Palaeontological Impact Assessment – Ver2

Proposed Development of a 132 kV Overhead Power Line and Associated Electrical Grid Infrastructure to support the Proposed Vhuvhili Solar Photovoltaic Energy Facility, near Secunda, Mpumalanga Province

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Executive Summary

Vhuvhili Solar RF (Pty) Ltd proposes the construction of a 132 kV overhead transmission power line and associated EGI to feed the electricity generated by the proposed Vhuvhili SEF to the switching station at the proposed Mukondeleli WEF. The electricity will be transferred from the proposed on-site substation at the proposed Vhuvhili SEF via a 132 kV power line that extends approximately 12 km in length to the proposed switching station at the proposed Mukondeleli WEF. The project is south of Secunda, Mpumalanga Province.

This report is for the palaeontological impact. Both the Mukondeleli on-site switching station connections (including both alternatives) and the proposed 132 kV power line (including all four alternatives) connecting the Vhuvhili SEF to the Mukondeleli WEF are on non-fossiliferous dolerite of the Jurassic so there is no impact on the palaeontology.

The Mukondeleli WEF switching station and the grid connection route to the Vhuvhili SEF complex will have no impact on the palaeontology. The proposed Vhuvhili on-site substations and hub connections (four alternatives) are on potentially very highly sensitive rocks of the Vryheid Formation (Ecca Group, Karoo Supergroup) that could preserve fossil plants of the *Glossopteris* flora. No fossils are likely to occur in the overlying soils but might occur below ground in undisturbed shales but would only be discovered once excavations commence. Mitigation would be the removal of any fossils found once excavations commence. The impact would only be during the construction phase. The impact before mitigation is low, and the impact post-mitigation is very low.

There are no identified fatal flaws and no objections on palaeontological heritage grounds to authorisation of the proposed power line project (all four alternative routings) on condition that (i) the recommended mitigation measures and (ii) the Fossil Chance Finds Protocol are implemented in full during the Construction Phase.

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EGI – Electrical Grid Infrastructure
PIA – Palaeontological Impact Assessment
SEF – Solar Energy Facility
WEF – Wind Energy Facility

1. Background and Project Description

Vhuvhili Solar RF (Pty) Ltd, the Applicant, is proposing the construction of a 132 kV overhead transmission power line and associated EGI to feed the electricity generated by the proposed Vhuvhili SEF to the switching station at the proposed Mukondeleli WEF. The electricity will be transferred from the proposed on-site substation at the proposed Vhuvhili SEF via a 132 kV power line that extends approximately 12 km in length to the proposed switching station at the proposed Mukondeleli WEF.

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- It is important to note that this Basic Assessment (BA) process only includes the assessment of the proposed 132 kV power line to transfer the electricity from the proposed Vhuvhili SEF to the proposed Mukondeleli WEF switching station. The proposed Vhuvhili SEF, including the on-site substation and Battery Energy Storage System (BESS), is subject to a separate Scoping and Environmental Impact Assessment (S&EIA) process which is currently underway (DARDLEA NEAS Reference Number: MPP/EIA/0001063/2022). The proposed Mukondeleli WEF, including the on-site switching station to which the proposed 132 kV power line will connect, is also subject to a separate S&EIA process (NEAS: MPP/EIA/0001099/2022), as summarised below.

Table 1: Details of this BA process and related S&EIA processes underway

Project	Process	Authority Reference Number	EAP	Status	Subject of this application and BA process
Proposed Vhuvhili-to-Mukondeleli 132 kV power line and associated EGI	BA	To be assigned	Paul Lochner (CSIR) (EAP 2019/745)	Application submitted	Yes
Proposed Vhuvhili SEF Proposed on-site substation and BESS complex at the proposed Vhuvhili SEF site	S&EIA	NEAS: MPP/EIA/0001063/2022	Paul Lochner (CSIR) (EAP 2019/745)	Application and Final Scoping Report submitted	No
Proposed Mukondeleli WEF Proposed switching station at the proposed Mukondeleli WEF site	S&EIA	NEAS: MPP/EIA/0001099/2022	WSP	WEF Draft Scoping Report out for public comment	No

- The Project Applicant is currently investigating four power line routing alternatives for the transfer of the electricity generated by the proposed Vhuvhili SEF to the switching station at the proposed Mukondeleli WEF. Please refer to Figure 1 for the power line routing alternatives that are assessed as part of this BA process. The Figure also includes the preferred and alternative substation and BESS complexes at the proposed Vhuvhili SEF site and the two switching station alternatives at the proposed Mukondeleli WEF site.

- This study will assess A: the four short grid connections associated with the Vhuvhili on-site substation alternatives, C: the long route between Vhuvhili and Mukondeleli, and B: the two short routes for the grid connection to the alternatives for the Mukondeleli switching stations.

A.1 - Proposed alternatives should the Vhuvhili on-site substation hub A-B (Preferred) be built:

- *Alternative 1 (Preferred) (A to E as marked in Figure 1)*

  - This is the Preferred power line routing should the proposed Preferred on-site substation hub A-B at the Vhuvhili SEF site be built. The proposed 132 kV power line will extend from the Preferred on-site substation hub at the proposed Vhuvhili SEF site to switching station E at the proposed Mukondeleli WEF site.

- *Alternative 2 (A to F as marked in Figure 1)*

  - Alternative proposed 132 kV power line that will extend from the Preferred on-site substation hub A-B at the proposed Vhuvhili SEF site to switching station F at the proposed Mukondeleli WEF site.

A.2 - Proposed alternatives should the Vhuvhili on-site substation hub C-D (Alternative 2) be built:

- *Alternative 3 (Preferred) (C to E as marked in Figure 1)*

  - This is the Preferred power line routing should the proposed Alternative 2 on-site substation hub C-D at the Vhuvhili SEF site be built. The proposed 132 kV power line will extend from the Alternative 2 on-site substation hub at the proposed Vhuvhili SEF site to switching station E at the proposed Mukondeleli WEF site.

- *Alternative 4 (C to F as marked in Figure 1)*

  - Alternative proposed 132 kV power line that will extend from the Alternative 2 on-site substation hub C-D at the proposed Vhuvhili SEF site to switching station F at the proposed Mukondeleli WEF site.

B – Proposed 132 kV overhead power line, approximately 12 km in length, from the Vhuvhili SEF onsite substation to the Mukondeleli WEF switching station.

- As explained above, a 132 kV power line of approximately 12 km is proposed to feed electricity from the on-site substation hub at the proposed Vhuvhili SEF to the switching station at the proposed Mukondeleli WEF. The Applicant provided four power line routing alternatives that are linked to the locality of the Vhuvhili on-site substation infrastructure as the starting point of the proposed power line, and the Mukondeleli switching station infrastructure as the end point of the proposed power line. The proposed power line will be supported by monopole or steel lattice pylons, or a combination of both where required. The choice of pylon type will depend on whether the pylons will be placed within a straight section within the power line corridor or at bends, as well as how sharp the bend is.

- The type of pylon to be used depends on the topography and the alignment of the power line corridor. In general, monopole-type pylons are used for transmission lines with shorter spans, whereas steel lattice-type pylons are only used where long spans (>500m) across valleys and rivers are required.

- Insulators will be used to connect the conductors to the towers. The span lengths are estimated to range between 200 m and 300 m. The exact specifications of the proposed pylon component will be determined during the detailed engineering phase and that the information provided below is seen as the worst-case scenario.

- As noted above, the power line will be constructed within the assessed 200 m wide EGI corridor.

- Underground power lines are not feasible because of technical losses involved with large lengths of underground cables and high costs. Maintenance is also easier on suspended power lines in comparison to underground cables, the latter of which would also result in more terrestrial disturbance.

C – Proposed alternatives for the routes to the Mukondeleli switching station

Alternative 1 (E on Figure 1)

Alternative 2 (F on Figure 1)

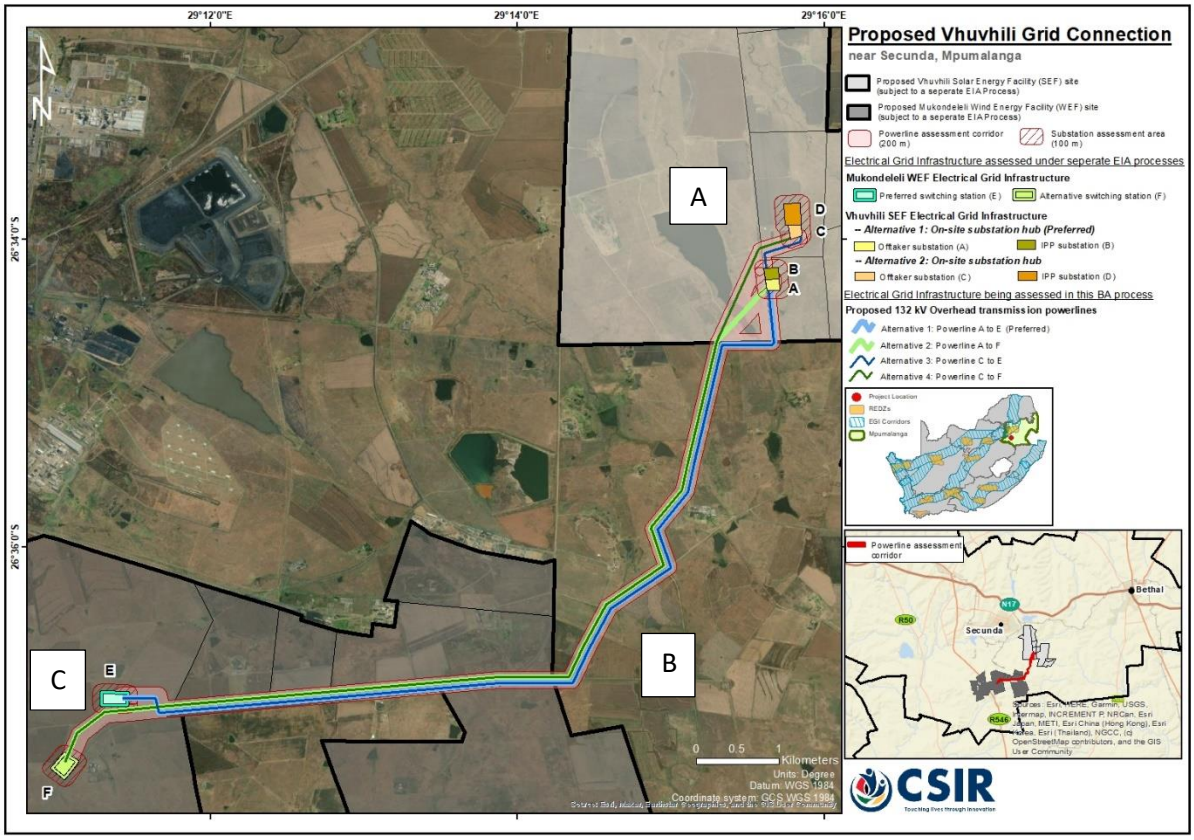

Figure 1: Locality map showing the proposed 132 kV overhead power line routing alternatives that extend from the proposed Vhuvhili SEF (subject of a separate S&EIA process) to the proposed Mukondeleli WEF (subject of a separate S&EIA process). A-B-C refer to the sections as divided for the palaeontology.

A description of the key components of the proposed power line and EGI project is provided in Table 2 below. It is important to note at the outset that the exact specifications of the proposed project components will be determined during the detailed engineering phase (subsequent to the issuing of EA, should such authorisation be granted for the proposed power line and EGI project) but that the information provided below is seen as the worst-case scenario for the proposed power line project.

Table 2: Description of the project components for the proposed 132 kV overhead power line and associated EGI

Component	Description
Power line/pylon height	Up to 40 m
Power line length	Approx. 12 km
Power line capacity	Up to 132 kV
Minimum conductor ground clearance	Approx. 8.1 m
Distance between conductors	Between 2.4 m and 3.8 m
Pylon type	Monopole or steel lattice pylons, or combination of both where required.
Servitude width	Once built, the registered servitude will be up to 32 m wide in line with guideline and requirements for 132 kV power lines stipulated in the 2011 Eskom Distribution Guide Part 19. Note that the entire servitude will not be cleared of vegetation. Vegetation clearance within the servitude will be undertaken in compliance with relevant standards and specifications. Specialists were required to assess an approximately 200 m wide power line corridor (100 m on either side of the centre line).
Associated Infrastructure	
Service roads	There are a number of existing gravel farm roads (some just jeep tracks) with widths ranging between 4 m and 5 m located around and within the proposed Vhuvhili power line corridor. A service road of approximately 5 m wide will be required below the power line.
Proximity to grid connection	The proposed 132 kV overhead power line will extend approximately 12 km from proposed Vhuvhili SEF to a switching station at the proposed Mukondeleli WEF site.

Overview of the Project Development Cycle

The proposed project can be divided into the following three main phases:

- Construction Phase; - relevant to the palaeontology
- Operational Phase; (not relevant) and
- Decommissioning Phase (not relevant).

Only the Construction Phase is relevant to the palaeontological impact because this is when the ground will be broken and if fossils are present they could be destroyed – or removed (mitigation). Thereafter, there would be no further impact on the palaeontology.

- **Construction Phase**

The construction phase will take place subsequent to the issuing of an EA from the Competent Authority (i.e., the Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs [DARDLEA]) and once the commercial agreements have been concluded with a suitable off-taker, which could either be private off-takers (such as Sasol) or via a public procurement programme (such as the Renewable Energy Independent Power Producer Programme [REIPPPP]). The construction phase for the proposed 132 kV overhead power line and associated EGI project is expected to be up to 24 months.

The main activities that are proposed to take place during the construction phase will entail:

- Site preparations, construction of servitude access and detailed geotechnical investigations of the power line servitude and grid corridor footprint;
- Preparation of a detailed layout of the grid connection infrastructure;
- Removal of vegetation within the power line servitude and substation site for the placement of pylons and EGI, where necessary;
- Stockpiling of topsoil and vegetation will be retained for replanting, where necessary;
- Establishment of a temporary laydown area for storage of construction equipment and machinery;
- Excavations of pylon infrastructure and associated anchorage, as well as busbar foundations;
- Onsite assembly and erection of pylon tower sections and stringing of the power line cables; and
- Rehabilitation of disturbed areas and removal of equipment and machinery following completion of power line construction.

The construction phase will also involve the transportation of personnel, construction materials and equipment to and from the site. All efforts will be made to ensure that all construction work will be undertaken in compliance with local, provincial and national legislation, local and international best practice, as well as the approved EMPr that has been compiled and appended to the BA Report. An independent Environmental Control Officer (ECO) will be appointed during the construction phase and will monitor compliance with the recommendations and conditions of the EMPr and EA, respectively.

- **Electricity Requirements**

In terms of electricity supply during the construction phase, the Project Developer will make use of generators on site.

The proposed EGI will consist of the components listed below. It is important to note at the outset that the exact specifications of the proposed project components will only be determined during the detailed engineering phase prior to construction (subsequent to the issuing of an EA), should such an authorisation be granted for the proposed project, but that the information provided below is seen as the worst-case scenario for the project. It is however important to note that these

specifications are subject to change as the BA process progresses. Any changes will be communicated to the specialists to update their specialist assessments and reports accordingly.

Table 2: Electricity requirements for the Construction Phase

Power line capacity:	132kV power line (single circuit or double circuit)
Power line corridor length	Approx. 12km
Power line corridors width	200m (100m on either side of centre line)
Power line servitude (once built)	32m
Power line pylons	Monopole or Lattice pylons, or a combination of both where required
Power line pylon height	Maximum 40m
Minimum conductor ground clearance	Approx. 8.1m
Distance between conductors	Between 2.4m and 3.8m
Battery and substation complex	A 100m buffer must be assessed around the approximately 2 hectare battery and substation complex which comprises the BESS, the 33/132 kV step-down SS and a collector SS.

Legislation for Palaeontology

A Palaeontological Impact Assessment was requested for the Vhuvhili EGI project. To comply with the regulations of the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed development and is reported herein.

Table 3: National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) and Environmental Impact Assessment (EIA) Regulations, 2014 (as amended) - Requirements for Specialist Reports (Appendix 6).

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	**Relevant section in report**
ai	Details of the specialist who prepared the report,	Appendix B
aii	The expertise of that person to compile a specialist report including a curriculum vitae	Appendix B
b	A declaration that the person is independent in a form as may be specified by the competent authority	Page **Error! Bookmark not defined.**
c	An indication of the scope of, and the purpose for which, the report was prepared	Section **Error! R eference source not found.**

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	**Relevant section in report**
ci	An indication of the quality and age of the base data used for the specialist report: SAHRIS palaeosensitivity map accessed – date of this report	Page 1
cii	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 4
d	The date and season of the site investigation and the relevance of the season to the outcome of the assessment	N/A
e	A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 0
f	The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 4
g	An identification of any areas to be avoided, including buffers	N/A
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;	N/A
i	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 6
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	Section **Error! R eference source not found.**
k	Any mitigation measures for inclusion in the EMPr	Section 5, Appendix A
l	Any conditions for inclusion in the environmental authorisation	Section 5
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 5, Appendix A
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 6
nii	If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Sections 6, 7
o	A description of any consultation process that was undertaken during the course of carrying out the study	N/A
p	A summary and copies of any comments that were received during any consultation process	N/A
q	Any other information requested by the competent authority.	N/A

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	**Relevant section in report**
r	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.	N/A

2. Methods and Terms of Reference

The Terms of Reference (ToR) for this study were to undertake a PIA and provide feasible management measures to comply with the requirements of SAHRA.
The methods employed to address the ToR included:

1. Consultation of geological maps, literature, palaeontological databases, published and unpublished records to determine the likelihood of fossils occurring in the affected areas. Sources included records housed at the Evolutionary Studies Institute at the University of the Witwatersrand and SAHRA databases;
2. Where necessary, site visits by a qualified palaeontologist to locate any fossils and assess their importance (*not applicable to this assessment*);
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility (*not applicable to this assessment*); and
4. Determination of fossils' representivity or scientific importance to decide if the fossils can be destroyed or a representative sample collected (*not applicable to this assessment*).

3. Geology and Palaeontology

3i. Project location and geological context

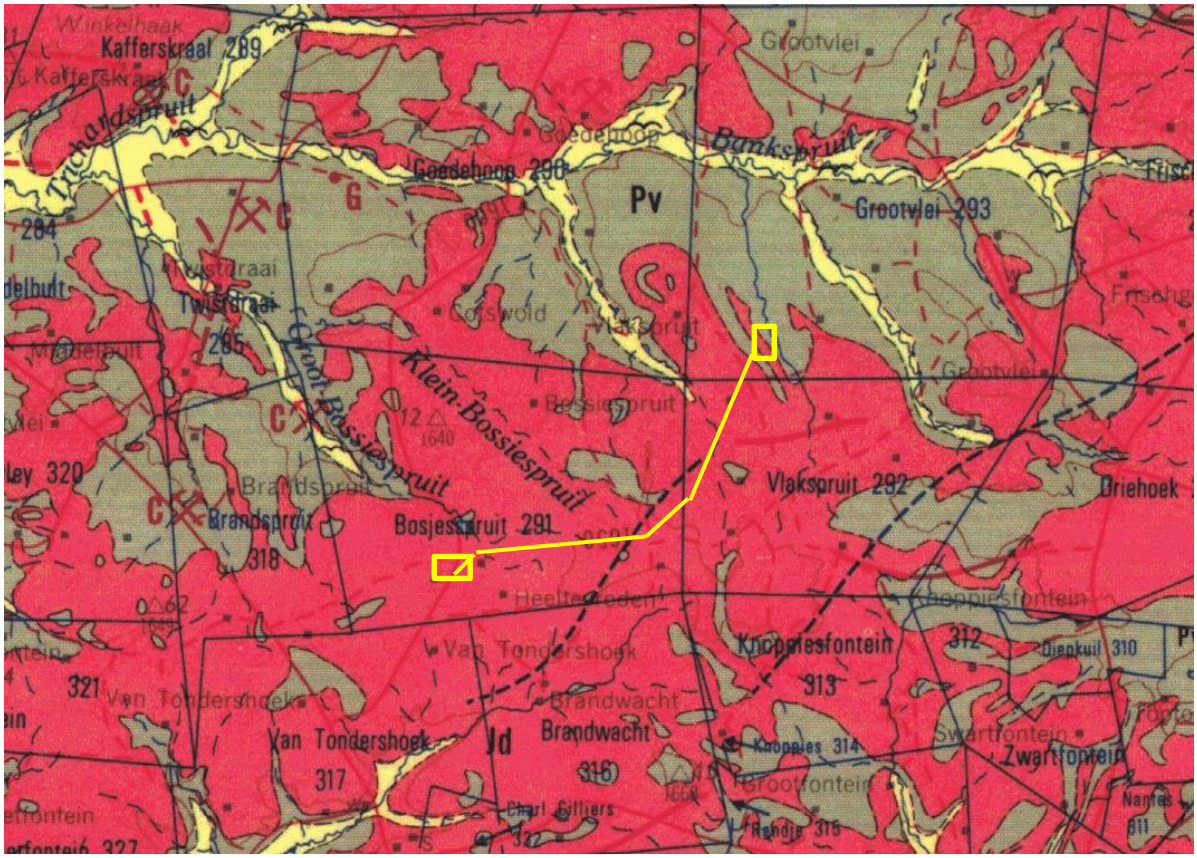

Figure 2: Geological map of the area around Secunda and the Vhuvhili EGI. The location of the proposed project is indicated within the yellow rectangles. Abbreviations of the rock types are explained in Table 4. Map enlarged from the Geological Survey 1: 250 000 map 2628 East Rand.

Table 4: Explanation of symbols for the geological map and approximate ages (2006. Johnson et al., 2006; Partridge et al., 2006). SG = Supergroup; Fm = Formation; Ma = million years; grey shading = formations impacted by the project.

Symbol	Group/Formation	Lithology	Approximate Age
Q	Quaternary	Alluvium, sand, calcrete	Quaternary ca 1.0 Ma to present
Jd	Jurassic dykes	Dolerite dykes, intrusive	Jurassic, approx. 183 Ma
Pv	Vryheid Fm, Ecca Group, Karoo SG	Shale, siltstone, sandstone, coal seams	Early Permian Ca 280-270 Ma

The project lies in the central part of the Karoo Basin where the older rocks of the Ecca Group are exposed. They are intruded by the non-fossiliferous igneous rocks, the dolerite dykes of Jurassic age. Along the rivers and streams, much younger transported alluvium and sands overlie the older rocks.

During the Late Carboniferous and Early Permian times (ca 300-250 million years ago) Africa was part of the continental landmass known as Gondwanaland. Southern Africa was positioned over the South Pole and was covered by a number of ice-sheets. These melted as the landmass moved slowly northwards and the sediments deposited from the ice sheets formed the Dwyka Group, the basal group of the Karoo Supergroup. Over time the large inland Karoo Sea filled with sediments and shrank. Overlying the Dwyka Group tillites and diamictites are the Ecca Group shales and sandstones that include coal seams formed by the buried peats that were the result of a very lush flora that had become established on the deltas and flood plains around the Karoo Sea. The next layers of infilling shales and sandstones are called the Beaufort Group, followed by the Stormberg Group as the sea shrank while the basin filled. Finally, all these sediments were capped by the massive basaltic outpourings of the Drakensberg Group. Associated with these eruptions are numerous dykes and sills that have intruded through the Karoo Group sediments. This signalled the end of the Karoo Supergroup. Since the underlying rocks, mostly the Transvaal Supergroup in the north and the Namaqua-Natal Group in the south, formed an undulating topography, as well as the flexure of this forearc basin, the Karoo sediments are not continuous across the basin. In particular, the coal seams are discontinuous because of the above, but also because the local setting and varied plant distributions affect the type and thickness of coal seams (Plumstead, 1969; McRae, 1999; McCarthy and Rubidge, 2005; Johnson et al., 2006).

Coal seams are layers of peat that have been buried and altered by temperature from geothermal energy, and pressure from the increasing overburden. The original plant matter that formed the peats is no longer distinguishable but impressions and compressions of plants can be preserved in the carbonaceous shales and siltstones between, above and below the coal seams. These Permian plants belong to the *Glossopteris* flora that includes *Glossopteris* leaves, seeds, reproductive structures, wood and roots, as well other plants such as lycopods, sphenophytes, ferns, cordaitales and early gymnosperms (Plumstead, 1969, Anderson et al., 1999).

Plants were diverse and abundant but during the early Permian there were very few vertebrates present as they evolved in the later Permian. In addition, for the preservation of fossil plants to occur requires reducing and anoxic environments, while bones can tolerate more oxidising environment. Therefore, one seldom finds fossil plants and animals in the same site (Cowan, 1995).

3ii. Palaeontology of the project footprint

The rocks present are those of the Jurassic dolerite dykes that do not preserve any fossils because they are of volcanic origin, and the Vryheid Formation shales that might preserve fossils of the *Glossopteris* flora associated with the coal seams. All these rocks are covered by modern soils; in some cases, they are quite deep and cultivated. Soils do not preserve fossils because they are formed by weathered sediments and organic matter.

In this area, known as the Highveld Coalfield, the uppermost seam, No 5, is more than 30 m below the surface (Kriel, Fig 16 in Snyman, 1998) and is covered by soil, interbedded shale and sandstone. No fossils are likely to occur in the sandstone as it is too coarse-grained but plant impressions might occur in the shales.

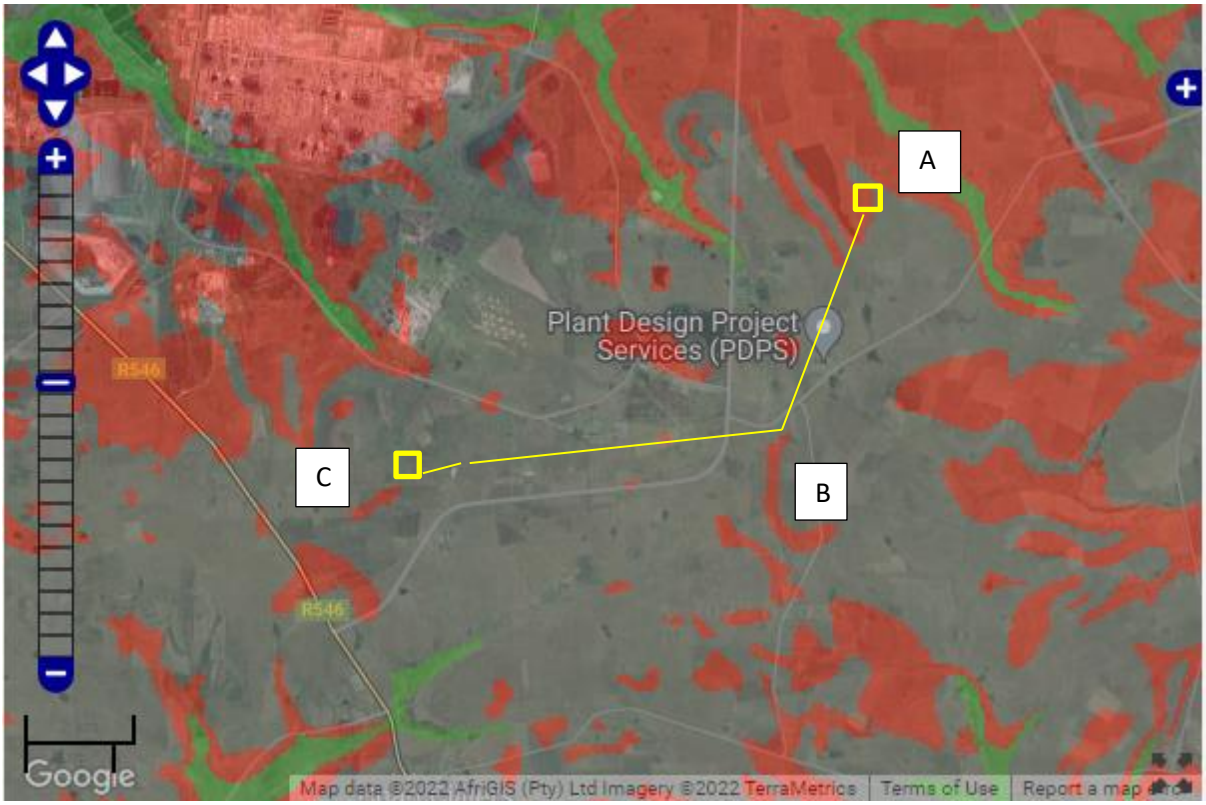

Figure 3: SAHRIS palaeosensitivity map for the proposed Vhuvhili EGI and overhead power line (OHPL) to Mukondeleli WEF shown by the yellow outlines. A = grid connections from Vhuvhili on-site Substation to the main OHLP; B = main OHPL route; C = grid connections to the Mukondeleli switching station. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

It should be noted that the proposed Mukondeleli WEF in the southwest have zero palaeosensitivity (Figures 3-5) while the proposed Vhuvhili SEF and EGI are partly on very highly sensitive rocks.

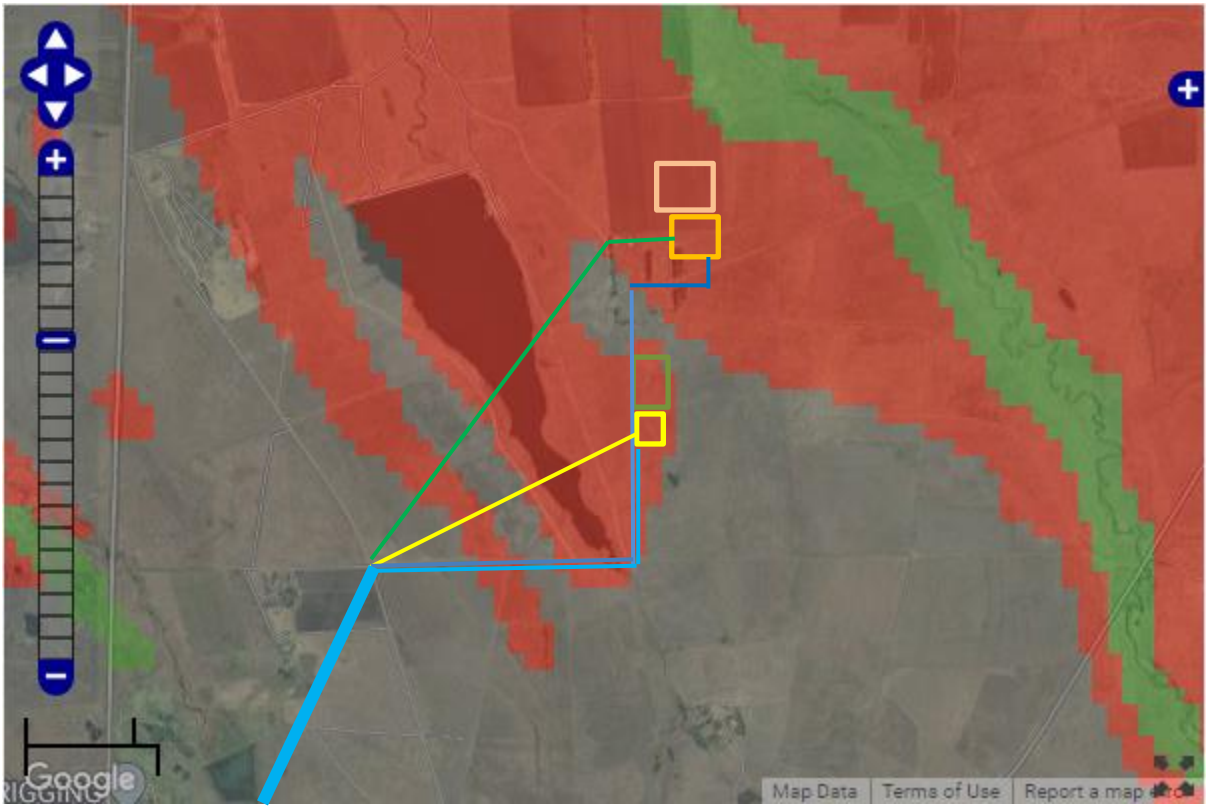

Figure 4: SAHRIS palaeosensitivity map for the proposed Vhuvhili EGI routes for the Vhuvhili on-site substation alternates A-D (cluster A). Line colours as in Figure 1. Background colours as in Figure 3.

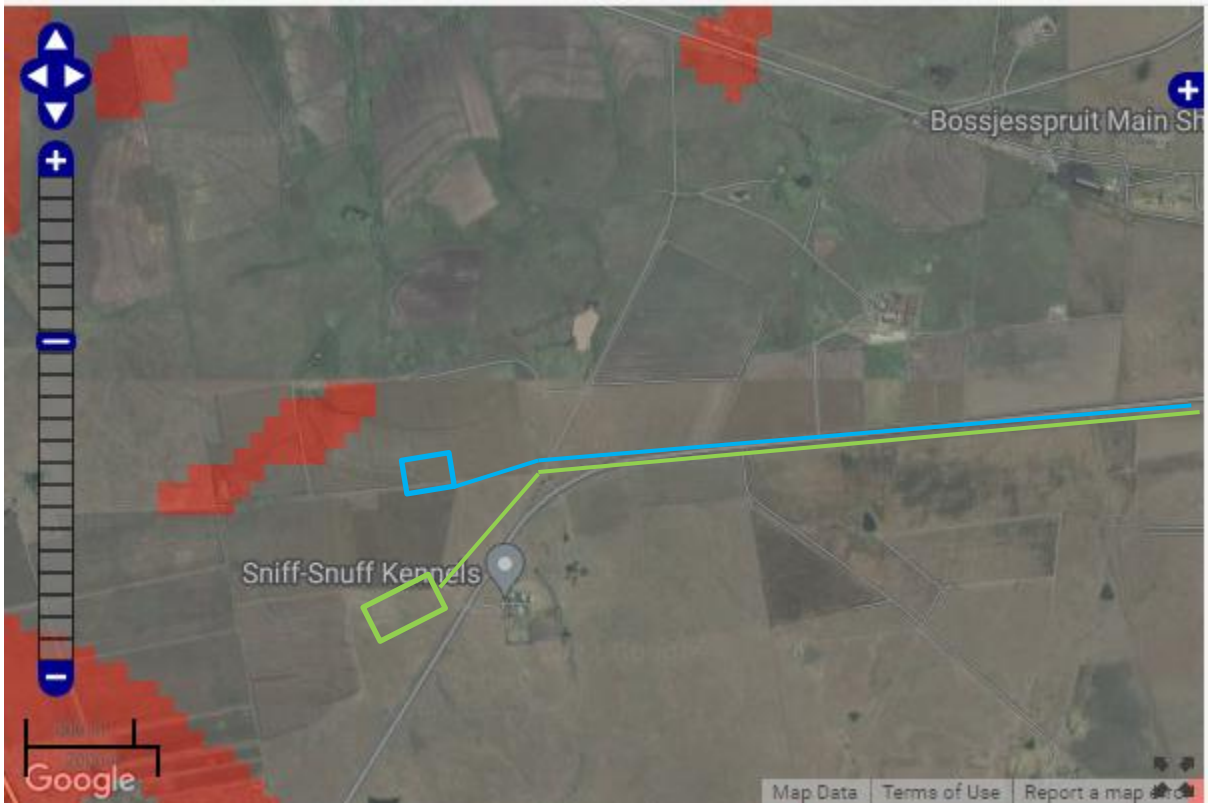

Figure 5: SAHRIS palaeosensitivity map for the proposed Vhuvhili EGI routes for the Mukondeleli switching station alternates E-F (cluster C). Line colours as in Figure 1. Background colours as in Figure 3. Note all zero sensitivity (grey)

4 – Impact Assessment

Specialist Impact Assessment Criteria

The identification of potential impacts includes impacts that may occur during the construction, operational and decommissioning phases of the proposed development. The assessment of impacts includes direct, indirect as well as cumulative impacts.

In order to identify potential impacts (both positive and negative) it is important that the nature of the proposed activity is well understood so that the impacts associated with the activity can be understood. The process of identification and assessment of impacts will include:

- Determine the current environmental conditions in sufficient detail so that there is a baseline against which impacts can be identified and measured;
- Determine future changes to the environment that will occur if the activity does not proceed;
- An understanding of the activity in sufficient detail to understand its consequences; and
- The identification of significant impacts which are likely to occur if the activity is undertaken.

The impact assessment methodology has been aligned with the requirements for BA Reports as stipulated in Appendix 1 (3) (j) of the 2014 EIA Regulations, which states the following:

“A BA Report must contain the information that is necessary for the Competent Authority to consider and come to a decision on the application, and must include an assessment of each identified potentially significant impact and risk, including –

- (i) cumulative impacts;
- (ii) the nature, significance and consequences of the impact and risk;
- (iii) the extent and duration of the impact and risk;
- (iv) the probability of the impact and risk occurring;
- (v) the degree to which the impact and risk can be reversed;
- (vi) the degree to which the impact and risk may cause irreplaceable loss of resources; and
- (vii) the degree to which the impact and risk can be mitigated”.

As per DEA *Guideline 5: Assessment of Alternatives and Impacts* the following methodology is to be applied to the prediction and assessment of impacts. Potential impacts should be rated in terms of the direct, indirect and cumulative:

- **Direct impacts** on our fossil heritage will occur only during the construction phase but only if there are fossils present in the site of each foundation or excavation, i.e. not between the substations or between the power line poles.
- **Cumulative impacts** are not relevant because each site is unique and may or may not have any fossils below ground. Once fossils have been destroyed or removed there can be no additional impact as it is finite. **Note from the CSIR: A separate list and map will be provided**

to the specialist in order to provide a list of other projects that need to be considered as part of the assessment.

- **Nature of impact** – the damage or destruction of fossils could happen if any fossils occur in the rocks that will be excavated for foundations, piping, and amenities. Fossils are part of our National Heritage and provide evidence of past life and environments so they are of scientific interest with respect to evolutionary processes, past ecosystems and biodiversity. By understanding the interaction between plants, animals and climate, we can better understand and plan for future climate change.

- **Spatial extent** – The size of the area that will be affected by the risk/impact:
  - Site specific; only the area that will be excavated is relevant for palaeontology because fossils can be in isolated areas, or lots of fossils (usually plants) can occur in layers over wide areas, such as in the shales associated with coal seams. In the latter setting, the fossils are likely to be all from the same flora.

- **Duration** – The timeframe during which the risk/impact will be experienced:
  - Very short term (instantaneous); fossils are not living so if damaged or destroyed this is a finite event.

- **Reversibility of impacts** - the extent to which the impacts/risks are reversible assuming that the project has reached the end of its life cycle (decommissioning phase) will be:
  - The reversibility is moderate with mitigation because fossils can be removed when they are found, donated to a research centre of museum and protected for future generations or for research;
  - Low reversibility of impacts; or

- **Irreplaceability of resource loss caused by impacts** – the degree to which the impact causes irreplaceable loss of resources assuming that the project has reached the end of its life cycle (decommissioning phase) will be:
  - Moderate irreplaceability of resources; although the individual fossil is not replaceable, in this formation the fossil plants, when present, are numerous. Mitigation and collection of fossils will have a positive impact on the science.

Using the criteria above, the impacts will further be assessed in terms of the following:

- **Consequence** – The anticipated severity of the impact:
  - Slight (negligible alteration of natural systems, patterns or processes, i.e. where no natural systems/environmental functions, patterns, or processes are affected). Fossils do not affect the modern environment.

- **Probability** – The probability of the impact occurring:
  - Very unlikely (<30% chance of occurring); it is very unlikely that fossils occur in the covering soils and sandstones that will be excavated, but there is small chance that fossils may occur below the ground surface in the shales (probably several metres below the surface).

- **Significance** – Pre-mitigation the consequence is moderate and the probability is very unlikely which gives a significance of moderate (4). Post-mitigation where any fossils occurring are

removed and rescued, the significance is reduced to a very low risk/impact (5). The significance is rated qualitatively as follows against a predefined set of criteria (i.e. probability and consequence) as indicated in Figure 6:

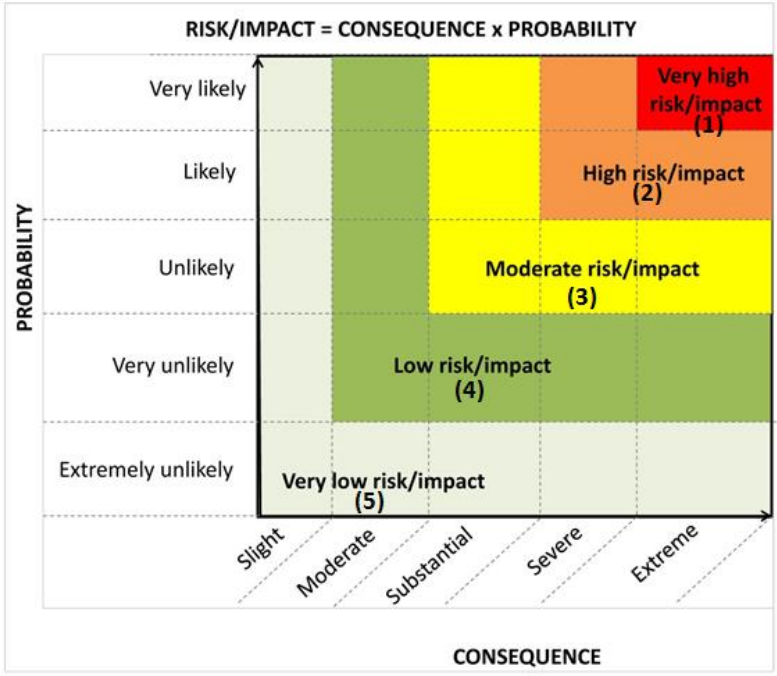

Figure 6: Guide to assessing risk/impact significance as a result of consequence and probability.

- **Significance** – Will the impact cause a notable alteration of the environment?
  - Very low (the risk/impact may result in very minor alterations of the environment and can be easily avoided by implementing appropriate mitigation measures, and will not have an influence on decision-making);
  - Low (the risk/impact may result in minor alterations of the environment and can be easily avoided by implementing appropriate mitigation measures, and will not have an influence on decision-making);
  - Moderate (the risk/impact will result in moderate alteration of the environment and can be reduced or avoided by implementing the appropriate mitigation measures, and will only have an influence on the decision-making if not mitigated);
  - High (the risk/impacts will result in a major alteration to the environment even with the implementation on the appropriate mitigation measures and will have an influence on decision-making); or
  - Very high (the risk/impacts will result in very major alteration to the environment even with the implementation on the appropriate mitigation measures and will have an influence on decision-making (i.e. the project cannot be authorised unless major changes to the engineering design are carried out to reduce the significance rating)).

With the implementation of mitigation measures, the residual impacts/risks must be ranked as follows in terms of significance:

  - Very low = 5;
  - Low = 4;
  - Moderate = 3;

- High = 2; and
- Very high = 1.

- **Status** - Whether the impact on the overall environment (social, biophysical and economic) will be:
  - Neutral - environment overall will not be affected. Loss of fossils will not affect the environment but would only be a loss to science and heritage so have a minor social impact.

- **Confidence** – The degree of confidence in predictions based on available information and specialist knowledge:
  - High because the geology is well mapped and from the literature and experience we know that fossils do not occur in overlying soils, and are only sporadically distributed in the shales. Mitigation (collection of fossils) would have a positive scientific and social impact.

Impacts will then be collated into an EMPr and these will include the following:

Collation of impacts for the EMPr.

Any impact on the palaeontology will occur only during the construction phase. No fossils will occur in the overlying soils but they might be present below ground but this is unknown until the rocks are broken open during the excavations for foundations for poles, substations and infrastructure. Monitoring of the rocks excavated by the responsible person, then mitigation in the form of rescuing and collection of fossils means they will not all be destroyed but will be preserved for future generations and scientific research (See Fossil Chance Find Protocol in Section 5)

Once the fossils, if present, have been removed then there would be no impact during operation or decommissioning phase.

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Table 6 Table for rating of impacts – Palaeontology of the three components A-B-C

Vhuvhili on-site substation connections – Alternatives 1 and 2; 3 and 4						
Impact	***Impact Criteria***		***Significance and Ranking (Pre-Mitigation)***	***Potential mitigation measures***	***Significance and Ranking (Post-Mitigation)***	***Confidence Level***
Construction Phase						
Damage or destruction of palaeontological materials in excavations	Status	Neutral	Low	Removal of all fossils on discovery	Very low	High
	Spatial extent	Site only				
	Duration	Very short				
	Consequence	Moderate				
	Probability	Very unlikely				
	Reversibility	Reversible				
	Irreplaceability	Moderate				
Operational Phase						
Damage or destruction of palaeontological materials	Status		None	None	None	
	Spatial extent					
	Duration					
	Consequence					

	Probability					
	Reversibility					
	Irreplaceability					
Decommissioning Phase						
Damage or destruction of palaeontological materials	Status		None	None	None	
	Spatial extent					
	Duration					
	Consequence					
	Probability					
	Reversibility					
	Irreplaceability					

EGI power line route between Vhuvhili and Mukondeleli						
Impact	***Impact Criteria***		***Significance and Ranking (Pre-Mitigation)***	***Potential mitigation measures***	***Significance and Ranking (Post-Mitigation)***	***Confidence Level***
Construction Phase						
Damage or destruction of palaeontological materials in excavations	Status	Neutral	None	Removal of all fossils on discovery	None	High
	Spatial extent	Site only				
	Duration	Very short				
	Consequence	Moderate				
	Probability	Very unlikely				
	Reversibility	Reversible				
	Irreplaceability	Moderate				
Operational Phase						
Damage or destruction of palaeontological materials	Status		None	None	None	
	Spatial extent					
	Duration					
	Consequence					
	Probability					
	Reversibility					
	Irreplaceability					
Decommissioning Phase						
Damage or destruction of palaeontological materials	Status		None	None	None	
	Spatial extent					
	Duration					
	Consequence					
	Probability					
	Reversibility					
	Irreplaceability					

Mukondeleli switching station connections – Alternatives 1 and 2						
Impact	***Impact Criteria***		***Significance and Ranking (Pre-Mitigation)***	***Potential mitigation measures***	***Significance and Ranking (Post-Mitigation)***	***Confidence Level***
Construction Phase						
Damage or destruction of palaeontological	Status	Neutral	None	Removal of all fossils on discovery	None	High
	Spatial extent	Site only				
	Duration	Very short				

materials in excavations	Consequence	Moderate				
	Probability	Very unlikely				
	Reversibility	Yes				
	Irreplaceability	Not				
Operational Phase						
Damage or destruction of palaeontological materials	Status		None	None	None	
	Spatial extent					
	Duration					
	Consequence					
	Probability					
	Reversibility					
	Irreplaceability					
Decommissioning Phase						
Damage or destruction of palaeontological materials	Status		None	None	None	
	Spatial extent					
	Duration					
	Consequence					
	Probability					
	Reversibility					
	Irreplaceability					

Table 7 Table for rating of impacts – Vhuvhili on-site Substation grid (both alternatives).

Aspect/ Impact pathway	Nature of potential impact/risk	Status	Spatial Extent	Duration	Consequence	Probability	Reversibility of impact	Irreplaceability of receiving environment/resource	Potential mitigation measures	Significance of impact/risk = consequence x probability		Ranking of impact/risk	Confidence level
										Without mitigation /management	With mitigation /management (residual risk/impact)		
Construction Phase													
Palaeontology	**Destruction of fossil materials**	L Neutral;	Site	Short term	Moderate	Very unlikely	Not reversible	Not	Removal of any fossils found on surface or below ground once excavations commence (EMPr)	Low	Very low	4	High

5. Monitoring Programme and Fossil Chance Find Protocol – to commence once the excavations / drilling activities begin.

1. The following procedure is only required if fossils are seen on the surface and when drilling/excavations commence.

2. When excavations begin the rocks and discard must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (plants, insects, bone or trace fossils) should be put aside in a suitably protected place. This way the project activities will not be interrupted.

3. Photographs of similar fossils must be provided to the developer to assist in recognizing the fossil plants, vertebrates, invertebrates or trace fossils in the shales and mudstones (for example see Appendix A). This information will be built into the EMPr's training and awareness plan and procedures.

4. Photographs of the putative fossils can be sent to the palaeontologist for a preliminary assessment.

5. If there is any possible fossil material found by the developer/environmental officer/miners then the qualified palaeontologist sub-contracted for this project, should visit the site to inspect the selected material and check the dumps where feasible.

6. Fossil plants or vertebrates that are considered to be of good quality or scientific interest by the palaeontologist must be removed, catalogued and housed in a suitable institution where they can be made available for further study. Before the fossils are removed from the site a SAHRA permit must be obtained. Annual reports must be submitted to SAHRA as required by the relevant permits.

7. If no good fossil material is recovered then no site inspections by the palaeontologist will be necessary. A final report by the palaeontologist must be sent to SAHRA once the project has been completed and only if there are fossils.

8. If no fossils are found and the excavations have finished then no further monitoring is required.

6. Assumptions and limitations

It is well known that fossils do not occur in Jurassic dolerite because it is of volcanic origin. Fossils are preserved in sedimentary rocks. Fossils of the *Glossopteris* flora have been recorded from the carbonaceous shales and mudstones from some sites in the Vryheid Formation but they are by no means ubiquitous. Much of the area has been cultivated for agriculture for decades which means the rocks are covered by much younger soils. Since soils are the product of weathering and breakdown of rocks, plus humus, they do not preserve fossils either. Therefore, there is only a chance of finding fossils in the underlying rocks of the Vryheid formation and in surface outcrops.

Further complicating the palaeontology, wetlands generally do not preserve fossils because the moisture and drying out destroys the delicate impressions of plants in the shales. In summary, fossils are very unlikely to occur on the ground surface in the northwestern part of the project footprint (Vhuvhili on-site substation hub). Fossils might occur below ground in the mostly dry and un-weathered shales of the Vryheid Formation, but this will not be determined until excavations for foundations commence.

7. Recommendation

A. Both alternatives for the Vhuvhili on-site substation and the four alternatives for grid connection routes are on potentially fossiliferous rocks BUT no fossils would occur on the ground surface (cultivation and wetland) but might occur below ground. Therefore, the fossil chance find protocol should be followed (Section 5).
B. The overhead power line route between the proposed Vhuvhili on-site substations hubs and the Mukondeleli switching stations is on dolerite so there is no impact on the fossils.
C. The Mukondeleli switching station grid connection (both alternatives) are on non-fossiliferous dolerite so there is no impact on the fossils.
    D. There are no identified fatal flaws and no objections on palaeontological heritage grounds to authorisation of the proposed power line project (all four alternative routings) on condition that (i) the recommended mitigation measures and (ii) the Fossil Chance Finds Protocol as discussed above, are implemented in full during the Construction Phase."

When the final grid connection route has been determined based on other specialist inputs, and excavations for pole foundations have commenced, and only if fossils are found, then the Vhuvhili substation site grid route should be visited by a palaeontologist and any fossils found should be removed (see Fossil Chance Find Protocol; Section 5).

8. References

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Visser, J.N.J., 1986. Lateral lithofacies relationships in the glacigene Dwyka Formation in the western and central parts of the Karoo Basin. Transactions of the Geological Society of South Africa 89, 373-383.

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9. Appendix A – examples of fossils that could occur in the Vryheid Formation

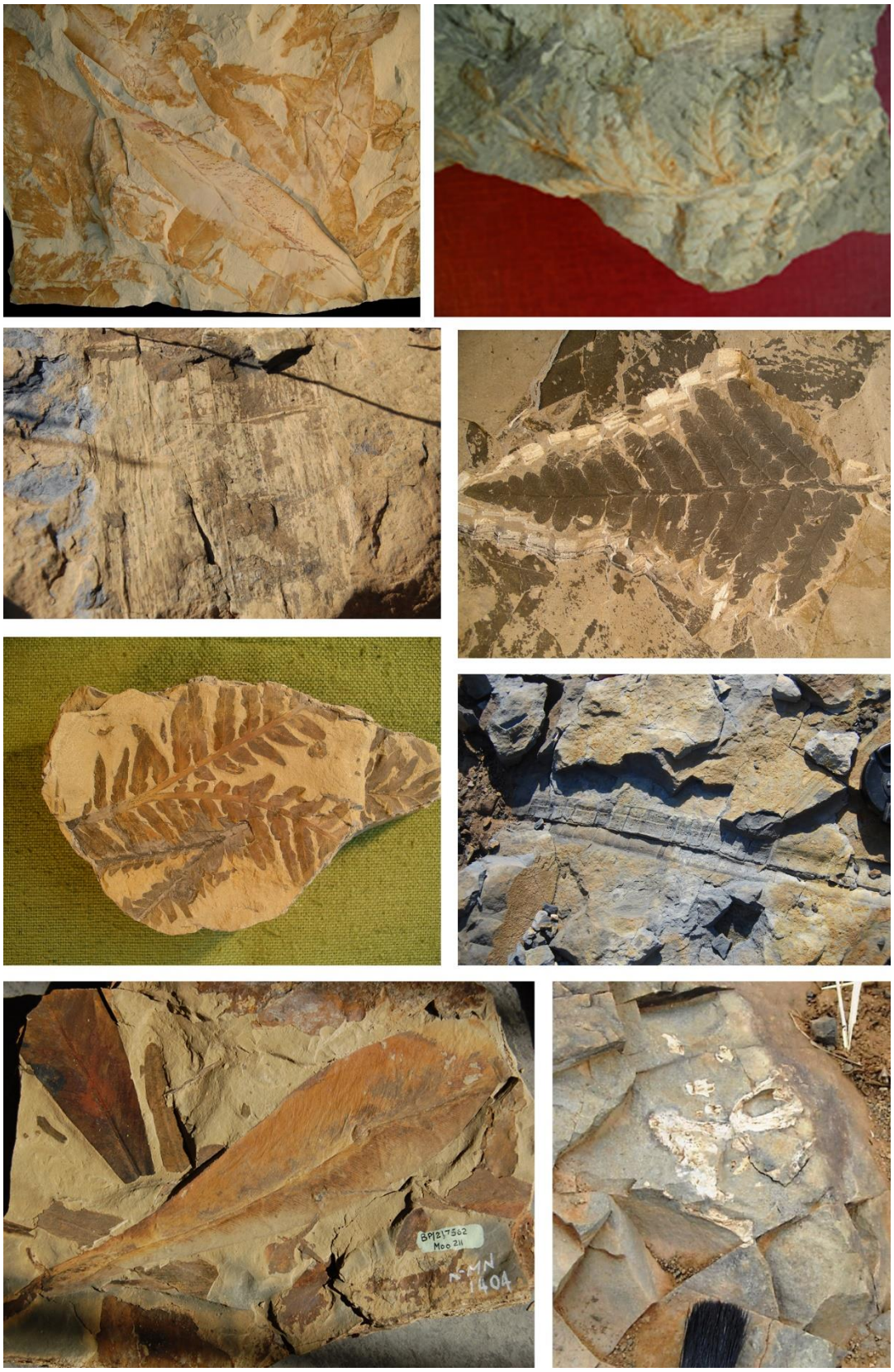

Figure 7: Photographs of a variety of plants that occur as impressions in rocks of the Vryheid Formation - glossopterids, ferns and sphenophytes. Bottom right shows bones in the rock.

10. Appendix B – Short CV of Specialist

Curriculum vitae (short) - Marion Bamford PhD
July 2022

I) Personal details

Surname	:	**Bamford**
First names	:	**Marion Kathleen**
Present employment	:	Professor; Director of the Evolutionary Studies Institute. Member Management Committee of the NRF/DST Centre of Excellence Palaeosciences, University of the Witwatersrand, Johannesburg, South Africa
Telephone	:	+27 11 717 6690
Fax	:	+27 11 717 6694
Cell	:	082 555 6937
E-mail	:	marion.bamford@wits.ac.za ; marionbamford12@gmail.com

ii) Academic qualifications

Tertiary Education: All at the University of the Witwatersrand:
1980-1982: BSc, majors in Botany and Microbiology. Graduated April 1983.
1983: BSc Honours, Botany and Palaeobotany. Graduated April 1984.
1984-1986: MSc in Palaeobotany. Graduated with Distinction, November 1986.
1986-1989: PhD in Palaeobotany. Graduated in June 1990.

iii) Professional qualifications

Wood Anatomy Training (overseas as nothing was available in South Africa):
1994 - Service d'Anatomie des Bois, Musée Royal de l'Afrique Centrale, Tervuren, Belgium, by Roger Dechamps
1997 - Université Pierre et Marie Curie, Paris, France, by Dr Jean-Claude Koeniguer
1997 - Université Claude Bernard, Lyon, France by Prof Georges Barale, Dr Jean-Pierre Gros, and Dr Marc Philippe

iv) Membership of professional bodies/associations

Palaeontological Society of Southern Africa
Royal Society of Southern Africa - Fellow: 2006 onwards
Academy of Sciences of South Africa - Member: Oct 2014 onwards
International Association of Wood Anatomists - First enrolled: January 1991
International Organization of Palaeobotany – 1993+
Botanical Society of South Africa
South African Committee on Stratigraphy – Biostratigraphy - 1997 - 2016

SASQUA (South African Society for Quaternary Research) – 1997+
PAGES - 2008 –onwards: South African representative
ROCEEH / WAVE – 2008+
INQUA – PALCOMM – 2011+onwards

vii) Supervision of Higher Degrees

All at Wits University

Degree	Graduated/completed	Current
Honours	11	0
Masters	13	3
PhD	11	7
Postdoctoral fellows	14	2

viii) Undergraduate teaching
Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 25 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 12 - 20 students per year.

ix) Editing and reviewing
Editor: Palaeontologia africana: 2003 to 2013; 2014 – Assistant editor
Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology: 2010 –
Associate Editor: Cretaceous Research: 2018-2020
Associate Editor: Royal Society Open: 2021 -
Review of manuscripts for ISI-listed journals: 25 local and international journals

x) Palaeontological Impact Assessments

25 years' experience in PIA site and desktop projects

Selected from recent projects only – list not complete:

- Bospoort Agriculture 2019 for Kudzala
- Overlooked Quarry 2019 for Cabanga
- Richards Bay Powerline 2019 for NGT
- Eilandia dam 2019 for ACO
- Eastlands Residential 2019 for HCAC
- Fairview MR 2019 for Cabanga
- Graspan project 2019 for HCAC
- Lieliefontein N&D 2019 for Enviropro
- Skeerpoort Farm Mast 2020 for HCAC
- Vulindlela Eco village 2020 for 1World
- KwaZamakhule Township 2020 for Kudzala

- Sunset Copper 2020 for Digby Wells
- McCarthy-Salene 2020 for Prescali
- VLNR Lodge 2020 for HCAC
- Madadeni mixed use 2020 for Enviropro
- Frankfort-Windfield Eskom Powerline 2020 for 1World
- Beaufort West PV Facility 2021 for ACO Associates
- Copper Sunset MR 2021 for Digby Wells
- Sannaspos PV facility 2021 for CTS Heritage
- Smithfield-Rouxville-Zastron PL 2021 for TheroServe
- Glosam Mine 2022 for AHSA
- Wolf-Skilpad-Grassridge OHPL 2022 for Zutari
- Iziduli and Msenge WEFs 2022 for CTS Heritage

Xi) Research Output

Publications by M K Bamford up to July 2022 peer-reviewed journals or scholarly books: over 165 articles published; 5 submitted/in press; 10 book chapters.
Scopus h-index = 30; Google Scholar h-index = 36; -i10-index = 95
Conferences: numerous presentations at local and international conferences.

11. Appendix C – Site Sensitivity Verification

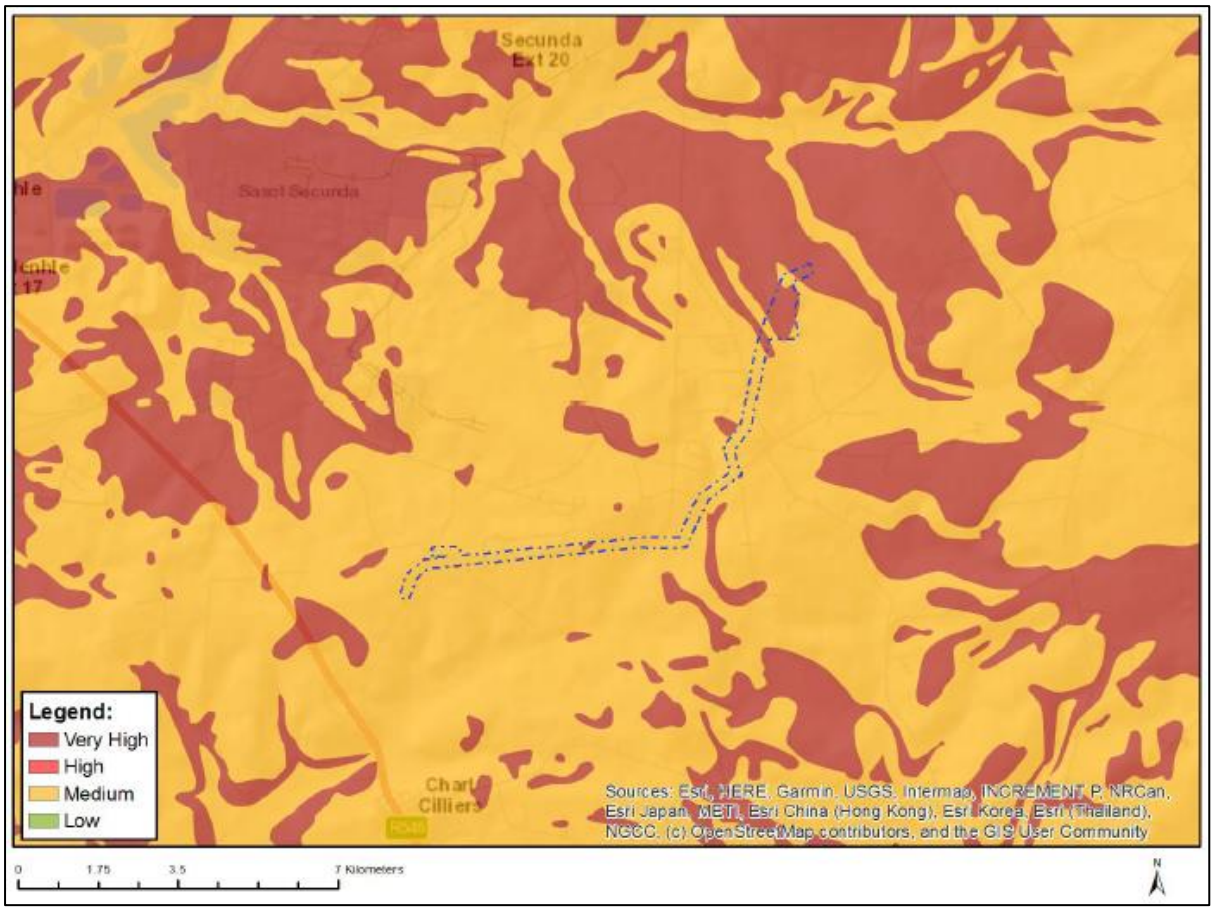

Figure 7: Palaeosensitivity map as required in Part A of the Government Gazette 43110, GN 320,

Note, the map (Figure 7) is not as detailed as the one provided on the SAHRIS website for which SAHRA bases their impact assessment requirements. The SAHRIS map is presented in Figures 3-5 and they consider that most of the route (orange in Figure 7 but grey in Figures 3-5) is on dolerite that has no fossils. This is correct because dolerite is a volcanic rock and does not preserve fossils. The northwestern portion corresponds on both maps (dark red in Figure 7 and red in Figures 3-5) because the site is on the Vryheid Formation that could have fossils so is very highly sensitive.