoides	Cyperaceae						1	1		
	Eleocharis atropurpurea	Cyperaceae						1			
	Eleocharis dregeana	Cyperaceae						1	1		
	Fimbristylis complanata	Cyperaceae						1	1		

						Vegetation / land-cover unit#					
	Species	**Family**	**SCC (Red Data)**	**Protected**	**AIS Regulations Category**	**Untransformed Grassland**	**Sandstone Scarp**	**Valley-bottom & seep**	**Pan wetland**	**Secondary Grassland**	**Transformed / highly Modified habitats #**
	Fuirena coerulescens	Cyperaceae						1	1		
	Fuirena pubescens	Cyperaceae						1			
	Fuirena cf. *stricta* var. *stricta*	Cyperaceae						1	1		
	Isolepis costata	Cyperaceae						1	1	1	
	Isolepis fluitans	Cyperaceae						1			
	Kyllinga cf. *alata*	Cyperaceae				1		1			
	Kyllinga erecta	Cyperaceae						1	1		
	Kyllinga melanosperma	Cyperaceae						1			
	Kyllinga pulchella	Cyperaceae					1	1			
	Lipocarpha nana	Cyperaceae						1			
	Pycreus cf. *nigricans*	Cyperaceae						1		1	
	Pycreus macranthus	Cyperaceae						1	1		
	Pycreus nitidus	Cyperaceae						1			
	Rhynchospora brownii	Cyperaceae						1			
	Schoenoplectus decipiens	Cyperaceae						1			
	Schoenoplectus cf. *muriculatus*	Cyperaceae						1			
	Schoenoplectus corymbosus	Cyperaceae						1			
	Scirpoides burkei	Cyperaceae				1		1			
	Scleria catophylla [=*Scleria aterrima*]	Cyperaceae						1			
	Scleria woodii	Cyperaceae						1			
	Cyperaceae sp 1	Cyperaceae							1		
	Dioscorea quartiniana	Dioscoreaceae		MNCA			1				
	Eriocaulon dregei var. *dregei*	Eriocaulaceae						1			
	Albuca setosa	Hyacinthaceae				1					
	Albuca shawii	Hyacinthaceae					1				
	Albuca virens	Hyacinthaceae					1				
	Dipcadi viride	Hyacinthaceae					1	1			
	Drimia calcarata	Hyacinthaceae				1	1				
	Eucomis autumnalis subsp. clavata	Hyacinthaceae		MNCA		1		1			
	Ledebouria cooperi	Hyacinthaceae						1			
	Ledebouria luteola	Hyacinthaceae				1					
	Ledebouria ovatifolia	Hyacinthaceae				1					
	Ornithogalum felxuosum	Hyacinthaceae					1				
	Schizocarphus nervosus	Hyacinthaceae				1					
	Lagarosiphon muscoides	Hydrocharitaceae						1			
	Hypoxis acuminta	Hypoxidaceae						1			
	Hypoxis filiformis	Hypoxidaceae						1			
	Hypoxis hemerocallidea	Hypoxidaceae				1					
	Hypoxis iridifolia	Hypoxidaceae				1					
	Hypoxis obtusa	Hypoxidaceae				1					
	Hypoxis rigidula	Hypoxidaceae				1	1				
	Aristea torulosa	Iridaceae				1		1			
	Babiana hypogea var. *hypogea*	Iridaceae				1					
	Crocosmia paniculata	Iridaceae					1	1			
	Dierama cf. *insigne*	Iridaceae				1					
	Gladiolus crassifolius	Iridaceae		MNCA		1					
	Gladiolus dalenii	Iridaceae		MNCA			1				
	Gladiolus ecklonii	Iridaceae		MNCA		1					
	Gladiolus papilio	Iridaceae		MNCA				1			
	Gladiolus permeabilis	Iridaceae		MNCA		1					
	Moraea stricta	Iridaceae				1					
	Moraea pallida	Iridaceae				1		1			
	*Sisyrinchium micranthum**	Iridaceae							1		
	Watsonia pulchra	Iridaceae		MNCA		1					
	Juncus exsertus	Juncaceae						1			
	Juncus dregeanus subsp. *dregeanus*	Juncaceae						1			
	Juncus effusus	Juncaceae						1	1		
	Juncus lomatophyllus	Juncaceae						1			
	Juncus punctorius	Juncaceae						1			
	Corycium dracomontanum	Orchidaceae		MNCA		1		1			
	Corycium nigrescens	Orchidaceae		MNCA		1		1			

						Vegetation / land-cover unit#					
	Species	**Family**	**SCC (Red Data)**	**Protected**	**AIS Regulations Category**	**Untransformed Grassland**	**Sandstone Scarp**	**Valley-bottom & seep**	**Pan wetland**	**Secondary Grassland**	**Transformed / highly Modified habitats #**
	Disa versicolor	Orchidaceae		MNCA				1			
	Disperis micrantha	Orchidaceae		MNCA			1				
	Eulophia foliosa	Orchidaceae		MNCA				1			
	Eulophia hians var *hians*	Orchidaceae		MNCA		1		1			
	Habenaria epipactidea	Orchidaceae		MNCA		1					
	Habenaria filicornis	Orchidaceae		MNCA				1			
	Habenaria sp. 1	Orchidaceae		MNCA				1			
	Satyrium longicauda var. *longicauda*	Orchidaceae		MNCA				1			
	Satyrium parviflorum	Orchidaceae		MNCA				1			
	Agrostis eriantha	Poaceae						1	1	1	1
	Agrostis lachnantha	Poaceae						1			
	Agrostis montevidensis	Poaceae									1
	Alloteriopsis semialata	Poaceae				1					
	Andropogon appendiculatus	Poaceae				1			1		
	Andropogon huillensis	Poaceae						1			
	Andropogon schirensis	Poaceae				1	1				
	Andropogon eucomis	Poaceae						1		1	1
	Aristida aequiglumis	Poaceae				1					
	Aristida congesta subsp. *congesta*	Poaceae				1	1			1	
	Aristida diffusa subsp *burkei*	Poaceae				1					
	Aristida junciformis subsp. *junciformis*	Poaceae				1	1	1			
	Aristida transvaalensis	Poaceae					1				
	Arundinella nepalensis	Poaceae						1			
	Bewsia biflora	Poaceae				1					
	Brachiaria bovonei	Poaceae				1					
	Brachiaria serrata	Poaceae				1	1				
	*Bromus catharticus**	Poaceae						1	1	1	
	*Calamagrostis epigeios**	Poaceae						1	1	1	
	Ctenium concinnum	Poaceae				1	1				
	Cymbopogon caesius	Poaceae					1				
	Cymbopogon pospischilii	Poaceae				1	1				
	Cymbopogon nardus	Poaceae					1			1	
	Cynodon dactylon	Poaceae				1	1	1	1	1	1
	Cynodon transvaalensis	Poaceae						1			
	Digitaria eriantha	Poaceae				1					
	Digitaria eylesii	Poaceae						1			
	Digitaria monodactyla	Poaceae				1	1				
	Digitaria tricholaenoides	Poaceae				1	1				
	Diheteropogon amplectens	Poaceae				1	1				
	Diheteropogon filifolius	Poaceae				1	1				
	Ehrhata erecta var. *natalensis*	Poaceae					1				
	Eleusine coracacana subsp. *africana*	Poaceae								1	1
	Elionurus muticus	Poaceae				1	1				
	Eragrostis capensis	Poaceae				1		1		1	
	Eragrostis chloromelas	Poaceae				1	1			1	
	Eragrostis curvula	Poaceae				1	1	1	1	1	1
	Eragrostis gummiflua	Poaceae				1	1	1	1	1	
	Eragrostis inamoena	Poaceae						1			
	Eragrostis nindensis	Poaceae					1				
	Eragrostis pattentissima	Poaceae						1			
	Eragrostis plana	Poaceae				1	1	1	1	1	
	Eragrostis planiculmis	Poaceae						1			
	Eragrostis pseudosclerantha	Poaceae				1				1	
	Eragrostis racemosa	Poaceae				1	1				
	Eragrostis sclerantha subsp. *sclerantha*	Poaceae					1				
	Harpochloa falx	Poaceae				1		1			
	Hemarthria altissima	Poaceae						1	1		
	Heteropogon contortus	Poaceae				1	1			1	
	Hyparrhenia dregeana	Poaceae				1	1			1	1
	Hyparrhenia filipendula	Poaceae									1
	Hyparrhenia hirta	Poaceae				1				1	1

						Vegetation / land-cover unit#					
	Species	**Family**	**SCC (Red Data)**	**Protected**	**AIS Regulations Category**	**Untransformed Grassland**	**Sandstone Scarp**	**Valley-bottom & seep**	**Pan wetland**	**Secondary Grassland**	**Transformed / highly Modified habitats #**
	Imperata cylindrica	Poaceae					1	1		1	
	Koeleria capensis	Poaceae						1			
	Leersia hexandra	Poaceae						1	1		
	Loudetia simplex	Poaceae				1	1				
	Melinis nerviglumis	Poaceae					1				
	Melinis repens	Poaceae				1	1				
	Microchloa caffra	Poaceae				1	1				
	Monocymbium ceresiiforme	Poaceae				1					
	Panicum hygrocharis	Poaceae						1	1		
	Panicum natalense	Poaceae				1	1				
	Panicum schinzii	Poaceae						1			1
	*Paspalum dilatatum**	Poaceae				1	1	1	1	1	1
	Paspalum distichum	Poaceae						1			
	*Paspalum notatum**	Poaceae								1	1
	Paspalum scrobiculatum	Poaceae						1			
	*Paspalum urvillei**	Poaceae						1			
	*Pennisetum clandestinum**	Poaceae			1b (in Protected Areas and wetlands)			1		1	1
	Pennisetum sphacelatum	Poaceae						1	1		
	Pennisetum thunbergii	Poaceae						1			
	Phalaris cf. *arundinacea**	Poaceae						1			
	Phragmites australis	Poaceae						1			
	Pogonarthria squarossa	Poaceae								1	1
	Rendlia altera	Poaceae				1					
	Sacciolepis typhoides	Poaceae						1			
	Schizachyrium sanguineum	Poaceae				1	1				
	Setaria pumila	Poaceae					1	1	1	1	
	Setaria sphacelata	Poaceae				1	1	1	1	1	
	Sporobolus africanus	Poaceae				1	1			1	1
	Sporobolus discosporus	Poaceae					1				
	Sporobolus pectinatus	Poaceae				1	1				
	Stiburus alopecuroides	Poaceae						1			
	Themeda triandra	Poaceae				1	1	1		1	
	Trachypogon spicatus	Poaceae				1		1			
	Trichoneura grandiglumis	Poaceae								1	
	Trisetopsis imberbis [=*Helictotrichon turgidulum*]	Poaceae						1	1	1	1
	Tristachya leucothrix	Poaceae				1		1			
	Tristachya rehmannii	Poaceae				1	1				
	Potamogeton nodosus [=*Potamogeton thunbergii*]	Potamogetonaceae						1			
	Potamogeton pectinatus	Potamogetonaceae						1			
	Eriospermum sp. 1	Ruscaceae					1				
	Eriospermum sp. 2	Ruscaceae						1			
	Smilax anceps	Smilacaceae						1			
	Typha capensis	Typhaceae						1			
	Xyris cf. *capensis*	Xyridaceae						1			
	DICOTYLEDONS										
	Blepharis innocua	Acanthaceae				1	1				
	Crabbea acaulis	Acanthaceae				1	1	1	1	1	
	Crabbea hirsuta	Acanthaceae				1	1				
	Justicia anagalloides	Acanthaceae				1	1				
	Kiggelaria africana	Achariaceae					1				
	Delosperma ashtonii	Aizoaceae				1	1			1	
	Delosperma carolinensis	Aizoaceae				1	1				
	Khadia carolinesis	Aizoaceae	VU			1	1				
	*Amarathus hybridus**	Amaranthaceae									1
	*Achyranthes aspera**	Amaranthaceae						1			1
	*Chenopodium album**	Amaranthaceae									1
	Cyathula uncinulata	Amaranthaceae					1				

						Vegetation / land-cover unit#					
	Species	**Family**	**SCC (Red Data)**	**Protected**	**AIS Regulations Category**	**Untransformed Grassland**	**Sandstone Scarp**	**Valley-bottom & seep**	**Pan wetland**	**Secondary Grassland**	**Transformed / highly Modified habitats #**
	*Gomphrena celosioides**	Amaranthaceae									1
	Kyphocarpa angustifolia	Amaranthaceae				1					
	Searsia magalismontanum	Anacardiaceae					1				
	Searsia dentata	Anacardiaceae					1				
	Searsia discolor	Anacardiaceae				1					
	Searsia pyroides var. *pyroides*	Anacardiaceae					1				
	Searsia tumulicola var. *meeuseana* forma *pumila*	Anacardiaceae				1	1				
	Afrosciadium magalismontanum	Apiaceae				1					
	Sensitive Species 1200	Apiaceae	EN					1			
	*Ciclospermum leptophyllum**	Apiaceae						1	1	1	
	Centella asiatica	Apiaceae						1	1		
	Heteromorpha arborescens var. *abyssinica*	Apiaceae					1				
	Asclepias aurea	Apocynaceae				1	1				
	Asclepias cf. *gibba*	Apocynaceae				1					
	Asclepias multicaulis	Apocynaceae				1					
	Asclepias stellifera	Apocynaceae				1					
	Ceropegia meyerii	Apocynaceae		MNCA			1				
	Cordylogyne globosa	Apocynaceae						1			
	Parapodium costatum	Apocynaceae				1					
	Raphionacme hirsuta	Apocynaceae				1					
	Riocreuxia burchellii	Apocynaceae					1				
	Sisyranthus imberbis	Apocynaceae						1			
	Xysmalobium undulatum	Apocynaceae						1		1	
	*Acanthospermum australe**	Asteraceae								1	1
	Afroaster serrulatus [=*Aster harveyanus*]	Asteraceae				1					
	*Aster squamatus**	Asteraceae						1	1		
	Athrixia elata	Asteraceae					1				
	Berkheya radula	Asteraceae				1		1			
	Berkheya setifera	Asteraceae				1	1				
	Berkheya speciosa	Asteraceae					1	1			
	*Bidens bipinnata**	Asteraceae					1			1	1
	*Bidens pilosa**	Asteraceae					1				1
	Callilepis leptophylla	Asteraceae				1					
	*Campuloclinium macrocephalum**	Asteraceae			1b	1		1			
	Cineraria lyrata	Asteraceae						1	1	1	
	*Cirsium vulgare**	Asteraceae			1b		1	1	1	1	1
	*Cosmos bipinnatus**	Asteraceae								1	
	*Conyza bonariensis** [=*Conyza albida*]	Asteraceae							1	1	1
	*Conyza canadensis**	Asteraceae									1
	*Cosmos bipinnatus**	Asteraceae									1
	*Crepis hypochaeridea**	Asteraceae				1				1	
	Crassocephalum cf. *x picridifolium*	Asteraceae						1			
	Cyanthillium cf. vernonioides [=*Vernonia meiostephana*]	Asteraceae						1			
	Denekia capensis	Asteraceae						1			
	Dicoma anomala subsp. *anomala*	Asteraceae				1	1				
	Euryops laxus	Asteraceae					1				
	Euryops transvaalensis subsp. *transvaalensis*	Asteraceae				1					
	Felicia filifolia	Asteraceae					1				
	Felicia muricata	Asteraceae				1	1			1	
	*Galinsoga parviflora**	Asteraceae					1				1
	*Gamochaeta pensylvanica**	Asteraceae								1	1
	Gazania krebsiana	Asteraceae				1	1				
	Geigeria burkei	Asteraceae				1					
	Gerbera ambigua	Asteraceae					1	1			
	Gerbera pilloseliodes	Asteraceae				1					
	Gerbera viridifolia	Asteraceae				1	1				
	Haplocarpha lyrata	Asteraceae				1		1			

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	Haplocarpha scaposa	Asteraceae						1			
	Helichrysum aureonitens	Asteraceae				1		1	1		
	Helichrysum caespititium	Asteraceae				1					
	Helichrysum callicomum	Asteraceae				1				1	
	Helichrysum cephaloideum	Asteraceae				1					
	Helichrysum cf. *chionosphaerum*	Asteraceae				1					
	Helichrysum coriaceum	Asteraceae				1		1			
	Helichrysum mundtii	Asteraceae						1			
	Helichrysum nudifolium var. nudifolium	Asteraceae				1	1			1	
	Helichrysum nudifolium var. pilosellum	Asteraceae				1	1			1	
	Helichrysum oreophilum	Asteraceae				1					
	Helichrysum rugulosum	Asteraceae				1				1	
	Helichrysum setosum	Asteraceae					1	1			
	Hilliardiella aristata [=Vernonia natalensis]	Asteraceae				1	1				
	Hilliardiella elaeagnoides [=Vernonia oligocephala]	Asteraceae				1	1				
	Hilliardiella hirsuta	Asteraceae					1				
	*Hypochaeris radicata**	Asteraceae				1	1	1	1	1	1
	Lactuca inermis	Asteraceae				1				1	
	Lopholaena coriifolia	Asteraceae					1				
	Macledium zeyheri	Asteraceae					1				
	Nidorella anomala	Asteraceae					1	1			
	Nidorella auriculata	Asteraceae				1	1	1			
	Nidorella hottentota	Asteraceae						1			
	Nidorella pinnata [=*Conyza pinnata*]	Asteraceae						1			
	Nidorella podocephala	Asteraceae				1	1	1	1	1	1
	Nolletia rarifolia	Asteraceae				1					
	Osteospermum muricatum	Asteraceae								1	
	Othona natalensis	Asteraceae				1					
	Polydora poskeana [*Vernonia poskeana*]	Asteraceae					1				
	*Pseudognaphalium luteoalbum**	Asteraceae						1	1	1	1
	Pseudognaphalium cf. oligandrum	Asteraceae						1		1	
	Pseudopegolettia tenella [=Vernonia galpinii]	Asteraceae				1	1				
	Pulicaria scabra	Asteraceae						1			
	Schistostephium crataegifolium	Asteraceae					1				
	*Schkuhria pinnata**	Asteraceae							1	1	1
	Senecio affinis	Asteraceae				1		1			
	Senecio corontus	Asteraceae				1					
	Senecio erubescens	Asteraceae						1			
	Senecio gerrardii	Asteraceae						1			
	Senecio hieraciodes	Asteraceae				1	1				
	Senecio cf. *inaequidens*	Asteraceae				1	1			1	
	Senecio inornatus	Asteraceae						1			
	Senecio oxyriifolius	Asteraceae					1				
	Senecio polyodon	Asteraceae						1			
	Senecio scitus	Asteraceae				1	1				
	Senecio venosus	Asteraceae					1				
	Senecio sp. 1	Asteraceae				1					
	Senecio sp. *2*	Asteraceae					1				
	Seriphium plumosum	Asteraceae				1	1	1		1	
	*Sonchus oleraceus**	Asteraceae						1		1	1
	*Tagetes minuta**	Asteraceae					1		1	1	1
	*Taraxacum officinale**	Asteraceae									1
	Ursinia nana	Asteraceae					1				
	Impatiens hochstetteri var. *hochstetteri*	Balsaminaceae					1				
	Cynoglossum lanceolatum	Boraginaceae					1	1			
	Heliophila rigidisciula	Brassicaceae						1			
	*Nasturtium officinale**	Brassicaceae			2			1			
	Wahlenbergia denticulata	Campanulaceae				1		1		1	
	Dianthus mooiensis subsp. mooiensis	Caryophyllaceae				1	1				
	Dianthus cf. *zeyheri* subsp. *zeyheri*	Caryophyllaceae				1	1				

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	Silene sp.	Caryophyllaceae					1				
	Pollichia campestris	Caryophyllaceae				1	1				
	Convolvulus sagittatus	Convolvulaceae				1	1				
	Ipomoea bathycolpos subsp. sinuatodentata	Convolvulaceae				1	1				
	Ipomoea crassipes var. crassipes	Convolvulaceae				1	1				
	Ipomoea ommaneyi	Convolvulaceae				1	1				
	*Ipomoea purpurea**	Convolvulaceae			1b						1
	Crassula capitella	Crassulaceae				1					
	Crassula pellucida subsp. *brachypetala*	Crassulaceae						1			
	Crassula lanceolata subsp. *transvaalensis*	Crassulaceae					1				
	Crassula setulosa var.setulosa	Crassulaceae					1				
	Crassula cf. *natans*	Crassulaceae				1	1				
	Crassula vaginata	Crassulaceae				1		1			
	Cucumis hirsutus	Cucurbitaceae				1					
	Cucumis zeyheri	Cucurbitaceae				1				1	
	Scabiosa columbaria	Dipsacaceae				1	1				
	Drosera burkeana	Droseraceae						1			
	Diospyros austro-africana	Ebenaceae				1	1				
	Diospyros lycioides subsp. guerkei	Ebenaceae				1	1				
	Erica drakensbergensis	Ericaceae		MNCA		1		1			
	Acalypha angustata	Euphorbiaceae				1	1				
	Acalypha villicaulis	Euphorbiaceae					1				
	Clutia natalensis	Euphorbiaceae					1				
	Clutia cf. *affinis*	Euphorbiaceae					1				
	Clutia pulchella	Euphorbiaceae					1				
	Euphorbia clavaroides	Euphorbiaceae				1					
	Euphorbia striata	Euphorbiaceae						1			
	*Acacia dealbata**	Fabaceae			2	1	1	1		1	1
	*Acacia mearnsii**	Fabaceae			2	1	1			1	1
	Aeschynomene nodulosa var. *nodulosa*	Fabaceae				1	1				
	Argyrolobium tuberosum	Fabaceae						1			
	Chamaecrista comosa	Fabaceae				1				1	
	Chamaecrista mimosoides	Fabaceae					1	1		1	
	Crotalaria distans subsp. *distans*	Fabaceae				1		1		1	
	Dichilus cf. *strictus*	Fabaceae				1					
	Elephantorrhiza elephantina	Fabaceae				1					
	Eriosema burkei	Fabaceae				1					
	Eriosema kraussianum	Fabaceae				1					
	Erythrina zeyheri	Fabaceae				1					
	Indigofera comosa	Fabaceae				1					
	Indigofera frondosa	Fabaceae					1	1			
	Indigofera hedyantha	Fabaceae				1					
	Indigofera hilaris	Fabaceae				1	1				
	Indigofera melanadenia	Fabaceae					1				
	Indigofera sp. 1	Fabaceae								1	
	Leobordia divaricata [=*Lotononis calycina]*	Fabaceae				1	1				
	Leobordia foliosa [=*Lotononis foliosa*]	Fabaceae				1	1				
	Listia heterophylla	Fabaceae						1			
	Listia sp.	Fabaceae					1				
	Melolobium cf. *wilmsii*	Fabaceae				1		1			
	Pearsonia cajanifolia	Fabaceae				1					
	Pearsonia grandifolia subsp. *latibracteolata*	Fabaceae				1					
	Pearsonia sessilifolia	Fabaceae					1				
	Rhynchosia caribaea	Fabaceae					1				
	Rhynchosia minima	Fabaceae				1		1		1	
	Rhynchosia totta	Fabaceae				1	1				
	Sphenostylis angustifolia	Fabaceae					1				
	Stylosanthes fruticosa	Fabaceae				1				1	
	Tephrosia capensis	Fabaceae				1	1			1	
	Tephrosia elongata	Fabaceae				1					

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	Trifolium africanum var. *lydenburgense*	Fabaceae						1			
	*Trifolium repens**	Fabaceae									1
	Vigna vexillata	Fabaceae					1			1	
	Zornia linearis	Fabaceae					1				
	Zornia cf. *milneana*	Fabaceae				1	1				
	*Quercus robur**	Fabaceae									1
	Chironia palustris subsp. *transvaalensis*	Gentianaceae						1			
	Chironia cf. *purpurascens* subsp. *humilis*	Gentianaceae						1			
	Sebaea grandis	Gentianaceae				1		1			
	Sebaea leiostyla	Gentianaceae						1			
	Monsonia angustifolia	Geraniaceae				1	1				
	Monsonia burkeana	Geraniaceae				1					
	Pelargonium dolomiticum	Geraniaceae				1			1		
	Pelargonium luridum	Geraniaceae				1		1			
	Hypericum lalandii	Hypericaceae						1			
	Hypericum aethiopicum	Hypericaceae				1		1			
	Aeollanthus buchnerianus	Lamiaceae					1				
	Ajuga ophridis	Lamiaceae				1					
	Leonotis ocymifolia	Lamiaceae					1				
	Mentha aquatica	Lamiaceae						1			
	Mentha longifolia	Lamiaceae						1			
	Ocimum obovatum subsp. *obovatum* var.obovatum [=*Becium obovatum*]	Lamiaceae				1					
	Pycnostachys reticulata	Lamiaceae						1			
	Rotheca hirsuta	Lamiaceae					1				
	Stachys natalensis var. galpinii	Lamiaceae				1					
	Teucrium trifidum	Lamiaceae					1			1	
	Genlisea hispidula	Lentibulariaceae						1			
	Urticularia prehensilis	Lentibulariaceae						1			
	Urticularia stellaris	Lentibulariaceae						1			
	Craterostigma wilmsii	Linderniaceae					1				
	Lindernia conferata	Linderniaceae					1				
	Lindernia wilmsii	Linderniaceae					1				
	Cyphia elata	Lobeliaceae					1				
	Lobelia angolensis	Lobeliaceae						1			
	Lobelia erinus	Lobeliaceae				1		1	1		
	Lobelia flaccida subsp. *flaccida*	Lobeliaceae						1	1	1	
	Monopsis decipiens	Lobeliaceae						1	1		
	Nesaea sagittifolia	Lythraceae						1			
	Corchorus asplenifolius	Malvaceae				1	1				
	Hermannia depressa	Malvaceae				1					
	Hermannia lancifolia	Malvaceae				1					
	Hermannia transvaalensis	Malvaceae				1	1				
	Hibiscus aethiopicus	Malvaceae				1	1				
	Hibiscus micropcarpus	Malvaceae				1					
	*Hibiscus trionum**	Malvaceae								1	1
	Pavonia columella	Malvaceae					1				
	Sparrmannia ricinocarpa	Malvaceae					1				
	Cissampelos abyssinica	Menispermaceae					1				
	Stephania abyssinica	Menispermaceae					1				
	Nymphoides senegalensis	Menyanthaceae						1			
	Psammotropha mucronata var. *mucronata*	Molluginaceae					1				
	Psammotropha myriantha	Molluginaceae				1	1				
	*Eucalyptus camaldulensis**	Myrtaceae			1b						1
	*Eucalyptus viminalis**	Myrtaceae									1
	*Oenothera indecora**	Onagraceae						1	1		1
	*Oenothera rosea**	Onagraceae					1	1			
	*Oenothera tetraptera**	Onagraceae									1
	Alectra sessiliflora	Orobanchaceae						1			
	Buchnera reducta	Orobanchaceae						1			
	Cycnium tubulosum	Orobanchaceae						1			

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	Gerardiina angolensis	Orobanchaceae					1	1			
	Ramphicarpa fistulosa	Orobanchaceae					1	1			
	Sopubia cana	Orobanchaceae						1			
	Striga asiatica	Orobanchaceae				1					1
	Striga bilabiata	Orobanchaceae				1	1				
	Striga elegans	Orobanchaceae				1					
	*Oxalis corniculata**	Oxalidaceae				1		1		1	1
	Oxalis obliquifolia	Oxalidaceae				1	1	1		1	
	*Phytolacca octandra**	Phytolaccaceae			1b						1
	Peperomia retusa	Piperaceae					1				
	*Plantago lanceolata**	Plantaginaceae						1	1	1	1
	*Plantago major**	Plantaginaceae								1	1
	Polygala amatymbica	Polygalaceae				1					
	Polygala hottentota	Polygalaceae				1	1				
	Oxygonum dregeanum subsp. *canescens* var. *canescens*	Polygonaceae				1					
	Persicaria attenuata subsp. africana	Polygonaceae						1			
	Persicaria decipiens	Polygonaceae						1			
	*Persicaria lapathifolia**	Polygonaceae						1	1		
	*Pericaria limbata**	Polygonaceae						1			
	Persicaria meisneriana	Polygonaceae						1			
	Rumex acetosella subsp. *angiocarpus**	Polygonaceae				1			1		
	Rumex crispus	Polygonaceae						1			
	Rumex lanceolatus	Polygonaceae							1		
	Rumex sagittatus	Polygonaceae					1				
	*Portulaca oleracea**	Portulacaceae									1
	Portulaca cf. *quadrifida*	Portulacaceae					1				
	Clematis brachiata	Ranunculaceae					1				
	Ranunculus meyeri	Ranunculaceae						1			
	Ranunculus multifidus	Ranunculaceae						1	1		
	*Agrimonia procera**	Rosaceae			1b		1	1			1
	*Pyracantha angustifolia**	Rosaceae			1b	1		1			
	Rubus rigidus	Rosaceae					1				
	Anthospermum herbaceum	Rubiaceae				1	1				
	Anthospermum rigidum	Rubiaceae					1				
	Kohautia amatymbica	Rubiaceae				1	1				
	Kohautia cf. *virgata*	Rubiaceae				1					
	Oldenlandia herbacea var. *herbacea*	Rubiaceae					1			1	
	Pentanisia angustifolia	Rubiaceae				1	1				
	Pentanisia prunelloides	Rubiaceae				1					
	Pygmaeothamnus chamaedendrum var. chamaedendrum	Rubiaceae				1	1				
	*Richardia brasiliensis**	Rubiaceae				1	1			1	1
	Rubia horrida	Rubiaceae					1				
	Vangueria pygmaea	Rubiaceae				1	1				
	Thesium sp. 1	Santalaceae				1	1				
	Thesium sp. 2	Santalaceae				1					
	Chaenostoma floribundum	Scrophulariaceae					1				
	Chaenostoma neglectum	Scrophulariaceae				1	1			1	
	Chaenostoma sp.	Scrophulariaceae					1				
	Diclis reptans	Scrophulariaceae						1			
	Hebenstretia angolensis	Scrophulariaceae					1				
	Jamesbrittenia aurantiaca	Scrophulariaceae									
	Limosella maior	Scrophulariaceae						1			
	Manulea parviflora var. parviflora	Scrophulariaceae				1					
	Melanospermum transvaalense	Scrophulariaceae					1				
	Mimulus gracilis	Scrophulariaceae						1			
	Nemesia albiflora	Scrophulariaceae					1				
	Nemesia fruticans	Scrophulariaceae				1				1	
	Selago cf. *densiflora*	Scrophulariaceae				1	1			1	
	Veronica anagallis-aquatica	Scrophulariaceae						1			

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	Zaluzianskya cf. pulvinata	Scrophulariaceae					1				
	*Ailanthus altissima**	Simaroubaceae			1b						1
	*Physalis peruviana**	Solanaceae									1
	*Solanum elaeagnifolium**	Solanaceae			1b	1				1	1
	Solanum incanum	Solanaceae				1				1	
	Solanum nigrum	Solanaceae					1				
	*Solanum sisymbrifolium**	Solanaceae			1b	1	1			1	1
	Withania somnifera	Solanaceae					1				
	Gnidia fastigiata	Thymeleaceae				1					
	Lasiosiphon burchellii	Thymeleaceae					1				
	Lasiosiphon caffer [=*Gnidia caffra*]	Thymelaeaceae				1	1				
	Lasiosiphon capitatus [=*Gnidia capitata*]	Thymelaeaceae				1					
	Lantana rugosa	Verbenaceae					1				
	*Verbena aristigera**	Verbenaceae									1
	*Verbena bonariensis**	Verbenaceae			1b		1	1	1	1	1
	*Verbena officinalis**	Verbenaceae						1		1	1
	*Verbena rigida**	Verbenaceae			1b	1				1	1
	Tribulus terrestris	Zygophyllaceae									1
						240	228	216	56	91	65
	* Alien species										
	**Protected in terms of Schedule 11 of the Mpumalanga Nature Conservation Act										
	#Includes homesteads, roads, railway lines, alien trees plantations and stands, quarries etc.										

APPENDIX 2: Flora data (recorded species) for 12 example sites surveyed using the timed-meander search method. A total of 193 sites were surveyed using either a brief timed-meander search or by sampling 100m^2 vegetation sampling quadrats using the Braun-Blanquet cover-abundance estimates.

Taxon	Timed-meander searches												
	Untransformed Grassland	Untransformed Grassland	Untransformed Grassland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Pan wetland	Secondary Grassland	Secondary Grassland	
	15	92	144	103	107a	123	44	117	135	49	27	41	
Agrostis eriantha							1	1	1	1	1		
Agrostis lachnatha							1	1					
Andropogon appendiculatus				1			1	1	1	1			
Andropogon eucomis											1		
Andropogon schirensis					1	1							
Aristida congesta				1							1		
Aristida diffusa		1			1								
Aristida junciformis						1	1		1				
Aristida transvaalensis		1				1							
Arundinella nepalensis				1			1	1					
Asparagus laricinus				1									
Bewsia biflora		1	1										
Brachiaria serrata	1	1	1	1	1	1			1				
*Calamgrostis epigeios**							1			1	1		
Ctenium concinnum		1			1								
Cymbopogon pospischilii		1	1	1	1	1							
Cynodon dactylon		1		1	1	1					1	1	
Digitaria monodactyla					1	1							
Digitaria tricholaenoides	1		1	1	1	1							
Diheteropogon amplectans	1		1						1				
Ehrhata erecta var. *natalensis*				1									
Elionurus muticus	1		1		1	1			1				
Eragrostis capensis	1		1						1		1		
Eragrostis chloromelas	1	1	1		1				1		1		
Eragrostis curvula	1	1	1	1	1	1	1	1	1	1	1	1	
Eragrostis gummiflua	1		1	1	1	1			1		1		
Eragrostis pattentissima							1	1					
Eragrostis plana	1				1	1		1		1	1	1	
Eragrostis planiculmis							1	1		1			
Eragrostis racemosa	1	1	1	1					1		1		
Eragrostis sp.	1												
Harpochloa falx	1			1				1					
Hemarthria altissima										1			
Heteropogon contortus	1	1	1		1	1							
Hyparrhenia dregeana				1							1	1	

Taxon	Timed-meander searches												
	Untransformed Grassland	Untransformed Grassland	Untransformed Grassland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Pan wetland	Secondary Grassland	Secondary Grassland	
	15	92	144	103	107a	123	44	117	135	49	27	41	
Hyparrhenia hirta											1	1	
Imperata cylindrica						1			1		1	1	
Leersia hexandra				1			1	1	1	1			
Melinis nerviglumis				1	1								
Melinis repens				1	1	1							
Microchloa caffra		1	1		1	1		1	1				
Panicum hygrocharis										1			
Panicum natalense		1	1	1	1								
Panicum schinzii	1												
*Paspalum dilatatum**							1			1		1	
Pennisetum cf. *sphacelatum*								1		1			
Phalaris cf. *arundinacea**							1						
Phragmites australis							1						
Pogonarthria squarossa											1		
Rendlia altera		1			1								
Setaria pumila	1							1					
Setaria sphacelata				1	1	1	1	1					
Sporobolus africanus								1			1		
Sporobolus pectinatus			1	1	1	1							
Sporobolus sp.							1						
Stiburus alopecuroides	1							1					
Themeda triandra	1		1	1	1	1	1	1	1				
Trachypogon spicatus	1		1	1	1	1			1				
Trichoneura grandiglumis											1		
Tristachya leucothrix	1	1	1	1	1								
Tristachya rehmannii					1								
Trisetopsis imberbis								1		1	1	1	
Abildgaardia ovata	1	1	1										
Acalypha cf. *angustata*			1										
Acalypha sp.				1									
Adiantum capillus-veneris				1									
Aeollanthus buchnerianus				1	1								
Aeschynomene cf. *nodulosa*						1							
Albuca virens				1									

Taxon	Timed-meander searches												
	Untransformed Grassland	Untransformed Grassland	Untransformed Grassland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Pan wetland	Secondary Grassland	Secondary Grassland	
	15	92	144	103	107a	123	44	117	135	49	27	41	
Sensitive Species 1200									1				
Aloe welwitschii			1										
Anthospermum rigidum	1	1	1										
Argyrolobium tuberosum							1						
Aristea torulosa	1												
Asclepia stellifera			1										
Asparagus laricinus						1							
Athrixia elata				1	1								
Babiana hypogea	1												
Berkheya setifera				1	1			1					
Berkheya speciosa				1									
*Bidens pilosa**				1		1				1			
Blechnum australe													
Blepharis innocua			1	1									
Boophone disticha						1							
Bulbostylis hispidula		1				1							
Bulbostylis sp. 1				1	1	1							
Bulbostylis sp. 2													
Callilepis leptophylla			1										
Centella asiatica				1			1	1	1	1			
Ceropegia meyerii				1	1								
Cheilanthes hirta					1								
Chaenostoma floribundum				1	1	1							
Chaenostoma neglectum				1	1						1		
Chamaecrista mimosoides	1											1	
Cheilanthes viridis var. viridis				1	1	1							
Cinereria lyrata		1		1		1		1		1			
*Cirsium vulgare**								1		1			
Clutia pulchella				1		1							
Chlorophytum cf. *fasciculatum*	1												
Cinereria lyrata								1		1			
Clematis brachiata				1	1								
Clutia natalensis				1									
Commelina africana	1		1	1	1	1	1	1	1		1		
Comelina subulata							1	1					

Taxon	Timed-meander searches												
	Untransformed Grassland	Untransformed Grassland	Untransformed Grassland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Pan wetland	Secondary Grassland	Secondary Grassland	
	15	92	144	103	107a	123	44	117	135	49	27	41	
*Conyza bonariensis**				1	1	1			1		1		
*Cosmos bipinnatus**											1		
Crabbea acaulis	1	1	1						1				
Crabbea cf. *hirsuta*				1	1								
Crassocephalum cf. x picridifolium							1						
Crassula capitella			1										
Crassula lanceolata	1	1	1	1		1							
Crassula natans	1				1			1					
Crassula setulosa				1	1	1							
Crassula vaginata				1									
*Crepis hypochaeridea**	1		1										
Crocosmia paniculata				1									
Cyanotis lapidosa				1		1							
Cyanotis speciosa		1	1		1								
Cyanthillium cf. vernonioides								1					
Cyathula uncinata				1		1							
Cyperus congestus							1						
Cyperus denudatus	1						1	1	1	1			
*Cyperus eragrostis**										1			
*Cyperus esculentus**										1		1	
Cyperus fastigiatus	1							1					
Cyperus longus							1			1			
Cyperus obtusiflorus var. *flavissimus*			1										
Cyperus rupestris					1	1							
Cyperus sphaerospermus									1				
Cyperus sp. 1	1	1											
Cyphia elata				1									
Cysopteris fragilis				1									
Delosperma ashtonii	1	1	1		1								
Delosperma carolinensis		1		1	1								
Denekia capensis							1						
Dianthus mooiensis				1	1				1				
Dicoma anomala		1	1		1								
Dierama cf. insigne	1		1										
Dioscorea cf. *quartiniana*				1									

Taxon	Timed-meander searches												
	Untransformed Grassland	Untransformed Grassland	Untransformed Grassland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Pan wetland	Secondary Grassland	Secondary Grassland	
	15	92	144	103	107a	123	44	117	135	49	27	41	
Diospyros lyciodes	1			1	1	1							
Dipcadi viride	1												
Disa versicolor									1				
Disperis micrantha				1									
Dracoscirpoides ficinoides										1			
Dryopteris pentheri				1									
Eleocharis atropurpurea										1			
Eleocharis dregeana							1	1		1			
Elephantorrhiza elephantina			1										
Erythrina zeyheri	1												
Erica drakensbergensis	1								1				
Eriosema burkei			1										
Eriospermum sp.							1						
Eucomis autumnalis			1	1									
Euryops traansvaalensis subsp. *transvaalensis*		1	1										
Felicia muricata	1					1							
Fimbristylis complanata							1			1			
Fuirena coerulescens							1		1	1			
Fuirena pubescens							1	1		1			
Fuirena stricta										1			
*Galinsoga parviflora**				1									
Gamochaeta pennsylvnica										1			
Gazania krebsiana		1											
Gerbera ambigua									1				
Gladiolus dalenii				1									
Gladiolus crassifolius	1	1											
Gladiolus ecklonis	1	1											
Gladiolus papilio							1						
Gnidia fastigiata		1											
*Gomphrena celosiodes**	1	1				1							
Haemanthus humilis				1									
Haplocarpa lyrata									1				
Hebenstretia angolensis				1	1								
Helichrysum aureonitens							1		1	1			

Taxon	Timed-meander searches												
	Untransformed Grassland	Untransformed Grassland	Untransformed Grassland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Pan wetland	Secondary Grassland	Secondary Grassland	
	15	92	144	103	107a	123	44	117	135	49	27	41	
Helichrysum caespititium		1											
Helichrysum callicomum	1	1									1	1	
Helichrysum coriaceum		1							1				
Helichrysum mundtii								1					
Helichrysum nudifolium var. *nudifolium*		1											
Helichrysum nudifolium var. pilosellum	1										1		
Helichrysum oreophilum	1	1	1										
Helichrysum rugulosum	1	1	1	1					1			1	
Helichrysum setosum				1	1								
Helichrysum sp. (small shrub)				1		1							
Hibiscus aethiopicus		1		1									
*Hibiscus trionum**		1		1							1		
Hilliardiella elaeagnoides	1	1		1	1								
Hilliardiella hirsuta				1		1							
Hypericum lalandii								1	1				
*Hypochaeris radicata**	1				1	1			1			1	
Hypoxis iridifolia		1											
Hypoxis obtusa		1											
Hypoxis rigidula		1	1		1								
Indigofera comosa			1										
Ipomoea crassipes			1	1	1	1							
Indigofera sp.						1						1	
Ipomoea ommaneyi				1	1	1							
Isolepis costata							1			1			
Isolepis fluitans							1						
Juncus dregeanus				1					1				
Juncus effusus							1	1		1			
Juncus exsertus								1					
Juncus punctorius				1									
Justicia anagalloides		1											
Khadia carolinensis					1								
Kiggelaria africana				1									
Kohautia amatymbica		1	1		1				1				
Kyllinga cf. *alata*				1									
Kyllinga erecta	1			1		1	1	1	1	1			

Taxon	Timed-meander searches												
	Untransformed Grassland	Untransformed Grassland	Untransformed Grassland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Pan wetland	Secondary Grassland	Secondary Grassland	
	15	92	144	103	107a	123	44	117	135	49	27	41	
Kyllinga melanosperma							1			1			
Kyllinga pulchella	1			1				1					
Kyphocarpa angustifolia		1											
Lactuca inermis												1	
Lagarosiphon muscoides								1					
Lasiosiphon burchellii						1							
Lasiosiphon capitatus			1										
Lasiosiphon caffer			1			1							
Ledebouria cooperi							1		1				
Ledebouria luteola	1	1	1										
Ledebouria ovatifolia	1	1	1										
Leonotis ocymifolia				1		1							
Leobordia divaricata						1							
Leobordia foliosa			1										
Lipocarpha nana								1					
Lindernia wilmsii	1					1							
Listia sp.	1					1							
Lobelia flaccida	1						1			1		1	
Melanospermum transvaalense				1									
Metha aquatica							1	1					
Metha longifolia								1					
Mohria vestita				1	1	1							
Monopsis decipiens								1	1	1			
Monsonia burkeana		1											
*Nasturtium officinale**								1					
Nemesia albiflora				1									
Nemesia fruticans	1												
Nidorella anomala									1				
Nidorella hottentota		1			1								
Nidorella podocephala												1	
Ocimum obovatum	1	1	1	1	1				1				
Oldenlandia herbacea					1								
*Oenothera indecora**								1		1			
*Oenothera tetraptera**								1			1		
Ophioglossum cf. polyphyllum											1		

Taxon	Timed-meander searches												
	Untransformed Grassland	Untransformed Grassland	Untransformed Grassland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Pan wetland	Secondary Grassland	Secondary Grassland	
	15	92	144	103	107a	123	44	117	135	49	27	41	
*Oxalis corniculata**	1					1							
Oxygonum dregeanum			1										
Pachystigma pygmaeum			1	1									
Pavonia columella				1									
Pelargonium lurdum			1						1				
Pellaea calomelanos				1	1	1							
Pennisetum cf. *sphacelatum*							1						
Pentanisia angustifolia	1	1	1	1	1								
Peperomia retusa				1									
Persicaria attenuata subsp. africana								1					
Persicaria decipiens							1	1					
*Persicaria lapathifolia**										1			
Pityrogramma argentea				1									
*Plantago major**											1		
Pollichia camperstris	1	1	1										
Polygala amatymbica		1							1				
Polygala hottentotica		1									1		
Potamogeton pectinatus								1					
Psammotropha myriantha				1	1	1							
*Pseudognaphalium luteoalbum**				1					1	1	1		
Pseudognaphalium cf. oligandrum	1											1	
Pseudopegolettia tenella			1		1	1							
Pteridium aquilinum				1	1								
Pteris cretica				1									
Pulicaria scabra								1					
Pycreus cf. *macranthus*							1		1	1	1		
Pycreus nitidus							1						
Pycreus sp.							1						
Pygmaeothamnus chamaedendrum var. *chamaedendrum*		1			1								
Ramphicarpa fistulosa								1					
Ranunculus multifidus							1						
Raphionacme hirsuta	1		1										
Rhynchosia minima				1								1	
Rhynchosia totta	1	1	1	1	1								

Taxon	Timed-meander searches												
	Untransformed Grassland	Untransformed Grassland	Untransformed Grassland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Pan wetland	Secondary Grassland	Secondary Grassland	
	15	92	144	103	107a	123	44	117	135	49	27	41	
*Richardia brasiliensis**	1	1				1			1		1	1	
Riocreuxia burchellii						1							
Rubus rigidus				1		1							
Rumex acetosella subsp. *angiocarpus**				1	1	1			1	1	1		
*Rumex crispus**								1					
Rumex lanceolatus										1			
Rumex sagittatus				1		1							
Satyrium longicauda									1				
Schoenoplectus decipiens								1					
Schoenoplectus corymbosus								1					
Schoenoplectus cf. *muriculatus*								1					
Scirpoides burkei								1					
Scleria catophylla									1				
Searsia pyroides				1									
Searsia dentata				1	1								
Searsia magalismontanum					1								
Searsia pyroides				1									
Searsia tumulicola var. *meeuseana*					1	1							
Selaginella dregei					1	1							
Selago densiflora											1	1	
Senecio affinis									1				
Senecio coronatus	1	1	1										
Senecio erubescens	1		1										
Senecio gerrardii							1						
Senecio hieraciodes		1				1							
Senecio inornatus									1				
Senecio polyodon							1						
Seriphium plumosum	1			1	1				1		1	1	
Silene sp.				1									
Solanum nigrum				1									
*Solanum sisymbrifolium**				1		1							
Sparrmannia ricinocarpa				1									
Stephania abyssinica				1		1							
Striga elegans	1												
*Tagetes minuta**										1			

Taxon	Timed-meander searches												
	Untransformed Grassland	Untransformed Grassland	Untransformed Grassland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Sandstone Scarp Shrubland	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Valley-bottom & Seep wetlands	Pan wetland	Secondary Grassland	Secondary Grassland	
	15	92	144	103	107a	123	44	117	135	49	27	41	
Tephrosia capensis		1		1								1	
Tephrosia elongata				1	1								
Thesium sp. 1		1											
Trachyandra saltii	1	1	1										
Typha capensis							1	1		1			
Ursini nana	1												
Urticularia stellata									1				
*Verbena bonariensis**				1						1	1	1	
*Verbena rigida**										1		1	
Veronica anagallis-aquatica							1						
Wahlenbergia denticulata	1			1					1		1		
Watsonia pulchra	1	1											
Xysmalobium undulatum												1	
Zaluzianskya cf. *pulvinata*					1								
Zanthedescia aethiopica								1					
Zornia cf. *milneana*	1	1	1	1	1								
Cyperaceae sp. 1										1			
Cyperaceae sp. 2									1				
Monocot sp. 1						1							
Monocot sp. 2						1							
Monocot sp. 3		1											
Monocot sp. 4					1								
Total no. of species per TMS	74	67	63	113	77	70	50	57	55	47	37	26	
Average no. of species per TMS		68			86,7			54		47	31,5		

APPENDIX 3: Details of the 12 example sites surveyed using a formal timed-meander search method as presented in Appendix 2.

TMS 15

Date: 12/01/2023
Start: 26º 11' 36.7" S 29º 58' 06.1" E
Time: 70min
Length: 640m
Vegetation Unit:
Untransformed Grassland
Habitat: Well grazed grassland on fairly shallow light brown sandy loam soils on the crest of a knoll which forms the highest point (1743masl) in the project area. Sandstone sheetrock habitat present.
No. species: 75

TMS 92

Date: 18/01/2023
Start: 26º 11' 36.7" S 29º 57' 13.0" E
Time: 75min
Length: 540m
Vegetation Unit:
Untransformed Grassland
Habitat: Grassland on fairly shallow light brown sandy loam soils on gentle NNW-facing slope on crest of gently undulating landscape. Patches of sparse grassland on skeletal, grey-brown soils overlying ferricrete also present.
No. species: 67

A	B	
		**TMS 144** **Date**: 21/01/2023 **Start:** 26º 10’ 45.1” S 30º 03’ 03.7” E **Time**: 35min **Length**: 350m **Vegetation Unit**: Untransformed Grassland **Habitat**: Grassland on fairly shallow, brown sandy loam soils on gentle NE-facing slope on crest of gently undulating landscape. **No. species**: 63 Photograph A taken in February 2023 and photograph B taken in Oct 2022.

		**TMS 107a** **Date**: 19/01/2023 **Start:** 26º 11’ 46.6” S 29º 57’14.3” E **Time**: 70min **Length**: 350m **Vegetation Unit**: Sandstone Scarp Shrubland **Habitat**: Grassland and shrubland communities of sheetrock (above cliffs), cliff, and steep, SSW-facing scree slopes below cliffs. **No. species**: 77




TMS 103

Date: 19/01/2023

Start: 26º 12’ 04.0” S 29º 27’ 57.9” E

Time: 125min

Length: 450

Vegetation Unit:
Sandstone Scarp Shrubland

Habitat: A mosaic of open shrubland, closed shrubland, well-developed dense thicket, rocky grassland and chasmophyte communities associated with tall cliffs (up to 6m in height), large boulders and steep, SW-facing scree slopes with numerous small seeps.

No. species: 113

TMS 123

Date: 20/01/2023
Start: 26º 13’ 49.3” S 29º 58’ 28.1” E
Time: 50min
Length: 360m
Vegetation Unit:
Sandstone Scarp Shrubland
Habitat: Sandstone scarp with low cliffs and large areas of sheetrock situated directly adjacent to a valley-bottom wetland. Vegetation comprises shrubland and sparse grassland of sheetrock habitats.
No. species: 70

TMS 44

Date: 13/01/2023
Start: 26º 12’ 20.4” S 29º 57’ 57.4” E
Time: 75min
Length: 490m
Vegetation Unit:
Valley-bottom & Seep wetland
Habitat: Seasonally to permanently saturated soils of large un-channelled valley-bottom wetland and associated seep. Transect mostly inundated at the time of the survey. Strong lateral zonation of vegetation.
No. species: 49


TMS 117
Date: 20/01/2023
Start: 26º 13’ 57.3” S 29º 58’ 25.3” E
Time: 65min
Length: 400m
Vegetation Unit:
Valley-bottom & Seep wetland
Habitat: Seasonally to permanently saturated soils of channelled valley-bottom wetland and adjacent seep. Wet sheetrock habitats present in seeps. Strong lateral zonation of vegetation.
No. species: 56

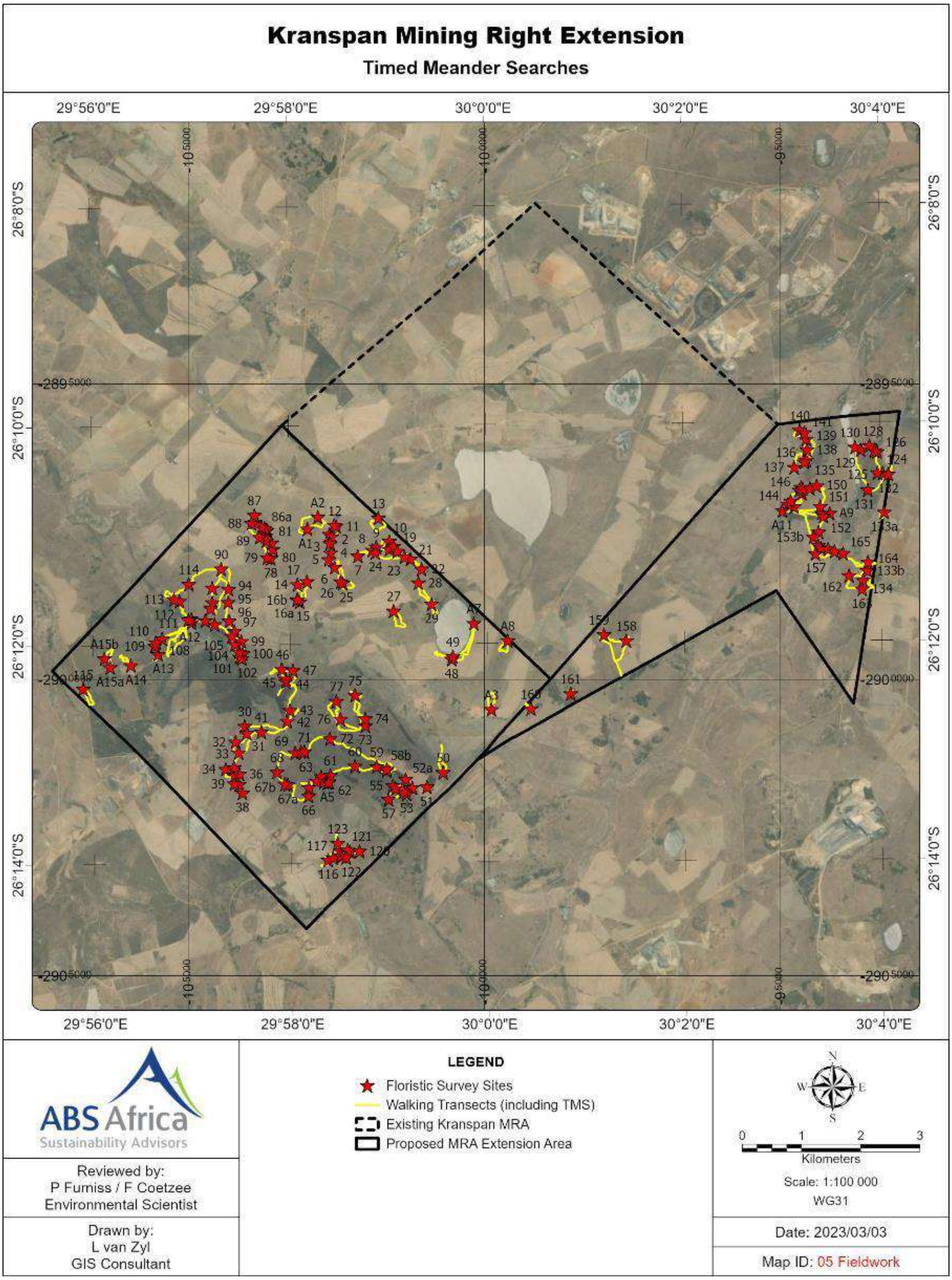

TMS 135
Date: 21/01/2022
Start: 26º 11’ 36.7” S 29º 58’ 06.1” E
Start: 26º 10’ 21.0” S 29º 03’ 15.0” E
Time: 45min
Length: 480m
Vegetation Unit:
Valley-bottom & Seep wetland
Habitat: Head-water seep with seasonally saturated soils and patches of skeletal soils overlying ferricrete.
No. species: 55

		**TMS 49** **Date**: 16/01/2022 **Start**: 26º 12’ 07.3” S 29º 59’ 39.1” E **Time**: 45min **Length**: 600m **Vegetation Unit**: Pan wetland **Habitat**: Margins (epi-littoral zone) of fully inundated Endorheic pan. **No. species**: 55

		**TMS 27** **Date**: 12/01/2023 **Start:** 26º 11 42.1” S 29º 59’ 03.2” E **Time**: 40min **Length**: 800m **Vegetation Unit**: Secondary Grassland **Habitat**: Secondary vegetation of an historically ploughed seep. **No. species**: 37

		**TMS 41** **Date**: 12/01/2023 **Start:** 26º 12 47.9” S 29º 57’ 42.2” E **Time**: 30min **Length**: 600m **Vegetation Unit**: Secondary Grassland **Habitat**: Secondary vegetation of an historically ploughed seep. **No. species**: 37

APPENDIX 4: Localities of all 193 sites walking transects surveyed within the Kranspan MRA Extension project area. All site numbers with an 'A' prefix were surveyed in October 2022 and all other sites were surveyed in January 2023.



APPENDIX 5: List of plant Species of Conservation Concern' (*sensu* Raimondo *et al*., 2009) historically recorded within the two quarter-degree grid squares within which the study area is situated, namely 2629AA and 2629BB. List also includes species not historically recorded in the aforementioned grid squares but listed in the Screening Tool report as potentially occurring on the basis of modelling conducted by SANBI. Species included in the Screening Tool as potentially occurring only on the basis of modelling are highlighted in grey. Lists of historically recorded species of conservation concern (SCC) were obtained from the Mpumalanga Tourism and Parks Agency's database of plant SCC and the New Plants of Southern Africa website (http://posa.sanbi.org., downloaded October 2022).

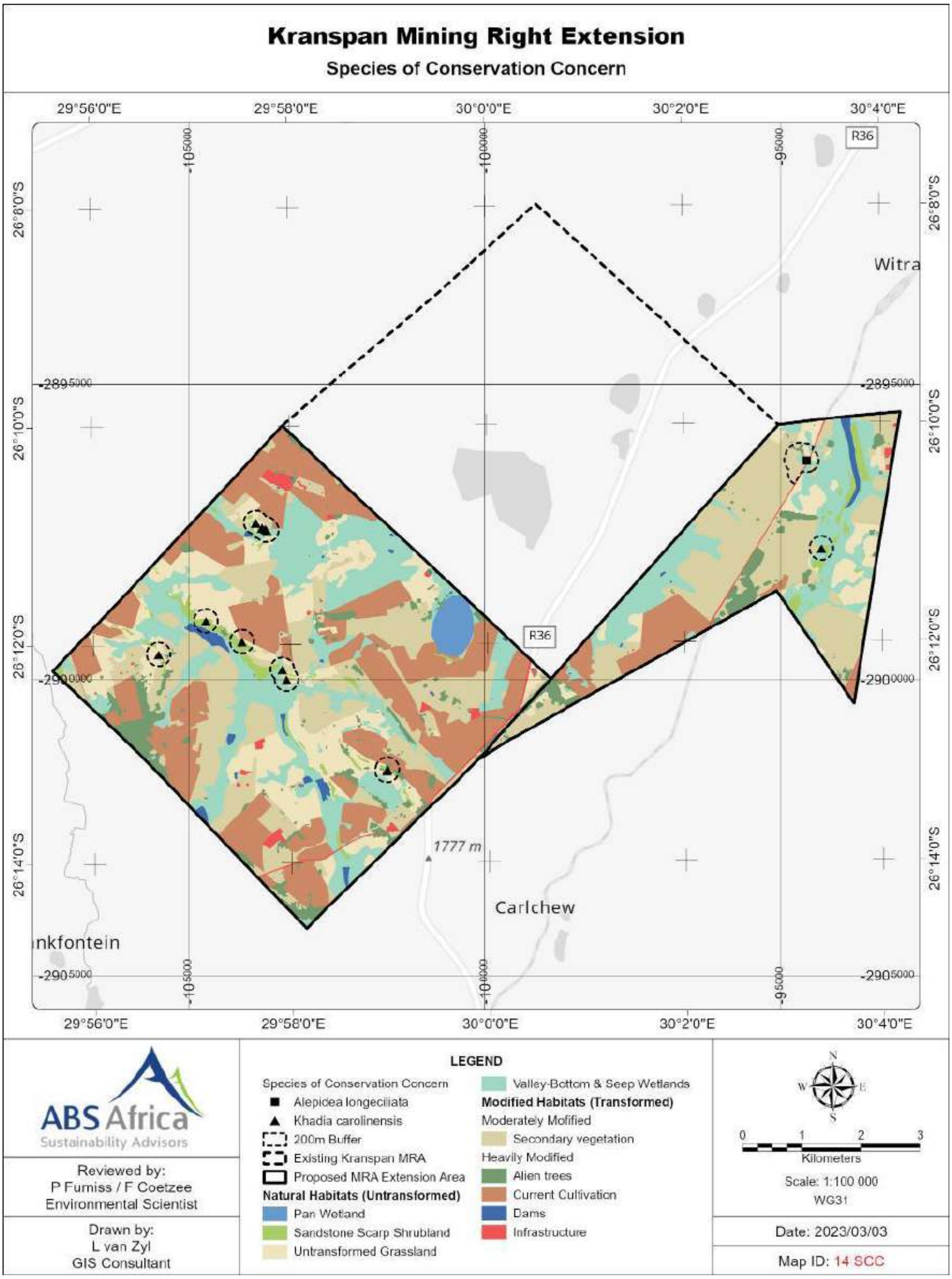
Taxon	**Conservation Status Category* at a National level**	**Habitat & occurrence**	**Flowering time**	**Likelihood of occurrence within the PA**
AIZOACEAE				
Khadia carolinensis (L. Bolus) L. Bolus	Vulnerable [**VU** A3c]	Well-drained sandy loam amongst low rocky outcrops, or at the edge of sandstone sheets in undulating Highveld grassland. 1700m.	September to December	**Confirmed** (Sites A13, 45, 46, 58, 86, 99, 107a & 155)
AMARYLLIDACEAE				
Nerine gracilis R.A. Dyer **Sensitive Species 691**	Vulnerable [**VU** B1ab (ii, iii, v)]	Found in Mpumalanga, North-West and Gauteng, in full sun in moist areas in grassland, usually in areas with an undulating topography. On hillslope seeps, vleis and banks of the upper reaches of streams. In the authors experience occurs predominantly on black, hydromorphic clay soils in areas that are periodically inundated. The nearest historical locality for this species in situated more than 50kms SSE of the project area and was recorded in 1936.	February to March	Low
APIACEAE				
Sensitive Species 1200	Endangered [**EN** A2c]	Grassland, Karoo Sandstone, above 1600 m. Possibly associated with edges of pans (http://redlist.sanbi.org, downloaded May 2019). In the authors experience of having recorded this species at three localities, this species is associated with moist terrestrial grassland hygrophilous grassland on the margins marsh vegetation of valley-bottom and seep wetlands.	November to January.	**Confirmed** (Sites & 135)
APOCYNACEAE				
Asclepias dissona N.E.Br.	Critically Endangered (Possible Extinct)	Damp grassland. Confirmed in 2630AA (Boesmanspruit 9IT) by all other historical records from eNtokozweni, Dullstroom and Weimarshoek more than 60km to the north of the	November & December	Low

Taxon	**Conservation Status Category* at a National level**	**Habitat & occurrence**	**Flowering time**	**Likelihood of occurrence within the PA**
		project area. Last recorded in 1932 and possible extinct.		
Aspidoglossum xanthosphaerum Hilliard	Vulnerable [**VU** D2]	Currently known from 18 specimens and approximately 12 localities (http://posa.sanbi.org and pers. com. P. Bester of SANBI), in south-eastern Mpumalanga and northern KZN around Ermelo, Carolina, Breyten (6 records), Wakkerstroom and Utrecht. According to Raimondo *et al.* (2009), recorded in 'montane grassland at marshy sites up to an altitude of 2000m'. The author has however recorded the species from two localities (Wonderfontein and Breyten), both in untransformed mesophytic grassland, and the view that it is predominately a species of mesophytic grassland is supported by P. Bester.	October and November	Moderate-High
Miraglossum davyi (N.E.Br.) Kupicha	Vulnerable [B1ab(ii,iii,iv,v)+B2ab(ii,iii,iv,v)]	Grassland on sand or heavy black loam. EOO<15 000 km² and known from five locations but suspected to occur at one or two more. Not historically recorded from the grids 2629BB or 2630AA.	January.	Low
Pachycarpus suaveolens (Schltr.) Nicholas & Goyder	Vulnerable [B1ab(iii)]	Short or annually burned grasslands, 1400-2000 masl. A very rare species known from only eight localities and not historically recorded within the grids 2629BB and 2630AA. Nearest known historical locality to project area is near Ermelo, but this locality is based on an herbarium specimen collected more than a century ago (http://posa.sanbi.org, accessed 03/03/2022).	December to January	Low
ASPHODELACEAE				
Kniphofia triangularis Kunth subsp. *obtusiloba* (A. Berger) Codd	Rare	Amongst quartzitic rocks in montane grassland. According to the MTPA database recorded from one locality in the grid 2630AA, but this locality is from near Slaaihoek in the high-lying, high rainfall parts of the Mpumalanga escarpment.	January to April	Low
FABACEAE				

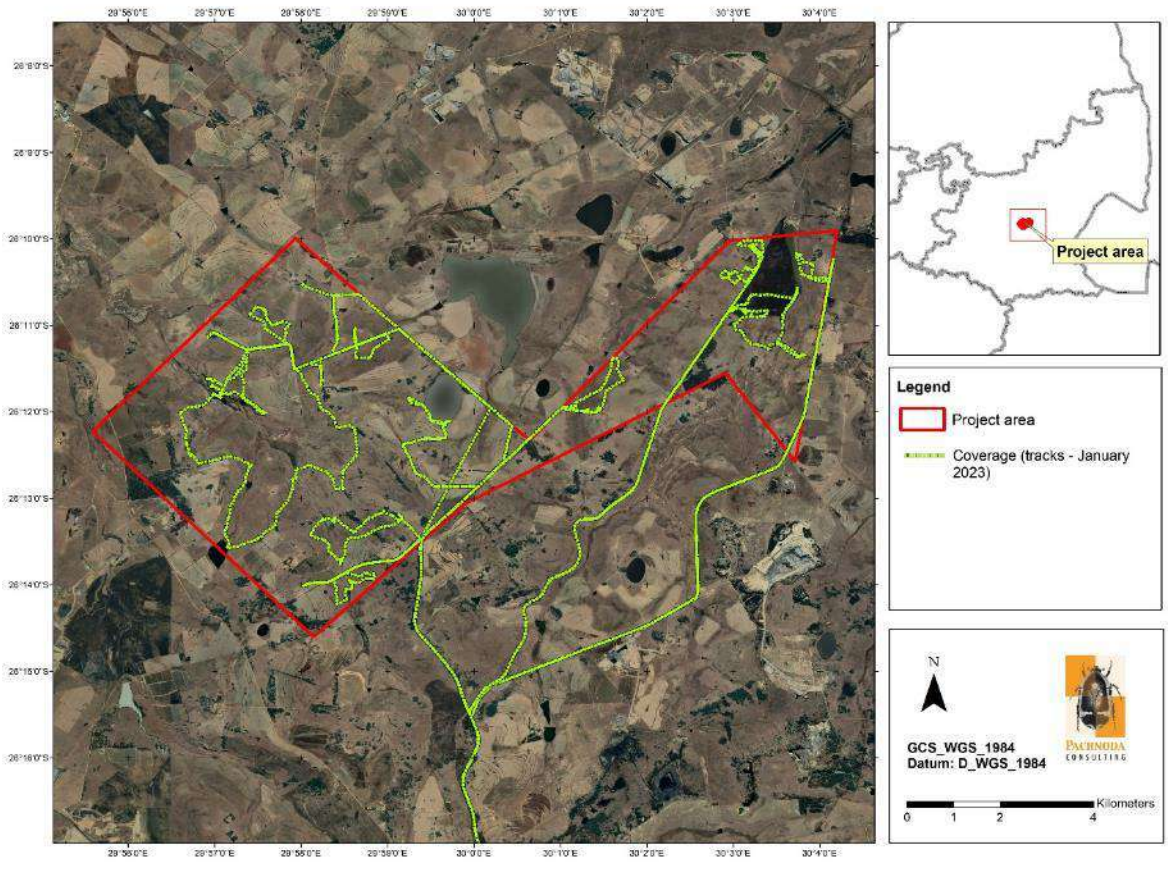
Taxon	Conservation Status Category* at a National level	Habitat & occurrence	Flowering time	Likelihood of occurrence within the PA
Lessertia phillipsiana Burtt Davy	Data Deficient – Insufficient Information (DDD)	A widespread but very poorly known species for which there is no published habitat description (Von Staden, 2016) and known from only six localities, all within the Highveld region (http://posa.sanbi.org, accessed 03/03/2022). Plants recorded by the author at two sites in the Ogies district, both sites in the seasonally or periodically flooded zones of endorheic pans that were dry at the time of the surveys and show signs of being moderately saline. Plants recorded by the author at Wonderfontein likewise occurred only in seasonally or periodically inundated zones of three large endorheic, saline pans, on largely bare clays in the company of *Chenopodium glaucum* or in species *poor Cynodon transvaalensis* dominated 'lawn' communities.	Not published, but recorded flowering by the author in January (Ogies) and from October to March (Wonderfontein).	Moderate-High
IRIDACEAE				
Gladiolus malvinus Goldbatt & J.C. Manning **Sensitive Species 1201**	Vulnerable [**VU** B1ab(i, ii, iii, iv, v)]	Known only from a small area (EOO 400km^2) of the hilly, upper Mpumalanga escarpment between Dullstroom and Belfast. Grows in heavy clay soils on dolerite outcrops in grassland.	October and November	Low
Gladiolus paludosus Baker **Sensitive Species 41**	Vulnerable [VU B1ab(i,ii,iii,iv,v) + 2ab(i,ii,iii,iv,v)]	In marshy or vlei habitats in high altitude grassland that remain wet throughout the year or dry out for only brief periods. Flowering in Spring before the grass flora has grown. A rare and localised species occurring from Dullstroom to Wakkerstroom. Only one record for this species (collected by the author at Spitskop Colliery in 2009) within a 15 km radius of the project area in the last 100 years (http://posa.sanbi.org, accessed 03/03/2022).	Mid-October to mid-November	Moderate

* Status follows the latest Red Data Plant Book of South African Plants (Raimondo *et al*., 2009), and the online Red List of South African Plants continuously updated by SANBI (http://redlist.sanbi.org, downloaded February 2023).

APPENDIX 6: Map of all localities for the threatened plant species *Khadia carolinensis* (VU) and *Sensitive Species 1200* recorded within the project area and proposed minimum buffer zones for these species, and a small-scale map of the minimum buffer zone prosed for *Sensitive Species 1200*.



APPENDIX 7: Coverage of the project area during faunal survey fieldwork in January 2023.



APPENDIX 8: A list of bird species expected to be present in the project area and immediate surroundings. The list provides an indication of the species occurrence according to SABAP2 reporting rates. The list was derived (and modified according to the availability of suitable habitat) from species recorded in pentad grid 2610_2955 and the eight surrounding grids. The reporting rates include submissions made during the January 2023 survey.

#	Common Name	Scientific Name	Global Red List category (IUCN, 2023)	Regional Red List category (Taylor et al, 2015)	SABAP2 Reporting Rate			
					Full Protocol (%)	Number of Cards	Ad Hoc Protocol (%)	Number of Cards
52	African Darter	*Anhinga rufa*			10.20	5	1.79	1
149	African Fish Eagle	*Haliaeetus vocifer*			14.29	7	0.00	0
360	African Grass Owl	*Tyto capensis*		VU	8.16	4	0.00	0
171	African Harrier-Hawk	*Polyboroides typus*			6.12	3	0.00	0
418	African Hoopoe	*Upupa africana*			4.08	2	0.00	0
167	African Marsh Harrier	*Circus ranivorus*		EN	8.16	4	0.00	0
387	African Palm Swift	*Cypsiurus parvus*			4.08	2	0.00	0
682	African Paradise Flycatcher	*Terpsiphone viridis*			2.04	1	0.00	0
692	African Pipit	*Anthus cinnamomeus*			73.47	36	3.57	2
197	African Rail	*Rallus caerulescens*			12.24	6	0.00	0
666	African Yellow Warbler	*Iduna natalensis*			2.04	1	0.00	0
386	Alpine Swift	*Tachymarptis melba*			2.04	1	0.00	0
606	Common Reed Warbler	*Acrocephalus scirpaceus*			20.41	10	0.00	0
81	African Sacred Ibis	*Threskiornis aethiopicus*			36.73	18	1.79	1
250	African Snipe	*Gallinago nigripennis*			48.98	24	1.79	1
85	African Spoonbill	*Platalea alba*			20.41	10	3.57	2
576	African Stonechat	*Saxicola torquatus*			85.71	42	14.29	8
208	African Swamphen	*Porphyrio madagascariensis*			22.45	11	7.14	4
247	African Wattled Lapwing	*Vanellus senegallus*			36.73	18	3.57	2
119	Amur Falcon	*Falco amurensis*			24.49	12	3.57	2
575	Ant-eating Chat	*Myrmecocichla formicivora*			85.71	42	10.71	6
202	Baillon's Crake	*Zapornia pusilla*			2.04	1	0.00	0
510	Banded Martin	*Riparia cincta*			46.94	23	1.79	1

#	Common Name	Scientific Name	Global Red List category (IUCN, 2023)	Regional Red List category (Taylor et al, 2015)	SABAP2 Reporting Rate			
					Full Protocol (%)	Number of Cards	Ad Hoc Protocol (%)	Number of Cards
493	Barn Swallow	*Hirundo rustica*			57.14	28	5.36	3
622	Bar-throated Apalis	*Apalis thoracica*			4.08	2	0.00	0
203	Black Crake	*Zapornia flavirostra*			12.24	6	0.00	0
159	Black Sparrowhawk	*Accipiter melanoleucus*			6.12	3	0.00	0
650	Black-chested Prinia	*Prinia flavicans*			42.86	21	0.00	0
431	Black-collared Barbet	*Lybius torquatus*			18.37	9	0.00	0
55	Black-headed Heron	*Ardea melanocephala*			63.27	31	5.36	3
245	Blacksmith Lapwing	*Vanellus armatus*			79.59	39	7.14	4
860	Black-throated Canary	*Crithagra atrogularis*			59.18	29	3.57	2
130	Black-winged Kite	*Elanus caeruleus*			81.63	40	25.00	14
282	Black-winged Pratincole	*Glareola nordmanni*	NT	NT	4.08	2	0.00	0
270	Black-winged Stilt	*Himantopus himantopus*			30.61	15	3.57	2
223	Blue Korhaan	*Eupodotis caerulescens*	NT		26.53	13	0.00	0
99	Blue-billed Teal	*Spatula hottentota*			6.12	3	7.14	4
722	Bokmakierie	*Telophorus zeylonus*			57.14	28	3.57	2
823	Bronze Mannikin	*Spermestes cucullata*			2.04	1	0.00	0
509	Brown-throated Martin	*Riparia paludicola*			44.90	22	7.14	4
873	Cape Bunting	*Emberiza capensis*			6.12	3	0.00	0
857	Cape Canary	*Serinus canicollis*			57.14	28	1.79	1
703	Cape Longclaw	*Macronyx capensis*			93.88	46	8.93	5
581	Cape Robin-Chat	*Cossypha caffra*			55.10	27	5.36	3
94	Cape Shoveler	*Spatula smithii*			32.65	16	7.14	4
786	Cape Sparrow	*Passer melanurus*			75.51	37	3.57	2
98	Cape Teal	*Anas capensis*			4.08	2	3.57	2
316	Ring-necked Dove	*Streptopelia capicola*			95.92	47	12.50	7
686	Cape Wagtail	*Motacilla capensis*			65.31	32	10.71	6
799	Cape Weaver	*Ploceus capensis*			20.41	10	0.00	0

#	Common Name	Scientific Name	Global Red List category (IUCN, 2023)	Regional Red List category (Taylor et al, 2015)	SABAP2 Reporting Rate			
					Full Protocol (%)	Number of Cards	Ad Hoc Protocol (%)	Number of Cards
1172	Cape White-eye	*Zosterops virens*			16.33	8	0.00	0
618	Cape Grassbird	*Sphenoeacus afer*			2.04	1	0.00	0
568	Capped Wheatear	*Oenanthe pileata*			16.33	8	0.00	0
450	Cardinal Woodpecker	*Dendropicos fuscescens*			6.12	3	0.00	0
872	Cinnamon-breasted Bunting	*Emberiza tahapisi*			2.04	1	0.00	0
631	Cloud Cisticola	*Cisticola textrix*			26.53	13	0.00	0
196	Common Buttonquail	*Turnix sylvaticus*			4.08	2	0.00	0
154	Common (=Steppe) Buzzard	*Buteo buteo vulpinus*			40.82	20	7.14	4
263	Common Greenshank	*Tringa nebularia*			10.20	5	1.79	1
507	Common House Martin	*Delichon urbicum*			6.12	3	0.00	0
210	Common Moorhen	*Gallinula chloropus*			46.94	23	12.50	7
734	Common Myna	*Acridotheres tristis*			18.37	9	1.79	1
189	Common Quail	*Coturnix coturnix*			51.02	25	0.00	0
233	Common Ringed Plover	*Charadrius hiaticula*			2.04	1	0.00	0
258	Common Sandpiper	*Actitis hypoleucos*			2.04	1	0.00	0
378	Common Swift	*Apus apus*			16.33	8	0.00	0
843	Common Waxbill	*Estrilda astrild*			63.27	31	7.14	4
439	Crested Barbet	*Trachyphonus vaillantii*			6.12	3	0.00	0
242	Crowned Lapwing	*Vanellus coronatus*			67.35	33	0.00	0
545	Dark-capped Bulbul	*Pycnonotus tricolor*			34.69	17	3.57	2
352	Diederik Cuckoo	*Chrysococcyx caprius*			38.78	19	1.79	1
219	Denham's Bustard	*Neotis denhami*		VU	2.04	1	0.00	0
1183	Eastern Clapper Lark	*Mirafra fasciolata*			24.49	12	0.00	0
89	Egyptian Goose	*Alopochen aegyptiaca*			77.55	38	12.50	7
404	European Bee-eater	*Merops apiaster*			6.12	3	0.00	0
132	European Honey-buzzard	*Pernis apivorus*			2.04	1	0.00	0
816	Fan-tailed Widowbird	*Euplectes axillaris*			53.06	26	1.79	1

#	Common Name	Scientific Name	Global Red List category (IUCN, 2023)	Regional Red List category (Taylor et al, 2015)	SABAP2 Reporting Rate			
					Full Protocol (%)	Number of Cards	Ad Hoc Protocol (%)	Number of Cards
665	Fiscal Flycatcher	*Melaenornis silens*			14.29	7	0.00	0
101	Fulvous Whistling Duck	*Dendrocygna bicolor*			6.12	3	0.00	0
395	Giant Kingfisher	*Megaceryle maxima*			8.16	4	1.79	1
83	Glossy Ibis	*Plegadis falcinellus*			28.57	14	3.57	2
56	Goliath Heron	*Ardea goliath*			6.12	3	0.00	0
4	Great Crested Grebe	*Podiceps cristatus*			2.04	1	0.00	0
58	Great Egret	*Ardea alba*			18.37	9	3.57	2
86	Greater Flamingo	*Phoenicopterus roseus*		NT	8.16	4	7.14	4
440	Greater Honeyguide	*Indicator indicator*			4.08	2	0.00	0
502	Greater Striped Swallow	*Cecropis cucullata*			57.14	28	5.36	3
419	Green Wood Hoopoe	*Phoeniculus purpureus*			10.20	5	0.00	0
54	Grey Heron	*Ardea cinerea*			34.69	17	8.93	5
288	Grey-headed Gull	*Chroicocephalus cirrocephalus*			16.33	8	10.71	6
176	Grey-winged Francolin	*Scleroptila afra*			12.24	6	0.00	0
84	Hadada Ibis	*Bostrychia hagedash*			83.67	41	0.00	0
72	Hamerkop	*Scopus umbretta*			6.12	3	0.00	0
192	Helmeted Guineafowl	*Numida meleagris*			44.90	22	3.57	2
384	Horus Swift	*Apus horus*			14.29	7	0.00	0
784	House Sparrow	*Passer domesticus*			24.49	12	3.57	2
60	Intermediate Egret	*Ardea intermedia*			40.82	20	1.79	1
152	Jackal Buzzard	*Buteo rufofuscus*			4.08	2	3.57	2
237	Kittlitz's Plover	*Charadrius pecuarius*			14.29	7	0.00	0
114	Lanner Falcon	*Falco biarmicus*		VU	4.08	2	0.00	0
317	Laughing Dove	*Spilopelia senegalensis*			63.27	31	1.79	1
87	Lesser Flamingo	*Phoeniconaias minor*	NT	NT	4.08	2	3.57	2
706	Lesser Grey Shrike	*Lanius minor*			4.08	2	0.00	0
442	Lesser Honeyguide	*Indicator minor*			2.04	1	0.00	0

#	Common Name	Scientific Name	Global Red List category (IUCN, 2023)	Regional Red List category (Taylor et al, 2015)	SABAP2 Reporting Rate			
					Full Protocol (%)	Number of Cards	Ad Hoc Protocol (%)	Number of Cards
604	Lesser Swamp Warbler	*Acrocephalus gracilirostris*			28.57	14	3.57	2
646	Levaillant's Cisticola	*Cisticola tinniens*			87.76	43	12.50	7
67	Little Bittern	*Ixobrychus minutus*			2.04	1	1.79	1
59	Little Egret	*Egretta garzetta*			16.33	8	0.00	0
6	Little Grebe	*Tachybaptus ruficollis*			61.22	30	14.29	8
609	Little Rush Warbler	*Bradypterus baboecala*			20.41	10	3.57	2
253	Little Stint	*Calidris minuta*			16.33	8	0.00	0
385	Little Swift	*Apus affinis*			18.37	9	1.79	1
138	Long-crested Eagle	*Lophaetus occipitalis*			2.04	1	0.00	0
818	Long-tailed Widowbird	*Euplectes progne*			89.80	44	23.21	13
103	Maccoa Duck	*Oxyura maccoa*	EN	VU	8.16	4	3.57	2
397	Malachite Kingfisher	*Corythornis cristatus*			2.04	1	0.00	0
751	Malachite Sunbird	*Nectarinia famosa*			18.37	9	1.79	1
361	Marsh Owl	*Asio capensis*			22.45	11	1.79	1
262	Marsh Sandpiper	*Tringa stagnatilis*			2.04	1	0.00	0
142	Martial Eagle	*Polemaetus bellicosus*	EN	EN	2.04	1	0.00	0
573	Mocking Cliff Chat	*Thamnolaea cinnamomeiventris*			4.08	2	0.00	0
564	Mountain Wheatear	*Myrmecocichla monticola*			22.45	11	0.00	0
183	Natal Spurfowl	*Pternistis natalensis*			8.16	4	0.00	0
10877	Nicholson's Pipit	*Anthus niholsoni*			2.04	1	0.00	0
1035	Northern Black Korhaan	*Afrotis afraoides*			2.04	1	0.00	0
637	Neddicky	*Cisticola fulvicapilla*			18.37	9	0.00	0
838	Orange-breasted Waxbill	*Amandava subflava*			16.33	8	1.79	1
635	Pale-crowned Cisticola	*Cisticola cinnamomeus*			24.49	12	1.79	1
269	Pied Avocet	*Recurvirostra avosetta*			8.16	4	0.00	0
522	Pied Crow	*Corvus albus*			8.16	4	1.79	1
394	Pied Kingfisher	*Ceryle rudis*			6.12	3	1.79	1

#	Common Name	Scientific Name	Global Red List category (IUCN, 2023)	Regional Red List category (Taylor et al, 2015)	SABAP2 Reporting Rate			
					Full Protocol (%)	Number of Cards	Ad Hoc Protocol (%)	Number of Cards
746	Pied Starling	*Lamprotornis bicolor*			71.43	35	16.07	9
490	Pink-billed Lark	*Spizocorys conirostris*			2.04	1	0.00	0
846	Pin-tailed Whydah	*Vidua macroura*			44.90	22	8.93	5
694	Plain-backed Pipit	*Anthus leucophrys*			2.04	1	0.00	0
57	Purple Heron	*Ardea purpurea*			8.16	4	5.36	3
844	Quailfinch	*Ortygospiza atricollis*			55.10	27	0.00	0
805	Red-billed Quelea	*Quelea quelea*			34.69	17	1.79	1
97	Red-billed Teal	*Anas erythrorhyncha*			46.94	23	7.14	4
488	Red-capped Lark	*Calandrella cinerea*			38.78	19	0.00	0
343	Red-chested Cuckoo	*Cuculus solitarius*			4.08	2	0.00	0
205	Red-chested Flufftail	*Sarothrura rufa*			10.20	5	0.00	0
813	Red-collared Widowbird	*Euplectes ardens*			8.16	4	5.36	3
314	Red-eyed Dove	*Streptopelia semitorquata*			69.39	34	8.93	5
820	Red-headed Finch	*Amadina erythrocephala*			6.12	3	0.00	0
212	Red-knobbed Coot	*Fulica cristata*			83.67	41	23.21	13
453	Red-throated Wryneck	*Jynx ruficollis*			16.33	8	0.00	0
178	Red-winged Francolin	*Scleroptila levaillantii*			18.37	9	0.00	0
50	Reed Cormorant	*Microcarbo africanus*			69.39	34	10.71	6
940	Rock Dove	*Columba livia*			14.29	7	1.79	1
123	Rock Kestrel	*Falco rupicolus*			4.08	2	0.00	0
506	Rock Martin	*Ptyonoprogne fuligula*			8.16	4	0.00	0
256	Ruff	*Calidris pugnax*			8.16	4	3.57	2
105	Secretarybird	*Sagittarius serpentarius*	EN	EN	6.12	3	3.57	2
608	Sedge Warbler	*Acrocephalus schoenobaenus*			2.04	1	0.00	0
504	South African Cliff Swallow	*Petrochelidon spilodera*			22.45	11	5.36	3
90	South African Shelduck	*Tadorna cana*			18.37	9	5.36	3
707	Southern Fiscal	*Lanius collaris*			91.84	45	19.64	11

#	Common Name	Scientific Name	Global Red List category (IUCN, 2023)	Regional Red List category (Taylor et al, 2015)	SABAP2 Reporting Rate			
					Full Protocol (%)	Number of Cards	Ad Hoc Protocol (%)	Number of Cards
82	Southern Bald Ibis	*Geronticus calvus*	VU	VU	24.49	12	5.36	3
4142	Southern Grey-headed Sparrow	*Passer diffusus*			38.78	19	1.79	1
803	Southern Masked Weaver	*Ploceus velatus*			83.67	41	16.07	9
102	Southern Pochard	*Netta erythrophthalma*			32.65	16	5.36	3
808	Southern Red Bishop	*Euplectes orix*			79.59	39	10.71	6
390	Speckled Mousebird	*Colius striatus*			16.33	8	0.00	0
311	Speckled Pigeon	*Columba guinea*			65.31	32	5.36	3
474	Spike-heeled Lark	*Chersomanes albofasciata*			32.65	16	1.79	1
368	Spotted Eagle-Owl	*Bubo africanus*			4.08	2	0.00	0
275	Spotted Thick-knee	*Burhinus capensis*			22.45	11	0.00	0
88	Spur-winged Goose	*Plectropterus gambensis*			57.14	28	5.36	3
62	Squacco Heron	*Ardeola ralloides*			6.12	3	5.36	3
867	Streaky-headed Seedeater	*Crithagra gularis*			2.04	1	0.00	0
185	Swainson's Spurfowl	*Pternistis swainsonii*			65.31	32	5.36	3
649	Tawny-flanked Prinia	*Prinia subflava*			6.12	3	0.00	0
238	Three-banded Plover	*Charadrius tricollaris*			44.90	22	5.36	3
639	Wailing Cisticola	*Cisticola lais*			4.08	2	0.00	0
359	Western Barn Owl	*Tyto alba*			4.08	2	0.00	0
61	Western Cattle Egret	*Bubulcus ibis*			59.18	29	3.57	2
689	Western Yellow Wagtail	*Motacilla flava*			4.08	2	0.00	0
305	Whiskered Tern	*Chlidonias hybrida*			48.98	24	8.93	5
80	White Stork	*Ciconia ciconia*			6.12	3	0.00	0
104	White-backed Duck	*Thalassornis leuconotus*			16.33	8	7.14	4
47	White-breasted Cormorant	*Phalacrocorax lucidus*			16.33	8	0.00	0
383	White-rumped Swift	*Apus caffer*			34.69	17	3.57	2
495	White-throated Swallow	*Hirundo albigularis*			30.61	15	3.57	2
304	White-winged Tern	*Chlidonias leucopterus*			12.24	6	8.93	5

#	Common Name	Scientific Name	Global Red List category (IUCN, 2023)	Regional Red List category (Taylor et al, 2015)	SABAP2 Reporting Rate			
					Full Protocol (%)	Number of Cards	Ad Hoc Protocol (%)	Number of Cards
814	White-winged Widowbird	*Euplectes albonotatus*			6.12	3	1.79	1
599	Willow Warbler	*Phylloscopus trochilus*			14.29	7	0.00	0
634	Wing-snapping Cisticola	*Cisticola ayresii*			59.18	29	1.79	1
264	Wood Sandpiper	*Tringa glareola*			26.53	13	3.57	2
866	Yellow Canary	*Crithagra flaviventris*			16.33	8	0.00	0
96	Yellow-billed Duck	*Anas undulata*			83.67	41	14.29	8
812	Yellow-crowned Bishop	*Euplectes afer*			59.18	29	7.14	4
859	Yellow-fronted Canary	*Crithagra mozambica*			4.08	2	0.00	0
629	Zitting Cisticola	*Cisticola juncidis*			65.31	32	5.36	3

APPENDIX 9: A shortlist of bird species observed in the project area during the January 2023 fieldwork.

Common Name	Scientific Name	Date Of Initial Observation	Time Of Initial Observation	Latitude	Longitude	Altitude
African Grass Owl	*Tyto capensis*	2023/01/20	08:16:16	-26.2271	29.97249	1704
African Palm Swift	*Cypsiurus parvus*	2023/01/18	15:54:03	-26.1985	29.95663	1698
African Pipit	*Anthus cinnamomeus*	2023/01/18	13:52:35	-26.1822	29.96022	1693
African Rail	*Rallus caerulescens*	2023/01/18	16:45:51	-26.1967	29.9526	1705
African Sacred Ibis	*Threskiornis aethiopicus*	2023/01/19	08:32:20	-26.2119	29.95617	1677
African Snipe	*Gallinago nigripennis*	2023/01/20	14:26:24	-26.1965	30.02291	1679
African Spoonbill	*Platalea alba*	2023/01/19	07:02:27	-26.1967	29.95137	1701
African Stonechat	*Saxicola torquatus*	2023/01/18	16:12:00	-26.2003	29.95904	1711
African Swamphen	*Porphyrio madagascariensis*	2023/01/21	11:23:35	-26.1784	30.06148	1718
African Wattled Lapwing	*Vanellus senegallus*	2023/01/19	10:37:15	-26.2107	29.9694	1674
African Yellow Warbler	*Iduna natalensis*	2023/01/18	16:01:57	-26.1985	29.95661	1709
Alpine Swift	*Tachymarptis melba*	2023/01/20	14:15:51	-26.1982	30.01968	1686
Amur Falcon	*Falco amurensis*	2023/01/19	13:40:07	-26.1884	29.98057	1674
Ant-eating Chat	*Myrmecocichla formicivora*	2023/01/18	14:05:02	-26.1802	29.95931	1696
Baillon's Crake	*Zaporina pusilla*	2023/01/19	07:14:20	-26.1965	29.94957	1656
Banded Martin	*Neophedina cincta*	2023/01/18	12:50:00	-26.1866	29.96348	1709
Barn Swallow	*Hirundo rustica*	2023/01/18	13:03:36	-26.1833	29.96448	1698
Bar-throated Apalis	*Apalis thoracica*	2023/01/18	16:01:11	-26.1985	29.95663	1698
Black Crake	*Zaporina flavirostra*	2023/01/19	07:14:14	-26.1965	29.94954	1657
Black Sparrowhawk	*Accipiter melanoleucus*	2023/01/20	06:39:39	-26.2205	29.98463	1773
Black-headed Heron	*Ardea melanocephala*	2023/01/18	13:42:54	-26.1823	29.96016	1703
Blacksmith Lapwing	*Vanellus armatus*	2023/01/18	15:54:53	-26.1985	29.95663	1698
Black-throated Canary	*Crithagra atrogularis*	2023/01/18	15:54:22	-26.1985	29.95663	1698
Black-winged Kite	*Elanus caeruleus*	2023/01/19	06:34:48	-26.188	29.95629	1736
Black-winged Stilt	*Himantopus himantopus*	2023/01/20	07:25:15	-26.2205	29.973	1698
Blue-billed Teal	*Anas hottentota*	2023/01/18	16:06:25	-26.1986	29.95693	1702

Common Name	Scientific Name	Date Of Initial Observation	Time Of Initial Observation	Latitude	Longitude	Altitude
Bokmakierie	*Telophorus zeylonus*	2023/01/18	15:49:55	-26.1985	29.95663	1708
Bronze Mannikin	*Lonchura cucullata*	2023/01/20	06:43:44	-26.2197	29.98338	1759
Brown-throated Martin	*Riparia paludicola*	2023/01/19	06:55:25	-26.1963	29.951	1719
Cape Bunting	*Emberiza capensis*	2023/01/19	06:55:32	-26.1963	29.951	1719
Cape Canary	*Serinus canicollis*	2023/01/18	15:03:47	-26.188	29.95631	1701
Cape Grassbird	*Sphenoeacus afer*	2023/01/18	15:50:02	-26.1985	29.95663	1708
Cape Longclaw	*Macronyx capensis*	2023/01/18	12:39:17	-26.1869	29.96358	1704
Cape Robin-Chat	*Cossypha caffra*	2023/01/18	15:51:10	-26.1985	29.95663	1697
Cape Robin-Chat	*Cossypha caffra*	2023/01/21	12:51:32	-26.1773	30.06194	1680
Cape Shoveler	*Anas smithii*	2023/01/18	16:38:10	-26.1967	29.95261	1702
Cape Sparrow	*Passer melanurus*	2023/01/18	13:52:21	-26.1823	29.9602	1698
Cape Teal	*Anas capensis*	2023/01/20	07:25:08	-26.2205	29.973	1698
Cape Wagtail	*Motacilla capensis*	2023/01/18	15:54:28	-26.1985	29.95663	1698
Cape Weaver	*Ploceus capensis*	2023/01/18	15:50:53	-26.1985	29.95663	1697
Cape White-eye	*Zosterops virens*	2023/01/18	13:52:27	-26.1823	29.9602	1698
Cardinal Woodpecker	*Dendropicos fuscescens*	2023/01/21	14:52:05	-26.1773	30.06194	1680
Cloud Cisticola	*Cisticola textrix*	2023/01/18	12:38:48	-26.1869	29.96358	1702
Common Buttonquail	*Turnix sylvaticus*	2023/01/18	17:03:40	-26.1937	29.94846	1680
Common Buzzard	*Buteo buteo*	2023/01/18	13:04:08	-26.1833	29.96451	1702
Common Greenshank	*Tringa nebularia*	2023/01/19	07:16:25	-26.1967	29.94963	1666
Common House Martin	*Delichon urbicum*	2023/01/20	14:15:38	-26.2015	29.99162	1686
Common Moorhen	*Gallinula chloropus*	2023/01/20	07:25:23	-26.2205	29.973	1698
Common Quail	*Coturnix coturnix*	2023/01/18	12:36:43	-26.1869	29.96359	1700
Common Reed Warbler	*Acrocephalus scirpaceus*	2023/01/19	07:14:29	-26.1965	29.94956	1659
Common Waxbill	*Estrilda astrild*	2023/01/18	12:36:18	-26.1869	29.96359	1708
Crowned Lapwing	*Vanellus coronatus*	2023/01/18	13:05:54	-26.1833	29.96451	1702
Dark-capped Bulbul	*Pycnonotus tricolor*	2023/01/18	15:50:16	-26.1985	29.95663	1698
Denham's Bustard	*Neotis denhami*	2023/01/18	16:53:43	-26.1957	29.95082	1688

Common Name	Scientific Name	Date Of Initial Observation	Time Of Initial Observation	Latitude	Longitude	Altitude
Diederik Cuckoo	*Chrysococcyx caprius*	2023/01/18	13:42:46	-26.1823	29.96016	1702
Eastern Clapper Lark	*Mirafra fasciolata*	2023/01/18	17:33:35	-26.1921	29.95463	1677
Egyptian Goose	*Alopochen aegyptiaca*	2023/01/18	16:38:18	-26.1967	29.9526	1701
Fan-tailed Widowbird	*Euplectes axillaris*	44944	0.547708	-26.1833	29.9645	1700
Fulvous Whistling Duck	*Dendrocygna bicolor*	44945	0.362037	-26.2135	29.95609	1675
Giant Kingfisher	*Megaceryle maxima*	44947	0.488356	-26.1762	30.06225	1664
Glossy Ibis	*Plegadis falcinellus*	44944	0.693356	-26.1967	29.9526	1702
Greater Striped Swallow	*Cecropis cucullata*	44944	0.526817	-26.1869	29.96358	1702
Grey Heron	*Ardea cinerea*	44944	0.697801	-26.1967	29.9526	1704
Grey-winged Francolin	*Scleroptila afra*	44945	0.274398	-26.188	29.95629	1741
Hadada Ibis	*Bostrychia hagedash*	44944	0.545671	-26.1833	29.96457	1704
Horus Swift	*Apus horus*	44945	0.344306	-26.2085	29.95282	1714
Intermediate Egret	*Ardea intermedia*	44946	0.627882	-26.1938	30.02898	1699
Lesser Swamp Warbler	*Acrocephalus gracilirostris*	44944	0.683102	-26.2001	29.95961	1706
Levaillant's Cisticola	*Cisticola tinniens*	44946	0.599907	-26.197	30.02194	1694
Little Egret	*Egretta garzetta*	44946	0.396215	-26.237	29.97357	1694
Little Grebe	*Tachybaptus ruficollis*	44947	0.488241	-26.1762	30.06226	1663
Little Rush Warbler	*Bradypterus baboecala*	44944	0.682882	-26.2002	29.95963	1710
Little Stint	*Calidris minuta*	44944	0.700671	-26.1966	29.95248	1708
Long-crested Eagle	*Lophaetus occipitalis*	44946	0.344815	-26.2271	29.97244	1687
Long-tailed Widowbird	*Euplectes progne*	44944	0.525278	-26.1869	29.96361	1708
Malachite Kingfisher	*Corythornis cristatus*	44946	0.396377	-26.237	29.97359	1685
Malachite Sunbird	*Nectarinia famosa*	44944	0.660602	-26.1985	29.95663	1697
Marsh Owl	*Asio capensis*	44946	0.447766	-26.2315	29.98072	1682
Mountain Wheatear	*Myrmecocichla monticola*	44944	0.566308	-26.1832	29.96093	1692
Neddicky	*Cisticola fulvicapilla*	44945	0.32485	-26.2065	29.9447	1666
Nicholson's Pipit	*Anthus nicholsoni*	44944	0.578333	-26.1822	29.96021	1692
Northern Black Korhaan	*Afrotis afraoides*	44944	0.573808	-26.1823	29.96016	1702

Common Name	Scientific Name	Date Of Initial Observation	Time Of Initial Observation	Latitude	Longitude	Altitude
Pale-crowned Cisticola	*Cisticola cinnamomeus*	44944	0.527025	-26.1869	29.96358	1703
Pied Starling	*Lamprotornis bicolor*	44944	0.53941	-26.1842	29.96369	1698
Pin-tailed Whydah	*Vidua macroura*	44944	0.607951	-26.1855	29.9621	1704
Purple Heron	*Ardea purpurea*	44946	0.318704	-26.2213	29.97295	1710
Quailfinch	*Ortygospiza atricollis*	44944	0.544236	-26.1833	29.96451	1703
Red-billed Quelea	*Quelea quelea*	44944	0.659826	-26.1984	29.95663	1699
Red-capped Lark	*Calandrella cinerea*	44944	0.73191	-26.1921	29.95462	1712
Red-chested Flufftail	*Sarothrura rufa*	44944	0.661088	-26.1985	29.95663	1697
Red-collared Widowbird	*Euplectes ardens*	44944	0.712488	-26.1937	29.94846	1679
Red-eyed Dove	*Streptopelia semitorquata*	44944	0.566227	-26.1832	29.96092	1700
Red-knobbed Coot	*Fulica cristata*	44944	0.627778	-26.188	29.9563	1709
Red-throated Wryneck	*Jynx ruficollis*	44944	0.608032	-26.1855	29.96213	1704
Reed Cormorant	*Microcarbo africanus*	44945	0.290868	-26.1966	29.95151	1707
Ring-necked Dove	*Streptopelia capicola*	44944	0.566076	-26.1832	29.96092	1700
Rock Martin	*Ptyonoprogne fuligula*	44944	0.662604	-26.1985	29.95663	1698
Ruff	*Calidris pugnax*	44944	0.700613	-26.1966	29.95248	1708
South African Cliff Swallow	*Petrochelidon spilodera*	44946	0.599815	-26.1971	30.02198	1690
South African Shelduck	*Tadorna cana*	44945	0.288646	-26.1963	29.95099	1712
Southern Fiscal	*Lanius collaris*	44944	0.544456	-26.1833	29.96451	1703
Southern Masked Weaver	*Ploceus velatus*	44944	0.566424	-26.1832	29.96093	1692
Southern Pochard	*Netta erythrophthalma*	44946	0.309051	-26.2204	29.97299	1767
Southern Red Bishop	*Euplectes orix*	44944	0.525382	-26.1869	29.9636	1699
Speckled Pigeon	*Columba guinea*	44944	0.566134	-26.1832	29.96092	1700
Spotted Eagle-Owl	*Bubo africanus*	44946	0.277373	-26.2205	29.98462	1776
Spotted Thick-knee	*Burhinus capensis*	44946	0.27772	-26.2205	29.98463	1772
Spur-winged Goose	*Plectropterus gambensis*	44944	0.670914	-26.1986	29.95694	1714
Squacco Heron	*Ardeola ralloides*	44946	0.396285	-26.237	29.97357	1694
Swainson's Spurfowl	*Pternistis swainsonii*	44945	0.274236	-26.188	29.95626	1741

Common Name	Scientific Name	Date Of Initial Observation	Time Of Initial Observation	Latitude	Longitude	Altitude
Tawny-flanked Prinia	*Prinia subflava*	44944	0.668993	-26.1985	29.95667	1704
Three-banded Plover	*Charadrius tricollaris*	44944	0.580579	-26.181	29.96001	1698
Wailing Cisticola	*Cisticola lais*	44944	0.682755	-26.2002	29.95968	1714
Western Barn Owl	*Tyto alba*	44946	0.277442	-26.2205	29.98463	1773
Western Cattle Egret	*Bubulcus ibis*	44944	0.70684	-26.1951	29.94939	1665
Whiskered Tern	*Chlidonias hybrida*	44944	0.693079	-26.1967	29.95259	1702
White-rumped Swift	*Apus caffer*	44945	0.288391	-26.1963	29.95116	1731
Willow Warbler	*Phylloscopus trochilus*	44945	0.337558	-26.2095	29.94818	1714
Wing-snapping Cisticola	*Cisticola ayresii*	44944	0.527188	-26.1869	29.96358	1703
Wood Sandpiper	*Tringa glareola*	44944	0.693519	-26.1967	29.95261	1703
Yellow-billed Duck	*Anas undulata*	44944	0.671042	-26.1986	29.95694	1708
Yellow-crowned Bishop	*Euplectes afer*	44944	0.571296	-26.1823	29.96017	1701
Zitting Cisticola	*Cisticola juncidis*	44944	0.526887	-26.1869	29.96358	1702

APPENDIX 10: Compliance Checklists

Terrestrial Plants

PROTOCOL FOR THE SPECIALIST ASSESSMENT AND MINIMUM REPORT CONTENT REQUIREMENTS FOR ENVIRONMENTAL IMPACTS ON TERRESTRIAL PLANT SPECIES	
Protocol	**Relevant Section in Report**
1. General	
1.1 An applicant intending to undertake an activity identified in the scope of this protocol, on a site identified by the screening tool as being of "very high" or "high" sensitivity for terrestrial plant species must submit a Terrestrial Plant Species Specialist Assessment Report.	Sections 1-4 and 5.1
1.2 An applicant intending to undertake an activity identified in the scope of this protocol on a site identified by the screening tool as being of "medium sensitivity" for terrestrial plant species must submit either a Terrestrial Plant Species Specialist Assessment Report or a Terrestrial Plant Species Compliance Statement, depending on the outcome of a site inspection undertaken in accordance with paragraph 4.	Sections 1-4 and 5.1
1.3 An applicant intending to undertake an activity identified in the scope of this protocol on a site identified by the screening tool as being of "low" sensitivity for terrestrial plant species must submit a Terrestrial Plant Species Compliance Statement.	Not applicable
1.4 Where the information gathered from the site sensitivity verification differs from the screening tool designation of "very high" or "high", for terrestrial plant species sensitivity and it is found to be of a "low" sensitivity, then a Terrestrial Plant Species Compliance Statement must be submitted.	Not applicable
1.5 Where the information gathered from the site sensitivity verification differs from the screening tool designation of "low" terrestrial plant species sensitivity and it is found to be of a "very high" or "high" terrestrial plant species sensitivity, a Terrestrial Plant Species Specialist Assessment must be conducted.	Not applicable
1.6 If any part of the development falls within an area of confirmed "very high" or "high" sensitivity, the assessment and reporting requirements prescribed for the "very high" or "high" sensitivity, apply to the entire development footprint. Development footprint in the context of this protocol means, the area on which the proposed development will take place and includes the area that will be disturbed or impacted.	Sections 1-4 and 5.1
1.7 The Terrestrial Plant Species Specialist Assessment and the Terrestrial Plant Species Compliance Statement must be undertaken within the study area.	Sections 3 and 4.2
1.8 Where the nature of the activity is not expected to have an impact on SCC beyond the boundary of the preferred site, the study area means the proposed development footprint within the preferred site.	Section 3
1.9 Where the nature of the activity is expected to have an impact on SCC beyond the boundary of the preferred site, the project areas of influence (PAOI) must be determined by the specialist in accordance with Species Environmental Assessment Guideline, and the study area must include the PAOI, as determined.	Section 3
2. Terrestrial Plant Species Specialist Assessment	

PROTOCOL FOR THE SPECIALIST ASSESSMENT AND MINIMUM REPORT CONTENT REQUIREMENTS FOR ENVIRONMENTAL IMPACTS ON TERRESTRIAL PLANT SPECIES	
Protocol	**Relevant Section in Report**
2.1 The assessment must be undertaken by a specialist registered with the South African Council for Natural Scientific Professions (SACNASP) with a field of practice relevant to the taxonomic group ("taxa") for which the assessment is being undertaken.	Section 1.4 and Appendix 11
2.2 The assessment must be undertaken within the study area.	Sections 3 and 4.2
2.3 The assessment must be undertaken in accordance with the Species Environmental Assessment Guideline; and must:	Section 4
2.3.1 identify the SCC which were found, observed or are likely to occur within the study area;	Section 5.1.4
2.3.2 provide evidence (photographs) of each SCC found or observed within the study area, which must be disseminated by the specialist to a recognised online database facility, immediately after the site inspection has been performed (prior to preparing the report contemplated in paragraph 3);	Sections 4.2.1 and 5.1.4
2.3.3 identify the distribution, location, viability and provide a detailed description of population size of the SCC, identified within the study area;	Section 5.1.4
2.3.4 identify the nature and the extent of the potential impact of the proposed development on the population of the SCC located within the study area;	Sections 5.1.4 and 6.1
2.3.5 determine the importance of the conservation of the population of the SCC identified within the study area, based on information available in national and international databases, including the IUCN Red List of Threatened Species, South African Red List of Species, and/or other relevant databases;	Sections 5.1.4 and 6.1
2.3.6 determine the potential impact of the proposed development on the habitat of the SCC located within the study area;	Sections 5.1.4, 5.8 and 6.1
2.3.7 include a review of relevant literature on the population size of the SCC, the conservation interventions as well as any national or provincial species management plans for the SCC. This review must provide information on the need to conserve the SCC and indicate whether the development is compliant with the applicable species management plans and if not, include a motivation for the deviation;	Section 5.1.4
2.3.8 identify any dynamic ecological processes occurring within the broader landscape that might be disrupted by the development and result in negative impact on the identified SCC, for example, fires in fire-prone systems;	Section 5.5
2.3.9 identify any potential impact of ecological connectivity in relation to the broader landscape, resulting in impacts on the identified SCC and its long-term viability;	Section 5.5
2.3.10 determine buffer distances as per the Species Environmental Assessment Guidelines used for the population of each SCC;	Section 5.1.4
2.3.11 discuss the presence or likelihood of additional SCC including threatened species not identified by the screening tool, Data Deficient or Near Threatened Species, as well as any undescribed species; and	Section 5.1.4 and Appendix 5
2.3.12 identify any alternative development footprints within the preferred site which would be of "low" or "medium" sensitivity as identified by the screening tool and verified through the site sensitivity verification.	Sections 5.1.2, 5.5 and 5.8
3. Terrestrial Plant Species Specialist Assessment Report	
3.1 This report must include as a minimum the following information:	

PROTOCOL FOR THE SPECIALIST ASSESSMENT AND MINIMUM REPORT CONTENT REQUIREMENTS FOR ENVIRONMENTAL IMPACTS ON TERRESTRIAL PLANT SPECIES	
Protocol	**Relevant Section in Report**
3.1.1 contact details and relevant experience as well as the SACNASP registration number of the specialist preparing the assessment including a curriculum vitae;	Section 1.4 and Appendix 11
3.1.2 a signed statement of independence by the specialist;	Section 1.5
3.1.3 a statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;	Section 4.2
3.1.4 a description of the methodology used to undertake the site sensitivity verification, impact assessment and site inspection, including equipment and modelling used where relevant;	Sections 4.2 and 4.3
3.1.5 a description of the assumptions made and any uncertainties or gaps in knowledge or data;	Section 4.5
3.1.6 a description of the mean density of observations/number of sample sites per unit area and the site inspection observations;	Section 4.2.1 and Appendix 11
3.1.7 details of all SCC found or suspected to occur on site, ensuring sensitive species are appropriately reported;	Section 5.1.4
3.1.8 the online database name, hyperlink and record accession numbers for disseminated evidence of SCC found within the study area;	Section 4.2.1
3.1.9 the location of areas not suitable for development and to be avoided during construction where relevant;	Sections 5.1.4, 5.6, 5.8 and 6.1
3.1.10 a discussion on the cumulative impacts;	Sections 5.1.4, 5.8 and 6.1
3.1.11 impact management actions and impact management outcomes proposed by the specialist for inclusion in the Environmental Management Programme (EMPr);	Section 6.1
3.1.12 a reasoned opinion, based on the findings of the specialist assessment, regarding the acceptability or not of the development and if the development should receive approval or not, related to the specific theme being considered, and any conditions to which the opinion is subjected if relevant; and	Sections 6.1 and 7
3.1.13 a motivation must be provided if there were any development footprints identified as per paragraph 2.2.12 above that were identified as having "low" or "medium" terrestrial plant species sensitivity and were not considered appropriate.	Not applicable
3.2 A signed copy of the assessment must be appended to the Basic Assessment Report or Environmental Impact Assessment Report.	To be undertaken by EAP

Terrestrial Animals

PROTOCOL FOR THE SPECIALIST ASSESSMENT AND MINIMUM REPORT CONTENT REQUIREMENTS FOR ENVIRONMENTAL IMPACTS ON TERRESTRIAL ANIMAL SPECIES	
Protocol	**Relevant Section in Report**
1. General	
1.1 An applicant intending to undertake an activity identified in the scope of this protocol, on a site identified by the screening tool as being of "very high" or "high" sensitivity for terrestrial animal species must submit a Terrestrial Animal Species Specialist Assessment Report.	Sections 1-4; 5.2, 5.3 & 5.4
1.2 An applicant intending to undertake an activity identified in the scope of this protocol on a site identified by the screening tool as being of "medium sensitivity" for terrestrial animal species must submit either a Terrestrial Animal Species Specialist Assessment Report or a Terrestrial Animal Species Compliance Statement, depending on the outcome of a site inspection undertaken in accordance with paragraph 4.	Sections 1-4; 5.2, 5.3 & 5.4
1.3 An applicant intending to undertake an activity identified in the scope of this protocol on a site identified by the screening tool as being of "low" sensitivity for terrestrial animal species must submit a Terrestrial Animal Species Compliance Statement.	Not applicable
1.4 Where the information gathered from the site sensitivity verification differs from the screening tool designation of "very high" or "high", for terrestrial animal species sensitivity and it is found to be of a "low" sensitivity, then a Terrestrial Animal Species Compliance Statement must be submitted.	Not applicable
1.5 Where the information gathered from the site sensitivity verification differs from the screening tool designation of "low" terrestrial animal species sensitivity and it is found to be of a "very high" or "high" terrestrial animal species sensitivity, a Terrestrial Animal Species Specialist Assessment must be conducted.	Not applicable
1.6 If any part of the development falls within an area of confirmed "very high" or "high" sensitivity, the assessment and reporting requirements prescribed for the "very high" or "high" sensitivity, apply to the entire development footprint. Development footprint in the context of this protocol means, the area on which the proposed development will take place and includes the area that will be disturbed or impacted.	Sections 1-4; 5.2, 5.3 & 5.4
1.7 The Terrestrial Animal Species Specialist Assessment and the Terrestrial Animal Species Compliance Statement must be undertaken within the study area.	Sections 3 and 4.2
1.8 Where the nature of the activity is not expected to have an impact on SCC beyond the boundary of the preferred site, the study area means the proposed development footprint within the preferred site.	Section 3
1.9 Where the nature of the activity is expected to have an impact on SCC beyond the boundary of the preferred site, the PAOI must be determined by the specialist in accordance with Species Environmental Assessment Guideline, and the study area must include the PAOI, as determined.	Section 3
2. Terrestrial Animal Species Specialist Assessment	
2.1 The assessment must be undertaken by a specialist registered with the SACNASP with a field of practice relevant to the taxonomic group ("taxa") for which the assessment is being undertaken.	Section 1.4 and Appendix 11
2.2 The assessment must be undertaken in accordance with the Species Environmental Assessment Guideline; and must:	Section 4

PROTOCOL FOR THE SPECIALIST ASSESSMENT AND MINIMUM REPORT CONTENT REQUIREMENTS FOR ENVIRONMENTAL IMPACTS ON TERRESTRIAL ANIMAL SPECIES	
Protocol	**Relevant Section in Report**
2.2.1 identify the SCC which were found, observed or are likely to occur within the study area;	Sections 5.2.3, 5.3.3 and 5.4.3
2.2.2 provide evidence (photographs or sound recordings) of each SCC found or observed within the study area, which must be disseminated by the specialist to a recognised online database facility, immediately after the site inspection has been performed (prior to preparing the report contemplated in paragraph 3);	Section 4.2
2.2.3 identify the distribution, location, viability and provide a detailed description of population size of the SCC, identified within the study area;	Sections 5.2.3 and 5.4.3
2.2.4 identify the nature and the extent of the potential impact of the proposed development on the population of the SCC located within the study area;	Sections 5.2.3, 5.4.3 and 6.2
2.2.5 determine the importance of the conservation of the population of the SCC identified within the study area, based on information available in national and international databases, including the IUCN Red List of Threatened Species, South African Red List of Species, and/or other relevant databases;	Sections 5.2.3 and 5.4.3
2.2.6 determine the potential impact of the proposed development on the habitat of the SCC located within the study area;	Sections 5.2.3, 5.4.3 and 6.2
2.2.7 include a review of relevant literature on the population size of the SCC, the conservation interventions as well as any national or provincial species management plans for the SCC. This review must provide information on the need to conserve the SCC and indicate whether the development is compliant with the applicable species management plans and if not, include a motivation for the deviation;	Sections 5.2.3, 5.4.3 and 6.2
2.2.8 identify any dynamic ecological processes occurring within the broader landscape that might be disrupted by the development and result in negative impact on the identified SCC, for example, fires in fire-prone systems;	Section 5.5
2.2.9 identify any potential impact of ecological connectivity in relation to the broader landscape, resulting in impacts on the identified SCC and its long-term viability;	Section 5.5
2.2.10 determine buffer distances as per the Species Environmental Assessment Guidelines used for the population of each SCC;	Sections 5.2.3 and 5.4.3
2.2.11 discuss the presence or likelihood of additional SCC including threatened species not identified by the screening tool, Data Deficient or Near Threatened Species, as well as any undescribed species; or roosting and breeding or foraging areas used by migratory species where these species show significant congregations, occurring in the vicinity; and	Sections 5.2.3, 5.3.3 and 5.4.3
2.2.12 identify any alternative development footprints within the preferred site which would be of "low" or "medium" sensitivity as identified by the screening tool and verified through the site sensitivity verification.	Sections 5.2.3, 5.3.3,, 5.4.3, 5.5 and 5.8
3. Terrestrial Animal Species Specialist Assessment Report	
3.1 This report must include as a minimum the following information:	
3.1.1 contact details and relevant experience as well as the SACNASP registration number of the specialist preparing the assessment including a curriculum vitae;	Section 1.4 and Appendix 11
3.1.2 a signed statement of independence by the specialist;	Section 1.5
3.1.3 a statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;	Section 4.2

PROTOCOL FOR THE SPECIALIST ASSESSMENT AND MINIMUM REPORT CONTENT REQUIREMENTS FOR ENVIRONMENTAL IMPACTS ON TERRESTRIAL ANIMAL SPECIES	
Protocol	**Relevant Section in Report**
3.1.4 a description of the methodology used to undertake the site sensitivity verification, impact assessment and site inspection, including equipment and modelling used where relevant;	Sections 4.2 and 4.3
3.1.5 a description of the mean density of observations/number of sample sites per unit area and the site inspection observations;	Sections 4.2
3.1.6 a description of the assumptions made and any uncertainties or gaps in knowledge or data;	Section 4.5
3.1.7 details of all SCC found or suspected to occur on site, ensuring sensitive species are appropriately reported;	Sections 5.2.3, 5.3.3 and 5.4.3
3.1.8 the online database name, hyperlink and record accession numbers for disseminated evidence of SCC found within the study area;	Section 4.2
3.1.9 the location of areas not suitable for development and to be avoided during construction where relevant;	Sections 5.2, 5.6, 5.8 and 6.2
3.1.10 a discussion on the cumulative impacts;	Sections 5.2, 5.8 and 6.2
3.1.11 impact management actions and impact management outcomes proposed by the specialist for inclusion in the Environmental Management Programme (EMPr);	Section 6.2
3.1.12 a reasoned opinion, based on the findings of the specialist assessment, regarding the acceptability or not of the development and if the development should receive approval or not, related to the specific theme being considered, and any conditions to which the opinion is subjected if relevant; and	Sections 6.2 and 7
3.1.13 a motivation must be provided if there were any development footprints identified as per paragraph 2.2.12 above that were identified as having “low” or “medium” terrestrial animal species sensitivity and were not considered appropriate.	Not applicable
3.2 A signed copy of the assessment must be appended to the Basic Assessment Report or Environmental Impact Assessment Report.	To be undertaken by EAP

Terrestrial Biodiversity

PROTOCOL FOR THE SPECIALIST ASSESSMENT AND MINIMUM REPORT CONTENT REQUIREMENTS FOR ENVIRONMENTAL IMPACTS ON TERRESTRIAL BIODIVERSITY	
Protocol	**Relevant Section in Report**
1. General	
1.1 An applicant intending to undertake an activity identified in the scope of this protocol, on a site identified by the screening tool as being of "very high sensitivity" for terrestrial biodiversity must submit a Terrestrial Biodiversity Specialist Assessment.	Sections 1-4 and 5.1
1.2 An applicant intending to undertake an activity identified in the scope of this protocol on a site identified by the screening tool as being of "low" sensitivity for terrestrial biodiversity must submit a Terrestrial Biodiversity Compliance Statement.	Not applicable
1.3 Where the information gathered from the site sensitivity verification differs from the screening tool designation of "very high" terrestrial biodiversity sensitivity and it is found to be of a "low" sensitivity, then a Terrestrial Biodiversity Compliance Statement must be submitted.	Not applicable
1.4 Where the information gathered from the site sensitivity verification differs from the screening tool designation of "low" terrestrial biodiversity sensitivity on the screening tool, a Terrestrial Biodiversity Specialist Assessment must be conducted.	Not applicable
1.5 If any part of the development falls within an area of confirmed "very high" sensitivity, the assessment and reporting requirements prescribed for the "very high" sensitivity, apply to the entire development footprint, excluding linear activities for which impacts on terrestrial biodiversity are temporary and the and in the opinion of the terrestrial biodiversity specialist, based on the mitigation and remedial measures, can be returned to the current state within two years of the completion of the construction phase, in which case a compliance statement applies. Development footprint in the context of this protocol means, the area on which the proposed development will take place and includes the area that will be disturbed or impacted.	Sections 1-4 and 5.1
2. Terrestrial Biodiversity Specialist Assessment	
2.1 The assessment must be undertaken by a specialist registered with the SACNASP with expertise in the field of terrestrial biodiversity.	Section 1.4 and Appendix 11
2.2 The assessment must be undertaken on the preferred site and within the proposed development footprint	Sections 3 and 4.2
2.3 The assessment must provide a baseline description of the site which includes, as a minimum, the following aspects:	
2.3.1 a description of the ecological drivers or processes of the system and how the proposed development will impact these;	Sections 5.1 to 5.5 and 6
2.3.2 ecological functioning and ecological processes (e.g. fire, migration, pollination, etc.) that operate within the preferred site;	Sections 5.1 to 5.5
2.3.3 the ecological corridors that the proposed development would impede including migration and movement of flora and fauna;	Section 5.5

PROTOCOL FOR THE SPECIALIST ASSESSMENT AND MINIMUM REPORT CONTENT REQUIREMENTS FOR ENVIRONMENTAL IMPACTS ON TERRESTRIAL BIODIVERSITY	
Protocol	**Relevant Section in Report**
2.3.4 the description of any significant terrestrial landscape features (including rare or important flora) - faunal associations, presence of strategic water source areas (SWSAs) or freshwater ecosystem priority area (FEPA) sub-catchments;	Section 5.6 and 5.7
2.3.5 a description of terrestrial biodiversity and ecosystems on the preferred site, including: (a) main vegetation types; (b) threatened ecosystems, including listed ecosystems as well as locally important habitat types identified; (c) ecological connectivity, habitat fragmentation, ecological processes and fine - scale habitats; and (d) species, distribution, important habitats (e.g. feeding grounds, nesting sites, etc.) and movement patterns identified;	Sections 5.1 to 5.7
2.3.6 the assessment must identify any alternative development footprints within the preferred site which would be of a low" sensitivity as identified by the screening tool and verified through the site sensitivity verification; and	Sections 5.1.2, 5.5 and 5.8
2.3.7 the assessment must be based on the results of a site inspection undertaken on the preferred site and must identify:	
2.3.7.1. terrestrial critical biodiversity areas (CBAs), including: (a) the reasons why an area has been identified as a CBA; (b) an indication of whether or not the proposed development is consistent with maintaining the CBA in a natural or near natural state or in achieving the goal of rehabilitation; (c) the impact on species composition and structure of vegetation with an indication of the extent of clearing activities in proportion to the remaining extent of the ecosystem type(s); (d) the impact on ecosystem threat status; (e) the impact on explicit subtypes in the vegetation; (f) the impact on overall species and ecosystem diversity of the site; and (g) the impact on any changes to threat status of populations of SCC in the CBA;	Section 5.6 and 7; as informed by Sections 5.1.1, 5.1.2 and 5.1.4
2.3.7.2. terrestrial ecological support areas (ESAs), including: (a) the impact on the ecological processes that operate within or across the site; (b) the extent the proposed development will impact on the functionality of the ESA; and (c) loss of ecological connectivity (on site, and in relation to the broader landscape) due to the degradation and severing of ecological corridors or introducing barriers that impede migration and movement of flora and fauna;	Section 5.6 and 5.7
2.3.7.3. protected areas as defined by the National Environmental Management: Protected Areas Act, 2004 including- (a) an opinion on whether the proposed development aligns with the objectives or purpose of the protected area and the zoning as per the protected area management plan;	Section 5.7
2.3.7.4. priority areas for protected area expansion, including (a) the way in which in which the proposed development will compromise or contribute to the expansion of the protected area network;	Section 5.7, 5.5 and 5.1.4
2.3.7.5. SWSAs including: (a) the impact(s) on the terrestrial habitat of a SWSA; and (b) the impacts of the proposed development on the SWSA water quality and quantity (e.g. describing potential increased runoff leading to increased sediment load in water courses);	Not applicable

PROTOCOL FOR THE SPECIALIST ASSESSMENT AND MINIMUM REPORT CONTENT REQUIREMENTS FOR ENVIRONMENTAL IMPACTS ON TERRESTRIAL BIODIVERSITY	
Protocol	**Relevant Section in Report**
2.3.7.6. FEPA sub-catchments, including- (a) the impacts of the proposed development on habitat condition and species in the FEPA sub-catchment;	Not applicable (briefly addressed In Section 5.7, Table 5-22)
2.3.7.7. indigenous forests, including: (a) impact on the ecological integrity of the forest; and (b) percentage of natural or near natural indigenous forest area lost and a statement on the implications in relation to the remaining areas.	Not applicable
3. Terrestrial Biodiversity Specialist Assessment Report	
3.1 This report must include as a minimum the following information:	
3.1.1 contact details and relevant experience as well as the SACNASP registration number of the specialist preparing the assessment including a curriculum vitae;	Section 1.4 and Appendix 11
3.1.2 a signed statement of independence by the specialist;	Section 1.5
3.1.3 a statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;	Section 4.2
3.1.4 a description of the methodology used to undertake the site sensitivity verification, impact assessment and site inspection, including equipment and modelling used where relevant;	Sections 4.1 and 4.2
3.1.5 a description of the assumptions made and any uncertainties or gaps in knowledge or data as well as a statement of the timing and intensity of site inspection observations;	Section 4.5 and 4.2
3.1.6 the location of areas not suitable for development and to be avoided during construction where relevant;	Sections 5.1.4, 5.6, 5.8 and 6.1
3.1.7 additional environmental impacts expected from the proposed development;	Sections 5.5. 5.8 and 6
3.1.8. any direct, indirect and cumulative impacts of the proposed development;	Sections 5.1.4, 5.8 and 6.1
3.1.9. the degree to which impacts and risks can be mitigated;	Sections 5.8 and 6
3.1.10. the degree to which the impacts and risks can be reversed;	Section 5.8 and 6
3.1.11. the degree to which the impacts and risks can cause loss of irreplaceable resources;	Section 5.6, 5.8 and 6
3.1.12. proposed impact management actions and impact management outcomes proposed by the specialist for inclusion in the Environmental Management Programme (EMPr);	Section 6
3.1.13. a motivation must be provided if there were development footprints identified as per paragraph 2.3.6 above that were identified as having a "low" terrestrial biodiversity sensitivity and that were not considered appropriate;	Not applicable
3.1.14. a substantiated statement, based on the findings of the specialist assessment, regarding the acceptability, or not, of the proposed development, if it should receive approval or not; and	Section 7

PROTOCOL FOR THE SPECIALIST ASSESSMENT AND MINIMUM REPORT CONTENT REQUIREMENTS FOR ENVIRONMENTAL IMPACTS ON TERRESTRIAL BIODIVERSITY	
Protocol	**Relevant Section in Report**
3.1.15. any conditions to which this statement is subjected.	Section 6 and 7
3.2. The findings of the Terrestrial Biodiversity Specialist Assessment must be incorporated into the Basic Assessment Report or the Environmental Impact Assessment Report, including the mitigation and monitoring measures as identified, which must be incorporated into the EMPr where relevant.	To be undertaken by EAP
3.3. A signed copy of the assessment must be appended to the Basic Assessment Report or Environmental Impact Assessment Report.	To be undertaken by EAP

APPENDIX 11: Report authors CVs.

Brief Curriculum Vitae for Antonio (Tony) D.P. De Castro

1. Name: Antonio D.P. De Castro

2. Specialist consulting fields: Ecology and Botany

3. Employer: De Castro & Brits cc

4. Date of Birth: 17/01/1970 **Nationality**: South African

5. Education

School, college and/or university attended	Degree/certificate or other specialised education obtained	Date obtained
Rand Afrikaans University	BSc Botany & Zoology	1991
Rand Afrikaans University	BSc Hons (Botany)	1994

6. Professional Certification or Membership in Professional Associations:

- SA Council of Natural Scientists: Professional Natural Scientist in Ecological Science and Botanical Science (Registration number: 400270/07).
- South African Wetlands Society: Ordinary Member.
- International Mire Conservation Group: Ordinary Member.

7. Other Relevant Training:

- Certificate in Seed Science: University of Pretoria. 1996.

8. Countries of Work Experience: South Africa, Lesotho, Swaziland, Mozambique, Botswana, Madagascar, Angola, Ethiopia and Guinea.

9. Languages

English: Good (speaking, reading and writing).
Portuguese: Good (speaking and reading).
Afrikaans: Good (speaking, reading and writing).

10. Employment Record

1999 – present	Botanical / Ecological specialist consultant and Managing Member at De Castro & Brits cc.
1997 - 1999	Senior Specialist Consultant at ECOSUN cc. Responsible for all botanical assessments and baseline ecological assessments.
1993 – 1997	Research Assistant to Prof. B-E. Van Wyk and part-time Technical Lecturer in the Department of Botany at the Rand Afrikaans University (now the University of Johannesburg).

11. Main areas of specialisation

Botanical and ecological specialist consultant on various biodiversity management, impact assessment and development projects involving the description of terrestrial, wetland and riparian ecosystems, the assessment and management of anthropogenic impacts on these systems and the sustainable utilisation of natural resources. Has collected over 2000 plant specimens that are lodged at the following herbaria: National Herbarium (Pretoria), Schweikerdt Herbarium (University of Pretoria), University of Johannesburg Herbarium and Compton Herbarium. Main areas of specialisation within this field are:

- plant taxonomy, floristics, threatened species biology and plant utilisation;
- ecosystem description and analysis;
- vegetation description and analysis in the Grassland, Savanna and Forest Biomes of Southern Africa.

Also acts as Co-ordinating Specialist/Team leader for biophysical aspects of larger Environmental Impact Assessments, Environmental Management Plans, Strategic Environmental Assessments, Resettlement Plans and Sustainable Utilisation Plans.

Antonio has also authored or co-authored eight refereed articles in accredited scientific journals and numerous scientific conference presentation and has been formally acknowledged for contributions to various botanical and zoological publications.

12. Examples of previously completed projects

Has completed over 570 specialist botanical and ecological consulting reports including the following:

2020 - present	Biodiversity Management Plan for the 13 000ha Northam Booysendal Platinum Mine (Roosenekal, Mpumalanga) surface rights area situated within the Steenkampsberg and Sekhukhuneland Centres of Plant Endemism. Project included the identification, description and mapping of vegetation units and BMUs, identification, description and mapping of ‘Core Biodiversity Management Areas’ and the development of management plans for all plant ‘SCC’ (*sensu* Raimondo *et al*., 2009). Also included the development of a Biodiversity Management Plan for the 1 900ha De Berg Private Nature Reserve with emphasis on the 38 plant SCC recorded by the author within the proposed Nature Reserve. Project for Clean Stream Biological Consultants, on behalf of Northam Booysendal Platinum Mine. Position: Principal Botanical and Ecological Specialist and Co-ordinator of Wetland and Entomological Specialist studies.
2017 - 2018	Distribution and Resource Survey for *Pelargonium sidoides* Projected included the determination of the Extent of Occurrence and Area of Occupancy of *Pelargonium sidoides* (a South African endemic), description of recorded habitat, quantitative sampling of sub-population sizes, estimation of sub-population and population size and development of protocols for sustainable wild harvesting. Project for Parceval (Pty) Ltd and the South African National Biodiversity Institute. Position: Principal Botanical and Ecological Specialist.
2015	Botanical Biodiversity Baseline Assessment and Biodiversity Management Plan for the 6 500ha AngloGold Ashanti, Mine Waste Solutions surface rights area. Project included the identification, description and mapping of vegetation and land-cover units, identification, description and mapping of ‘Core Biodiversity Management Areas’ and the development of management plans for Threatened and Near Threatened species recorded by the author. Project for Clean Stream Biological Consultants, on behalf of AngloGold Ashanti. Position: Principal Botanical and Ecological Specialist.
2014 - 2015	EIA and EMP for the proposed SASOL PSA and LPG development project study area (Inhassoro, Inhambane Prov., Mozambique), comprising the construction of approximately 150km of new hydrocarbon flow lines and 25 new gas and oil wells. Responsible for the description of the wetland and terrestrial habitats and botanical biodiversity of the 49 000ha study area, the identification of potential impacts to habitats and biodiversity and the development of suitable mitigation measures. De Castro identified a Critical Habitat (*sensu* IFC) during this study. Project for Golder

	Associates on behalf of SASOL Temane (Pty) Ltd. Position: Principal Botanical and Ecological Specialist.
2012 – 2013	Botanical Biodiversity Baseline Assessment update, Development of a comprehensive Alien Plant Control Programme and Monitoring of vegetation and 'plant SCC' at the 12000ha AngloGold Ashanti, Vaal Reefs Mine Complex. Project included the identification, description and mapping of 'Core Biodiversity Management Areas' and the development of 'management plans for five Threatened and Near Threatened species recorded by the author. Project for Clean Stream Biological Consultants, on behalf of AngloGold Ashanti (2012-2013). Position: Principal Botanical and Ecological Specialist.
2012	Ecological Scoping Study for the 4944ha Imaloto Coal Exploration Block (Toliar Province, Madagascar). Project included a seven day field survey during which a scoping level assessment of vegetation, floral biodiversity and terrestrial vertebrate diversity was conducted. Project for CT Environmental on behalf of Badger Consulting. Position: Principal Botanical and Ecological Specialist.
1999 - 2005	Maguga Dam Project, Task MDC-7 (Swaziland): Including all Ecological aspects of the Review of Task MDC-6, all botanical studies required for the completion of the environmental studies (including a Scoping Report, EIA & EMP Reports and Recommendation of Monitoring Programme), and implementation of EMP's for the Reservoir area and the Resettlement area for displaced people. A new locality record for the Critically Endangered species *Siphonochilus aethiopicus* was discovered by the author during this survey and a conservation strategy was successfully developed and implemented. Project for Maguga Dam Network on behalf of Komati River Basin Water Authority. Position: Ecologist and Principal Biophysical Environmentalist.
2000 - 2001	Ecological Reserve Determination for the Ngagane River catchment (KwaZulu-Natal, South Africa). Project for Waites, Meiring and Barnard Pty (Ltd) on behalf of the Department of Water Affairs. Position: Riparian Vegetation Specialist.
1998	Habitat Integrity Assessment of the Waterval River (Mpumalanga, South Africa). Project for Waites, Meiring and Barnard Pty (Ltd), on behalf of SASOL. Position: Specialist Ecological Consultant and Project Manager.
1998	Environmental Impact Assessment, with emphasis on Instream Flow Requirements, for the proposed Pumped Storage Hydroelectric Scheme on the Steelpoort River (Mpumalanga, South Africa). Project for Loxton, Venn & Associates on behalf of Eskom. Position: Specialist Botanical and Instream Flow Requirements Consultant.

Certification

I certify that to the best of my knowledge and belief, this CV correctly describes me, my qualifications, and my experience; and that I am available for the assignment for which I am proposed.

I understand that any wilful misstatement or misrepresentation herein may lead to my disqualification or removal from the selected team undertaking the assignment.

Date: 10/02/2023

CURRICULUM VITAE

Name:	**LUKAS JURIE NIEMAND**
Company:	**Pachnoda Consulting cc (Director)**
Date of Birth:	1974-03-12
Nationality:	South African
Languages:	English and Afrikaans

EDUCATIONAL QUALIFICATIONS

1992	Hoërskool Hartbeespoort, Hartbeespoort - Senior Certificate.
1996	University of Pretoria, Pretoria - B.Sc. (Zoology and Entomology).
1997	University of Pretoria, Pretoria - B.Sc. (Hons) (Entomology).
2001	University of Pretoria, Pretoria - M.Sc. (Restoration Ecology/Zoology).

MEMBERSHIP IN PROFESSIONAL SOCIETY

- Professional Natural Scientist (Pr. Sci. Nat.) (Reg. no. 400095/06 - Ecology & Zoology)
- BirdLife South Africa (1039913)
- Hartbeespoort Natural Heritage Society

COMPANY EXPERIENCE

Pachnoda Consulting CC is a small enterprise based in Pretoria, South Africa providing specialised consulting services and products in the terrestrial ecological milieu for mining companies, environmental consultants, developers and other industry related institutions throughout Africa and abroad.

Pachnoda Consulting envisions a holistic approach to ensure the sustainable development and preservation of natural resources based on accepted scientific methods. Since its establishment in 2007, it has produced several ecological assessments, including botanical and faunal surveys spanning all nine provinces in South Africa and a number of African countries. It provides a broad-range of quality services that specialises in ornithology (avifauna), entomology (invertebrates) and general zoology. In addition, it values a long-standing relationship with various non-governmental and tertiary institutions notably the University of Pretoria, Endangered Wildlife Trust, the Agricultural Research Council and the South African Biodiversity Institute.

Core services include:

- Objective and quantified ecological assessments (a holistic ecosystem approach based on approved scientific methods) in accordance with International Best Practice (e.g. International Finance Corporation's Performance Standards & Millennium Challenge Corporation's Guidelines)
- Ecological due diligence and risk assessments;
- Taxon-specific surveys in the botanical, mammalian, avifaunal and invertebrate fields;
- Bird impact studies for power lines and renewable energy plants;
- Biodiversity action plans; and
- Mapping and modelling of species distributions and ecological sensitivities.

MEMBERS

Lukas Niemand is director and founding member of Pachnoda Consulting. He has been involved in the discipline of consultant ecologist since 2000, and his core services include ecological studies with emphasis on ornithological (the study of birds), faunal and entomological (the study of invertebrates) assessments.

He has travelled extensively to many remote places as far afield as Marion Island, and has worked on numerous international projects pertaining to the African continent (South Africa, Lesotho, Mozambique, Burundi, Congo-Brazzaville, Liberia, Gabon, Zambia, Tanzania, Guinea, Kenya and Ethiopia) and the Middle East (Saudi Arabia)He worked on projects earmarked for the urban and mining sector and has been involved in linear projects, monitoring programmes, biodiversity action plans as well as specific investigations regarding species with rare/elusive life-history traits (e.g. threatened species).

He is also registered with the panel of the Birds and Renewable Energy division of BirdLife South Africa.

RECENT PROJECTS

A. Work conducted in South Africa

1. General Ecological Assessments (Fauna, Flora and Red Data Scans, including both functional and compositional aspects) for urban, residential, recreational and light industrial developments:

- NuLeaf Planning & Environmental, Ecological evaluation for the Tuna park open space project, Nigel, Gauteng (2019).
- Kyllinga Consulting, Fauna assessment for the proposed residential development on Portion 58 of the Farm Zwavelpoort 373 JR, Bronberg area, Gauteng (2019);
- Envirolution Consulting, Ecological evaluation for a Tyre recycling plant on Portion 156 of Farm Zandspruit 191 IQ, Gauteng (2020);
- Adienvironmental/Kyllinga Consulting, Ecological assessment for the proposed light industrial development on Portion 58 of the Farm Vaalbank 289 JS, Middelburg, Mpumalanga (2020).

2. Mining and Industrial related projects (ecological assessments):

- Bathusi Environmental/ENVASS, Terrestrial fauna and avifaunal survey and impact assessment for the mining of heavy mineral sands at areas known as Die Kom and Grouwduin se Kop, near Koekenaap, Western Cape (2019);
- De Castro & Brits Ecological Consultants/ Cleanstream Environmental, Bio-monitoring survey for Exxaro Glisa coal mine: Vertebrate Wetland Fauna Assessment, Belfast, Mpumalanga (2020);
- De Castro & Brits Ecological Consultants/Cleanstream Environmental, Vertebrate Fauna Assessment on 376.5ha of Kriel Colliery Pit F, Kriel, Mpumalanga (2020).

3. Avifaunal and Invertebrate Assessments:

- Nyengere Solutions/ Waterberg Joint Venture - Avifauna, Invertebrate and Bat benchmark surveys for the proposed Waterberg mining project (wet season), Makgabeng, Central Limpopo Province (2019);
- Eskom/Bathusi Environmental, environmental management plan; Avifaunal Component for the dismantling of the Grootpan-Brakfontein double circuit powerline near Ogies, Mpumalanga (2019);
- Bathusi Environment/Terramanzi, Conflict resolution actions for the proposed Alkantpan Airstrip on a Portion of the Farm Smous Pan 105: Avifaunal Component, Copperton, Northern Cape (2019);
- Eskom/EkoInfo, Avifaunal and general terrestrial fauna assessment for a 400kV powerline as required for the East Coast Gas Project, Richards Bay, KwaZulu-Natal (2019).

4. Other Assessments:
Facilitation, project management and conduction of environmental scoping exercises, Environmental Impact Assessments, Environmental Management Plans, Feasibility Reports, for a range of projects and issues such as:

- City of Joburg Property Development Company, Ecological Management Plan for the Orlando Dam intersection, Soweto, Gauteng (2006);

- GJ van Zyl Trust, Alien Eradication Programme for the proposed development of a resort on the Farm Witpoort 216 JS, Mpumalanga (2006);
- GJ van Zyl Trust, Fire Management Plan for the proposed development of a resort on the Farm Witpoort 216 JS, Mpumalanga (2006); and
- Khutala Collieries (Inkwe Collieries), Biodiversity Assessment and database compilation (2006)

5. Linear Assessments:

- Shangoni Management Services/ Ekurhuleni Metropolitan Municipality - Ecological Evaluation for the upgrade of the Serengeti Sewer Pump Station and rising main, Ekurhuleni Metropolitan Municipality, Pomona, Gauteng (2018);
- AdiEnvironmental/Kyllinga Consulting, Ecological Assessment for the Empuluzi - Methula Phase 1 bulk water supply scheme, Mpuluzi, Mpumalanga (2018);
- SRK Consulting, Ecological Evaluation for the proposed Baviaanspoort pipeline, northern Pretoria, Gauteng (2019).

B. Work conducted in other African countries:

- Allied Gold/ Flora, Fauna and Man Ecological Services, An Invertebrate survey for the proposed mining of gold at Ashashire in western Ethiopia, Ethiopia (2020);
- Kenya Highway Authority/ Flora, Fauna and Man Ecological Services, An avifauna dry season survey for the proposed upgrade and expansion of the Rironi to Mau Summit Highway, central Kenya (2021); and
- Kenya Highway Authority/ Flora, Fauna and Man Ecological Services, An avifauna wet season survey for the proposed upgrade and expansion of the Rironi to Mau Summit Highway, central Kenya (2021).

Employment History:

March 2007 – Current: of Director of Pachnoda Consulting cc
2004- January 2007: Strategic Environmental Focus (Pty) Ltd - Terrestrial Ecologist

2003 – 2004: Enviro-Afrik (Pty) Ltd– Environmental Consultant

2001 – 2003: University of Pretoria - Research Assistant

PUBLICATIONS/CONFERENCE PAPERS:

- GAUGRIS, J., NIEMAND, L., THOMAS A., ORBAN, B., MORLEY, R., MELVILLE, H., DRESCHER, D. AND VASICEK GAUGRIS, C.A. 2021. A snapshot camera trap assessment of mammals in Congo's Massif du Chaillu with a noteworthy record of grey-necked rockfowl *Picathartes oreas*. *African Journal of Ecology* 2021;00:1–6..
- BURGER, M., ZASSI-BOULOU, A.G., BOUKAKA, V., KABAFOUAKO, G., MAMONEKENE, V., MIABANGANA, E.S., NGOULOU, C., NSONGOLA, G., JONKER, M., NIEMAND, L., ORBAN, B., WALSH, G., GAUGRIS, J., CHANNING, A., RÖDEL, M-O. 2017. The value of "standards" driven Environmental Impact Assessments for the advancement of biodiversity knowledge in the Republic of Congo. Paper presented at the 17th African Amphibian Working Group Meeting: Closing the Knowledge Gap on Amphibian Conservation in Africa, Ghana.
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PRESENTATIONS, PUBLIC AWARENESS & NATIONAL GUIDELINES:

- Co-presenter at the Wetland Training Course (30 July – 3 August 2007) entitled: "Wetland-associated fauna". University of Pretoria, Pretoria.
- Co-presenter and lecturer of the pre-conference training course (entitled "Can rehabilitation contribute towards biodiversity?") at the 3rd Annual LaRSSA (Land Rehabilitation Society of Southern Africa) Conference (8-11 September 2015), Glenburn Lodge, Muldersdrift, Gauteng.
- Technical advisor to the **Go/Weg** magazine in response to bird and ecological related queries from the public.
- **Lead author for Invertebrates**: South African National Biodiversity Institute (SANBI). 2020. *Species Environmental Assessment Guideline. Guidelines for the implementation of the Terrestrial Fauna and Terrestrial Flora Species Protocols for environmental impact assessments in South Africa*. South African National Biodiversity Institute, Pretoria. Version 2.1 2021.

APPENDIX 8D: HYDROLOGICAL REPORT

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ABS Africa
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KRANSPAN MINING RIGHT EXTENSION PROJECT

HYDROLOGICAL SPECIALIST REPORT

TITLE	**KRANSPAN MINING RIGHTS EXTENSION PROJECT** **HYDROLIGICAL SPECIALIST REPORT**
PREPARED FOR	ABS AFRICA (PTY) Ltd. PO Box 14003 VORNA VALLEY 1686 SOUTH AFRICA Tel: + 27 11 805 0061
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DATE	30/07/2022
REFERENCE NUMBER	0155_ KRANSPAN MINING RIGHT EXTENSION PROJECT_HYDROLOGICAL SPECIALIST REPORT
PROJECT TEAM	H.S Peens _ ________________ *Pr.TechEng.*
STATUS	*SECOND DRAFT REPORT*

EXECUTIVE SUMMARY

Peens and Associates was appointed by ABS Africa (Pty) to produce a Hydrological Specialist Report for the proposed Kranspan Mining Right Extension Project that is situated on the farms Kranspan 49 IT, Roodebloem 51 IT and Vaalbank 212 IS near Carolina in the Mpumalanga Province.

This report covers the current hydrological situation of the proposed mining right extension area. The outputs generated in the report will be utilised to populate the relevant sections of the EIA and EMPr.

The conclusions drawn from the analyses done for the current situation are as follows:

- The proposed mining right extension area is located in the **X11A** and **X11B** quaternary sub-catchments of the Komati River Drainage Basin;
- The Boesmanspruit and the Vaalwaterspruit are the major streams flowing past the proposed mining right extension area with effective catchment areas of **597** km^2 and **672** km^2;
- The proposed mining right extension area has a Mean Annual Precipitation (MAP) of **698** mm;
- The proposed mining right extension area has a Mean Annual Evaporation (MAE) of **1 450** mm;
- The Nett Mean Annual Runoff (MAR) of the Boesmanspruit is **26.2** mil m^3;
- The Nett Mean Annual Runoff (MAR) of the Vaalwaterspruit is **23.7** mil m^3;
- The proposed mining right extension area contributes **3.39** mil m^3 or **12.9**% of the nett mean annual runoff of the Boesmanspruit;
- The proposed mining right extension area contributes **1.66** mil m^3 or **7.0**% of the nett mean annual runoff of the Vaalwaterpruit;
- The Base / Normal Flow of the Boesmanspruit is **0.1** m^3/s;
- The Base / Normal Flow of the Vaalwaterspruit is **0.1** m^3/s;
- The proposed mining right extension area contributes **0.0145** m^3/s or **13.2**% of the base flow for the Boesmanspruit;
- The proposed mining right extension area contributes **0.0070** m^3/s or **7.0**% of the base flow for the Vaalwaterspruit;
- The drainage density of the proposed mining right extension area was calculated at **0.53** km/km^2; and
- The recommended 100 year flood levels of the three most significant pans are as follows:
  - "S1" = 1 654.90 masl
  - "S2" = 1 654.66 masl

- "S3" = 1 651.80 masl
- "S6" = 1651.34 masl

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1. INTRODUCTION

Peens and Associates was appointed by ABS Africa (Pty) to produce a Hydrological Specialist Report for the proposed Kranspan Mining Right Extension Project that is situated on the farms Kranspan 49 IT, Roodebloem 51 IT and Vaalbank 212 IS near Carolina in the Mpumalanga Province.

This report covers the current hydrological situation of the proposed mining right extension area. The outputs generated in the report will be utilised to populate the relevant sections of the EIA and EMPr.

2. APPROACH AND METHODOLOGY

The following approach and methodology was adopted during the compilation of the hydrological specialist report:

- Gather existing information from credible sources such as those available from the Department of Water and Sanitation and site observations.
- Evaluate data sets such a rainfall data and river flow records for errors.
- Compile drawings and sketches on the 1:50 000 topographical maps for catchment delineation, catchment and river characteristics.
- Analyse data sets to determine the outputs such as the mean annual precipitation and the mean annual runoff.

3. DESCRIPTION OF BASELINE

3.1. CATCHMENT DESCRIPTION

3.1.1. Drainage Region

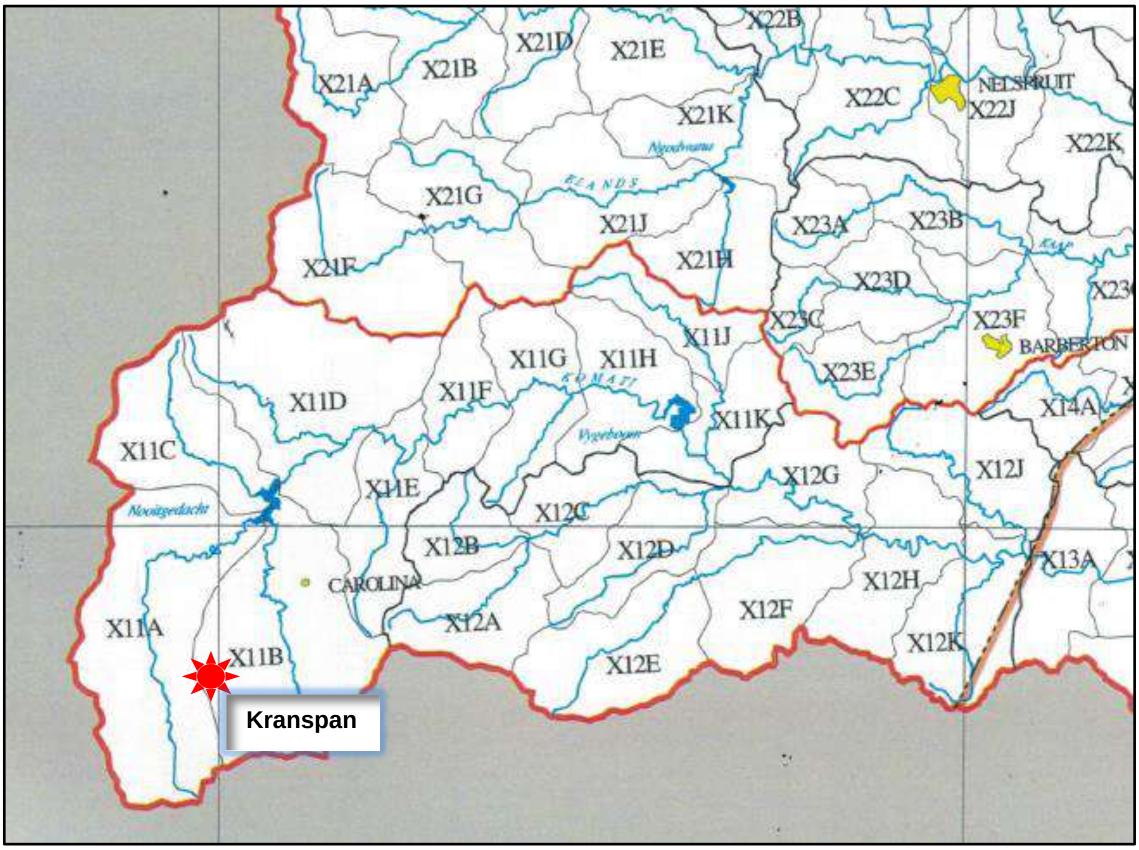
The proposed mining right extension area is situated in the X11A and X11B quaternary sub-catchments of the Komati River Drainage Region as per the Volume VI: Water Resources of South Africa 1990.

The Nooitgedacht Dam is the major reserving water body of the X11A and X11B quaternary sub-catchments that might be impacted by the proposed mine. The Nooitgedacht Dam total catchment area, i.e. quaternary sub-catchments; X11A, X11B and X11C combined is 1 588 km^2. The mean annual runoff (MAR) into Nooitgedacht Dam is 64.1 million m^3 per annum.

Quaternary sub-catchments X11A and X11B under laying geology are basic or mafic and ultramafic intrusive lavas, which forms part of the igneous group. Igneous rocks are formed by volcanic activities and in moderate to wet regions it decompose to form clay. The overburden soils are moderate to deep sandy loam.

The mean annual rainfall/ precipitation (MAP) of quaternary sub-catchment X11B is 714mm and the mean annual runoff (MAR) is 44mm, with a catchment area of 597 km^2 and its Nett MAR is 26.2 million m^3 per annum.

FIGURE 1: LOCATION OF PROPOSED MINING RIGHT EXTENSION AREA IN QUATERNARY SUB-CATCHMENT X11B



The mean annual rainfall/ precipitation (MAP) of quaternary sub-catchment X11A is 682mm and the mean annual runoff (MAR) is 35mm, with a catchment area of 672 km^2 and its Nett MAR is 23.7 million m^3 per annum.

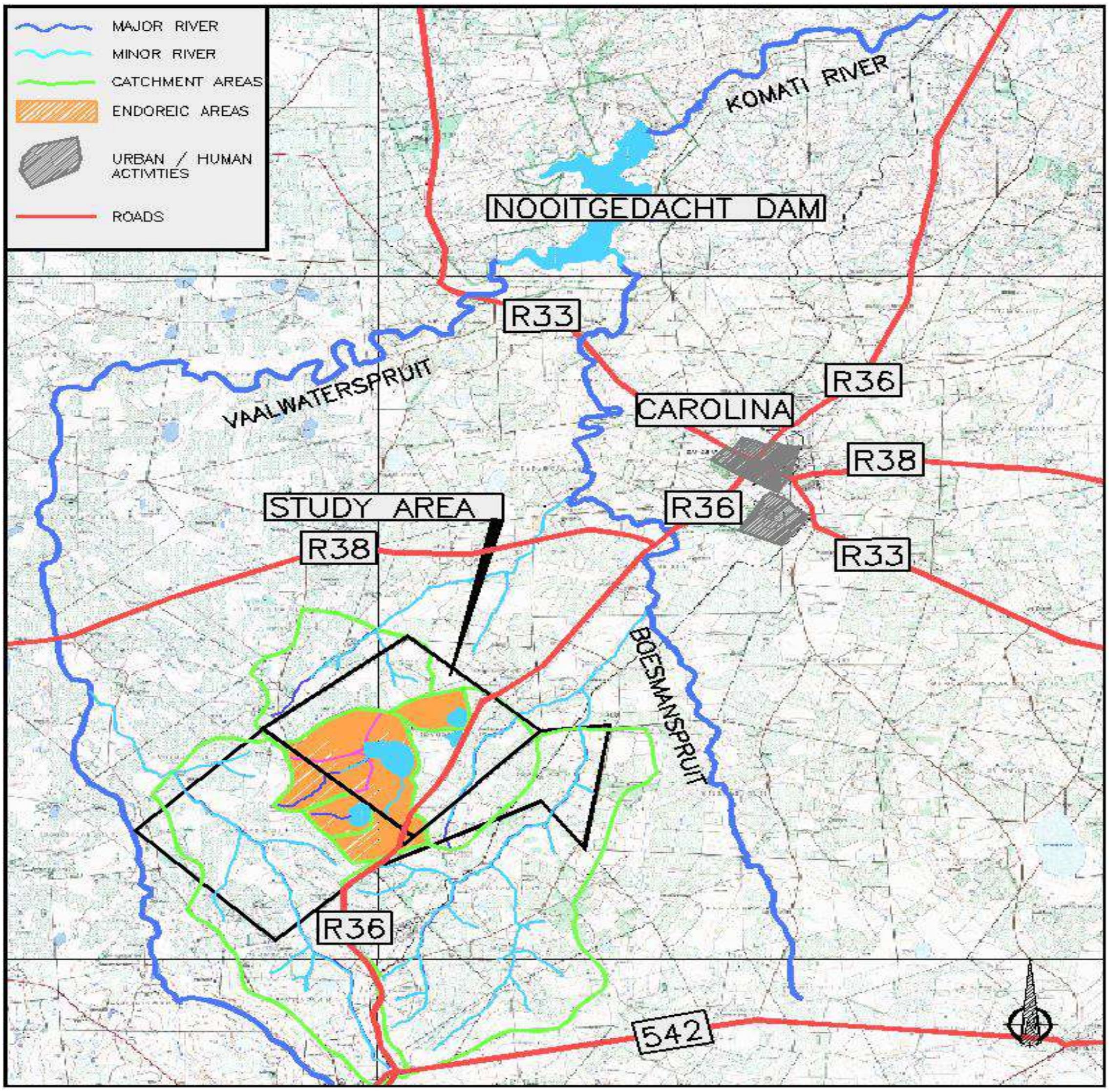
3.1.2. Major Rivers and Receiving Water Bodies

The proposed mining right extension area (Farms Kranspan, Vaalbank and Roodebloem) occur within the Boesmanspruit and the Vaalwaterspruit catchments. Both the Boesmanspruit and the Vaalwaterspruit are tributaries of the Nooitgedacht Dam and the Komati River.

Four pans are located within the proposed mining right extension area of which three have no outflow and their catchment areas can therefore be classified as endorheic areas that do not contribute to the runoff towards Nooitgedacht Dam.

The proposed mining right extension area is 76.0 km^2 in size of which 19.6% (14.9km^2) is endorheic areas; hence the portion of the proposed mining right extension area contribution to the Boesmanspruit runoff is 36.3 km^2 and the contribution to the Vaalwaterspruit runoff is 24.8 km^2. Thus the portion of the proposed mining right extension area that contributes to runoff in the Boesmanspruit is 6.1% of the Boesmanspruit catchment, which has a total catchment of 597 km^2 and the proposed mining right extension area that contributes to runoff in the Vaalwaterspruit is 3.7% of the Vaalwaterspruit catchment, which has a total catchment of 672 km^2.

FIGURE 2: PROPOSED MINING RIGHT EXTENSION AREA IN RELATION TO MAJOR RIVERS AND RECEIVING WATER BODIES



3.1.3. Minor Rivers / Watercourses in Proposed Mining Right Extension Area

The proposed mining right extension area consists of both endorheic areas and non-endorheic areas. Nodes S1, S2 and S6 are accumulation points of such endorheic areas, node S3 acts as an attenuation system with only extreme flood events discharging into the catchment of node S4.

However the discharge from S3 will never contribute to the flood peaks of S4 as the response times of the catchments will not synchronise with the same storm events. The locations for nodes S4, S5, S7 and S8 were selected to obtain the minimum catchment area of each stream that will be affected by the proposed mining right extension area. The catchment areas mainly consist of grass lands and cultivated fields with predominantly flat slopes. The overburden soils are moderate to deep sandy loam and are classified as permeable soils.

FIGURE 3: SUB-CATCHMENTS AND NODES

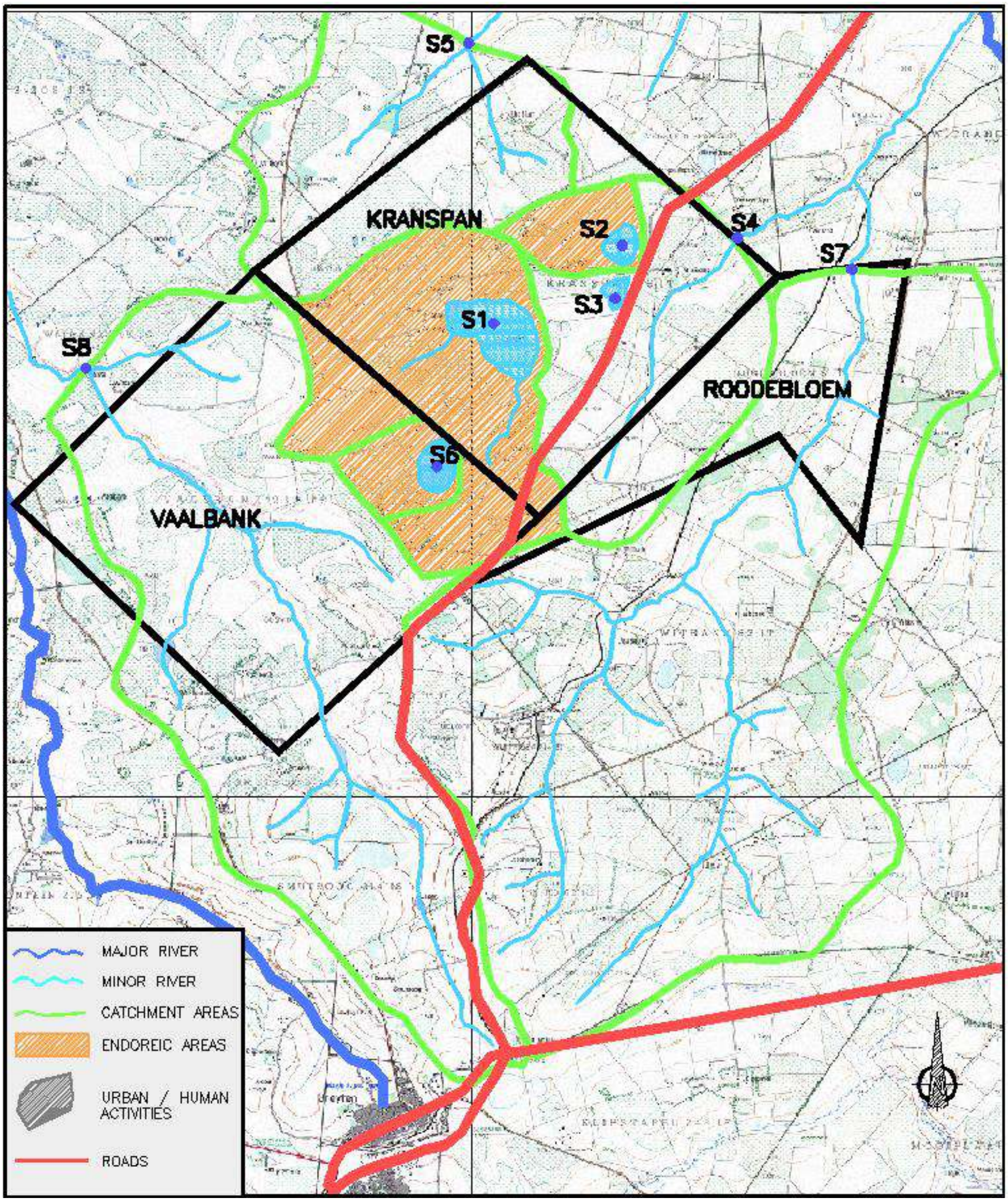


TABLE 1: SUMMARY OF WATERCOURSES CATCHMENTS ON SITE

Node Name	Effective Catchment Area (km^2)	Stream Length (Km)	10-85 Method Avg. Slope (1 :.....)	Overland Flow Length (Km)	Overland Avg. Slope (1: .....)
S1	15.490	3.62	49.35	-	-
S2	2.485	-	-	1.77	32.18
S3	2.222	-	-	3.37	134.77
S4	11.86	5.74	107.64	-	-
S5	16.49	4.62	86.66	-	-
S6	2.22	1.21	30.25	-	-
S7	63.21	13.14	240.41	-	-
S8	44.81	13.62	134.41	-	-

Note: where no defined water course or stream is present in the catchment area the longest overland flow length and slope is determine to calculate the response time of the catchment.

3.2. SURFACE WATER RESOURCES HYDROLOGY

3.2.1. Rainfall

The rainfall characteristics of the proposed mining right extension area are documented in the Surface Water Resources of South Africa 1990 Volume VI and within the X1A rainfall zone as per Map No 1.3 in the Book of Maps. The closest rainfall station to the proposed mining right extension area is the South African Weather Station 0480267W – Kranspan which is located on the south-western boundary of the proposed mining right extension area, 2 km south-west of the node S1.

3.2.1.1. Mean Annual and Monthly Rainfall

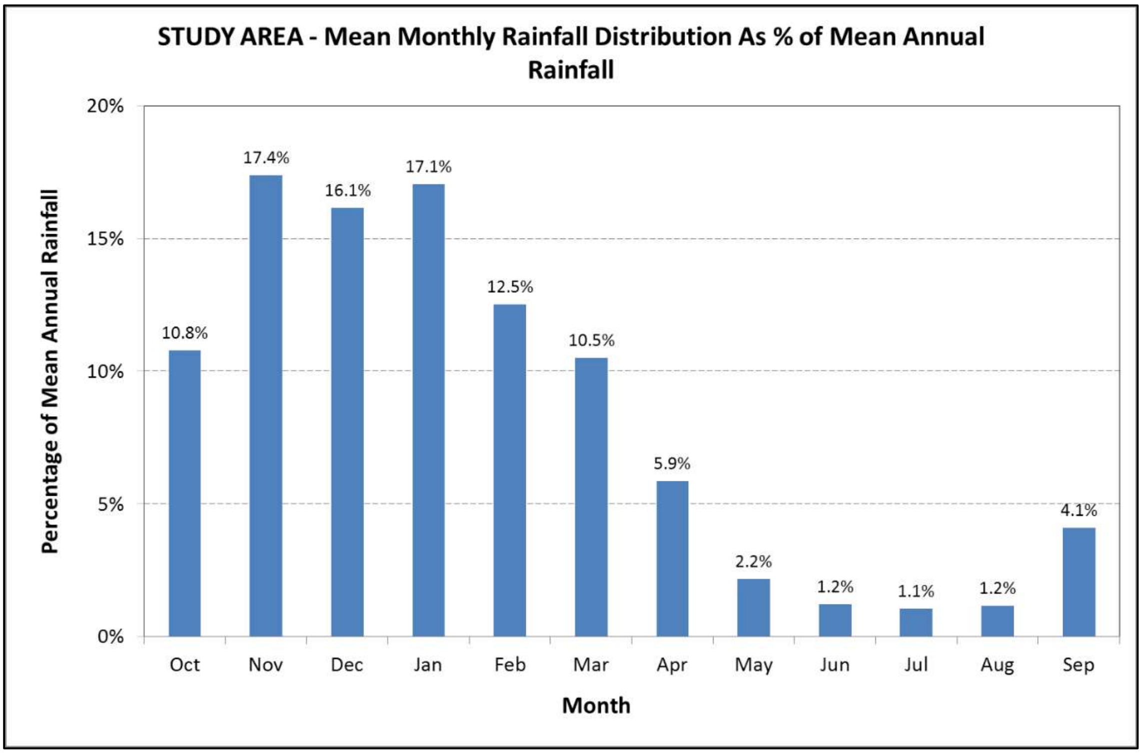
The mean annual rainfall for South African Weather Station 0480267W – Kranspan is **698mm** based on 44 years of data as indicated in the TR102 Southern African Storm Rainfall from PT Adamson. The mean monthly rainfall distributions as listed in the Surface Water Resources of South Africa 1990 Volume VI Appendix 2.2 were used to calculate the mean monthly rainfall and the annual standard deviation was used to estimate the typical wet and dry seasons.

The mean monthly rainfall distributions from Surface Water Resources of South Africa 1990 Volume VI Appendix 2.2 are listed in the table and shown in the figure below.

TABLE 2: MEAN MONTHLY RAINFALL DISTRIBUTIONS IN PERCENTAGE (%)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep
Distribution	10.8	17.4	16.1	17.1	12.5	10.5	5.9	2.2	1.2	1.1	1.2	4.1

FIGURE 4: PERCENTAGE MEAN MONTHLY DISTRIBUTION OF MEAN ANNUAL RAINFALL (MAP)



The mean monthly and annual rainfall for the proposed mining right extension area as well as that for typical wet and dry years is listed in the table below.

TABLE 3: MEAN MONTHLY AND ANNUAL RAINFALL (MM)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
Wet	87	139	129	137	100	84	47	17	11	8	10	33	802
Mean	75	121	113	119	87	73	41	15	9	7	9	29	698
Dry	64	103	96	101	74	62	35	13	8	6	8	24	594

3.2.2. Evaporation (S – Pan)

There are no weather stations with evaporation data in the vicinity of the proposed mining right extension area, hence the recommended values in the Water Research Commission's "Surface Water Resources of South Africa 1990 Manual" Volume 1 were used.

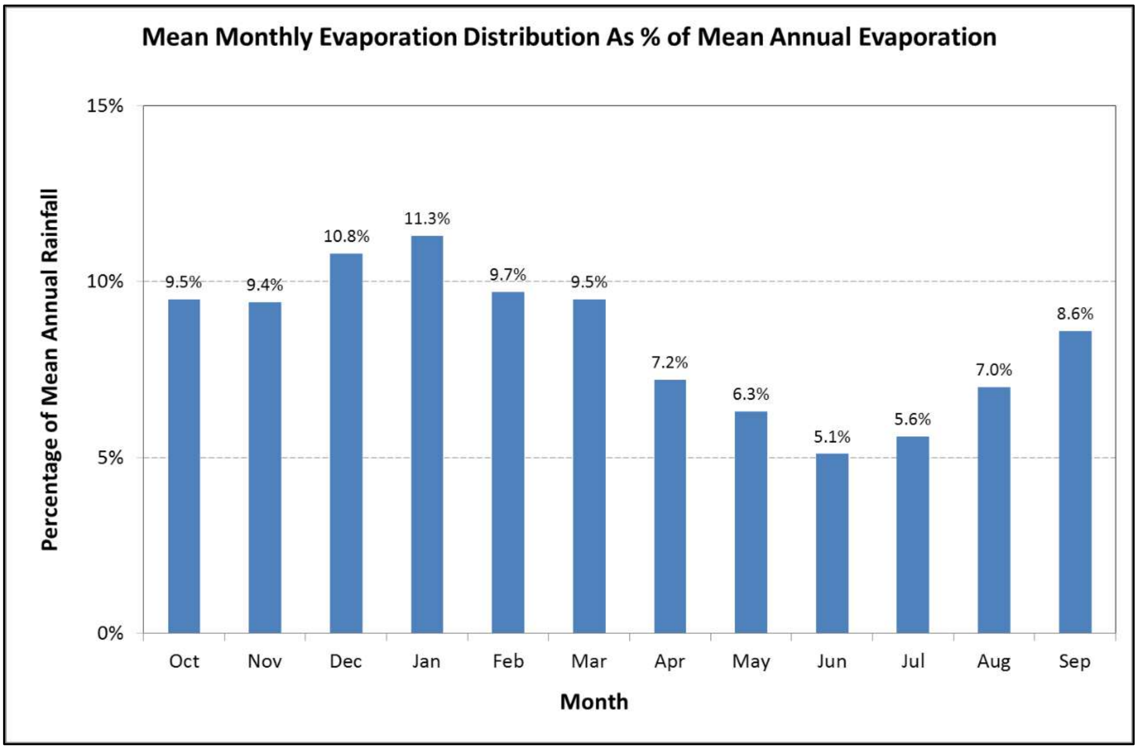
All the sub-catchments in the proposed mining right extension area are situated in quaternary sub-catchments X11A and X11B with a Mean Annual Evaporation (MAE) of 1 450mm. Both Quaternary sub-catchments are within evaporation zone 5A.

The mean monthly evaporation distributions from Surface Water Resources of South Africa 1990 Volume VI Appendix 3.2 for zone 5A are listed in the table and shown in the figure below.

TABLE 4: MEAN MONTHLY EVAPORATION DISTRIBUTIONS IN PERCENTAGE (%)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep
Distribution	9.5	9.4	10.8	11.3	9.7	9.5	7.2	6.3	5.1	5.6	7	8.6

FIGURE 5: PERCENTAGE MEAN MONTHLY DISTRIBUTION OF MEAN ANNUAL EVAPORATION (MAE)



The mean monthly and annual evaporation for the proposed mining right extension area is listed in the table below.

TABLE 5: MEAN MONTHLY AND ANNUAL EVAPORATION (MM)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
Mean	138	136	157	164	141	138	104	91	74	81	102	124	1 450

3.2.3. Runoff

3.2.3.1. Mean Annual Runoff

There is no river flow gauging stations in neither the Boesmanspruit nor Vaalwaterspruit in the vicinity of the proposed mining right extension area. Further, no gauging station could be located with sufficient data that can be used as a representation of this catchment area. In the absence of representative data, the recommended values in the Water Research Commission's "Surface Water Resources of South Africa 1990 Manual" Volume 1 were used.

a) Boesmanspruit

The proposed mining right extension area falls within quaternary sub-catchment X11B - Boesmanspruit. The calculated net MAR for the Boemanspruit is ***26.2 million m³***.

TABLE 6: MEAN ANNUAL RUNOFF FOR THE BOESMANSPRUIT

Quaternary Sub – catchment Name	Net Area (km2)	Net MAR (10^6 m^3/a)
X11B	**597**	**26.2**

a) Vaalwaterspruit

The proposed mining right extension area falls within quaternary sub-catchment X11A - Vaalwaterspruit. The calculated net MAR for the Vaalwaterspruit is ***23.7 million m³***.

TABLE 7: MEAN ANNUAL RUNOFF FOR THE BOESMANSPRUIT

Quaternary Sub – catchment Name	Net Area (km2)	Net MAR (10^6 m^3/a)
X11A	**672**	**23.7**

b) Proposed Mining Right Extension Area

All the sub-catchments in the proposed mining right extension area are situated in quaternary sub-catchments X11B and X11B. The mean annual rainfall for this site is 698mm. The rainfall / runoff response number for this quaternary sub-catchment is 8, relating to a mean annual runoff (MAR) of 37mm runoff depth.

TABLE 8: MEAN ANNUAL RUNOFF OVER PROPOSED MINING RIGHT EXTENSION AREA

Catchment Name	Catchment Size (km^2)	MAR (m^3/a)	Comment
S1	15.490	573 130	Does not contribute to the mean annual runoff for the Boesmanspruit.
S2	2.485	91 945	
S3	2.222	82 214	
S4	11.86	438 820	Contributes to Boesmanspruit
S5	16.49	610 130	Contributes to Boesmanspruit
S6	2.22	82 140	Does not contribute
S7	63.21	2 338 770	Contributes to Boesmanspruit
S8	44.81	1 657 970	Contributes to Vaalwaterspruit
TOTAL	158.79	5 045 690	Total excludes S1, S2, S3 & S6

3.2.3.2. Mean Monthly Runoff

a) Boesmanspruit and Vaalwaterspruit

The mean monthly runoff distribution ratios are obtained from the Water Research Commission's "Surface Water Resources of South Africa 1990 Manual Volume 1".

The entire catchments of the Boesmanpruit and Vaalwaterspruit are situated within the HYDRO Zone VI-P for which the manual recommends a percentage of the MAR for each month of the hydrological year.

TABLE 9: BOESMANSPRUIT MEAN MONTHLY RUNOFFS AND RATIOS

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	1.1	4.1	5.3	4.8	4.3	2.3	1.4	0.9	0.7	0.5	0.4	0.4	26.2
%	4.3	15.6	20.2	18.2	16.3	8.7	5.3	3.8	2.5	1.9	1.5	1.7	100

TABLE 10: VAALWATERSPRUIT MEAN MONTHLY RUNOFFS AND RATIOS

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	1.0	3.7	4.8	4.3	3.8	2.1	1.3	0.9	0.6	0.5	0.3	0.4	23.7
%	4.3	15.6	20.2	18.2	16.3	8.7	5.3	3.8	2.5	1.9	1.5	1.7	100

FIGURE 6: BOESMANSPRUIT MEAN MONTHLY RUNOFF VOLUMES

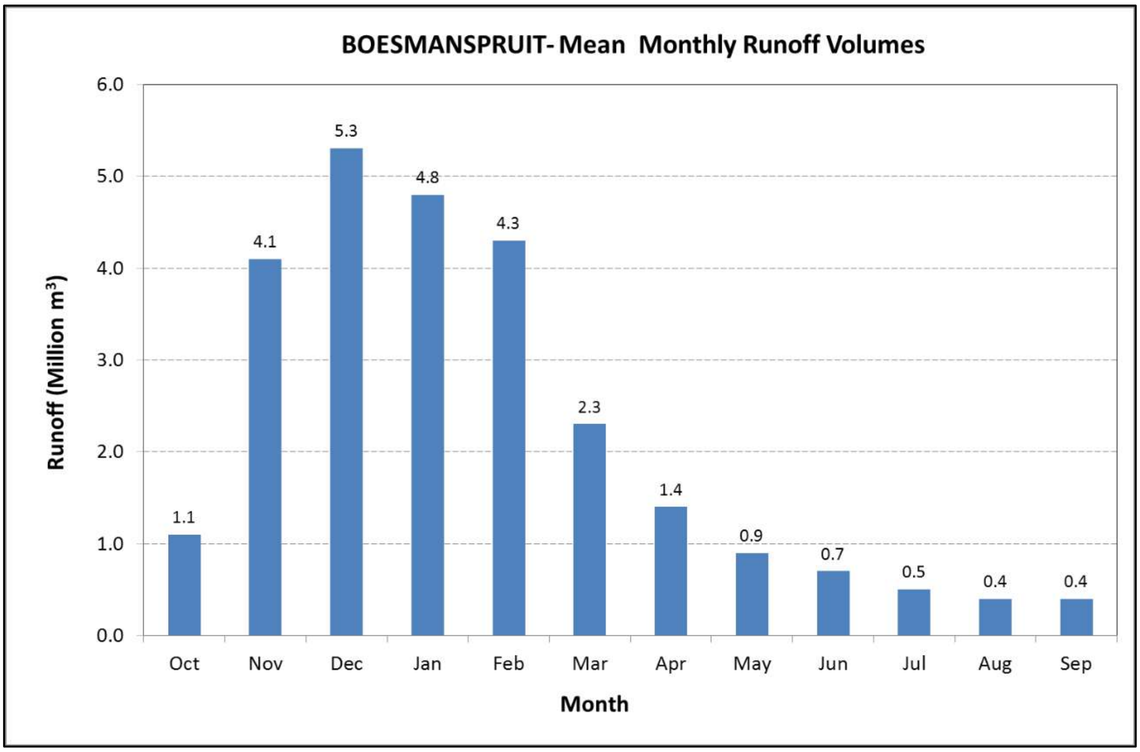
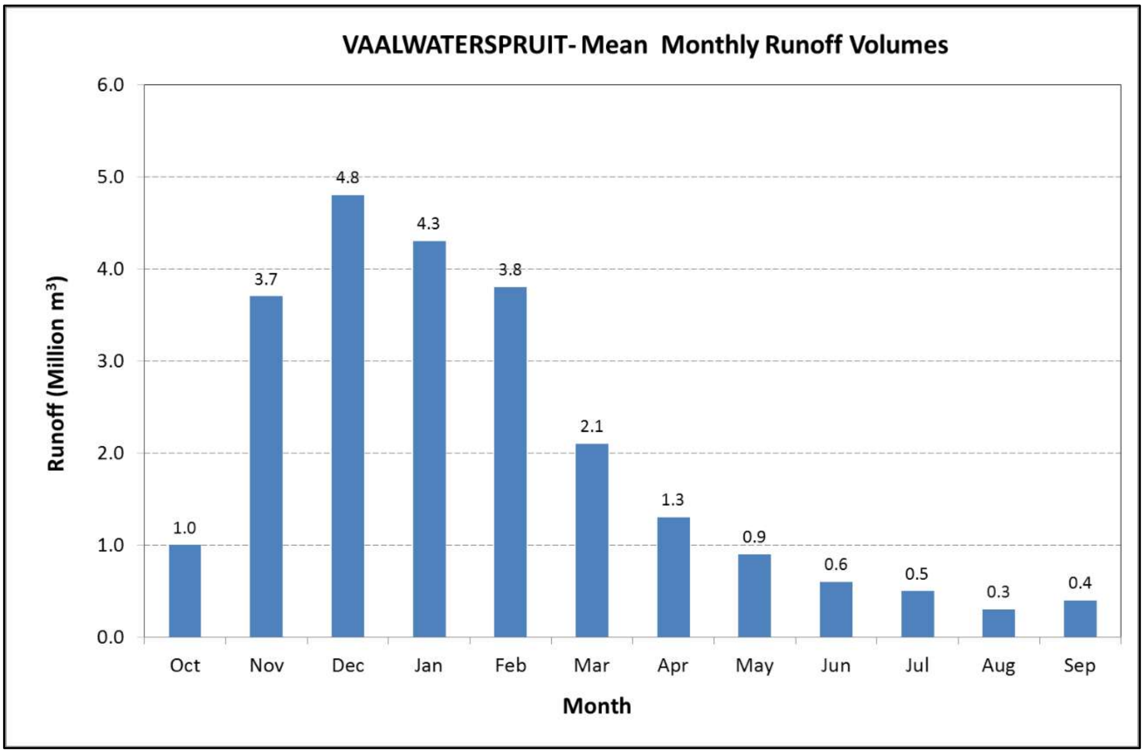


FIGURE 7: VAALWATERSPRUIT MEAN MONTHLY RUNOFF VOLUMES



b) Proposed Mining Right Extension Area

The mean monthly runoff distribution ratios used for the Boesmanspruit were utilised for each sub-catchment within the proposed mining right extension area and are listed in the tables below.

TABLE 11: "S1" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.02	0.09	0.12	0.10	0.09	0.05	0.03	0.02	0.01	0.01	0.01	0.01	0.573

TABLE 12: "S2" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.00	0.01	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.091

TABLE 13: "S3" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.00	0.01	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.082

TABLE 14: "S4" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.02	0.07	0.09	0.08	0.07	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.439

TABLE 15: "S5" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.03	0.10	0.12	0.11	0.10	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.610

TABLE 16: "S6" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.00	0.01	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.082

TABLE 17: "S7" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.10	0.36	0.47	0.43	0.38	0.20	0.12	0.09	0.06	0.04	0.04	0.04	2.339

TABLE 18: "S8" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.07	0.26	0.33	0.30	0.27	0.14	0.09	0.06	0.04	0.03	0.02	0.03	1.658

3.2.3.3. Base flow

The Water Act defines "Normal Flow" or base flow as that portion of the stream flow that can be beneficially used for irrigation without the aid of storage at a site.

Base flow is often estimated as the flow available 70% of the time during the critical irrigation season, i.e. the period of maximum demand and minimum runoff. This occurs usually during the months of June to September in the summer rainfall areas.

For the purpose of preliminary estimates the "Surface Water Resources of South Africa 1990 Manual" Volume 1 provides Deficient Flow – Duration – Frequency curves from where the base flow can be related to a percentage of the mean annual runoff.

TABLE 19: BASE FLOW FOR BOESMANSPRUIT AND VAALWATERSPRUIT

Quaternary Sub – catchment Name	Base Flow Ratio of MAR (%)	Base Flow (10^6 m^3/a)	Average Monthly Base Flow (10^6 m^3/a)	Average Base Flow Rate (m^3/s)
X11A	4.34	1.03	0.258	0.10
X11B	4.34	1.14	0.285	0.11

TABLE 20: BASE FLOW FOR SUB-CATCHMENT (S4)

Node Name	Base Flow Ratio of MAR (%)	Base Flow (10^6 m^3/a)	Average Monthly Base Flow (10^6 m^3/a)	Average Base Flow Rate (m^3/s)
S4	4.34	0.019	0.005	0.0018

TABLE 21: BASE FLOW FOR SUB-CATCHMENT (S5)

Node Name	Base Flow Ratio of MAR (%)	Base Flow (10^6 m^3/a)	Average Monthly Base Flow (10^6 m^3/a)	Average Base Flow Rate (m^3/s)
S5	4.34	0.026	0.007	0.0026

TABLE 22: BASE FLOW FOR SUB-CATCHMENT (S7)

Node Name	Base Flow Ratio of MAR (%)	Base Flow (10^6 m^3/a)	Average Monthly Base Flow (10^6 m^3/a)	Average Base Flow Rate (m^3/s)
S7	4.34	0.102	0.026	0.0101

TABLE 23: BASE FLOW FOR SUB-CATCHMENT (S8)

Node Name	Base Flow Ratio of MAR (%)	Base Flow (10^6 m^3/a)	Average Monthly Base Flow (10^6 m^3/a)	Average Base Flow Rate (m^3/s)
S8	4.34	0.072	0.018	0.0070

3.3. FLOOD HYDROLOGY

3.3.1. Design Storm

The closest rainfall gauging station to the proposed mining right extension area is the 0480267W – Kranspan. The design rainfall events associated with this gauging station is documented in the TR 102 Southern African Storm Rainfall.

For storm duration less than 6 hours the following relationship developed by Hershfield and later modified by Alexander is used to calculate point rainfall:

$P_t,T = 1.13(0.41 + 0.64^* \ell n\ T)(-0.11 + 0.27^* \ell n\ t)(0.79M^{0.69}R^{0.20})$

* R = 60 days/year that thunder is seen.

TABLE 24: DESIGN 24 HOUR RAINFALL DATA

Station Number	Description	MAP (mm)	24-Hour Rainfall (mm)						
			1:2	1:5	1:10	1:20	1:50	1:100	1:200
0480267	Kranspan	698	62	82	97	112	135	153	173

3.3.2. Flood Peaks and Volumes

The flood peaks was calculated utilising the Rational Method. The flood volume was calculated using a triangular hydrograph with the time of concentration equal to a third of the storm duration.

The table below summarises the peak flows and flood volumes for the range recurrence intervals.

Table 25: Flood Peaks And Volumes For Water Courses In Proposed Mining Right Extension Area

Catchment Name		Recurrence Interval						
		1:2	1:5	1:10	1:20	1:50	1:100	1:200
S1	Flood Peak (m^3/s)	32.7	58.9	81.3	107.1	141.5	171.6	194.3
	Flood Volume (10^3 m^3)	141.6	255.0	351.9	463.6	612.6	742.9	841.1
S2	Flood Peak (m^3/s)	4.0	7.2	10.0	13.0	17.2	20.9	23.7
	Flood Volume (10^3 m^3)	25.1	45.1	62.6	81.4	107.7	130.9	148.5
S3	Flood Peak (m^3/s)	2.3	4.2	5.8	7.6	10.1	12.2	13.8
	Flood Volume (10^3 m^3)	27.1	49.4	68.3	89.5	118.9	143.6	162.5
S4	Flood Peak (m^3/s)	14.2	25.5	35.5	46.4	61.4	74.4	84.3
	Flood Volume (10^3 m^3)	118.1	212.1	295.2	385.9	510.6	618.7	701.0
S5	Flood Peak (m^3/s)	23.7	42.6	59.2	77.4	102.4	124.2	140.6
	Flood Volume (10^3 m^3)	153.6	276.0	383.6	501.6	663.6	804.8	911.0
S6	Flood Peak (m^3/s)	7.8	14.1	19.5	25.6	33.8	41.0	46.4
	Flood Volume (10^3 m^3)	12.0	21.7	30.0	39.4	52.0	63.1	71.4
S7	Flood Peak (m^3/s)	41.3	74.3	103.2	135.0	178.5	216.4	245.0
	Flood Volume (10^3 m^3)	888	1 597	2 218	2 901	3 836	4 651	5 266

Table 25: Continues……………								
Catchment Name		Recurrence Interval						
		1:2	1:5	1:10	1:20	1:50	1:100	1:200
S8	Flood Peak (m^3/s)	34.0	61.1	85.0	111.2	147.0	178.3	210.9
	Flood Volume (10^3 m^3)	600	1 079	1 501	1 964	2 596	3 148	3 724

3.4. DRAINAGE DENSITY

The drainage density is the total stream and river lengths in a particular catchment divided by the total catchment area. The density of the drainage system will directly influence the proportion of the precipitation that will contribute to direct runoff.

The proposed mining right extension area's drainage density is therefore ***0.53 km/km²***.

4. FLOOD LEVELS IN PANS

4.1. FLOOD VOLUMES

The maximum 100 year return period flood level in the pans was determined by calculating the water level associated with the largest runoff volume between the 1:100 year flood peak volume, the 1:100 year 1 day storm and the 1:100 year 7 day storm.

This approach was taken as the pans do not have outflows except for S3 which will only discharge a small portion of the incoming flood under extreme floods due to the culvert crossings under the R36 road beings roughly 1m above the current surveyed water level.

The flood volumes associated with various storm events are listed in the table below.

TABLE 26: FLOOD VOLUMES INTO PANS

Node Name	1:100 year (flood peak volume) (10^3 m^3)	1:100 year (1 day storm flood volume) (10^3 m^3)	1:100 year (7 day storm flood volume) (10^3 m^3)
S1	742.9	710.9	***1 291.8***
S2	130.9	114.1	***207.2***
S3	143.6	127.1	***231.0***
S6	63.1	102.0	***185.0***

4.2. PANS STAGE – STORAGE DATA

The stage versus storage volumes were calculated based on the survey with 1m contour intervals provided for the project. Although the pans dry up in winter the water edge level as on the day of the survey was taken as the normal water level. The mean annual runoff into all the pans is between two and four time less than the maximum 100 year flood volume. It is expected that only during extreme events a noticeable rise in water level will be observed in the pans. The tables below list the stage vs accumulative storage volumes for the four pans marked as nodes “S1”, “S2”, “S3” and “S6”.

TABLE 27: NODE “S1” STAGE VS VOLUME

Node “S1”			
Stage (masl)	**Accu. Volume (10^3 m^3)**	**Stage (masl)**	**Accu. Volume (10^3 m^3)**
1654	0	1656	3 098
1655	1 444	1657	4 912

TABLE 28: NODE “S2” STAGE VS VOLUME

Node “S2”			
Stage (masl)	**Accu. Volume (10^3 m^3)**	**Stage (masl)**	**Accu. Volume (10^3 m^3)**
1654	0	1657	670.1
1656	312.8	1658	1 062.7

TABLE 29: NODE “S3” STAGE VS VOLUME

Node “S3”			
Stage (masl)	**Accu. Volume (10^3 m^3)**	**Stage (masl)**	**Accu. Volume (10^3 m^3)**
1651	0	1653	720.4
1652	298.3	-	-

TABLE 30: NODE "S6" STAGE VS VOLUME

Node "S6"			
Stage (masl)	Accu. Volume (10^3 m^3)	Stage (masl)	Accu. Volume (10^3 m^3)
1672	0	1674	1 160.3
1673	556.9	-	-

4.3. 100 YEAR FLOOD LEVELS

The water levels associated with the flood volumes for the three scenarios were calculated by applying a regression curve to the stage versus storage curves for each pan. In all three cases the 7 day storm event resulted in the highest water levels in the pans, the instantaneous flood peak events and the 1 day storm events produced similar levels.

These results support the observations from the site visit that no outflow from S1, S2 and S6 is possible and that outflow from S3 is only expected for extreme events since the level reached during a 100 year event is still less than the estimated invert level of the culvert under the R36.

TABLE 31: 100 YEAR FLOOD LEVELS

Node Name	1:100 year (flood peak volume) Water Level (masl)	1:100 year (1 day storm flood volume) Water Level (masl)	1:100 year (7 day storm flood volume) Water Level (masl)
S1	1654.51	1654.49	***1654.90***
S2	1654.42	1654.37	***1654.66***
S3	1561.51	1561.46	***1651.80***
S6	1651.12	1651.19	***1651.34***

5. CONCLUSIONS

The conclusions drawn from the analyses done for the current situation are as follows:

- The proposed mining right extension area is located in the **X11A** and **X11B** quaternary sub-catchments of the Komati River Drainage Basin;
- The Boesmanspruit and the Vaalwaterspruit are the major streams flowing past the proposed mining right extension area with effective catchment areas of **597** km^2 and **672** km^2;
- The proposed mining right extension area has a Mean Annual Precipitation (MAP) of **698** mm;
- The proposed mining right extension area has a Mean Annual Evaporation (MAE) of **1 450** mm;
- The Nett Mean Annual Runoff (MAR) of the Boesmanspruit is **26.2** mil m^3;
- The Nett Mean Annual Runoff (MAR) of the Vaalwaterspruit is **23.7** mil m^3;
- The proposed mining right extension area contributes **3.39** mil m^3 or **12.9**% of the nett mean annual runoff of the Boesmanspruit;
- The proposed mining right extension area contributes **1.66** mil m^3 or **7.0**% of the nett mean annual runoff of the Vaalwaterpruit;
- The Base / Normal Flow of the Boesmanspruit is **0.1** m^3/s;
- The Base / Normal Flow of the Vaalwaterspruit is **0.1** m^3/s;
- The proposed mining right extension area contributes **0.0145** m^3/s or **13.2**% of the base flow for the Boesmanspruit;
- The proposed mining right extension area contributes **0.0070** m^3/s or **7.0**% of the base flow for the Vaalwaterspruit;
- The drainage density of the proposed mining right extension area was calculated at **0.53** km/km^2; and
- The recommended 100 year flood levels of the three most significant pans are as follows:
  - "S1" = 1 654.90 masl
  - "S2" = 1 654.66 masl
  - "S3" = 1 651.80 masl
  - "S6" = 1 651.34 masl

6. REFERENCES

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APPENDIX A
WR90 - FIGURES AND TABLES

8.7

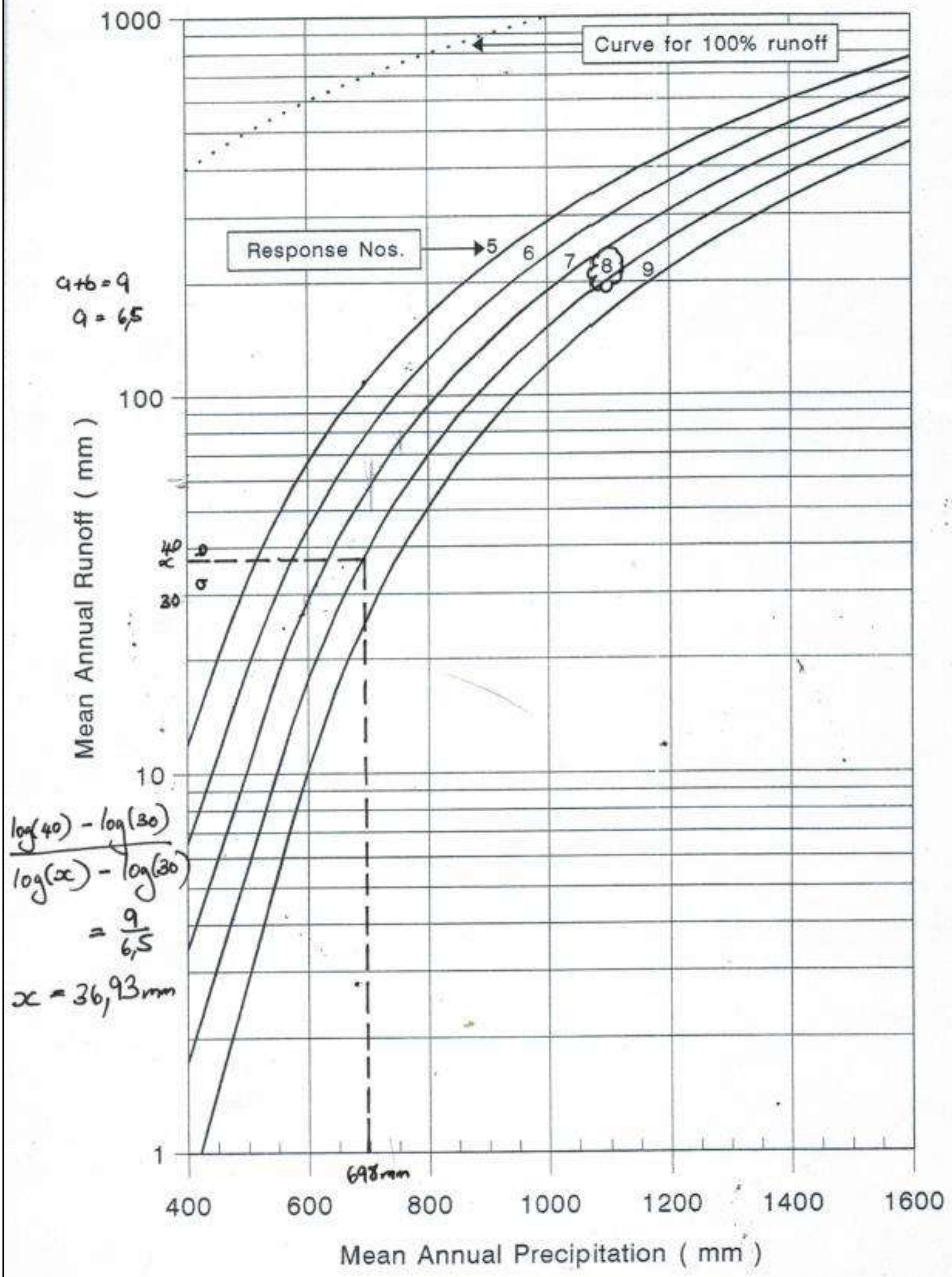
(VOLUME VI) APPENDIX 8 : QUATERNARY AND TERTIARY CATCHMENT INFORMATION (contd.)

CATCHMENT	GROSS AREA (km²)	NET AREA (km²)	FOREST AREA (km²)	IRRIG AREA (km²)	EVAP ZONE	MAE (mm)	RAIN ZONE	MAP (mm)	MAR (mm)	MAP-MAR RESP.	NET MAR (10^6m^3)	GROSS MAR (10^6m^3)	CV	HYDRO ZONE	DAMS
W57A	593	593		3.6	13A	1400	W5J	824	179	5	106.1	106.1	.704	C	
W57B	434	434		1.1	13A	1450	W5J	784	67	8	28.9	28.9	1.419	Q	
W57C	575	575		.4	13A	1450	W5J	755	59	8	33.7	33.7	1.463	Q	
W57D	366	366		2.4	13A	1400	W5J	862	197	5	72.0	72.0	.696	C	
W57E	403	403		13.7	13A	1450	W5J	701	46	8	18.4	18.4	1.541	Q	
W57F	223	223		.3	13A	1450	W5J	774	151	5	33.7	33.7	.720	C	
W57G	623	623		1.7	13A	1450	W5J	644	34	8	21.2	21.2	1.612	Q	
W57H	426	426		62.2	13A	1500	W5J	710	45	8	19.4	19.4	1.533	Q	
W57J	522	522		37.1	13A	1500	W5J	628	30	8	15.7	15.7	1.622	Q	
W57K	301	301	3		13A	1500	W5J	628	30	8	9.1	9.1	1.622	Q	
W57	4466	4466	3	122.5		1453		729	80		358.0		1.023		
W60A	172	172	1	1.7	13A	1400	W6A	1156	411	5	70.7	70.7	.406	A	
W60B	143	143		3.4	13A	1400	W6A	1201	439	5	62.8	62.8	.406	A	
W60C	233	233		5.1	13A	1400	W6A	1161	414	5	96.5	96.5	.406	A	
W60D	187	187		6.8	13A	1400	W6B	937	206	6	38.5	38.5	.626	C	
W60E	134	134		.2	13A	1450	W6B	806	73	8	9.8	9.8	1.254	Q	
W60F	418	418		2.2	13A	1450	W6B	801	71	8	29.9	29.9	1.259	Q	
W60G	222	222		.8	13A	1400	W6A	912	187	6	41.5	41.5	.549	C	
W60H	365	365		1.6	13A	1450	W6B	796	70	8	25.5	25.5	1.264	Q	
W60J	447	447			13A	1450	W6B	819	77	8	34.5	34.5	1.241	Q	
W60K	665	665		115.9	13A	1500	W6B	825	75	8	50.1	50.1	1.238	Q	
W60	2986	2986	1	137.7		1445		893	154		459.8		.693		
W70A	2589	589	255		22C	1500	W3E	769	43	9	25.3	111.2	1.049	L	
W70	2589	589	255			1500		769	9.8		25.3		1.049		
X11A	672	672			5A	1450	X1A	682	35	8	23.7	23.7	.900	P	$
* X11B	597	597			5A	1450	X1A	714	44	8	26.2	26.2	.860	P	$
X11C	319	319	5		5A	1450	X1A	716	45	8	14.2	14.2	.857	P	$
X11D	590	590		11.8	5A	1450	X1B	744	88	6	51.8	51.8	.432	B	$
X11E	242	242	1	4.9	5A	1400	X1B	760	98	6	23.8	23.8	.441	B	$
X11F	183	183	1	3.7	5A	1400	X1B	820	120	6	22.0	22.0	.462	B	$
X11G	264	264	39	5.3	5A	1400	X1C	867	180	6	47.6	47.6	.333	B	$
X11H	265	265	42	5.3	5A	1400	X1C	951	222	6	58.8	58.8	.337	B	
X11J	186	186	138		5A	1400	X1C	1040	271	6	50.5	50.5	.334	B	$
X11K	211	211	21	16.3	5A	1400	X1C	895	194	6	40.9	40.9	.334	B	$
X11	3529	3529	247	47.3		1431		779	102		359.6		.410		
X12A	244	244	54	1.3	5A	1400	X1D	802	127	6	31.0	31.0	.446	B	
X12B	155	155	58	.8	5A	1400	X1D	834	140	6	21.8	21.8	.446	B	
X12C	186	186	1	1.1	5A	1400	X1D	876	160	6	29.7	29.7	.442	B	
X12D	223	223	14	8.2	5A	1400	X1D	860	80	8	17.9	17.9	.705	F	
X12E	333	333	113	2.0	5A	1400	X1D	889	91	8	30.3	30.3	.688	F	
X12F	313	313	22	1.9	5A	1400	X1D	870	84	8	26.2	26.2	.699	F	
X12G	239	239	3		5A	1400	X1D	901	96	8	22.9	22.9	.680	F	$
X12H	286	286			5A	1400	X1E	922	121	8	34.6	34.6	.772	F	
X12J	296	296	77		5A	1400	X1E	1158	232	8	68.6	68.6	.553	C	
X12K	286	286	4		5A	1400	X1E	911	116	8	33.2	33.2	.777	F	
X12	2561	2561	346	15.3		1400		910	123		316.2		.580		
X13A	245	245	50		5A	1400	X1E	1200	255	8	62.4	62.4	.549	C	
X13B	237	237	86		5A	1400	X1E	1157	231	8	54.8	54.8	.553	C	
X13C	195	195			5A	1400	X1E	1267	294	8	57.4	57.4	.540	C	
X13D	181	181	7	1.0	5A	1400	X1F	1185	268	8	48.5	48.5	.732	G	
X13E	212	212		1.2	5A	1400	X1F	1019	187	7	39.6	39.6	.746	G	
X13F	217	217	50	1.3	5A	1400	X1F	1007	182	7	39.4	39.4	.745	G	
X13G	335	335	6		5A	1400	X1F	822	82	8	27.4	27.4	1.287	Q	
X13H	306	306			5A	1450	X1F	742	54	8	16.5	16.5	1.429	Q	
X13J	789	789		7.7	5A	1500	X1H	676	32	8	25.4	25.4	1.796	R	
X13K	621	621		79.4	5A	1550	X1H	609	19	7	11.8	11.8	2.112	C	$
X13L	286	286		36.5	5A	1550	X1H	605	18	7	5.3	5.3	2.126	C	$
X13	3624	3624	199	127.1		1464		842	107		388.5		.777		

$ At least one registered dam situated in the quaternary catchment
# The quaternary has been split into two hydro zones
* The MAP derived from the CCWR isohyetal map has been adjusted

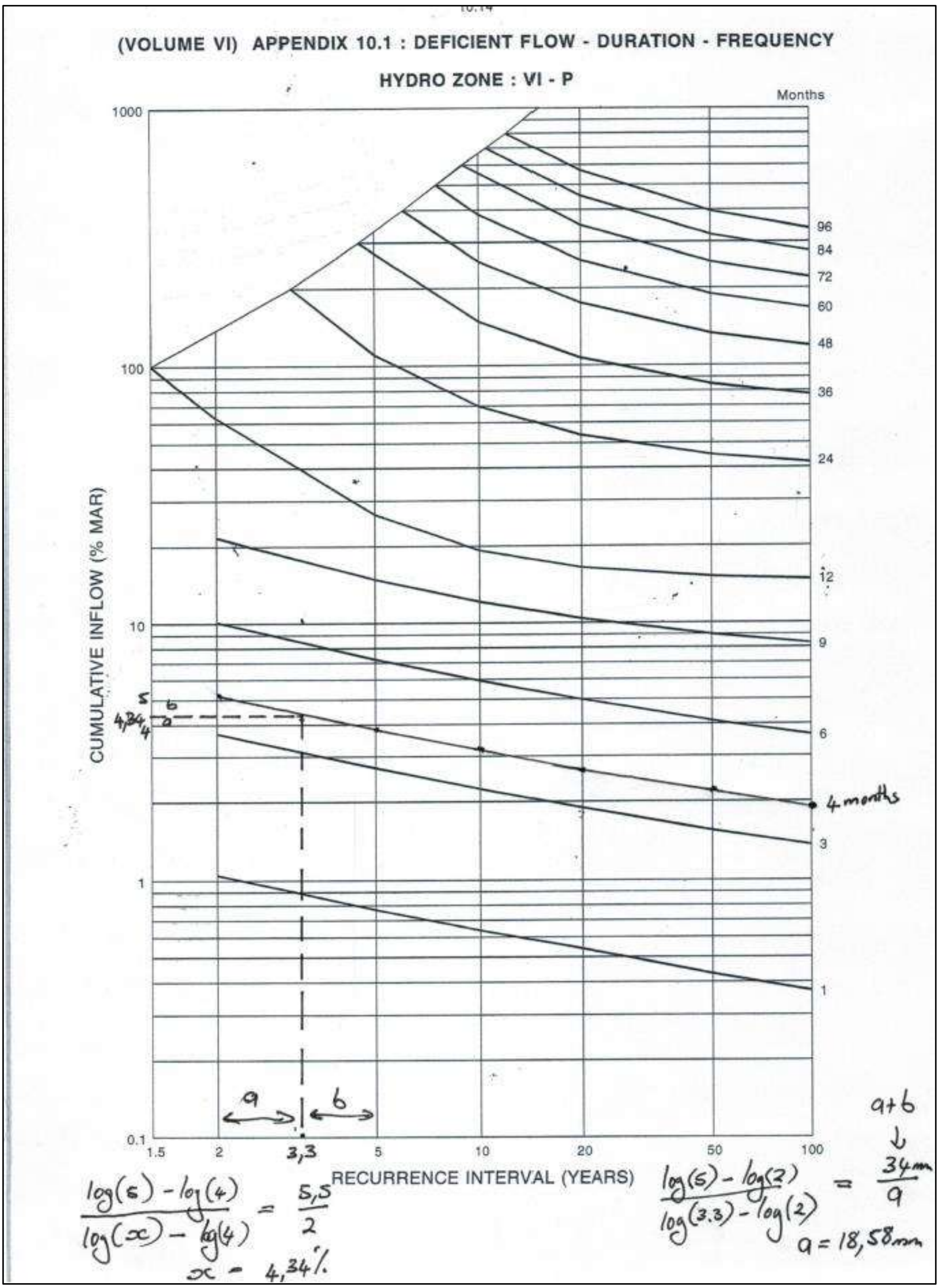
9.1

(VOLUME VI) APPENDIX 9 : RAINFALL - RUNOFF RESPONSE



(VOLUME VI) APPENDIX 10.2 : AVERAGE MONTHLY FLOWS EXPRESSED AS PERCENT MAR

HYDRO ZONE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
VI-A	4.4	7.3	10.8	14.1	15.8	13.7	9.8	6.9	5.3	4.4	3.9	3.6
VI-B	4.1	9.2	13.6	15.4	15.8	12.3	8.7	6.3	4.7	3.8	3.2	2.9
VI-C	4.3	8.5	12.6	16.1	17.8	14.2	8.8	5.3	3.8	3.1	2.7	2.8
VI-E	4.8	9.3	13.6	17.7	18.8	16.9	8.0	3.3	1.8	1.3	1.5	3.0
VI-D	6.7	11.9	14.0	16.1	15.4	12.6	7.4	4.2	2.8	2.8	2.4	3.7
VI-F	3.5	6.7	11.8	15.6	19.4	14.4	8.2	5.6	4.5	3.8	3.4	3.1
VI-G	2.7	5.6	10.1	16.7	21.7	18.6	9.8	4.5	3.2	2.6	2.3	2.2
VI-H	5.8	12.9	16.6	20.0	17.3	11.5	6.1	3.0	1.7	1.4	1.4	2.3
VI-J	4.1	7.9	11.8	18.2	21.2	18.6	8.6	3.0	1.4	1.0	1.2	3.0
VI-K	6.8	9.3	10.0	10.5	13.1	16.5	10.2	6.2	5.0	3.5	2.9	6.0
VI-L	7.0	6.6	7.0	8.7	11.2	14.6	10.7	8.0	6.9	6.5	5.5	7.3
VI-M	8.5	8.5	9.1	8.3	12.9	14.3	8.9	7.3	5.6	4.9	3.8	7.9
VI-N	6.2	11.0	13.7	17.5	17.5	13.6	6.5	3.2	1.8	2.2	2.1	4.7
* VI-P	4.3	15.6	20.2	18.2	16.3	8.7	5.3	3.8	2.5	1.9	1.5	1.7
VI-Q	3.9	8.7	12.1	20.4	23.3	17.7	6.3	1.8	1.2	1.3	0.9	2.4
VI-R	0.3	3.7	8.9	22.2	35.4	23.1	5.7	0.4	0.0	0.0	0.0	0.3


(VOLUME VI) APPENDIX 10.1 : DEFICIENT FLOW - DURATION - FREQUENCY
HYDRO ZONE : VI - P
Months
CUMULATIVE INFLOW (% MAR)
RECURRENCE INTERVAL (YEARS)
1000
100
10
1
0.1
1.5
2
5
10
20
50
100
96
84
72
60
48
36
24
12
9
6
3
1
4 months
3,3
4,34
a
b
a+b
log(5) - log(4) / log(x) - log(4) = 5,5 / 2
x = 4,34%
log(5) - log(2) / log(3.3) - log(2) = 34mm / a
a = 18,58mm

APPENDIX B
FLOOD CALCULATIONS

Utility Programs for Drainage
Flood calculations

Sinotech

Project name:	**Kranspan - Coal Mine**
Analysed by:	**HS Peens**
Name of river:	**N/A**
Description of site:	**C1**
Filename:	**S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVL\05 Calculations\Stormwater\C1.fld**
Date:	**9 January 2019**

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Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan - Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C1
Date	= 2019/01/09
Area of catchment	= 15.49 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 3.62 km
Flow of water	= Defined water course
Height difference along 10-85 slope	= 55.0 m
Area distribution	= Rural: 92 %, Urban: 0 %, Lakes: 8 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	8	Very permeable	0	Thick bush & forests	0
Flat area	92	Permeable	100	Light bush & cultivated land	40
Hilly	0	Semi-permeable	0	Grasslands	60
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.02026 m/m
Time of concentration	= 48.1 min
Run-off factor	
Rural - C1	= 0.326
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.300

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	0.80	27.89	97.1	33.81	0.75	22.5	32.72
1:5	0.80	47.05	97.1	57.03	0.80	24.0	58.88
1:10	0.80	61.55	97.1	74.60	0.85	25.5	81.83
1:20	0.80	76.05	97.1	92.17	0.90	27.0	107.05
1:50	0.80	95.21	97.1	115.39	0.95	28.5	141.47
1:100	0.80	109.70	97.1	132.96	1.00	30.0	171.59
1:200	0.80	124.20	97.1	150.53	1.00	30.0	194.26

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Sinotech

Project name:	**Kranspan - Coal Mine**
Analysed by:	**HS Peens**
Name of river:	**N/A**
Description of site:	**C2**
Filename:	**S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVL\05 Calculations\Stormwater\C2.fld**
Date:	**9 January 2019**

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Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan – Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C2
Date	= 2019/01/09
Area of catchment	= 2.485 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 1.77 km
Flow of water	= Overland flow
Height difference	= 55.0 m
Value of r for over land flow	= Moderate grass (r=0,4)
Area distribution	= Rural: 88 %, Urban: 0 %, Lakes: 12 %

Catchment description – Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description – Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	12	Very permeable	0	Thick bush & forests	0
Flat area	88	Permeable	100	Light bush & cultivated land	36
Hilly	0	Semi-permeable	0	Grasslands	64
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.03107 m/m
Time of concentration	= 1.16 h
Run-off factor	
Rural – C1	= 0.328
Urban – C2	= 0.000
Lakes – C3	= 0.000
Combined – C	= 0.289

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	1.16	30.84	100.0	26.68	0.75	21.6	3.986
1:5	1.16	52.03	100.0	45.00	0.80	23.1	7.173
1:10	1.16	68.06	100.0	58.86	0.85	24.5	9.969
1:20	1.16	84.09	100.0	72.73	0.90	26.0	13.04
1:50	1.16	105.28	100.0	91.05	0.95	27.4	17.23
1:100	1.16	121.30	100.0	104.92	1.00	28.9	20.90
1:200	1.16	137.33	100.0	118.78	1.00	28.9	23.67

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Sinotech

Project name:	**Kranspan - Coal Mine**
Analysed by:	**HS Peens**
Name of river:	**N/A**
Description of site:	**C3**
Filename:	**S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVL\05 Calculations\Stormwater\Kranspan Third.fld**
Date:	**9 January 2019**

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Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan - Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C3
Date	= 2019/01/09
Area of catchment	= 2.222 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 3.37 km
Flow of water	= Overland flow
Height difference	= 25.0 m
Value of r for over land flow	= Moderate grass (r=0,4)
Area distribution	= Rural: 90 %, Urban: 0 %, Lakes: 10 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	10	Very permeable	0	Thick bush & forests	0
Flat area	90	Permeable	100	Light bush & cultivated land	26
Hilly	0	Semi-permeable	0	Grasslands	74
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.00742 m/m
Time of concentration	= 2.18 h
Run-off factor	
Rural - C1	= 0.339
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.305

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	2.18	35.95	100.0	16.48	0.75	22.9	2.327
1:5	2.18	60.65	100.0	27.80	0.80	24.4	4.187
1:10	2.18	79.34	100.0	36.36	0.85	25.9	5.820
1:20	2.18	98.02	100.0	44.92	0.90	27.5	7.613
1:50	2.18	122.73	100.0	56.24	0.95	29.0	10.06
1:100	2.18	141.41	100.0	64.80	1.00	30.5	12.20
1:200	2.18	160.10	100.0	73.37	1.00	30.5	13.82

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Sinotech

Utility Programs for Drainage
Flood calculations

Project name:	**Kranspan - Coal Mine**
Analysed by:	**HS Peens**
Name of river:	**N/A**
Description of site:	**C4**
Filename:	**S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVIL\05 Calculations\Stormwater\C4.fld**
Date:	**9 January 2019**

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Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan - Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C4
Date	= 2019/01/09
Area of catchment	= 11.86 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 5.74 km
Flow of water	= Defined water course
Height difference along 10-85 slope	= 40.0 m
Area distribution	= Rural: 90 %, Urban: 0 %, Lakes: 10 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	40	Very permeable	0	Thick bush & forests	0
Flat area	60	Permeable	100	Light bush & cultivated land	53
Hilly	0	Semi-permeable	0	Grasslands	47
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.00929 m/m
Time of concentration	= 1.54 h
Run-off factor	
Rural - C1	= 0.297
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.267

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	1.54	33.16	100.0	21.49	0.75	20.0	14.20
1:5	1.54	55.95	100.0	36.26	0.80	21.4	25.54
1:10	1.54	73.18	100.0	47.43	0.85	22.7	35.50
1:20	1.54	90.42	100.0	58.60	0.90	24.1	46.44
1:50	1.54	113.20	100.0	73.37	0.95	25.4	61.38
1:100	1.54	130.44	100.0	84.54	1.00	26.7	74.44
1:200	1.54	147.67	100.0	95.71	1.00	26.7	84.28

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Sinotech

Project name: Kranspan - Coal Mine
Analysed by: HS Peens
Name of river: N/A
Description of site: C5
Filename: S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVL\05 Calculations\Stormwater\CA6.fld
Date: 9 January 2019

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Flood Frequency Analysis: Alternative Rational Method

Project = Kranspan - Coal Mine
Analysed by = HS Peens
Name of river = N/A
Description of site = C5
Date = 2019/01/09
Area of catchment = 16.49 km²
Dolomitic area = 0.0 %
Length of longest watercourse = 4.62 km
Flow of water = Defined water course
Height difference along 10-85 slope = 40.0 m
Area distribution = Rural: 90 %, Urban: 0 %, Lakes: 10 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	40	Very permeable	0	Thick bush & forests	0
Flat area	60	Permeable	100	Light bush & cultivated land	50
Hilly	0	Semi-permeable	0	Grasslands	50
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard = 60 days/year
Weather Services station number = 480267
Weather Services station location = KRANSPAN
Mean annual precipitation (MAP) = 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope = 0.01154 m/m
Time of concentration = 1.20 h
Run-off factor
Rural - C1 = 0.300
Urban - C2 = 0.000
Lakes - C3 = 0.000
Combined - C = 0.270

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	1.20	31.15	98.5	25.54	0.75	20.3	23.69
1:5	1.20	52.54	98.5	43.08	0.80	21.6	42.62
1:10	1.20	68.73	98.5	56.35	0.85	23.0	59.24
1:20	1.20	84.92	98.5	69.62	0.90	24.3	77.49
1:50	1.20	106.32	98.5	87.16	0.95	25.7	102.41
1:100	1.20	122.50	98.5	100.43	1.00	27.0	124.21
1:200	1.20	138.69	98.5	113.71	1.00	27.0	140.62

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Sinotech

Project name:	Kranspan - Coal Mine
Analysed by:	HS Peens
Name of river:	N/A
Description of site:	C6
Filename:	S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVL\05 Calculations\Stormwater\C6.fld
Date:	9 January 2019

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Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan - Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C6
Date	= 2019/01/09
Area of catchment	= 2.22 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 1.21 km
Flow of water	= Defined water course
Height difference along 10-85 slope	= 30.0 m
Area distribution	= Rural: 83 %, Urban: 0 %, Lakes: 17 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	25	Very permeable	0	Thick bush & forests	0
Flat area	75	Permeable	100	Light bush & cultivated land	61
Hilly	0	Semi-permeable	0	Grasslands	39
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.03306 m/m
Time of concentration	= 17.1 min
Run-off factor	
Rural - C1	= 0.297
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.246

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	0.29	19.58	100.0	68.61	0.75	18.5	7.809
1:5	0.29	33.04	100.0	115.74	0.80	19.7	14.05
1:10	0.29	43.22	100.0	151.39	0.85	20.9	19.53
1:20	0.29	53.39	100.0	187.05	0.90	22.1	25.55
1:50	0.29	66.85	100.0	234.18	0.95	23.4	33.76
1:100	0.29	77.02	100.0	269.83	1.00	24.6	40.95
1:200	0.29	87.20	100.0	305.49	1.00	24.6	46.36

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Sinotech

Project name:	Kranspan - Coal Mine
Analysed by:	HS Peens
Name of river:	N/A
Description of site:	C7
Filename:	S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVIL\05 Calculations\Stormwater\C7.fld
Date:	20 July 2022

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Flood Frequency Analysis: Alternative Rational Method

Project                                 = Kranspan - Coal Mine
Analysed by                             = HS Peens
Name of river                           = N/A
Description of site                     = C7
Date                                    = 2022/07/20
Area of catchment                       = 63.21 km²
Dolomitic area                          = 0.0 %
Length of longest watercourse           = 13.14 km
Flow of water                           = Defined water course
Height difference along 10-85 slope     = 41.0 m
Area distribution                       = Rural: 99 %,  Urban: 0 %,  Lakes: 1 %

Catchment description - Urban area (%)
Lawns                         Residential and industry Business
Sandy, flat (<2%)       0     Houses              0     City centre       0
Sandy, steep (>7%)      0     Flats               0     Suburban          0
Heavy soil, flat (<2%)  0     Light industry      0     Streets           0
Heavy soil, steep (>7%) 0     Heavy industry      0     Maximum flood     0
Catchment description - Rural area (%)
Surface slopes                Permeability              Vegetation
Lakes and pans          30    Very permeable      0     Thick bush & forests          0
Flat area               70    Permeable           100   Light bush & cultivated land  34
Hilly                   0     Semi-permeable      0     Grasslands                    66
Steep areas             0     Impermeable         0     Bare                          0
Days on which thunder was heard         = 60 days/year
Weather Services station number         = 480267
Weather Services station location       = KRANSPAN
Mean annual precipitation (MAP)         =  698  mm
Duration 2      5      10     20     50     100    200
1 day    62     82     97     112    135    153    173
2 days   77     102    120    140    167    189    213
3 days   86     115    136    158    188    213    240
7 days   113    151    179    207    246    278    312
The modified recalibrated Hershfield relationship was used to determine point rainfall.
-----------------------------------------------------------------------------------------------
Average slope                           = 0.00416 m/m
Time of concentration                   = 3.98 h
Run-off factor
Rural - C1                              = 0.321
Urban - C2                              = 0.000
Lakes - C3                              = 0.000
Combined - C                            = 0.318
-----------------------------------------------------------------------------------------------
Return      Time of        Point      ARF      Average      Factor      Runoff        Peak
period      concentration  rainfall            intensity    Ft          coefficient   flow
(years)     (hours)        (mm)       (%)      (mm/h)                   (%)           (m³/s)
-----------------------------------------------------------------------------------------------
1:2         3.98           40.79      96.2     9.86         0.75        23.8          41.27
1:5         3.98           68.81      96.2     16.64        0.80        25.4          74.27
1:10        3.98           90.00      96.2     21.76        0.85        27.0          103.22
1:20        3.98           111.20     96.2     26.89        0.90        28.6          135.03
1:50        3.98           139.22     96.2     33.66        0.95        30.2          178.45
1:100       3.98           160.42     96.2     38.79        1.00        31.8          216.44
1:200       3.98           181.62     96.2     43.92        1.00        31.8          245.04
Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable
catchments

Calculated using Utility Programs for Drainage 1.1.0
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Utility Programs for Drainage
Flood calculations

Sinotech

Project name:	**Kranspan - Coal Mine**
Analysed by:	**HS Peens**
Name of river:	**N/A**
Description of site:	**C8**
Filename:	**S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVL\05 Calculations\Stormwater\C8.fld**
Date:	**20 July 2022**

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Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan - Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C8
Date	= 2022/07/20
Area of catchment	= 44.81 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 13.62 km
Flow of water	= Defined water course
Height difference along 10-85 slope	= 76.0 m
Area distribution	= Rural: 97 %, Urban: 0 %, Lakes: 3 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	30	Very permeable	0	Thick bush & forests	0
Flat area	70	Permeable	100	Light bush & cultivated land	33
Hilly	0	Semi-permeable	0	Grasslands	67
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.00744 m/m
Time of concentration	= 3.27 h
Run-off factor	
Rural - C1	= 0.322
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.312

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	3.27	39.21	97.2	11.66	0.75	23.4	34.00
1:5	3.27	66.14	97.2	19.67	0.80	25.0	61.18
1:10	3.27	86.52	97.2	25.73	0.85	26.5	85.03
1:20	3.27	106.90	97.2	31.79	0.90	28.1	111.23
1:50	3.27	133.83	97.2	39.80	0.95	29.7	147.00
1:100	3.27	154.21	97.2	45.86	1.00	31.2	178.29
1:200	3.27	174.59	97.2	51.92	1.00	31.2	201.85

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

APPENDIX 8E: SURFACE WATER ECOSYSTEMS ECOLOGICAL SURVEYS AND IMPACT ASSESSMENT

ILIMA COAL COMPANY (PTY) LTD

KRANSPAN MINING RIGHTS APPLICATION EXTENSION, MPU.

PTNS, RE/1, RE/2, RE/3, RE/4, 5, RE/6, 7, RE/8, 9, 10, 11 & RE OF THE FARM VAALBANK 212-IS, AND PTNS, 1, 2, 3 & RE OF THE FARM ROODEBLOEM 51-IT.

SURFACE WATER ECOSYSTEMS ECOLOGICAL SURVEYS & IMPACT ASSESSMENT

Prepared for:

ABS Africa (Pty) Ltd

Report authors:	Dr Mathew Ross (*Pr Sci Nat*); Dr Tahla Ross
Report Ref:	KranspanExt_Wetlands 202212
Date:	Feb 2023
Version:	DRAFT v1.0

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DECLARATION

PROJECT: ILIMA COAL COMPANY: MINING RIGHTS APPLICATION EXTENSION FOR THE KRANSPAN PROJECT: Surface Water Ecosystem Ecological and Impact surveys.

This report has been prepared according to the requirements of the Environmental Impact Assessments Regulations (GNR 982) in Government Gazette 38282 of 4 December 2014, and DWS (2008) Guidelines for wetland delineations. We (the undersigned) declare the findings of this report free from influence or prejudice.

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Field of expertise:

Fish ecology, fishway evaluations, biomonitoring and wetland evaluations, aquatic ecology, aquatic & terrestrial fauna and flora.

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Field of expertise:

Biomonitoring and wetland evaluations, aquatic ecology, aquatic & terrestrial fauna and flora.

Date: 16 Feb 2023

Dr T Ross

DISCLAIMER

The findings of the survey provided within this report, together with the results and general observations, and the conclusions and recommendations provided upon completion of the survey are based on the best scientific and professional knowledge of the field specialists. This is also dependent on the data and resources available at the time. The report is based on survey and assessment techniques that are limited by time and budgetary constraints relevant to the type and level of investigation undertaken.

Although EnviRoss and its research staff exercises due care and diligence in rendering services and preparing documents, EnviRoss accepts no liability, and the client, by acceptance of this document, indemnifies EnviRoss, members and employees against all actions, claims, demands, losses, liabilities, costs, damages, and expenses arising from or in connection with services rendered, directly or indirectly by EnviRoss.

CONSULTANT QUALIFICATIONS & EXPERTISE

Dr Mathew Ross (*Pr Sci Nat*) from EnviRoss acted as lead ecological consultant for the ecological surveys pertaining to this project. A summary of qualifications, affiliations and expertise is provided below:

- BSc Biological Sciences (Botany and Zoology) completed in 2000.
- BSc Hons (Aquatic Health) completed in 2001.
- MSc Aquatic Health completed in 2004.
- PhD Aquatic Health completed in 2015.
- Registered Professional Natural Scientist under the South African Council for Natural and Scientific Professionals (SACNASP) in the fields of ecological sciences and aquatic sciences.
- SASS5 accredited practitioner.
- Actively worked as a specialist ecological consultant for 18 years and have authored more than 500 ecological survey reports for projects across 16 countries.
- Founder Member and Principal Scientist at EnviRoss CC.
- Expertise include terrestrial fauna and flora biodiversity, habitat evaluations, red data listed species evaluations, vegetation ecological surveys, exotic vegetation management, avifaunal impact studies, aquatic ecological surveys, aquatic biomonitoring, specialist fish and aquatic macro-invertebrate surveys, fish migrations and fishway development, wetland ecological and delineation surveys.
- Experience in the mining, wastewater treatment, overhead powerline (transmission and distribution), pipeline, renewable energy (solar and hydropower), residential estate development, and instream infrastructure development sectors.
- Proficient in GIS modelling and analysis.
- Proficient in AutoCAD 2D and 3D modelling.
- Proficient in hydraulic analysis of instream structures, including HEC-RAS modelling.

Dr Tahla Ross from EnviRoss co-authored the survey report – providing the role of project management, scientific review, and support. A summary of qualifications, affiliations and expertise is provided below:

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- Expertise include terrestrial fauna and flora biodiversity, habitat evaluations, red data listed species evaluations, vegetation ecological surveys, exotic vegetation management, avifaunal specialist impact studies, aquatic ecological surveys and aquatic biomonitoring.

ABBREVIATIONS, ACRONYMS & DEFINITIONS

TERM	EXPLANATION
Alluvial	Transportation of sediments through hydraulic forces of flowing water within a watercourse.
Antagonistic	When combined elements act against each other to reduce function of effect
CBA	Critical Biodiversity Area. An area evaluated in terms of ecological function and found to support RDL species or provide habitat suitable for the support of such species, or a habitat unit that has not suffered transformation.
CE	Critically endangered. A conservation status provided to a species.
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora.
DARDLEA	Mpumalanga Province Department of Agriculture, Rural Development, Land and Environmental Affairs.
DD	Data deficient. A conservation status provided to a species.
DFFE	Department of Forestry, Fisheries, and the Environment.
DHSWS	Department of Human Settlements, Water and Sanitation.
DWA	Department of Water Affairs. An outdated an unofficial name for the present DHSWS but which remains relevant for literature and policy referrals.
DWAF	Department of Water and Forestry. An outdated an unofficial name for the present DHSWS but which remains relevant for literature and policy referrals.
DWS	Department of Water and Sanitation. An outdated an unofficial name for the present DHSWS but which remains relevant for literature and policy referrals.
ECO	Environmental Control Officer. A suitably qualified person appointed to oversee the construction procedures to ensure environmental compliance (also sometimes referred to as the Environmental Compliance Officer).
EcoStatus Models	A standard set of ecological condition determination models aimed at determining the overall ecological integrity of rivers. Ecological integrity is presented in the form of a grading system from A to F.
EIA	Environmental Impact Assessment.
EN	Endangered. A conservation status provided to a species.
ESA	Ecological Support Area. An area identified that enhances function of ecological processes such as animal migrations. These are not necessarily zones of high ecological integrity.
EX	Extinct (in the wild). A conservation status provided to a species.
Facultative wetland species	Floral species that occur in wetlands or the outer skirts of wetland units where soils are seasonally saturated.
Ferrolysis	A chemical process that occurs within hydromorphic soils associated with wetland conditions where the cyclic precipitation and dissolution of iron (and other minerals) within the soils due to oxidation induced by a seasonally fluctuating water table induces metal nodule formation. This is useful as an indication of wetland conditions.
Floodplain	A terraced zone adjacent to a watercourse that is activated seasonally under elevated flow conditions.
GIS	Geographic Information System.
GPS	Global Positioning System.
HGM	Hydrogeomorphic. A referral to the type of wetland unit that is dependent on topographical, geomorphological, and hydrological characteristics.
Hydrophytic	Floral species specifically adapted to grow within water inundated (saturated) soils or water
Hypoxic	A state of oxygen deprivation.
I&AP	Interested and Affected Party.
IUCN	International Union for Conservation of Nature.
LC	Least concern. A conservation status provided to a species.
MRA	Mining Rights Application
NFEPA	National Freshwater Ecosystem Priority Areas
NT	Near Threatened. A conservation status provided to a species.

TERM	EXPLANATION
PES	Present Ecological State.
Pioneer species	A floral species that is typically the first to colonize a disturbed area as part of the plant succession process. Characteristically hardy to sustain harsh environmental conditions, it then provides more favourable conditions for other floral species to establish.
Plagioclimax species	A floral species that represents the climax stage of veld succession but is not the natural climax species for the vegetation unit. It therefore is indicative of historical disturbance impacts.
RDL	Red Data Listed. A referral to the conservation status of species, categorized as EX, CE, EN, VU.
Riparian vegetation	A floral community associated with a river that is dependent on the water and other resources offered by the watercourse.
RIVER-IHI	River Index of Habitat Integrity.
SANBI	South African National Biodiversity Institute.
SLV	Special Limit Values (for water quality standards).
Synergistic	When combined elements act together to enhance function or effect.
VU	Vulnerable. A conservation status provided to a species.
WETLAND-IHI	Wetland Index of Habitat Integrity.

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1. INTRODUCTION

1.1. Background & Project Description

Ilima Coal Company (Pty) Ltd has initiated the process of the extension of the mining rights application (MRA) for the Kranspan Project, which includes Portions 5, 7, 9, 10 and 11, and the remainder of Portions 1, 2, 3, 4, 6 and 8, together with the remainder of the Farm Vaalbank 212-IS, and the remaining portion, and Portions 1, 2 and 3 of the Farm Roodebloem 51-IT, located to the southwest of the town of Carolina in Mpumalanga Province. The survey area measures approximately 4975 ha. The extended MRA lies to the adjacent southeast and southwest of the existing Kranspan Project area. EnviRoss was requested by ABS Africa (Pty) Ltd to undertake the surface water ecosystems ecological and delineation surveys, together with the associated impact assessments pertaining to the surface water ecosystems within the project area. The locality of the site, together with its association with the existing Kranspan Project site, is presented in Figure 1. This report details the findings of multiple surveys undertaken between November 2022 and January 2023.

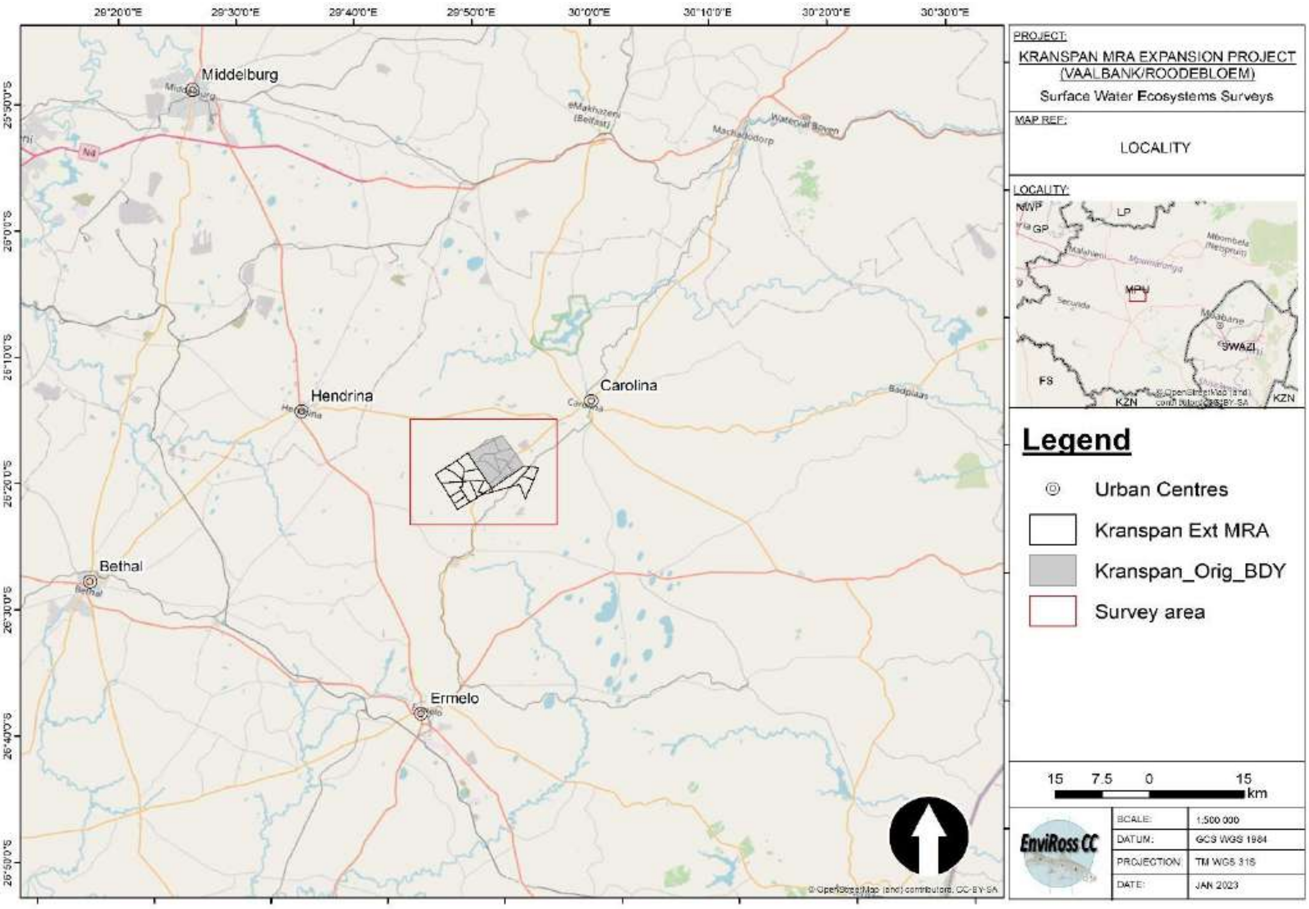


Figure 1: Locality of the survey area.

1.2. Scope of Work

The Scope of Work for the surface water ecosystem survey was to determine the overall ecological integrity and functionality of the surface water ecosystem units that are associated with the development area and to designate appropriate conservation buffers to these units as a protective factor to the wetland units from the terrestrial development activities. The ecological integrity of the wetland habitat units was also to be determined which would allow for the determination of the overall significance of the impacts to the wetland and aquatic habitat units.

Application of the DWS Risk Assessment Matrix was also to be applied to the wetland units associated to the development area as part of the survey.

1.3. Assumptions & Limitations

The conclusions to the overall perceived impacts have been based on a desktop survey that was reiterated by ground-truthing through field surveys of the area encompassing the proposed development. Comprehensive physical surveys for an area as large as the survey area are not always possible nor practical, which necessitates that a trend analysis of the correlation between the physical site conditions and what can be ascertained from the aerial imagery be used to delineate wetland conditions in some areas. Aerial imagery analysis therefore plays an integral part in wetland analyses within large areas. Vegetation structures and some floral species are mentioned within the report. This mention is purely for the purpose of delineating the wetland boundaries and is not meant as an account of the full species lists and ecological potential of the proposed development site and should not be taken as such. Detailed biodiversity accounts should be taken from the relevant specialist assessments.

1.4. Aims & Objectives

The objective of this report is to indicate the present ecological state of the surface water ecosystem units as well as to indicate the limits of the outer boundaries of these units that are associated with the survey area. The survey also aims to offer recommendations to the general management of the wetland units to limit the present and potential future deleterious impacts. This information can be utilised as supporting information for the design, construction, and management teams of the proposed development activities.

The report was also to be generated as a supporting document according to the requirements of the Environmental Impact Assessments Regulations (GNR 982) in Government Gazette 38282 of 4 December 2014, and DWS (2008) Guidelines for wetland delineations.

1.5. Applicable Legislature

1.5.1. National

Conservation of aquatic and wetland habitat units and resources is protected by a myriad of legislature, including the Constitution of South Africa (Act no 108 of 1996), which states that everyone has a right to an environment that is not harmful or detrimental to their health and which is sustainable for future generations. Further to this, South Africa uses environmental-specific legal frameworks based on principles found in the National Environmental Management Act (NEMA) (Act no 107 of 1998). Section 28 (1) states that any person who causes or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing, or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment.

The National Water Act (Act no 36 of 1998), which is the main water regulation statute of South Africa, defines what is meant as a "water use" as activities that require authorisation. Sections most applicable to developments impinging upon or within surface water ecosystem boundaries, including wetlands, are section 21(c) *impeding or diverting the flow of* *water in a watercourse;* and 21(i) *altering the bed, banks, course or characteristics of a watercourse*. As per definition, this means any change affecting the resource quality within the riparian habitat or 1:100 year flood line, whichever is the greater distance. Subsequent to this, DWA issued a Government Notice (GN) within the Government Gazette, No 1199 (18 December 2009), in which Section 6(b) indicates that any development within a 500 m radius of any wetland must seek authority through a Water User Licence Application (WULA) and that authority for these activities through a General Authorisation is no longer applicable (discretionary powers do, however, lie with DWS authorities on a *per project* basis). As the development activities are within a 500 m radial regulatory zone of the surrounding wetlands, authority will have to be sought prior to any development taking place.

Other water uses that may require authorization under section 21 of the NWA include the discharge of a effluent into a watercourse, abstraction of water from a watercourse, and the storage of water.

1.5.2. Provincial

Data at the provincial level are provided within the Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs (DARDLEA) Conservation Plan (Ferrar & Lötter, 2007) and the accompanying a GIS spatial dataset (Lötter, 2006). These data identify those areas of ecological significance from the region that provide varying levels of biodiversity support and therefore require focused attention for the aspects identified to be associated with the project area.

2. WETLANDS FORMS & FUNCTIONS

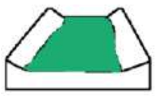
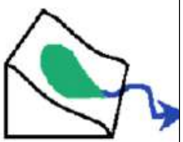
A wetland is defined as land that is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water and which, under normal circumstances, supports or would support vegetation typically adapted to life in saturated soil (National Water Act 36 of 1998). The identification of a wetland therefore requires a combination of factors, including hydrological (water drainage and movement), geomorphological (soil types, characteristics, and inundation) as well as vegetation (identification of hydrophytic species and communities).

2.1. Hydrogeomorphic forms

The classification of the hydrogeomorphic forms of wetlands associated with the proposed development area are based on those defined in Table 1. Wetland units form and are supported by an interplay of various physical and biological features. Underlying soil layering that inhibits percolation through the soils, topographical features, erosive forces and the quantity and origin of the water source all dictates the hydrogeomorphic form of any particular wetland unit.

Table 1: Hydrogeomorphic forms of wetland habitat units.

Hydrogeomorphic types		Description	Source of water maintaining the wetland	
			Surface	Sub-surface
Floodplain		Valley bottom areas with a well-defined stream channel, gently sloped and characterised by floodplain features such as oxbow depressions and natural levees and the alluvial (by water) transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*

Hydrogeomorphic types		Description	Source of water maintaining the wetland	
			Surface	Sub-surface
Valley bottom with a channel		Valley bottom areas with a well-defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterised by the net accumulation of alluvial deposits or may have steeper slopes and be characterised by net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*/***
Valley bottom without a channel		Valley bottom areas with no clearly defined stream channel, usually gently sloped and characterised by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from the channel entering the wetland and also from adjacent slopes.	***	*/***
Hillslope seepage linked to a stream channel		Slopes on hillsides, which are characterised by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and output is usually via a well-defined stream channel connecting the area directly to a stream channel.	*	***
Isolated hillslope seepage		Slopes on hillsides, which are characterised by the colluvial movement of materials. Water inputs mainly from sub-surface flow and outflow either very limited or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a stream channel.	*	***
Depression (includes pans)		A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. it is inward draining). It may also receive sub-surface water. An outlet is usually absent, and therefore this type is usually isolated from the stream channel network.	*/***	*/***

Wetland units also tend to be interconnected, with a seep zone often developing into a valley-bottom wetland, which then often develops into an established aquatic riverine system that then acts as a drainage watercourse for the catchment area.

2.2. Soil types and characteristics

The occurrence of wetland conditions is almost primarily due to a combination of soil conditions (including stratification characteristics), soil type, and a water source (surface water, lateral movement of soil water, or the upwelling of groundwater). Soil forms that are regarded as being always associated with wetland conditions include Champagne, Katspruit, Willowbrook and Rensburg soils. Those soil forms that are *sometimes* associated with wetlands include Inhoek, Klapmunts, Dresden, Bloemdal, Dundee, Longlands, Tukulu, Avalon, Witfontein, Wasbank, Cartref, Pinedene, Sterkspruit, Lamotte, Fernwood, Glencoe, Sepane, Estcourt, Westleigh, Bainsvlei and Valsrivier (DWAF, 1999).

The degree of soil saturation is also important in discerning temporary, seasonal and permanent zones of wetland habitat units, as well as the colour (chroma) and degree of ferrolysis (observable as mottling) within the upper 500 mm of the soil profile. This feature is elaborated on under the section of Wetland Delineation Methods.

A specialist soil survey was undertaken for the site and close interaction between the soil specialist (Earth Science) and Enviross (as the wetland ecologists) was undertake throughout the various phased of the survey. This was also true for the terrestrial biodiversity specialists (Ecorex) assigned to the project.

2.3. Vegetation structures

Wetlands tend to be transitional in nature and therefore a gradual transition of soils, inundation and vegetation structures can be observed from the terrestrial areas, temporary, seasonal and into the permanent zones of a wetland. The ability to identify and differentiate wetland floral species as being obligate wetland species, facultative wetland species, facultative species and facultative dryland species is important in discerning the occurrence of wetland conditions. Vegetation associated with any wetland units within the survey area tended to be facultative wetland species. Due to the arid climate of the region, surface water retention is limited to shortened periods and therefore wetland units tend to be temporary or seasonal in nature.

3. MATERIALS & METHODS

3.1. Desktop Review

The purpose of the desktop review process is to provide an overview of the associated ecological processes, the ecological descriptors and habitat units, and the important ecological and conservational features that have been identified at both the national and provincial level that are relevant to the project area. Review of the applicable resources pertaining to ecological aspects of the project area allows for a planned and targeted field survey that then allows for ground truthing of the pertinent areas identified through the desktop review process.

3.1.1. Environmental Screening Tool Assessment

The survey area was subject to the **s**creening assessment to determine the level of sensitivity for the various themes. This provided an indication of the required level of detail to be implemented during the analysis of the various ecological themes associated with the project area.

3.1.2. Literature & Database Sources

Data at the provincial level are provided within the Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs (DARDLEA) Conservation Plan (Ferrar & Lötter, 2007) and the accompanying a GIS spatial dataset (Lötter, 2006). These data identify those areas of ecological significance from the region that provide varying levels of biodiversity support and therefore require focused attention for the aspects identified to be associated with the project area.

The identification of the vegetation units and associated characteristics in terms of climatic data, topographical features, general geological and soil characteristics, defining floral species identified as being diagnostic of the vegetation unit, conservation status of the vegetation unit, and other relevant data are provided by SANBI (2006), together with the accompanying GIS spatial datasets (updated in 2012) that indicate the extent of the vegetation units at the national level.

The most recent as well as historical aerial imagery from Google Earth ® Pro was utilised to evaluate the project area. Digital 1:50,000 topographical maps and topographical mapping GIS spatial datasets (Chief Directorate Surveys and Mapping, Department of Land Affairs) and GIS datasets from ongoing internal GIS dataset development within EnviRoss. Spatial resources pertaining to surface water ecosystems were sourced through the National Freshwater Ecosystem Priority Areas (NFEPA) mapping datasets (Nel *et al*, 2011).

Faunal and floral species identification was supported by various printed field guides, digital field guides and other taxa-specific resources, as well as experience and knowledge of the field consultants undertaking the surveys. The conservation status of relevant species was obtained through www.redlist.sanbi.org, and published red data books and conservation assessments pertaining to specific taxa. Avifaunal species lists for the project area were sourced through the South African Bird Atlas Project 2 (SABAP2) (Brooks & Ryan, 2021). Only faunal and floral biodiversity applicable to surface water ecosystems were focused on for the project.

3.2. Field Survey

The field survey allowed for the ground-truthing of the desktop review process pertaining to the regional ecological characteristics of the project area. This included the land use, identification of the pressures and drivers of ecological change relevant to the project area, the association that the project area has with various habitat units and the ecological condition of those habitat units and determining the relevance that those habitat units have in supporting faunal and floral diversity within the area. This would ultimately allow for determining the overall ecological impact significance should a development of this nature be undertaken within an area of that encompasses those ecological processes and mechanisms.

The field survey was undertaken as a "drive-through", which allowed for the observations and identification of the ecological processes, as well as the pressures and drivers of ecological change associated with the project area. Regular stops were made within areas considered to be representative of the different habitat units and those areas considered to be ecologically sensitive to allow for a more comprehensive investigation of site conditions. This method was deemed suitable for the type and characteristics of the development and allowed for an acceptable level of study to adequately develop an impact significance rating for the proposed development activities.

3.2.1. General habitat evaluations

The desktop review allowed for the identification of pertinent habitat features that would be expected to support the highest level of biodiversity as well as those areas that have been subject to largescale transformation and degradation (such as actively cultivated land, infrastructure development, etc.). The field survey then focused on ecologically sensitive habitat areas, with a lesser significance being placed on degraded and transformed areas. Even if ecological integrity and functionality of an area is reduced, degraded areas still need to be assessed as ecological processes that occur within these areas (such as erosion, exotic vegetation recruitment, etc.) could influence the greater area. Degraded areas therefore are also included within the field assessment, albeit at a lower level of intensity.

3.2.2. Faunal & floral features

Floral species that are found to be dominant within specific habitat areas are identified and the ecological processes represented by the floral species community structures are noted. This could include the dominance of pioneering floral species, dominance of exotic species, active recruitment, and invasion of a particular habitat type by exotic species, bush encroachment within grassland areas, etc. It should be noted that the purpose of the field survey is to identify species dominance and species community structures relevant to indication of wetland conditions. It is not to provide a full account of floral species.

The assessment of faunal features takes the known historical geographical distribution data into account, and then cross references this to habitat type, spatial extent, ecological connectivity, and quality data to determine the relevance of the survey area to supporting faunal species diversity. Species of conservational significance are emphasised during the survey and when undertaking the impact evaluations. The limited time spent at the site during the field survey does not allow for comprehensive direct observations of faunal diversity and therefore the observations noted during the survey are regarded as reiterative and supplementary to assessing the ecological functionality of the wetland units.

3.2.3. Surface water ecosystems

The desktop review process plays an important role in assessing the surface water ecosystems within the survey area. The use of GIS spatial databases (at the national and provincial level), aerial imagery, topographical maps, and background reports provide for a relatively comprehensive analysis of the extent of surface water ecosystems within the greater survey area. The field survey allows for the ground-truthing of the desktop review data. It also allows for the identification of surface water ecosystems at a more focused level. The DWSHS Risk Assessment Matrix (RAM) is applied to surface water ecosystems that are identified to fall within the 500 m regulatory zone associated with the RAM to ascertain the overall risk that the road refurbishing procedures would potentially have on the water resources within the greater area.

If surface water ecosystems are identified during the field survey, then these units are delineated according to the methods outlined in DWAF (2008). The Risk Assessment Matrix (RAM) is also applied to these units to ascertain the overall ecological risk. If the unit is an established aquatic or wetland environment, then the present ecological integrity of the units is also determined through standard methods.

3.2.4. Delineation of surface water ecosystems

Following on from the desktop review process where a general impression of the project area can be ascertained, a ground-truthing field survey to identify all surface water ecosystem units associated with the project area and to determine the extent of those units is performed. This procedure is undertaken according to the *DWAF (=DWSHS) Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas* (DWAF, 2008).

According to these guidelines, the wetland delineation procedure considers the following attributes to determine the outer boundaries of each unit:

- Terrain Unit Indicator – helps to identify those parts of the landscape where wetlands are more likely to occur,
- Soil Form Indicator – identifies the hydromorphic soil forms and the chemical processes that are associated with prolonged and frequent saturation and associated anoxia and ferrolysis.
- Soil Wetness Indicator – identifies the morphological "signatures" developed in the soil profile resulting from prolonged and frequent saturation, and,
- Vegetation Indicator – identifies hydrophilic vegetation associated with frequently saturated soils.

> *According to the wetland definition used in the National Water Act, vegetation is the primary indicator, which must be present under normal circumstances. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role. The reason is that vegetation responds relatively quickly to changes in soil moisture regime or management and may be transformed; whereas the morphological indicators in the soil are far more permanent and will hold the signs of frequent saturation long after a wetland has been drained (perhaps several centuries) (DWAF, 2008).*

3.2.4.1. Terrain Unit Indicator (TUI)

The TUI takes into consideration the topography of the area to determine those areas most likely to support a wetland (DWAF, 2008). These include depressions and channels where water would be most likely to accumulate. This is done with the aid of topographical maps, aerial photographs, and engineering and contour data (if available, these are most often used as they offer the highest degree of detail needed to accurately delineate the valley-bottom and depression features that would be conducive to supporting wetland features). Seepage zones are also very often characterised by depressions, the identification of which aids in determining the presence of a wetland from a topographical perspective.

3.2.4.2. Soil Form Indicator (SFI)

The SFI considers the identification of hydromorphic soils that display unique characteristics resulting from prolonged and repeated saturation. This ongoing saturation leads to the soil eventually becoming anaerobic and therefore a change in the chemical characteristics of the soil. Certain soil components, such as iron and manganese, which are insoluble under aerobic conditions, become soluble when the soil becomes anaerobic, and can thus be leached out of the soil profile. Iron is one of the most abundant elements in soils and is responsible for the red and brown colours of many soils. Once most of the iron has been dissolved out of the soil because of the prolonged anaerobic conditions, the soil matrix is left a greyish, greenish, or bluish colour, and is said to be "gleyed". A fluctuating water table, common in wetlands that are seasonally or temporarily saturated, results in alternation between aerobic and anaerobic conditions in the soil. Aerobic conditions in the soil leads to the iron returning to an insoluble state and being deposited in the form of patches or mottles within the soil. Recurrence of this cycle of wetting and drying over many decades concentrates these insoluble iron compounds. Thus, soil that is gleyed and has many mottles may be interpreted as indicating a zone that is seasonally or temporarily saturated (DWAF, 2008).

Soil samples are taken periodically in a line running perpendicular to the permanent water zone (or other obvious signs of wetland conditions) until the outer limits of this zone are identified. This normally coincides with a particular contour level, but transformations and modifications to the landscape often lead to the zone limits not conforming to this theory. Soil samples are taken using a Dutch-type soil auger to a depth of 500 mm. The soil sample is then examined for indications of soils particular to the characteristics described above. Sample pits are also dug periodically as a more thorough and therefore more reliable means of confirming the presence or absence of hydromorphic soil characteristics. These get dug using a garden spade and the profiles thus created are examined for hydromorphic processes (ferrolysis) within the soil.

3.2.4.3. Soil Wetness Indicator (SWI)

In practise, this indicator is used as the primary indicator, but can be rendered unreliable during heavy rainfall periods. The colour of various soil components is also often the most diagnostic indicator of hydromorphic soils. Colours of these components are strongly influenced by the frequency and duration of soil saturation. Generally, the higher the duration and frequency of saturation in a soil profile, the more prominent grey colours become in the soil matrix. Coloured mottles, another feature of hydromorphic soils, are usually absent in permanently saturated soils, and are at their most prominent in seasonally saturated soils, becoming less abundant in temporarily saturated soils, until they disappear altogether in dry soils (DWAF, 2008). This indicator is also identified by taking a soil sample using a Dutch-type soil auger, or by digging a hole to examine the soil profile to a depth of 500 mm. The soil sample (or vertical profile) is then examined for indications of soils displaying the above-mentioned characteristics.

3.2.4.4. Vegetation Indicator (VI)

Vegetation is a key component of the wetland definition in the NWA. However, using vegetation as a primary indicator requires undisturbed conditions and expert knowledge (DWAF, 2008). As a result of this, greater emphasis is often placed on the SWI and SFI. Nonetheless, plant community structure analyses are still viewed as helpful guides to finding the boundaries of wetlands. Plant communities undergo distinct changes in species composition along the wetness gradient from the centre of the wetland to the edge, and into adjacent terrestrial areas. This change in species composition provides valuable clues for determining the wetland boundary, and wetness zones. When using vegetation indicators for delineation, emphasis is placed on the group of species that dominate the plant community, rather than on individual indicator species (DWAF, 2008). In wetlands that have undergone extensive transformation through landscaping, the vegetation unit indicators can potentially be absent.

3.2.5. Wetland hydrogeomorphic forms associated with the project area

Once the wetland units applicable to the project area have been identified and the boundaries of the units delineated, the different units are classified according to their different hydrogeomorphic forms. This was done according to the nomenclature presented in Ollis *et al.* (2013).

3.2.6. Assessing the Present Ecological State (PES) of the wetland habitat units

The survey area falls within an area historically utilised for agriculture and, more recently, increasing mining activities. Loss of natural habitat, impoundments, and overall catchment degradation are amongst the most important pressures and drivers of ecological change that impact on the functionality of surface water ecosystems within the area.

3.2.6.1. Wetland Index of Habitat Integrity (WETLAND-IHI)

The WETLAND-IHI (Wetland Index of Habitat Integrity) is a wetland habitat assessment tool that was utilised to establish the overall PES of the various wetland habitat units associated with the proposed development area. The WETLAND-IHI was developed as a tool for use in the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP), formerly known as the River Health Programme (RHP). The WETLAND-IHI was developed to allow the NAEHMP to include *floodplain and channelled valley bottom wetland types* to be assessed and the monitoring data incorporated into the national monitoring programme (DWA, 2007). The WETLAND-IHI has been applied to each wetland habitat unit associated with the project area and the results of each zone have been presented separately. The output scores of the WETLAND-IHI model are presented in the standard DHSWS A-F ecological categories (Table 2) and provide a score of the Present Ecological State (PES) of the habitat integrity of the wetland system being examined.

Table 2: Description of the A-F ecological categories (after Kleynhans, 1996; 1999) *from DWA, 2007.*

Ecological Category	PES % Score	Description
A	90-100%	Unmodified, natural.
B	80-90%	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	60-80%	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D	40-60%	Largely modified. A large loss of habitat, biota and basic ecosystem functions has occurred.
E	20-40%	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	0-20%	Critically/Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

The model is composed of four modules (shown in Figure 2). The *Hydrology, Geomorphology* and *Water Quality* modules all assess the contemporary *driving processes* behind the wetland formation and maintenance. The *Vegetation Alteration* module provides an indication of the intensity of human land-use activities on the wetland surface itself and how these have modified the condition of the wetland. The integration of the scores from these four modules provides and overall PES score for the wetland system being examined (DWA, 2007).

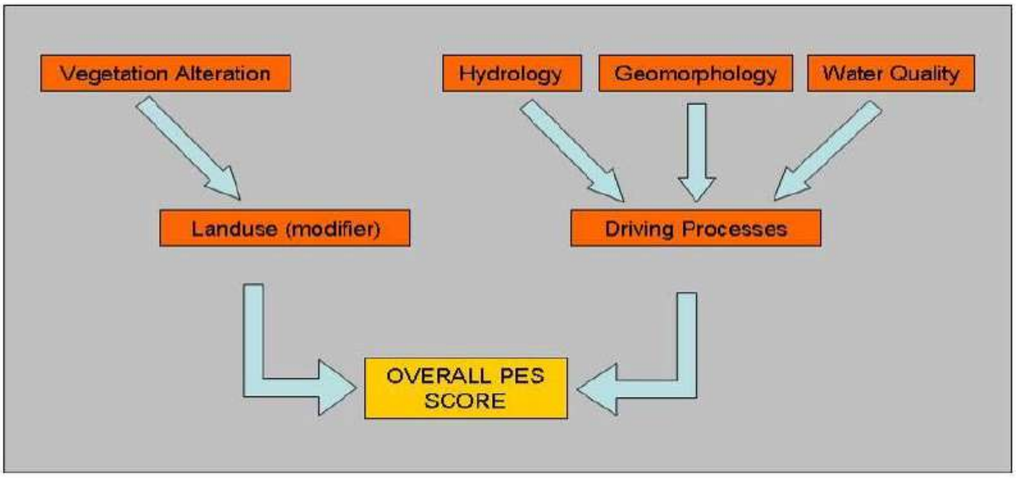


Figure 2: The four modules of the WETLAND-IHI model, and their relationship to the overall PES score, which is derived from them (from DWA, 2007).

Further observations of general ecological integrity at each site during the routine surveys will also be reported on. These points include:

- Erosion trends,
- Degree of siltation at downstream points,
- Unnecessary vegetation removal,
- Other general impacts on the aquatic system (dumping of rubble, litter, etc),
- Impacts of surrounding land use, including encroachment, restriction on the natural movement of water, etc.

3.2.6.2. WET-Ecoservices

WET-Ecoservices (Kotze *et al*, 2007) was used to assess the goods and services that individual the wetlands within each zone provide. This is taken as a combination of both ecological services and provision of services and resources to users. Through a series of scoring matrices for 15 different goods and service characteristics of a particular wetland, a rating score (out of 4) is provided. This is then compared to the class categories presented in Table 3.

Table 3: Recommended ecological importance and sensitivity categories (*adapted from* WCS, 2007). Interpretation of the median values and categories is also provided.

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
Very high Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and ≤4	A
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and ≤3	B

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and ≤2	C
Low/marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and ≤1	D

3.2.7. DHSWS Risk Assessment Matrix

If surface water ecosystems are found to be applicable within a 500 m radius of the proposed development, then the application of the Risk Assessment Matrix applies. The DHSWS developed a risk-based analysis matrix (published in Government Gazette 39458, Notice 1180 of 2015, 27 Nov 2015) that stipulates that a Risk Assessment Matrix be applied to water users in terms of the NWA, which then allows for the categorisation of the severity of the ecological risks pertaining to proposed developments associated with wetland habitat units. Based on the outcome of the Risk Assessment Matrix, *Low* risk activities will be generally authorised with conditions, while *moderate* to *high*-risk activities will be required to go through a WULA Process. Water use activities that are authorised in terms of the GA will still need to be registered with the DHSWS. The Risk Assessment Matrix has been used in the assessment of the risk posed to the wetland ecosystems for the proposed development to better quantify the risk to the resource. The categories (and interpretations of the scores) are assigned to the final ratings based on the ratings analysis (Table 4).

Table 4: Ratings of the risk and associated management descriptions used for the DHSWS Risk Assessment Matrix.

RATING	CLASS	MANAGEMENT DESCRIPTION
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated.
56 – 169	(M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input. Licence required.
170 – 300	(H) High Risk	Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve. Licence required.

3.3. Area Mapping, Habitat Unit Characterisation and Ecological Sensitivity Analysis

The desktop review allows for a preliminary land use characterisation of the project area to be established and then the ground-truthing field survey allows for the identification of the pressures and drivers of ecological change that influence the ecological processes that are associated with the survey area. This, in turn, allows for the identification and demarcation of the project area according to the various land uses that take place within the area. Aerial imagery is used to support this process. Once the land use and the associated drivers of ecological change are separated out from the natural areas, then a meaningful impact evaluation can be undertaken for proposed development infrastructure and activities.

From the field survey observations and delineation procedures, a handheld GPS (Global Positioning System) (Model: *Garmin Montana 680*), and the smartphone application *Gaia GPS* was used to mark the outer edges of the various wetland zones at strategic points throughout the survey area. These data are then compared to aerial imagery to generate digital shapefiles and maps of the various wetland zones and the designation of appropriate conservation buffer zones.

3.4. Ecological Impact Evaluations

Once the various proposed infrastructure components have been assessed against the present land use, the associated pressures and drivers of ecological change, the interactions with natural areas and the ecological integrity of both the disturbed and natural areas have been established, then the process of the impact evaluation can take place according to the standard procedures outlined in Appendix 6 of the EIA Regulations (GNR 982) – Specialist reports.

3.5. Preferred Alternatives

No alternatives to layout plans were presented for analysis at the time of the survey.

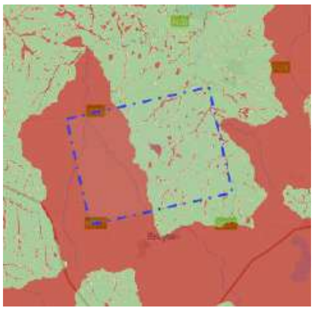
4. RESULTS & DISCUSSIONS

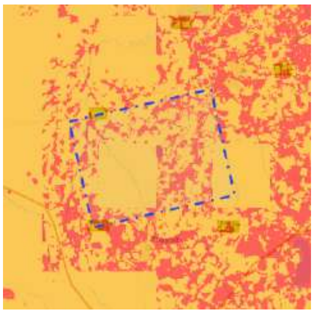
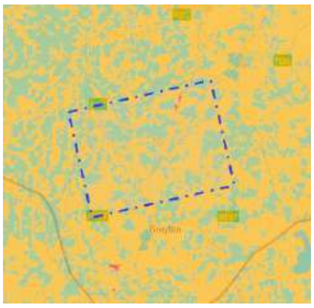
4.1. Desktop Review

4.1.1. Screening Tool Analysis

As part of the desktop review process, regulations stipulated by the DFFE, there is a requirement to submit a report generated by the national web-based environmental screening tool in terms of section 24(5)(h) of the NEMA and regulation 16(1)(b)(v) of the EIA regulations, 2014, as amended. The survey area was subject to the screening assessment to determine the level of analysis for the site for various themes. All relevant ecological themes associated with this survey are included as there is an interplay between the surface water ecosystems and aspects of the plant and animal themes that are supported by them. The designated sensitivity of each theme and notes associated with each theme relevant to the survey area are presented in Table 5.

Table 5: The results of the DFFE screening tool analysis for the survey area.

Theme	Screening Tool Classification		Descriptors
Aquatic biodiversity	Very High Sensitivity Rating. *Very high* (red band along western side) allocated to wetlands and watercourses included as CBAs within the MPU C-Plan. Isolated red areas including known wetland units/complexes, which are regarded as inherently ecologically sensitive features. Low (green) allocated to the remaining areas.		Wetland zones are designated as ecologically sensitive features, regardless of ecological status. Habitat units are statutorily conserved. Aquatic CBAs, wetlands, and freshwater ecosystem priority area quinary catchments.

Theme	Screening Tool Classification		Descriptors
Animal species	High Sensitivity Rating. The project area intersects with high (red zones) and medium (orange) zones.		Area offers suitable habitat for conservationally significant mammalian and avifaunal species. Avifauna: *Tyto capensis, Circus ranivorus, Balearica regulorum, Geronticus calvus, Sagittarius serpentarius, Eupodotis senegalensis, Hydroprogne caspia,* and *Geronticus calvus*. *Tyto capensis* (African Grass-owl) and *Circus ranivorus* (African marsh harrier) are two avifaunal species particularly relevant to the wetland habitat units within the survey area. Mammals: *Chrysospalax villosus, Crocidura maquassiensis, Hydrictis maculicollis, Ourebia ourebi*. *Chrysospalax villosus* (Rough haired golden mole) and *Hydrictis maculicollis* (Spotted neck otter) would be relevant species that could potentially associate with wetland habitat units.
Plant species	High Sensitivity Rating Project area includes medium (yellow) and low (green) sensitivity areas		Various plants species of conservational significance. Wetland habitat units tend to support a relatively high floral species diversity and the potential of

4.1.2. Threatened ecosystems analysis

The survey area falls within a vegetation unit that is regarded as endangered, namely Eastern Highveld Grassland of the Mesic highveld Grassland bioregion, which falls within the Grassland biome. This vegetation unit is classified as "hardly protected' and is under threat through transformation to accommodate cultivation, road development, and mining. Relatively large areas of natural grassland remain within the survey area.

4.1.3. Mpumalanga DARDLEA C-Plan

Data at the provincial level are provided within the Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs (DARDLEA) Conservation Plan (MBCP) (Ferrar & Lötter, 2007) and the accompanying a GIS spatial dataset (Lötter, 2006) provides an evaluation of the biodiversity (both terrestrial and aquatic) potential and functionality of areas at the provincial level. In terms of surface water ecosystems, important areas have been identified at the sub catchment level and classified according to ecological significance. An indication of the sub catchment categories for the region pertaining to the survey area is presented in Figure 3, from which the site associates with a sub-catchment area categorised as "highly significant" within its north-eastern area. The proposed development area also has an association with zones designated as Critical Biodiversity Areas (CBAs), and Ecological Support Areas (ESAs) (indicated in Figure 4). These habitat features tend to be ecologically connected and therefore support migratory freedom of mobile faunal species that can then exploit the habitat availability within the area.

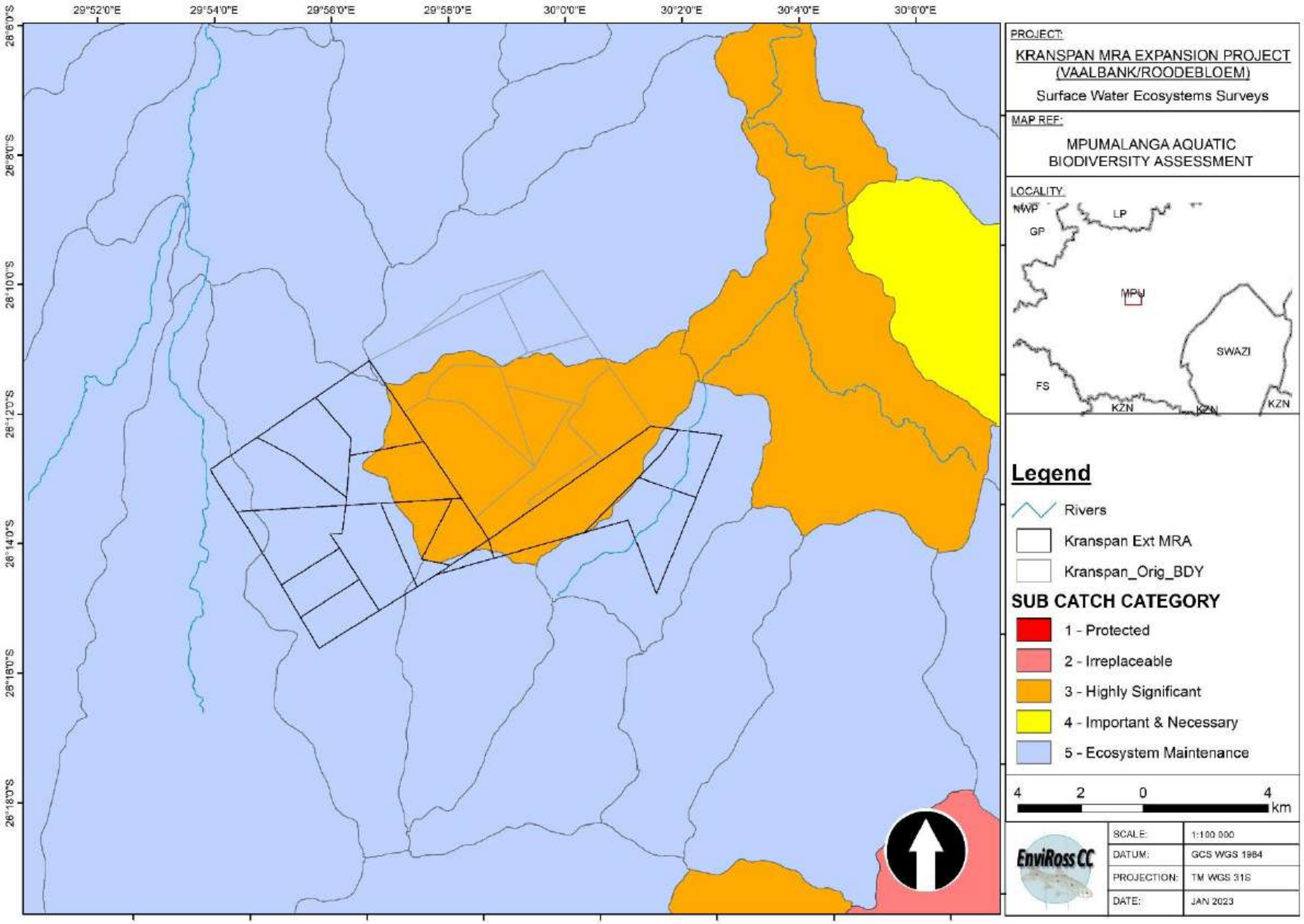


Figure 3: The survey area and how it associates with the aquatic biodiversity sub catchment categories identified within the Mpumalanga C-Plan for the area (source: Lötter, 2006).

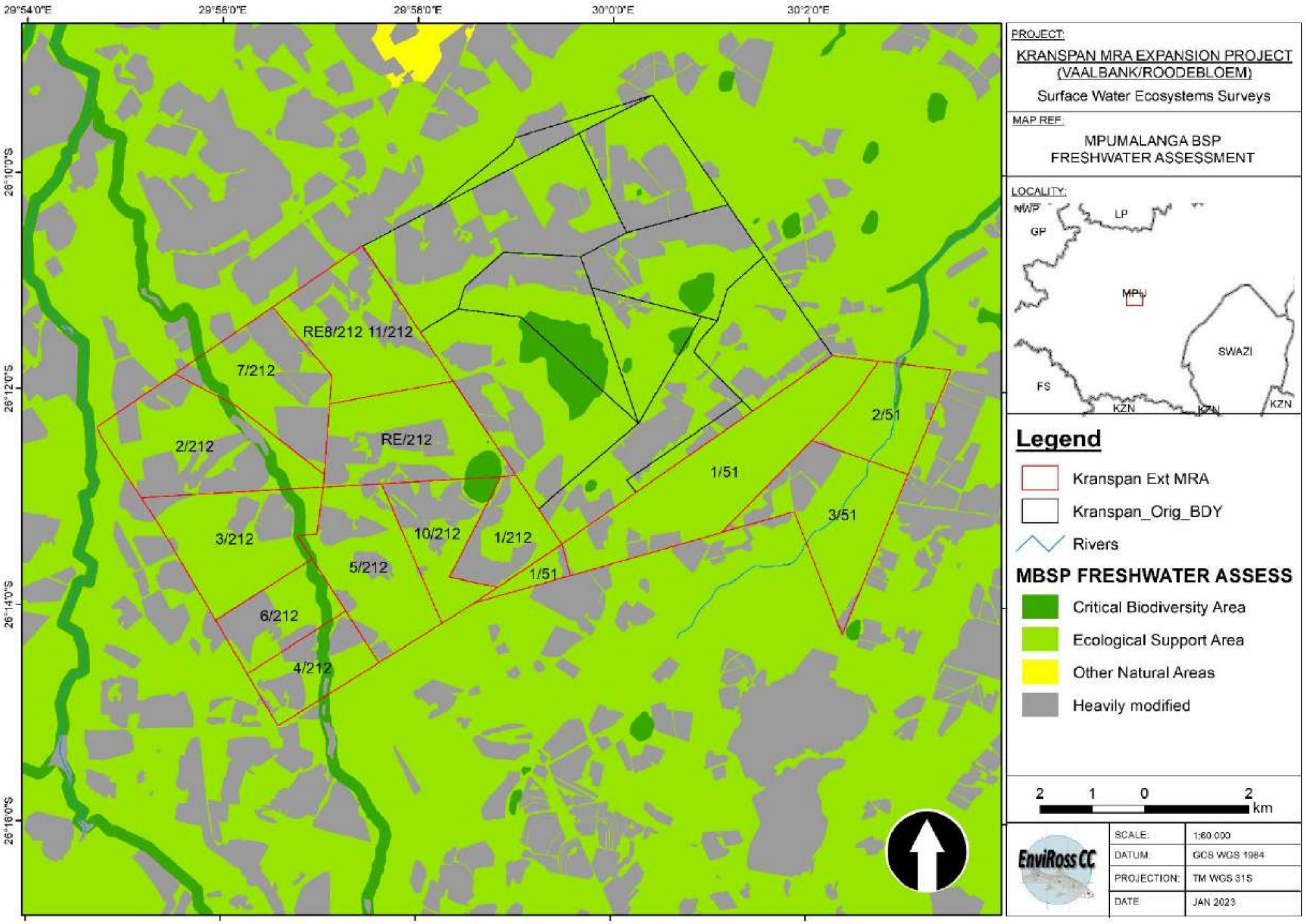


Figure 4: Regional assessment of the CBA, ESA, and other land parcel features pertaining to the MBSP Freshwater Assessment.

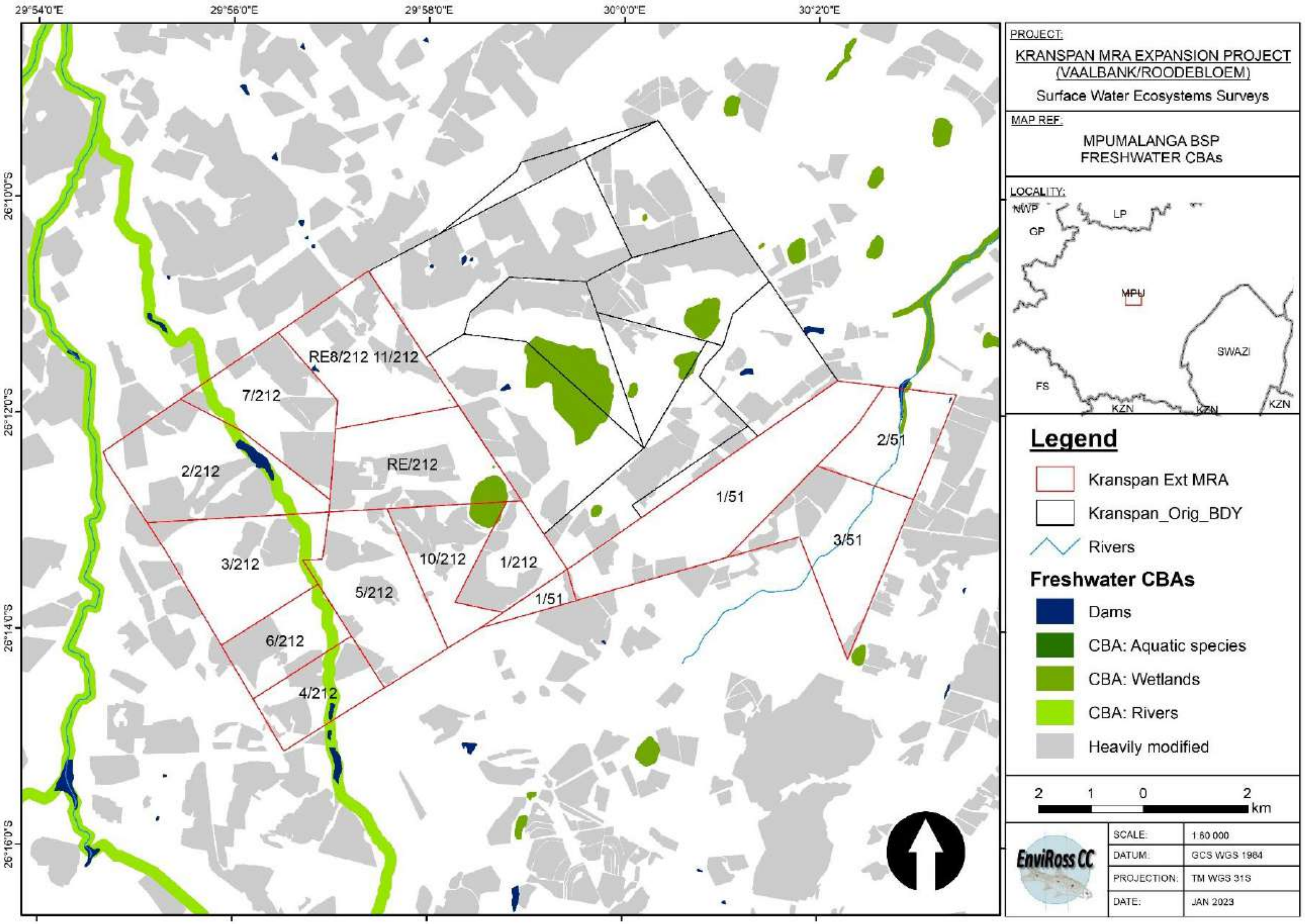


Figure 5: The CBA sub-categories for the region pertaining to the MBSP Freshwater Assessment and how they associate with the development area.

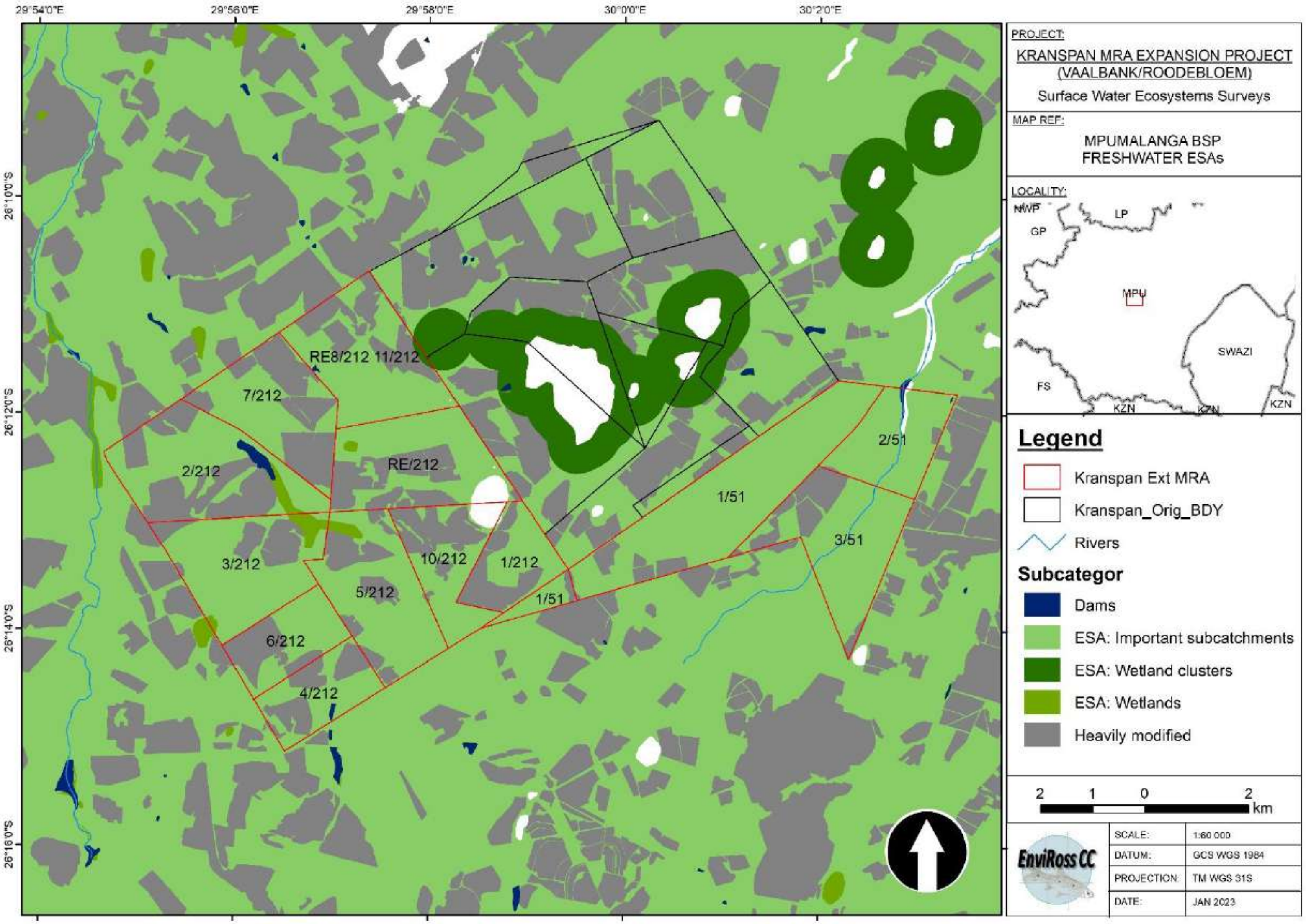


Figure 6: The ESA sub-categories for the region pertaining to the MBSP Freshwater Assessment and how they associate with the development area.

One of the key features of the conservation planning initiatives is to provide for land use guidelines that fall in line with the conservation strategies associated with each. The MBCP Plan also includes the land parcel categories stipulated by the National Freshwater Ecosystem Priority Areas (NFEPA) biodiversity spatial planning documents (Driver *et al.,* 2011 and Nel *et al.,* 2011). Management objectives are set for the areas according to the classification of the unit, with guidelines stipulated that outline the land use categories that are allowed according to their perceived impacts to the ecological functioning of the unit. Areas are defined according to terrestrial or aquatic ecosystems and are designated according to the following structure:

- Critical Biodiversity Areas (CBA): These are areas where the maintenance of ecological functionality is required to meet biodiversity targets, for species, ecosystems or ecological processes and infrastructure. Areas where natural conditions have been retained and which have been identified as critical to achieving conservation targets are included as CBAs, and classified within sub-categories according to the habitat units which they represent (e.g., wetlands, rivers, important catchment zones, aquatic species, etc.). The management objective for CBA areas is to maintain them in a natural or near-natural state, with no further loss of habitat being incurred. Degraded areas should be rehabilitated and only low-impact, and biodiversity-sensitive land-uses are appropriate. The applicable classification of the CBA subunits for the project area is presented in Figure 5.
- Ecological Support Areas (ESA): These are areas that are not essential for meeting biodiversity targets, but that play an important role in supporting the functioning of Protected Areas (PA) or CBAs, and that are often vital for delivering ecosystem services. These zones provide supportive roles often associated with ecologically sensitive features such as wate recharge zones, wetlands, rivers, areas that support threatened species and/or ecosystems. The management objective for these areas is to maintain them in a functional, near-natural state. Some habitat loss is acceptable, provided the underlying biodiversity objectives and ecological functioning are not compromised. The appliable classification of the ESA subunits for the project area is presented in Figure 6.
- Protected Areas (PA): Areas that are set aside for the purpose of the conservation of biodiversity and/or other important ecological features that are protected through legislature. These areas may be at the national, provincial, municipal, or private land-owner scale. Management objectives for PAs are generally determined by the strategies that were established at the time the area was proclaimed and tend to be aimed at preserving the functionality and features that motivated the original proclamation of the area. In the absence of this, management objectives for PAs generally align with those particular to CBA1 areas.

The sub catchment associated with the north-eastern section of the survey area is regarded as highly significant in terms of aquatic species richness, facilitating migrations and provision of refugia for aquatic biodiversity.

4.1.4. Land cover and characteristics

The land cover within the project area is dominated by formal and active cultivation and mining activities. These areas are indicated in Figure 4 to Figure 6 as "heavily modified". Residential farm dwellings, roadways and other infrastructure constitute a lesser land use within the area. Mining activities are seen to be increasing within the regional catchment context and will potentially feature as the dominant land use within the region in the future.

4.2. Study area & catchment characteristics

4.2.1. Regional catchment descriptions

The survey area falls within the Komati/Crocodile (X) Primary catchment, the X1 Secondary catchment and the Inkomati/Usuthu (3) DWS water management area (WMA) and the Komati West sub water management area (SWMA). It spans across two quaternary catchments, namely X11A to the west and X11B to the east. The watershed of the survey area falling within X11A drains westward toward the Vaalwaterspruit, which drains northwards and then eastwards to confluence with the northward flowing Boesmanspruit, which drains X11B, to join with the Komati River. The Nooitgedacht Dam is located at the northern end of the quaternary catchment of X11B, at the confluence of the Boesmanspruit, Vaalwaterspruit and Witkloofspruit. The watercourse from the Nooitgedacht Dam that drains toward the northeast is the Komati River. The DWS has designated Present Ecological State (PES), Ecological Importance (EI) and Ecological Sensitivity (ES) for all the catchment areas nationally. The quaternary catchment of X11B has a PES of C (moderately modified), an EI of moderate and an ES of high (DWS, 2014). The Boesmanspruit has retained a PES of B (near natural) up until it drains into Nooitgedacht Dam, after which the Komati River (which is the main watercourse leaving the dam) has a PES of C (moderately modified) (SANBI, 2009 & NFEPA, 2010) (Figure 7). These data are relatively dated so reference conditions may have changed in the interim. The region is shown to have a moderate mean annual runoff (MAR) groundwater recharge rate (Figure 8 and Figure 9). Land use within the region is dominated by formal agriculture and mining and the associated transformation to physical characteristics and degradation of water quality tend to be the main pressures and drivers of ecological change of the surface water ecological features.

Table 6: Catchment summary details pertaining to the survey area.

Determinant	Site detail			
Primary catchment	Komati/Crocodile (X)			
Secondary catchment	X1 (Komati West)			
Tertiary catchment	X11			
Water management area	Inkomati/Usuthu (3)			
Sub water management area	Komati West			
Aquatic ecoregion	Highveld (11)			
Quaternary catchments	X11A		X11B	
Main watercourses of the quaternary catchment (PES) (NFEPA, 2011)	Vaalwaterspruit (C – Moderately modified)		Boesmanspruit (B – Largely natural)	
Area	671 km^2		596 km^2	
Water supply: MAR values	35		90	
Water supply: Recharge values	82		41	
Sub quaternary catchment (DWS, 2015)	Ref: 1358		Ref: 1272	
	PES	C	E (Largely modified)	C
	EI	Moderate	Low	Moderate
	ES	High	Moderate	High
Catchment pressures and drivers of ecological change	Formal cultivation dominates the spatial context of the catchment areas that has encroached on wetland units, imposing an edge effect on the wetland units. Historical agricultural activities have resulted in the occurrence of many impoundments along the watercourses. Cultivation has altered vegetation structures and destabilised soils, resulting in siltation of the watercourses from colluvial runoff. Agrochemical usage would impact the overall ecological integrity of surface water ecosystems. Road crossings with poorly designed culverts and bridges that inhibit freedom of migrational movement of fish are commonplace. This is often due to poorly managed and/or damaged infrastructure. An increasing mining sector within the region has resulted in physical alteration of watercourses, and loss of wetland habitat. Mining has resulted in degraded water quality and habitat integrity of the wetlands and watercourses. Services established to support the mining sector has resulted in a greater development of roads, increased volumes of heavy trucks and traffic in general, which increases surface water runoff intensity and sedimentation within the watercourses. An increase in opencast mining has also resulted in altered hydrological functioning of the wetland and aquatic units.			

Mpumalanga Province conservation authorities have developed a biodiversity spatial conservation plan (Mpumalanga Biodiversity Conservation Plan – MBCP) that details the importance of various regions to the conservation of natural resources throughout the province. Figure 10 shows that much of the site has been categorised as “highly significant”. This is due to the area providing a source of water and the refugia offered and biodiversity supported by the interconnected wetland habitat.

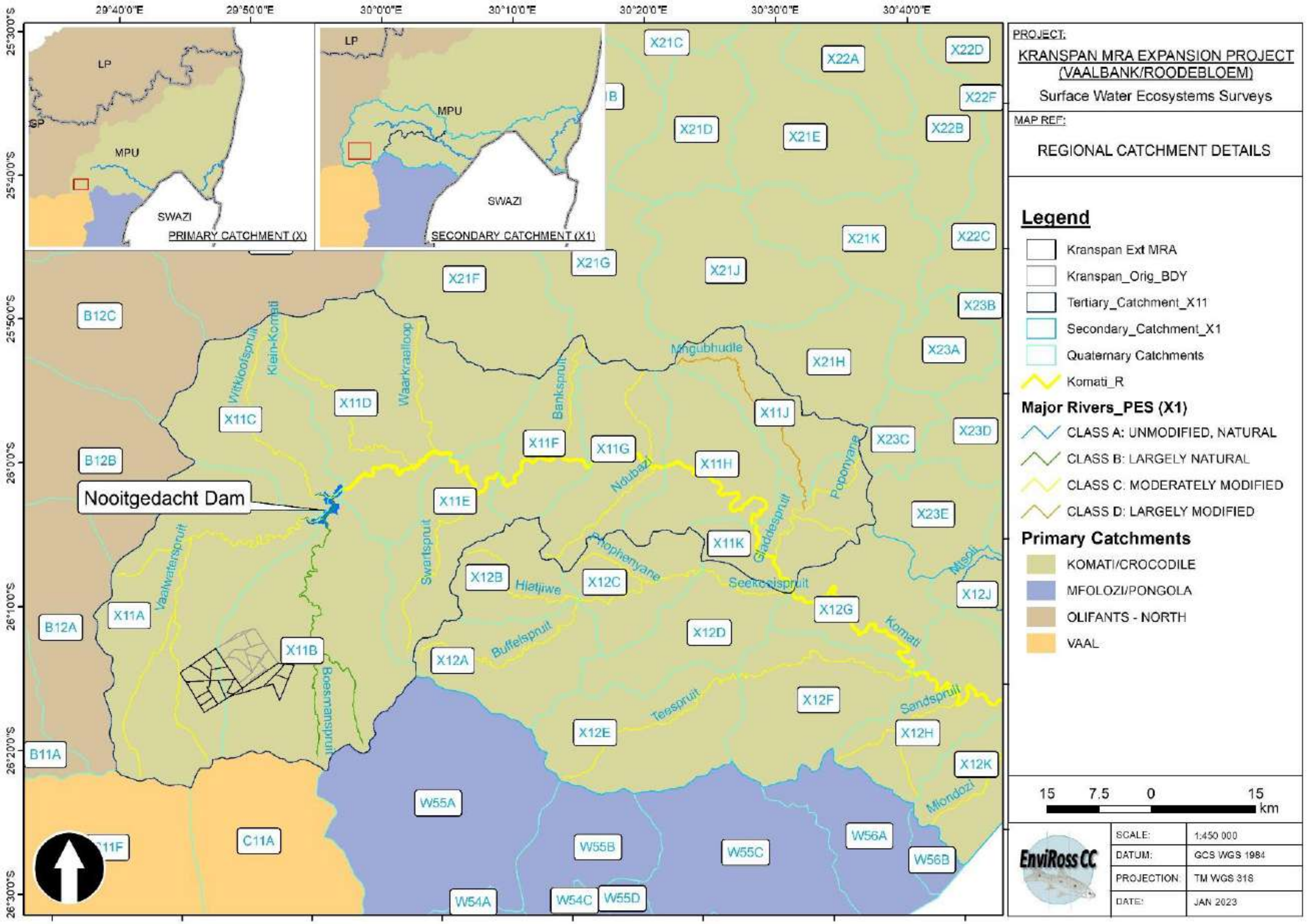


Figure 7: Regional catchment details.

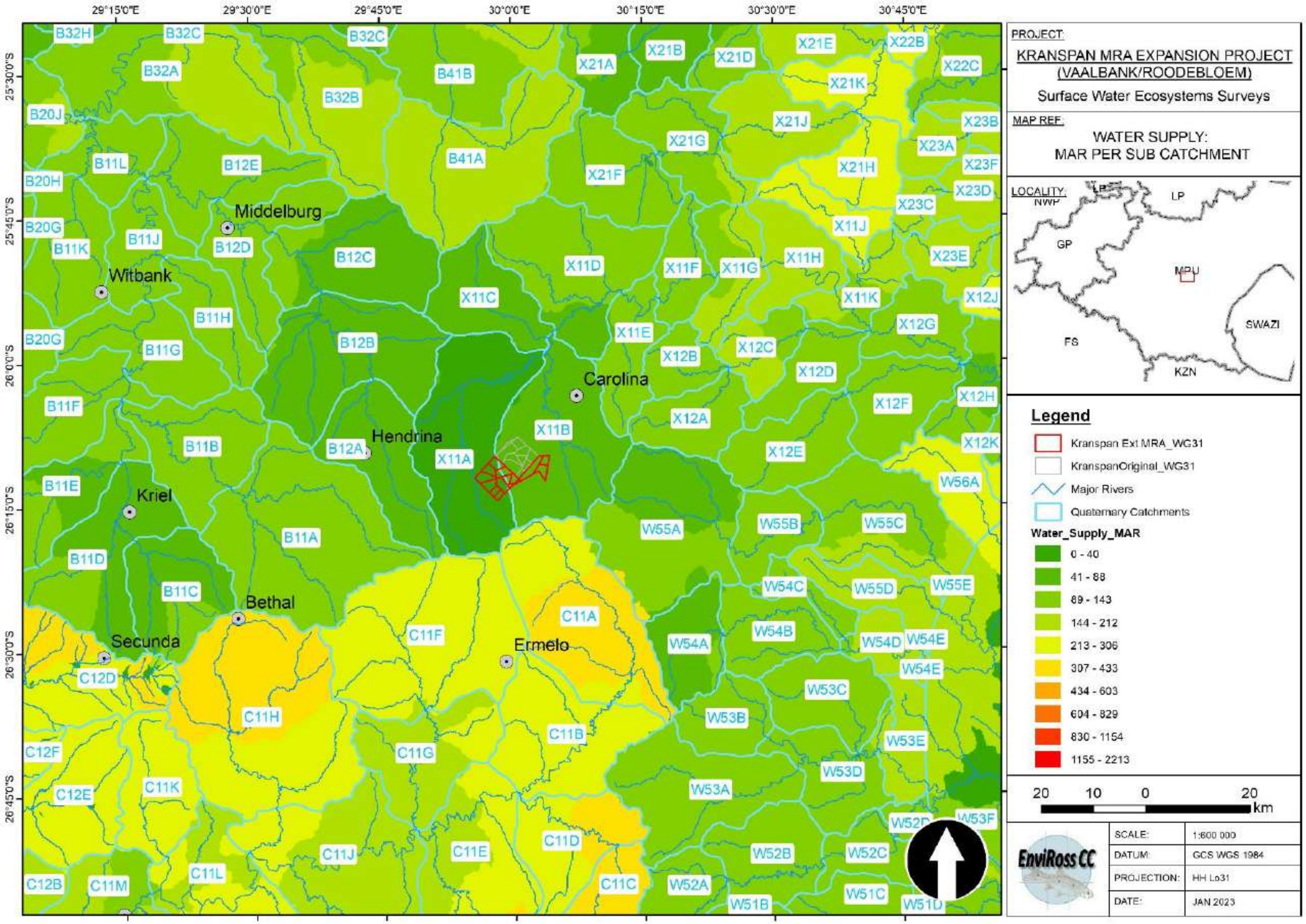


Figure 8: The Mean Annual Runoff (MAR) of the region.

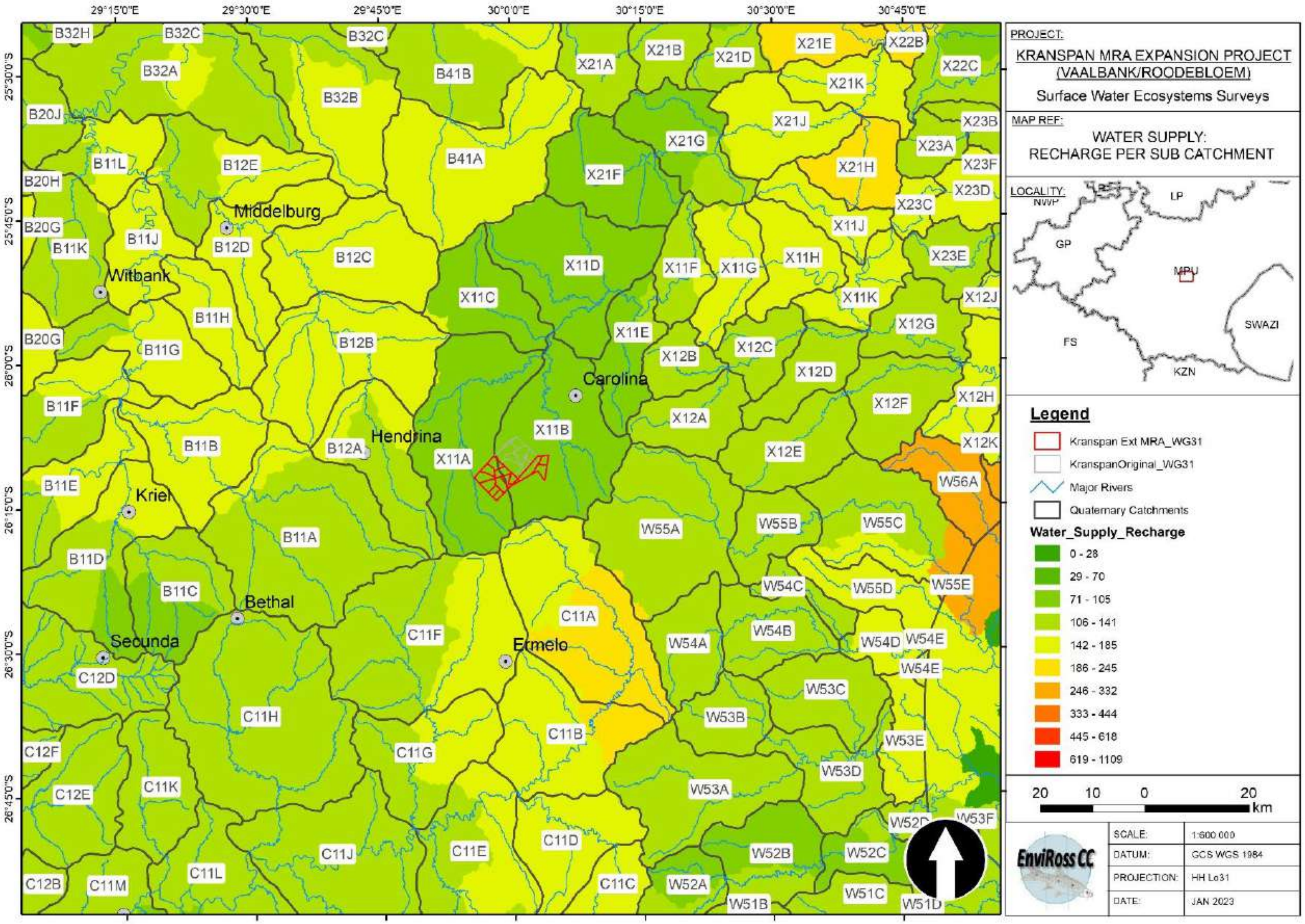


Figure 9: The groundwater recharge status of the region.

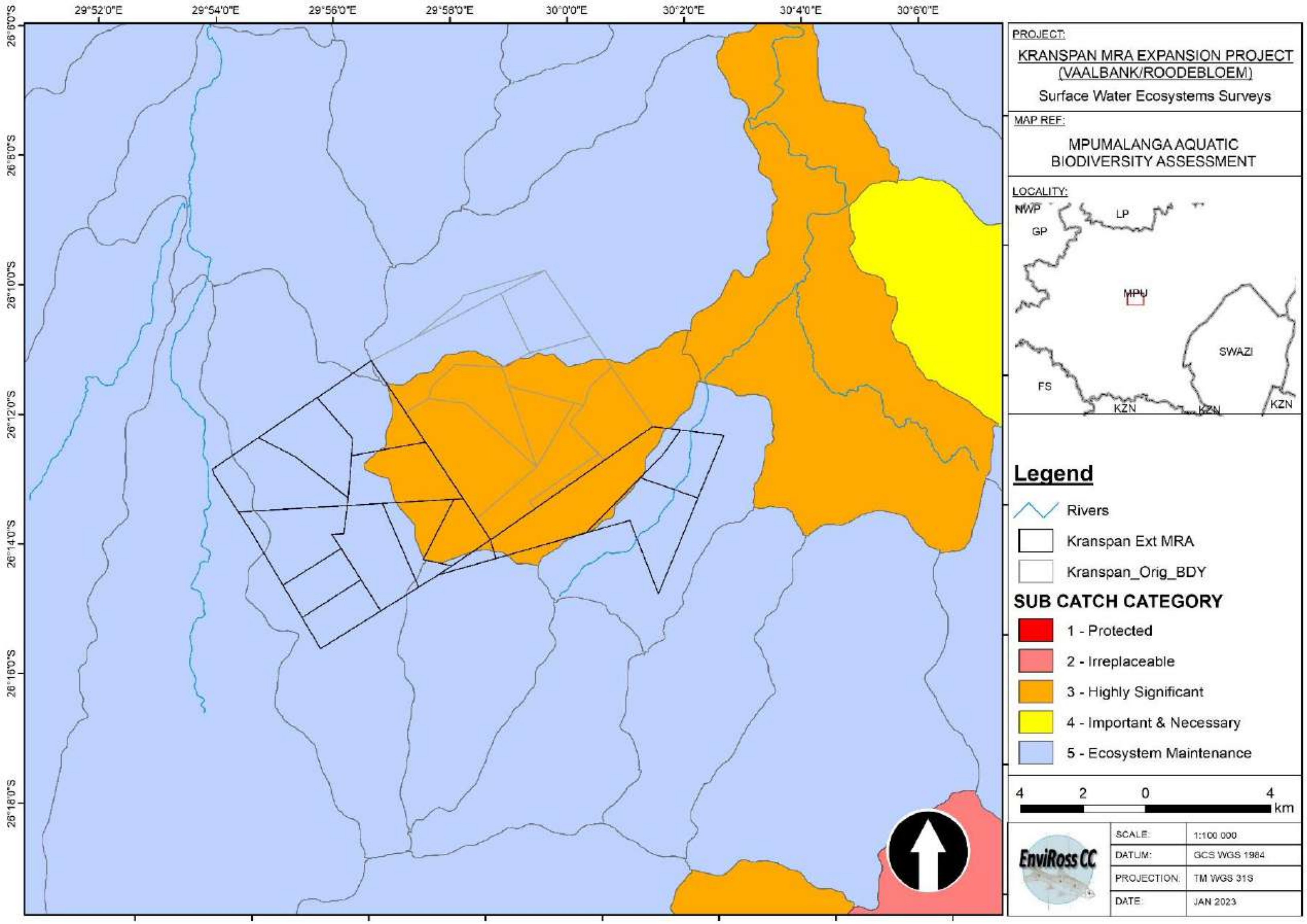


Figure 10: The MBCP sub catchment categories pertaining to the protection of the aquatic resources for the region.

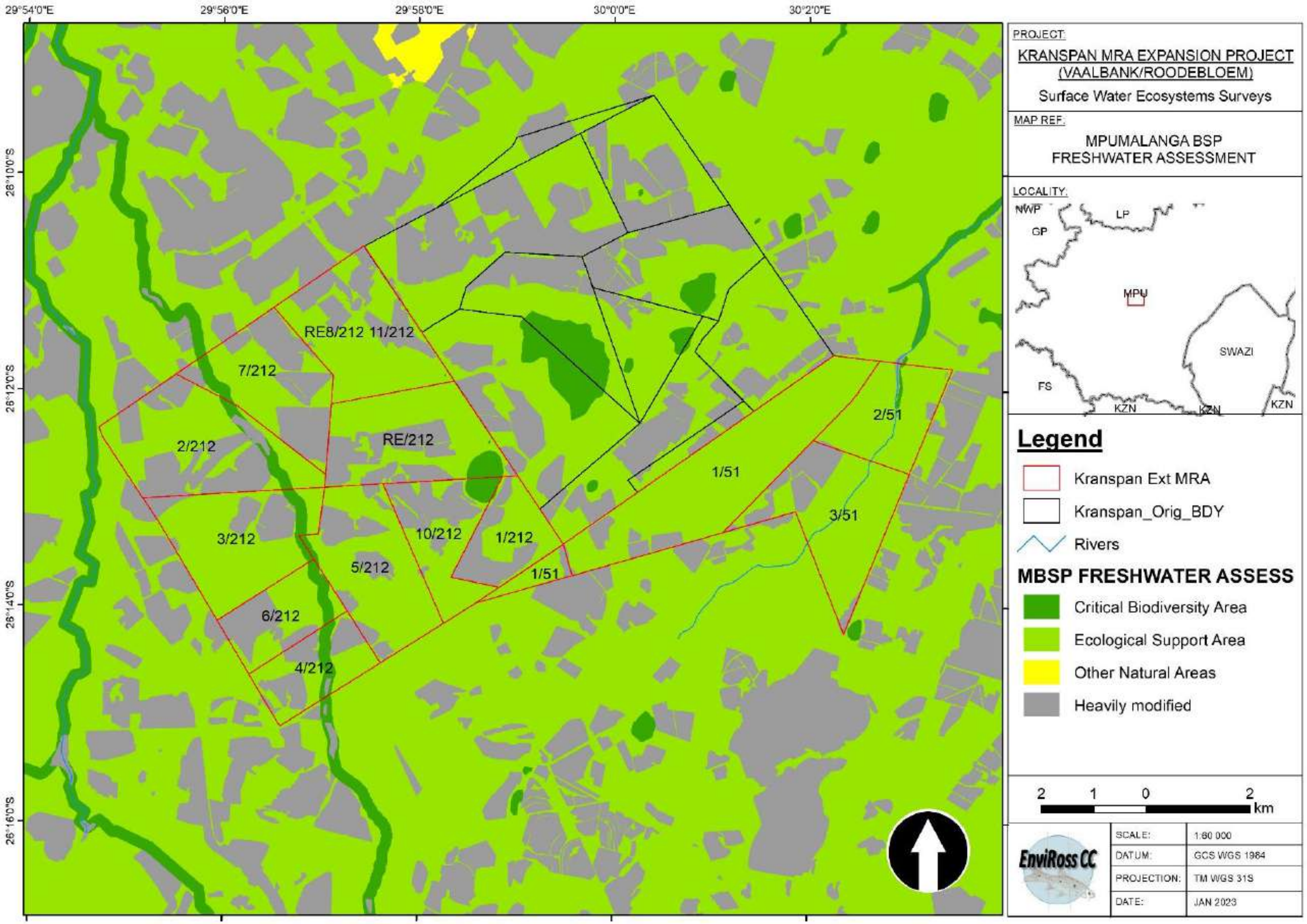


Figure 11: The MBCP regional unit categories pertaining to the protection of the aquatic resources for the region.

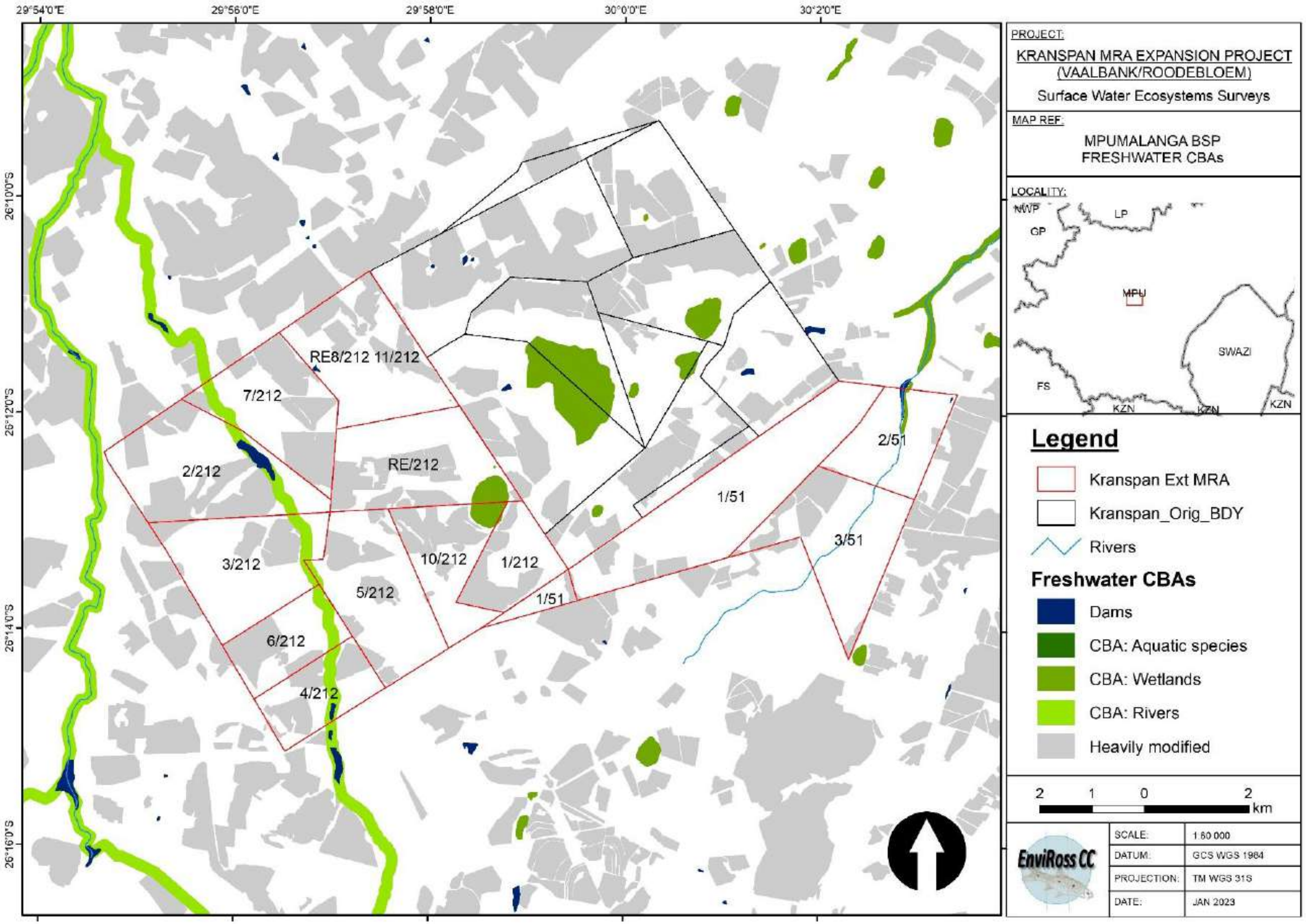


Figure 12: The MBCP CBA categories pertaining to the protection of the aquatic resources for the region.

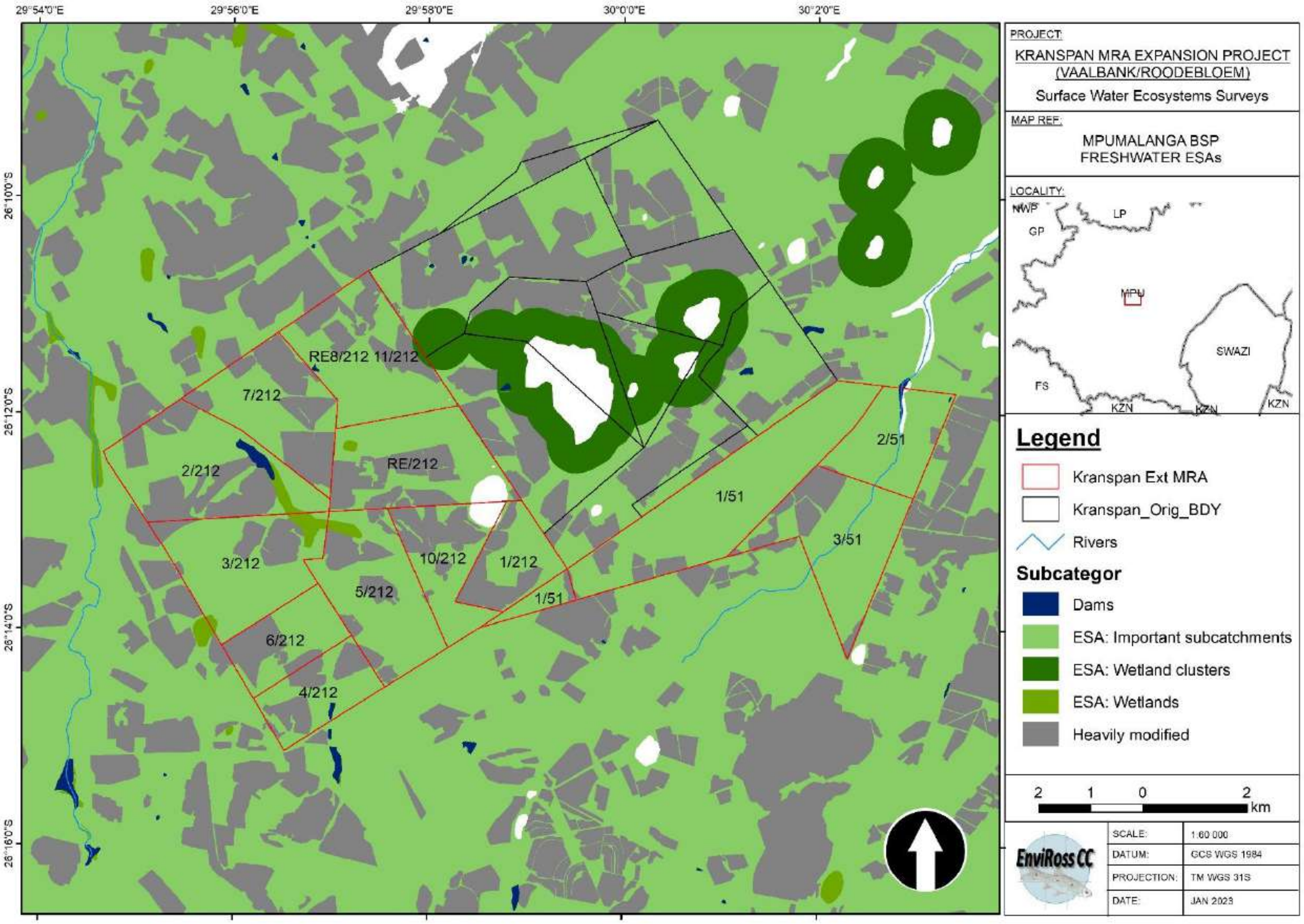


Figure 13: The MBCP ESA categories pertaining to the protection of the aquatic resources for the region.

The dominant veld type of the surrounding area is Eastern Highveld Grassland, of the Mesic Highveld Grassland bioregion within the Grassland biome. Conservationally, this is regarded as an *endangered* vegetation type, which is largely due to largescale transformation to accommodate the agricultural and mining sectors and the general lack of protection within formal conservation areas. Well-developed wetlands within the region include the vegetation type of Eastern Temperate Freshwater Wetlands, which is an azonal inland freshwater vegetation type that is embedded within the Highveld Grassland biome. This is regarded as *Least Threatened* conservationally (Mucina & Rutherford, 2006).

4.2.2. Local catchment descriptions and surface water habitat units

The survey area is dominated by formal agriculture and cultivation seems to have occurred wherever soil and physical characteristics have allowed for it. This has led to large tracts of cultivated lands. Linear wetland units and hillslope seepages are also commonplace within the survey area, which support relatively large areas of natural grassland zones as well. Watercourses tend to be seasonal and therefore instream impoundments are common and are an impacting feature noted along all the watercourses within the survey area. This was a common historical agricultural practice to ensure a reliable water supply for cattle (mostly) as well as irrigation water. These impoundments range in size and many of the impoundment earthen walls have since breached, which has reduced the footprint of the historical inundation zones. Mobilised silts, originating mostly from cultivated areas, have been transported to the watercourses and deposited within the impoundments. This has resulted in the progressive loss of water volume, with the water column being displaced by the settled silts and sediments. The result of this is that the impoundments are generally shallow and inundated with aquatic vegetation. As impoundments like this would have required routine and active silt management, it is most likely that landowners sought an alternative water source, and this was presumably replaced by boreholes outfitted with electric pumps when electrical distribution became available within the region.

Exotic vegetation tends to feature in the western areas and seems to be reminiscent of historical tree plantations. Isolated pockets of exotic vegetation do occur in association with watercourses and along the periphery of depression wetlands and impoundments. Typical agricultural weeds do occur as well. The western areas of Portions 2 and 3, and the southern areas of Portion 4 Vaalbank feature the greatest concentration of exotic trees.

The development area has an undulating terrain and valley-bottoms tend to support well-developed valley bottom wetland units. These units are strongly supported by relatively large hillslope seepage zones, valleyhead seep zones, and some active freshwater springs feeding directly into the watercourses. Depression type wetland units are also relatively common within the area. There is a rocky ridge associated with many of the prominent watercourses that occurs along the upslope side of these habitat units. Seepages are commonly associated with this ridge, leading to the assumption that the rocky ridge forms a complex of impermeable underlying rock that maintains a perched water table close to the surface. The occurrence, depth and direction of soil water interflow associated with this perched water table is dictated by the characteristics of the underlying rock layer to the point that subsurface soils water interflow very often does not necessarily coincide with surface topographical features. This means that localised catchment zones of individual valley bottoms are very often interconnected within their headwater (valleyhead seep) zones and wetland bench zones occur at the hilltop crest (watershed zone). Figure 14 presents a three-dimensional rendering of the survey area, which allowed for a perspective of the watershed zones of the site. There are four watershed zones associated with the site. The extremes of the western areas drain westwards toward the main watercourse of the Vaalwaterspruit. There is the main watercourse that runs from the south to the north of the survey area, which drains the central regions and a small area in the north northwards to later form a tributary of the Vaalwaterspruit. The northern and eastern zones tend to drain eastwards to collectively drain towards the depression wetland, Kranspan, which then drains north-eastwards to for a tributary of the Boesmanspruit, which runs from the southwest to the northeast of the site. There is a higher-lying watershed that roughly divides the portions of land included from the farm Roodebloem, with the northern section draining toward the tributary that rains from Kranspan, and the southern areas that drain toward the Boesmanspruit. The watershed zones can be used as a useful pollution control management tool where effluentcreation activities could be grouped within the same watershed zone that has a single outlet watercourse. This is useful for monitoring purposes as well as remediation procedures should the need arise.

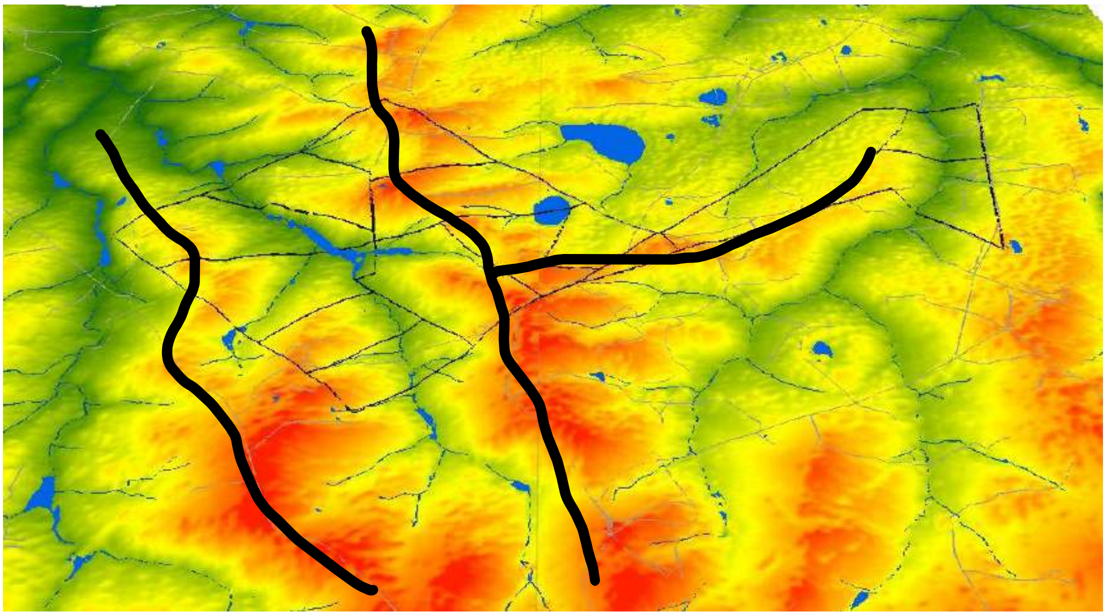


Figure 14: A 3D rendering of the survey area showing a clearer perspective of the watershed zones associated with the site.

	
A typical upper temporary zone hillslope seep zone looking toward the associated valley bottom wetland. Rocky ridge type habitat that includes further seep zones can be seen in the distance.	Livestock grazing is common within the wetland zones of the survey area, but has had a seemingly insignificant impact due to small herd sizes.

	
A typical depression-type wetland unit that has been artificially impounded within a valley-bottom wetland area. The shallow and gradual slopes of the banks, together with established aquatic vegetation within inner areas indicates the shallow water depth. This is largely due to sedimentation transported into the valley bottom from surrounding cultivated fields over the years.	A seasonal wetland zone surrounded by recruiting exotic trees.
	
Excavations within a wetland just outside of the southern boundary fo the MRA area to facilitate a road crossing.	A typical hillslope seep zone feeding toward an unchannelled valley bottom wetland.
	
Floral zonation indicating a transitional zone of a wetland unit between the seasonal and permanent zones during the low flow season. The rocky ridge habitat can be see on the right bank of the watercourse.	A seemingly purposefully beached impoundment wall that has imapcted on the ecological integrity of the valley bottom wetland unit.

 The main valley bottom wetlnad unit running from south to north through the MRA area.	 An eroded watercourse of a valley bottom wetland, which is typical at the downstream side of a culvert bridge crossing. The watercourse is restricted and stormwater converges through the culverts resulting in high velocity and highly turbulent water flow that scours the banks of the watercourse.
 Seasonal seep zones feeding into a valley bottom wetland, showing clear vegetation zonation.	 The valley bottom wetland that is impounded by the road crossing as the watercourse runs northwards from Vaalbank. Clearing of the vegetation and manipulation of the watercourse has taken place within this area. Water quality degradation, substrate destabilisation and veegtation of the wetland can be readily observed.
Seasonal seep zones feeding into a valley bottom wetland, showing clear vegetation zonation.	The valley bottom wetland that is impounded by the road crossing as the watercourse runs northwards from Vaalbank. Clearing of the vegetation and manipulation of the watercourse has taken place within this area. Water quality degradation, substrate destabilisation and veegtation of the wetland can be readily observed.
Seasonal seep zones feeding into a valley bottom wetland, showing clear vegetation zonation.	The valley bottom wetland that is impounded by the road crossing as the watercourse runs northwards from Vaalbank. Clearing of the vegetation and manipulation of the watercourse has taken place within this area. Water quality degradation, substrate destabilisation and veegtation of the wetland can be readily observed.

Figure 15: Various views of the wetland associated characteristics throughout the survey area.

4.3. Standard wetland delineation indicators

It is important to note that not all the four wetland indicators will necessarily be present at any one site. Disturbance factors and landscaping often lead to the vegetation indicators being largely transformed and unreliable. Landscaping also often diverts surface water flow that can dry certain areas of the wetlands, leading to the loss of the soil wetness indicators, or an arid climate could mean that limited soil moisture occurs if the survey takes place outside of the wet season. Incised and eroded watercourses also tend to induce premature draining of the associated wetland units. Therefore, the combination of the four indicators of wetland conditions should be taken into consideration as well as a certain degree of "intuitive rationalisation" gained through experience when assessing the existence of wetland zones. Analysis of aerial imagery, together with available contour maps, digital elevation models, and watercourse patterns is also a very useful tool in identifying the outer boundaries of wetland units and/or analysing wetland drainage and flow patterns. This is especially relevant to projects that span over a large study area where physical first-hand observations and comprehensive soil profiling to ascertain wetland conditions are often deemed impractical.

4.3.1. Terrain Unit Indicator (TUI)

The TUI (taken from topographical maps, GIS data and visual observations at the site) indicated that the terrain is topographically conducive to supporting wetlands, with a well-defined valley bottom wetland complex situated within an area of undulating topography. The topography of the region tends to support a generally northward-draining watershed, with the western and central areas of the survey area draining northwards and the central to eastern zones draining toward the northeast. The application of the other indicators was therefore applied to facilitate the determination of the limits of the further wetland zones. Depression wetlands were also noted within the limits of the survey area. Many wetland zones were obscured by the historical establishment of a relatively high amount of instream impoundments that increase the persistence of open surface water or can increase the footprint of the inundation zones. Earthen dam walls and the placement of the associated spillways very often alter the direction and shape of the watercourse – very often inducing an incised watercourse. Where breaches of the impoundments have occurred, the watercourse is often subject to erosion factors, altered vegetation structures, velocity-depth profiles and other aspects that can obscure the wetland zones. The TUI tends to support the identification of the valley bottom wetlands, valleyhead seep zones, and the depression wetlands, but provides little evidence to support the identification of the hillslope seepage zones.

4.3.2. Soil Form Indicator (SFI)

Sampling pits were dug using a garden spade at strategic points to observe soil profiles *in situ* for confirmation of wetland conditions. The mottling effect, which is a result of ferrolysis within seasonally inundated hydromorphic soils were readily observed within the profiles of seasonal to temporary wetland zones. Surface Laterite extrusions were also observed, although this is very often an indication of historical wetland zones. Examples of the mottling effect formed through the process of ferrolysis are shown in Figure 16. Observations of bleached soils associated with shallow and fluctuating water tables typical of wetland units were also taken as positive indications of hydromorphic soils. This is where iron is leached out due to a cyclic fluctuation of a shallow water table. The soil form indicator therefore was strongly supported throughout the survey area, indicating wetland (hydromorphic) soils.

A permanent zone wetland profile, showing the dark, organic rich soil with very limited mottling.

A soil profile indicative of a temporary wetland zone. Limited iron mottling is present, which is typical of inundation of the soils for less than 3 months of the year.

Organic-rich soil indicative of a permanently inundated wetland zone.

An accumulation and attraction of the iron nodules within hydromorphic soils often culminates in a latterite extrusion. This is a small piece found on the surface of a historical wetland area. Extrusions often occur in historical wetland areas where they are unearthed due to erosion or excavations.

A soil profile indicative of seasonally inundated wetland zones. Infiltration of oxygen into the soil profile that follows a receding water table very often coincides with plant roots. Ferroysis showing up as red mottling is also clear within this soil profile.

Iron oxide precipitates within the water when hypoxic water reaches the surface and interacts with oxygen. This is a clear indication of a wetland soil profile. Excavations with no follow up soil reinstatement leads to the premature drainage of the soils.

Figure 16: Examples of indications of ferrolysis (mottling) within the soils is a positive indication of hydromorphic conditions. These are samples taken of hydromorphic soils throughout the survey area.

Aerial imagery can be used to identify hydromorphic soils, which tend to show a distinct difference in colour when compared to the surrounding landscape. Aerial imagery is not used exclusively to identify hydromorphic soils.

Ground-truthing of soil profile reference points and the identification of the patterns of the soil profiles are done during the field survey, and then these reference points are compared to the aerial imagery for confirmation purposes. The extent of the wetland units, especially in large survey area, can then be inferred by making use of aerial imagery. Drainage patterns can also be identified through aerial imagery through the identification of soil forms.

4.3.3. Soil Wetness Indicator (SWI)

The valley bottom wetland units throughout the survey area tended to be well developed and therefore soil wetness indicators were readily supported. Seepage zones along hillslopes associated with rocky outcroppings and flat bench areas where soil depth was limited showed a strongly seasonal wetland condition. An underlying bedrock layer supports a perched water table in many areas, which then tends to induce soil wetness and seasonal saturation. Relatively shallow soils within these areas means that levels of saturation vary with rainfall as well as from inter-soil lateral and vertical water movement. These areas were noted to support prolonged soil saturation for long enough within the season to support floral components indicative of wetland conditions, but this would also vary with climatic cycles more so than the established valley bottom wetland units. Soil wetness indicators were strongly supported for delineation purposes and was considered a reliable indicator.

4.3.4. Vegetation Indicator (VI)

Wetlands tend to be transitional in nature and therefore a gradual transition of soils, levels of inundation and vegetation structures can be observed from the terrestrial areas, temporary, seasonal and into the permanent zones of a units. The ability to identify and differentiate wetland floral species as being obligate wetland species, facultative wetland species, facultative species and facultative dryland species is important in discerning the occurrence of wetland conditions.

Imperata cylindrica is a grass species that very often forms colonies within seasonal and temporary zone wetland units and provide a clear example of wetland flora zonation.

Floral species zonation providing evidence of a transitional zone between seasonal and permanent wetland zones.

An example of hydrophytic floral zonation, where the sedges in the foreground are indicative of the seasonal-permanent zone interface.

A clear indication of floral species zonation within an established valley bottom wetland unit.

Figure 17: Wetland boundaries can very often be ascertained by identifying the floral species zonation of wetland dependent species.

Wetland-dependent (hydrophytic) vegetation has a floral species community structure that is dominated by species specifically adapted to inhabiting soils of varying degrees of waterlogging, and what can flourish in oxygen-poor (hypoxic) soils. Various species are adapted to survive under varying periods of prolonged water saturated soils and therefore form distinct communities. This is largely true for undisturbed floral community structures associated with wetlands. The outer limits of the various wetland zones can therefore very often be determined by the changes in floral community structures. Floral zonation is also very often visible from aerial imagery however this should be used with caution. This unit indicator was found to be a useful tool as floral species indicative of the various wetland zones were observed. The wetland units were regarded as being well-developed, with structures typical of floral zonation being readily observed. The vegetation indicator was regarded as a reliable indicator of discerning the limits of the various zones of the wetland units. Table 7 presents the dominant floral species pertaining to the wetland units noted during the field survey.

Table 7: Dominant floral species noted within the wetland zones pertaining to the survey area.

Family	Species	Zonal indicator
Apiaceae	*Centella asiatica*	Exotic (seasonal zones)
Cyperaceae	*Alinula paradoxa*	Seasonal & outer permanent zones
	Ascolepis capensis	Seasonal & outer permanent zones
	Bulbostylis hispidula	Seasonal & outer permanent zones
	Carex austro-africana	Seasonal & outer permanent zones
	Cyperus compressus	Seasonal & outer permanent zones
	Cyperus congestus	Seasonal & outer permanent zones
	Cyperus denudatus	Seasonal & outer permanent zones
	Cyperus laevigatus	Seasonal & outer permanent zones
	Cyperus longus var. tenuiflorus	Seasonal & outer permanent zones
	Cyperus sexangularis	Seasonal & outer permanent zones
	Eleocharis acutangula	Seasonal & outer permanent zones
	Eleocharis dregeana	Seasonal & outer permanent zones
	Fimbristylis dichotoma	Seasonal & outer permanent zones
	Fuirena pubescens	Seasonal & outer permanent zones
	Fuirena stricta	Seasonal & outer permanent zones
	Isolepis fluitans	Seasonal & outer permanent zones
	Isolepis sepulcralis	Seasonal & outer permanent zones
	Kyllinga erecta	Seasonal & outer permanent zones
	Pycreus nitidus	Seasonal & outer permanent zones
	Schoenoplectus brachyceras	Seasonal & outer permanent zones
	Schoenoplectus corymbosus	Seasonal & outer permanent zones
Hydrocharitaceae	*Lagarasiphon major*	Permanent zones
	Lagarasiphon muscoides	Permanent zones
Iridaceae	*Watsonia densiflora*	Seasonal to temporary zones
Juncaceae	*Juncus dregeaus*	Seasonal & outer permanent zones

Family	Species	Zonal indicator
	Juncus lamatophyllus	Seasonal & outer permanent zones
Menyanthaceae	*Nymphoides thunbergiana*	Permanent zones
Onagraceae	*Ludwigia adscendens*	Permanent zones
Polygonaceae	*Persicaria lapathifolia*	Permanent & permanent/seasonal zone interface
	Persicaria decipiens	Permanent & permanent/seasonal zone interface
Poaceae	*Hemarthria altissima*	Seasonal zones
	Agrostis lachnantha	Seasonal zones
	Arudinella nepalensis	Seasonal zones
	Imperata cylindrica	Seasonal to temporary zones
	Leersia hexandra	Seasonal to permanent zones
	Sporobolus pyramidalis	Seasonal to temporary zones
	Andropogon eucomus	Seasonal to temporary zones
	Ischaemum fasciculatum	Seasonal to temporary zones
	Paspalum distichum	Seasonal to permanent zones
	Andropogon appendiculatus	Seasonal zones
	Paspalum dilitatum	Seasonal zones
	Paspalum scrobiculatum	Seasonal zones
	Setaria sphacelata var. sphacelata	Seasonal zones
Potamogetonacaea	*Potamogeton thunbergii*	Permanent zones
Scrophulariaceae	*Cycnium tubulosum*	Seasonal to temporary zones

4.4. Extent of the wetland units, buffer zones & designation of ecological sensitivity

The proposed development does have an association with wetland habitat units and therefore mandatory and legislated conservation buffer zones are applicable. The wetland units perform vital functions within the landscape and should be regarded as being ecologically sensitive features. Conservation of this habitat unit forms an integral part of the conservation of the surface water resources throughout the catchment area in terms of quality and quantity. The proposed development is also regarded as being of a relatively high impact to the wetland units associated with it. The wetlands that are regarded as high priority (high value) features that support the main watercourses and incorporate the network of the most well-developed valley bottom wetland units are rated as Priority 1 units. In addition, the more prominent seepage zone wetlands that support the hydrological functioning of these units are also categorised as Priority 1 units. Priority 1 wetland units have been designated a 100 m buffer zone. Priority 2 and Priority 3 wetland units are those wetland features that provide a supportive function to more sensitive Priority 1 units in terms of vegetation structures, seepage zones and overall ecological functionality (including wetland-dependent biodiversity support) to a greater and lesser extent, are designated buffer zones of 50 m and 30 m, respectively. Priority 4 wetland units are units that have suffered degradation, are poorly developed wetland units, and are not thought to provide significant supporting ecological value to the more established and sensitive priority 1 to 3 wetland units. No buffer zones have been designated to these units. The buffer zones are indicated in Figure 18, which takes this priority rating into collective consideration.

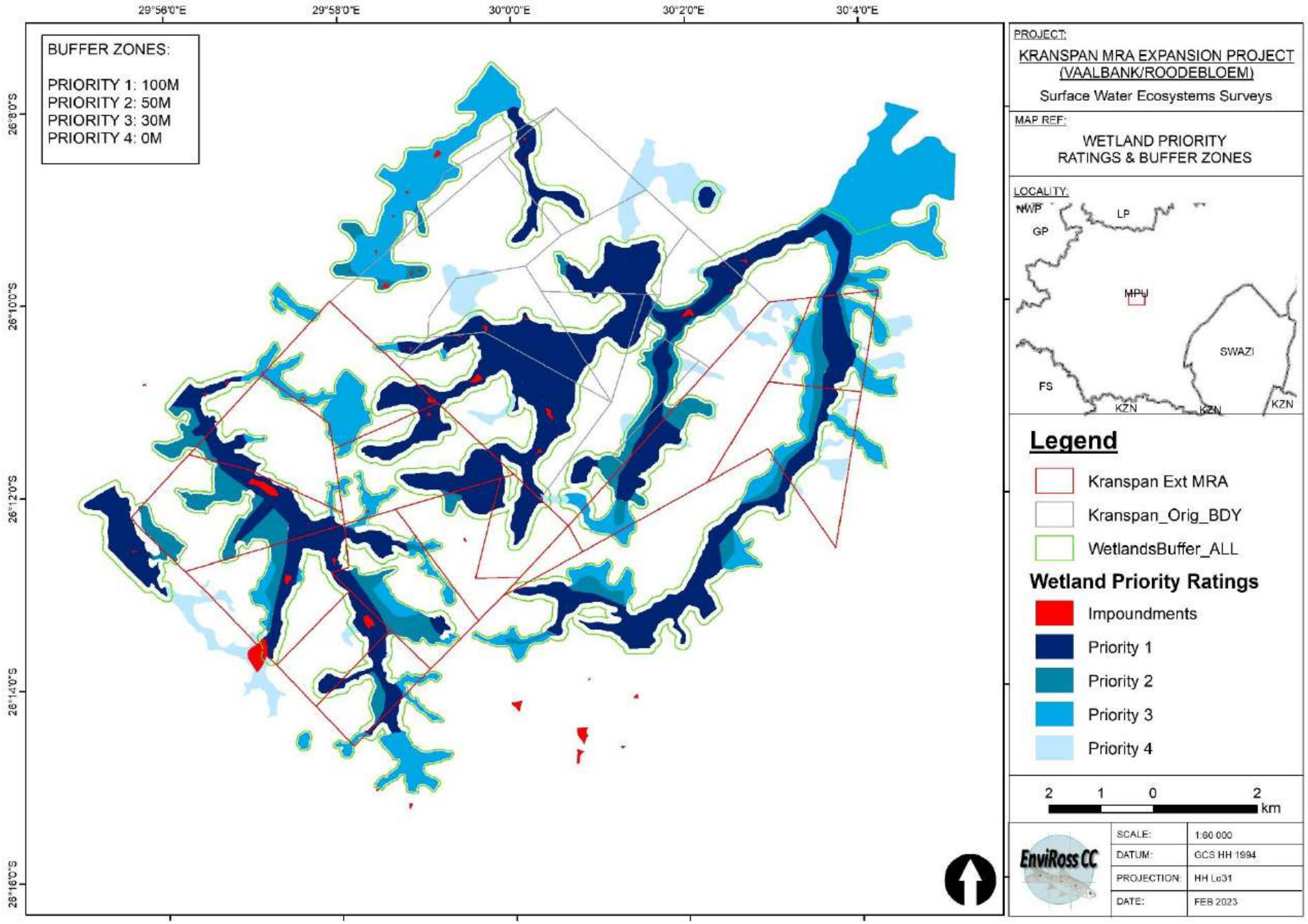


Figure 18: The delineation of the wetland units and the extent of the associated conservation buffer zones for the site. The priority ranking of all the wetland units are indicated.

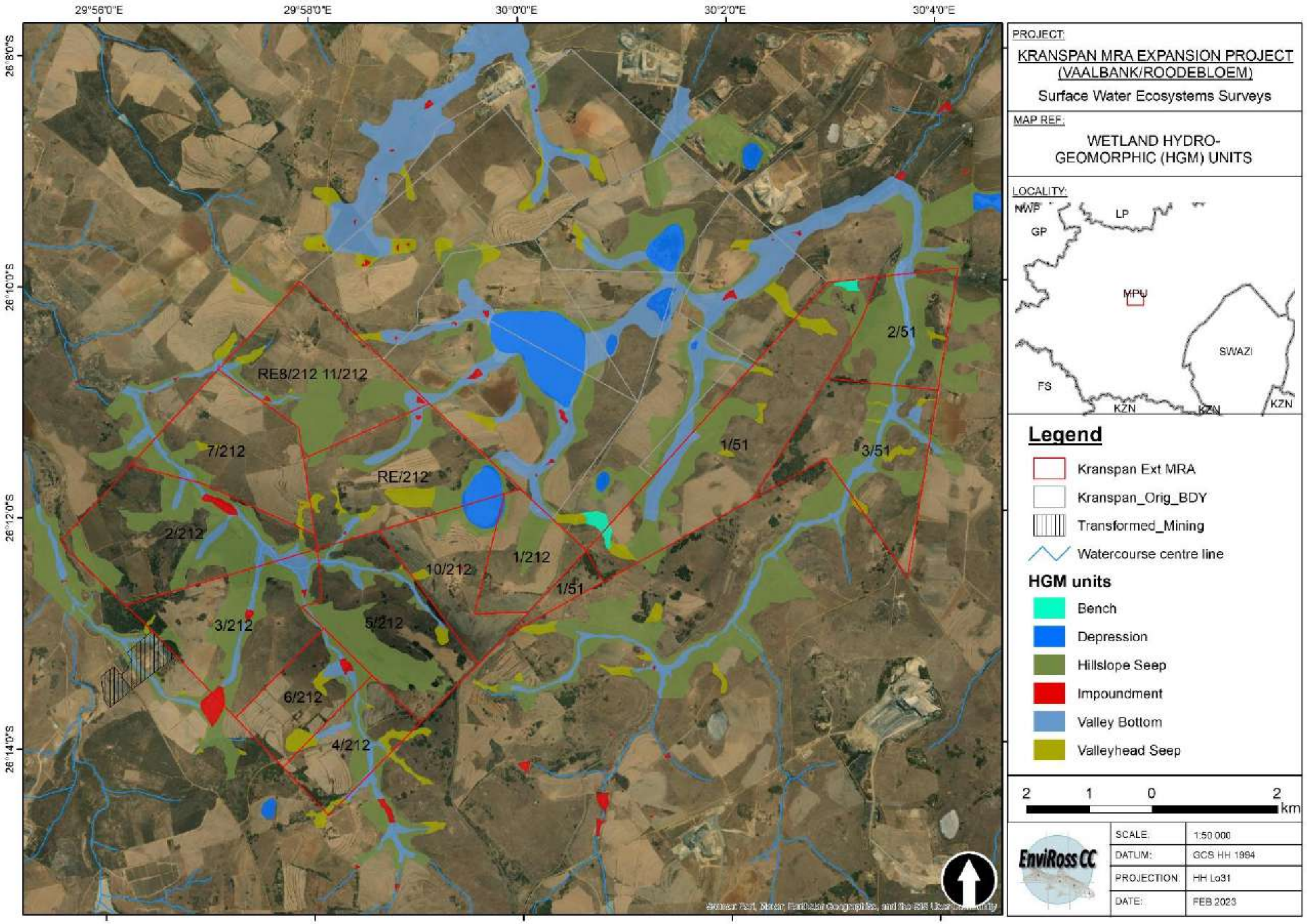


Figure 19: The different HGM wetland units associated with the site. Much of the peripheral wetland areas have been utilised for cultivation. Only the extended MRA was done in detail.

The wetland delineation and buffer zone digital files accompany this report.

Sensitivity mapping of the ecological features coincides with the wetland delineation and the associated buffer zones.

4.5. Wetland hydrogeomorphic (HGM) forms present within the area

The region is characterised by well-established and developed valley bottom wetland units that interchange between a channelled and unchannelled watercourse. All these valley bottom units are supplemented by hillslope seepage zones with varying spatial extents. The site is located within the upper reaches of the catchment area and therefore valleyhead seep zones that develop into valley-bottom wetland units that then feed into the main wetland complex are common. Hillslope seepages are not always directly linked to the main watercourse and some isolated features do occur. These tend to also incorporate temporary seepage zones areas and therefore no isolated seepage zones were indicated in the delineation mapping. Depression-type wetland units are also common, but many have been artificially manipulated to increase the capacity and period that they support persistent open surface waters. Being a well-established agricultural area, instream impoundments to support agricultural activities are common, but many of the earth dam walls have breached. Larger impoundments still do occur. Perpetual sediment transport to the impoundments through surface water runoff that gets deposited within the impoundments has resulted in these impoundments becoming relatively shallow, and aquatic and marginal wetland vegetation has become established in the shallower peripheral zones. These relatively large areas, together with expansive valley bottom and hillslope seep wetlands that support natural to near-natural vegetation structures support a high level of biodiversity – many of which are wetland dependent species.

There is an underlying bedrock layer that supports a perched water table relatively close to the surface. This is especially noteworthy within the wetland seep zones associated with the rocky ridge areas that tend to run parallel to the established watercourses. This bedrock very often supports bench-type wetland units, which is most noticeable at the crests of hilltops and watershed zones that gives the impression that the hilltop wetland units supply water to both sides of the watershed.

Wetland habitat units are regarded as well-established and developed within the area, with underlying soil and geological features that support a high water table and a relatively large ground-surface water interchange, which has led to soil characteristics that indicate that the majority of the area was historically established wetland areas. Land use that has led to unnatural channelling of valley-bottom wetlands that decreases landscape water retention periods, catchment management practices, as well as cyclic climatic changes are all contributing factors that have induced the overall reduction of the functional areas of the wetland units. Hydromorphic soils reminiscent of historical wetland zones therefore tend to indicate larger expanses than what are considered functional and active wetland zones, but which cannot be considered part of the wetland complex any longer.

4.6. Ecological functionality & ratings

Although there is a relatively high degree of interlinking, the survey area includes four main drainage areas, which are indicated in Figure 20. Group 4, although indicated in Figure 20, is included to present the extent of the holistic wetland complexes for the area but is not included within the analysis as it falls outside of the scope of work for this survey. Further wetland units that fall outside of the scope of work for this survey are indicated as “group 0”.

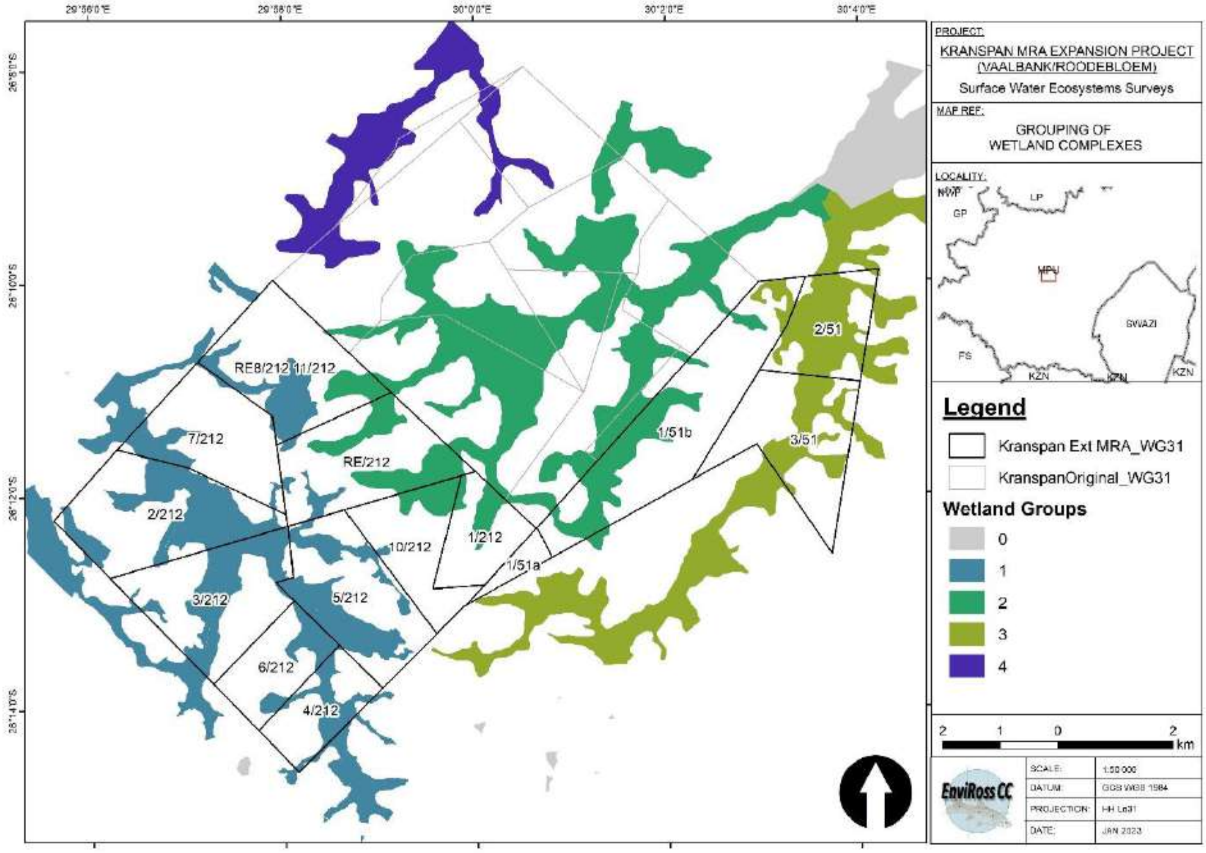


Figure 20: The groupings of the main wetland systems within the survey area. Only those wetland units that are associated with the survey area are included within the analysis and not the ones that only occur within the original Kranspan area.

Areas that are subject to similar pressures and drivers of ecological change, and which have similar catchment land uses and characteristics are grouped into subgroups of these main drainage areas. These subgroups are indicated in Figure 21. Again, those units falling outside of the scope of work for this project are indicated as “0”.

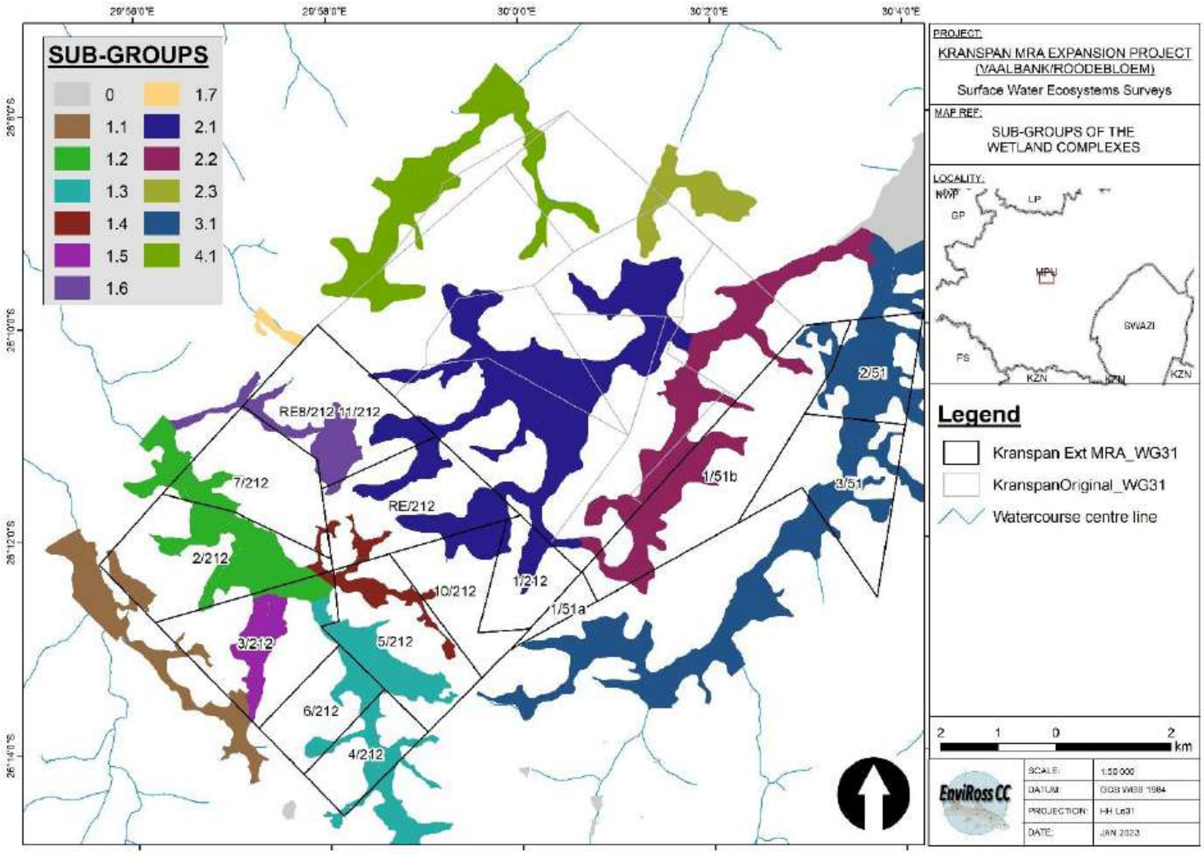


Figure 21: The subgroups of the main wetland systems within the survey area. These are grouped according to similar catchment land use characteristics and similar pressures and drivers of ecological change.

Mining activities are expanding and displacing cultivation, grazing land and natural grasslands. Existing land use activities that were identified as the main pressures and drivers of ecological change of the wetland ecological integrity within the region include numerous small impoundments located along all watercourses, active cultivation (which is commonplace within the higher-lying areas) and livestock grazing (generally throughout all the grassland areas). These factors have deleterious impacts on the overall functionality of the wetland features. Hydrological, vegetation and geomorphological features therefore tend to be similar for the subunits, which then allows for grouping of the ecological integrity of the subunits as well.

4.6.1. WETLAND-IHI

The WETLAND-IHI was applied to the wetland units associated with the survey area that include a valley bottom linear unit and which were relevant to the survey area. Due to the largely homogenous land use throughout the catchment area and the similar pressures and drivers of ecological change experienced by the wetland units, there is little variation in scores and ratings within the units themselves. The overall average Present Ecological State (PES) of the wetland units throughout the whole survey area calculates to within a C range. Variations do occur due to differences in vegetation cover, proximity to formal agriculture and transformation due to mining (where the water quality would be more prone to deleterious effects of agrochemicals and other contaminants), erosion features and proximity to and number of impoundments. These variations account for the scores ranging between B/C and D categories. The summary of the Wetland-IHI ratings is presented in Table 8.

Table 8: Results from the WETLAND-IHI for the wetlands associated with the proposed development area. Sub-unit codes from Figure 21.

Wetland Group	Sub unit code	HGM Description	Main pressures & drivers of ecological change	WETLAND IHI Ratings				Overall PES
				Vegetation	Hydrology	Geomorphology	Water quality	
Group 1	1.1	Main unit is a channelled and unchannelled valley bottom wetland unit with hillslope seepages along whole watercourse. Hillslope seepage zone above rocky ridge habitat to the east is channelled toward the main watercourse. Instream impoundments are common.	Cultivation within the western slopes leading to sediment transport toward the channel. Upper zones directly impacted by existing mining activities, leading to physical alteration. Road crossings and various excavations have also impacted the wetland ecological integrity. Overall ecological function and integrity improves downstream.	45.3%	59.9%	59.6%	82.0%	55.1% (D)
	1.2	The downstream section of the watercourse that bisectes the survey area. Highly developed and established channelled and unchannelled valley bottom wetland unit with vast hillslope seepages that supplement the hydrological features of the unit. Side tributaries feed into the main watercourse in the form of valleyhead seepage zones, valley bottoms and hillslope seepages. Instream impoundments do occur.	Some cultivation and low density livestock grazing. Surrounding landscape tends to be in a natural to near natural ecological state. Impoundments have altered some of the hydrological and geomorphological functioning, but tends to be insignificant in the spatial context in relation to the wetland unit that has a high proportion of the unit (approx 80%) that represents reference state conditions.	85.2%	79.7%	69.2%	84.3%	80.3% (B/C)
	1.3	The upstream section of the main watercourse that bisects the survey area. Highly developed and established channelled and unchannelled valley bottom wetland unit with hillslope seepages that supplement the hydrological features of the unit. Side tributaries feed into the main watercourse in the form of valleyhead seepage zones, valley bottoms and hillslope seepages. Instream impoundments do occur.	Cultivation and livestock grazing occurs within the unit. Much of the surrounding landscape tends to be in a natural to near natural ecological state. Road crossings and poorly designed bridges have resulted in an eroded and incised banks of the watercourse at the downstream side of the crossing points. More significant impoundments along the watercourse have altered some of the hydrological and geomorphological functioning, but allows for expansive open surface waters that are relatively shallow, which supports a thriving wetland avifaunal community. Relatively high proportion of the unit (approx 65%) that represents reference state conditions.	85.2%	79.7%	69.2%	84.3%	80.3% (B/C)
	1.4	Valleyhead seep and hillslope seepages that feed into valley bottom units that are generally poorly developed.	Cultivation and livestock grazing dominates much of the area immediately associated with this unit.	39.3%	66.5%	23.6%	64.3%	51.3% (D)

Wetland Group	Sub unit code	HGM Description	Main pressures & drivers of ecological change	WETLAND IHI Ratings				Overall PES
				Vegetation	Hydrology	Geomorphology	Water quality	
	1.5	Falls wihtin an interconnection zone that feeds into units 1.1 and 1.2 in the form of a flat bench wetland at the hillcrest feeding both sides of the watershed.	Cultivation and some livestock grazing.	Wetland-IHI not applicable				
	1.6	Hillslope seepages that flow westward toward an unchannelled valley bottom unit, supplemented by valleyhead seepages. The valley bottom watercourse forms a confluence with unit 1.2 further downstream.	Some cultivation and livestock grazing.	87.8%	70.0%	56.4%	72.7%	75.2% (C)
	1.7	A valleyhead and hillslope seepage feeding into a valley bottom unit. Only the very upper reaches are associated with the survey area.	Some cultivation and livestock grazing.	Wetland-IHI not applicable				
Group 2	2.1	The majority of the catchment of this unit falls within the original Kranspan survey area. The north-eastern boundary zones of the MRA survey area includes hillslope seepages, valleyhead seepages and unchannelled valley bottom units that feed into a depression wetland unit and other valley bottoms to converge as the main Kranspan (a depression wetland unit). This unit interlinks with a valley bottom wetland running to the east (unit 2.2) that drains northwards.	The wetland sections that fall within the survey area (the proposed MRA) suffer some fringing effects of cultivation. Road crossings have impacted the hydrological functioning of the units somewhat, but subsurface flow that seems to be deeper than the road foundations tend to have sustained the hydrological connectivity of the unit. Some livestock grazing occurs within the units.	83.7%	86.4%	70.0%	72.7%	80.1% (B/C)
	2.2	A main watercourse that drains through the original Kranspan project area but is supplemented by hillslope seepages and valleyhead seepage zones along its eastern side within the Roodebloem area. Impoundments occur along the watercourse.	Cultivation, road crossings and livestock grazing are the main drivers of ecological change within unit 2.2 that fall within the survey area.	43.4%	29.6%	23.6%	85.3%	38.9% (D/E)
	2.3	Outside the scope of the survey						

Wetland Group	Sub unit code	HGM Description	Main pressures & drivers of ecological change	WETLAND IHI Ratings				Overall PES
				Vegetation	Hydrology	Geomorphology	Water quality	
Group 3	3.1	A main watercourse that originates outside of the survey area. Upper limits of valleyhead seepages have a close association with 5 and 10 of Vaalbank. The watercourse drains to the northeast, where it enters from the south into Roodebloem. The main watercourse is a well developed channelled and unchannelled valley bottom unit supplemented by numerous valleyhead seepages feeding into side tributary valley bottom units. Hillslope seepages associate with the main watercourse along the whole length that is associated with the MRA survey area. Impoundments occur along the watercourse. Units 3.1 and 2.2 converge to form a single watercourse to the north of the MRA survey area.	Cultivation, road crossings and livestock grazing, and exotic vegetation encroachment are the main drivers of ecological change within the upstream areas. Mining activities, road crossings, and existing cultivation tend to be the main drivers within the mid to downstream areas.					
Group 4	4.1	Outside the scope of the survey						

As can be expected, the ecological integrity ratings of the wetland units vary according to the associated land use impacts within the catchment area. Variations within the actual wetland units that include vegetation cover are largely due to actively cultivated fields that occur within the fringing zones of wetland areas, exotic vegetation encroachment, and active mining in some areas. Geomorphological variations occur due to the varying sources of sediment sources that get delivered to the wetland units, which are mostly from cultivated areas, active mining areas, and gravel road runoff. The varying amounts of impoundments that act to trap sediments within the wetlands, together with some active erosion zones that tend to transport the sediments through the wetlands at different levels, also account for the geomorphological variations between the wetland units. Hydrological variations are largely due to impoundments that capture and attenuate surface water flows. Water quality does vary across the survey area, which is largely due to proximity of the wetland units to sources of contaminants (be it agrochemicals or mining-related contaminants), and sources of runoff that may induce increased turbidity, sources of effluents, etc. In general, the wetland units were noted to have retained overall good ecological integrity.

4.6.2. Ecological Importance-Sensitivity (EIS)

The EIS was undertaken according to the methods outlined in WET-EcoServices (Kotze *et al*, 2007). The wetland units throughout the survey area are all subject to similar pressures and drivers of ecological change, and all the units fall within a catchment area that shares a similar land use. The wetland units are located on private land, so utilisation of the wetland resources by a rural community are limited. Impoundments are located along all the watercourses, which is typical of an established agricultural area. The EIS of the wetland units are therefore mostly similar as they all share similar features. The EIS ratings were therefore calculated for larger wetland groups that share characteristics rather than each individual subunit. The EIS scores are presented in in Table 9.

Table 9: The results of the WET-Ecoservices index to determine the EIS of the wetland units.

Wetland functional feature	Group 1	Group 2	Group 3
Flood attenuation	2.2	2.2	2.4
Stream flow regulation	2.7	2.7	2.5
Sediment trapping	2.5	2.5	2.5
Phosphate trapping	3.2	3.2	2.9
Nitrate removal	3.3	3.3	2.8
Toxicant removal	2.9	2.9	2.5
Erosion control	2.5	2.5	2.4
Carbon storage	2.0	2.0	1.3
Maintenance of biodiversity	3.8	3.8	3.5
Water supply for human use	1.4	1.4	1.4
Natural resources	0.4	0.4	0.4
Cultivated foods	0.0	0.0	0.0
Cultural significance	0.0	0.0	0.0
Tourism and recreation	2.7	2.6	2.1
Education and research	1.5	1.5	1.5
Runoff intensity from the wetland unit's catchment	1.5	1.5	1.5
Alteration of sediment regime	3.0	1.0	3.0
Alteration of nutrient/toxicant regime	3.0	1.0	3.0
Level of threat	3.0	3.0	3.0
Levels of opportunity	3.0	3.0	3.0
Rating	2.2	2.0	2.1

These scores indicate that the wetlands supply a moderate to high ecological service. The threat level to the habitat units remain as relatively high (3 out of 4), with the levels of opportunity, which could be interpreted as the degree to which the wetland habitat units could perform these services, also scored relatively high as well (3 out of 4) (Table 9).

The various input features and how they scored for the wetland unit are presented in Figure 22. This shows which features (services) that are performed by the wetlands are currently scoring the highest, and which ones are ranked lower. The ecological services supplied by the wetlands are rated as the relative highest, and the wetland functionality elements (flood attenuation, and water purification) are also ranked high. Tourism and recreation also ranks relatively high due to the scenic beauty and opportunity for birding within these areas, but the survey area does not fall within a tourist-friendly region, which lowers the relevance of these factors. Low-scoring elements include the dependency of the rural sector on the resources offered by the wetland units (all located on private land) and cultural significance of the wetland units.

Figure 22: Scoring of the various aspects of ecological services provided for by the wetland habitat units present within the survey area.

Although the wetland units have scored average EIS and PES ratings, they remain ecologically sensitive habitat units, and they do offer value to protecting the water resource, maintenance of biodiversity, as well as provision of water to downstream ecosystems and water users, as well as provision of flood attenuation. The ecological value of such wetland units should therefore not be discounted.

4.7. DWSHS Risk Assessment Matrix

The DWS Risk Assessment Matrix (RAM) is designed to ascertain and quantify the significance of the risk profile of the proposed development that may be imposed on the wetland unit. As per current legislature, there is a regulatory zone of 500 m surrounding the wetland unit that applies to the application of the RAM and therefore there are development activities that fall within the wetland unit (if applicable), that which falls within the conservation buffer zone of the wetland unit (again, if applicable), and those activities that fall within the terrestrial areas that may impact on the ecological integrity of the wetland unit. All three of these factors are applicable to the project.

The risk profile to any wetland or aquatic unit is dependent on the intensity, the spatial and temporal scale, the occurrence of historical and existing impacting infrastructure and features, and the type of development. Another factor to consider is the level of development of the wetland unit, and the volume of water that the watercourse conveys. These are factors that require consideration when implementing mitigation measures. The risk profile is then also dependent on the overall success rate of the rehabilitation measures that would be applied post construction as part of the mitigation measures to abate the ecological impacts. Activities with a high intensity require larger and often more complex mitigation measures, which then carries a greater risk profile as opposed to low intensity activities that only require relatively simple mitigation measures to achieve site rehabilitation and to restore ecological functionality. As activities that take place further afield than the extent of the buffer zones can often lead to impacts to the surface water ecosystems, the Risk Assessment Matrix (RAM) is inclusive of the risks that these activities may impose as well. This is especially true for developments that take place within areas of steep topographies that have a profile that carries a high intensity of runoff, and which are vulnerable to erosion. The transport of sediments and contaminants from these impact site very often carry further than those that emanate from areas of flatter topographies.

The level of risk to a wetland unit posed by a development is largely determined by the proximity of the development activities to the wetland unit. Developments that are to take place within wetland units pose an obvious risk and therefore specific mitigation measures would apply. The significance of the risk is, however, also determined by the ecological state of the wetland unit and whether the impact feature associated with permanent, seasonal, or temporary (peripheral) zones of the unit as this dictates the type of mitigation measures to be implemented, and the level of the complexity of the mitigation measures tends to decrease with increasing distance from the permanent zones of a wetland unit. This implies that the potential for a satisfactory result also increases with increasing distance from the permanent zones of a surface water ecosystem feature.

Table 10: Summary of the Risk Assessment Matrix pertaining to activities that are to take place within the wetland unit.

Summary of RAM Ratings & Descriptions			
Activity #1 Construction activities within wetland areas			
Phase	Construction		
Aspect	Construction within the wetland/riparian zones to establish surface mining support infrastructure leading to altered physical habitat, vegetation structures, hydrological and geomorphological functioning of the wetland/riparian unit.		
Impact	Damage to wetland/riparian vegetation.		
Ratings		Control measures	
Flow regime	5	The excavations and land preparations necessary to accommodate the surface infrastructure that fall wihtin wetland areas will represent a moderate risk to the overall wetland unit if undertaken in an area where no existing infrastructure occurs. Mitigation guidelines pertaining to excavating and site reinstatement within wetland zones have been provided (section 5). The significance of the risk can be successfully lowered with implementation of appropriate mitigation measures.	
Physico-chemical (Water quality)	5		
Habitat (Geomorphology + Vegetation)	5		
Biota	5		
SEVERITY	5		
Spatial scale	1		
Duration	1		
CONSEQUENCE	7		
Frequency of Activity	1		
Frequency of Impact	2		
Legal Issues	5		
Detection	2		
LIKELIHOOD	10	Confidence Level	95%
SIGNIFICANCE	70	Borderline LOW Moderate rating classes	Yes
RISK RATING	MOD	PES & EIS of watercourse	No change
Phase	Construction/Operations		
Aspect	Establishment of opencast mine pits in wetland zones or in close proximity		
Impact	Direct loss to wetland habitat through infiltration of wetland water into the pit rather than sustaining the wetland unit leading to altered hydrological functionality and loss of wetland function.		

Summary of RAM Ratings & Descriptions			
Ratings		Control measures	
Flow regime	5	Significance of the imapct to the wetland is dependent on the water balance between the pit and the wetland unit. This water balance between the pit and the wetland should be determined by the appropriate specialist (hydropedologist or geohydrologist). Decant water could be used to feed back into the wetland unit, but the quality should be ascertained to determine if if confirms to target water quality values. This risk profile increases with the priority ranking of the wetland unit (see section 4.4 and Figure 18) that is to be impacted, the proximity of the opencast pit in relation to the wetland, the level of development of the wetland unit and the significance of the ecological contribution of that wetland unit into the greater wetland complex. Depending on the above factors, the spatial scale and the severity can be lowered, which would alter the risk profile to represent a moderate risk.	
Physico-chemical (Water quality)	5		
Habitat (Geomorphology + Vegetation)	5		
Biota	5		
SEVERITY	5		
Spatial scale	2		
Duration	5		
CONSEQUENCE	12		
Frequency of Activity	5		
Frequency of Impact	5		
Legal Issues	5		
Detection	1		
LIKELIHOOD	16	Confidence Level	95%
SIGNIFICANCE	192	Borderline LOW Moderate rating classes	No
RISK RATING	HIGH	PES & EIS of watercourse	Changed
Impact	Destabilisation of soils and mobilisation of silts and sediment		
Ratings		Control measures	
Flow regime	5	The excavations and land preparations necessary to accommodate the surface infrastructure that fall wihtin wetland areas will represent a moderate risk to the overall wetland unit if undertaken in an area where no existing infrastructure occurs. Mitigation guidelines pertaining to excavating and site reinstatement within wetland zones have been provided (section 5). The significance of the risk can be successfully lowered with implementation of appropriate mitigation measures.	
Physico-chemical (Water quality)	5		
Habitat (Geomorphology + Vegetation)	5		
Biota	5		
SEVERITY	5		
Spatial scale	1		
Duration	1		
CONSEQUENCE	7		
Frequency of Activity	1		
Frequency of Impact	2		
Legal Issues	5		
Detection	1		
LIKELIHOOD	9	Confidence Level	95%
SIGNIFICANCE	63	Borderline LOW Moderate rating classes	Yes
RISK RATING	MOD	PES & EIS of watercourse	No change
Impact	Physical alteration to the wetland/riparian areas.		
Ratings		Control measures	
Flow regime	5	Physical alteration of wetland units will occur where minig activities take place within the wetland units, or where roads and other infrastructure is to be established that require landscaping. The risk to the wetland is again dependent on the spatial scale of the infrastructure or mining activities, but, due to it taking place within the wetland area, it can be assumed to be moderate to high. Mitigation guidelines pertaining to excavating and site reinstatement within wetland zones have been provided (section 5). Mitigation measures could reduce the significance of the impact and the risk profile is implemented correctly.	
Physico-chemical (Water quality)	5		
Habitat (Geomorphology + Vegetation)	5		
Biota	5		
SEVERITY	5		
Spatial scale	2		
Duration	5		
CONSEQUENCE	12		
Frequency of Activity	5		
Frequency of Impact	5		
Legal Issues	5		
Detection	1		
LIKELIHOOD	16	Confidence Level	95%
SIGNIFICANCE	192	Borderline LOW Moderate rating classes	No
RISK RATING	HIGH	PES & EIS of watercourse	Changed
Activity #2 Fuel spillages from vehicles and/or equipment.			
Phase	Construction		

<table>
<tr><td colspan="5">Summary of RAM Ratings & Descriptions</td></tr>
<tr><td>Aspect</td><td colspan="4">Fuel/oil spillages from vehicles and/or equipment will lead to soil contamination and pollution of the water, impacting on biodiversity.</td></tr>
<tr><td>Impact</td><td colspan="4">Hydrocarbon contamination of a natural waterbody has negative impacts on the biodiversity.</td></tr>
<tr><td colspan="2">Ratings</td><td colspan="3">Control measures</td></tr>
<tr><td colspan="1">Flow regime</td><td>5</td><td colspan="3" rowspan="13">The likelihood of this impact occurring is low due to the relatively small extent of the wetland zones within the crossing points. Earthmoving equipment will be active within these areas during excavations, meaning that it is a potential impacting feature.
Construction vehicles and equipment on site must be routinely serviced and monitored for any fluid leaks.
If fluid leaks are detected, contaminated soils must be immediately removed and disposed of at a registered disposal facility.
No refuelling of vehicles and equipment should be allowed within the wetland and buffer zones.
This is an impact that can have profound impacts to the aquatic environment (i.e., further downstream) if it does occur.
Avoidance of this impact can be readily achieved through simple mitigation measures.</td></tr>
<tr><td>Physico-chemical (Water quality)</td><td>5</td></tr>
<tr><td>Habitat (Geomorphology + Vegetation)</td><td>5</td></tr>
<tr><td>Biota</td><td>5</td></tr>
<tr><td>SEVERITY</td><td>5</td></tr>
<tr><td>Spatial scale</td><td>1</td></tr>
<tr><td>Duration</td><td>1</td></tr>
<tr><td>CONSEQUENCE</td><td>7</td></tr>
<tr><td>Frequency of Activity</td><td>1</td></tr>
<tr><td>Frequency of Impact</td><td>2</td></tr>
<tr><td>Legal Issues</td><td>5</td></tr>
<tr><td>Detection</td><td>2</td></tr>
<tr><td></td><td></td></tr>
<tr><td>LIKELIHOOD</td><td>10</td><td colspan="2">Confidence Level</td><td>95%</td></tr>
<tr><td>SIGNIFICANCE</td><td>70</td><td colspan="2">Borderline LOW Moderate rating classes</td><td>Yes</td></tr>
<tr><td>RISK RATING</td><td>MOD</td><td colspan="2">PES & EIS of watercourse</td><td>No change</td></tr>
<tr><td colspan="5">Activity #3
Erosion due to poor site reinstatement.</td></tr>
<tr><td>Phase</td><td colspan="4">Operations</td></tr>
<tr><td>Aspect</td><td colspan="4">Any disturbed soils that are exposed to running water will be vulnerable to erosion. The proper reinstatement of soils following disturbances, will consolidate the soils, allow for the re-establishment of vegetation and the subsequent protection of soils.</td></tr>
<tr><td>Impact</td><td colspan="4">Soil erosion management is an ongoing concern pertaining to all sectors of development.</td></tr>
<tr><td colspan="2">Ratings</td><td colspan="3">Control measures</td></tr>
<tr><td>Flow regime</td><td>5</td><td colspan="3" rowspan="12">Erosion control must be considered an ongoing concern throughout all phases of the development.
Vulnerable areas must be monitored for emerging erosion. Any development of erosion must be timeously rectified, and impacted areas stabilised as soon as practically possible.

Removal of vegetation within the wetland/riparian areas will destabilise soils and aggravate erosion. Exotic vegetation within the riparian area should be managed and/or removed. This should be done in a phased approach with indigenous species counterparts being allowed to establish whilst exotic species are removed. A controlled and phased approach will assure the stabilisation of soils through natural processes offered by vegetation (i.e., soil consolidation through the process of root binding, etc).

Erosion management is relatively easily achieved if integrated within the planning phase of the project from the beginning. Mitigation guidelines pertaining to excavating and site reinstatement within wetland zones have been provided (section 5).</td></tr>
<tr><td>Physico-chemical (Water quality)</td><td>5</td></tr>
<tr><td>Habitat (Geomorphology + Vegetation)</td><td>5</td></tr>
<tr><td>Biota</td><td>5</td></tr>
<tr><td>SEVERITY</td><td>5</td></tr>
<tr><td>Spatial scale</td><td>1</td></tr>
<tr><td>Duration</td><td>1</td></tr>
<tr><td>CONSEQUENCE</td><td>7</td></tr>
<tr><td>Frequency of Activity</td><td>1</td></tr>
<tr><td>Frequency of Impact</td><td>2</td></tr>
<tr><td>Legal Issues</td><td>5</td></tr>
<tr><td>Detection</td><td>2</td></tr>
<tr><td>LIKELIHOOD</td><td>10</td><td colspan="2">Confidence Level</td><td>95%</td></tr>
<tr><td>SIGNIFICANCE</td><td>70</td><td colspan="2">Borderline LOW Moderate rating classes</td><td>Yes</td></tr>
<tr><td>RISK RATING</td><td>MOD</td><td colspan="2">PES & EIS of watercourse</td><td>No change</td></tr>
</table>

Table 11: Summary of the Risk Assessment Matrix pertaining to activities that are to take place within the buffer zones of the surface water habitat unit.

Summary of RAM Ratings & Descriptions			
Activity #1 Excavations			
Phase	Construction		
Aspect	Construction within the buffer zones leading to altered physical habitat, vegetation structures, hydrological and geomorphological functioning of the unit.		
Impact	Damage to wetland/riparian vegetation.		
Ratings		Control measures	
Flow regime	2	The overall risk profile is considered low.	
Physico-chemical (Water quality)	2		
Habitat (Geomorphology + Vegetation)	2		
Biota	2		
SEVERITY	2		
Spatial scale	1		
Duration	1		
CONSEQUENCE	4		
Frequency of Activity	1		
Frequency of Impact	2		
Legal Issues	5		
Detection	2		
LIKELIHOOD	10	Confidence Level	95%
SIGNIFICANCE	40	Borderline LOW Moderate rating classes	No
RISK RATING	LOW	PES & EIS of watercourse	No change
Phase	Construction/Operations		
Aspect	Establishment of opencast mine pits in wetland buffer zones or in close proximity		
Impact	Direct loss to wetland habitat through infiltration of wetland water into the pit rather than sustaining the wetland unit leading to altered hydrological functionality and loss of wetland function.		
Ratings		Control measures	
Flow regime	4	Significance of the impact to the wetland is dependent on the water balance between the pit and the wetland unit, which would dissipate with distance between the wetland unit and the pit. This water balance between the pit and the associated wetland should be determined by the appropriate specialist (hydropedologist or geohydrologist). Decant water could be used to feed back into the wetland unit, but the quality should be ascertained to determine if if confirms to target water quality values. This risk profile increases with the priority ranking of the wetland unit (see section 4.4 and Figure 18) that is to be impacted, the proximity of the opencast pit in relation to the wetland, the level of development of the wetland unit and the significance of the ecological contribution of that wetland unit into the greater wetland complex. Depending on the above factors, the spatial scale and the severity can be lowered, which would alter the risk profile to represent a moderate risk.	
Physico-chemical (Water quality)	4		
Habitat (Geomorphology + Vegetation)	4		
Biota	4		
SEVERITY	4		
Spatial scale	2		
Duration	5		
CONSEQUENCE	11		
Frequency of Activity	5		
Frequency of Impact	5		
Legal Issues	5		
Detection	1		
LIKELIHOOD	16	Confidence Level	95%
SIGNIFICANCE	176	Borderline LOW Moderate rating classes	Yes
RISK RATING	HIGH	PES & EIS of watercourse	Changed
Impact	Destabilisation of soils and mobilisation of silts and sediment.		
Ratings		Control measures	
Flow regime	2	The overall risk profile is considered low.	
Physico-chemical (Water quality)	2		
Habitat (Geomorphology + Vegetation)	2		
Biota	2		
SEVERITY	2		
Spatial scale	1		
Duration	1		
CONSEQUENCE	4		
Frequency of Activity	1		

Summary of RAM Ratings & Descriptions			
Frequency of Impact	2		
Legal Issues	5		
Detection	2		
LIKELIHOOD	10	Confidence Level	95%
SIGNIFICANCE	40	Borderline LOW Moderate rating classes	No
RISK RATING	LOW	PES & EIS of watercourse	No change
Activity #2 Fuel spillages from vehicles and/or equipment.			
Phase	Construction		
Aspect	Fuel/oil spillages from vehicles and/or equipment will lead to soil contamination and pollution of the water, impacting on biodiversity.		
Impact	Hydrocarbon contamination of a natural waterbody has negative impacts on the biodiversity.		
Ratings		Control measures	
Flow regime	1	Construction vehicles and equipment on site must be routinely serviced and monitored for any fluid leaks. If fluid leaks are detected, contaminated soils must be immediately removed and disposed of at a registered disposal facility. No refuelling of vehicles and equipment should be allowed within the wetland and buffer zones. This is an impact that can have profound impacts to the aquatic environment if it does occur. Avoidance of this impact can be readily achieved through simple mitigation measures.	
Physico-chemical (Water quality)	2		
Habitat (Geomorphology + Vegetation)	1		
Biota	2		
SEVERITY	1.5		
Spatial scale	1		
Duration	1		
CONSEQUENCE	3.5		
Frequency of Activity	1		
Frequency of Impact	2		
Legal Issues	5		
Detection	2		
LIKELIHOOD	10	Confidence Level	95%
SIGNIFICANCE	35	Borderline LOW Moderate rating classes	No
RISK RATING	LOW	PES & EIS of watercourse	No change
Activity #3 Erosion due to poor site reinstatement.			
Phase	Operations		
Aspect	Any disturbed soils that are exposed to running water will be vulnerable to erosion. The proper reinstatement of soils following disturbances, will consolidate the soils, allow for the re-establishment of vegetation and the subsequent protection of soils.		
Impact	Soil erosion management is an ongoing concern pertaining to all sectors of development.		
Ratings		Control measures	
Flow regime	2	Erosion control must be considered an ongoing concern throughout all phases of the development. Vulnerable areas must be monitored for emerging erosion. Any development of erosion must be timeously rectified, and impacted areas stabilised as soon as practically possible. Removal of vegetation within the wetland/riparian areas will destabilise soils and aggravate erosion. Exotic vegetation within the riparian area should be managed and/or removed. This should be done in a phased approach with indigenous species counterparts being allowed to establish whilst exotic species are removed. A controlled and phased approach will assure the stabilisation of soils through natural processes offered by vegetation (i.e., soil consolidation through the process of root binding, etc). Erosion management is relatively easily achieved if integrated within the planning phase of the project from the beginning.	
Physico-chemical (Water quality)	2		
Habitat (Geomorphology + Vegetation)	2		
Biota	2		
SEVERITY	2		
Spatial scale	1		
Duration	1		
CONSEQUENCE	4		
Frequency of Activity	1		
Frequency of Impact	2		
Legal Issues	5		
Detection	2		
LIKELIHOOD	10	Confidence Level	95%
SIGNIFICANCE	40	Borderline LOW Moderate rating classes	Yes
RISK RATING	LOW	PES & EIS of watercourse	No change

Table 12: Summary of the Risk Assessment Matrix pertaining to activities that are to take place within the terrestrial zones near to the wetland units.

Summary of RAM Ratings & Descriptions			
Activity #1 Construction activities within terrestrial areas but which fall within the 500 m regulatory zones			
Phase	Construction		
Aspect	Construction activities leading to altered physical habitat, vegetation structures, hydrological and geomorphological functioning of the nearby wetland units.		
Impact	Increased sediment runoff following soil disturbances.		
Ratings		Control measures	
Flow regime	1	Construction footprint to remain as localised as possible. Limit soil disturbance impacts as much as possible. Reinstatement of soils that are properly landscaped to negate erosive forces and altered surface hydrology. Stormwater management and sediment control within road reserves should be in place.	
Physico-chemical (Water quality)	2		
Habitat (Geomorphology + Vegetation)	2		
Biota	1		
SEVERITY	1.5		
Spatial scale	1		
Duration	1		
CONSEQUENCE	3.5		
Frequency of Activity	1		
Frequency of Impact	2		
Legal Issues	5		
Detection	2		
LIKELIHOOD	10	Confidence Level	95%
SIGNIFICANCE	35	Borderline LOW Moderate rating classes	No
RISK RATING	LOW	PES & EIS of watercourse	No change
Activity #2 Fuel spillages from vehicles and/or equipment.			
Phase	Construction		
Aspect	Fuel/oil spillages from vehicles and/or equipment will lead to soil contamination and pollution of the water impacting on biodiversity.		
Impact	Hydrocarbon contamination of a natural waterbody has negative impacts on the biodiversity.		
Ratings		Control measures	
Flow regime	1	Construction vehicles and equipment on site must be routinely serviced and monitored for any fluid leaks. If fluid leaks are detected, contaminated soils must be immediately removed and disposed of at a registered disposal facility. Refuelling of vehicles and equipment must be undertaken only within designated and authorised areas where suitable protection measures are in place to abate the impacts of potential spillages. This is an impact that can have profound impacts to the aquatic environment if it does occur. Avoidance of this impact can be readily achieved through simple mitigation measures.	
Physico-chemical (Water quality)	2		
Habitat (Geomorphology + Vegetation)	2		
Biota	1		
SEVERITY	1.5		
Spatial scale	1		
Duration	1		
CONSEQUENCE	3.5		
Frequency of Activity	1		
Frequency of Impact	2		
Legal Issues	5		
Detection	2		
LIKELIHOOD	10	Confidence Level	95%
SIGNIFICANCE	35	Borderline LOW Moderate rating classes	No
RISK RATING	LOW	PES & EIS of watercourse	No change

The significance of the risks to the surface water ecosystems within the area for the activities that fall within the habitat zones calculated at between 63 and 192, which can be classified as moderate to high risk activities (Table 10), those within the buffer zones between 35 and 176 (low to high risk) (Table 11), and those within the terrestrial areas but which fall within the regulatory zone of the surface water habitat units at 35 (low risk) (Table 12). Proposed mitigation measures to abate impacts have been outlined in section 5.

4.8. Further biological indicators

Sites were selected which were thought to best represent typical watercourses within the survey area as well as having the highest potential of supporting fish fauna to gain an insight into the fish species distributions throughout the area. The localities of the survey sites are presented in Figure 23.

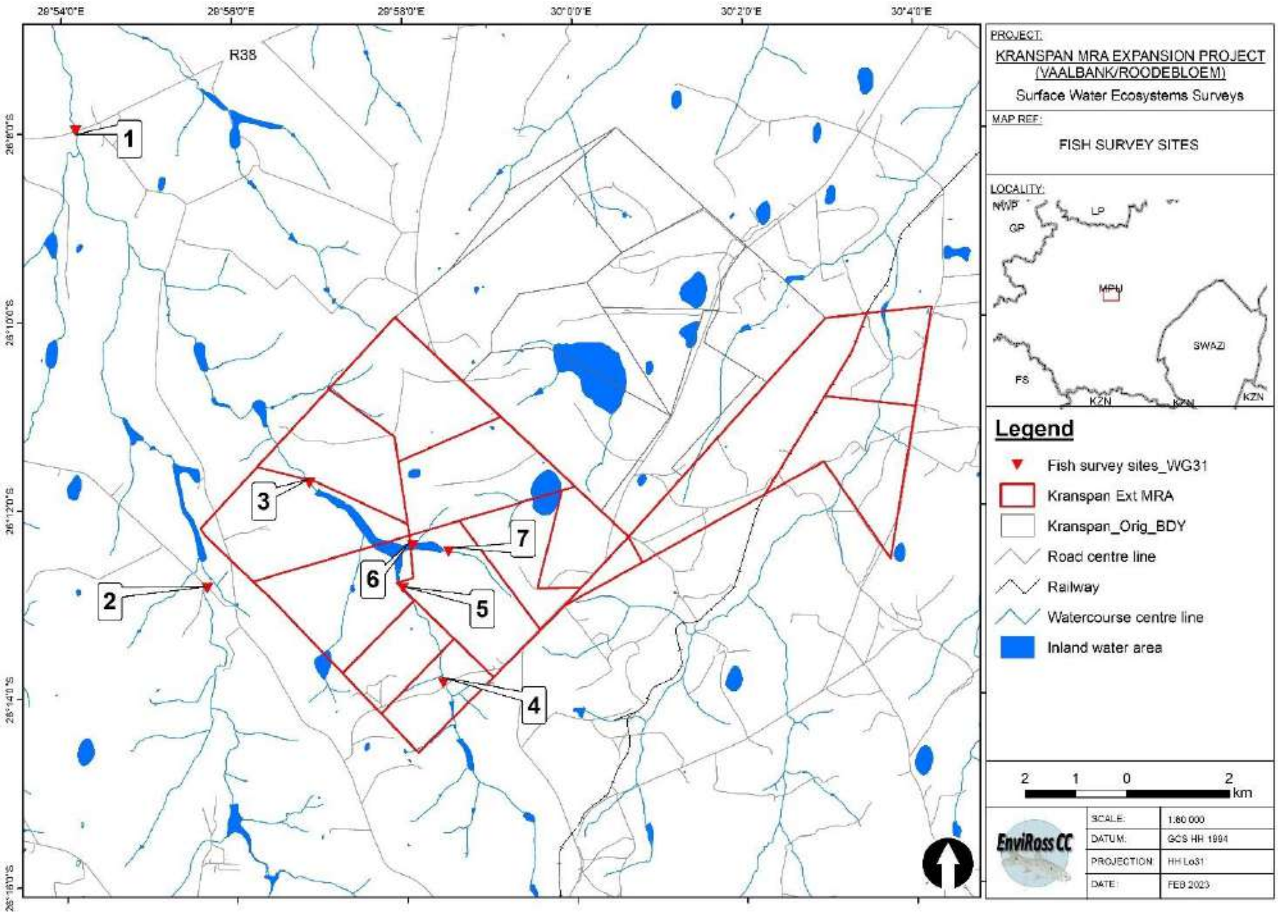


Figure 23: Localities of the fish survey sites.

The distribution of fish within the catchment area is determined by many factors, with the most influential being the occurrence of instream migratory barriers that physically block the migratory movements of fish. Many of the impoundments have been breached and therefore do not pose as barriers, and road watercourse crossing points that are impassable under low flow conditions become passable under moderate to high flow conditions (i.e., during the summer season).

Figure 24: Poorly designed road crossings create migratory barriers to fish and impact fish populations through habitat fragmentation (the bridge crossing point associated with site 4).

Factors such as chemical boundaries (e.g., confluence of two streams of a chemical composition different enough to create a chemical boundary to fish, which can be natural and/or effluent related), temperature boundaries, difficult hydraulic conditions such as lack of suitable hydraulic depth to support swimming of deeper-bodied and larger fish, and physical barriers, all influence the distribution of fish within a catchment area. Seasonal variation also plays an important role, with fish tending to swim upstream into headwater streams during the summer cycle for breeding purposes and retreating downstream again during the winter season to escape colder and fluctuating water temperatures. The survey area includes headwater streams associated with wetland units. The streams tend to be seasonal, with the increased water volume throughout the catchment allowing for greater accessibility for the fish to disperse up into the catchment area. The habitat of the streams is dominated by well-vegetated marginal zones (mostly reeds and other grasses) with a high level of aquatic vegetation as well. This habitat type is well suited for supporting breeding of many of the smaller *Enteromius* species. Some rocky substrates do occur, but this is largely artificial where rocks have been purposefully placed to curb erosion or to facilitate a watercourse crossing point. The site furthest downstream (Site 1) includes a higher level of rocky substrates as it coincides with a derelict vehicular bridge where the concrete and rocks associated with old culverts provide for a diversity of habitat types. Sampling was undertaken during a low flow period and a high flow period, both within flowing streams and standing waterbodies. Table 13 presents a summary of the results of the fish survey.

Note that a fish survey was not part of the Scope of Work and therefore a comprehensive fish survey was not undertaken. The results presented here are therefore intended to act as supplementary data to the surface water ecosystem assessment and to provide a general overview of the fish species distribution within the survey area.

Table 13: Summary of the fish sampling sites and the results of the survey.

Site	Photo records & General descriptions	Collection technique	Fish species
Site 1	 *A downstream view of the derelict low level concrete bridge showing evidence of a previous bridge structure that had historically failed.*  *An upstream view looking toward the present R38 bridge from the derelict concrete low level bridge.* Downstream of the R38 road crossing, between the R38 bridge and the derelict low level concrete bridge as well as a further failed culvert bridge. Variable channel depth and water velocity. Substrate dominated by mud upstream of old bridge infrastructure. Old bridge provides a mixture of rocky and sandy substrates, with a diversity of water depth and flow velocities. Established tree in the watercourse provided for good cover. Marginal vegetation dominated by grasses, sedges and herbaceous floral species.	Electrofishing	*Enteromius anoplus* (mixed age classes). *Enteromius paludinosus* (mixed age classes). *Presudocrenilabrus philander* (mixed age classes). *Tilapia sparrmanii* (mixed age classes). *Micropterus salmoides* (ex) (young).
Site 2	 Channelled valley bottom wetland, downstream of road crossing. Emergent instream and marginal vegetation (reeds). Variable water depth and water velocity. Substrate mostly mud and sediment.	Electrofishing	None
Site 3	 *View from the nearby hillside of the dam wall showing the eroded outlet during a low flow period.*  *Looking upstream of the dam during a low flow period.*  *The same impoundment during the wet season, looking upstream from the dam wall.*  *The same impoundment during the wet season, looking downstream from the upstream inundation area.*	Cast netting	*Clarias gariepinus* (adults) *Cyprinus carpio* (ex) (adults) Spawning activity of both species at the time of sampling – during low flow conditions.

Site	Photo records & General descriptions	Collection technique	Fish species
Site 4	 *Downstream view from the bridge (road).*  *Looking upstream toward the road crossing.* Downstream of road crossing. Channelled valley bottom wetland with variable water depth and velocity. Gravel and mud/sand substrates. Marginal vegetation mostly sedges and grasses. Small stream with limited hydraulic depth in parts.	Electrofishing	*Enteromius anoplus* (mixed population of adults and young)
Site 5	 *Open water.*  *Watercourse inundated with aquatic vegetation.* Channelled valley bottom wetland. Packed rocks at fenceline created rocky-substrate small impoundment. Variable depth with limited flow. Watercourse includes depressions with substrate dominated by silt. High level of aquatic vegetation (dominated by *Apponogeton* sp and *Elodea* sp. Emergent instream and marginal vegetation (reeds and sedges).	Electrofishing	*Enteromius anoplus* (young) *Tilapia sparrmanii* (young)
Site 6	 Downstream of the confluence of the stream fed by a strong spring. Water notably high EC. High sediment and mud substrate, loosened by cattle activity. Variable water depth, slow water velocity. Emergent vegetation mostly sedges and grasses.	Electrofishing	*Tilapia sparrmanii* (1x adult)
Site 7	 Upstream of the confluence of the stream fed by a strong spring. Channelled valley bottom wetland with upstream-progressing headcut erosion. Sampled within open pool created by the plungepool of the headcut. Downstream the channel is a mixed channelled to unchannelled valley bottom wetland. Impoundments are common along the watercourse.	Electrofishing	*Enteromius anoplus* (all adults)

Results of the informal fish surveys highlight the important role that these smaller tributary streams play in providing suitable breeding and refuge habitat for fish. A relatively high number of tadpoles were also included in the capture efforts as they are also susceptible to the effects of electrofishing. Positive identification of the tadpoles did not form part of the scope of this survey.

Figure 25: Some fish captured during the survey (*Clarias gariepinus* - to left; *Cyprinus carpio* to right; *Enteromius anoplus* – bottom).

4.9. Water quality analysis

Eight water samples were collected during the field survey and sent to an accredited laboratory for analysis. The site localities of the sampling sites are presented in Figure 26. The results are presented in Table 14 and Table 15.

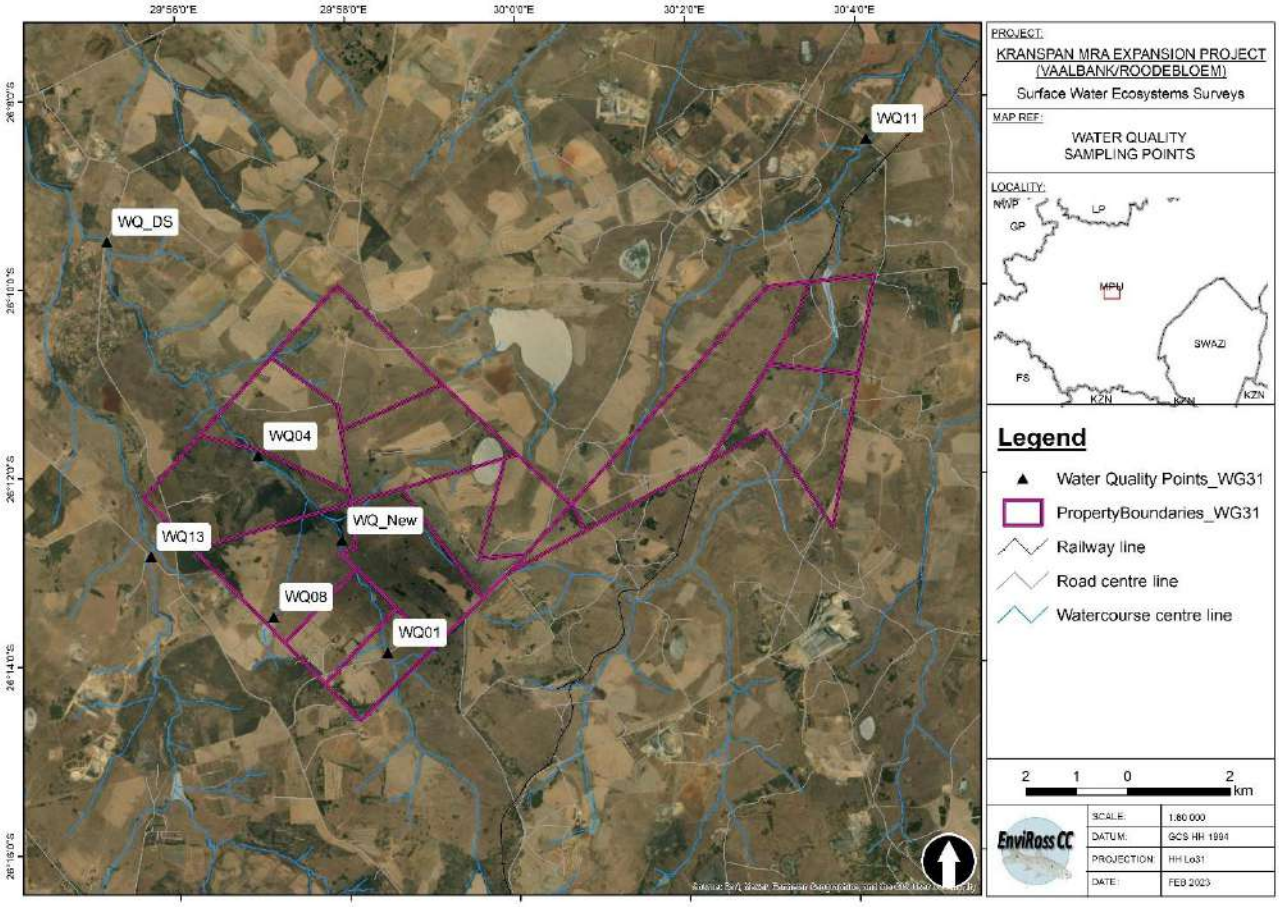


Figure 26: Water quality sampling sites.

The electrical conductivity (EC) of the samples all tended to be relatively high throughout the sample area, which can be expected from a catchment area with the land use being dominated by agriculture and mining. Site 8 showed the lowest EC values, which is most likely due to the associated wetland seep zones (the source of the water to the watercourse) not being associated with the same geological features as those associated with the other sites. Springs upwelling from groundwater tended to show relatively high EC values, with the KSP_New site being located a little distance downstream of a high volume spring that feeds water into the main watercourse. Sample sites 1, KSP_new, 4 and KSP_DS are along the same watercourse, with the sequence of upstream to downstream being in that order. The first three sites from upstream to downstream show in increasing trend in EC values, which then reduces at the downstream site. As no mining activities take place along this watercourse, it is assumed that the high EC values are a product of the underlying geology and soils that contribute to the high salt concentrations. The lowered values recorded at the downstream site could be the result of dilution factors feeding into the watercourse with water from different underlying geological features.

Table 14: General water quality parameters for the four sampling sites.

General water quality parameters (mg/ℓ)	KSP_DS	KSP_1	KSP_4	KSP_8	KSP_11	KSP_13	KSP_New
pH - Value @ 25 ºC	7.1	7.7	8.4	9.4	6.9	7.1	7.1
Electrical Conductivity in µS/cm at 25°C	668	1050	1210	207	1040	640	1140
Total Dissolved Solids at 180°C	400	828	1006	144	850	470	932
Suspended Solids at 105°C	41	18	11.3	4	9.3	87	6.7
Turbidity in N.T.U.	34	4.8	8.9	2.7	4.3	105	4.9
Total Alkalinity as $CaCO_3$	44	148	108	72	28	52	36
Chloride as Cl	15	7	8	14	13	8	13
Sulphate as SO_4	191	410	517	7	478	238	533
Fluoride as F	0.2	0.3	0.3	0.4	0.2	0.3	0.2
Nitrate as N	0.1	0.2	0.2	0.1	0.1	<0.1	<0.1
Total Coliform Bacteria / 100 mℓ	580	190	180	150	59	870	260

General water quality parameters (mg/ℓ)	KSP_DS	KSP_1	KSP_4	KSP_8	KSP_11	KSP_13	KSP_New
Faecal Coliform Bacteria / 100 mℓ	12	4	3	<1	<1	15	2
E. coli / 100 mℓ	9	3	3	<1	<1	12	2
Free & Saline Ammonia as N	0.2	0.2	0.2	0.3	0.2	0.2	0.2
% Balancing *	98.8	98.7	99.9	99	99.8	99.8	99.5

Another component that warrants further discussion is the sulphate concentrations. Sulphates may be rendered toxic to aquatic organisms under certain conditions. Under hypoxic conditions, bacteria break down sulphates to extract the oxygen molecules, with the by-product being hydrogen sulphide gas, which can be toxic to aquatic organisms. Zinc was indicated in the water samples, but cadmium was not. Sulphates also can also synergistically combine with other elements such as cadmium and zinc, with the resultant metal sulphates being acutely toxic to fish. Pyrite crystals often occur in sedimentary rock and constitutes a source of sulphates in the ground water. This is typical of coal-bearing deposits, so increased sulphates in the groundwater and springs that feed groundwater onto the surface can be expected. The opencast mining and the resultant rock stockpiles will unearth sulphur-bearing minerals (mostly in the form of iron sulphides), which will then be exposed to atmospheric oxygen, moisture (rainfall) and bacterial action that promotes the formation of sulphuric acid. This sulphuric acid dissolves heavy metals from mined materials and forms an acidic pH solution with elevated concentrations of arsenic, cadmium, lead, copper, etc. This solution can infiltrate into the ground water but can also be transported to surface water ecosystems via stormwater runoff. This process is generalised under the term Acid Mine Drainage (AMD), which is regarded as one of the most significant sources of pollution to both ground and surface waters.

E. coli was also noted within the samples. Samples KSP_1 and KSP_13 showed greatest concentrations of cells. Both these samples are from watercourses that flow into the survey area and therefore represent contamination that originates from outside of the area. The only source of *E. coli* is from untreated human sewerage. The low concentrations tend to imply minor contamination sources such as informal ablutions near to watercourses, or similar. As *E. coli* presents as a human health risk, it is recommended that this be included in the water quality parameters tested for as part of the water quality monitoring.

Table 15: Results of the element scan of the eight samples.

Element (analysed in mg/ℓ)	KSP_DS	KSP_1	KSP_4	KSP_8	KSP_11	KSP_13	KSP_New
Sodium as Na	32	24	31	16	16	19	33
Potassium as K	3	3.7	4.1	4.8	5.7	2.9	3.7
Calcium as Ca	46	112	135	11	98	56	125
Magnesium as Mg	20	57	60	7	63	31	52
Aluminium as Al	0.232	<0.100	0.15	<0.100	<0.100	0.444	<0.100
Antimony as Sb	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Arsenic as As	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Barium as Ba	0.062	0.035	0.051	0.035	0.069	0.12	0.062
Beryllium as Be	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Bismuth as Bi	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Boron as B	0.031	0.098	0.092	0.01	0.052	0.047	0.062
Cadmium as Cd	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Caesium as Cs	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cerium as Ce	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chromium as Cr	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cobalt as Co	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Copper as Cu	<0.010	<0.010	<0.010	0.082	<0.010	<0.010	<0.010
Dysprosium as Dy	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Erbium as Er	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Europium as Eu	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Gadolinium as Gd	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Galium as Ga	<0.010	<0.010	<0.010	<0.010	<0.010	0.01	<0.010
Germanium as Ge	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Gold as Au	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Hafnium as Hf	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Holmium as Ho	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Indium as In	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iridium as Ir	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010

Element (analysed in mg/ℓ)	KSP_DS	KSP_1	KSP_4	KSP_8	KSP_11	KSP_13	KSP_New
Iron as Fe	0.823	0.073	0.357	0.317	0.093	0.764	0.302
Lanthanum as La	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Lead as Pb	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Lithium as Li	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Lutetium as Lu	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Manganese as Mn	0.286	0.034	0.258	<0.025	0.332	0.538	0.304
Mercury as Hg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Molybdenum as Mo	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Neodymium as Nd	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nickel as Ni	<0.010	<0.010	<0.010	<0.010	<0.010	0.01	<0.010
Niobium as Nb	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Osmium as Os	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Palladium as Pd	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Phosphorus as P	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Platinum as Pt	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Praseodymium as Pr	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Rhodium as Rh	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Rubidium as Rb	<0.010	<0.010	<0.010	<0.010	0.012	<0.010	<0.010
Ruthenium as Ru	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Samarium as Sm	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Scandium as Sc	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Selenium as Se	0.045	0.045	0.036	0.014	0.032	0.051	0.033
Silicon as Si	4.4	1.9	2.2	<0.2	2.3	6.1	3.2
Silver as Ag	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Strontium as Sr	0.606	2.76	3.12	0.13	0.978	0.41	2.58
Tantalum as Ta	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tellurium as Te	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Terbium as Tb	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Thallium as Tl	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Thorium as Th	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Thulium as Tm	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tin as Sn	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Titanium as Ti	0.015	0.033	0.038	<0.010	0.03	0.021	0.03
Tungsten as W	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium as U	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Vanadium as V	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Ytterbium as Yb	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Yttrium as Y	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Zinc as Zn	0.12	0.113	0.122	0.066	0.013	<0.010	0.01
Zirconium as Zr	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010

Besides slightly elevated levels of zinc (Table 15), no elemental concentrations noted within the water samples were shown to occur in concentrations regarded as a risk to environmental or human health risks.

5. SIGNIFICANCE RATINGS OF PERCEIVED ENVIRONMENTAL IMPACTS

The proposed development activities include the excavations to facilitate opencast mining operations, and the development of supporting services, processes, and infrastructure to aid in the establishment of the mining operations. The development area has been historically utilised for formal agriculture and therefore, barring some existing access roads that would be used, all mining infrastructure will be newly established. Therefore, planning of infrastructure layout, which is largely dependent on physical and geological factors, will also have to take ecological features into account to reduce overall negative ecological impacts. With mitigation measures in place, the overall ecological impacts that will persist beyond the construction and rehabilitation phases can be reduced in terms of conservation of the surface water ecosystems within the region.

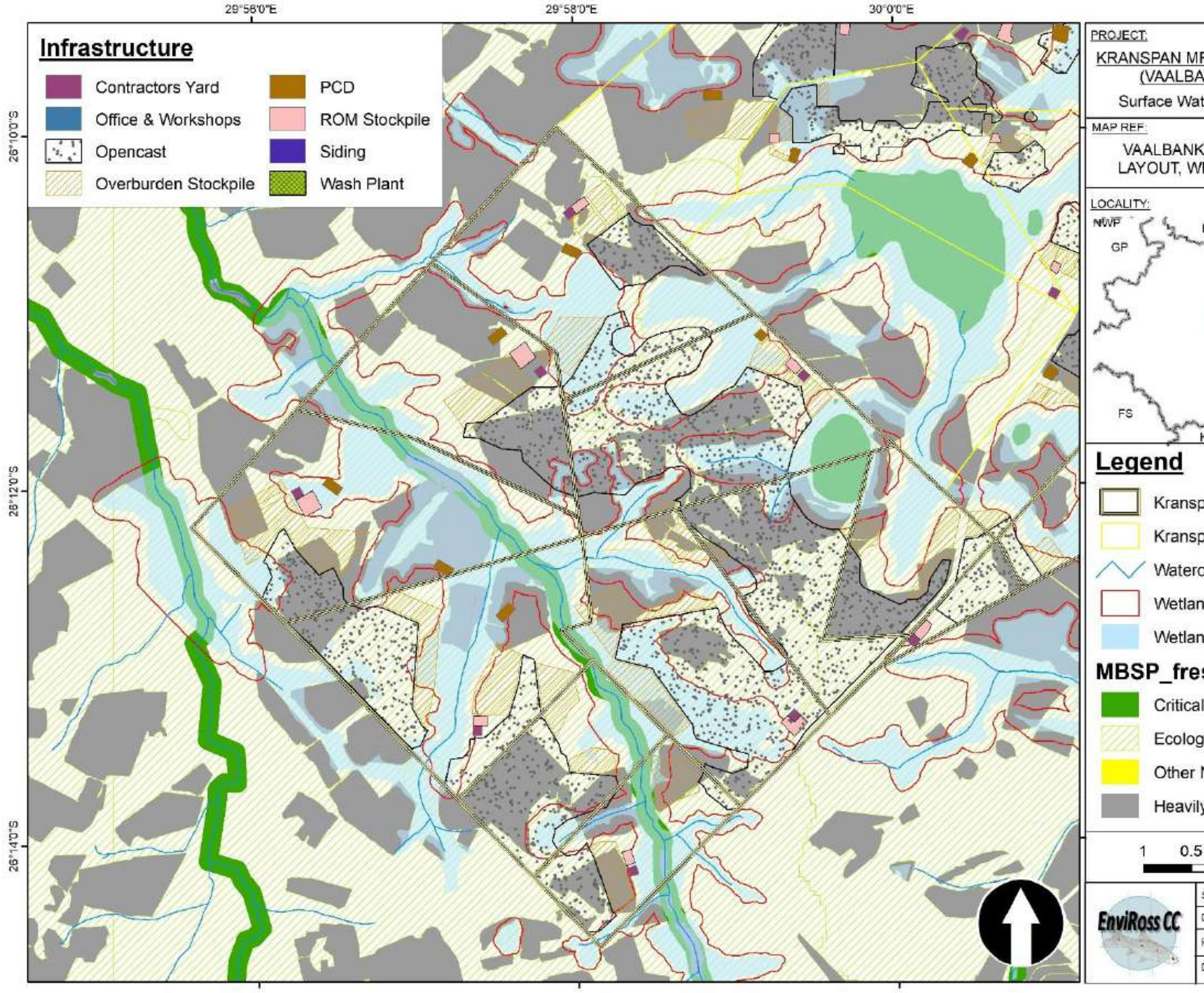


Figure 27: The proposed infrastructure layout and the association with surface water ecosystems, buffer zones, and the MBSP freshwater assessment, with focus on Vaalbank.

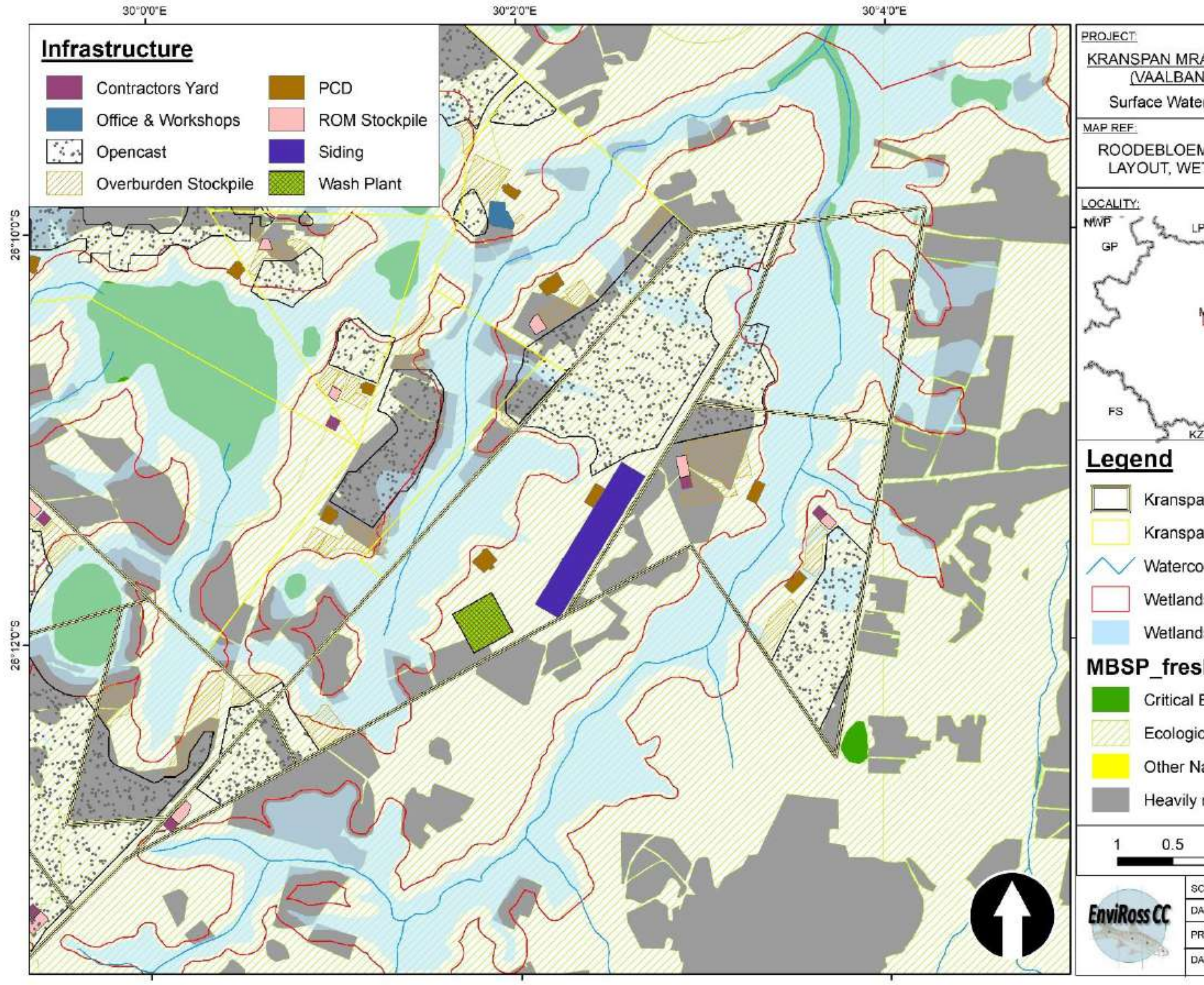


Figure 28: The proposed infrastructure layout and the association with surface water ecosystems, buffer zones, and the MBSP freshwater assessment, with focus on Roodebloem.

Table 19 presents the significance ratings of the potential ecological impacts for the *pre-construction and construction* as well as the *management phases* of the proposed development activities. The ratings are calculated for the scenarios of both before and after the implementation of mitigation measures. This was done to show how the degree of impacts can be reduced by careful planning and the following of relatively simple mitigation measures.

5.1. Introduction

The first phase of impact assessment is the identification of the various project activities which may impact upon the identified environmental aspects. The identification of significant project activities is supported by the identification of the various receiving environmental receptors and resources. These receptors and resources allow for an understanding of the impact pathways and assessment of the sensitivity of the receiving environment to change. The significance of the impact is then assessed by rating each variable numerically, according to defined criteria as provided in Table 17.

5.2. Impact significance rating

The purpose of the significance rating of the identified impacts is to develop a clear understanding of the influences and processes associated with each impact. The severity (magnitude), spatial scope and duration of the impact together comprise the consequence of the impact; and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact and can obtain a maximum value of 10. The values for likelihood and consequence of the impact are then read from a significance rating matrix as shown in Table 17 and Table 18.

Table 16: Criteria for Assessing the Significance of Impacts.

Severity of impact	**Rating**	
Insignificant / non-harmful	1	Consequence
Small / potentially harmful	2	
Significant / slightly harmful	3	
Great / harmful	4	
Disastrous / extremely harmful	5	
Spatial scope of impact	**Rating**	
Activity specific	1	
Area specific	2	
Whole project site / local area	3	
Regional	4	
National	5	
Duration of impact	**Rating**	
One day to one month	1	
One month to one year	2	
One year to ten years	3	
Life of operation	4	
Post closure / permanent	5	
Frequency of activity / Duration of aspect	**Rating**	Likelihood
Annually or less / low	1	
6 monthly / temporary	2	
Monthly / infrequent	3	
Weekly / life of operation / regularly / likely	4	
Daily / permanent / high	5	
Frequency of impact	**Rating**	
Almost never / almost impossible	1	
Very seldom / highly unlikely	2	
Infrequent / unlikely / seldom	3	
Often / regularly / likely / possible	4	
Daily / highly likely / definitely	5	

Activity: a distinct process or task undertaken by an organisation for which a responsibility can be assigned.

Environmental aspect: an element of an organisation's activities, products or services which can interact with the environment.

Environmental impacts: consequences of these aspects on environmental resources or receptors.

Receptors: comprise, but are not limited to, people or man-made structures.

Resources: include components of the biophysical environment.

Frequency of activity: refers to how often the proposed activity will take place.

Frequency of impact: refers to the frequency with which a stressor will impact on the receptor.

Severity: refers to the degree of change to the receptor status in terms of the reversibility of the impact; sensitivity of receptor to stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent setting; threat to environmental and health standards.

Spatial scope: refers to the geographical scale of the impact.

Duration: refers to the length of time over which the stressor will cause a change in the resource or receptor.

The model outcome of the impacts is then assessed in terms of impact certainty and consideration of available information. The Precautionary Principle is applied in instances of uncertainty or lack of information by increasing assigned ratings or adjusting final model outcomes. In certain instances where a variable or outcome requires rational adjustment due to model limitations, the model outcomes are adjusted. Arguments and descriptions for such adjustments, as well as arguments for each specific impact assessments are presented in the text and encapsulated in the assessment summary table linked to each impact discussion.

Table 17: Significance Rating Matrix

	CONSEQUENCE (SEVERITY + SPATIAL SCOPE + DURATION)														
LIKELIHOOD (FREQUENCY OF ACTIVITY + FREQUENCY OF IMPACT)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

Table 18: Positive/Negative mitigation rating

Colour Code	Significance Rating	Value	Negative Impact Management Recommendation	Positive Impact Management Recommendation
	Very High	126-150	Improve current management	Maintain current management
	High	101-125	Improve current management	Maintain current management
	Medium-High	76-100	Improve current management	Maintain current management
	Low-Medium	51-75	Maintain current management	Improve current management
	Low	26-50	Maintain current management	Improve current management
	Very Low	1-25	Maintain current management	Improve current management

5.3. Activities having an impact

The key project activities for the Project upon which the impact assessment was based are described in the EIS. These activities are summarised below per project phase.

5.3.1. Construction Phase Activities

- Clearing and grubbing of vegetation.

Clearing of vegetation will lead to soil destabilisation that could potentially lead to erosion and siltation of the nearby surface water ecosystems if not mitigated for. The potential risk to the wetland units is dependent on the proximity of the activity to the surrounding wetland features (i.e., the closer to the wetland unit, the greater the risk will be). This is also true for the degree of slope of the impacted area, where the steeper the slope, the greater the potential for erosion to occur and the more readily sediments will be transported down the slope toward the surface water units. This impact, if the potential of which is identified correctly, can be readily mitigated.

- Site perimeter fencing and internal fencing of different sections of the mine.

This is a feature that is thought to have an insignificant impacting feature to the surface water ecosystems, but certain factors need to be considered. The vegetation along a corridor associated with the fencing is often cleared to reduce the impacts of grass fires on the fencing infrastructure. It is also done to ensure correct functioning of electrified security fencing (if applicable), to provide an unobscured view for patrolling security personnel, and provides for freedom of access for security personnel to patrol the boundary fencing. This vegetation clearing would then include the potential erosion features as mentioned in the previous point and would be mitigated for in a similar way.

Perimeter fencing that allows for the natural drainage of surface water would have a lesser impact to solid walling that inhibits free and natural drainage patterns.

- Removal and stockpiling of topsoil.

Again, removal of topsoil requires the stripping of vegetation and therefore aligns with the first point. Stockpiling of topsoil that is unprotected is typically unconsolidated and susceptible to erosion, especially within the initial stages before it has settled. Unprotected topsoil stockpiles will lead to transport of sediment toward the surface water ecosystems during rainfall events. Topsoil stockpiles during the initial stages prior to settling are also susceptible to wind (aeolian) erosion. This is an impacting feature that can be readily mitigated for. Again, the significance of the potential risk to the associated wetland units is dependent on the proximity of the stockpile site to the wetland units.

- Delivery and storage of vehicles, equipment, machinery, and materials.

Delivery of vehicles and all equipment and materials would be undertaken along existing roads and therefore the impact of this is regarded as being limited. The storage of vehicles, machinery, and equipment, if done outside of wetland buffer zones, and if adequate protection measures to abate the potential of dangerous compounds emanating from the equipment, materials and vehicles being transported toward the surface water ecosystems are implemented, then the significance of this potential impact can be minimal.

- Construction of access roads, platforms, and drainage structures.

Any activities that require vegetation removal and which would result in soil destabilisation has the potential to impact on nearby watercourses. This feature then aligns with the impacts noted under the first point.

- Construction of process plant infrastructure and installation of required equipment and machinery.

The significance of this impact and the associated risk to nearby surface water ecosystems is again dependent on the proximity to the wetland units as well as the implementation of appropriate erosion protection measures, if applicable.

- Construction of the main mine administration complex.

This activity again aligns with vegetation clearing, topsoil removal, equipment, materials, and vehicles being transported and stored at the site, stockpiling of topsoil, and other features noted within the above paragraphs. The stormwater management plan will include this area and ensure the suitable collection, transport and attenuated release of stormwater. Another potential impacting feature associated with this feature is the appropriate management of sewerage. Whether there is an onsite sewerage processing plant or basic septic tank systems are to be implemented, it must be assured that no untreated sewerage is allowed to contaminate clean water systems and that any effluents meet the criteria stipulated within the target water quality guideline values.

- Installation of power and water supply infrastructure.

The installation of power infrastructure is largely limited to surface infrastructure and overhead powerlines. Excepting for the potential leakage of transformer oil during routine maintenance or resulting from infrastructure failure leading to contamination of soils and potential transport of the oil to nearby watercourses, this feature could also align with the aforementioned impacts.

Water supply infrastructure requires excavations to accommodate pipeline networks. The proximity of these excavations to wetland units as well as the spatial extent of the network and the magnitude of the required excavations will determine the level of significance of the impacting feature.

5.3.2. Operational Phase Activities

- Clearing and grubbing of vegetation.

As noted in previous paragraphs.

- Dewatering.

Dewatering of surface water ecosystems will result in loss of the wetland unit and associated ecological functioning, including loss of the resource, destruction, and displacement of wetland dependent biodiversity. The ecological significance of this feature is dependent on the spatial extent on the wetland, the ecological implication to downstream units, the present ecological state of the wetland unit, and the current contribution of that unit to the ecological functionality of the greater wetland complex.

- Open-cast mining of various pits through a combination of excavation and blasting.

The establishment of an opencast pit will go through the phases of vegetation stripping, topsoil removal and subsequent stockpiling, excavating underlying rock layers and stockpiling, before the actual resource can be mined. Previous paragraphs describe the potential impacts associated with vegetation and topsoil removal and stockpiling. The stockpiling of rock could, however, lead to water quality impacts to nearby surface water ecosystems during rainfall events. Unearthed minerals will dissolve in the rainwater and be transported via stormwater runoff toward nearby watercourses. Depending on the geological compounds and minerals that would dissolve in the water, this impact could be completely insignificant or could be deleterious to the water quality within the area. This would have to be determined and be included within the water quality monitoring plan for the mining operations.

Depending on the proximity to a wetland unit and the underlying soil and geological features, open cast mining located in close proximity to a wetland unit could disrupt the hydrological functioning of the wetland and lead to an impact significance ranging from total loss of the wetland to a marginal effect. The inter soil lateral movement of water normally maintained at a relatively shallow depth due to an underlying impermeable soil or rock layer that sustains a wetland unit could be disrupted and the water could infiltrate into the pit rather than continue to feed the wetland. The quantification of the impact should be verified by the suitable specialist (hydropedologist and/or geohydrologist).

- Construction and operation of the soil and overburden stockpiles.

This is a feature that aligns with those mentioned within previous paragraphs.

- Hauling of raw materials to the process plant.

This is a feature that aligns with those mentioned within previous paragraphs.

- Management of clean and dirty water runoff from stormwater systems, wash bays, etc.

A stormwater management plan, which describes the basic requirements to ensure ecological sustainability, has been included under Section 6.

- Raw materials processing at the process plant.

The stormwater management plan must address the runoff of dirty water and the separation of clean and dirty water systems. If appropriately managed, this could have an insignificant ecological impact, but could have the potential to create a profound impact if not engineered correctly and managed appropriately.

- Concurrent rehabilitation of exposed areas (as is practicable).

Ongoing rehabilitation of exposed areas carries its own inherent impacts. These could include the erosion risks coupled to the destabilisation of soils and removal of vegetation (where appropriate), the movement of heavy earthmoving equipment that result in compaction of soils, potential contamination by leaking fluids from poorly services equipment and machinery, and many of the aspects that have been mentioned within the above paragraphs.

- Delivery and storage of vehicles, equipment, machinery, and materials.

As above.

5.3.3. Closure and Decommissioning Phase Activities

- Dismantling and removal of all identified above-ground infrastructure.

This process will carry much of the risks to ecological integrity as per the construction phase, but the ecological impacts emanating from this process (in isolation) tend to be of lower significance than that of the construction activities as the impact areas have now already suffered transformation.

- Rehabilitation of the open-cast pits and overburden stockpiles; and placement of topsoil and re-vegetation of exposed areas.

Rehabilitation measures call for the largescale transportation of soil stockpiles, and the contouring and landscaping of that soil. Erosion, soil compaction, potential contamination from engine fluid leaks, etc., are all factors that could result in negative ecological outcomes. The rehabilitation of soils using inappropriate floral species could also result in a negative ecological outcome.

Figure 27 and Figure 28 present the proposed infrastructure layout planning, showing the extent of the wetland units, the proposed buffer conservation zones, and the MBSP designation of freshwater CBA and ESA areas for the Vaalbank and Roodebloem cluster of properties, respectively. This provides an indication of the potential impact of the proposed mining development on those ecological features that have been identified as ecologically sensitive within the area. Figure 27 shows that much of the area destined for opencast mining within the Vaalbank area has already been designated as “heavily modified” by the MBSP assessment. Following various revisions of the proposed layout planning, it also shows where the proposed opencast mining areas will inevitably impact on existing wetland units. No freshwater CBA areas will be directly impacted. Figure 28 indicates that opencast mining areas have largely avoided the wetland and CBA-designated areas as well within the Roodebloem area.

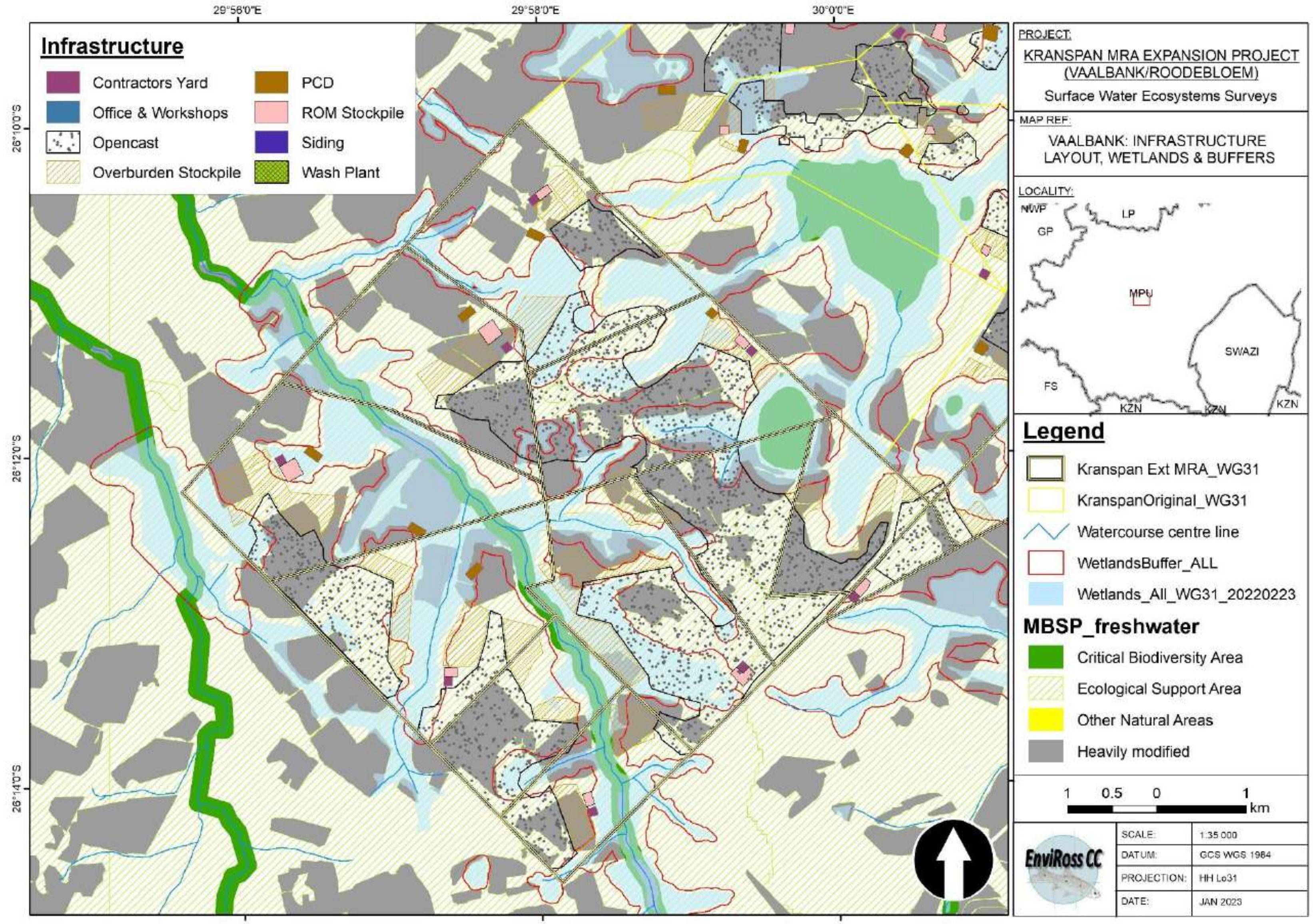


Figure 27: The proposed infrastructure layout and the association with surface water ecosystems, buffer zones, and the MBSP freshwater assessment, with focus on Vaalbank.

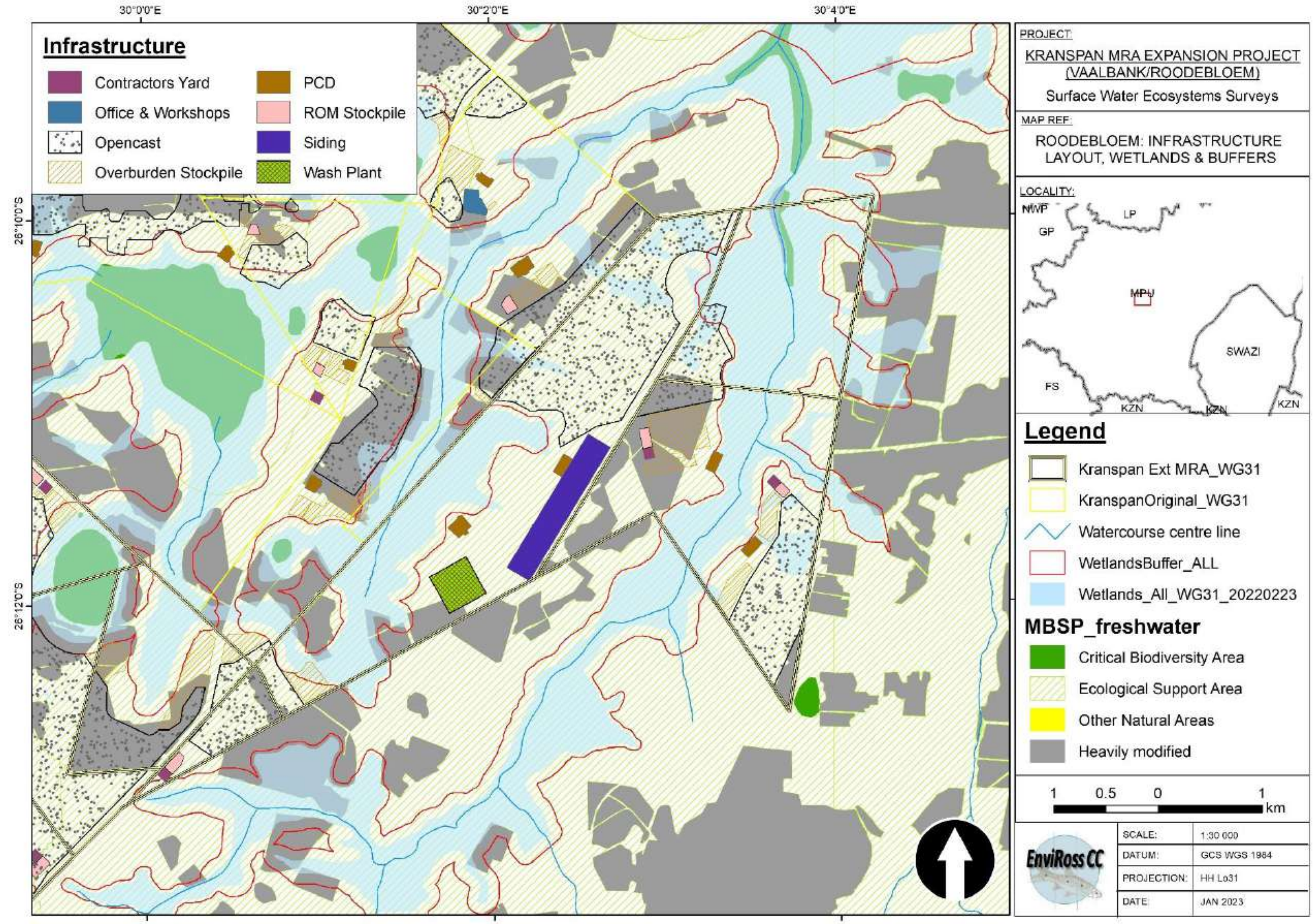


Figure 28: The proposed infrastructure layout and the association with surface water ecosystems, buffer zones, and the MBSP freshwater assessment, with focus on Roodebloem.

Table 19: A generalised significance rating both before and after implementation of mitigation measures of the main potential ecological impacts perceived to be associated to the proposed development activities.

Ecologically sensitive habitat (Wetland units)								
Project Activity		Destruction of sensitive habitat	Likelihood		Consequence			Significance Rating
Destruction of wetland units during all construction phase activities due to heavy machinery and indiscriminate habitat destruction.	Phase of Project	Construction & Operations Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Destruction of wetland habitat during construction phase if buffer zones are not taken into consideration.	4	4	4	3	5	96 (MH)
			Significance Post-Mitigation					
		Destruction of wetland habitat as operations progress.	4	4	3	3	5	88 (MH)
Project Activity		Water quality degradation	Likelihood		Consequence			Significance Rating
Impacts to wetland units during the operations phase from runoff pollution, siltation, habitat smothering and vegetation alteration.	Phase of Project	Operations Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Everyday operations that will impact on wetland habitat integrity.	4	4	4	4	5	104 (H)
			Significance Post-Mitigation					
			3	3	3	3	4	63 (LM)
Project Activity		Impact to the hydrological functioning of wetlands	Likelihood		Consequence			Significance Rating
Excavation of deep opencast pits near to wetland habitat that will deviate lateral inter soil flow patterns into the pits that would otherwise sustain wtland units, leading to loss of water source for the wetland and subsequent loss of the unit.	Phase of Project	Operations Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Direct and Indirect Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Dewatering of wetland units and loss of water source that will lead to loss of the impacted unit.	4	4	4	4	5	104 (H)
			Significance Post-Mitigation					
			4	4	2	3	5	80(MH)
Project Activity		Fragmentation of linear surface water habitat.	Likelihood		Consequence			Significance Rating

Ecologically sensitive habitat (Wetland units)								
Fragmentation of interconnected wetland units (watercourses) that would otherwise offer migratory corridors.	Phase of Project	Construction/Operations phases	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Secondary Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Fragmentation of interconnected habitat	5	5	3	3	4	100 (MH)
			Significance Post-Mitigation					
			2	2	2	1	1	16 (VL)
Project Activity		Destruction of sensitive habitat	Likelihood		Consequence			Significance Rating
Wetland vegetation alteration following disturbances that will enhance exotic vegetation encroachment.	Phase of Project	All phases of project	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Secondary & Cumulative Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Disturbances that induce invasion of exotic flora	5	5	3	2	5	100 (MH)
			Significance Post-Mitigation					
			1	1	2	1	1	8 (VL)
Soils								
Project Activity		Soil erosion that impacts watercourses and wetland habitat	Likelihood		Consequence			Significance Rating
All construction phase activities that result in soil destabilisation.	Phase of Project	All phases of project	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Secondary & Cumulative Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Soil erosion will impact watercourses both locally as well as downstream within more established habitat.	4	4	4	4	5	104 (H)
			Significance Post-Mitigation					
			2	2	2	1	1	16 (VL)
Water quality								
Project Activity		Water quality	Likelihood		Consequence			Significance Rating
All construction phase and operations phase activities	Phase of Project	All phases of project	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	

Ecologically sensitive habitat (Wetland units)									
associated with water contamination	Impact Classification	Direct, Secondary & Cumulative Impact	Significance Pre-Mitigation						
	Resulting Impact from Activity	Contamination of surface water will impact the integrity of all surface water resources and will reach further downstream to the greater aquatic system.	4	4	4	4	5	104 (H)
			Significance Post-Mitigation						
			3	3	3	2	4	54 (LM)

5.4. Mitigation measures pertaining to impact features

5.4.1. Destruction of sensitive habitat features

Wetlands and surface water ecosystems are regarded as inherently ecologically sensitive features due to a variety of reasons, including that they provide a source of water, provide flood management of watercourses, and support a wide biodiversity. Therefore, regardless of ecological state, wetland and aquatic units are statutorily protected and subject to their own unique environmental legislature. The survey area falls within a region that is rich in wetland units, which coincides with suitable agricultural areas and rich mining deposits. The main land use within the region is therefore dominated by formal agriculture and mining (with the dominant form of mining being opencast coal mining). These are two high-impact land uses that have had deleterious impacts on the existence as well as functioning of wetland units within the region and therefore impact on the aquatic habitat located further downstream within the catchment areas as well. Historically, cultivation has been confined to higher-lying areas as inundated (wetland/hydromorphic) soils tend to be impractical to cultivate. The main wetland linear units have therefore often been retained within the landscape. The outer edges (outer temporary zones) have often, however, been included within the cultivated areas and these wetland units have lost a degree of functionality. Impoundments along the watercourses for practical agricultural usage as well as aesthetic value within the landscape are also commonplace throughout all the watercourses within the region. Historically there has been a level of cumulative loss of wetland habitat throughout the region due to agriculture, albeit limited in significance in most cases. More recently, mining is gaining ground in displacing agriculture as a more lucrative land use, with the consequence of the wetland units suffering higher ecological degradation and relatively higher cumulative loss of physical presence and/or ecological functionality. Much of this is due to hydrological alteration resulting from opencast mines, and water contamination from effluents such as decanting of opencast pit infiltration water and general surface water runoff from contaminated areas. These factors impact the wetland functionality, leading to a loss and/or degradation of the resource, and loss of wetland dependent biodiversity.

It is regarded as inevitable that some portions of wetland units will be lost if the mining development is undertaken. The significance of the impacting features that will affect the wetland units within the survey area is dependent on what level the unit will lose functionality. This can be anywhere from total loss (both physical and functional) to barely perceptible marginal losses that do not alter functioning within the landscape. The significance of the impact on ecologically sensitive habitat (i.e., wetland units) is therefore largely dependent on the overall loss of habitat through transformation to accommodate the mining infrastructure. It is therefore recommended that the mining infrastructure layout be planned to accommodate as much of the wetland habitat functioning areas as possible. A priority ranking based on this principle has been proposed for the project, where highly functional, well developed, and ecologically significant core wetland zones have been prioritised over fringing and poorly developed wetland units and those that have suffered ecological degradation. This is presented in section 4.4 and Figure 18. Digital mapping files detailing this feature accompany this report.

Opencast mining operations that take place near any wetland units could potentially result in altered hydrological characteristics of the wetland units through the decanting of the soil water into the opencast pits rather than remaining within the soil profile where it would supply the resource to sustain the wetland unit. The loss of the source of water to the wetland unit will have a consequential effect on all wetland-dependent components, including the biodiversity that it sustains. This will also not only impact on the local wetland unit but on the habitat downstream as well that would normally be supplied with the water source. Moving downstream within a wetland (or watercourse) tends to gain momentum as water supply to the wetland increases with cumulative infiltration from adjacent seepage zones. The soil water may decant toward the opencast pit and the source to the wetland would be lost. This may result in transforming a permanent wetland into a seasonal or temporary zone wetland unit, which would retain some level of ecological functionality or it could result in the transformation of wetland habitat to terrestrial habitat. Hydromorphic soils that suffer from desiccation loses structural integrity and then becomes vulnerable to erosion – more so than terrestrial soils. Although this can be identified as an impacting feature, the significance of this impact should be quantified by a relevant specialist (e.g., hydropedologist or geomorphologist). This will also allow the determination of the water balance scenario between the volumes decanting into the opencast pits and what remains to supply the wetland unit. Mitigation measures to abate this could be that the water that seeps into the pit that requires decanting could be pumped to an attenuation feature that then releases the water back into the wetland unit. This would depend on the quality of the water, which may require a level of processing prior to it being released. The attenuation feature should be engineered to ensure that the outfall does not induce erosion of the watercourse. Depending on the elemental content of the water, the wetland itself could be utilised as a biological filter and management tool to ensure suitable water quality for the downstream wetlands, aquatic habitats, and other water users. Intact ecological integrity of the wetland units located downstream of decanting sites is vital to the successful implementation of a water management scheme such as this. The details of such a proposal are beyond the scope of this assessment, but it is recommended that this be explored further, especially as this will be relevant to multiple sites within the MRA.

Vegetation and extent of groundcover plays an important role in preserving wetland functionality. It binds soils to protect from erosion, reduces the scouring potential of runoff water through the reduction of velocity and energy dissipation and also provides the micro-habitat and refuge for supporting a greater array of wetland-dependent biodiversity. Indiscriminate destruction of vegetation layers from wetland areas that fall outside of the ultimate infrastructure footprint should be avoided. A delineation map has been presented (Figure 18), which indicates the extent of the 100 m conservation buffer zones. It is recommended that these buffer zones be fenced off within applicable areas to avoid indiscriminate habitat destruction and treated as "no-go" areas. This includes using these areas for soil stockpiling, equipment storage, fuelling areas, etc.

Erosion is regarded as a major driver of ecological change of wetland habitat. Sediments and silts that are transported to lower-lying valley-bottoms and depressions during rainfall events via stormwater runoff will impact functionality through smothering of habitat and will displace surface water volume and dependent biodiversity. Silts that enter the aquatic systems increases turbidity and smothers substrates, very often it decreases oxygen content within the water, and leading to displacement of biodiversity and loss of overall function. Erosion and sedimentation must therefore be managed as an ongoing concern throughout all the phases of the development activities. This includes protection of stockpiled soils, rock dumps and other stored materials. Stormwater management must ensure erosion protection at the outfall points into the receiving environment. There are multiple impoundments along most of the watercourses within the survey area that already act as sediment traps. Before an engineering solution to sediment management is sought, it is recommended that a monitoring plan be developed to determine the level of functionality that these impoundments already offer as the various phases of the proposed mining development progress.

Disturbance of soils will often lead to enhancing the encroachment of opportunistic alien vegetation. Wetland areas provide ideal conditions for supporting rapidly-growing exotic and invasive floral species, which quickly out-compete and displace natural vegetation. This will lead to displacement of biodiversity in general, an increase in water consumption and destabilisation of soils. This is an aspect that is readily managed and a management strategy should be in place and in practice throughout all phases of the development.

5.4.2. Soil impacting features

Wetland functionality largely depends on the integrity of the layered characteristics of the underlying soils. It is this layering of the underlying soils that ensures the persistence of inundated soils near the surface and the sustaining of a wetland feature. Trenching and excavations that alter the characteristics of these layers and/or compaction of the layers through (for example) the movement of heavy vehicles on hydromorphic soils, will impact the natural hydrological functioning of the wetland units. Impacting features that intercept soil water and either diverts it away or into areas, will all have impacts on the functionality of the soils and the ultimate functionality of the wetland units. Trenching near a wetland unit will often lead to desiccation of the soils and the loss of the wetland unit. Trenching within wetland soils is, however, often necessary from infrastructure developments (especially linear infrastructure such as entrenched pipelines of roads) and therefore some guidelines to mitigate the impacts have been offered. With proper mitigation, the deleterious impacts of trenching within wetlands to accommodate pipelines (etc) can be successfully abated.

As mentioned, wetland functionality is largely governed by a perched water table that occurs due to the stratification characteristics of the underlying soils, including an impermeable base layer that inhibits percolation to deeper groundwater. Retention of wetland functionality through the preservation of lateral water movement through the soils is dependent on correct soil layering and profiling. Therefore any soil that is removed for trenching purposes must be stored in their respective layers and returned to the excavation in reverse order. The soils must be stored outside of the wetland and buffer zones in order not to smother established wetland vegetation. Adequate site reinstatement must be implemented to abate the formation of erosion through modification of the surface water hydrology. Silt traps and fencing should be used in areas of steeper topography (if applicable). The movement of heavy machinery within wetland zones should be limited to only single access roadways. Upon completion of the construction phase, this roadway should be ripped and/or disk ploughed to loosen the compacted soils and to allow for the establishment of vegetation within the affected areas, which should be a mixture of veld grasses typical of the surrounding area within similar habitat units. Indiscriminate habitat destruction should be avoided and the construction footprint, including service and support areas should be kept to a minimum.

5.4.3. Water quality

Another impacting feature pertaining to the proposed development is contamination of surface water resources. Water quality degradation will displace dependent biodiversity and will have an impact that will also perpetuate downstream throughout the system. Possible sources of contamination include hydrocarbons (from poorly designed and managed fuelling stations and/or workshop and maintenance areas), and runoff water from processing areas that should be kept separate from clean water runoff with a suitable stormwater management system, and general surface water runoff that should be treated prior to release into the environment. Coupled to this, erosion management also plays an important role in preventing water quality degradation. Onsite sewerage treatment and/or management also plays a crucial role in avoiding contamination of the surface water ecosystems. Untreated sewerage contamination of the surface water ecosystems could occur due to poorly designed sewerage treatment systems, treatment systems where processing capacity is exceeded, poorly maintained infrastructure leading to water-borne effluent leaks prior to processing, sewerage spills during (for example) septic tank pumping, and informal ablutions near watercourses. Sewerage contamination of the surface waters leads to proliferation of *E. coli*, which is a potentially dangerous risk to human and livestock health, and, depending on the volumes of contamination, leads to a spike in bacterial activity within the watercourses that has a high biological oxygen demand and creating hypoxic conditions that leads to a die-off of aquatic biodiversity. Careful attention to sewerage treatment and sewerage systems will reduce the risk of contamination of the resource.

Another source of surface water degradation would be from the decanting of the infiltration water from the opencast mining pits. Water that infiltrates the deeper opencast pits associated with coal mining is associated with sulphur-bearing compounds that dissociate and/or oxidise when they come into contact with air when reaching the surface. A by-product of this is sulphuric acid, which leads to water with a low pH. Water that infiltrates into the opencast pit must be decanted to allow for ongoing practical harvesting of the resource. Decanting of this acidic water into the receiving environment will lead to deleterious impact to aquatic biodiversity. This decanted water also would carry other high concentrations of dissolved salts and other compounds, which makes it unsuitable for direct release into the environment. The pit water therefore must be routinely tested at an accredited laboratory to develop an appropriate management strategy to treat the water to within target water quality standards prior to release. Routine monitoring and testing of the water will also determine whether treatment is, in fact, required prior to release.

5.5. Offset mitigation strategy to compensate for loss of wetland units within the site

In looking at the extent of the wetland units within the survey area, and to retain the viability of the proposed mining operation, it is inevitable that some areas originally delineated as wetland features are required to be sacrificed. When looking to mitigate for a particular ecological impact there is a stepwise hierarchy of impact mitigation that is considered. These steps include the following (Lukey & Paras, 2017):

- Avoid or prevent: Avoidance or prevention refers to the consideration of options in project location, sitting, scale, layout, technology and phasing to avoid impacts on biodiversity, associated ecosystem services, and people. This is referred to as 'the best option', but it is acknowledged that avoidance or prevention is not always possible.
- Minimize: Minimization refers to the consideration of alternatives in the project location, sitting, scale, layout, technology, and phasing that would minimize impacts on biodiversity and ecosystem services.
- Rehabilitate: Rehabilitation refers to the consideration of the rehabilitation of areas where impacts are unavoidable, and measures are provided to return impacted areas to a near-natural state or an agreed land use.
- Offset: Offsetting refers to the consideration of measures over and above rehabilitation to compensate for the residual negative effects on biodiversity, after every effort has been made to minimize and then rehabilitate impacts.

The first two points have been exhaustively explored and the initial proposed infrastructure layout was reduced considerably to accommodate the ecologically sensitive features, but some wetland features remained within the prescribed infrastructure and impact footprint areas. The nature of the proposed mining development is such as rehabilitation measures to pre-development status is not practically viable as it requires deep excavations and removal of the unearthed materials. Prescribed rehabilitation measures for large open cast operations at present is to slope the steeper sides, line the pit with topsoil and wither re-vegetate, or allow the pit to naturally fill with water. Considering that the functionality of the present wetland features largely rely on soil layering characteristics at relatively shallow depths, the deep excavations will remove the historical functionality of the wetland unit. This cannot be practically mitigated and therefore an offset mitigation may be the only viable means of mitigating for the loss of wetland features within the survey area. If this is indicated as a requirement by the relevant conservation authorities, then a prescribed method for offset mitigation procedures is followed according to relevant guidelines (MacFarlane *et al*., 2016), which outlines the best practice guidelines for wetland offsets.

The focus of biodiversity offsets as a mitigation option is to provide a "like for like" area of the same ecosystem type, species composition and ecological function to fully remedy that which is lost (DEA, 2017).

In terms of designing and locating an offset, the following procedural guideline should be followed (DEA, 2017):

1. Obtain a measure of the residual loss of biodiversity (i.e., residual negative impacts) because of the proposed development. The measure at minimum relates to the area and condition of affected ecosystem/habitat.
2. Determine the best type of offset.
3. Determine the required size of the offset and, where applicable, its optimum location.
4. Investigate candidate offset site(s) in the landscape that could meet the offset requirements. Check whether and any eligible offset receiving area is suitable.
5. Decide on the best way to secure the offset, and ensure that the offset option would be acceptable to the relevant conservation authorities.
6. Prepare an Offsets Report or dedicated section within the EIA report; and
7. Conclude agreements on offsets (between the applicant and an implementing agent) and develop an Offset Management Programme, where applicable.

A guideline document that was drafted as a collaboration between SANBI and DWS entitled Wetland offsets: A best practice guideline for South Africa (MacFarlane *et al*., 2016) would be utilised to address the offset process. This gives an indication of the extent of the wetland to offset area ratio for the offset mitigation option.

It should be noted that offset mitigation measures are usually regarded as the last resort measure in the hierarchy of mitigation strategies but within a catchment area where the land use will soon become dominated by mining activities, the ecological functionality of wetland units as an entire and interconnected complex of watercourses will become increasingly important to the management of water volumes and the conservation of water quality. Wetland units that have retained a high level of ecological functionality will aid in both water purification and managing water volumes and therefore it is in the collective interest to maintain the ecological integrity of the wetland complex. This is applicable to the catchment area and not limited to only this MRA locality.

6. PROPOSED STORMWATER MANAGEMENT PRACTICES & MONITORING MEASURES

6.1. Stormwater management

The purpose of a stormwater management plan is largely to (from *City of Cape Town Management of Urban Stormwater Impacts Policy*):

- Improve on the quality of stormwater runoff.

The development of an area calls for unearthing of underlying geologies that would otherwise not have been exposed to weathering, which may create oxidising agents and/or changes in pH and other pollutants within the runoff water that would otherwise been immobile within the environment. The development of an area also brings in various pollution sources (hydrocarbons, chemicals, nutrient and biological contaminants) that would not have been present under natural and undisturbed scenarios. It should be the aim of the stormwater management plan to ensure that the stormwater remains within a target water quality range prior to any release into the environment (DWS target water quality guidelines, 1996).

- Control the quantity and rate of stormwater runoff.

Under natural conditions, varying topography, unconsolidated soils, and vegetation features would naturally slow down the runoff by retaining the water within the landscape. This would ensure a slow release into the environment. The development of an area typically strips off the vegetation and topsoil, unearthing a hardened layer of soil. Landscaping also often ensures that surfaces are harder than before the development, which decreases the percolation rate. The rate of discharge is then increased, which often leads to erosion impacts and flooding of the local watercourses.

- Encourage natural groundwater recharge.

As mentioned, by increasing the rate of runoff through the various abovementioned factors, the retention time of the stormwater within the landscape is reduced. This means that the surface water is not given chance to percolate within the soils to recharge the groundwater levels.

Government Notice (GN) 704 from the water Quality Management Series, operational Guideline No. M6.1 (DWAF, 2000) is a comprehensive document outlying the requirements of stormwater management in terms of a mining activity. This document should be consulted when designing a stormwater management system for the quarry site. The points below highlight points from this document (and other sources) that are thought to be pertinent from an ecological impact and management perspective.

Section 26(1) of the National Water Act, 1998 (Act 36 of 1998) provides for the development of regulations to, amongst others (from GN 704, DWAF [2000]):

- require that the use of water from a water resource be monitored, measured and recorded.
- regulate or prohibit any activity to protect a water resource or in-stream or riparian habitat; and
- prescribe the outcome or effect which must be achieved through management practices for the treatment of waste, or any class of waste, before it is discharged or deposited into or allowed to enter a water resource.

When making regulations, the need for the following must be considered (section 26(4) of the National Water Act):

- promoting economic and sustainable use of water.
- conserving and protecting water resources or, in-stream and riparian habitat.
- preventing wasteful water use.
- facilitating the management of water use; and
- facilitating the monitoring of water use and water resources.

6.1.1. Separation of clean and dirty water

One of the ways to achieve these objectives is to isolate clean (unpolluted) water from any dirty (polluted) water and/or area. The distinction between clean and dirty water relies on the specific requirements of a water resource and should therefore be determined on a catchment specific basis. The quality of water as per definition of “clean water” should be gauged against the DWAF (1996) target water quality guidelines for freshwater aquatic ecosystems (vol 7). Further to this, the water quality of the receiving environment (Orange River in this case) should be monitored over an extended period to determine water quality trend data. Many of the parameters defined within the water quality guidelines stipulate a limitation of the range of the parameter that should not be altered. This will be different for every watercourse and therefore background data and trend analysis of the receiving watercourse should be gained.

To separate polluted from unpolluted water, any clean water system operating on the quarry site should be designed, constructed and maintained so that it is not likely to spill into any dirty water system more than once in 50 years.

The containment of unpolluted water should only occur if the volumes pose a risk, the water couldn’t be diverted to a watercourse by gravitation, or for attenuation purposes. The unpolluted water should as far as possible be released into natural watercourses under controlled conditions. As the storage of water is defined as a water use in section 21 of the National Water Act, the person in control of a mining or related activity need to apply for a water use licence, unless covered under a General Authorisation (DWAF, 2000).

When designing a dam, the emphasis should be placed on “at all times capable of handling the 1:50 year flood-event.” How this is calculated and complied with will be determined by the specific circumstances and processes involved. It is proposed that acceptable engineering principles be used during the design of a water system. Therefore, a suitably qualified person must be responsible for the design of a water system and the construction thereof should take place under the supervision of that person.

6.1.2. Reuse and reticulation of dirty water

Another component is to collect the water arising within any dirty area, including water seeping from mining operations, outcrops, or any other activity, into a dirty water system. Any water arising from an area, which causes, has caused or is likely to cause pollution of a water resource, including polluted stormwater, must be contained within a dirty water system. To reduce the volume of polluted water, contaminated areas should be minimised. While clean water should be diverted to natural watercourses, polluted water should be re-used wherever possible, thereby reducing the use of clean water.

The purpose of any stormwater management plan is the protection of the water resource. In order to achieve this, it is the responsibility of the quarry management to prevent water containing waste or any substance which causes or is likely to cause pollution of a water resource from entering any water resource, either by natural flow or by seepage, and must retain or collect such substance or water containing waste for use, re-use, evaporation or for purification and disposal in terms of the Act (National Water Act no 36 of 1998). Any water containing waste should be diverted to a dirty water system and prevented from entering and polluting a water resource. This requirement is in line with section 19 of the National Water Act and subscribes to the principle of *pro-active pollution control.*

The intention of this is not to prohibit the discharge or disposal of water containing waste, but only to control such aspects. The person in control of a mining or related activity could apply for a water use licence in terms of section 40 of the National Water Act for the disposal or discharge of any water containing waste. The conditions for the specific disposal or discharge of water containing waste should be based on the site-specific circumstances and stipulated within the water use licence.

It is also the responsibility of the quarry management to design, modify, locate, construct and maintain all water systems, including residue deposits, in any area so as to prevent the pollution of any water resource through the operation or use thereof and to restrict the possibility of damage to the riparian or in-stream habitat through erosion or sedimentation, or the disturbance of vegetation, or the alteration of flow characteristics.

6.1.3. Prevention of flow through mining areas

Measures should be in place to minimise the flow of any surface water or floodwater into mine workings, opencast workings, other workings, or subterranean caverns, through cracked or fissured formations, subsided ground, sinkholes, outcrop excavations, adits, entrances, or any other openings. The intention of this regulation is mainly the following:

- to prevent the flooding of mine workings, both underground and opencast, that could cause the loss of life or the sterilisation of the mineral resource.
- to minimise the quantity of clean water contaminated by either the mixing with dirty water or the contamination thereof by the activity. In this way the volume of clean water that can be diverted to the natural resource is maximised; and
- to prevent the pollution of the groundwater resource.

6.1.4. Maintenance and management of operational systems

Another measure to protect the water resource is to design, modify, construct, maintain and use any dam or any residue deposit or stockpile used for the disposal or storage of mineral tailings, slimes, ash, or other hydraulic transported substances, so that the water or waste therein, or falling therein, will not result in the failure thereof or impair the stability thereof. The failure of such structures can result in in major pollution of a water resource. This regulation requires that such a structure be designed, constructed, and maintained in such a way as to prevent the failure thereof. A suitably qualified person, e.g., civil engineer, who can professionally be held liable in the case of a disaster (loss of human life, extreme water pollution, etc.) or a failure, should design the dam or residue deposit.

6.1.5. Avoidance of leaching from stockpiles and protection of receiving environment

The erosion or leaching of materials from any residue deposit or stockpile from any area and contain material or substances so eroded or leached in such area by providing suitable barrier dams, evaporation dams or any other effective measures to prevent this material or substance from entering and polluting any water resources must also be prevented. Erosion of a residue deposit or stockpile should be prevented through proper management thereof, with inspection and maintenance done on such structures on a regular basis. The dual objectives of this requirement are firstly to prevent the eroded material from entering and polluting a water resource, and secondly to prevent structural failure thereof.

6.1.6. Recycling of dirty water

Another aspect of protection of the water resource is to ensure that water used in any process at a mine or activity is recycled as far as practicable, and any facility, sump, pumping installation, catchment dam or other impoundment used for recycling water, is of adequate design and capacity to prevent the spillage, seepage or release of water containing waste at any time. Dirty water must be re-used as far as possible on the premises of a mining or related activity, thereby minimising the use of clean water and the disposal or discharge of polluted water. Any operations facilities utilised in the management of polluted water must be maintained and operated in a manner that will ensure functionality as infrastructure failure can result in contamination of the receiving environment.

6.1.7. Management of wastewater emanating from domestic use

It is not only dirty water that occurs because of mining operations that can create a pollution source to the receiving environment. Water for domestic use (wash water, water-borne sewerage, etc) that cannot be disposed of directly into a municipal sewerage system is to be disposed of in terms of authorisation under the National Water Act. In terms of section 40 of the National Water Act, a person in control of a mining or related activity needs to apply for a water use licence for the disposal of domestic waste and wash-water if not disposed of in a municipal sewage system. The site-specific conditions need to be stipulated within the water use licence.

6.1.8. Further aspects to consider

The opencast areas, for the large part, are subterranean and therefore surface runoff from the pits does not occur, but runoff will occur from surface processing, processing, and transport facilities. If large volumes of water do accumulate within the quarry pit, then it is assumed that it would be drained through pumping it to the surface or to an unused/inactive part of the pit where it must be managed as part of the polluted / dirty water system. Inflow of clean runoff stormwater into the pit should be avoided through creating embankments that surround the pits area that will divert clean stormwater toward a clean water management system. It is assumed that stormwater accumulation will be limited in extent and that most of it would be utilised through the routine dust suppression activities that would take place throughout the site (i.e., spraying of roads, sand/rock piles, etc.). It does need to be acknowledged, however, that transformation of the landscape through vegetation removal and surface hardening will increase the surface water runoff and therefore it is recommended that an attenuation pond be established. It is not advised that polluted water be used for dust suppression outside of the quarry pit area as this will merely lead to contamination of clean water areas from runoff.

Points to consider during the planning and construction of such an attenuation pond follow:

- This should be placed at the lowest point of the development area for practical purposes as stormwater runoff is gravity driven (outside of the quarry pit), but not within the riparian zones or associated buffer areas.
- It should be of sufficient volume to capture the magnitude of a reasonable flood event. This should be calculated by a suitably qualified engineer.
- It should be protected from other pollution sources (i.e., placed away from any area where fuel and/or oils are stored and separated from any dirty water storage or reticulation).
- This pond should be constructed of a material that will allow for practical usage of the water (e.g., pumping into water tanks for road irrigation for the purpose of dust suppression), but should also be designed in a way to allow for slow seepage into soils or for slow release into the receiving environment.
- The overflow outfall of the pond should be designed in a way that will protect the receiving environment from the impacts of erosion. High velocity water being directed onto loose soils will create erosion and impact the aquatic environment that it will eventually enter. Energy dissipation mechanisms should be in place to slow down the velocity of the flowing water.
- Quarry water that is pumped to the surface should be routinely monitored for quality prior to release into the pond. If it is found that the quality falls outside of guideline values, then further treatment may be required prior to release of usage throughout the site.
- It is not thought that the stormwater release into the environment, however, will create a significant impact to the receiving environment.

Further recommendations to improve stormwater management is to use permeable paving wherever paving is required to stabilise road and/or building surfaces and for dust suppression within the service area (administration areas, etc). This will enhance percolation of water into the soils for groundwater recharge.

6.2. Proposed monitoring plan

The monitoring of ongoing surface water ecological function and overall health and integrity is aimed at monitoring the same points that are utilised in assessing overall wetland health initially, viz vegetation status, hydrology, and geomorphology. Fish were shown to be an important part of the watercourses within the survey area and therefore sampling for fish during the monitoring would be a good indication of ecological health. Water quality should also be monitored for at least every six months (biennially) during normal operations but will increase in response to accidental spillages or other incidences that warrant more frequent monitoring.

Site photographs from set points at all the monitoring stations should be taken for all monitoring periods for reference and comparative purposes. These will be useful when undertaking trend analyses of the various monitoring aspects.

The following points should be included in the monitoring:

6.2.1. Vegetation features

- Extent of vegetation cover and the trend of increasing or decreasing extent of cover should be monitored for.
- Species composition and analysis of indigenous versus exotic species communities. Grass species composition should be analysed in terms of status (pioneering, decreaser of increaser species) as an indication of succession.
- Exotic vegetation must be monitored for to enable early detection of exotic invasive species so that this can be timeously managed; and
- A change in floral species communities will also indicate the extent of the wetland functioning areas. A decrease or increase in facultative of obligatory wetland species over time will alert to this change.

6.2.2. Hydrological features

- The changes in baseflows will be most noticeable if the water levels within the instream impoundments are monitored. Cumulative data will indicate trending data over time and allow for the trends pertaining to seasonal variation to be accounted for during data interpretation.
- Increases of flow volumes emanating from the stormwater/clean water runoff from the site should be monitored to determine if the increase capacity is creating scouring impacts within the receiving environment.
- Decreases in water volume should also be monitored and areas of wetland desiccation should be flagged for increased monitoring frequency. This is due to the impact that desiccation has on hydromorphic soil structures, which exposes them to structural failure and subsequent erodibility.

6.2.3. Geomorphological features

- Geomorphological features pertain to the sediment load and the sediment transport capacity of the wetland feature. Soil erosion within the wetland unit falls within this category and is perhaps the primary and most pertinent monitoring aspect that warrants active and ongoing management.
- Decreasing vegetation cover, increase in exotic vegetation invasion, increase in water volumes and velocity within a channel and subsequent modification of soil features, are all interplaying aspects that manifest in modification of geomorphological features of a wetland unit.

- Emerging erosion, in all forms, must be routinely monitored for throughout all areas of the wetland units and management intervention must be undertaken immediately once a problem area has been identified. Erosion is relatively simple to rectify if caught early but increases in scale and complexity with time. Early intervention also allows for the use of natural features (natural vegetation to stabilise soils, etc), whereas a perpetuating erosion impact will eventually require costly civil structure intervention.
- One of the single most important driving factors behind wetland ecological integrity and functionality is erosion control, which is a function of vegetation structure and balanced hydrological features.

6.2.4. Water quality monitoring

- A functioning wetland unit provides a water quality remediation process and therefore adds a protection factor to perhaps more sensitive aquatic habitat located downstream within the system. The capacity for water purification has an obvious limit and is different from one wetland unit to the next. Preserving the overall ecological integrity and functionality of a wetland unit will enhance its capacity for water purification.
- The quality of the water that is being discharged into the wetland units (be it clean stormwater runoff, dirty process water or just the water the flows within the wetland zones) needs to be monitored and the results compared to target water quality guideline values. General water quality parameters, elemental scans and bacteriological counts should be part of routine analysis, undertaken at least every six months.
- If an incident occurs on site, such as an accidental spill, chemical leaks, sewerage contamination and the like, then a water quality monitoring schedule, targeting specifically the offensive pollutant, must be implemented at a frequency recommended by the ECO designated to the site.
- If poor or deteriorating water quality trends are observed, then the source of the pollutants must be identified and remedied appropriately, according to the type of pollution impacts identified.
- Water quality monitoring should be undertaken at the same site each time and the sampled analysed at an accredited laboratory.
- Water samples were taken during the baseline survey to gain an understanding of the water quality within the survey area. This can be modified at the discretion of the plant management if necessary.
- Monitoring should be undertaken within watercourses prior to the impact zones as well as within the same watercourses as they leave the impact zones. Recommended water quality monitoring points have been presented in Figure 29. As the collection of water samples is dependent on the presence of surface waters, the inclusion of all the recommended points may not be practical. Further to those points recommended, effluent and decanting water outfalls, outfalls of attenuation ponds, and outfalls pertaining to the stormwater management plan should also be included.
- Monitoring points must also include as many of the local catchments within the site as possible to gain an overall understanding of the impacts to water quality, how those contaminants are being transported and to where they are being transported to. Managing a local catchment that has a single draining watercourse is then easier to manage, should the need arise.

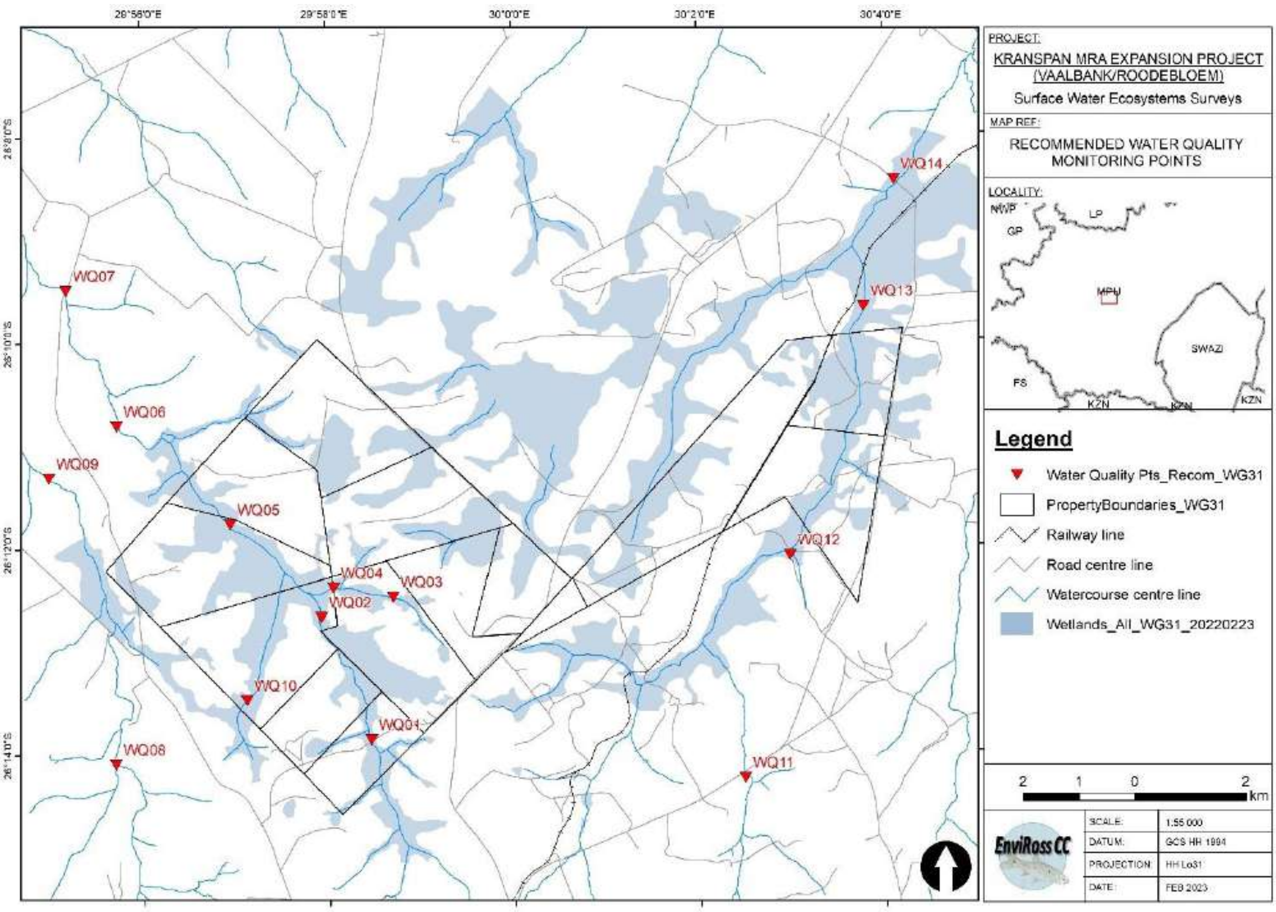


Figure 29: Recommended points to be utilised for routine water quality monitoring.

7. CONCLUSIONS & RECOMMENDATIONS

Various field surveys were undertaken between the period October 2022 and January 2023 to evaluate the surface water ecosystems associated with the area pertaining to the proposed extension to the Mining Rights Application area for the Ilima Coal Kranspan Coal. Following the field survey of the proposed development area, analyses of the data, the following salient recommendations can be proposed to aid in the conservation of the overall ecological integrity of the wetlands within the region:

- The proposed development area was shown to incorporate a relatively high proportion of wetland habitat units, ranging from valleyhead seeps, hillslope seeps, channelled and unchannelled valley-bottom and depression-type wetland units. These units have been delineated and their outer boundaries, together with conservation buffer zones, are presented in Figure 18.
- The wetland units are interspersed amongst formal cultivation, which was observed to be the most prominent pressure and driver of ecological change at present, and much of the peripheral wetland units have lost functionality and ecological contribution due to cultivation. This was taken into consideration when developing the final buffer zone designation (as indicated in Figure 18).
- The wetland units were shown to all fall within a PES category range of B/C (moderately modified) to D/E (largely modified), with a high ecological importance and sensitivity.
- Laboratory analysis of water samples showed that the wetlands retain a relatively good water quality, with some areas of elevated electroconductivity readings (showing an elevated level of dissolved salts) and some elevated sulphate levels. There were also some elevated levels of E. coli indicated in samples, but these were associated with watercourses that flow into the development area and therefore are sourced from outside of the site. A water quality

monitoring plan has been proposed that is aimed at abating ecological degradation and to reduce the risk to both human and livestock health.

- The DWS Risk Assessment Matrix indicates that all proposed mining activities that will impact the wetland directly carry a high risk factor. The impact significance ratings also indicate that the potential impacts carry a high significance post mitigation. The significance of the impacts is largely due to the direct involvement of deleterious impacts to wetland habitat units. The significance is, however, largely dependent on the extent of wetland habitat that will be directly affected by mining activities and the severity of those impacts.
- The presented infrastructure layout indicates that some wetland areas are required to be included within the mining area and therefore will be lost. Opencast mining excavations taking place in close proximity to wetland units will have an impact on hydrological components of those wetlands where water moving laterally through the subsurface soil layers will decant into the opencast pits rather than feeding the wetland units. This, depending on the severity, have a profound impact on the wetland units. In severe cases, the entire ecological functionality of the wetland unit could be lost. It is recommended that an appropriate specialist (hydropedologist or geohydrologist) ascertain the level of water loss to the wetland units should this take place. This impact could, however, be mitigated with the decant water being supplied directly back to the wetland unit if the quality of the decanted water meets the target water quality values.
- The significance of the ecological loss is dependent on the sensitivity as well as the present functionality of the wetland units. Ultimately, infrastructure layout planning that takes into consideration the wetland delineation mapping, associated conservation buffer zones, as well as the proposed mitigation measures, can greatly reduce the overall significance of the impacts to the wetland systems associated with the site.

It should be noted that, to conserve the wetland ecological structures within the area, the wetland needs to be viewed as an interconnected larger system and the individual units should be managed as such. This includes keeping general habitat destruction and construction footprints to an absolute minimum within the terrestrial habitat as well. Conserving the habitat units will ultimately conserve the species communities that depend on it for survival. This can only be achieved by the efforts of the contractor during the construction phase and by strict management during the operations phase.

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APPENDIX 8F: GEOHYDROLOGICAL IMPACT ASSESSMENT

IRENE LEA ENVIRONMENTAL & HYDROGEOLOGY

Ilima Coal Company (Pty) Ltd

GEOHYDROLOGICAL STUDY FOR THE KRANSPAN MINING RIGHT EXTENSION

FINAL REPORT

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ABS Africa Sustainability Advisors

Report No iLEH-ABS KRA 05-22

MARCH 2023

PROJECT DETAILS

PROJECT:	**Kranspan Mining Right Extension**
Report Title:	Geohydrological Study for the Kranspan Mining Right Extension
Client:	ABS Africa
Client Contact	Paul Furniss
Project Number	ILEH-ABS KRA 05-22
Date Submitted	13 March 2023
Author	Irene Lea (M. Sc. *Pri. Sci. Nat*)

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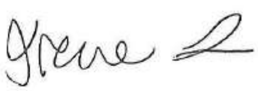

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13 March 2023

EXECUTIVE SUMMARY

Background

A geohydrological specialist study was completed for the mining right application for the proposed Ilima Kranspan Extension project with the objective of evaluating the risks to groundwater availability and quality associated with the proposed mining activities. The project will entail opencast and underground coal mining of the B, C and E Seams on the farms Vaalbank and Roodebloem in the Ermelo Coal Field. The coal will be washed and processed on site; an activity has already received environmental approval.

Of significance to the Vaalbank mining area is the presence of historical underground workings associated with Union Colliery. One decant point associated with the historical mining area was identified and sampled as part of the study. Ilima plans to mine above the historical mining area and in places into the old workings. The outcome of this assessment however emphasises that should mining of the C Seam on the farm Vaalbank extend into the historical Union Colliery workings, provision must be made to dewater and contain increased volumes of mine water during the operational phase and post closure as part of decant management.

In order to complete the geohydrological specialist study, two pairs of additional shallow and deep monitoring boreholes as well as one deep monitoring borehole were drilled and tested to obtain information to characterise the aquifer present. The borehole locations were determined with the aid of surface geophysical methods. Three northeast-southwest striking lineaments transect the proposed mining area, which were specifically targeted. A geophysical survey was used to pinpoint the locations of these and monitoring boreholes were used to characterise aquifer conditions associated with the lineaments. The results indicate that the lineaments have enhanced aquifer characteristics and will act as preferential flow paths to groundwater. Groundwater samples were taken from the monitoring boreholes for chemical analysis to establish ambient groundwater quality conditions.

The information obtained from the monitoring boreholes indicates that there are two aquifers present, namely a shallow weathered aquifer that extends to a depth of 15m and a deeper fractured rock aquifer.

The average depth to groundwater in the weathered aquifer is 4m. In low-lying areas, the groundwater table is however shallower and springs occur in the area. Where the topography intersects the groundwater table, zones of seepage occur which are associated with the presence of wetlands within the mining area. The shallow weathered aquifer is not considered significant in terms of water supply due to its limited thickness. It does however play an important role in terms of the recharge of rainwater and baseflow to streams and pans, especially during the dry season.

The weathered aquifer is underlain by a deeper fractured rock aquifer. The fractured rock aquifer is most prominent along the two lineaments identified, which have higher permeabilities compared to the unfractured rocks. Regionally the permeability of unfractured rock formations is low and very little groundwater occurs in the region. This was confirmed during the hydrocensus completed as well as from aquifer tests conducted. The average depth to groundwater in the fractured rock aquifer is 5m.

A hydrocensus of private groundwater use was also completed as part of the study. A total of 19 additional private boreholes and springs were identified during the 2022 hydrocensus. Groundwater level measurements could be taken in 13 of these boreholes. Five groundwater samples were furthermore taken from selected hydrocensus boreholes for chemical analysis and to establish baseline conditions. The weathered aquifer is not isolated from the fractured rock aquifer and aquifer tests confirmed that there is interaction between the two aquifers.

Groundwater flow patterns that were established from the data obtained from the monitoring and hydrocensus boreholes indicate that groundwater flow is mainly towards the largest of the pans present on site. Local variations in groundwater flow occur and groundwater also flows towards the smaller pans.

The results of the chemical analysis of groundwater samples taken from the monitoring and private boreholes indicate that groundwater quality is generally good and complies with South African drinking water standards. The dominant cation is sodium and the dominant anions are bicarbonate and to a lesser extent chloride. The groundwater is however naturally hard, which can result in scaling and has a so-called “soap destroying” nature. Elevated concentrations of iron and manganese were also recorded. At the concentrations recorded, staining in plumbing may be expected.

The geohydrological impact assessment was completed with the aid of a numerical groundwater flow and contaminant transport model, which was calibrated with data obtained from the monitoring and private boreholes. In order to ensure that boundary conditions do not affect the outcome of the assessment, a modelled area was created that is much larger than the project site. The results of model calibration indicate that the calibration criteria set for the project were met. The model is therefore considered suitable to complete the impact assessment with the available dataset. The outcome of the assessment indicates that the model is sensitive to large fluctuations in the permeability of the fractured rock aquifer and storage coefficient and specific yield of the aquifers. Model calibration and confidence levels can be improved once additional monitoring information becomes available from the site. Model verification should therefore be undertaken once mining starts and the groundwater monitoring programme results are available.

The calibrated model was used to complete the impact assessment for the project. During simulations, the opencast and underground mine plans made available by Ilima was incorporated into the model. The impact of mining on wetlands was a specific focus during the assessment. The extent of the wetlands and associated buffer zones.

The initial source term for the project was updated with the results of additional leach tests as well as information gathered from the historical Union Colliery decant point.

The model was used to complete a geohydrological risk assessment for each of the scenarios discussed above and to determine the resultant impact on private groundwater users as well as on adjacent wetlands. The latest extent of wetlands as well as of mining were considered during simulations, both of which were adjusted based on the outcome of the EIA phase of the mining rights application.

The results of the revised impact assessment are summarised as follows:

- **Impact on groundwater availability during the operational phase**: Groundwater is expected to flow preferentially along the regional faults lines that transect the mining area. The intersection of these structures during mining is expected to result in increased seepage to mining areas. The rate of groundwater seepage to the mining areas was calculated. Larger seepage volumes are expected for pits associated with the regional fault lines as well as those that will extend over large areas. This information must be used to design the PCDs. These designs must ensure that all dirty water can be captured and contained. The impact assessment indicates that mining and mine dewatering will significantly impact on private groundwater users. Twenty private boreholes will be destroyed during mining. Three of these fall on ground belonging to Ilima. In addition, 14 boreholes would be significantly impacted by mine dewatering, of which six fall on ground belonging to Ilima. The zone of impact on groundwater availability during the operational phase was delineated and can be used to assess the resultant impacts on wetlands.

- **Impact on groundwater quality during the operational phase**: . It is shown that the operational zone of impact on groundwater quality does not significantly extend beyond the mining footprint areas. Some preferential flow may take place along the regional fault lines, but not significantly so. The plumes are also not likely to reach the rivers and streams draining through the mining areas by the end of the operational phase of mining.
- **Risk of decant**: Decant is possible from the pits as the rate of recharge to the backfilled pits are expected to be higher compared to natural conditions. If this is the case at closure, a total of 36 potential decant points were identified as part of this assessment. In addition to the specific decant points it is possible that seepage, most likely sub-surface seepage, may be associated with the areas where wetlands have developed. The wetlands are associated with zones of groundwater seepage, especially near streams and dams. The risk of decant can be significantly reduced and minimised post closure if the rate of recharge to the pits can be reduced to near-natural rates. It is likely that some of the smaller pits will not decant under these conditions. If decant cannot be avoided, the estimated timing to decant, volume and quality of decant was assessed in this study. This information must be used to plan for efficient rehabilitation to avoid adverse long-term impacts.
- **Long-term impact on groundwater quality:** The extent of the long-term zone of impact on groundwater quality was assessed with the model. The plumes are expected to move preferentially along the regional fault lines. These structures were identified as preferential flow paths to groundwater and therefore also to potential contamination. Plume movement in unfractured rock is expected to be much lower due to low regional rock permeabilities. In places, the plumes are expected to reach the rivers and streams in the long-term, especially where the regional fault zones sub-outcrop. In these areas, sulphate concentrations exceeding 500 mg/l may reach the streams as part of the groundwater component to stream baseflow. The zone of impact on groundwater quality in the deeper fractured rock aquifers are not expected to significantly move beyond the mining areas, except along the regional fault lines. Along these structures, the plumes may migrate more than 1500m along these preferential flow paths in places. In unfractured rock, the plumes will probably not migrate more than 300m from the mining areas. Private boreholes drilled into the deeper fractured rock aquifer that fall within the zone of influence on groundwater quality will be destroyed during mining.

A groundwater management plan was developed, based on the outcome of the impact assessment presented. The management plan is based on objectives and targets set for the project. Over-arching groundwater management measures are provided, which are aimed at planning for groundwater management from the start of the project and installing good house-keeping measures. All dirty water must be contained in suitably sized and designed facilities and clean water must be diverted around the mining area back into the catchment. Mine design must consider the results of this study, specifically relating to underground mine stability (to prevent subsidence) and the concurrent backfilling and rehabilitation of opencast pits.

Specific groundwater management measures are proposed for each of the impacts identified. These include measures to minimise the impact of mine dewatering as well as of the long-term impact of decant and deteriorating groundwater qualities. It is important that additional information is obtained to characterise borehole depth, construction and yield of private boreholes that fall inside the delineated zones of impact prior to the commencement of mining. This information must be used as a basis for discussions and negotiations with private borehole owners that may be negatively impacted during mining. It is important that the mine provides feedback to private borehole owners on a regular basis regarding mining, rehabilitation and monitoring activities.

The impact on groundwater and decant quality can be minimised by positioning surface infrastructure off the three lineaments, which are preferential flow paths to groundwater. In addition, the risk and/or occurrence of decant must be monitored. Should the monitoring indicate an increased risk of decant, suitable measures must be put in place to captured and contained it to prevent unacceptable long-term impacts.

An Acid Mine Drainage management plan is also detailed in the study.

A dedicated groundwater monitoring programme must be implemented during the construction phase of mining and maintained throughout the life of mine. The monitoring information must be used to measure the short and long-term impact of mining on groundwater levels and quality. Should adverse impacts be identified, the monitoring programme must trigger the necessary response and implementation of additional management measures, as required. This information must further be used to update, verify and re-calibrate the numerical groundwater flow and contaminant transport model prepared as part of the assessment. This will increase the level of confidence in the impact prediction results.

Key findings

Of specific concern with regards to mine rehabilitation is the risk of decant and the long-term impact on groundwater quality. In order to minimize these impacts on groundwater Ilima must implement a rehabilitation strategy focused on reducing the rate of recharge to the pits during and post mining.

Should Ilima not be in a position to prevent decant, all seepage from the pits during and post mining must be captured in suitable containment facilities that comply with legal requirements, should monitoring results indicate that the decant is not suitable for release into the catchment.

The impact of mining on existing private groundwater users must be monitored as indicated in this report. Should monitoring results trigger an action or response from Ilima, these must be discussed with affected parties and a mutually acceptable solution must be negotiated to mitigate adverse impacts associated with mining activities.

Private boreholes that will be destroyed during mining must be replaced, or suitable alternatives must be discussed and negotiated with affected landowners.

Specific recommendations

A comprehensive groundwater management plan was developed based on the outcome of the groundwater impact assessment. The objective of the management plan is to reduce and/or eliminate adverse impacts on existing private groundwater users and watercourses downgradient of the mining area. The groundwater management plan includes the following components:

- An over-arching management plan focussed on good house-keeping measures at the mine.
- Measures to address impacts on groundwater availability.
- Measures to address impacts on groundwater quality.
- Measures to reduce the risk of decant
- An acid mine drainage management plan from a groundwater perspective
- Incorporation of the results of this study into the mine rehabilitation plan
- Post closure groundwater management measures

The study was used to develop a comprehensive groundwater monitoring programme. This programme includes the existing mine monitoring boreholes, private boreholes within the zones of impact on groundwater availability and quality as well as private boreholes that fall within the identified zones of impact zones.

The monitoring programme is geared to record water level and quality trends, to improve the understanding of the aquifer characteristics, to check the accuracy of predicted impacts, to trigger groundwater management actions in the event of adverse impacts recorded and to be used to improve mine management practices and procedures to protect groundwater.

Should the monitoring triggering-response criteria presented in this report be exceeded, a specific action plan is prescribed to inform affected parties and remediate impacts.

Based on the above, it is recommended that:

- The mine planning and design as well as the planning and implementation of the concurrent and final rehabilitation programme must consider the outcome of the geohydrological impact assessment.
- The groundwater management plan developed for the mining project is implemented and used to identify and minimise or eliminate impacts on groundwater. Specific focus must be placed on managing the impacts on existing private groundwater users.
- The groundwater monitoring plan presented in this report is implemented and maintained as detailed in the report.
- Ilima provide financial provision to implement and maintain the groundwater management and monitoring programme developed.

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LIST OF ACRONYMS USED

BH	Borehole
BPG	Best Practice Guideline
CDT	Constant Discharge Test
DTM	Digital Terrain Model
DWS	Department of Water and Sanitation
DWAF	Former Department of Water Affairs and Forestry
EA	Environmental Authorisation
EIA	Environmental Impact Assessment
EMP	Environmental Management Programme
iLEH	Irene Lea Environmental and Hydrogeology cc
Ilima	Ilima Coal Company (Pty) Ltd
IWUL	Integrated Water Use License
HDPE	High Density Polyethylene
K	Hydraulic conductivity or permeability (unit: m/d)
L/h	Litre per hour
LOM	Life of Mine
LOW	Limit of weathering
mamsl	Metres above mean sea level
MAP	Mean Annual Precipitation
m bgl	Metres below ground level
Ml/d	Megalitres per day
NA	Not applicable
NS	Not specified
PCD	Pollution Control Dam
RMSE	Root mean square error
S	Storage coefficient (-)
S_y	Specific yield (-)
S&EIR	Social and Environmental Impact Assessment Report
SANAS	South African National Accreditation System
SANS	South African National Standards
SDT	Step Drawdown Test
SWL	Static Water Level
T	Transmissivity (unit: m^2/d)
WL	Water level
WMA	Water Management Area
WML	Waste Management License

1 PROJECT BACKGROUND

Ilima Coal Company (Pty) Ltd (Ilima) is the holder of a Mining Right (10224MR) over the farm Kranspan 49 IT. The project is situated approximately 18 km northeast of the town of Carolina in Mpumalanga Province.

Within the existing Mining Right, an Integrated Environmental Authorisation (EA) and an approved Environmental Management Programme Report (EMP) is in place (Ref. MP 30/5/1/2/3/2/110224EM). In addition, an Integrated Water Use License (IWUL) was issued (05/X11B/ACGIJ/10834).

Ilima is in the process of applying to extend the Mining Right by incorporating two adjacent prospecting rights on the farm Vaalbank 212 IS (prospecting right 1100PR) and Roodebloem 51 IT (prospecting right 218PR). The area of the Mining Right extension is indicated on Figure 1.

This report represents an addendum to the original geohydrological impact assessments completed by iLEH (2019a and b) for the Kranspan Project. Where applicable, data from the 2019 study was incorporated into the assessment presented in this report.

1.1 Project Description

The project is located within an area where historical coal mining has taken place. Some of the old mining areas have not been rehabilitated. Tselentis Colliery is situated southeast of Kranspan Colliery, as indicated on Figure 1. The historical Union Colliery underground workings are located in the southwestern and southern sections of the Vaalbank prospecting right. Steyn (2019) reports that mining at Union Colliery started in 1900 and ended in 1975. It is understood that the C and E Seams were mined from the Union underground workings. A decant point was identified in the Union underground workings as part of the fieldwork completed for the Kranspan project. Details regarding the decant are provided later in this report. Steyn (2019) however reports that there are seven known decant points at Union Colliery.

The following activities will be considered in the groundwater impact assessment study (ABS Africa, 2022; and Ilima, 2022):

- Opencast and underground coal mining activities over a life of 30 years. The extent of these activities are indicated on Figure 1. In addition to the extension areas, the groundwater study will also consider the updated mine plan and mining schedule for the combined Kranspan project. This information was sourced from the Mine Work Programme (Ilima (2022). The B, CL and E Seams will be mined at the colliery.
- Placement of overburden/waste rock as well as run of mine stockpiles.
- Construction, operation and maintenance of several pollution control dams (PCD). These dams will be used to contain and reuse dirty water generated within the mining area, but will also be used to contain extraneous water from the pits and underground workings.
- Operation of two coal processing plants, which will entail dry crushing and screening and a wash plant. The first of this is the existing and approved dry crushing plant at Kranspan and the second the proposed new wash plant at Roodebloem.
- Potable water will be sourced from groundwater. A small water treatment plant will be built to produce potable water from groundwater. This plant is already approved as part of the existing mining right on the farm Kranspan.
- Process water will be sourced from underground and pit dewatering and from the PCDs.

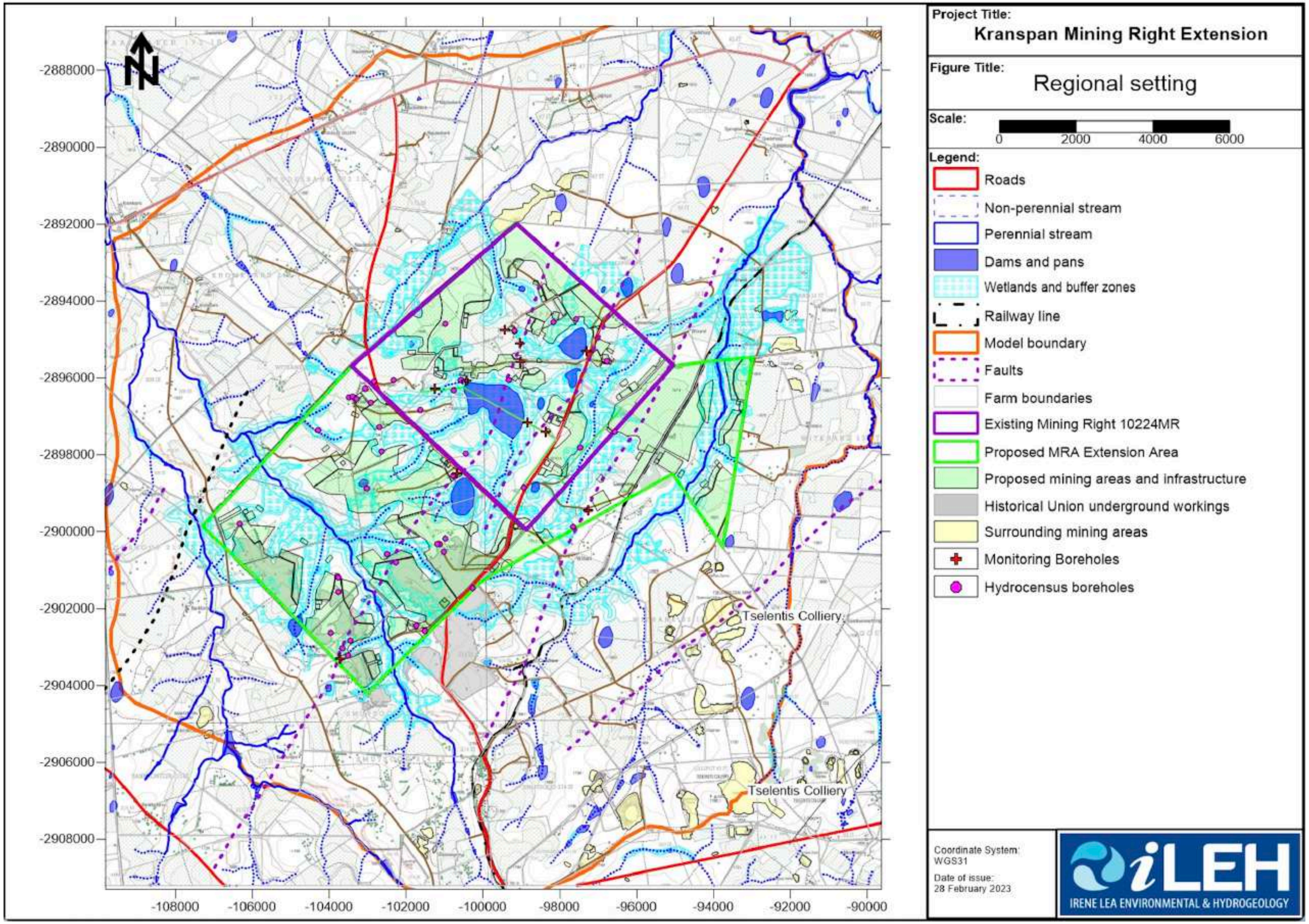

Figure 1 Regional project setting

1.2 Details of the Specialists

The project was managed by Irene Lea. She has 31 years' experience in the field of geohydrology. She has a M.Sc. degree in Geohydrology and is a registered Professional Natural Scientist (400278/06). Her focus includes numerical groundwater flow and contaminant transport modelling, water treatment, integrated water and waste management strategies, rehabilitation and closure projects, environmental management systems and risk assessments.

The fieldwork programme was managed and undertaken by Lucas Smith of Groundwater Abstract. He has 30 years' experience in the field of geohydrology. He also has a M.Sc. degree in Geohydrology and is a registered Professional Natural Scientist.

Both consultants that completed the project have no direct or indirect beneficial interest or contingent in the Ilima Kranspan Project at present or in the past. They will be paid a fee by ABS Africa, the environmental consultants appointed to the project for coordinating the groundwater specialist study, numerical groundwater flow and contaminant transport modelling within normal professional consulting practice. Payment of these fees is in no way contingent upon the conclusions or opinions expressed in this report.

2 PROJECT METHODOLOGY

The geohydrological impact assessment was completed with information obtained from ABS Africa, Ilima as well as from a dedicated fieldwork programme. The following project methodology was followed:

- A hydrocensus was conducted during July 2022. The survey included the Vaalbank and Roodebloem prospecting right areas and concentrated on identifying existing private boreholes. During the hydrocensus 19 new groundwater sites (boreholes and springs) were identified, the details of which are presented in Appendix 1. In addition to the 19 new sites, 24 boreholes identified during the 2019 hydrocensus and drilling programmes were re-assessed to define the water table and quality status. Thus, 43 groundwater sites were assessed during the 2022 hydrocensus. During the hydrocensus the following information was collected for each site:
    - Borehole position (X, Y, Z-coordinates);
    - Information relating to equipment installed;
    - Borehole construction details;
    - Borehole yield – if known;
    - Groundwater level, if possible; and
    - Current use.
- Water levels were measured during the 2022 hydrocensus by using a dip meter to measure the distance from the mouth of the borehole (borehole collar elevation) to the groundwater table depth in the borehole. The height of the borehole collar was to calculated the elevation for all water table measurements in metres above mean sea level (m amsl).
- A desktop study was completed to evaluate all information that became available since the 2019 studies were completed. This includes EIA-related documents, mine design, project layouts, mine monitoring data, field data and public databases and maps. The list of documents reviewed are provided in the references at the end and are discussed in the applicable sections of the report.
- The information was used to update the existing conceptual geohydrological model. This formed the basis of the numerical modelling used to complete the impact assessment

presented in this report.

- The numerical model design was adjusted to include the proposed new mining areas. The model was calibrated with the 2022 dataset and was used to complete the impact prediction presented.
- This report is compiled based on the requirements of GNR 267 of the National Water Act (1998) (NWA). The report format is also based on the requirements of the Department of Water and Sanitation (DWS) Best Practice Guideline (BPG) G4 (2008).
- Compliance to the requirements of the Regulations of the National Environmental management Act (Act no. 107 of 1998), GN No. 326 of 07 April 2017 is presented in Table 2 of this report.

2.1 Alternatives considered

According to ABS Africa (2022), the following alternatives were considered:

- The No-go Option was assessed, but not considered feasible for economic development reasons.
- Property on which the project is located: this is restricted to the local geology and the targeted resource, which are the economic coal seams. The Kranspan Extension area is therefore also controlled by the presence of the target resource and the consideration of an alternative is not feasible.
- Ilima intends to mine shallower coal seams via opencast mining using the roll-over method. On the farm Vaalbank, the B and CL Seams will be mined. On the farm Roodebloem the E Seam will be mined. Underground mining is planned for a small section of the E Seam on the farm Kranspan. Coal seam depth and thickness dictates the feasible mining method. There are no alternatives for the type of mining.
- The design of the mining area has taken into consideration the environmental restrictions of the location. These include wetlands, pans, dams, ecologically sensitive areas as well as roads and railways. Buffer distances and minimum safety distances were used to delineate the extent of the mining areas. The position of the historical Union Colliery underground workings was also taken into consideration in the mine design.
- Ilima proposes to undertake concurrent rehabilitation during opencast mining. An alternative is to complete rehabilitation at the end of the life of the operations. Due to several considerations, including environmental impacts, this option is not under consideration. The concurrent rehabilitation approach is expected to have a positive impact on groundwater, as discussed later in this report.
- The mining schedule furthermore also includes planning for concurrent rehabilitation. The objective is to return as much as possible of the disturbed area to productive use post closure.
- A coal washing plant with a filter press will be established on the Farm Roodebloem within the Kranspan Extension area to process coal earmarked for export. Dry crushing and screening of the coal earmarked for local supply to ESKOM will take place at the existing and already approved at Kranspan Mine.
- Two discard management alternatives were considered during the 2019 geohydrological studies for the farm Kranspan (iLEH 2019a and b). This includes a surface discard disposal facility and alternatively in-pit disposal. This activity will not be re-assessed as part of the Kranspan Extension project, as all discard generated from the Kranspan Extension project will be disposed of to Pit 5 on the farm Kranspan. Ilima is currently in the process of applying for a water use license to obtain permission to do so.
- Other infrastructure-related alternatives considered include the use of conveyors instead of trucking of coal and the implementation of a railway siding as an alternative.

2.2 Report format

This report is compiled based on the requirements of GNR 267 of the National Water Act (1998) (NWA). The report format is also based on the requirements of the Department of Water and Sanitation (DWS) Best Practice Guideline (BPG) G4 (2008).

Compliance to the requirements of the Regulations of the National Environmental management Act (Act no. 107 of 1998), GN No. 326 of 07 April 2017 is presented in Table 2 of this report.

2.3 Geographical setting

The Kranspan Extension area is in the Komati River catchment, traversing quaternary catchments X11A and X11B, forming part of the Inkomati-Usuthu Water Management Area (WMA:3).

Most of the Farm Vaalbank is in the X11A quaternary catchment; drained by the Vaalwaterspruit. The Vaalwaterspruit is located west of the Farm Vaalbank and discharges into the Nooitgedacht Dam, approximately 17 km north from the project area. Farm portions in the eastern and north-eastern section of the Farm Vaalbank are in the adjacent X11B quaternary catchment.

The main drainage associated with quaternary catchment X11B is the Boesmanspruit and it is located approximately 5 km east of the project area. The Boesmanspruit also discharges into the Nooitgedacht Dam.

2.4 Geohydrological Study Objectives

The amended geohydrological impact assessment has the following objectives:

- Update the existing numerical model to define groundwater related impacts associated with Kranspan Extension Project;
- Delineate the zone of influence associated with the proposed mining activities.
- Delineate extent of possible contamination originating from the proposed mining areas and mine infrastructure, based on the additional dataset
- Complete a decant assessment based on the extent of mining; and
- Prepare recommendations relating to the groundwater management and the monitoring in addition to that proposed in the 2019 study (iLEH 2019a and b).

2.5 Hydrocensus

A hydrocensus was completed during July 2022 over the farms Kranspan, Vaalbank and Roodebloem.

As discussed earlier, 19 additional groundwater sites (boreholes and springs) were identified in addition to the hydrocensus completed in 2019 (iLEH 2019a and b). The locations of these boreholes are indicated on Figure 2. Details regarding the outcome of the hydrocensus are discussed later in this report.

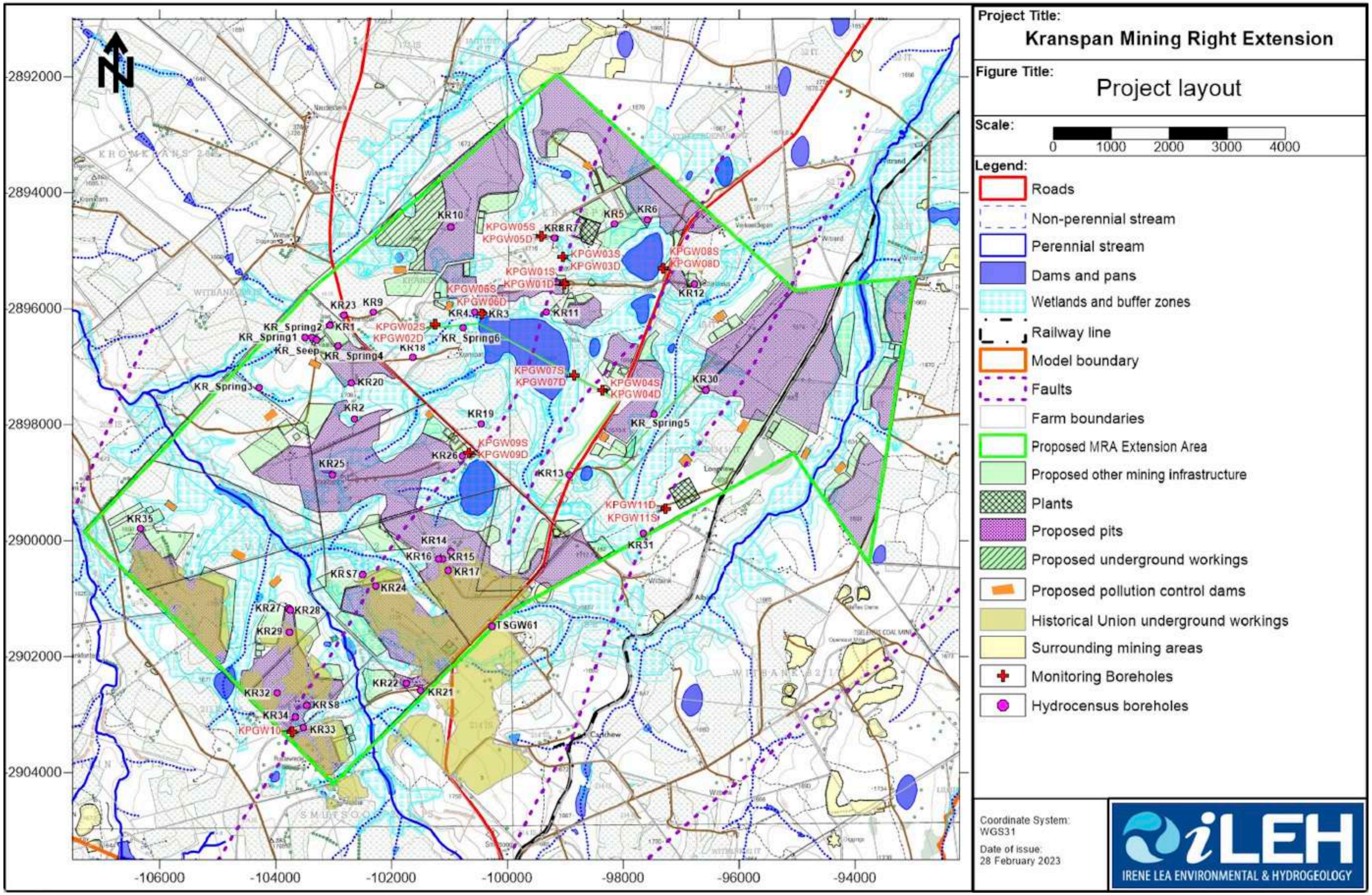

Figure 2 Project layout map

2.6 Additional fieldwork undertaken as part of the assessment

The following fieldwork in addition to the hydrocensus discussed above, was undertaken as part of the Kranspan Extension Project:

- A geophysical survey to identify drilling targets for dedicated groundwater monitoring boreholes.
- A groundwater monitoring borehole drilling programme.
- Aquifer testing of newly drilled monitoring boreholes.
- Groundwater sampling of new monitoring boreholes.
- Sampling of rocks for geochemical analysis and acid base accounting.

The activities listed above are discussed in more detail later in this report.

2.7 Recharge

Based on a literature review, the rate of recharge to undisturbed Karoo sediments vary between 1 – 3% of MAP.

The rate of recharge can however increase significantly over subsided mining areas. Steyn (2019) reports that the rate of recharge over rehabilitated sinkholes is estimated to be around 9% of MAP.

In addition to this information, the following recharge rates published in literature was considered:

- Recharge over pits: 11 – 18% of MAP (Van Tonder et al, 2006).
- Recharge over stooping: 6 – 13% of MAP (Hodgson and Lucas, 2010)
- Recharge over rehabilitated opencast pits: 14% of MAP (JMA, 2012)

2.8 Groundwater modelling

The information available for the project area was used to construct and calibrate a numerical groundwater flow and contaminant transport model. Details of this are discussed later in this report.

2.9 Groundwater availability assessment

Ilima has indicated that potable water will be supplied to the mine from groundwater. Based on an assessment of the 2019 and 2022 borehole drilling and testing programmes, a number of boreholes are available for abstraction for this purpose. These are listed in Table 1. Please note that the borehole IDs have been assigned according to the Ilima format in the table. Borehole IDs used in the fieldwork programme are also provided as reference.

The newly drilled boreholes are earmarked for monitoring and was not constructed for water supply purposes. In the deeper monitoring boreholes, the shallow groundwater strikes are sealed off with steel casing. Shallow groundwater strikes were encountered in the weathered aquifer, but it is not guaranteed that groundwater can be sustainably abstracted from these boreholes. Additional pumping tests will be required to confirm this.

It is not recommended that any of the boreholes listed in Table 1 are pumped for longer than 8 hours per day. Any groundwater abstraction must furthermore be closely monitored to ensure that over abstraction does not take place.

Based on the information presented in Table 1, the boreholes with the highest yield that can be considered for groundwater supply are KPGW06D (PM1) and KPGW08D (PM3), the locations of which are indicated on Figure 2. These boreholes are both located near the two large pans on the farm Kranspan.

Table 1 Estimated borehole sustainable yield

BH ID	Latitude	Longitude	BH Depth (m)	Blow yield	Estimated sustainable yield (l/s)
KPGW02D (2-50)	26°10'18.91"S	29°59'14.14"E	50	0.3l/s at 35m	0.20
KPGW03D (5-110)	26° 9'41.29"S	30° 0'33.81"E	50	2.8l/s at 35m	1.50
KPGW04D (6-220)	26°10'56.51"S	30° 0'57.79"E	50	0.7l/s at 45m	0.34
KPGW05D (Site 8)	26° 9'29.79"S	30° 0'20.37"E	50	0.3l/s at 35m	0.3
KPGW06D (PM1)	26°10'12.94"S	29°59'43.45"E	50	0.6l/s at 30m	2.1
KPGW08D PM3	26° 9'48.17"S	30° 1'36.13"E	50	>2.8l/s	18.8 (fracture) 5.7 (formation)
KPGW09S (VAGW01S)	26°11'30.82"S	29°59'35.14"E	20	0.41 l/s at 10m	0.05
KPGW11S (ROGW03S)	26°11'58.10"S	30°01'45.15"E	20	0.27 l/s at 15m	0.21

Borehole yield information was not available for hydrocensus boreholes visited during 2022. Owners indicated that the borehole yields were low.

2.10 Date and season of investigation

The hydrocensus completed for the project was undertaken in July 2022. Dedicated groundwater monitoring boreholes were subsequently drilled between November and December 2022.

In addition, monitoring data made available by Ilima for the Kranspan area spans the period May 2020 to October 2022.

The data considered in this assessment therefore represents wet and dry season conditions.

2.11 Wetlands

The extent of wetlands presented in this amended report was provided by ABS Africa in digital format. The extent of wetlands is included in all figures presented in this report.

2.12 Climate and rainfall

The climate of the project area is mild to warm during the summer and cool to cold during the winter. During the rainy season it is sub-humid, but during the cold dry season it is mildly sub-arid. Rain occurs as mild to heavy showers and thunderstorms during the summer months between November and February, with an average of 500 to 750mm per year (ABS Africa, 2018). The winter months are dry. Heavy falls (>100mm) in a single 24-hour period do not occur.

The mean annual precipitation (MAP) for the mining area is 698mm/a (Peens & Associates, 2019). In comparison, the mean annual evaporation (MAE) for the area is 1 450mm/a, which is twice as high as the rainfall.

3 PREVAILING GROUNDWATER CONDITIONS

The information presented in this section of the report is similar to that included in the initial geohydrological impact assessment (iLEH, 2019). It is included for ease of reference and added to where additional information is available.

3.1 Geological setting

3.1.1 Regional and site-specific geology

The Kranspan project is located in the Ermelo Coal Field. Compared to the adjacent Witbank and Highveld Coal Fields, the Ermelo Coal Field hosts thinner seams, is sedimentologically and structurally more complex and is not as well studied or understood (Ilima, 2018 and 2022). The coalfield is underlain by glacial pre-Karoo rock formations, including the Dwyka tillite. The Karoo Supergroup hosts all the South African coal deposits. The coal in the Carolina area occurs within the Vryheid Formation of the Ecca Group, which forms part of the Karoo Supergroup. Five coal seams are recognised within an 80 – 90m thick sedimentary succession. These are, from the top down, the A to E Seams. The regional geological setting for the project is indicated on Figure 3.

A dolerite sill occurs in the area, usually above the C-seam and has been identified towards the west and north of the big pan, on the farm Kranspan. The intrusion has resulted in the devolatisation of the coal in certain areas in the south of the project area. No significant structural faults have been identified (Ilima, 2018 and 2022). It is however noted that dolerite intrusions typically act as aquitards and tend to compartimentalise aquifers. The contact zone between the intrusion and the host rock can however form preferential flow paths to groundwater.

There are two major structural geological features which may have an impact on groundwater flow and possibly mining. These possible dyke structures extend from north to south, with the one structure underlying the big pan on the farm Kranspan and the second roughly following the R36 road.

In addition, five regional lineaments strike in a northeast-southwest direction across the mining area, as indicated in Figure 3. These sub-parallel and is thought to sub-outcrop in the area. The dip of these structures are not fully understood, but they are generally horizontal to sub-horizontal in nature.

The groundwater monitoring borehole drilling programmes undertaken during 2019 and 2022 focussed specifically on the regional lineaments. They were identified and fault zones within the Karoo sediments that exhibit enhanced aquifer conditions. It is noted that several private boreholes identified during the hydrocensus also target these fault zones, suggesting that they form important aquifers in a regional context.

The coal seams are underlain by Dwyka Tillite, which forms the basement of the Karoo sediments. A section of tillite is exposed to the north and east of the mining area, as shown in Figure 3.

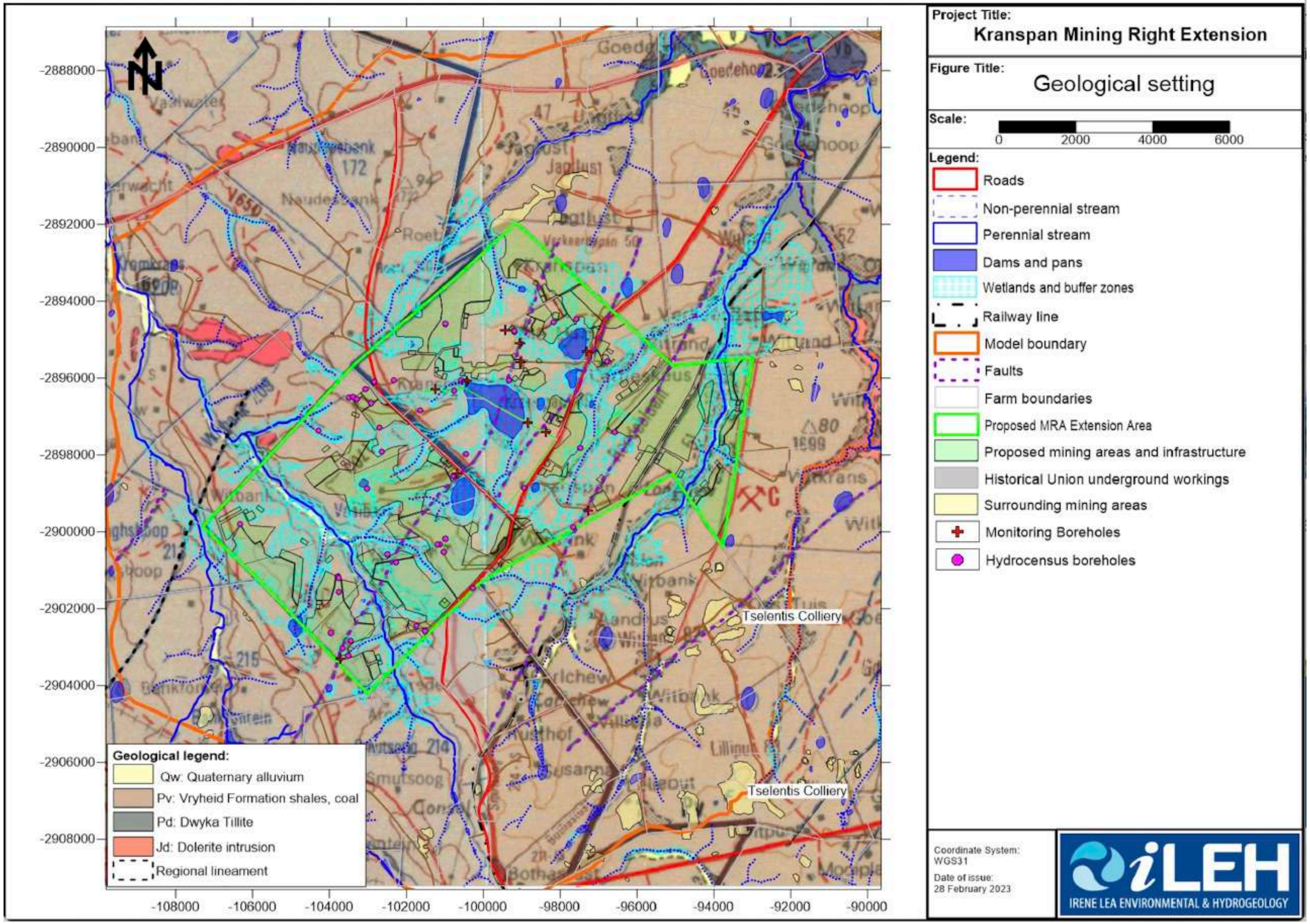

Figure 3 **Geological setting**

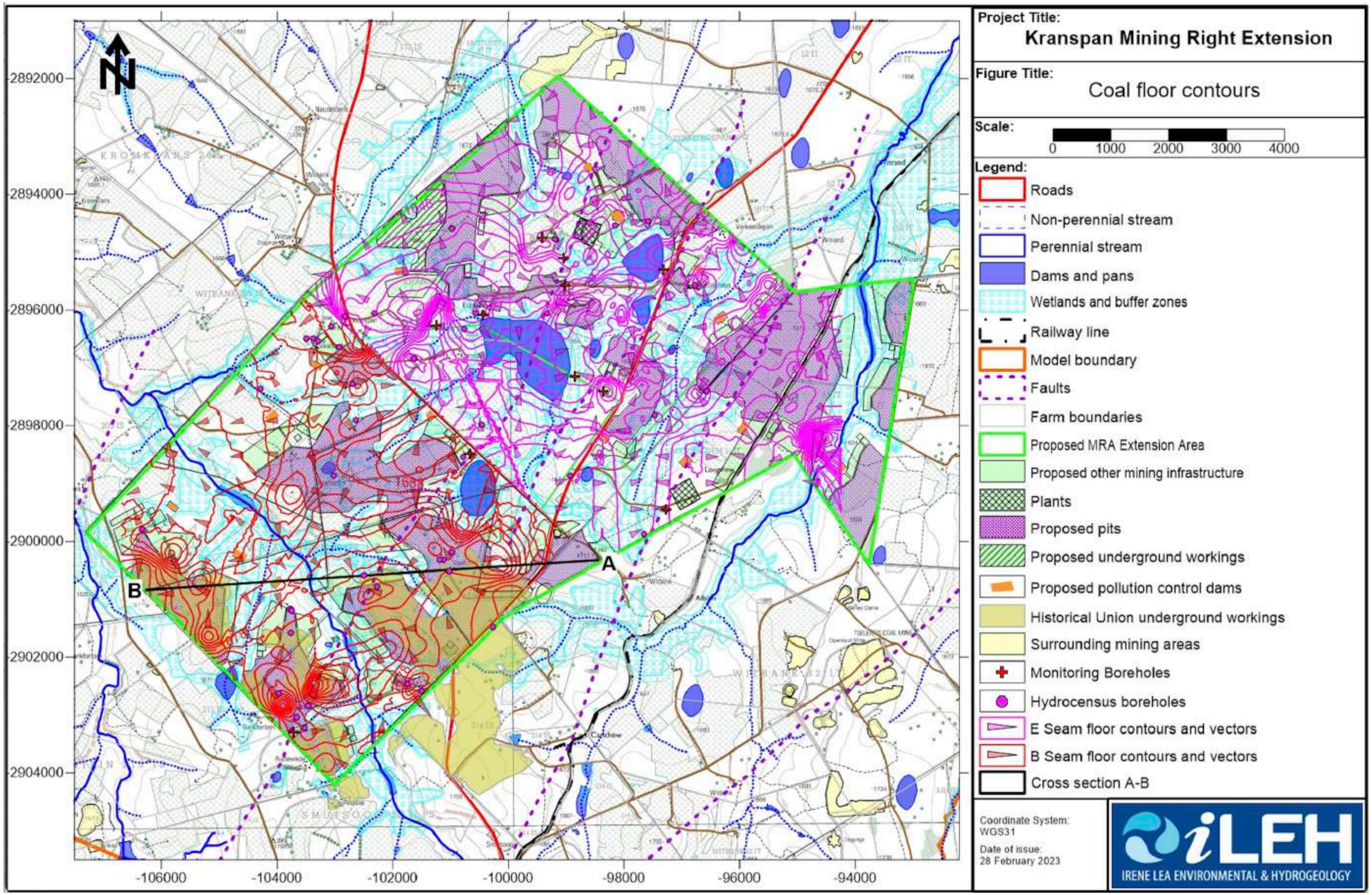

Figure 4 **Coal floor contours**

3.1.2 Coal seam floor contours

As mentioned, within the Ermelo Coalfield, five coal seams are present within an 80 – 90m thick sedimentary succession. The A Seam, although present in the project area, is too thin to be of economic interest (Ilima, 2018 and 2022). The B Seam varies from 1 – 2,7m in thickness and splits into two units, referred to as the B Lower and B Upper Seams. It is thought that the quality of the B Seam is often inferior to that of the C Seam, which makes it uneconomical. Normally the C Seam is the main economic coal deposit in the Ermelo Coal Field. Unfortunately it is not economically mineable in the Kranspan area. The D Seam is of good quality, but is generally too thin (0,1 – 0,4m) to be of economic importance. The E Seam is the main mining target in the Kranspan project area. The coal is mostly bright and banded and has a competent sandstone roof and floor. It is sometimes split by a thin sandstone or carbonaceous fines parting.

Within the Kranspan and Roodebloem mining areas, mining will be undertaken to the depth of the E Seam floor. The shape of the coal floor in the pits and underground workings will control the movement of water during mining and post closure. For this reason, it is important to understand the coal floor contours. The E Seam floor contours in the Kranspan and Roodebloem areas are presented in Figure 4. It is shown that the coal floor undulates over the paleo basement sediments. The E Seam regionally however seem to dip in a northerly to westerly direction, with local variations as shown.

Ilima will target the B and CL Seams in the Vaalbank mining area. Most of the mining is however focussed on the B Seam. The B seam floor contours are presented in Figure 4. The coal floor contours dip in a southerly to westerly direction. In places, the seam is displaced by the regional fault zones. For example, in the southern portion of the Vaalbank mining area, the seam is displaced by up to 30m on either side of the fault.

The C and E Seam was mined from the old Union Colliery underground workings. Ilima therefore proposes to mine above the historical workings, but may intersect the C Seam underground workings during opencast mining. Based on exploration borehole information made available, the Union underground E Seam workings will be 10 – 30m below the proposed Ilima opencast pits.

3.2 Acid generating capacity

ABS Africa completed leach tests and acid base accounting on 12 rock samples. The results of the analysis are presented in Table 2.

Table 2 Acid base accounting on rock samples.

Sample ID	Nett acid generation pH	Nett acid generation 4.5 (kg H_2SO_4/t)	Nett acid generation 7 (kg H_2SO_4/t)	Acid Potential (kg H_2SO_4/t)	Nett neutralising capacity (H_2SO_4/t)	Nett acid producing potential (H_2SO_4/t)
RBM 12 Shale 10m	5,86	<0.01	1,76	2,70	1,77	-4,47
RBM 12 Sand Coal Roof	2,62	18,82	4,70	30,63	-0,25	-30,38
RBM 12 Coal Floor	3,19	4,70	4,51	7,24	0,25	-7,50
RBM 13 C. Sand 6.5m	4,08	1,18	6,27	2,36	0,51	-2,87
RBM 13 21-22.20m	3,12	4,51	2,55	7,32	0,00	-7,32
RBM 13 21-22.20m	3,09	5,29	2,16	7,32	-0,25	-7,07
RBM 13 Floor	5,07	6,86	2,94	9,12	-0,25	-8,87
RBM 15 TOH	6,65	0,98	8,04	0,31	-0,25	-0,06
RBM 15 Sand 11.5m	7,49	<0.01	0,98	7,81	12,00	-19,81
RBM 15 Roof	7,36	<0.01	5,88	3,37	3,29	-6,66
RBM 15 Floor	5,68	6,27	2,94	10,92	-0,76	-10,17
RBM 15 Floor	5,64	6,47	3,33	10,76	0,51	-11,26

The information presented in Table 2 was used to evaluate the acid forming potential of the samples taken. The nett acid generation pH and the nett acid producing potential calculated from the data were used to assess whether the rock samples are potentially acid forming according to AMIRA, 2002). The results are presented in Figure 5. It is shown that most of the samples are classified as non-acid forming due to negative net acid producing potentials.

None of the samples plot in the potentially acid forming zone.

Five of the samples are classified as uncertain. These include the coal roof and floor of two samples and overburden material from three samples. It is noted that the coal roof and floor samples taken are classified as Type 1 rocks (Usher et al, 2003). These samples are considered potentially acid forming , based on this geochemical screening method.

In conclusion, most of the rock samples taken are not likely to form acid during the life of mine and post closure. The coal roof and floor samples are however considered to be acid forming.

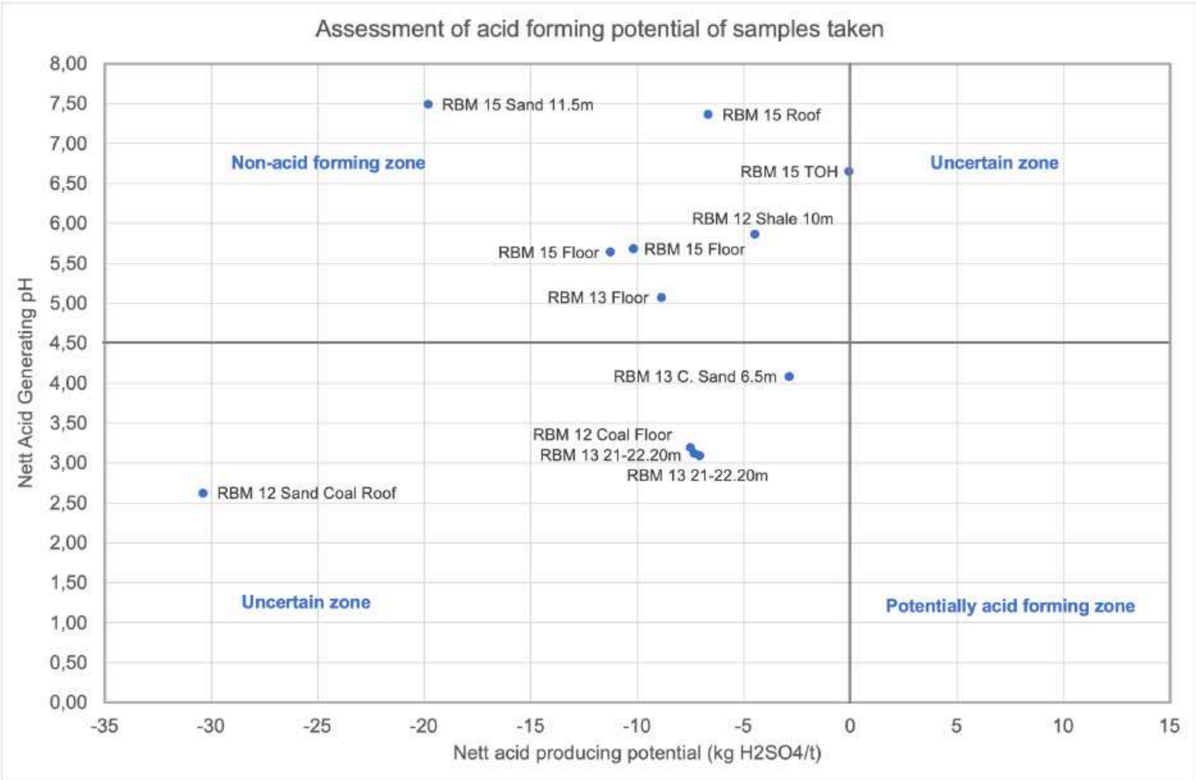

Figure 5 Assessment of acid forming potential of rock samples taken

An analysis of the pH of existing groundwater samples from the current study as well as monitoring information from 2022 to 2022 from the Kranspan boreholes, is presented in Figure 6. In this figure, the correlation between pH and Total Dissolved Solid (TDS) is presented.

It is shown that all but one of the samples fall within SANS241:2015 Drinking Water Standards in terms of pH and TDS concentrations. The majority of the samples have a neutral to alkaline pH and TDS concentrations below 300 mg/l. Five of the samples have slightly acidic to neutral pH, including two private boreholes (KR19 and KR25). The locations of these boreholes are indicated on Figure 2. Neither of these boreholes are near existing mining activities and therefore probably represent natural groundwater conditions. Borehole KPGW09D is located along one of the fault zones identified, but is also not situated near existing mining activities.

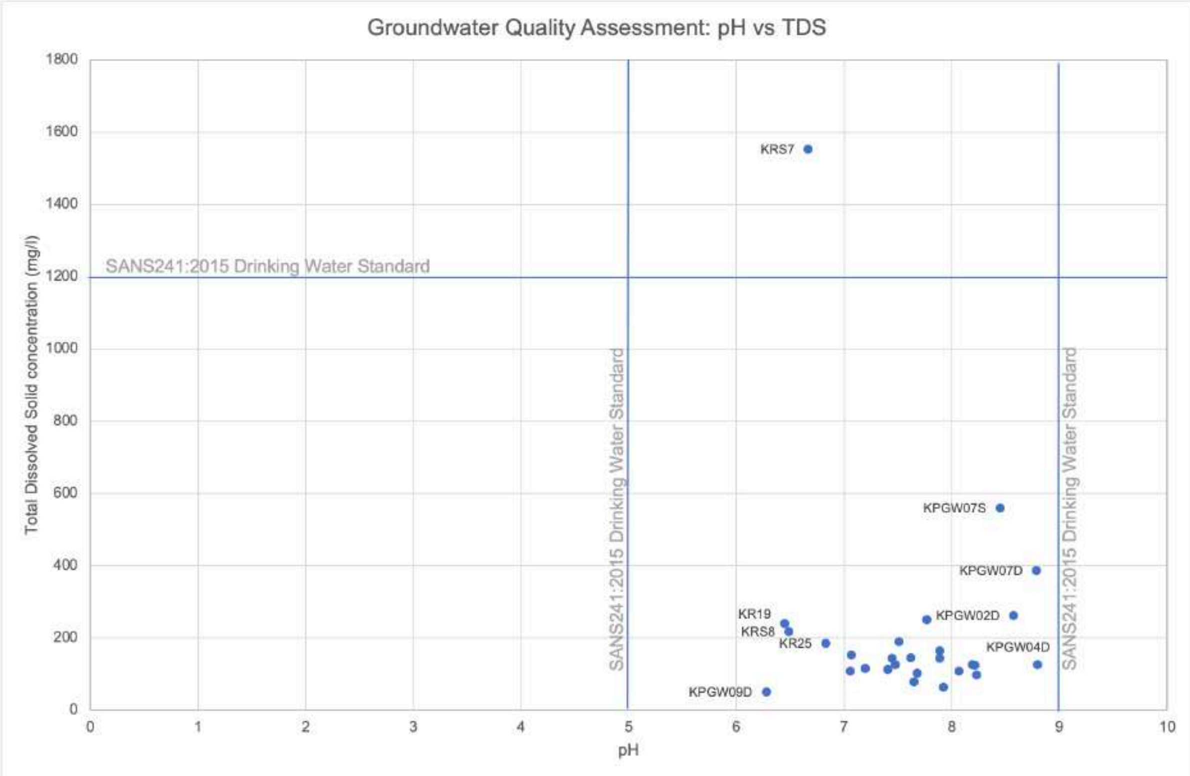

Figure 6 Groundwater: comparison between pH and TDS

Sample KRS7 represents the current decant point from the historical Union Colliery workings. This water has elevated TDS concentrations and a slightly acidic pH.

Sample KRS8 is also a spring identified in the historical Union Colliery mining area and could also be associated with mine decant. The quality of this sample is however markedly different from KRS7 and has low TDS concentrations and a slightly acidic pH.

Analysis of the groundwater monitoring data confirms that ambient groundwater is of good quality. Water affected by historical mining has high salt content and a slightly acidic pH.

3.3 Geohydrology

3.3.1 Current groundwater use

Groundwater Abstract conducted a hydrocensus across the proposed Kranspan mining area during July 2022. The survey included the proposed mining footprint areas as well as the adjacent properties. The hydrocensus focussed on identifying existing private boreholes and private groundwater use and to enhance the knowledge of the aquifers present. The details recorded are presented in Appendix 1.

The 19 sites identified during the 2022 hydrocensus, including 17 boreholes and 2 springs. The 2 springs are used for domestic and animal use. The one (strong flowing) spring (KRS7) was identified as an old underground mining decanting point. Groundwater use is summarised as follows:

- 6 of the 17 boreholes are in use:
  - 3 boreholes fitted with a submersible pump;
  - 2 boreholes are fitted with a windpump;
  - 1 borehole fitted with a handpump;

- 4 boreholes are equipped, but not in use – old mono- and windpumps; and
- 3 open boreholes are used for groundwater monitoring, by nearby mines; and
- 4 open boreholes, not in use.

Groundwater level measurements were possible in 13 of the 2022 hydrocensus boreholes and in 16 of the 2019 hydrocensus. Pumping equipment blocked the remaining boreholes visited. Eleven groundwater samples were collected for water quality analysis during the hydrocensus.

Based on communication with the land owners the springs in the area are seasonal, with the exception of KRS7 and KRS8 that flow throughout the year. The springs serve as water supply to livestock and wildlife in the area. KRS7 is the most prominent feature identified during the 2022 hydrocensus, based on flow rate. During the hydrocensus the discharge rate was +10,000 L/hr, but red staining was evident on the rocks and streambed. As mentioned, this was identified as a decant point associated with the old Union underground mine workings.

Detailed information in terms of borehole construction and yields are not available for the identified private boreholes. The information provided by land owners suggest low borehole yields for most of the project area.

3.3.2 Groundwater monitoring boreholes

3.3.2.1 Geophysical Survey

A ground geophysical investigation was conducted to identify geological structures, which could act as preferential groundwater flow paths and potentially good water yielding aquifers. The geophysical survey has been used in conjunction with the available remote sensing images and geological maps. The two north-south striking lineaments indicated on the published geological map were the main targets. Others included the dolerite sill and potential deep weathered zones across the study area, plus the old underground mine decant point.

The geophysical investigation was conducted during October 2022. The following techniques were applied:

- EM 34–3 electromagnetic (EM) system, with a coil spacing of 20 m, and a station spacing of 10 m; and
- Magnetic survey.

The survey included 5 survey lines, and line and station coordinates were marked in the field using a Garmin hand-held GPS. The geophysical data is presented in Appendix 2.

3.3.2.2 Drilling Programme

Based on the geophysical survey results and an understanding of the local geology, 3 suitable drilling positions for groundwater characterisation purposes were identified. The percussion drilling programme was carried out during November 2022 by WJ Water Drilling. Two groundwater characterisation and monitoring boreholes were drilled at each of the three target areas. The first borehole was drilled to a depth of 50 m below surface, with the aim of characterising and monitoring the deeper fractured aquifer. The second borehole was drilled 20 m deep, with the aim of monitoring the shallow weathered aquifer and possible connection between the deeper fractured aquifer and the shallow weathered aquifer in the area. The borehole construction details are as follows:

- Deep boreholes (50 m) – diameter of the solid steel casing is 170 millimetres (mm) from surface to 20 m below surface. Beyond this depth the diameter of the borehole is 165 mm.
- Shallow boreholes (20 m) – drill diameter is 215 mm with 165 mm steel casing installed over the full depth of the borehole. The bottom 12 m is perforated.

Data collected include the recording of geological formations at 1 metre intervals, water strike depths, the cumulative final blow yield and final rest water level. The borehole logs are presented in Appendix 3.

A summary of the 2022 drilling programme is presented in Table 3. The borehole IDs assigned during the fieldwork programme were changed in this report to reflect Ilima borehole naming convention. Both borehole IDs are however indicated in the table for ease of reference.

It is shown that the depth of weathering in the boreholes vary between 6 and 27m in the monitoring boreholes.

The monitoring boreholes produced blow yields of between zero (thus dry) and 1 500 L/h, which is equivalent to 0.42l/s. In general, borehole yields throughout the project area are low.

Most of the groundwater strikes are associated with the shallow weathered aquifer, varying between 10 to 15m below surface. The weathered and fractured sandstone and the fractured dolerite yielded more water. The coal seams, deeper fractured formations and the geological contacts only intersected seepage.

At present, planning is underway to drill additional boreholes in the vicinity of the identified decant point. This drilling is hampered by wet field conditions. This information will be incorporated into the geohydrological study, when available.

Table 3 Summary of 2022 groundwater monitoring borehole drilling programme

		Borehole ID	KPGW09S Previously: VAGW01S	KPGW09D Previously: VAGW01D	KPGW10 Previously: VAGW02	KPGW11S Previously: ROGW03S	KPGW11D Previously: ROGW03D
Borehole Location	WGS84	Latitude	26°11'30.82"S	26°11'30.83"S	26°14'06.56"S	26°11'58.10"S	26°11'58.07"S
		Longitude	29°59'35.14"E	29°59'35.09"E	29°57'44.44"E	30°01'45.15"E	30°01'45.09"E
		Elevation	1691 mamsl	1690 mamsl	1717 mamsl	1699 mamsl	1698 mamsl
Borehole Data	Borehole Depth (m)		20	50	70	20	50
	Blow Yield (L/h)		1500	Seepage (shallow strikes sealed of)	dry	1000	Seepage (shallow strikes sealed of)
	Water Strike depth (m)		10m – 0.41L/s	10m – 0.3L/s 32m – seepage 37m - seepage	none	11m – seepage 15m – 0.27L/s	11m – seepage 13m – 0.55L/s 31m – seepage 41m – seepage
	Main Strike Geology		weathered sandstone	Fractured sandstone in sandstone sandstone carbonaceous shale contact	---	fractured dolerite dolerite/ sandstone contact	weathered dolerite fractured dolerite fractured shale sandstone colour change contact
	Borehole Geology		Sandstone, shale, coal	Sandstone, shale, coal	Sandstone, shale, coal	Sandstone, dolerite	Sandstone, shale, dolerite
	Casing installed		8 m solid steel casing. 12m perforated casing at bottom. 170 mm ID	20 m solid steel casing. 170 mm ID	20 m solid steel casing. 170 mm ID	8 m solid steel casing. 12m perforated casing at bottom. 170 mm ID	20 m solid steel casing. 170 mm ID
	Static Water Level (m bgl)		11.11	3.76	29.17	3.08	21.47
	Depth of Weathering		10m	6m	14m	15m	27m

3.3.2.3 Aquifer Testing

Following completion of the drilling programme, an aquifer test programme was initiated to determine the hydrogeological characteristics of the local aquifers. The following information was obtained from the tests:

- Borehole drawdown and recovery characteristics.
- Aquifer hydraulic parameters: Transmissivity (T) defined as the product of the average hydraulic conductivity (K) and the saturated aquifer thickness. It is a measure of the rate of flow under a unit hydraulic gradient through a cross-section of unit width over the whole saturated thickness of the aquifer. The unit of measurement is m^2/day.
- Characterisation of aquifer flow boundaries such as low permeable, no-flow or recharge boundaries. No-flow or low permeable boundaries refer to a lower transmissive structure (e.g., fracture with a lower conductance or low permeable dyke) or aquifer boundary (limit of aquifer – no-flow boundary) that results in an increase in groundwater drawdown during borehole abstraction. Recharge boundaries relate often to leakage from surface water bodies.

The aquifer testing was completed during December 202, as follows:

- 12-hour constant drawdown test on 2 new boreholes:
  - KPGW09S (VAGW-01 s), which was dewatered within 30 minutes
  - KPGW11S (ROGW-03 s)
- Slug test were completed on the following boreholes as a result of low blow yields:
  - KPGW09D (VAGW-01 d)
  - KPGW10 (VAGW-02)
  - KPGW11D (ROGW -03 d).

Prior to the aquifer test, static groundwater levels are measured in the pumping and observation boreholes to enable drawdown calculations during test pumping. Pumped water was released via a discharge pipe at least 100 m from the test borehole, to avoid rapid recharge from the discharged water. During the test, the abstraction rate is continuously monitored by means of electronic flow meters and calibrated by manually measuring the time it takes to fill a container of known volume, with a stopwatch and drum. The pumping test programme included the following different tests:

- A step drawdown test (SDT) is performed. During the SDT the borehole is pumped at a constant discharge rate for 60 minutes, where after the step is repeated at a progressively higher discharge rate. During the SDT the drawdown over time is recorded in the pumping borehole. The advantage of this test is that the pumping rate for any specific drawdown can easily be determined from the relationship between laminar and turbulent flow. After the test was completed, residual drawdown is measured until approximately 90% recovery of the water level has been reached. The discharge rate for the constant discharge test is calculated from the interpretation of the time drawdown data generated during the SDT.
- The constant discharge test (CDT) follows the SDT. During a CDT a borehole is pumped for a predetermined time at a constant rate. During the CDT test the drawdown over time is recorded in the pumping and observation boreholes. Discharge measurements are taken at predetermined time intervals to ensure that the constant discharge rate is maintained throughout the test period. Any changes in discharge rate are recorded. The duration of CDT at Vaalbank and Roodebloem was 12-hours. During CDT, the aquifer needs to be stressed sufficiently to identify boundary effects that may impact on long-term

aquifer utilization.

- The recovery test (RT) follows directly after the CDT is completed. The residual drawdown over time (water level recovery) is measured in pumped and observation boreholes until approximately 90% recovery is reached. Aquifer parameters and sustainable borehole yields can be derived from the time drawdown data of the CDT and recovery tests by application of a variety of analytical methods.

The aquifer test data was analysed using the Flow Characteristic Method or FC Method (Van Tonder et al, 2001). The FC method uses the first and second order derivatives interpreted from time drawdown data (during test pumping), available drawdown, boundary conditions and recharge to derive sustainable borehole yields. The method is suited for characterising fractured rock aquifers.

A summary of the test programme is given in Table 4.

The recovery of the groundwater level after abstraction is a good indicator of the aquifer's transmissivity, recharge and the borehole's potential yield. The recovery data (for the tested boreholes) indicate that the recovery is slow and that full recovery (100%) is often not achieved within the predetermined testing timeframe. The aquifers intercepted were all shallow (first 15 m below surface).

The low borehole yields, fast water level drawdown and slow recovery observed during the aquifer testing indicate low transmissivity (T) aquifers, with low recharge. The average T-values calculated from the test data range between 0.3 and 2.1 m^2/d. The highest T-value (2.1 m^2/d) was observed at the boreholes on Roodebloem, which targets fractured dolerite. The slug tests yielded hydraulic conductivity values of approximately 0.09 to 0.3 m/d.

Table 4 Aquifer test programme summary

		Borehole ID	KPGW09S (VAGW-01 s)	KPGW11S (ROGW-03s)	KPGW09D (VAGW-01d)	KPGW10 (VAGW-02)	KPGW11D (ROGW-03d)
Location	WGS84	Lat	26°11'30.82"S	26°11'58.10"S	26°11'30.83"S	26°14'06.56"S	26°11'58.07"S
		Long	29°59'35.14"E	30°01'45.15"E	29°59'35.09"E	29°57'44.44"E	30°01'45.09"E
		Elevation	1688 mamsl	1699 mamsl	1687 mamsl	1717 mamsl	1698 mamsl
Aquifer Test Data	Available Drawdown (m)		13	16	--	---	---
	Step 1 (L/s) / Drawdown (m)		0,19 / 13.1	0.29 / 2.0	---	---	---
	Step 2 (L/s) / Drawdown (m)		---	0.42 / 4.15	---	---	---
	Step 3 (L/s) / Drawdown (m)		---	0.81 / 8.72	---	---	---
	Step 4 (L/s) / Drawdown (m)		---	1.5 / 14.32	---	---	---
	Step Recovery - % vs time		34% (6hrs)	906% (1.5 hrs)	---	---	---
	Constant Discharge (L/s)		--	0.54	slug test	slug test	slug test
	Duration (min)		--	720	9	5	11
	Available Drawdown (m)		--	16	47	40	47
	Final Drawdown (m)		--	10.68	0.39	0.3	0.47
	Obs Bhs		--	water level 3.81m / 50m deep / 2.61 m DD	---	---	---
	Recovery - % vs time		--	90% (12hrs)	100% (8.5 min)	very slow recovery	45% (11 min)
	FC Method						
	T - m^2/day		0.3 to 1.0	2.1	--	--	--
	K - m/day (Bouwer-Rise)		---	---	0.091	0.224	0.367
	Safe abstraction rate (L/s)		0,05	0.21	--	---	---

3.3.3 Unsaturated zone

ABS Africa (2022) reports that the soils present are typically associated with Highveld Soils Cantena. These include pedologically young and shallow lithosols of the Hutton (Hu) and Glenrosa (GS) Formations. These soils generally have a red and yellow colour and are considered to be weak structured soils with a high organic content.

The project is situated in the Eastern Temperate Freshwater Wetlands. At least four wetland types were identified. At least four wetland types were identified within the proposed mining area, including channelled and unchanneled valley-bottom wetlands, as well as depression wetlands and seeps. The locations of these wetlands including the defined buffer zones, were taken into consideration in this study. This is discussed in more detail in the conceptual model below.

3.3.4 Saturated zone

Two main aquifers are typically found in the Karoo sediments of the Ermelo Coal Field. These are a shallow weathered aquifer and a deeper fractured rock aquifer. These are discussed in more detail below.

Please note that perched water in the soil horizon does not form part of the geohydrological study. It is noted that this water often contributes to wetland functioning in the region.

3.3.4.1 Weathered aquifer

The shallow weathered aquifer forms within the limit of weathering (LOW). Information on the LOW available from exploration boreholes, National Groundwater Database (NGDB) boreholes and the newly drilled monitoring boreholes is summarised in Table 5.

Table 5 Summary of information on the limit of weathering in the project area

Source	Minimum depth (m)	Maximum depth (m)	Average depth (m)
NGDB boreholes	0,3	15,8	6,4
Exploration boreholes	1,3	14,9	5,7
Monitoring boreholes	3	50	15,5

It is shown that the average depth of the LOW varies between 5,7 and 15,5 from the three available sources. For the purpose of conceptualisation, it will be assumed that the average LOW is down to a depth of 15m. This depth will be used to estimate the extent of the upper weathered aquifer during the geohydrological impact assessment presented in this report.

Clay material was found in boreholes drilled around the larger of the two pans on site. This suggests that the pans are formed on clay lenses that do not facilitate vertical infiltration of surface water. The clay lenses are most probably associated with highly weathered dolerite sills that were identified during the exploration drilling phase of the project.

The permeability of weathered aquifer is variable, but groundwater occurrence is most often associated with the transition between weathered and fresh rock. In this area, the dolerite sill could form a barrier between the upper weathered and deeper fractured rock aquifers. At present, the permeability of the dolerite is not known, but based on experience in similar aquifer conditions, it is thought that the permeability of fresh and unfractured dolerite is low compared to the host rock and that it will therefore act as an aquitard or even an aquiclude, forming a barrier to the vertical flow of groundwater from the weathered to fractured rock aquifers.

In low-lying areas, the groundwater table is shallow. Springs develop in the weathered aquifer where groundwater seeps to surface along areas of lower permeability for example against a dolerite intrusion or a palaeographic high or where the topography cuts into the water table. Six springs were identified during the hydrocensus (see Appendix 1).

The average depth to groundwater in all shallow boreholes drilled varies between 1,04 and 11,11m below surface.

This aquifer is not considered significant in terms of water supply due to its limited thickness. Two of the shallow boreholes drilled during 2022 yielded groundwater. These water strikes were encountered at depths of between 10 and 15m below surface. This is typical of the area, where groundwater recharged from rainwater collects along the depth of weathering. The shallow groundwater occurrence is also linked to the position of wetlands in this area.

The transmissivity of the shallow aquifer is calculated as 0.3 – 1 m^2/d at borehole KPGW09S. This borehole is also associated the large pan present.

The rate of recharge to this aquifer is typically assumed to be around 1- 3% of the mean annual precipitation (MAP) (Hodgeson and Kranz, 1998). It is thought that recharge is closely linked to the wetlands present in the mining area.

3.3.4.2 Fractured rock aquifer

Underneath the shallow weathered aquifer, groundwater is associated with fractures, faults, bedding planes and contact zones with intrusions. The rock matrices are tight and do not transmit significant volumes of groundwater, as indicated from the results of the aquifer tests. Groundwater flow in the fractured rock aquifer therefore takes place along the identified preferential flow paths. These include the two major north NE-SW striking lineaments and the dolerite intrusions.

The lineaments delineated on the regional geological map (Figure 3) were identified as aquifers and will therefore preferentially transmit groundwater. Monitoring boreholes KPGW01, KPGW03, KPGW04, KPGW08, KPGW09, KP10 and KPGW11 target these lineaments. Some of the private boreholes also target these lineaments, including KR11, KR19, KR24, KR26, KR31, KR33, KR34 and the two seepage points KRS7 and KRS8.

The permeability of these aquifers is highly variable as it is dependent on the nature and extent of the secondary features mentioned. Results from the aquifer tests on these boreholes suggest that although the fractures carry groundwater, they are quickly dewatered when pumped due to the fact that inflows from the rock matrix are slow and cannot therefore sustain high volumes of groundwater abstraction. Transmissivities calculated from the aquifer tests for the lineaments vary between 19 and 26 m^2/d. Shallow boreholes that target these lineaments have enhanced aquifer conditions, for example KPGW09S with transmissivities of between 0,3 and1m^2/d. This is higher compared to transmissivities calculated for the unfractured rocks, where transmissivities vary between 0,3 – 7 m^2/d. The wide range in transmissivities calculated from the available data is typical of the heterogeneous nature of fractured rock aquifers.

For the purpose of this study, the lineaments will be referred to as fault zones.

The aquifer testing data obtained during this study further indicates that vertical groundwater flow between the weathered and fractured rock aquifers are generally low, except along the strike of the NE-SW faults. Where present, zones of increased permeability allow groundwater flow through otherwise tight rock matrices . Measurements in borehole pairs that were drilled into the lineaments confirm that groundwater levels in the shallow boreholes react when the deeper boreholes are pumped.

Depth to groundwater in the deeper boreholes varies between 09 and 29.17m, based on data from the private and monitoring boreholes. Groundwater levels in the monitoring boreholes vary between 0,9 and 29.17m below surface, which is on average similar to that measured in the shallow boreholes. How well the seals were installed into the annulus of the deeper boreholes affects groundwater level measurements. For the purpose of this study, it will be assumed that the seals are intact and that groundwater level measurements in the deep monitoring boreholes indicate conditions in the fractured rock aquifer.

Based on the information obtained, the average depth to groundwater in the deeper boreholes based on all the data points is 9,4m, which is just below the average limit of weathering. The average depth to groundwater in the monitoring boreholes is 4,7m, which falls within the limit of weathering. Based on this information, the fractured rock aquifer seems to be confined to semi-confined, as groundwater levels rest above the depth of groundwater strikes in these. The dolerite sill could play a role in creating confined conditions in the fractured rock aquifer, where it is present.

3.3.5 Hydraulic conductivity and transmissivity of the aquifers

Aquifer parameters obtained from the 2022 fieldwork programme are provided in Table 4.

3.4 Groundwater levels

Ilima has undertaken groundwater level monitoring in the Kranspan boreholes. The results are presented in Table 6. If it shown the average depth to groundwater in the shallow boreholes is 3.7m and 5.2m in the deep boreholes. This is comparable to the 2022 field dataset, with the exception of deeper groundwater levels in the southern and western portions of the farm Vaalbank. In this area, groundwater levels are deeper that regional trends, which is attributed to the impact of the historical Union Colliery. This is discussed below.

Table 6 Mine groundwater level measurements

Borehole	Elevation (mamsl)	Collar Height (m)	Groundwater level (mbgl)			
			May-20	Aug-20	Jul-22	Aug-22
KP GW01d	1689	0,5	8,03	8,72	8,34	8,53
KP GW01s	1689	0,7	2,22	2,87	1,75	1,83
KP GW02d	1681	0,5	4,32	4,83	2,92	3,24
KP GW02s	1681	0,6	4,39	4,91	3,23	3,48
KP GW03d	1702	0,5	5,79	6,45	4,533	4,78
KP GW03s	1702	0,8	6,67	7,42	4,91	5,27
KP GW04d	1673	0,7	4,43	4,85	3,41	3,66
KP GW04s	1673	0,5	4,06	4,59	3,55	3,52
KP GW05d	1720	0,5	11,32	12,13	10,86	11,12
KP GW05s	1720	0,7	6,1	6,61	4,78	5,17
KP GW06d	1662	0,5	1,2	2,2	1,27	1,1
KP GW06s	1662	0,8	1,56	2,87	0,99	1,01
KP GW07d	1660	0,5	0,79	0,96		
KP GW07s	1660	0,7	1,27	1,37		
KP GW08d	1656	1	6,39	6,2	5,6	5,78
KP GW08s	1656	0,8	6,05	6,33	3,25	3,34

Groundwater levels measured during the 2022 fieldwork phase of the project are presented in Table 2 and Appendix 1. This information was used to evaluate the correlation between topographical elevation and the depth to groundwater. The extent to which these parameters correlate will provide information on regional groundwater flow patterns. The results of the assessment are presented in Figure 7.

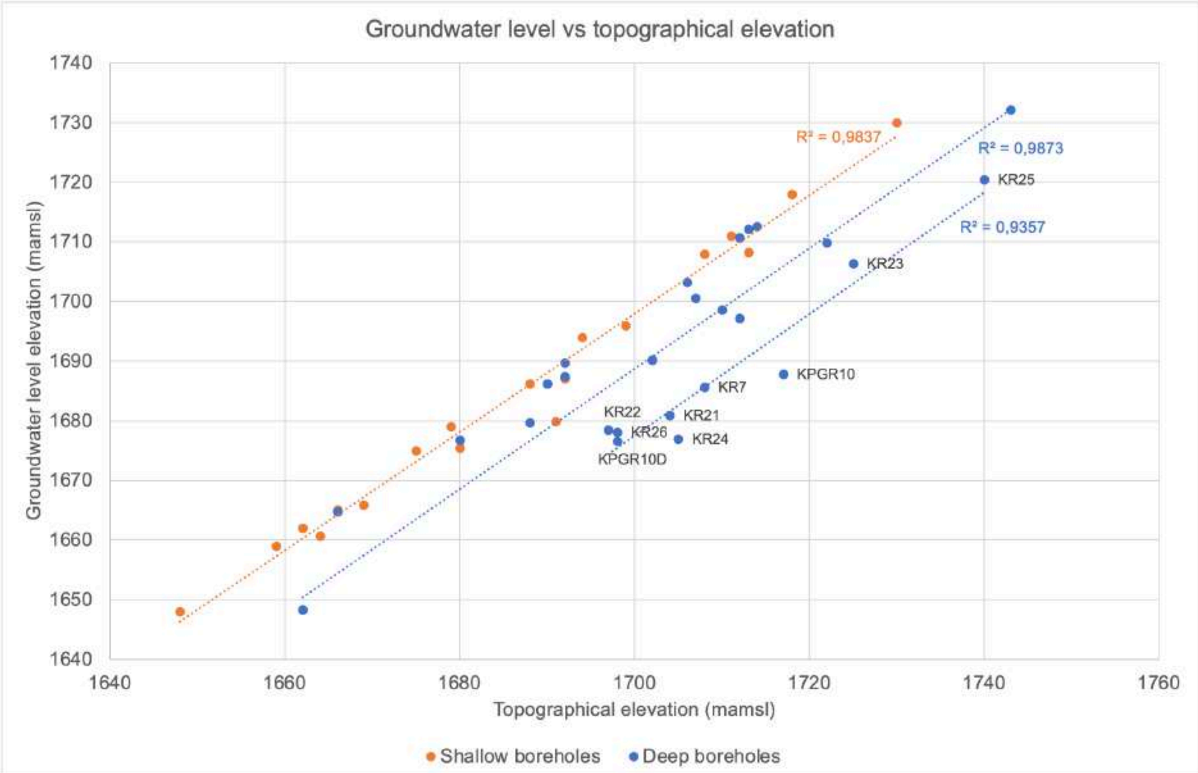

Figure 7 **Correlation between groundwater and topography**

The information presented indicates that the shallow boreholes and unaffected deep boreholes have similar correlations of around 98%. Some of the deeper boreholes deviate from this trend and specifically boreholes in the southern and western sections of the farm Vaalbank, where groundwater levels are 15 – 20m below the regional trends. In this area, it is thought that groundwater levels are lowered as a result of the impact of the historical Union Colliery.

Groundwater flow contours were generated with the information obtained from the monitoring boreholes for both the shallow weathered and the deeper fractured rock aquifers in order to establish groundwater flow patterns at the site. The flow contours for the two aquifers are shown in Figures 8 and 9.

The groundwater flow gradient in the shallow weathered aquifer is towards pans. This suggests that groundwater from the shallow weathered aquifer discharges to the pans, especially during the wet season. The springs to the west of the Kranspan farm boundary are higher compared to that of the monitoring boreholes, as shown. Groundwater flows radially from this area. The groundwater flow gradient in weathered aquifer is approximately 1:53 (0,019).

Groundwater flow patterns in the fractured rock aquifer still indicates a depression around private boreholes KR3 and KR4 and monitoring borehole KPGW06D. This is most probably indicative of groundwater flow towards the large pan, as no groundwater abstraction takes place from boreholes KR3 and KR4.

A depression in groundwater flow is also recorded around the historical Union Colliery, as discussed earlier.

The average groundwater flow gradient in the fractured rock aquifer is 1:83 (0,012), which is flatter compared to the weathered aquifer.

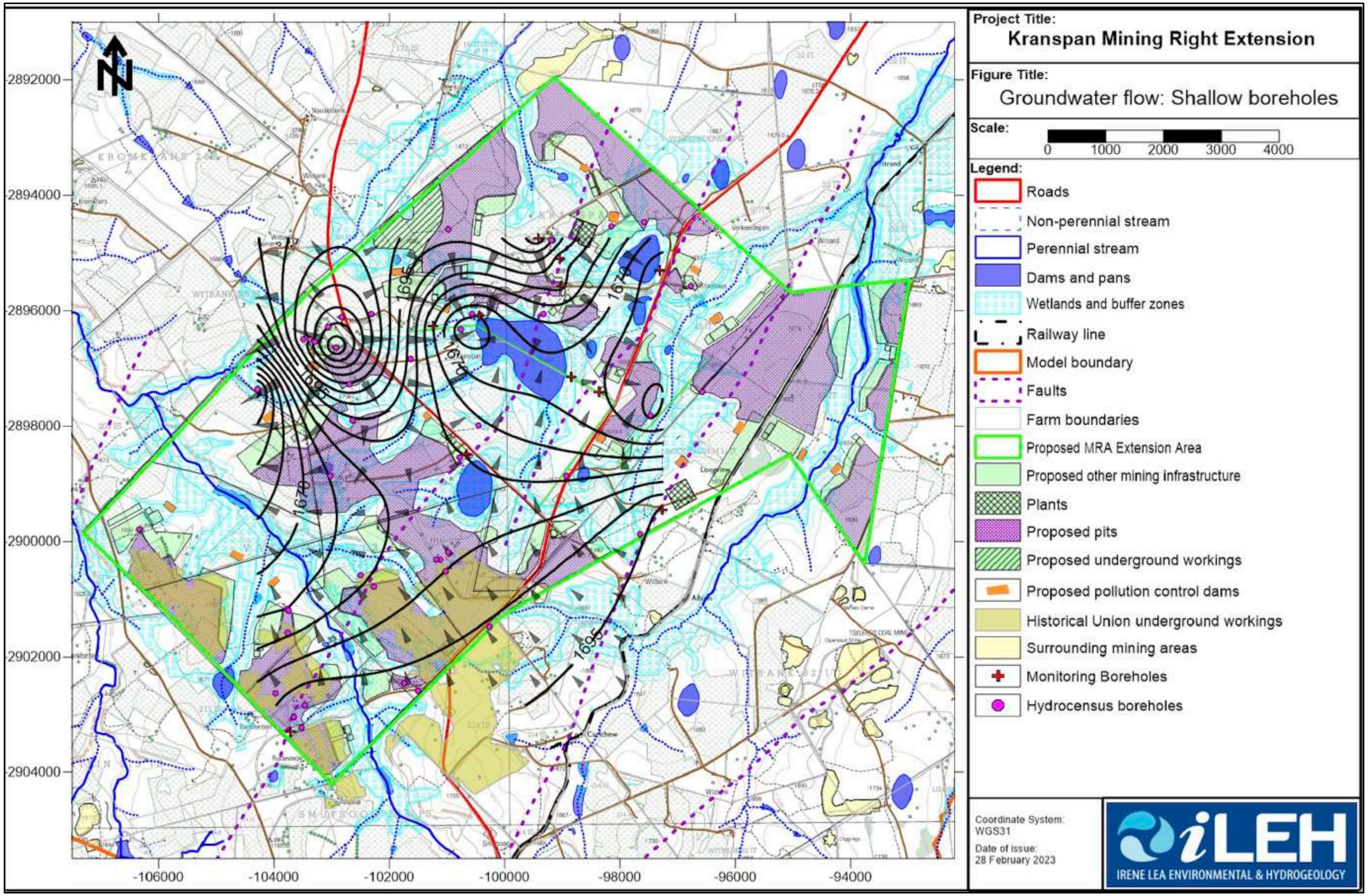

Figure 8 **Groundwater flow patterns in shallow boreholes**

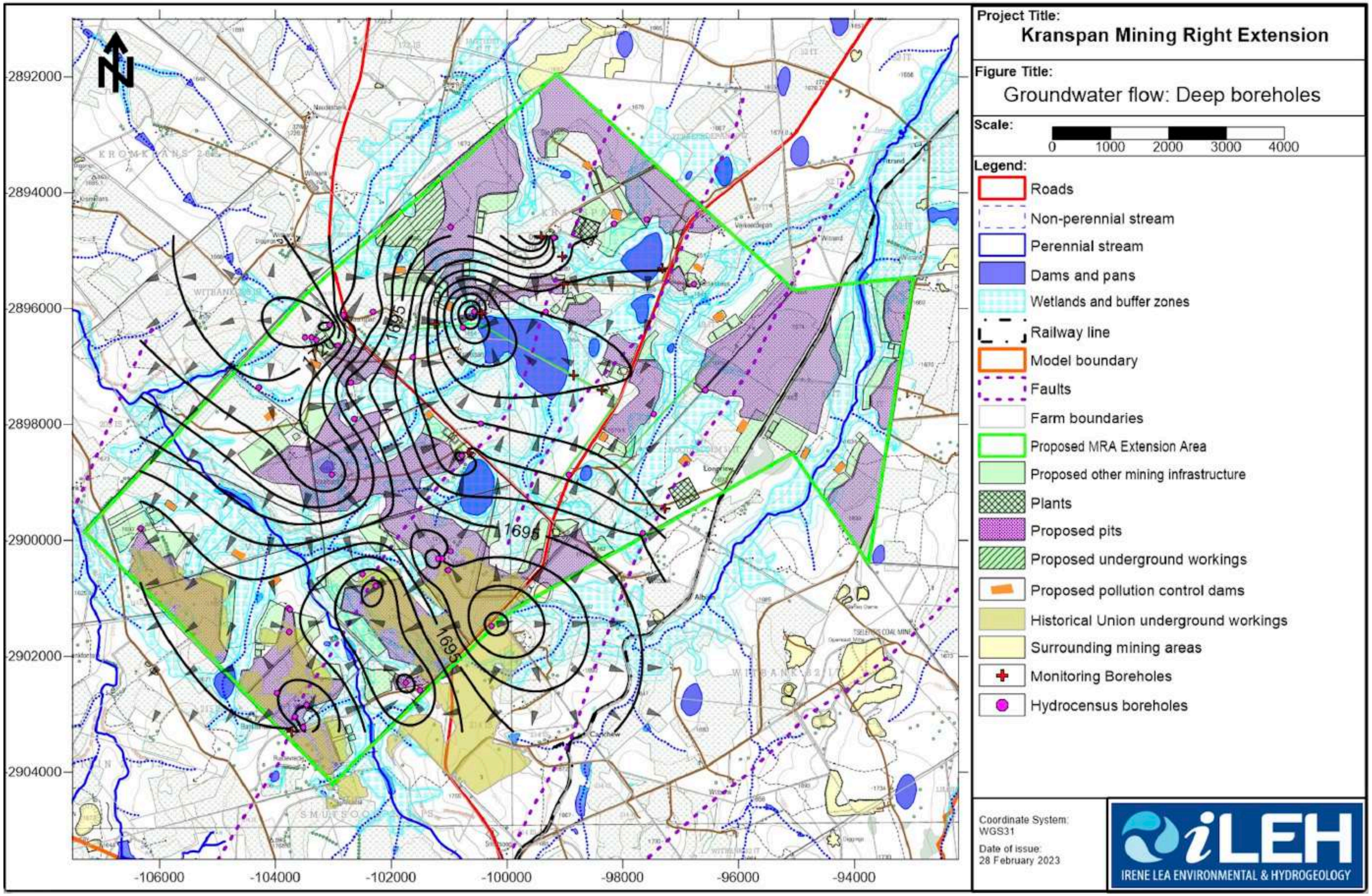

Figure 9 **Groundwater flow patterns in deep boreholes**

3.5 Groundwater potential contaminants

Of the available dataset, the decant point sampled at the historical Union Colliery can be used to approximate the impact coal mining on groundwater quality. This decant point was sampled during the 2022 hydrocensus. The results are presented in Figures 10 and 11. It is shown that sulphate is the most dominant anion, while sodium is the most dominant cation. TDS concentrations of this sample exceeded 1500 mg/l, with sulphate concentrations of around 900 mg/l.

The most dominant metals include strontium and manganese. Elevated manganese concentrations were also recorded in some of the monitoring boreholes.

The results of the geochemical leach tests completed on rock samples were used to evaluate potential contaminants associated with the project. These results are presented in Appendix 5. These tests suggests that sulphate is the most significant anion and iron the most significant metal.

The impact assessment presented in this report will be undertaken at the hand of sulphate, which is a well-established indicator element for the impact of coal mining on groundwater quality.

3.6 Groundwater quality

Groundwater Abstract collected six groundwater and surface seepage samples during the 2022 hydrocensus. The boreholes sampled are indicated in Figure 2. The water samples were submitted to a South African National Accreditation System (SANAS) accredited laboratory (Aquatico), for analysis. Samples were collected from boreholes across the project area to ensure a good indication of ambient groundwater qualities.

Samples were taken using single valve, decontaminated bailers or from pump discharge lines in the case of boreholes, which were equipped, and in use. Sterilized 1 litre sample bottles were used and filled to the top. Samples were stored in a cooler box during the site surveys.

The water samples were analysed for basic inorganic parameters and the results were compared against the SANS 241:2015 Drinking Water Standards. It is recommended that all identified boreholes, used for abstraction for domestic and agricultural purposes be sampled again before the construction phase of mining, if the application is successful in order to update the baseline assessment and build a water quality database for the area. The database will help to identify water quality and level trends in the area and will serve as reference to identify and quantify potential impacts on private boreholes.

Groundwater samples were also collected from the six monitoring boreholes during the 2022 aquifer testing programme. The results are discussed below.

The results of the analyses are presented in Table 7 and 8 and the certificates of analyses in Appendix 5. It is noted that the results indicate that the concentrations of most of the trace elements are below laboratory detection limits.

Sample KRS7 is also included in the tables. Please note that this is a decant point and not a private borehole.

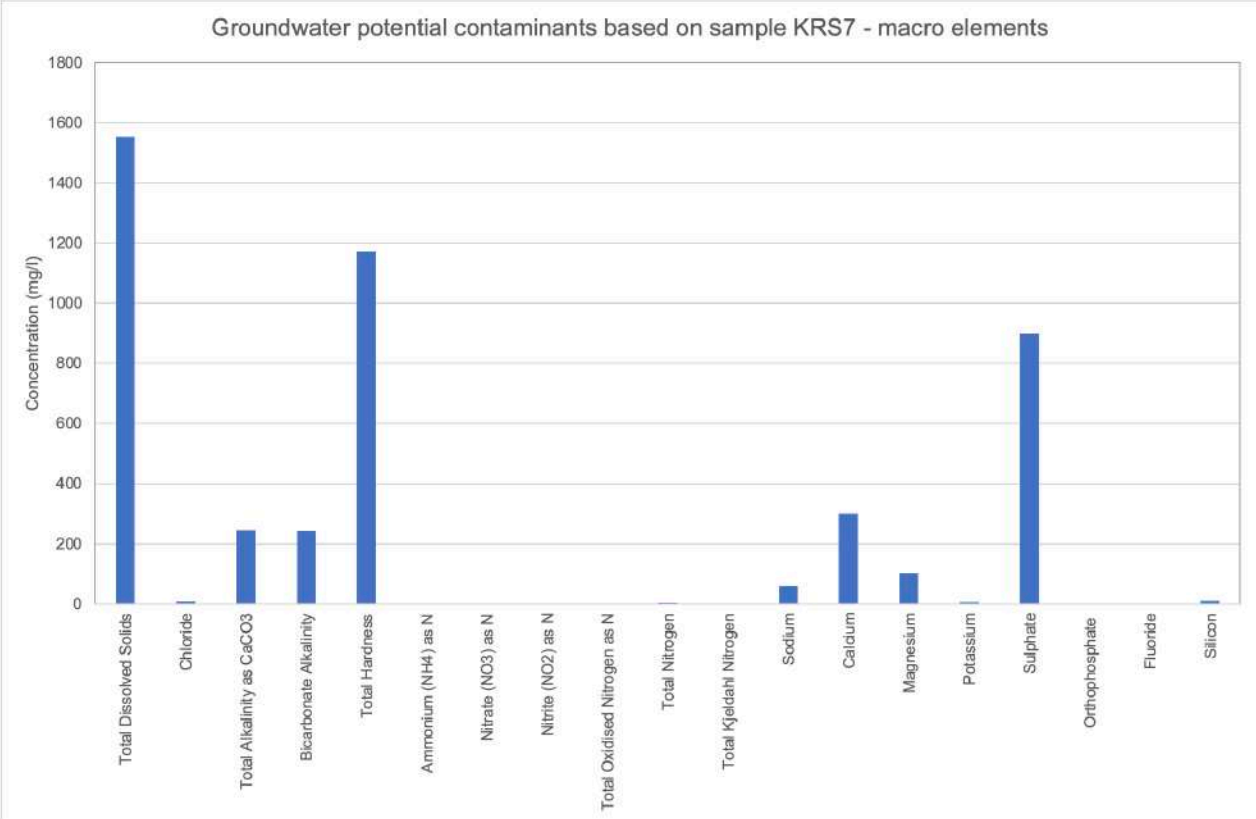

Figure 10 **Potential groundwater contaminants: Macro elements**

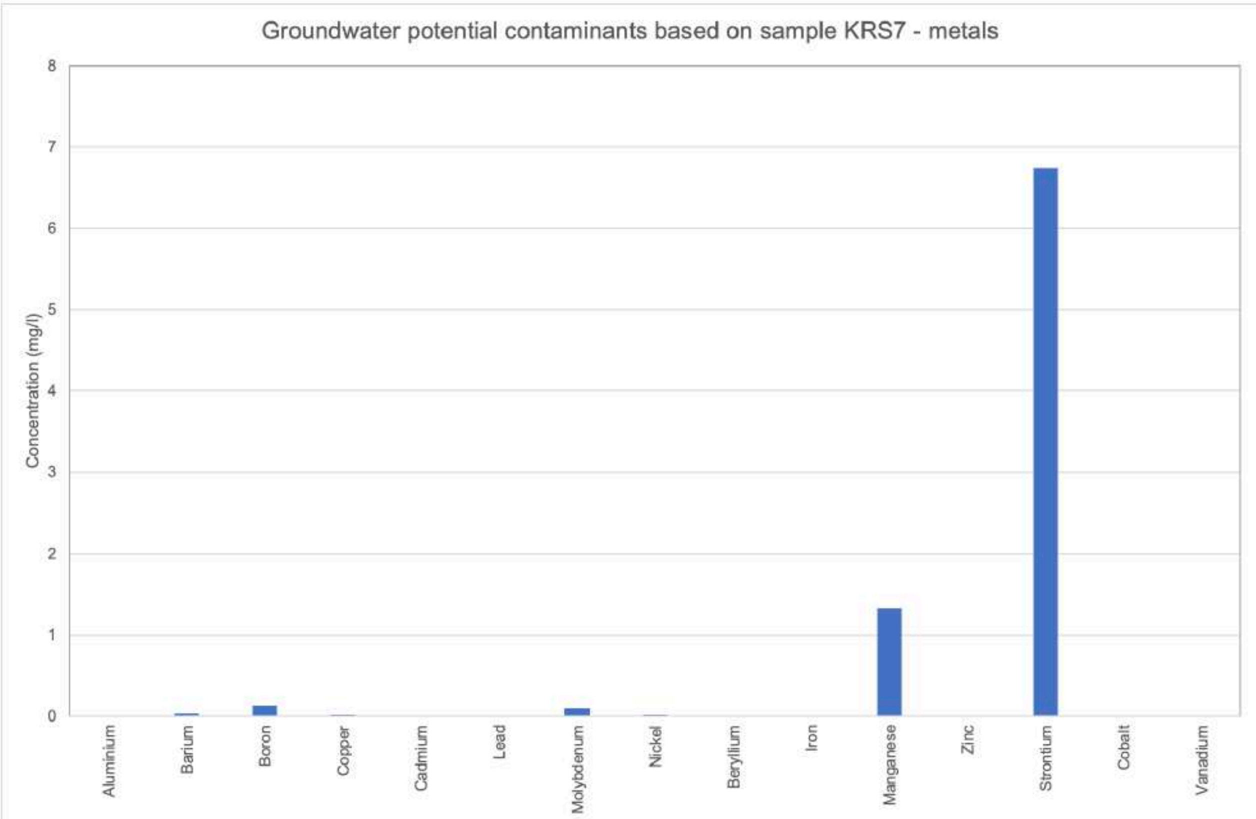

Figure 11 **Potential groundwater contaminants: Metals**

Table 7 Groundwater Quality – Hydrocensus (July 2022)

ELEMENT	Unit	SANS 241:2015 STANDARD LIMIT Operational	SANS 241:2015 STANDARD LIMIT Health	KRS 7 (decant)	KRS 8	KR14 (2019)	KR 14 (2022)	KR19 (2019)	KR 19 (2022)	KR 25	KR 28
pH		≥5 to ≤9.7		6.76	6.49	8.8	7.06	7.7	6.45	6.83	7.89
Electrical Conductivity	mS/m	Aesthetic ≤170		188	27.6	25.2	12.6	31.2	31.5	24.2	19.2
Total Dissolved Solids	mg/L	Aesthetic ≤1200		1553	217	255	107	285	239	184	163
Chloride	mg/L	Aesthetic ≤300		7.96	33.6	14	12.4	2	1.66	21.6	<0.557
Total Alkalinity as $CaCO_3$	mg/L			245	59.6	100	35.9	80	92.8	42.8	121
Bicarbonate Alkalinity	mg $CaCO_3$/L			244	59.6	99	35.8	98	92.8	42.8	121
Total Hardness	mg $CaCO_3$/L	more than 180 mg/l, very hard		1171	105	42	24	94	119	69	54
Ammonium (NH_4) as N	mg/L	Aesthetic ≤1,5		0.595	0.034	1.1	0.039	0.2	0.221	0.101	0.189
Nitrate (NO_3) as N	mg/L		Acute health ≤11	0.345	5.33	0.3	1.23	0.2	0.467	8.19	0.488
Nitrite (NO_2) as N	mg/L		Acute health ≤0,9	<0.065	<0.065	0.2	<0.065	<0.05	<0.065	<0.065	<0.065
Total Oxidised Nitrogen as N	mg/L			0.381	5.36	--	1.27	--	0.507	8.23	0.551
Total Nitrogen	mg/L			3.67	14.7	1.6	4.34	1.4	2.73	19.7	2.76
Total Kjeldahl Nitrogen	mg/L			2.69	9.29	1.1	3.03	1.1	2.01	11.4	2.02
Sodium	mg/L	Aesthetic ≤200		58.5	14.8	32	15.8	20	16.4	18.0	24.3
Calcium	mg/L			301	31.5	10	4.95	20	24.1	14.7	11.5
Magnesium	mg/L			102	6.41	5	2.87	13	14.3	7.79	6.24
Potassium	mg/L			5.99	4.75	3.2	4.96	7.6	9.95	6.64	6.46
Sulphate	mg/L	Aesthetic ≤250	Acute health ≤500	899	22.1	14	9.91	69	81.9	19.2	0.276
Orthophosphate	mg/L			<0.005	<0.005	<0.1	<0.005	<0.1	<0.005	<0.005	0.04
Fluoride	mg F/L		Chronic health ≤1,5	<0.263	<0.263	0.2	<0.263	0.7	0.324	<0.263	<0.263
Aluminium	mg/L	Operational ≤ 0,30		<0.002	<0.002	0.15	<0.002	<0.1	<0.002	<0.002	<0.002
Barium	mg/L		Chronic health ≤0.7	0.029	0.202	--	0.099	--	0.137	0.434	0.203
Boron	mg/L		Chronic health ≤2.4	0.133	<0.013	--	<0.013	--	0.041	<0.013	<0.013
Copper	mg/L		Chronic health ≤2	0.019	0.002	--	<0.002	--	0.005	0.005	<0.002
Cadmium	mg/L		Chronic health ≤0.003	<0.002	<0.002	--	<0.002	--	<0.002	<0.002	<0.002
Lead	mg/L		Chronic health ≤0.01	<0.004	<0.004	--	<0.004	--	<0.004	<0.004	<0.004

ELEMENT	Unit	SANS 241:2015 STANDARD LIMIT Operational	SANS 241:2015 STANDARD LIMIT Health	KRS 7 (decant)	KRS 8	KR14 (2019)	KR 14 (2022)	KR19 (2019)	KR 19 (2022)	KR 25	KR 28
Molybdenum	mg/L			0.093	0.026	--	0.005	--	0.026	0.015	0.016
Nickel	mg/L		Chronic health ≤0.07	0.016	<0.002	--	<0.002	--	<0.002	<0.002	<0.002
Beryllium	mg/L			<0.005	<0.005	--	<0.005	--	<0.005	<0.005	<0.005
Iron	mg/L	Aesthetic ≤0,3	Chronic health ≤2	<0.004	<0.004	0.161	<0.004	0.35	0.211	<0.004	0.013
Manganese	mg/L	Aesthetic ≤0,1	Chronic health ≤0,4	1.32	0.011	--	<0.001	--	0.316	0.022	0.004
Zinc	mg/L	Aesthetic ≤5		<0.002	<0.002	--	<0.002	--	0.432	<0.002	0.341
Strontium	mg/L			6.74	0.194	--	0.054	--	0.393	0.194	0.177
Cobalt	mg/L			0.008	<0.003	--	<0.003	--	<0.003	<0.003	<0.003
Vanadium	mg/L			<0.001	<0.001	--	<0.001	--	<0.001	<0.001	<0.001
Silicon	mg/L			10.1	16.1	--	10.7	--	11.8	12.2	13.8

Table 8 Groundwater Quality – Monitoring Boreholes

ELEMENT	Unit	SANS 241:2015 STANDARD LIMIT Operational	SANS 241:2015 STANDARD LIMIT Health	KPGW09S (VAGW-01 s)	KPGW09D (VAGW-01)	KPGW10 (VAGW-02)	KPGW11S (ROGW-03 s)	KPGW11D (ROGW0-03)
pH		≥5 to ≤9.7		7.2	6.28	7.07	7.68	7.65
Electrical Conductivity	mS/m	Aesthetic ≤170		20.0	7.01	19.4	12.5	12.7
Total Dissolved Solids	mg/L	Aesthetic ≤1200		114	49	152	102	78
Chloride	mg/L	Aesthetic ≤300		4.66	5.3	4.29	<0.557	<0.557
Total Alkalinity as $CaCO_3$	mg/L			88.5	16.6	70.3	41	62.6
Bicarbonate Alkalinity	mg $CaCO_3$/L			88.4	16.6	70.2	40.8	62.3
Total Hardness	mg $CaCO_3$/L	more than 180 mg/l, very hard		67	13	66	35	40
Ammonium (NH_4) as N	mg/L	Aesthetic ≤1,5		0.482	0.309	0.044	0.046	0.174
Nitrate (NO_3) as N	mg/L		Acute health ≤11	0.716	0.902	4.55	0.726	0.26
Nitrite (NO_2) as N	mg/L		Acute health ≤0,9	0.098	0.07	0.218	<0.065	0.076
Total Oxidised Nitrogen as N	mg/L			0.814	0.972	4.77	0.772	0.336
Total Nitrogen	mg/L			1.81	1.68	7.78	0.864	0.684
Total Kjeldahl Nitrogen	mg/L			0.51	<0.5	2.97	<0.5	<0.5
Sodium	mg/L	Aesthetic ≤200		10.5	5.57	12.1	3.94	5.89
Calcium	mg/L			16.1	3.03	16.5	6.91	8.72

ELEMENT	Unit	SANS 241:2015 STANDARD LIMIT Operational	SANS 241:2015 STANDARD LIMIT Health	KPGW09S (VAGW-01 s)	KPGW09D (VAGW-01)	KPGW10 (VAGW-02)	KPGW11S (ROGW-03 s)	KPGW11D (ROGW0-03)
Magnesium	mg/L			6.59	1.22	5.99	4.42	4.43
Potassium	mg/L			6.25	2.93	4.02	1.93	7.70
Sulphate	mg/L	Aesthetic ≤250	Acute health ≤500	4.04	1.33	<0.141	5.02	<0.141
Orthophosphate	mg/L			0.042	0.009	0.011	0.152	0.066
Fluoride	mg F/L		Chronic health ≤1,5	<0.263	<0.263	<0.263	<0.263	<0.263
Aluminium	mg/L	Operational ≤ 0,30		<0.002	<0.002	<0.002	<0.002	<0.002
Barium	mg/L		Chronic health ≤0.7	0.295	0.085	0.176	0.021	0.082
Boron	mg/L		Chronic health ≤2.4	<0.013	<0.013	<0.013	<0.013	<0.013
Copper	mg/L		Chronic health ≤2	<0.002	<0.002	<0.002	<0.002	<0.002
Nickel	mg/L		Chronic health ≤0.07	<0.002	<0.002	<0.002	<0.002	<0.002
Iron	mg/L	Aesthetic ≤0,3	Chronic health ≤2	<0.004	<0.004	<0.004	<0.004	<0.004
Manganese	mg/L	Aesthetic ≤0,1	Chronic health ≤0,4	<0.001	0.128	0.131	<0.001	0.087
Zinc	mg/L	Aesthetic ≤5		<0.002	0.102	0.015	<0.002	<0.002
Strontium	mg/L			0.215	0.019	0.225	0.026	0.112
Tellurium	mg/L			<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L			<0.001	<0.001	<0.001	0.004	<0.001
Thallium	mg/L			<0.037	<0.037	<0.037	<0.037	<0.037

3.6.1.1 Interpretation of groundwater quality information

The results of the chemical analyses presented in Tables 6 and 7 show that the groundwater quality in the hydrocensus and monitoring boreholes generally comply with the SANS241:2015 Drinking Water Standards. The exceptions are hardness, iron and manganese. These are discussed in more detail below. Reference is made to DWAF (1996) in the interpretation of the result :

- **Acute Health effects**: Exceedances may pose an intermediate unacceptable health risk.
- **Aesthetic effects**: Exceedances may taint the water with respect to taste, odour or colour, but does not pose an unacceptable health risk.
- **Hardness**: the groundwater is naturally hard. This is caused by high concentrations of calcium and magnesium salts. Temporary hardness is due to the presence of bicarbonates and can be removed by boiling the water. Permanent hardness is attributed to other salts (sulphates and chloride salts), which cannot be removed by boiling. Excessive hardness can result in scaling in plumbing and household heating appliances and pose a nuisance to personal hygiene (the so-called "soap destroying" nature of water).
- **Iron**: elevated iron concentrations were recorded in one private borehole. The elevated iron concentrations are considered natural and is probably associated with the rock formations present. It is unlikely that the surrounding mining activities could impact on groundwater quality at the Kranspan project. At the concentrations reported, the impacts are likely to be aesthetic (taste) and staining of plumbing.
- **Manganese**: elevated concentrations are reported for one private borehole and two monitoring boreholes. At the concentrations reported, impacts are expected to be aesthetic (taste) and staining of washing or plumbing.

The information presented in Tables 6 and 7 as well as information reported in the 2019 study (iLEH, 2019a and b) will form the groundwater quality baseline for the project. Future monitoring results must be compared to these concentrations to establish the impact of coal mining on groundwater quality.

3.6.1.2 Piper Diagram

A Piper Diagram was prepared with the water quality results for all of the groundwater and surface water samples considered as part of this study and is presented in Figure 12. These diagrams are used to plot the equivalent concentrations of several elements in order to characterise the types of water in the study area according to hydrogeological facies and the dominant cation and ion concentrations.

Figure 12 indicates data from the 2019 and 2022 datasets. The dominant cation in the groundwater samples is sodium (Na), although some of the samples don't show a dominant cation and are thus well mixed. The dominant anion is bicarbonate (HCO_3), but for some sites chloride or sulphate dominates.

Groundwater sampled from the decant point (KRS7) is distinctly different from the rest of the samples evaluated. It is sulphate dominant and plots in an area of the Piper Diagram that is characteristic of the impact of coal mining on groundwater.

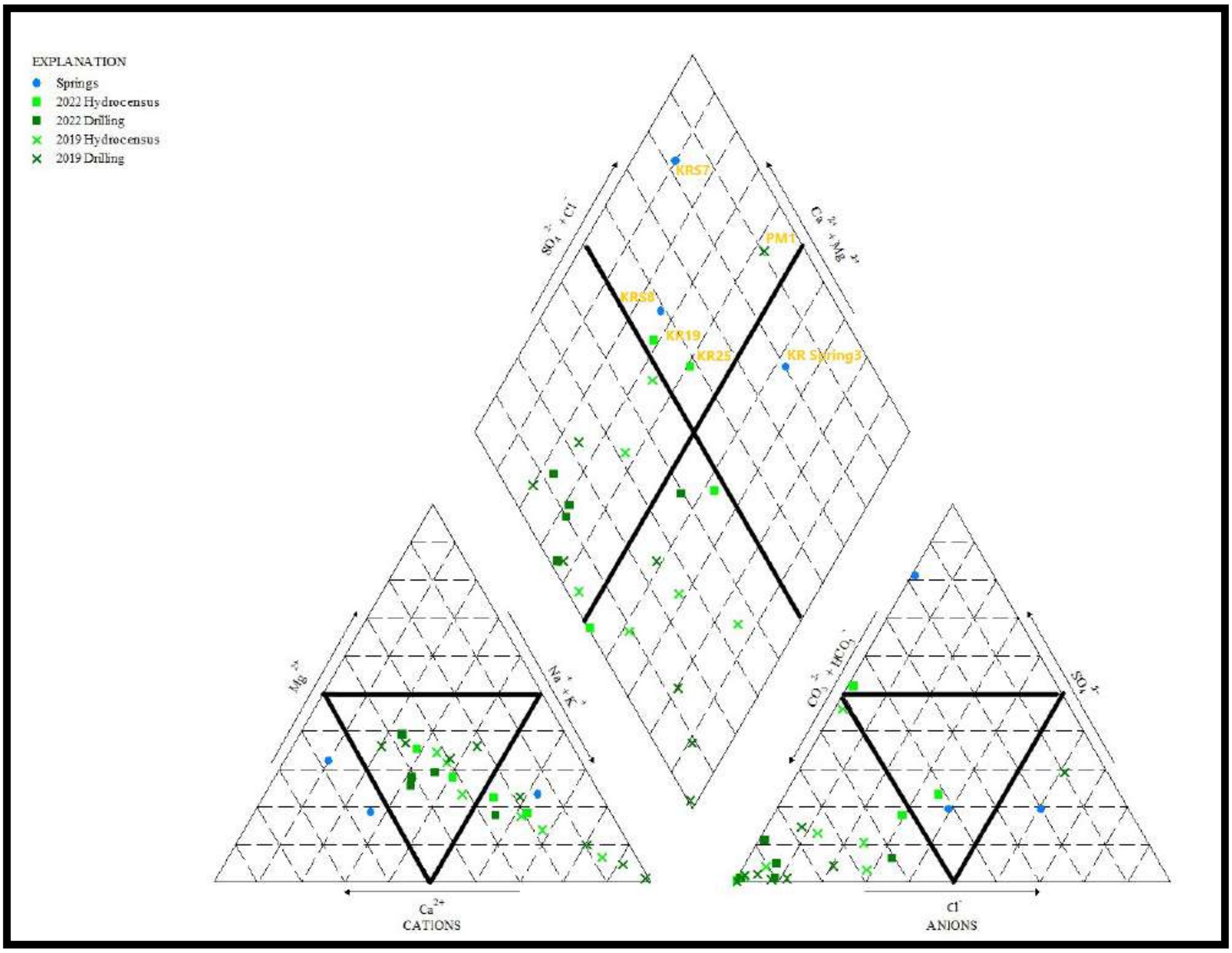

Figure 12 Piper Diagram

4 AQUIFER CHARACTERISATION AND VULNERABILITY

Based on aquifer classification methodology and regions published in the Aquifer Classification Map Series of South Africa (DWS, 2012), the aquifers present in the project area are minor aquifers with low yields and variable quality. It is however noted that groundwater is often the sole source of water available to farmers and for this reason, should be protected. Ambient groundwater quality associated with the Karoo sediments are generally acceptable for potable use except where mining activities have affected groundwater quality.

The aquifers fall in a moderate vulnerable category, which means they are vulnerable to some pollutants in the long-term when these are continuously discharged or leached.

Overall, the aquifers presented are ranked with a medium susceptibility to the impacts of pollutants.

Based on the information above, as well as the methodology described by Parsons (1995), the aquifer protection classification is rated as medium. This is due to the fact that groundwater is often the only water resource available to farmers and that groundwater can been impacted by regional mining activities.

5 CONCEPTUAL MODEL

The schematic cross section through the project area presented in Figure 13 demonstrates the conceptual model developed from the information discussed above. The location of the cross section is indicated on Figure 4. The cross section was generated from the exploration borehole data, coal roof and floor data provided, the digital terrain model (DTM) generated for the area, the geological map presented in Figure 3 and the aquifer information obtained from monitoring and hydrocensus boreholes.

The cross section indicates the extent of the aquifers as well as the position of the B, C and E Seams to be mined using opencast (pits). The historical Union Colliery underground workings are also indicated on the cross section. The NE-SW striking lineaments indicated on the regional geological map is indicated. In the absence of specific information, it is assumed that these structures are sub-vertical and extend to the base of the Ecca Formation. The basement of the geological succession pertinent to the groundwater impact assessment is assumed to be situated beneath the coal seam and comprises Dwyka Tillites.

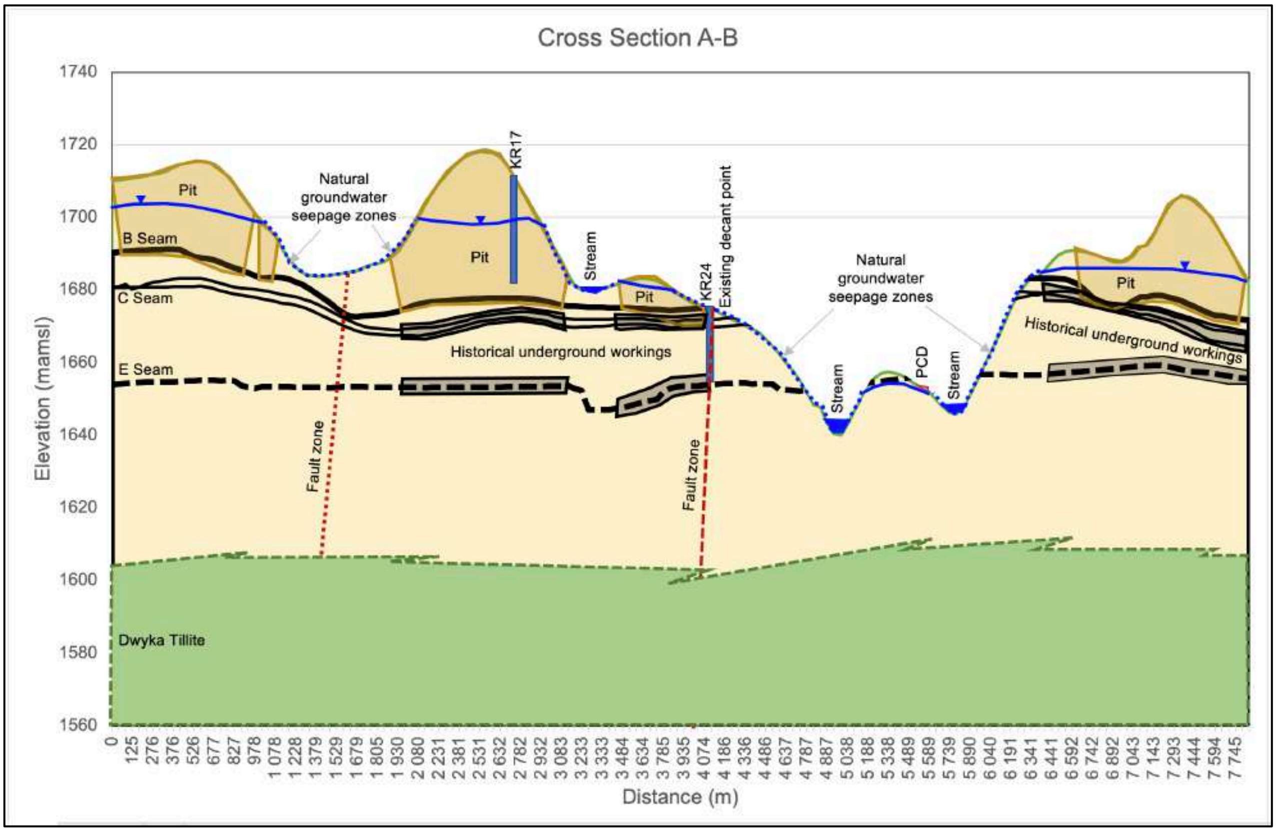

Figure 13 Schematic cross section through the project area

Of significance in the cross section is the role that the topography plays in the context of the aquifers present. It is shown that where the topography cuts through the groundwater table, zones of natural groundwater seepage are formed. These zones are associated with the streams draining across the mining area as well as with the wetlands delineated.

The Ilima opencast mining activities over the farm Vaalbank will be 20 – 40m above the E Seam workings of historical Union Colliery. In places Ilima plans to mine into the Union C Seam underground workings, as indicated.

The fault zone that transects the Union Colliery underground workings and the topographical dip in this area towards the stream has facilitated the decant point at KRS7. It is thought that this fault zone outcrops or sub-outcrops and forms a conduit of mine water to surface. Steyn (2019) reports that there are several areas of subsidence associated with the historical underground workings. Increase recharge over these areas to the underground workings result in water pressure building up in the workings, which forces the water to surface along the fault zone.

It is noted that borehole KR24 is located in this fault zone.

The conceptual aquifer parameters that will be used as a starting point during model calibration area presented in Table 9.

Table 9 Conceptual model configuration

Layer	Description	Thickness (m)	K (m/d): Avg (min; max)	Assumed		
				Sy (-)	S (-)	Porosity (%)
1	Weathered aquifer	15	0,2 (0,1 – 0,3)	0,1		10
2	Fractured aquifer, B and CL Seam	30	0,08 (0,01 – 0,15)		1,00E-04	1
3	Fractured aquifer and E Seam	50	0,08 (0,01 – 0,15)		1,00E-04	1
	Dolerite sill: discrete zone	Varies	0,58 (0,48 – 0,67)		1,00E-03	5
	NE-SW faults: discrete zones	Varies	0,58 (0,48 – 0,67)		1,00E-03	5

6 SOURCE TERM

The source term presented here is based on the work completed in 2019 for the Kranspan section (iLEH, 2019a and b) as well as information obtained as part of the 2022 Kranspan Extension project.

The 2019 source term evaluated the results of several slurry and discard handling scenario which were quantified at the hand of a detailed geochemical study completed on the material. These scenarios will not be repeated in the impact assessment discussed below, as environmental permission and a WUL has already been granted for the Kranspan mining area. The updated 2022 mine plan is however included in the assessment below. Focus will however be placed on mining activities on the farms Vaalbank and Roodebloem.

The 2019 study considered leachate quality for high neutralising/low acid potential conditions and for low neutralising/high acid potential conditions. Based on the updated dataset and the analysis of mine water from the historical Union Colliery, it is shown that a low neutralising/high acid potential environment is not likely for the Kranspan mining area. For this reason, the assessment presented in this study will be based on geochemical conditions associated with a high neutralising/low acid potential environment. Sulphate concentrations obtained from the 2019 geochemical assessment for this scenario are comparable to the Union Colliery mine water quality. The water sampled from the decant point represents the impact of coal mining since the 1900's and which have been dormant since 1975. For this reason, it is considered to provide a more accurate indication of mine water quality associated with coal mining in this area.

The updated source term to be used during simulations is presented in Table 10. The impact assessment will be completed using sulphate as an indicator element.

Table 10 2022 Source Term

Mining component	Operational phase SO_4 concentration (mg/l)	Long-term SO_4 concentration (mg/l)
Opencast pits	250	1500
Underground mining	250	900
Discard/slurry	250	2400

7 POTENTIAL PATHWAYS AND RECEPTORS

Based on the available dataset, the following aquifer pathways are identified for the project:

- Vertical flow through the unsaturated soil horizon from surface source of contamination to the underlying weathered and fractured rock aquifers. The rate at which the vertical flow can take place is governed by the permeability of the soils.
- It is noted that the PCDs will be HDPE lined and as such should not impact on groundwater quality unless they overflow or if the liners leak.
- Vertical and horizontal flow through the weathered aquifer from surface sources of contamination as well as mining areas that intersect this aquifer. It is noted that the contact between fresh and weathered rock is considered a preferential flow path to groundwater.
- The dolerite sill that has intruded into the shallow Ecca Formation sediments in the western part of the Kranspan area is expected to act as a barrier to vertical flow over the extent that it has been mapped. The rate at which potential contamination could migrate through the dolerite sill is not clearly understood and assumptions have been made during simulations, which must be tested and updated as necessary.
- Once the possible contamination reaches the fractured rock aquifer, the preferential flow paths include fractures, faults, joints and bedding planes in the rock formations. Groundwater will also flow through the rock matrix, but at much lower rates compared to the preferential pathways (NE-SW trending faults).

The following receptors were identified:

- Existing private groundwater users.
- The pans present within the mining area.
- Wetlands and pans down gradient of and adjacent to each mining area. Groundwater is expected to contribute to wetland and pan baseflow, specifically during the wet season result of the recharge of rainwater.

8 KEY ASSUMPTIONS AND LITERATURE-BASED DATA INPUTS

The numerical modelling is based on the following assumptions:

- Aquifer parameters were inferred from the fieldwork programme completed as part of this study. Aquifer parameters used to construct the numerical model are presented in Table 9, based on the 2019 study (iLEH 2019a and b) as well as the 2022 dataset. Parameters that were assumed include aquifer storage coefficients, porosities and the rate of recharge. It is further assumed that the vertical permeability is 1/10th that of the horizontal permeability.
- The source characterisation used for the project was inferred from the existing dataset. The values that will be assigned during simulations are presented in Table 10.
- Only advective transport of contaminants was simulated. Assumptions made regarding advection, are discussed below. While it is acknowledged that attenuation will take place in the soils, there is currently insufficient information available to quantify the extent to which this takes place. As such, simulations are based on the precautionary principle and take the worst-case scenario into consideration.
- The extent of the numerical model is based on natural groundwater barriers, as discussed below. These include water divides as well as rivers and streams. The extent and timing of mining activities were obtained from information made available as part of the study. Details of this are discussed below.

9 NUMERICAL GROUNDWATER MODELLING

9.1 Software model choice

The numerical model for the project was constructed using MODFLOW 2005 and MT3DMS. MODFLOW is a modular three-dimensional groundwater flow model and MT3DS a modular three dimensional solute transport model published by the United States Geological Survey. MODFLOW and MT3DS use 3D finite difference discretization and flow codes to solve the governing equations. MODFLOW and MT3DS are a widely used simulation codes, which is well documented. MODFLOW is used to simulate groundwater flow rate and direction. MT3DS is superimposed on the MODFLOW simulation results and is used to predict the rate and direction of contaminant movement in the aquifers.

MODFLOW, the modelling software used during simulations, is based on the assumption that aquifers are continuous porous media. For this reason, average aquifer parameters are assigned during simulations. The heterogeneous nature of a fractured rock aquifer is therefore approximated by a homogenous porous flow field. This is the nature of all groundwater modelling software and not just of MODFLOW.

9.2 Modelling objectives

The objectives of the updated numerical modelling undertaken as part of the project are to:

- Determine the zone of impact of mining on the farms Vaalbank and Roodebloem on groundwater quality. This zone of influence is determined by the impact of mine dewatering. Focus will be placed on identifying impacts on existing private groundwater users.
- Evaluate the volume of groundwater that would seep into the opencast and underground workings based on the Kranspan Extension mine plan.
- Evaluate the impact of mine dewatering on rivers, streams and wetlands.
- Determine the risk of the decant from the mining areas.
- Determine the zone of impact of mining activities on groundwater quality on the shallow weathered and deeper fractured rock aquifers during and post mining.
- Estimate the impact of groundwater contamination associated with the mining areas on private groundwater users and wetlands.

9.3 Model set-up, boundaries and geometric structure

The project location within the chosen model boundary is indicated on Figure 14. The following aspects were considered during the delineation of the model boundary:

- Natural groundwater flow boundaries, for example streams, rivers, water divides and geological contact zones.
- The extent of the existing Kranspan and the proposed Kranspan Extension project areas.
- The outcome of the 2022 hydrocensus, which indicates existing groundwater use in the proposed mining area.

The model grid comprises cubic cells, used to represent the aquifers present. A finer grid is used to simulated the proposed mining activities within the mining and prospecting rights boundaries. Further away from the area of interest, the grid is coarser.

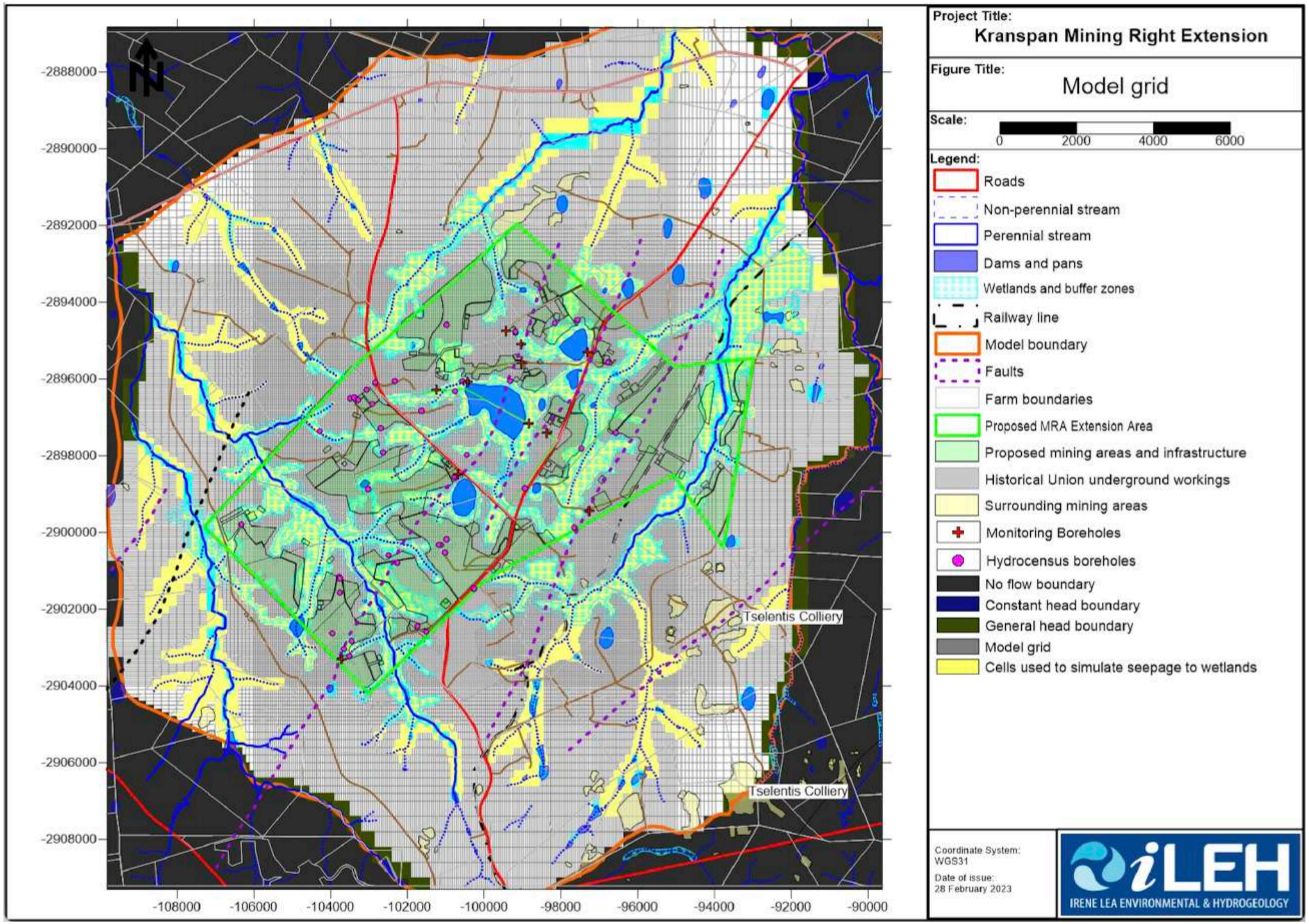

Figure 14 Model grid

In the vertical direction, three layers were included in the model. The position and thickness of each layer was inferred from the exploration and monitoring borehole data made available to the study. The upper layer presents the weathered aquifer. The second and third layers represent the fractured Karoo aquifer and the coal seams. The dolerite sill is included as a discrete zone in Layer 2 of the model.

The upper layer was simulated as an unconfined aquifer. The remainder of the layers were simulated as varying between confined and unconfined conditions with the transmissivity for each layer calculated from the hydraulic conductivities prescribed and the varying groundwater levels. All units used during simulations were presented in metres (length) and days (time).

The MT3DS contaminant transport model used for the project is based on the calibrated flow model. During simulations contamination was simulated only under advective and dispersive conditions. Darcy's Law governs advective flow. Under advective flow, the distance that the simulated plumes may move under uniform flow conditions is calculated from the flow velocity and the specified simulation times.

It was assumed that flow would predominantly take place in the horizontal flow direction and that transverse dispersivity is 10 times lower. Molecular diffusion, which is mainly the result of transverse dispersivity, was simulated with a coefficient value of 8,64E-5 m^2/d and that the longitudinal dispersivity is between 50 and 100m.

It is acknowledged that other factors play a role in the movement of contamination in the aquifers, other than advection and dispersion. This may include chemical reaction with or adsorption to clay and soil material, ion exchange or precipitation of salts from solution. These chemical reactions were not included during simulations undertaken for the project. It is acknowledged that these chemical processes would in most instances further retard plumes thus reducing the concentrations of contaminants. There is currently insufficient information available to consider these factors during simulations. As such, advective and dispersive contaminant transport simulations provide a worst-case outcome scenario, as it assumes that the plume will move at the same rate as groundwater flow.

The impact of the Kranspan Extension project will be simulated using SO_4 as indicator element. The conceptual source term used to commence contaminant transport simulations is presented in Table 10.

During simulations, it was assumed that the pollution control dams (PCDs) will be lined with HDPE and are designed to meet the requirements of GN704. As such, these dams are not expected to leak or spill during the operational phase and should therefore not pose a threat to groundwater contamination. If leaks and spills occur, it would be impossible to predict when, where and how these would take place, excluding realistic simulations with the model. Upon closure, the PCDs will be removed and fully rehabilitated, leaving no long-term risk to groundwater contamination.

9.4 Groundwater elevation and gradient

The conceptual model discussed above was used to construct the numerical model for the project area. The modelling input parameters used are based on the information currently available for the project area, as discussed earlier in this report. The initial parameters were gradually adjusted during calibration to obtain an acceptable fit between simulated and measured heads, as discussed below.

The initial head conditions, used during model calibration, were interpolated from the digital terrain model (DTM) for the model domain. It was assumed that the average depth to groundwater in the upper weathered aquifer is 4m, as calculated from the groundwater monitoring dataset. The average depth to groundwater in the underlying fractured rock aquifer is 6m.

The DTM was also used to ensure that the elevations of the river and General Head and Constant Head Boundary conditions reflect the ground conditions as closely as possible.

9.5 Conceptual groundwater model

The parameters that will be used during groundwater modelling, as derived from 2019 and 2022 field data, assumed or obtained from literature presented above, are presented in Table 9. These will be used as a starting point during model calibration for this phase of the project and will be adjusted to minimise the model calibration error, as discussed below.

Aquifer conceptualisation is discussed in Section 5 and presented as a schematic cross section in Figure 13.

9.6 Groundwater flow model calibration results

Calibration of a numerical model refers to the demonstration that the model is capable of reproducing field-measured data, which are the calibration values. Calibration is achieved when a set of parameters, boundary conditions, source terms and stresses are found that produce simulated heads and concentrations that match field measured data within the calibration criteria set for the project. This is an important step in the modelling project, which ensures that model results are reliable.

The calibration criteria set for the project are presented in Table 11.

Table 11 Flow model calibration criteria

Requirement	Acceptability criteria	Compliance
Model convergence	Maximum change in head of 0,001m	Complied with (see discussion below)
Water balance	Difference between inflow and outflow <1%	Complied with (see discussion below)
Root Mean Square Error	<5m for targets	Complied with (see discussion below)
Calibration error	80% of targets with <5m error between simulated and measured head	Complied with (see discussion below)

The model convergence of 0,001m was achieved during calibration. The water balance error obtained at the end of calibration was 0%.

It is shown that the calibration residual (the difference between measured and simulated head) is less than 5m for 85% of the steady state calibration data points. The term “head” refers to the groundwater levels.

The root mean square error (RMSE) of the calibration results was calculated in order to determine the goodness of fit of the calibration results. This calculation provides an indication of the standard deviation of the calibration errors. As the calibration error measures how far the simulated values are from the regression line, the root mean square error provides an indication of how spread out the calibration errors are. The RMSE of the calibration results is 3,8m, which is within the calibration criteria set. The RMSE also plots equally above and below the regression line, which indicates that the model does not over- or under-simulates groundwater levels.

The calibration results are presented in Table 12.

Table 12 Steady state calibration results

Monitoring position	Simulated head (mamsl)	Measured head (mamsl)	Residual (m)
KPGW01S	1684,00	1686,23	-2,24
KPGW01D	1676,60	1679,66	-3,06
KPGW02S	1671,99	1675,48	-3,49
KPGW02D	1673,89	1676,79	-2,90
KPGW03S	1684,62	1687,08	-2,46
KPGW03D	1683,07	1687,45	-4,38
KPGW04S	1660,44	1655,87	4,57
KPGW05S	1703,26	1708,20	-4,94
KPGW05D	1707,86	1712,13	-4,27
KPGW06S	1660,56	1665,00	-4,44
KPGW06D	1661,38	1664,72	-3,34
KPGW08S	1655,82	1660,73	-4,91
KPGW09S	1681,67	1679,89	1,78
KPGW09D	1681,88	1686,24	-4,36
KPGW10	1688,22	1687,83	0,39
KPGW11S	1691,48	1695,92	-4,44
KPGW11D	1680,96	1676,53	4,43
KR20	1703,05	1697,17	5,88
KR21	1675,81	1680,88	-5,07
KR22	1677,85	1678,48	-0,63
KR23	1711,35	1706,32	5,03
KR24	1678,56	1676,96	1,60
KR25	1714,77	1720,41	-5,64
KR26	1683,90	1678,06	5,84
KR27	1669,37	1675,00	-5,63
KR31	1688,77	1689,69	-0,92
KR33	1697,88	1703,23	-5,35
KR34	1698,27	1700,60	-2,33
KR35	1688,63	1690,18	-1,55
KRS7	1678,87	1679,00	-0,13
KRS8	1692,71	1694,00	-1,29
TSGW61	1714,84	1712,54	2,30
KR1	1728,22	1732,16	-3,94
KR4	1652,66	1648,27	4,39
KR7	1688,10	1685,62	2,48
KR9	1711,54	1709,82	1,72
KR14	1683,91	1682,39	1,52
KR15	1700,06	1698,55	1,51
KR16	1708,75	1710,74	-1,99
SPRING2	1708,22	1708,00	0,22
SPRING3	1650,52	1648,00	2,52
SPRING4	1729,04	1730,00	-0,96
SPRING5	1660,03	1659,00	1,03
SPRING6	1663,71	1662,00	1,71
KRSEEP	1716,81	1718,00	-1,19

9.6.1 Measures to improve calibration results

Factors that influence the calibration process and results include the following:

- Errors in the coordinates and elevations recorded for the boreholes. The coordinates used were recorded with a hand-held GPS.
- Errors in groundwater level measurements. It is further likely that groundwater levels have not yet recovered in some boreholes after the drilling programme, for example in KPGW10.

- The absence of borehole logs with which to characterise the aquifer conditions that groundwater levels in hydrocensus boreholes represent.
- The assumed mining conditions associated with the historical Union Colliery.
- As mentioned earlier in this report, the modelling code assumes a continuous porous medium, which means that the aquifers are simulated using average parameters. This does not allow for local variations in permeability that affects groundwater levels in the aquifers. Discrete zones were however included to represent the mapped faults.

9.7 Model sensitivity

A sensitivity analysis was completed on the model. The purpose of the sensitivity analysis is to quantify the uncertainty in the calibrated model caused by uncertainty in the estimates of aquifer parameters, stresses and boundary conditions. The level of heterogeneity of the aquifer material can never be accurately measured with field data. The uncertainty of the impact of heterogeneity on simulations is therefore assessed as part of the sensitivity analysis. Test simulations were therefore undertaken to determine the sensitivity of the modelling results to variations in key parameter values.

The results of the sensitivity analysis are presented in Figure 15. The larger the head changes during the analysis, the more sensitive the model is to that parameter.

The results indicate that the model is most sensitive to changes in permeability of the fractured aquifer as well as to specific yield of the upper weathered aquifer. A better understanding of these parameters can be obtained through analysis of hydrographs (groundwater level fluctuations with time) that will be available once a groundwater monitoring programme is in place at the proposed mine.

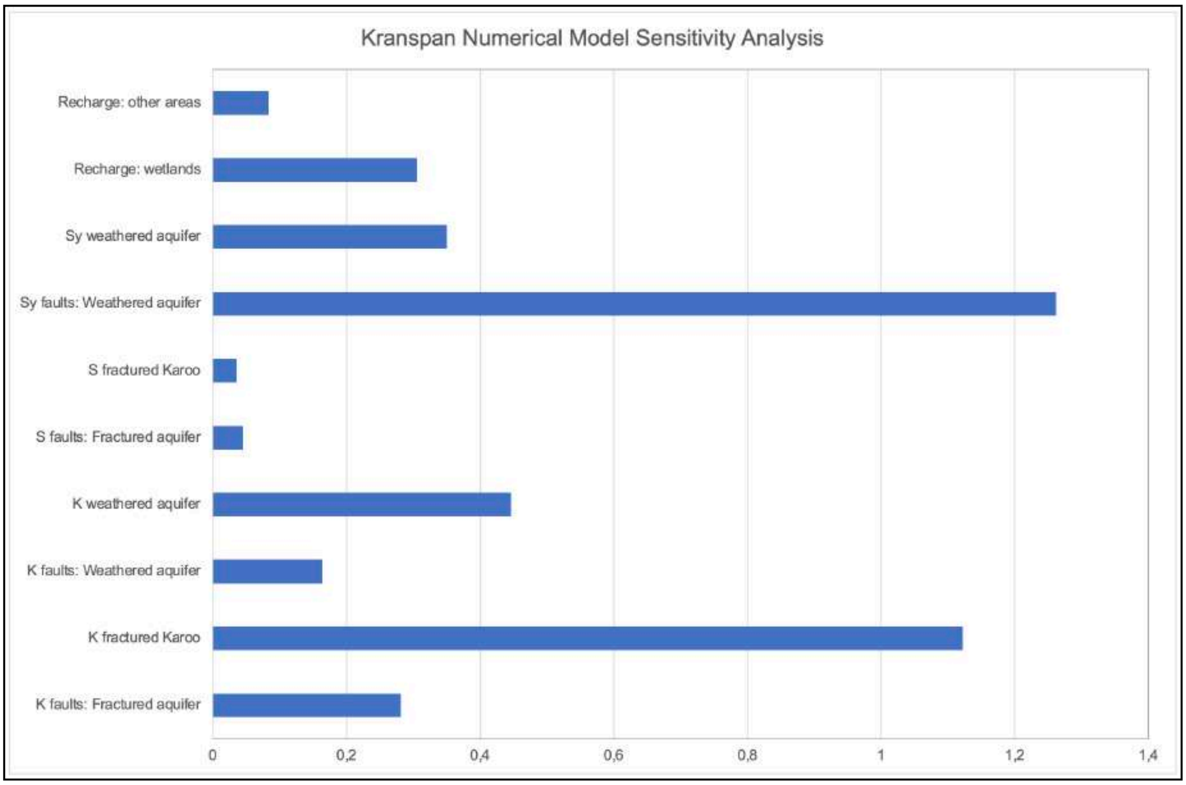

Figure 15 Sensitivity analysis

9.8 Assessment uncertainties

The accuracy of the modelling project depends on the quality of the input data, the available information, time available to complete the calibration process and to test the outcome of scenario modelling. Even with an unchanging environment, impacts are difficult to predict with absolute certainty. Predictions were calculated with the calibrated flow model, which is a simplified version of reality. The model represents a tool that can be used to assess the impact of the proposed mining areas on the aquifers and to identify data gaps. The calibration error is discussed above and is thought to be acceptable. The model should be updated and verified with site-specific monitoring information when it becomes available. Calibration against hydrographs will be of specific value in improving the current understanding of aquifer parameters. It is noted that Ilima has implemented a groundwater level monitoring programme at the Kranspan section. This data was incorporated into the current study and should continue to enable further improvement in model confidence.

Uncertainties are approached conservatively, based on the precautionary principle, in order to ensure that the predictions and impact assessment in this report addresses the maximum potential impact of the proposed development. The uncertainties in the model include:

- **Uncertainties regarding aquifer conditions within the project area**: This understanding can be improved through the continuation of groundwater level and quality monitoring at the mine. The regional fault lines, the existing decant point and the impact of historical mining activities are of specific interest in this regard. It is noted that Ilima is in the process of completing additional fieldwork at the decant point associated with the historical Union Colliery underground workings. The outcome of this should be considered in future groundwater impact assessments.
- **Uncertainties regarding borehole depth, construction and geology intersected**: This information is not available for the hydrocensus boreholes. For this reason, it was assumed that all hydrocensus boreholes target the fractured rock aquifer.
- **Uncertainties regarding the borehole elevations**: The elevations of hydrocensus boreholes used during simulations were inferred from hand-held GPS measurements and inaccuracies may occur. It is however thought that the error in elevation will not exceed the calibration error of 5m.
- **Mathematical modelling uncertainties**: It is not possible with the available information to quantify the heterogeneity present in the aquifers simulated. For this reason, there are inherent uncertainties in the model. The level of confidence in the model can be improved with the incorporation of additional monitoring data.

The uncertainties listed above can be reduced or eliminated through continuation of the groundwater monitoring programme at the mine. It can further be reduced by integrating the results of the groundwater monitoring programme proposed in this study. This information can be used to improve aquifer parameter estimation and model calibration.

9.9 Results of the model

The results of the modelling completed as part of this assessment are discussed below.

10 GEOHYDROLOGICAL IMPACT ASSESSMENT

10.1 Integration of the mining environment into the impact assessment

10.1.1 Mine plan used

The mine plan and mining schedule used during the simulations is presented in Figure 16. The mine plan was revised following the completion of the EIA phase of the project. The revisions were implemented to accommodate the locations of wetlands and their buffer zones. Figure 13 indicates the extent and timing of both opencast and underground mining used during simulations. The mine schedule was inferred from the Mining Work Programme (Ilima, 2018) and was adjusted to match the revised extent of mining.

For the sake of convenience, the pits were numbered in the sequence in which they will be mined. Mining will commence from Pit 1 situated close to the Plant area. Opencast mining will be undertaken over a 14-year period. Mining will be completed at Pits 10 and 11. Underground mining will be completed over a period of 12 years, as indicated in the Mining Work Programme submitted for the project (Ilima, 2018).

The E Seam floor contours are overlain on the figure. It is shown that the depth to coal increases towards the northwest. In this area, underground mining is proposed. The coal seam is shallower in the southern and eastern mining areas. The dip of the coal seam is indicated as vectors on Figure 16. It is shown that the dip of the coal seam is variable over the mining area.

10.1.2 Wetlands

The wetlands are often associated with areas of shallow groundwater table conditions, as well as with the pans and streams present. Field data evaluated as part of this assessment indicate that zones of groundwater seepage formed in areas where the topography cuts into the groundwater table are associated with the locations of wetlands delineated for the project. This is illustrated in Figure 13.

As such, the impact of mining on the shallow weathered aquifer is of importance to the sustainability of wetlands during and after mining. A lowering in groundwater levels would have a negative impact on wetlands. The impact of mine dewatering is therefore of importance when evaluating the impact on wetlands. The extent of the wetlands were delineated and provided by ABS Africa. The extent of these is indicated on all figures in this report.

It is thought that any permanent lowering of the groundwater table will reduce the groundwater that feeds many of the wetlands in the area, on which the wetland fauna and flora is dependent for survival. This could result in a loss of riparian vegetation and wildlife habitat. The depth of groundwater fluctuation that would negatively affect wetland sustainability will depend on the root depth of the plants. For the simulations discussed below, it is assumed that wetlands that fall in zones of impact where the groundwater level is lowered by more than 1 m, would be negatively affected during mining. This assumption needs to be confirmed and re-assessed, if necessary. It is however a conservative approach, as a 1 m drawdown in groundwater level would be closely associated with the edge of the zone of influence delineated by the 0 m drawdown contour.

In addition to the impact of fluctuations in groundwater levels, contaminated groundwater that infiltrates from the mining areas will also have adverse impacts on wetland flora and fauna. Any changes in the geochemical character of the soil and/or water are expected to have a negative impact on biological communities in the wetlands. This is especially true if the pH of water drops because of acid mine drainage or if the salt and metal concentrations increase to toxic levels in the groundwater discharging to the wetlands.

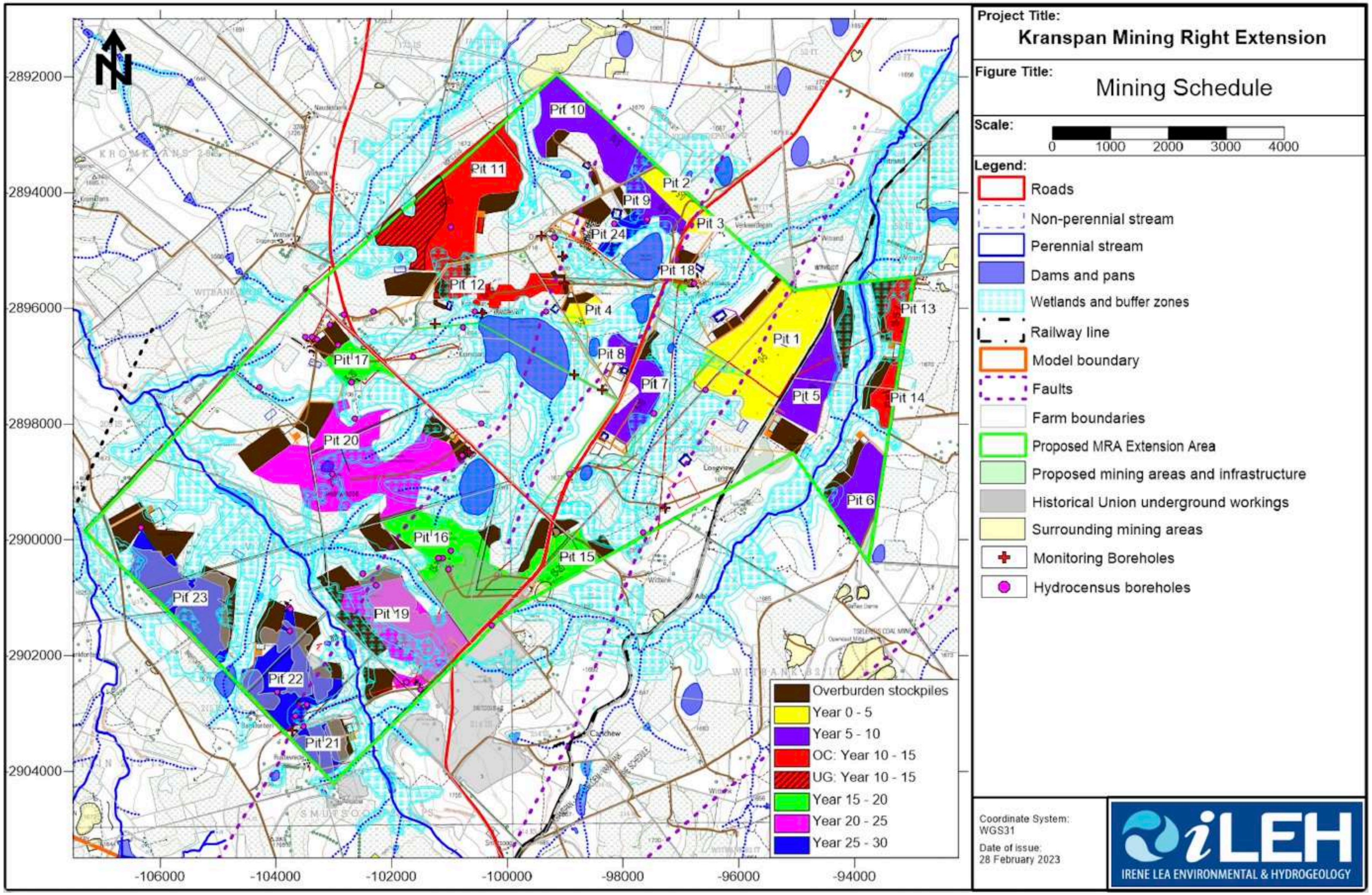

Figure 16 **Mine plan and mining schedule used in this assessment**

10.1.3 Discard management

Discard management was assessed in detail during the 2019 assessment (iLEH 2019a and b). Ilima is in the process of applying for a water use license for the preferred discard management option, which is backfilling of discard into the earmarked pit at Kranspan mine. No further assessment will be undertaken as part of this study, as the same discard disposal option for the Kranspan operations will be used during the proposed mining from the farms Vaalbank and Roodebloem.

10.1.4 Rehabilitation measures included during simulations

It was assumed that all surface infrastructure would be removed and rehabilitated upon mine closure, including the plant area. The surface will be rehabilitated and made free draining. Under these conditions, the rate of recharge would revert back to natural rates.

The overburden dumps will be continually backfilled into mined out pits during the operational phase. During simulations, it was assumed that rehabilitation would reduce the rate of recharge of rainwater to the facilities from 20% of MAP to 5% of MAP. This will in turn reduce the volume of contaminated leachate that could infiltrate from the overburden stockpiles to the underlying aquifers in future. At closure, it was assumed that all overburden stockpiles will be backfilled into mined-out pits and that the remnant surface areas would be rehabilitated, shaped and free draining. The rate of recharge to unrehabilitated and rehabilitated opencast mining areas were taken from Grobbelaar et al (2004), as summarised in Table 13.

Table 13 Recharge rates used during simulations (after Grobbelaar et al, 2004)

Mining area	Literature-based recharge rate (% of MAP)	Value used
Unrehabilitated waste rock/surface discard dump	30 – 80%	50%
Levelled waste rock/surface discard dump	15 – 30%	20%
Rehabilitated waste rock/surface discard dump	5 – 10%	5%

During long-term simulations, it was assumed that the adit will be backfilled, shaped and made free draining. Under these conditions, the rate of recharge to the underground workings would revert to natural rates. It is further assumed that no subsidence will take place above the underground workings. This will be achieved through sound planning and the implementation of the necessary safety factors to ensure stability. As no subsidence of ground is expected above the underground workings, the rate of recharge to areas disturbed by underground mining will be at ambient rates.

This is in contrast with the situation at the historical Union Colliery underground workings. As discussed, Steyn (2019) indicates that numerous areas of subsidence have developed at the old mining areas. This is the driving force behind the current decant from the old mine, as discussed in more detail below.

In the opencast mining areas, it is assumed that backfilling and shaping of the pits will reduce the rate of recharge, but not to natural rates. It is unlikely that rehabilitation of the disturbed areas would result in pre-mining recharge conditions.

10.2 Plume delineation

The modelling results are presented as estimated sulphate (SO_4) concentrations in the weathered as well as the fractured rock aquifers. The extent of the plume is delineated by the 250 mg/l sulphate concentration contour. This is the SANS241:2015 standard for sulphate for domestic use based on aesthetic impacts. The effects of aluminium on aesthetics and human health, as described by DWAF (1997) is presented in Table 14. . For the sake of identifying zones of significant impact on groundwater quality, the 500mg/l sulphate concentration contour line will be indicated on the plumes discussed below, based on the SANS241:2015 Drinking Water standard for impacts related to chronic health. Groundwater will sulphate concentrations exceeding 500 mg/l is expected to result in diarrhoea in most individuals and the groundwater will have a pronounced bitter taste.

The shape of the plume is defined by aquifer conditions as described above. The regional fault lines are preferential flow paths due to a higher measured and calibrated permeabilities and thus higher groundwater flow rates.

10.3 Impact prediction: Construction phase

No significant impacts on groundwater are anticipated during the construction phase of the project. It is acknowledged that historical impacts associated with the historical Union Colliery are evident and will continue to impact on groundwater during all phases of the project.

Please note that general and specific groundwater management measures are recommended for the planning and construction phases. These relate the implementing a monitoring programme as well as to propose design amendments based on the outcome of this assessment. These are presented in Table 19 below.

10.4 Impact prediction: Operational phase

10.4.1 Impact on groundwater availability

The impact on groundwater availability was assessed with the aid of the calibrated groundwater flow model prepared for the project.

As discussed earlier in this report, the model assumes average permeabilities for the rock formations that will be intersected during mining. The aquifers are however heterogeneous and variable groundwater seepage rates can therefore be expected. For example, if a water-bearing feature is intersected, the rate of groundwater seepage will increase. On average however, the aquifers present in the area are not considered strong, as suggested by the outcome of the hydrocensus and the results of the monitoring borehole drilling and testing programme.

The NE-SW trending faults indicated on the regional geological map and discussed earlier in the report, are however expected to act as preferential flow paths to groundwater. The intersection of these structures during mining could therefore result in increased groundwater inflow into the mining areas. Three of these lineaments transect the mining area.

The rate of groundwater seepage is influenced by the depth, the method of mining and the impact of adjacent mining or rehabilitated areas. Within the context of the mining area, groundwater levels are expected to be drawn down and recover dynamically throughout the life of the operations. Mining that takes place at shallow depths that intersects the shallow weathered aquifer may experience increased groundwater seepage rates, as these formations are expected to have higher permeabilities. Increased groundwater seepage rates are anticipated along the zone of transition from weathered to fresh rock.

Underground mining in the fractured rock aquifer is expected to experience groundwater seepage at lower rates, as the average permeability with depth is expected to decrease as the rock formations become tighter. Higher seepage rates will however be encountered if a water-bearing structure is intersected. In summary, the rate of groundwater seepage is influenced by the following factors:

- The extent of mining: groundwater seepage rates will increase for larger and mining areas.

- Depth of mining: groundwater seepage rates to shallower mining areas are expected to be higher compared to deeper mining areas where the water-bearing fractures are expected to be tighter.
- The intersection of water-bearing features: the three main lineaments are expected to increase the groundwater seepage volumes if and when intersected during mining.
- Cumulative impact of mine dewatering: the rate of groundwater seepage may be high when new ground is broken, but may reduce as the aquifers around the mining areas are dewatered. Groundwater levels will also start to recover in areas where pits are backfilled and rehabilitated, thus affecting groundwater flow gradients and seepage rates.
- The cumulative impact of historical mining at Union Colliery. Available groundwater level measurements suggest that groundwater levels are lowered by 10 – 20m above the old workings from which decant is currently taking place.

10.4.2 Rate of groundwater seepage to the pits and underground workings

The results of simulations to calculate the rate of groundwater seepage during the operational phase of mining are presented in Tables 14 and 19 and Figures 17 and 18. The information is presented per mining area (Table 14 and Figure 17) and mining phase (Table 15 and Figure 18).

Three scenarios were tested as part of the assessment. These include the likely seepage rate, which is based on the assumption that each pit would be rehabilitated when mining is completed within the mining phase. These seepage rates take the position of the regional fault lines into consideration. The minimum seepage rate represents a scenario if the intersection of faults and fractures yield less groundwater. Based on the fieldwork data, it is likely that actual seepage volumes will fall between the minimum and likely estimated values. The maximum estimated seepage rate assesses the impact if the faults and fractures intersected during mining yield more groundwater that average conditions.

Table 14 Estimated groundwater seepage rates per mining area (Unit: m^3/d)

Mining area	Estimated groundwater seepage rate (m^3/d)		
	Minimum	Likely	Maximum
Pit 1	170	510	2570
Pit 2	20	70	330
Pit 3	10	20	110
Pit 4	15	40	220
Pit 5	65	200	970
Pit 6	60	170	840
Pit 7	40	120	600
Pit 8	10	40	190
Pit 9	30	90	440
Pit 10	85	260	1270
Pit 11	120	360	1800
UG	50	160	800
Pit 12	40	120	600
Pit 13	20	70	355
Pit 14	20	51	260
Pit 15	40	110	550
Pit 16	160	470	2360
Pit 17	30	90	450
Pit 18	5	15	80
Pit 19	130	380	1910
Pit 20	210	620	3100
Pit 21	30	75	370
Pit 22	100	300	1480
Pit 23	100	290	1460
Pit 24	20	60	280

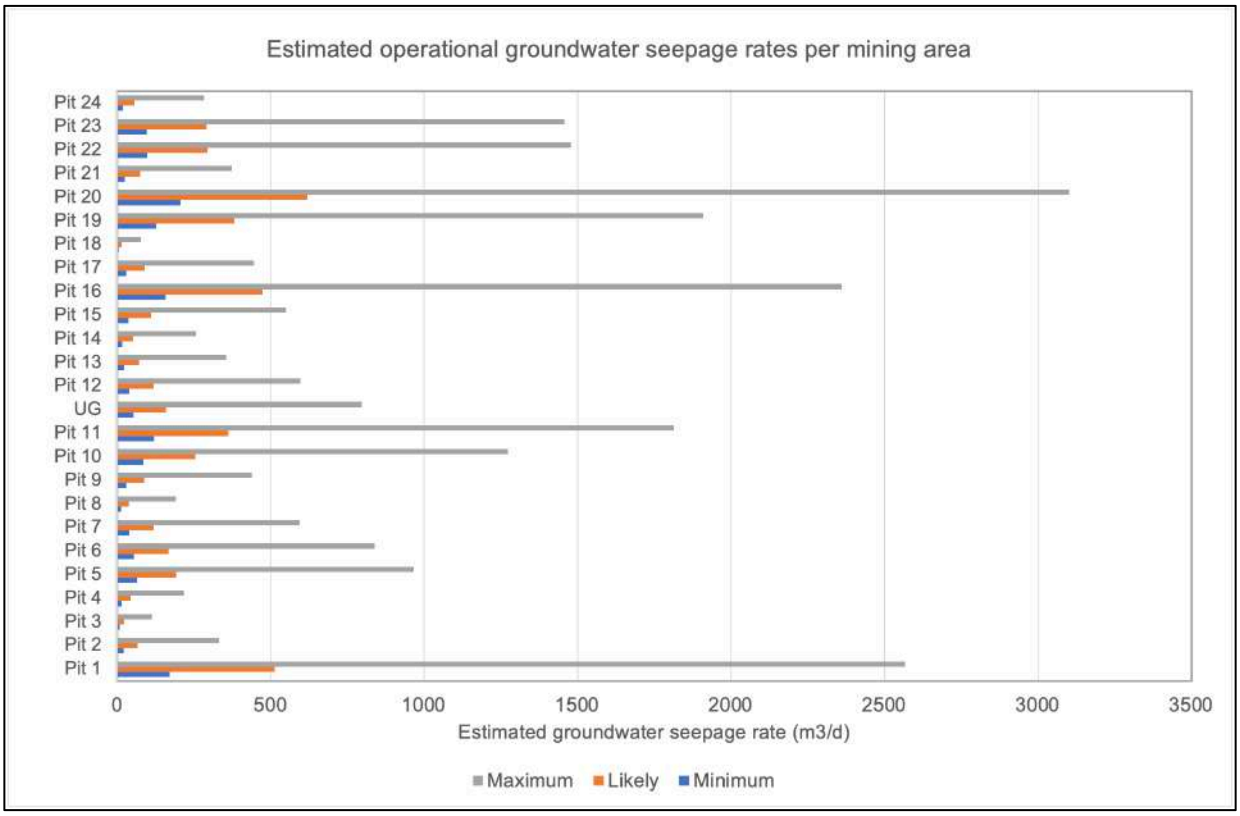

Figure 17 Estimated operational groundwater seepage per mining area

If the groundwater assessment is evaluated per mining area, the following is concluded:

- Based on likely seepage rates, the groundwater seepage rates may vary between 15 and 620 m^3/d, depending on the pit size and mining depth. The seepage rates represents the total pit area, as no specific mining scheduling was available for the pits. These rates could however be lower, possibly varying between 5 and 210 m^3/d. Aquifer conceptualisation confirms that the permeability of the aquifers is low. The intersection of the regional fault lines will therefore play a role in the volume of seepage that has to be managed from each mining area.
- Largest seepage volumes are expected at Pits 20, 1, 16, 19 and 11.
- Based on low permeability aquifer conditions and the fact that only a few of the pits would intersect the regional fault lines, it is unlikely that the maximum estimated seepage rates would be encountered during mining. These are however included in the event that significant groundwater seepage is encountered during mining. Of specific concern would be the pits that are likely to intersect the regional fault lines, including Pits 1, 3, 10, 12, 16, 19 and 22.
- The information presented in Table 18 can be used to size pollution control dams for the operations.
- The information in Table 18 suggests that sizes of the PCDs must cater for a varying groundwater seepage rate. It is noted that some PCDs will be used to contain dewatering from more than one mining area.

Table 15 Estimated groundwater seepage rates per mining phase (Unit: m^3/d)

Mining Phase	Estimated groundwater seepage rate (m^3/d)		
	Minimum	Likely	Maximum
Year 0-5	215	650	3230
Year 5-10	290	860	4300
Year 10-15	250	760	3820
Year 15-20	230	690	3435
Year 20-25	570	1720	8600

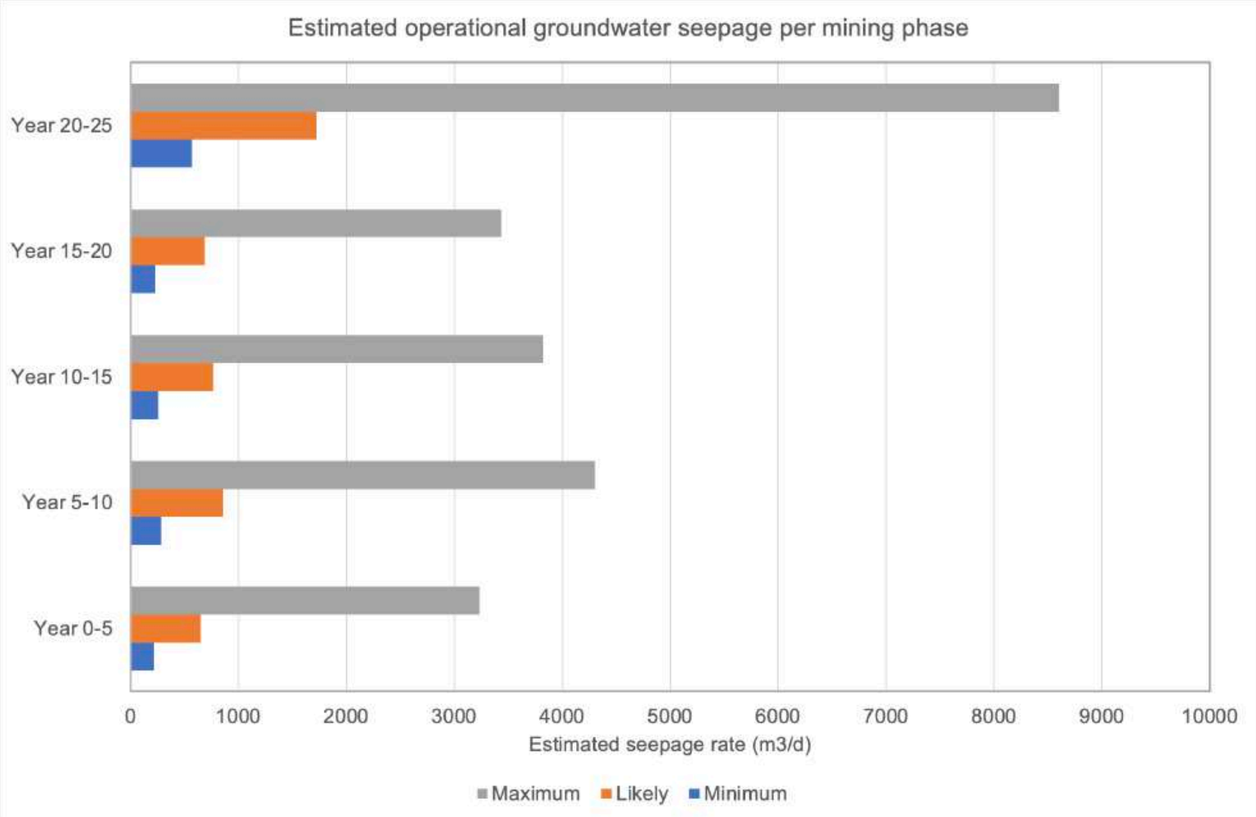

Figure 18 Estimated operational groundwater seepage per mining phase

The estimated groundwater seepage rates per mining phase are presented in Table 19 and Figure 18. This information demonstrates the total volume of groundwater seepage that will have to be handled per mining phase.

As for the information discussed above, minimum, likely and maximum seepage volumes are provided. Based on the available field data, the groundwater seepage rates are expected to vary between the minimum and likely volumes indicated.

The total likely seepage rates per mining phase could vary between $650m^3/d$ and $1720m^3/d$.

10.4.3 Impact of mining on private groundwater users

The extent over which groundwater levels could be lowered by 1m and more is indicated on Figures 19 and 20. The zone of influence on groundwater levels is presented per mining phase in Figure 19. The cumulative zone of influence, based on all mining phases, is presented in Figure 20 at the end of the operational phase of mining. This indicates the overall maximum extent to which groundwater levels could be impacted by mine dewatering. The zone of influence also considers observed impacts associated with the historical Union Colliery underground working.

The zone of influence on groundwater quality is impacted by the depth and extent of mining as well as the presence of the regional fault zones. Groundwater seepage to the wetlands in low-lying areas is also considered in the assessment.

The estimated impact of mine dewatering on existing private groundwater users is summarised in Table 16. Three main impacts are evaluated. The first is boreholes that would be destroyed during the proposed opencast mining activities. These boreholes are located within the opencast mining areas. The second is boreholes that could be significantly affected by mine dewatering. These boreholes are not located within the planned opencast mining areas, but are located close enough to all planned mining activities that groundwater levels could be lowered by more than 5m during the operational phase. It is likely that this would result in a significant reduction in borehole performance. The third impact lists boreholes that fall within the zone of influence, but are not likely to be significantly impacted. Groundwater levels in these boreholes are not expected to be lowered by more than 2m during mining.

It is noted that the zone of influence on groundwater levels do not significantly extend beyond the mining areas. This is due to the fact that the permeability of the aquifers is low, which is likely to result in steep flow gradients over short distances to the pits during the operational phase. The cone of depression in groundwater levels due to mine dewatering is expected to extend 200 – 1000m from the pits and underground workings. In places where the regional fault lines transect the mining areas, the impact may extend further, up to 2km along the structures. These impacts are more likely in the deeper mining areas (E Seam workings), including the historical Union Colliery underground workings.

The information presented in Table 16 indicates that the majority of the hydrocensus boreholes fall within the zone of influence on groundwater levels. Twenty of the boreholes will be destroyed during mining. Of these, three fall on ground that belongs to Ilima. It is further likely that 14 of the hydrocensus boreholes would be significantly affected by mine dewatering. Of these, six fall on ground that belongs to Ilima.

Based on the assessment completed, it is concluded that the impact of mining and mine dewatering will have a significantly negative impact on private groundwater use and that many of the boreholes will be permanently lost as a result of mining.

10.4.4 Impact on the shallow weathered aquifer, wetlands and springs

Wetlands that may be affected by the lowering of groundwater levels during mining or that may be destroyed during mining, are indicated on Figure 20. It is anticipated that the wetlands will not function optimally in these areas and may be permanently lost due to a decrease in groundwater availability as a result of mine dewatering.

It is likely that the wetlands associated with the Kranspan would be most significantly affected during mining. Mining in this area is deeper as the pits target the E Seam. The lowering of groundwater levels is therefore likely to be more significant. Mining on the farm Vaalbank will be shallower as the B and C Seams will be targeted. In this area, the impact on wetlands will be restricted to areas closer to the pits.

It is further likely that spring flow will be negatively affected during mining. Six springs were identified during the hydrocensus. One spring is associated with Pit 7 and would be affected during Year 5 – 10 of mining. Three of these springs are located near Pit 17 and would be affected during Year 15 – 20 of mining.