PALAEONTOLOGICAL HERITAGE REPORT: COMBINED DESKTOP & FIELD-BASED ASSESSMENT

PROPOSED LERATO SOLAR POWER PLANT ON PORTION 4 OF THE FARM HOUTHAALDOORNS 2 NEAR LICHTENBURG, DITSOBOTLA LOCAL MUNICIPALITY, NORTH WEST PROVINCE

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EXECUTIVE SUMMARY

Lerato Solar Power Plant (RF) (Pty) Ltd is proposing to develop a photovoltaic solar facility and associated infrastructure, including a battery storage facility, on Portion 4 of the Farm Houthaaldoorns 2, situated *c*. 15 km north of Lichtenburg, Ditsobotla Local Municipality, North West Province. The solar facility will have an installed capacity of up to 150 MW and a total footprint of approximately 300 hectares. The on-site substation will connect to a collector substation on the property which will be linked in turn to the National Grid *via* a *c*. 9-11 km long 132 kV powerline to the existing Watershed MTS Substation for which a 100m-wide corridor (3 route options) is assessed here.

The solar facility and grid connection project areas are underlain near-surface and at depth by shallow marine carbonate bedrocks of the Monte Christo Formation (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*). Desktop studies as well as a palaeontological site visit indicate that exposure levels of Precambrian bedrocks within the project area (*i.e.* solar facility *plus* associated grid connection corridor) are generally poor due to low topographic relief and karstic weathering across an ancient land surface, widespread sandy soil and residual gravel cover and dense grassy vegetation. The stromatolite assemblages recorded within the solar power plant project area comprise common types that are likely to be widely distributed within the extensive outcrop area of the Monte Christo Formation. Unique, well-preserved occurrences of stromatolites of high scientific or conservation value have not been recorded here. Resistant-weathering silcrete bodies at surface might be of Late Cretaceous / Neogene age associated with the “African Land Surface” (unconfirmed). No occurrences of ancient (Cretaceous / Neogene) fluvial gravels or Late Caenozoic bone breccia within karstic solution hollows (best detected by geophysical surveying) were encountered during the short palaeontological field survey.

Pending the potential discovery of fossiliferous karst breccias or ancient (Cretaceous / Neogene) fluvial gravels), it is concluded that the palaeontological sensitivity of the project area - including the solar power plant, 132kV grid connection corridor and all associated infrastructure - is Low. Potential impacts during the construction phase are assessed as being of Medium (Negative) significance without mitigation and Low (Negative) significance

following proposed mitigation. No palaeontological No-Go areas or fossil sites requiring specialist mitigation have been identified within the solar facility development footprint, including the associated grid connection corridor.

Given (1) the low levels of visibility due to summer grasses as well as time constraints during the site visit as well as (2) the limited data on Monte Christo Formation stromatolite assemblages in the scientific literature, it is recommended that, if the solar power plant (SPP) projects are authorized, a photographic record of representative well-preserved stromatolites within the combined SPP project area is compiled by a professional palaeontologist during the dry (*i.e.* winter season) and *before* construction commences.

Any discoveries – for example through geophysical surveys - of substantial Cretaceous to Palaeogene fluvial gravels or Neogene karst-infill bone breccias at or beneath the ground surface within the SPP and grid connection project areas should be subject to a specialist palaeontological study (*i.e.* site visit, recording and description of fossil occurrences and their geological context, recommendations to SAHRA for any further studies or mitigation).

There is no preference of palaeontological heritage grounds between any of the three grid connection options under consideration. 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, bone breccias within karstic solution hollows, petrified wood within ancient fluvial gravels - and the necessity to protect 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 Lerato Solar Power Plant (RF) (Pty) Ltd is proposing to develop a photovoltaic solar power plant (SPP) and associated infrastructure on Portion 4 of the Farm Houthaaldoorns 2, situated on the eastern side of the R505 tar road some 15 km north of Lichtenburg in the Ditsobotla Local Municipality, North West Province (Figs. 1 to 3). The Lerato Solar Power Plant will have an installed capacity of up to 150 MW and a total footprint of approximately 300 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 onsite 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 Lerato 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 Watershed 275/132/88 MTS Substation. The Project will inject up to 100MW into the National Grid. The installed capacity will be approximately 150MW.
  One route is proposed from the onsite substation to the collector station situated on the property whereas two possible connection corridor routes are proposed from the collector station to the Watershed 275/132/88 MTS Substation. Within the preferred corridor (southeast of the farm) a new line of approximately 9km will be constructed to the Watershed MTS or, alternatively, one of the existing Eskom lines will be upgraded. For the alternative corridor (southwest of the farm) a new line of approximately 11km will be constructed to the Watershed MTS.
- **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 will be obtained from the R505 Regional Road onto a proposed new gravel access road situated adjacent the development footprint where direct access

will be obtained to the facility. 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).

N.B. The term project area in this report refers to the solar power plant (SPP) project area on Portion 4 of the Farm Houthaaldoorns 2 as well as the associated grid connection to the existing Watershed MTS Substation (Figs. 1 & 2). The combined solar power plant and grid connection project area refers to the project areas of the three adjoining SPPs on Portion 4 of the Farm Houthaaldoorns 2 as well as their associated 100 m wide grid connection corridors as shown in satellite map Figure 3.

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

Component	Description / dimensions
Height of PV panels	6 meters
Area of PV Array	300 Hectares (Development footprint)
Number of inverters required	Minimum 50
Area occupied by inverter / transformer stations / substations / Battery Energy Storage System (BESS)	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: 300 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: 8 m Maximum volume: 1740 m^3
Length of internal roads	Approximately 20 km
Width of internal roads	Between 6 & 12 meters
Proximity to grid connection	Approximately 9 kilometers
Height of fencing	Approximately 2.5 meters

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 Very High Palaeosensitivity (Fig. 41). 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: Lisa Opperman

Environamics Environmental Consultants, 14 Kingfisher Street, Tuscany Ridge Estate, Potchefstroom, 2531. Telephone: 086 762 8336. Cell: 084 920 3111. Electronic Mail: lisa@environamics.co.za). This report will contribute to the overarching Heritage Impact Assessment as well as the Environmental Management Programme (EMPr) for the solar power 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 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.

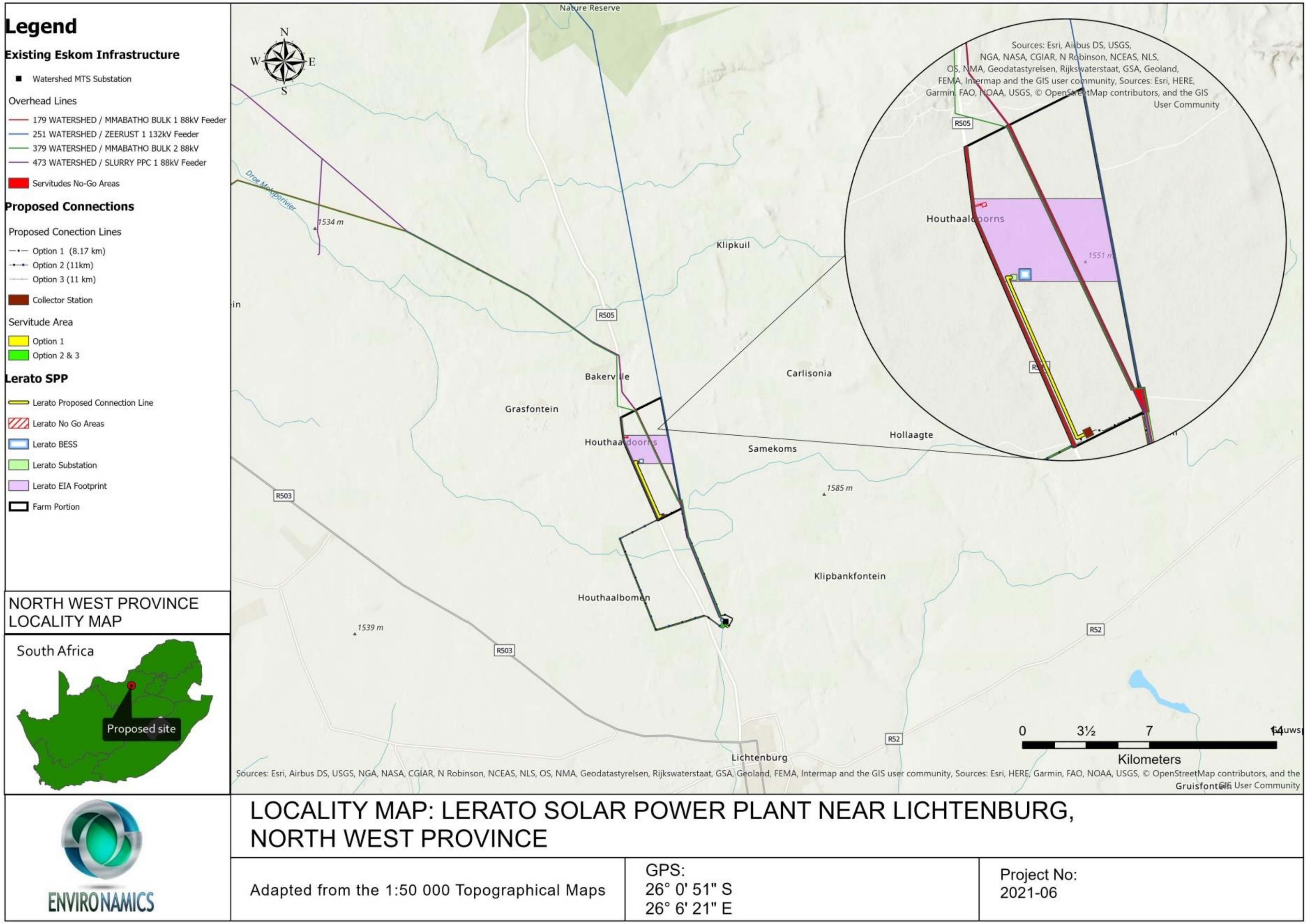

Figure 1: Locality map for the proposed Lerato Solar Power Plant on Portion 4 of the Farm Houthaaldoorns 2 near Lichtenburg, North West Province (Image supplied by Environamics Environmental Consultants).

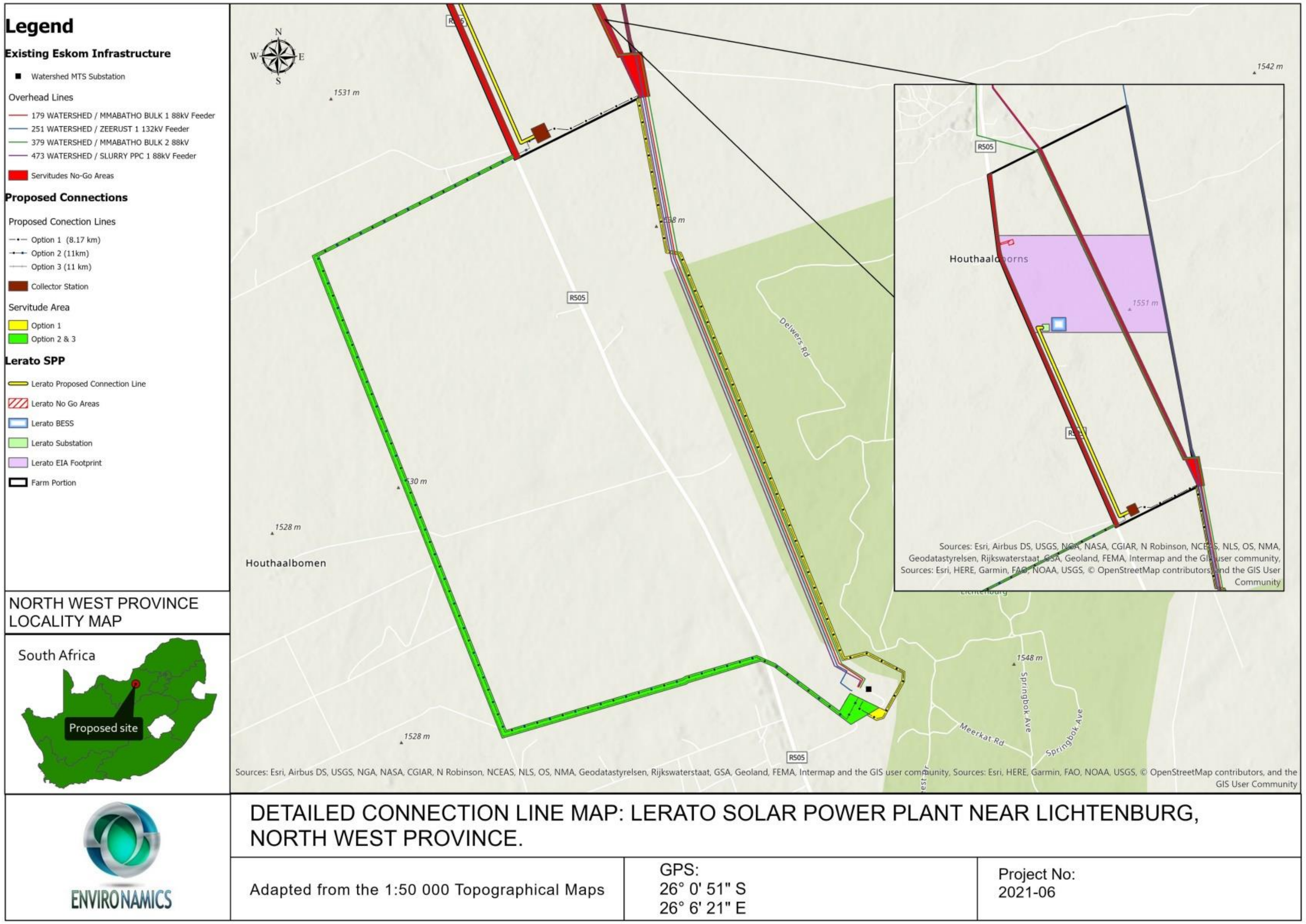

Figure 2: Map showing grid connection route options between the Lerato Solar Power Plant and the existing Watershed MTS Substation near Lichtenburg (Image supplied by Environamics Environmental Consultants).

Figure 3: Google Earth© satellite image showing the *combined* Subsolar Boitumelo (red), Lerato (orange) and Kutlwano (green) SPP project areas situated on Portion 4 of the Farm Houthaaldoorns 2 *plus* the associated grid connection corridor options (pale blue) to the north of Lichtenburg (N is towards the LHS). Access points are shown in blue. Note the more featureless terrain in the Boitumelo SPP and grid corridor project areas. The more rugged terrain in the Lerato SPP and Kutlwano SPP project areas is due to numerous horizons of resistant-weathering chert in the underlying Malmani Subgroup bedrocks, as shown by the faint ENE-WSW trending stripes seen here and extending outside the area towards the ENE.

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 North West Province (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 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.* Rubidge 2012, Almond 2013, 2016a, 2016b, Groenewald 2015, 2016, 2017a, 2017b, Bamford 2019), including the three adjoining solar power plants proposed for Portion 4 of the Farm Houthaaldoorns 2 (Almond 2021, in prep.).

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

4. A short (one-day) palaeontological field assessment of the combined solar power plant project area on Portion 4 of the Farm Houthaaldoorns 2 in March 2021 by the author (*N.B.* Previous field-based palaeontological reports for most of the present grid connection project area have been provided by Groenewald (2017a, 2017b). The majority of the grid connection corridor as well as the northernmost sector of the combined project area has been largely assessed here at desktop level only. This is considered sufficient, given the very 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 Lichtenburg in North West Province exposure of potentially fossiliferous bedrocks is limited due to the low relief terrain, extensive soil / gravel cover and dense grassy vegetation during summer. Given the additional time constraints, and paucity of farm tracks, it was only possible to visit the more accessible portions of the combined SPP project area. 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 following short, illustrated account outlines the geology of the *combined* Subsolar Boitumelo, Lerato and Kutlwano SPP project areas on Portion 4 of the Farm Houthaaldoorns 2, based on desktop as well as recent field data. Please note that, given the low levels of bedrock exposure within the Lerato SPP project area itself as well as most of the associated grid connection corridor, these have been largely assessed at desktop level (*cf* field data for this area provided by Groenewald 2017a, 2017b).

The combined solar power plant project area on Portion 4 of the Farm Houthaaldoorns 2, as well as the 100 m wide grid connection corridor extending southwards to the existing Watershed MTS Substation, are situated in low-relief, semi-arid grassland terrain between *c*. 1510 m and 1530 m amsl. This watershed region lying north of Lichtenburg is drained to the southwest by the Hartsrivier and to the west by the Molopo River. No major active surface drainage lines traverse the project area itself but subsurface karstic drainage conduits may be present here, as is commonly the case in areas underlain by carbonate bedrocks. The combined SPP project area falls within the Northwestern Highveld Geomorphic Province of Partridge *et al.* (2010) and features extensive cover by sparsely to very gravelly, sandy soils, cherty eluvial gravels and dense grassy vegetation (in summer) *plus* bushy vegetation and occasional trees, especially in more elevated rocky areas (Figs. 7 to 9). Levels of bedrock exposure are moderate to low, mainly comprising small, karstified patches and occasional low ridges of limestone / dolomite and cherty rocks (Figs. 9, 12 & 16). In the northern sector of Portion 4 of the Farm Houthaaldoorns 2 as well as in the grid connection corridor in the south the overlying sandy soils are generally thicker, with little or no bedrock exposure. The terrain here is less rugged, with fewer trees and higher levels of transformation for agriculture, as seen on satellite images (Fig. 3). Open cast mining and prospecting for diamonds associated with ancient fluvial or sinkhole gravels is evident near Bakerville to the north of solar power plant project area while several small-scale prospecting excavations also occur within the project area itself (*e.g.* close to the R505 tar road) (Figs. 20 & 21).

The geology of the Lichtenburg region is depicted on adjoining 1: 250 000 sheets 2526 Rustenburg in the north and 2626 West Rand in the south (Fig. 5). A short explanation for the former sheet only has been published by Walraven (1981). The combined solar power plant project area on Portion 4 of the Farm Houthaaldoorns 2 as well as the associated grid connection corridor are underlain by shallow marine platform carbonate bedrocks of the **Malmani Subgroup** (Chuniespoort Group, Transvaal Supergroup) of Precambrian age (*viz*. late Archaean, *c*. 2.6 billion years old). Closer to Rustenburg the ancient Malmani carbonate bedrocks are unconformably overlain by Permo-Carboniferous glacial sediments of the Dwyka Group (Karoo Supergroup); similar, more readily denuded rocks would have once extended across the present study area as well. The region was planed-off during the time of the polyphase Late Cretaceous – Neogene “African Land Surface” which was probably associated with renewed karstification, accumulation of cherty regolith gravels as well as pedocrete formation (*viz*. silcretes).

As shown on the geological map, the fairly complete carbonate-dominated Malmani Subgroup succession to the north of Lichtenburg youngs broadly towards the north, with generally very low bedding dips. The only Malmani Subgroup subunit mapped within the present project area is the 300-500 m thick **Monte Christo Formation** (See stratigraphic column in Fig. 4). According to Walraven (1981), Schutte (1993) and Eriksson *et al.* (2006) the **Monte Christo Formation** consists largely of pale grey, shallow marine platform dolomites, stromatolitic and oolitic in part, with abundant secondary chert which has given rise to abundant surface gravels of downwasted cherty material. Small-scale sedimentological features include oolites, ripple marks, interference ripple marks, climbing ripples and rare beds of edgewise conglomerates (Button, 1973a, 1973b).

On the 1: 250 000 geological map a central zone of chert-rich carbonate within the Monte Christo formation is differentiated from chert-poor, oolitic facies above and below (*N.B.* This appears to be mistakenly mapped on the Rustenburg sheet). The cherty middle zone underlies the central and southern portions of the solar power plant project area where it gives rise to rougher, slightly higher-relief terrain (Fig. 3). The chert-poor bedrocks underlying the northernmost sector of the power plant project area as well as the grid connection project area, in contrast, feature very low relief terrain with much more limited bedrock exposure and extensive cover by sandy to gravelly soils.

It is noted that Obbes (1995), following Eriksson and Truswell (1974), discusses the subdivision of the Monte Christo Formation succession into a series of three to four members differentiated on the basis of the dolomite coloration, stromatolite occurrence and proportion of chert but little attempt is made here to apply this more detailed scheme (Fig. 6). The more rugged, cherty outcrop area underlying the central and southern sectors of the solar power plant project area can be provisionally assigned to the **Mooiplaats Member**, characterised by dark grey dolomites with high levels of secondary chert, silicified stromatolitic horizons, ripple marks and oolitic beds. On aerial and satellite images the outcrop area of the member has a pale, streaky appearance, prominent relief and well-defined stratification (Fig. 3). The overlying **Rietspruit Member** cropping out in the northern sector of the project area features intercalated chert-poor, colour-banded dolomites and chert-in-shale breccias. On aerial / satellite images it shows darker tones, low relief and unclear stratification.

Overall, bedrock exposure within the combined solar power plant project area is poor, very patchy and is not clearly visible on satellite images. On the ground the generally low-relief exposures are often obscured by grassy vegetation. Extensive low exposures of well-jointed, pale greyish Malmani carbonate bedrocks (probably dolomite) are common and usually show evidence of karstic weathering (widened joints, rugose elephant-skin weathered surfaces *etc*) with partial secondary silicification and / or dark ferro-manganese mineralisation (Fig. 9). The carbonates vary from superficially massive (sometimes finely-mottled) to thinly or thickly laminated or vuggy (full of irregular small cavities) and are locally thin- to medium-bedded (Figs. 10 & 11). Where present, stromatolitic lamination building small-scale domes or columns is often obscure, unless emphasized by secondary silicification (Section 4).

Low-relief, parallel ridges conformable with the regional stratigraphy are seen on satellite images of the solar power plant project area where they clearly extend in a ENE-WSW direction parallel to the bedrock stratigraphy and may be associated with denser bushy vegetation (Fig. 3). These features are probably related to resistant-weathering, stratiform horizons of intensely silicified bedrocks within the middle portion of the Monte Christo Formation.

The sedimentological origin and age of the widespread cherty facies observed within portions of the Malmani Subgroup outcrop area is contested. Some chert lenses and horizons may be or early diagenetic origin (*i.e.* Late Archaean) while others are clearly secondary silicified carbonate facies, preserving some of the original small-scale sedimentary features of the original limestone or dolomite parent rocks. Secondary silicification may have occurred during more than one time interval. Button (1976) suggests that silicification occurred in Transvaal Supergroup times (*i.e.* Late Archaean – Early Proterozoic) as a result of intermittent episodes of exposure of the shallow carbonate platform during periods of lowered sea level. This is in accordance with the association of high chert content with particular lithostratigraphic units, such as the middle portion of the Monte Christo Formation.

Surface exposures of tough, brownish, speckled, often vuggy cherty facies showing a well-developed conchoidal fracture, with local silcretised breccias containing clasts of laminated carbonate, quartzite and (especially) silcfrete and / or chert, may represent Phanerozoic (post-Precambrian) silcretes (Figs. 16 to 19). The speckling reflects small, irregular-shaped vugs infilled with pale micro-crystalline quartz, or more rarely by ferro-manganese minerals, within a brownish, fine-grained sandy matrix. The exposures are generally mantled by well-rounded boulders and cobbles of silcrete. The possibility that some of the silcrete-like cherts and silicified breccias may be of Late Cretaceous / Palaeocene age and formed in association with the long-lasting, multi-phase "African Erosion Surface" needs to be considered (*cf* Partridge 1998). Elsewhere in North West Province white to grey silcretes up to 50m thick have been reported in the Vryburg 1: 250 000 sheet area (Keyser & Du Plessis 1993).

In addition to the dominant pale greyish dolomites and various secondary chert facies - including occasional pale veins and pods of pale greyish, flinty chert that have been locally exploited for stone tools - minor thin- to medium-bedded packages of greyish-brown quartzites (or possibly silicified dolarenites) also occur within the Monte Christo Formation (Figs. 13 to 15). Concentrations of fine platy clasts (preserved as moulds) of carbonate or mudrock towards the bed tops might reflect wave winnowing. Upper bedding surfaces showing well-defined, high relief symmetrical wave ripples were probably originally developed on shallow sandy sea beds. Clear preservation of internal ripple lamination here - often subconformable with the ripple surface (*i.e. not* wavy cross-lamination) and sometimes planed-off by erosion - suggests the involvement of sediment-binding microbial mats facilitating vertical sediment accretion under the influence of wave action of varying intensity.

A large proportion of the combined solar power plant project area is mantled by as well as by orange-brown sandy soils as well as downwasted, angular to subrounded residual (eluvial) surface gravels, dispersed or concentrated into sheets and patches (Figs. 23 to 25). The latter are composed of orange- to yellowish-brown or pale grey clasts of chert or silcrete (the latter especially showing conchoidal fracture), dark rusty-brown to black ferro-manganese clasts and minor quartzite. Scattered patches of blocky to rubbly cherty surface debris overlying silicified stromatolitic beds are seen locally and are of uncertain origin.

Thicker (up to several meters), cemented to unconsolidated rubbly deposits of poorly-sorted, oligomict, angular gravels intermixed with orange-brown sands, generally associated with shallow excavations, are encountered in association with karstic solution hollows and possible sinkholes within the study area (Figs. 20 & 21). Examples are seen *c*. 220 m SW of the main farm buildings as well as along the western edge of the southern project area. These appear to be karst-infill deposits of possible Late Cretaceous or younger age (possibly multi-generational) that have probably been prospected for diamonds. Pronounced karstic weathering of the underlying dark-patinated carbonate bedrocks beneath the gravelly regolith is occasionally visible here. Excavated boulder-sized blocks include unusual matrix-supported pebbly to cobbly conglomerates with a pale calcretised matrix, gravelly, brown, ferricrete-like material, as well as secondarily ferruginised quartzite and carbonate facies. The presence within the combined SPP project area of other, and possibly more extensive, karstic solution structures at or beneath the ground surface may be determined from geophysical surveying.

As summarized by recent palaeontological heritage studies by Almond (2016a, b), the diamond deposits in the Lichtenburg area are associated with weathered, kaolinitised alluvial or eluvial (residual) gravels of Late Cretaceous or younger Tertiary age that may have been associated with south-flowing tributaries of the palaeo-Harts drainage system across the Cargonian palaeo-highlands (De Wit 1981, De Wit *et al.* 2000, Partridge *et al.* 2006, Partridge 1998, *cf* Dollar 1998). According to the first authors, these gravels occur as surface stringers or inside karstic hollows (sinkholes) within the underlying dolomitic bedrocks. The sinkholes as well as secondary manganese ores in the region may be related to an extensive ancient (Late Cretaceous) African erosion surface. The basal productive Older Gravels consist mainly of downwasted angular clasts of chert and vein quartz within a kaolinitic matrix. This facies is overlain by similar but reddish gravels comprising chert, agate, vein quartz and rare diamonds. The Older Gravels are largely of non-fluvial (*i.e.* residual) origin and may be of Late Cretaceous age. They are unconformably overlain by greyish to reddish-brown, locally cross-bedded and diamondiferous Younger Gravels of fluvial origin. Surface gravels in the present study region are dominated by cherty and dolomitic clasts downwasted from the Malmani dolomites.

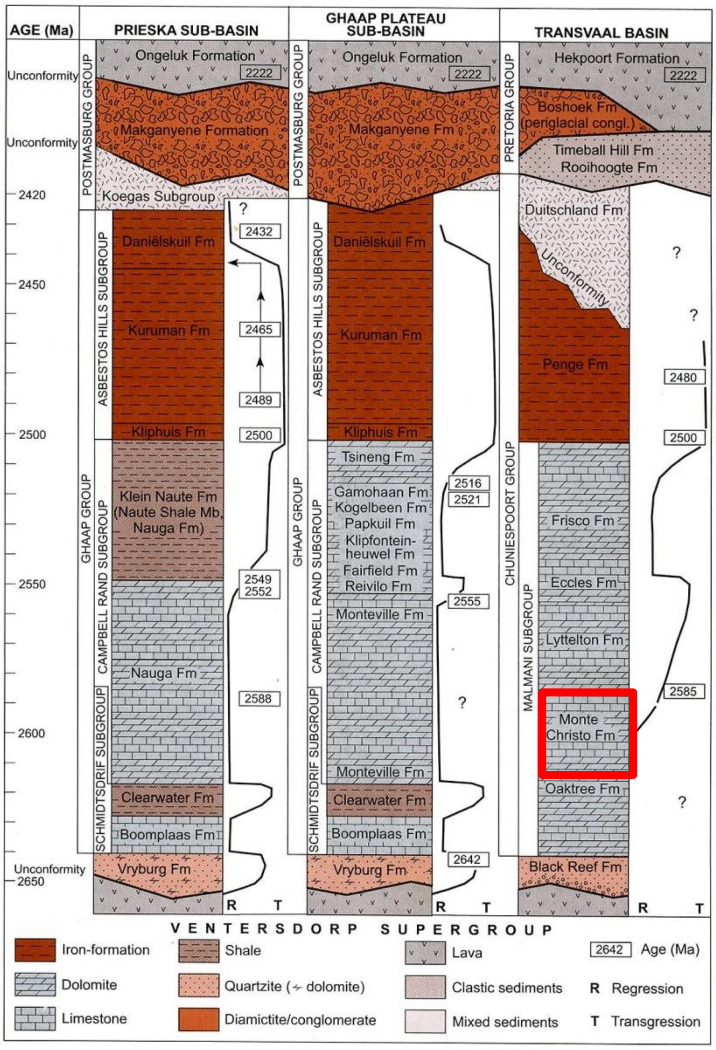

Figure 4: Position of the Monte Christo Formation within the Transvaal Supergroup succession of the Transvaal Basin (red rectangle) (From Eriksson *et al.* 2006).

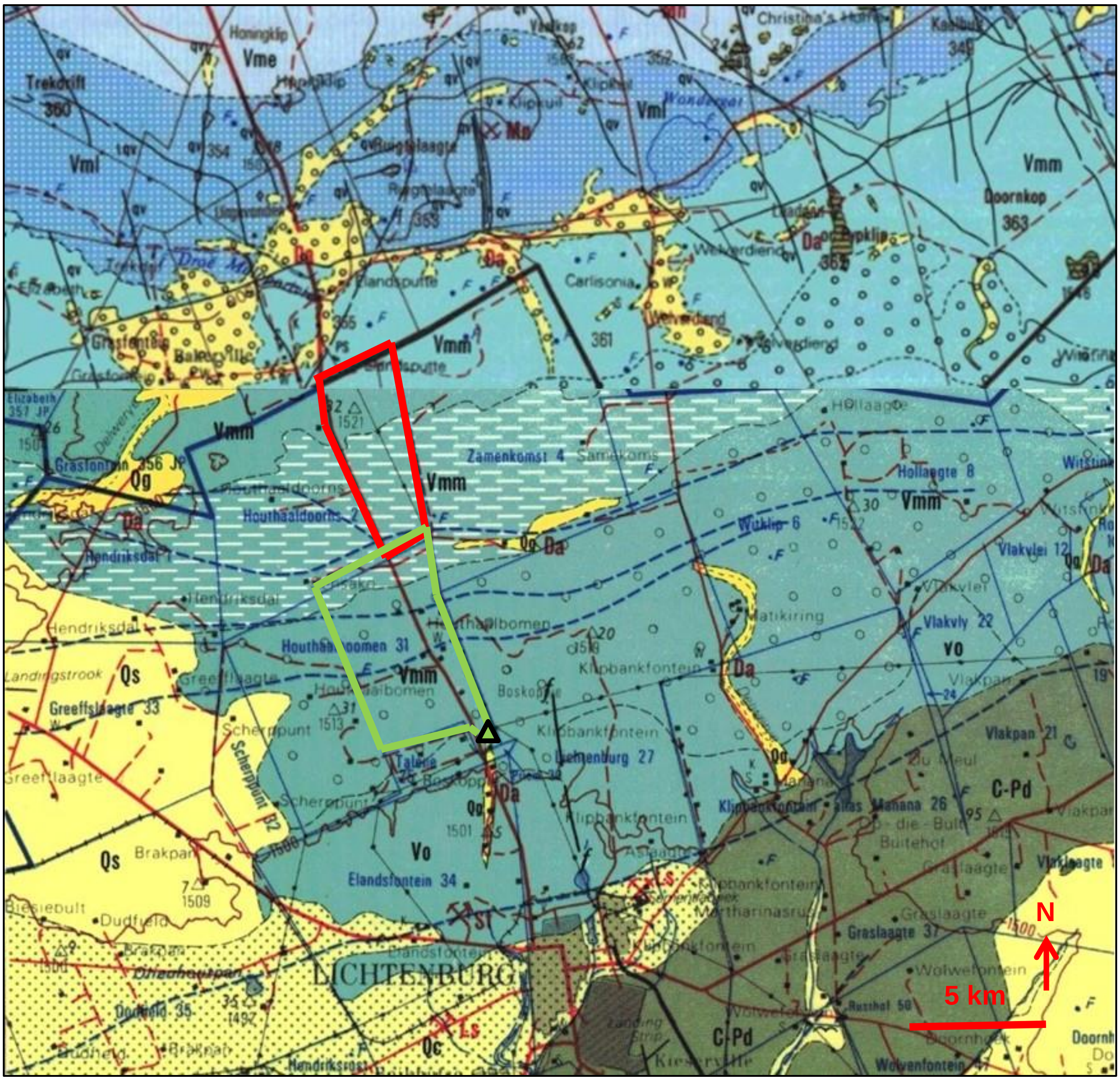

Figure 5: Extracts from adjoining 1: 250 000 geology sheets 2526 Rustenburg (N) and 2626 West Rand (S) showing the combined Subsolar solar power plant project areas on Portion 4 of the Farm Houthaaldoorns 2 (red polygon) between Lichtenburg and Bakerville, Ditsobotla Local Municipality, Northwest Province. The green line *approximately* indicates the 100 m–wide grid connection corridor options to the existing Watershed MTS Substation (green triangle) located *c*. 6 km to the SSE of the solar power plant project area (See Figs. 1 to 3 for more detail). The main lithostratigraphic rock unit mapped within the solar power plant and grid connection project areas comprises Precambrian (Latest Archaean) carbonate and cherty bedrocks of the Chuniespoort Group (Malmani Subgroup) assigned to the Monte Christo Formation (Vmm, blue-green). Oolitic and cherty facies within the Monte Christo Formation are differentiated here (small circles = oolitic carbonates; dashed ornament = chert-rich facies) but at this level the stratigraphy does not match well across the boundary between the two map sheets (probably a cartographic error). E-W trending blue dashed lines are ill-defined lineaments (possibly dykes within the basement). Linear bodies of Lichtenburg diamondiferous gravels of probable Late Cretaceous (rather than Quaternary) age occur just N, E and S of the solar power plant and grid connection project area (Qg, yellow, with or without ornament of small circles; Da = diamondiferous deposits). Smaller-scale infilled sinkholes into carbonate bedrocks do occur within the project area but are not mapped at this scale.

Supergroup	Group	Subgroup	Formation	Member	Lithology	Reference names *
Transvaal	Pretoria		Rooihoogte	Pologround	Sandstone and interbedded siltstone	
					Shales and interbedded siltstones	
				Bevets	Chert conglomerate in ferruginous matrix	Bevets Conglomerates
					Shales and siltstones	
	Chuniespoort	Malmani	Frisco		Chert-free dark-brown dolomite	Mixed zone
			Eccles	Leeuwenkloof	Giant Chert Breccia	Upper chert and dolomite zone
					Chert-rich light-grey dolomite	
			Lyttelton		Chert-free dark-brown dolomite	Principal chert poor zone
			Monte Christo	Crocodile River	Chert-rich grey-brown dolomite	Lower chert and dolomite zone
				Rietspruit	Chert-rich and colour-banded dolomite	
				Mooiplaats	Chert-rich light-grey dolomite	
				Rietfontein	Chert-free light-grey dolomite	
			Oaktree		Chert-free dark-brown dolomite	Transition Zone
			Black Reef		Interbedded quartzite and shale	

Figure 6: Lithostratigraphic subdivision of the Transvaal Supergroup showing the subunits recognised within the Chuniespoort Group (Malmani Subgroup) of the Transvaal Basin, including the members recognised within the Monte Christo Formation southwest of Pretoria (Based on Obbes 2000). The present study area is primarily underlain by the Mooiplaats and Rietspruit Members (emphasized here in red).

Figure 7: Undulating, low-relief, grassy terrain within minimal bedrock exposure in the northern sector of Portion 4 of the Farm Houthaaldoorns 2.

Figure 8: Negligible bedrock exposure and poor ground visibility in low relief, grassy terrain is also found in the southern sector of the combined SPP project area, including the grid connection corridors.

Figure 9: Low, extensively karstified exposures of massive, grey, non-cherty Malmani Subgroup carbonate bedrocks seen in many areas in the central and southern sectors of Portion 4 of the Farm Houthaaldoorns 2.

Figure 10: Close-up of massive, speckled dolostone showing contrasting darker, coarsely granular and pale, fine-grained lithologies. The darker, irregular rounded regions seen here are *c*. 1-2 cm across.

Figure 11: Float block of thinly-laminated dolostone without obvious stromatolites (Hammer = 30 cm).

Figure 12: Extensive horizons of resistant-weathering secondary cherty within the Malmani Subgroup bedrocks are responsible for areas of rugged but low-relief terrain.

Figure 13: Tabular, thin-to medium-bedded quartzites (possibly secondarily silicified dolarenites) with small, wave-winnowed intraclasts towards the bed tops (Scale = 15 cm).

Figure 14: Quartzite bed tops showing symmetrical, linear-crested bed tops with concordant internal lamination suggesting vertical accretion under the influence of benthic microbialites and wave action (Scale in cm).

Figure 15: Probable wave-rippled or undulose quartzite bed top planed-off by wave action to reveal the concentric internal lamination (Scale = 15 cm).

Figure 16: Low ENE-WSW trending ridges with denser shrubby vegetation seen on satellite images may be associated with resistant-weathering cappings of brownish silcrete, typically showing well-developed conchoidal fracture (Hammer = 30 cm).

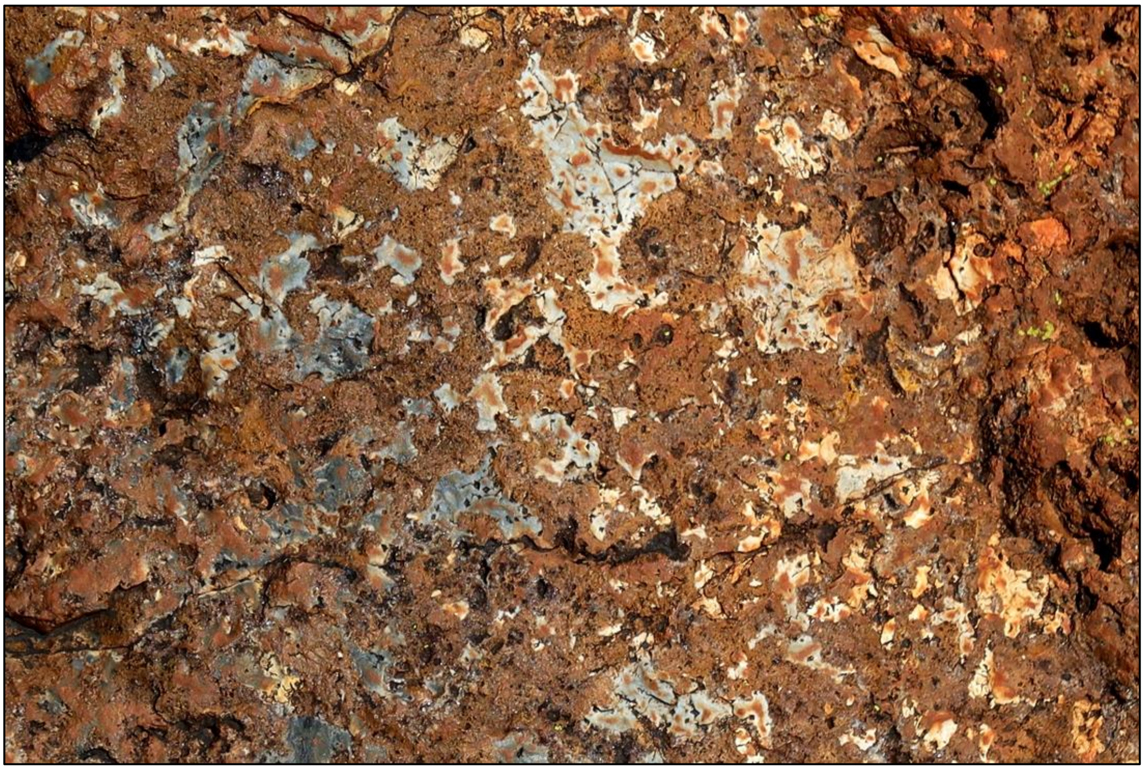

Figure 17: Close-up of silcretes showing pale, very irregular-shaped areas cryptocrystalline chert (chalcedony) – possibly vug infills – within a brownish, fine-grained sandy matrix. The pale areas are up to 2 cm across.

Figure 18: Prominent-weathering silcretised breccias with poorly-sorted, angular clasts of silcrete / chert / silicified limestone and quartzite (Hammer = 30 cm).

Figure 19: Detail of silcretised chert breccia facies with many angular clasts showing complex internal lamination – probably silicified microbialites (Scale in cm and mm).

Figure 20: Partially-excavated solution hollow within karstified carbonate bedrocks (*cf* smooth, grey pinnacle) infilled with rubbly downwasted cherty gravels and orange-brown sandy soils.

Figure 21: Blocky rubble of carbonate, quartzite and gravelly ferricrete excavated from a solution hollow, several showing a very dark ferromanganese patina.

Figure 22: Block of distinctive calcretised, matrix-supported conglomerate of possible Cretaceous or Paleogene age excavated from a solution hollow. Scale is 15 cm long.

Figure 23: Sheet of pale, subrounded to angular eluvial (downwasted) gravels of silcrete, chert and quartzite mantling a silcretised topographic high.

Figure 24: Sheet of reworked pale yellow to orange-patinated, subrounded silcrete gravels overlying orange-brown sandy soils (Hammer = 30 cm).

Figure 25: Rubbly surface gravels of poorly-sorted, angular, pale cherty material overlying silcretised stromatolitic dolostone bedrocks.

4. PALAEONTOLOGICAL HERITAGE

In this section of the report a brief illustrated account is provided of the fossil record of the main sedimentary rock units represented within the combined SPP and grid connection project areas on Portion 4 of the Farm Houthaaldoorns 2 near Lichtenburg as well as a representative sample of fossils recorded during the recent palaeontological site visit. GPS data for key fossil sites is provided in Appendix 1 where they are mapped on satellite images.

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 (*cf* Eriksson 1977, Eriksson *et al.* 2006). 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, Obbes 1995). 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), Obbes (1995), 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).

Stromatolites and crinkly microbiolites are recorded within the basal Malmani Subgroup successions in the Mafikeng, Rustenburg and Vryburg 1: 250 000 sheet areas in North West Province. Specific details of stromatolitic assemblages within the Monte Christo Formation are not readily available in the scientific literature, however. Obbes (1995), for example, illustrates Malmani Subgroup stromatolites recorded to the southwest of Pretoria without reference to a particular formation.

Stromatolites and microbialites (microbially generated bio-sedimentary structures) occur very widely within the topographically subdued exposures of the Monte Christo Formation in the combined Subsolar solar power plant project area near Lichtenburg and are very abundant (dominant) at some horizons (See Figs. 26 to 40 for selected examples). Most of the examples recorded here at surface have been secondarily silicified, and in some cases have a very dark, almost black patina suggesting ferro-manganese mineralisation. The stromatolite-rich horizons appear to have been especially susceptible to secondary silicification and, due their superior resistance to weathering, are therefore “over-represented” at the present land surface compared with interbedded non-stromatolitic carbonate facies (Figs. 30 & 31). Fine, paper-thin, convex-up lamination building laterally-connected domes and columns may be preserved within some cherty beds (Fig. 29). Pseudostromatolites due to the abiogenic precipitation of isopachous cement on the sea floor are also observed (Fig. 27). Where silicification has not occurred, stromatolites may still be present but are much less apparent to the eye on weathered carbonate surfaces, often appearing only as faint, finely-laminated domes, columns or structures of uncertain geometry (Fig. 26).

So far only a limited spectrum of stromatolites and other microbialites have been recorded from the SPP project areas near Lichtenburg. These comprise:

- Dispersed or closely-nested, medium-scale (few dm diameter) stromatolitic domes with a smooth surface and well-developed, onion-like internal lamination (Fig. 36);
- Commonly closely-spaced, medium-scale domal or rounded, cushion-like features with a crinkly, rugose or densely pustulose outer surface (Figs. 37 & 38);
- Small-scale micro-stromatolitic buttons of various sizes (< 1m up to few cm diam.), dispersed or forming an extensive carpet, sometimes superimposed on a larger basal dome or forming small domical build-ups (Figs. 33 to 35);
- A range of pustular, crinkly and "bubbly" surface textures, most of which are probably of microbial mat (bio-sedimentary) origin, though others may be a consequence of secondary silicification at surface (Figs. 28 & 32);
- *Possible*, but so far equivocal, large domal features up to ~75 cm in diameter (Fig. 39).

Low-relief build-ups of tightly-packed to overlapping, domical to irregular stromatolites probably formed patch reef-like features on the Archean sea bed. The existence of higher-relief stromatolitic mounds is still unclear due to Phanerozoic land denudation. Prominent-weathering (~ 50 cm high) exposures of grey-brown vuggy carbonate observed in the southern sector of the project area might be reefal in nature but this remains to be established (Fig. 40). Moderately high sediment dips observed locally may be primary, reflecting aprons of sediment around reef margins.

It is noted here that:

- The stromatolite localities listed here represent only a *small sample* of those present at surface within the combined SPP project area (with further stromatolitic horizons present beneath the surface).

- All the recorded stromatolite occurrences are of common button to domical or cushion types that occur widely within the outcrop areas of the Monte Christo Formations. They are therefore *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 (Section 6).

- A recent palaeontological field survey by Groenewald (2017a, 2017b and earlier refs) of the farm Houthaalboomen 31, situated to the south of the present SPP project area on both western and eastern sides of the R505 (and including most of the grid connection corridor for the present SPP projects top the Watershed MTS Substation) did not reveal substantial *in situ* stromatolite fossil sites or karstic infill deposits.

Figure 26: Float block of unsilicified grey dolostone showing faint columnar stromatolites picked out by darker, closely-spaced, upward-convex lamination (Scale = 15 cm).

Figure 27: Stromatolite-like concentric lamination within pale grey, karstified dolostone (Scale = 15 cm). The patterns seen here may be due to abiogenic precipitation of isopachous cement on the sea floor rather than to microbial mats.

Figure 28: Pustoluse textures on various scales within dolostone were associated with growth of benthic microbial mats (Scale in cm and mm).

Figure 29: Pale chert horizon (secondarily silicified dolostone) preserving finely-spaced, convex-up stromatolitic lamination (Scale in cm and mm).

Figure 30: Low exposures of pale grey Malmani dolostone showing prominent weathering-out of secondarily silicified stromatolites (darker features), several of which are illustrated among the following figures (Hammer = 30 cm).

Figure 31: Close-up of the exposures illustrated above showing contrast between the pale dolostone and darker stromatolites preserved in resistant-weathering secondary chert (Hammer = 30 cm).

Figure 32: Carpet of secondarily silicified microbial pustules and small, button- or wart-shaped microstromatolites (Scale = 15 cm).

Figure 33: Densely-packed horizon of superimposed microstromatolites (Scale = 15 cm). The dark, metallic hues seen here are due to secondary ferromanganese mineralisation.

Figure 34: Small, silicified elliptical stromatolitic domes composed of superimposed, smaller-scale stromatolitic buttons (Scale in cm).

Figure 35: Several spaced-out, small stromatolitic pinnacles or domes composed of button-like microstromatolites (Scale in cm).

Figure 36: Medium-scale domical stromatolites with smooth, onion-like internal lamination clearly picked-out by secondary silicification (Scale = 15 cm).

Figure 37: Possible small, slightly elevated reef patch on the sea floor composed of closely-spaced, medium-scale stromatolitic domes or cushions with a pustulose rather than smooth surface texture (Hammer = 30 cm).

Figure 38: Close-up of medium-scale, pustulose stromatolitic domes or cushions showing the varied, circular to elliptical to irregular shape in plan view (Scale = 15 cm).

Figure 39: Possible large-scale domical stromatolite (Scale = 15 cm). Unequivocal large (m)-scale domes have not yet been recorded in the study area.

Figure 40: Prominent-weathering exposure of distinctive greyish-brown, vuggy silicified carbonate which *might* be of stromatolite reef origin (this requires further study) (Hammer = 30 cm).

4.2. Fossils within Mesozoic to Late Caenozoic superficial sediments

To the author's knowledge, fossils have not been recorded within much more ancient (possible Late Cretaceous or Paleogene) silcretes, such as those associated with the African Surface near Lichtenburg. There may be potential for silicified plant material (*e.g.* petrified wood) in such settings. Sparse fossil remains have been recorded from Tertiary or younger silcretes of the Grahamstown and equivalent formations by Roberts (2003) and earlier authors. These include a small range of trace fossils (*e.g.* rhizoliths or plant root casts and invertebrate burrows such as *Skolithos*), charophyte algae (calcareous stoneworts), reed-like wetland plants resembling the extant *Phragmites* (*fluitjiesriet*), and reworked Late Permian silicified wood from the Beaufort Group (See also Adamson 1934, Du Toit 1954, and Roberts *et al.,* 1997). Silicified termitaria might also be expected here, although termite activity is inhibited by waterlogged soils that probably prevailed in areas where silcrete formation occurred. Narrow, regularly-spaced vertical tubes seen within many silcretes are apparently abiogenic and not relictual root structures (Roberts 2003).

Calcretised fine alluvium and pebbly to cobbly fluvial conglomerates preserved within palaeochannels at Mahura Muthla on the Ghaap Plateau contain petrified logs of both gymnosperm and angiosperm affinities spanning a wide range of ages, including Upper Karoo (post-Permian), Early Cretaceous, Late Cretaceous and Tertiary (Partridge 1998, Bamford *in* De Wit *et al.* 2009). The presence of comparable fossiliferous ancient fluvial gravels within the present project area has not been established; they are especially well-represented around Bakerville just to the north (See geological map Fig. 5).

The mainly unconsolidated, Pleistocene to Recent superficial deposits in the project area - *viz*. sandy soils, downwasted / eluvial surface gravels – 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.

4.3. Fossils in Late Caenozoic karstic solution hollow and cave deposits

Gravelly infills of karstic solution hollows are recorded locally within the SPP project area while fossiliferous bone breccias or reworked petrified woods have not been observed here so far. Fossil pollens and petrified woods of Late Cretaceous age have been recorded from lateritized deposits within a sinkhole on Farm Grasfontein west of Bakerville, to the northwest of Lichtenburg (De Wit 1981, Partridge 1998, De Wit *et al.* 2000; *cf* also De Wit *et al.* 2009).

Gravelly infills of superficial and underground karstic solution hollows, by analogy with breccias in dolomite caves in the Cradle of Humankind and Makapansgat Valley for example (Gauteng, North West and Limpopo Provinces), might be bone-bearing and thus of considerable palaeontological interest. Within the fossiliferous breccias the bone clasts may appear variously white, or secondarily reddened by ferric compounds, or even stained black by manganese minerals. The biostratigraphy and taxonomy of the rich Late Pliocene to Pleistocene mammalian faunas, including micromammal and hominin remains, that have been recorded from dolomite cave infills in the South African interior have been reviewed by authors such as Brain (1981), Klein (1984), McKee *et al.* (1995), Maguire (1998), Partridge (2000), Tobias (2000), Avery (2000) and Kuykendall in Bonner *et al.* (2007). Accessible, well-illustrated accounts of these fossil assemblages are provided by MacRae (1999), Hilton-Barber and Berger (2004), Partridge and Clarke (2010) and Carruthers (2019). Caves such as Sterkfontein have in addition yielded well-preserved fossil plant remains, including petrified (calcified) woods, pollens and spores (Bamford *in* Bonner *et al.* 2007, pp. 91-101). Useful accounts of the accumulation of fossiliferous cave breccias and cave taphonomy within a southern African context have been provided by Brain (1981), Maguire *et al.* (1980) and Partridge (2000), among others. These authors emphasize the important role played by carnivores, such as hyaenas, leopards and owls, in mammal bone accumulation within caves – including important micromammal assemblages. Passive introduction of skeletal remains into caves through open shafts acting as fossil traps as well as the redistribution of bones within the cave system by gravity and water flow also played important roles.

It should be noted that not all breccias associated with dolomite caves are fossiliferous. Breccias may owe their origins variously to (1) energetic sedimentary processes in the original depositional basin (*e.g.* debris flows), (2) episodes of palaeokarst formation during Precambrian times, (3) fracturing of host rocks along major fault planes, as well as (4) deposition during the early to late phases of cave formation and subsequent cave infilling (*e.g.* roof-fall or collapse breccias, talus and debris cone breccias, or breccias formed by secondary reworking of debris cone material). Fossil-bearing breccias often contain extraneous (*i.e.* extra-cave) material such as soil, cave earth and gravels in addition to dolomitic and chert debris. In the present case, this extraneous material might include gravel clasts of chert, silcrete, quartzite and reddish, ferruginous soils that typify the area as well as more exotic lithologies derived from the Cretaceous / Paleogene alluvial gravels recorded in the Lichtenburg – Bakerville region.

No fossils were found in association with the rubbly solution hollow infills encountered during the site visit. However, should substantial infilled karstic solution features be detected during the geophysical survey of the combined SPP project area, these will need to be assessed in the field by a specialist palaeontologist *before* construction commences and might well require specialist mitigation during the construction phase itself (*cf* also recommendations in Groenewald 2017a, 2017).

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

5.1. Site sensitivity verification

A VERY HIGH palaeosensitivity has been provisionally assigned to the Lerato Solar Power Plant project area on Portion 4 of the Farm Houthaaldoorns 2 and associated grid connection corridor near Lichtenburg by the DFFE screening tool (Fig. 41, abstracted from the Screening Report for Environmental Authorisation prepared by Environamics Environmental Consultants, February 2021). This high inferred palaeosensitivity is triggered by potentially rich stromatolite occurrences within the Precambrian carbonate bedrocks as well as, perhaps, by the potential for Neogene bone breccias within karstic solution hollows here.

Pending the *potential* (but hitherto unconfirmed) discovery of (a) Cretaceous to Palaeogene fluvial gravels or (b) Neogene karst-infill bone breccias at or beneath the ground surface within the SPP and grid connection project area (best picked-up by geophysical surveys) the originally proposed Very High palaeosensitivity of the Lerato Solar Power Plant project area is *contested* here. Rather, a generally LOW palaeosensitivity is assigned to this area in the present PIA report, largely based on:

- The sparse occurrence of unique or rare, well-preserved, scientifically valuable stromatolitic exposures in this largely flat-lying, karstified region (based on the recent site visit);
- The probable widespread occurrence of very similar stromatolitic assemblages within the extensive outcrop area of the Precambrian bedrock unit concerned (*viz*. Monte Christo Formation) within the Transvaal Basin, including a large outcrop area north of Lichtenburg;
- The thin to thick blanket of largely or entirely unfossiliferous aeolian sands and residual cherty gravels covering substantial portions of the project area.

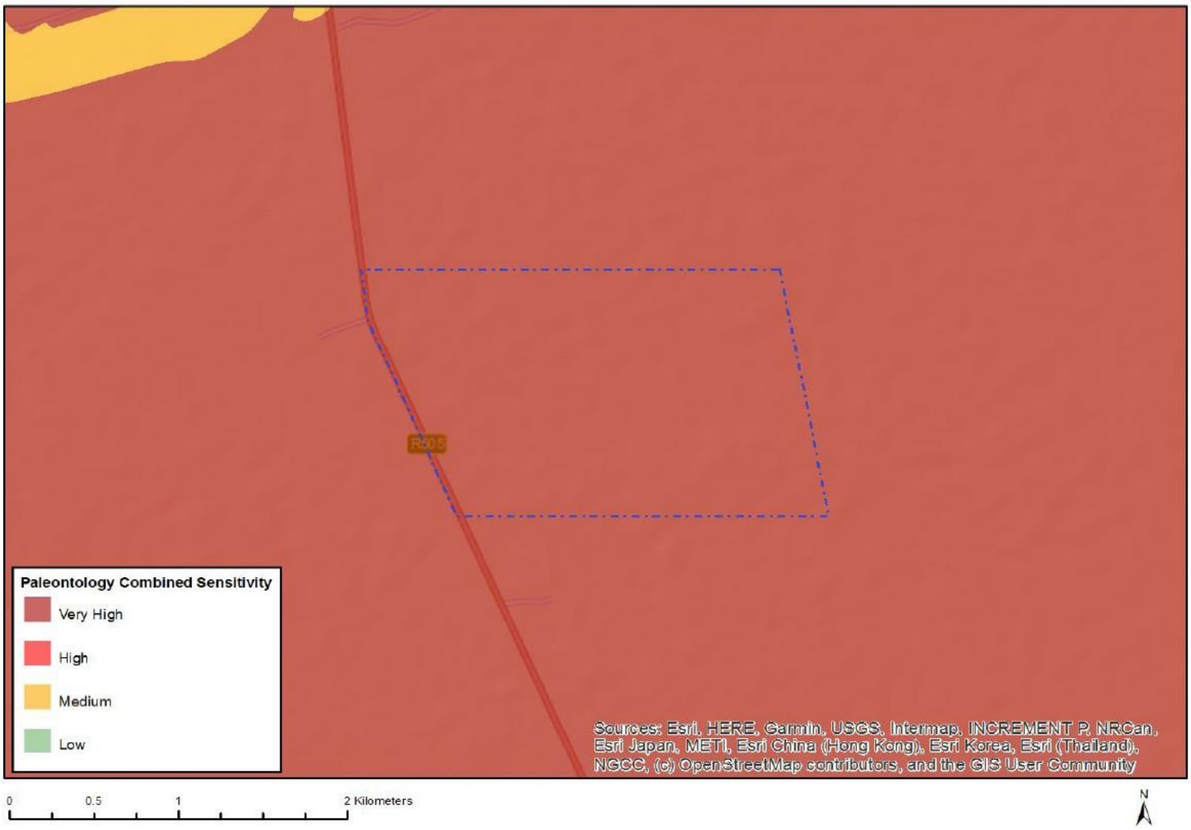

Figure 41: Palaeosensitivity map for the Lerato Solar Power Plant project area (blue dotted polygon) (Figure abstracted from the Screening Report for Environmental Authorisation prepared by Environamics Environmental Consultants). The solar facility project area, including the associated grid connection corridor extending to the south, is provisionally mapped here as of Very High palaeosensitivity. A Low palaeosensitivity is inferred in this report, however, based on desktop and field data.

5.2. Impact assessment

The Lerato Solar Power Plant project area is located in a region that is underlain by fossiliferous sedimentary rocks of Precambrian and younger, Cretaceous / Neogene and 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. Historical diamond prospecting might have also compromised fossils such as petrified wood within Cretaceous / Neogene fluvial and solution hollow infill gravels. These historical or on-going impacts are partially 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 (Three route options 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) often low levels of bedrock exposure within the solar power plant and grid connection project areas and (3) the unmapped and unpredictable distribution of karstic solution hollow breccias and 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*.* 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-through, the impact significance would fall to *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.

There is no preference of palaeontological heritage grounds between either of the grid connection options under consideration.

There are no fatal flaws associated with the proposed solar PV 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 Lerato Solar Power Plant near Lichtenburg, North West Province (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	Possible (2)	Unlikely (1)
Duration	Permanent (4)	Permanent (4)
Magnitude	Low (2)	Low (1)
Reversibility	Irreversible (4)	Irreversible (4)
Irreplaceable loss of resources	Marginal (2)	Marginal (2)
Cumulative impact	Low (2).	
Significance	**Negative medium (30)**	**Negative low (14)**
Can impacts be mitigated?	Before start of construction phase: • Compilation of photographic record of representative stromatolite assemblages within SPP project area by palaeontological specialist (winter season); • Specialist palaeontological field study of any substantial karst breccias or bodies of ancient fluvial gravels identified by geophysical surveys or other means. During construction phase: 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. This assessment assumes that there are probably no substantial unmapped karst breccias or Cretaceous / Neogene fluvial gravels at or near-surface within the project area concerned.

5.2. Cumulative impact assessment

A tabulated summary of comparable renewable energy projects within a 30 km radius of the present project area near Lichtenburg is presented in Table 3 and Figure 42 below (Data provided by Environamics Environmental Consultants). Based on the SAHRIS website, palaeontological heritage assessments (PIAs) for this review by (Almond 2013), Rubidge (2012), Groenewald (2015, 2016, 2017a, 2017b) and Bamford (2019) are available. Combined desktop and field-based studies have been conducted for the adjoining proposed Boitumelo, Lerato and Kutlwano SPPs on Portion 4 of the Farm Houthaaldoorns 2 (Almond in prep., 2021). It is noted that (1) several 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 *except* where there is reasonable potential for Caenozoic karstic bone breccias (See Groenewald 2017a, 2017b). 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.

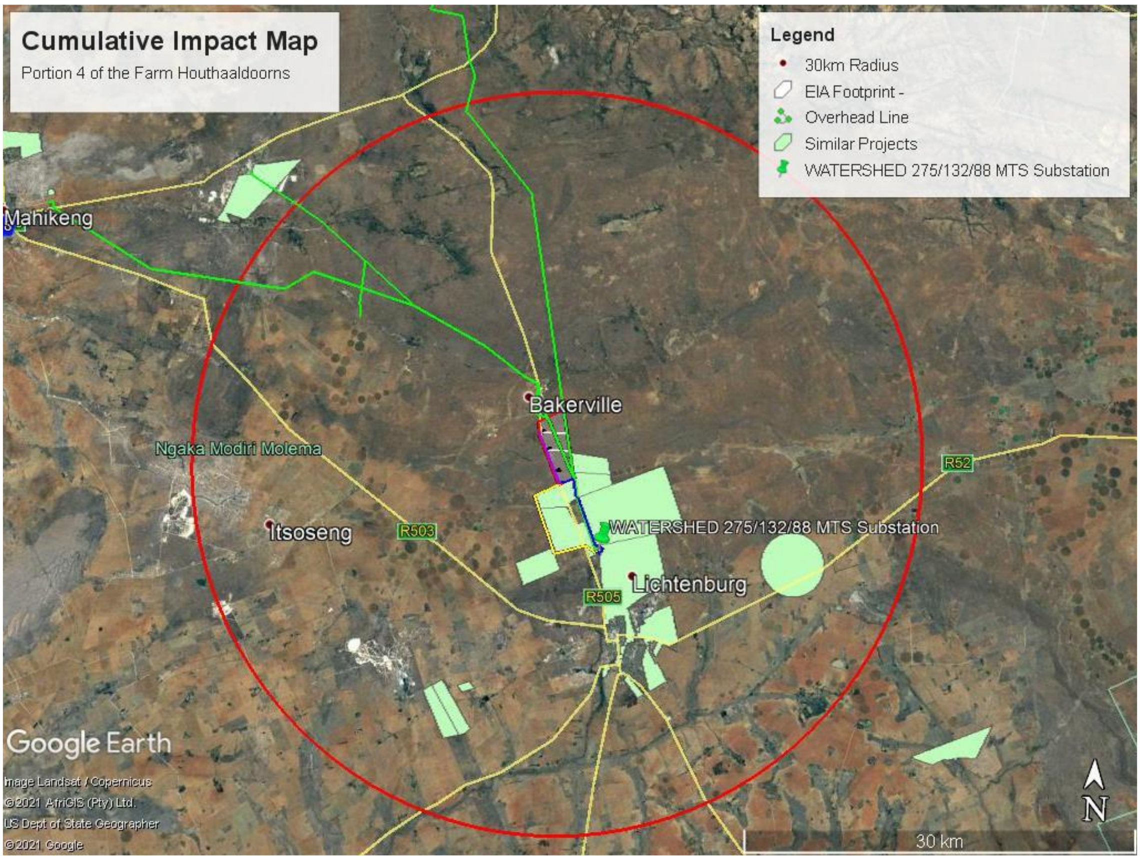

Figure 42: Map of renewable energy developments within a 30 km radius of the Lerato Solar Power Plant near Lichtenburg (Image provided by Environamics Environmental Consultants).

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, unique or unusual 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 Lichtenburg region – including the three adjoining Subsolar SPPs proposed on Portion 4 of the Farm Houthaaldoorns 2 - is assessed as Medium (negative) without mitigation, potentially falling to Low (negative) 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 Lichtenburg region, including the three proposed Subsolar SPPs on Portion 4 of the Farm Houthaaldoorns 2 (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	Probable (3)	Possible (2)
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	Low (2)	Low (2)
Significance	**Negative medium (34)**	**Negative low (16)**
Can impacts be mitigated?	Yes. • Photographic recording of representative fossil assemblages (*e.g.* stromatolites) within SPP project area by palaeontological specialist in pre-construction phase (winter season); • Specialist palaeontological field study of any substantial karst breccias or bodies of ancient fluvial gravels identified by geophysical surveys or other means; • ECO monitoring of surface clearance and excavations for fossil remains; • Implementation of recommended Chance Fossil Finds Procedure; • Protection of recorded sensitive fossil sites through buffers and / or judicious professional collection.	

***** *N.B.* Refers essentially to impacts on well-preserved and / or rare fossils of scientific and conservation value. This assessment assumes that there are probably no substantial unmapped karst breccias or Cretaceous / Neogene fluvial gravels at or near-surface within the project areas concerned.

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). Two other proposed Subsolar solar power plants on Portion 4 of the Farm Houthaaldoorns 2 have also been taken into account.

Site name	Distance from study area	Proposed generating capacity	DEFF reference	EIA process	Project status
Hibernia solar Energy Facility	23.3 km	-	14/12/16/3/3/2/1062	Scoping and EIA	Approved
ACSA PV	20.3 km	3 MW	12/12/20/2149	BAR	Approved
Lichtenburg 1 solar PV energy	1.6 km	100 MW	14/12/16/3/3/2/1091	Scoping and EIA	Approved
Lichtenburg 2 solar PV energy	1.7 km	100 MW	14/12/16/3/3/2/1092	Scoping and EIA	Approved
Lichtenburg 3 solar PV energy	2 km	100 MW	14/12/16/3/3/2/1093	Scoping and EIA	Approved
Lichtenburg Solar Park	10 km	70 MW	14/12/16/3/3/2/270	Scoping and EIA	Approved
Tlisitseng PV1 SEF	8 km	75 MW	14/12/16/3/3/2/974	Scoping and EIA	Approved
Tlisitseng PV2 SEF	8.5 km	75 MW	14/12/16/3/3/2/975	Scoping and EIA	Approved
Watershed Solar Energy Facility	11 km	75 MW	14/12/16/3/3/2/557	Scoping and EIA	Approved

6. RECOMMENDATIONS FOR MONITORING AND MITIGATION

Proposed monitoring and mitigation measures for the Lerato 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, all the recorded occurrences recorded are considered to be of low conservation or scientific value and no special mitigation measures regarding them are proposed here.

No palaeontological No-Go areas or fossil sites requiring specialist mitigation have been identified within the solar facility development footprint, including the associated grid connection corridor.

Given (1) the low levels of visibility due to summer grasses as well as time constraints during the site visit as well as (2) the limited data on Monte Christo Formation stromatolite assemblages in the scientific literature, it is recommended that, if the SPP projects are authorized, a photographic record of representative well-preserved stromatolites within the combined SPP project area is compiled by a professional palaeontologist during the dry (winter season) and *before* construction commences.

Any discoveries – for example through geophysical surveys - of substantial Cretaceous to Paleogene fluvial gravels or Neogene karst-infill bone breccias at or beneath the ground surface within the SPP and grid connection project areas should be subject to a specialist palaeontological study (*i.e.* site visit, recording and description of fossil occurrences and their geological context, recommendations to SAHRA for any further studies or mitigation).

The ECO responsible for the construction phase of the solar facility should be aware of the potential for important fossil finds (*e.g.* well-preserved stromatolites, karstic-related bone breccias) 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 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 authority. 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.

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Table 4: Proposed monitoring and mitigation measures for incorporation into the EMPr for the Lerato Solar Power Plant project (Pre-construction / 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 (fluvial gravels, alluvium, soils, breccias within karstic solution hollows) with fossil remains.	Photographic recording of stromatolite assemblages within project footprint. Palaeontological field study of any substantial bodies of fluvial gravels or karst breccia. Monitoring of all major site clearance and excavation work for fossil remains. Substantial well-preserved fossils (vertebrate bones, teeth) to be safeguarded, preferably *in situ*, and reported to SAHRA. Fossil recording and sampling.	Pre-construction phase Pre-construction phase On-going during construction phase. On-going during construction phase. Following report of chance fossil finds.	Palaeontological specialist Palaeontological specialist ECO ECO Developer to appoint palaeontologist following significant new fossil finds Palaeontological specialist	Compliance to be verified by ECO.

Table 5: Summary of impacts and mitigation measures for the Lerato 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	Compilation by palaeontological specialist of photographic record of fossil stromatolite assemblages within SPP footprint before construction phase (winter season) Palaeontological field study of any substantial bodies of fluvial gravels or karst breccia before construction phase. 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.

8. REFERENCES

ADAMSON, R.S. 1934. Fossil plants from Fort Grey near East London. Annals of the South African Museum 31, 67-96.

ALMOND, J.E. 2013. Proposed Hibernia PV Solar Energy Facility near Lichtenburg, Ditsobotla Local Municipality, North West Province. Recommended exemption from further palaeontological studies, 6 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2016a. Proposed Kwa-Nozici Minerals (Pty) Ltd small-scale alluvial diamond and manganese mining project on Farm 361 JP, near Lichtenburg, North West. Palaeontological heritage comment: recommended exemption from further palaeontological specialist studies, 7 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2016b. Proposed Mosotetsi (Pty) Ltd Diamond Mining Operation on Farm Kwaggaslaagte 121-1 near Ventersdorp, North West Province. Palaeontological heritage comment: recommended exemption from further palaeontological specialist studies, 7 pp. Natura Viva cc, Cape Town.

AVERY, D.M. 2000. Micromammals. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.305-338. Oxford University Press, Oxford.

BAMFORD, M. 2019. Palaeontological Impact Assessment for three proposed PV projects near Lichtenburg, Northwest Province Phase 2 / Site Visit Report, 21 pp.

BENDER, P.A. & BRINK, J.S. 1992. A preliminary report on new large mammal fossil finds from the Cornelia. South African Journal of Science 88, 512-515.

BONNER, P., ESTERHUYSEN, A. & JENKINS, T. (Eds.) 2007. A search for origins. Science, history and South Africa's 'Cradle of Humankind', xviii + 313 pp. Wits University Press, Johannesburg.

BOSHOFF, A. & KERLEY, G. 2013. Historical incidence of the larger mammals in the Free State Province (South Africa) and Lesotho, 480 pp. Centre for African Conservation Ecology, Nelson Mandela Metropolitan University, Summerstrand, Port Elizabeth, South Africa.

BOUSMAN, C.B. *et al.* 1988. Palaeoenvironmental implications of Late Pleistocene and Holocene valley fills in Blydefontein Basin, Noupoort, C.P., South Africa. Palaeoecology of Africa 19: 43-67.

BRAIN, C.K. 1958. The Transvaal ape-man-bearing cave deposits. Memoirs of the Transvaal Museum 11, 1-131.

BRAIN, C.K. 1981. The hunters or the hunted? An introduction to African cave taphonomy, x + 365 pp. The University of Chicago Press, Chicago & London.

BRAIN, C.K. & WATSON, V. 1992. A guide to the Swartkrans early hominid cave site. Annals of the Transvaal Museum 35, 343-365.

BRINK, J.S. 1987. The archaeozoology of Florisbad, Orange Free State. Memoirs van die Nasionale Museum 24, 151 pp.

BRINK, J.S. et al. 1995. A new find of Megalotragus priscus (Alcephalini, Bovidae) from the Central Karoo, South Africa. Palaeontologia africana 32: 17-22.

BRINK, J.S. & ROSSOUW, L. 2000. New trial excavations at the Cornelia-Uitzoek type locality. Navorsinge van die Nasionale Museum Bloemfontein 16, 141-156.

BRINK, J.S., BERGER, L.R. & CHURCHILL, S.E. 1999. Mammalian fossils from erosional gullies (dongas) in the Doring River drainage. Central Free State Province, South Africa. In: C. Becker, H. Manhart, J. Peters & J. Schibler (eds.), Historium animalium ex ossibus. Beiträge zur Paläoanatomie, Archäologie, Ägyptologie, Ethnologie und Geschichte der Tiermedizin: Festschrift für Angela von den Driesch. Rahden/Westf : Verlag Marie Leidorf GmbH, 79-90.

BUTTON, A. 1973a. A regional study of the stratigraphy and development of the Transvaal Basin in the eastern and northeastern Transvaal. Unpublished PhD thesis, University of the Witwatersrand, 352 pp.

BUTTON, A. 1973b. The stratigraphic history of the Malmani Dolomite in the Eastern and North-eastern Transvaal. Transactions of the Geological Society of South Africa 76, 229-247.

BUTTON, A. 1986. The Transvaal Sub-basin of the Transvaal Sequence. In: Anhaeusser, C.R. & Maske, S. (Eds.) Mineral deposits of southern Africa, 811-817. Geological Society of South Africa, Johannesburg.

BUTTRICK, D.B., VAN ROOY, J.L. & LIGTHELM, R. 1993. Environmental geological aspects of the dolomites of South Africa. Journal of African Earth Sciences 16, 53-61.

CARRUTHERS, V. 2019. Cradle of Life. The story of the Magaliesberg and the Cradle of Humankind, 256 pp. Penguin Random House, Cape Town.

CATUNEANU, O. & ERIKSSON, P.G. 1999. The sequence stratigraphic concept and the Precambrian rock record: an example from the 2.7-2.1 Ga Transvaal Supergroup, Kaapvaal craton. Precambrian Research 97, 215-251.

CHURCHILL, S.E. *et al.* 2000. Erfkroon: a new Florisian fossil locality from fluvial contexts in the western Free State, South Africa. South African Journal of Science 96: 161-163.

COOKE, H.B.S. 1974. The fossil mammals of Cornelia, O.F.S., South Africa. In: Butzer, K.W., Clark, J.D. & Cooke, H.B.S. (Eds.) The geology, archaeology and fossil mammals of the Cornelia Beds, O.F.S. Memoirs of the National Museum, Bloemfontein 9: 63-84.

DE WIT, M.C.J. 1981. A geophysical investigation and geological interpretation of part of the diamondiferous gravels on the farm Grasfontein (356JP), west of Bakerville. Unpublished MSc thesis, University of Pretoria.

DE WIT, M.C.J. 1999. Post-Gondwana drainage and the development of diamond placers in western South Africa. Economic Geology 94: 721-740.

DE WIT, M.C.J., MARSHALL, T.R. & PARTRIDGE, T.C. 2000. Fluvial deposits and drainage evolution. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.55-72. Oxford University Press, Oxford.

DE WIT, M.C.J., WARD, J.D., BAMFORD, M.K. & ROBERTS, M.J. 2009. The significance of the Cretaceous diamondiferous gravel deposit at Mahura Muthla, Northern Cape Province, South Africa. South African Journal of Geology 112, 89-108.

DOLLAR, E.S.J. 1998. Palaeofluvial geomorphology in southern Africa: a review. Progress in Physical Geography 22,325-349.

DU TOIT, A. 1954. The geology of South Africa. xii + 611pp, 41 pls. Oliver & Boyd, Edinburgh.

ERIKSSON, K. A. 1977. Tidal flat and subtidal sedimentation in the 2250 M.Y. Malmani Dolomite, Transvaal, South Africa. Sedimentary Geology 18, 223–244.

ERIKSSON, K.A. & TRUSWELL, J.F. 1974. Stratotypes from the Malmani Subgroup north-west of Johannesburg, South Africa. Transactions of the Geological Society of South Africa 77, 211-222.

ERIKSSON, K.A. & MACGREGOR, I.M. 1981. Precambrian palaeontology of southern Africa. In: Hunter, D.R. (Ed.) Precambrian of the southern hemisphere, pp. 813-833. Elsevier, Amsterdam.

ERIKSSON, P.G., SCHWEITZER, J.K., BOSCH, P.J.A., SCHREIBER, U.M., VAN DEVENTER, L. & HATTON, C.J. 1993. The Transvaal Sequence: an overview. Journal of African Earth Sciences 16, 22-51.

ERIKSSON, P.G., HATTINGH, P.J. & ALTERMANN, W. 1995. An overview of the geology of the Transvaal Sequence and Bushveld Complex, South Africa. Mineralia Deposita 30, 98-111.

ERIKSSON, P.G. & ALTERMANN, W. 1998. An overview of the geology of the Transvaal Supergroup dolomites (South Africa). Environmental Geology 36, 179-188.

ERIKSSON, P.G., ALTERMANN, W. & HARTZER, F.J. 2006. The Transvaal Supergroup and its precursors. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 237-260. Geological Society of South Africa, Marshalltown.

GRINE, F.E. *et al.* 2007. Late Pleistocene human skull from Hofmeyr, South Africa, and modern human origins. Science 315, 226-229.

GROENEWALD, G.H. 2015. Palaeontological Desktop Assessment for the proposed Tlisitseng Solar PV. Internal Report, PGS Heritage (Pty) Ltd.

GROENEWALD, G. H. 2016. Biotherm (Pty) Ltd – Tlisitseng PV Solar Project. Palaeontological heritage assessment report.

GROENEWALD, G.H. 2017a. Tlisitseng project - Tlisitseng 1 substation and power line. Palaeontological assessment report, 50 pp. PGS Heritage.

GROENEWALD, G.H. 2017b. Tlisitseng project - Tlisitseng 2 substation and power line. Palaeontological assessment report, 50 pp. PGS Heritage.

HILTON-BARBER, B. & BERGER, L.R. 2004. Field guide to the Cradle of Humankind. Skerfontein, Swartkrans, Kromdraai & environs World Heritage Site, 212 pp. Struik Publishers, Cape Town.

KEYSER, N. & DU PLESSIS, C.P. 1993. The geology of the Vryburg area. Explanation to 1: 250 000 geology sheet 2624 Vryburg, 28 pp. Council for Gesocience, Pretoria.

KLEIN, R.G. 1984. The large mammals of southern Africa: Late Pliocene to Recent. In: Klein, R.G. (Ed.) Southern African prehistory and paleoenvironments, pp 107-146. Balkema, Rotterdam.

LATHAM, A.G. 1999 Cave Breccias and Archaeological Sites. Capra 1. Available at - http://capra.group.shef.ac.uk/1/breccia.html.

LATHAM, A.G., HERRIES, A.I.R. & KUYKENDALL, K. 2003. The formation and sedimentary infilling of the Limeworks Cave, Makapansgat, South Africa. Palaeontologia Africana 39, 69-82.

MACGREGOR, M. 2002. The Precambrian fossil heritage of the Cradle of Humankind. In: Cradle of Humankind Cultural Heritage Resources Survey, Section B, 4-11.

MACRAE, C. 1999. Life etched in stone. Fossils of South Africa. 305 pp. The Geological Society of South Africa, Johannesburg.

MAGUIRE, J.M. 1998. Makapansgat. A guide to the palaeontological and archaeological sites of the Makapansgat Valley, 90 pp. Unpublished guidebook (Copyright J.M. Maguire).

MAGUIRE, J.M., PEMBERTON, D. & COLLETT, M.H. 1980. The Makapansgat Limeworks grey breccia: hominids, hyaenas, hystricids or hillwash? Palaeontologia africana 23, 75-98.

McCARTHY, T. & RUBIDGE, B. 2005. The story of Earth and life: a southern African perspective on a 4.6-billion-year journey. 334pp. Struik, Cape Town.

McKEE, J.K., THACKERAY, J.F. & BERGER, L.R. 1995. Faunal assemblage seriation of southern African Pliocene and Pleistocene fossil deposits. American Journal of Physical Anthropology 96, 235-250.

OBBES, A.M. 1995. The structure, stratigraphy and sedimentology of the Black Reef – Malmani – Rooihoogte succession of the Transvaal Supergroup south-west of Pretoria. Unpublished Master's Thesis, Rand Afrikaans University, 136 pp.

PARTRIDGE, T.C. 1998. Of diamonds, dinosaurs and diastrophism: 150 million years of landscape evolution in southern Africa. South African Journal of Geology 101 (3), 167-184.

PARTRIDGE, T.C. 2000. Hominid-bearing cave and tufa deposits. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.100-130. Oxford University Press, Oxford.

PARTRIDGE, T.C. & MAUD, R.R. 1987. Geomorphic evolution of southern Africa since the Mesozoic. South African Journal of Geology 90: 179-208.

PARTRIDGE, T.C. & MAUD, R.R. 2000. Macro-scale geomorphic evolution of Southern Africa. Pp. 3-18 in Partridge, T.C. & Maud, R.R. (eds.) The Cenozoic of Southern Africa. Oxford University Press, Oxford.

PARTRIDGE, T.C. & SCOTT, L. 2000. Lakes and pans. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.145-161. Oxford University Press, Oxford.

PARTRIDGE, T.C., BOTHA, G.A. & HADDON, I.G. 2006. Cenozoic deposits of the interior. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 585-604. Geological Society of South Africa, Marshalltown.

PARTRIDGE, T.C. & CLARKE, R.J. 2010. Caves of the ape-men. South Africa's Cradle of Humankind World Heritage Site 151 pp. S.E. Publications (Pty) Ltd, Pretoria and Wits University Press, Johannesburg.

PARTRIDGE, T.C., DOLLAR, E.S.J., MOOLMAN, J. & DOLLAR, L.H. 2010. The geomorphic provinces of South Africa, Lesotho and Swaziland: a physiographic subdivision for earth and environmental scientists. Transactions of the Royal Society of South Africa 65, 1-47.

ROBERTS, D.L. 2003. Age, genesis and significance of South African coastal belt silcretes. Council for Geoscience Memoir 95, 61 pp. Pretoria.

ROBERTS, D.L., BAMFORD, M. & MILLSTEED, B. 1997. Permo-Triassic macro-plant fossils in the Fort Grey silcrete, East London. South African Journal of Geology 100, 157-168.

ROSSOUW, L. 2006. Florisian mammal fossils from erosional gullies along the Modder River at Mitasrust Farm, Central Free State, South Africa. Navorsinge van die Nasionale Museum Bloemfontein 22, 145-162.

RUBIDGE, B. S. 2012. Palaeontological Assessment – Lichtenburg Solar Park, 5 pp.

SAHRA 2013. Minimum standards: palaeontological component of heritage impact assessment reports, 15 pp. South African Heritage Resources Agency, Cape Town.

SCHOPF, J.W. 2006. Fossil evidence of Archaean life. Philosophical Transactions of the Royal Society B (2006) 361, 869-885.

SCHUTTE, I.C. 1993. Die geologie van die gebied Kroonstad. Explanation to 1: 250 000 geology sheet 2726, 84 p. Council for Geoscience, Pretoria.

SKEAD, C.J. 1980. Historical mammal incidence in the Cape Province. Volume 1: The Western and Northern Cape. 903pp. Department of Nature and Environmental Conservation, Cape Town.

SUMNER, D. Y. 2000. Microbial vs environmental influences on the morphology of Late Archean fenestrate microbialites. In: RIDING, R. E. & AWRAMIK, S. M. (eds) Microbial Sediments, 307–314. Springer, Berlin.

SUMNER, D.Y. & BEUKES, N.J. 2006. Sequence stratigraphic development of the Neoarchaean Transvaal carbonate platform, Kaapvaal Craton, South Africa. South African Journal of Geology 109, 11-22.

TANKARD, A.J., JACKSON, M.P.A., ERICKSSON, K.A., HOBDAY, D.K., HUNTER, D.R. & MINTER, W.E.L. 1982. Crustal evolution of Southern Africa – 3.8 billion years of earth history. xv + 523 pp. Springer Verlag, New York.

TOBIAS, P.V. 2000. The fossil hominids. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.252-276. Oxford University Press, Oxford.

TRUSWELL, J.F. & ERIKSSON, K.A. 1972. The morphology of stromatolites from the Transvaal Dolomite northwest of Johannesburg, South Africa. Transactions of the Geological Society of South Africa 75, 99-110.

TRUSWELL, J.F. & ERIKSSON, K.A. 1973. Stromatolite associations and their palaeoenvironmental significance: a reappraisal of a Lower Proterozoic locality in the North Cape Province, South Africa. Sedimentary Geology 10, 1-23.

TRUSWELL, J.F. & ERIKSSON, K.A. 1975. A palaeoenvironmental interpretation of the early Proterozoic Malmani Dolomite from Zwartkops, South Africa. Precambrian Research 9, 277-303.

WALRAVEN, F. 1981. The geology of the Rustenburg area. Explanation to 1: 250 000 geology sheet 2526 Rustenburg, 37 pp. Council for Geoscience, Pretoria.

WELLS, L.H. & COOKE, H.B.S. 1942. The associated fauna and culture of Vlakkraal thermal springs, O.F.S.; III, the faunal remains. Transactions of the Royal Society of South Africa 29: 214-232.

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.

Recorded fossil sites are mapped below on satellite images in Figures A1 and A2.

Please note that:

- The stromatolite localities listed here represent only a *small sample* of those present at surface within the combined SPP project area (with further stromatolitic horizons present beneath the surface).
- All the recorded stromatolite occurrences are of common button to domical or cushion types that occur widely within the outcrop areas of the Monte Christo Formations. They are therefore *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.
- Given (1) the low levels of visibility due to summer grasses as well as time constraints during the site visit as well as (2) the limited data on Monte Christo Formation stromatolite assemblages in the scientific literature, it is recommended that, if the SPP projects are authorized, a photographic record of representative well-preserved stromatolites within the combined SPP project area is compiled by a professional palaeontologist during the dry (winter season) and *before* construction commences.

LOC	GPS DATA	COMMENTS
003	26 01 18.5 S 26 06 13.3 E	Thin- to medium-bedded silicified sediments (quarzites / dolarenites) with small scale stromatolitic domes.
009	26 01 12.3 S 26 06 11.9 E	Extensive, low exposures of silicified carbonates with pustular to crinkly microbialites, stromatolitic microdomes, dispersed small scale, smooth domical stromatolites.
010	26 01 11.9 S 26 06 11.0 E	Carpet of closely-packed, small-scale micro-stromatolitic buttons and domes with crinkly lamination impregnated with dark ferromanganese minerals.
012	26 01 12.6 S 26 06 09.3 E	Small-scale silicified stromatolitic pinnacles composed of button-like microstromatolites.
013	26 01 12.6 S 26 06 09.3 E	Secondary chert horizon preserving finely-spaced stromatolitic lamination.
013a	26 01 11.5 S 26 06 09.2 E	Carpet of closely-packed, small-scale micro-stromatolitic buttons and domes with crinkly lamination impregnated with dark ferromanganese minerals.
021	26 00 37.4 S 26 06 56.6 E	Large float blocks of grey, thin- to medium-bedded unsilicified dolostone, locally with subtle columnar stromatolites.
022	26 00 40.0 S 26 06 56.4 E	Low exposures of karstified grey stromatolitic dolomite with stromatolitic lamination and possible pseudo-stromatolites generated by precipitation of isopachous cement.
023	26 01 03.8 S 26 07 01.8 E	Low exposures of karstified grey stromatolitic dolomite containing small scale domical to columnar stromatolites, thin cherty interbeds with possible small-scale stromatolites or interference-rippled microbialites.
027-059	26 01 37.5 S 26 06 15.8 E to 26 01 33.6 S 26 06 19.7 E	Extensive SW-NE trending zone comprising low exposures of grey, partially silicified dolomite with various types of prominent-weathering, dispersed to closely-packed ,secondarily silicified and sometimes ferromanganese-impregnated stromatolites (pustules, small buttons, low pinnacles composed of mini-stromatolite buttons, smooth, crinkled to pustulose, medium-scale domes and low rounded cushions, occasional *equivocal* larger domes up to 75 cm across *etc*). Stromatolites may occasionally have formed low patch reefs on sea floor. Underlying grey dolostones locally also stromatolitic but microbialites are generally obscure when not silicified.
062	26 01 54.8 S 26 06 16.5 E	Low ridge of grey-brown, very vuggy silicified carbonate, in part ferruginized (darker on satellite images) – possibly a palaeoreefal structure (equivocal).

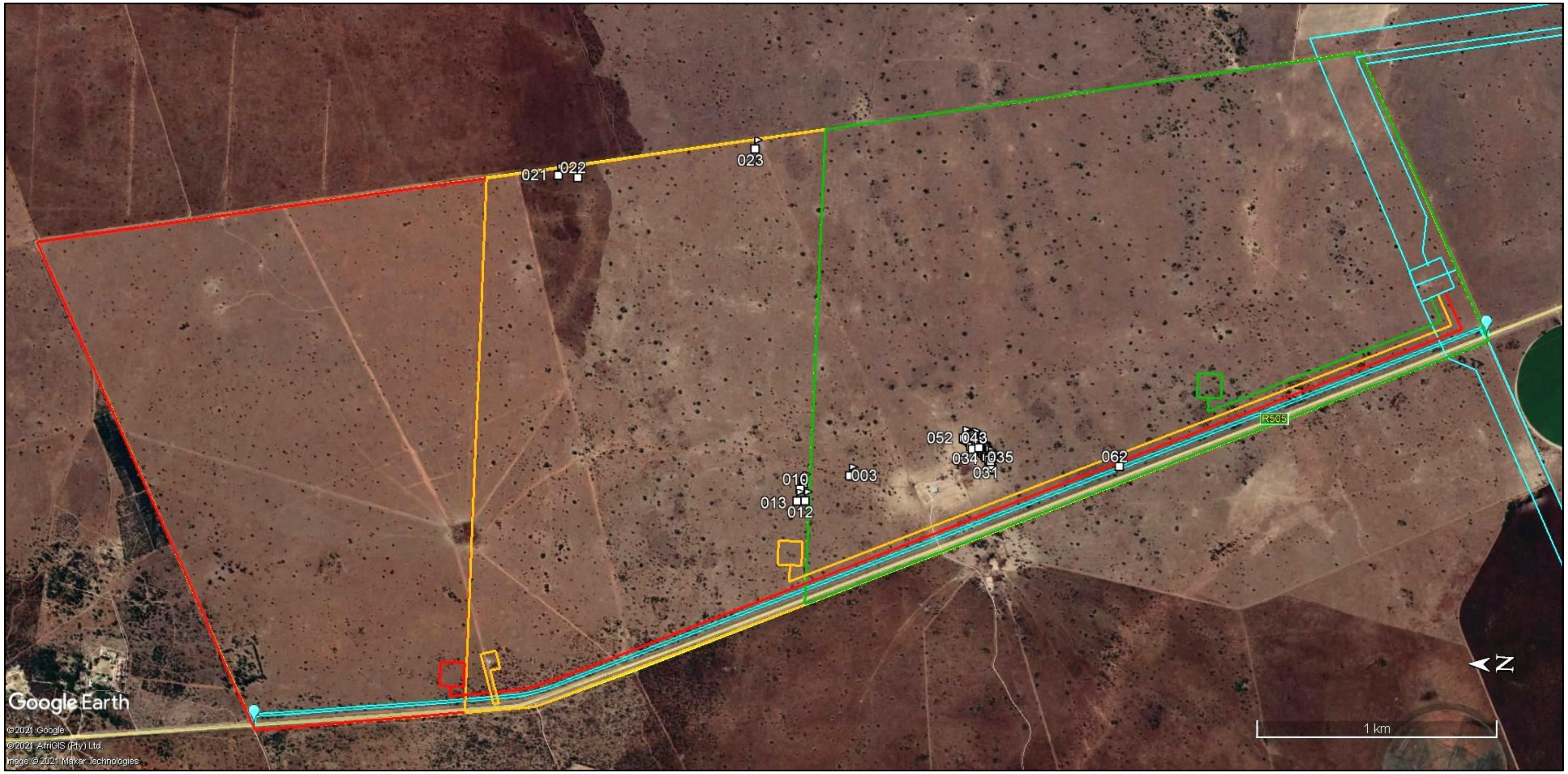

Figure A1: Google Earth© satellite image of the combined SPP project areas on Portion 4 of the Farm Houthaaldoorns 2 near Lichtenburg (N towards the LHS of the image) showing numbered fossil stromatolite sites recorded within the Malmani Subgroup bedrocks during the site visit (See Appendix 1 for GPS locality details). *N.B.* These represent only a *small* fraction of stromatolites preserved at surface within the area. The great majority of these stromatolite occurrences are of common button to domical or cushion types that probably occur widely within the outcrop area of the Monte Christo Formation outside the project area. They are therefore not considered to be of high scientific or conservation value here (Proposed Field Rating IIIC Local Resource) and no special mitigation measures regarding them are proposed. There is also potential for palaeontologically highly-sensitive breccia infills of karstic solution features within the carbonate bedrocks within the project area; these are best detected by geophysical surveying and may require pre-construction specialist mitigation

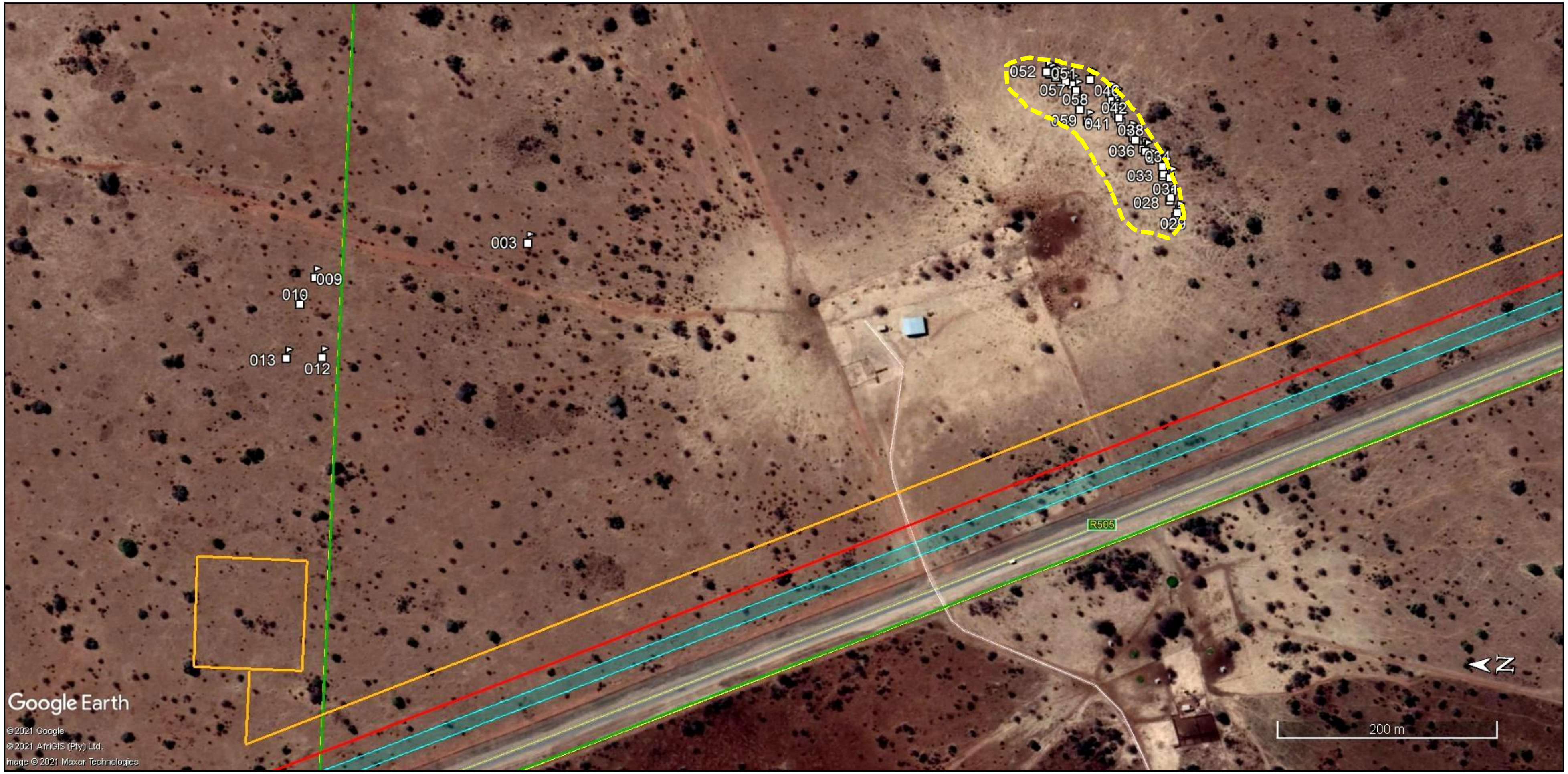

Figure A2: Google Earth© satellite image showing a central western sector of Portion 4 of the Farm Houthaaldoorns 2 (part of the Kutlwano SPP project area) east of the R505 tar road. Note the especially high concentration of stromatolitic occurrences here in low silicified dolomite exposures to the south of the main farm buildings (outlined by dashed yellow polygon). These fossiliferous exposures do not show up clearly in satellite images. It is not proposed here that the stromatolite-rich area should be excluded from the project footprint since the stromatolites concerned are rated as of low scientific / conservation value (Proposed Field Rating IIIC Local Resource) while comparable stromatolite-rich exposures probably occur widely within the outcrop area of the Monte Christo Formation outside the combined SPP project areas

<table>
<tr><td colspan="3">APPENDIX 2: CHANCE FOSSIL FINDS PROCEDURE: Lerato Solar Power Plant on Portion 4 of the Farm Houthaaldoorns 2 near Lichtenburg</td></tr>
<tr><td>Province & region:</td><td colspan="2">North West Province: Ditsobotla 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, possible Cretaceous / Neogene silcretes, Late Caenozoic karstic solution hollow infills, Pleistocene to Holocene sands, downwasted residual surface gravels.</td></tr>
<tr><td>Potential fossils</td><td colspan="2">Stromatolites (domes, columns etc, often secondarily silicified) within Precambrian bedrocks. Possible Plio-Pleistocene of older bone breccias within karstic solution hollows (macro- and micro-mammalian remains), petrified wood within silcretes or ancient fluvial gravels. 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>