PALAEONTOLOGICAL HERITAGE REPORT: COMBINED DESKTOP & FIELD-BASED ASSESSMENT

PROPOSED SIYANDA SOLAR POWER PLANT ON THE REMAINING EXTENT OF PORTION 1 OF THE FARM GROOTDRAAI 468 NEAR VILJOENSKROON, MOQHAKA LOCAL MUNICIPALITY, FREE STATE PROVINCE

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EXECUTIVE SUMMARY

Siyanda Solar Power Plant (RF) (Pty) Ltd is proposing to develop a photovoltaic solar facility and associated infrastructure, including a battery storage facility, on the Remaining Extent of Portion 1 of the farm Grootdraai 468, situated *c*. 30 km NNW of Viljoenskroon, Moqhaka Local Municipality, Free State Province. The solar facility will have an installed capacity of up to 150 MW and a total footprint of approximately 283 hectares. Three options for connection to the National Grid are under consideration. Grid Option 1 involves a *c*. 3 km long 132 kV powerline to the existing Vaal Reef Substation for which a 100m-wide corridor is assessed here. The much shorter Grid Options 2 and 3 lie directly adjacent to the on-site substation with a Li-Lo connection line into the two existing 88kV lines.

The solar facility and grid connection project areas are underlain near-surface or at depth by shallow marine carbonate bedrocks of the Malmani Subgroup (Chuniespoort Group, Transvaal Supergroup) of Precambrian age that are known to contain fossil stromatolites (laminated microbial bio-sedimentary structures) of various shapes and sizes (domes, columns *etc*). Indeed, stromatolite occurrences on Farm Grootdraai 468 are specifically mentioned in the Kroonstad 1: 250 000 geological sheet explanation by Schutte (1993). A combined desktop study and palaeontological site visit indicated that exposure levels of Precambrian bedrocks within the solar facility and grid connection project areas are generally very low due to low topographic relief and karstic weathering across an ancient land surface, widespread sandy soil cover and dense grassy vegetation. Well-preserved occurrences of stromatolites worthy of scientific interest are apparently rare, while the stromatolite varieties recorded here are likely to be of widespread occurrence within the bedrock units concerned (*viz*. the Oaktree and Monte Christo Formations). The thin to thick, Late Caenozoic (Pleistocene to Recent) unconsolidated sandy deposits mantling the carbonate bedrocks, especially in the south, are generally unfossiliferous and so far no fossil material has been found within them.

Two conservation-worthy fossil / geological sites have been recorded within the project area. Several blocks of finely-laminated stromatolitic rock on either side of the farm track at site 101 (Figs. 2 & 20) should be protected from damage by carefully moving them - avoiding surface scratching - at least 5 m away from the project footprint during construction (Their

location should therefore not influence the project design). Disturbance to stromatolitic bedrocks in the vicinity of sites 108-110 (small red circle in Figs. 20 & 21) should be limited to existing tracks within the area.

It is concluded that, with the exception of the two sensitive fossil sites mentioned above, the palaeontological sensitivity of the project area - including the 132 kV solar plant, grid connection corridor and all associated infrastructure - ranges from Medium to Low. Potential impacts during the construction phase are assessed as being of Medium (Negative) significance without mitigation and Low (Negative) significance following proposed mitigation. The latter comprises safeguarding two small, sensitive stromatolite / geological sites from damage during development as well as a Chance Fossil Finds Procedure to be implemented by the ECO during the Construction Phase. The anticipated cumulative impact of the proposed or authorized solar power plant developments in the Vryburg region - including the proposed Siyanda Solar Power Plant as well as the proposed neighbouring Paleso Solar Power Plant on the Remaining Extent of the farm Grootdraai 468 - is assessed as MEDIUM (without mitigation), potentially falling to LOW (with full mitigation), given their comparatively small footprint compared with the extensive outcrop areas of the fossiliferous rock units concerned (notably the Malmani Subgroup). The No-Go Option would probably have a neutral impact significance.

Grid Options 2 and 3 are equally preferred over Grid Option 1 on palaeontological heritage grounds since considerably longer Option 1 line is likely to have a greater negative impact on any fossils exposed within the grid corridor.

There are no fatal flaws associated with the proposed solar power plant project from a palaeontological heritage viewpoint. There are no objections to authorization of the development, provided that the recommended mitigation measures (summarized in Tables 4 and 5) are incorporated into the EMPr for this project and fully implemented.

The ECO responsible for the construction phase of the project should be aware of the potential for important new fossil finds –most notably well-preserved stromatolites - and the necessity to conserve them for possible professional mitigation. The ECO should monitor all site clearance and substantial excavations for fossil remains on an on-going basis during the construction phase (See Chance Fossil Finds Procedure outlined in Appendix 2). Recommended mitigation of chance fossil finds involves safeguarding of the fossils (preferably *in situ*) by the responsible ECO and reporting of finds to SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). Where appropriate, judicious sampling and recording of fossil material and associated geological data by a qualified palaeontologist, appointed by the developer, may be necessary, under a Fossil Collection Permit issued by the relevant heritage resources authority (SAHRA). Any fossil material collected should be curated within an approved repository (museum / university fossil collection) by a qualified palaeontologist.

1. PROJECT DESCRIPTION & BRIEF

The company Siyanda Solar Power Plant (RF) (Pty) Ltd is proposing to develop a photovoltaic solar facility and associated infrastructure on the Remaining Extent of Portion 1 of the farm Grootdraai 468, situated on the southern side of the Vaal River just south of

Orkney and some 30 km NNW of Viljoenskroon within the Moqhaka Local Municipality, Free State Province (Figs. 1 & 2). The Siyanda Solar Power Plant will have an installed capacity of up to 150 MW and a total footprint of approximately 283 hectares (including supporting infrastructure on site). According to the Project Description Document prepared by Environamics Environmental Consultants (19 March 2021) the proposed renewable energy development will comprise the following key components:

- **PV Panel Array** - To produce up to 150MW, 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 on-site substation will be required on the site to step the voltage up to 132kV, after which the power will be evacuated into the national grid. Whilst Siyanda Solar Power Plant (RF) (Pty) Ltd. has not yet received a cost estimate letter from Eskom, it is expected that generation from the facility will tie in with Vaal Reefs Nine 132/6.6 kV Substation. The Project will inject up to 100MW into the National Grid. The installed capacity will be approximately 150MW. The preferred power line route (Grid Option 1) is located north east of the project footprint. The route from the site to the Vaal Reefs substation is approximately 3 kilometres long and is assessed within a 100m wide grid connection corridor. Grid Option 2 (Western Reef SWS / Jersey DS 1 88kV Feeder HV Overhead Line) and Grid Option 3 (Western Reef SWS / Jersey DS 2 88kV Feeder HV Overhead Line) both lie directly adjacent to the substation with a Li-Lo connection line into the 2 existing 88kv lines (See Fig. 1).
- **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:
  - Office (~200m²);
  - Switch gear and relay room (~400m²);
  - Staff lockers and changing room (~200m²); and
  - Security control (~60m²)
- **Battery storage** – A Battery Storage Facility with a maximum height of 8m and a maximum volume of 1740m^3 of batteries and associated operational, safety and control infrastructure.
- **Roads –** Access to the facility will be obtained *via* a gravel road from the Stokkiesdraai road connected to the R30 Provincial Road. An internal site road network will also be required to provide access to the solar field and associated infrastructure. The access and internal roads will be constructed within a 25-meter corridor.
- **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.

Further technical details for the project are outlined in Table 1 below (likewise abstracted from the Project Description Document prepared by Environamics Environmental Consultants).

The term project area in this report refers to the solar power plant on the Remaining Extent of the farm Grootdraai 468 as well as the associated grid connection to the Vaal Reefs Nine 132/6.6 kV Substation.

Table 1: Technical details for the proposed Siyanda Solar Power Plant

Component	Description / dimensions
Height of PV panels	6 meters
Area of PV Array	283 Hectares (Development footprint)
Number of inverters required	Minimum 50
Area occupied by inverter / transformer stations / substations / Battery Energy Storage System	Central inverters+ LV/MV trafo: 20 m^2 HV/MV substation with switching station: 15 000 m^2 BESS: 4 000 m^2
Capacity of on-site substation	Minimum 130MVA in HV/MV substation
Area occupied by both permanent and construction laydown areas	Permanent Laydown Area: 283 Hectares Construction Laydown Area: ~2000 m^2
Area occupied by buildings	Security Room: ~60 m^2 Office: ~200 m^2 Staff Locker and Changing Room: ~200 m^2
Battery storage facility	Maximum height: 8m Maximum volume: 1740 m^3
Length of internal roads	Approximately 20 km
Width of internal roads	Between 7 & 12 meters
Proximity to grid connection	Approximately 3 kilometers
Height of fencing	Approximately 2.5 meters

Since the site lies within a gazetted Renewable Energy Development Zone (*cf* REDZ Focus Area 2 *in* Van der Walt 2019) it is subject to a Basic Assessment process. According to the Environmental Screening Report prepared for the proposed solar facility by Environamics (through the use of the Department of Forestry, Fisheries and the Environment Screening Tool) the project area is of Medium to Very High Palaeosensitivity (Fig. 22). The present combined desktop and field-based palaeontological heritage assessment has accordingly been commissioned on behalf of the proponent by the responsible independent EAP, Environamics Environmental Consultants, Potchefstroom (Contact details: Christia van Dyk. Environamics Environmental Consultants, 14 Kingfisher Street, Tuscany Ridge Estate, Potchefstroom, 2531. Telephone: 086 762 8336 (f); 083 450; 0406 (Cell). Electronic Mail: christia@environamics.co.za). This report will contribute to the overarching Heritage Impact Assessment as well as the Environmental Management Programme (EMPr) for the solar plant development.

1.1. Brief for the palaeontological study

1.1.1. General requirements

Specialists' reports must be aligned with Appendix 6 of GNR326 published under sections 24(5), and 44 of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended, and also consider the standard protocols for site sensitivity verification reports, whereby the following are to be included:

- The details of-
    - the specialist who prepared the report; and
    - the expertise of that specialist to compile a specialist report including a curriculum vitae;
- A declaration that the specialist is independent in a form as may be specified by the competent authority;
- An indication of the scope of, and the purpose for which, the report was prepared;
    - An indication of the quality and age of base data used for the specialist report;
    - A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;
- The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;
- A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;
- Details of an assessment of the specific 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;
- An identification of any areas to be avoided, including buffers;
- 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;
- A description of any assumptions made and any uncertainties or gaps in knowledge;
- A description of the findings and potential implications of such findings on the impact of the proposed activity, or activities;
- Any mitigation measures for inclusion in the EMPr;
- Any conditions for inclusion in the environmental authorisation;
- Any monitoring requirements for inclusion in the EMPr or environmental authorisation;
- A reasoned opinion-
    - whether the proposed activity, activities or portions thereof should be authorised;
        - regarding the acceptability of the proposed activity or activities; and
    - 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;
- A description of any consultation process that was undertaken during the course of preparing the specialist report;
- A summary and copies of any comments received during any consultation process and where applicable all responses thereto; and
- Any other information requested by the competent authority.

In addition to the above, specialists are expected to:

- Identify any issue or aspect that needs to be assessed and provide expert opinion on any issue in their field of expertise that they deem necessary in order to avoid potential detrimental impacts;
- Assess the degree and extent of all identified impacts (including cumulative impacts) that the preferred project activity and its proposed alternatives, including that of the no-go alternative, may have;
- Identify and list all legislation and permit requirements that are relevant to the development proposal in context of the study;
- Reference all sources of information and literature consulted; and
- Include an executive summary to the report.

1.1.2. Terms of reference for the paleontological heritage assessment

The scope of work for the palaeontological assessment study will consist of:

- A desktop investigation of the area, in which all geological maps, published scientific literature, previous paleontological impact studies in the same region and the author's field of experience (consultation with professional colleagues as well as examination of institutional fossil collections and data) should be studied and used.
- Based on the outcome of the screening report, the need for a field assessment must be determined. The desktop investigation must be supplemented with a field assessment if required.
- Assess the potential impacts, based on a supplied methodology.
- Describe mitigation measures to address impacts during the construction, operation and decommissioning stages.
- Describe cumulative impacts of the project on paleontological resources in both the local study area regional study area and the proponent's plans to manage those effects.
- Supply the client with geo-referenced GIS shape files of any sensitive areas.

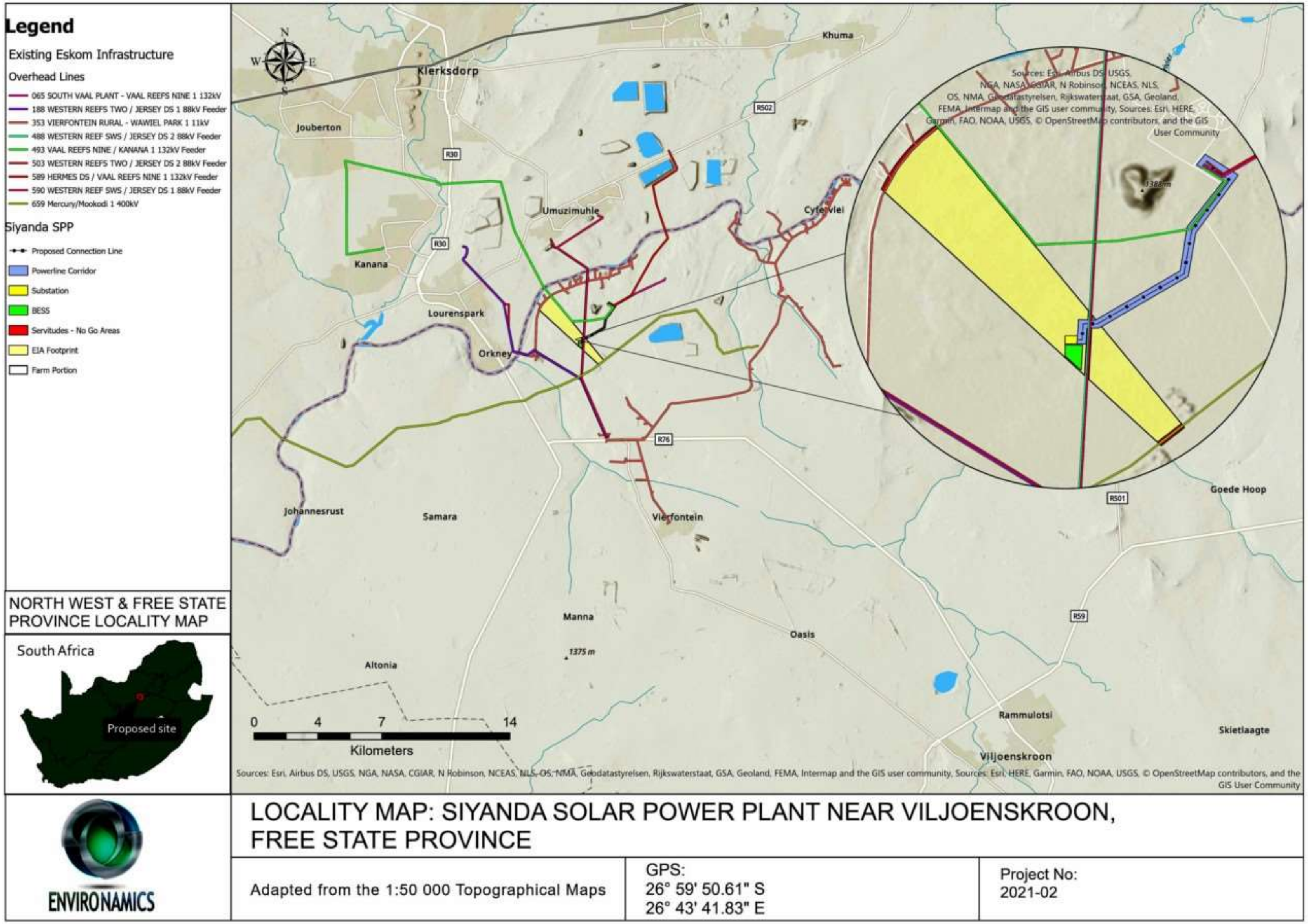

Figure 1: Locality map for the proposed Siyanda Solar Power Plant and associated grid connection near Viljoenskroon, Free State Province (Image supplied by Environamics Environmental Consultants). Only Grid Option 1 is shown here.

Figure 2: Google Earth© satellite image showing the Remaining Extent of Portion 1 the farm Grootdraai 468 (red polygon), situated on the southern side of the Vaal River some 30 km NNW of Viljoenskroon, Free State Province, the project area for the Siyanda Solar Power Plant (black polygons), alternative access points from Stokkiesdraai Road (blue triangles). Grid Option 1 lies within a *c*. 3 km long, 100m wide grid connection corridor to the Vaal Reefs Nine 132/6.6 kV Substation (elongate black polygon). Grid Options 2 & 3 lie directly adjacent to the substation with a Li-Lo connection line into the 2 existing 88kv lines. Note N lies towards the left in this image.

2. APPROACH TO THE PALAEONTOLOGICAL HERITAGE STUDY

The approach to this palaeontological heritage study is briefly as follows. Fossil bearing rock units occurring within the broader study area are determined from geological maps and satellite images. Known fossil heritage in each rock unit is inventoried from scientific literature, previous assessments of the broader study region, and the author's field experience and palaeontological database. Based on this data as well as field examination of representative exposures of all major sedimentary rock units present, the impact significance of the proposed development is assessed with recommendations for any further studies or mitigation.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps and satellite images. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience. Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following field assessment during the compilation of the final report. This data is then used to assess the palaeontological sensitivity of each rock unit to development. The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most significantly the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a Phase 1 field assessment study by a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any monitoring or mitigation required before or during the construction phase of the development.

On the basis of the desktop and Phase 1 field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phases. Phase 2 mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) may be required (a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or (b) during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for palaeontological collection permits from the relevant heritage management authorities, *i.e.* SAHRA for the Free State (Contact details: SAHRA, 111 Harrington Street, Cape Town. P.O. Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

GPS data for some geological and all fossil localities mentioned in the text and figure legends are provided separately in Appendix 1 to this report.

2.1. Information sources

The information used in this palaeontological heritage study was based on the following:

1. A short project description, maps and kmz files provided by Environamics Environmental Consultants, Potchefstroom;

2. A review of the relevant satellite images, topographical maps and scientific literature, including published geological maps and accompanying sheet explanations, as well as several previous desktop and field-based palaeontological assessment studies in the broader study region (*e.g.* Bamford 2012, Butler 2015, Millsteed 2015a, 2015b), including the proposed Paleso Solar Power Plant adjacent to the Siyanda Solar Power Plant project area (Almond 2021, in prep).

3. The author's previous field experience with the formations concerned and their palaeontological heritage;

4. A short (half-day) palaeontological field assessment of the solar plant project area in March 2021 by the author, including only part of the grid connection corridor (*N.B.* The majority of the grid connection corridor was assessed at desktop level which is considered sufficient given the low bedrock exposure levels here).

2.2. Assumptions & limitations

The accuracy and reliability of palaeontological specialist studies as components of heritage impact assessments are generally limited by the following constraints:

1. Inadequate database for fossil heritage for much of the RSA, given the large size of the country and the small number of professional palaeontologists carrying out fieldwork here. Most development study areas have never been surveyed by a palaeontologist.

2. Variable accuracy of geological maps which underpin these desktop studies. For large areas of terrain these maps are largely based on aerial photographs alone, without ground-truthing. The maps generally depict only significant ("mappable") bedrock units as well as major areas of superficial "drift" deposits (alluvium, colluvium) but for most regions give little or no idea of the level of bedrock outcrop, depth of superficial cover (soil *etc*), degree of bedrock weathering or levels of small-scale tectonic deformation, such as cleavage. All of these factors may have a major influence on the impact significance of a given development on fossil heritage and can only be reliably assessed in the field.

3. Inadequate sheet explanations for geological maps, with little or no attention paid to palaeontological issues in many cases, including poor locality information.

4. The extensive relevant palaeontological "grey literature" - in the form of unpublished university theses, impact studies and other reports (*e.g.* of commercial mining companies) - that is not readily available for desktop studies.

5. Absence of a comprehensive computerized database of fossil collections in major RSA institutions which can be consulted for impact studies. A Karoo fossil vertebrate database is now accessible for impact study work.

In the case of palaeontological desktop studies without supporting Phase 1 field assessments these limitations may variously lead to either:

(a) *underestimation* of the palaeontological significance of a given study area due to ignorance of significant recorded or unrecorded fossils preserved there, or

(b) *overestimation* of the palaeontological sensitivity of a study area, for example when originally rich fossil assemblages inferred from geological maps have in fact been destroyed by tectonism or weathering, or are buried beneath a thick mantle of unfossiliferous "drift" (soil, alluvium *etc*).

Since most areas of the RSA have not been studied palaeontologically, a palaeontological desktop study usually entails *inferring* the presence of buried fossil heritage within the study area from relevant fossil data collected from similar or the same rock units elsewhere, sometimes at localities far away. Where substantial exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, the reliability of a palaeontological impact assessment may be significantly enhanced through field assessment by a professional palaeontologist.

In the case of the present study area near Orkney in the Free State exposure of potentially fossiliferous bedrocks is limited due to the largely flat terrain, extensive soil cover and dense grassy vegetation during summer. However, it is considered that sufficient bedrock and cover sediment exposures were examined during the course of this study to assess the broader palaeontological heritage sensitivity of the study area. Comparatively few academic palaeontological studies or field-based fossil heritage impact studies have been carried out in the region, so any new data from impact studies here are of scientific interest.

2.3. Legislative context for palaeontological assessment studies

The proposed alternative energy project is located in an area that is underlain by potentially fossiliferous sedimentary rocks of Precambrian and younger, Late Tertiary or Quaternary, age (Sections 3 and 4). The construction phase of the proposed development will entail substantial excavations into the superficial sediment cover and into the underlying bedrock as well. These may include, for example, surface clearance and excavations for the PV panel footings, internal and access roads, underground cables, power line pylon footings, on-site electrical substation and BESS, auxiliary buildings and construction site camp. All these developments may adversely affect potential fossil heritage within the study area by destroying, disturbing or permanently sealing-in fossils at or beneath the surface of the ground that are then no longer available for scientific research or other public good. The operational and decommissioning phases of the renewable energy facility are unlikely to involve further adverse impacts on local palaeontological heritage, however.

The various categories of heritage Resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act include, among others:

- geological sites of scientific or cultural importance;
- palaeontological sites;
- palaeontological objects and material, meteorites and rare geological specimens.

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:

(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage Resources authority.

(2) All archaeological objects, palaeontological material and meteorites are the property of the State.

(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage Resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage Resources authority.

(4) No person may, without a permit issued by the responsible heritage Resources authority—

(a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;

(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;

(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or

(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.

(5) When the responsible heritage Resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage Resources management procedure in terms of section 38 has been followed, it may—

(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;

(b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;

(c) if mitigation is deemed by the heritage Resources authority to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and

(d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

Minimum standards for the palaeontological component of heritage impact assessment reports (PIAs) have been published by SAHRA (2013).

3. GEOLOGICAL CONTEXT

The project area (including the 100m wide grid connection corridor) for the proposed Siyanda Solar Power Plant near Orkney is situated in low-relief terrain between *c*. 1290 and 1320 m amsl that stretches up to 4.8 km south-eastwards from the densely vegetated banks of the Vaal River and is bounded along its northern boundary by the Stokkiesdraai road (Fig. 2). The area is flat to gently sloping with extensive cover by sparsely gravelly, sandy soils and grassy vegetation (Figs. 5 to 7). Levels of bedrock exposure are low, mainly comprising small, karstified patches and occasional low ridges of limestone / dolomite or secondary chert. Along the northern edge as well as to the south of a low rocky scarp near the proposed onsite substation location the sandy alluvial soils are thicker, with little or no bedrock exposure; these regions appear striped on satellite images as a result of agricultural activities (Fig. 2). Open cast and subsurface mines as well as flat-topped spoil heaps are seen some 1.7 km southeast of the project area as well as 2-5 km to the northeast and east.

The geology of the Orkney region is depicted on adjoining 1: 250 000 sheets 2626 West Rand and 2726 Kroonstad (Fig. 3). A short explanation for the latter sheet only has been published by Schutte (1993). The project area on Portion 1 of Farm Grootdraai 468 as well as the associated grid connection corridor are underlain near surface and at depth by shallow marine platform carbonate bedrocks of the **Malmani Subgroup** (Chuniespoort Group, Transvaal Supergroup) of Precambrian (late Archaean) age. In the Vaalbrug area south of Orkney only the two lowermost subunits of the Malmani Subgroup succession are mapped, namely the Oaktree and Monte Christo Formations (See stratigraphic column Fig. 4). According to the 1: 250 000 geological maps, the Malmani carbonates near Orkney rest unconformably on Archaean volcanics of the Rietgat Formation (Ventersdorp Supergroup). Basal Transvaal Supergroup quartzites of the Black Reef Formation are not mapped along the contact here.

According to Schutte (1993) and Eriksson *et al.* (2006) the **Oaktree Formation** here comprises basal black mudrocks followed by *c*. 300 m of chocolate brown-weathering, chert free and occasional stromatolitic dolomite with local development of quartzite facies. A volcanic tuff unit within the Oaktree Formation has been dated to 2.6 Ga (billion years ago). Patchy, low exposures of grey- and brown-weathering Oaktree carbonates are dispersed over the project area (Fig. 13). More prominent, kartsified exposures of typical chocolate-hued Oaktree bedrocks are well seen just beyond the south-western edge of the project area; some of these show well-developed stylolitic surfaces generated by diagenetic solution as well as thin stromatolitic horizons (Figs. 8).

The overlying **Monte Christo Formation** consists largely of paler dolomites, stromatolitic and oolitic in part, with abundant secondary chert which gives rise to surface gravels of downwasted cherty material. *Possible* occurrences of these younger Malmani carbonate rocks are seen in a low rocky scarp traversing the southern sector of the project area just south of the proposed on-site substation location and north of the existing powerline, although this is not shown by the geological map and requires confirmation since the beds here are often brownish-weathering (Figs. 6 & 10).

Over most of the solar plant project area the Precambrian bedrocks are overlain by a thin veneer of sandy soils with sparse downwasted gravels dominated by pale grey to yellowish secondary chert (Fig. 12). The bedrocks in the southern sector of the project area are mantled **by aeolian sands** of probable Pleistocene age. These wind-blown sands are broadly equivalent to those of the Kalahari Group and overlie a regional land surface incised across the Precambrian bedrocks that is inferred to be of Paleogene (Early Tertiary) age

(Schutte 1993). On satellite images these sandy areas are striated (due to agriculture) and prominently spotted, perhaps due to insect or mammal bioturbation (Fig. 2). Pleistocene and younger **alluvial deposits** occur along the densely-wooded banks of the Vaal River (*ibid.*) and extend into the north-western borders of the project area adjacent to the Stokkiesdraai Road; this area has now been largely transformed for agriculture. Older, semi-consolidated fine-grained alluvium will not be directly impacted by the proposed development and such deposits were not encountered within the solar power plant and grid connection project area during the recent site visit. However, local concentrations of well-rounded boulders of pale quartzite as well as chert overlying Malmani bedrocks in the southern part of the project area might represent downwasted old terrace gravels of the Vaal River and its tributaries (Figs. 10 & 12). Blocks of well-developed, coffee-brown glaebular ferricrete (Fig. 11) suggest the previous presence of swampy *vlei* areas in this southern region.

Figure 3: Extracts from adjoining 1: 250 000 sheets 2626 West Rand (above) and 2726 Kroonstad (below) (Council for Geoscience, Pretoria) showing the geology of the Remaining Extent of Potion 1 of the farm Grootdraai 468 on the southern side of the Vaal River south of Orkney, Moqhaka Local Municipality, Free State Province (pale blue polygon). The short grid connection corridor falls within the dark blue dashed rectangle. The major lithostratigraphic rock units mapped at surface here include Precambrian carbonate bedrocks of the Chuniespoort Group (Malmani Subgroup) – *viz* the Oaktree Formation (Vmo, pale blue) and the overlying Monte Christo Formation (Vmm, dark blue) – which are mantled in the south by Quaternary aeolian sands (Qs, yellow) as well as by Late Caenozoic alluvial deposits along the banks of the Vaal River. Scale bar = 5 km. N towards the top of the image.

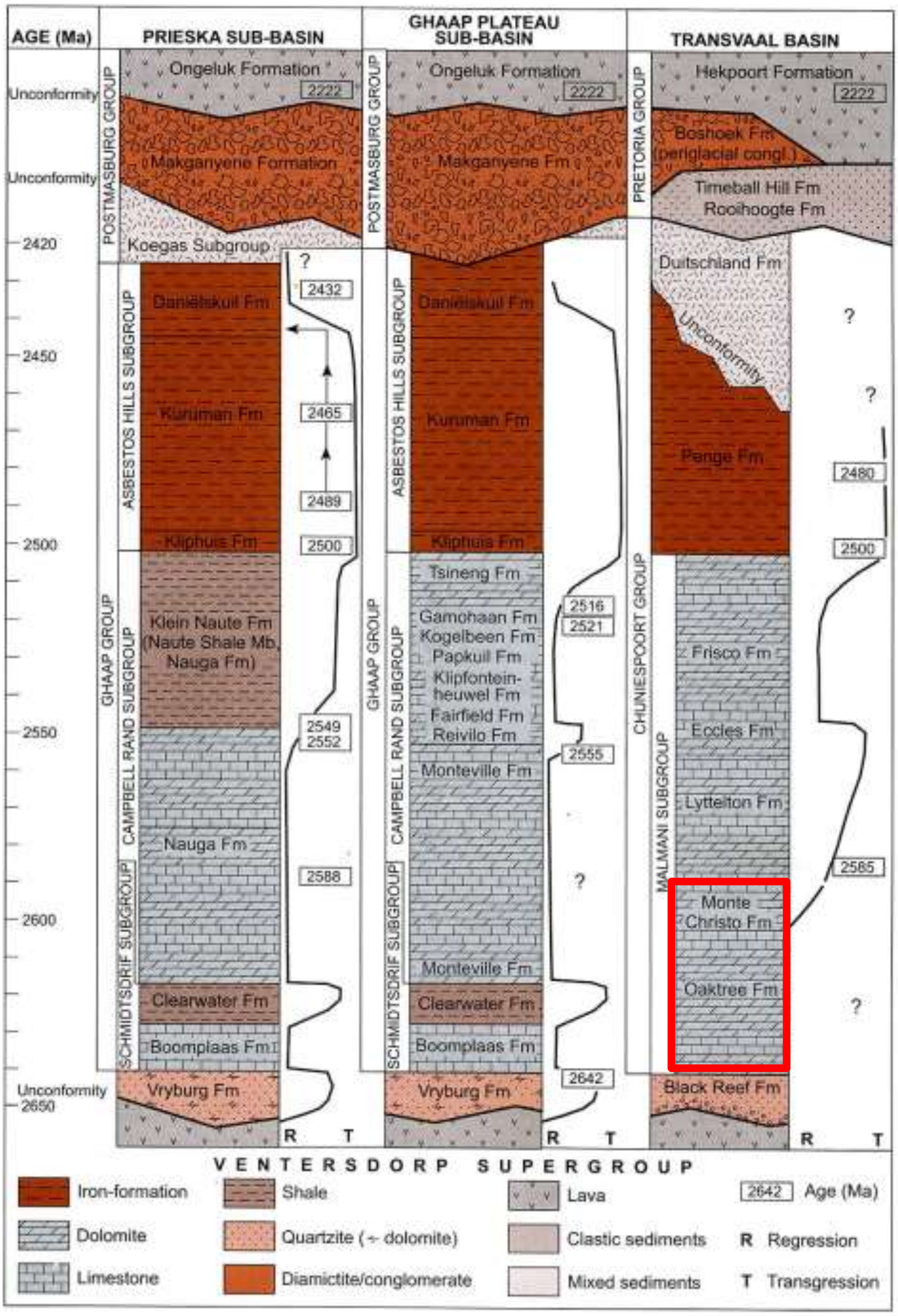

Figure 4: Lithostratigraphy of the Transvaal Supergroup showing the Precambrian carbonate bedrock units within the Transvaal Basin that are represented within the present study area near Orkney (red rectangle) (Image from Eriksson *et al.* 2006).

Figure 5: Typical flat to gently-sloping terrain mantled by sandy soils and grassy vegetation within the central sector of the Siyanda Solar Power Plant project area.

Figure 6: Orange-hued sandy soils mantling bedrocks within most of the project area are best exposed along farm tracks, here along its south-western edge.

Figure 7: View north-eastwards from the solar plant project area towards the Vaal Reefs Nine 132/6.6 kV Substation adjacent to the mine seen on the skyline. The proposed grid connection will run across the intervening flat grassy terrain where bedrock exposure is very limited.

Figure 8: Rounded boulders of brownish-weathering Oaktree Formation carbonates observed just outside the south-western edge of the Siyanda Solar Power Plant project area, relicts of a karstified regional land surface.

Figure 9: Extensive exposure of well-jointed, pale brown Malmani carbonate bedrocks to the south of the proposed on-site substation, just north of the existing power line. Note the pronounced undulating surface with low ridges and swells that is *possibly* related to large stromatolitic domes.

Figure 10: Impersistent veneer of downwasted cherty gravels with occasional small boulders of quartzite and chert of probable fluvial origin overlying chocolate-brown Malmani carbonate bedrocks building a low, south-facing scarp that traverses the southern sector of the project area (Hammer = 30 cm).

Figure 11: Well-developed dark rusty brown ferricrete blocks that probably developed in association with ancient wetland areas, grid connection project area (Hammer = 30 cm).

Figure 12: Man-made heaps of coarse surface gravels, dominated by boulders of pale brown quartzite, dark brownish carbonate as well as ferricrete blocks that have been cleared from adjoining agricultural lands in the grid connection project area. The better-rounded clasts are probably related to ancient fluvial gravels of the Vaal River and its tributaries.

4. PALAEONTOLOGICAL HERITAGE

4.1. Fossils within Precambrian carbonate bedrocks

The **Malmani Subgroup** platform carbonates of the Transvaal Basin host a variety of stromatolites (microbial laminites or laminated bio-sedimentary structures), ranging from supratidal mats to intertidal columns and large subtidal domes. These biogenic structures are of biostratigraphic as well as of palaeoecological interest; for example, the successive Malmani dolomite formations are in part differentiated by their stromatolite biotas (Eriksson *et al.* 2006). There is an extensive literature dealing with the Malmani stromatolites, including articles by Button (1973), Truswell and Eriksson (1972, 1973, 1975), Eriksson and MacGregor (1981), Eriksson and Altermann (1998), Sumner (2000), Schopf (2006), among others. Microbial filaments and unicells have been reported from stromatolites of the Transvaal Supergroup (Eriksson & MacGregor 1981, MacGregor 2002 and refs. therein).

Eriksson *et al*. (2006) mentions stromatolites within both the Oaktree and Monte Christo Formations while it is notable that Schutte (1993) specifically refers to stromatolitic occurrences on Farm Grootdraai 468. Stromatolites and crinkly microbiolites are likewise recorded within these two basal Malmani Subgroup successions in the Mafikeng and Vryburg 1: 250 000 sheet areas in North West Province.

Many of the low karstified exposures of greyish to brown-weathering **Oaktree Formation** carbonates encountered during the site visit to Farm Grootdraai 468 display microbial laminites, including crinkly laminites as well as small- (few cm diam.) to medium-scale (few dm diam) domical stromatolites and rarer columnar stromatolites (Fig. 13). In many cases the stromatolitic zones have been secondarily silicified during diagenesis and it is consequently likely that they are over-represented on karstified land surfaces such as present here compared to intervening non-stromatolitic facies. Since most of these bio-sedimentary structures are of widespread occurrence within the outcrop area of the formation and are not particularly well preserved, they are not considered to be of high conservation value (Proposed Field Rating IIIC Local Resource).

Possible (but equivocal) larger-scale, low stromatolitic domes that are several meters across and *not* secondarily silicified are seen in the only area of well-exposed carbonate bedrocks in the southern sector of the project area north of the existing power line (Locs. 108, 110) (Figs. 9, 17 & 18). Some of the domes are asymmetrical, their growth perhaps influenced by tidal currents. It is unclear if these interesting undulose beds should be assigned to the Oaktree Formation (as mapped), as perhaps suggested by their brownish weathering, or might belong to the slightly younger Monte Christo Formation. As far as possible, disturbance should be limited to existing farm tracks in this particular area during the construction phase (See satellite maps in Figs. 20 & 21)**.** It is likely, however, that similar subtle domal features are also represented within the low rocky scarp stretching several hundred meters to the west and east of the recorded *sites.*

Occasional oblate sphaeroidal concretions of diagenetic ferruginous carbonate have a stromatolite-like concentric internal lamination (Fig. 19). However, the laminae are convex down as well as up, so these may be regarded as potentially-misleading pseudofossils. More problematic are large blocks of weathering-resistant, pale yellowish to grey, vuggy chert showing very regular to convolute, millimeter-scale lamination which sometimes resembles zones of small-scale stromatolites (Figs. 14 to 16). An alternative interpretation of this facies is that it results from the abiogenic precipitation of isopachous cement from carbonate-saturated seawater overlying the sea floor; *i.e.* these nested sets of convex-upwards laminae may also be a form of pseudofossil. Zones of convolute lamination may be due to slumping or seismic activity. It is notable that the microlaminated beds are intensely silicified, as is the case with stromatolite-rich horizons.

4.2. Fossils within Late Caenozoic superficial sediments

The mainly Pleistocene to Recent superficial deposits in the project area - viz. sandy soils, downwasted surface gravels, possible pedocretes (such as ferricretes observed in the southern part of the grid connection corridor), alluvium – are poorly known in palaeontological terms. They are likely to be of Low to Very Low palaeosensitivity for the most part. However, these younger sediments may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals (*e.g.* Cooke 1974, Skead 1980, Klein 1984, MacRae 1999, Partridge & Scott 2000, Churchill et al. 2000, Boshoff & Kerley 2013). These may include ancient human remains of considerable palaeoanthropological significance (*e.g*. Grine *et al.,* 2007). Other potential late Caenozoic fossil biotas from these superficial deposits include non-marine molluscs (bivalves, gastropods), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria and other insect burrows or nests, coprolites, rhizoliths), and plant remains such as peats or palynomorphs (pollens) in fine-grained, organic-rich alluvial horizons. Quaternary alluvial sediments may contain reworked Stone Age artifacts that are useful for constraining their maximum age.

No fossil mammalian or invertebrate remains or trace fossils were recorded from the superficial sediments during the site visit. Potentially fossiliferous alluvial deposits along the banks of the Vaal River lie outside the project footprint. Surface gravels of downwasted or high energy fluvial origin are unlikely to contain fossils.

Figure 13: Low exposure of greyish karstified Malmani carbonate with prominent-weathering zone of darker, secondarily silicified domal stromatolites (Hammer = 30 cm) (Loc. 105).

Figure 14: One of several surface blocks of pale yellowish to grey, vuggy chert containing fine-scale, stromatolite-like lamination (Scale = 15 cm) (Loc. 101). See following two figures for more detail. These blocks are conservation-worthy and should be safeguarded from damage during the construction phase by moving them outside the project footprint (See Section 6).

Figure 15: Close-up of laminated chert block illustrated above showing zones with nested sets of upward-convex lamination (Scale in cm). These stromatolite-like features *might* have been produced by regular carbonate precipitation (isopachous cement) on the sea floor rather than microbial growth and sediment binding, however.

Figure 16: Close-up of similar, vuggy chert block at Loc. 101 showing local development of irregular, convolute lamination – perhaps due to local slumping (Scale in cm).

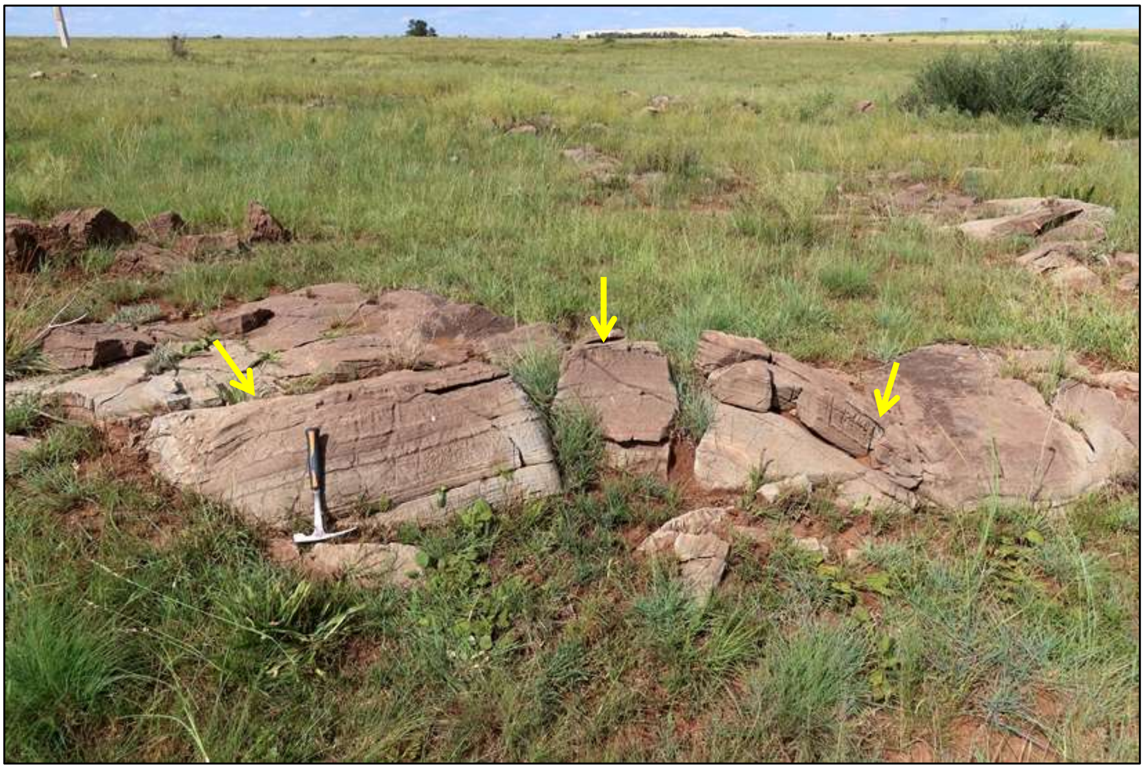

Figure 17: Possible large-scale, low stromatolitic domes or swells (arrows) within pale brown, unsilicified carbonates of the Malmani Subgroup in the southern sector of the project area (Loc. 108) (Hammer = 30 cm). As far as possible, disturbance here should be limited to existing farm tracks in this particular area during the construction phase (See satellite maps in Figs. 20 & 21).

Figure 18: Asymmetric, elongate stromatolitic dome in the same area as the previous figure (Hammer = 30 cm). Dome elongation may be related to the influence of tidal currents.

Figure 19: Oblate sphaeroidal concretion of brown-weathering ferruginous carbonate showing concentric internal lamination and embedded within pale grey carbonate bedrock (Scale in cm). The laminae are convex-down, so this is not an upward-growing stromatolite but a pseudofossil.

Figure 20: Google Earth© satellite image of the Siyanda Solar Power Plant project area (red polygon) showing *selected* occurrences of fossil stromatolites recorded within the Malmani Subgroup carbonate bedrocks in relation to the final layout (See Appendix 1 for GPS locality details). The great majority of these stromatolite occurrences are of common domical types that occur widely within the outcrop areas of the rock units concerned (*viz*. Oaktree and Monte Christo Formations). They are not considered to be of high scientific or conservation value (Proposed Field Rating IIIC Local Resource) and no special mitigation measures regarding them are proposed here. Several laminated chert blocks adjacent to a farm track at Loc. 101 are conservation-worthy and should be safeguarded from damage during construction. See following figure for Locs. 108, 110.

Figure 21: Google Earth© satellite image showing the southern portion of the Siyanda Solar Power Plant project area (red polygon) as well as the proposed grid connection corridor (grey), BESS area (green) and on-site substation location (black). The small subcircular area outlined in red contains examples of somewhat equivocal large domal stromatolitic features of conservation value. As far as possible, disturbance should be limited to existing farm tracks in this particular area during the construction phase. Further low domes may be present along the rocky ridge or low scarp extending to the west and east of the red-outlined circular area.

5. SITE SENSITIVITY VERIFICATION AND EVALUATION OF IMPACTS ON PALAEONTOLOGICAL HERITAGE

5.1. Site sensitivity verification

A MEDIUM to VERY HIGH palaeosensitivity has been provisionally assigned to the Siyanda Solar Power Plant project area on the Remaining Extent of Portion 1 of Farm Grootdraai 468 and associated grid connection corridor near Orkney by the DFFE screening tool (Fig. 22, abstracted from the Screening Report for Environmental Authorisation prepared by Environamics Environmental Consultants, February 2021). It is noted that the project area is mapped as being of high palaeontological sensitivity in the wind and solar SEA heritage report by Van der Walt (2019). This high inferred palaeosensitivity is triggered by potentially rich stromatolite occurrences within the Precambrian carbonate bedrocks.

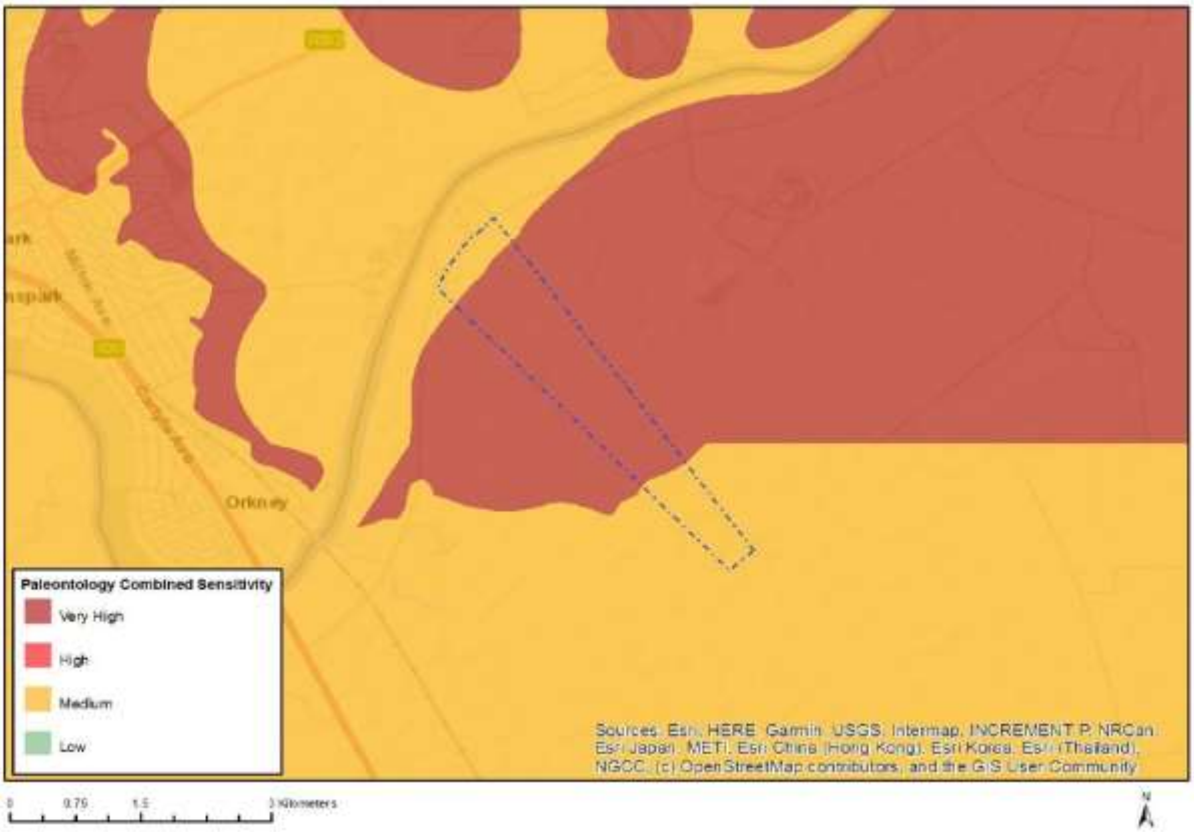

Figure 22: Palaeosensitivity map for the Siyanda Solar Power Plant project area (blue dotted polygon) (Figure abstracted from the Screening Report for Environmental Authorisation prepared by Environamics Environmental Consultants). Most of the solar facility project area, including the associated grid connection corridor extending to the NE, is provisionally mapped here as of Very High palaeosensitivity. However, a Medium to Low palaeosensitivity is inferred based on desktop and field data.

The originally proposed Medium to Very High palaeosensitivity of the Siyanda Solar Power Plant project area is *contested* here. Rather, a generally MEDIUM to LOW palaeosensitivity is assigned to this area in the present PIA report, largely based on:

- The sparse occurrence of well-preserved, scientifically valuable stromatolitic exposures in this largely flat-lying, karstified region (based on a recent site visit);

- The probable widespread occurrence of similar stromatolitic assemblages within the extensive outcrop areas of the Precambrian bedrock units concerned (Oaktree and Monte Christo Formations) within the Transvaal Basin;
- The thin to thick blanket of largely or entirely unfossiliferous aeolian sands covering substantial portions of the project area.

5.2. Impact assessment

The Siyanda Solar Power Plant project area is located in a region that is underlain by fossiliferous sedimentary rocks of Precambrian and younger, Pleistocene to Holocene age (Sections 3 & 4). Existing impacts to palaeontological heritage within the project area are likely to be minimal, largely comprising occasional damage to stromatolite fossils exposed at the ground surface through agricultural activities. These on-going impacts are offset by the slow exposure of fresh stromatolites through bedrock weathering.

The construction phase of the proposed solar energy facility will entail substantial excavations into the superficial sediment cover and locally into the underlying bedrock as well. These include, for example, surface clearance and excavations for the PV panel footings, laydown areas, internal and access roads, underground cables, power line pylon footings, on-site electrical substation and battery storage facility, auxiliary buildings and construction camp. All these activities may adversely affect potential legally-protected fossil heritage within the project footprint as a result of excavations and surface disturbance (*e.g.* surface clearing and vehicle activity) during the construction phase by destroying, disturbing or permanently sealing-in fossils preserved at or beneath the surface of the ground that are then no longer available for scientific research or other public good.

The inferred impact of the proposed PV solar plant on legally-protected, local fossil heritage resources of scientific or broader conservation value is briefly evaluated here in Table 2A. This assessment applies only to the *construction phase* of the development since further significant impacts on fossil heritage during the planning, operational and decommissioning phases of the facilities are not anticipated. The assessment also applies equally to the PV solar project area as well as to the short associated 132 kV grid connection (as assessed within a 100m wide grid connection corridor). Confidence levels in this assessment are *medium*, given (1) the limited palaeontological literature on the Precambrian bedrocks concerned in addition to (2) very low levels of bedrock exposure within the solar facility and power line project areas and (3) the unpredictable distribution of well-preserved fossils in the subsurface.

As motivated in Table 2A, the impact significance of the proposed development in terms of palaeontological heritage is assessed as *Medium (Negative)* without mitigation and *Low (Negative)* following mitigation. Should the recommended mitigation measures for the construction phase of the solar facility development, as outlined in Section 6 (incl. Table 4) and Appendix 2 of this report, be consistently followed-though, the impact significance would remain *low* (*negative*) but would entail both positive and negative impacts. Residual negative impacts from inevitable loss of *some* valuable fossil heritage would be partially offset by an improved palaeontological database for the study region as a direct result of appropriate mitigation. The latter is a *positive* outcome because any new, well-recorded and suitably-curated fossil material from this palaeontologically little-known region would constitute a useful addition to our scientific understanding of the fossil heritage of the Transvaal Basin in southern Africa. The No Go option would probably have a neutral impact significance; protection of local fossils from damage or destruction would be partially offset by natural surface weathering processes as well as lost opportunities to improve the palaeontological database through professional mitigation of chance fossil finds.

Grid Options 2 and 3 are equally preferred over Grid Option 1 on palaeontological heritage grounds since considerably longer Option 1 line is likely to have a greater negative impact on any fossils exposed within the grid corridor.

There are no fatal flaws associated with the proposed PV solar project from a palaeontological heritage viewpoint and no objects to authorisation of the development, provided that the recommended mitigation measures are fully implemented.

Table 2A: Evaluation of anticipated impacts on local palaeontological heritage resources due to the proposed Siyanda Solar Power Plant near Orkney, Free State (Construction Phase)

Palaeontological Heritage Impacts*	Disturbance, damage or destruction of legally-protected fossil heritage within the development footprint during the construction phase	
	Pre-mitigation impact rating	**Post mitigation impact rating**
Status (positive or negative)	Negative	Negative / positive
Extent	Site (1)	Site (1)
Probability	Probable (3)	Probable (3)
Duration	Permanent (4)	Permanent (4)
Magnitude	Medium (2)	Low (1)
Reversibility	Irreversible (4)	Irreversible (4)
Irreplaceable loss of resources	Marginal (2)	Marginal (2)
Cumulative impact	Medium (3).	
Significance	**Negative medium (34)**	**Negative low (17)**
Can impacts be mitigated?	Yes. Protection of recorded sensitive fossil sites: • Safeguarding of stromatolitic blocks either side of farm track at site 101 by removal at least 5m outside project footprint; • Limit disturbance in vicinity of sites 108-110 to existing farm tracks. Implementation of recommended Chance Fossil Finds Procedure.	

***** *N.B.* Refers essentially to impacts on well-preserved and / or rare fossils of scientific and conservation value.

5.2. Cumulative impact assessment

A tabulated summary of comparable renewable energy projects within a 30 km radius of the present project area near Orkney is presented in Table 3 and Figure 23 below (Data provided by Environamics Environmental Consultants). Based on the SAHRIS website, palaeontological heritage assessments (PIAs) are available only for the Kabi Vaalkop PV

Solar project (Bamford 2012), Orkney Solar Farm (Butler 2015) as well as the Buffels Solar 1 and 2 PV projects (Millsteed 2015a, 2015b). It is noted that (1) all of the available PIA reports are desktop studies with no field-based ground truthing and (2) a LOW palaeontological impact significance is inferred for all the projects concerned, including those involving Precambrian stromatolitic bedrocks comparable to those mapped in the present project area. Recent fieldwork for the - geologically similar- neighbouring Paleso Solar Power Plant project area on the Remaining Extent of Farm Grootdraai 468 supports a Medium (negative) impact significance for this development (Almond 2021, in prep.).

In the author's opinion:

- Palaeontological impact significances inferred for renewable energy projects, where these are assessed at all, may well reflect different assessment approaches rather than contrasting palaeontological sensitivities and impact levels;

- Meaningful cumulative impact assessments require comprehensive data on *all* major developments within a region, not just those involving renewable energy, as well as an understanding of the extent to which recommended mitigation measures are followed through;

- Trying to assess cumulative impacts on different fossil assemblages from different stratigraphic units (for example, Precambrian stromatolites from 2.6 billion years ago *versus* Pleistocene alluvial deposits less than 2.5 million years old) has limited value.

Given (1) the comparatively small combined footprint of the renewable energy projects under consideration compared with the very extensive outcrop areas of Malmani Group stromatolitic carbonate bedrocks as well as (2) the probable (albeit *unconfirmed*) rarity of scientifically valuable occurrences of well-preserved stromatolites within flat-lying terrain preferred for solar energy projects, the cumulative impact of the proposed or authorized solar power plant developments in the Vryburg region region - including the proposed Siyanda Solar Power Plant as well as the proposed neighbouring Paleso Solar Power Plant on the Remaining Extent of the farm Grootdraai 468- is assessed as MEDIUM (without mitigation), potentially falling to LOW (with full mitigation) (See Table 2B). There are therefore no objections on palaeontological grounds to authorization of this project.

Table 2B: Evaluation of anticipated cumulative impacts on local palaeontological heritage resources due to solar power developments in the Vryburg region, including the proposed Siyanda Solar Power Plant (Construction Phase)

Palaeontological Heritage Impacts*	Disturbance, damage or destruction of legally-protected fossil heritage within the development footprints during the construction phase	
	Pre-mitigation impact rating	**Post mitigation impact rating**
Status (positive or negative)	Negative	Negative / positive
Extent	Local (2)	Local (2)
Probability	Definite (4)	Probable (3)
Duration	Permanent (4)	Permanent (4)
Magnitude	Medium (2)	Low (1)

Reversibility	Irreversible (4)	Irreversible (4)
Irreplaceable loss of resources	Marginal (2)	Marginal (2)
Cumulative impact	Medium (3).	
Significance	**Negative medium (38)**	**Negative low (18)**
Can impacts be mitigated?	Yes. • Protection of recorded sensitive fossil sites through buffers and / or judicious professional collection: • ECO monitoring of surface clearance and excavations for fossil remains; • Implementation of recommended Chance Fossil Finds Procedure.	

***** *N.B.* Refers essentially to impacts on well-preserved and / or rare fossils of scientific and conservation value.

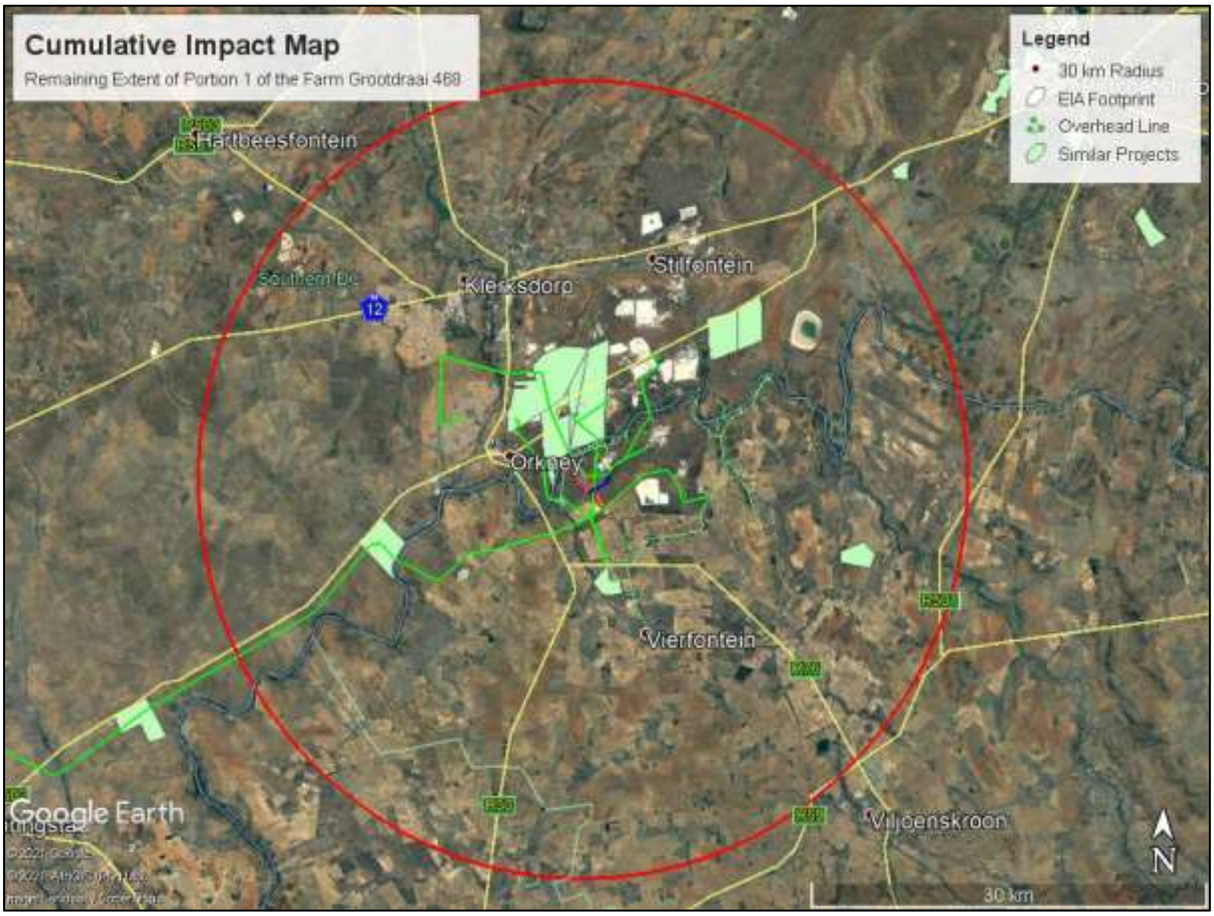

Figure 23: Map of renewable energy developments within a 30 km radius of the Siyanda Solar Power Plant (Image provided by Environamics Environmental Consultants).

Table 3: Summary of related renewable energy projects within a 30 km radius of the present project area that may contribute to cumulative impacts (Data collated by Environamics Environmental Consultants). The Paleso Solar Power Plant on Farm Grootdraai 468 has also been taken into account.

Site name	Distance from study area	Proposed generating capacity	DEFF reference	EIA process	Project status
Kabi Vaalkop PV	1.4km	75 MW	12/12/20/2513/3	Scoping and EIA	Approved
Kabi Solar (Pty) Ltd	5.4 km	75 MW	12/12/20/2513/2	Scoping and EIA	Approved
Kabi Vaalkop PV	1.4 km	75 MW	12/12/20/2513/4	Scoping and EIA	Approved
Kabi Vaalkop PV	1.4 km	75 MW	12/12/20/2513/1	Scoping and EIA	Approved
Buffels Solar PV 1	15.3 km	75 MW	14/12/16/3/3/2/777	Scoping and EIA	Approved
Buffels Solar PV 2	16 km	100 MW	14/12/16/3/3/2/778	Amendment	Approved
Witkop Solar	2 km	61 MW	12/12/20/2507/2	Scoping and EIA	In Process
Rietvlei solar	7 km	-	14/12/16/3/3/2/450	Scoping and EIA	Withdrawn/Lapsed
Genesis Orkney Solar (Pty) Ltd	14 km	100MW	14/12/16/3/3/2/954	Scoping and EIA	Approved
Afropulse 538 Pty Ltd	22 km	50MW	12/12/20/2280	BAR	Withdrawn/Lapsed

6. RECOMMENDATIONS FOR MONITORING AND MITIGATION

Proposed monitoring and mitigation measures for the Siyanda Solar Power Plant, to be incorporated into the Environmental Management Programme for the renewable energy development, are summarized in Tables 4 and 5.

Although fossil stromatolites are widely scattered within the project area, the great majority of occurrences here are considered to be of low conservation or scientific value and no special mitigation measures regarding them are proposed here. Two exceptions include:

- Several large blocks of finely-laminated chert of possible stromatolitic origin on either side of the farm track at site 101 (*e.g.* Fig. 14) should be protected from damage during construction, for example by carefully moving them (avoiding surface scratching) at least 5 m away from the project footprint during construction. Their location should therefore not influence the project design.

- Possible large-scale, low stromatolitic domes (Figs. 17 & 18) recorded inside the grid connection corridor (sites 108, 110) should be protected from disturbance by limiting vehicle use as far as possible to existing farm tracks in this particular area during the construction phase as well as spanning of sensitive area by powerline, if feasible (See small area outlined in red on satellite maps in Figs. 20 & 21)**.**

No palaeontological No-Go areas or other fossil sites requiring specialist mitigation have been identified within the solar facility development footprint, including the associated grid connection corridor. Potentially fossiliferous alluvial deposits along the banks of the Vaal River lie outside the solar power plant and grid connection project areas.

The ECO responsible for the construction phase of the solar facility development should be aware of the potential for important fossil finds and the necessity to conserve them for possible professional mitigation. The ECO should monitor all substantial surface clearance operations and excavations into sedimentary rocks for fossil remains such as well-preserved stromatolites on an on-going basis during the construction phase. A Chance Fossil Finds Procedure for this development is outlined in Appendix 2.

Recommended mitigation of chance fossil finds during the construction phase of the solar facility and associated grid connection involves safeguarding of the fossils (preferably *in situ*) by the responsible ECO and reporting of finds to SAHRA (Contact details: SAHRA, 111 Harrington Street, Cape Town. PO Box 4637, Cape Town 8000, South Africa. Phone: +27 (0)21 462 4502. Fax: +27 (0)21 462 4509. Web: www.sahra.org.za). Where appropriate, judicious sampling and recording of fossil material and associated geological data by a qualified palaeontologist, appointed by the developer, may be required by the relevant heritage regulatory authorities. Any fossil material collected should be curated within an approved repository (museum / university fossil collection) by a qualified palaeontologist. These recommendations should be included within the Environmental Management Programme for the proposed renewable energy project.

7. ACKNOWLEDGEMENTS

Ms Christia Van Dijk and Ms Carli Steenkamp of Environamics Environmental Consultants, Potchefstroom are both thanked for commissioning this study and for providing the relevant background information. Additionally, I am grateful to Ms Lisa Opperman of Environamics for careful editorial work on the draft PIA reports and to Mr Nico Venter of Subsolar Energy, Pretoria for facilitating the palaeontological fieldwork.

Table 4: Proposed monitoring and mitigation measures for incorporation into the EMPr for the Siyanda Solar Power Plant project (Construction phase)

POTENTIAL ASPECTS RESULTING IN POTENTIAL ENVIRONMENTAL IMPACT DURING CONSTRUCTION	RECOMMENDED MITIGATION MEASURES					
	Desired Outcomes	**Targets & Indicators**	**Management and mitigation measures**	**Timeframe**	**Responsibility**	**Monitoring**
Fossil Heritage Resources						
Disturbance, destruction or damage to fossils preserved at or below surface through surface clearance and excavations during construction phase.	Protection of identified or new sensitive fossil sites from damage during construction phase. Reporting of chance fossil finds to SAHRA for professional recording and sampling.	Areas of bedrock exposure displaying well-preserved stromatolites. Superficial deposits (alluvium, soils, gravels) with fossil remains.	Safeguarding of designated sensitive fossil sites from damage: • Removal of stromatolitic blocks either side of farm track at site 101 at least 5m outside project footprint; • Limit disturbance in vicinity of sites 108-110 to existing farm tracks. Monitoring of all major site clearance and excavation work for fossil remains. Substantial well-preserved fossils (stromatolites, vertebrate bones, teeth) to be safeguarded, preferably *in situ*, and reported to SAHRA. Fossil recording and sampling.	On-going during construction phase. Following report of chance fossil finds.	ECO ECO ECO Developer to appoint palaeontologist following significant new fossil finds. .	Compliance to be verified by ECO.

Table 5: Summary of impacts and mitigation measures for the Siyanda Solar Power Plant project (Construction Phase)

SPECIALIST STUDY	**IMPACT**	**PRE-MITIGATION RATING**	**POST MITIGATION RATING**	**SUMMARY OF MITIGATION MEASURES**
Palaeontological heritage	Disturbance, destruction or damage to fossils preserved at or below surface through surface clearance and excavations during construction phase.	Negative medium	Negative low	• Safeguarding designated sensitive fossil sites from damage. • Removal of stromatolitic blocks either side of farm track at site 101 at least 5m outside project footprint. • Limit disturbance in vicinity of sites 108-110 to existing farm tracks. • Monitoring of all major site clearance and excavation work for fossil remains by ECO. • Substantial well-preserved fossils (stromatolites, vertebrate bones, teeth) to be safeguarded, preferably *in situ*, and reported by ECO to SAHRA. • Recording and sampling of significant new fossil finds by professional palaeontologist.

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9. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape, Mpumalanga, Free State, Limpopo, Northwest and Kwazulu-Natal under the aegis of his Cape Town-based company *Natura Viva* cc. He has been a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Practitioners – Western Cape).

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed development project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

Dr John E. Almond.
Palaeontologist,
***Natura Viva* cc**

APPENDIX 1: GPS LOCALITY DATA

All GPS readings were taken in the field using a hand-held Garmin GPSmap 60CSx.

101	26°59'25.07"S 26°42'58.42"E	Several large float blocks on either side of farm track comprising pale grey to yellowish-weathering chert within mm-scale fine internal lamination, locally convolute or with zones of regular, stromatolite-like, upward-convex stacked laminae. These might be pseudostromatolites - *i.e.* abiogenic sedimentary structures formed by isopachous cement growth - rather than true microbially-bound stromatolites. Proposed Field Rating IIIB Local Resource. Blocks should be protected from damage during construction phase, for example by carefully moving them (avoiding scratching) at least 5 m away from project footprint. Their location should therefore not influence the project design.
105	27° 0'5.48"S 26°43'42.50"E	Low exposure of greyish karstified Malmani carbonate with prominent-weathering zone of darker, secondarily silicified domal stromatolites. Proposed Field Rating IIIC Local Resource. No mitigation recommended.
108	27° 0'13.68"S 26°43'58.38"E	Possible but equivocal large (several m diam.), low stromatolitic domes within pale brown Malmani carbonates. Proposed Field Rating IIIB Local Resource. Domes should be protected from disturbance by limiting vehicle use as far as possible to existing farm tracks in this particular area during the construction phase.
110	27° 0'13.68"S 26°43'59.03"E	Possible but equivocal large (several m diam.), low stromatolitic domes within pale brown Malmani carbonates. Proposed Field Rating IIIB Local Resource. Domes should be protected from disturbance by limiting vehicle use as far as possible to existing farm tracks in this particular area during the construction phase.

<table>
<tr><td colspan="3">APPENDIX 2: CHANCE FOSSIL FINDS PROCEDURE: Siyanda Solar Plant on Remaining Extent of Portion 1 of the farm Grootdraai 468 near Orkney, Free State</td></tr>
<tr><td>Province & region:</td><td colspan="2">Free State: Moqhaka Local Municipality</td></tr>
<tr><td>Responsible Heritage Resources Agency</td><td colspan="2">SAHRA, P.O. Box 4637, Cape Town 8000.
Contact: Dr Ragna Redelstorff. Tel: 021 202 8651. Email: rredelstorff@sahra.org.za
or Ms Natasha Higgitt. Tel: 021 462 4502. Email: nhiggitt@sahra.org.za</td></tr>
<tr><td>Rock unit(s)</td><td colspan="2">Precambrian Malmani Subgroup carbonates, Pleistocene to Holocene aeolian sands, downwasted surface gravels</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Stromatolites (domes, columns etc) within Precambrian bedrocks, vertebrate bones & teeth, vertebrate and other burrows (e.g. calcretised termitaria) within superficial sediments.</td></tr>
<tr><td rowspan="5">ECO protocol</td><td colspan="2">1. Once alerted to fossil occurrence(s): alert site foreman, stop work in area immediately (N.B. safety first!), safeguard site with security tape / fence / sand bags if necessary.</td></tr>
<tr><td colspan="2">2. Record key data while fossil remains are still in situ:
• Accurate geographic location – describe and mark on site map / 1: 50 000 map / satellite image / aerial photo
• Context – describe position of fossils within stratigraphy (rock layering), depth below surface
• Photograph fossil(s) in situ with scale, from different angles, including images showing context (e.g. rock layering)</td></tr>
<tr><td>3. If feasible to leave fossils in situ:
• Alert Heritage Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation
• Ensure fossil site remains safeguarded until clearance is given by the Heritage Resources Agency for work to resume</td><td>3. If not feasible to leave fossils in situ (emergency procedure only):
• Carefully remove fossils, as far as possible still enclosed within the original sedimentary matrix (e.g. entire block of fossiliferous rock)
• Photograph fossils against a plain, level background, with scale
• Carefully wrap fossils in several layers of newspaper / tissue paper / plastic bags
• Safeguard fossils together with locality and collection data (including collector and date) in a box in a safe place for examination by a palaeontologist
• Alert Heritage Resources Agency and project palaeontologist (if any) who will advise on any necessary mitigation</td></tr>
<tr><td colspan="2">4. If required by Heritage Resources Agency, ensure that a suitably-qualified specialist palaeontologist is appointed as soon as possible by the developer.</td></tr>
<tr><td colspan="2">5. Implement any further mitigation measures proposed by the palaeontologist and Heritage Resources Agency</td></tr>
<tr><td>Specialist palaeontologist</td><td colspan="2">Record, describe and judiciously sample fossil remains together with relevant contextual data (stratigraphy / sedimentology / taphonomy). Ensure that fossils are curated in an approved repository (e.g. museum / university / Council for Geoscience collection) together with full collection data. Submit Palaeontological Mitigation report to Heritage Resources Agency. Adhere to best international practice for palaeontological fieldwork and Heritage Resources Agency minimum standards.</td></tr>
</table>