



PALAEONTOLOGICAL IMPACT ASSESSMENT

CARMEL SOLAR 2
PHOTOVOLTAIC ENERGY
FACILITY, NEAR
CARLETONVILLE, GAUTENG
PROVINCE.

2022

COMPILED FOR:
ENVIRONAMICS ENVIRONMENTAL



Declaration of Independence

I, Elize Butler, declare that –

General declaration:

- I act as the independent palaeontological specialist in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favorable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting palaeontological impact assessments, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I will take into account, to the extent possible, the matters listed in section 38 of the NHRA when preparing the application and any report relating to the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- I will ensure that information containing all relevant facts in respect of the application is distributed or made available to interested and affected parties and the public and that participation by interested and affected parties is facilitated in such a manner that all interested and affected parties will be provided with a reasonable opportunity to participate and to provide comments on documents that are produced to support the application;
- I will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favorable to the applicant or not
- All the particulars furnished by me in this form are true and correct;
- I will perform all other obligations as expected a palaeontological specialist in terms of the Act and the constitutions of my affiliated professional bodies; and



- I realize that a false declaration is an offense in terms of regulation 71 of the Regulations and is punishable in terms of section 24F of the NEMA.

Disclosure of Vested Interest

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

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SIGNATURE:



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

Table 1: Checklist for Specialist studies in conformance with Appendix 6 of the EIA Regulations of 2014 (as amended)		
Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	The relevant section in the report	Comment where not applicable.
1.(1) (a) (i) Details of the specialist who prepared the report	Page ii and Section 3 of Report – Contact details and company and Appendix A	-
(ii) The expertise of that person to compile a specialist report including a curriculum vita	Section 3 – refer to Appendix A	-
(b) A declaration that the person is independent in a form as may be specified by the competent authority	Page ii of the report	-
(c) An indication of the scope of, and the purpose for which, the report was prepared	Section 5 – Objective	-
(cA) An indication of the quality and age of base data used for the specialist report	Section 6 – Geological and Palaeontological history	-
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 11	-



Table 1: Checklist for Specialist studies in conformance with Appendix 6 of the EIA Regulations of 2014 (as amended)		
Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	The relevant section in the report	Comment where not applicable.
(d) The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 1;10 & 12	
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 8 Approach and Methodology	-
(f) details of an assessment of the specifically identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 1;10 & 11	
(g) An identification of any areas to be avoided, including buffers	Section 1 & 12	
(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 6 – Geological and Palaeontological history	
(i) A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 8.1 – Assumptions and Limitation	-
(j) A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 1 and 12	



Table 1: Checklist for Specialist studies in conformance with Appendix 6 of the EIA Regulations of 2014 (as amended)		
Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	The relevant section in the report	Comment where not applicable.
(k) Any mitigation measures for inclusion in the EMPr	Section 1 & 12	
(l) Any conditions for inclusion in the environmental authorisation	Section 1 & 12	
(m) Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 1 & 12	
(n)(i) A reasoned opinion as to whether the proposed activity, activities or portions thereof should be authorised and	Section 1 & 12	
(n)(iA) A reasoned opinion regarding the acceptability of the proposed activity or activities; and		
(n)(ii) If the opinion is that the proposed activity, activities 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	Section 1 and 12	-
(o) A description of any consultation process that was undertaken during the course of carrying out the study	N/A	Not applicable. A public consultation process was handled as part of the Environmental



Table 1: Checklist for Specialist studies in conformance with Appendix 6 of the EIA Regulations of 2014 (as amended)		
Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	The relevant section in the report	Comment where not applicable.
		I Impact Assessment (EIA) and Environmental Management Plan (EMP) process.
(p) A summary and copies of any comments that were received during any consultation process	N/A	Not applicable. To date, no comments regarding heritage resources that require input from a specialist have been raised.
(q) Any other information requested by the competent authority.	N/A	Not applicable.
(2) Where a government notice by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Section 3 compliance with SAHRA guidelines	



EXECUTIVE SUMMARY

Banzai Environmental was appointed by Environamics Environmental Consultants to conduct the **Palaeontological Impact Assessment (PIA)** to assess the Carmel Solar 2 Photovoltaic Solar Energy Facility, near Carletonville, Gauteng Province. In accordance with the National Environmental Management Act 107 of 1998 (NEMA) and to comply with the National Heritage Resources Act (No 25 of 1999, section 38) (NHRA), this PIA is necessary to confirm if fossil material could potentially be present in the planned development area and to evaluate the potential impact of the proposed development on the Palaeontological Heritage of the area.

The Power line of the Carmel 2 Solar development is underlain by the Malmani Subgroup (Chuniespoort Group, Transvaal Supergroup) while the rest of the facility is underlain by the Rooihogte and Timeball Hill Formations (Pretoria Group, Transvaal Supergroup) as well as unfossiliferous diabase. According to the PalaeoMap of the South African Heritage Resources Information System (SAHRIS) the Palaeontological Sensitivity of the Malmani Subgroup is Very High, that of the Timeball Hill Formation is High, while the Rooihogte has a Low Palaeontological Sensitivity. The Palaeontological Significance of the diabase is Zero as it is igneous in origin (Almond *et al*, 2013; SAHRIS website).

A site-specific field survey of the development footprint was conducted on foot and by motor vehicle on 3 November 2022. During the site investigation no fossiliferous outcrops were detected. It is thus considered that the proposed Carmel Solar 2 Photovoltaic Solar Energy Facility will not lead to detrimental impacts on the palaeontological resources of the area. The construction of the development may therefore be authorised as the development footprint is not considered sensitive in terms of palaeontological resources. **It is consequently recommended that no further palaeontological heritage studies, ground truthing and/or specialist mitigation are required pending the discovery of newly discovered fossils.**

If fossil remains are discovered during any phase of construction, either on the surface or uncovered by excavations, the ECO/site manager in charge of these developments must be notified immediately. These discoveries must be secured and the ECO/site manager must alert SAHRA so that appropriate mitigation (documented and collection) can be undertaken by a professional palaeontologist (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Tel: 021 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). The specialist would need a collection permit from SAHRA. Fossil material must be curated in an approved collection (museum or university) and all fieldwork and reports must meet the minimum standards for palaeontological impact studies developed by SAHRA



Impact Summary

Environmental parameter	Issues	Rating prior to mitigation	Average	Rating post mitigation	Average
Planning Stage	No Impact		No Impact		No Impact
Construction Stage Carmel 2 Solar	Destroy or permanently seal-in fossils at or below the surface that are then no longer available for scientific study	45	Negative Medium impact	15	Negative Low impact
Operational Phase Carmel 2 Solar	No Impact		No Impact		No Impact
Decommissioning Phase Carmel 2 Solar	No Impact		No Impact		No Impact
Construction Stage Power line Loss of fossil heritage	Destroy or permanently seal-in fossils at or below the surface that are then no longer available for scientific study	45	Negative Medium impact	15	Negative Low impact
Power line Operational Phase	No Impact		No Impact		No Impact
Power Line Decommissioning Phase	No Impact		No Impact		No Impact

It is therefore considered that the proposed Carmel Solar 2 Photovoltaic Solar Energy Facility Power Plant will not lead to detrimental impacts on the palaeontological reserves of the area if mitigation measures are adhered to. As such the construction of the development may be authorised in its whole extent.



TABLE OF CONTENT

1	INTRODUCTION	1
1.2	TECHNICAL DETAILS	3
1.3	CONSIDERATION OF ALTERNATIVES	4
2	LEGAL MANDATE AND PURPOSE OF THE REPORT	4
3	QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR	6
4	LEGISLATION.....	6
5	OBJECTIVE	8
6	GEOLOGICAL AND PALAEOLOGICAL HISTORY	9
7	GEOGRAPHICAL LOCATION OF THE SITE	20
8	METHODS	20
8.1	ASSUMPTIONS AND LIMITATIONS	21
9	ADDITIONAL INFORMATION CONSULTED.....	21
10	SITE VISIT	21
11	IMPACT ASSESSMENT METHODOLOGY	23
12	FINDINGS AND RECOMMENDATIONS	29
13	CHANCE FINDS PROTOCOL	30
14	BIBLIOGRAPHY	31



LIST OF FIGURES

Figure 1: Locality Map of the proposed Carmel Solar 2 Photovoltaic Solar Energy Facility, near Carletonville, Gauteng Province.	1
Figure 2: Regional topography of the proposed Carmel Solar 2 Photovoltaic Solar Energy Facility, near Carletonville, Gauteng Province.	2
Figure 3: Extract of the 1:250 000 West-Rand 2626 (1986) Geological Map (Council for Geosciences, Pretoria) indicating the geology of the proposed Carmel 2 Photovoltaic Solar Energy Facility.	12
Figure 4: Extract of the 1: 250 000 SAHRIS PalaeoMap map (Council of Geosciences) indicating the proposed Carmel Solar 2 Photovoltaic Solar Energy Facility.	15
Figure 5: Updated Geology (Council of Geosciences, Pretoria) of the proposed Carmel Solar 2 Photovoltaic Solar Energy Facility indicates that the development is underlain by the Malmani Subgroup (Chuniespoort Group, Transvaal Supergroup as well as Diabase and the Timeball Hill and Rooihoogte Formations of the Pretoria Group (Transvaal Supergroup).	16
Figure 6: Stratigraphy of the Transvaal Supergroup of the Transvaal Basin. The proposed development is indicated in blue (Eriksson, et al. 2006).	17
Figure 7: Carmel Solar 2 Photovoltaic Solar Energy Facility - Geographic area of evaluation with utility-scale renewable energy generation sites and power lines.	18
Figure 8: General Palaeontological Sensitivity of the Carletonville area.	20
Figure 9: General view over the development indicates open plains with grassy vegetation and small trees.	22
Figure 10: Quartzite, chert breccia.	23



LIST OF TABLES

Table 1: Checklist for Specialist studies in conformance with Appendix 6 of the EIA Regulations of 2014 (as amended)	iv
Table 2: General site information	2
Table 3: Technical details	4
Table 4: Listed activities (SPPs)	4
Table 5: Legend of the 2626 West-Rand (1986) Geological Map (Council for Geoscience, Pretoria) Relevant sediments are indicated in a red squares.	13
Table 6: Extract of the Palaeotechnical Report of Gauteng Province (Groenewald, et al., 2014) indicating the relevant sediments in black.	14
Table 7: Palaeontological Sensitivity according to the SAHRIS PalaeoMap (Almond et al, 2013; SAHRIS website).....	15
Table 8: A summary of related facilities, that may have a cumulative impact, in a 30 km radius of the Carmel Solar 2 Photovoltaic Solar Energy Facility.	19
Table 9: The rating system	24
Table 10: Summary of Impact ratings	29

Appendix A: CV



1 INTRODUCTION

The Applicant, **Carmel Solar 2 (Pty) Ltd**, is proposing the construction of a photovoltaic (PV) solar energy facility (known as the Carmel Solar 2) and associated grid infrastructure on Portions 1, 11, 23 and 28 of the Farm Doornfontein No. 118. The solar PV facility will comprise several arrays of PV panels and associated infrastructure and will have a contracted capacity of up to 240 MW. The development area is located approximately 8 km south west of Carletonville, within the Merafong Local Municipality and the West Rand District Municipality, in the Gauteng Province. The site is accessible via D92 district road located adjacent to the development area.

An additional up to 240 MW PV facility is concurrently being considered on the same properties and is being assessed through separate Environmental Impact Assessment (EIA) processes.

The proposed Carmel Solar 2 will cover up to approximately 480 ha and will include the following infrastructure:

- » PV modules and mounting structures
- » Inverters and transformers
- » Battery Energy Storage System (BESS)
- » Site and internal access roads (up to 8m wide)
- » Operation and Maintenance buildings including a gate house and security building, control centre, offices, warehouses and workshops for storage and maintenance.
- » Temporary and permanent laydown area
- » Grid connection infrastructure, including:
 - 33kV cabling between the project components and the facility substation
 - A 132kV facility substation
 - A 132kV Eskom Switching Station
 - Up to 132kV powerline between the facility substation, Eskom Switching Station and the Carmel Main Transmission Substation.



Table 2: General site information	
Description of affected farm portion	<u>Solar Power Plant</u> Portions 1, 11, 23 and 28 of the Farm Doornfontein No.118
Province	Gauteng
District Municipality	West Rand District Municipality
Local Municipality	Merafong City Local Municipality
Ward numbers	
Closest towns	The town of Carletonville is located approximately 8km northeast of the proposed development.
21 Digit Surveyor General codes	<u>Solar Power Plant</u> Portion 1 of the Farm Doornfontein No.118 - T0IQ0000000011800001 Portion 11 of the Farm Doornfontein No.118 T0IQ0000000011800011 Portion 23 of the Farm Doornfontein No.118 T0IQ0000000011800023 Portion 28 of the Farm Doornfontein No.118 T0IQ0000000011800028
Type of technology	Photovoltaic solar facility
Structure Height	Panels ~6m, buildings ~ 6m, and battery storage facility ~8m height
Battery storage	Within a 5-hectare area
Surface area to be covered (Development footprint)	Approximately 370 ha
Laydown area dimensions (EIA footprint)	Assessed 370 ha
Structure orientation	The panels will either be fixed to a single-axis horizontal tracking structure where the orientation of the panel varies according to the time of the day, as the sun moves from east to west or tilted at a fixed angle equivalent to the latitude at which the site is in order to capture the most sun.
Generation capacity	Up to 240MW
Expected production	N/A - this will be dependent on the chosen technology.



1.2 TECHNICAL DETAILS

The term photovoltaic describes a solid-state electronic cell that produces direct current electrical energy from the radiant energy of the sun through a process known as the Photovoltaic Effect. This refers to light energy placing electrons into a higher state of energy to create electricity. Each PV cell is made of silicon (i.e., semiconductors), which is positively and negatively charged on either side, with electrical conductors attached to both sides to form a circuit. This circuit captures the released electrons in the form of an electric current (direct current). The key components of the proposed project are described below:

- **PV Panel Array**

To produce up to 240MW, the proposed facility will require numerous linked cells placed behind a protective glass sheet to form a panel. Multiple panels will be required to form the solar PV arrays which will comprise the PV facility. The PV panels will be tilted at a northern angle in order to capture the most sun or using one-axis tracker structures to follow the sun to increase the Yield.

- **Wiring to Inverters**

Sections of the PV array will be wired to inverters. The inverter is a pulse width mode inverter that converts direct current (DC) electricity to alternating current (AC) electricity at grid frequency.

- **Connection to the grid**

Connecting the array to the electrical grid requires transformation of the voltage from 480V to 33kV to 132kV. The normal components and dimensions of a distribution rated electrical substation will be required. Output voltage from the inverter is 480V and this is fed into step up transformers to 132kV. An onsite substation will be required to step the voltage up to 132kV, after which the power will be evacuated into the national grid. Whilst Carmel Solar 2 Solar Power Plant has not yet received a cost estimate letter from Eskom, it is expected that generation from the facility will tie in with the proposed 132kV powerline between the facility substation, Eskom Switching Station and the Carmel Main Transmission Substation. The Project will inject up to 240MW into the National Grid. The installed capacity will be approximately 240MW.

- **Electrical reticulation network**

An internal electrical reticulation network will be required and will be laid ~2-4m underground as far as practically possible.

- **Supporting Infrastructure**

The following auxiliary buildings with basic services including water and electricity will be required on site:

- A 33 kV switch room,



- A gate house, ablutions, workshops, storage and warehousing areas, site offices and a control centre.

- **Battery storage**

A Battery Storage Facility with a maximum height of 8m and development footprint of ~5 ha and associated operational, safety and control infrastructure..

- **Roads**

The majority of the access road will follow existing, gravel farm roads that may require widening up to 10 m (inclusive of storm water infrastructure). Where new sections of road need to be constructed (/lengthened), this will be gravel/hard surfaced access road and only tarred if necessary. A network of gravel internal access roads and a perimeter road (up to 33 km), each with a width of up to ± 6 m, will be constructed to provide access to the various components of the PV development.

- **Fencing**

For health, safety and security reasons, the facility will be required to be fenced off from the surrounding farm. Fencing with a height of 2.5 meters will be used.

Table 3: Technical details	
Component	Description / dimensions
Height of PV panels	Up to 6 meters
Area of PV Array	370 Hectares (Development footprint)
Area occupied by inverter / transformer stations / substations / BESS	BESS: up to ± 5 ha Facility substation: up to 1 ha
Capacity of on-site substation	132kV
Capacity of the power line	132kV
Area occupied by both permanent and construction laydown areas	Permanent Laydown Area: Up to 1 Hectare Construction Laydown Area: ~20 Hectares
Area occupied by buildings	A 33 kV switch room, a gate house, ablutions, workshops, storage and warehousing areas, site offices and a control centre.
Battery storage facility	Maximum height: 8m
Length of internal roads	Approximately 33 km

1.3 CONSIDERATION OF ALTERNATIVES

The DEAT 2006 guidelines on 'assessment of alternatives and impacts' proposes the consideration of four types of alternatives namely, the no-go, location, activity, and design alternatives. It is however, important to note that the regulation and guidelines specifically state that only 'feasible' and 'reasonable'



alternatives should be explored. It also recognizes that the consideration of alternatives is an iterative process of feedback between the developer and EAP, which in some instances culminates in a single preferred project proposal. An initial site assessment was conducted by the developer the affected properties and the farm portions were found favorable due to its proximity to grid connections, solar radiation, ecology and relative flat terrain. These factors were then taken into consideration and avoided as far as possible.

The following alternatives were considered in relation to the proposed activity:

No-go alternative

This alternative considers the option of 'do nothing' and maintaining the status quo. The site is currently zoned for agricultural and mining land uses. Should the proposed activity not proceed, the site will remain unchanged and will continue to be used for agricultural purposes. The potential opportunity costs in terms of alternative land use income through rental for energy facility and the supporting social and economic development in the area would be lost if the status quo persist.

Location alternatives

The site selection process for a PV facility is almost always underpinned by a good solar resource. Other key considerations include environmental and social constraints, proximity to various planning units and strategic areas, terrain and availability of grid connection infrastructure.

Based on the above site-specific attributes, the study area is considered to be highly preferred in terms of the development of a solar PV facility. As such, no property / location alternatives will be considered.

Battery storage facility

As technological advances within battery energy storage systems (BESS) are frequent, two BESS technology alternatives are considered: Solid state battery electrolytes and Redox-flow technology.

Solid state battery electrolytes, such as lithium-ion (Li-ion), zinc hybrid cathode, sodium ion, flow (e.g. zinc iron or zinc bromine), sodium sulphur (NaS), zinc air and lead acid batteries, can be used for grid applications. Compared to other battery options, Li-ion batteries are highly efficient, have a high energy density and are lightweight. As a result of the declining costs, Li-ion technology now accounts for more than 90% of battery storage additions globally (IRENA, 2019).

Flow batteries use solid electrodes and liquid electrolytes. The most used flow battery is the Vanadium Redox Flow Battery (VRFB), which is a type of rechargeable flow battery that employs vanadium ions in different oxidative states to store chemical potential energy.

Considering the nature of the project, **only a solid-state technology type would be envisaged for implementation.**



Design and layout alternatives

It is customary to develop the final/detailed construction layout of the solar PV facility only once an Independent Power Producer (IPP) is awarded a successful bid under the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) or an alternative programme, after which major contracts are negotiated and final equipment suppliers identified.

For the purpose of the Environmental Impact Assessment (EIA), site layout alternatives will not be comparatively assessed, but rather a single layout will be refined as additional information becomes available throughout the EIA process (e.g. specialist input, additional site surveys, ongoing stakeholder engagement).

The development area presented in the Scoping Report has been selected as a practicable option for the facility, considering technical preference and constraints, as well as initial No-Go layers informed by specialist site surveys.

Following further site screening by the specialists (scheduled to take place during the EIA phase), the development footprint will be finalised for impact assessment.

Technology alternatives

There are several types of semiconductor technologies currently available and in use for PV solar panels. Two, however, have become the most widely adopted, namely crystalline silicon (Mono-facial and Bi-facial) and thin film. The technology that (at this stage) proves more feasible and reasonable with respect to the proposed solar facility is crystalline silicon panels, due to it being non-reflective, more efficient, and with a higher durability. However, due to the rapid technological advances being made in the field of solar technology the exact type of technology to be used, such as bifacial panels, will only be confirmed at the onset of the project.

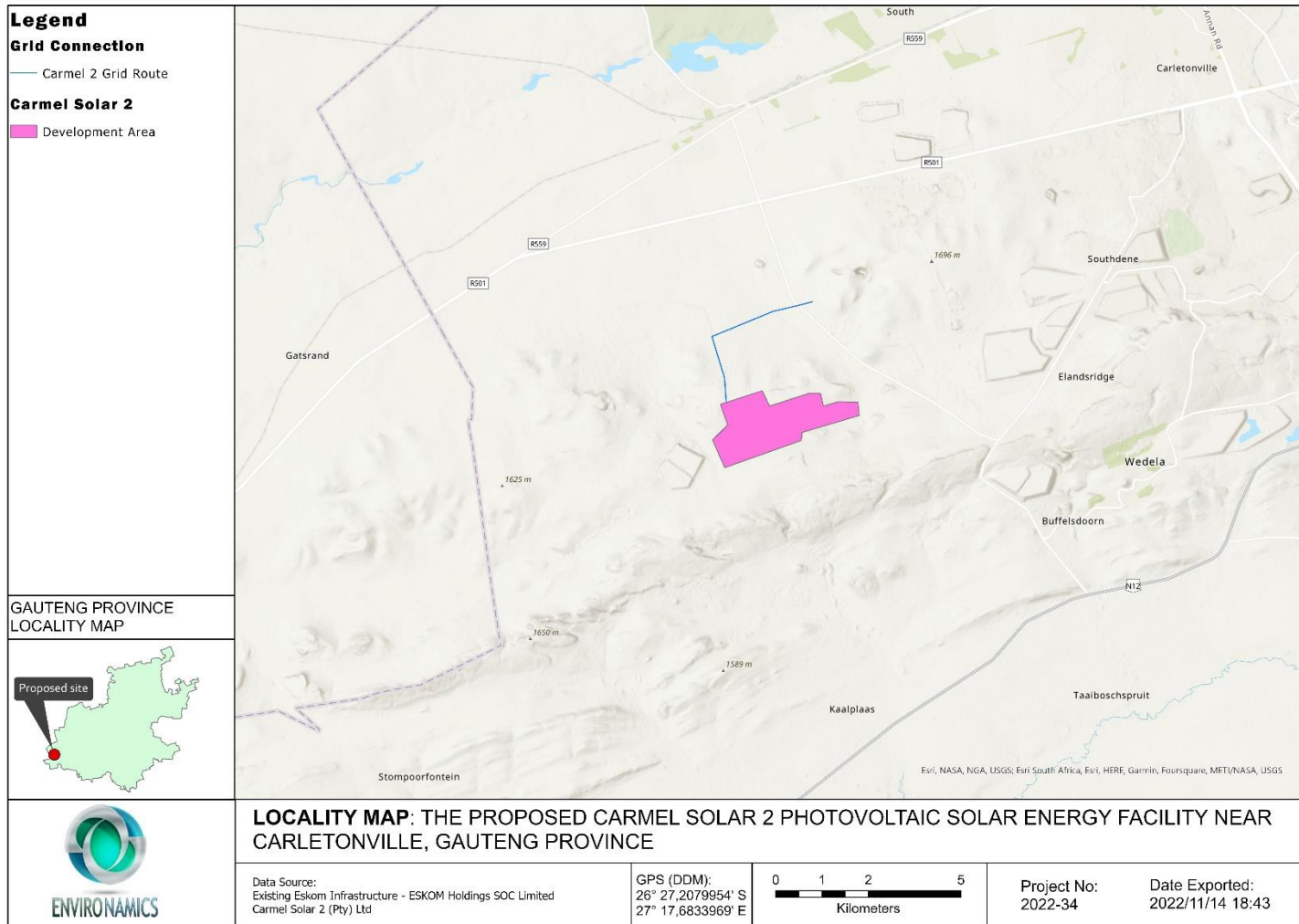


Figure 1: Locality Map of the proposed Carmel Solar 2 Photovoltaic Solar Energy Facility, near Carletonville, Gauteng Province.

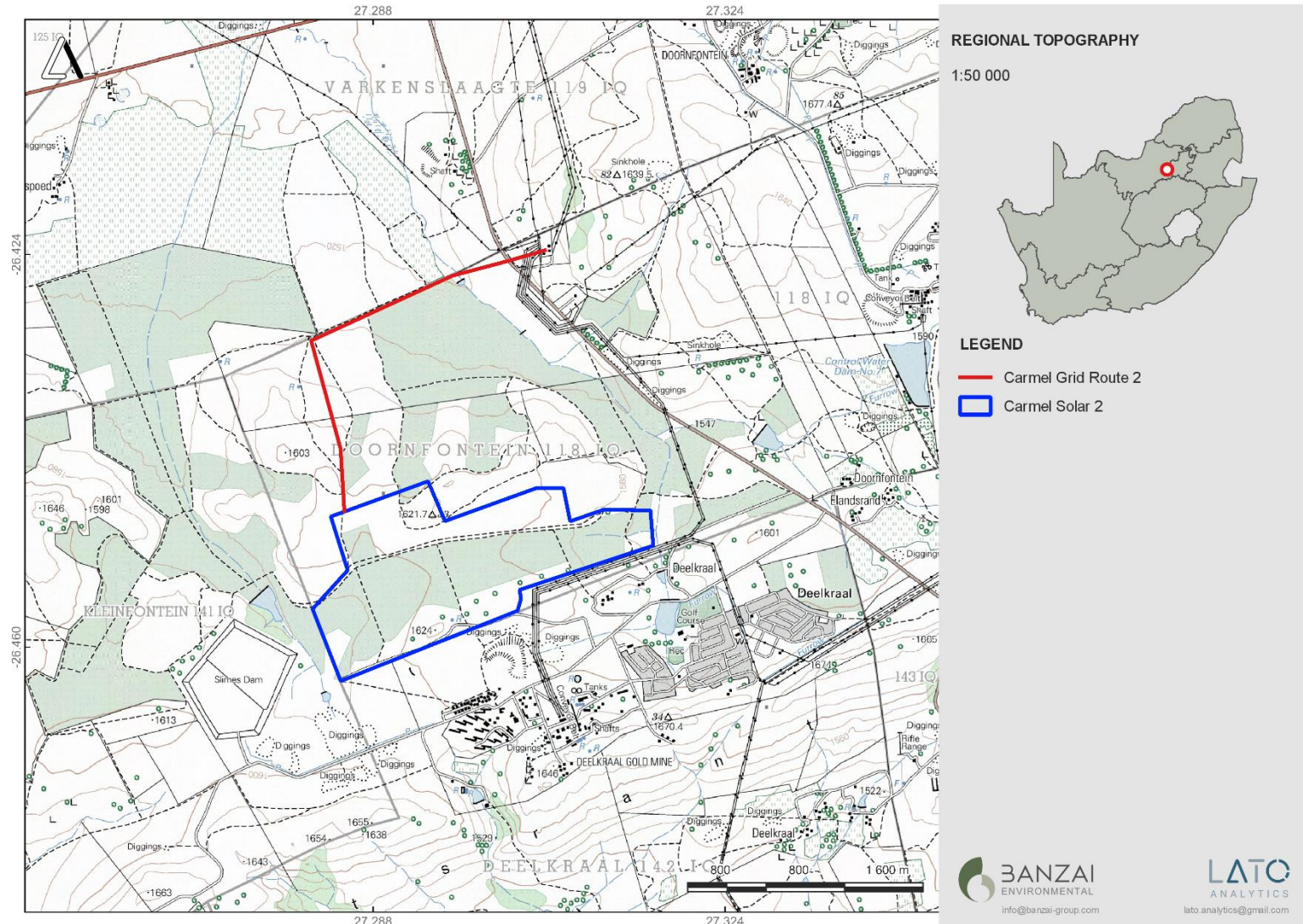


Figure 2:Regional topography of the proposed Carmel Solar 2 Photovoltaic Solar Energy Facility, near Carletonville, Gauteng Province.





2 LEGAL MANDATE AND PURPOSE OF THE REPORT

The National Environmental Management Act identifies listed activities (in terms of Section 24) which are likely to have an impact on the environment. These activities cannot commence without obtaining an EA from the relevant competent authority. Sufficient information is required by the competent authority to make an informed decision and the project is therefore subject to an environmental assessment process which can be either a Basic Assessment Process or a full Scoping and Environmental Impact Assessment process.

The EIA Regulations No. 324, 325, and 327 outline the activities that may be triggered and therefore require EA. The following listed activities with special reference to the proposed development is triggered:

Table 4: Listed activities (SPPs)		
Relevant notice:	Activity No (s)	Description of each listed activity as per project description:
GNR. 327 (as amended in 2017)	Activity 11(i)	<ul style="list-style-type: none"> • <i>“The development of facilities or infrastructure for the transmission and distribution of electricity (i) outside urban areas or industrial complexes with a capacity of more than 33 but less than 275 kilovolts.”</i> • Activity 11(i) is triggered as the proposed photovoltaic solar facility will transmit and distribute electricity of 132 kilovolts outside an urban area.
GNR. 327 (as amended in 2017)	Activity 24(ii)	<ul style="list-style-type: none"> • <i>“The development of a road (ii) with reserve wider than 13,5 meters, or where no reserve exists where the road is wider than 8 meters;</i> • Activity 24(ii) is triggered as the internal roads will vary between 6 and 12 meters in width.
GNR. 327 (as amended in 2017)	Activity 28(ii)	<ul style="list-style-type: none"> • <i>“Residential, mixed, retail, commercial, industrial or institutional developments where such land was used for agriculture or afforestation on or after 1998 and where such development (ii) will occur outside an urban area, where the total land to be developed is bigger than 1 hectare.”</i> • Activity 28(ii) is triggered as portions of the affected farm has been previously used for grazing and the property will be re-zoned to “special” use.



GNR. 327 (as amended in 2017)	Activity 56 (ii):	<ul style="list-style-type: none"> • <i>“The widening of a road by more than 6 metres, or the lengthening of a road by more than 1 kilometre (ii) where no reserve exists, where the existing road is wider than 8 metres...”</i> • Activity 56 (ii) is triggered as the existing access to the affected property does not have a reserve and will need to be widened by more than 6 metres.
GNR. 325 (as amended in 2017)	Activity 1	<ul style="list-style-type: none"> • <i>“The development of facilities or infrastructure for the generation of electricity from a renewable resource where the electricity output is 20 megawatts or more.”</i> • Activity 1 is triggered since the proposed photovoltaic solar facility will generate up to 240 megawatts electricity through the use of a renewable resource.
GNR. 325 (as amended in 2017)	Activity 15	<ul style="list-style-type: none"> • <i>“The clearance of an area of 20 hectares or more of indigenous vegetation.”</i> • More than 20 hectares of indigenous vegetation will be cleared.
GNR. 324 (as amended in 2017)	Activity 4 (c)(i)(iv)	<ul style="list-style-type: none"> • <i>The development of a road wider than 4 metres with a reserve less than 13,5 metres, (c) in Gauteng, (iv) within sites identified as Critical Biodiversity Areas (CBAs) or Ecological Support Areas (ESAs) in the Gauteng Conservation Plan or in bioregional plans</i> • Activity 4(c)(iv) is triggered as the internal roads will vary between 6 and 12 meters in width.
GNR. 324 (as amended in 2017)	Activity 10 (c)(iv)	<ul style="list-style-type: none"> • <i>The development and related operation of facilities or infrastructure for the storage, or storage and handling of a dangerous good, where such storage occurs in containers with a combined capacity of 30 but not exceeding 80 cubic metres (c) in Gauteng, (iv) within sites identified as Critical Biodiversity Areas (CBAs) or Ecological Support Areas (ESAs) in the Gauteng Conservation Plan or in bioregional plans.</i> • Activity 10 (c)(iv) will be triggered since more than 30 cubic metres of fuel will be stored on site.
GNR. 324 (as amended in 2017)	Activity 12 (c)(ii)	<ul style="list-style-type: none"> • <i>The clearance of an area of 300 square metres or more of indigenous vegetation except where such clearance of indigenous vegetation in (c) Gauteng (ii) Within Critical</i>



		<p><i>Biodiversity Areas or Ecological Support Areas identified in the Gauteng Conservation Plan or bioregional plans”.</i></p> <ul style="list-style-type: none"> • Activity 12 (b)(i) is triggered since approximately 483 hectares of indigenous vegetation will be cleared.
GNR. 324 (as amended in 2017)	Activity 18 (c)(iv)	<ul style="list-style-type: none"> • <i>The widening of a road by more than 4 metres, or the lengthening of a road by more than 1 kilometre in (c) Gauteng (v) Sites identified as Critical Biodiversity Areas (CBAs) or Ecological Support Areas (ESAs) in the Gauteng Conservation Plan or in bioregional plans.</i> • Activity 18 (c)(iv) is triggered as the existing access to the affected property does not have a reserve and will need to be widened by more than 6 metres.

The activities triggered under Listing Notice 1, 2 and 3 (Regulation 327, 325 and 324) for the project implies that the development is considered as potentially having an impact on the environment and therefore require the implementation of appropriate mitigation measures.

3 QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR

This study has been conducted by Mrs Elize Butler. She has conducted approximately 300 palaeontological impact assessments for developments in the Free State, KwaZulu-Natal, Eastern, Central, and Northern Cape, Northwest, Gauteng, Limpopo, and Mpumalanga. She has an MSc (*cum laude*) in Zoology (specializing in Palaeontology) from the University of the Free State, South Africa and has been working in Palaeontology for more than twenty-eight years. She has experience in locating, collecting, and curating fossils, including exploration field trips in search of new localities in the Karoo Basin. She has been a member of the Palaeontological Society of South Africa (PSSA) since 2006 and has been conducting PIAs since 2014.

4 LEGISLATION

National Heritage Resources Act (25 of 1999)

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

The identification, evaluation and assessment of any cultural heritage site, artefact or finds in the South African context is required and governed by the following legislation:



- National Environmental Management Act (NEMA) Act 107 of 1998
- National Heritage Resources Act (NHRA) Act 25 of 1999
- Minerals and Petroleum Resources Development Act (MPRDA) Act 28 of 2002
- Notice 648 of the Government Gazette 45421- general requirements for undertaking an initial site sensitivity verification where no specific assessment protocol has been identified.

The next section in each Act is directly applicable to the identification, assessment, and evaluation of cultural heritage resources.

GNR 982 (Government Gazette 38282, 14 December 2014) promulgated under the National Environmental Management Act (NEMA) Act 107 of 1998

- Basic Assessment Report (BAR) – Regulations 19 and 23
- Environmental Impacts Assessment (EIA) – Regulation 23
- Environmental Scoping Report (ESR) – Regulation 21
- Environmental Management Programme (EMPr) – Regulations 19 and 23

National Heritage Resources Act (NHRA) Act 25 of 1999

- Protection of Heritage Resources – Sections 34 to 36
- Heritage Resources Management – Section 38

MPRDA Regulations of 2014

Environmental reports to be compiled for application of mining right – Regulation 48

- Contents of scoping report – Regulation 49
- Contents of environmental impact assessment report – Regulation 50
- Environmental management programme – Regulation 51
- Environmental management plan – Regulation 52

The NEMA (No 107 of 1998) states that an integrated EMP should (23:2 (b)) “...*identify, predict and evaluate the actual and potential impact on the environment, socio-economic conditions and cultural heritage*”.

In agreement with legislative requirements, EIA rating standards as well as SAHRA policies the following comprehensive and legally compatible PIA report have been compiled.

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



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

- the construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300 m in length.
- the construction of a bridge or similar structure exceeding 50 m in length.
- any development or other activity which will change the character of a site—
- (Exceeding 5 000 m² in extent; or
- involving three or more existing erven or subdivisions thereof; or
- involving three or more erven or divisions thereof which have been consolidated within the past five years; or
- the costs of which will exceed a sum set in terms of regulations by SAHRA or a provincial heritage resources authority
- the re-zoning of a site exceeding 10 000 m² in extent.
- or any other category of development provided for in regulations by SAHRA or a Provincial heritage resources authority.

5 OBJECTIVE

The objective of a Palaeontological Impact Assessment (PIA) is to determine the impact of the development on potential palaeontological material at the site.

According to the “SAHRA APM Guidelines: Minimum Standards for the Archaeological and Palaeontological Components of Impact Assessment Reports” the aims of the PIA are: 1) to **identify** the palaeontological status of the exposed as well as rock formations just below the surface in the development footprint 2) to estimate the **palaeontological importance** of the formations 3) to determine the **impact** on fossil heritage; and 4) to recommend how the developer ought to protect or mitigate damage to fossil heritage.

The terms of reference of a PIA are as follows:

General Requirements:

- Adherence to the content requirements for specialist reports in accordance with Appendix 6 of the EIA Regulations 2014, as amended;
- Adherence to all applicable best practice recommendations, appropriate legislation and authority requirements;
- Submit a comprehensive overview of all appropriate legislation, guidelines;



- Description of the proposed project and provide information regarding the developer and consultant who commissioned the study,
- Description and location of the proposed development and provide geological and topographical maps
- Provide palaeontological and geological history of the affected area.
- Identification of sensitive areas to be avoided (providing shapefiles/kmls) in the proposed development;
- Evaluation of the significance of the planned development during the Pre-construction, Construction, Operation, Decommissioning Phases and Cumulative impacts. Potential impacts should be rated in terms of the direct, indirect and cumulative:
 - a. **Direct impacts** are impacts that are caused directly by the activity and generally occur at the same time and at the place of the activity.
 - b. **Indirect impacts** of an activity are indirect or induced changes that may occur as a result of the activity.
 - c. **Cumulative impacts** 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.
- Fair assessment of alternatives (infrastructure alternatives have been provided):
- Recommend mitigation measures to minimise the impact of the proposed development; and
- Implications of specialist findings for the proposed development (such as permits, licenses etc).

6 GEOLOGICAL AND PALAEOLOGICAL HISTORY

The geology of the proposed Carmel Solar 2 Photovoltaic Solar Energy Facility, near Carletonville, Gauteng Province is depicted on the 1: 250 000 West-Rand 2626 (1986) Geological Map (Council for Geosciences, Pretoria). The Power line is underlain by the Malmani Subgroup (Vmd, light blue) (Chuniespoort Group, Transvaal Supergroup) while the rest of the facility is underlain by the Rooihogte (Vr, orange) and Timeball Hill Formations (Vt, brown with red lines) (Pretoria Group, Transvaal Supergroup) as well as unfossiliferous diabase (di, green) (**Figure 3, Table 5**). The Malmani Subgroup in this area is undifferentiated. According to the PalaeoMap of the South African Heritage Resources Information System (SAHRIS) the Palaeontological Sensitivity of the Malmani Subgroup is Very High, that of the Timeball Hill Formation is High, while the Rooihogte has a Low Palaeontological Sensitivity. The Palaeontological Significance of the diabase is Zero as it is igneous in origin (Almond *et al*, 2013; SAHRIS website; **Figure 4; Table 6**). However, the existence of the



diabase rocks would have had a thermal metamorphic effect on the adjoining sediments and would decrease the chance of the fossil preservation in these sediments.

The Palaeotechnical Report of the Gauteng Province (**Table 6**; Groenewald et al, 2014) indicates the updated geology (Council of Geosciences, Pretoria) and is depicted in **Figure 5**. The updated geology indicates that the Carmel Solar 2 Photovoltaic Solar Energy Facility is underlain by the Malmani Subgroup (Chuniespoort Group, Transvaal Supergroup as well as Diabase, Timeball Hill and Rooihoogte Formations of the Pretoria Group (Transvaal Supergroup).

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

The Timeball Hill Formation is known to contain stromatolites and are associated with thin carbonate interbeds within turbidite sequences in the lower part of the formation (Catuneanu & Eriksson 2002). Stromatolites are first found in Precambrian rocks and are known as the earliest known fossils. Stromatolites are layered mounds, columns and sheet-like sedimentary rocks. These structures were originally formed by the growth of layer upon layer of cyanobacteria, a single-celled photosynthesizing microbe. These algae photosynthesised in the low oxygen atmosphere and deposited layer upon layer of calcium sulphate, magnesium sulphate and calcium carbonate as well as other compounds to form these domes. Researchers have examined and classified the stromatolite structures but seldomly find preserved algal cells. The oxygen atmosphere that we depend on today was generated by numerous cyanobacteria photosynthesizing during the Archaean and Proterozoic Era. Stromatolites have not been recorded from the overlying fluvio-deltaic Klapperkop Quartzite Member. Other subunits in the Pretoria Group containing stromatolites possibly also contain organic-walled microfossils. The Rooihoogte Formation comprises of carbonates (alluvial fan, lakes, karst infill), basal breccio-conglomerates, mudrocks and quartzites. No fossils have been found in the Rooihoogte Formation.

The Malmani Subgroup is subdivided into five formations (**Figure 6**) that are classified by the amount of chert, stromatolitic morphology, erosion surfaces and intercalated shales in them. The Malmani Subgroup overlies the Black Reef Formation. The oldest Formation in the Malmani Subgroup is the Oaktree Formation that consists of stromatolitic dolomites, carbonaceous shales, and locally developed quartzites. This formation overlies the (Monte Christo Formation that comprises of stromatolitic and oolitic platform dolomites as well as erosive breccia. The Lyttleton Formation overlies the Monte Christo Formation and consists of stromatolitic dolomites as well as shale quartzites. The Eccles Formation follows and comprises of erosional breccias while the youngest Formation is the Frisco Formation that mostly comprises of stromatolitic dolomites.



The Malmani Subgroup carbonates of the Transvaal Basin (**Figure 6**) comprise of an assortment of stromatolites (microbial laminates), ranging from supratidal mats to intertidal columns and large subtidal domes (Eriksson *et al.* 2006).

Stromatolites and oolites from the Transvaal Supergroup have been described by various authors (Eriksson and Altermann, 1998). Detailed descriptions of South African Archaean stromatolites are available in the literature (Altermann, 2001; Buick, 2001; and Schopf, 2006). The Malmani stromatolites literature includes articles by Truswell and Eriksson (1972, 1973, 1975), Eriksson and MacGregor (1981), Eriksson and Altermann (1998), Sumner (2000), Schopf (2006).

The Malmani Subgroup succession is about 2 km-thick and consists of a series of formations of oolitic and stromatolitic carbonates (limestones and dolomites), black carbonaceous shales and minor secondary cherts. The Malmani Dolomites also consist of historic lime mines, and palaeocave fossil deposits. Dolomite (limestone rock) forms in warm, shallow seas from slow gathering remainders of marine microorganisms and fine-grained sediment. Dolomites of the Malmani Subgroup has a higher magnesium content than other limestones. These materials contain high levels of calcium carbonate and are often referred to as *carbonates*.

Currently very few palaeontologists study stromatolites but geologists find the stromatolites interesting because they reveal the change from a reducing environment (that is an oxygen-poor) to an oxidizing environment (oxygen-rich). This transition is known as the Great Oxygen Event (Eroglu *et al.*, 2017).

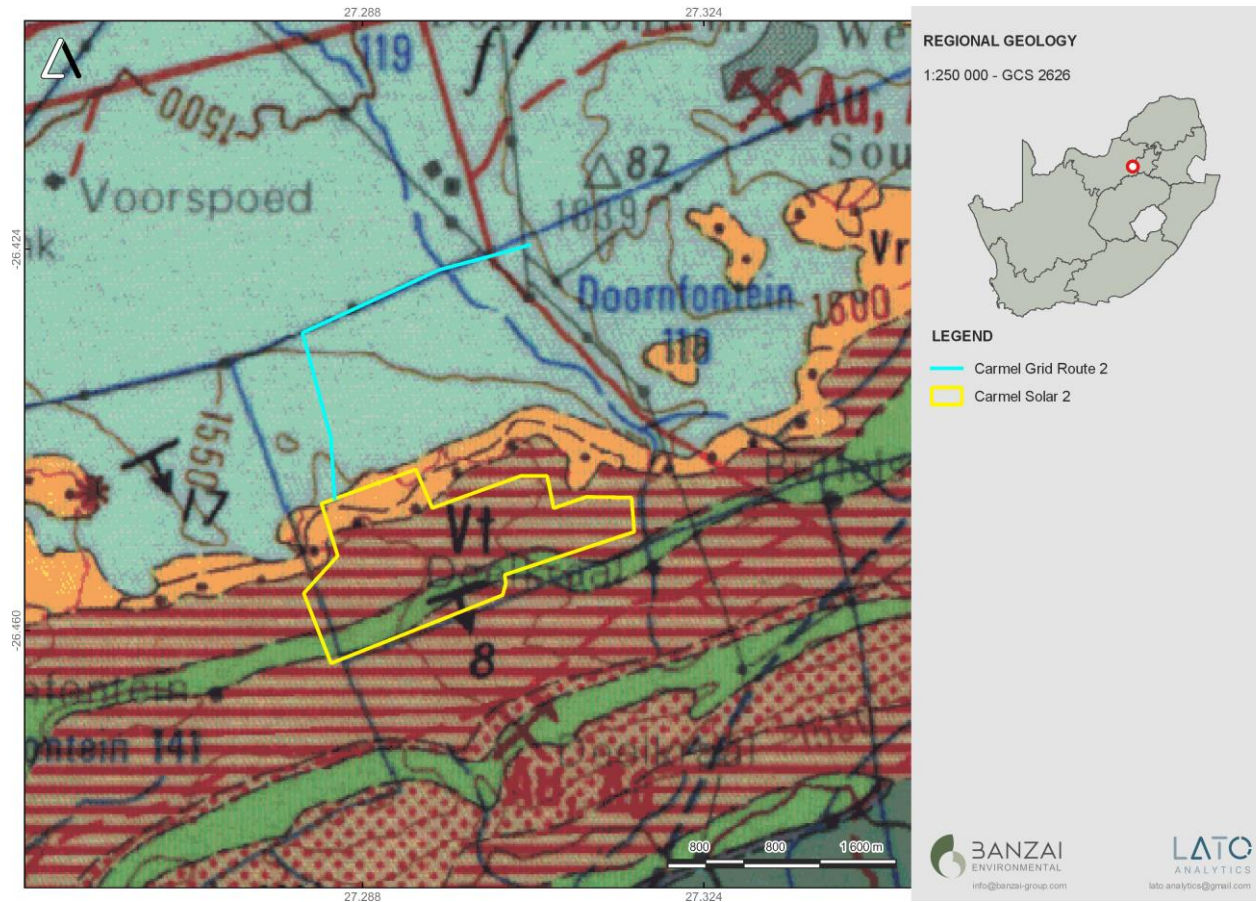


Figure 3: Extract of the 1:250 000 West-Rand 2626 (1986) Geological Map (Council for Geosciences, Pretoria) indicating the geology of the proposed Carmel 2 Photovoltaic Solar Energy Facility.

According to this geological map the proposed Powerline is underlain by the Malmani Subgroup (Chuniespoort Group and Transvaal Supergroup), the Rooihooft and Timeball Hill Formations (Pretoria Group, Transvaal Supergroup) as well as diabase.



Table 5: Legend of the 2626 West-Rand (1986) Geological Map (Council for Geoscience, Pretoria) Relevant sediments are indicated in a red squares.

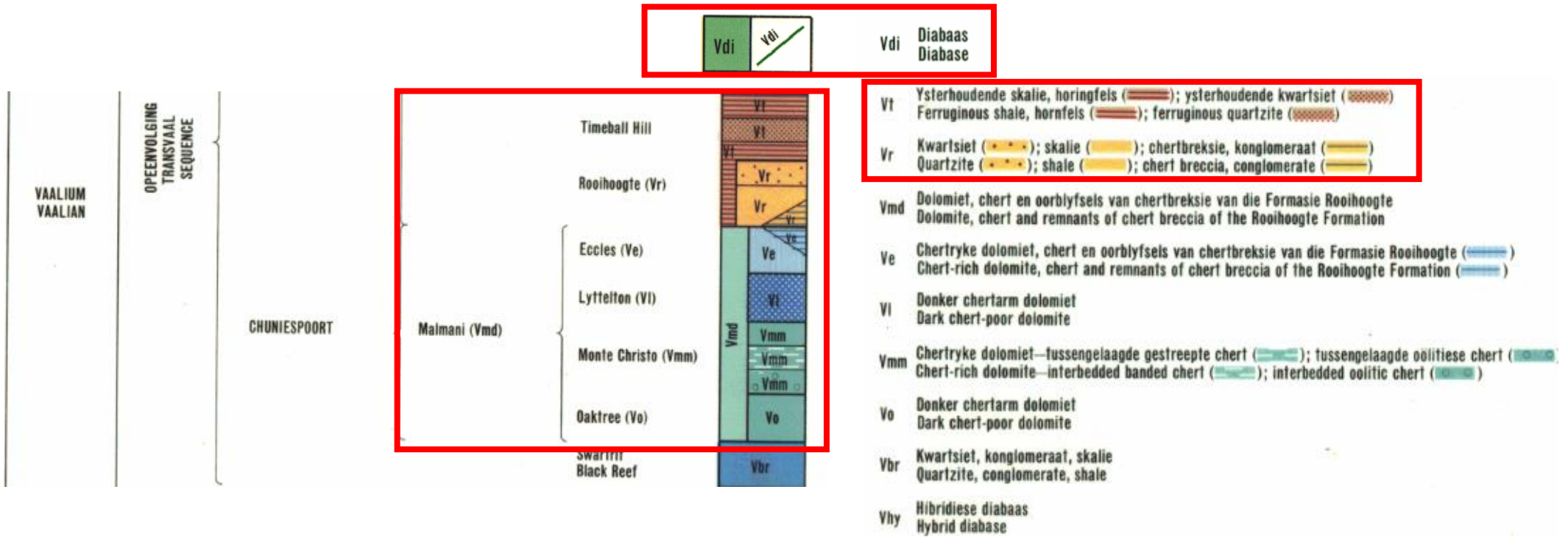




Table 6: Extract of the Palaeotechnical Report of Gauteng Province (Groenewald, et al., 2014) indicating the relevant sediments in black.

TRANSVAAL	PRETORIA		Magaliesberg (Vmg)(Vlm)		Coastal sandstones with mudrocks	Microbial mat structures (Desiccated mats sometimes resemble trace fossils)	Pretoria Group subunits with stromatolites probably also contain microfossils. This may also apply to carbonaceous mudrocks.	
			Silverton (Vsi)		Marine mudrocks with minor carbonates, volcanic rocks (= Machadodorp Member)	Stromatolites		
			Igneous intrusions (Vdi)		Igneous intrusions	No fossils recorded		
			Daspoort (Vda, Vhd, Vdq; Vdp)		Alluvial, fluvial and deltaic sandstones and mudrocks, marine sediments in east	Stromatolites		
			Strubenkop (Vs, Vst; Vhd)		Lacustrine mudrocks with minor sandstone	No fossils recorded		
			Dwaalheuwel (Vdw, Vhd)		Alluvial sandstones, conglomerates and mudrocks	No fossils recorded		
			Hekpoort (Vh, Vhd, Vha)		Volcanics (basalts, pyroclastics) with minor lacustrine shales	No fossils recorded		
			Boshoek (Vb)		Sandstones, conglomerates, diamictite (alluvial fans, slumps)	No fossils recorded		
			Timeball Hill (Vt; Vti)	Klapperkop (Vkp)	Lacustrine and fluvio-deltaic mudrocks with diamictite, conglomerates, quartzite, minor lavas. Shale, siltstone, conglomerate, quartzite	Stromatolites	Integrated within top of Transvaal Supergroup but now regarded as separate succession	
			Rooihoogte (Vt)		Basal breccio-conglomerates, quartzites, mudrocks, carbonates (alluvial fan, lakes, karst infill)	No fossils recorded		
		CHUNIESPOORT			Duitschland (Vd)	Conglomerate	No fossils recorded	Good examples of stromatolites in Cradle of Humankind region
					Penge (Vp)	Iron-rich shale	Stromatolites	
				Malmani (Vm; Vmd; Vma)			Stromatolitic carbonates (limestones / dolomites), minor secondary cherts, mudrocks including carbonaceous shales	
				Black Reef (Vbr)	Diamicritic sediments (matrix sandstones plus minor mudrocks, conglomerates) deposited during a fluvial to shallow marine transition	Possible equivalent of Black Reef Fm in N. Cape (Vryburg Formation) contains stromatolitic carbonates	ALERT FOR POTENTIALLY FOSSILIFEROUS LATE CAENOZOIC CAVE BRECCIAS WITHIN "TRANSVAAL DOLOMITE" OUTCROP AREA (breccias not individually mapped)	

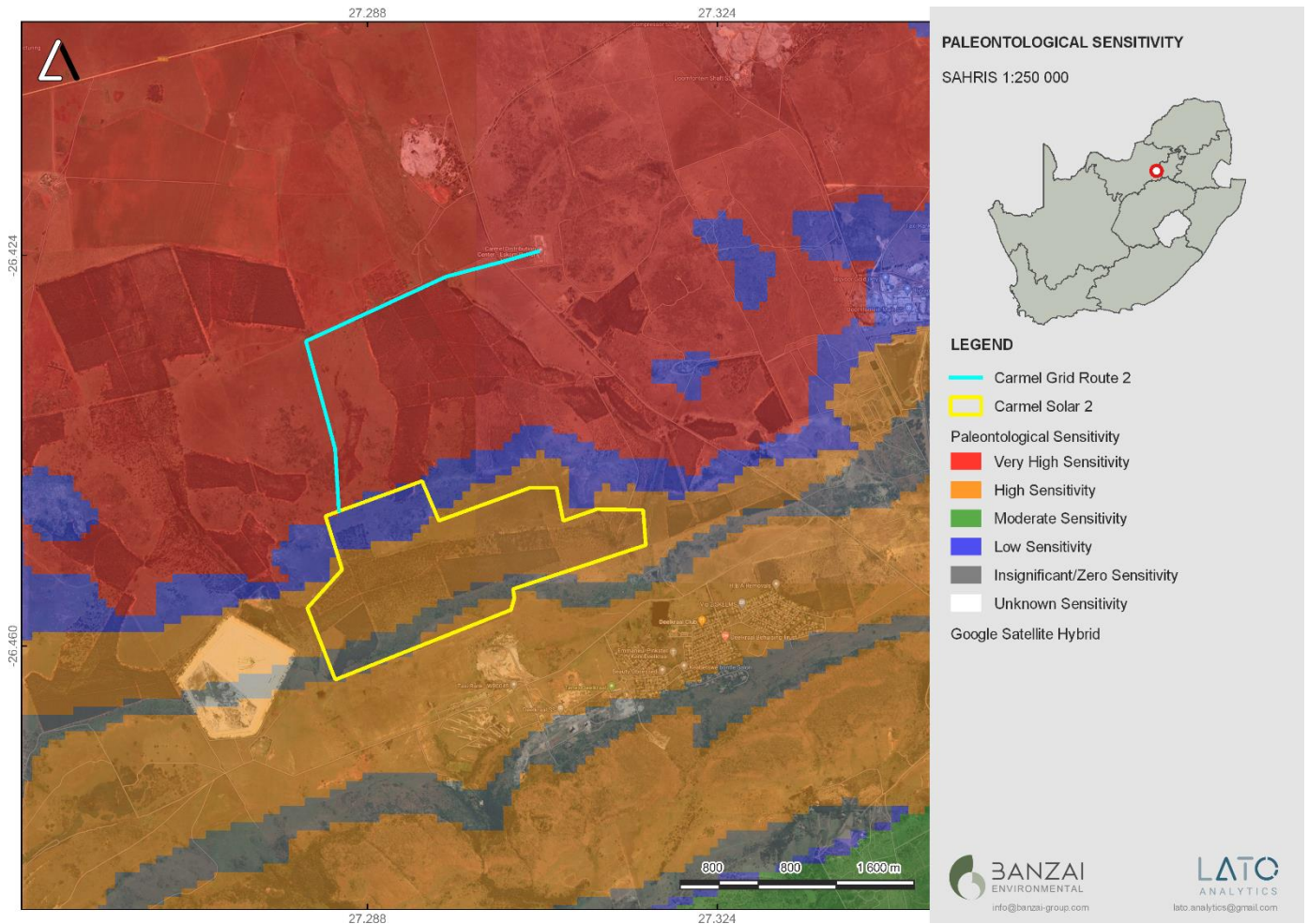


Figure 4: Extract of the 1: 250 000 SAHRIS PalaeoMap map (Council of Geosciences) indicating the proposed Carmel Solar 2 Photovoltaic Solar Energy Facility.

Table 7: Palaeontological Sensitivity according to the SAHRIS PalaeoMap (Almond et al, 2013; SAHRIS website)

Colour	Sensitivity	Required Action
RED	VERY HIGH	Field assessment and protocol for finds is required
ORANGE/YELLOW	HIGH	Desktop study is required and based on the outcome of the desktop study; a field assessment is likely
GREEN	MODERATE	Desktop study is required

BLUE	LOW	No palaeontological studies are required however a protocol for finds is required
GREY	INSIGNIFICANT/ZERO	No palaeontological studies are required
WHITE/CLEAR	UNKNOWN	These areas will require a minimum of a desktop study. As more information comes to light, SAHRA will continue to populate the map.

According to the SAHRIS Palaeosensitivity map (Figure 4) the proposed development is underlain by sediments with a Very High (red), High (orange) and Low (blue) Palaeontological Significance.

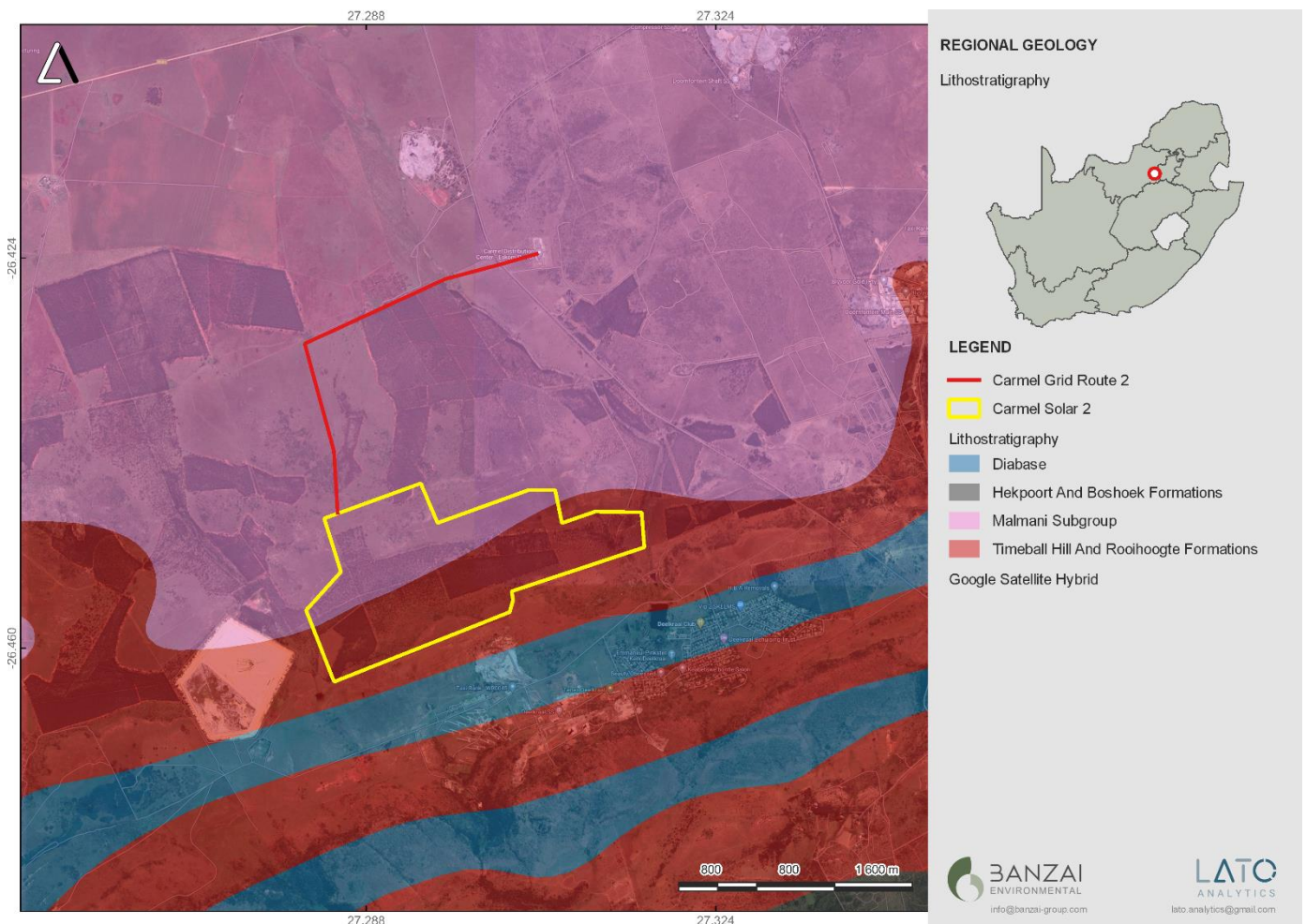


Figure 5: Updated Geology (Council of Geosciences, Pretoria) of the proposed Carmel Solar 2 Photovoltaic Solar Energy Facility indicates that the development is underlain by the Malmani Subgroup (Chuniespoort Group, Transvaal Supergroup as well as Diabase and the Timeball Hill and Rooihogte Formations of the Pretoria Group (Transvaal Supergroup).

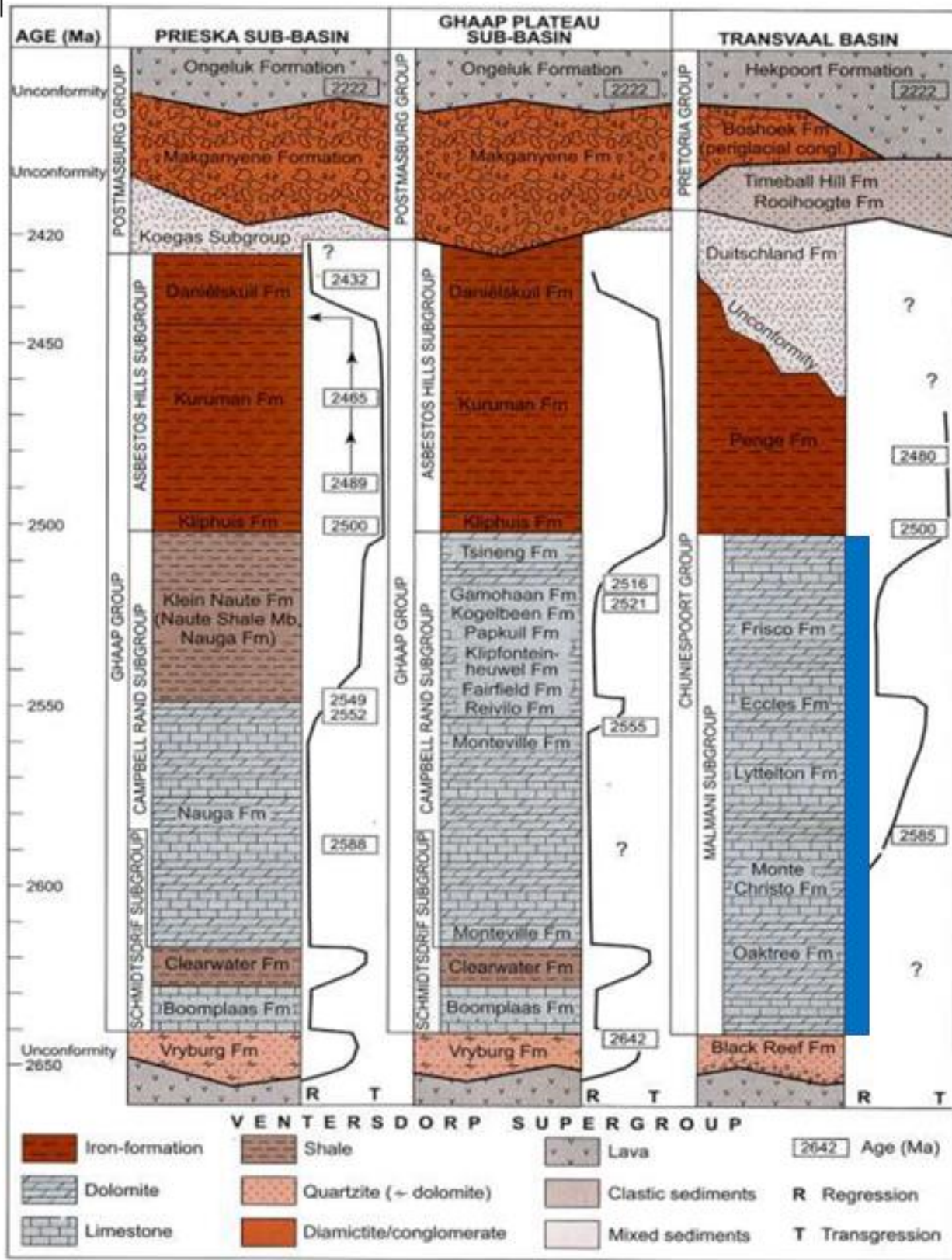


Figure 6: Stratigraphy of the Transvaal Supergroup of the Transvaal Basin. The proposed development is indicated in blue (Eriksson, et al. 2006).

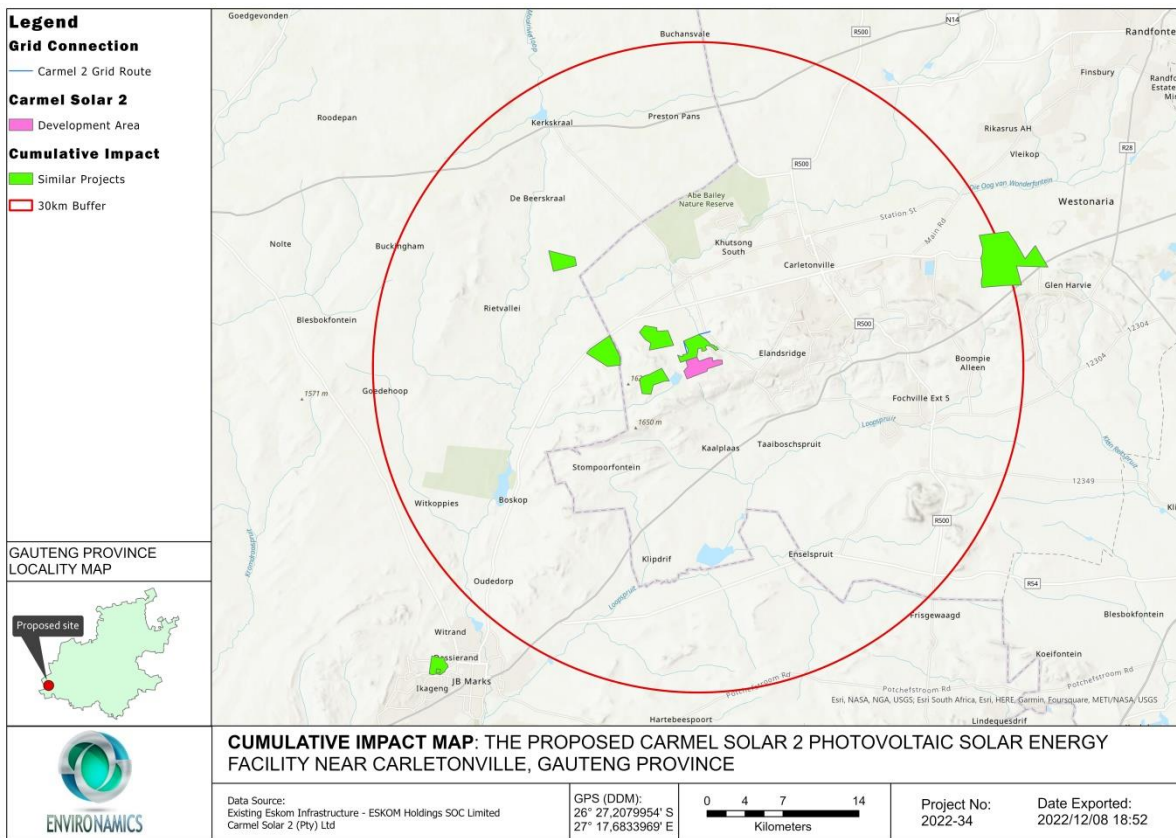


Figure 7: Carmel Solar 2 Photovoltaic Solar Energy Facility - Geographic area of evaluation with utility-scale renewable energy generation sites and power lines.

The geographic spread of PV solar projects, administrative boundaries and any environmental features (the nature of the landscape) were considered when determining the geographic area of investigation. It was argued that a radius of 30km would generally confine the potential for cumulative effects within this particular environmental landscape. The geographic area includes projects located within the Free State Province specific temporal or spatial impacts of a resource. For example, the socioeconomic cumulative analysis may include a larger area, as the construction workforce may draw from a much wider area. The geographic area of analysis is specified in the discussion of the cumulative impacts for that resource where it differs from the general area of evaluation described above.

A temporal boundary is the timeframe during which the cumulative effects are reasonably expected to occur. The temporal parameters for these cumulative effects analysis is the anticipated lifespan of the Proposed Project, beginning in 2024 and extending out at least 20 years, which is the minimum expected project life of the proposed project. Where appropriate, particular focus is on near-term cumulative impacts of overlapping construction schedules for proposed projects in the area of evaluation.



The general Palaeontological Sensitivity of the area is Low to High (see SAHRIS Palaeomap (Figure 5). However, it is important to note that the quality of preservation of these different sites will most probably vary and it is thus difficult to allocate a Cumulative Sensitivity to the projects. If all the mitigation measures are carried out, a conservative estimate of the Cumulative impacts on fossil Heritage will vary between Low and Medium.

Table 8: A summary of related facilities, that may have a cumulative impact, in a 30 km radius of the Carmel Solar 2 Photovoltaic Solar Energy Facility.

Site name	Distance from study area	Proposed generating capacity	DFFE reference	EIA process	Project status
PV Facility for Sibanye Gold	25km	200 MW	14/12/16/3/3/2/919	Scoping and EIA	Approved
Carmel Solar 3	1,82km	240 MW	-	Scoping and EIA	In Process
Carmel Solar 1	0km	240 MW	-	Scoping and EIA	In Process
Varkenslaagte Solar	1km	240 MW	-	Scoping and EIA	In Process
Turffontein Solar 1	5,31km	240 MW	-	Scoping and EIA	In Process

It is unclear whether other projects not related to renewable energy is or has been constructed in this area, and whether other projects are proposed. In general, development activity in the area is focused on agriculture and mining. It is quite possible that future solar farm development may take place within the general area.

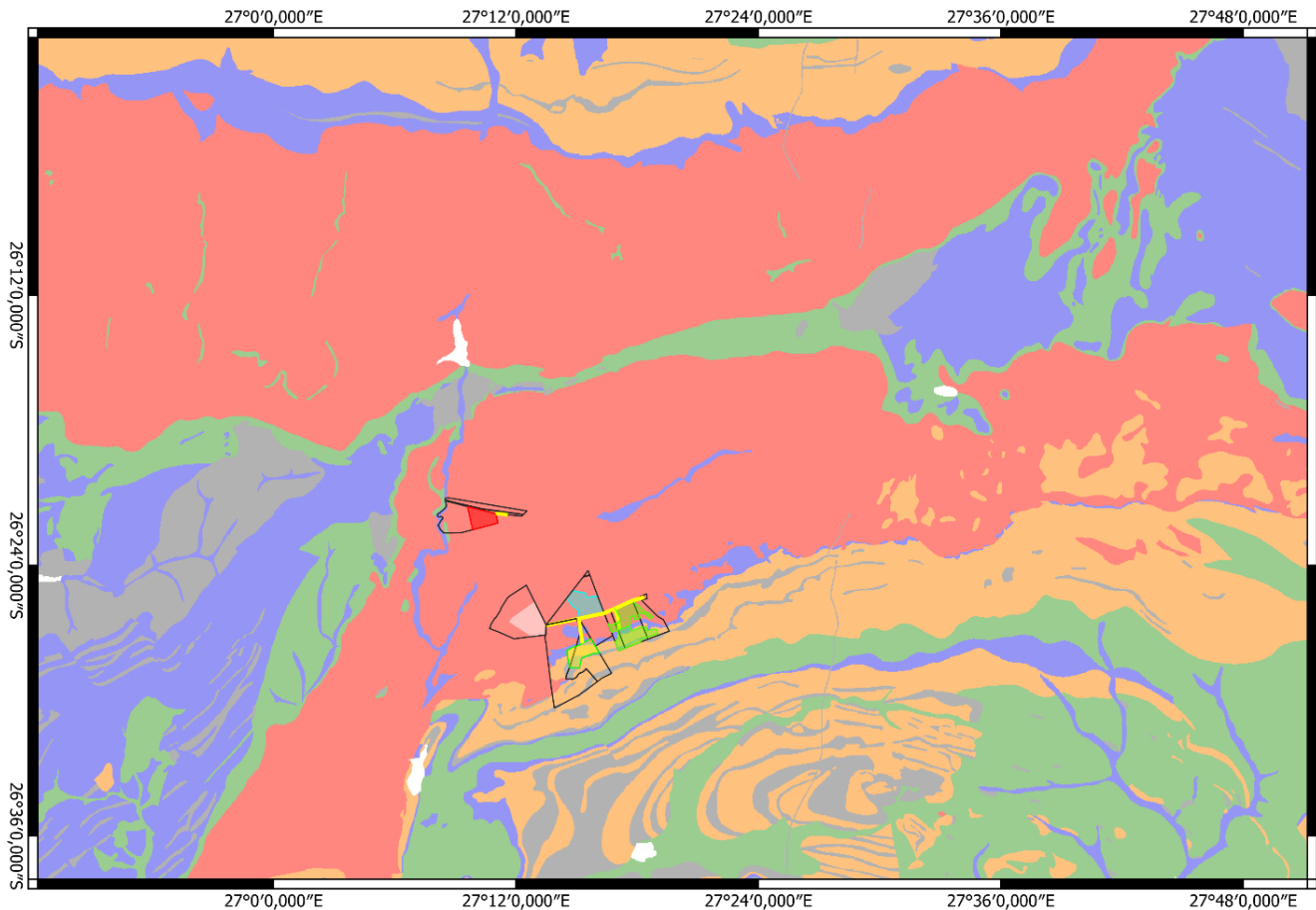


Figure 8: General Palaeontological Sensitivity of the Carletonville area.

The general Palaeontological Sensitivity of the area is Low to Very High (see SAHRIS Palaeomap (**Figure 8**)). However, it is important to note that the quality of preservation of these different sites will most probably vary and it is thus difficult to allocate a Cumulative Sensitivity to the projects. If all the mitigation measures are carried out, a conservative estimate of the Cumulative impacts on fossil Heritage will vary between Low and Medium.

7 GEOGRAPHICAL LOCATION OF THE SITE

The proposed Carmel Solar 2 PV Facility is located on Portion 1 of the Farm Varkenslaagte No. 119, Portion 3 of the Farm Kleinfontein No. 141 and Portions 1, 11, 23 and 28 of the Farm Doornfontein No. 118. The development area is located approximately 12 km east of Carletonville, within the Merafong Local Municipality and the West Rand District Municipality, in the Gauteng Province (**Figure 1-2**).

8 METHODS

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



8.1 ASSUMPTIONS AND LIMITATIONS

The focal point of geological maps is the geology of the area and the sheet explanations of the Geological Maps were not meant to focus on palaeontological heritage. Many inaccessible regions of South Africa have never been reviewed by palaeontologists and data is generally based on aerial photographs alone. Locality and geological information of museums and universities databases have not been kept up to date or data collected in the past have not always been accurately documented.

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

9 ADDITIONAL INFORMATION CONSULTED

In compiling this report the following sources were consulted:

- Geological map 1:100 000, Geology of the Republic of South Africa (Visser 1984)
- A Google Earth map with polygons of the proposed development was obtained from Environamics.
- 1: 250 000 West-Rand 2626 (1986) Geological Map (Council for Geosciences, Pretoria)

10 SITE VISIT

A site-specific field survey of the development footprint was conducted on foot and by motor vehicle on 3 November 2022. No fossiliferous outcrops were detected.



Figure 9: General view over the development indicates open plains with grassy vegetation and small trees.



Figure 10: Quartzite, chert breccia.

11 IMPACT ASSESSMENT METHODOLOGY

The environmental assessment aims to identify the various possible environmental impacts that could result from the proposed activity. Different impacts need to be evaluated in terms of their significance and in doing so highlight the most critical issues to be addressed.

Significance is determined through a synthesis of impact characteristics which include context and intensity of an impact. Context refers to the geographical scale i.e., site, local, national or global whereas intensity is defined by the severity of the impact e.g., the magnitude of deviation from background conditions, the size of the area affected, the duration of the impact and the overall probability of occurrence. Significance is calculated as shown in Table 4.1.

Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The total number of points scored for each impact indicates the level of significance of the impact.

Impact Rating System



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

- planning
- construction
- operation
- decommissioning

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

Table 9: The rating system		
NATURE -Loss of fossil heritage.		
GEOGRAPHICAL EXTENT		
This is defined as the area over which the impact will be experienced.		
1	Site	The impact will only affect the site.
2	Local/district	Will affect the local area or district.
3	Province/region	Will affect the entire province or region.
4	International and National	Will affect the entire country.
PROBABILITY		
This describes the chance of occurrence of an impact.		
1	Unlikely	The chance of the impact occurring is extremely low (Less than a 25% chance of occurrence).
2	Possible	The impact may occur (Between a 25% to 50% chance of occurrence).
3	Probable	The impact will likely occur (Between a 50% to 75% chance of occurrence).



4	Definite	Impact will certainly occur (Greater than a 75% chance of occurrence).
DURATION		
This describes the duration of the impacts. Duration indicates the lifetime of the impact as a result of the proposed activity.		
1	Short term	The impact will either disappear with mitigation or will be mitigated through natural processes in a span shorter than the construction phase (0 – 1 years), or the impact will last for the period of a relatively short construction period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 2 years).
2	Medium term	The impact will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (2 – 10 years).
3	Long term	The impact and its effects will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter (10 – 30 years).
4	Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered indefinite.
INTENSITY/ MAGNITUDE		
Describes the severity of an impact.		
1	Low	Impact affects the quality, use and integrity of the system/component in a way that is barely perceptible.
2	Medium	Impact alters the quality, use and integrity of the system/component but system/component still continues to function in a moderately modified way and maintains general integrity (some impact on integrity).
3	High	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component is severely



		impaired and may temporarily cease. High costs of rehabilitation and remediation.
4	Very high	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component permanently ceases and is irreversibly impaired. Rehabilitation and remediation often impossible. If possible rehabilitation and remediation often unfeasible due to extremely high costs of rehabilitation and remediation.
REVERSIBILITY		
This describes the degree to which an impact can be successfully reversed upon completion of the proposed activity.		
1	Completely reversible	The impact is reversible with implementation of minor mitigation measures.
2	Partly reversible	The impact is partly reversible but more intense mitigation measures are required.
3	Barely reversible	The impact is unlikely to be reversed even with intense mitigation measures.
4	Irreversible	The impact is irreversible and no mitigation measures exist.
IRREPLACEABLE LOSS OF RESOURCES		
This describes the degree to which resources will be irreplaceably lost as a result of a proposed activity.		
1	No loss of resource	The impact will not result in the loss of any resources.
2	Marginal loss of resource	The impact will result in marginal loss of resources.
3	Significant loss of resources	The impact will result in significant loss of resources.
4	Complete loss of resources	The impact is result in a complete loss of all resources.
CUMULATIVE EFFECT		
This describes the cumulative effect of the impacts. A cumulative impact is an effect which in itself may not be significant but may become significant if added to other existing or potential impacts emanating from other similar or diverse activities as a result of the project activity in question.		



1	Negligible cumulative impact	The impact would result in negligible to no cumulative effects.
2	Low cumulative impact	The impact would result in insignificant cumulative effects.
3	Medium cumulative impact	The impact would result in minor cumulative effects.
4	High cumulative impact	The impact would result in significant cumulative effects
SIGNIFICANCE		
<p>Significance is determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The calculation of the significance of an impact uses the following formula: (Extent + probability + reversibility + irreplaceability + duration + cumulative effect) x magnitude/intensity.</p> <p>The summation of the different criteria will produce a non-weighted value. By multiplying this value with the magnitude/intensity, the resultant value acquires a weighted characteristic which can be measured and assigned a significance rating.</p>		
Points	Impact significance rating	Description
6 to 28	Negative low impact	The anticipated impact will have negligible negative effects and will require little to no mitigation.
6 to 28	Positive low impact	The anticipated impact will have minor positive effects.
29 to 50	Negative medium impact	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.
29 to 50	Positive medium impact	The anticipated impact will have moderate positive effects.
51 to 73	Negative high impact	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact.
51 to 73	Positive high impact	The anticipated impact will have significant positive effects.
74 to 96	Negative very high impact	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated



		adequately. These impacts could be considered "fatal flaws".
74 to 96	Positive very high impact	The anticipated impact will have highly significant positive effects.

**Table 10:** Summary of Impact ratings

(Extent + probability + reversibility + irreplaceability + duration + cumulative effect) x magnitude/intensity.

	Extent	Duration	Magnitude	Reversibility	Irreplicable loss	Cumulative effect	Impact
Pre-Mitigation	1	4	3	4	4	2	45
Post-Mitigation	1	4	1	4	4	2	15

12 FINDINGS AND RECOMMENDATIONS

The Power line of the Carmel 2 Solar development is underlain by the Malmani Subgroup (Chuniespoort Group, Transvaal Supergroup) while the rest of the facility is underlain by the Rooihogte and Timeball Hill Formations (Pretoria Group, Transvaal Supergroup) as well as unfossiliferous diabase. According to the PalaeoMap of the South African Heritage Resources Information System (SAHRIS) the Palaeontological Sensitivity of the Malmani Subgroup is Very High, that of the Timeball Hill Formation is High, while the Rooihogte has a Low Palaeontological Sensitivity. The Palaeontological Significance of the diabase is Zero as it is igneous in origin (Almond *et al*, 2013; SAHRIS website).

A site-specific field survey of the development footprint was conducted on foot and by motor vehicle on 3 November 2022. During the site investigation no fossiliferous outcrops were detected. It is thus considered that the proposed Carmel Solar 2 Photovoltaic Solar Energy Facility will not lead to detrimental impacts on the palaeontological resources of the area. The construction of the development may therefore be authorised as the development footprint is not considered sensitive in terms of palaeontological resources. **It is consequently recommended that no further palaeontological heritage studies, ground truthing and/or specialist mitigation are required pending the discovery of newly discovered fossils.**

If fossil remains are discovered during any phase of construction, either on the surface or uncovered by excavations, the ECO/site manager in charge of these developments must be notified immediately. These discoveries must be secured and the ECO/site manager must alert SAHRA so that appropriate mitigation (documented and collection) can be undertaken by a professional palaeontologist (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Tel: 021 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). The specialist would need a collection permit from SAHRA. Fossil material must be curated in an approved collection (museum or university) and all fieldwork and reports must meet the minimum standards for palaeontological impact studies developed by SAHRA.



13 CHANCE FINDS PROTOCOL

The following procedure will only be followed if fossils are uncovered during the excavation phase of the development.

Legislation

Cultural Heritage in South Africa (includes all heritage resources) is protected by the **National Heritage Resources Act (Act No 25 of 1999) (NHRA)**. According to Section 3 of the Act, all Heritage resources include **“all objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens”**.

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

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

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

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

Chance Find Procedure

- If a chance find is made the person responsible for the find must immediately **stop working** and all work that could impact that finding must cease in the immediate vicinity of the find.
- The person who made the find must immediately **report** the find to his/her direct supervisor which in turn must report the find to his/her manager and the ESO or site manager. The ESO or site manager must report the find to the relevant Heritage Agency (South African Heritage Research Agency, SAHRA). (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa.



Tel: 021 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za. The information to the Heritage Agency must include photographs of the find, from various angles, as well as the GPS co-ordinates.

- A preliminary report must be submitted to the Heritage Agency within **24 hours** of the find and must include the following: 1) date of the find; 2) a description of the discovery and a 3) description of the fossil and its context (depth and position of the fossil), GPS co-ordinates.
- Photographs (the more the better) of the discovery must be of high quality, in focus, accompanied by a scale. It is also important to have photographs of the vertical section (side) where the fossil was found.
- Upon receipt of the preliminary report, the Heritage Agency will inform the ESO (or site manager) whether a rescue excavation or rescue collection by a palaeontologist is necessary.
- The site must be secured to protect it from any further damage. **No attempt** should be made to remove material from their environment. The exposed finds must be stabilized and covered by a plastic sheet or sand bags. The Heritage agency will also be able to advise on the most suitable method of protection of the find.
- If the fossil cannot be stabilized the fossil may be collected with extreme care by the ESO. Fossils finds must be stored in tissue paper and in an appropriate box while due care must be taken to remove all fossil material from the rescue site.
- Once the Heritage Agency has issued the written authorization, the developer may continue with the development on the affected area.

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APPENDIX A

CURRICULUM VITAE

ELIZE BUTLER

PROFESSION: Palaeontologist

YEARS' EXPERIENCE: 30 years in Palaeontology

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

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

Management Course, 1991
University of the Orange Free State

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

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

MEMBERSHIP

Palaeontological Society of South Africa (PSSA) 2006-currently

EMPLOYMENT HISTORY

Part time Laboratory assistant	Department of Zoology & Entomology University of the Free State Zoology 1989-1992
Part time laboratory assistant	Department of Virology University of the Free State Zoology 1992
Research Assistant	National Museum, Bloemfontein 1993 – 1997
Principal Research Assistant and Collection Manager	National Museum, Bloemfontein 1998–2022

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