PALAEONTOLOGICAL SPECIALIST ASSESSMENT: DESKTOP STUDY

Proposed photovoltaic energy plant on Farm Struisbult (Portion 1 of Farm 104) near Copperton, Northern Cape Province

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1. EXECUTIVE SUMMARY

Mulilo Renewable Energy (Pty) Ltd, Cape Town, is proposing to construct a photovoltaic energy plant (PV2) on the farm Struisbult (Portion 1 of Farm 104), situated some 50 km southwest of Prieska and adjacent to the small mining village of Copperton, Northern Cape Province. A preferred site of 300 ha for a 100 MW solar energy facility as well as an alternative site of 900 ha for a 300 MW facility, both southeast of Copperton, are under consideration. The study area, currently used for stock farming, is largely underlain by Permo-Carboniferous glacial sediments of the Dwyka Group (Karoo Supergroup) that overlie unfossiliferous granitoid and highly metamorphosed Precambrian basement rocks. These older bedrocks are generally covered by a range of superficial deposits of Pleistocene to Recent age, including alluvium, downwasted or fluvially reworked coarse gravels, calcrete hardpans, aeolian sands, sandy to silty soils and pan sediments.

Previous field assessments in the Copperton area suggest that the poorly-exposed upper Dwyka Group bedrocks here do not contain rich trace fossil assemblages, petrified wood or other fossil material, and are therefore of low palaeontological sensitivity. The only fossils recorded from the Dwyka succession in the region are ice-transported erratic boulders of Precambrian limestone or dolomite that contain small stromatolites (microbial mounds or columns). The overlying superficial sediments are likewise of low palaeontological sensitivity for the most part. However, important assemblages of mammalian fossils of the Late Pleistocene Florisian Mammal Age (estimated 300 - 200 000 BP) have been recorded from pan sediments at Bundu Pan only 22 km to the northwest of Copperton (Kiberd 2006), and somewhat younger fossil teeth are reported from subsurface gravels in a borrow pit on the farm Hoekplaas 11 km to the southeast of the village (Orton 2012). It is quite likely that comparable concentrations of Pleistocene vertebrate fossils are also preserved on buried palaeosurfaces and within alluvial gravels or pan sediments on the Farm Struisbult. However, these occurrences are likely to be sparse and their distribution is largely unpredictable.

As far as fossil heritage is concerned, the impact significance of the proposed solar energy facility is considered to be LOW for the following reasons:

- The Precambrian basement rocks are entirely unfossiliferous;
- The Karoo Supergroup bedrocks here are deeply weathered and at most sparsely fossiliferous;
- The development footprints for both the preferred and alternative sites are small and largely underlain by superficial deposits of low palaeontological sensitivity;

- Significant fossil material (*e.g.* mammal remains) at or near surface is probably very sparsely distributed within the study area; and

- Extensive, deep bedrock excavations are not envisaged during the construction phase.

Potential impacts on fossil heritage are confined to the development footprint and are only anticipated, if at all, during the construction phase. There is no preference on fossil heritage grounds for the preferred *versus* alternative development area within the boundaries of Struisbult Farm. Neither of these sites has fatal flaws in palaeontological heritage terms. A number of other alternative energy projects – including both wind energy and solar energy facilities – have been proposed for the Copperton area. Given the generally low palaeontological sensitivity of the Karoo bedrocks and Pleistocene to Recent superficial sediments in the region as a whole, the cumulative impact of these developments is not considered to be of high significance.

It is recommended that:

- The Environmental Control Officer (ECO) responsible for the development should be aware of the possibility of important fossils (*e.g.* mammalian bones, teeth) being present or unearthed on site and should monitor all substantial excavations into superficial sediments as well as fresh (*i.e.* unweathered) sedimentary bedrock for fossil remains;

- In the case of any significant fossil finds (*e.g.* vertebrate teeth, bones, burrows, petrified wood) during construction, these should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to the relevant heritage management authority (SAHRA, Cape Town) so that any appropriate mitigation (*i.e.* recording, sampling or collection) by a palaeontological specialist can be considered and implemented, at the developer's expense; and

- These recommendations should be incorporated into the Environmental Management Plan (EMP) for the Struisbult PV2 solar energy facility project.

The palaeontologist concerned with any mitigation work will need a valid collection permit from SAHRA. All work would have to conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere to the minimum standards for Phase 2 palaeontological studies currently being developed by SAHRA.

2. INTRODUCTION & BRIEF

The company Mulilo Renewable Energy (Pty) Ltd (Mulilo), Cape Town, is proposing to construct a photovoltaic energy plant (PV2) on the farm Struisbult (Portion 1 of Farm 104), situated some 50 km southwest of Prieska and adjacent to the small mining village of Copperton, Northern Cape Province (Fig. 1) (DEA REF. NO. 12/12/20/2099). The study area, currently used for stock farming, lies to the northeast of the Copperton Mine and south of the airstrip. A preferred site of 300 ha for a 100 MW (Alternative 1, preferred) solar energy facility to the southeast of Copperton village as well as an alternative site of 900 ha for a 300 MW (Alternative 2) facility in the same area are under consideration (Fig. 2). The type of foundations required for the PV panels (isolated concrete bases / continuous concrete bases / concrete piles / thrusted supporting structures) has not yet been determined, and will depend on soil characteristics within the chosen development area.

In addition to the PV module array, the following main infrastructural developments will be required:

- Upgrading of existing internal farm roads and construction of new roads to accommodate construction vehicles and access to the site;

- Construction of a 132 kV transmission line to connect the proposed PV plant with Eskom's grid *via* the Cuprum Substation located to the southwest of the study area (Fig. 2);

- Construction of an electrical fence to prevent illegal trespassing, as well as to keep livestock from roaming between the solar arrays and causing accidental damage; and

- Construction of an office, connection centre and a guard cabin.

The Mulilo PV2 solar energy facility would be built over a period of 18 to 30 months and will have a life span of approximately 20 years.

Aurecon South Africa (Pty) Ltd (Aurecon) has been appointed to undertake the requisite environmental process as required in terms of the National Environmental Management Act (No. 107 of 1998), as amended, on behalf of Mulilo. Given the presence of potentially fossiliferous Karoo Supergroup and Late Caenozoic sediments in the study area, a desktop palaeontological assessment for the project has been commissioned by Aurecon in accordance with the requirements of the National Heritage Resources Act, 1999. The terms of reference for this study, as defined by Aurecon, are briefly as follows:

- To undertake a Palaeontological Impact Assessment of the study site which would include:
  (1) Conducting a detailed desk-top level investigation to identify all palaeontological resources /features in the proposed development area; and
  (2) Document (GPS coordinates and map) all sites identified on the proposed sites.

- To compile a report which would include:
  (1) Identification of palaeontological sites within the proposed development areas;
  (2) Assess the sensitivity and significance of palaeontological resources / features in the site;
  (2) Evaluation of the potential impacts of construction, operation and maintenance of the proposed development on palaeontological resources / features, in terms of the scale of impact (local, regional, national), magnitude of impact (low, medium or high) and the duration of the impact (construction, up to 10 years after construction (medium term), more than 10 years after construction (long term));
  (3) Recommendation of mitigation measures to ameliorate any negative impacts on areas of palaeontological importance; and
  (4) Consideration of relevant guidelines.

2.1. Project implications for palaeontological heritage & relevant legislation

The proposed solar energy facility is located in an area of the Main Karoo Basin of South Africa that is underlain by potentially fossiliferous sedimentary rocks of the Karoo Supergroup that are of Late Carboniferous to Early Permian age. The construction phase of the development will entail excavations into the superficial sediment cover (soils, alluvial gravels *etc*) and perhaps also into the underlying potentially fossiliferous bedrock. These notably include excavations for the PV panel support structures, buried cables, internal access roads, any new power line pylons and associated infrastructure. All these developments may adversely affect potential fossil heritage within the study area by destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good. Once constructed, the operational and decommissioning phases of the PV power station will not involve further adverse impacts on palaeontological heritage, however.

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 August 2011.

2.3. Approach to this palaeontological study

This report provides an assessment of the observed or inferred palaeontological heritage within the Copperton study area, with recommendations for any specialist palaeontological mitigation where this is considered necessary. The report is based on (1) a review of the relevant scientific literature, (2) geological maps, and (3) several previous palaeontological heritage assessments for alternative energy developments in the Copperton region (*e.g.* Almond 2010a, 2010b, 2011a, 2011b, 2012a, 2012b).

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 following scoping during the compilation of the final report. This data is then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Northern Cape have been compiled by 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 and scale 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 field-based assessment by a professional palaeontologist is usually warranted.

On the basis of the desktop study, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) – is usually most effective during the construction phase when fresh fossiliferous bedrock has been exposed by excavations, although pre-construction recording of surface-exposed material may sometimes be more appropriate. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority (*i.e.* SAHRA, Cape Town). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

2.4. Assumptions & limitations

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

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

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

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

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

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

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

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

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

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

In the case of palaeontological studies in the Copperton region, the main limitation is the very high levels of bedrock cover by alluvial and colluvial soils, calcretes and gravels. Since several good bedrock exposures are available in roadside borrow pits and small quarries for building stone within the broader Copperton study region, as recorded in the recent study by Almond (2012a), however, confidence levels in the conclusions presented here are moderately high.

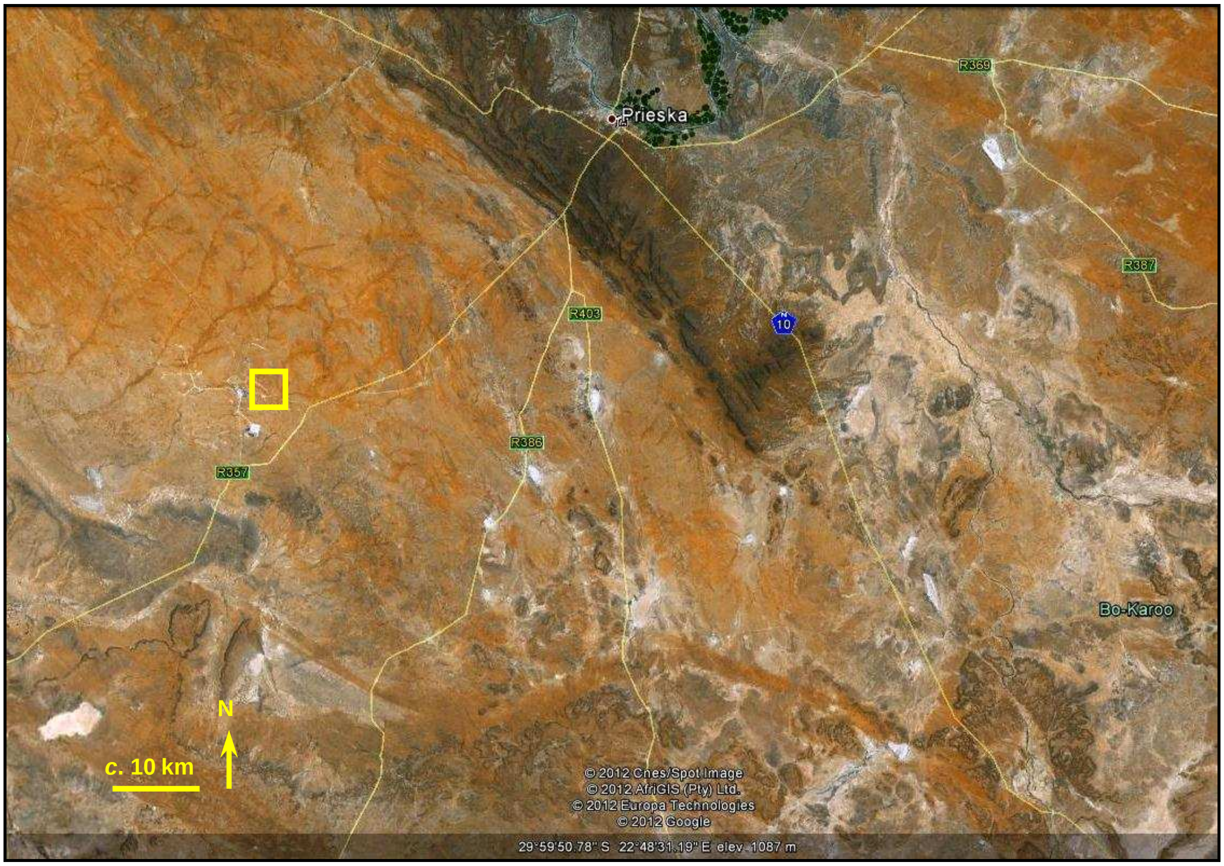

Fig. 1. Google Earth© satellite image of the Northern Cape study region showing the *approximate* location (yellow square) of the proposed Mulilo PV2 solar energy plant study area on the farm Struisbult, situated adjacent to Copperton and some 50 km southwest of the town of Prieska on the River Orange (top centre)(See also Fig. 2).

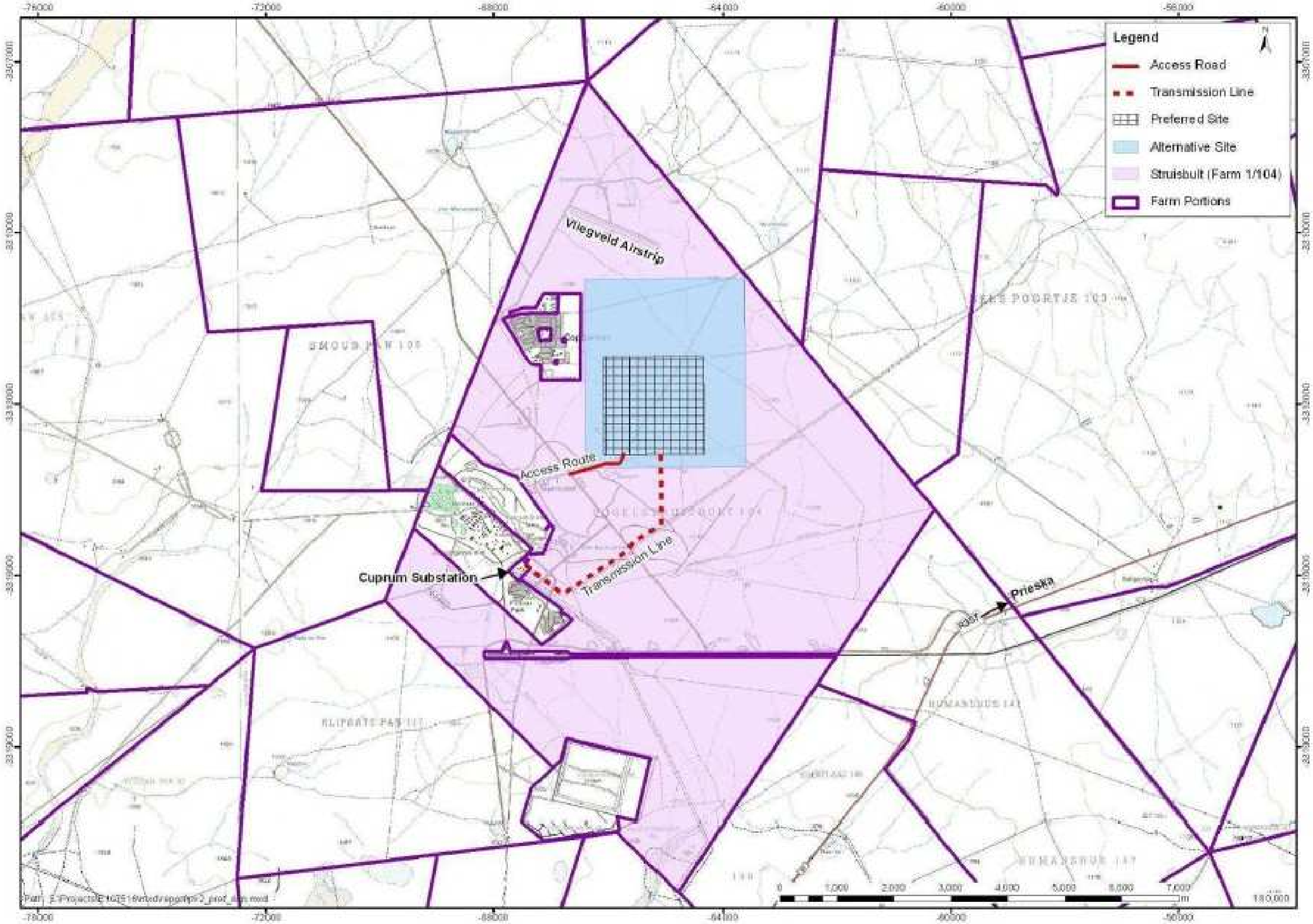

Fig. 2. Map showing the boundaries of Struisbult Farm 104 surrounding the mining village and mine at Copperton (lilac area). The preferred and alternative sites for the proposed PV2 energy plant as well as a proposed short 132 kV transmission line to the nearby Cuprum Substation (dashed red line) are also shown (Image abstracted by the Final Scoping Report by Gresse & Corbett 2012, Aurecon South Africa (Pty) Ltd).

3. GEOLOGICAL BACKGROUND

Satellite images of the PV2 study area near Copperton (Fig. 3) show that it largely consists of fairly flat-lying, semi-arid, sandy to gravelly terrain lying at elevations of *c*. 1050 to 1100 m amsl. This region forms part of the low-relief *Kaiingveld* of eastern Bushmanland. Drainage is limited to small, intermittently active streams and pans (*e.g.* Perdepan and Saaipan in the south-western part of the area). The regional drainage shows a net flow towards the west into old Tertiary drainage systems rather than the Orange River to the north. Vegetation cover is low, comprising sparse bossies (dwarf shrubs) and summer grasses with taller, shrubby vegetation around pan margins and along water courses. Levels of bedrock exposure are very low due to pervasive cover by superficial sediments (*e.g.* soil, alluvium, gravels, calcrete). However, good sections through the superficial sediments are seen in roadside borrow pits along the R357 between Prieska and Vanwyksvlei that runs just to the south of the study area (Almond 2012a, 2012b).

The geology of the study area around Copperton is shown on the 1: 250 000 geology map 2922 Prieska (Council for Geoscience, Pretoria; Fig. 4 herein). There is as yet no explanation published for the Prieska sheet but several of the various rock units mapped here are treated in some detail in the accompanying sheet explanation by Prinsloo (1989).

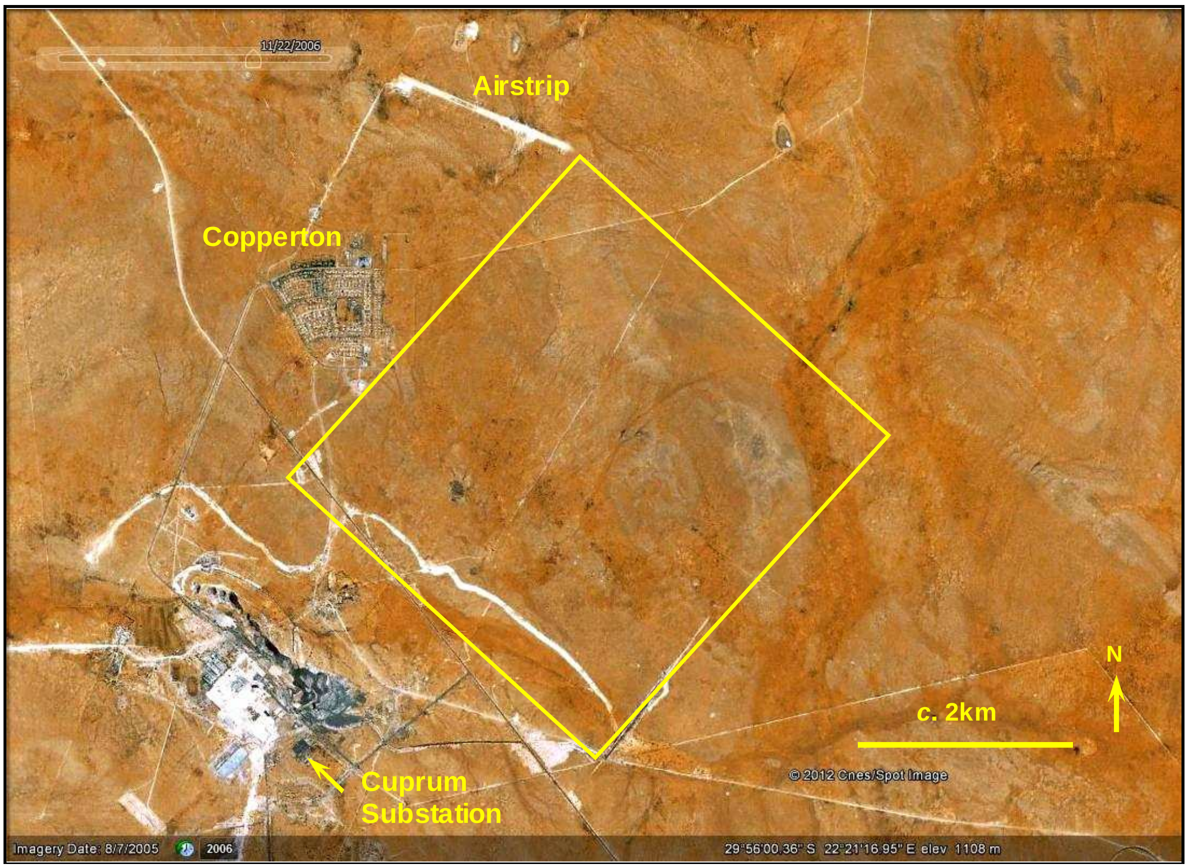

Fig. 3. Google Earth© satellite image of the Struisbult PV2 study area (broadly defined by the yellow rectangle) adjacent to the mining village of Copperton. The boundaries of the study area are shown more accurately in Fig. 2 above. Copperton Mine lies to the north of the Cuprum Substation.

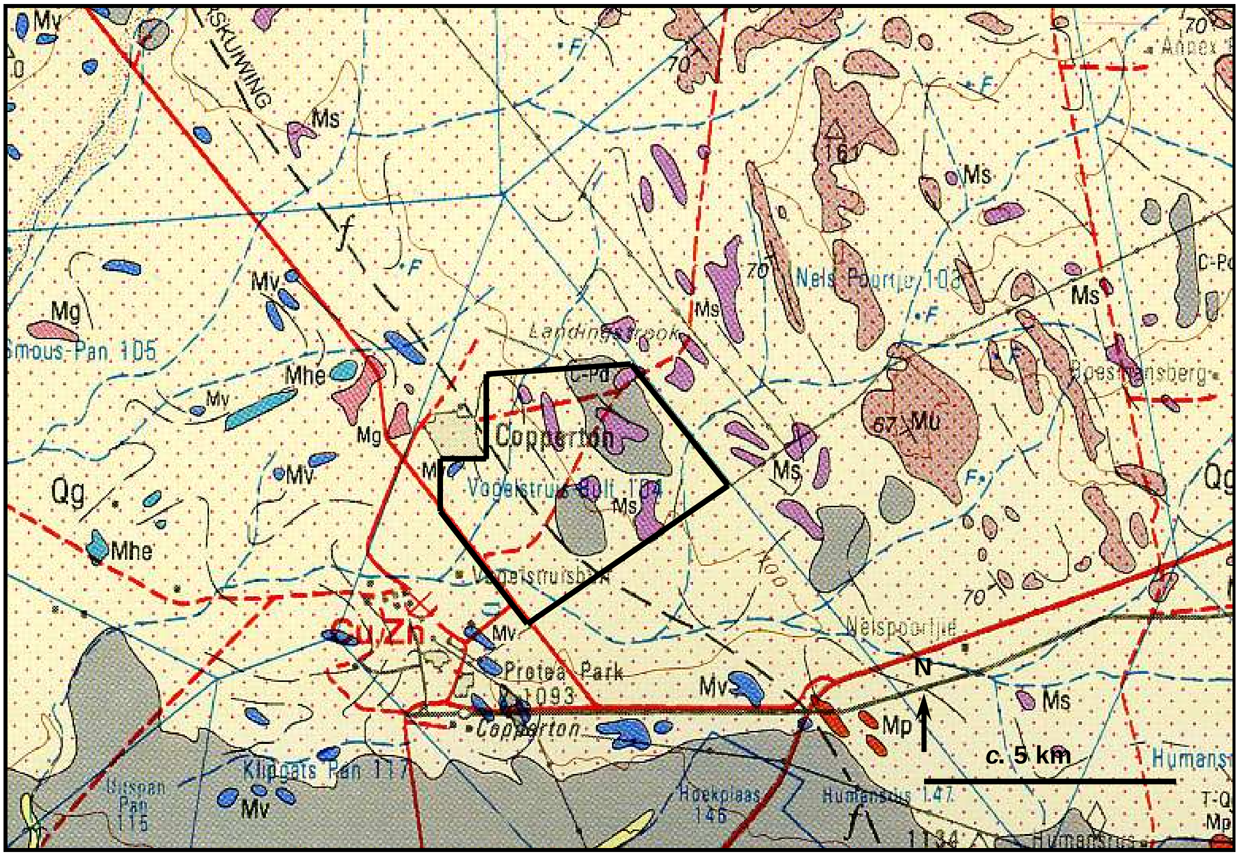

Fig. 3. Extract from 1: 250 000 geology map 2922 Prieska (Council for Geoscience, Pretoria) showing approximate outline of the proposed Mulilo PV2 solar energy facility near Copperton (black polygon).

The main geological units mapped within the Copperton PV2 study region are:

1. Precambrian basement rocks (igneous / metamorphic):

Purple (Ms) = Spioenkop Formation (Marydale Group)
Dark blue (Mv) = Vogelstruisbult Formation (Jacobsmyn Pan Group)

2. Karoo Supergroup sediments:

Grey (C-Pd) = Mbizane Formation (Dwyka Group)

3. Late Caenozoic (Quaternary to Recent) superficial deposits:

Pale yellow (Qg) = Gordonia Formation (Kalahari Group)

(*N.B.* calcrete hardpans extensively present in the subsurface and superficial soils and gravels are not mapped at this scale)

3.1. Precambrian basement rocks

Numerous small inliers of ancient **Precambrian basement rocks** emerge through the cover of Kalahari sands in the Copperton area. Those to the southwest of the NW-SE fault line running past Copperton (dashed black line through PV2 study area in Fig. 3), are assigned to the **Vogelstruisbult Formation** of the **Jacobsmyn Pan Group** (**Mv**). This group of basement rocks mainly consists of high grade metamorphic rocks (banded pelitic gneiss, migmatites) that are unfossiliferous (Slabbert *et al*., 1999, Cornell *et al*., 2006). They are of undetermined Mokolian age, *i.e.* mid-Proterozoic (between 1000 to 2050 Ma = million years old). An isolated remnant of Mokolian basement rocks was protected from pre-Dwyka erosion to the southeast of Copperton (Visser 1985). Metasedimentary basement rocks to the northeast of the fault line, within the PV2 study area, are assigned to the **Spioenkop Formation** of the **Marydale Group** (**Ms**). They consist mainly of metamorphosed sediments (quartzites, schists) with some metamorphosed igneous rocks as well (*e.g.* amphibolites). The Marydale Group rocks form part of a 2 - 8 km thick Archaean (Early Precambrian) greenstone belt (ancient oceanic crust) along the southwest margin of the ancient Kaapvaal continent and are over 2.5 billion years old (Prinsloo 1989, Potgieter & Botha 1982, Brandl *et al.*, 2006).

These ancient basement rocks were last metamorphosed some one billion or so years ago (1 – 1.2 Ga) and since they are entirely unfossiliferous they will not be considered further here.

3.2. Permo-Carboniferous Dwyka Group

Beneath the superficial sediment cover Permo-Carboniferous glacial sediments of **Dwyka Group** (**C-Pd, Karoo Supergroup**) underlie most of the Struisbult study area, although they are extensively mantled here by Late Caenozoic superficial deposits. Dwyka bedrocks may therefore be intersected by deeper excavations during development. The geology of the Dwyka Group has been summarized by Visser (1989), Visser *et al.* (1990) and Johnson *et al.* (2006), among others.

The Dwyka Group along the north-western margin of the Main Karoo Basin, including the Prieska Subbasin in particular, has been reviewed by Visser (1982, 1985). In Dwyka times the Prieska – Copperton area lay within a basement high region between the Sout River Valley in the west and the Prieska Basin in the east (Fig. 5). This area is referred to as the Kaiing Hills or Kaiing Veld Region by Visser and is characterized by a relatively thin Dwyka succession (normally < 50m). This mainly comprises massive clast-rich diamictites and clast–poor argillaceous diamictites ("boulder shale") overlain by a thin zone of laminated dropstone argillite with outsized clasts composed mainly of quartzite and gneiss (Visser 1985; Fig. 6 below). Note the presence of an isolated peak (*monadnock*) of Proterozoic basement rocks emerging through the Dwyka cover rocks to the southeast of Copperton (*ibid*.). Ice transport directions initially towards the south and later towards the southwest are reconstructed by Visser (1985, his fig. 17). The source area of many of the exotic boulder erratics (*e.g.* stromatolitic carbonates of Griqualand West succession, amygdaloidal lavas of the Ventersdorp Supergroup) seen in the Dwyka succession near Copperton, as well as the Prieska Basin to the east, is the elevated Ghaap Plateau to the north of Prieska (Visser 1982, his fig. 2).

Further detailed observations on the Dwyka beds on the northern edge of the Britstown 1: 250 000 sheet, just south of the present study area, are provided by Prinsloo (1989). Good surface outcrops of the Dwyka beds are rare here due to extensive cover by thin surface gravels. Massive tillites at the base of the Dwyka succession were deposited by dry-based ice sheets in deeper basement valleys. Later climatic amelioration led to melting, marine transgression and the retreat of the ice sheets 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 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.

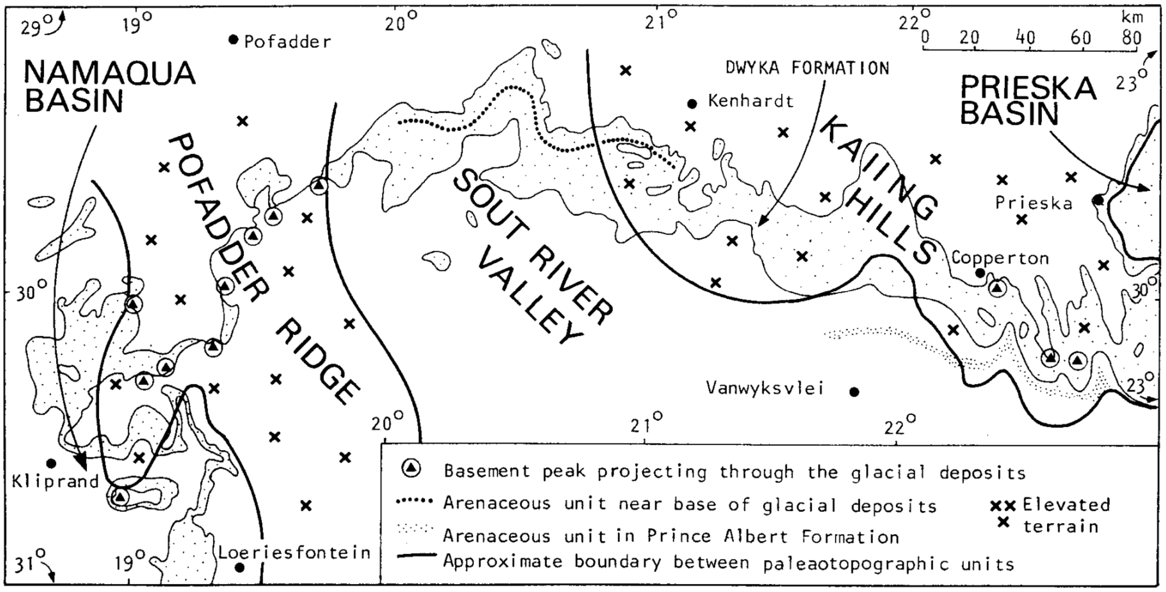

Fig. 5. Reconstruction of the topography along the northern margin of the Karoo Basin in Dwyka times showing location of the Prieska-Copperton area on a basement high with scattered peaks of basement rock projecting through the Dwyka glacial sediment cover (From Visser 1985).

According to maps in Visser *et al.* (1990) and Von Brunn and Visser (1999) the Dwyka rocks in the Prieska-Copperton 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 190 m thick, is recognized across the entire northern margin of the Main Karoo Basin where it may variously form the whole or (as here) 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.

Judging from satellite images (Fig. 3), there are no extensive natural exposures of Dwyka bedrocks in the Struisbult study area. Slightly greyish areas seen in the eastern portion of the area may indicate Dwyka bedrocks close to the surface, however. Deeply-weathered pale grey mudrocks with sparse cobbly to boulder erratics ("boulder shales") of the upper Dwyka Group are exposed in several roadside quarries along the R357 (Almond 2012a, 2012b). The upper one or two meters of the Dwyka bedrocks here are extensively calcretised, with a network of calcrete veins. Good exposures of Dwyka boulder shales and dropstone laminites on the farm Klipgats Pan, 15 km south of Copperton, have been briefly described by Almond (2012a).

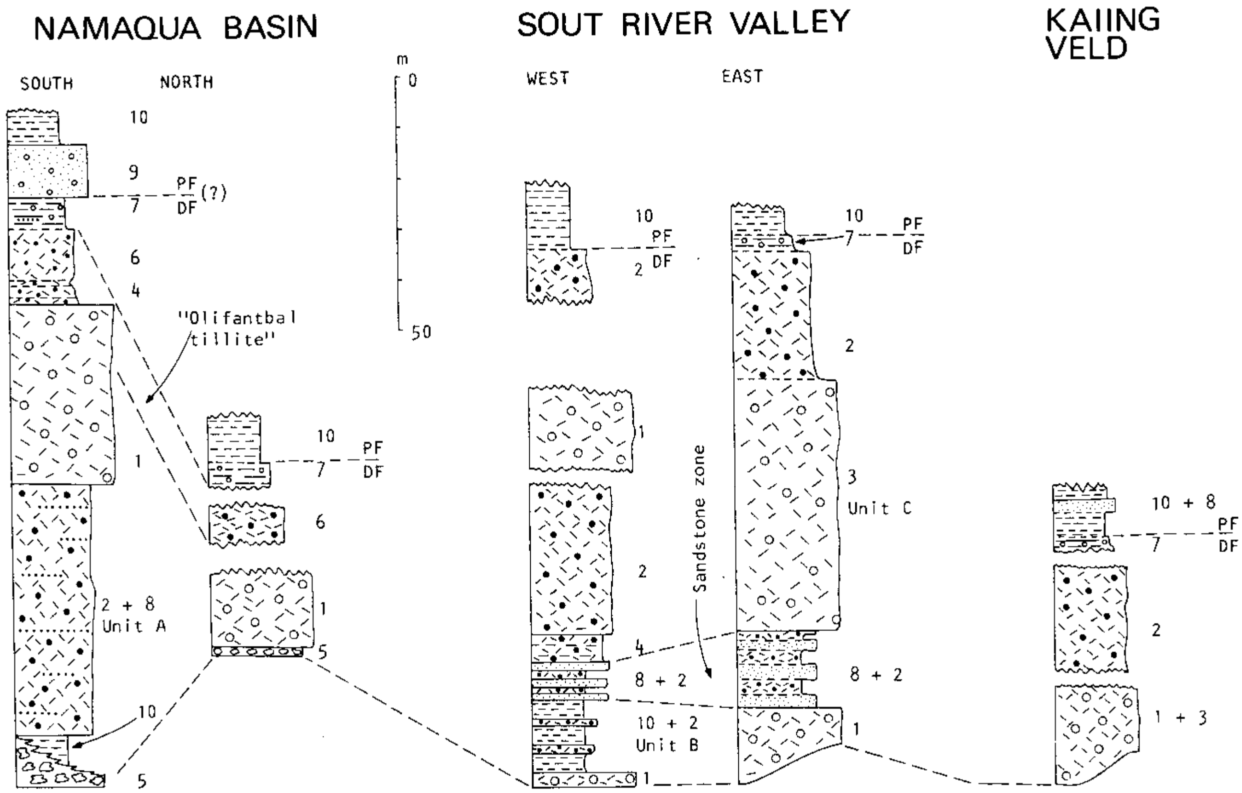

Figure 2

Regional stratigraphic sequences of the Dwyka Formation between Loeriesfontein and the Doringberg Range with the lithofacies indicated by numbers. 1. Massive clast-rich arenaceous diamictite. 2. Massive clast-poor argillaceous diamictite ("boulder shale"). 3. Massive diamictite (undifferentiated). 4. Bedded diamictite. 5. Brecciated basement rocks (local tillite). 6. Massive carbonate-rich diamictite ("olifantbal tillite"). 7. Dropstone argillite ("varved shale"). 8. Fine- to coarse-grained sandstone. 9. Pebbly sandstone. 10. Dark grey to black, micaceous shale and mudstone. Lithological units numbered A, B, and C will be referred to in the text. DF = Dwyka Formation, PF = Prince Albert Formation (see Fig. 1 for location of regions).

Fig. 6. Stratigraphic logs through the Dwyka Group along the northern margin of the Main Karoo Basin. The short Kaiing Veld log on the RHS, dominated by diamictite facies, is most relevant to the Copperton area (From Visser 1985).

3.3. Late Caenozoic superficial sediments

A wide range of superficial sediments of probable Pleistocene to Recent age mantle the Precambrian and Palaeozoic bedrocks in the Struisbult study area, but for the most part these are not mapped at 1: 250 000 scale (Fig. 4). Similar sediments are briefly described from the farm Klipgats Pan, 15 km south of Copperton, by Almond (2012a), from which the following account is largely taken.

Polymict, **boulder gravels** generated by downwasting of resistant weathering, exotic erratics from the underlying Dwyka glacial rocks may directly overlie the Dwyka bedrock or subsurface calcrete hardpans. In some areas these surface gravels have been concentrated and reworked during Late Caenozoic times into fluvial gravels or other superficial sediments, including soils and calcretes. The gravels are angular to well-rounded and occasionally show glacial facetting and striation. They consist of a wide range of exotic lithologies (granites, gneisses, schists, quartzites, hornfels, jaspilitic banded iron formation, cherts, vein quartz, carbonates including limestone and dolomite, amygdaloidal and other lavas, reworked calcrete *etc*) and have locally been flaked. Many iron- or manganese-rich rock types have developed a shiny dark desert varnish.

Sandy to silty soils mantle a large portion of the study area and may reach thickesses of 1 - 2 m, but are usually much thinner. The superficial sandy soils are generally orange-brown and unconsolidated; they probably have a substantial wind-blown component. These are underlain by paler buff, better-consolidated silty soils that are often incipiently calcretised. The soils contain sparse gravel clasts that locally are concentrated into lenticular to laterally-persistent 10 to 40 cm thick horizons of fine gravels (occasionally flaked) accompanied by reworked, well-rounded calcrete clasts that clearly represent buried ancient palaeosurfaces.

Unconsolidated aeolian sands attributed to the Pleistocene to Recent **Gordonia Formation** of the Kalahari Group (Fig. 7) are mapped over large areas of the Struisbult study area (Qg in Fig. 3). Their thickness in the study region is uncertain. The geology of the Late Cretaceous to Recent Kalahari Group is reviewed by Thomas (1981), Dingle *et al.* (1983), 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, dated in part from enclosed Middle to Late Stone Age stone tools (Dingle et al., 1983, p. 291). Note that the recent extension of the Pliocene - Pleistocene boundary from 1.8 Ma back to 2.588 Ma would place the Gordonia Formation entirely within the Pleistocene Epoch.

A number of older Kalahari formations underlie the young wind-blown surface sands in the main Kalahari depository to the north of the study area (Fig. 7). However, at the latitude of Copperton (*c*. 30° S) Gordonia Formation sands less than 30 m thick are likely to be the main or perhaps only Kalahari sediments present (*cf* isopach map of the Kalahari Group, fig. 6 *in* Partridge *et al*., 2006). These unconsolidated sands are probably locally to extensively underlain by thin surface gravels equivalent to the **Obobogorop Formation**, formed from down-wasted (residual) or water-transported clasts weathered out of the Dwyka tillites, as well as by calcretes of Pleistocene age or younger (*cf* **Mokalanen Formation**, Fig. 7).

A well-developed massive and vuggy to laminated **calcrete hardpan** underlies the soil horizons over large parts of the Copperton study region, as can be seen in quarry excavations along the R357 (Almond 2012a, 2012b). Extensive calcrete development is typical of the Ecca and Dwyka outcrop areas in Bushmanland, especially around pans (Prinsloo 1989). A horizon of poorly-sorted downwasted gravels usually occurs on the upper surface, beneath the superficial soil capping, and coarse gravels are often embedded within the calcrete hardpan. There have clearly been several phases of Late Caenozoic calcrete development in the region. Reworking of older calcretes into younger horizons is shown by lenticles of calcrete breccia and even well-developed conglomerates up to 2 m thick composed of well-rounded pebbly and cobbly calcrete clasts. Sizeable solution hollows (*dolines* or *makondos*) have not been reported, but may be present. Calcretisation extends several meters down as a network of veins into the underlying, deeply-weathered Dwyka mudrock saprolite (*in situ* weathered bedrock). These calcretes and overlying gravels may be tentatively equated with the Pleistocene Mokalanen and Obogorop Formations respectively of the Kalahari Group to the north (Fig. 7).

A variety of gravelly, sandy and silty **alluvial sediments** line shallow, intermittently-flowing water courses, while pan areas typically contain fine-grained silts and calcrete-rich subsoils (*cf* Partridge & Scott 2000, Partridge *et al.* 2006). In areas of sparse vegetation where the soil surface has been ablated by wind and / or sheetwash processes, extensive sheets of sparse gravels clasts are present. Many of these are too large to have been moved by sheetwash processes, and must have downwasted more or less *in situ* as the Dwyka outcrop was denuded by erosion.

The detailed description of the superficial sediment stratigraphy at Bundu Pan, located only some 22 km northwest of Copperton, by Kiberd (2006 and refs. therein) is very relevant to the present study area. Seven stratigraphic units (Groups 1-7), some of them fossiliferous, were recognised in trenches into the pan area. Among these, the uppermost four units bear close comparison with deposits observed within borrow pits in the Copperton study area. These are, in ascending order, Group 4 (laminated to massive calcrete hardpan, locally silcretised), Group 3 (pebbly and cobbly gravels, locally calcretised), Group 2 (sands / silts with horizons of gravels) and Group 1 (reddish surface sands).

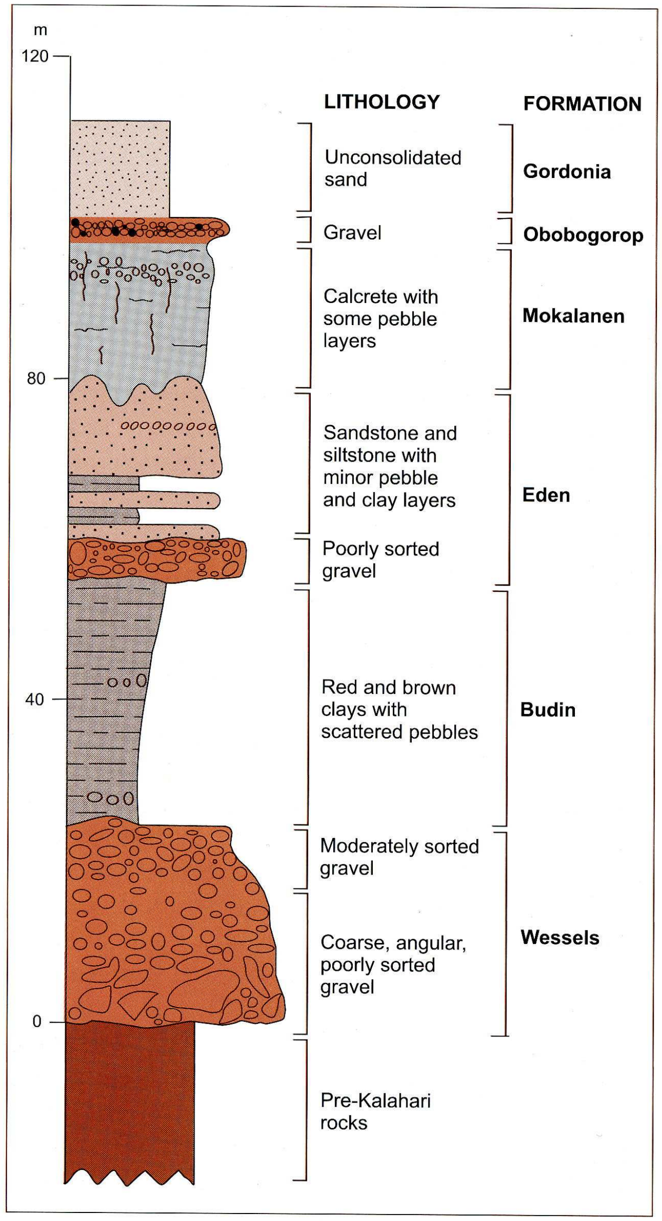

Fig. 7. Stratigraphy of the Kalahari Group (From Partridge *et al.,* 2006). Superficial sediments within the study area are tentatively equated with the uppermost three formations of the Kalahari Group.

4. PALAEONTOLOGICAL HERITAGE

The fossil heritage recorded within each of the main sedimentary rock units mapped at surface level within the study area is outlined here in order of decreasing geological age (see also summary of fossil heritage in Table 1 below). Note that the Precambrian basement rocks are not treated here since they are entirely unfossiliferous.

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, Visser 2003, Almond & Pether 2008) is hardly surprising given the glacial climates that prevailed during much of the Late Carboniferous to Early 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 dropstone laminites and sporadic vascular plant remains, 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), especially in the Kalahari Basin of southern Namibia but also in some cases within the Main Karoo Basin in South Africa (Oelofsen 1986, Visser 1989, 1997, Visser *et al*. 1997, Bangert *et al*. 1999, Stollhofen *et al*. 2000, Almond 2008). 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, Stollhofen *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 (Stollhofen *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 2008, 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) (Fig. 17). 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). Visser (1982) makes brief but unspecific references to bioturbation and trace fossils within the Dwyka sediments of the Prieska Basin, for example within his sandstone-siltstone-shale and (late glacial to post-glacial) varved mudrock facies.

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 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. 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).

Fig. 8. Large U-burrows of the ichnogenus *Rhizocorallium* in ripple-marked sandstones of the upper Dwyka Group, Britstown sheet area (From Prinsloo, 1989).

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. Since the Prieska-Copperton area lay on a basement high in Dwyka times (Fig. 5), interglacial mudrocks are unlikely to be well represented here. Late-glacial or post-glacial mudrocks, such as those containing a fairly rich shelly fossil record at Douglas in the Northern Cape (McLachlan & Anderson 1973) have apparently been lost to erosion in the Prieska region.

The only fossils recorded from the Dwyka Group in the Copperton area are small domical to columnar stromatolites within bouldery erratics grey carbonate (probably dolomite) from the farm Klipgats Pan by Almond (2012a). These erratics have probably been transported by ice movement from the Campbell Rand Subgroup (Ghaap Group) that crops out in the Ghaap Plateau to the north of Prieska.

4.2. Fossils in the superficial sediments

The various superficial "drift deposits" of the Bushmanland and Karoo regions of South Africa, including aeolian sands, alluvium, calcretes and pan deposits, have been comparatively neglected in palaeontological terms. However, they may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals as well as remains of reptiles like tortoises. Good examples are the Pleistocene mammal faunas at Florisbad, Cornelia and Erfkroon in the Free State and elsewhere (Wells & Cooke 1942, Cooke 1974, Skead 1980, Klein 1984, Brink, J.S. 1987, Bousman *et al.* 1988, Bender & Brink 1992, Brink *et al*. 1995, MacRae 1999, Meadows & Watkeys 1999, Churchill *et al*. 2000 Partridge & Scott 2000). Other late Caenozoic fossil biotas from these superficial deposits include non-marine molluscs (bivalves, gastropods), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites), and plant remains such as peats or palynomorphs (pollens, spores) in organic-rich alluvial horizons (Scott 2000) and siliceous diatoms in pan sediments. Calcrete hardpans might also contain trace fossils such as rhizoliths, termite nests and other insect burrows, or even mammalian trackways. Solution hollows within well-developed calcrete horizons may have acted as fossil traps in the past, as seen in Late Caenozoic limestones near the coast and Precambrian carbonate successions of the Southern African interior. Dense concentrations of vertebrate remains (*e.g.* small mammals, reptiles) or terrestrial molluscs, for example, are a possibility here. In Quaternary deposits, fossil remains may be associated with human artefacts such as stone tools and are also of archaeological interest (*e.g.* Smith 1999 and refs. therein). Stone artefacts of Pleistocene and younger age may additionally prove useful in constraining the age of superficial deposits such as gravelly alluvium and pedocretes within which they are occasionally embedded.

Important fossil mammalian remains assigned to the Florisian Mammal Age (*c*. 300 000 – 12 000 BP; MacRae 1999) have recently been documented from stratigraphic units designated Group 4 to Group 6 (*i.e.* calcrete hardpan and below) at Bundu Pan, some 22 km northwest of Copperton (Kiberd 2006 and refs. therein). These are among very few Middle Pleistocene faunal records from stratified deposits in the southern Africa region (Klein 1980, 1984a, 1984b, 2000) and are therefore of high palaeontological significance. Characteristic extinct Pleistocene species recorded at Bundu Pan are the giant Cape Horse or Zebra (*Equus capensis*) and the Giant Hartebeest (*Megalotragus priscus*). Other extant to extinct taxa include species of warthog, blesbok, black wildebeest, springbok and baboon. There is additionally trace fossil evidence for hyaenids (tooth marks) as well as ostrich egg shell. Preliminary dating and the inferred ecology of the fossil taxa present suggests the presence of standing water within a grassy savanna setting during the 200-300 000 BP interval when the Bunda Pan faunal assemblage accumulated. A sequence of Earlier, Middle and Later Stone Age artefact assemblages is also recorded from this site. Stratigraphic Groups 4 to 6 (*i.e.* calcrete hardpan and below) contain a Final Acheulian or transitional Earlier Stone Age (ESA) / Middle Stone Age (MSA) artefact assemblage, while Groups 2-3 above the calcrete horizon contain a MSA artefact assemblage.

Orton (2012) recorded a single fossil equid tooth associated with a rich MSA artefact assemblage exposed in an erosion donga leading into the southern edge of quarry Q2 on the farm Hoekplaas (originally a pan). The source horizon is probably equivalent to Group 2 or Group 3 of Kiberd's (2006) stratigraphic scheme (Almond 2012b). It is quite likely that fossil bones and teeth of mammals are preserved within buried Pleistocene fluvial and pan sediments within the Struisbult study area, as seen at Bundu Pan in the same region. However, such fossil sites are likely to be sparsely distributed and their locations difficult to predict, given the extensive younger sedimentary cover.

Table 1: Fossil heritage in the Copperton area

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONT-OLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
KALAHARI GROUP ***plus*** **various unassigned superficial sediments of comparable age and origin**	Surface aeolian sands (Gordinia Formation), sandy and silty soils, calcrete hardpans, downwasted gravels, *plus* fluvial gravels, alluvium, freshwater pan deposits MAINLY 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*	GENERALLY LOW BUT LOCALLY HIGH (*e.g.* concentrations of mammalian fossils, molluscs in pan and fluvial sediments)	Any substantial fossil finds (*e.g.* mammalian bones, teeth) to be reported by ECO to SAHRA
Mbizane Formation **DWYKA GROUP**	Tillites, interglacial mudrocks, deltaic & turbiditic sandstones, minor thin limestones LATE CARBONIFER-OUS – EARLY PERMIAN	Sparse petrified wood & other plant remains, palynomorphs, trace fossils (*e.g.* arthropod trackways, fish trails, U-burrows) possible stromatolites in limestones, fossiliferous erratics (*e.g.* stromatolitic limestones / dolomites)	LOW	Any substantial fossil finds (*e.g.* petrified wood) to be reported by ECO to SAHRA
Vogelstruisbult Formation (Jacobsmyn Pan Group) **Spioenkop Formation (Marydale Group)**	Small inliers of various granitic and high grade metamorphic rocks PRECAMBRIAN (ARCHAEAN TO MID PROTEROZOIC)	NONE	N/A	None

5. ASSESSMENT OF SIGNIFICANCE OF PALAEONTOLOGICAL HERITAGE IMPACTS

The significance of impacts on palaeontological heritage resources within the Struisbult PV2 photovoltaic energy plant study area is assessed for the construction phase in Table 2 below. Please note that the operational and decommissioning phases of the solar energy facilities will not involve further significant adverse or other impacts on palaeontological heritage.

Table 2: Evaluation of impacts of proposed PV2 photovoltaic energy plant (Alternative 1 and Alternative 2) on farm Struisbult near Copperton on local fossil heritage resources

CRITERIA	STATUS	COMMENTS
Scale	Local (site specific)	Limited to development footprint
Magnitude	Low	Karoo bedrocks here are probably deeply weathered and at most sparsely fossiliferous. Development footprint is largely underlain by superficial deposits of low palaeontological sensitivity. Significant fossil material (*e.g.* mammal remains) at or near surface level is most likely very sparsely distributed within the study area. Development footprint is small. Extensive, deep bedrock excavations are not envisaged during the construction phase.
Duration	Long term	Permanent.
Significance	Low	Specialist monitoring or mitigation measures therefore not proposed for this project.
Probability	Unlikely	Within development footprint the potentially fossiliferous sediments are usually buried beneath superficial deposits which may be one or more meters thick (*e.g.* calcrete hardpan, soils).
Confidence	Moderately high	Limited by low levels of bedrock exposure within study area (This is partially compensated by study of better exposures elsewhere)
Reversibility	Irreversible	Loss of fossil heritage is generally permanent. Appropriate mitigation of any significant fossil finds (reporting by ECO, recording by professional palaeontologist) will lead to positive impact in terms of increased palaeontological knowledge.

6. CONCLUSIONS & RECOMMENDATIONS

Previous field assessments suggest that the poorly-exposed upper Dwyka Group bedrocks in the Copperton area do not contain rich trace fossil assemblages, petrified wood or other fossil material, and are therefore of low palaeontological sensitivity. The only fossils recorded from the Dwyka succession in this region are ice-transported erratic boulders of Precambrian limestone or dolomite that contain small stromatolites (microbial mounds or columns) (Almond 2012a). The study area is largely mantled by Pleistocene to Recent superficial sediments (soils, alluvium, calcretes, gravels *etc*) that are likewise generally of low palaeontological sensitivity (Almond & Pether 2008). However, important mammal fossil remains assigned to the Late Pleistocene Florisian Mammal Age (estimated 300 - 200 000 BP) have been recorded from pan sediments at Bundu Pan only 22 km to the northwest of Copperton (Kiberd 2006), and somewhat younger fossil teeth have been reported from subsurface gravels on Hoekplaas (Orton 2012). It is quite likely that comparable concentrations of Pleistocene vertebrate fossils are also preserved on buried palaeosurfaces and within alluvial gravels or pan sediments on Farm Struisbult. However, these occurrences are likely to be sparse and their distribution is largely unpredictable.

As far as fossil heritage is concerned, the impact significance of the proposed solar energy facility is considered to be LOW for the following reasons:

- The Precambrian basement rocks are entirely unfossiliferous;
- The Karoo Supergroup bedrocks here are deeply weathered and at most sparsely fossiliferous;
- The development footprints for both the preferred and alternative sites are small and largely underlain by superficial deposits of low palaeontological sensitivity;
- Significant fossil material (*e.g.* mammal remains) at or near surface is probably very sparsely distributed within the study area; and
- Extensive, deep bedrock excavations are not envisaged during the construction phase.

Potential impacts on fossil heritage are confined to the development footprint and are only anticipated, if at all, during the construction phase. There is no preference on fossil heritage grounds for the preferred *versus* alternative development area within the boundaries of Struisbult Farm. Neither of these sites has fatal flaws in palaeontological heritage terms. A number of other alternative energy projects – including both wind energy and solar energy facilities – have been proposed for the Copperton area (*cf* Almond 2010a, 2010b, 2011a, 2011b, 2012a, 2012b; Gresse & Corbett 2012). Given the generally low palaeontological sensitivity of the Karoo bedrocks and Pleistocene to Recent superficial sediments in the region as a whole, the cumulative impact of these developments is not considered to be of high significance.

It is recommended that:

- The ECO responsible for the development should be aware of the possibility of important fossils (*e.g.* mammalian bones, teeth) being present or unearthed on site and should monitor all substantial excavations into superficial sediments as well as fresh (*i.e.* unweathered) sedimentary bedrock for fossil remains;
- In the case of any significant fossil finds (*e.g.* vertebrate teeth, bones, burrows, petrified wood) during construction, these should be safeguarded - preferably *in situ* - and reported by the ECO as soon as possible to the relevant heritage management authority (SAHRA, Cape Town) so that any appropriate mitigation (*i.e.* recording, sampling or collection) by a palaeontological specialist can be considered and implemented, at the developer's expense; and
- These recommendations should be incorporated into the EMP for the Struisbult PV2 solar energy facility project.

The palaeontologist concerned with any mitigation work will need a valid collection permit from SAHRA. All work would have to conform to international best practice for palaeontological fieldwork and the study (*e.g.* data recording fossil collection and curation, final report) should adhere to the minimum standards for Phase 2 palaeontological studies currently being developed by SAHRA.

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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.

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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 alternative energy 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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