PALAEONTOLOGICAL DESKTOP ASSESSMENT FOR THE PROPOSED EMKHIWENI SUBSTATION AND 400KV LINE FROM EMKHIWENI SUBSTATION TO SILIMELA

PREPARED FOR NEMAI CONSULTING (PTY) LTD
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Prepared by:
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2 February 2020

Declaration of Independence

I, Elize Butler, declare that –

General declaration:

- I act as the independent palaeontological 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 favorable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting palaeontological impact assessments, 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 will take into account, to the extent possible, the matters listed in section 38 of the NHRA when preparing the application and any report relating to the application;
- 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;
- I will ensure that information containing all relevant facts in respect of the application is distributed or made available to interested and affected parties and the public and that participation by interested and affected parties is facilitated in such a manner that all interested and affected parties will be provided with a reasonable opportunity to participate and to provide comments on documents that are produced to support the application;
- I will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favorable to the applicant or not
- All the particulars furnished by me in this form are true and correct;
- I will perform all other obligations as expected a palaeontological specialist in terms of the Act and the constitutions of my affiliated professional bodies; and
- I realize that a false declaration is an offense in terms of regulation 71 of the Regulations and is punishable in terms of section 24F of the NEMA.

Disclosure of Vested Interest

I do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remuneration for work performed in terms of the Regulations;

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SIGNATURE:

The following Palaeontological Desktop Assessment has been compiled considering the National Environmental Management Act 1998 (NEMA) and Environmental Impact Regulations 2014 as amended, requirements for specialist reports, Appendix 6, as indicated in the table below.

Table 1: NEMA Requirements

NEMA Regs (2014) - Appendix 6	**Relevant section in report**
1. (1) A specialist report prepared in terms of these Regulations must contain-	
a) details of-	Page ii and iii of Report – Contact details and company and Appendix B
i. the specialist who prepared the report; and	
ii. the expertise of that specialist to compile a specialist report including a curriculum vitae;	
b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Page ii
c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 4 – Objective
(cA) an indication of the quality and age of base data used for the specialist report;	Section 5 – Geological and Palaeontological history
(B) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 9
d) the date, duration and season of the site investigation and the relevance of the season to the outcome of the assessment;	N/A Desktop Study
e) a description of the methodology adopted in preparing the report or carrying out the specialized process inclusive of equipment and modeling used;	Section 7 Approach and Methodology
f) details of an assessment of the specifically identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 1 and 10
g) an identification of any areas to be avoided, including buffers;	Not identified, Section 10
h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 5 – Geological and Palaeontological history

NEMA Regs (2014) - Appendix 6	Relevant section in report
i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 7.1 – Assumptions and Limitation
j) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment or activities;	Section 10
k) any mitigation measures for inclusion in the EMPr;	Section 11
l) any conditions for inclusion in the environmental authorization;	Section 11
m) any monitoring requirements for inclusion in the EMPr or environmental authorization;	Section 11
n) a reasoned opinion- i. as to whether the proposed activity, activities or portions thereof should be authorized; (iA) regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorized, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 10
o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	Not applicable.
p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Not applicable.
q) any other information requested by the competent authority.	Not applicable.
2) Where a government notice *gazetted* by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Section 3 compliance with SAHRA guidelines

EXECUTIVE SUMMARY

Banzai Environmental was appointed by Nemai Consulting to conduct the **Palaeontological Desktop Assessment** (PDIA) to assess the proposed Emkhiweni Substation and 400KV Line from Emkhiweni Substation to Silimela. The National Heritage Resources Act (No 25 of 1999, section 38) (NHRA) declares that a Palaeontological Impact Assessment (PIA) is key to verify the presence of fossil material within the planned development. This Assessment is thus necessary to evaluate the effect of the construction on palaeontological resources.

The proposed Emkhiweni Substation and 400KV Line from Emkhiweni Substation to Silimela is underlain by the following sediments.

- Dwyka Group, Karoo Supergroup (Low Sensitivity)
- Waterberg Group, Wilge Rivier Formation (Low Sensitivity)
- Waterberg Group, Loskop Formation (Low Sensitivity)
- Rooiberg Group, Kwaggasnek and Schrikkloof Fm (Very Low Sensitivity)
- Bushveld Complex, Lebowa Granite Suite (Zero Sensitivity)
- Transvaal Supergroup; Pretoria Group, Magaliesberg Fm (Moderate Palaeontological Sensitivity)
- Transvaal Supergroup; Pretoria Group, Silverton Fm (Moderate Palaeontological Sensitivity)
- Transvaal Supergroup; Pretoria Group, Daspoort Fm (**High** Palaeontological Sensitivity)
- Transvaal Supergroup; Pretoria Group, Timeball Hill Fm (**High** Palaeontological Sensitivity)
- Transvaal Supergroup; Chuniespoort Group, Malmani Subgroup (**High** Palaeontological Sensitivity)

According to the PalaeoMap of South African Heritage Resources Information System the Palaeontological Sensitivity of the Dwyka Group is Low; Wilge Rivier and Loskop Formations is Low; Kwaggasnek and Schrikkloof Formations is Very Low; Lebowa Granite Suite is Zero, Magaliesberg and Silverton Fm is Moderate; while the Daspoort and Timeball Hill Formations and Malmani Subgroup is High. As the proposed impact of each tower will be small and the area has been previously disturbed by farming the **overall impact of the development will be low**.

In the event that fossil remains are discovered during any phase of construction, either on the surface or exposed by fresh excavations the **Chance Find Protocol** must be implemented by the ECO/site manager in charge of these developments. These discoveries ought to be protected (if possible *in situ*) and the EC must report to SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Tel: 021 462

4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za) so that correct mitigation (*e.g.* recording and collection) can be carry out by a paleontologist.

Preceding any collection of fossil material, the specialist would need to apply for a collection permit from SAHRA. Fossil material must be curated in an accredited collection (museum or university collection), while all fieldwork and reports should meet the minimum standards for palaeontological impact studies suggested by SAHRA.

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Appendix A: CV

1 INTRODUCTION

Eskom Holdings (SOC) Ltd employed Nemai Consulting as the Independent Environmental Assessment Practitioner (EAP) to assume the EIA for the proposed Emkhiweni Substation and 400KV Line from Emkhiweni Substation to Silimela (Figure 1-3). In turn Nemai Consulting employed Banzai Environmental to conduct the **Palaeontological Desktop Assessment** (PDIA) to assess the Palaeontological Heritage on the proposed development footprint.

In 2009 Nemai Consulting was selected by Eskom in 2009 to commence the EIA as part of the 2006 EIA Regulations for the following:

- Construction of the Emkhiweni Substation (then known as the Rockdale B Substation), with 2x500MVA 400/132kV transformers and loop-in lines; and
- Construction of the Emkhiweni Substation to Silimela 400kV line (then referred to Rockdale B to Wolwekraal 400kV line).

Both projects were approved in May 2011 (Emkhiweni Substation) and July 2011 (Emkhiweni Silimela 400kV line). Construction of the Emkhiweni Substation and Emkhiweni Silimela 400kV line (which is approximately 108-110km) proceeded but, the Record of Decision (RoD) lapsed. Nemai Consulting are thus embarked on a new application for Environmental Authorisation (EA) as part of the 2014 EIA Regulations, as amended (07 April 2017). Due to a lack of funding for the project Eskom was not able to continue with construction within the ROD timeframes.

The planned project relates to the transmission network and its correlated substations in the Limpopo and Mpumalanga Provinces. Mpumalanga and Limpopo Provinces have two transmission subsystems known as “Highveld North West” and “Lowveld North”. These interconnected subsystems are at present experiencing problems:

- The lines in the study area are heavily loaded;
- Insufficient transfer capacity
- Rockdale substation reached its firm capacity in 2007;
- Distribution network supplied by the Vulcan substations is failing
- Distribution network in the Marble Hall area is suffering low voltage difficulties
- Proposed Steelpoort (Tubatse) Pumped Storage Scheme needs Transmission network strengthening.

Numerous phased projects for which environmental assessments have been authorised, have been undertaken and include:

• Mokopane to Wolwekraal 400kV power line and associated secondary infrastructure;
• Steelpoort to Wolwekraal 400kV power line and associated secondary infrastructure; and
• Wolwekraal substation and associated secondary infrastructure.

Once these projects are implemented the following would have been achieved:
• The network security will be improved;
• Capacity for future load increases would be created; and • Eskom's revenue would be increased[1].

The distribution network in the Marble Hall area is supplied from the Simplon substation, this network is currently experiencing low voltage problems. In future the Simplon and Rockdale substations will supply additional power to the network, however this additional power cannot be supported by the existing network without violating its operational limits[1].

The Emkhiweni Substation and Emkhiweni Substation to Silimela 400kV line provides the means to support the additional power supply within operational limits[1].

Rockdale is an existing substation located to the southwest of Middleburg near the N11. The transmission lines that feed into it are the two Arnot – Rockdale 275kV lines. The firm capacity at the Rockdale substation is 500MVA and was exceeded in 2007. The new loads at the substation cannot be accommodated without violating the loading conditions of the transformers, which are 45 years old. The existing Rockdale substation also does not have the correct busbar arrangement. If a single transformer is lost, load shedding would be necessary. If a transformer needs to be maintained, then this would also result in load shedding. Additional power demands are expected for the Rockdale substation, however due to the abovementioned problems these cannot be accommodated.
The proposed solution is the construction of a new substation near to the existing Rockdale substation, the Emkhiweni substation[1].

The scope of the project includes:
• Construction of the Emkhiweni Substation, with 2x500MVA 400/132kV transformers and loop-in lines; and
• Construction of the Emkhiweni-Silimela 400kV line.
A power line typically consists of pylons, which are tower-like structures that support electrical cables above the ground. The distance between each pylon is dependent on the type of terrain the lines cross. The standard width of a servitude for a 400kV Transmission line is 55m (27.5m on either side of the power line).
In order for maintenance staff to access the lines and undertake routine maintenance or repair faults, it may be necessary to construct access roads. Eskom have advised that these access roads do not exceed any thresholds in terms of the EIA Regulations of 2014, as amended (07 April 2017).
There are several types of towers/pylons. The types of pylons chosen for the project depend on several factors, these include terrain; expense; and recommendations from the visual specialist. Eskom tries not to bind themselves to one tower/pylon type during the environmental assessment in case another type, based on the factors mentioned above, would be more suitable.
The Emkhiweni-Silimela 400kV powerline would link into the proposed Silimela substation in the north and the proposed Emkhiweni substation in the south.

The proposed Emkhiweni Substation would support the existing Rockdale substation. The proposed Emkhiweni Substation would have a 600m x 600m footprint which would include the following:

• Two 400kV loop-in lines;
• Loop-in lines to the Arnot Kendal power line;
• Offices and control rooms;
• Transformers;
• Communications mast tower;
• Breakers; and
• Other equipment necessary for connecting the 400kV lines to the substation and the 132kV lines out of the substation.

The loop-in lines (Figure 3) would traverse approximately 3km to loop into the existing Arnot - Kendal 400kV line.

[1]Information Provided by Nemai Consulting

2 QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR

The author (Elize Butler) has an MSc in Palaeontology from the University of the Free State, Bloemfontein, South Africa. She has been working in Palaeontology for more than twenty-six years. She has extensive experience in locating, collecting and curating fossils, including exploration field trips in search of new localities in the Karoo Basin. She has been a member of the Palaeontological Society of South Africa for 14 years and has been conducting PIAs since 2014.

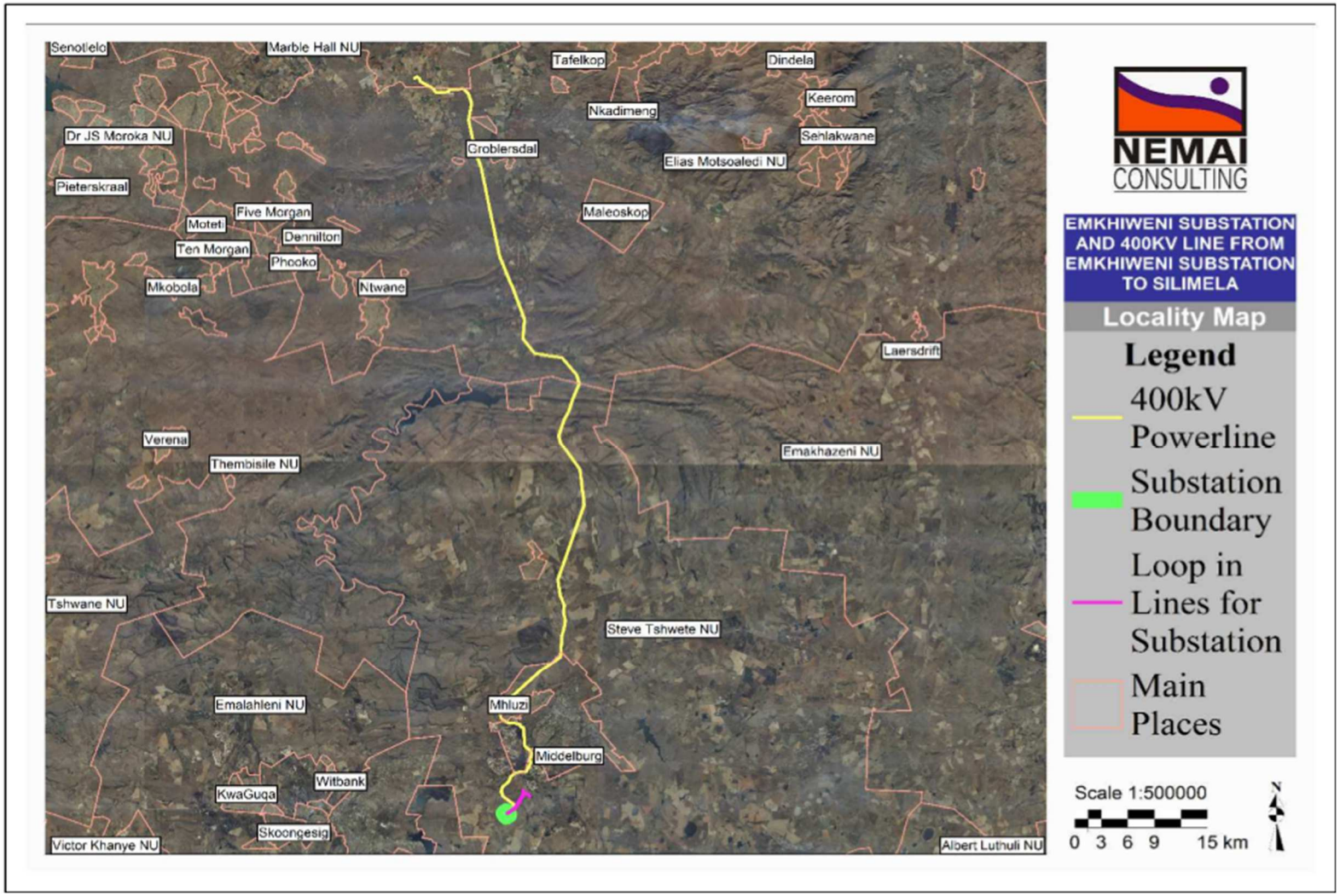


Figure 1: Locality Map.

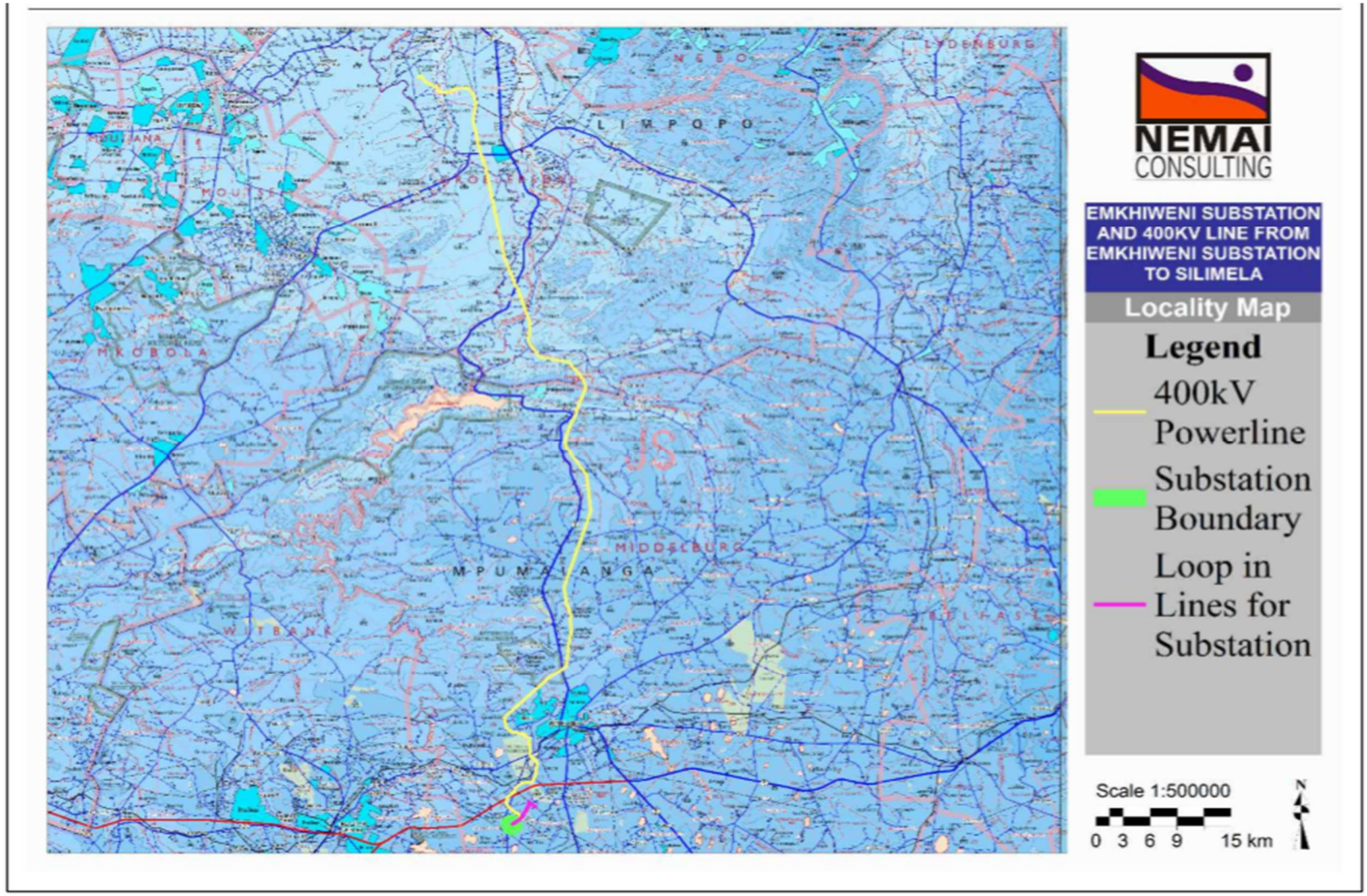


Figure 2: Topographical map (1:250 000).

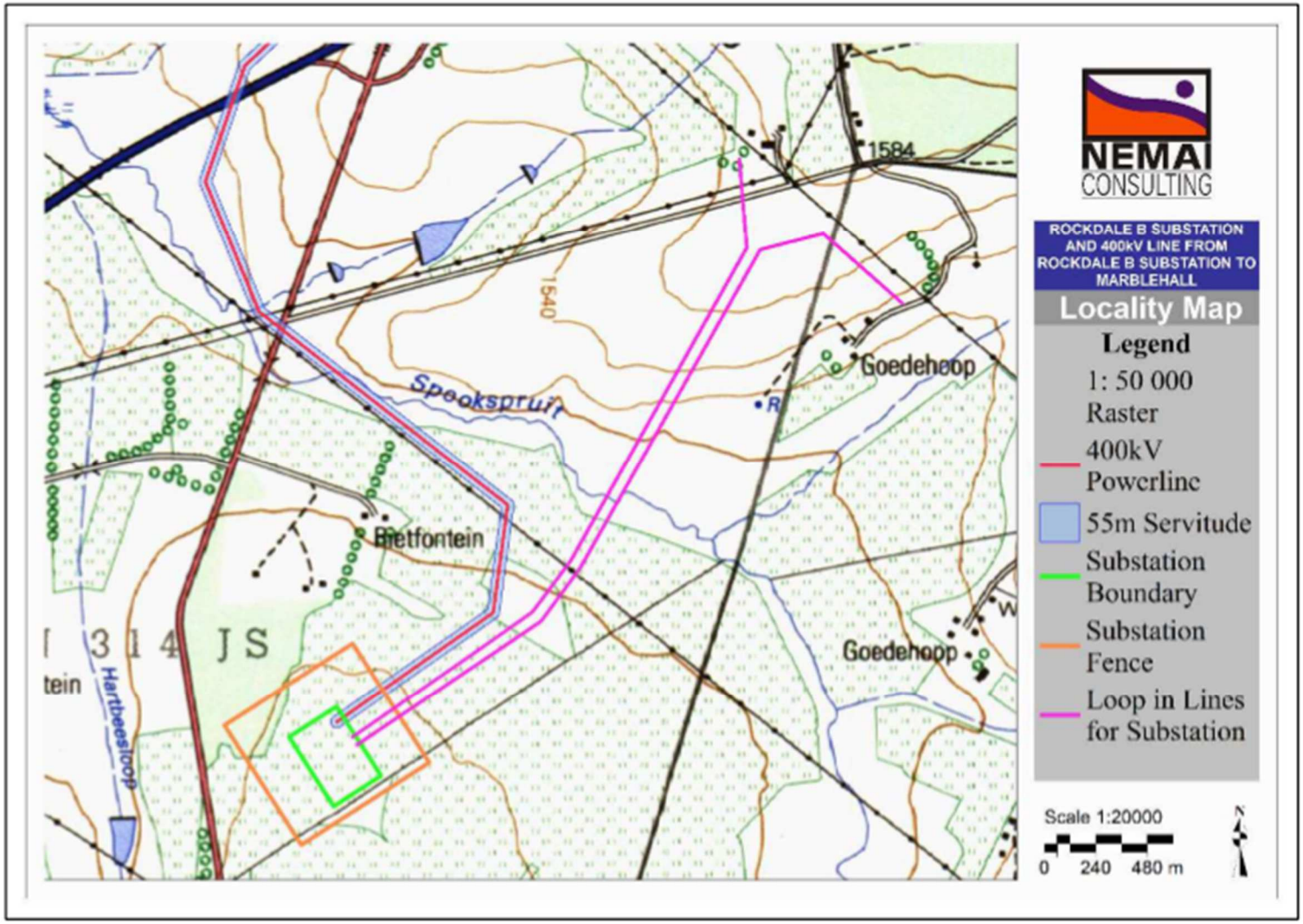


Figure 3: Loop-in Lines and the Emkhiweni Substation.

3 LEGISLATION

3.1 National Heritage Resources Act (25 of 1999)

National Heritage Resources Act (25 of 1999)

Cultural Heritage includes all heritage resources and is protected by the National Heritage Resources Act (Act 25 of 1999) (NHRA). Heritage resources as defined in Section 3 of the Act comprise **"all objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens**".

Palaeontological heritage is exceptional and non-renewable and is protected by the NHRA. Palaeontological resources and may not be unearthed, broken moved, or destroyed by any development without prior assessment and without a permit from the relevant heritage resources authority as per section 35 of the NHRA.

This Palaeontological Impact assessment forms part of the Heritage Impact Assessment (HIA) and adhere to the conditions of the Act. According to **Section 38 (1)**, an HIA is required to assess any potential impacts to palaeontological heritage within the development footprint where:

- the construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300 m in length;
- the construction of a bridge or similar structure exceeding 50 m in length;
- any development or other activity which will change the character of a site—
- (exceeding 5 000 m^2 in extent; or
- involving three or more existing erven or subdivisions thereof; or
- involving three or more erven or divisions thereof which have been consolidated within the past five years; or
- the costs of which will exceed a sum set in terms of regulations by SAHRA or a provincial heritage resources authority
- the re-zoning of a site exceeding 10 000 m^2 in extent;
- or any other category of development provided for in regulations by SAHRA or a Provincial heritage resources authority.

4 OBJECTIVE

The aim of a Palaeontological Impact Assessment (PIA) is to decrease the effect of the development on potential fossils at the development site.

According to the "SAHRA APM Guidelines: Minimum Standards for the Archaeological and Palaeontological Components of Impact Assessment Reports" the purpose of the PIA are: 1) to **identify** the palaeontological importance of the rock formations in the footprint; 2) to evaluate the palaeontological magnitude of the formations; 3) to determine the **impact** on fossil heritage; and 4) to **recommend** how the property developer should guard against and lessen damage to fossil heritage.

The terms of reference of a PIA are as follows:

General Requirements:

- Adherence to the content requirements for specialist reports in accordance with Appendix 6 of the EIA Regulations 2014, as amended.
- Adherence to all applicable best practice recommendations, appropriate legislation and authority requirements.
- Submit a comprehensive overview of all appropriate legislation, guidelines.
- Description of the proposed project and provide information regarding the developer and consultant who commissioned the study.
- Description and location of the proposed development and provide geological and topographical maps.
- Provide Palaeontological and geological history of the affected area.
- Identification sensitive areas to be avoided (providing shapefiles/kml's) in the proposed development.
- Evaluation of the significance of the planned development during the Pre-construction, Construction, Operation, Decommissioning Phases and Cumulative impacts. Potential impacts should be rated in terms of the direct, indirect and cumulative:
    a. **Direct impacts** are impacts that are caused directly by the activity and generally occur at the same time and at the place of the activity.
    b. **Indirect impacts** of an activity are indirect or induced changes that may occur as a result of the activity.
    c. Cumulative impacts result from the incremental impact of the proposed activity on a common resource when added to the impacts of other past, present or reasonably foreseeable future activities.
- Fair assessment of alternatives (infrastructure alternatives have been provided):
- Recommend mitigation measures to minimise the impact of the proposed development; and

Implications of specialist findings for the proposed development (such as permits, licenses etc).

5 GEOLOGICAL AND PALAEONTOLOGICAL HISTORY

The geology of the Emkhiweni Substation and 400KV Line from Emkhiweni Substation to Silimela is depicted on the 1: 250 000 2528 Pretoria Geological Map (Council for Geoscience, Pretoria). The proposed development is underlain by the following rock formations (Figure 4-7, Table 2).

Table 2: Geology of development footprint

Complex	Supergroup/Group/Suite	Formation	Lithology	Fossil Heritage	Palaeontological Sensitivity	Map abbrev.
	Dwyka (Karoo Supergroup)		Conglomerates, glacial to fluvioglacial diamictites, sandstones, shales	Trace fossil assemblage, pre and post glacial, possible plants and shelly invertebrates	Low	Pd
	Waterberg	Wilge Rivier	Conglomerates; sandstones and mudrocks, tidal flat, lacustrine beach and aeolian and marine deposits	Probable Cyanobacterial mats	Low	Mw
	Waterberg	Loskop	Conglomerates sandstone, shale and volcanic rocks	Probable Cyanobacterial mats	Low	Vls
	Rooiberg	Kwaggasnek and Schrikkloof Formations (known as Old Selons River Fm)	Intrusive volcanic rocks (Bushveld Complex), metamorphised sediments (cherts, mudrocks, quartzites and sandstones) largely fluvial origin	Unlikely because of metamorphism	Very Low	Vse
Bushveld Complex	Lebowa Granite Suite		Intrusive mafic rocks, gabbo, gabbo-norite granites and granophyres	Non recorded	Zero	Mn
	Transvaal Supergroup; Pretoria Group	Magaliesberg Fm	Sandstones and mudstones of coastal origin	Microbial mat structures/trace fossils	Moderate	Mg
		Silverton Fm	Volcanic rocks, marine mudrocks with carbonates	Stromatolites	Moderate	Vsi
		Daspoort	Fluvial and Alluvial, deltaic sandstones and mudrocks, in east is marine sediments	Stromatolites	High	Vdq
		Timeball Hill	Quartzite, siltstone, shale, conglomerate, Fluvio-deltaic and lacustrine mudrocks with diamictite, quartzite, minor lavas.	Stromatolites	High	Vt
	Transvaal Supergroup; Chuniespoort Group	Malmani	Minor secondary mudrocks, cherts,	Stromatolites Shallow marine to intertidal	High	Vmd

			containing carbonaceous shale, stromatolitic carbonates (limestones / dolomites),	stromatolites organic-walled microfossils		

Dwyka Group

The Permo-Carboniferous Dwyka Group is the oldest deposit in the Karoo Supergroup and spans the Late Carboniferous to Early Permian. The Dwyka Group overlies the glaciated Precambrian bedrocks in the north and unconformably and paraconfoformably the Cape Supergroup in the south and in the east it overlies the Natal Group and Msikaba Formation unconformably. Glacial pavements underlaying the Dwyka Group has well-developed striations (specifically in the north) (Johnson et al, 2006). The Dwyka Group is believed to be deposited in a marine basin (Visser, 1989). South Africa was covered by an ice sheet during the Dwyka. These deposits were thus deposited in a cold, glacially dominated environment. The Group consists primarily of gravelly sediments with subordinate vorved mudstones and shales with scraped and facetted pebbles. The retreating glaciers deposited dark-grey tillite (Visser et al, 1987). The Dwyka is known for its rich assemblage of dropstones of various sizes as well as its track ways (trace fossils). These track ways were formed by fish and arthropods, while fossilized coprolites or faeces have also been recovered. Body fossils consists of gastropods, invertebrates and marine fish. Fossil plants from this group include various conifers, cordaitaleans, glossopterids, ginkgoaleans, horsetails, lycopods, pollens and spores ferns (Almond and Pether, 2008).

The Transvaal Supergroup is preserved in three structural basins on the Kaapvaal Craton of South Africa namely the Griqualand West Basin, Transvaal Basin, as well as the Kanye Basin in Botswana. The Griqualand West Basin can be subdivided into the Ghaap Plateau and Prieska sub basins. The geometry of the three basins is mostly stratiform with the exclusion of the volcanic precursor of the Kanye Basin and parts of the Griqualand West Basin. Extensive deformation has taken place in the south-western portion of the Griqualand West Basin. Rocks of the Transvaal Supergroup in the Transvaal Basin were intruded by the Bushveld Complex approximately 2060 million years ago. The Transvaal Supergroup overlays the Archaean basement as well as the Witwatersrand and Ventersdorp Supergroups. In the far western and Kanye Basins rocks belonging to the Kanye Formation and Gaborone Granite Suite is also overlain by the Transvaal Supergroup.

The Precambrian Transvaal Supergroup is approximately 2550-2050 Ma years old (Bekker et al. 2008; Catuneanu et al 1999),) (Late Archaean to Early Proterozoic) and is about 15 km thick. This Supergroup consists of sedimentary, volcanic and unmetamorphosed clastic rocks. The sandstone dominated Magaliesberg Formation overlies the mudrocks of the Silverton Formation, and in turn the Silverton Formation overlies the sandstone dominated Daspoort Formation. The Silverton Formation is a lithologically varied, mudrock-dominated sequence that was deposited on an offshore shelf along the borders of the Kaapvaal Craton (Eriksson et al. 2002, 2009). Volcanic ash-rich intervals are common as well as minor beds of carbonate and chert. Sandstones become more

regular in the upper part of the sequence and was deposited under shallower conditions. In the eastern part of the Pretoria Basin, the Machadodorp Member lies in the middle of the Silverton Formation and is represented by a conspicuous interval of volcanic rocks (including agglomerates basaltic lavas as well as tuffs). The presence the volcanic pillow lavas and water-lain tuffs indicates that they were formed beneath the sea. The deep-water Silverton mudrocks were deposited in high sea levels and was followed by shallowing fluvial and deltaic sandstones in low sea levels of the overlying Magaliesberg Formation.

In the eastern part of the Transvaal Basin the Silverton Formation is approximately 1-3 km thick and consists of recessive weathering producing a topography of rolling hills and valleys (Visser 1989). Carbonate rocks are present at the top of the Silverton Formation. Research indicated that microbial activity under low oxygen conditions causes organic carbon within the shales (Eriksson et al. 1989). Organic-walled microfossils thus may be present in these carbon-rich mudrocks of the Silverton Formation while the chert horizons may contain other microbial assemblages. However, the Silverton Formation is not known to contain macrofossils.

The diabase is igneous rocks and are thus considered to have no palaeontological significance. However, the existence of the diabase rocks would have had a thermal metamorphic effect on the adjoining Silverton Formation and would decrease the chance of the fossil preservation in this formation.

The Timeball Hill Formation comprises of conglomerates, diamictite, quartzite, minor lavas with lacustrine and fluvio-deltaic mudrocks, while the overlying Klapperkop Member of the Timeball Hill Formation consist of conglomerate, quartzite, shale and siltstone (Groenewald 2014). Catuneanu & Eriksson (2002) is of the opinion that the Timball Hill Formation was deposited within a deep marine basin (Table 3).

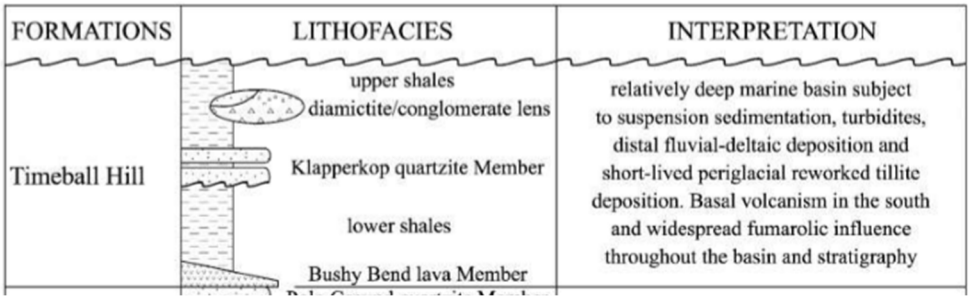


Table 3: Stratigraphy and depositional settings if the Timeball Hill Formation at the base of the Pretoria succession (Catuneanu and Eriksson 2002).

The Timeball Hill Formation is known to contain stromatolites and are associated with thin carbonate interbeds within turbidite sequences in the lower part of the formation (Catuneanu & Eriksson 2002). Stromatolites have not been recorded from the overlying fluvio-deltaic Klapperkop

Quartzite Member. Other subunits in the Pretoria Group containing stromatolites possibly also contain organic-walled microfossils.

Stromatolites are layered mounds, columns and sheet-like sedimentary rocks. These structures were originally formed by the growth of layer upon layer of cyanobacteria, a single-celled photosynthesizing microbe. Cyanobacteria are prokaryotic cells (simplest form of modern carbon-bases life). Stromatolites are first found in Precambrian rocks and are known as the earliest known fossils. The oxygen atmosphere that we depend on was generated by numerous cyanobacteria photosynthesizing during the Archaean and Proterozoic Era.

The Malmani Subgroup platform carbonates of the Transvaal Basin comprise of an assortment of stromatolites (microbial laminites), ranging from supratidal mats to intertidal columns and large subtidal domes (Eriksson *et al.* 2006). This Subgroup is approximately 2 km-thick and consists of a series of formations of stromatolitic and oolitic carbonates (limestones and dolomites), minor secondary cherts and black carbonaceous shales.

Stromatolites and oolites from the Transvaal Supergroup have been described by various authors (Eriksson and Altermann, 1998). Detailed descriptions of South African Archaean stromatolites are available in the literature (Altermann, 1995; Altermann 2001; Buick, 2001; and Schopf, 2006).

The Bushveld Complex is the largest mafic layered intrusion in the world. It consists of three different groups of igneous rocks. The oldest is a series of volcanic rocks, followed by basaltic magma that did not reach the surface and formed an enormous underground chamber of approximately 400 x 300 km across the Limpopo, North West and Mpumalanga provinces reaching a maximum thickness of approximately 8km. Magma intruded above the basaltic body and crystallized as granite. The three components are known as the Rooiberg Group, Rustenburg Layered Suite and Lebowa Granite Suite, which together make up the Bushveld Complex. As this is igneous rocks it does not contain fossils and the Palaeontological Sensitivity is thus zero.

Table 4: Currently accepted nomenclature and subdivisions of the Bushveld Complex (Cawthorn et al, 2006)

Lebowa Granite Suite	Nebo, Makhutso, Klipkloof, Bobbejaanskop and Verena Granites	
Rashoop Granophyre Suite	Stavoren and Diepkloof Granophyres, Rooikop Porphyritic Granite, Zwartbank Pseudogranophyre	
Rustenburg Layered Suite	Upper Zone	Subzone C (Ol-Ap diotite Subzone B (Ol-Mt gabbronorite) Subzone A (Mt gabbronorite)
	Main Zone Upper	Upper Subzone (gabbronorite) Lower Subzone (gabbronorite, norite)

	Critical Zone	Upper Subzone (norite, anothosite, pyroxenite Lower Subzone (pyroxenite) Lower Subzone (pyroxenite)
	Marginal Zone	(norite)
Rooiberg Group	Schrikkloof Formation (flow-banded rhyolite) Kwaggasnek Formation (dacite, rhyolite) Dullstroom Formation (basaltic andesite)	

The Waterberg Group is in Gauteng, Mpumalanga and Limpopo Provinces in South Africa and extends westwards in Botswana as well. The main Waterberg Basin is in the Limpopo Province extending into Botswana. The Loskop Fm overlies the Wilge River Formation of the Waterberg Group and is at its thickest north of Middelburg reaching approximately 1000 m. The Loskop Formation consists of argillaceous clastic sedimentary rocks with lesser coarse sedimentation. The rocks of the Waterberg Group are typically dark greyish red in colour apparently due to the haematite coatings which formed in its early history suggesting and oxidising environment (Barker *et al*, 2006). There is a low possibility of cyanobacterial mats in the Waterberg Group.

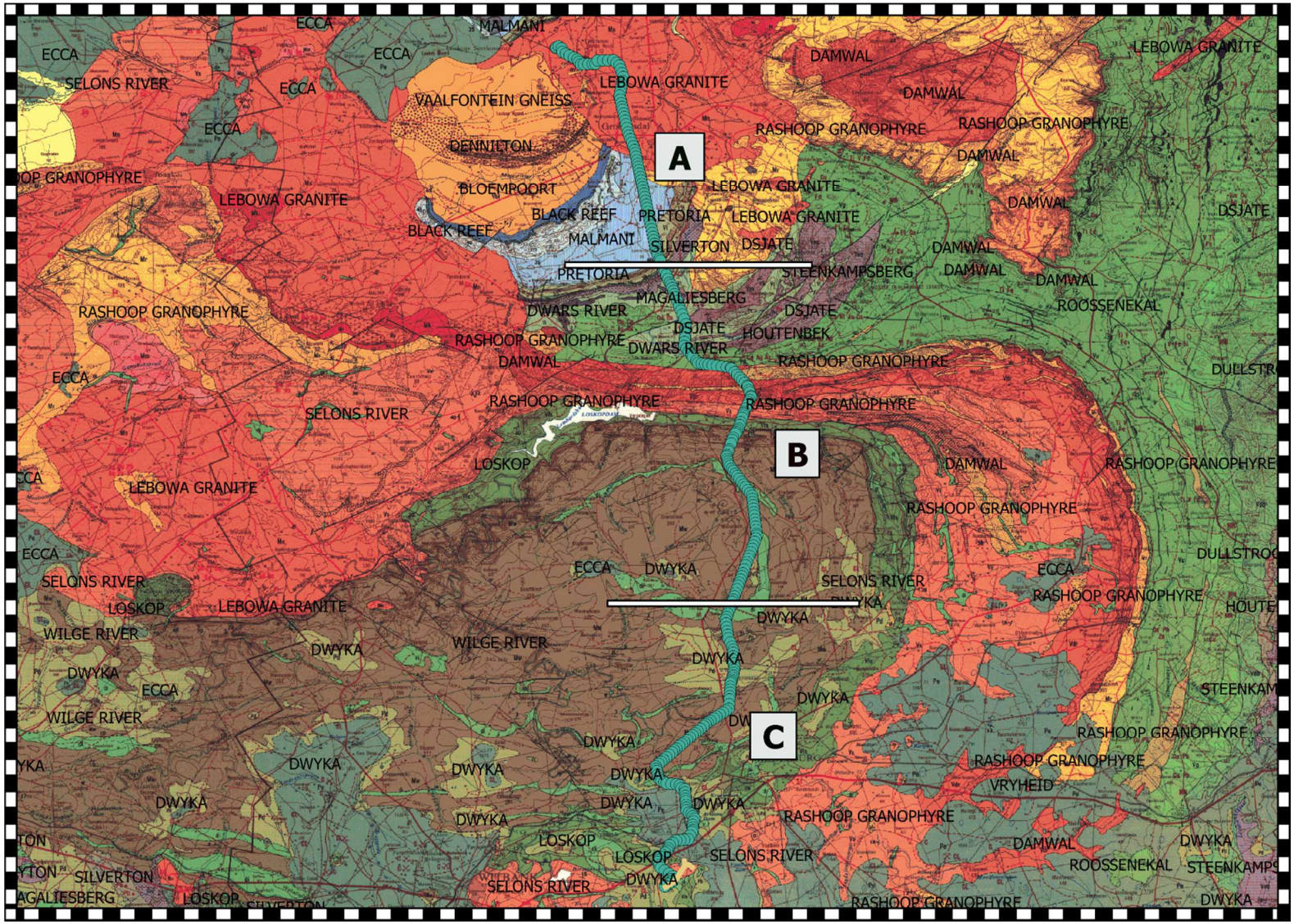


Figure 4: Extract of the 1: 250 000 2528 Pretoria Geological Map (Council for Geoscience, Pretoria) indicating the subdivisions of the proposed development used in this report.

*Figure 5: Geological sediments represented in Section A of the proposed development footprint are Lebowa Granite Suite; (Bushveld Complex; **Mn);** Malmani Subgroup, (Chuniespoort Group, Transvaal Supergroup, **Vmd**); Timeball Hill (**Vt**) and Daspoort (**Vdq**) (Pretoria Group, Transvaal Supergroup) and diabase (**di**) Map drawn by QGIS 2.18.28.*

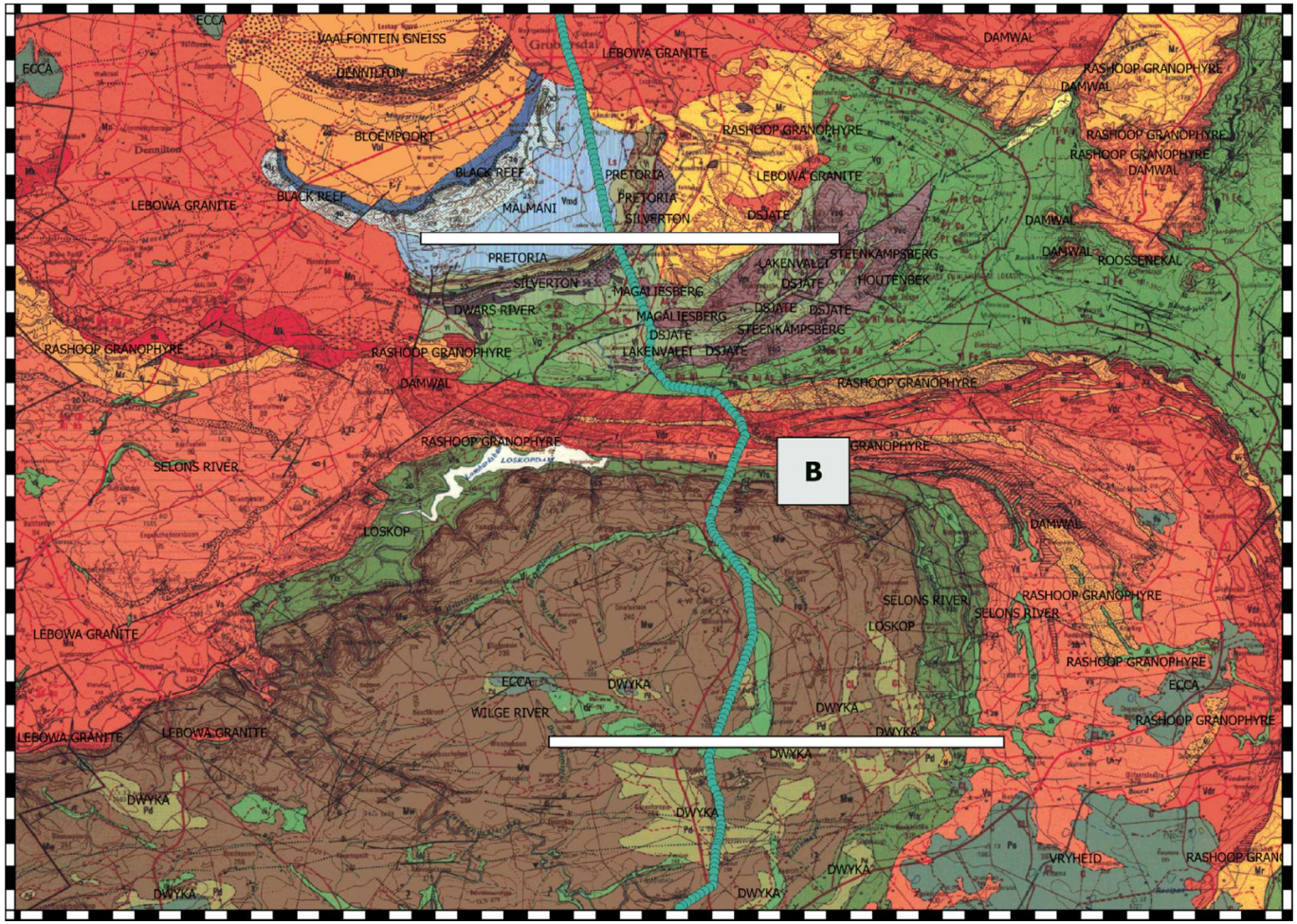


*Figure 6: Geological sediments represented in Section B of the proposed development footprint is Silverton (Vsi), Magaliesberg (**Mw**), and Lakenvalei (**Vlg**) Formation (Pretoria Group, Transvaal Supergroup); Loskop (**Vls**); Dsjate Rashoop Granophyre (**Mr**); Damwal (**Vdr**) (Rooiberg Group); Wilge Rivier (**Mw**) (Waterberg Group) and diabase (**di**). Map drawn by QGIS 2.18.28.*

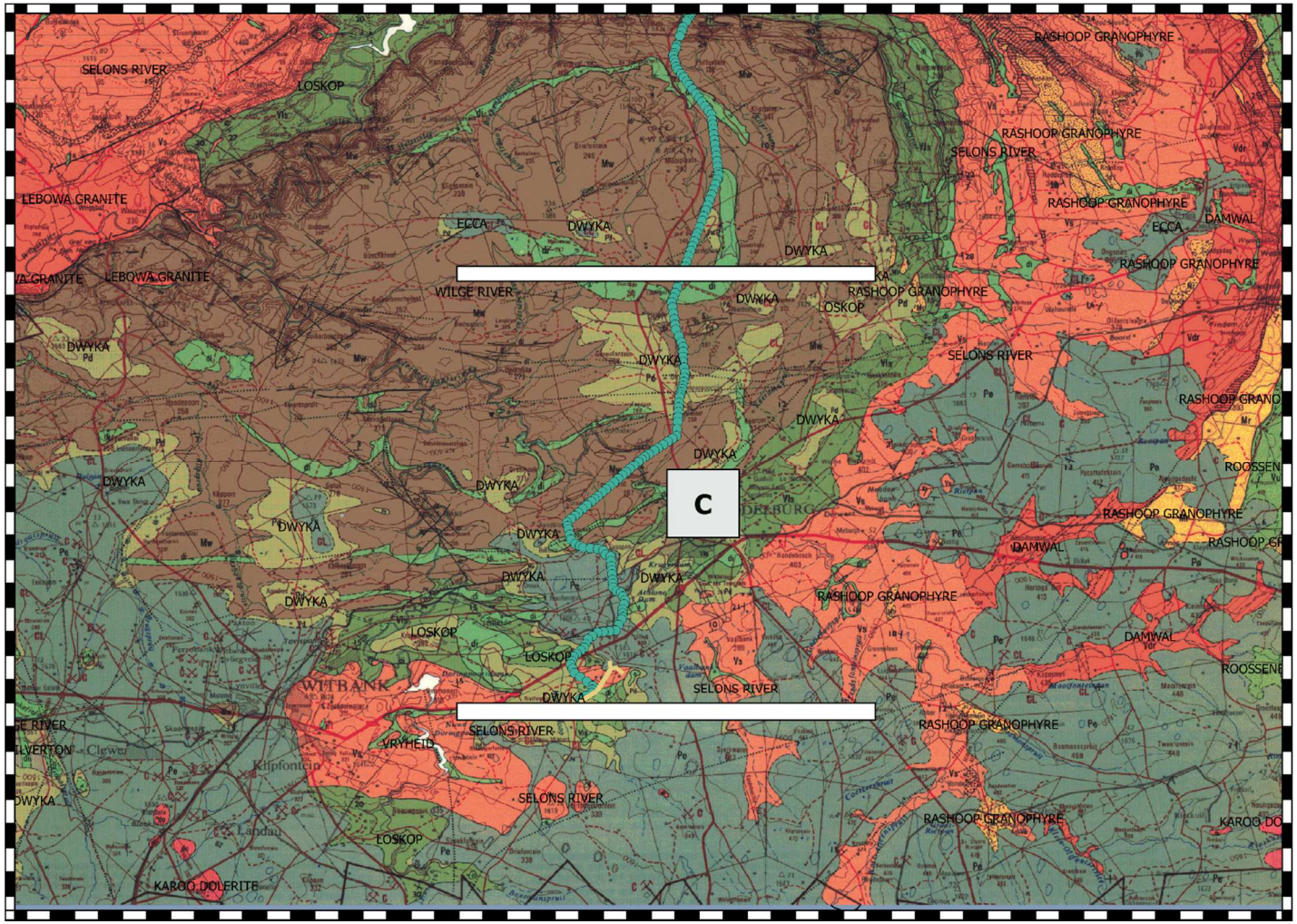
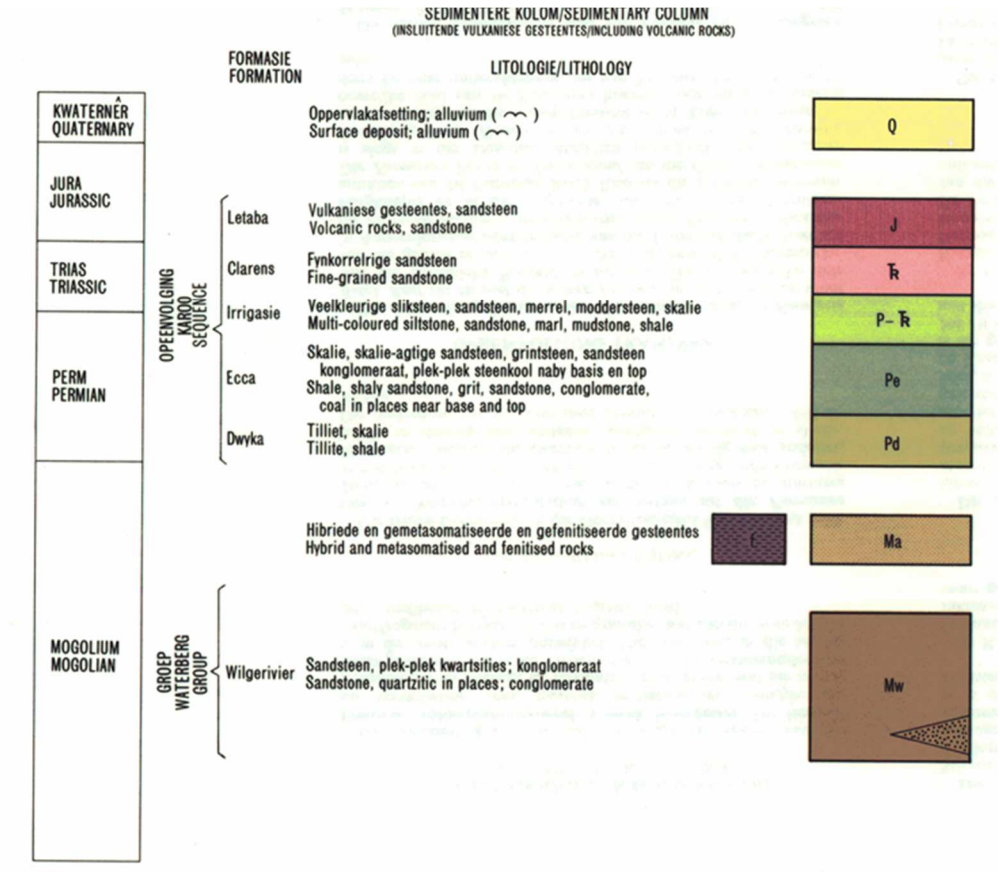
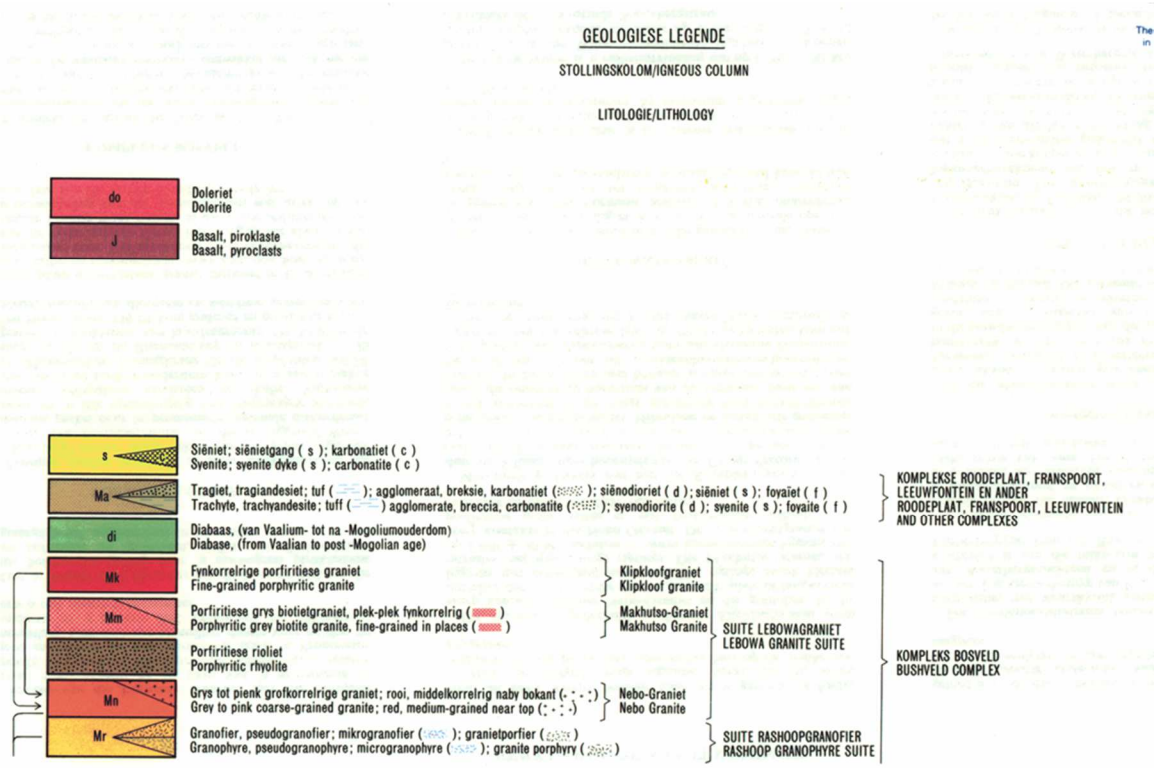
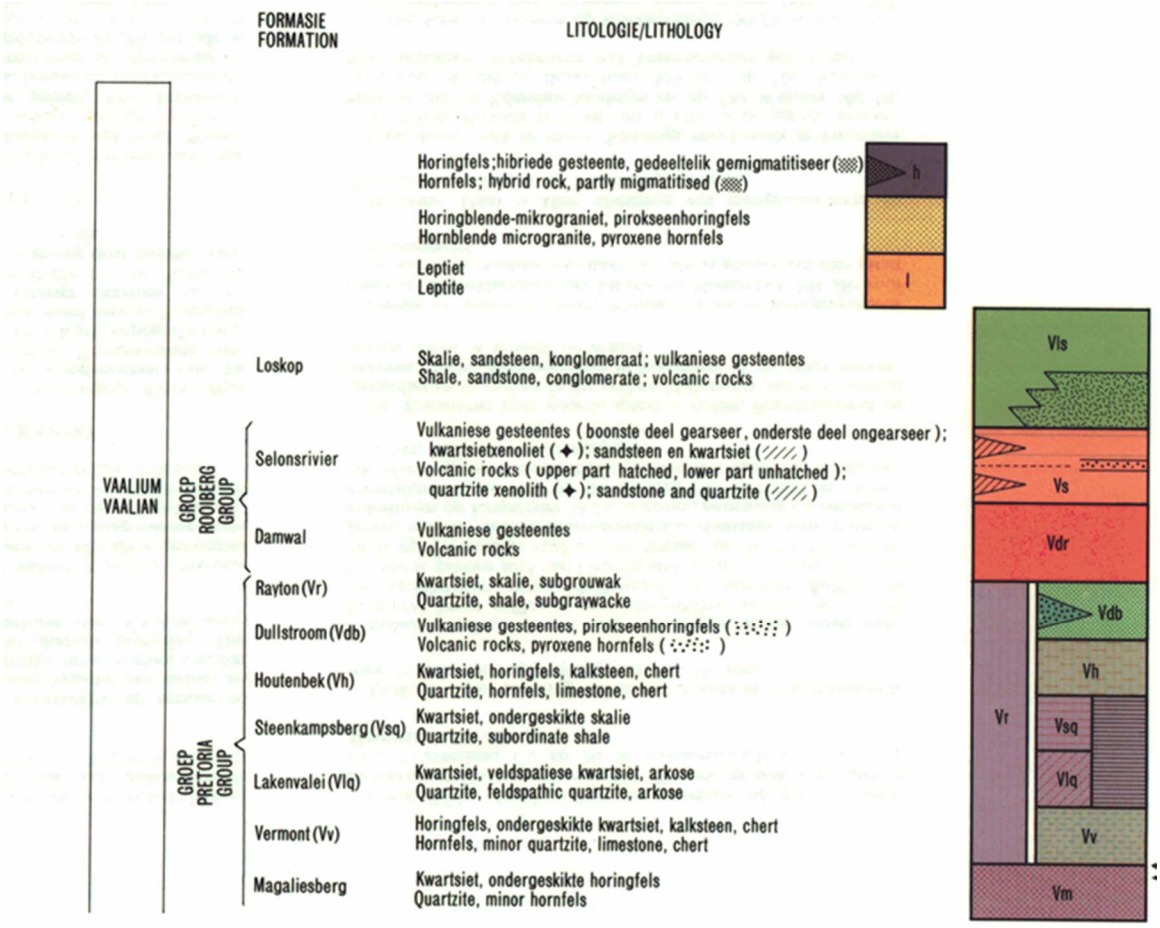


*Figure 7: Geological sediments represented in Section C of the proposed development footprint is diabase (di), Dwyka Group (Karoo Supergroup)(Pd); Wilge Rivier (**Mw**) (Waterberg Group), Selonsrivier Formation (Rooiberg Group). Map drawn by QGIS 2.18.28.*

LEGEND


SEDIMENTERE KOLOM/SEDIMENTARY COLUMN
(INSLUITENDE VULKANIESE GESTEENTES/INCLUDING VOLCANIC ROCKS)
FORMASIE
FORMATION
LITOLOGIE/LITHOLOGY
KWATERNÊR
QUATERNARY
JURA
JURASSIC
TRIAS
TRIASSIC
PERM
PERMIAN
MOGOLIUM
MOGOLIAN
OPEENVOLGING
KAROO
SEQUENCE
GROEP
WATERBERG
GROUP
Oppervlakafsetting; alluvium ( )
Surface deposit; alluvium ( )
Q
Letaba
Vulkaniese gesteentes, sandsteen
Volcanic rocks, sandstone
J
Clarens
Fynkorrelrige sandsteen
Fine-grained sandstone
Tr
Irrigasie
Veelkleurige sliksteen, sandsteen, merrel, moddersteen, skalie
Multi-coloured siltstone, sandstone, marl, mudstone, shale
P–Tr
Ecca
Skalie, skalie-agtige sandsteen, grintsteen, sandsteen konglomeraat, plek-plek steenkool naby basis en top
Shale, shaly sandstone, grit, sandstone, conglomerate, coal in places near base and top
Pe
Dwyka
Tilliet, skalie
Tillite, shale
Pd
Hibriede en gemetasomatiseerde en gefenitiseerde gesteentes
Hybrid and metasomatised and fenitised rocks
f
Ma
Wilgerivier
Sandsteen, plek-plek kwartsities; konglomeraat
Sandstone, quartzitic in places; conglomerate
Mw


GEOLOGIESE LEGENDE
STOLLINGSKOLOM/IGNEOUS COLUMN
LITOLOGIE/LITHOLOGY
do
Doleriet
Dolerite
J
Basalt, piroklaste
Basalt, pyroclasts
s
Siënïet; siënïetgang (s); karbonatiet (c)
Syenite; syenite dyke (s); carbonatite (c)
Ma
Tragiet, tragiandesiet; tuf ( ); agglomeraat, breksie, karbonatiet ( ); siënodioriet (d); siënïet (s); foyaïet (f)
Trachyte, trachyandesite; tuff ( ) agglomerate, breccia, carbonatite ( ); syenodiorite (d); syenite (s); foyaite (f)
KOMPLEKSE ROODEPLAAT, FRANSPOORT, LEEUWFONTEIN EN ANDER
ROODEPLAAT, FRANSPOORT, LEEUWFONTEIN AND OTHER COMPLEXES
di
Diabaas, (van Vaalium- tot na -Mogoliumouderdom)
Diabase, (from Vaalian to post -Mogolian age)
Mk
Fynkorrelrige porfiritiese graniet
Fine-grained porphyritic granite
Klipkloofgraniet
Klipkloof granite
Mm
Porfiritiese grys biotietgraniet, plek-plek fynkorrelrig ( )
Porphyritic grey biotite granite, fine-grained in places ( )
Makhutso-Graniet
Makhutso Granite
SUITE LEBOWAGRANIET
LEBOWA GRANITE SUITE
KOMPLEKS BOSVELD
BUSHVELD COMPLEX
Porfiritiese rioliet
Porphyritic rhyolite
Mn
Grys tot pienk grofkorrelrige graniet; rooi, middelkorrelrig naby bokant ( )
Grey to pink coarse-grained granite; red, medium-grained near top ( )
Nebo-Graniet
Nebo Granite
Mr
Granofier, pseudogranofier; mikrogranofier ( ); granietporfier ( )
Granophyre, pseudogranophyre; microgranophyre ( ); granite porphyry ( )
SUITE RASHOOPGRANOFIER
RASHOOP GRANOPHYRE SUITE



6 GEOGRAPHICAL LOCATION OF THE SITE

Project Location

The proposed activity entails the construction of a 400kV power line from the Middelburg area in the south to the Marble Hall/Wolwekraal area in the north. The proposed line originates at the Silimela Substation, which is situated approximately 13km to the southeast of Marble Hall (Limpopo Province) on the Farm Loskop Noord 12 JS and runs south-eastwards. The line terminates at the proposed Emkhiweni Substation within Mpumalanga. The proposed development falls within the jurisdiction of the Steve Tshwete Local Municipality (LM), Elias Motsoaledi LM and Ephraim Mogale LM[1].

The width of the powerline servitude upon completion would be 55m. In addition to the Specialist Studies, a walk-down survey of the previously authorized powerline route was undertaken to ensure that the final pylon placement has a minimal impact.

Start Point

25°5'10.31"S; 29°17'55.02"E

Midpoint

25°28'26.86"S; 29°27'35.52"E

End Point

25°52'22.73"S; 29°24'2.89"E
The coordinates of the proposed Emkhiweni Substation are 25°52'19.20"S; 29°23'60.00"E[1].

[1]Information provided by Nemai Consulting

7 METHODS

The aim of a desktop study is to evaluate the risk to palaeontological heritage in the proposed development. This include all trace fossils and fossils. All available information is consulted to compile a desktop study and includes: Palaeontological impact assessment reports in the same area; aerial photos and Google Earth images, topographical as well as geological maps.

7.1 Assumptions and Limitations

When conducting a DIA several factors can affect the accuracy of the assessment. The focal point of geological maps is the geology of the area and the sheet explanations were not meant to focus on palaeontological heritage. Many inaccessible regions of South Africa have not been reviewed by palaeontologists and data is generally based on aerial photographs. Locality and geological information of museums and universities databases have not been kept up to date or data collected in the past have not always been accurately documented.

Comparable Assemblage Zones in other areas is used to provide information on the existence of fossils in an area which was not yet been documented. When similar Assemblage Zones and geological formations for Desktop studies is used it is generally **assumed** that exposed fossil heritage is present within the footprint. A field-assessment is thus necessary to improve the accuracy of the desktop assessment, where necessary.

8 ADDITIONAL INFORMATION CONSULTED

In compiling this report the following sources were consulted:

- Geological map 1:100 000, Geology of the Republic of South Africa (Visser 1984)
- 1: 250 000 2528 Pretoria Geological map (Council of Geoscience)
- A Google Earth map with polygons of the proposed development was obtained from Nemai Consultants.

9 IMPACT ASSESSMENT METHODOLOGY

Impact assessment must take account of the nature, scale and duration of impacts on the environment whether such impacts are positive or negative. Each impact is also assessed according to the following project phases:

• Construction

• Operation

• Decommissioning

Where necessary, the proposal for mitigation or optimisation of an impact should be detailed. A brief discussion of the impact and the rationale behind the assessment of its significance should also be included. The rating system is applied to the potential impacts on the receiving environment and includes an objective evaluation of the mitigation of the impact. In assessing the significance of each impact the following criteria is used:

Table 5: The rating system

NATURE		
The Nature of the Impact is the possible destruction of fossil heritage		
GEOGRAPHICAL EXTENT		
This is defined as the area over which the impact will be experienced.		
1	Site	The impact will only affect the site.
2	Local/district	Will affect the local area or district.
3	Province/region	Will affect the entire province or region.
4	International and National	Will affect the entire country.
PROBABILITY		
This describes the chance of occurrence of an impact.		
1	Unlikely	The chance of the impact occurring is extremely low (Less than a 25% chance of occurrence).
2	Possible	The impact may occur (Between a 25% to 50% chance of occurrence).
3	Probable	The impact will likely occur (Between a 50% to 75% chance of occurrence).
4	Definite	Impact will certainly occur (Greater than a 75% chance of occurrence).
DURATION		
This describes the duration of the impacts. Duration indicates the lifetime of the impact as a result of the proposed activity.		

1	Short term	The impact will either disappear with mitigation or will be mitigated through natural processes in a span shorter than the construction phase (0 – 1 years), or the impact will last for the period of a relatively short construction period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 2 years).
2	Medium term	The impact will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (2 – 10 years).
3	Long term	The impact and its effects will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter (10 – 30 years).
4	Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered indefinite.
INTENSITY/ MAGNITUDE		
Describes the severity of an impact.		
1	Low	Impact affects the quality, use and integrity of the system/component in a way that is barely perceptible.
2	Medium	Impact alters the quality, use and integrity of the system/component but system/component still continues to function in a moderately modified way and maintains general integrity (some impact on integrity).
3	High	Impact affects the continued viability of the system/ component and the quality, use, integrity and functionality of the system or component is severely impaired and may temporarily cease. High costs of rehabilitation and remediation.
4	Very high	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component permanently ceases and is irreversibly impaired. Rehabilitation and remediation often impossible. If possible rehabilitation and remediation often unfeasible due to extremely high costs of rehabilitation and remediation.
REVERSIBILITY		
This describes the degree to which an impact can be successfully reversed upon completion of the proposed activity.		

1	Completely reversible	The impact is reversible with implementation of minor mitigation measures.
2	Partly reversible	The impact is partly reversible but more intense mitigation measures are required.
3	Barely reversible	The impact is unlikely to be reversed even with intense mitigation measures.
4	Irreversible	The impact is irreversible and no mitigation measures exist.
IRREPLACEABLE LOSS OF RESOURCES		
This describes the degree to which resources will be irreplaceably lost as a result of a proposed activity.		
1	No loss of resource	The impact will not result in the loss of any resources.
2	Marginal loss of resource	The impact will result in marginal loss of resources.
3	Significant loss of resources	The impact will result in significant loss of resources.
4	Complete loss of resources	The impact is result in a complete loss of all resources.
CUMULATIVE EFFECT		
This describes the cumulative effect of the impacts. A cumulative impact is an effect which in itself may not be significant but may become significant if added to other existing or potential impacts emanating from other similar or diverse activities as a result of the project activity in question.		
1	Negligible cumulative impact	The impact would result in negligible to no cumulative effects.
2	Low cumulative impact	The impact would result in insignificant cumulative effects.
3	Medium cumulative impact	The impact would result in minor cumulative effects.
4	High cumulative impact	The impact would result in significant cumulative effects
SIGNIFICANCE		
Significance is determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The calculation of the significance of an impact uses the following formula: (**Extent + probability + reversibility + irreplaceability + duration + cumulative effect) x magnitude/intensity.** The summation of the different criteria will produce a non-weighted value. By multiplying this value with the magnitude/intensity, the resultant value acquires a weighted characteristic which can be measured and assigned a significance rating.		
Points	Impact significance rating	Description
6 to 28	Negative low impact	The anticipated impact will have negligible negative effects and will require little to no mitigation.
6 to 28	Positive low impact	The anticipated impact will have minor positive effects.

29 to 50	Negative medium impact	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.
29 to 50	Positive medium impact	The anticipated impact will have moderate positive effects.
51 to 73	Negative high impact	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact.
51 to 73	Positive high impact	The anticipated impact will have significant positive effects.
74 to 96	Negative very high impact	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately. These impacts could be considered "fatal flaws".
74 to 96	Positive very high impact	The anticipated impact will have highly significant positive

9.1 Summary of Impact Tables

Only the site will be affected. The expected duration of the impact is assessed as potentially permanent to long term. In the absence of mitigation procedures the damage and destruction of any fossils will be permanent and irreversible. Impacts on palaeontological heritage during the construction phase could potentially occur but are regarded as having a low possibility. However, it is probable that an impact could occur. As the proposed impact of each tower will be small and the area has been largely previously disturbed, the significance of the impact will be negative low.

10 FINDINGS

The proposed Emkhiweni Substation and 400KV Line from Emkhiweni Substation to Silimela is underlain by the following sediments.

- Dwyka Group, Karoo Supergroup. (Low Sensitivity)
- Waterberg Group, Wilge Rivier Formation (Low Sensitivity)
- Waterberg Group, Loskop Formation (Low Sensitivity)
- Rooiberg Group, Kwaggasnek and Schrikkloof Fm (Very Low Sensitivity)
- Bushveld Complex, Lebowa Granite Suite, (Zero Sensitivity)
- Transvaal Supergroup; Pretoria Group, Magaliesberg Fm (Moderate Palaeontological Sensitivity)
- Transvaal Supergroup; Pretoria Group, Silverton Fm (Moderate Palaeontological Sensitivity)
- Transvaal Supergroup; Pretoria Group, Daspoort Fm (**High** Palaeontological Sensitivity)

- Transvaal Supergroup; Pretoria Group, Timeball Hill Fm (**High** Palaeontological Sensitivity)
- Transvaal Supergroup; Chuniespoort Group, Malmani Subgroup (**High** Palaeontological Sensitivity)

According to the PalaeoMap of South African Heritage Resources Information System the Palaeontological Sensitivity of the Dwyka Group is Low; Wilge Rivier and Loskop Formations is Low; Kwaggasnek and Schrikkloof Formations is Very Low; Lebowa Granite Suite is Zero, Magaliesberg and Silverton Fm is Moderate; while the Daspoort and Timeball Hill Formations and Malmani Subgroup is High. As the proposed impact of each tower will be small and the area has been previously disturbed by farming and other activities the overall impact of the development will be low.

In the event that fossil remains are discovered during any phase of construction, either on the surface or exposed by fresh excavations the **Chance Find Protocol** must be implemented by the EC in charge of these developments. These discoveries ought to be protected (if possible *in situ*) and the EC must report to SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Tel: 021 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za) so that correct mitigation (*e.g.* recording and collection) can be carry out by a palaeontologist.

Preceding any collection of fossil material, the specialist would need to apply for a collection permit from SAHRA. Fossil material must be curated in an accredited collection (museum or university collection), while all fieldwork and reports should meet the minimum standards for palaeontological impact studies suggested by SAHRA.

11 PROTOCOL FOR FINDS

11.1 Legislation

Cultural Heritage in South Africa (includes all heritage resources) is protected by the **National Heritage Resources Act (Act 25 of 1999) (NHRA).** According to Section 3 of the Act, all Heritage resources include **"all objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens**".

Palaeontological heritage is unique and non-renewable and is protected by the NHRA and are the property of the State. It is thus the responsibility of the State to manage and conserve fossils on behalf of the citizens of South Africa. Palaeontological resources may not be excavated, broken, moved, or destroyed by any development without prior assessment and without a permit from the relevant heritage resources authority as per section 35 of the NHRA.

11.2 Background

A fossil is the naturally preserved remains (or traces) of plants or animals embedded in rock. These plants and animals lived in the geologic past millions of years ago. Fossils are extremely rare and irreplaceable. By studying fossils, it is possible to determine the environmental conditions that existed in a specific geographical area millions of years ago.

11.3 Introduction

This informational document is intended for workmen and foremen on construction sites. It describes the actions to be taken when mining or construction activities accidentally uncovers fossil material.

It is the responsibility of the Environmental Officer (EO) of the project to train the workmen and foremen in the procedure to follow when a fossil is accidentally uncovered. In the absence of the EO, a member of the staff must be appointed to be responsible for the proper implementation of the chance find protocol as not to compromise the conservation of fossil material.

11.4 Chance Find Procedure

- If a chance find is made the person responsible for the find must immediately **stop working** and all work must cease in the immediate vicinity of the find.
- The person who made the find must immediately **report** the find to his/her direct supervisor which in turn must report the find to his/her manager and the EO or site manager. The EO must report the find to the relevant Heritage Agency (South African Heritage Research Agency, SAHRA). (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Tel: 021 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). The information to the Heritage Agency must include photographs of the find, from various angles, as well as the GPS co-ordinates.
- A preliminary report must be submitted to the Heritage Agency within **24 hours** of the find and must include the following: 1) date of the find; 2) a description of the discovery and a 3) description of the fossil and its context (depth and position of the fossil), GPS co-ordinates.
- Photographs (the more the better) of the discovery must be of high quality, in focus, accompanied by a scale. It is also important to have photographs of the vertical section (side) where the fossil was found.

Upon receipt of the preliminary report, the Heritage Agency will inform the ECO (site manager) whether a rescue excavation or rescue collection by a palaeontologist is necessary.

- The site must be secured to protect it from any further damage. **No attempt** should be made to remove material from their environment. The exposed finds must be stabilized and covered by a plastic sheet or sand bags. The Heritage authority will also be able to advise on the most suitable method of protection of the find.
- If the fossil cannot be stabilized the fossil may be collected with extreme care by the ECO (site manager). Fossils finds must be stored in tissue paper and in an appropriate box while due care must be taken to remove all fossil material from the rescue site.
- Once the Heritage authority has issued the written authorization, the developer may continue with the development.

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Appendix A – Elize Butler CV

CURRICULUM VITAE

ELIZE BUTLER

PROFESSION: Palaeontologist

YEARS' EXPERIENCE: 26 years in Palaeontology

EDUCATION: B.Sc Botany and Zoology, 1988
University of the Orange Free State

B.Sc (Hons) Zoology, 1991
University of the Orange Free State

Management Course, 1991
University of the Orange Free State

M. Sc. *Cum laude* (Zoology), 2009
University of the Free State

Dissertation title: The postcranial skeleton of the Early Triassic non-mammalian Cynodont *Galesaurus planiceps*: implications for biology and lifestyle

Registered as a PhD fellow at the Zoology Department of the UFS
2013 to current

Dissertation title: A new gorgonopsian from the uppermost D*aptocephalus Assemblage Zone*, in the Karoo Basin of South Africa

MEMBERSHIP

Palaeontological Society of South Africa (PSSA) 2006-currently

EMPLOYMENT HISTORY

Part-time Laboratory assistant — Department of Zoology & Entomology University of the Free State Zoology 1989-1992

Part-time laboratory assistant — Department of Virology University of the Free State Zoology 1992

Research Assistant	National Museum, Bloemfontein 1993 – 1997
Principal Research Assistant and Collection Manager	National Museum, Bloemfontein 1998–currently

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