Annex H

Archaeological, Heritage and Paleontological Specialist Report

HERITAGE IMPACT ASSESSMENT (ARCHAEOLOGY AND PALAEONTOLOGY): PROPOSED OLYVEN KOLK SOLAR POWER PLANT, NORTHERN CAPE PROVINCE

(Assessment conducted under Section 38 (8) of the National Heritage Resources Act as part of an EIA.)

Prepared for:
ERM

On behalf of:
AES Solar Energy Limited

Prepared by:

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EXECUTIVE SUMMARY

ACO Associates cc have been appointed by Environmental Resources Management Southern Africa (Pty) Ltd (ERM) on behalf of the proponent, AES Solar Energy Limited (AES), to undertake a Heritage Impact Assessment (archaeology and palaeontology), as part of the EIA process, for the establishment of a 190 MW solar power plant on the Olyven Kolk Farm located approximately 36km due south east of Kenhardt in the Northern Cape Province. Visual impact is assessed as a separate study.

The proposed areas that will be utilised for the solar arrays were examined for archaeology and built environment issues by way of fieldwork undertaken on the 4th and 5th June 2011. It involved a walk and drive survey of the proposed solar array sites within the overall farm boundary. Given the uniformity of the site, our observations can be projected more broadly. A desktop palaeontological study was also undertaken.

No significant limitations to conducting the survey were encountered.

<u>Heritage Findings:</u>

The Pre-colonial Archaeology:

- Archaeological sites are present in the form of stone artefact scatters from the Early stone age (ESA), Middle stone age (MSA) and Late stone age (LSA).
- Artefact scatters tend to be widespread rather than discrete and are found on extensive gravel pavements between scrub vegetation;
- The absence of associated organic material, and lack of discrete individual sites reduces the significance of the material overall;
- Further mitigation of sites is considered unnecessary in this case.

Palaeontology:

- The palaeontological sensitivity of the rock units within the study area is generally low.

The Built Environment:

- There are no buildings of heritage significance on the site.

Graves:

- No surface traces of graves were observed

Cultural Landscape:

- The proposed solar plant is isolated and will not be visible from any scenic route;
- The cultural landscape is agricultural in nature, exclusively stock farming; and
- The visual impact of the solar plant will be assessed by a separate Visual Impact Assessment.

Summary

The potential impacts resulting from the installation of a solar power plant (including solar panels, roads, power lines, operational facilities) on heritage resources are all considered to be of minor significance, and no mitigation is recommended.

1. INTRODUCTION

1.1 Overview and context

ACO Associates cc have been appointed by ERM on behalf of the proponent, AES, to undertake a Heritage Impact Assessment, as part of the EIA process, for the establishment of a solar power plant within the boundary including Portions 14 (a portion 4 of portion 4, and portion 15) of the farm Olyven Kolk 187, situated approximately 36 km due southwest of Kenhardt, in the Northern Cape Province (Figure 1).

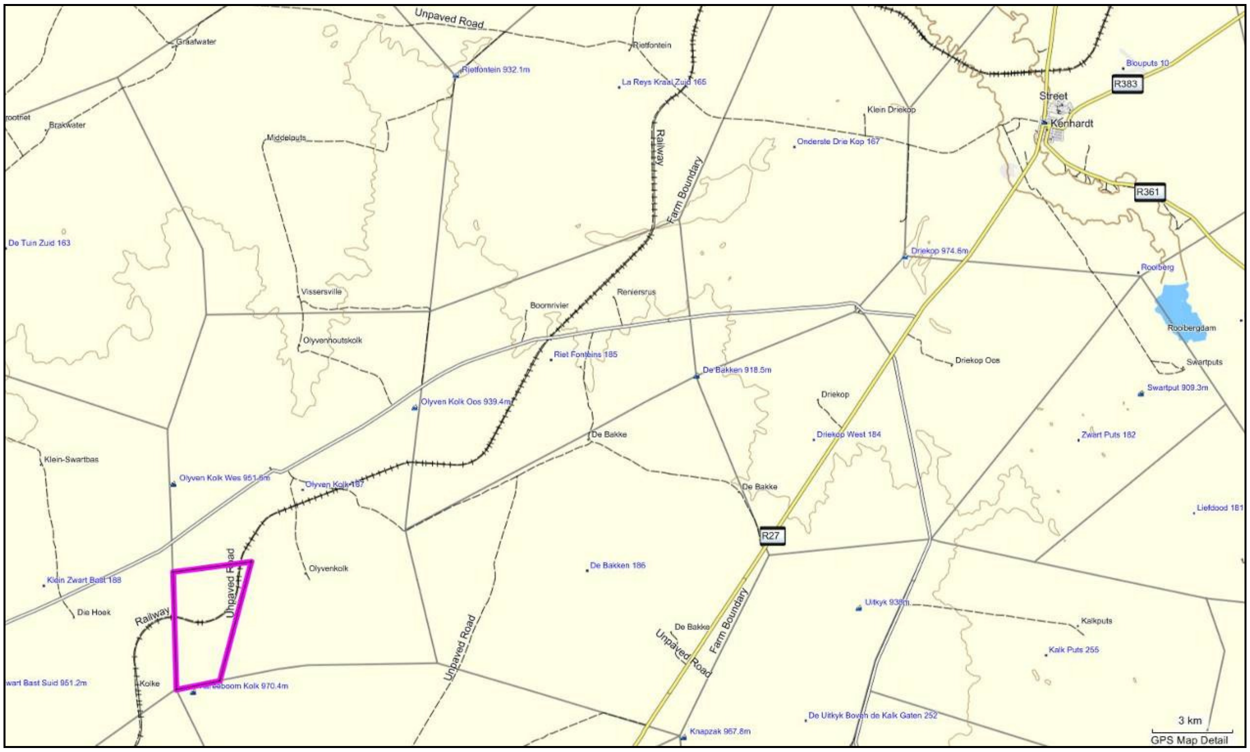

Figure 1: The location of the site (purple polygon) in regional context. Key features include the town of Kenhardt to the north east, and the Sishen-Saldanha railway which bisects the site. (Mapsource).

1.2 Development Proposals

The proposed development includes the installation and operation of solar panels with a projected output of up to 190 MW. Constraints and limitations on the site that were identified during the initial EIA studies, were used to inform the final layout of infrastructure (Figures 2,3) . The area of the proposed site overall is approximately 1010.47 ha (10.1 km^2) while the footprint of the solar panels will be around 357.73 ha (35.4 percent of the site, Figure 2A) when the full 190 MW is installed (Figure 3). PV arrays would include rows of panels which would extend across the site. Some space is necessary between rows of solar panels to minimise shadow effects from one row to the next, and will remain free from any construction or impact. Panels would be mounted on metal frames, supported by poles which will be screwed or piled into the ground, depending on the substrate type encountered and prevailing wind conditions. The panels will be north facing in order to capture the maximum sunlight.

Prior to construction, the site would be prepared as necessary, including removal of tall vegetation if present, and creating access roads, and foundations for single control and accommodation buildings. Each of the solar array areas will be fenced for security purposes rather than the whole site.

Once operational, the plant is expected to have a lifespan of some 25 years. At the end of this time the plant could be refurbished or decommissioned.

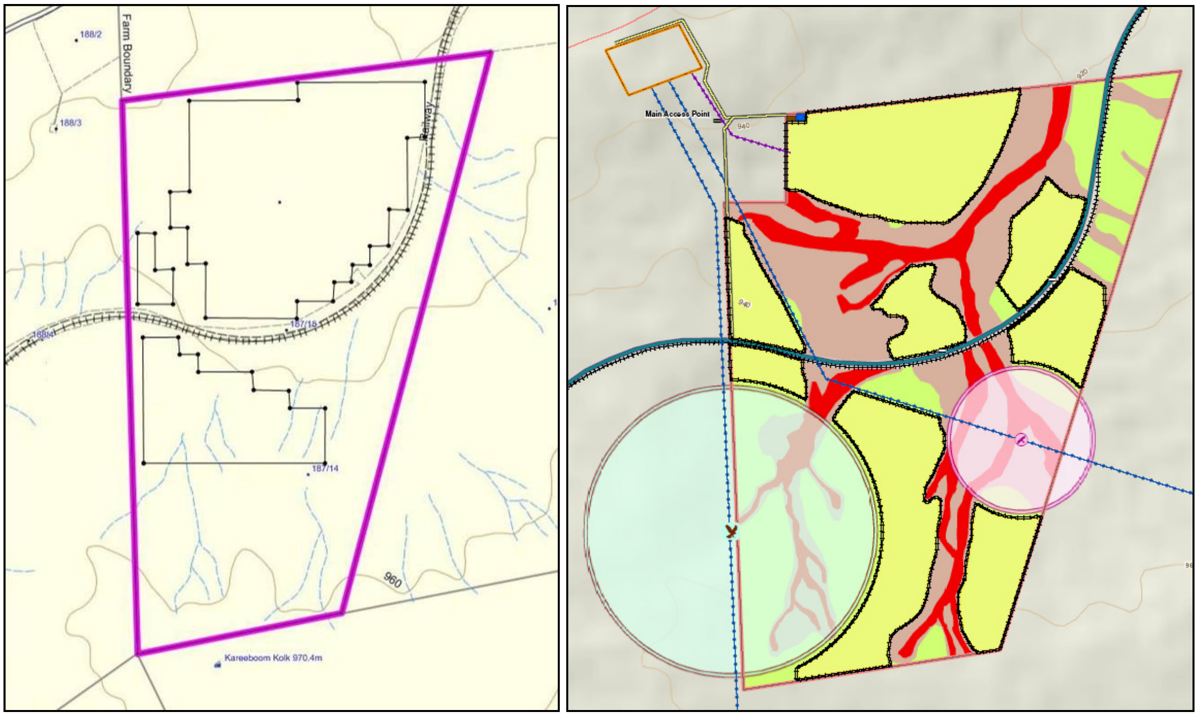

Figure 2: The original proposed Alternative Layout 1 (left), and Layout Alternative 2 (right) which has resulted from the specialist inputs on environmental sensitivity following a mitigation workshop. Yellow areas represent the areas for solar panels (see figure 3 for more detail and full key)

Figure 2A: Alternative 2 areas to be used for solar arrays with sizes indicated

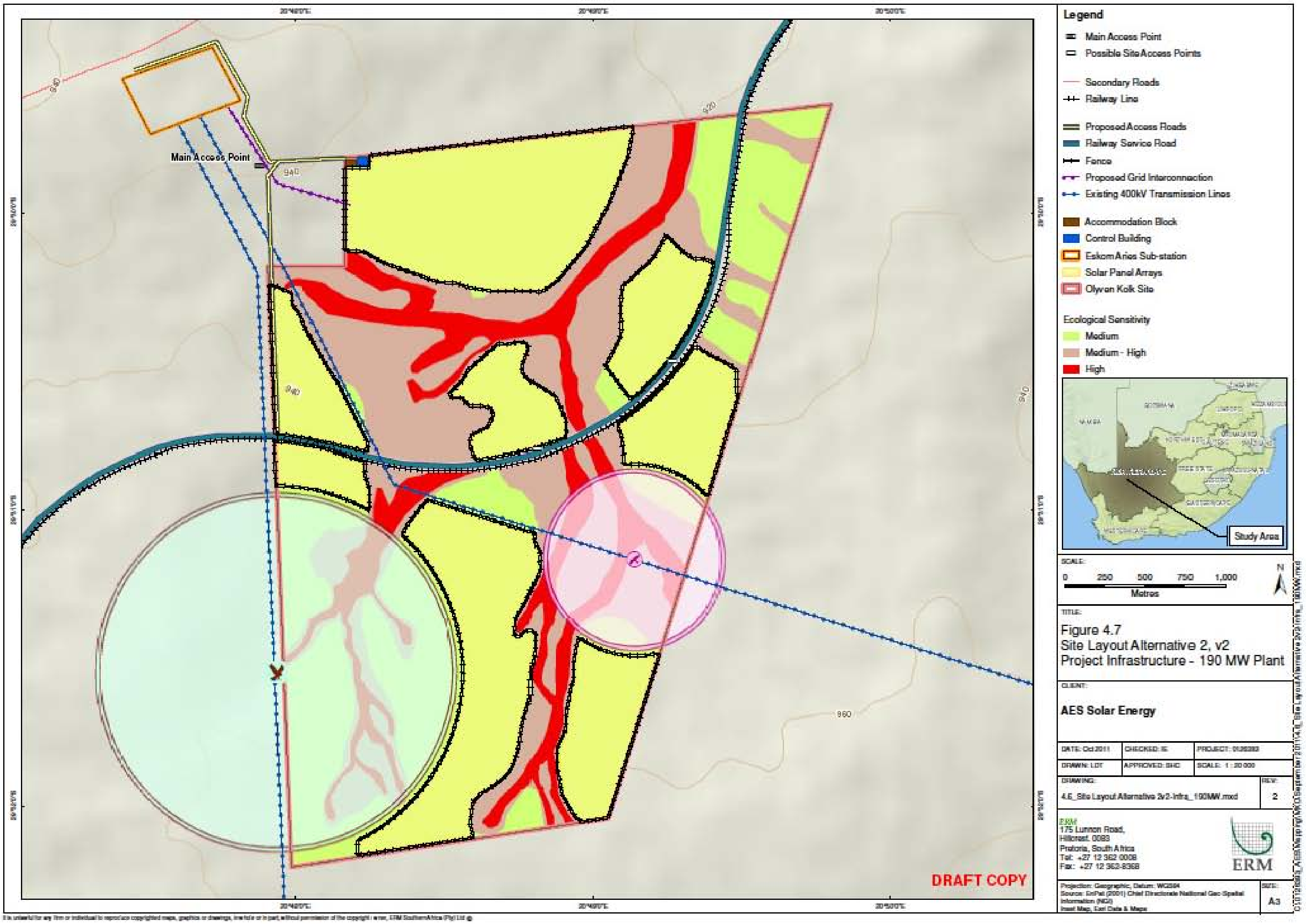

Figure 3: Proposed areas for PV arrays (yellow) within the property. Exclusion areas resulted from the initial specialist studies. (Figure used with permission of ERM).

1.3 Specialist team

David Halkett (BA, BA Hons, MA (UCT)) is an Archaeologist. and Member of the Association of Professional Archaeologists of Southern Africa accredited with Principal Investigator status. He has been working in heritage management for 23 years and has considerable experience in impact assessment with respect to a broad range of archaeological and heritage sites including those in the Northern Cape. He is a member of the Archaeology, Palaeontology and Meteorites Committee and the Impact Assessment Committee of the Heritage Western Cape (HWC), the Provincial Heritage Resources Authority.

Jayson Orton (BA, MA (UCT)) is an archaeologist with 7 years of working experience in heritage consultancy. He is a member of the Association of Professional Archaeologists of Southern Africa accredited with Principal Investigator status. He has worked on a number of impact assessment projects in the Northern Cape.

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 under the aegis of his Cape Town-based company Natura Viva cc. He is 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 APHAP (Association of Professional Heritage Assessment Practitioners - Western Cape).

1.4 Declaration of Independance

Mr David Halkett, Mr Jayson Orton and Dr John Almond are independent specialist consultants who are in no way connected, financially or otherwise, with the proponent, other than in the delivery of consulting services on the project.

2. REGULATORY AND LEGISLATIVE OVERVIEW

The basis for all heritage impact assessment is the National Heritage Resources Act 25 (NHRA) of 1999, which in turn prescribes the manner in which heritage is assessed and managed. The National Heritage Resources Act 25 of 1999 has defined certain kinds of heritage as being worthy of protection, by either specific or general protection mechanisms. In South Africa the law is directed towards the protection of human made heritage, although places and objects of scientific importance are covered. The National Heritage Resources Act also protects intangible heritage such as traditional activities, oral histories and places where significant events happened. Generally protected heritage which must be considered in any heritage assessment includes:

- Cultural landscapes (described below)
- Buildings and structures (greater than 60 years of age)
- Archaeological sites (greater than 100 years of age)
- Palaeontological sites and specimens
- Shipwrecks and aircraft wrecks
- Graves and grave yards.

Section 38 of the NHRA requires that Heritage Impact Assessments (HIA's) are required for certain kinds of development such as rezoning of land greater than 10 000 m2 in extent or exceeding 3 or more sub-divisions, or for any activity that will alter the character of a site greater than 5000 m^2. Only the Western Cape and Kwa-Zulu Natal have functioning Provincial Heritage Authorities, and consequently SAHRA administers heritage in the remaining provinces particularly where archaeology and palaeontology are the dominant concerns. Heritage Northern Cape (Ngwao Boswa Kapa Bokoni) deals largely with built environment issues at this stage. Amongst other things Boswa administers:

- World Heritage Sites
- Provincial Heritage Sites
- Heritage Areas
- Register Sites
- 60 year old structures
- Public monuments & memorials

Archaeology, including rock art, graves of victims of conflict and other graves not in formal cemeteries are administered by the national heritage authority, SAHRA. [1]

2.1 Cultural Landscapes

Section 3(3) of the NHRA, No 25 of 1999 defines the cultural significance of a place or objects with regard to the following criteria:

(a) its importance in the community or pattern of South Africa's history;
(b) its possession of uncommon, rare or endangered aspects of South Africa's natural or cultural heritage;
(c) its potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage;
(d) its importance in demonstrating the principal characteristics of a particular class of South Africa's natural or cultural places or objects;

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[1] http://www.northern-cape.gov.za/index.php?option=com_content&view=article&id=321

(e) its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group;
(f) its importance in demonstrating a high degree of creative or technical achievement at a particular period;
(g) its strong or special association with a particular community or cultural group for social cultural or spiritual reasons;
(h) its strong or special association with the life or work of a person, group or organisation of importance in the history of South Africa; and
(i) sites of significance relating to the history of slavery in South Africa.

2.2 Heritage Grading

Heritage resources are graded following the system established by Winter and Baumann (2005) in the guidelines for involving heritage practitioners in EIA's (Table 1).

Table 1: Grading of heritage resources (Source: Winter & Baumann 2005: Box 5).

Grade	Level of significance	Description
1	National	Of high intrinsic, associational and contextual heritage value within a national context, i.e. formally declared or potential Grade 1 heritage resources.
2	Provincial	Of high intrinsic, associational and contextual heritage value within a provincial context, i.e. formally declared or potential Grade 2 heritage resources.
3A	Local	Of high intrinsic, associational and contextual heritage value within a local context, i.e. formally declared or potential Grade 3A heritage resources.
3B	Local	Of moderate to high intrinsic, associational and contextual value within a local context, i.e. potential Grade 3B heritage resources.
3C	Local	Of medium to low intrinsic, associational or contextual heritage value within a national, provincial and local context, i.e. potential Grade 3C heritage resources.

3. METHODOLOGY

This study has been commissioned as the heritage component of an EIA. It assesses the identified range of impacts in terms of actual observations on site and in terms of accumulated knowledge of the area based on scientific or other heritage assessments related to archaeological and palaeontological work undertaken in the broader area. An on-site foot and drive survey of heritage resources (particularly the archaeology) has been conducted and sites have been identified and mapped. The locations of the proposed PV arrays were loaded onto handheld GPS receivers (set to the WGS84 datum) to facilitate the identification of the search area during field work undertaken on 4th & 5th June 2011. Walk paths and site locations were recorded with GPS and finds were photographed and described.

The archaeological study reported on here has been significantly reliant on a physical survey of the site, but we have established that some previous work done in the wider region provides a good basis for comparison with our observations (Pelser 2011, Beaumont et al 1995; Smith 1995).

Based on the low sensitivity of the site determined by its geological context, the palaeontological study was limited to a desktop study. In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area were determined from geological maps. The known fossil heritage within each rock unit was 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 during the compilation of the final report). This data was then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008). The likely impact of the proposed development on local fossil heritage was then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature of the development itself, most notably the extent of fresh bedrock excavation envisaged.

An independent Visual Assessment forms part of the EIA.

3.1 Limitations

There were no significant physical limitations encountered when undertaking the field study and surface visibility was excellent. This part of the Northern Cape has not been intensively investigated for archaeology, but recently an assessment of material was undertaken for another proposed solar energy plant on the farm Klein Zwart Bast 188 immediately to the east of Olyven Kolk (Pelser 2011). Beaumont et al (1995) also describe making a collection of artefacts on Olyven Kolk but have not indicated where specifically that was from. We have made certain assumptions about the archaeology based on the specific landscape characteristics of the site, and knowledge of the broader archaeological issues. The lack of significant landscape features such as rock outcrops, caves, pans etc, greatly reduces the likelihood of finding significant sites.

From a palaeontological point of view, the lack of any natural exposures of bedrock on the site have meant that conclusions are broad, based on existing literature and observations elsewhere.

4. BASELINE DESCRIPTION OF THE AFFECTED ENVIRONMENT

The Study Area is located some 36 km southwest of Kenhardt in Bushmanland. It is a semi-arid region with summer rainfall mostly in the form of thunderstorms. The knee high bushy vegetation is sparse over the fairly flat site which lacks any major relief features (Plates 1 & 2). At the time of the survey, there was significant grass cover following good rains. Numerous bare gravel and rock covered pavements occur across the site on which we find most of the archaeological material. In places, the surface is covered by shallow orange wind blown sand which obscures the gravel pavement. There is some variation of surface caused by shallow drainage channels but these are scarcely visible in the field other than moderate increase in vegetation. The north western part of the site slopes up in the direction of the visually prominent Aries electrical substation. Occasional rock outcropping is noted to the north of the railway line while to the south, small outcrops were more common, though still very low to the ground and localised. The types of rock are variable but include grey quartzitic material in slabs often tilted vertically. Dolomite is also noted.

There are two major powerlines connecting into the sub-station (Eskom's Aries-Kronos and Aries-Juno 400 kV lines). One of these runs down the western edge of the site while the other crosses diagonally more or less through the middle of the site itself (Figure 3). Other prominent man-made elements include the Sishen-Saldanha railway line and its service road that loop through the site. There is one labourer's cottage and an associated informal structure on the site. Both appear to be recent in age and are probably associated with stock management. The usual stock fences and gates are present.

Despite the prominent human interventions at the site, it remains predominantly natural and moderately isolated, and typical of the area (Plates 1 and 2).

Plate 1: General view of the landscape looking towards the northwest from the railway service road, illustrating the flatness and sparse scrub and grass vegetation. The Aries sub-station is visible at left on the skyline.

Plate 2: Looking north towards the powerline that crosses the site. Aries sub-station visible on the skyline at left behind a pylon.

5. FINDINGS

The location of archaeological sites identified and walk paths undertaken during the archaeological field investigation are shown in Figure 4.

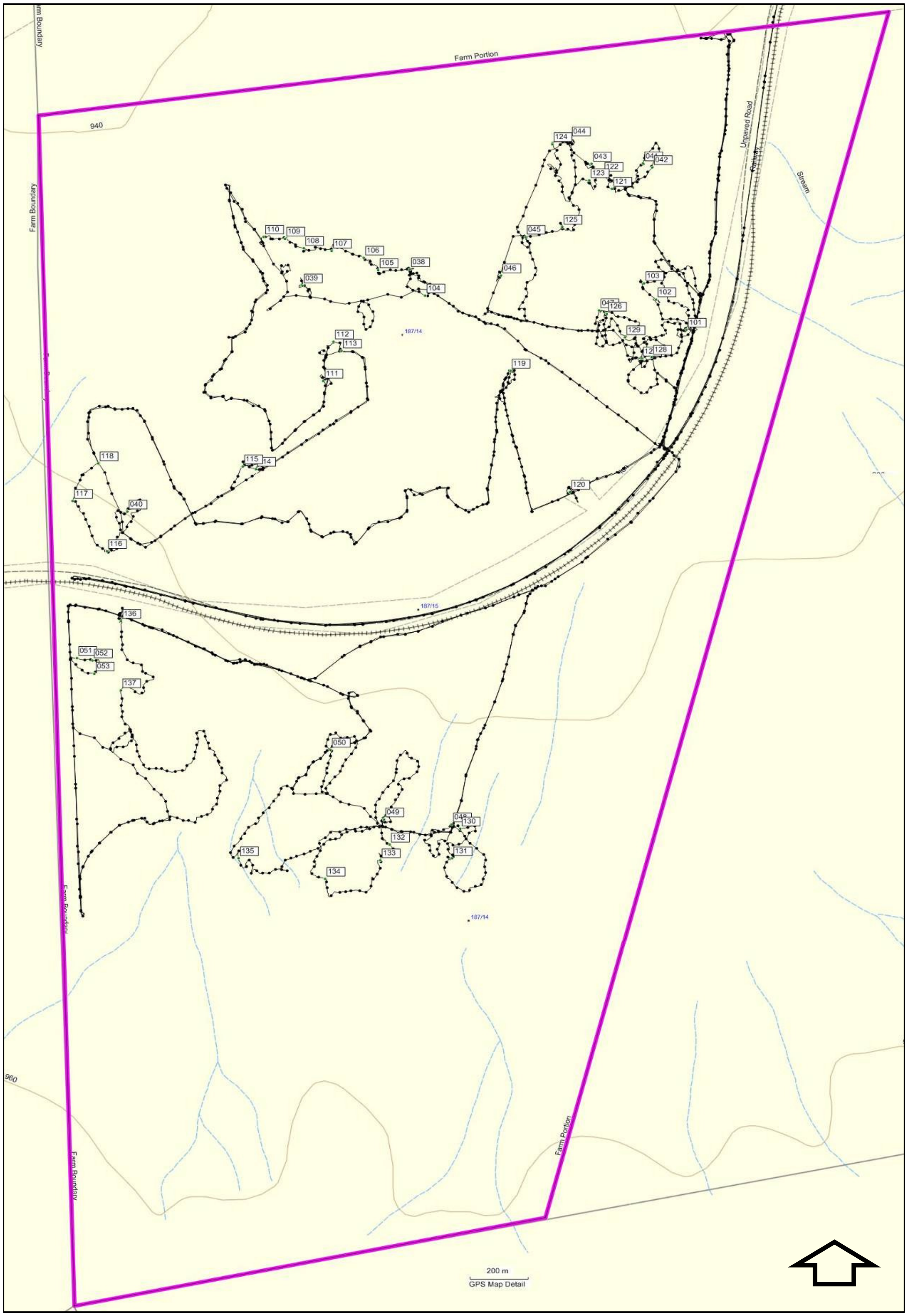


Figure 4: Site boundary (purple) archaeological sites (green dots labelled), and walk paths (black with dots)

5.1 Palaeontology

The detailed palaeontological report is presented in Appendix 2. Palaeontology is a specialist field and one of the components that must be considered as part of a broader Heritage Impact Assessment as required by the NHRA. In summary, the site of the proposed solar power plant is underlain by glacial-related sediments of the Permo-Carboniferous Dwyka Group (Mbizane Formation) that are generally of low palaeontological sensitivity. The main categories of fossils recorded from the Mbizane beds include a small range of interglacial trace fossils, petrified woods and other plant materials, palynomorphs and supposed stromatolites (the last possibly spurious). Quaternary aeolian sediments of the Gordonia Formation (Kalahari Group) as well as alluvial gravels, sands and calcretes of comparable age, all of low palaeontological sensitivity, are also represented within the study area. Fossils preserved within alluvial sediments will be largely safeguarded by the proposed final layout that avoids drainage areas.

5.2 Built Environment

There are two buildings on the site (Plates 3 & 4) situated close together. One is a shed built with corrugated iron , while the other is a small brick dwelling (labourer's cottage) with a metal sheet lean to. Neither of these constitutes significant heritage.

Plates 3 & 4: Two small structures on the site are of relatively recent construction

5.3 Pre-colonial Archaeology

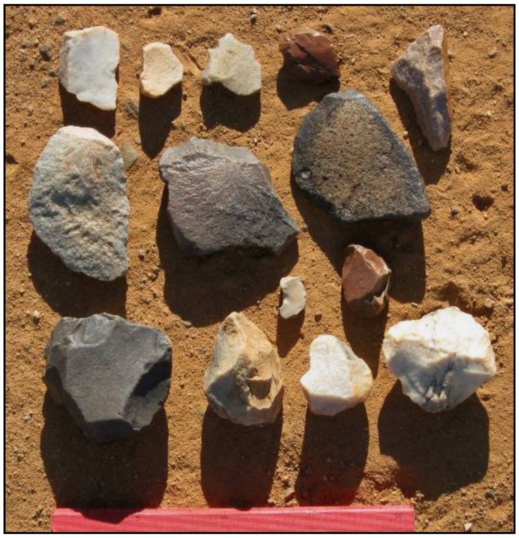
Although our main observations were made on the northern two thirds of the site, it was absolutely clear that the these would apply to the site as a whole. Numerous stone artefacts were recorded across the surface of the northern area on extensive gravel pavements (Plate 5). In fact there were only few areas where surface traces were absent, largely due to the surface being obscured by windblown sand. In some areas density appeared higher but it would be difficult to define individual sites and scatters. All observations made are of the surface and there were no indicators that would suggest there would be deeply stratified material anywhere on the site (for example caves). No associated organic remains were noted with any of the stone scatters.

A few isolated large implements were recovered which resembled sub-classic bifaces (ESA) but the items were very weathered and observations remain equivocal (Plates 5 & 6). One clear biface of a size suggestive of Fauresmith type was recognised (Plate 7). Most of the material we observed can probably be ascribed to the Middle Stone Age (MSA) (Plates 8 & 9), and distinctive flakes were noted some of which were retouched (Plates 10 & 11). There were also 2 scatters of stone tools with a fresh appearance interpreted as Late Stone Age (LSA), although no distinctive formal LSA implements were recovered or noted (Plates 12 - 15). We found 3 typical lower grindstones in close association with these artefacts seeming to confirm our interpretation. No LSA ceramics were observed nor were any organic materials found in association.

The patination and sandblasting on many of the artefacts is consistent with significant vintage. Flakes, blades, chunks and cores make up the majority of the scatters, and retouch was present on some items. The most predominant raw material was grey quartzite with some fine grained chert also noted.

Plate5: Typical gravel pavement context where most stone artefacts are found

Plates 6-8: Bifaces are uncommon on the site and the leftmost two examples are adjudged to be sub-classic handaxes from the ESA period. The biface example at right is fresher in appearance and displays greater workmanship, possibly a Fauresmith type variant. This was the only clear example seen on the site (left J113, middle D049, right J118).




Plates 8& 9: Middle Stone Age artefacts made primarily on local quartzite (left J122, right J125).


Plates 10 & 11: Distinctive MSA flakes with retouch (left D043, right D048


Plates 12 & 13: A number of fresh flakes and cores in association with a lower grindstone at J127 are adjudged to be LSA artefacts.

Plates 14 & 15: A number of fresh flakes and cores in association with a lower grindstone at J128 are adjudged to be LSA artefacts. Younger material was deposited on older scatters

5.4 Graves

Due to the lack of any discernible historic settlements, coupled with the rocky nature of the site in general, it was considered unlikely that graves would be found on site. While there is considerable evidence for stone age use of the area, formal burials have never been found in South Africa that date to the MSA, and while graves from the LSA are found from time to time, these tend to be found in softer soils, as would also have been the case in the colonial period. No typical surface grave markers were observed and we consider it highly unlikely that any graves are present on the site.

5.5 Cultural Landscape

The affected portions of Olyven Kolk 187 represent very typical landscape characteristics for the area. Flat, featureless with scrubby low vegetation and bare patches of gravel pavement, the farm continues to be used for small stock farming. Man made features in the form of the Aries sub-station, two powerlines and the Sishen-Saldanha railway and service road are the most visible features located within the site or in close proximity. The non-industrial built environment on the farm is marginal. The cultural landscape of the solar plant site, as defined in Section 3.1 above, is therefore considered to be of low significance.

6. IMPACT IDENTIFICATION AND ASSESSMENT

6.1 Impact identification and mitigation

The activities likely to result in impacts to archaeology include: site preparation, creation of roads, construction of buildings and installation of cables. Installation of the solar panel frames will be secondary to the previous activities and so would the impacts would be minor. Drilling or screwing frames into place would however represent a possible threat to palaeontological resources if they existed on site.

There is little or no difference between the impacts of Alternate layout 1 or Alternate layout 2.

6.1.1 Palaeontology

The site of the proposed solar power plant is underlain by glacial-related sediments of the Permo-Carboniferous Dwyka Group (Mbizane Formation) that are generally of low palaeontological sensitivity. The main categories of fossils recorded from the Mbizane beds include a small range of interglacial trace fossils, petrified woods and other plant materials, palynomorphs and supposed stromatolites (the last possibly spurious). Quaternary aeolian sediments of the Gordonia Formation (Kalahari Group) as well as alluvial gravels, sands and calcretes of comparable age, all of low palaeontological sensitivity, are also represented within the study area.

Mitigation and management of impacts

Further specialist palaeontological mitigation of this project is not considered necessary. Should substantial fossil remains be exposed during construction however, these should be recorded (GPS, photos), safeguarded if possible in situ, and SAHRA should be notified by the ECO so that appropriate mitigation can be considered.

6.1.2 Archaeology

Extensive scatters of stone artefacts dating from the ESA and MSA and LSA will be impacted by the proposed activities.

Mitigation and management of impacts

The lack of stratified archaeological deposits and associated non-lithic materials limit its scientific value. We have photographed and recorded small collections of material across the solar plant site and believe that these are representative of the material as a whole. Further mitigation is unlikely to result in a greater understanding of the material and the various time periods, and as a result we do not believe further intervention from an archaeological point of view is necessary.

6.1.3 Graves

There is always a possibility of finding unmarked graves no matter how remote a site is. In this case however we consider it very unlikely due to the proximity of bedrock to the surface. The most likely areas would be in the softer deposits of drainage channels, which are in any event to be avoided for ecological reasons.

Mitigation and management of impacts

In the unlikely event that graves are found, (due to the proximity of bedrock to the surface), they should not be further exposed. The area should be cordoned off and the find reported to SAHRA. They would decide on the appropriate action which is likely to consist of exhumation.

The visual impacts will be addressed as a separate specialist study.

A mitigation workshop was held with all specialists (the palaeontologist was unable to attend) who presented their findings. Based on those presentations, a new Alternate Layout 2 was proposed, largely reflecting ecological concerns, where infrastructure would be placed in such a way so as to avoid drainage channels and bird nests. As there were no significant heritage issues, the new layout was acceptable to the heritage specialist.

6.2 Impact assessment

The impact assessment methodology used in the accompanying Tables was provided by ERM. Since there no real differences in the impacts on heritage resources of Alternative Layouts 1 or 2, these are both considered together.

6.2.1 Archaeology

Scatters of Stone Age artefacts were recognised, mainly on extensive gravel pavements. Some of the scatters (which lack discrete boundaries) will/may be impacted by construction and are likely to be disturbed. In general, the stone scatters are considered to be of minor significance. They are probably not in original context, and not associated with organic remains such as bone, which could provide valuable information on prehistoric lifeways.

Beaumont et al (1995:240) note that "thousands of square kilometres of Bushmanland are covered by a low density lithic scatter. The raw materials (mainly quartzite cobbles) are derived from the Dwyka till which is ubiquitous across this peneplain…" They indicate (1995:240) that systematic collection of material was undertaken on the broader Olyven Kolk Farm (indicated as site 13 on their distribution map), although a precise location for the collection is unknown at this time. In referring to the material from this and other collections in the region, they note that the material "separates out on the basis of abrasion state, into a fresh component, with advanced prepared cores, blades, and convergent points, that is ascribable to the Middle Stone Age, and a larger fraction of moderately to heavily weathered Early Stone Age. This is typified by the presence of long blades, Victoria West cores (mainly on dolerite) and an extremely low incidence of formal tools (handaxes and cleavers)…". Our observations are largely consistent with these. LSA sites are known to be present in the area too, with perhaps the best studied being the site of Droëgrond, approximately 60 km to the northwest (Smith 1995). This site contained both lithic and organic remains in tight context. Our finding of LSA lithics is therefore not unexpected. The exposed nature of the LSA at Olyven Kolk is unlikely to have favoured the preservation of non lithic remains however.

Construction (surface clearing, cables, frames, operation facilities and laydown areas) will be limited to a relatively small area of the site and other areas will remain relatively undisturbed. It is our opinion that the impact of disturbance of stone age material in the affected zones will be minimal.

The visual and impacts will be addressed as separate specialist study.

Table 1: Alternative 2: Archaeology - Construction Impacts on the pre-colonial archaeology of the study area

<table>
<tr><th></th><th>Pre- Mitigation</th><th>Post- Mitigation</th></tr>
<tr><td>Magnitude</td><td>On-site</td><td>On-site</td></tr>
<tr><td>Impact Nature/Type</td><td>Negative</td><td>Negative</td></tr>
<tr><td>Duration</td><td>Permanent</td><td>Permanent</td></tr>
<tr><td>Intensity</td><td>Negligible</td><td>Negligible</td></tr>
<tr><td>Likelihood</td><td>Definite</td><td>Definite</td></tr>
<tr><td>Significance</td><td>Minor</td><td>Minor</td></tr>
<tr><td colspan="3">Mitigation: Although some archaeological material will be impacted, the impact is considered minor. No mitigation has been suggested as this material is abundant and preserved extensively elsewhere. Lack of associated organic remains or discrete site boundaries reduces scientific value greatly. In the <u>unlikely</u> event that unmarked graves are present and found during the construction phase (proximity of bedrock), work at that location must be halted, the feature should be cordoned off and the heritage authority (SAHRA) notified. They are likely to suggest mitigation in the form of exhumation.</td></tr>
<tr><td colspan="3">Operational Phase: n/a</td></tr>
<tr><td colspan="3">Decommissioning Phase: n/a</td></tr>
</table>

Table 2: Alternative 2: Palaeontology- construction impacts of on the palaeontology of the study area

<table>
<tr><th></th><th>Pre- Mitigation</th><th>Post- Mitigation</th></tr>
<tr><td>Magnitude</td><td>On-site</td><td>On-site</td></tr>
<tr><td>Impact Nature/Type</td><td>Negative</td><td>Negative</td></tr>
<tr><td>Duration</td><td>Permanent</td><td>Permanent</td></tr>
<tr><td>Intensity</td><td>Negligible</td><td>Negligible</td></tr>
<tr><td>Likelihood</td><td>Unlikely</td><td>Unlikely</td></tr>
<tr><td>Significance</td><td>Negligible</td><td>Negligible</td></tr>
<tr><td colspan="3">Mitigation: Since the palaeontological sensitivity of the rock units within the entire study area is generally minor, the development footprint is relatively small, and extensive bedrock excavations are not envisaged, the impact significance as far as fossil heritage is concerned is likely to be negligible. Fossils preserved within alluvial sediments will be largely safeguarded by the proposed final layout that avoids drainage areas. Therefore further specialist palaeontological studies or mitigation for this project are not considered necessary. Should substantial fossil remains be exposed during construction, however, these should be recorded (GPS, photos) and safeguarded, if possible in situ, by the ECO who should also notify SAHRA so that appropriate palaeontological mitigation can be considered.</td></tr>
<tr><td colspan="3">Operational Phase: n/a</td></tr>
<tr><td colspan="3">Decommissioning Phase: n/a</td></tr>
</table>

The following table summarises the pre- and post-mitigation impact ratings of the original layout (Alternative 1) and the layout established after scoping (Alternative 2). Since the impacts on heritage resources are minor/negligible, no mitigation has been recommended. There will however still be an impact on archaeological resources from the proposed activities.

Table 3: Summary impact ratings for layout alternatives 1 and 2 for archaeology and palaeontology

Impact	**Layout Alt1 Pre-mitigation**	**Layout Alt2 Pre-mitigation**	**Layout Alt2 Residual Impact (post mitigation)**
Construction Phase			
Archaeology	minor	minor	minor
Palaeontology	negligible	negligible	negligible
Operational Phase			
Archaeology	minor	minor	minor
Palaeontology	negligible	negligible	negligible

7. CONCLUSION AND RECOMMENDATIONS

Having considered the heritage sensitivities at the site, the proposed development will have impacts of negligible to minor significance (the magnitude of the proposed development is sufficiently small, latest planning and re-design has taken into account initial concerns, and the heritage resources are considered to be of limited scientific value) on the heritage components of the site.

Heritage	**Anticipated/identified resources**	**Unanticipated Subsurface resources**
Palaeontology	Further specialist palaeontological studies or mitigation for this project are not considered necessary.	Action: Should substantial fossil remains be exposed during construction, however, these should be recorded (GPS, photos) and safeguarded, if possible *in situ*, by the ECO who should also notify SAHRA so that appropriate palaeontological mitigation can be considered.
Archaeology	Samples of artefacts photographed and described. No further mitigation required.	Action: Work at that location to cease and remains to be cordoned off. Report the find to SAHRA.
Graves	No graves identified from surface evidence.	Action: Should any graves or human remains be identified during construction, work at that location to cease and remains to be cordoned off. Report the find to SAHRA. If avoidance is not an option, it is likely that exhumation would be suggested as mitigation.

8. LIST OF DEFINITIONS AND ABBREVIATIONS

Palaeontology: *'Palaeontological'' means any fossilised remains or fossil trace of animals or plants which lived in the geological past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains or trance;*

Archaeology: *Remains resulting from human activity which is in a state of disuse and are in or on land and which are older than 100 years, including artefacts, human and hominid remains and artificial features and structures.*

Early Stone Age: *The archaeology of the Stone Age between 700 000 and 2500 000 years ago***.**

Fossil: *Mineralised bones of animals, shellfish, plants and marine animals.*

Heritage: *That which is inherited and forms part of the National Estate (Historical places, objects, fossils as defined by the National Heritage Resources Act 25 of 1999).*

Holocene: *The most recent geological time period which commenced 10 000 years ago.*

Late Stone Age: *The archaeology of the last 20 000 years associated with fully modern people.*

Middle Stone Age: *The archaeology of the Stone Age between 20-300 000 years ago associated with early modern humans.*

National Estate: *The collective heritage assets of the Nation.*

Palaeontology: *Any fossilised remains or fossil trace of animals or plants which lived in the geological past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains or trace.*

SAHRA: *South African Heritage Resources Agency – the compliance authority which protects national heritage.*

Structure (historic): *Any building, works, device or other facility made by people and which is fixed to land, and includes any fixtures, fittings and equipment associated therewith. Protected structures are those which are over 60 years old.*

Trace fossil: *The track or footprint of a fossil animal that is preserved in stone or consolidated sediment.*

Acronyms

BP	Before the Present
DEA	Department of Environmental Affairs
ESA	Early Stone Age
GPS	Global Positioning System
HIA	Heritage Impact Assessment
LSA	Late Stone Age
MSA	Middle Stone Age
NHRA	National Heritage Resources Act, No 25 of 1999
SAHRA	South African Heritage Resources Agency

9. REFERENCE LIST

Baumann, N. & Winter, S. 2005. Guideline for involving heritage specialists in EIA process. Edition 1. CSIR report No ENV-S-C 2005 053E. Provincial Government of the Western Cape: Department of Environmental Affairs and Developmental Planning.

Beaumont, P.B., Smith A.B. and Vogel J.C. 1995. Before the Einiqua: The archaeology of the frontier zone. In Smith A.B. ed. Einiqualand: Studies of the Orange River frontier. UCT Press: 236-264.

Pelser, A.J. 2011 A report on an archaeological impact assessment (aia) for the proposed solar energy plant on Klein Zwart Bast 188, Kenhardt district, northern Cape. Unpublished report AE1104 prepared for Robert De Jong & Associates. Archaetnos.

Smith A.B. Archaeological observations along the Orange River and its hinterland. In Smith A.B. ed. Einiqualand: Studies of the Orange River frontier. UCT Press: 265-300.

(see Dr Almond's report in the Appendix 2 for palaeontological references)

Appendix 1: List of heritage sites recorded during the survey

SITE	LAT S (dec deg)	LONG E (dec deg)	DESCRIPTION	GRADING
D038	29.50236100	20.81140500	gravel pavement, low density artefact scatter esa/msa	ungraded
D039	29.50289800	20.80738600	gravel pavement, low density artefact scatter esa/msa gravel pavement, possible biface	ungraded
D040	29.51037100	20.80081100	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
D041	29.49887000	20.82015400	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
D042	29.49899500	20.82051200	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
D043	29.49888100	20.81822500	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
D044	29.49805100	20.81743900	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
D045	29.50129300	20.81574400	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
D046	29.50256500	20.81483200	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
D047	29.50371500	20.81850900	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
D048	29.52068500	20.81297900	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
D049	29.52052100	20.81044000	gravel pavement, low density artefact scatter esa/msa gravel pavement, possible biface	ungraded
D050	29.51822400	20.80843400	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
D051	29.51519600	20.79892300	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
D052	29.51528100	20.79950900	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
D053	29.51571200	20.79957600	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J101	29.50435730	20.82178400	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J102	29.50335690	20.82064720	gravel pavement, low density artefact scatter esa/msa gravel pavement, several small, fresh quartzite flakes here.	ungraded
J103	29.50282120	20.82019620	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J104	29.50322850	20.81198470	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J105	29.50239120	20.81022580	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J106	29.50198070	20.80968750	gravel pavement, low density artefact scatter esa/msa gravel pavement, ESA radial core.	ungraded
J107	29.50175370	20.80848120	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J108	29.50166260	20.80743190	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J109	29.50135290	20.80672560	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J110	29.50128900	20.80593350	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J111	29.50603920	20.80816000	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J112	29.50474800	20.80854790	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J113	29.50504830	20.80885260	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J114	29.50894470	20.80563360	gravel pavement, artefact scatter esa/msa gravel pavement quite a dense patch	ungraded
J115	29.50886150	20.80514860	gravel pavement, artefact scatter esa/msa gravel pavement quite a dense patch	ungraded
J116	29.51167260	20.80004320	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J117	29.51001720	20.79876410	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J118	29.50876080	20.79972240	gravel pavement, low density artefact scatter esa/msa gravel pavement, small biface (hand-axe) (115 x 60 x 32 mm) Fauresmith?	ungraded
J119	29.50570760	20.81518000	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J120	29.50972090	20.81741370	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J121	29.49970780	20.81899290	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J122	29.49921910	20.81866140	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J123	29.49942790	20.81814300	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J124	29.49823640	20.81675410	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J125	29.50096310	20.81712620	gravel pavement, artefact scatter esa/msa gravel pavement, very dense area	ungraded
J126	29.50382810	20.81879450	gravel pavement, artefact scatter esa/msa gravel pavement fairly dense area	ungraded
J127	29.50530750	20.82010670	usual scatter but including a proper LSA site with an upside down lower grindstone and quartz and quartzite artefacts.	3c
J128	29.50525230	20.82048270	as above but with quite a bit of CCS included. Lower grindstone found right way up	3c
J129	29.50460460	20.81948390	double-sided lower grindstone with best side found facing up. GS flaked all round the edges. Also a hammer stone/upper grindstone	ungraded
J130	29.52082200	20.81330460	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J131	29.52180190	20.81299730	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J132	29.52135060	20.81065350	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J133	29.52186920	20.81030460	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J134	29.52247870	20.80823710	concentrated scatter of pale quartzite flakes and cores in a very small area.	ungraded
J135	29.52180060	20.80498890	artefacts extremely sparse in this whole area.	ungraded
J136	29.51397710	20.80057450	gravel pavement, low density artefact scatter esa/msa gravel pavement	ungraded
J137	29.51626460	20.80057040	outcrop of fine pale quartzite that has been flaked in situ – quarry site. Only one flake in vicinity so rest were carried away.	ungraded

Appendix 2: Palaeontological report

PROPOSED AES SOLAR POWER PLANT ON THE FARM OLYVEN KOLK 187 NEAR KENHARDT, NORTHERN CAPE PROVINCE

PALAEONTOLOGICAL ASSESSMENT: DESKTOP STUDY

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August 2011

1. SUMMARY

AES Solar Energy Ltd is proposing to develop a photovoltaic (PV) solar power plant of 190 MW capacity on the farm Olyven Kolk 187, situated some 37 km southwest of the town of Kenhardt, Siyanda District Municipality and KAI!GARIB! Municipality, Northern Cape Province, RSA. The site of the proposed solar power plant is underlain by glacial-related sediments of the Permo-Carboniferous Dwyka Group (Mzibane Formation) that are generally of low palaeontological sensitivity. The main categories of fossils recorded from the Mbizane beds include a small range of interglacial trace fossils, petrified woods and other plant materials, palynomorphs and supposed stromatolites (the last possibly spurious). Quaternary aeolian sediments of the Gordonia Formation (Kalahari Group) as well as alluvial gravels, sands and calcretes of comparable age, all of low palaeontological sensitivity, are also represented within the study area. Fossils preserved within alluvial sediments will be largely safeguarded by the proposed final layout that avoids drainage areas.

Since the palaeontological sensitivity of the rock units within the entire study area is generally low, the development footprint is relatively small, and extensive bedrock excavations are not envisaged, the impact significance of the proposed 190 MW solar power plant as far as fossil heritage is concerned is likely to be **MINOR**. Therefore further specialist palaeontological studies or mitigation for this project are not considered necessary. Should substantial fossil remains be exposed during construction, however, these should be recorded (GPS, photos) and safeguarded, if possible *in situ*, by the ECO who should also notify SAHRA so that appropriate palaeontological mitigation can be considered.

2. INTRODUCTION & BRIEF

AES Solar Energy Limited (AES) is proposing to develop a PV solar power plant of 190 MW capacity adjacent to the Aries electrical substation on the farm Olyven Kolk 187. The study site is situated some 37 km southwest of the town of Kenhardt, Siyanda District Municipality and KAI!GARIB! Municipality, Northern Cape Province. The site lies to the northwest of the R27 tar road between Kenhardt and Brandvlei and is bisected by the Sishen-Saldanha railway line (Figs. 1, 2, 3). A palaeontological assessment for the proposed (120 MW) Solar Cape Photovoltaic Electricity Generation Facility also on the same farm has been provided by Almond (2011).

The proposed AES solar power plant development comprises the following major components:

- Solar panels with a projected output of up to 190 MW. These panels would be PV arrays and would include rows of panels extending across the site. The panels would be mounted on metal frames which will be screwed or piled into the ground, depending on the substrate type encountered and prevailing wind conditions. The arrays would face north in order to capture the maximum sunlight;
- New access roads;
- Power line;
- Underground power cables (where feasible);
- A control building and small ancillary buildings.

The 70 MW development would be built in phases. The final layout has been designed to minimise impact on drainage areas and other sensitive features identified within the site by various specialist studies in particular birds and terrestrial ecology studies. Once the facility is operational it is expected that the facility would have a lifespan of around 25 years.

The proposed development area overlies potentially fossiliferous bedrock of the Palaeozoic Dwyka Group as well as Quaternary sands of the Kalahari Group. A palaeontological impact assessment for the project is therefore necessary in compliance with the requirements of the National Heritage Resources Act, 1999. This desktop palaeontological assessment has accordingly been commissioned by the Archaeology Contracts Office, University of Cape Town on behalf of Environmental Resources Management (ERM) as a contribution to an Environmental Impact Assessment (EIA) for the proposed 75 MW solar power plant.

Contact details for ACO are: Tim Hart / Dave Halkett
ACO Associates cc
8 Jacobs Ladder
St James 7945
Cell 0731418606

2.1. National Heritage Resources Act

The extent of the proposed development (over 5000 m^2) falls within the requirements for a Heritage Impact Assessment (HIA) as required by Section 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999). The various categories of heritage resources recognised as part of the National Estate in Section 3 of the Heritage Resources Act include, among others:

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

Minimum standards for the palaeontological component of heritage impact assessment reports are currently being developed by SAHRA. The latest version of the SAHRA guidelines is dated May 2007.

2.2. General approach used for palaeontological impact desktop studies

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. 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 during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to the proposed development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008). 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 of the development itself, most notably 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 palaeontological field assessment by a professional palaeontologist is usually warranted. Most detrimental impacts on palaeontological heritage occur during the construction phase when fossils may be disturbed, destroyed or permanently sealed-in during excavations and subsequent construction activity. Where Phase 2 specialist palaeontological mitigation is recommended, this may take place before construction starts or, most effectively, during the construction phase while fresh, potentially fossiliferous bedrock is still exposed for study. Mitigation usually involves the judicious sampling, collection and recording of fossils as well as of relevant contextual data concerning the surrounding sedimentary matrix. It should be emphasised that, *provided* appropriate mitigation is carried out, many developments involving bedrock excavation actually have a *positive* impact on our understanding of local palaeontological heritage. Constructive collaboration between palaeontologists and developers should therefore be the expected norm.

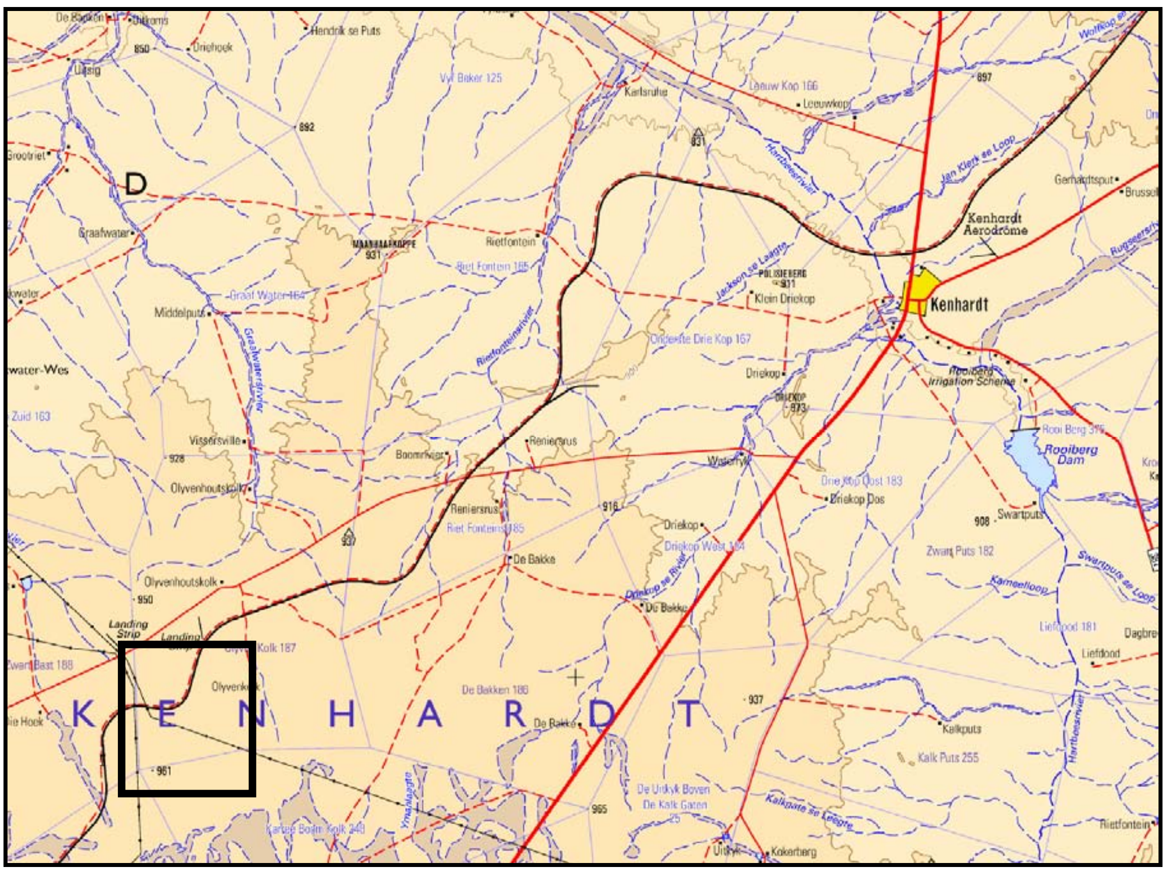

Figure 1. Extract from 1: 250 000 topographical sheet 2920 Kenhardt showing *approximate* location of the Olyven Kolk solar power plant study area (black rectangle) *c*. 37 km southwest of Kenhardt, Northern Cape Province (Courtesy of the Chief Directorate of Surveys and Mapping, Mowbray).

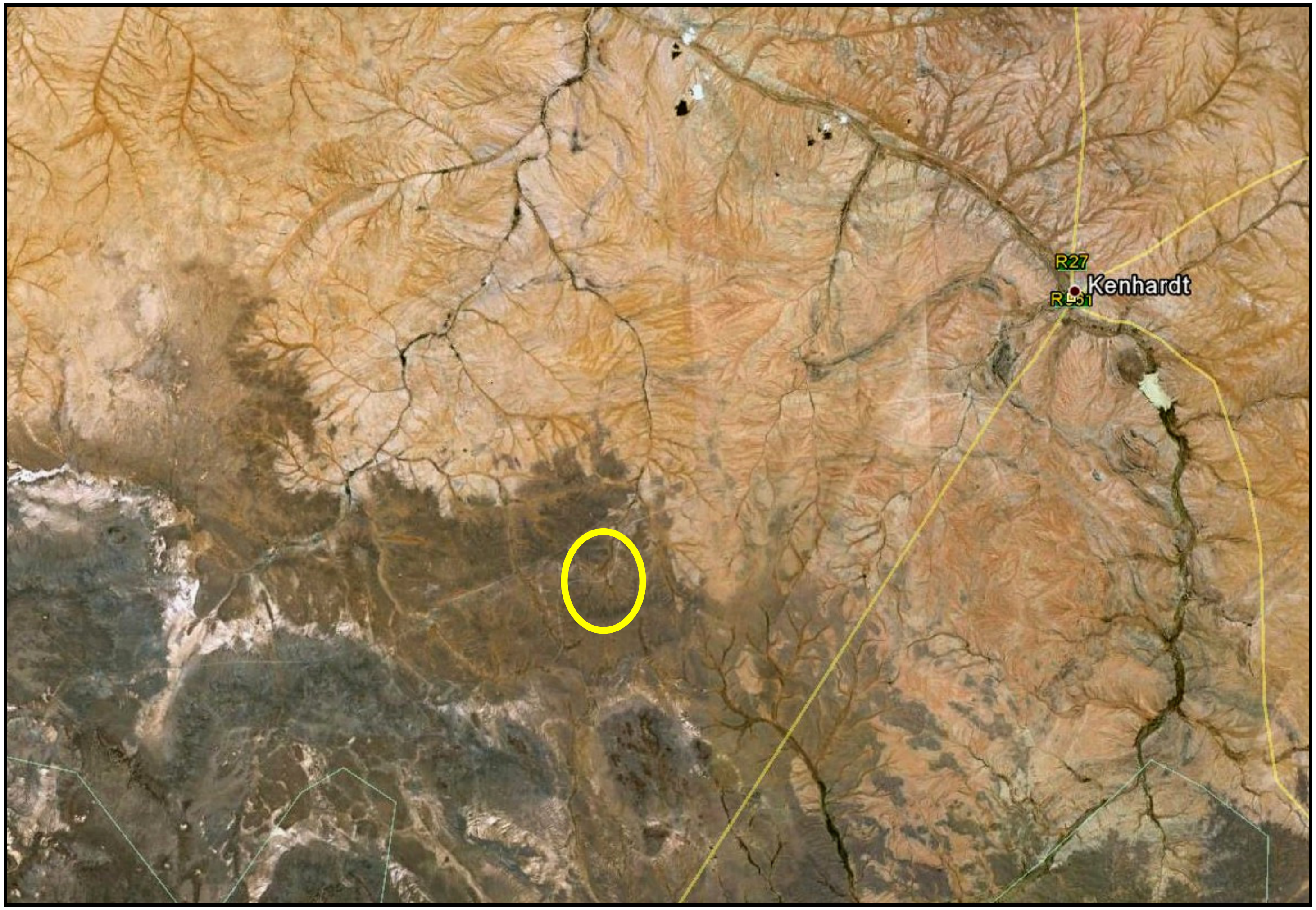

Figure 2. *Google Earth* satellite image showing the location (yellow oval) of the proposed AES solar power plant *c*. 37 km southwest of Kenhardt, Northern Cape Province. The dark grey area in the south western part of the image is underlain by glacially-related sediments of the Dwyka Group. The pale buff area to the northeast is underlain by Precambrian basement rocks mantled with Quaternary aeolian sands of the Kalahari Group (Compare geological map in Fig. 4). Note extensive erosional dissection of the landscape in this region by tributaries of the Hartbeesrivier.

3. GEOLOGICAL BACKGROUND

The Olyven Kolk study area some 37 km southwest of Kenhardt is situated in a topographically subdued, semi-arid part of eastern Bushmanland at an elevation of 915 to 960m amsl. The site is bisected by the Sishen-Saldanha railway line and lies just to the south of a dust road between Kenhardt and Pofadder. As is clear from satellite imagery (Figs. 2, 3) the region is dissected by a dendritic system of small tributaries of the Graafwater River that flows northwards into the Hartbeesrivier and thence into the Orange River. These images show a greyish background representing glacial rocks of the Dwyka Group that are locally overlain by pale buff aeolian (wind-blown) sands and darker alluvial deposits within drainage channels (*N.B.* these are both mapped as wind-blown sand at 1: 250 000 scale; Fig. 4).

Figure 3. Detailed *Google Earth* satellite image of the Olyven Kolk study area (approximately outlined by yellow polygon) straddling the Sishen – Saldanha railway line (white line) and just southeast of the Aries electrical substation. Note dendritic array of tributary streams of the Harbeesrivier drainage system, pale buff wind-blown sands, darker brown alluvium and background greyish outcrop area of the Dwyka Group.

The geology of the study area is outlined on the 1: 250 000 geology map 2920 Kenhardt (Council for Geoscience, Pretoria; Fig. 4 herein). An explanation to the Kenhardt geological map has been published by Slabbert *et al.* (1999). Several of the relevant rock units are also treated in the explanations for the adjacent 1: 250 000 sheets such as the Britstown sheet to the southeast (Prinsloo 1989), the Pofadder sheet to the west (Agenbacht 2007) and the Sakrivier sheet to the south (Siebrits 1989).

According to the Kenhardt 1: 250 000 geology map (Fig. 4) the Olyven Kolk site is underlain by the Permocarboniferous **Dwyka Group** (Karoo Supergroup, **C-Pd**). Dwyka sediments underlie most of the western portion of farm Olyven Kolk 187, with Quaternary to Recent alluvium lining the major water courses. Quaternary to Recent aeolian (wind-blown) sands and associated fluvial sediments and pedocretes of the **Gordonia Formation** (Kalahari Group, **Q**) are also mainly associated with the water courses. Unconsolidated sands here are alternately reworked by stream and aeolian processes and the two units are often conflated at 1: 250 000 scale.

3.2. Dwyka Group

Permocarboniferous glacially-related sediments of the **Dwyka Group** (**C-Pd** in Fig. 4) underlie the thin, superficial cover of Gordonia sands, calcrete and Late Caenozoic alluvium both north and south of the Orange River and crop out at surface within the study area southwest of Kenhardt. The geology of the Dwyka Group has been summarized by Visser (1989), Visser *et al.* (1990) and Johnson *et al.* (2006), among others. The geology of the Dwyka Group along the north-western margin of the Main Karoo Basin as far east as Prieska has been reviewed by Visser (1985). Other studies on the Dwyka in or near the Prieska Basin include those by Visser *et al.* (1977-78; summarized by Zawada 1992) and Visser (1982). Fairly detailed observations by Prinsloo (1989) on the Dwyka beds on the northern edge of the Britstown 1: 250 000 geology sheet are in part relevant to the more proximal (near-source) outcrops at Kenhardt. Massive tillites at the base of the Dwyka succession (**Elandsvlei Formation**) were deposited by dry-based ice sheets in deeper basement valleys. Later climatic amelioration led to melting, marine transgression and the retreat of the icesheets onto the continental highlands in the north. The valleys were then occupied by marine inlets within which drifting glaciers deposited dropstones onto the muddy sea bed ("boulder shales"). The upper Dwyka beds (**Mbizane Formation**) are typically heterolithic, with shales, siltstones and fine-grained sandstones of deltaic and / or turbiditic origin. These upper successions are typically upwards-coarsening and show extensive soft-sediment deformation (loading and slumping). Varved (rhythmically laminated) mudrocks with gritty to fine gravely dropstones indicate the onset of highly seasonal climates, with warmer intervals leading occasionally even to limestone precipitation.

According to maps in Visser *et al.* (1990) and Von Brunn and Visser (1999; Fig. 5 herein) the Dwyka rocks in the Kenhardt area close to the northern edge of the Main Karoo Basin belong to the **Mbizane Formation**. This is equivalent to the "Northern (valley and inlet) Facies" of Visser *et al.* (1990). The Mbizane Formation, up to 190m thick, is recognized across the entire northern margin of the Main Karoo Basin where it may variously form the whole or only the *upper* part of the Dwyka succession. It is characterized by its extremely heterolithic nature, with marked vertical and horizontal facies variation (Von Brunn & Visser 1999). The proportion of diamictite and mudrock is often low, the former often confined to basement depressions. Orange-tinted sandstones (often structureless or displaying extensive soft-sediment deformation, amalgamation and mass flow processes) may dominate the succession. The Mbizane-type heterolithic successions characterize the thicker Dwyka of the ancient palaeovalleys cutting back into the northern basement rocks. The key Reference Stratotype C section for the valley fill facies of the Mbizane Formation is located a few kilometres west of Douglas on the northern side of the Vaal River (Von Brunn & Visser 1999). The composite section, which overlies glacially-striated Precambrian bedrock, is some 25-30m thick. The lower part of the section consists of massive diamictites with subordinate conglomerates and siltstones. The upper half is dominated by laminated mudrocks with thin diamictites, lonestones (dropstones) and calcareous concretions.

The section is conformably overlain by mudrocks of the Prince Albert Formation (Ecca Group) which is not represented in the study area.

For details of the Dwyka Group rocks in the Kenhardt area the reader is referred to the accounts of Visser (1985) and Slabbert *et al.* (1999). The study area southwest of Kenhardt lies close to the eastern edge of the Sout River palaeovalley identified by Visser (1985, fig. 12 therein). The Dwyka succession in this area comprises both massive, muddy diamictites ("boulder shales") as well as heterolithic intervals dominated by interbedded reddish-brown, pebbly sandstones, conglomerates, and diamictite (ibid., figs. 2, 4). Slabbert *et al.* (1999, p. 107) report that the uppermost Dwyka beds contain stromatolites, oolites and calcareous concretions.

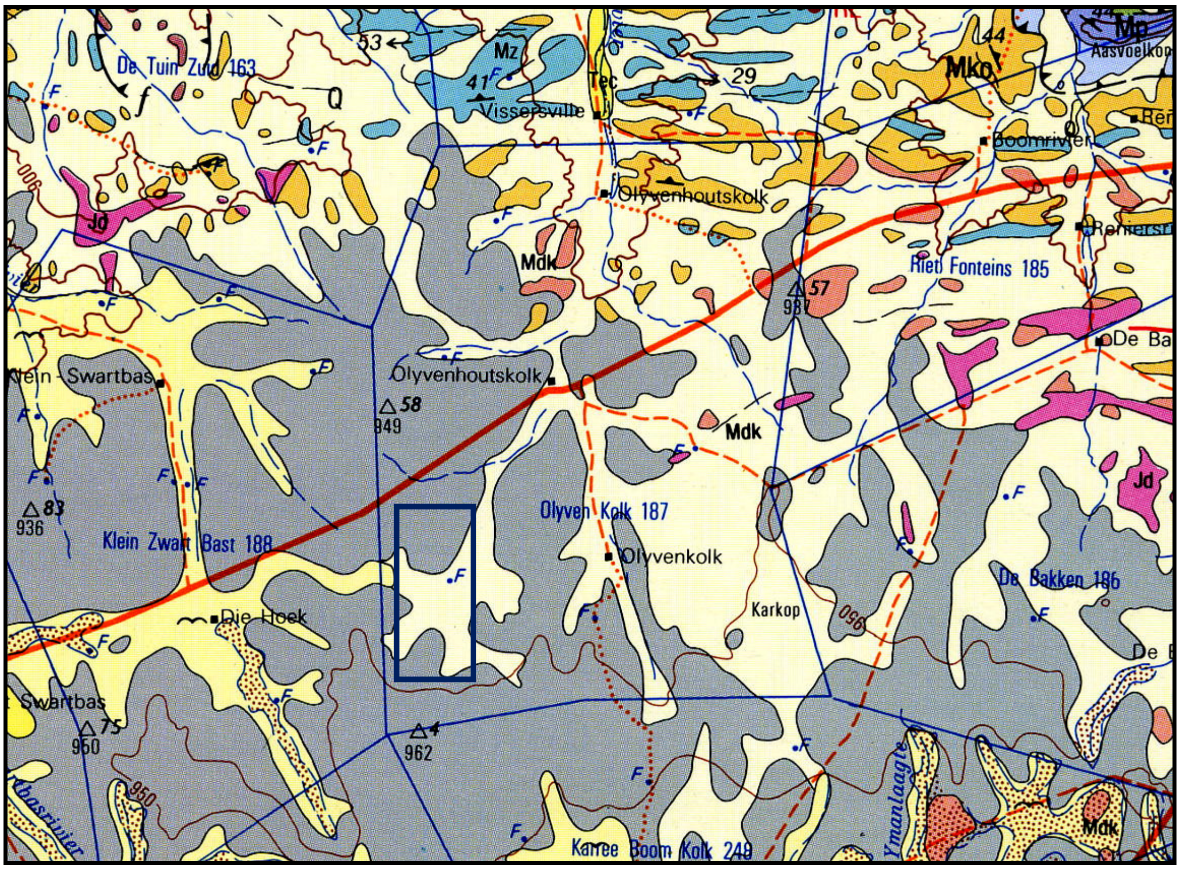

Figure 4. Extract from 1: 250 000 geological map 2920 Kenhardt (Council for Geoscience, Pretoria) showing the approximate location of proposed AES solar power plant study area on the northern part of farm Olyven Kolk 187 (dark blue rectangle). The area is underlain by Dwyka Group glacial deposits (grey) as well as Quaternary to Recent alluvium and wind-blown sand (pale yellow) that are mainly associated with shallow drainage courses.

MAIN GEOLOGICAL UNITS:
Grey (C-Pd) = Mbizane Formation (Permo-Carboniferous Dwyka Group, Karoo Supergroup)
Pale yellow (Q) = Quaternary to Recent sands and sandy soil of the Gordonia Formation (Kalahari Group)
Middle Yellow with "flying bird" symbol = Quaternary to Recent alluvium

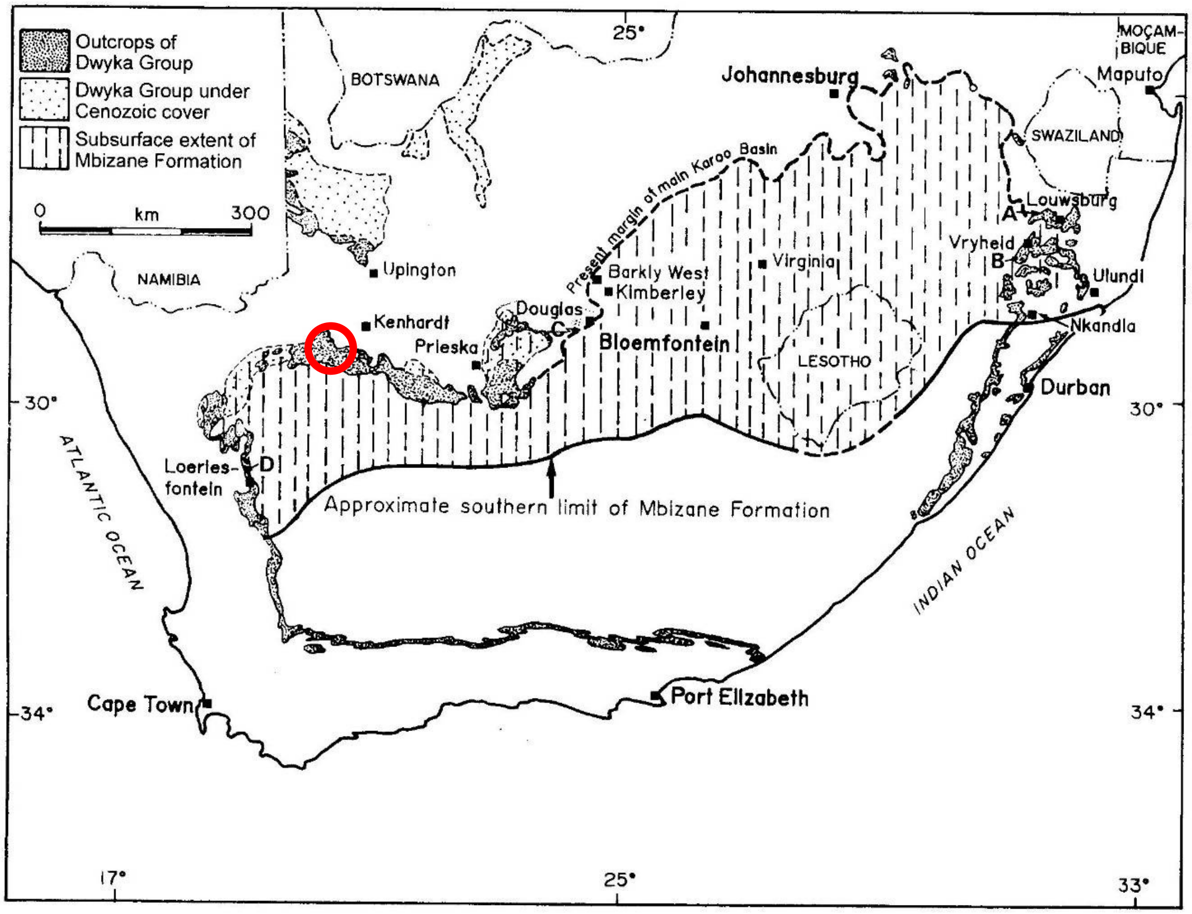

Figure 5. Outcrop map of the Dwyka Group within the Main Karoo Basin of South Africa. Exposures in the study area southwest of Kenhardt (red circle) are assigned to the outcrop area of the Mbizane Formation (From Von Brunn & Visser 1999).

3.2. Superficial deposits: Kalahari Group sands, calcretes, alluvial gravels

Unconsolidated, reddish-brown aeolian (*i.e.* wind-blown) sands of the Quaternary **Gordonia Formation** (**Kalahari Group**) (**Q** in Fig. 4) blanket large areas of the landscape in the Kenhardt area (Slabbert *et al.* 1999). The geology of the Late Cretaceous to Recent Kalahari Group is reviewed by Thomas (1981), Dingle *et al.* (1983), Thomas *et al.* (1988), Thomas & Shaw 1991, Haddon (2000) and Partridge *et al.* (2006). The Gordonia dune sands are considered to range in age from the Late Pliocene / Early Pleistocene to Recent, dated in part from enclosed Middle to Later Stone Age stone tools (Dingle *et al*., 1983, p. 291). Note that the recent extension of the Pliocene - Pleistocene boundary from 1.8Ma back to 2.588 Ma would place the Gordonia Formation almost entirely within the Pleistocene Epoch.

According to Slabbert *et al.* (1999, p. 109) Gordonia wind-blown sands in the Kenhardt area, far to the south of the main Kalahari Basin, are thin, rarely preserve longitudinal dune bedforms (these are seen along the Hartbeesrivier near Kenhardt but not further west), and are probably of Holocene age. In the study area the thin superficial blanket of sandy sediments is admixed with local weathering products of the Karoo and other bedrocks. According to these geological survey authors, the sands capping the plains west of the Hartbeesrivier might not in fact be correlated with the Gordonia Formation proper, although they are at least in part derived from the Kalahari Basin.

Late Caenozoic **alluvial deposits** of the Hartbeesrivier tributaries are not described or discussed in detail by Slabbert *et al.* (1999). In addition to finer-grained silts and sands, in the study area they probably include an admixture of coarser gravels derived from weathering of the Karoo rocks (*e.g.* polymict, bouldery erratics and pebbles from diamictites and conglomerates of the Dwyka Group). De Wit (1999) discusses the post-Gondwana evolution of the drainage systems in the Bushmanland region, including pans between Kenhardt and Brandvlei that fed floodwaters from the region *via* the Sakrivier and Hartbees Rivers into the Orange from at least the Plio-Pleistocene times (Ibid., fig. 13. See also De Wit *et al.* 2000).

4. BASELINE-PALAEONTOLOGICAL HERITAGE

The fossil heritage recorded within each of the main sedimentary rock successions occurring within the study region near Kenhardt is outlined here (See also summary provided in Table 1 below).

4.1. Fossils in the Dwyka Group

The generally poor fossil record of the Dwyka Group (McLachlan & Anderson 1973, Anderson & McLachlan 1976, Visser 1989, Visser *et al*., 1990, Von Brunn & Visser 1999, Visser 2003, Almond & Pether 2008) is hardly surprising given the glacial climates that prevailed during much of the Late Carboniferous to Permian Periods in southern Africa. However, most Dwyka sediments were deposited during periods of glacial retreat associated with climatic amelioration. Sparse, low diversity fossil biotas from the Mbizane Formation in particular mainly consist of arthropod trackways associated with interglacial to post-glacial dropstone laminites and sporadic vascular plant remains (drifted wood and leaves of the *Glossopteris* Flora), while palynomorphs (organic-walled microfossils) are also likely to be present within finer-grained mudrock facies. Glacial diamictites (tillites or "boulder mudstones") are normally unfossiliferous but do occasionally contain fragmentary transported plant material as well as palynomorphs in the fine-grained matrix. There are interesting records of limestone glacial erratics from tillites along the southern margins of the Great Karoo (Elandsvlei Formation) that contain Cambrian eodiscid trilobites as well as archaeocyathid sponges. Such derived fossils provide important data for reconstructing the movement of Gondwana ice sheets (Cooper & Oosthuizen 1974, Stone & Thompson 2005).

A limited range of marine fossils are associated with the later phases of several of the four main Dwyka deglaciation cycles (DSI to DSIV). These are especially well known in the Kalahari Basin of southern Namibia but also occur sporadically within the Main Karoo Basin in South Africa (Oelofsen 1986, Visser 1989, 1997, Visser *et al*. 1997, Bangert *et al*. 1999 & 2000, Stolhoffen *et al*. 2000, Almond 2008a, b). These deglaciation sequences are estimated to have lasted five to seven million years on average (Bangert *et al*. 1999). A range of stenohaline (*i.e.* exclusively salt water) invertebrate fossils indicates that fully marine salinities prevailed at the end of each sequence, at least in the western outcrop area (Namibia, Northern Cape). These invertebrates include echinoderms (starfish, crinoids, echinoids), cephalopods (nautiloids, goniatites), articulate brachiopods, bryozoans, foraminiferans, and conulariids, among others. Primitive bony fish (palaeoniscoids), spiral "coprolites" attributable to sharks or eurypterids, as well as wood and trace fossils are also recorded from mudrock facies at the tops of DSII (Ganikobis Shale Member), DS III (Hardap Member) and DSIV (Nossob Shale Member), as well as base of the Prince Albert Formation (Ecca Group) in southern Namibia and, in the last case at least, in the Northern Cape near Douglas (McLachlan and Anderson 1973, Veevers *et al*. 1994, Grill 1997, Bangert *et al*. 1999, Pickford & Senut 2002, Evans 2005). The Ganikobis (DSII) fauna has been radiometrically dated to *c*. 300 Ma, or end-Carboniferous (Gzhelian), while the Hardap fauna (DSIII) is correlated with the *Eurydesma* transgression of earliest Permian age (Asselian) that can be widely picked up across Gondwana (Dickens 1961, 1984, Bangert *et al*. 1999, Stolhoffen *et al*. 2000). The distinctive thick-shelled bivalve *Eurydesma*, well known from the Dwyka of southern Namibia, has not yet been recorded from the main Karoo Basin, however (McLachlan and Anderson 1973). The upper part of DSIV, just above the Dwyka / Ecca boundary in the western Karoo Basin (*i.e.* situated within the basal Prince Albert Formation), has been radiometrically dated to 290-288 Ma (Stolhoffen *et al*. 2000).

Low diversity ichnoassemblages dominated by non-marine arthropod trackways are widely associated with cold water periglacial mudrocks, including dropstone laminites, within the Mbizane Formation in the Main Karoo Basin (Von Brunn & Visser, 1999, Savage 1970, 1971, Anderson 1974, 1975, 1976, 1981, Almond 2008a, 2009). They are assigned to the non-marine / lacustrine *Mermia* ichnofacies that has been extensively recorded from post-glacial epicontinental seas and large lakes of Permian age across southern Gondwana (Buatois & Mangano 1995, 2004). These Dwyka ichnoassemblages include the arthropod trackways *Maculichna*, *Umfolozia* and *Isopodichnus*, the possible crustacean resting trace *Gluckstadtella*, sinuous fish-fin traces (*Undichna*) as well as various unnamed horizontal burrows. The association of these interglacial or post-glacial ichnoassemblages with rhythmites (interpreted as varvites generated by seasonal ice melt), the absence of stenohaline marine invertebrate remains, and their low diversity suggest a restricted, fresh- or brackish water environment. Herbert and Compton (2007) also inferred a freshwater depositional environment for the Dwyka / Ecca contact beds in the SW Cape based on geochemical analyses of calcareous and phosphatic diagenetic nodules within the upper Elandsvlei and Prince Albert Formations respectively. Well-developed U-shaped burrows of the ichnogenus *Rhizocorallium* are recorded from sandstones interbedded with varved mudrocks within the upper Dwyka Group (Mbizane facies) on the Britstown sheet (Prinsloo 1989). Similar *Rhizocorallium* traces also described from the Dwyka Group of Namibia (*e.g.* the Hardap Shale Member, Miller 2008). References to occurrences of the complex helical spreiten burrow *Zoophycos* in the Dwyka of the Britstown sheet and elsewhere (*e.g.* Prinsloo 1989) are probably in error, since in Palaeozoic times this was predominantly a shallow marine to estuarine ichnogenus (Seilacher 2007).

Scattered records of fossil vascular plants within the Dwyka Group of the Main Karoo Basin record the early phase of the colonisation of SW Gondwana by members of the *Glossopteris* Flora in the Late Carboniferous (Plumstead 1969, Anderson & McLachlan 1976, Anderson & Anderson 1985 and earlier refs. therein). These records include fragmentary carbonized stems and leaves of the seed ferns *Glossopteris* / *Gamgamopteris* and several gymnospermous genera (*e.g. Noeggerathiopsis, Ginkgophyllum*) that are even found within glacial tillites. More "primitive" plant taxa include lycopods (club mosses) and true mosses such as *Dwykea*. It should be noted that the depositional setting (*e.g.* fluvial *versus* glacial) and stratigraphic position of some of these records are contested (*cf* Anderson & McLachlan 1976). Petrified woods with well-developed seasonal growth rings are recorded from the upper Dwyka Group (Mbizane Formation) of the northern Karoo Basin (*e.g.* Prinsloo 1989) as well as from the latest Carboniferous of southern Namibia. The more abundant

Namibian material (*e.g. Megaporoxylon*) has recently received systematic attention (Bangert & Bamford 2001, Bamford 2000, 2004) and is clearly gymnospermous (pycnoxylic, *i.e.* dense woods with narrow rays) but most woods cannot be assigned to any particular gymnosperm order.

Borehole cores through Dwyka mudrocks have yielded moderately diverse palynomorph assemblages (organic-walled spores, acanthomorph acritarchs) as well as plant cuticles. These mudrocks are interbedded with diamictites in the southern Karoo as well as within Dwyka valley infills along the northern margin of the Main Karoo Basin (McLachlan & Anderson 1973, Anderson 1977, Stapleton 1977, Visser 1989, Anderson & Anderson 1985). Thirty one Dwyka palynomorph species are mentioned by the last authors, for example. Anderson's (1977) Late Carboniferous to Early Permian Biozone 1 based on Dwyka palynomorph assemblages is characterized by abundant *Microbaculispora*, monosaccate pollens (*e.g. Vestigisporites*) and nontaeniate bisaccate pollens (*e.g. Pityosporites*) (Stephenson 2008). Prinsloo (1989) mentions stromatolitic limestone lenses within the uppermost Dwyka Group in the Britstown sheet area while stromatolites are also recorded within the uppermost Dwyka beds in the Kenhardt area (Slabbert *et al.* 1999). These may be comparable to interglacial microbial mats and mounds described from the Ganikobis Shale Member (DSII) of southern Namibia by Grill (1997) and Bangert *et al.* (2000). However, it should be noted that abiogenic cone-in-cone structures developed within ferruginous diagenetic carbonate nodules have also been frequently mistaken for stromatolites in the past. Some of these Karoo stromatolite records may therefore in fact refer to pseudofossils.

Although a wide range of fossils are now known from the Dwyka Group, most sediments assigned to this succession are unfossiliferous (with the possible exception of microfossils). The overall palaeontological sensitivity of the Dwyka Group is therefore rated as low (Almond & Pether 2008). Any interglacial mudrocks and heterolithic successions (*i.e.* interbedded sandstones and mudrocks) are worth investigating for fossils, however, and the more proximal Mbizane Formation may be considered to be of moderate palaeontological sensitivity.

4.2. Fossils within the superficial deposits

The fossil record of the **Kalahari Group** is generally sparse and low in diversity. The **Gordonia Formation** dune sands were mainly active during cold, drier intervals of the Pleistocene Epoch that were inimical to most forms of life, apart from hardy, desert-adapted species. Porous dune sands are not generally conducive to fossil preservation. However, mummification of soft tissues may play a role here and migrating lime-rich groundwaters derived from the underlying Dwyka Group may lead to the rapid calcretisation of organic structures such as burrows and root casts. Occasional terrestrial fossil remains that might be expected within this unit include calcretized rhizoliths (root casts) and termitaria (*e.g. Hodotermes*, the harvester termite), ostrich egg shells (*Struthio*) and shells of land snails (*e.g. Trigonephrus*) (Almond 2008a, Almond & Pether 2008). Other fossil groups such as freshwater bivalves and gastropods (*e.g. Corbula, Unio*) and snails, ostracods (seed shrimps), charophytes (stonewort algae), diatoms (microscopic algae within siliceous shells) and stromatolites (laminated microbial limestones) associated with local watercourses and pans. Microfossils such as diatoms may be blown by wind into nearby dune sands (Du Toit 1954, Dingle *et al.*, 1983). These Kalahari fossils (or subfossils) can be expected to occur sporadically but widely, and the overall palaeontological sensitivity of the Gordonia Formation is therefore considered to be low. Underlying **calcretes** might also contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways.

Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings) may be expected occasionally expected within Kalahari Group sediments and calcretes, as well as in associated ancient alluvial gravels. A brief review of fossil biotas within Neogene alluvial deposits of the Loeriesfontein / Bushmanland region has been given by Almond (2008a; see also papers by Cooke 1949, Wells 1964, Butzer *et al.* 1973, Helgren 1977, Klein 1984, Macrae 1999). They include remains of fish, reptiles, mammals, freshwater molluscs, petrified wood and trace fossils (*e.g.* De Wit 1990, 1993, De Wit & Bamford 1993, Bamford 2000, Bamford & De Wit 1993, Senut *et al.* 1996). It is noted that the final layout of the 75 MW solar power plant is designed to minimise impacts on the drainage areas and so any fossil heritage preserved within alluvial deposits will be largely safeguarded.

5. IMPACT ASSESSMENT

Impacts of solar power plant developments on palaeontological heritage generally occur only in the construction phase. They stem from the disturbance, destruction or sealing-in of fossil material preserved at or beneath the ground surface.

The significance of the proposed AES solar power plant as far as fossil heritage is concerned is summarised in Table 2 in the HIA. The impact is considered to be NEGLIGIBLE given:

(a) the low palaeontological sensitivity of the Palaeozoic bedrocks as well as the superficial sediments (alluvium, wind-blown sands) within the development footprint;

(b) the minor excavations of potentially fossiliferous bedrocks involved (*e.g.* foundations for ancillary buildings, trenches for buried cables);

(c) Fossils preserved within alluvial sediments will be largely safeguarded by the proposed final layout that avoids drainage areas.

MITIGATION

Since the palaeontological sensitivity of the rock units within the study area is generally low, the development footprint is fairly small, and extensive bedrock excavations are not envisaged, the impact significance of the proposed solar power plant as far as fossil heritage is concerned is likely to be very small. Therefore further specialist palaeontological studies or mitigation of this project are not considered necessary.

6. CONCLUSIONS & RECOMMENDATIONS

The site of the proposed Olyven Kolk solar power plant is largely underlain by Permocarboniferous glacial-related sediments of the Dwyka Group (Mzibane Formation) that are generally of low palaeontological sensitivity. Quaternary to Recent aeolian sediments of the Gordonia Formation (Kalahari Group) as well as similar-aged alluvial gravels and calcretes, both of low palaeontological sensitivity, may also be encountered near-surface in the study area, especially along drainage lines, but these units are largely safeguarded by the proposed layout for the plant.

Should substantial fossil remains be exposed during construction, however, these should be recorded (GPS, photos) by the responsible ECO and safeguarded, if possible *in situ*. SAHRA should be notified by the ECO so that appropriate specialist mitigation can be considered.

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GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONTOLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
Quaternary alluvium	sands, silts, gravels	sparse remains of fish, reptiles, mammals, freshwater molluscs, petrified wood and trace fossils	**LOW**	none recommended any substantial fossil finds to be reported by ECO to SAHRA
Gordonia Formation KALAHARI GROUP plus SURFACE CALCRETE	mainly aeolian sands plus minor fluvial gravels, freshwater pan deposits, calcretes PLEISTOCENE to RECENT	calcretised rhizoliths & termitaria, ostrich egg shells, land snail shells, rare mammalian and reptile (e.g. tortoise) bones, teeth freshwater units associated with diatoms, molluscs, stromatolites etc	**LOW**	none recommended any substantial fossil finds to be reported by ECO to SAHRA
Mbizane Formation DWYKA GROUP	tillites, interglacial mudrocks, deltaic & turbiditic sandstones, minor thin limestones LATE CARBONIFEROUS – EARLY PERMIAN	sparse petrified wood & other plant remains, palynomorphs, trace fossils (e.g. arthropod trackways, fish trails, U-burrows) possible stromatolites in limestones	**LOW TO MODERATE**	none recommended any substantial fossil finds to be reported by ECO to SAHRA

8. REFERENCES

Agenbacht, A.L.D. 2007. The geology of the Pofadder area. Explanation of 1: 250 000 geology sheet 2918. 89 pp. Council for Geoscience, Pretoria.

Almond, j.e. 2008a. Fossil record of the Loeriesfontein sheet area (1: 250 000 geological sheet 3018). Unpublished report for the Council for Geoscience, Pretoria, 32 pp.

Almond, J.E. 2008b. Palaeozoic fossil record of the Clanwilliam sheet area (1: 250 000 geological sheet 3218). Unpublished report for the Council for Geoscience, Pretoria, 49 pp. (To be published by the Council in 2009).

Almond, J.E. 2009. Contributions to the palaeontology and stratigraphy of the Alexander Bay sheet area (1: 250 000 geological sheet 2816), 117 pp. Unpublished technical report prepared for the Council for Geoscience by Natura Viva cc, Cape Town.

Almond, J.E. & Pether, J. 2008. Palaeontological heritage of the Northern Cape. Interim SAHRA technical report, 124 pp. Natura Viva cc., Cape Town.

Almond, J.E. 2011. Proposed Solar Cape Photovoltaic Electricity Generation Facility near Kenhardt, Northern Cape Province. Palaeontological impact assessment: desktop study, 18 pp.

Anderson, A.M. 1974. Arthropod trackways and other trace fossils from the Early Permian lower Karoo Beds of South Africa. Unpublished PhD thesis, University of Witwatersrand, Johannesburg, 172 pp.

Anderson, A.M. 1975. Turbidites and arthropod trackways in the Dwyka glacial deposits (Early Permian) of southern Africa. Transactions of the Geological Society of South Africa 78: 265-273.

Anderson, A.M. 1976. Fish trails from the Early Permian of South Africa. Palaeontology 19: 397-409, pl. 54.

Anderson, A.M. 1981. The *Umfolozia* arthropod trackways in the Permian Dwyka and Ecca Groups of South Africa. Journal of Paleontology 55: 84-108, pls. 1-4.

Anderson, A.M. & Mclachlan, I.R. 1976. The plant record in the Dwyka and Ecca Series (Permian) of the south-western half of the Great Karoo Basin, South Africa. Palaeontologia africana 19: 31-42.

Anderson, J.M. 1977. The biostratigraphy of the Permian and the Triassic. Part 3: A review of Gondwana Permian palynology with particular reference to the northern Karoo Basin, South Africa. Memoirs of the Botanical Survey of South Africa 45, 14-36.

Anderson, J.M. & Anderson, H.M. 1985. Palaeoflora of southern Africa. Prodromus of South African megafloras, Devonian to Lower Cretaceous, 423 pp, 226 pls. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

Bamford, M.K. 2000. Fossil woods of Karoo age deposits in South Africa and Namibia as an aid to biostratigraphical correlation. Journal of African Earth Sciences 31, 119-132.

Bamford, M.K. 2004. Diversity of woody vegetation of Gondwanan South Africa. Gondwana Research 7, 153-164.

Bamford, M.K. & De Wit, M.C.J. 1993. Taxonomic description of fossil wood from Cainozoic Sak River terraces, near Brandvlei, Bushmanland, South Africa. Palaeontologia africana 30: 71-80.

Bangert, B., Stolhoffen, H., Lorentz, V. & Armstrong, R. 1999. The geochronology and significance of ash-fall tuffs in the glacigenic Carboniferous – Permian Dwyka Group of Namibia and South Africa. Journal of African Earth Sciences 29: 33-49.

Bangert, B., Stolhofen, H., Geiger, M. & Lorenz, V. 2000. Fossil record and high resolution tephrostratigraphy of Carboniferous glaciomarine mudstones, Dwyka Group, southern Namibia. Communications of the Geological Survey of Namibia 12, 235-245.

Bangert, B. & Bamford, M. 2001. Carboniferous pycnoxylic woods from the Dwyka Group of southern Namibia. Palaeontologia africana 37, 13-23.

Buatois, L. & Mangano, M.G. 1995. The paleoenvironmental and paleoecological significance of the lacustrine *Mermia* ichnofacies: an archetypal subaqueous nonmarine trace fossil assemblage. Ichnos 4: 151-161.

Buatois, L. & Mangano, M.G. 2004. Animal-substrate interactions in freshwater environments: applications of ichnology in facies and sequence stratigraphic analysis of fluvio-lacustrine successions. In: McIlroy, D. (Ed.) The application of ichnology to palaeoenvironmental and stratigraphic analysis. Geological Society, London, Special Publications 228, pp 311-333.

Butzer, K.W., Helgren, D.M., Fock, G. & Stuckenrath, R. 1973. Alluvial terraces of the Lower Vaal River, South Africa: a re-appraisal and re-investigation. Journal of geololgy 81, 341-362.

Cooke, H.B.S. 1949. Fossil mammals of the Vaal River deposits. Memoirs of the geological Survey of South Africa 35, 1-117.

Cooper, M.R. & Oosthuizen, R. 1974. Archaeocyathid-bearing erratics from Dwyka Subgroup (Permo-Carboniferous) of South Africa, and their importance to continental drift. Nature 247, 396-398.

De Wit, M.C.J. 1990. Palaeoenvironmental interpretation of Tertiary sediments at Bosluispan, Namaqualand. Palaeoecology of Africa and the surrounding islands 21: 101-118.

De Wit, M.C.J. 1993. Cainozoic evolution of drainage systems in the north-western Cape. Unpublished PhD thesis, University of Cape Town, Cape Town, 371 pp.

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. & Bamford, M.K. 1993. Fossil wood from the Brandvlei area, Bushmanland as an indication of palaeoenvironmental changes during the Cainozoic. Palaeontologia africana 30: 81-89.

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.

Dickens, J.M. 1961. *Eurydesma* and *Peruvispira* from the Dwyka Beds of South Africa. Palaeontology 4: 138-148, pl. 18.

Dickens, J.M. 1984. Late Palaeozoic glaciation. BMR Journal of Australian Geology and Geophysics 9: 163-169.

Dingle, R.V., Siesser, W.G. & Newton, A.R. 1983. Mesozoic and Tertiary geology of southern Africa. viii + 375 pp. Balkema, Rotterdam.

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

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.

Evans, F.J.E. 2005. Taxonomy, palaeoecology and palaeobiogeography of some Palaeozoic fish of southern Gondwana. Unpublished PhD thesis, University of Stellenbosch, 628 pp.

Grill, H. 1997. The Permo-Carboniferous glacial to marine Karoo record in southern Namibia: sedimentary facies and sequence stratigraphy. Beringeria 19: 3-98, 1 pl.

Haddon, I.G. 2000. Kalahari Group sediments. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp. 173-181. Oxford University Press, Oxford.

Helgren, D.M. 1977. Geological context of the Vaal River faunas. South African Journal of Science 73, 303-307.

Herbert, C.T. & Compton, J.S. 2007. Depositional environments of the lower Permian Dwyka diamictite and Prince Albert shale inferred from the geochemistry of early diagenetic concretions, southwest Karoo Basin, South Africa. Sedimentary Geology 194: 263-277.

Johnson, M.R., Van Vuuren, C.J., Visser, J.N.J., Cole, D.I., De V. Wickens, H., Christie, A.D.M., Roberts, D.L. & Brandl, G. 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 461-499. Geological Society of South Africa, Marshalltown.

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.

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

Mclachlan, I.R. & Anderson, A. 1973. A review of the evidence for marine conditions in southern Africa during Dwyka times. Palaeontologia africana 15: 37-64.

Miller, R.M. 2008. Karoo Supergroup, pp. 16-1 to 16-115 in Miller, R.G. The geology of Namibia. Volume 3. Upper Palaeozoic to Cenozoic. Geological Survey, Namibia.

Oelofsen, B.W. 1986. A fossil shark neurocranium from the Permo-Carboniferous (lowermost Ecca Formation) of South Africa. In: Uyeno, T, Arai, R., Taniuchi, T & Matsuura, K. (Eds.) Indo-Pacific fish biology. Proceedings of the Second International Conference on Indo-Pacific Fishes. Ichthyological Society of Japan, Tokyo, pp 107-124.

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.

Pickford, M. & Senut, B. 2002. The fossil record of Namibia. 39 pp. The Geological Survey of Namibia.

Plumstead, E.P. 1969. Three thousand million years of plant life in Africa. Alex Du Toit Memorial Lectures No. 11. Transactions of the Geological Society of South Africa, Annexure to Volume 72, 72pp. 25 pls.

Prinsloo, M.C. 1989. Die geologie van die gebied Britstown. Explanation to 1: 250000 geology Sheet 3022 Britstown, 40 pp. Council for Geoscience, Pretoria.

Savage, N.M. 1970. A preliminary note on arthropod trace fossils from the Dwyka Series in Natal. IUGS Second Gondwana Symposium, South Africa, 1970, Proceedings and Papers, pp 627-635, pls. 1-5.

Savage, N.M. 1971. A varvite ichnocoenosis from the Dwyka Series of Natal. Lethaia 4: 217-233.

Seilacher, A. 2007. Trace fossil analysis, xiii + 226pp. Springer Verlag, Berlin.

Senut, B., Pickford, M., Ward, J., De Wit, M., Spaggiari, R. & Morales, J. 1996. Biochronology of the Cainozoic sediments at Bosluis Pan, Northern Cape Province, South Africa. South African Journal of Science 92: 249-251.

Siebrits, L.B. 1989. Die geologie van die gebied Sakrivier. Explanation of 1: 250 000 geology sheet 3020, 19 pp. Council for Geoscience, Pretoria.

Slabbert, M.J., Moen, H.F.G. & Boelema, R. 1999. Die geologie van die gebied Kenhardt. Explanation to 1: 250 000 geology Sheet 2920 Kenhardt, 123 pp. Council for Geoscience, Pretoria.

Stapleton, R.P. 1977. Carboniferous unconformity in southern Africa. Nature 268, 222-223.

Stephenson, M.H. 2008. A review of the palynostratigraphy of Gondwanan Late Carboniferous to Early Permian glacigene successions. In: Fielding, C.R., Frank, T.D. & Isbell, J.L. (eds). Resolving the Late Paleozoic Ice Age in time and space. Geological Society of America Special Paper 441, 317-330.

Stolhoffen, H., Stanistreet, I.G., Bangert, B. & Grill, H. 2000. Tuffs, tectonism and glacially-related sea-level changes, Carboniferous-Permian, southern Namibia. Palaeogeography, Palaeoclimatology, Palaeoecology 161: 127-150.

Stone, P. & Thomson, M.R.A. 2005. Archaeocyathan limestone blocks of likely Antarctic origin in Gondwanan tillite from the Falkland Islands. Geological Society, London, Special Publications 246, 347-357.

Thomas, M.J. 1981. The geology of the Kalahari in the Northern Cape Province (Areas 2620 and 2720). Unpublished MSc thesis, University of the Orange Free State, Bloemfontein, 138 pp.

Thomas, R.J., Thomas, M.A. & Malherbe, S.J. 1988. The geology of the Nossob and Twee Rivieren areas. Explanation for 1: 250 000 geology sheets 2520-2620. 17pp. Council for Geoscience, Pretoria.

Thomas, D.S.G. & Shaw, P.A. 1991. The Kalahari environment, 284 pp. Cambridge University Press.

Veevers, J.J., Cole, D.I. & Cowan, E.J. 1994. Southern Africa: Karoo Basin and Cape Fold Belt. Geological Society of America, Memoir 184: 223-279.

Visser, J.N.J. 1982. Upper Carboniferous glacial sedimentation in the Karoo Basin near Prieska, South Africa. Palaeogeography, Palaeoclimatology, Palaeoecology 38, 63-92.

Visser, J.N.J. 1985. The Dwyka Formation along the north-western margin of the Karoo Basin in the Cape Province, South Africa. Transactions of the Geological Society of South Africa 88, 37-48.

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

Visser, J.N.J. 1997. Deglaciation sequences in the Permo-Carboniferous Karoo and Kalahari Basins of southern Africa: a tool in the analysis of cyclic glaciomarine basin fills. Sedimentology 44: 507-521.

Visser, J.N.J. 2003. Lithostratigraphy of the Elandsvlei Formation (Dwyka Group). South African Committee for Stratigraphy, Lithostratigraphic Series No. 39, 11 pp. Council for Geoscience, Pretoria.

Visser, J.N.J., Loock, J.C., Van Der Merwe, J., Joubert, C.W., Potgieter, C.D., Mclaren, C.H., Potgieter, G.J.A., Van der Westhuizen, W.A., Nel, L. & Lemer, W.M. 1977-78. The Dwyka Formation and Ecca Group, Karoo Sequence, in the northern Karoo Basin, Kimberley-Britstown area. Annals of the Geological Survey of South Africa 12, 143-176.

Visser, J.N.J., Von Brunn, V. & Johnson, M.R. 1990. Dwyka Group. Catalogue of South African Lithostratigraphic Units 2, 15-17. Council for Geoscience, Pretoria.

Visser, J.N.J., Van Niekerk, B.N. & Van Der Merwe, S.W. 1997. Sediment transport of the Late Palaeozoic glacial Dwyka Group in the southwestern Karoo Basin. South African Journal of Geology 100: 223-236.

Von Brunn, V. & Visser, J.N.J. 1999. Lithostratigraphy of the Mbizane Formation (Dwyka group). South African Committee for Stratigraphy, Lithostratigraphic Series No. 32, 10 pp. Council for Geoscience, Pretoria.

Wells, L.H. 1964. The Vaal River 'Younger Gravels" faunal assemblage: a revised list. South African Journal of Science 60, 92-94.

Zawada, P.K. 1992. The geology of the Koffiefontein area. Explanation of 1: 250 000 geology sheet 2924 Koffiefontein, 30 pp. Council for Geoscience, Pretoria.

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 under the aegis of his Cape Town-based company *Natura Viva* cc. He is 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 APHAP (Association of Professional Heritage Assessment 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.

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