Project 2 - Palaeontological Impact Assessment: Basic Assessment or Electricity Grid Infrastructure standard, if applicable, for the proposed development of a 132 kV overhead and underground Power lines and associated EGI (i.e., Volta EGI) from the Volta PV Facility to the planned Artemis Main Transmission Substation (MTS) near Dealesville, Free State

Desktop Study (Phase 1)

For

VOLTA PV (Pty) Ltd and CSIR

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Expertise of Specialist

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Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by Evolution Africa (Pty) Ltd, South Africa. The views expressed in this report are entirely those of the author and no other interest was displayed during the decision making process for the Project.

Specialist: Prof Marion Bamford

Signature: 

Executive Summary

A Palaeontological Impact Assessment was requested for the Basic Assessment or Electricity Grid Infrastructure standard, if applicable, for the proposed development of a 132 kV overhead and underground power lines and associated EGI (i.e., Volta EGI) from the Volta PV Facility to the planned Artemis Main Transmission Substation (MTS) near Dealesville, Free State. This report is for Project 2 for the assessment of the VOLTA EGI.

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.

The proposed route lies on the non-fossiliferous Jurassic dolerite, highly sensitive Quaternary Calcretes and the moderately sensitive Tierberg Formation and Quaternary aeolian sands. Except for the volcanic dolerite, these formations might preserve trace fossils or fragmentary fossils, although none has been recorded from the site. Nonetheless, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no further palaeontological impact assessment is required unless fossils are found by the contractor, environmental officer or other designated responsible person once excavations for foundations and amenities have commenced. Since the impact will be low, as far as the palaeontology is concerned, the project should be authorised.

The significance pre-mitigation is low and post-mitigation is very low.
There is no cumulative impact.
There is no no-go area.

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1. Background

Volta PV (Pty) Ltd (hereinafter referred to as "Volta" or the Project Applicant) has appointed the CSIR to undertake the necessary Environmental Assessments for the proposed development of the 290 MW Volta Solar Photovoltaic (PV) Facility (i.e., Volta PV) and associated Electrical Grid Infrastructure (EGI) near Dealesville in the Free State. The assessments to be undertaken are indicated below:

- Project 1: Basic Assessment for the proposed development of the 290 MW Volta Solar Photovoltaic (PV) Facility (i.e., Volta PV Facility) and Battery Energy Storage System (BESS) near Dealesville, Free State.
- **Project 2: Basic Assessment or Electricity Grid Infrastructure standard, if applicable, for the proposed development of a 132 kV Overhead and Underground Power lines and associated EGI (i.e., Volta EGI) from the Volta PV Facility to the planned Artemis Main Transmission Substation (MTS) near Dealesville, Free State**.

The proposed Volta PV Facility (SEF) is located within the Renewable Energy Development Zone 5 (i.e., Kimberley REDZ). Therefore, the proposed project requires a BA Process instead of a full Scoping and Environmental Impact Assessment (EIA) Process and will be subjected to a reduced decision-making timeframe of 57 days in line with GN 114 dated February 2018. The proposed powerlines and associated EGI are also located within the Central Power Corridor - one of five EGI Power Corridors that were gazetted for implementation on 16 February 2018 in GG 41445, GN 113. Therefore, the EGI project will be subjected to Registration via the Power Line and Substation Standard [Government Gazette (GG) 47095; GN 2313, dated 27 July 2022] where it does apply; or a BA Process (where the Standard does not apply). The Standard will apply for any part of the power line that is in the EGI Power Corridor and in low or medium sensitivity for each theme as assigned in the Screening Tool. The applicability of the Standard will be confirmed as the process progresses.

Separate Applications for Environmental Authorisation (EA) for the PV facility and the EGI component and separate BA Reports will be submitted to the DFFE for decision-making. Where the EGI Standard (GG 47095; GN 2313, dated 27 July 2022) applies, separate registration forms and environmental sensitivity reports will be compiled.

Table 1: Affected farm portions for the proposed 290 MW Volta Solar PV Facility and associated Electrical Grid Infrastructure project.

Affected Farm Portion	Project 1: Volta Solar PV	Project 2: Volta EGI
Mooihoek (RE/1551)	X	X
Cornelia (RE/1550)	X	X
Carlton (RE/74)	X	
Vadersrust (RE/822)	X	
Modderpan (RE/750) #		X
Oxford (1/1030)	X	X
Klipfontein (RE/305) #		X
Leliehoek (RE/748) #		X

#Note: There are existing EA's and EMPr's for parts of the Volta EGI, previously done for Mainstream and IBVogt Projects, on the farms Modderpan (RE/750), Klipfontein (RE/305) and Leliehoek (RE/748). As far as the palaeontology is concerned, each site is unique and may or may not have fossils, therefore, there no cumulative impact.

Table 2: Project description

Project Description for VOLTA PV 290 MW Solar PV and BESS		
Component	**Dimensions / Specifications**	
Solar PV	Height of PV panels:	Max 3,5m
	Capacity of the PV Facility:	290 MW
	Area of PV Array (i.e. proposed area occupied by PV Modules):	500 hectares
	Total developable area (i.e. the area that includes all associated infrastructure within the **fenced** off area of the PV facility):	720 hectares
	Number of inverter-transformer stations:	1050 inverters 30 inverters (per Tx station) x 35 Tx stations 800V/33000V
	Area occupied by inverter-transformer stations and height:	The inverters are distributed evenly and mounted in the array field on a small plinth 2x2m, the 35 Tx stations are distributed evenly throughout the solar arrays each having underground cables (800V) from 30 inverters trenched to them. The Tx stations will have a 33 kV underground cable that carries the power to 33/132kV collector stations as shown on the plan. Datasheets attached for inverters and transformer stations – note this is based on current technology that will evolve and improve. This should reduce the EA impact if anything.
	Number of On-Site Substations Complexes and area occupied by these substations:	Two collector/switching substations each a 200m x 200m footprint. Platform 75m x 75m. Larger area for 132kV overhead lines to turn in.
	Capacity of On-site Substation Complex:	Site A 500 MVA. Site B 500MVA
Construction Compound	Construction camp area (ha):	2 – 3 Ha
	Temporary laydown area (ha):	2 to 3 Ha
Main access roads	Width of access roads (m):	5m
	Length of access roads (km):	Less than 500m
Internal access roads to be constructed between different development portions	Width of access roads (m):	4m
	Length of access roads (km):	Approx. 20km of internal roads – in order for security patrols and to access all the equipment (module cleaning and equipment maintenance)
Upgrading of existing access road/s	Yes / No:	Yes – no tar, only aggregate
	Current width (m):	4m turn into farm
	Upgraded width (m):	5m

On-site substation hub (including collector and/or switching yard)	Number of substation alternatives:	No alternatives as the Artemis MTS position has been set by ESKOM as well as collector stations for REIPP Rounds 5 and 6 being set
	Footprint (ha):	For each Site A (SS A) and Site B (SS B) (as per kmz/diagrams) a 0,7 ha platform for substation, surrounded by 4ha, fenced . The remainder of 4ha is open ground for overhead lines to turn and connect into the substation
	Capacity:	Each approx. 500MVA on Site A and site B
	Height (m):	Max 30 m (lightening conductors) 132kV OHL pylons need 16m clearance from ground (including earth and structure 20m maximum height) All other plant including transformers, CTs, VTs Breakers, SCADA and control room, fencing etc will be below 10m
Internal transmission and/or distribution lines	Under or aboveground:	Underground
	Capacity (kV):	800V from inverters to containerised mini-subs. 33kV from mini-subs to substations SS A and SS B
	If above: height (m) If below: maximum depth (m)	Max depth 1M
	If above - width of service road below powerline(s) (m):	As per ESKOM spec- see attached ESKOM restrictions document
	Length (m):	Estimate
Overhead transmission powerlines for connection of PV facility to existing national grid	Capacity (kV):	132 kV
	Pylon type:	Monopole Twin circuit – various designs available
	Tower type:	Monopole
	Height (m):	Max 20m
	Foundation:	Concrete with anchors
	Width of registered servitude (m):	See attached ESKOM restrictions document 18 meters
	Width of service road below powerline (m):	5m
	Width of powerline corridor for specialist assessment (m):	30m
	Length of powerline (km):	Less than 4km from Volta PV collector substation SS A to Artemis MTS of 132kV OHL
	Any additional infrastructure – please describe?	
Underground transmission powerlines for connection of PV facility to existing national grid	Capacity (kV)	132 kV
	Trench width (m)	3.6m
	Trench Depth (m)	1.2m
	Width of registered servitude (m):	15m
	Width of service road below powerline (m):	5m
	Width of powerline corridor for specialist assessment (m):	30m
	Length of powerline (km):	Less than 2.1km from Volta PV collector substation SS B to Artemis MTS of 132kV OHL
	Any additional infrastructure – please describe?	Danger tape will be placed 30cm above the cable and 70cm below ground (at least one tape for each circuit) At joins a widening of the trench will be needed (approx. double the width)
Warehouse/Workshop	Maximum height (m):	3,6m

	Footprint (m²):	300m2
Site offices	Number of buildings:	4
	Maximum height (m):	3,6
	Footprint (m²):	500m2
Operational and Maintenance Control Centre Building	Maximum height (m):	2
	Footprint (m²):	300m2
Guard houses	Maximum height (m):	3,6
	Footprint (m²):	100m2
Ablution facilities	Maximum height (m):	3,6
	Footprint (m²):	50m2
Battery storage	Battery technology type (preferred):	Lithium-Ion, Sodium-Ion, Solid State
	Battery technology type (alternative):	Redox Flow, Liquid Metal (https://ambri.com/) and other technology types will be considered
	Location:	See kmz/diagram
	Approx. footprint (ha):	BESS A::Mooihoek BESS N Mooihoek BESS S & Cornelia BESS = TOTAL 26.31ha BESS B:Oxford BESS N, OXFORS BESS C & Oxford BESS N = TOTAL 20.95ha – see attached BESS kmz/diagram
	Maximum height (m):	Containers approx.. 6x3 x 3 (3m max height)
	Capacity:	Site SS A; approx. .550MVA / 2200 Mwh (Store 100% of VOLTA PV average daily yield energy for 4 hours) Site SS B: approx. 450MVA / 1800Mwh
	For the storage and handling of a dangerous goods (e.g., electrolytes), where such storage occurs in containers on site, have a combined capacity of 80 m³ or more but not exceeding 500 m³ at any one time?	We have engaged a specialist to advise and ensure we can meet the Health and Safety Compliance and mitigate any hazardous substance risk Debra Mitchell from iSHEcon

A Palaeontological Impact Assessment was requested for Project 2, the Electrical Grid Infrastructure that includes both overhead and underground power lines, for the Volta SEF 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 1
c	An indication of the scope of, and the purpose for which, the report was prepared	Section 1
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	Yes
cii	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5
d	The date and season of the site investigation and the relevance of the season to the outcome of the assessment	Desktop
e	A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 2
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	None
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 3
i	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 5
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 4
k	Any mitigation measures for inclusion in the EMPr	Section 8, Appendix A
l	Any conditions for inclusion in the environmental authorisation	Section 8
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 8, 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, 8
o	A description of any consultation process that was undertaken during the course of carrying out the study	EAP

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

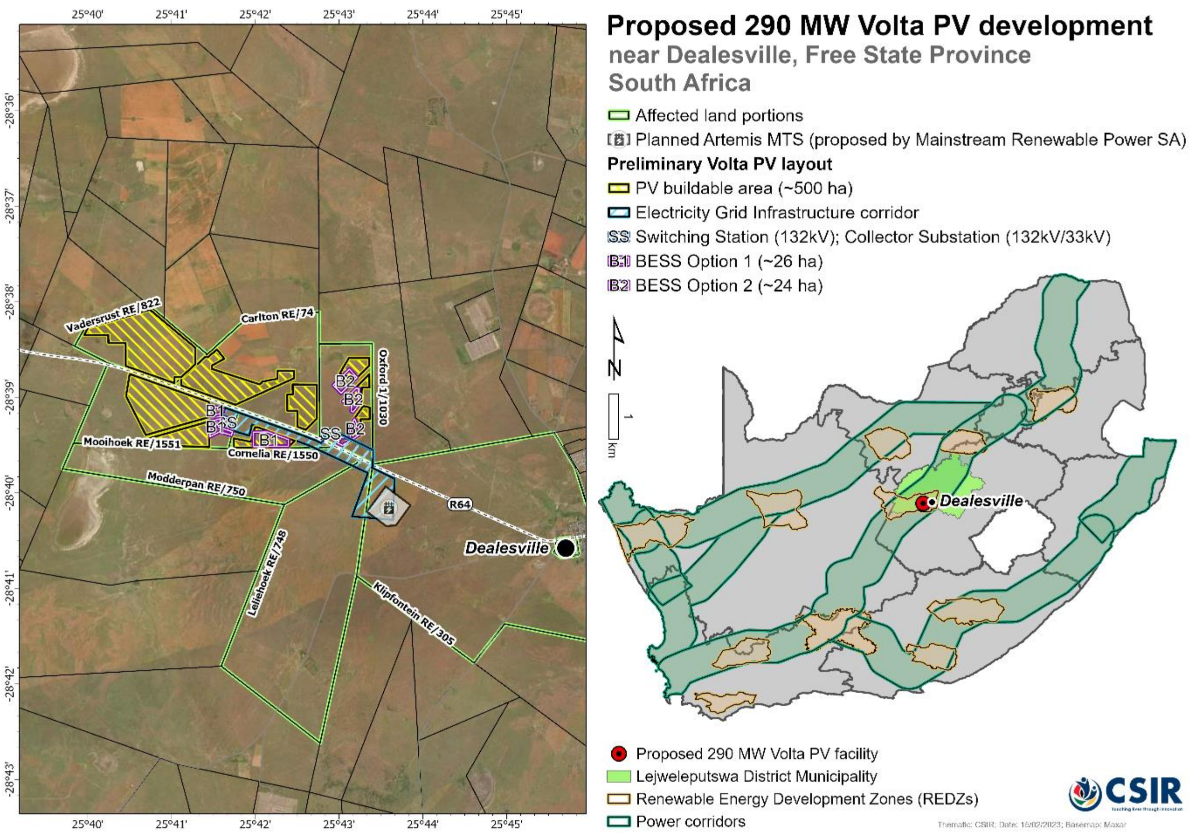


Figure 1: Annotated aerial map of the general area to show the Volta SEF project. EGI shown is shown by the light blue hatched area; Solar PV is shown by the yellow hatched area. Map supplied by the CSIR.

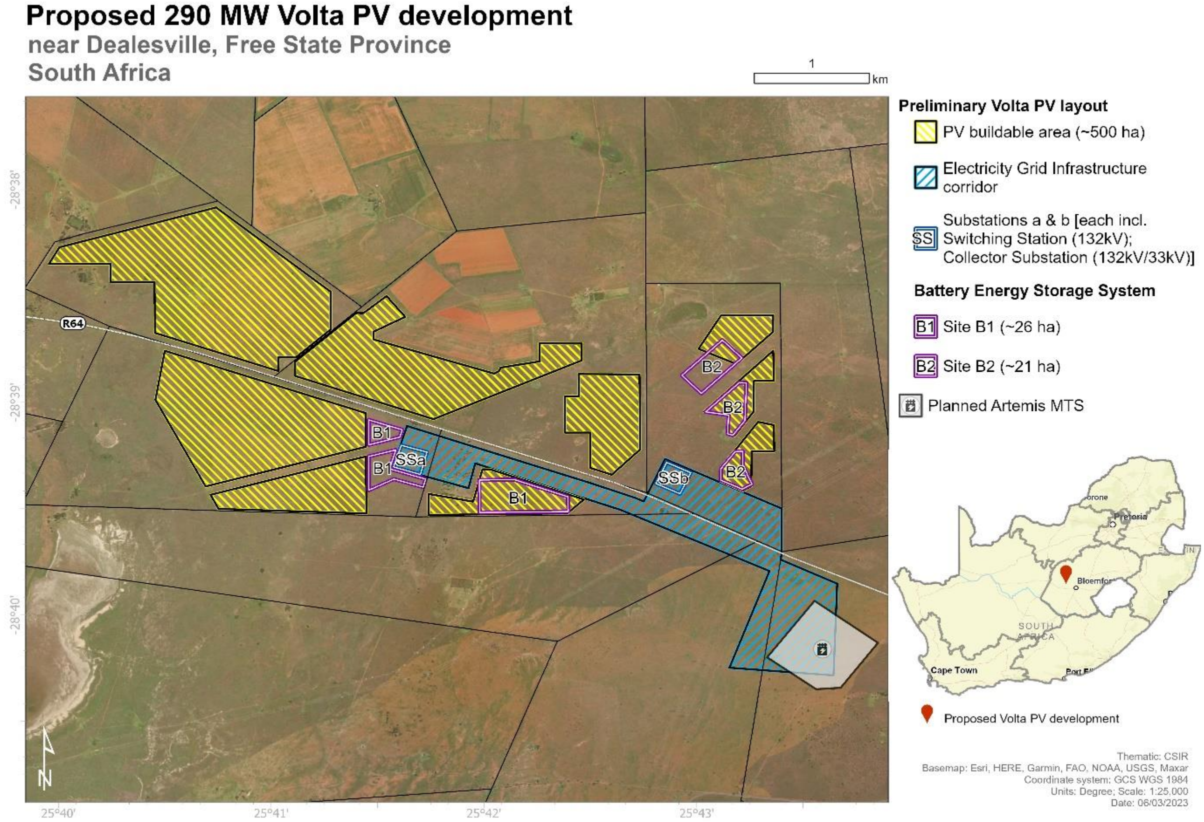


Figure 2: Google Earth Map of the proposed EGI for the 290MW Volta Solar Energy Facility with the EGI footprint shown by the blue outline.). Map supplied by CSIR. See Figure 3 for components of the EGI.

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. Comply with the Assessment Protocols that were published on 20 March 2020, in Government Gazette 43110, GN 320. This specifically includes Part A, which provides the Site Sensitivity Verification Requirements where a Specialist Assessment is required but no Specific Assessment Protocol has been prescribed.
2. Provide a Site Sensitivity Verification Report based on the requirements documented in the Assessment Protocols published on 20 March 2020, in Government Gazette 43110, GN 320.
3. Compile a Palaeontological Impact Assessment (PIA) in compliance with Appendix 6 of the 2014 NEMA EIA Regulations (as amended) and any additional relevant legislation and guidelines that may be deemed necessary.
4. 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; the SAHRIS palaeosensitivity map is more accurate than the DFFE screening tool (but both maps are provided below in Figures 5-6).

5. Where necessary, site visits by a qualified palaeontologist to locate any fossils and assess their importance (*not applicable to this assessment*);
6. 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
7. 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*).

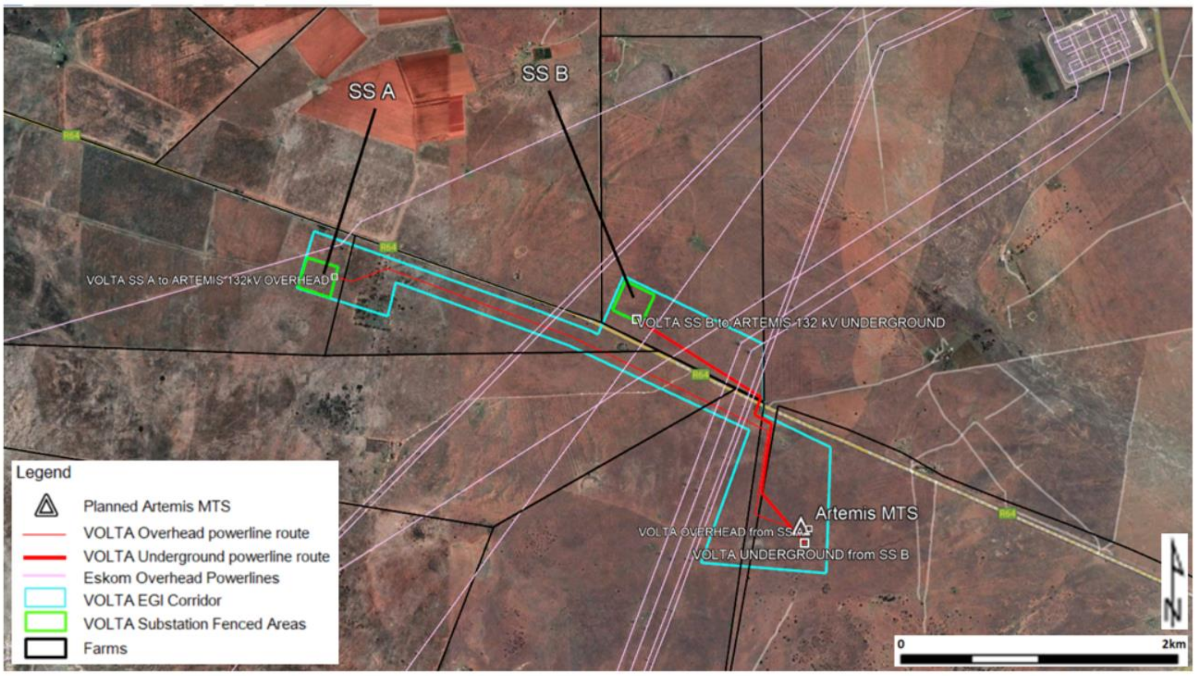


Figure 3: Detailed map showing the EGI area and components for the VOLTA Solar project:
In Figure 3 the bold red line is the VOLTA 132 kV Underground cable proposed route, the thin red line is the VOLTA Overhead 132kV cable proposed route

3. Geology and Palaeontology

i. Project location and geological context

The project lies in the central part of the main Karoo Basin where the older sediments have are present and have been intruded by the Jurassic dolerite dykes. Unconformably overlying much of the area are younger Quaternary sands and calcrete of the Kalahari Group (Figure 4).

The Karoo Supergroup rocks cover a very large proportion of South Africa and extend from the northeast (east of Pretoria) to the southwest and across to almost the KwaZulu Natal south coast. It is bounded along the southern margin by the Cape Fold Belt and along the northern margin by the much older Transvaal Supergroup rocks. Representing some 120 million years (300 – 183Ma), the Karoo Supergroup rocks have preserved a diversity of fossil plants, insects, vertebrates and invertebrates.

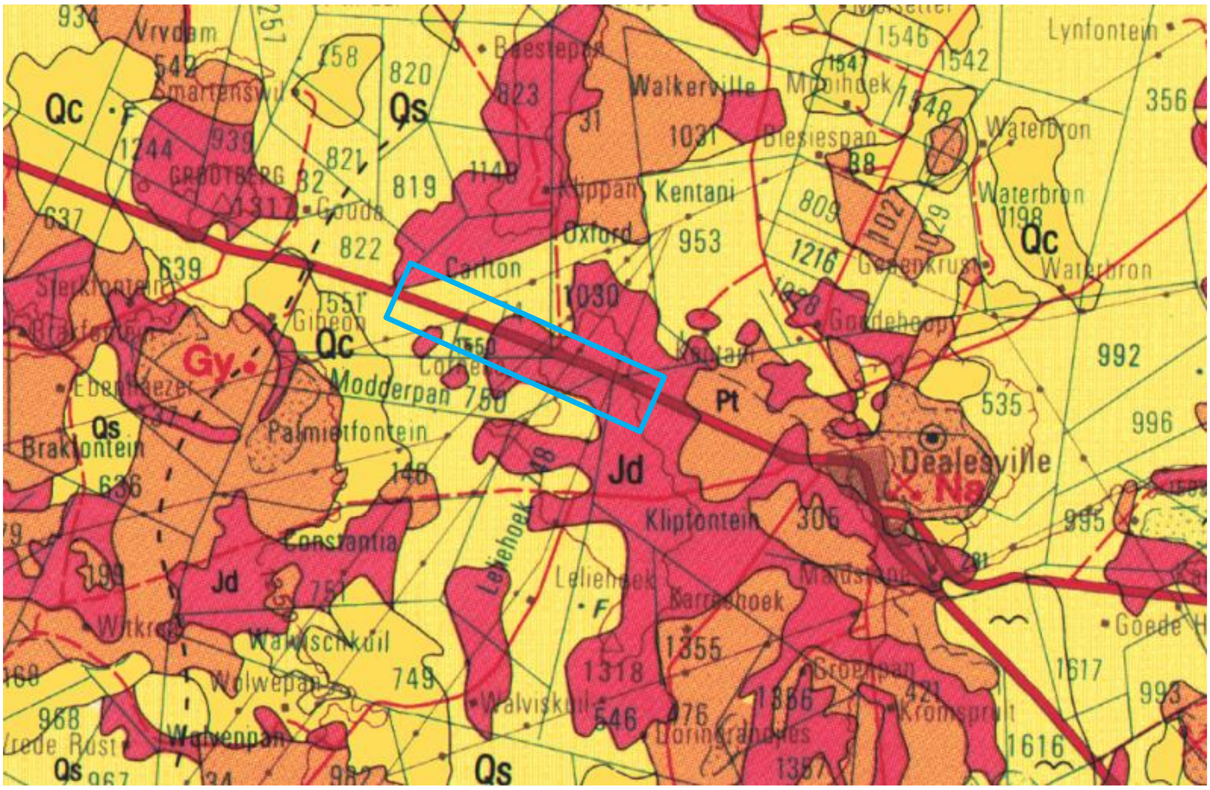


Figure 4: Geological map of the area around the Volta SEF and EGI, Dealesville. The location of the proposed EGI project is indicated within the blue rectangle. Abbreviations of the rock types are explained in Table 4. Map enlarged from the Geological Survey 1: 250 000 map 2824 Kimberley.

Table 4: Explanation of symbols for the geological map and approximate ages (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
Qs	Kalahari Group, Quaternary	Sand, red and grey aeolian sand	Quaternary, ca 1.0 Ma to present
Qc	Kalahari Group, Quaternary	Calcrete, calcified pandune, surface limestone	Quaternary, ca 1.0 Ma to present
Jd	Jurassic dykes	Dolerite dykes, intrusive	Jurassic, approx. 183 Ma
Pt	Tierberg/Fort Brown Fm, Ecca Group, Karoo SG	Brown to grey shale	Middle Permian ca 269 – 266 Ma

During the Carboniferous Period South Africa was part of the huge continental landmass known as Gondwanaland and it was positioned over the South Pole. As a result, there were several ice sheets that formed and melted, and covered most of South Africa (Visser, 1986, 1989; Isbell et al., 2012). Gradual melting of the ice as the continental mass moved northwards and the earth warmed, formed fine-grained sediments in the large inland sea. These are the oldest rocks in the system and are exposed around the outer part of the ancient Karoo Basin, and are known as the Dwyka Group. They comprise tillites, diamictites, mudstones, siltstones and sandstones that were deposited as the basin filled (Johnson et al., 2006).

Overlying the Dwyka Group rocks are rocks of the Ecca Group that are Early Permian in age. There are eleven formations recognised in this group but they do not all extend throughout the Karoo Basin. In the west and central part are the following formations, from base upwards: Prince Albert Formation, Whitehill Formation, Collingham Formation, Laingsburg / Ripon Formations, **Tierberg** / Fort Brown Formations, and Waterford Formation. All of these sediments have varying proportions of sandstones, mudstones, shales and siltstones and represent shallow to deep water settings, deltas, rivers, streams and overbank depositional environments.

Large exposures of Jurassic dolerite dykes occur throughout the area. These intruded through the Karoo sediments around 183 million years ago at about the same time as the Drakensberg basaltic eruption.

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 5 (SAHRIS) and 6 (DFFE Screening tool). The site for development is in the highly sensitive (orange) Quaternary calcretes, the moderately sensitive (green) Tierberg Formation and with no sensitivity (grey) for the Jurassic dolerite (see Figure 4).

In the westernmost part of the basin the **Tierberg Formation** is predominantly argillaceous. In the northwest of its occurrence where it is in contact with the Collingham or Whitehill Formations, it grades up into the arenaceous overlying Waterford Formation (Johnson et al., 2006). Trace fossils of *Nereites, Planolites* and *Zoophycus* can be found in the fine mudstones (Johnson et al., 2006).

There are numerous pans of **Quaternary** age in the Kalahari, generally 3–4 km in diameter (Haddon and McCarthy, 2005). According to Goudie and Wells (1995) there are two conditions required for the formation of pans. Firstly, the fluvial processes must not be integrated, and second, there must be no accumulation of aeolian material that would fill the irregularities or depressions in the land surface. Favoured materials or substrates for the formation of pans in South Africa are Dwyka and Ecca shales and sandstones (ibid).

Most pans in the Kalahari Basin are filled by a layer of clayey sand or calcareous clays and are flanked by lunette dunes formed as a result of deflation of the pan floor during arid periods (Lancaster, 1978a,b; Haddon and McCarthy, 2005). At some localities in the south western Kalahari spring-fed tufas have formed at the margins of pans during periods where groundwater discharge was high (Lancaster, 1986). These tufas may contain evidence of algal mats and stromatolites and may also be associated with calcified reed and root tubes (Lancaster, 1986).Many of the pans are characterised by diatomaceous earth, diatomite or kieselguhr, a white or grey, porous, light-weight, fine-grained sediment composed mainly of the fossilised skeletons of diatoms. Associated with some palaeo-pans and palaeo-springs are fossil bones, root casts, pollen and archaeological artefacts. Well-known sites are Florisbad and Deelpan in the Free State, Wonderkrater in

Limpopo and Bosluispan in the Northern Cape. In in this region under study is the Kathu Complex.

Palaeo-pans and palaeo-springs are visible in satellite imagery because of their topography and often are associated with lunette dunes. Vegetation changes are also common. Apart from the large mapped pans, no other such features are seen in the Google Earth images. Aeolian sediments that cover most of the region, do not preserve fossils because they are reworked and windblown, but the sands may cover palaeo-pans.

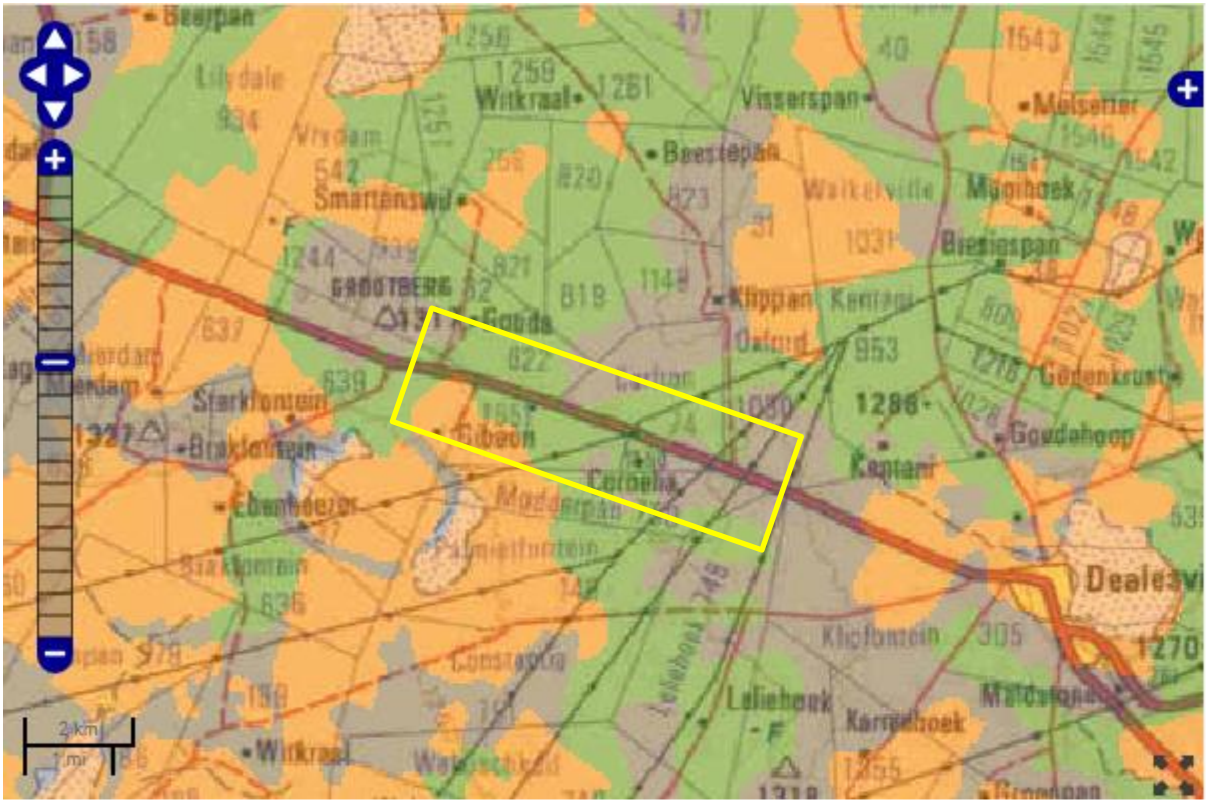


Figure 5: SAHRIS palaeosensitivity map for the site for the proposed Volta SEF shown within the yellow rectangle. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

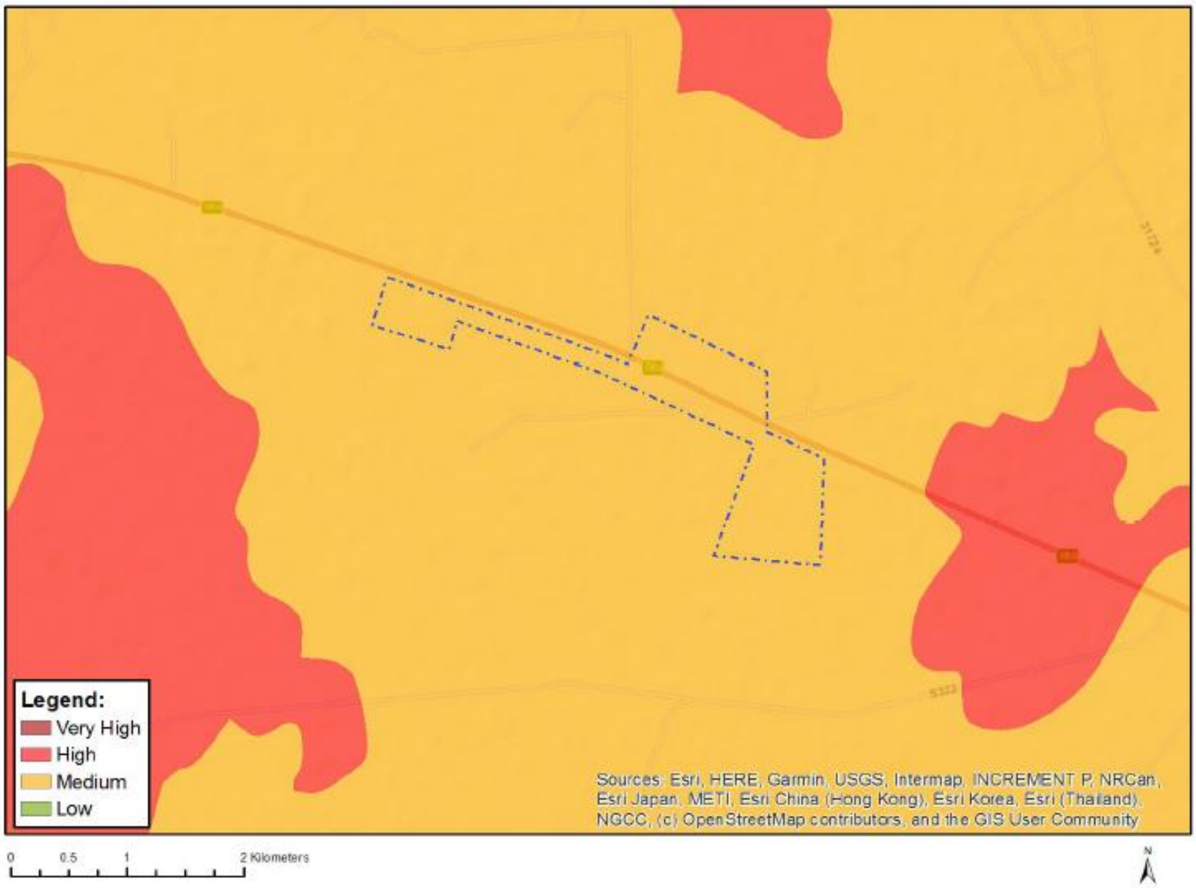


Figure 6: DFFE Screening tool map for palaeosensitivity. Note that this map does not distinguished the non-fossiliferous Jurassic dolerite from the genuinely moderately fossiliferous Quaternary sands (both orange in this map).

4. Impact assessment

Specialist Impact Assessment Criteria for CSIR

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 that 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** are impacts that are caused directly by the activity and generally occur at the same time and at the place of the activity. These impacts are usually associated with the construction, operation or maintenance of an activity and are generally obvious and quantifiable.

- **Indirect impacts** of an activity are indirect or induced changes that may occur as a result of the activity. These types of impacts include all the potential impacts that do not manifest immediately when the activity is undertaken or which occur at a different place as a result of the activity.

- **Cumulative impacts** are impacts that 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. Cumulative impacts can occur from the collective impacts of individual minor actions over a period of time and can include both direct and indirect impacts. **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.** For the palaeontology, each site is unique so there are no cumulative impacts.

- **Nature of impact** - this reviews the type of effect that a proposed activity will have on the environment and should include "what will be affected and how?"

- **Spatial extent** – The size of the area that will be affected by the risk/impact:
    - Site specific;
    - Local (<10 km from site);
    - Regional (<100 km of site);
    - National; or

- International (e.g. Greenhouse Gas emissions or migrant birds).

- **Duration** – The timeframe during which the risk/impact will be experienced:
  - Very short term (instantaneous);
  - Short term (less than 1 year);
  - Medium term (1 to 10 years);
  - Long term (the impact will cease after the operational life of the activity (i.e. the impact or risk will occur for the project duration)); or
  - Permanent (mitigation will not occur in such a way or in such a time span that the impact can be considered transient (i.e. the impact will occur beyond the project decommissioning)).

- **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:
  - High reversibility of impacts (impact is highly reversible at end of project life, i.e. this is the most favourable assessment for the environment. For example, the nuisance factor caused by noise impacts associated with the operational phase of an exporting terminal can be considered to be highly reversible at the end of the project life);
  - Moderate reversibility of impacts;
  - Low reversibility of impacts; or
  - Impacts are non-reversible (impact is permanent, i.e. this is the least favourable assessment for the environment. The impact is permanent. For example, the loss of a palaeontological resource on the site caused by building foundations could be non-reversible).

- **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:
  - High irreplaceability of resources (project will destroy unique resources that cannot be replaced, i.e. this is the least favourable assessment for the environment. For example, if the project will destroy unique wetland systems, these may be irreplaceable);
  - Moderate irreplaceability of resources;
  - Low irreplaceability of resources; or
  - Resources are replaceable (the affected resource is easy to replace/rehabilitate, i.e. this is the most favourable assessment for the environment).

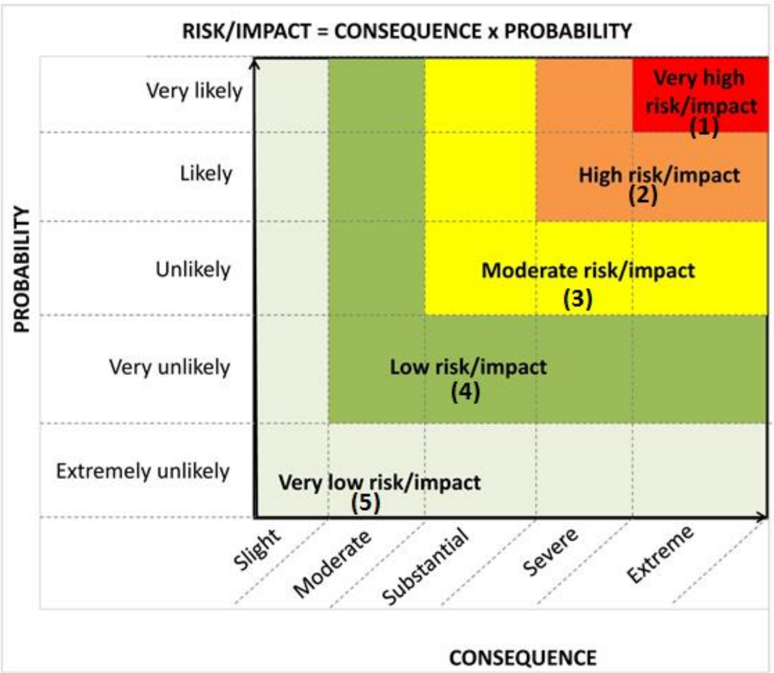
Using the criteria above, the impacts will be assessed further in terms of the following:

- **Consequence** – The anticipated severity of the impact:
  - Extreme (extreme alteration of natural systems, patterns or processes, i.e. where environmental functions and processes are altered such that they permanently cease);
  - Severe (severe alteration of natural systems, patterns or processes, i.e. where environmental functions and processes are altered such that they temporarily or permanently cease);

- Substantial (substantial alteration of natural systems, patterns or processes, i.e. where environmental functions and processes are altered such that they temporarily or permanently cease);
    - Moderate (notable alteration of natural systems, patterns or processes, i.e. where the environment continues to function but in a modified manner); or
    - Slight (negligible alteration of natural systems, patterns or processes, i.e. where no natural systems/environmental functions, patterns, or processes are affected).

- **Probability** – The probability of the impact occurring:
    - Extremely unlikely (little to no chance of occurring);
    - Very unlikely (<30% chance of occurring);
    - Unlikely (30-50% chance of occurring)
    - Likely (51 – 90% chance of occurring); or
    - Very likely (>90% chance of occurring regardless of prevention measures).

- **Significance** – To determine the significance of an identified impact/risk, the consequence is multiplied by probability (qualitatively as shown in Figure 1 below). The approach incorporates internationally recognised methods from the Intergovernmental Panel on Climate Change (IPCC) (2014) assessment of the effects of climate change and is based on an interpretation of existing information in relation to the proposed activity, to generate an integrated picture of the risks related to a specified activity in a given location, with and without mitigation. Risk is assessed for each significant stressor (e.g. physical disturbance), on each different type of receiving entity (e.g. the municipal capacity, a sensitive wetland), qualitatively (very low, low, moderate, high, very high) against a predefined set of criteria (as shown in Figure 1 below). The significance is rated qualitatively as follows against a predefined set of criteria (i.e. probability and consequence) as indicated in Figure 1:



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)).

The above assessment must be described in the text (with clear explanation provided on the rationale for the allocation of significance ratings) and summarised in an impact assessment Table in a similar manner as shown in the example below (Table 1).

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:
  - Positive - environment overall will benefit from the impact;
  - Negative - environment overall will be adversely affected by the impact; or
  - Neutral - environment overall will not be affected.

- **Confidence** – The degree of confidence in predictions based on available information and specialist knowledge:
  - Low;
  - Medium; or
  - High.

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

- Management actions and monitoring of the impacts;
- Identifying negative impacts and prescribing mitigation measures to avoid or reduce negative impacts; and
- Positive impacts will be identified and enhanced where possible.

Error! Reference source not found. below is to be used by specialists for the rating of impacts.

Other aspects to be taken into consideration in the assessment of impact significance are:

- Impacts will be evaluated for the construction, operational and decommissioning phases of the development. The assessment of impacts for the decommissioning phase will be brief, as there is limited understanding at this stage of what this might entail. The relevant rehabilitation guidelines and legal requirements applicable at the time will need to be applied;
- The impact evaluation will, where possible, take into consideration the cumulative effects associated with this and other facilities/projects which are either developed or in the process of being developed in the local area; and
- The impact assessment will attempt to quantify the magnitude of potential impacts (direct and cumulative effects) and outline the rationale used. Where appropriate, national standards are to be used as a measure of the level of impact.
- Impacts should be assessed for all layouts and project components.
- **IMPORTANT NOTE FROM THE CSIR**: Impacts should be described both before and after the proposed mitigation and management measures have been implemented. The assessment of the potential impact "before mitigation" should take into consideration all management actions that are already part of the project design (which are a given). The assessment of the potential impact "after mitigation" should take into consideration any additional management actions proposed by the specialist, to minimise negative or enhance positive impacts.

Table 5: Table for rating of impacts – Note trenching and pole foundations have the same impact on moderately fossiliferous rocks.

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	Status		Low	Remove any fossils found when excavations commence	Very low	High
	Spatial extent	local				
	Duration	shortterm				
	Consequence	slight				
	Probability	unlikely				
	Reversibility	high				
	Irreplaceability	low				
			Operational Phase			
Damage or destruction of palaeontological materials	Status		N/A		N/A	
	Spatial extent					
	Duration					
	Consequence					
	Probability					
	Reversibility					
	Irreplaceability					
			Decommissioning Phase			
Damage or destruction of palaeontological materials	Status		N/A		N/A	
	Spatial extent					
	Duration					
	Consequence					
	Probability					

	Reversibility					
	Irreplaceability					

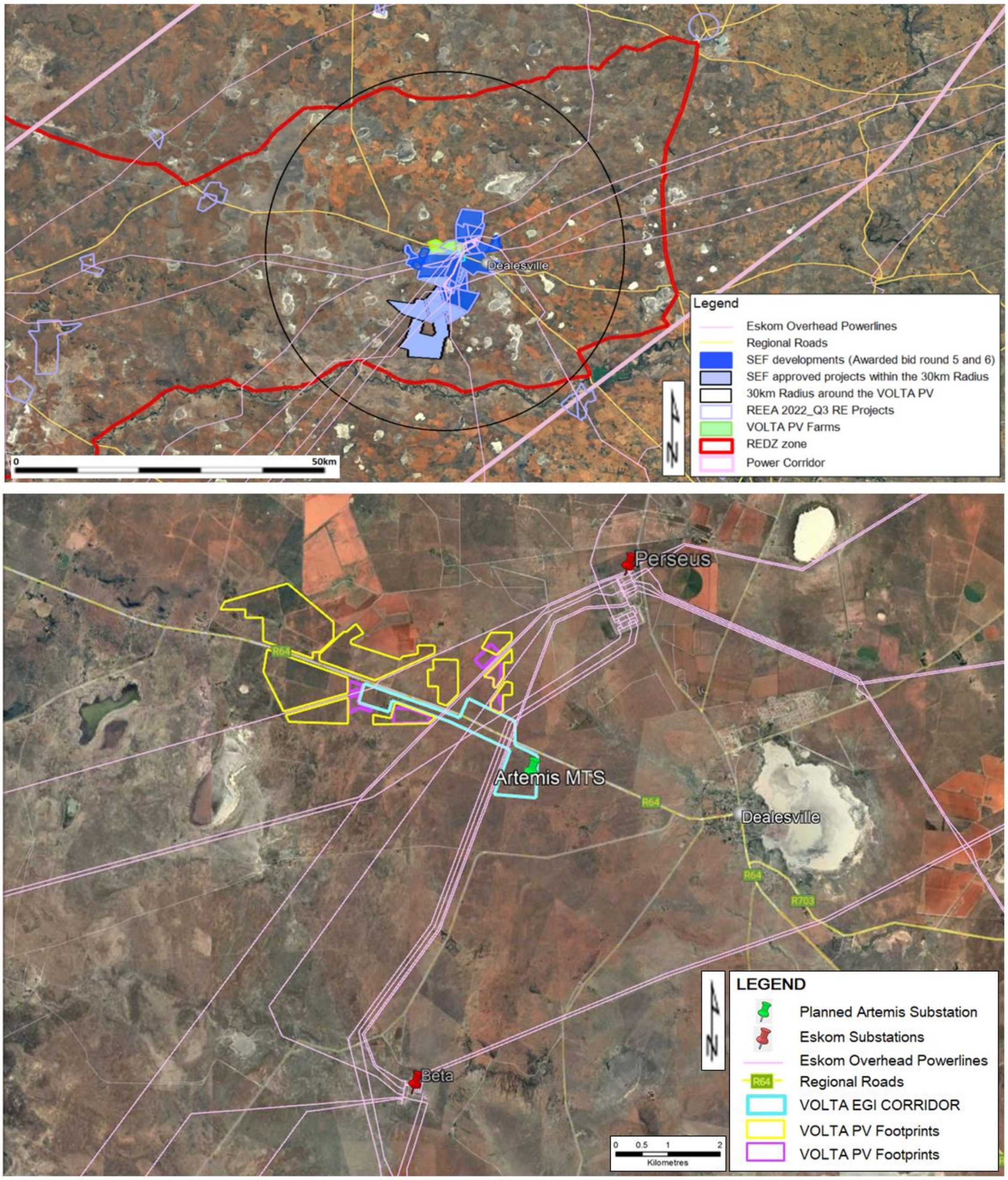


Figure 7a): Google Earth map to show the substations in the vicinity of the VOLTA project b). Eskom Substations in the vicinity of the VOLTA footprint

Cumulative Impact:

There are three substations in the vicinity of the VOLTA footprint (Figure 7b), to the north is the Perseus Substation on Farm Kentani 953, the Beta Substation to the south is on Farm Bracklaagte 149 and the Artemis substation adjacent to this project (Figures 3-4). All the substations are on only moderately fossiliferous Quaternary sands and soils so none of them a significant impact on the palaeontology. There are no very highly sensitive rocks within a 30km radius of Dealesville (Council for Geosciences map 1:250 000 2824 Kimberley) so any other solar facilities within a 30 km radius (Figure 7a) would not impact the palaeontology either. Therefore, there is no cumulative impact.

The Volta EGI project will have an impact only on the footprint. The impact will be permanent if fossils are destroyed. The destruction would be irreversible but since the fossils, when they occur they are common, so they would be partly replaceable. Pre-mitigation the consequence would be moderate but post-mitigation the consequence would be very low and positive. The probability of finding fossils is more difficult to assess:
From the geology and literature we know there is a chance of fossils occurring in the project footprint (encapsulated in the SAHRIS palaeosensitivity map, Figure 4) but the type of fossil and likelihood vary (see summary table below, Table 6). However, until the excavations commence it is not possible to know if fossils are below the ground. For mitigation, any fossils found should be photographed, removed and a palaeontologist consulted to determine their scientific value and take the necessary steps (Section 8). If important fossils are found that would otherwise have gone unnoticed before the project commenced, this will be a positive impact on the scientific knowledge and palaeontological heritage. The impact will only be during the construction phase when excavations are done. If there are no excavations during the operational and decommissioning phase, there will be no impact on the fossils.

Since each site is unique as far as the palaeontology is concerned, there will be no cumulative impact from the other energy projects in the area.

There is no no-go area because any fossils can be removed and the project can continue.

Table 6: types of fossils, likelihood of occurrence, action required for each formation and farm.

Geology and Palaeontology	Chance	Action	Farm*							
			1	2	3	4	5	6	7	8
Volta SEF farms			0	0	0	0		0		
Volta EGI farms			0	0			0		0	0
Quat sand – fragments	low	FCFP	X	X	X	X	X	X		X
Quat calcrete – pans, fragments	medium	FCFP					X			
Tierberg Fm - trace fossils	medium	FCFP					X	X	X	
Jurassic dolerite	high	None	X	X	X	X	X	X	X	X

**Farm Key:*
1 = Mooihoek (RE/1551); 2 = Cornelia (RE/1550); 3 = Carlton (RE/74); 4 = Vadersrust (RE/822); 5 = Modderpan (RE/750); 6 = Oxford (1/1030); 7 = Klipfontein (RE/305); 8 =Leliehoek (RE/748).
FCFP = Fossil Chance Find Protocol in Section 8.

Quat = Quaternary

The **Significance** of this project on the palaeontological heritage is low without mitigation but very low with mitigation (removal of fossils and curation in a recognised institution; Section 8) and positive because previously unknown fossils will be available for scientific research.

5. Assumptions and uncertainties

Based on the geology of the area and the palaeontological record as we know it, it can be assumed that the formation and layout of the dolomites, sandstones, shales and sands are typical for the country and only some might contain fossil plant, insect, invertebrate and vertebrate material. The sands of the Quaternary period would not preserve fossils.

6. Recommendation

Based on experience and the lack of any previously recorded fossils from the area, it is extremely unlikely that any fossils would be preserved in the overlying sands and soils of the Quaternary. There is a very small chance that trace fossils may occur in the shales of the early Permian Tierberg Formation or transported and fragmentary fossils in the Quaternary sands, so a Fossil Chance Find Protocol should be added to the EMPr. If fossils are found by the environmental officer or other responsible person, once excavations for foundations and infrastructure have commenced, then they should be rescued and a palaeontologist called to assess and collect a representative sample. **The impact on the palaeontological heritage would be low pre-mitigation and very low post mitigation, so as far as the palaeontology is concerned the project should be authorised. There is no cumulative impact and there is no no-go area.**

7. Impact Assessment Summary

A summary of the overall impact significance findings (following mitigation) for the proposed solar facility and power line projects is provided in Table 7 below.

Table 7: Overall Impact Significance (Post Mitigation)

Damage or destruction of palaeontological materials	**Overall Impact Significance**
Construction	Very Low
Operational	Not applicable
Decommissioning	Not applicable
Loss of palaeontological heritage	**Overall Impact Significance**
Cumulative - Construction	Very Low
Cumulative - Operational	Not applicable

8. References

Goudie, A.S., Wells, G.L., 1995. The nature, distribution and formation of pans in arid zones. Earth Science Reviews 38, 1–69.

Haddon. I.G., McCarthy, T.S., 2005. The Mesozoic–Cenozoic interior sag basins of Central Africa: The Late-Cretaceous–Cenozoic Kalahari and Okavango basins. Journal of African Earth Sciences 43, 316–333.

Lancaster, I.N., 1978a. The pans of the southern Kalahari, Botswana. Geographical Journal 144, 80–98.

Lancaster, I.N., 1978b. Composition and formation of southern Kalahari pan margin dunes. Zeitschrift für Geomorphologie 22, 148–169.

Lancaster, N., 1986. Pans in the southwestern Kalahari: a preliminary report. Palaeoecology of Africa 17, 59–67.

Lukich, V., Cowling, S., Chazan, M., 2020. Palaeoenvironmental reconstruction of Kathu Pan, South Africa, based on sedimentological data. Quaternary Science Reviews 230, 106153. https://doi.org/10.1016/j.quascirev.2019.106153

Partridge, T.C., Maud, R.R., 1987. Geomorphic evolution of southern Africa since the Mesozoic. South African Journal of Geology 90, 179-208.

Partridge, T.C., Maud, R.R., 1989. The end Cretaceous event: new evidence from the southern hemisphere. South African Journal of Science 85, 428 – 430.

Partridge, T.C., Maud, R.R., 2000. Macroscale geomorphic evolution of southern Africa. In: Partridge, T.C. and Maud, R.R. (eds). The Cenozoic of Southern Africa. Oxford University Press, New York. 406pp.

Thomas, D.S.G., Shaw, P.A., 2002. Late Quaternary environmental change in central southern Africa: new data, synthesis, issues and prospects. Quaternary Science Reviews 21 (7), 783–797.

Walker, S.J.H., Lukich, V., Chazan, M., 2014. Kathu Townlands: A High Density Earlier Stone Age Locality in the Interior of South Africa. PLoS ONE 9(7): e103436. doi:10.1371/journal.pone.0103436.

Isbell, J.L., Henry, L.C., Gulbranson, E.L., Limarino, C.O., Fraiser, F.L., Koch, Z.J., Ciccioli, P.l., Dineen, A.A., 2012. Glacial paradoxes during the late Paleozoic ice age: Evaluating the equilibrium line altitude as a control on glaciation. Gondwana Research 22, 1-19.

Johnson, M.R., van Vuuren, C.J., Visser, J.N.J., Cole, D.I., Wickens, H.deV., Christie, A.D.M., Roberts, D.L., Brandl, G., 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R., Anhaeusser, C.R. and Thomas, R.J., (Eds). The Geology of South Africa. Geological Society of South Africa, Johannesburg / Council for Geoscience, Pretoria. Pp 461 – 499.

Plumstead, E.P., 1969. Three thousand million years of plant life in Africa. Geological Society of southern Africa, Annexure to Volume LXXII. 72pp + 25 plates.

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.

Visser, J.N.J., 1989. The Permo-Carboniferous Dwyka Formation of southern Africa: deposition by a predominantly subpolar marine icesheet. Palaeogeography, Palaeoclimatology, Palaeoecology 70, 377-391.

9. Chance Find Protocol

Monitoring Programme for Palaeontology – 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 coal) 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 Figures 8-9). This information will be built into the EMP'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 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.

10. Appendix A – Examples of fossils from the Tierberg formation and Quaternary deposits

Figure 8: Photographs of trace fossils that could be found in the Tierberg Formation (Ecca Group, Karoo Supergroup).

A – leaf impression in sandstone; B – silicified wood fragments in a stream bed; C – fossil bone fragments in the shales.

Figure 7: Photographs of fragmentary but robust, transported fossil that could be found in the Quaternary calcretes or aeolian sands.

11. Appendix B – Details 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.
NRF Rating: C-2 (1999-2004); B-3 (2005-2015); B-2 (2016-2020); B-1 (2021-2026)

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	13	0
Masters	11	3
PhD	11	6
Postdoctoral fellows	15	1

viii) Undergraduate teaching
Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 45 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 Open Science UK: 2021 -
Review of manuscripts for ISI-listed journals: 30 local and international journals
Reviewing of funding applications for NRF, PAST, NWO, SIDA, National Geographic, Leakey Foundation

x) Palaeontological Impact Assessments

Selected from the past five years only – list not complete:

- Mala Mala 2017 for Henwood
- Modimolle 2017 for Green Vision
- Klipoortjie and Finaalspan 2017 for Delta BEC
- Ledjadja borrow pits 2018 for Digby Wells
- Lungile poultry farm 2018 for CTS
- Olienhout Dam 2018 for JP Celliers
- Isondlo and Kwasobabili 2018 for GCS
- Kanakies Gypsum 2018 for Cabanga
- Nababeep Copper mine 2018
- Glencore-Mbali pipeline 2018 for Digby Wells
- Remhoogte PR 2019 for A&HAS
- 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

xi) Research Output

Publications by M K Bamford up to January 2022 peer-reviewed journals or scholarly books: over 160 articles published; 5 submitted/in press; 10 book chapters.
Scopus h-index = 30; Google scholar h-index = 35; -i10-index = 92
Conferences: numerous presentations at local and international conferences.